UNIVERSITAT AUTÒNOMA DE BARCELONA
FACULTAT DE FILOSOFIA I LLETRES
DEPARTAMENT DE PREHISTÒRIA
DOCTORAT EN ARQUEOLOGIA PREHISTÒRICA

SPACE-TEMPORAL ANALYSIS OF RADIOCARBON EVIDENCE AND ASSOCIATED ARCHAEOLOGICAL RECORD: FROM DANUBE TO EBRO RIVERS AND FROM BRONZE TO IRON AGES

by

Giacomo Capuzzo

Thesis submitted for the degree of Doctor in Prehistoric Archaeology

Supervisor: Prof. Juan Antonio Barceló Álvarez, *UAB*

Co-Supervisor: Prof. Giovanni Leonardi, *Università degli Studi di Padova*

2014

A mia nonna

CONTENTS

1 ARCHAEOLOGY, TIME AND SPACE: CULTURAL HOMOGENIZATION AT THE END OF LATE BRONZE AGE IN EUROPE?

1.1 Introduction

The main goal of archaeological research is to reconstruct social actions in the past from a more or less coherent sub-sample of material remains from that past context having survived in the present. Our purpose is to understand why someone made something somewhere and somewhen.

In the case of Prehistoric and Protohistoric Archaeology, to attain such a goal, the only source of information at our disposal is the archaeological record. Although part of such information is lost due to post-depositional processes, our knowledge depends exclusively on how we are able to analyze the archaeological deposit, both in the field and in the laboratory.

We must be aware that the sediment alone and the material remains buried in it do not give directly a solution to our questions. They are just the data. It is only through scientific and statistical analysis that we will obtain answers to our hypothesis.

In this work our aim is to investigate the causes of space-time distributions of archaeological observables. We take for granted that the cause of an observed spatial distribution is not "space", but the nature of social action that generated the precise location and accumulation of material evidences at specific places and specific moments, and the local circumstances at the moment of the action. If an action *A* took place at some location *L*, and at some time *T*, it should be related with the occurrence of observed material evidences around *L* that can be determined were generated at time *T*, but also with observed material evidences located elsewhere, and at *T-1* and *T+1*, to explain why *A* took place where it took place and not in another location and at another place (Barceló 2005; Maximiano 2007).

The proper location of archaeological materials in time and in space is a necessary requisite for any archaeological investigation. Nevertheless, although huge advances have been made in recent years, precise measuring of time and place are not the norm in archaeological research. Time and space concepts are frequently defined in a qualitative way by archaeologists. For instance, in the archaeological literature time is often described in a qualitative way using the traditional phases of conventional chronology based on typological analysis of human artifacts. Regarding space, the spatial location of a site is frequently addressed without any mention to georeferentiation, just a toponym. Such an approach does not allow us to analyze the variability of space-time distributions of settlements, burials and pottery, among others.

Therefore, in this work we want to adopt a different focus. Temporal locations are defined by the results of the radiocarbon dating with their associated standard errors, and dendro-chronological calibration correction. Spatial location, which describes where something (such as a collection) is physically located, are defined by geospatial coordinates such as latitude and longitude, expressed either in meters (UTM coordinates) or in decimal degrees.

As we are interested in studying historical process in their correct spatial and temporal dimensions, we will introduce both separately, and their integration thereafter. The definition of the concept of *time* is not univocal, nor in archaeology, nor in any other scientific discipline. Last decades have witnessed a proliferation and diversification of theoretical discussions about time and its impact on archaeological interpretation (Murray 1999; Bailey 2005, 2007; Lucas 2005; Lock & Molyneaux 2006; Holdaway & Wandsnider 2008, Nicolucci and Hermon 2014). What we learn from this debate is that time does not exist as an autonomous physical entity, which can be observed, described and measured. What exists is the evidence of change.

It is more or less the same for the notion of space, which is ambiguous in current speaking, but also between different scientific disciplines. We can refer to “abstract” spaces, “physic” spaces, “social” spaces or even to “archaeological” spaces. Abstract space is governed by the principles of mathematical logic. Physical space relates to the localization of objects in the real world and the time needed to reach them, what impose “distances” among them. Social space is a framework in which the entities are social agents which carry on different activities and social actions of production, consumption, distribution and reproduction (Bunge 1962; Harvey 1971, 1976, 2003, 2007; Folke 1972, 1973; Anderson 1973; Santos 1974, 1977, 2000; Sánchez 1981, 1991). Archaeological space deals with the localizations of archaeological remains which are the material evidences of past social actions (Clarke 1968; Barceló 2001b; Maximiano 2007). In our research we are going to deal with all these aspects.

To sum up, when we are referring to an archaeological site, besides the physical location of material evidence, we should make reference also to the moment at which someone made something at that particular place. Archaeological sites are formed by the intersection of social agents, social actions and natural processes in space and through time. Hence, the notion of event or success should be introduced (Barceló 1991, 1993; Andresen et al. 1993; Doerr et al. 2003; Mantegari 2010). Events are "not observable; they are latent and observed through, but not defined by, noisy data. An "event it thus a theoretical construct" (Parnell et al. 2008, p. 1873). As Buck and Millard have noticed: in order to measure such events, i.e. to measure the evidences of change, all the methods should have a common factor: "they take a collection of dates or temporal relationships for a series of individual events and combine them with other information to synthesize a chronology which may include the inferred dates of events for which no direct dating evidence is available" (Buck & Millard 2004, p. V).

According to Tobler's law "everything is related to everything else, but near things are more related than distant things" (Tobler 1970). Here we should take the idea of "distance" both in its temporal and spatial sense. This principle constitutes a key-concept in order to explain the spatio-temporal dynamics of any series of events archaeological record.

Before the introduction of absolute dating and georeferentiation several attempts were made in order to "quantify" spatio-temporal dynamics in Prehistory. Nelson first managed to create chronological types, useful for measuring time (Nelson 1909). Through the typo-chronological seriation he selected attributes (shape, decoration, color and design of artifacts) that changed through time and across space. Such variations were used to measure the temporal duration of events that took place at some specific location, like, for instance, the adoption of some pottery decoration (Fig. 1).

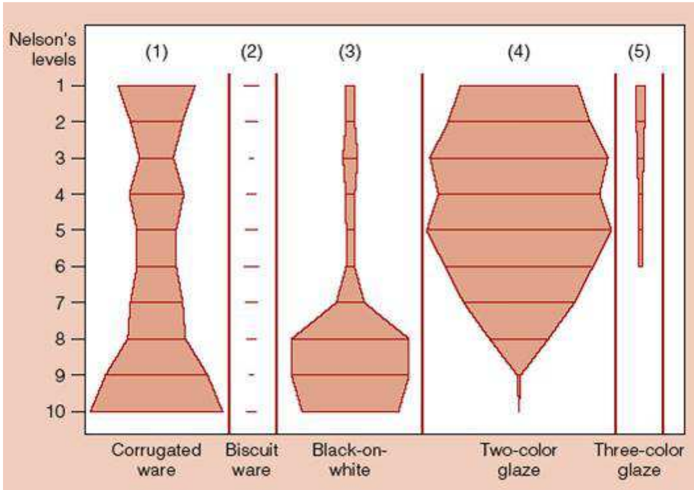

Fig. 1- Seriation diagram based on Nelson's San Cristobal potsherd frequencies (Source: Kelly & Thomas 2012).

With the introduction of radiocarbon dating at the end of the forties the material evidences of social actions started to be measured in a quantitative way. The first attempts of quantifying the duration of events summing a group of radiocarbon estimates were introduced by Ottaway (Ottaway 1972; Aitchison et al. 1991). The author introduced the concept of culture *floruit* that is the period of time when the 50% of artifacts characterizing a specific group of people from a specific geographical area ("a culture") were produced. This can be represented using a frequency distribution of the number of characteristic artifacts per unit time (Fig. 2). The *floruit* of an archaeological site can be defined in exactly the same manner (Aitchison et al. 1991).

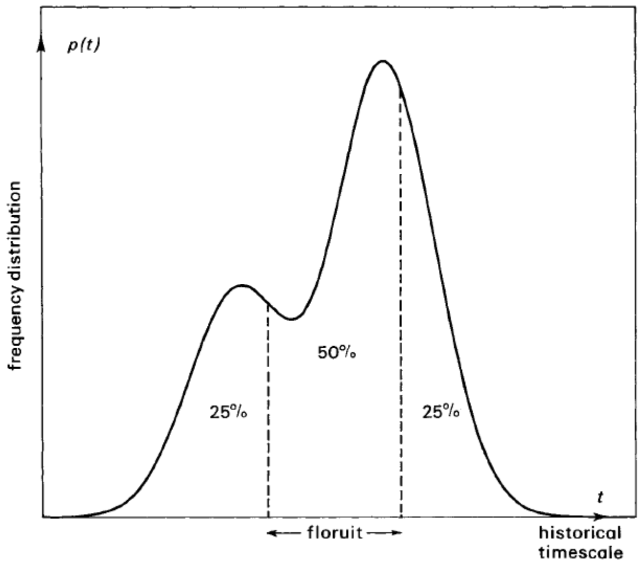

Fig. 2 – Definition of the *floruit* of a culture (Source: Aitchison et al. 1991).

Nevertheless, human history cannot be reduced to a mere sequence of time intervals during which some objects become fashionable or entered in disfavor. As mentioned previously, social events (actions) have a location in space and in time. Therefore, a proper definition of a historical period (see chapter 4.4) should be expressed in terms of the interval of time within which an undetermined number of single events happened. Such events should be understood in terms of the occurrence of social actions that were performed by someone who produced something somewhere and some-when. In general, the duration of an historical period can be estimated in terms of the temporal duration of performed social actions. Our interest is to isolate such historical events through the detection of discontinuities, which can be measured by radiocarbon dates.

1.2 Expansion and movement in archaeology

The idea of *expansion* allows us to explain the implicit relationship between time and space, as expressed in Tobler's Law, in dynamic ("historical") terms. We refer to expansive phenomena as dynamical systems such that every location at some well specified underlying space has a distinctive behavior through time. Our definition comes from the mathematical concept of *expansivity*, which formalizes the idea of points moving away from one-another under the action of an iterated function.

The concept of expansion has been extensively treated in a large variety of fields. In physics, expansion is seen as an increase in volume resulting from an increase in temperature. Contraction is the reverse process. When heat is applied to a body, the rate of vibration and the distances between the molecules composing it are increased and, hence, the space occupied by the body, i.e. its volume, increases through time. This increase in volume is not constant for all substances for any given rise in temperature, but is a specific property of each kind of matter. In business, the term "expansive cycle", referred to periodic changes in the economy, describes the phases of growth and decline in an economy. The expansion is a single stage during this process, which include four stages: contraction (when the economy starts slowing down). It's usually accompanied by a bear market (when the economy hits bottom, usually in a recession), expansion (when the economy starts growing again) and peak (when the economy is in a state of "irrational exuberance").

More related with our research goal is the notion of *expansion* in geography, usually correlated with the notion of directivity. In this domain, expansion refers to a system in which a gradient of a scalar field can be detected. Three types of gradient can be detected, a spatial gradient, a temporal gradient and a spatio-temporal one. They are closely connected; we cannot consider the spatial gradient without the time dimension but within it. The variation in space or in time of any quantity can be represented graphically by a slope. The gradient represents the steepness and direction of that slope and it can be represented by a vector field that points in the direction of the greatest rate of increase of the scalar field, and whose magnitude is that rate of increase (Fig. 3). In dynamical terms, we may explain the presence of some degree of directivity in spatio-temporal data in terms of movement, and hence of "expansion", in the mathematical and physical senses of the word.

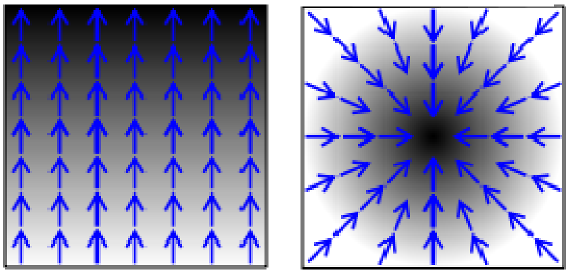

Fig. 3 - Spatial gradient in a homogenous space.

Therefore, the formal conditions for an expansive phenomenon are the existence of a spatial gradient and directivity, which implies a similarity in neighbor regions, as explained in the Tobler's Law (Tobler 1970).

Expansive phenomena in historical research have been traditionally related with the movement of people through space: invasions, migrations, colonizations, and conquests what gives the appearance of an expanding population of men and women moving through space (and time). In recent times, however, expansive phenomena in historical research are not limited to the assumption of population movement but can imply also the movements of goods and/or ideas. Therefore, "historical expansions" are not always a consequence of movement of people (a demic diffusion) but can be caused also by phenomena of cultural diffusion (acculturation) dealing with the "migration" of ideas (Prien 2005), knowledge or goods. As soon as time passes, farther places begin to use previously unknown goods or ideas, increasing the distance between the place where the good or idea appeared for the first time, and the place where it is used anew.

In fact, the discovery of a spatio-temporal gradient in a distribution of georeferenced radiocarbon estimates can also be related to other social mechanisms like exchange, imitation or cultural transmission. It is important to remark that not all spatio-temporal gradients are the result of people movements across space at different moments. In particular for early complex societies, besides classic demic diffusion models we should also take into account other social mechanisms that may fit better the archaeological data we investigate. For instance, trade, acculturation, imitation, transmission, political domination (imperialism) or others may be used to explain the spatio-temporal differences or similarities in the adoption of certain cultural features like a particular kind of instrument, a pot with distinctive decoration, a new funerary ritual, a new economic practice, a new language, a new religion.

The term *diffusion* has been defined as the process in which something new is communicated through certain channels over time among the members of a social system (Hagerstand 1967; Brown 1981; Rogers 2003). Ideas, practices or objects are usually referred as “innovations” when they are perceived as new or different by an individual or other unit of adoption. According to Schumpeter (1934), to innovate is to introduce something “new” or different by *propagating* it in an environment, and generating irreversibilities in the evolution of this environment. The more complex the innovation, the more influence its diffusion process will have on transformation of its propagation environment, as effects induced by its adoption will be all the more increased. Diffusion is as well the action as the result of phenomenon of expansion, and therefore it is assumed to transmit and propagate through space and time may be not in a uniform way, but with some global and unifying pattern, which allows its causal explanation. Social expansions in human history should be thus expressed by people, goods and/or ideas moves which, whatever their driving force, increased their spatial distances jointly.

Nevertheless, innovations are not necessarily improvements, nor they should be labeled positively. One of the shortcomings of diffusion research is its pro-innovation bias (Rogers 2003), implying that any innovation should be always diffused and adopted by all members of a social system because it is necessarily “better”. Such a bias leads us to ignore the study of ignorance about social, economic, cultural and technological change, to underemphasize the rejection or discontinuance of change. We should not refer to “innovativeness” as a positive characteristic of early adopters, because the adoption or rejection is the consequence of social decision, and hence a rational decision weighted by the social and economic situation in which it is taken. In fact, innovation is a complex process involving numerous and often unidentified factors (Dürrwächter 2009).

An innovation should be studied as something that did not existed before, be it better or worse than what existed before. We use the words “innovation” and “change” as synonyms. ”New” means here “different than what existed before, or what was previously unseen” by an individual or another social agent. The adoption of something “different” is then an evidence for “change”. Changes in ideas, practices or objects are also tightly linked with change in time and in space. Without change in time it is impossible to imagine qualitative changes, it is an independent variable of the said interaction. There is space only, when the observer does not consider time, that is “dynamics”. And we can speak of time as a generalization of changes and modifications in place (Barceló 2005). A pattern existing at one moment of time is the result of the operation of processes that have differential spatial impacts. The key aspect is here the “*location* of cultural, social, economic or technological changes”. *Location* should be understood in its spatiotemporal signification. We understand by it, a characteristic of a concrete event that defines how the characteristics of the event have changed from state 0_1 to state 0_2 at two different places E_1 and E_2, and at two different moments of time T_1 and T_2. When we discover some regularity across space and time, we may say that there is a certain degree of *dependence* between changes and the adoption of innovations, and this dependence, is exactly what gives its appearance of unity to the process of adopting the innovation. What we are looking for are the causes of this location, and we are trying to explain them in terms of the "influence" that another event located in the space-time has on the events located in the proximity. The assumption is that *space* is a system of concrete relations between physical objects and *time* is some function of modifications which are going on in these objects.

But how can we detect expansive processes and adoption of innovations in archaeology?

Through the analysis of the remains of social actions carried out in the past and buried in the archaeological record, archaeologists try to reconstruct a wide series of phenomena like exchange networks, people movements, episodes of colonization, among others. For instance, a great effort has been dedicated in recent years to the study of one of the most relevant expansive phenomena in human History, i.e. the diffusion of agriculture and the process of Neolithization. The so called Neolithic Revolution implied the change from a society of hunters-gatherers to a sedentary one based in built-up settlements whose substance base was mainly composed of agricultural and stock farming. Such a discontinuity can be archaeologically detected by the presence of domesticated plants, in particular cereals, usually found as macroscopic charred remains or identified microscopically through pollens analysis. Such study was introduced at the beginning of the seventies by Ammerman and Cavalli Sforza in the paper “Measuring the rate of spread of early farming in Europe” (Ammerman & Cavalli-Sforza 1971). Analyzing a wide dataset of georeferenced radiocarbon dates the authors suggested a model of demic diffusion to understand the sudden apparition of early farmers at different moments and at different places according to a relatively regular gradient. According to their model from a point of origin located in the area of Jericho, in the Middle East, the agriculture would have expanded to Eastern and the North-Eastern territories through several waves of advance. The authors calculated a constant isotropic expansion rate of 1km/year. The main cause for explaining such a movement traditionally was traced in an episode of demographic growth that would have led to an excessive stress on the available resources. Therefore, this increase in the demographic pressure would have produced a sort of migration toward territories with a lower degree of exploitation. Modern developments of such an approach do not equate exactly demic diffusion with migration (Ammerman & Cavalli-Sforza 1984; Gkiasta et al. 2003; Russell 2004; Pinhasi et al. 2005; Dolukhanovet al. 2005; Bocquet-Appel et al. 2009; Isern et al. 2012).

The wave of advance model to describe people movement assumes the existence of a logistic population growth and a random migratory movement.

The logistic growth model describes a process that is exponential with an initial growth rate α, when the population density ρ *(x, y, t)* has low values, and it is self-limiting for large densities, with a maximum possible density $\rho_{max.}$ The logistic rate of change of the population size can be described in the following equation:

$$F(\rho) = \alpha\rho\left(1 - \frac{\rho}{\rho_{max}}\right)$$

in which $F(\rho)$ is the variation of the population density over time experienced due to population growth, α is the initial growth rate and ρ_{max} is the carrying capacity.

The migratory process is described by the formula:

$$m = \langle\Delta^2\rangle/T$$

Where Δ is the displacement of an individual during a time-span T and the symbols $\langle\ldots\rangle$ indicate average.

The two assumptions were included in the Fisher model (Fisher 1937), which was first created for describing the diffusion of some advantageous genes. The result was the developing of the reaction-diffusion equation:

$$\frac{d\rho}{dt} = D\left(\frac{d^2\rho}{dx^2} + \frac{d^2\rho}{dy^2}\right) + \alpha\rho\left(1 - \frac{\rho}{\rho_{max}}\right)$$

Variation of the population density over time

Diffusion $D = \frac{\langle\Delta^2\rangle}{4T}$

Reaction: logistic growth

A problem related to the application of such a model to sedentary societies, like the agricultural ones, is the absence of delay between the end of a migration and the beginning of another migration. In fact, in sedentary societies children do not move during their childhood until they reach the adulthood and can migrate to create a new family. Therefore, it has been proposed to introduce a time-delayed model to describe such a process in sedentary societies (Fort & Méndez 1999; Isern et al. 2012). The introduction of a time-delayed reaction-diffusion equation implied that slower front speed in the wave of advance, due to the effects of the time delay.

A second problem relates to the assumption of a homogeneous process of diffusion taking place in an isotropic space. However, it is relevant to consider that Neolithic spread took place in an already inhabited space, whose effects on the rate of spread has to be taken into account.

1.3 European Bronze Age as a case study

Can the term *diffusion* be adopted to define processes of adoption of innovation, like the introduction of cremation burial and new pottery typologies which took place in the in the Bronze Age? These innovations were adopted because they were necessarily "better" as they represented improvements? Their adoption or rejection was a consequence of a social decision?

To answer to these and many others questions we need to take into account a time span which is long enough to allow us to analyze the emergent space-time gradients.

The 2nd and the beginning of the 1st millennia BC represent a perfect framework in order to test different hypothesis of movement of people, goods, practices and/or ideas.

We have decided to investigate the period 1800-750 BC. In particular, we want to focus to historical events during the last part of this temporal range. A time-span of one millennium long is enough to study important changes in historical behavior and culture like the introduction of cremation burials, the diffusion of fortified settlements and the spread of some specific pottery typologies.[1] The end of the temporal interval under

[1] Several pottery typologies are characteristic of the time-span 1800-750 BC. As we are interested in modeling their routes of circulation, we looked for typologies with a macro-scale distribution in space and a value of time-markers.

study is due basically to problems related to the radiocarbon curve, and precision of chronological estimates, as explained in the details in the chapter 4.3.2.1.

The geographic area under study encompasses a large territory from the Ebro to the Danube River (Fig. 4). It includes Eastern Iberian Peninsula with the Autonomous Communities of Catalonia, Aragon (Provinces of Huesca and Zaragoza), Navarre and the Basque Country; southern France including from west to east the regions of Aquitaine, Midi-Pyrénées, Languedoc-Roussillon, Limousin, Auvergne, Burgundy (only the departments of Côte-d'Or, Nièvre and Saône-et-Loire), Rhône-Alpes, Provence-Alpes-Côte d’Azur, Franche-Comté, Alsace; northern Italy (regions of Aosta Valley, Piedmont, Lombardy, Trentino/Alto Adige-Südtirol, Veneto, Friuli Venezia Giulia, Liguria, Emilia Romagna and Tuscany; the entire territory of Switzerland, as well of Austria, and the southern part of Germany with the states of Baden-Württemberg and Bavaria (Lower Franconia, Upper Franconia and Middle Franconia not included). The geographic extension of such an area is of 525090.51 km². In some specific case, we have decided to make reference to territories and sites located outside this area. In such circumstances we have discussed case by case the reason for those choices.

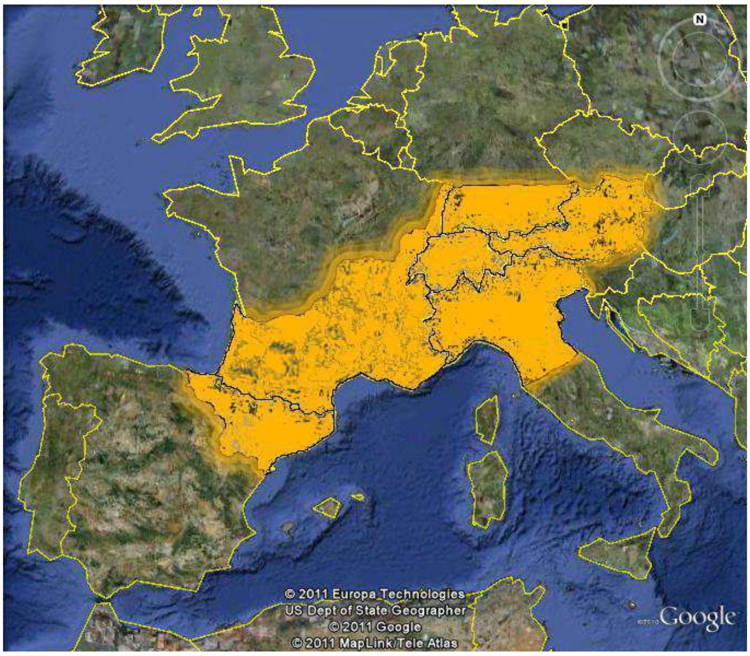

Fig. 4 - Analyzed geographic area.

We have limited our study to such geographical region for practical reasons, and not for any specific historical phenomenon characteristic of the area. Our study area corresponds to the north-western part of the Mediterranean basin which experimented influences from Eastern Mediterranean cities through marine network routes and where contacts with the Central Europe through continental routes are archaeologically evident. Moreover, the area includes two important geographic barriers, the Pyrenees and the Alps, which never constituted a barrier in a social or economic sense. Historically, most of the area under study corresponds partially to the territory of distribution of the so called *Urnfield culture* archaeological complex, which is one of the more characteristic phenomena in European Late Bronze Age (see chapter 3.3).

As mentioned previously, in the time span 1800-750 we can detect several phenomena of introduction of innovation. The main one is perhaps the introduction of iron metallurgy over a wide scale. We are aware that in Central Mediterranean iron was used for prestigious ornaments since the Middle Bronze Age[2], but it is in the Late Bronze Age-Early Iron Age transition that it is attested an increase of iron for objects. It become of common use only during the so called Iron Age. We would have liked to study the diffusion of iron in Protohistoric Europe, regrettably the very small amount of contexts, most of which not radiocarbon dated, do not allow to analyze such an innovation, which were probably part of the trade of prestigious objects from the Eastern to the Western Mediterranean (Giardino 1995, 2005, 2011). Moreover, the common use of iron coincides in time with the so called Hallstatt disaster with the related problems in the reliability of radiocarbon estimates, which are discussed in chapter 4.3.2.1.

As a consequence, we have decided to analyze other phenomena of diffusion and adoption of innovation, whose effect could have implied a radical change in the behavior of past societies. Among them, the most outstanding is the change of funerary rite from inhumation to cremation of bodies, which developed in Europe in the 2nd half of the 2nd millennium BC. Such an innovation has been traditionally linked to the so called *Urnfield culture* and therefore considered as a homogenous cultural assemblage together with some specific pottery typologies, for instance fluted pottery. The adoption of a new funerary ritual with all its social and cognitive meanings is of high value to understand a social transformation, more that the mere adoption of a tool type.

We can understand this process of cultural change in terms of a transformation of a population from one with a low proportion of early adopters of the *Urnfield culture* to

[2] We can mention the iron ring found in the *terramare* of Gorzano, in the Po valley (Northern Italy), dated to the Middle Bronze Age. Other examples are a ring from the cemetery of Castelluccio di Noto, dated before 1500 BC, and two square rods from a tomb at Thapsos containing a Mycenaean III A vessel, both in Sicily (Giardino 2005).

one with a high proportion of sites with evidence of cremation burials and the related series of related artifact types by means of information diffusion through global and interpersonal contact. This definition of change in terms of diffusion may generate the idea that the decisive mechanism is to be found in the concept that innovations are transmitted from group *A* to group *B* and then on to group *C*. When one then proceeds to terms like “follow”, one goes a step further and suggests that changes occur through a process where some agents or groups adopt the life-style patterns of other communities through some form of imitation or social role modeling (Lindbladh et al. 1997).

There is no doubt that the behavior of one individual in an interacting population affects the behavior of his fellows. Therefore the heart of a diffusion model consists on the precise definition of interpersonal network exchanges between those agents who have already adopted an innovation and those agents who are influenced to follow or imitate their decision. As a consequence, the adoption of innovations has been studied many times as a special type of communication, as a process in which the participants create and share information with one another in order to reach a mutual understanding. This definition implies that communication appears to be a process of convergence (or divergence) as two or more agents exchange information or goods in order to move toward each other (or apart) in the meanings they give to certain events. The perceived difference the innovation supposes for the agent determines the reaction to it because this difference introduces alternatives to action. Therefore, the innovation-decision process appears to be essentially an information seeking and information processing activity in which an agent is motivated to reduce uncertainty about the advantages and disadvantages of the innovation (Hagerstand 1967; Rogers 2003).

So called “Darwinian archaeologists” have approached this problem in a similar way: the social mechanisms underlying the spreading of cultural traits are twofold: either these traits become prevalent through a process of “natural selection” (selective advantage to the group using these traits) or through a process of copy (because they are more effective in some way) (O’Brien and Bentley 2011; Shennan 2009). The former would reveal expansion of social groups, which is change in population or in social structures, and therefore discontinuities. The latter, being a process of endogenous or exogenous copy, would reveal contacts occurring in circumstantial situations, that is cultural changes, and therefore continuities. With material culture as with other cultural phenomena, adoption may occur both among producers and consumers of an innovation. Second, most innovation studies focus on adoption, but inadequately deal with the persistence of cultural variants (Premo & Scholnick 2011). We should investigate the possibility that local persistence can be generated through social learning among spatially structured populations which is analogous to isolation by distance in genetic populations. When social learning occurs among a population of agents in spatially restricted neighborhoods, not globally, spatial drift decreases local and global cultural diversity.

When generalizing the possible mechanisms leading towards the "diffusion" of cremation burials and affecting the probabilities for cultural, economic or technological change we can identify different types of decisions, and hence, different diffusion mechanisms:

- Optional - the decision of accepting or rejecting the "Urnfield package" is taken independently from other social systems members decision: it is a personal decision;
- Collective - the choices are taken in consensus in between social system members;
- Authority - the decision is taken by some individuals within the social system which have authority, status or knowledge in the matter with the other members limited to implement the decision.

How such mechanisms may be used to explain the historical evidence of the new rite and new typologies in areas populated by people who previously practiced different funerary rituals and used other artifacts? To trace the diffusion of an innovation we can investigate:

1 *The Innovation*
2 *Interaction Channels*
3 *Time*
4 *Space*
5 *The Social System*

The *innovation* is represented by the new funerary practice. From the end of the Middle Bronze Age onwards, human communities across Europe and on some places of the northern basin of Mediterranean began to adopt a new funerary practice characterized by the burial of cremated body parts, frequently inside an urn. We consider this change can be analyzed in terms of the diffusion of a standard, according to Weitzel et al. (2006) sense of the term: *standard* is used to refer to any technology or product incorporating specifications that provide for *compatibility* or cultural consensus. Cultural consensus theory assumes that cultural beliefs are learned and shared across people. The challenge to this view is that it assumes social mechanisms through which members of a group can identify how much they share (Romney et al. 1986, 1996; Romney 1999; Garro 2000; Weller 2007; Sieck 2010). Consequently, instead of *assuming* that agents have common identity traits based on membership to an already existing "ethnic" group, agents may ask themselves as to the extent to which they "believe" they are similar to those of others in the neighborhood, and queried as to whether the outcomes of those values are perceived to be similar. Cultural consensus should be considered as a relevant property of a social system that enables social agents to "somehow go together" and makes them subject to a network effect. Hence, cultural compatibility standards enable agents (Barceló, Capuzzo, Bogdanović 2013). We use then "cultural consensus" in the sense of active *standardization* as the implementation and use of a standard to interact with a communication partner. The theoretical bottom-line argument for standardization cultural processes is that the discrepancy between individual (at the level of the agent or the household) and collective (network wide) gains leads to coordination problems. With incomplete information about other actors' preferences, *excess inertia* can occur, as no actor is willing to bear the disproportionate risk of being the first adopter of a new social practice and then becoming stranded in a small network if all others eventually decide in favor of another set of cultural features. This startup problem can prevent the adoption of any cultural innovation at all, even if it is preferred by everyone. Conversely, *excess momentum* is a possible outcome. There may be local incentives to build new networks (incorporate new members to an expanding social network) that can overcome inertia problems; however, they do not guarantee social optimality *per se*. The basic question underlying the agent cultural change decision is whether the costs of building a new cultural consensus through standardization exceed the benefits. The problem is that the social (or even economic) benefits of integrating a given cultural consensus often are even not quantifiable after the adoption. While the increased cultural similarity can lead to direct savings due to faster, more frequent and predictable communication, cultural consensus may also induce more strategic benefits: avoiding conflict and increasing the flow of goods and labor among culturally similar agents (Del Castillo et al. 2014).

For Mahajan and Peterson (1985) *Interaction Channels,* or channels of communication, are mediums by which information is transmitted to or within a social system. The nature of the interaction relationship between a pair of agents determines the conditions under which a source will or will not transform the innovation to the receiver and the effect of such transfer. This is our problem in archaeology, because we have only access to a small subset of goods that may have circulated through those interaction channels. We do not know the agents, the way they contacted, and what they exchanged or how (peacefully or violently, trade or war and banditry). In any case, we may suggest different processes that have the potential to explain such a large-scale transitions: demic diffusion (movement of people), exchange (movement of goods) and cultural transmission (movement of ideas). Elite dominance (the conquest by a small minority that takes control of institutions and imposes its language and cultural traits) is another process that should be taken into account. Distinguishing between demic diffusion, exchange networks, cultural transmission and elite dominance in the archaeological record is problematic, especially where there is evidence of a diffusive spread of a novel trait into a region that has evidence of a population already in place.

A basic puzzle posed by cremation burials and new typologies diffusion is why long *time* lags occur between an innovation's first appearance and its general acceptance within a population. Among the factors that have been suggested are temporal delays in acting on information, a desire to conform, learning from others, and changes in external factors (Young 2009). In a diffusion model the time dimension takes part in: (1) the innovation-decision process by which an agent passes from first knowledge of an alternative way of doing things (the "innovation") through its adoption or rejection; (2) the relative earliness/lateness with which the innovation is adopted, compared with other members of a system; and 3) the innovation's rate of adoption, usually measured as the number of members of the system who adopt the innovation in a given time. The rate of adoption can also be measured as the length of time required for a certain percentage of the members of a system to adopt an innovation. Therefore, we can see as the rate of adoption is measured for an innovation in a system, rather than for an individual as the unit of analysis.

A second puzzle posed by cremation burials and new typologies diffusion is why long *space* lags occur between the place where an innovation has made its first appearance and its general acceptance across a given territory. As soon as time passes, farthest places begin to use previously unknown goods or ideas, increasing the distance between the place where the good or idea appeared for the first time, and the place where it is used anew. Among the factors that have been suggested are the existence of spatial barriers impeding or constraining information transmission. What we should look for is whether the adoption of an innovation or an evidence for change at some place is the cause of what will be adopted in neighboring locations. A model of diffusion pretends to examine if the characteristics of social action at one location have anything to do with characteristics in a neighboring location, through the definition of a general model of spatial dependencies. The characteristics of space as a dimension, rather than the properties of phenomena, which are located in space, are of central and overriding concern (Clark 1982). We may assume, the degree of influence between neighboring social actions should depend on the knowledge each agent has about neighboring agents, distance between social agents at different locations and frequency and nature of interactions between agents at different locations. Modeling spatial dimension of the diffusion process involves basic principles implemented in *interaction* models (effect of masses, and of distance, barrier effects, etc.), which quite often take the form of an exponential function of distance with a negative exponent. The concept of *distance* can be understood then as an influence mechanism, because we usually assume that "everything is related to everything else, but near things are more related than distant things" (Tobler's law). This assumption is based on the Neighborhood Principle (Boyce et al. 1967, 1971; Fix 1975), which relates the intensity of influences converging to a single location from the neighboring locations. When relating the nature of a diffusion mechanism to Tobler's Law we make emphasis on the idea that over-coming space requires expenditure of energy and re-sources, something that nature and humans try to minimize (although not exclusively, of course) (Miller 2004).

Decision making is a social mechanism by which social behaviors are constrained (or even determined) by social influences and consequences. The social context then plays a global role in the decision-making process of adopting an innovation and changing to a new state. Therefore, if we assume that a *Social System* is "a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal" (Rogers

2003), then the structure of such a system can facilitate or prevent the diffusion of innovations and change. All human societies are comprised of individuals connected to one another by overlapping arrays of social ties that together constitute a social network. Social networks are emergent phenomena that both influence and are produced by the behavior of individuals. The channels of information, people, genes, and resources can be used to define the extent of a social system. The importance of social networks makes them a fundamental factor for studying social change (White 2013). Social interaction, and hence, the flow of people, goods and ideas, depends upon the agent's network of interpersonal contact or his network of social communication and that the configuration of this network is primarily dependent on the presence of various social barriers which impede, divert and channel communications. To advance in the investigation of the active role of the social network on the possibilities of change we should go beyond the classical definition of spatial and temporal distance , and creating a measure of social distance defined as the difference between the values of any property between two (or more) nodes in a social network (Gatrell 1983).

We should ask whether cremation burials in the second half of the 2nd millennium BC and at the beginning of the 1st millennium BC "diffused", that is, whether the distances between their spatial locations increased with time (Hazelwood & Steele 2004). We assume that for a new practice in funerary rituals to diffuse over time and space, there should have existed a mechanism of contact and cultural transmission to transmit the phenomenon (Boyd & Richardson 1985): in each time period every potential adopter of the new ritual practice made contact with other persons (the number depends on the network structure) with a likelihood based on the nature, intensity and frequency of interactions. We also assume that the spread behavior is not determined by independent assessment but there are external constraints (economic, social and cultural).

The real point seems to be to evaluate the relative importance of demic, exchange and cultural diffusion in different regions of Europe because in some areas different interaction channels are likely to have contributed to the social and cultural change. Up to now, mathematical models of population spread and social learning have not been applied to the controversy between the demic and cultural expansions of the Late Bronze Age-Iron Age transition, probably due to the lack of academic acceptance of the very idea of diffusion (Rahmstorf 2011).

Change in prehistoric technologies and socio-economic systems should be recognized to be a nonlinear phenomenon that includes elements of both development (performance improvement) and diffusion (propagation of new technologies and/or improvements to existing technologies) (White 2008).

The adoption of a new cultural consensus has always been asymmetric in time, irreversible, and nondeterministic. Uncertainty is the degree to which a number of alternatives are perceived with respect to the occurrence of an event and the relative probabilities of these alternatives. However, the fact that we cannot predict the precise moment and the main characteristics of the process that lead to the adoption of the innovation does not mean, that cultural, social, economic or technological change cannot be analyzed as conditioned by a series of social actions and determined by other actions. This is a consequence of the fact that social actions are (or have been) performed in an intrinsically better or worse spatial/temporal location for some purpose because of their position relative to some other location for another action or the reproduction of the same action (Barceló & Pallarés 1998). As a social science, archaeology is not interested on individual action, or on individual psychology. We are interested in collective action, that is, why different people made the same action, or different actions at the same place and at the same moment. Our research goal should be to explain the sources or causes of that variability. Why habitants south of the Pyrenees adopted the cultural consensus of cremating the dead body of their relatives and buried those cremated remains in urns? Why this new funerary practice appeared more or less at the same time in Central Italy? Why people living in very far places used the same instruments to work and to symbolize social and political life? An explanation to such questions should not limit themselves to the study of how cultural, economic, or technological changes occurred over time.

Diffusion phenomena bear a resemblance to complex adaptive systems, because the relationship between cause and effect is not smooth and proportionate. In a diffusion mechanism, agents respond to changes in a non proportionational way to the intensity of change: small changes in initial conditions, and later interventions of whatever size, can result in disproportionately large effects (Rogers et al. 2005). Diffusion occurs in complex systems where networks connecting system members are overlapping, multiple, and complex. Diffusion occurs most often in heterogeneous zones, i.e., transitional spaces where sufficient differentiation among network members comes to obtain. Such heterogeneous network connections, which comprise the innovation-diffusion system, occur among innovators and other engaged members of target populations.

Our study looks at both the fine and global scales of social behavior and the relationships between people at the aggregated level. We intend to understand cultural change at the end of prehistory as a set of emergent behaviors and feedback when aggregates of individual behavior are scaled up to a similar behavior on a system level. Beginning with the level of local interactions, the fine scale, we study how the diffusion of a new cultural consensus took place through a network consisting of meso-scale units (households and local groups as potential adopters). As agents adopted the cremation and new pottery typologies or rejected it, their behavior contributed to the macro system-level scale of behavior. As the rate of cultural change accelerated and innovation diffusion took off, emergent adoptive behavior occurred at the system level. As the new ritual practice was adopted by additional agents in the new and evolving social system, a feedback loop may have occurred in the diffusion process as observability of the new cultural standard increased everywhere reducing uncertainties associated with the new idea, process, or technology.

2 ARCHAEOLOGICAL EVIDENCES FROM DANUBE TO EBRO

2.1 Introduction

In prehistory, since the late 19th century archaeologists started to identify homogenous human groups from the analysis of the material evidences of past societies.

Such studies were first developed in the German area with the works of Gustaf Kossinna, who claimed that a regionally delimited ethnicity could be defined by the material culture excavated from a site. The German prehistorian stressed in the so called Kossina's law that "sharply defined cultural areas correspond unquestionably with the areas of particular people or tribes" (Leo 1999). Although Kossina's theory was subject to criticism, it had a large success among the German academic community.

In the English-speaking world analogous statements were introduced by the Australian prehistorian Gordon Childe and the German-American anthropologist Franz Boas. Childe, studying the area along the Danube River, recognized that it marked a natural boundary between two different macro regions. In his studies he formulated the concept of archaeological culture arguing that "We find certain types of remains – pots, implements, ornaments, burial rites, house forms – constantly recurring together. Such a complex of regularly associated traits we shall term a 'cultural group' or just a 'culture'. We assume that such a complex is the material expression of what today would be called a people" (Childe 1929).

With the post-processual archaeology a new understanding of culture was introduced. According to Hodder (1982) culture is a socially and symbolically constructed, which can be linked to a variety of social traditions, from ethnicity to cosmology.

Nowadays the concept of "culture" is slowly decaying in favor of other more appropriate terms like "groups" or "archaeological *facies*". The second one is usually adopted in order to identify the recurrence of an assemblage of artifacts from a specific place and time, which constitutes the material evidence of a past human society. In addition, the concept of "culture" has also been extended to define human groups not only on the base of the produced artifacts, but also using other parameters, like, the settlement type or the funerary rite.

Traditionally, for the Bronze Age and the Iron Age transition in Central and Western Europe the different "cultures" or it would be better to say *horizons,* have been identified frequently on the basis of the typological seriation of pottery and metallic artifacts. We will focus on the most relevant archaeological *facies* over a large territory from the Ebro to the Danube River. We would have liked to analyze together this macro area due to the existence of "classical cultures" which cover a wide territory greater than the boundaries of modern states. Regrettably, despite of the existence of such cultural groups over large regions, the definition of cultural phases has always been characterized by a regional connotation which is a result of the research traditions in the different parts of Europe. This certainly represents an obstacle when we want to analyze complex phenomena whose magnitude exceeds modern state boundaries.

As a consequence, also the debate about a uniformed and unambiguous chronological framework for the Bronze Age and the beginning of European Iron Age is far from over among the scientific community. Defining a structured division in phases, based most of all on the typo-chronological seriation of human artifacts, has been the primary objective in 20th c. archaeological studies. The result has been that the chronological framework of European Prehistory and Protohistory is mostly a relative chronology based on the typology and stratigraphic data. In fact, since the beginning of the discipline archaeologists have always been trying to divide time in well defined time spans, usually based on the typo-chronological analysis of human artifacts, in particular metallic objects and pottery. Those conventional periods or phases based on what it is buried in the archaeological record are usually the starting point for every kind of archaeological study. The main problem of such a qualitative division system is the not uniform acceptance among the scientific community; furthermore frequently the terminology used for each phase is different from one country to the other, taking the geographic and the political borders of the country as the distinctive mark. This approach has its origin in the prehistoric traditional studies carried on in European countries along the 20th century. In addition, the synchronization of different time periods suffers for the lack of absolute dates and therefore disagreements between different chronological schemes are difficult to reconcile. Only in the last decade the diffusion of absolute dating techniques, like in particular dendrochronology and radiocarbon dating, has allowed to review the conventional chronology and to convert into absolute dates the boundaries of each phase.

In this chapter we manage to present briefly the conventional chronological scheme (Fig. 5) and to make an overview on the “classical cultures”, which populated the territories from the Ebro to the Danube River during the Bronze Age and the Iron Age transition. We focus on the major archaeological cultures from the regions of Central Europe, corresponding nowadays to Switzerland, Austria and southern Germany, and moving toward Northern Italy, Southern France and the North-East of Iberian Peninsula

2.2 North of the Alps area

In the territories located north of the Alps the chronology of the Bronze Age (*Bronzezeit – Bz*) is divided in six main phases: *BzA*, *BzB*, *BzC*, *BzD*, *HaA*, *HaB*. The following phase is the Iron Age (*HaC*).
The Early Bronze Age (*Frühbronzezeit*) is made up by just one phase, the *BzA*, which conventionally has been divided in two subphases *BzA1* and *BzA2*. The first phase is based on the absolute dates of the necropolis of Singen, in the German Baden-Württemberg region. The Middle Bronze Age (*Mittelbronzezeit*) is traditionally divided in three phases: *BzB*, *BzC* and *BzD*, of which only the *BzC* is divided in two subphases (*BzC1* and *BzC2*). As a result, the Late Bronze Age (*Spätbronzezeit*) traditionally starts with the Hallstatt period, which takes the name from the LBA lake-side settlement of Hallstatt, in the Austrian Alps, famous for the exploitation of salt mines located in district. [3]

The terminology of such a division in phases of the *Bronzezeit A-D* and the *Hallstatt A-D* was introduced in the works of Paul Reinecke (1965), who during the end of the 19th and beginning of the 20th century contributed significantly to the refinement of the Central European chronology. The starting point of his chronological framework was the combination of the typological method with the dating of single contexts through finds combination. Reinecke first established a detailed Bronze Age chronology for

[3] According to a fashion diffused in the 20th century , it is relevant to detect how, also the term Halstatt has been used both to identify a material culture (*Hallstattkultur*) which would be coincide the phases *HaC* and *D*, and a chronological phase (*Hallstattzeit*) including the whole period *HaA-HaD*. In the case of this term the second meaning finally prevailed.

Hungary in 1899 (Reinecke 1899). In order to link Hungarian material with the German one, the cemetery of Hallstatt played a crucial role. In 1900, Reinecke published his first suggestion for a division in phases based mainly on weapon forms (Reinecke 1900).

Concerning the “classical cultures” of the North of the Alps region, in north-western territories during the Early Bronze Age the so called *Únětice culture* is diffused over a large area along the Danube River, from the South-Western Slovakia to central Germany passing through Northern Lower Austria, Moravia and Bohemia, including also Silesia and Greater Poland. Such a culture takes the name from the Czech village of Únětice, northwest of Prague, where the Czech archaeologist Čeněk Rýzner discovered a large inhumation cemetery in 1879. Flat cemeteries are one of the main features of such archaeological culture; barrows are also attested (Moucha 1963; Gimbutas 1965; Bartelheim 1998; Primas 2008; Jockenhövel 2013).

Another major group in the Early Bronze Age is the lake-dwelling or pile-dwelling culture, characterized by settlements constructed with wooden beams and poles and located close to humid zones like lakes. Although lakeshore and wetland settlements are attested since the Neolithic period, it is during the first phases of the Bronze Age that pile-dwellings reached their maximum diffusion. The area with the highest concentration can be identified in a large region including the surroundings of the Alps (Eastern France, Switzerland, Southern Germany, Northern Italy, Austria and Slovenia) (Keller 1866; Leonardi et al. 1979; Balista & Leonardi 1996; Menotti 2004; Fokkens & Harding 2013).

In the Western territories, corresponding to the Swiss cantons of Valais and Bern during the first phases of the Bronze Age is attested the *Rhône culture* (Mordant 2013). Such a culture will spread on a territory including part of Western France as we will mention later.

In the Middle Bronze Age one of the major archaeological cultures in Central Europe is the *Tumulus culture* (*Hügelgräberkultur*). Such a culture was defined mainly on the base of the funerary ritual characterized by the practice of inhumating beneath a burial mound or a tumulus, frequently the bodies were accompained by rich graves. The great amount of mounds led to the creation of large cemeteries often made up by dozens of tumuli (Görner 2002; Jockenhövel 2013).

In east and central Alps, in particular in the area of the Swiss Grisons and surrounding territories, the *Inner Alpine group* has been recognized for the Middle Bronze Age (Rageth 1986a, 1986b). However, not all the scholars agree in identifying such a culture, whose material culture represents a perduration and an increase of specific forms attested in the Grisons and Valais during the Early Bronze Age (Della Casa 2013). The chronology of the Late Bronze Age (*Spätbronzezeit*), phases *HaA* and *B* according to Reinecke's scheme, was the object of an intense debate from the beginning of the 20th century. Such a debate was focused on the major LBA culture in Central Europe, the so called *Urnfield culture*. Such a complex phenomenon deserves a particular attention as it represents a key concept in this thesis; therefore we have tackled it in the details in the chapter 3.3.

Regarding the chronological aspects of the Urnfield period (*Urnenfelderzeit*, period of diffusion of the *Urnenfelderkultur*) in Central Europe we need to cite the prehistorian Hermann Müller Karpe and his studies about the diffusion of such a culture in the north and south of the Alps based on the typology of Bronze finds (Müller-Karpe 1959). Hermann Müller-Karpe after the analysis of the Italian findings (which play a role of a link between the *Urnfield culture* and the Aegean zone) managed to date phase *BzD* to the 13th century BC and of *HaB3* to the 8th century BC (Przybiła 2009).

He also created a division in three main phases for the *Urnenfelderkultu*r horizon and hence for the so called "Urnfield period", which could be divided in *ältere*, *mittlere* and *jüngere Urnenfelderzeit* and they correspond to the conventional Hallstatt phases, *HaA1*, *HaA2* and *HaB1* (Giardino 1995). In particular, on the basis of the Cemetery I from Ruše in Slovenia, H. Müller-Karpe (1959) founded a chronological scheme for the later period of the *Urnfield culture*, with three chronological phases (*HaB1-3*) (Teržan 1999).

A stumbling block for the construction of a real chronology for the last phases of the LBA and the transition to the Iron Age lies in the adopted methodology. The analysis of the pottery assemblages and the association of "central European" typologies with imported ceramics from the Eastern Mediterranean, especially Attic pottery with a function of fossil guide, was based on the idea of a contemporaneity of the same elements located in different places, without taking into account the possibilities of time gaps between the date of manufacture and the time of deposition (Olivier 1999; Trachsel 2004; Arnold 2012). The cross dating did not consider the need of adding a necessary time span calculated according to the diffusion of the items from one geographic place to the other, sometimes located hundreds of kilometers away.

An improved division of *Urnenfelderzeit* according to regional variations was proposed by Lothar Sperber in 1987 (Sperber 1987). His chronological scheme was based on the association between radiocarbon dates and typological seriation of metallic and ceramic objects discovered between the 1981 and the 1984 from the Swiss lake dwellings, for instance in the Zürchersee (Zürich-Haumesser, Zürich-Alpenquai, Zürich-Grosser Hafner), in the Zugersee (Zug-Sumpf), in the Bielersee (Vinelz, Le Landéron), in the Lac de Neuchâtel (Auvernier-Nord).

Nowadays, most of the archaeologists agree in fixing the LBA/Iron Age transition in the last phases of the *HaB* (Giardino 1995) or at the beginning of the *HaC* (Sperber 1987; David Elbiali 2009), with slightly differences according to the analyzed geographic region. For example, in Slovenia the beginning of Iron Age is placed within the horizon *Hallstatt B3* (Gleirscher 2006). This scheme agrees with Paul Reinecke's chronological framework, elaborated at the beginning of the 20th century. Currently, the beginning of the phase *HaC* is placed about the year 780 BC (Friedrich & Henning 1995; Roberts et al. 2013).

In the last decades the dendrochronological analysis carried out on lakeside settlements from the North-Alpine area have been representing a powerful tool in order to fix the relative chronology with absolute dates. In this way the beginning of phase *HaA2* should be placed in the year 1100 BC (Rychner 1995) and the start of the *HaB1* phase in the 1050 BC or slightly later (Rychner 1995; Friedrich & Henning 1995; Rychner et al. 1996).

2.3 Northern Italy

In the area south of the Alps, which nowadays corresponds to Northern Italy the Bronze Age has been divided in four conventional phases: *BA*, *BM*, *BR* and *BF*.

The Early Bronze Age (*Bronzo Antico*) is formed by only two subphases *BA1* and *BA2*. The Middle Bronze Age (*Bronzo Medio*) is divided in three subphases *BM1*, *BM2* and *BM3*. The LBA is conventionally divided in two phases, the *BR* (*Bronzo Recente*) which is also composed by two subphases *BR1* and *BR2*. More complicated it is the chronological sequence for the last part of the LBA the *BF* (*Bronzo Finale*), usually formed by *BF1*, *BF2* and *BF3*. The following phase is the Iron Age (*Fe*).

Regarding the archaeological cultures in the Early Bronze Age the *Polada culture* developed in Northern Italy in the territories north of the Po River (Piedmont, Lombardy, Veneto and Southern Trentino) (Laviosa Zambotti 1940; Peroni 1971; Peroni 1996; Bietti Sestieri 2010). The area with the greatest concentration of Polada settlement is located south of the Garda Lake between regions of Lombardy and Veneto. The most outstanding evidence of such a culture is the presence of pile-dwelling settlements. Due to the analogies in the settlement structure with the north of the Alps lake-dwellings it was proposed that arise of *Polada culture* had to be explained by the movements of people from Switzerland and Southern Germany as proposed by Barfield (1994).

In Northern Italy the legacy of the lake-dwelling population was inherited by the *Terramare culture*, which flourished from the beginning of the Middle Bronze Age in the Po Valley (Peroni 1996; Bernabò Brea et al. 1997; Bietti Sestieri 2010). Such a culture is frequently named *cultura palafitticolo-terramaricola* (*pile-dwelling/terramare culture*) as to mark the continuity with the previous system.

In fact, the main feature of a *terramare* is a wooden settlement structure characterized by the presence of a rectangular earthwork rounded by a wide moat supplied with running water (Bernabò Brea et al. 1997). The developments of this settlement system created a large network in the area with a high density till the beginning of the Late Bronze Age. In the material culture of *Terramare* settlements, a large variety of pottery decoration is attested, including fluted decorations, solar and cross motives, zig-zag, meanders and many others. Moreover, it is relevant to highlight the large presence of handle with vertical expansion in association with carinated cups. Such features represent an innovation produced in the *Polada culture* and developed in the *Terramare*'s contexts. Such new types spread over a wide region, in particular along the French Riviera and the Languedoc in the Mediterranean coast (see Chapter 4.2.2).

In the Middle Bronze Age the *facies* of *Scamozzina* and *Viverone* are attested in Piedmont, whilst the pre Apennine *facies* of *Grotta Nuova* and *Candalla Farneto* developed in the central regions of Italy from the Romagna to the territory of Rome. To the same period can be dated the proto Appennine (*Protoappenninico*) *facies* in Southern Italy. Such cultures developed in the last phase of the Middle Bronze Age and in the LBA (*Bronzo Recente*) into the Apennine (*Appenninico*) and Subappennine (*Subappenninico*) *facies* (Cocchi Genick 1995) in Central and Southern Italy.

During the LBA and in particular in the *Bronzo Finale* phase in Northern Italy we can notice a phenomenon of regionalization with an increasing number of archaeological *facies* whose differences correspond to those ones observed in the historical period.

In North-Eastern Italy the *castellieri culture* has been identified for the *Bronzo Recente* phase. With the term *castellieri* we refer to fortified villages usually located on hills and provided with one or more walls of stones or a wooden palisade which rounded the settlements (Marchesetti 1903; Montanari Kokelj 2005; Bietti Sestieri 2009). Such a culture is also attested in Istria, Dalmatia and surrounding area.

In North-Western Italy the *facies* of *Canegrate* has been recognized in Piedmont, Western Lombardy and Canton Ticino for the *Bronzo Recente*. In the same chronological phase, but in the southern territories which include an area from Southern Piedmont to Western Emilia, we can distinguish the archaeological *facies* of *Alba-Solero* and *S. Antonino di Perti*. The analysis of materials remains of such cultures show connections with the *RSFO group* (see forwards) (De Marinis & Spadea 2004; Bietti Sestieri 2010).

For the *Bronzo Finale* phase in Northern Italy we can identify three major archaeological cultures. The *Protogolasecca* and the *Golasecca* culture in Piedmont and Western Lombardy, which show contacts with South-Eastern France and Switzerland, as detected for the previous *facies*. The *Luco-Meluno* (*Laugen-Melaun*) group, which developed in the Centro Alpine area: regions of Trentino-Alto Adige/Südtirol, Tirol and Engadin. And the so called "*Protovillanoviano padano*", whose evidences are spread over an area which embraces Eastern Lombardy and Veneto regions.

Regarding the chronology of the Iron Age transition in the scientific debate two different positions were proposed: the first one of Renato Peroni and his school and the second one based on Raffaele De Marinis' studies. Renato Peroni's school (Peroni 1990; Peroni 1995; Peroni 1996) follows the division in three phases of *HaB* as proposed by Müller-Karpe[4]. After a typological analysis and a cross-dating of bronze artifacts recovered north and south of the Alps, the Roman school of Peroni set the 1020 as the beginning of the Iron Age (De Marinis 2005, p. 21; Pacciarelli 2005). The date is in agreement with the chronology supported by Lothar Sperber (Sperber 1987). The recent works of Nijboer based on the analysis of radiocarbon dates from Latial contexts agree with this high chronology (Nijboer et al. 1999-2000; Nijboer & Van der Plicht 2008; Van der Plicht et al. 2009). The other school is led by De Marinis who organized the first three phases of the Bronze Age framework on the stratigraphic sequence of the

[4] Müller-Karpe first suggested a division in three phases of *Hallstatt B* Period (*HaB1*, *HaB2* and *HaB3*). Nevertheless, in later publication (Müller-Karpe 1974) referring to *jüngere Urnenfelderzeit* (*HaB1*) and *späte Urnenfelderzeit* (*HaB2-3*) he chose for a bipartition of *HaB* (De Marinis 2005, p. 20).

settlement of Lavagnone (in Northern Italy). According to his position, the beginning of the Iron Age should be dated in the end of the 10th and the beginning of the 9th c. BC (De Marinis 1999; De Marinis 2005).

North Italian conventional phases have been correlated with the North of the Alps chronology. Although the debate is far from over the most widely accepted synchronization for the Middle Bronze Age and the beginning of the Late Bronze Age is: *BM1=BzB1*, *BM2=BzB2/C1*, *BM3=BzC/C2*, *BR=BzD* (Carancini et al. 1996; Vital 1999). In the light of such correspondences the beginning of Iron Age (*Fe*) traditionally has been synchronized with the *HaB* phase.

Regarding the LBA in the 90' of the 20th century the significance of North Italian assemblages for cross dating the north of the Alps area was questioned (Randsborg 1991; Della Casa & Fischer 1997). Precisely dated Greek imports in Northern Italy are attested in large number only in a later period, not before the Villanova I phase (8th c. BC), which correspond to the *HaC* phase in the Reinecke's chronology (Pare 1998). Moreover, the previously accepted full synchronization of phase *BzD* with the North Italian Peschiera phase (*BR*) is questioned in particular due to the presence of pottery stylistically dated to the Late Helladic IIIB in Apennine contexts which can be referred to the *BM3* (Urban 1993; Vital 1999; Przybiła 2009).

2.4 Southern France

In Southern France the Bronze Age has conventionally been divided into three main phases: *Bronze Ancien* (*BA*); *Bronze Moyen* (*BM*), *Bronze Final* (*BF*). The Early Bronze Age is traditionally composed of three subphases *BA1*, *BA2* and *BA3*. The Middle Bronze Age is made up of three subphases *BM1*, *BM2*, and *BM3*, although the *BM3* phase has not been detected everywhere and it is frequently included in the *BM2*. Finally, the Late Bronze Age is composed of three subphases *BF1*, *BF2* and *BF3* and it is followed by the Iron Age (*Fer*).

A division of periods for the French chronology was first proposed in the work of J. Déchelette, the *Manuel d'archéologie préhistorique*, published at the beginning of the 20th c. (Déchelette 1910), and thus contemporary with Reinecke's system. After this research the creation of a chronological framework composed of three main phases is attributed to J.-J. Hatt (1955a, 1955b, 1958) and it is consolidated by J.-P. Millotte (1970). Hatt developed his chronological scheme starting from the typo-chronological analysis of the archaeological evidences from sites located in Western France and their correspondences with those from the Middle-Europe.

Regarding the “classical cultures” in the Early Bronze Age, in Eastern France (Franche-Comté, eastern Burgundy) the previously mentioned *Rhône culture* is attested. Such a culture expanded from the northern Alps close to the Swiss Plateau, cantons of Valais and Bern, over an area including Western Switzerland and Eastern France till the Massif Central (Gallay 1996). The definition of such a culture is based mainly on the production of metallic typologies and pottery known as “Rhodanian” which were spread using the route marked by the Rhône corridor (Mordant 2013). In the same period in the French and Swiss Jura it is attested the *Saône group*, whose material culture presents many analogies with the *Rhône group* (Della Casa 2013).

The major archaeological culture of the Middle Bronze Age in Central Europe, the *Tumulus culture* (*Hügelgräberkultur*), is attested in Western France with no relevant differences from that one present in North of the Alps regions. The eastern *Tumulus culture* spread to Paris Basin and the Loire Valley highlihting the significant extension reached by such a cultural group (*Dynamiques du Bronze Moyen 1989*; Jockenhövel 2013; Mordant 2013). Contemporary to this process is the formation of the *Duffaits cultur*e, attested from the Charente region to the Middle Loire and characterized by Atlantic features (Gomez 1995; Mordant 2013). South of this region, in the western part of the Massif Central the cultural group of the *Noyer* has been identified (Gascó 2011).

Such cultures were followed in the LBA by the *Urnfield culture*. In particular, in the north-Alpine area, traditionally included in the Urnfield world, the *group Rhin-Suisse-France oriental* (*RSFO*) was identified during the eighties thanks to the works of Patrice Brun (Brun 1984; Brun & Mordant 1989). Such a culture is characterized by the systematic practice of cremation but also by fine incised and combed decorated pottery (Brun & Mordant 1989; Mordant 2013). The influences of such a group on surrounding areas will be highlighted in the chapter 3.3. In the same period in the Atlantic facade of modern France the Atlantic Bronze Age developed over a large area. Such a cultural group is closely linked to the British Isles, the North Sea countries, and the North Iberian Peninsula. It reached its maximum visibility in the 12th and 11th c. BC (Mordant 2013).

In Southern France the most relevant culture for the LBA (*Bronze Final 3b*) is the

Mailhacien culture or also named *Maihlac* I, identified first in western Languedoc by Jean Guilaine in 1972 (Guilaine 1972). Such a culture is characterized by the existence of large cremation rite cemeteries, like those of Moulin at Mailhac or Castres (Janin 2000; Giraud et al. 2003; Janin 2009). Janin (2009) detected seven regional groups within the *Mailhacien culture*: the group of the Bas-Languedoc Audois, the Provençal group, the group of the Rhône valley, the group of the eastern Languedoc, the group of Tarn and Toulousain, the group of Roussillon and the Catalan group.

Regarding the debate about the chronological aspects, as it happened with the North Italian chronology, also the Late Bronze Age in Southern France constituted the most discussed time span of the whole sequence. Hatt's division of the LBA includes a further partition in two sub phases marked by the letters "*a*" and "*b*" for both the *BF2* and the *BF3*. Starting from the 70's a new subdivision of the LBA was proposed by a group of French Protohistorians, who grouped the *Bronze Final 1-2a*, *2b-3a* and *3b-Hallstatt Ancien* (Brun 1984; Brun & Mordant 1988; Gaucher 1992; Lachenal 2010). Brun argued that the caesuras between the phases "*a*" and "*b*" of the *BF2* and the *BF3* were more relevant than those between the main phases *BF1*, *BF2* and *BF3*. The influence can clearly be traced to Reinecke's division and the tendency to correlate the French chronological sequence to the one adopted for regions north of the Alps is a common denominator in Protohistoric research. Therefore, the following correspondences have traditionally been adopted between the two systems: *BF1=BzD*, *BF2a=HaA1*, *BF2b=HaA2*, *BF3a=HaB1*, *BF3b=HaB2* (of the Reychner sequence) and *=HaB2/3* (of the Müller Karpe system), *Fer* (or *Hallstatt ancien*)=*HaC*.

2.5 The North-East of Iberian Peninsula

More complicated is the conventional chronology for the North-East of the Iberian Peninsula. Still nowadays the lack of a homogeneous conventional chronology for such an area has produced different regional framework based on the typo-chronological analysis of local artifacts. The little attempts to correlate such systems into a supra-regional sequence led to the creation of a variety of conventional chronologies whose acceptance was not uniform. Moreover, the typo-chronological studies carried out in the border countries like France, did not find a direct correspondence in the territories on the other side of the Pyrenees. As a result, among the archaeological materials very few pottery types were defined as fossil-guides and the amount of metal types were even less, furthermore their relations were mostly with the Trans-Pyrenean area, than with the other Spanish regions. In the light of such fragmentary situation the construction of a unique conventional chronology represents a challenging work.

Therefore, scientific methods of dating, like radiocarbon dates, were widespread used as a tool for building chronological sequences based on the analysis of organic samples of different archaeological *facies*. This led to the creation of a collection and its interpretation of isotopically determined archaeological contexts from the most relevant cultural evidences during the Bronze Age in the Iberian Peninsula (Castro et al. 1996). A simplified and updated version of such a system was proposed by Pingel (2001), who integrated in his work more recent radiocarbon dates. The main problem is that the radiocarbon dates were not always a result of stratigraphic analysis of the associated contexts described by characteristic typologies; therefore they were frequently characterized by a level of uncertainty that could not be controlled.

From the eighties of the last century several proposals for the Bronze Age chronology in the North-East were presented. It has been divided in three main periods: the Early Bronze Age (*Bronce Antiguo*), the Middle Bronze Age (*Bronce Medio*) and the Late Bronze Age (*Bronce Final*) (Rovira & Santacana 1980). Although due to the continuity, which characterizes the first two phases some authors have preferred to take into account only two main phases, joining the Early and the Middle Bronze Age (Toledo & Pons 1992; Maya & Petit 1986; Petit 1990). For the Early Bronze Age several terms have been adopting and employing interchangeably (*Bronce Inicial*, *Bronce Antiguo*, *Bronce Pleno*), without a clear distinction between them with the consequence of causing no little confusion. To make the things more difficult in other regions of modern Spain the Late Bronze Age or also named *Bronce Tardío* is divided in two phases *Bronce Reciente* and *Bronce Final*. Such divisions, which are theoretic in most of the areas, do not always find a direct correspondence in the archaeological data (Almagro Gorbea 1997). Moreover, for the same area different archeologists introduced different schemes, whose effect was to increase the level of uncertainty. For instance, Maya (1992b) in the attempting of correlating the Southern France sequence to the Catalan one, divided the Bronze Age in two main phases, the *Bronce Inicial*, which includes the *Bronze Ancien*, *Moyen* and *Final 1* of the Southern France, and the *Bronce Final*, that should correspond to the *Bronze Final 2* and *3* of the Hatt's division. At the end of the nineties of the 20th century an effort of integrating the various chronological schemes into a common framework was made by Almagro Gorbea (1997), even though it was more a relative chronology formed by sequences of phases and their most relevant features for the various regional areas.

In Catalonia if the internal chronology of the first two phases was almost unknown, for the *Bronce Final* phase, several divisions were created taking as a starting point the analysis of the contexts referred to the *Urnfield culture* and modeling their chronology using the Hatt's periodization (*Bronze Final 1, Bronze Final 2a/b, Bronze Final 3a/b*) adopted for Southern France (Guilaine 1972). The term *Bronce Reciente* in the Catalan area it is not widely attested, whilst it is preferred the use of *Bronce Final*. In fact, in this area the *Bronce Reciente* should correspond to the first phase of the *Bronce Final* and it could also be an equivalent of the Italian *Bronzo Recente*, but much less well defined (Roberts et al. 2013). Therefore, when it is employed the *Bronce Reciente* in Catalonia is thought to correspond to the French *Bronze Final 1* and the *Bronce Final* to the French *Bronze Final 2*. According to an archaeological perspective such an approach can be explained by the numerous common traits that Catalonia, in particular the North-Eastern *comarques* share with the French contexts of Mailhac phases, in the Gulf of Lion (Toledo & Pons 1982; Pons 1984; Janin 1992; Janin 2000; Janin 2009; Pons et al. 2010).

Still nowadays no systematic attempts have been made to relate the mentioned traditional phases to well-defined pottery or metallic assemblages. In fact, the attention for the creation of a widely accepted absolute chronology on a large scale is still lacking and the variety of adopted terminology for defining the conventional phases represents a clear stumbling block in order to reach such a goal. Such difficulties can be traced also in the definition of the major archaeological cultures in the North-East of the Iberian Peninsula. For the Early Bronze Age local culture presents elements of continuity with the previous Bell Beaker tradition, without developing an inner homogeneity and individuality. The perduration of the megalithism is widely attested and cultural boundaries in area and in time are often vague or non-existent. The exception can be traced in the Atlantic facade, where the Atlantic Bronze Age is attested (Harrison 1974; Ruiz Gálvez 1979, 1984; Almagro Gorbea 1997; Lull et al. 2013). Such a culture, obtained the deserved relevance after the work of Macwhite (1951), regarding its geographic distribution it reached its maximum extension in the LBA as previously recognized for the French Atlantic coast.

The Middle Bronze Age is characterized by the Trans-Pyrenean influences, in particular regarding the North-Italian typologies connected to the *Polada culture*, like the so called handles "de apéndice de botón" (See chapter 5.3.2.1).

Eventually, the main cultural group of the LBA in the Mediterranean facade is the *Urnfield culture*, characterized by the large diffusion of cremation burials cemeteries in the Catalan territory. For the details of this process we make reference to the chapter 3.3.

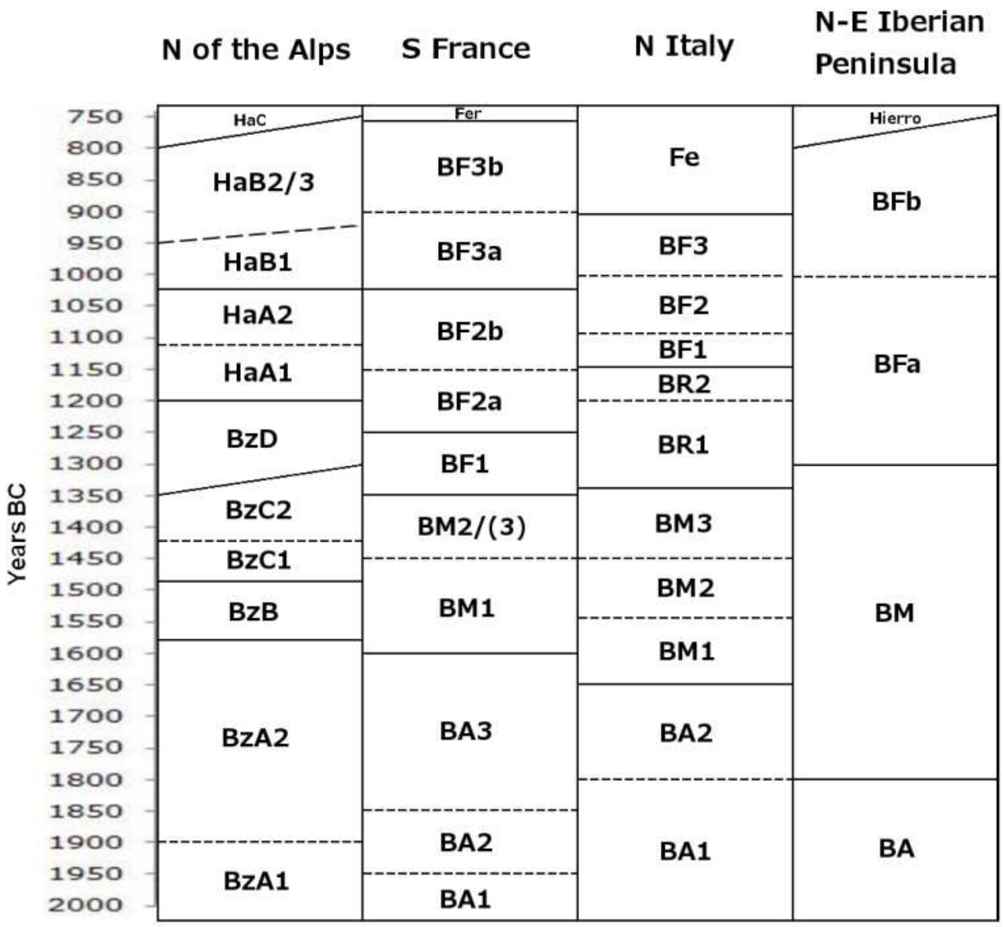

Fig. 5 – Chronological scheme of the traditional conventional chronology in the four regions: North of the Alps, Southern France, Northern Italy and North-Eastern part of the Iberian Peninsula. Some slight variations may be encountered depending on the various publications. For the Iberian Peninsula we show the chronology suggested by F. Lopez Cachero (personal communication).

3 ARCHAEOLOGICAL EVIDENCES FROM THE BRONZE TO THE IRON AGE

3.1 Introduction

Ever since the beginning of archaeological studies a great effort has been made to divide human history into well defined time-spans characterized by internal homogeneity thus allowing for the definition of each time-span as a uniform period or phase.

A historical division based on the raw material of which archaeological objects were made was first proposed by a number of Danish historians in the last part of the 18th century (Suhm 1776) and in the first half of the 19th (Thomsen 1836), according to a principle of technological progress. It divided universal prehistory in what those authors considered were "three ages": Stone Age, Bronze Age and Iron Age. With the further distinction between Paleolithic and Neolithic[5], it constitutes the basis for the periodization of human Prehistory and Protohistory even nowadays.

Such a framework grounds a more detailed qualitative division of Prehistory in phases based mainly on the character of archeological remains. In fact, for the study of the behavior of prehistoric societies during the Bronze and Iron Ages, the typo-chronological studies of human artifacts has represented the most widely-accepted methodology. We can take as a paradigmatic example the German school of archaeological thinking, which led to the birth of the famous series of "*Prähistorischen Bronzefunde*", whose final purpose was to catalogue the descriptions of bronze objects from different areas and regions. This approach implied that characteristic items in a "typical" assemblage were adopted to define a particular phase or even an "ethnicity", as for example, the cremation of bodies and the deposition of cremated bones in urns to define the *Urnfield culture* or the presence of a pottery vase with a particular shape (bell-beaker) to identify the end of Chalcolitic and beginning of Bronze Age, and supposed to represent a "Bell-beaker population"[6].

---

[5] John Lubbock in "Pre-historic times, as illustrated by ancient remains, and the manners and customs of modern savages" published in 1865 adopted the terms Paleolithic and Neolithic to denote an old and a recent phase of Stone Age.

[6] Nowadays, the traditional model which considered the spread of the characteristic ceramic recipient called Bell-Beaker in the 2nd millennium BC, together with an assemblage of associated materials, in

The consequence has been the rise during the first half of the 20th c. of a series of conventional divisions for the Bronze Age based on such features as the type of burial. For instance, adopting the German terminology, the Early Bronze Age (*BzA* phase) has been referred to as *Hockergräberzeit* (period of the crouched burials), the Middle Bronze Age (*BzB-C* phases) as *Hügelgräberzeit* (period of the burial mounds during the so called "Tumulus culture") and the Late Bronze Age (*BzD-HaA/B* phases) as *Urnenfelderzeit* (period of the cremation burials in urn) (Jockenhovel 1994, p. 11). The term that has been the most successful for naming an historical period, but also a kind of society and a "culture" has been *Urnenfelderzeit*, i.e. the period of diffusion of the *Urnfield culture*, which became synonymous with the Late Bronze Age.

As far as the Iron Age is concerned and following almost the same system implemented for the Bronze Age, at the end of the 19th century Hans Hildebrand (1874) suggested dividing the Central European Iron Age into two consecutive periods: the *Hallstatt* phase, from the name of the main settlement located in the Austrian Alps, and the *La Tene* phase.

Nowadays, although traditional research still represents a fundamental basis for the study of Bronze Age communities, the introduction of absolute dating techniques like radiocarbon dating and dendrochronology has changed the focus of research, giving new breath to a more objective approach regarding the definition of phase, the episodes of change, and an absolute chronology for each historical event.

In this chapter we want to present the state-of-the-art on the Bronze Age and the transition to the Iron Age, focusing on the social and economic changes which took place in Europe at that time. In particular, we focus on the emergence of the historical conditions in which the social and cultural changes took place, notably the increasing social and economic complexity that preceded the adoption of new technology (adoption of Iron) and made it a historical reality.

---

particular related to the role of the warrior (arrowheads, spearheads, daggers), as a demic diffusion has lost part of its acceptance as too reductive for describing a so complex phenomenon.

3.2 The Bronze Age and the transition to the Iron Age in Protohistoric Europe

In European Prehistory, the Bronze Age and especially the transition to the Iron Age has deserved a particular attention due to its historical relevance. Among the so called "Metal Ages", the Bronze Age was assumed to be a transitional period between two different social and economic systems: a previous one in which subsistence was a matter of agriculture and cattle rising, and a posterior one seeing the rise of new technologies and social structures, like new ways to manufacture bronze alloy, and the increase of the frequency of long distance exchange networks relating different regions and territories, often under the control of a small part of the population.

Archaeological evidence suggests that during the 2nd millennium and the beginning of the 1st millennium BC, several social, cultural, and economic changes took place: a new funerary ritual, different settlement strategies, new exchange networks and important changes on the means of production. The main consequence of such changes was an increase in the complexity of social and economic dynamics. There is also an increase in horizontal social differences (gender, age, kinship) but also on vertical social differences, with the emergence of a new leadership mechanism in which the "chief" of a community increased *his* prestige (it was supposed to be exclusively a male) due to its position in the lineage and its role in war. Moreover, it has been suggested a common tendency towards demographic concentration in larger settlements, whose consequence would be the birth of the first proto-towns during the early phases of the Iron Age in the first half of the 1st millennium BC in Northern Italy.

In the light of such a situation, the 2nd and the beginning of the 1st millennia BC can be defined in terms of technological change and the gradual development of social differentiation, in a trajectory originated at the same moment than a productive economy started (in the Neolithic), and ended with the beginning of state systems (Yoffee 1979; Guidi 2000).

Traditionally, the beginning of Iron Age in the 1st half of the 1st millennium BC has been defined by the introduction of a new raw material and a new technique for its elaboration. However, the adoption on a large scale of iron metallurgy was not an abrupt change but it was a slow and gradual process characterized by different phases (Pons 1989; Stöllner et al. 2003; Giardino 2005; Pare 2008; Brun et al. 2009). The first sporadic finds can be dated to the Late Middle Bronze Age in the Central Mediterranean with the already mentioned ring, which could be have been made of meoteoritic iron as it has never been analyzed, collected in the cemetery of Castelluccio di Noto, dated before 1500 BC, and two square rods from a tomb at Thapsos containing a Mycenaean III A vessel, both in Sicily (Giardino 2005). The arrival of such objects has to be linked to the Aegean and Eastern Mediterranean routes, which could explain such an early date for the occurrence of iron objects. To the beginning of the Middle Bronze Age and the Late Bronze Age can be possibly dated the iron rings found in the *terramare* of Gorzano, in the Po valley (Northern Italy), a more precise date is impossible to obtain (Giardino 2005). In central Europe first irons can be dated slightly later, to the 12th c. BC (Brun et al. 2009). In any case, the adoption at the beginning did not affect all the spheres of the social and economic system (Pons 1989; Pare 2008). At the very first moment of its apparition iron was considered an element with supernatural or magic properties, becoming common among the social elites for the military equipment and for ornaments and objects for personal use. Only starting from the end of the 6th century BC, iron became usual for the production of craft tools. And only in the 4th and 3th c. BC iron was a common metal for the manufacture of agricultural tools (Pons 1989; Brun at al. 2009).

The iron metallurgy represented a major social, cultural and economic discontinuity beyond a mere change in raw material or technology. Bronze metallurgy needed a social network of raw materials exchange of a very particular type in order to control the circulation and routes of copper and tin from the mining districts to the areas where manufacture took place. Iron, on the contrary, is a metal with a wider diffusion in Europe, and hence, with an easier accessibility, although it requires a know-how of higher complexity and greater investment in means of production: it melts at higher temperatures, and it requires higher quantities of fuel and much more labor than bronze smithing. In fact, the melting point of iron is 1573°C, even though at 1150-1200°C bloomer iron is produced by smelting iron oxides ores into sponge metallic iron together with slag (Maddin 2003; Giardino 2005).

In the light of such discussion it is clear that the Bronze Age to Iron Age transition cannot be identified as an event with a common punctual location in time. Moreover, such a transition cannot be caused by only a single factor as iron, nor it cannot be conceptualized as located at a particular point in time or space. As, it was already highlighted at the end of the eighties by Sørensen and Thomas (1989) “The transition is an expression of change, but changes have to be appreciated as the result of the ways people lived and their interactions with each other and the environment".

As an outcome, when we refer to the term "transition" between Late Bronze Age and Iron Age we want to avoid the old definition, i.e. just a change in metallurgy and smithing, but we want to take into account the continuous increase in social and economic complexity since the beginning of using this technological innovation, which led to an important transformation in the social system as a whole. We speak about "transformation" because it is not a mere feature that signals the shift from a period to another. Archaeological division of phases is a human construction, whose purpose is a simplifying the quantitative description of time in a qualitative way. Following the reasoning by Christopher Pare, we may argue that the transition from one phase to the next can be defined, by changes in fashion, for example, in fibula construction and style of pottery decoration. By contrast, the transition from one period to the next is characterized by transformation in all aspects of life – not just change in fashion and ornamentation (Pare 2008, p. 69).

From that, we can argue that the introduction of iron did not represent just a change in technology, but a change in the social and economic strategies, in particular concerning the circulation of goods, ideas and probably of people. Phenomena of discontinuity and continuity, regarding the settlement pattern and the funerary rite, are an inner characteristic of every historical period. When we have a correspondence in space and in time detected for the discontinuities we could probably employ the term "transition" in order to define such a particular period. In any case, the intensity of the transition can vary from one place to the other and from one time to the other. For such a reason the Bronze Age-Iron Age transition has not to be taken for granted, but it needs constantly to be considered in order to understand deeper its historical relevance. It follows that we must never regard the history of any society as a succession of "frozen" phases. Bronze Age society was not followed by an Iron Age society and this latter one did not "collapse" at the end of its vital cycle. Any kind of human society is a dynamic organism which suffers from a steady transformation because of the everyday newly born tensions and contradictions, even though it can take them centuries to appear in social and/or economical behavior (Barcelo 1999).

At the end of the 2nd half of the 2nd millennium BC, European regions seem to share a common cultural background on the basis of archaeological knowledge. Such a cultural *koiné* is testified by the wide-spread of Urnfield complexes, which cover a wide territory from the Balkans to the Iberian Peninsula. Such an apparently homogenous picture in less than 400 years lead to the arise of a large range of cultural trajectories well distinguishable in their own individuality. Such trajectories were responsible of the developing of the Iron Age regional cultures and human groups, with the social, political and cultural identity made up by language, traditions and beliefs, which characterize them.

Hence, how in a common cultural background so many processes of social transformations could have taken place? But first, we have to answer to another question, which is perhaps the main one. Which are those processes of change and how we can identify their intensity both in space and in time?

As the iron metallurgy was not enough for describing a transition we need to take into account other phenomena, like changes in the funerary rite, in specific pottery typologies and in settlement patterns.

3.3 The so called *Urnfield culture*: cremation burials and new pottery typologies

One of the main archaeological phenomena of European Late Bronze Age is the spread over a wide area of the so called *Urnfield culture*. The magnitude of such an event was so high that the term *Urnfield* has frequently been used as chronological concept, as a synonymous of Late Bronze Age. In any case, in this section we refer to a phenomenon formed by different components which were included, sometimes according to a too simplistic view, under the same scheme. The chronological debate about *Urnenfelderzeit* has been treated in the chapter 2.

With the term *Urnfield culture* or *Urnenfelderkultur* in the German terminology we mean the diffusion of a “new” grave type and a funerary ritual with the cremation of bodies and placing of their ashes in urns as the main characteristic. The long term deposition of urns for more than a single generation led to the formation of extended cemeteries with a high concentration of burials (Müller-Karpe 1959; Sperber 1987). The accepted chronology of this “new” burial practice comprises a large period between the *BzD* and *HaB3* conventional phases (Kossack 1954; Kossack 1955; Müller-Karpe 1959; Holste 1962; Teržan 1999).

The first scholar writing about “urn fields of the Bronze Age” was probably Otto Tischler in 1886 (Probst 1996, p. 258). It was around the end of the 19th century and the beginning of the 20th century, with the ever-increasing discovery of cemeteries formed by cremated remains in urns, when cremation started to be considered as the dominant burial practice during Late Bronze Age. The discussion was led by personalities like the Swedish archaeologist Oscar Montelius (1885, 1903) and the Danish paleontologist Sophus Müller (1897). According to the historical traditions at that time, in a socio-political background that tended to look for the origins and roots of modern population in a remote and often “sacralized” past, urnfield were interpreted as the material evidence of a supposed Urnfield society, whose main feature was the adoption of a new funerary ritual. Despite the association between one ethnos (a coherent social and cultural entity) and material evidences recorded in the archaeological record was a quite usual at the end of 19th century, some archaeologists, like Ingvald Undset (1882, p. 132) strongly asserted the lack of relationship between this cultural practice and a distinct historical period or an individualized “population” (Stig Sørensen & Rebay-Salisbury 2008).

At the end of the first half of 20th century, researchers like Wolfgang Kimmig started to approach the phenomenon in a global European scale. He was probably the author of the first studies of urnfields in Baden (Southwestern Germany) and in France (Kimmig 1940, Kimmig 1951, De Mulder et al. 2008). The result of those early investigations was that the oldest urnfields appeared to be those found in Central Europe, in the Carpatho-Danubian-Balkan region (Schauer 1975). From there, the burial practice would have “expanded” in waves to the Western, North, South and South-Western regions during the Hallstatt period, which was characterized by an intense demographic growth, as evidenced by the increase in the number and size of settlements and necropolis (Fig. 6). In fact, “it was assumed that similar forms of material culture in different geographical areas must have had a common source, hence cultural change is seen as a result of diffusion rather than evolution (Sklenář 1983, p. 146)” (quoted by Stig Sørensen & Rebay-Salisbury 2008, p. 62). The result of such waves of expansion would have led to the spread of both cremations burials and certain types of metallic and ceramic objects, such as ornaments, weapons, and pottery decorations. Wolfang Kimmig in his article *Seevolkerbewegung und Urnenfelderkultur* had started proposed this hypothesis, connecting the expansion of *Urnfield culture* peoples with the attack committed by the so called Sea Peoples in the Eastern basin of the Mediterranean in the

12th century BC (Kimmig 1964). According to this line of reasoning, the *Urnfield culture* of central Europe and in particular in the regions located north of the Alps developed as a result of the arrival of human groups from Eastern Europe and their interaction with local population (Kimmig 1952, De Mulder et al. 2009). According to this perspective, the archaeological record located in the Middle Danubian Valley was interpreted as the result of a migration of people that could be identified with the Lusatian culture, as proposed by Gordon Childe years ago (Childe 1929). Childe, who strongly defended the importance of movements of people and cultural influences, assumed a triple origin for the Hungarian and North Alpine Urnfield *volk:* 1) as descendants of an autochthonous population, 2) due to invasions, or 3) a combination of the two hypothesis (Childe 1929). He finally theorized that cremation burials were introduced from Greece not by a mass migration but by missionaries, chieftains or a conquering aristocracy (Childe 1950).

In the same years, a fervent debate about the origin and the spread of Urnfields was animating by the Catalan archaeologist Pere Bosch Gimpera. He introduced the term *Campos de Urnas* to characterize the archaeological record of the first Iron Age in Northeastern Iberian Peninsula (Catalonia), referring to a "Culture of the urns" in analogy with the *Urnenfelderkultur* from Southern Germany (Bosch Gimpera 1919; Ruiz Zapatero 1985). Evidence for the existence of Urnfield burials in the North-Eastern part of Iberian Peninsula were the necropoles of Les Obagues de Montsant, and El Calvari del Molar, both in the Southern part of Catalonia, around the Ebro Valley, studied by Salvador Vilaseca i Anguera at the end of the first half of the 20th century (Vilaseca 1943; Vilaseca 1947). The theory of an invasion from the Central Europe to the Southwestern part of Europe gained agreement among Spanish historians and archaeologists. The arrival of a new population, whose ethnic origin was often described as Celtic, would explain the first apparition of a ritual practice unknown in the area until this period, and would be useful for understanding the chronological position of some pottery and metallic typologies. In particular pottery decorated with grooved motifs (*acanalados*) has been traditionally linked with the diffusion of Urnfields (see chapter 5.3.2.2). This kind of decoration, formed by large flat grooves decorating the exterior and the interior part of vessels, especially funerary urns (Vilaseca 1954; Almagro Gorbea 1977), was considered as a proof for the arrival of the new people.

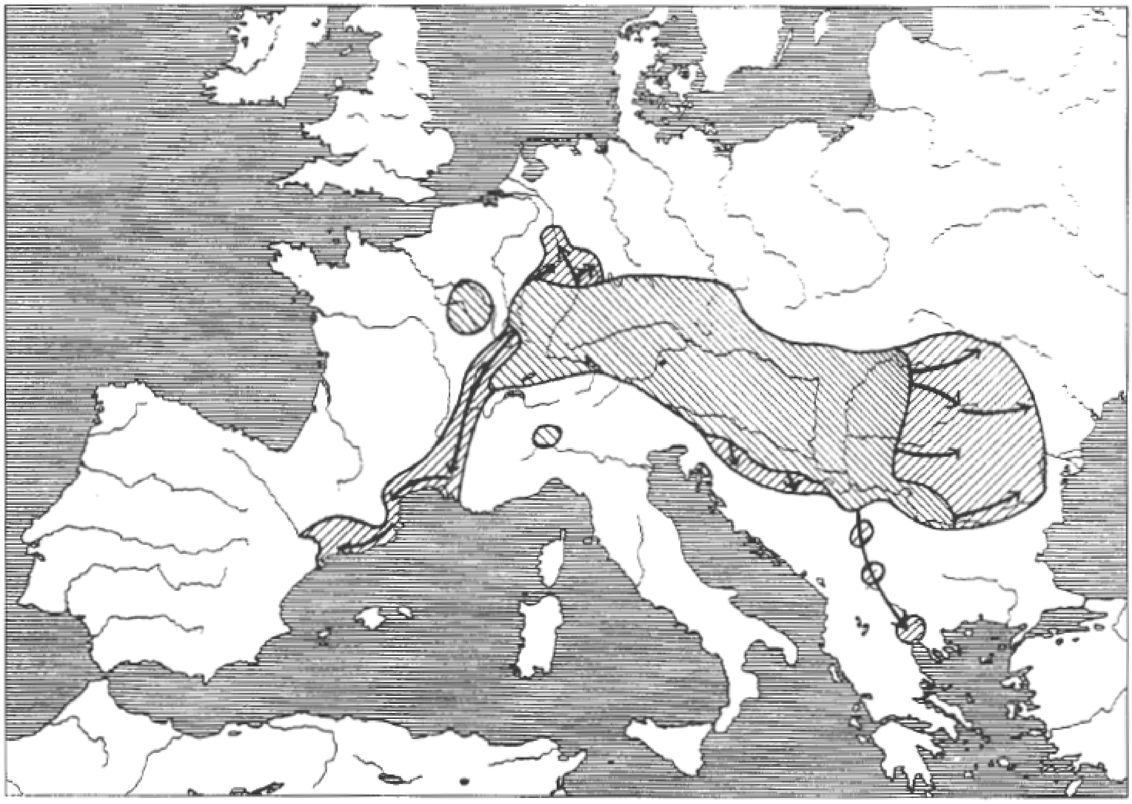

Fig. 6 – The region of formation of the first *Urnfield culture* and its expansion during the *HaA1* phase (Source: Falkestein 1997).

The main debate in North-Eastern Spain, till the ’60 of the last century was focused on the number of possible invasions from central Europe. The positions were mainly two, the first one, by Bosch Gimpera and other archaeologists (“the Catalan school”), who maintained the idea of a series of invasions, like waves of expansion, and the one defended by the Spanish archaeologist Martín Almagro Basch, who identified the existence of only one invasion for explaining the phenomenon (Almagro 1935; Almagro 1952; Ruiz Zapatero 1985). In the ’70s, this “invasionist” hypothesis lost part of its acceptance. An invasion could explain the first appearance of some archaeological features, but not the posterior development, which would be explained better according to an autochthonous evolution. This new hypothesis was the consequence of a far greater number of archaeological excavations on a wider scale, which revealed the existence of differentiation at a regional scale (Almagro Gorbea 1977).
It the ’80s, and thanks to the work of Patrice Brun (Brun 1984; Brun & Mordant 1989), the term “group Rhin-Suisse-France oriental (RSFO)” was introduced to account for central European cultural influences in Late Bronze Age sites from Eastern France. It is important to remark that such an “archaeological group” was considered to be within

the definition of *Urnfield culture* (Bourgeois 1989; De Mulder et al. 2007). In any case, far from the invasionist hypothesis, Patrice Brun shifted emphasis from migrations to a socio-economic interpretation of the changes observed in the LBA archaeological record (De Mulder et al. 2008). The geographic location of the RSFO group includes a wide territory which covers part of Southern Germany, Switzerland and northeast France. From these regions, the RSFO group would have expanded through movements of population in a northern-west and south direction (Fig. 7). In this latter case, the communication axis was located along the valley of the river Rhone (Lachenal 2011a). The main archaeological features of such a group are the occupation of open-air sites, the bronze deposits and the use of cremation burials (Brun 1989). The period of its development correspond to the traditional phases *Bronze Final 2b* and *3a* in the Hatt's chronological scheme, which correspond to *Hallstatt A2* and *B1* in the Müller Karpe chronological framework (Lachenal 2011a).

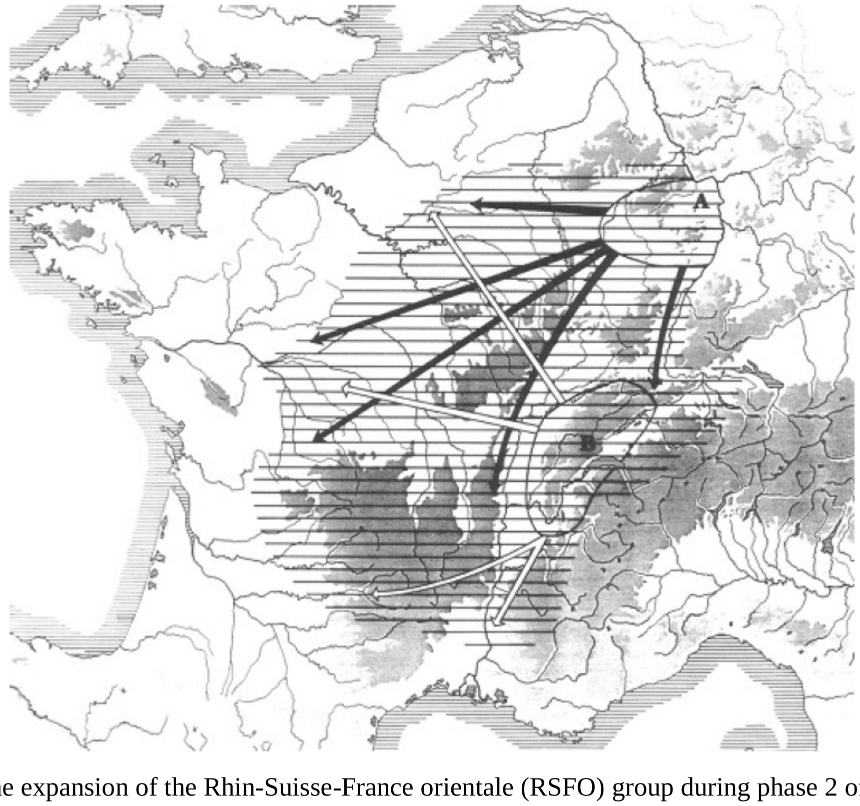

Fig. 7 – The expansion of the Rhin-Suisse-France orientale (RSFO) group during phase 2 of LBA. The areas A and B represent the core areas from which the group RSFO spread over northwestern Europe (Source: Kristiansen 1998b; De Mulder et al. 2009).

Traditionally the first arrival of the Urnfields in the Iberian Peninsula was considered to be from Southern France, following a terrestrial way, through the Eastern Pyrenees. In fact, it is undeniable that autochthonous population living in the Southwestern part of the actual France played a relevant role in the diffusion/transmission of new cultural elements from North Alps towards the other side of the Pyrenees. Relationships between the Iberian Urnfield groups and those linked with the RSFO are attested by the presence of similar decoration and pottery typologies, like urn with cylindrical neck (Neumaier 2006), traditionally used as a time marker (Guilaine 1972; Pons 1984). In the ’90s, Jordi Rovira i Port (1991), after determining that the oldest Urnfields were located in Catalonia along the middle and southern coast, proposed a maritime arrival for the Catalan cremation burials, which would be dated around 1300/1200 BC. The phenomenon was interpreted in terms of the arrival of small groups, which would have expanded later towards the interior of Iberian Peninsula.

Nowadays, the focus on the still called *Urnfield culture* has slightly moved towards other topics. The identification of the original Urnfielders has been a widely debated topic among the scholars; various hypotheses have been addressed (Illyrians, Celts, Dorians and Thracians). In recent times, the possibility that Urnfielders could have originated from different tribes with various ethnicities has also been taken into account (Kristiansen 1998b; Kristinsson 2010). Kristiansen (1998b) stressed that for the period 1100-750 BC a global tendency towards settlement concentration, demographic growth and social-political hierarchization. Moreover, he observed that these processes have an East to West trend. The expansion of Urnfielders during the *Ha A2* and the *Ha B1* was mainly from the RSFO region to the north-east and the south-east (Fig. 7) (Kristiansen 1998b).

In general, a greater attention distinguishing the different components of the phenomenon can be recognized in recent studies. Instead of taking into account the *Urnfield culture* as a homogenous process, it is decomposed in single features analyzed individually. For instance, several differences in the typology of the cremation burials have been recognized: 1) with urn, 2) urnless, where calcined bones are covered by the ash and the charcoal of the hearth, 3) urnless, where calcined bones are mixed withby the ash and the charcoal of the hearth (*brandgrube*). In some other cases, a small mound covered the tomb, as attested in the cremation burials which can be dated to a phase of transition between the “Tumulus culture” **(***Hügelgräberkultur*) characteristic of Middle Bronze Age in Central Europe and the *Urnfield culture* of the Late Bronze Age. It is relevant the fact in the *BzC* and the *BzD* phases in Styria (Austria) cremated bones appear in flat graves, and cremations burials under tumuli are documented in only three cases (Tiefengraber 2007b; Ložnjak Dizdar 2011)**.** The result of such archaeological variability is the need to argue for the development of innumerable regional and local expressions and specific forms (Teržan 1999; Przybiła 2009).

The diffusion of fluted pottery, a widespread kind of pottery characterized by a fluted decoration which can cover either the external surface or the internal one (see chapter 5.3.2.2), which traditionally was linked with the expansion of Urnfields, to the extreme that this archaeological type was seen as a synonymous of the oldest Urnfields (Almagro Gorbea 1977), has been recently considered as the consequence of autonomous processes (Ruiz Zapatero 1997; Neumaier 2006; López Cachero 2008). It is interesting to note that, for example in Catalonia, previous forms of settlement and burial practice, and older traditions of pottery decoration and metallurgical types (the local substratum) did not disappear simultaneously with the first presences of Urnfield items. On the contrary, in Central Europe, older traditions of pottery making and metallurgy seem to disappear at the end of the conventional phase *BzD* (Neumaier 1995).

A particular care needs the analysis of funerary remains and related archaeological contexts of the Italian Peninsula during the Late Bronze Age. Although traditionally the presence of Urnfields has not been a widely debated topic in the archaeological literature, there are several elements which can be linked to the phenomenon, first of all, the funerary ritual. Cremation burials in urns are largely attested from the end of the Middle Bronze Age in Northern Italy and they become a common phenomenon during Late Bronze Age (Vannacci Lunazzi 1971; Salzani 1985, 1994b; Venturino Gambari & Villa 1993; Cardarelli 1997; Tirabassi 1997; Gambari & Venturino Gambari 1998, 2012; Cardarelli et al. 2003, 2006; Salzani 2004; Simone Zompfi 2005a, 2005b). We can mention the necropolis with cremation burials of Canegrate in Lombardy, which gives the name to the homonymous archaeological *facies* spread also in Piedmont and Canton Ticino. As a consequence of Bosch Gimpera's works, the influence of the Urnfield world in Northern Italy were recognized in 1963 by F. Rittatore Vonwiller (1963), who proposed an invasion of Urnfielders along the axis of the Ticino, after the analysis of the *Canegrate culture* remains.

De Marinis (1988) proposed to place in the Middle Bronze Age, specifically in the phase BM2, the introduction in Italy of the cremation burial practice, following Urnfield characteristics. In Piedmont and Liguria, the introduction of cremation rite would have coincided with an apparent phase of mixed rite (inhumation and cremation). Those

oldest cremation burials (perhaps originally under tumuli), like those discovered at the necropolis of Alba (Cuneo) had an inner organization different from the usual disposition in transalpine Urnfields and in cemeteries of the *Canegrate culture* (Gambari & Venturino Gambari 1998). Such difference has been explained in terms of a "progressional development" of new elements, instead of a sudden arrival ("invasive") of Urnfield elements in Northern Italy as a consequence of migration (Gambari & Venturino Gambari 1998, p. 245).
It is also important to remember that incineration is one of the main elements of many other cultures of Northern and Central Italian Peninsula around the same time. For example the Veneto culture in the Northern Adriatic and the Golasecca world in the Italian regions of Lombardia and Piemonte. Without any doubt, the most significant presence of incineration is in the proto-Villanovan period in the Apennine peninsula. The incineration of bodies and the placing of the ashes in a biconical urn is perhaps the most distinctive feature of such archaeological culture. According to a recent study (Kukoč 2010), the oldest presence of a cremation burial among the communities established in the South-Western part of the Adriatic coast coincided with the disappearance of local Subapennine culture. New elements of proto-Villanovan culture were introduced during the 11th century BC, as the findings in the archaeological excavations at Torre Castelluccia in Apulia suggest. Evidence of proto-Vilanovian contacts would be the cremation burials of the necropolis of Sala Consilina, Capua and Pontecagnano in Campania. Therefore the introduction of incineration in Southern Italy could be explained by movements both from the proto-Vilanovan regions and the Danube area across the Balkans and the Adriatic Sea (Kukoč 2010; Blečić Kavur 2011).

3.4 From East to West and the other way around

The name "Celts" first appeared among Greek writers, with Hecataeus of Miletus who, in the 6th century BC, mentioned Marseilles as being near Celtic territory (Dillon & Chadwick 1967). Herodotus in the 5th century BC referred to the people north of Hellas as the Κελτοί "Keltoi" (Wells 2002). Julius Caesar in its firsthand account on the Gallic Wars (*De Bello Gallico*) uses the name, claiming that, although the Romans used the name *Galli* (Gauls) in their own language, they are called Celts (Cunliffe 2003; Temple

2010): “Gallia est omnis divisa in partes tres, quarum unam incolunt Belgae, aliam Aquitani, tertiam qui ipsorum lingua Celtae, nostra Galli appellantur”.

Traditionally, Celts were a group of societies joined by the use of the Celtic languages and a similar culture. Karl (2010) suggests that "a Celt is someone who either speaks a Celtic language or produces or uses Celtic art or material culture or has been referred to as one in historical records or has identified himself or been identified by others as such".

The major source of information about the area of diffusion of Celtic languages and Celtic Peoples are the classical texts. According to Herodotus (*Histories* 2.33) “the big Danube (Ἴστρος in ancient Greek) has its source among the Celts near Pyrenees - the Celts live beyond the Pillars of Hercules (Gibraltar) next to the Cynesians who are the most Westerly people of Europe".

In the 4th c. BC the Greek geographer Pytheas comments on the location of the British Isles as being "North of the land of the Celts".

Another Greek geographer Pausanias, who lived in the 2nd c. AD, tells us that the Gauls "originally called Celts live in the remotest region of Europe on the coast of an enormous tidal sea. Okeanos (the River of Ocean which surrounds the world) is the most distant part of the sea - the people who live beside it are Iberians and Celts - it contains the island of Britain. The remotest Celts are called Kabares who live on the edges of the ice desert - a very tall race of people." In this case, we have a reference of two major areas under Celtic influence - Gaul (France) and Iberian Peninsula (Spain and Portugal).

Nowadays we know that the languages spoken by Celts can be rooted in the so called Indoeuropean languages. Celtic languages were spoken in Roman republican times in Northern Italy, France, Britain and parts of Iberian Peninsula (Fig. 8).

Fig. 8 – Distribution map of Celtic languages (Source: Mallory & Adams 1997).

But what are the origins of the Celts, geographically and temporally?

We can stress that the importance of Celtic culture for our research derives from its connections to the previous cultures that inhabited Europe, among which the most outstanding for its macro-scale distribution was the already treated *Urnfield culture*.

Analyzing the major Celtic cultural area, we realize that it includes a large territory located in the Alps of Central Europe. According to the traditionally theory from this region Celts would have expanded toward southern, northern and western regions (Fig. 9). Such a process has been traditionally dated to the Iron Age, La Tène phases in the Reinecke chronology (Powell 1958; Rankin 1987; Moscati et al. 1991; Ruiz Zapatero & Lorrio 1999; Kruta 2000; Temple 2010).

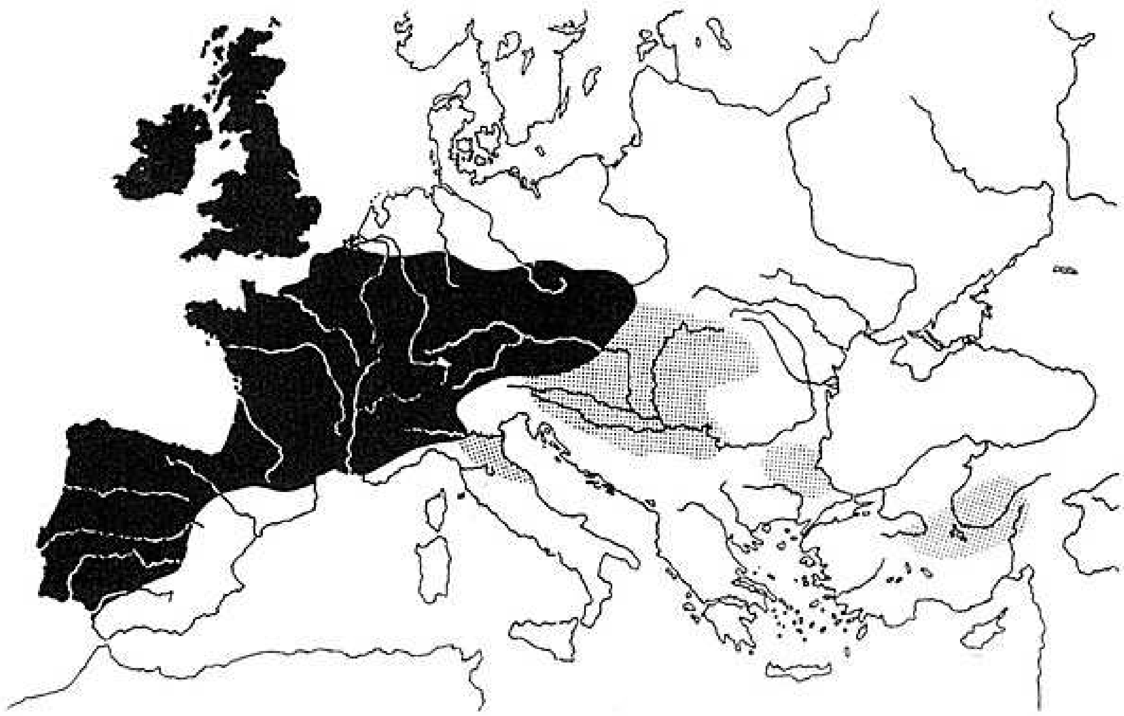

Fig. 9 – Distribution area of the Celts (Source: Kruta 2000).

Another theory has been recently proposed by Cunliffe (Cunliffe & Koch 2010), who made a revision of the tradition paradigm of Celts from the east. He suggested an alternative proposal for the origins of the Celtic speaking peoples of Europe. After the analysis of the processes of interaction and exchanges, which characterized the Atlantic facade during the Bronze Age (Cunliffe 2001), Cunliffe argued that technological innovations and new forms of material culture did not necessarily follow an east-to-west diffusion pattern. Therefore, he addressed the possibility of the western development of the Celtic languages, as a result of long-term interactions along the Atlantic coast. As a consequence, Cunliffe stressed that Celtic trade languages could have developed in the Atlantic Zone and moved eastward.

Nevertheless, some areas where "Unrfield culture" is traditionally attested, for instance Catalonia, are not included in the Celtic world, the analogies between the spatial distributions of Celts and "Unrfield culture" are clear; hence a relation between the two phenomena could be suggested. Doubtless, the Pre-Celtic groups who inhabited Europe at the end of the Bronze Age and at the beginning of Iron Age are contemporary to the phenomenon of cultural standardization testified by the macro-scale diffusion of cremation burials and specific pottery and metallic typologies.

Therefore, we could ask if the material consequences of population movements at the end of the Bronze Age and at the beginning of the Iron Age lead to a preliminary formation of pre-Celtic entities.

Such a topic is an old problem, already addressed in the first half of the last century by the Catalan archaeologist Bosch Gimpera (1932, 1942), who identified the Celts with the *Urnfield culture* of the north-east of the Iberian Peninsula. He suggested the existence of various invasions to explain the Celtisation in such an area.

Moreover, regarding Celtic languages, Koch (2006, 2008) assumed that they should come from a single common branch spoken in Bronze Age, if not earlier. According to such a perspective, Rankin (1987) stressed that the differentiated Celtic languages that ultimately spread across the Europe emerged out of the Urnfield complex.

As a consequence the two phenomena, the space-time diffusion of Urnfield contexts and the space-time diffusion of the Celts, need to be studied using the same approach. We are aware that Bronze Age is characterized by long-term processes of spreading of people and ideas, which reached a high magnitude in the LBA. Hence, we wonder if those episodes can be linked to the spatial distribution of Early Iron Age Celtic people. Perhaps, we cannot find a definitive solution for such an issue, but we can model processes which took place in last phases of Bronze Age, which are the main subject of this work.

The idea of expansion is strictly linked to three possible hypotheses: the substitution of population, the adaptive hypothesis and the socio-political hypothesis.

The first one can be interpreted as a result of one or more episodes of migrations, which could have lead to a gradual replacement of autochthons populations by the new ones. The adaptive hypothesis embraces all those processes which lead to one or more episodes of people movement caused by a lack in the available resources. Such a decrease in resources can be caused either by a deterioration in climatic conditions or by the excessive human exploitation in a specific territory.

The third hypothesis deals with the socio-cultural and political conditions, which include ideological beliefs, political structure, trade organization, all elements that represent the backbone of past and present societies. In this case, more than episode of massive migration of population we should talk of movements of persons, objects, materials and ideas.

In this thesis we want to test the three mentioned hypotheses for the 2nd and the beginning of the 1st millennium BC on the base of the archaeological record.

3.5 The Substitution of populations hypothesis

Traditionally, the increase in population has been correlated to the phenomena of expansion and often regarded as a major cause for people movement. An episode of substitution of population would be characterized by an episode of massive demographic growth and a migration of such a large number of people from a place x_1 to a place x_2. Depending on the magnitude of such a phenomenon the new population would have replaced the previous one, and such an abrupt change should be detected.

Nowadays we can study the effects of the substitution of population. In this framework, the most widespread tools which allow to detect such changes are the paleolinguistic reconstruction and the study of genetic markers. Trough these methodologies we can infer the characteristics of the expansion process, like the place of origin and the rate of spread both in space and in time.

3.5.1 Linguistic data and paleolinguistic reconstruction

Language and its evolution along time constitute an important source of information to study developments of present and past populations. One of the main aims of linguistic studies is to define the origin of modern languages analyzing their roots and the events of splitting having generated divergences detectable in modern vocabulary, for instance by calculating the extent to which vocabularies of different languages and dialects appear to be statistically diverse. This approach can be defined “lexicostatistics” and it is based on the quantification of such divergences through the analysis of the percentage of terms shared from two or more languages (Bryant et al. 2005). In this ways languages can be organized in groups and subgroups according to these criteria.

It has been suggested the possibility of measuring the degree of "cultural" distance between individuals from different human populations from the varying linguistic similarity of their dialects. The linguistic diversity observed here and now is assumed to be the cumulative result of a sequence of changes and mutations experienced by a presumed previous common language from which the currently spoken comes from. The greater or lesser similarity between modern languages is assumed to be a function of the time they diverged from a common ancestral language. In other words, the more words and grammatical structures have in common two languages, the closer the historical relationship and therefore the more likely both come from a common ancestor. As the number of common linguistic features decrease, the similarity and understandability of each language also decrease. Values between 5 and 12% of common elements lead linguists to assume that it has been some connection in the past between those languages (Campbell 1998; Hock & Joseph 2009; Pagel 2009). Glottochronology is a technique to calculate the temporal separation or divergence between languages that are supposed to be relatives. Using this method it seems possible to estimate the date at which two or more languages formed a single unity. The method is based on the percentage of words or cognates replaced by other words along time. The result is often a tree structure (dendrogam), wherein each branch is interpreted as the time at which a significant change in the proportion of traits in common was generated (Swadesh 1972; Embleton 1986; Ringe 1992; Nichols 1997; Atkinson et al. 2005; Dunn et al. 2005; McMahon and McMahon 2005; Holman et al. 2008). The rationale of the method derives from common assumption that population isolation leads to linguistic and "cultural" diversification (Cavalli Sforza 1997). It seems well proved that those languages related historically as a result of physical interaction of speakers are structurally and lexically more similar to those in which speakers were not connected and were also more geographically distanced (Nichols 1997; Holman 2004; Holman et al. 2008) . The probable relationship between genetic distances and linguistic distances and hence of “cultural” differences is the fact that human populations (and therefore languages) “move” in a predictable way on particular geographical, economic and social contexts. Therefore, the genetic distances between populations can be related in some way to the degree of statistical differentiation between the languages spoken by these people. Biological and “cultural” similarity then decrease as the degree of involvement between people (social interaction) decreases as a result of an increase in the geographical and temporal distance.

The problem is that the basic evolutionary premise - the higher degree of similarity, the lesser time has elapsed since differentiation started - works only when the process is assumed to be stochastic. That is to say,

1. the rate of change (genetic mutation, lexical substitution, cultural change, technological innovation and / or political transformation) is approximately constant, especially considering very long periods of time,

2. the rate of change (genetic mutation, lexical substitution, cultural change, technological innovation and / or political transformation) is approximately uniform across all languages,
3. Once separated two languages or other cultural trait in a taxonomic tree, they cannot rejoin, i.e. do not return to exchange traits.

These assumptions may be valid when the action of the individual has been unconscious and it can be represented stochastically. When we introduce the possibility of rational decisions (either in a global sense, logical, or limited to opportunities for local decision, that is, a limited or heuristic rationality of social actors), the assumption of a more or less constant rate of linguistic change between generations is not sustainable. Only in the case that the processes of change (macro scale) had been in Bronze Age Europe sufficiently constant over time, we may come to accept that the degree or intensity of similarities and differences observed in the linguistic present adequately measure the time occurred since the beginning of the process that led to the present differentiation. If that were the case, then we could infer the possible existence in Bronze Age (or even earlier) of a series of population fission events (segregation), processes of expansion into new areas, and/or isolation of some populations with respect to an initial homogenous population or fairly similar populations (Cavalla-Sforza 1997, 2002; Cavalla-Sforza et al. 1993).

Obviously, the relationship: *higher cultural difference between different populations…the longer time since original group fission* would be proportional only if it was shown that aggregation or other events of social union (exchange networks, military conquest, acculturation, etc.) have not taken place. One of the key issues is to find the relationship that may have existed between linguistic diversity and the forces and processes that have produced this variability throughout history. Part of the answer is related to the genetics of human populations (fission and /or fusion of biological communities), but also the mechanisms of learning and cultural transmission between successive generations of a population. In this sense, human languages are shaped by genetic, communicative and social factors simultaneously, resulting in different solutions to similar problems, as well as a contingent variation (Eddie 2009).

Differences between modern European languages have been carried out in Indoeuropean studies. The term “Indo-European” was first introduced by Thomas

Young in 1813 (Lebedynsky 2011). During the 19th century several researchers started to describe accurately the various modern languages that were assumed to have a common origin: Albanian, Anatolian, Armenian, Baltic, Celtic, Phrygian, German, Greek, Sanskrit, Iranian, Italic, Slavic, Tocharian and Trace. The aim was to identify and to reconstruct the original mother language: “Indo-european”. From the beginning of such investigations, scholars argued that the ancient Indoeuropean was the language spoken by a quite homogeneous ethno-cultural group, Indoeuropeans, who spread over a large territory from the same place of origin. The historical process was not very clear, but most studies agreed in identifying a linguistic feature with an ethnic or at least a cultural connotation. In fact, as Dumézil stressed (1968), the common language could be conceived without any unity of race and without political unity but not without a hint of common civilization, and intellectual civilization meant for those scholars, religion as well as material culture.

In order to define a chronological period for the original bifurcations of the Indoeuropean proto-language, researchers applied glottochronological criteria (Swadesh 1972). The result highlighted that the separation between the different Indoeuropean branches should be placed between 4500 and 3500 BC (Lebedynsky 2011), which correspond to the end of the Neolithic and the Calcolithic in Europe. Despite of such studies, Renfrew connected the expansion of the Indoeuropean languages to the process of Neolithization (Renfrew 1987). According to this author, agriculture and Indoeuropean languages would have been introduced from Anatolia following a wave of advance model. On the contrary, according to other authors, and based on the idea of a presumed continuity of deep cultural elements since Paleolithic times, Indoeuropean languages would have been the result of a series of events of differentiation among autochthonous communities (Meinander 1973; Otte 1995; Alinei 1998, 2002).

The hypothesis introduced by Marija Gimbutas deserves a particular attention (Gimbutas 1967, 1977). The famous Lithuanian scholar identified first Indo-Europeans with the people belonging to the “Kurgan culture”, who developed in the area of modern Ukraine and Southern Russia in the 5th millennium BC. From this area they would have expanded according to a three waves of migration system to the western and south-western territories.

Among the Indoeuropean languages, we need to focus on Celts, as it is related to the topic of our research.

We are aware that Celtic languages were spoken in Roman republican times in Northern Italy, France, Britain and parts of Iberian Peninsula. Moreover, archaeological finds have the existence of text written in Celtic languages, whose oldest evidences can be traced in the Early Iron Age. For the 6th c. BC we refer to the Lepontic inscriptions recovered in Northern Italy around the Lake Maggiore and Lake Como, and in Southern Switzerland near Lugano. The early Lepontic phase coincides with the last period of the archaeological Golasecca culture (De Marinis 1991; Frey 1995; De Marinis & Biaggio Simona 2000; Uhlich 2007; Stifter 2008). In addition, recently Kock (2009a, 2009b, 2013a, 2013b) stressed that the Tartessian inscriptions located in the Southern-West of Iberian Peninsula are in a Celtic language and can be dated back to 800 BC.

Although they are now dead languages (except for residual languages in Britain), they are assumed to come from a single common language spoken in Bronze Age, if not earlier (Koch 2006, 2008). Isaac (2004) suggested an eastern European origin for the development of proto-Celtic based on the amount of innovative morphological characteristics which are shared by Celtic and Eastern Indo-European languages (Indo-Iranian, Baltic, Slavic, Greek, Tocharian, and Albanian). According to such a perspective, as already mentioned Rankin (1987) stressed that the differentiated Celtic languages that ultimately spread across the Europe emerged out of the Urnfield complex. It would be logical to assume then, for Late Bronze Age in Central and Western Europe the formation of a mosaic of relatively little differentiated languages, despite the possible lexical differences, spoken in particular geographic areas well differentiated. Various processes may have produced this result. For Nichols (1997, 2008) this would indicate the dominance of small scale economic systems in which a particular group of speakers of some language could not expand at the expense of another (and to the detriment of the language spoken by that group). Nettle (1999a, 1999b, 1999c), however, suggests that a low linguistic diversity - as it is presumed for the group of Celtic languages - would have been caused by the small number of speakers per language and would have affected the proportion of lexical change, so that the ancient languages known from Latin sources, appear more related to the original languages from which they come. Bellwood (1994, 1996, 2008) has suggested that high lexicostatistics correspondence between a proto-language and its derivatives suggests a lower apparent age of linguistic differentiation, what implies less time for its population grew and expand to neighboring areas. Contrary to this assumption are Campbell (1998) Holman (2004), Hunley et al. (2007), Currie and Mace (2009).

In prehistoric Europe, as in any other region and period, languages may have expanded in two possible ways.

1. Speakers of a language can expand to another area
2. A linguistic change occurs when different populations of people adopt a new language.

Without the kind of cohesive force of complex state-like political institutions, in Late Bronze Age Europe residential mobility would have tended to the fragmentation of social groups. In these circumstances, languages tend to change rapidly, not only because of the geographical isolation but accentuated by the use of language as a form of group identity. Therefore, it may be suggested that linguistic homogeneity (proto-language) could not have lasted long.

The geographic isolation caused by landscape variation and topographic barriers is not necessary a major factor in determining the area covered by each language. Cultural economic, political, and social separation may have been more important. Any human group can create its own borders that limit social interaction, exchange of words and information. A more logical explanation of why some Celtic languages seem to be more circumscribed than others may be in the difficulty of human groups with no central authority to prevent social fission, i.e. the separation of individuals who prefer to find their livelihood outside the group where they have birth, or joining a different community.

Such mechanisms of isolation and expansion are also detectable in the Iberian Peninsula where a local variation of a Celt language (celtiberian) is attested in many inscriptions from 6th century BC onwards. Two main theories for the origin of this language people have been proposed. The first one assumes the arrival of the first Celtic peoples from Central Europe following one or various migratory movement toward Western and South-Western Europe (Almagro 1935, 1952; Powell 1958; Pauli 1980, Renfrew 1987). In this framework, the Catalan archaeologist Bosch Gimpera associated the material evidences of the *Urnfield culture* in the NE of Iberian Peninsula to the arrival of such "Celtic" people, carriers of the new language (Bosch Gimpera 1921, 1932, 1944).

An alternative hypothesis assumes the existence of a local formation process for Celtic culture in the Iberian Peninsula, in which we have to include different phenomena of acculturation and evolution (Almagro Gorbea 1987, 1991, 1992; Lorrio & Ruiz Zapatero 2005). Episodes of population movement are not completely discarded, but their magnitude is limited in this model, in which local "proto-Celtic cultures" had a key role. For the specificity of Celts in Iberia the term "Celtiberic culture" has been introduced. According to Almagro-Gorbea (1994) the Celts should be linked with "a wide, fluid and polymorphous Atlantic Bronze Age "proto-Celtic" culture". The relation with the Atlantic Bronze Age for the formation of the Celtiberian culture has also been highlighted by Manyanós (1999-2000), who analyzed the Peninsular Celticization and interpreted it as a result of a double process, made up by both a relation to the Atlantic Bronze Age and contacts with the eastern Meseta in relation to the trans-Pyrenean arrival of elements belonging to the *Urnfield culture*. The problem is addressed on a different perspective by the work of Arenas (1999, 2001-2002), who attempted to describe the genesis and the evolution of the Celtiberian world in relation to the Mediterranean world.

Eventually, a synthesis on this issue has been proposed by Lorrio and Ruiz Zapatero (Ruiz Zapatero & Lorrio 1999; Lorrio & Ruiz Zapatero 2005). They point out the undeniable influence of the *Urnfield culture* in Northeastern Iberian Peninsula on the formation of the Celtiberian world. These contacts are confirmed by several elements, like the characteristic of burials and grave goods, common elements in the tradition of ceramics and metallurgy, and some architectural characteristics of fortified settlements. The authors stress that the Celtiberian world would have emerged out of the interaction between the socio-economic model imposed in the 8th and 7th centuries BC by the *Urnfield culture* from NE Iberian Peninsula, and the local cultures, which played an important role in this process. In fact, the penetration of Urnfield human groups is widely accepted and at least in its initial phase. The possibility that these infiltrating Urnfield groups may have brought with them an Indo-European language should not be rejected, although their role in creating the Celtiberian world has yet to be determined (Lorrio & Ruiz Zapatero 2005).

3.5.2 Genetic markers and population flows

Nowadays, due to scientific advances in human biology, new relevant tools have been created to analyze the genetic differences among human populations both in the present and in the past. Such differences can be interpreted as an evidence of people movements and episodes of substitution of population in a specific place and during a certain time.

Therefore, the interest for genetic analysis is directly linked with the topics addressed in our research.
Genetics provides new approaches for the study of our ancestors based on mechanisms of inheritance of variations and traits of living organisms (Griffiths 2000; Hartl & Jones 2005; King et al. 2006). The first attempts of using classical genetic markers, like blood groups, taken on living population in order to reconstruct human evolution can be traced in the work of Cavalli Sforza and Edwards (1965). The spatial variation in such markers has been correlated with contemporary linguistic groups or population, as suggested for the Basque Country, where a high frequency of the Rhesus negative blood groups was detected (Mourant et al. 1976). Among these studies we can mention the paper by Menozzi et al. (1978), in which the authors analyzed the classical genetic markers in Europe using Principal Component Analysis, and the study by Cavalli-Sforza et al. (1994) in which such an analysis was extended worldwide. Genetic differences have lead to Ammerman & Cavalli-Sforza (1973, 1984) a model for the demic diffusion of early farming in Europe according to a wave of advance model in which a new population, with characteristic genetic markers, substituted (or in some cases, mixed with) the local inhabitants. Cavalli-Sforza discovered the existence of several patterns although the genetic homogeneity was predominant. In particular, the most relevant one was a north-western to south-western cline with a focus located in the Near Eastern. He managed to identify such a cline with the expansion of the agriculture from the Middle East in the Neolithic Period. The town of Jericho was recognized as the origin of the spreading movement (Ammerman & Cavalli-Sforza 1971, 1984; Cavalli-Sforza 1997, 2002). The author focused also on the diffusion of the Kurgan culture in the European Steppe north of the eastern part of the Black Sea (Cavalli-Sforza et al. 1994). Such studies are of great importance in order to try to correlate the Neolithic expansion and the diffusion of Indoeuropeans detected through the analysis of derived languages. Nowadays, the Y-haplogroup R1a is a proposed marker of these “Kurgan” genes, although the haplogroup as a whole could be older than the language family (Underhill et al. 2009).
In the same way as in the case of the origins of modern languages, the pattern of genetic variability among modern populations is assumed to be the cumulative result of a sequence of changes and mutations experienced by a presumed previous genetically homogenous population from which we come from. The greater or lesser similarity in alleles and other genetic markers (DNA) is assumed to be a function of the time they

diverged from a common ancestral population. In the last decades, thanks to the progresses reached in the technique, the archaeological community has started to be interested in the use of DNA sequencing applied to the analysis of past human remains. Moreover, the ever increasing number of archaeological excavations of funerary contexts in Europe has enhanced such an interest. Renfrew (Renfrew & Boyle 2000) refers to this new discipline with the term “archeogenetics”. Currently, DNA-base analysis in archaeology has focused mainly in the study of the mitochondrial DNA (mtDNA) for detecting specific lineages in the female line (Wainscoat et al. 1986; Cann et al. 1987; Sajantila et al. 1995; Simoni et al. 2000; Plaza et al. 2003; Forster et al. 2004; Sampietro et al. 2005; Achilli et al. 2007; Gamba et al. 2012) and the Y-chromosome for the male line (Cooper et al. 1996; Malaspina et al. 1998; Rosser et al. 2000; Wilson et al. 2001; Rootsi et al. 2004; Faux 2008). The bases for most of the researches must be placed in the phylogenetic seriation and the cladistic studies (Cavalli-Sforza & Edwards 1967; Moore 1994; O’Brien & Lee Lyman 2002, 2003; Mace et al. 2005).

The advantage of analyzing DNA is particularly clear when we want to evidence of population movements and the subsistence of human groups that may have taken place in the past. However, when studying an ancient phenomenon of diffusion, archaeologists must “calibrate” samples of modern DNA collected from living populations with all the modifications that may be the consequence of later events, like population movements during the Roman Empire of the medieval Muslim expansion in Southern and Eastern Europe. On the contrary, ancient DNA is a primary source of information, as no other posterior mechanism was responsible of the observed genetic variation. The main problem in such cases relates to the preservation of human bones, which frequently does not guarantee a sufficient amount of DNA in good conditions, suitable for the analysis.

In the framework of expansive phenomena, differences in the haplogroup J have been used to analyze the possible spread of Neolithic groups (Barbujani et al. 1998; Simoni et al. 2000), in addition phylogenetic analysis of mitochondrial DNA has shown that populations from both shores of the Mediterranean share a common set of mtDNA haplogroups (Plaza et al. 2003). Regarding the Neolithic expansion recent genetic studies on mtDNA (Bramanti et al. 2009) showed an absence of continuity in Europe between the Mesolithic and the Linearbandkeramik, which represents the major archeological horizon in the European Neolithic. Such a result points first farmers in

Europe were immigrant people with a different genetic ancestry. Analogous conclusions were reached by Gamba et al. (2012). Through the analysis of ancient DNA collected on sample from Neolithic contexts located in the North-East Iberia, Gamba et al. (2012) stressed that Early Neolithic in the Iberian Peninsula was associated to movements of small human groups whose genetic ancestry was not local. To sum up, currently "all paleogenetic studies of hunter-gatherers and early farmers are consistent with a scenario whereby farmers immigrated into Europe from the South and Southeast" (Pinhasi et al. 2012).

A debated topic in genetic analysis and not only is the origin of Etruscans.

Researches carried out on modern DNA have suggested a Near Eastern Origin of Etruscan people, analyzing the nature and the extent of mtDNA variation both in ancient and modern Tuscans (Vernesi et al. 2004; Achilli et al. 2007). This would be in agreement with the theory of the Greek historian Herodotus, who first argued the oriental origin of the Etruscans, explaining their arrival as a consequence of a migration dorm Lydia, at the Eastern coast of Anatolia. On the contrary, according to Dionysius of Halicarnassus the genesis of the Etruscans must be located in the Italian Peninsula, as they were an autochthonous population. Such a theory has been currently confirmed by a recent mtDNA study (Ghirotto et al. 2013) carried on ancient DNA, from burials in the Etruscan necropoles, comparing the results with both medieval and modern DNA have suggested that the Etruscan culture developed locally and therefore not as a consequence of an arrival of people from Anatolia. Contacts between Tuscany and Anatolia certainly took place, but they must be dated back to at least 5000 years ago (Ghirotto et al. 2013). It is meaningful to remember that the developing of Etruscan culture originates in the Villanovan and Proto-Villanovan cultures that practiced the funerary ritual of the cremation, which is also attested among the Etruscans communities.

The mtDNA analysis has been considered also suitable for the analysis of the Ancient Iberians, showing a haplogroups composition similar to that found in modern Iberian Peninsula Populations (Sampietro et al. 2005), what suggests the continuity of population since prehistoric times and the low modifications in the population pattern during Roman Times and Medieval ages. New researches carried out on modern mithocondrial DNA and Y-Chromosome structure of the Iberian Peninsula population have highlighted the existence of stronger Atlantic versus Mediterranean than North to South differentiation and large diversities in the South (Santos et al. 2014). In particular,

the authors detected major haplotypic affinities between all the Iberian Peninsula regions and North Africa as well as the Atlantic Island. Such resemblances could be interpreted as a result of an Atlantic network during Copper and Bronze Age cultures in this part of Europe (Santos et al. 2014).
For the chronological period we are studying here, relevant results have been produced in the works carried out by De Beule (2010, 2011). The author studied the diffusion in space and in time of the I-L38 haplotype, which was first detected in the skeletons of the Lichtenstein burial cave in Osterode-am-Harz (Niedersaksen, Germany) (Fig. 10). In the cave were found 40 skeletons which were dated between 1000 and 700 BC through the typo-chronologically analysis of the funerary assemblages, composed of pottery and metallic objects belonging to the *Urnfield culture* (Schilz 2006). Comparing the presence of this haplotype in the archaeological remains and in modern populations, De Beule suggests an east to west migration of the I-L38, which could be correlated to the spread of *Urnfield culture* in Late Bronze Age and at the beginning of the Iron Age. In particular, the research signals the role of the Upper Rhine region in the expansion. From such an area the I-L38 haplogroup expanded to the coast of Normandy (France) to cross the Channel to enter England and Ireland. There are also connections toward the south (Spain), north (Southern Norway) and east (Poland).

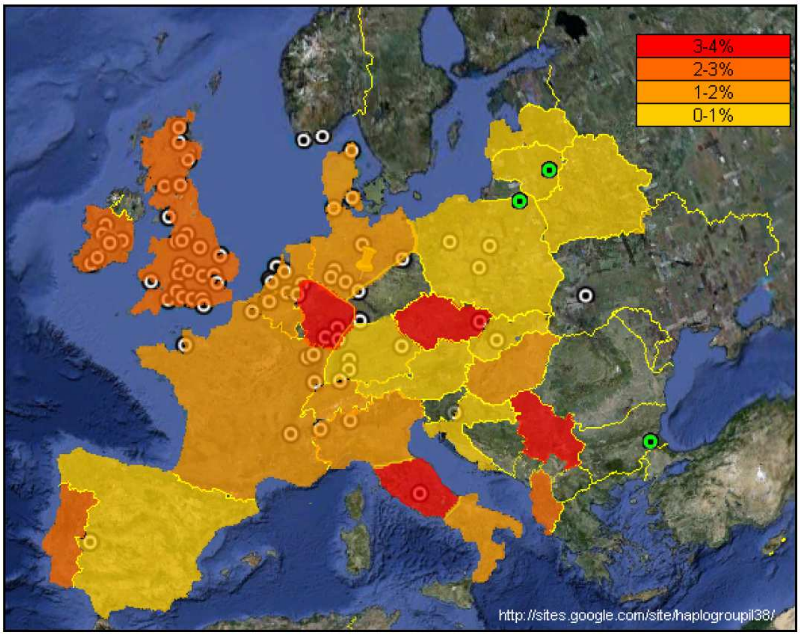

Fig. 10 - Spatial estimation (%) of the I-L38 haplogroup in modern populations per country (Source: De Beule 2011).

For a period slightly later in time, which corresponds to the lower boundary of the time-span of our research, David Faux (2008) studied the relation between the Y-Chromosomal Marker S28 and the Central European Celtic ancestry of the Hallstatt and La Tene phases. As highlighted by Kristiansen (1998b), the conventional phases *Hallstatt C* and *D*, which traditionally correspond to the beginning of Iron Age in the north of the Alps regions, corresponded to a period of movements of *Hallstatt C* warrior elites, which spread across Central and Western Europe, at a time when trade routes to the north diminished.

Although Faux's conclusions are questionable, he asserted that only the haplogroup R1b in the marker S28/U152 can be "infallibly associated" to Hallstatt and La Tene populations and more generally people who are S28 positive are living descendants of the ancient Celtic people (Faux 2008).

In the light of genetic analysis and paleolinguistic studies, we should ask if the spread of Indoeuropeans in the Neolithic or Calcolithic period and Celts in the Iron Age can be described by the same process of demic diffusion, and therefore the results on the local human groups would have been a substitution of people.

As we have discussed in this paragraph the main problem of genetic analysis is to link the cline detected in the spatial distribution of DNA haplogroups with a specific time-span and therefore to correlate the cline with an already known episode of people movements and dispersal. It follows that a cline could be theoretically correlated to one o more processes of migration and substitution of people, which makes even more difficult a clear correspondence to one or another event.

An additional problem relates to the nature of the diffusion, in fact not all the expansive phenomena must be described by a massive demic movement. A process of spread could not have lead to a significant variation the genetic record, for instance when we are dealing with phenomena of acculturation and diffusion of innovations.

3.6 The adaptive hypothesis: growth-decline of population as a result of climatic change

The intensity at which human activities developed in the past is supposed to be in close relation with past climatic conditions. The ties between climate and human behavior are a widely studied topic. Among archaeologists, however, considering climate as a main factor behind cultural development is often regarded as determinism and therefore it is frequently denied strongly, although the interaction between people and nature is obvious.

A multidisciplinary approach is usually the basis for any kind of analysis concerning the interrelationships between climate and human behavior. In fact, the research and the quantification of the intensity of climatic and landscape changes needs a close cooperation between archaeological and scientists from other branches, like geology, paleoecology, environmental sciences, among others.

In Prehistory, studies focus especially on the investigation on phenomena of adaptation to episodes of climatic deterioration, which could be responsible of changes in settlement strategies and occupation patterns, subsistence base and economic exchanges. Climatic change can be connected to phenomena of diffusion as recently stressed for the spread of Scythian culture in south-central Siberia (Panyushkina I.P. 2012; Val Geel et al. 2013). In this case, wetter climatic conditions converted a desert area into a landscape with a high biomass production and high carrying capacity, leading to both episodes of people movements and demographic growth (Van Geel et al. 2013).

In this section we want to center our attention to the possibility of such events, during 2nd millennium and the beginning of the 1st millennium BC. In particular, we are interested in high magnitude climatic changes, whose consequences may be detected over a wide-scale. Therefore, regional studies and researches, which are often the basis for a reliable reconstruction of paleoenvironment, will be considered only when in direct correlation to the major event under study.

Available data originates from a large variety of proxies, like the analysis of the amount of ^{14}C in the atmosphere, expressed in the calibration curve, geoarchaeological surveys, pollen analysis, stable isotopes analysis of ancients plant remains, analysis of submarine and lake sediment cores (Vernet et al. 1996; Van Geel et al. 1996, 1998; Swindles et al. 2007; Riehld et al. 2008; Fiorentino et al. 2008, 2009; Kaniewski et al. 2010; Caracuta et al. 2012; Borrelli et al. 2014; Joannin et al. 2014; Kaiser et al. 2014; Morley et al. 2014). Among the first archaeologists interested in the relations between the patterns of human expansion and climate change on a global scale, Wendland and Bryson (1974) in the first half of the seventies, compared in a quantitative way radiocarbon dated Holocene environmental changes with cultural changes. The authors found a synchrony between the radiocarbon record and the evidence of cultural change.

The main discontinuity in the climatic condition during the Bronze Age and Iron Age transition can be identified in the boundary from Subatlantic to Subboreal (2800-2500 BP; 996/914-766/551 2σ cal. BC). Such period "has globally been identified as a time of marked climatic change. Stratigraphical, paleobotanical and archaeological evidence point to a change from a dry and warm to a more humid and cool climate in central and northwestern Europe" (Tinner et al. 2003). The climatic deterioration which characterizes this chronological range is directly responsible of the plateau in the calibration curve between 760 and 420 BC (2500-2425 BP) (see chapter 4.3.2.1). The climatic oscillation around 2700 BP (896/813 2σ cal. BC) has been detected worldwide. Van Geel et al. (1996, 1998) and Speranza et al. (2002) found an abrupt shift around 850 BC in changing species composition of peat-forming mosses in European Holocene raised bog deposits. The change was from mosses preferring warm conditions to those preferring colder and wetter environments. Archaeological evidence supports such a change. Bronze Age settlements located in the Netherlands were suddenly abandoned after a long period of occupation which last around one millennium (Dergachev et al. 2004). Other studies confirmed the climatic discontinuity; Schilman et al. (2001) studied $\delta^{18}O$ and $\delta^{13}C$ in deposits from the southeastern Mediterranean, off Israel, and recognized the presence of two humid events in the time ranges of 3500-3000 BP (1884/1772-1263/1215 2σ cal. BC) and 1700-1000 BP (332/389-1016/1030 2σ cal. AD) and a period of arid conditions between 3000 and 1700 BP (1263/1215 2σ cal. BC-332/389 2σ cal. AD). Barber and Langdon (2001) identified three main long climatic deteriorations 2900-2830 BP (1119/1037-1012/934 2σ cal. BC), 2630-2590 BP (810/797-801/788 2σ cal. BC) and 1550-1400 BP (430/549-637/658 2σ cal. AD) through the analysis of plant macrofossils in a peat deposit of Walton Moss located in Northern England and comparing such data with a temperature reconstruction based on chironomids in the sediment of a nearby lake.

For the Alpine area a great variety of climatologic studies have been produced (Hänsel 1998; Maise 1998; Della Casa 1999; Wanner et al. 2000; Menotti 2001; Tinner et al.

2003; Desmet et al. 2008; Mandl & Stadler 2010; Kneisel et al. 2012;). Mountains constitute a perfect environment for the analysis climatological variability due to the intensity in such regions of parameters like temperature, precipitation and air pressure (Blumen 1990). Moreover, the glacial deposits allow us to obtain primary hand data about their fluctuations, which are highly sensitive to climatic changes (Fig. 11).

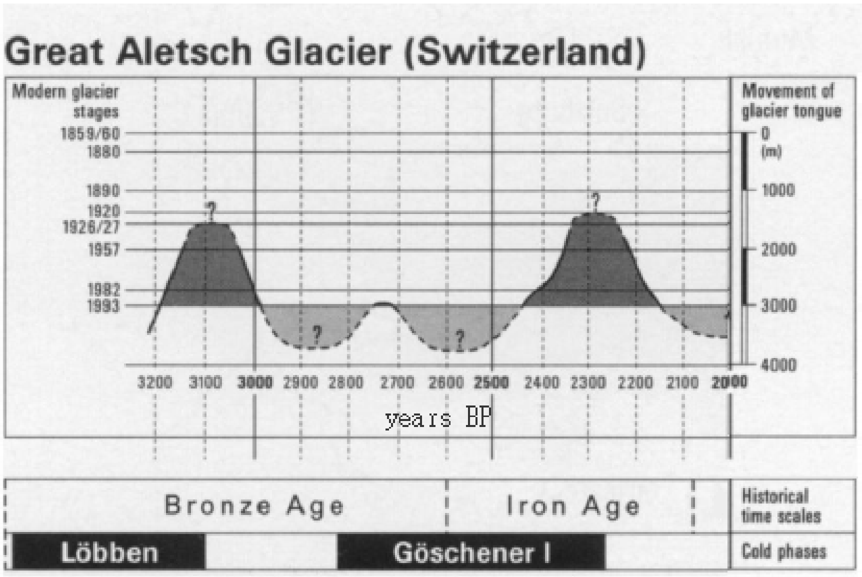

Fig. 11 – Variation in the Aletsch Glacier located in the Swiss Alps during the Bronze and the Iron Age. The broken line with question marks periods with sparse data coverage (Source: Wanner et al. 2000).

Tinner et al. (2003) stressed that climatic fluctuation north and south of the Alps were synchronous for the period 2300-800 BC although the general vegetation histories were different. The authors based their study on a dataset composed of palynological analysis of radiocarbon dated sediments from four lakes in Switzerland, tree-ring density curves, glacier oscillations, paleobotanical timberline studies, ^{14}C content in tree rings and comparing the gathered information with the GRIP and GISP2 climatic record from Greenland. Additional results stressed that human societies of the alpine area were not able to compensate rapidly to periods of climatic deteriorations. In fact, pollen data suggest that the reduction of agricultural activities (maximum of tree pollen, minimum of Cerealia and *Plantago lanceolata* pollen) north and south of the Alps was accompanied by spontaneous reforestation.

Eventually the authors identified a warm period in time span 1450-1250 BC corresponding to tree-pollen minima which indicate forest clearances in the both sides of the Alps. In fact, warm and dry conditions during the last centuries of the Sub-Boreal were recognized. This could have implied an increase in the possibility of contacts among the regions North and South of the Alps, due to the access to high and middle-altitude mountain passes which may constitute alternatives to the traditional routes (Maise 1998; Rubat Borel 2006; Mordant et al. 2007; Desmet et al. 2008). Such a period is followed by a climatic deterioration with the income of the Sub-Atlantic period around 860-850 BC, which correspond to a period of land abandonment (800-650 BC), as observed in the Soppensee record (Maise 1998; Tinner et al. 2003). Such phase is accompanied by a short period with a concentration of phenomena of intense rain, with obvious disastrous consequences on the flow of the main rivers and the growth of groundwater levels. This situation implies a territorial crisis with the abandonments of the pile-dwelling settlements located in low plains or close to lake basins, like in Northern Italy and in the Western Switzerland (De Marinis & Spadea 2007).

Further important studies were produced Eastern France and Western Switzerland. The analysis of the level variations of lakes located in the Jura region, in the French Northern Pre Alps and the Swiss plateau, the ^{14}C deviations in the atmosphere evidenced a positive correlation with the frequency of lake-side settlements in such a region (Magny et al. 2005; Billaud & Marguet 2007; Magny et al. 2007; Magny & Peyron 2008; Marguet et al. 2008). The results stressed that the lack of lake-settlements characterizing the Middle Bronze Age corresponded to a period with high lake levels and high values of the percentage of residual atmospheric radiocarbon. In this framework, the abandonment of lakeshore Swiss pile-dwellings has been dated to around 1520 BC (Menotti 2001). However, such a phenomenon does not appear everywhere with the same intensity, in fact in the Inner Alps the Middle Bronze Age seems to be a phase of relative settlement expansion and intensification (Della Casa 2000, 2013). In any case, slightly later in time episodes of flood events and lake-level highstand at 3100 BP (1415/1311 2σ cal. BC) and 2800 BP (996/914 2σ cal. BC) have been recently detected in the Southern Alps, in the sediment cores extracted from the Lake Ledro, located in the province of Trento (Joannin et al. 2014). Such events may suggest that climate was relatively humid and unstable at that time. It is meaningful to highlight that at 3100 BP (1415/1311 2σ cal. BC) a decline of agricultural activities has been observed both in Northern Alps (Tinner et al. 2003; Schmidl et al. 2005; Rey et al. 2013; Röpke & Krause 2013) and in the Po Valley in Northern Italy (Valsecchi et al. 2006). Moreover such a period corresponds to the decline of the *Terramare culture* with the depopulation of the Southern part of the Po Valley (Bernabò Brea et al. 1997; Cremaschi et al. 2006; Mercuri et al. 2006, 2012).

Adopting a macro-scale focus Berglund (2003), comparing eleven paleoclimatic records, managed to identify two main periods of crisis during the Bronze Age (Fig. 12). The first one is dated to the beginning of the Bronze Age, around 3800 BP (2285/2200 2σ cal. BC). This period was characterized especially in Central Europe by an abrupt change from more continental climate to an oceanic one, which led to a raise of lake levels, expanding bogs, lowered tree limit and an increase in glacier activity. The second one must be placed in the Late Bronze Age, between 3000 BP (1263/1215 2σ cal. BC) and 2800 BP (996/914 2σ cal. BC). In such a time span, cool/wet conditions just before 3000 BP (1263/1215 2σ cal. BC) were followed by a warm/dry phase and then it was detected another change to a cool and wet period around 2800 BP (996/914 2σ cal. BC). Moreover, a general trend of raised lake levels and an increased glacier activity is attested around 3000 BP (1263/1215 2σ cal. BC) (Berglund 2003).

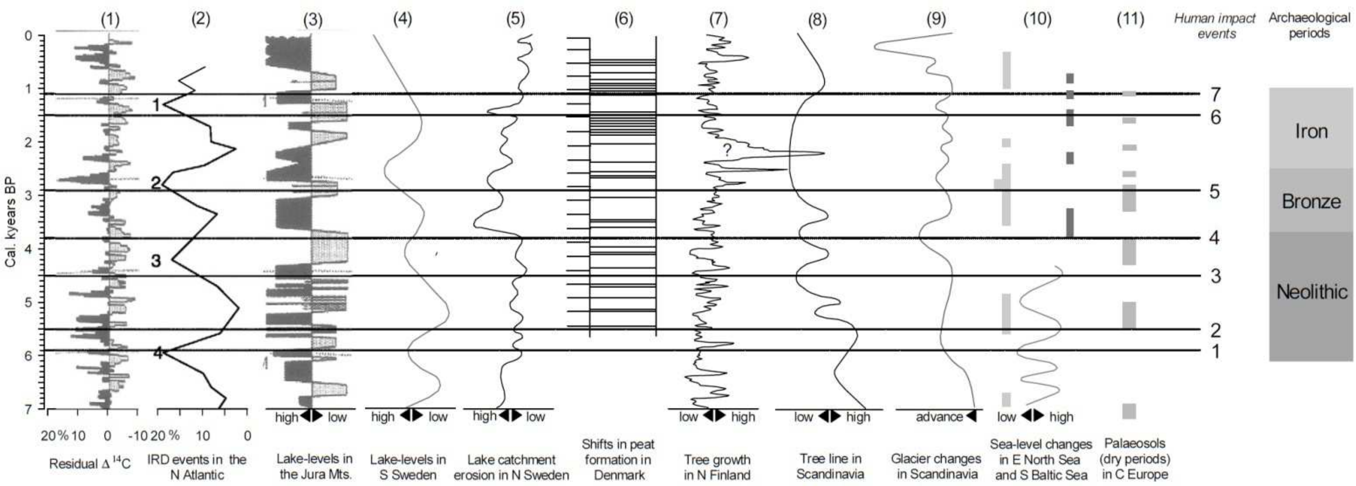

Fig. 12 – Comparison of eleven paleoclimatic records. The points 4 (3800 BP) and 5 (3000-2800 BP) represent important periods of discontinuity at the beginning and at the end of Bronze Age (Source: Berglund 2003).

3.7 The social, economic and political hypothesis. A criticism of the substitution of population hypothesis

If we hypothetically could assume that no relevant episodes of migration can be detected in the Bronze Age and in the transition to the Iron Age in Prehistoric Europe, therefore, the apparent cultural homogeneous background, which characterizes the LBA is due to other kinds of phenomena. It follows that we have to research among the different processes of diffusion as proved by the analysis of the archaeological record. Alterative diffusion processes take into account a wide range of possibilities depending basically on the nature of exchange. For the 2nd and the beginning of the 1st millennia BC we have identified five major ways of circulation of people, objects or ideas:

- The circulation of raw materials, in particular tin and bronze
- The circulation of prestige items
- The circulation of ideas: the armed elites
- Exchanges of individuals as a consequence of wars and marriage alliances
- Center-periphery and the world system theory

3.7.1 The circulation of raw materials: tin and bronze

In the Bronze Age, the circulation of raw materials is widely attested over a large scale. Tableware pottery was usually locally produced, due to the wide-spread distribution of its principal components (clay, water and other materials). Therefore, the exchanges of ceramic vessel for daily use were not a common denominator in the 2nd millennium BC. On the contrary, the production of the bronze alloy required the supply of tin and copper from the productive districts (mining areas) and their circulation to the places where the mineral was elaborated to produce tin ingots, copper ingots and bronze ingots as well. The elaboration into finished objects usually took place in the workshops, where following a quite homogeneous processes the different artifacts were obtained from casting the melted bronze into terracotta or stone moulds. The technique for the production of the bronze alloy firstly and the finished objects secondly need the craftsmen to have specific skills in order to control the complex processes. The control of the percentage of tin and copper was fundamental in order to produce the bronze alloy. Recent studies (Mödlinger et al. 2013) on bronze helmet from the Carpathian basin dated to the 14-12th c. BC have shown that the alloy composition was made with a tin percentage range of 5–14 wt.%. For the helmet's cap the percentage was between 6 and 14 wt.%, which indicates an advanced knowledge in the production of thin bronze sheet objects, even with higher tin amount up to 14 wt.%.

In any case, before that such a process could have taken place it was necessary knowledge of the mining districts where either tin or copper could be extracted. In the 2nd millennium BC the principal ore deposits in Europe were located at specific places (Jovanović 1986; Craddock 1995; Giardino 1995, 2005, 2011; Martinek 1996; Pare 1997; Hänsel 1998; Mordant et al. 1998; Krause 1999; Hunt-Ortiz 2003; Stöllner et al. 2003; Weisgerber & Goldenberg 2004; Ambert & Vaquer 2005; Höppner et al 2005; Bartelheim 2007; Clark 2009; Ling et al. 2014). The known main active areas during the Bronze Age were located in: The British Isles where copper ores are found in association with the lead ores in Wales, Cheshire, Ireland, Isle of Man and Cornwall (Ling et al. 2014). Such basins were exploited mainly in the Early Bronze Age (Timberlake 2009), however in the Middle and Late Bronze Age mining activities are attested at Mount Gabriel, Ireland (O'Brien 2004; Timberlake 2009).

The Alpine region, and in particular the Eastern Alps are known for large deposits of copper, lead and silver. The exploitation of the mines of copper minerals located in Tyrol and south of Salzburg has been widely recognize (Stöllner et al. 2003; Giardino 2005; Höppner et al 2005; Krismer et al. 2011; Ling et al. 2014). The importance of such an area not only for mining but also for metallurgical production is confirmed by the archaeological evidence. Nine smelting furnaces for copper working dated to the Late Bronze Age (13th-11th c. BC) were discovered at the Redebus Pass, Bedollo (Trento) and four similar furnaces were found at Cortaccia (Bolzano) in the Trentino/Südtirol region (Marzatico 1997; Marzatico & Tecchiati 1998, 2002). Among the Alpine radiocarbon dated contexts were smithing activities took place we have to mention the site of Kupferschmelzplatz S1 in Styria (Klemm 2003), the furnaces of Jochberg near Kitzbühel in Tyrol (Goldenberg 2004) and the site of Pingen-Hochmoss near Sankt Johann im Pongau in the Salzburgerland (Gstrein & Lippert 1987).

Also the Massif Central in South-Western France has shown mining activities with a well documented evidence of copper extraction (Prange & Ambert 2005).

The Carpathian Mountains constitute another important area with ore deposits containing multimetallic minerals (Cu, Pb, Zn, Au, and Ag). Specifically, the major districts are located in the Central Slovakia and Romanian Baia Mare and South Apuseni Mountains (Neubauer et al. 2005; Ling et al. 2014). In such areas, it is attested the emergence of major production centers (Jovanović 1986; Pare 1997; Schalk 1998), which were responsible for the widespread distribution of many of the Bronze Age standard ornament and implement types, such as neck torques, axes and other heavy bronze ornaments (O'Shea 2011).

Also Cyprus was a well-known producer of copper for the eastern Mediterranean (Stos-Gale & Gale 1994). It is widely attested the exploitation of copper ores in particular in the phase 1400-1100 BC (Stos-Gale et al. 2007; Stos-Gale & Gale 2009).

Copper ores are attested also in Tuscany, Liguria and Sardinia. Eventually, the Iberian Peninsula was an important source for copper ores and lead deposits in the south and east, and for copper, tin and gold in the massive Iberian Pyrite Belt in the south-west (Hunt-Ortiz 2003; Tornos et al. 2004, 2005).

Thanks to the advances produced in the last decades in the study of lead isotope ratios of metallic artifacts and the geochemistry of ores from deposits selected by their isotope ratios, nowadays it is possible to distinguish the copper and tin deposit from which the finished object originates (Hauptmann et al. 1992, 1999; Krause 2003; Niederschlag et al. 2003; Höppner et al. 2005; Jung & Mehofer 2013; Ling et al. 2014). Moreover, lead isotope data are relevant because of their direct representation of the age of the ore formation (Ling et al. 2014). Such kind of analysis applied to metal ingots is useful in order to determine the chemical compositions and the metallurgical process, detecting a primary source and a secondary re-melted origin. In fact, in the Bronze Age the phenomena of metal recycling were frequent (Bray & Pollard 2012; Ling et al. 2014). We are aware that in the Bronze Age the place where an objects was manufactured could vary hundreds of kilometers from the mining area where the copper and tin ores where extracted, therefore the idea that produced metal from a certain region is equated to with the use of ores from the same region is a simplistic hypothesis for the 2nd millennium BC (Ling et al. 2014). The existence of a large and complex network of trades and routes linking the different mining areas and the inhabited territories was a reality. Lead isotope and elemental analysis, carried out by Ling (2014) and his research group, on Scandinavian Bronze Age artifacts have argued the possibility of two main system of metal flow from Europe to Sweden, one maritime Atlantic and another via

Central and South-East Europe, following the path of the amber route. Moreover, their results indicated that the sources of metal varied in relation to chronology. In fact, analyzed artifacts dated to the Early Bronze Age were correlated to copper ores located in North Tyrol, Cyprus and the west Mediterranean districts, on the contrary during the Middle Bronze Age studied objects were manufactured with copper ores originating from Sardinia and south-Iberia. Finally, most artifacts dated to the Late Bronze Age can be correlated with ores in south Iberia (Vandkilde 1996, Ling et al. 2014).
Such results point the variability of exchange routes during the 2nd millennium BC, whose causes, which are often unclear, should be analyzed case by case.

3.7.2 The circulation of prestige items

The nature of long-distance trade or exchanges during the 2nd and the beginning of the 1st millennia BC is a widely debated topic. Different positions have been proposed among the scholars. Stjernquist (1985) included in trade all bilateral transactions concluded between communities or individuals. Hardings (1987) stated that any product or resource that has been transported from one place to another can be treated as an object of trade. Nevertheless, such a statement is not entirely shared by the whole scientific community. Steuer (1999), on a different perspective, stressed that the term "trade" should be applied only to exchanges between communities with monetary economy and characterized by the presence of specialized market places. In any case, beyond the exchange processes we must be aware of the existence of other ways of distribution of resources and products, such as looting, unilateral gifts, and specific redistribution inside the "vertical" social structures (Przybiła 2009).
The so called "peaceful interaction" (Barceló 1999) implied not only the circulation of raw materials but also the flow of finished objects. The consequences of such a circulation should theoretically be a homogeneity regarding the most diffused forms and techniques. On the contrary, the village-level production tended to be more traditional and circumscribed, with frequent phenomena of regionalization in particular in pottery forms and decorations. Such homogeneity was granted by the flow of artifacts on a macro scale, which frequently followed the paths established by the major European rivers. Indeed, it is widely recognized that exchange networks during the Bronze Age were mainly influenced by the waterways, which constitute a primary element for the

development of complexity due to their role in prehistoric and protohistoric travel, boundary demarcation and the transport of materials (Bell 2006; Davison et al. 2006; Westerdahl 2006; O'Shea 2011). In the absence of an organized and wide-spread network of roads and infrastructure, they constitute a rapid way to link different geographic areas, and also different populations. The main advantage of river line circulation was to increase the speed of the trades and exchanges, regarding people, goods and information. As a consequence, an increase of waterways allowed distant communities to interact developing larger social aggregates (Howey 2007). Therefore, the study of river's paths in the past is essential in order to understand the complexity of Bronze Age society, identifying regional pattern of social contact and interaction.

Among the major waterways, the Danube–Morava–Vardar was proposed by Childe (1939) as a primary link between Eastern Mediterranean and Central Europe. It has long been assumed that the Danube river constitute the major "highway" of the Prehistory. Archaeological researches in the Carpathian basic have evidenced that the distribution of metal finds and large hoards was closely tied to the river system of the Danube, Tisza and Maros (O'Shea 2011). The overland/riverine flow did not affect only metals but also other materials like in particular amber. Starting from the end of the 3rd millennium BC from the Baltic regions amber arrived to Central Europe throughout the major rivers Elbe, Oder, Vistole and Rhine as well. Chronologically the oldest route was the Western, as the deposits were scarcer the Eastern ones started to be exploited. From Central Europe the amber road followed through the Danube, the Adige and the Po River reaching the Mediterranean regions (Sherrat 1993a; Kristiansen 1998b; Pydyn 1999; Du Gardin 2003). Whilst some materials, like amber followed a north to south route, others, like pottery, faïence and ivory pursued a south to north path. Numerous are the archaeological evidences, which testify the existence of a system of commercial routes between the Mediterranean cities, in particular Greek and Phoenician, and central European communities (Sørensen & Thomas 1989; Peroni 1996; Bernabo' Brea et al. 1997; Kristiansen 1998b; Bartoloni & Delfino 2005; Bietti Sestieri 2010; Cupitò 2011; Fokkens & Harding 2013).We can refer to the imports from Eastern Mediterranean (the Aegean world and the Levantine coast) of Mycenaean ceramic as attested in the settlements located in the Padan Plain, dated between the 12th and the 11th c. BC. Ceramic dated to Mycenaean IIIC have been found in the villages of Fondo Paviani, Fabbrica dei Soci, Castello del Tartaro, Frattesina, Montagnana in Northern Italy (Vagnetti 1979, 2002; Salzani et al. 2006; Cupitò 2011). We must take into account that archeometric analysis carried out on some of those fragments have shown that some of those vessel were locally manufactures imitating Mycenaean models, perhaps due to the transfer of artisans directly from the Aegean world (Jones et al. 2002; Vagnetti 2002). Indeed, a phenomenon that highlights the importance of such networks is the manufacture and imitation using local materials of products coming from distant areas. This empathizes the relevance that exotic products or their imitation cover in the exchange network, mainly due to their "exoticism" and the value of prestige and superiority that they symbolize (Müller & Bernbeck 1996; Pydyn 1999; Kristiansen & Larsson 2005). We can find another example of long-distance trades in the settlement of Bernstorf, in the municipality of Kranzberg, in Upper Bavaria (Germany). The archaeological excavation carried out in the village have brought to light fragments of amber beads with a text engraved in Mycenaean Linear B and an assemblage of golden items (a needle, elements of belt, a tiara, pieces of a crown and other golden sheets) (Gebhard 2000; Moosauer & Bachmaier 2000).

Such finds are a clear evidence of emergent new elites, who stated his high status through the collection of prestige objects. The homogeneity of the elites, established by the control, the storage and the exhibition of luxury and exotic materials (gold, silver, ivory, amber, etc.) was a key concept to understand the power relationships in the 2nd half of 2nd millennium BC. The consequence is the increasing demand for exchange goods lead to monopolization of prestige goods. When monopolized, those materials rise in worth (their buying becomes difficult and they are not owned by all the group members), which signifies a change: the item becomes as important as the relationship, so that the storing from exchange goods from outside will be as important as having kept interaction with outside groups. As soon as some resources become storable, competition for their control (political power) starts. This situation will just be possible when the demand for prestige goods becomes constant, that is, when outside social agents keep asking for the same items for the sake of political alliances. This is what happens with metal (copper, iron, gold and silver), an item whose demand keeps constant and is used to increase the relationships with foreign groups: the need of certain materials forces a certain group to establish contact with the suppliers (Barceló 1999). The emergence of new elites implied the formation of what scholars (Brun et al. 2009; Kristiansen 2009, 2011, 2012) define an "aristocratic lifestyle", in which perhaps other materials, such as salt, timber, cloth or foodstuffs, were important and appreciated commodities, but we are handicapped by their relative invisibility in the archaeological record (O'Shea 2011).

3.7.3 The circulation of ideas: the armed elites

Urnfield burials between the Ebro and the Danube River are usually characterized by the absence of funerary goods. The lack, in most cases, of an assemblage composed by metals, prestige objects or ceramic vessels could suggest a picture of apparent equality at the end of the Bronze Age. However, inferring a direct relation between the number of metallic objects among the grave goods and the social status is a simplistic and simplified approximation of social complexity (Ruiz Zapatero 2004). As Wells (1984) stressed it is reasonable to suppose that the distribution of wealth in Urnfield graves is a poor indicator of how wealth was distributed in LBA agrarian communities. In fact, if we focus on the archaeological evidences in its completeness there are several elements which support the existence of role and class differences, which implied a developed social hierarchization among LBA communities. Specifically, a common denominator in 2nd half of the 2nd millennium BC seems to be the rise of armed elites which spread or whose idea spread on a European macro-scale.

Examples for the circulation of metallic finished items related to the role of the warrior are various. Among them, the diffusion of metal hoards and votive deposits, in particular composed of weapons, which were frequently located along the major river, probably following the same flow channels used for raw materials and prestige objects. In this field we can cite the radiocarbon dated hoard of Peggau, in Styria (Austria), which gathered 229 objects of the *HaA2-HaB3* phases with a total weight of 14.2 kg; 17.1% of the items were weapons (Weihs 2004). Another example is the hoard of Pila del Brancón (Nogara, Verona) discovered in the Po Valley (Italy) and typologically dated to the *Bronzo Recente 2* phase almost the totality of the materials are weapons (12 swords; 2 daggers, 51 spearheads) (Salzani 1994a; Salzani 1998; Jankovitz 1998-1999; Cupitò & Leonardi 2005). Such hoards have been interpreted as cultural offers basically because the objects are intentionally fragmented. At Pila del Brancón the objects after having been exposed to fire were deposited in the humid area (peat bog) as "water offering", according to a tradition widely attested in European Bronze Age (Bradley 1990). Analogous rituals were carried on in the site of Corte Lazise, not far from the

North Italian deposit, where 5 swords and other bronze objects were discovered (Salzani 2005a; Salzani 2006).
The relevance of the role of the warrior is testified not only in Central and in the Mediterranean facade by it assumes a European scale in the last phase of the Bronze Age. The spread of bronze swords and the idea behind their diffusion is widely attested also in the Atlantic facade. From the Britain Iles to northern Spain and Portugal the Atlantic type swords, *espadas pistiliformes* in Spanish, are largely attested in the LBA (Quilliec 2003; Brun et al. 2009).
In addition, weapons were not an exclusively feature of metal deposits or out of context finds. Whilst the majority of urnfield burials show a great poverty, there are some inhumations and cremation that are clearly in contradiction with such an assumption. Perhaps the most outstanding evidence is the necropolis of Olmo di Nogara (Verona-Italy) dated to the Middle and the Late Bronze Age were both inhumation and cremation burials are attested. As common the cremations, were not accompanied by funerary goods. On the contrary among the inhumations some masculine graves of eminent personalities included a sword and helmet fragments (Salzani 2005b). It has been suggested that the prestige role of the warrior was hereditary transmitted as two individuals were characterized by *spina bifida occulta* (Cupitò & Leonardi 2005). Eventually, the apparent reality of social equality testified by LBA urnfield burials can be definitely discarded at the Iron Age transition by the archaeological excavation at the Hexenbergle site, near Wehringen in Bayern (Germany). The monumental radiocarbon dated mound with a cremation burial of an adult male accompanied by a great amount of objects, including a sword, elements decorating a wagon and an extensive set of painted pottery (Hennig 1995). The dendrochronological date obtained on the wagon (778±5BC) provides a precise temporal location for an upper-class deceased with sepulchral paraphernalia in the Hallstatt period (Friedrich & Henning 1995, 1996).
In the light of such evidences we can clearly prove that the acquisition of bronze was closely tied to the acquisition of prestige and social standing. Therefore the power of the armed elites was guaranteed not only by the weapons use practices, but also by the control of exchange network, the accumulation of bronze in large number, the organization of production, the control of craftsmen/workshops and the possession of prestige goods (Váczi 2013). Process of social hierarchization was achieved also by the control on the food production surpluses by a small part of the population. Thanks to surpluses, a leading group could obtain exotic and luxury goods from outside, which

were frequently introduced in the system of ritual exchanges among similar centers (Przybiła 2009).

Among the material effect for the presence of armed elites on a European scale the so called metallurgical *koiné* is one of the most outstanding.

During the last phases of Bronze Age the high circulation of weapons, armour, dress accessories and implements from the Atlantic coast of the Iberian Peninsula to the classical world implied a relevant increase in the metallurgical productions, which was accompanied by a process of homogenization of the types and the techniques as a consequence of the intense circulation of models, raw material and artifacts (Bouzek 1985; Giardino 1995; Bietti Sestieri 2010; Fokkens & Harding 2013; Jung & Mehofer 2013).

3.7.4 Exchanges of individuals: wars and marriage alliances

The power and the prestigious of armed elites were undoubtedly tied to the war activities. The diffusion over a large scale of warrior and the system that they represent made part of the "violent interaction", where the warrior or bandit tends to be interested in keeping his warlike status and hoards loot, enhancing thus his military triumph or creating alliances with members of his own group or from the neighbor groups (Barceló 1999). On a European scale this implied the circulation of individuals to take part of struggles and war activities. Evidences of contacts among the North Italian warriors and the Aegean ones are unquestionable. Several researches argued that mercenaries from the Italian peninsula were employed by the Mycenaean palace states between the last decades of the 13th c. BC and the beginning of the 12th c. BC (Catling 1968; Bettelli 2002; Eder & Jung 2005). The existence of "peaceful interaction" relating the metallurgical know-how was already proved by the Italic sword types Allerona and Cetona, which became the most common swords of Mycenaean warriors in the Late Helladic IIIC Advanced phase (Deger-Jalkotzy 2006). To strengthen the evidences of transfer of weapons and weapons technology from the Adriatic coasts to Greece we have to highlight that no sword moulds of any typology have been found in Greece so far (Jung & Mehofer 2013). By contrasts, the two-part moulds suitable for sword casting are known from all over Italy (Bianco Peroni 1970; Lefevre-Lehoerff 1992; Frontini 1997; Albanese Procelli 2000). Moreover, the existence of locally produced handmade pottery of Italic type in layers dated to the Late Helladic IIIB Developed and Final at Tiryns, Midea, Mycenae and Nichoria in Greece supports the hypothesis that people coming from continental Italy settled among the indigenous Mycenaean population before the fall of the Mycenaean palace system (Jung & Mehofer 2013).

Without any doubt the ideology of armed elites dominated Europe as attested by the distribution of swords, sparrowheads and elements of armour (Kristiansen 1998b, 1999a, 1999b, 2002, 2009, 2011, 2013). Their existence implied that war and struggle were a common phenomenon in the late phases of the Bronze Age. Therefore, it is not surprising an increase of the number and a diffusion of hillforts and fortified villages during the LBA and in particular at the beginning of the Iron Age in the *HaC* period (Ruiz Zapatero 1983; Kristiansen 1998b). Examples are various. For instance, in the Eastern Transdanubia region the building of fortifications started at the same time with the consolidation processes of armed elites, observable in depositions and burials which point a kind of isolation and centralization began. The main consequence of this process was provided by fortified settlements. Their building, maintenance, possession and sharing became a new form of expressing prestige during the closing phase of the Urnfield period (Váczi 2013). More examples can be traced in the *Castellieri* culture, developed in North-Eastern Italy, Istria, Dalmatia and neighboring areas, whose main feature were settlements usually locate don hills and rounded by one or more walls of stones or a wooden palisade (Marchesetti 1903; Montanari Kokelj 2005; Bietti Sestieri 2009). The apparently territorial nature and the distribution of European fortified settlements suggests the existence of a quasi political organization that in the Iron Age led to defined tribal territories, as known from classical authors (Harding 2013).

Kristinsson (2010) analyzed the causes of the cremation burials expansion and tried to assess what the Urnfielders advantage was. The authors suggested that origin of the Urnfield phenomenon has to be placed in the "militarization process fuelled by competitions between polities in Central Europe". The spread of Urnfielders was helped by the development of runners armed with a shield and a couple of small javelins or darts, some of them were also provided with swords and helmets. Warriors equipped with javelins and shields were the backbone of the chieftains during the 2nd and the 1st millennium BC (Kristiansen 1998b, 1999; David Elbiali 2009). Although Bronze Age European metal defensive armour, as opposed to weapons, is scarce we are aware that the first armour appears in Central and Eastern Europe in the beginning of the *Urnfield culture*. Nowadays, we know of approximately 120 helmets, 95 shields, 55 greaves and

30 cuirasses from the European Bronze Age (Mödlinger et al. 2013). Moreover, warriors, armed with shield and javelin, appear as a decoration of Mycenaean and Greek vessel as well as in the bronze horn of Wismar (Kristiansen 1998b). In any case, not only armed runners were diffused during the Late Bronze Age. An armored cavalry was also diffused, as attested in the cemetery of Neckarsulm in southwestern Germany. The majority of the skeletal remains of inhumated adult males, dated to the LBA, exhibit specialized facets that most likely resulting from horseback riding (Wahl & Price 2013).

It is relevant to remind that episodes of people movement were not new phenomenon in the Mediterranean Protohistory. At the end of the Bronze Age documents from the Middle East and the Aegean world refer of the so called Sea Peoples, identified in a various groups of seafaring raiders whose origin should be located in an unknown place in the eastern Mediterranean (Sandars 1978; Drews 1995; Oren 2000; Martín 2007).

Exchanges of population, men and women, were not only determined by military activities. Among the armed elites and in particular among those groups who interacted regularly, additional cohesion was established by the marriage exchanges which implied alliances and consolidated the ritual friendship among the chiefs and the communities (Ruiz-Galvez 1992; Kristiansen 1998b; Marchesini 2012; Steel 2013). The major aim of intermarriage was to create especially binding familial ties, which are intended to establish trust between two societies and ensure peace (Steel 2013). Archaeological examples of such a practice are various and dispersed all over the European territory. In northern Europe a deposit in a vessel found in the Island of Møn, in Denmark, included a complete assemblage composed of jewelry manufactured in the Lausitz culture. Such a deposit owed certainly to a woman married with a Danish chief (Thrane 1958; Kristiansen 1998b). Another example can be traced in the burial of Cavalupo di Vulci in Central Italy north of Rome dated to the end of the 9th c. BC, where the presence of Nuragic bronze artifacts was interpreted as a deposition of an “aristocratic” woman, perhaps married with an Etruscan man (Camporeale 2010; Marzatico 2012). A third possible example is the inhumation burial, radiocarbon dated to the end of the 12th and the 11th c. BC, found at Domat/Ems in the Rhin Valley, Canton of Graubünden (Switzerland) (Seifert 2000). The burial is attributed to an “aristocratic” feminine individual for the rich funerary goods including bronze objects (10 rings, a fibula, fragments of a pin, earrings), a crane bone and vessels. The origin of the assemblage can be traced in the Luco/Laugen culture, spread in Trentino Alto Adige/Südtirol, Tyrol and Lower Engadine. Due to the foreign objects it has been suggested the possibility that the rich woman got married to a local man (Seifert 2000; Marzatico 2012).

3.7.5 Center-periphery and the world system theory

To sum up, there is enough archaeological evidence for the existence of diverse and complex exchange networks in the Bronze Age. Therefore, contacts among different regions are estimated to have been frequent and they constitute the base for the social economic and political organization of 2nd millennium societies. The presence of raw material, finished objects, goods and individual far away the place of their original provenience is a clear evidence of the high level of complexity reached among the Late Bronze Age societies.

As a consequence, it is impossible to establish a local picture of the social, political and economic dynamics without references and comparisons with other areas. Trade and alliances were re-oriented causing new links to be established and contacts with new areas to be opened, but also some regions to be isolated from the larger exchange systems (Sørensen & Thomas 1989). As we have presented in the chapters before, the interaction channels information, people, raw material, manufactured goods may have moved through, are the main cause of the emergence of distinct social networks. Hence, to study social interactions and to explain the emergence of cultural standards and homogenization at some places and moments, we need to adopt a European perspective which takes into account the Bronze Age society in its complexity.

It has been suggested previously that a progressive differentiation of centers and territories with regard to their function. Further examples are the settlements of Peschiera (Verona) and Frattesina (Rovigo) located in Northern Italy. The first one, due to the high concentration of metal objects, was supposed to be a central place for the production and the distribution of bronze finished object and models all over the Italian Peninsula (Bietti Sestieri 2010). The second one was located along an ancient branch of the River Po, connected to the Adriatic Sea through the river route. During the excavation, carried out in the last decades, a wide range of artifacts made from exotic materials were found. The objects, including amber, ivory and glass, were also exported. Consequently, the Frattesina, due to its specific position hold a predominant role in manufacturing and distribution of goods on a large scale (Bietti Sestieri 1975; Salzani 1989; Bietti Sestieri 2010).

In the light of such situation, archaeologists stressed the importance covered by networks in the 2nd millennium BC, with the existence of centers (primary nodes) with the function of production and distributions.

The historical process of differentiation between a core and a periphery, or using the word of Sherrat (1993a, 1993b) “nucleus” and “margins”, is one of the most interesting models for explaining cross-cultural connections among “interacting politico-economic units” (Wallerstein 1974).

A fundamental stage in the description of human behavior in past societies is the World System Theory (WST) or also named Core-Periphery Theory, introduced in the 1st half of the seventies by Immanuel Wallerstein (1974). The American sociologist and social scientist claimed that “there is only one world connected by a complex network of economic exchange relationships”, in which the accumulation of capitals by a part of the population is the key concept for the development of a systemic economic and political relations between centers and peripheral areas. In the core area the processes of production take place, it’s where the innovations are developed, from there they are introduced to peripheral areas in which their influence can cause changes in the social divisions. Chase-Dunn and Hall (1997) argued that the nature of what is transmitted is various, including bulk goods, political and military interactions, luxury or prestige good exchanges, and information exchanges. Moreover, in such a process a sort of periodicity can be detected: cycles of relative boom were followed by periods of crisis in the exchange network.

The amount of research dealing with World-Systems Theory increased exponentially in the last decades; in 1995 the *Journal of World-Systems Research* was founded by Christopher Chase-Dunn, who in the previous years focused into the theory following a sociological perspective also including references to the archaeology (Chase-Dunn & Hall 1991, 1993; Hall & Chase-Dunn 1993). The applicability of this theory over a long period was highlighted also by Gunder Frank, who reported there was a “5000-years old World System” that extended in “unbroken historical continuity between the central civilization/world system of the Bronze Age and our contemporary modern capitalist world system” (Frank 1993, p. 387). Therefore, as in its recent work Harding stressed “WST is essentially a means of understanding, or at least describing, how one area becomes dependent on another, so that developments in one will affect the other” (Harding 2013, p. 379).

In the last years, the number of contributions in this field has continued to increase significantly (Kardulias & Hall 2008; Hall et al. 2010; Galaty 2011; Harding 2013) and WST or according to a more archaeological approach World System Analysis (WSA) constitute a set of tolls to understand changes among past communities, in particular regarding the dynamics of impositions or absorption of innovations, including consequently local efforts to resist or to negotiate with outside forces.

Such a theory was initially applied to the capitalist world but very early archaeologists realized that it was suitable in archaeology for describing the complexity of protohistoric societies, like the Bronze Age ones (Friedman & Rowland 1977; Kohl 1987; Kristiansen 1987; Kristiansen & Larsen 1987; Frank 1993; Frank & Gills 1993; Kristiansen 1994; Sherrat 1993a, 1993b, 1994; Bintliff 1997; Kristiansen 1998b; Kümmel 2001). The first event that focused on the this theory was a conference organized by Rowlands with Mogens Trolle and Kristian Kristiansen in 1980 in Aarhus and entitled “Relations between the Near East, the Mediterranean World and Europe – 3rd to 1st Millennium BC” (Rowlands et al. 1987). Kristiansen (1998) argued that a world system in the European Bronze Age emerged from the interactions between the Near East, the Mediterranean, and Central Europe starting from the 2000 BC.

4 HOW TO MEASURE THE OCCURRENCE OF HISTORICAL EVENTS? RADIOCARBON DATING

4.1 Introduction

Since the onset of prehistoric studies, defining a chronology for human artifacts has been one of our main aims. The necessity of creating chronological sequences for the material remains of human activity in the past has led to the creation of different frameworks whose backbone has been the position of materials in the archaeological record, based on the principles of archaeological stratigraphy, i.e. the materials coming from the lower strata should be older than those from upper layers. This led to the creation of different "phases" in a sequence, expressing a relative chronology. Such a system gives just a notion of *a* is older or newer than *b*, or synchronous, and in which *a* and *b* can be objects or sets of objects. The following step was to link this sequence to a calendar chronology (expressed in solar years).

One of the first and most successful methods to correlate a relative and an absolute chronology was developed in the last years of the 19th century by the British archaeologist Sir Flinders Petrie (1899). This technique, which is called cross-dating, was based on the finds of Aegean pottery in Egyptian contexts whose age was known thanks to the list of pharaohs. Such a system starting from the association of Mycenaean typologies with Egyptian materials enabled to date other contexts in which the dated typology was found. It led to the creation of a chronological framework for the metal age in the basin of the eastern Mediterranean based on an assemblage of typologies with the function of fossil guides. Regrettably, this kind of dating takes the contemporaneity of the same typology in different kinds of context as a starting point. Probably, this aspect represents the primary critique towards such a cross dating schema. Indeed, it does not take into account the possibility of a chronological gap, due, for instance, to the geographic diffusion of the typology, which does not guarantee the same age for different contexts.

The "chronological revolution" took place in the middle of 20th century, with the physical-chemical studies by Willard Libby in USA (Libby et al. 1949; Libby 1962; Libby 1963). As a result of those investigations, he invented the radiocarbon dating method, which allowed a totally new approach to the "the temporalities of taphonomic processes [which] became an object of study in their own right and, combined with artifact sequences, were considered a material expression of temporal shifts in prehistoric cultural evolution" (Arnold 2012, p. 86).

This chapter does not pretend to be a treatise in physics; our aim is to present an overview of the technique of the radiocarbon dating focusing on those aspects which are related to the archaeology.

4.2 The fundamentals of radiocarbon dating

Since the first archaeological objects dated by radiocarbon, wood samples from the Egyptian tombs of Zoser at Sakkara and Sneferu of Meydum (Libby et al. 1949; Hajdas 2009), almost seven decades have passed and radiocarbon dating has become the most used technique for dating organic remains of past societies having lived sometime in the last 40000 years.

Thanks to their studies on the radioactive decay of the isotope carbon-14 (^{14}C), Libby and his colleagues at the University of Chicago managed to develop a method for dating organic materials. The technique was developed in 1946 and represented a radical change in the way of dating archaeological contexts.

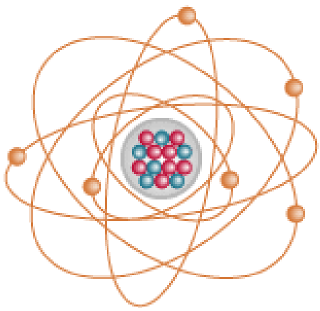

Fig. 13 – The atomic structure of ^{14}C

(Source: *The Worlds of David Darling • The Encyclopedia of Science)*

This measuring technique is based on the natural phenomenon of radioactive decay of isotopes (Fig. 13) due to a higher number of neutrons (8) than protons (6) in the nucleus. Because of this instability, the atomic nucleus tends to recover its previous stable status by β particles emission (radioactive decay). As a consequence, what was initially an atom of ^{14}C becomes an atom of ^{14}N. The duration of this process is known and it corresponds to 5730 years, during which for the original percentage of ^{14}C in a C sample reduces to its half.

The carbon-14 isotope is continuously produced in the stratosphere and upper troposphere as a consequence of the interaction between the atoms of Nitrogen and the cosmic rays. When a neutron collides with a nitrogen atom, a nitrogen-14 atom (seven protons and seven neutrons) turns into a carbon-14 atom, an instable isotope, that tends to recover its original atomic signature (Fig. 14).

These processes of generation and degradation of ^{14}C are naturally equilibrated in the atmosphere, because ^{14}C radioactive (instable) isotopes are mixed with the non radioactive isotopes (^{12}C) in the carbon dioxide present in atmosphere. At the bottom part of Earth atmosphere, about one part per trillion (ppt) of carbon is ^{14}C (Keenan 2012). Compared to the other isotopes of C, ^{12}C and ^{13}C, the concentration of the ^{14}C in the atmosphere is low, around 10%.

Through the photosynthesis, ^{14}C is incorporated by plants and hence the ratio of $^{14}C/^{12}C$ in them is similar to the atmospheric one. When the atmospheric CO_2 enter in the biological cycles this ratio decreases due to a process called isotopic fractionation.

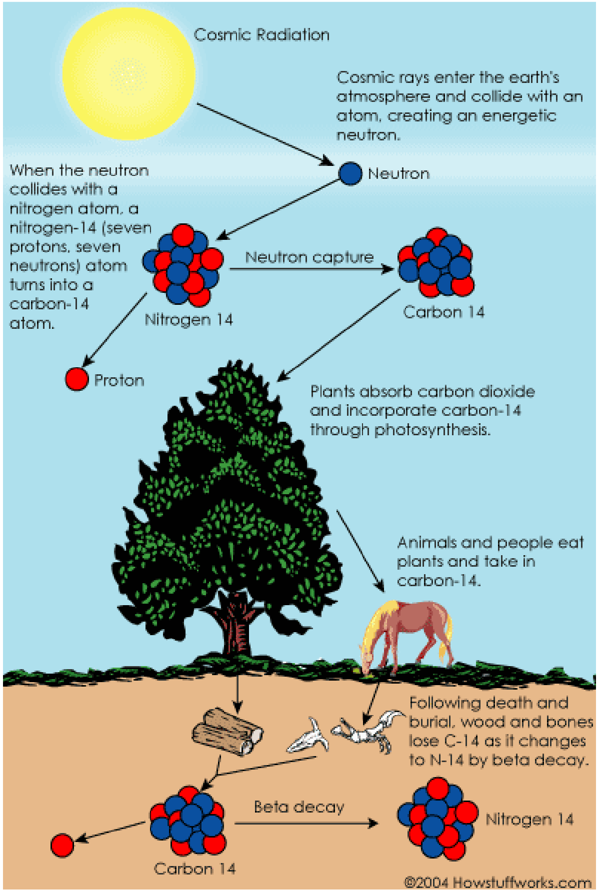

Fig. 14 – The radiocarbon cycle
(Source: *www.science.howstuffworks.com*).

The next stage is the transmission of the ^{14}C to animals and humans through alimentation. Animals and people eat plants with ^{14}C or eat animals that have eaten plants. Consequently, about 1 ppt of our carbonic content exists in the form of ^{14}C (Keenan 2012).

After the death of a living being, this process ends and there is no more incorporation of new isotopes of ^{14}C by the organism. The percentage of the ^{14}C starts decaying according to a constant rate. After 5730 years about half of the original amount of ^{14}C has radioactive decayed, hence only about 0,5 ppt of the carbonic content in the death organism remains as ^{14}C. Counting the amount of radioactivity (β particles) emitted by the sample equals to estimate the radiocarbon composition actually left in the sample. Knowing the half-life of this isotope, we can date the sample (Mestres 2008; van der Plicht & Mook 1987; Aitken 1990; Bowman 1990).

4.3 Uncertainty of radiocarbon dating

As already noticed by Barceló (2008a), although radiocarbon dating is referred as an absolute method for dating organic samples in the archaeological literature, it is not as absolute and precise as it seems, but a probabilistic estimate of the true date. Uncertainty is then a necessary characteristic of each radiocarbon chronological estimate, in such a way that the only result of this dating method is a more or less regular interval in which there is a not null probability to find the most accurate estimate

It is important to take into account that the process of radiocarbon dating is affected by two main sources of error. The first one relates to the symmetric errors, whilst the second one to the asymmetric ones. The probabilistic symmetric errors are expressed by a Gaussian normal distribution, with a central point and an error homogeneously distributed around it. Therefore, they can be controlled easily. As an example, we can mention the error introduced during the process of measurement in the laboratory, which is recognized in the standard deviation. More difficult is to deal with the asymmetric errors because they do no to follow a Gaussian distribution. In this group we have to include several errors, like those related to the calibration and the nature of the sample.

The estimation of the radiocarbon age is a probabilistic process that should minimize the effects of seemingly aberrant dating of specific events, recognizing them as extreme values of a distribution of probabilities or excluding parts of the resulting lower probability interval and concentrating where most probability concentrates (Bayliss et al. 2007). There is a growing agreement in the scientific community that absolute dating is in fact a probabilistic inference as a consequence of uncertainty and measurement error (Buck et al. 1991; Bronk Ramsey 1998; Weninger et al. 2011).

In order to control the possible sources of error it is advisable to take care of all the stages which lead to the final result. Precision and accuracy always depend on the protocol followed in the process of dating and the algorithms used to build the probability interval in which the true date may be found. It should be a common and widely agreed procedure followed not only by the physics and chemists in the laboratory, but also by the archaeologist who collected the sampled in the field and checked for its context reliability. In the next paragraph we focus on the various phases of this process in order to find out which are the most common sources of error and how to deal with them.

4.3.1 Gaussian errors: measuring problems

The main source for an assumed symmetric (Gaussian) error is produced in the process of radiocarbon dating itself, and it is due to the sample preparation in the laboratory and the probabilistic nature of radioactive decay measurement. The Gaussian error is included in the standard deviation associated to the radiocarbon date, as provided by the laboratories.

Until the middle of 1980s, when Accelerator Mass Spectrometry was developed (Nelson et al. 1986), organic samples were measured by decay counting techniques, either gas proportional counters or liquid scintillation counters. Decay counting requires relatively large amount of material to be dated (about 1gr of carbon), therefore often charcoal was decided to be dated instead of the seeds. Instead, with the AMS measuring technique, ^{14}C proportion in the organic sample is directly counted (Hajdas 2009), what implies reducing the sample size required for age determination. When the ^{14}C atoms contained in a sample are counted with the AMS method, and internal statistical error (the counting statistics of the measured total counts, N, in the series of measurements) and an external statistical error (comparisons of the error in the mean of a series of n AMS measurements for a sample) have to be introduced. The first error is calculated using the total number of ^{14}C counts measured for each target $(\pm\sqrt{n})$. The second one is calculated from the reproducibility of multiple exposures for a given target.

The reproducibility of these measurements provides a good estimate of the true experimented error. As a consequence, the final error is the larger of the internal or external statistical errors.

If μ is the mean of a group of individual measurements, each with variance $\sigma 2$ (here assumed equivalent for all measurements), the fractional precisions is equivalent:

$$\sigma_{ext}^2 = \frac{\sigma^2}{n(n-1)\mu^2} = \sigma^2 int = \frac{1}{N_{total}}$$

In fact, the equivalence of the standard error in the mean of AMS measurements to the precision expected from counting statistics demonstrated the degree to which the spectrometer and its operation are free of systematic error (Wölfli et al. 1983; Donahue et al. 1984; Farwell et al. 1984; Suter et al. 1984; Vogel et al. 2004).

Moreover, the development of a uniform sample material for radiocarbon AMS systems, filamentous or fullerene graphite (Vogel et al. 1984), provided intense ion beams for all samples and standards, bringing the internal and external uncertainties into routine equivalence for precise ($\sigma \leq 1\%$) AMS quantification (Bonani et al. 1987; Vogel at al., 1987).

In addition to the normal statistical errors characteristic of the counting of ^{14}C measurements, there also statistical errors which are associated with the correction applied for the Fraction Modern that we account for. For instance, the $\delta^{13}C$ correction, from a stable mass spectrometer has an uncertainty of approximately 0.1‰. The error associated with $\delta^{13}C$ is calculated by:

$$\delta^{13}C_{error} = \frac{\left(\frac{4 \times 10^{-6}\ (0.1 \times 0.1)}{(1 + \delta^{13}C \times 10^{-3})}\right)}{(1 + \delta^{13}C \times 10^{-3})}$$

This component of the *Fm* error is then added as follows:

$$Error_{Fm_{\delta^{13}C}} = Fm_{\delta^{13}C} \cdot \sqrt{\frac{Error_{Fm}^2}{Fm^2} + \delta^{13}C_{error}^2}$$

Another source of Gaussian error is due to the natural isotropic fractionation, whose consequences are the differential uptakes of one isotope with respect to another. The assumption is that the fractionation of ^{14}C relative to ^{12}C is twice that of ^{13}C, reflecting the difference in mass. In order to remove the effects of isotopic fractionation, the Fraction Modern is corrected to the value it would have if its original $\delta^{13}C$ were -25 per mil (the $\delta^{13}C$ value to which all radiocarbon measurements are normalized.) The Fraction Modern corrected for $\delta^{13}C$ is:

$$Fm_{\delta^{13}C} = Fm \cdot \left[\frac{(1-25/1000)}{(1+\delta^{13}C/1000)}\right]^2$$

Radiocarbon age is calculated from the $\delta^{13}C$-corrected Fraction Modern according to the following formula:

$$Age = -8033\ln{(Fm)}$$

The error in the age is given by 8033 times the relative error in the Fm. Therefore a 1% error in fraction-modern leads to an 80 year error in the age.

The AMS measurement technique implied an improvement in the sample preparation, selecting only the area with less contamination. Only about 1mg of carbon is needed for the AMS technique, and short lived samples of very small size (i.e. seeds) have proved to be more reliable.

The sample preparation in the laboratory is a basic point in order to isolate the datable fraction and hence to obtain a reliable date (Mook & Streurman 1983). Indeed, it is during this phase that we remove all the traces of contaminants, both ancient and modern, from the sample and we get the graphite suitable for the dating. Without entering in the detail of the procedure, we just want to focus on its major steps. First of all, it is necessary to wear gloves and to lay out an aluminum foil sheet in the working area, it also important to clean all the utensils to be used. These measurements are to avoid any contamination of oil or grease or unwanted contributions of carbon-containing materials during sample preparation (Olson & Broecker 1958; Yizhaq et al. 2005).

Then, we have to follow the chemical pretreatment of the samples, which is made up by three main steps which are called AAA (Acid-Alkali-Acid) or ABA (Acid-Base-Acid). During the first acid treatment the carbonate part of the sample and possibly infiltrated humic acids, which correspond to the sediment that we could have collected together with the sample, are dissolved by the HCl. The second Alkali step with NaOH is for melting away the soil humates (i.e. the contamination of the soil). The third one again with HCl is for the possible modern contamination due to the absorption of CO_2 during the previous steps of the laboratory treatment. After each step the sample must be rinsed with water and the pH has to be checked.

On the light of such a procedure it is clear the relevance of caring about all the stages through which the sample is submitted in the laboratory. In fact, during this phase it is reduced not only the modern contamination but also the contamination which took place in the field, whose consequences would be a wrong radiocarbon date if it is not eliminated in a proper way. For that we must be sure on the procedure followed in the radiocarbon laboratory where our samples are going to be analyzed, a reduced error in this phase means a reduced error in the final result.

Recently, in order to control the systematic error of radiocarbon dating, usually caused by slight variations in the methodologies adopted for sample preparations among the different laboratories, the applied procedures have been tested by periodic inter-laboratory comparisons of a variety of samples whit a known date (Rozanski et al. 1992; Naysmith et al. 2007; Scott et al. 2010; Adolphi et al. 2013).

4.3.2 Non-Gaussian errors: calibration

The main Non-Gaussian error is due to the calibration curve and the process of calibration. Chemical-physical timescales (isotopic degradation) and astronomical timescales (relative motion earth-sun) are not graded in the same units; therefore, "^{14}C years" are not necessarily the same as the "calendar years" (van Srtrydonck et al. 1999). This is due because the concentration of ^{14}C has not been uniform all along the time span of the astronomical scale (Aitken 1990, Bowman 1990). In fact, many factors have caused an increase and decrease in the percentage of ^{14}C in atmosphere. Although most of it is related to variations in the flow of galactic cosmic rays (Kudela & Bobik 2004) and also to changes in solar activity and the geomagnetic field of the Earth, there are other factors which are responsible of such fluctuation. For instance, climatic changes and natural phenomena, such as volcanic eruptions, can play a relevant role in the proportion of ^{14}C in atmosphere, what directly influences the amount of it in biosphere, whose dead samples we want to analyze.

The solution to this problem is called *calibration* (Damon 1987; Pearson 1987; van der Plicht & Mook 1987; Pazdur & Michzynska 1989; Litton & Leese 1991; Dehling & van der Plicht 1993; Talma & Vogel 1993; Gruet 1996; van der Plicht 2004; Buck et al. 2006). By "calibration" we mean a statistical procedure that predicts a quantity from another using ratios. The procedure consists of two steps: the first one implies calculating the relationship between the observed rate and the response; confidence intervals are constructed on the regression function. In the second step, the problem of calibration is solved by reversing the prediction intervals for the response variable. Obviously the goal of calibration is not to estimate the regression function but to estimate the parameter "^{14}C years" that corresponds to a set of observations ^{14}Cyears/calendar years that meet the conditions of what a calendar year is in terms of time span.

In other words, we should find a target function or mechanism to put in relation the calendar timescale (or historical) with the physical - chemical timescale. This is usually done by comparing concentration measurements of 14C with calendar estimates obtained independently. This can be done with wood samples from well individualized growth rings of trees from different parts of the northern hemisphere, and whose chronology has been well established dendrochronologically. When the sequence of tree rings is continuous and known from the present to the past, we may assign a reliable and precise enough calendar dating to each of the available wood samples, whose ratio of ^{14}C has also been measured.

In order to correct a radiocarbon date it has been introduced the calibration curve. It describes the amount of radiocarbon in the atmosphere starting from 48000 years ago, in case of the last calibration curve IntCal13 (Reimer at al. 2013). The calibration curve is the result of radiocarbon dates of material whose age was already known thanks to several methods. Till 12000 years ago the main technique is the dendrochronology, till 30000 years ago by dating coral fossil samples through the uranium-thorium method and till 48000 years ago dating glaciers and lake sediments (varves) and annual geological stratigraphies like cave deposits (Fig. 15).

The two phases of the calibration procedure act as follows: the first is the "estimation step", in which a database of dendrochronological dates and radiocarbon measurements of the same sample is built (IntCal86: Stuiver & Pearson 1986; IntCal93: Stuiver & Pearson 1993; IntCal98: Stuiver et al. 1998; IntCal04: Reimer et al. 2004, Blackwell et al. 2006; IntCal09: Reimer et al. 2009; IntCal13: Reimer et al. 2013).

Samples	Approximate age range (cal BP)	Nr of rings per sample	References
Netherlands oak (n = 13)	670–840	10–24	van der Plicht et al. (1995)
Irish oak (n = 57)	1140–1710	10	McCormac et al. (2008); Hogg et al. (2009)
Bristlecone pine (n = 53)	2300–2750	10	Taylor and Southon (2013)
German oak (n = 111)	2600–2640 3060–3660	9–10	Kromer et al. (2010); IntCal13 database
Floating German and Swiss trees (n = 232)	12,580–13,900[a]	3–47	Hua et al. (2009); Schaub et al. (2008); IntCal13 database

[a]The tree-ring data set extends back to 14,200 but has been terminated in the model at 13.9 cal kBP due to sparse measurements for the earlier period.

Fig. 15 – Additional tree-ring samples, cal age range, number of samples (n), and number of rings per sample included in the IntCal13 database (Source: Reimer et al. 2013).

The trouble is that such relationship is very complex and typically non-linear and non-monotonic , which is represented by an extremely irregular curve defined firstly by a long term trend, whose wave length is about 9000 years (Bowman 1990), and several overlapping cycles of variation of less duration, about 2400 years (Dergachev & Zaitseva 1999). “Wrinkles” or cycles of much shorter duration (a few decades) also appear. The curve sinuosity then reflects the history of irregular variations in the atmosphere of ^{14}C. Differences in latitude, depth of ocean waters, wind patterns, etc. explain additional error margins of ~ 1 ‰ (8 years ^{14}C) between samples from different parts of the Northern Hemisphere, except the Arctic Circle .

In the "predictive stage" a calendar estimate corresponding to a new radiocarbon measurement is calculated, based on the point where the raw ^{12}C value intercepts the curve. Because prediction is defined by the particular form of the relationship at the point at which the raw ^{14}C value intercepts the curve and the standard error (Gaussian) of its measurement, the specific way in which that part of the curve has been mathematically defined will affect the outcome of the prediction. That is to say, as noticed by Keenan (2012) “the calibration “curve” is not a curve in the common sense; rather each point on the curve has a potential error, which is usually specified by the standard deviation of the measurements”. This is what has been called “stochastic distortion calibrated” (Bronk Ramsey 1998).

On the other hand, it must be remembered that the ^{14}C calibration function is simply the statistical reduction of a cloud of points (consecutive measurements of the reference database). Computer programs that interpolate the cloud of points, like Calib (Stuiver &

Reimer 1993; Stuiver et al. 2005), BCAL (Buck et al. 1999), OxCal (Bronk Ramsey 2009a) and Calpal (Weninger & Jöris 2004) give equivalent results in most cases (Gómez-Portugal et al. 2002; Blackwell & Buck 2004; Buck et al. 2006).

While the uncertainty of the raw ^{14}C measurement (standard error) could be represented by a symmetrical normal distribution, centered around its mean, the calibrated range, or ranges of probability, are not symmetrical, and their central tendency are not statistically significant. In other words, we cannot say that the probability of estimating the true date outside a central point of the calibrated interval significantly decreases as we move away from that point. To further complicate matters, the assumption that all points of the calibration interval are equally probable is not valid (van der Plicht & Mook 1987; van Strydonck et al. 1999; Gómez-Portugal et al. 2004; Guilderson et al . 2005) (Fig. 16).

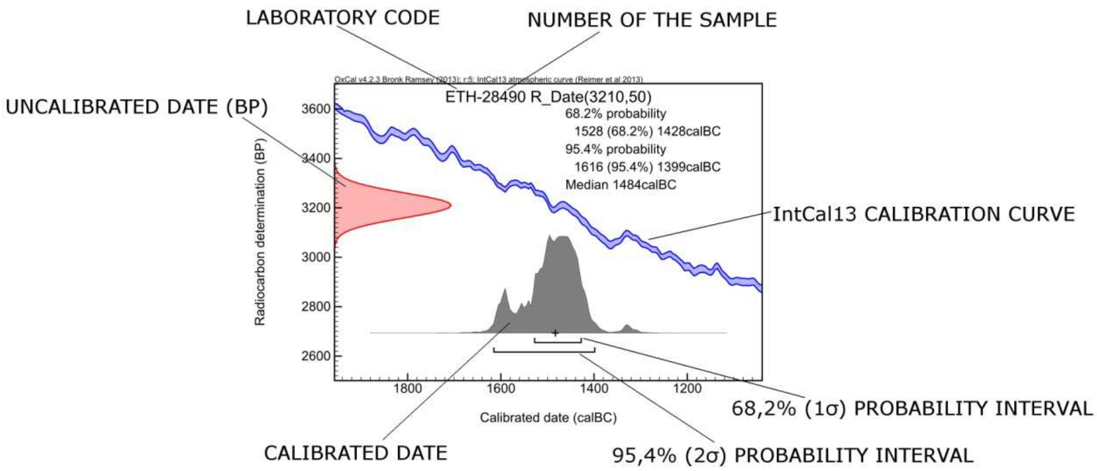

Fig. 16 – Calibration graph of a radiocarbon date (Software: OxCal 4.2; Bronk Ramsey 2009a).

Therefore, we cannot use either the average or the median of any part of the range of the calibrated interval as representatives of a possible meaningful central tendency that does not exist. We cannot expect a single value to provide satisfactory results. That is, within the calibration range, two dates are indistinguishable and there is no reason to think that one is better than another, for the sake of being in the center of the interval. Recall that this interval has a characteristic asymmetric probability density distribution, and in many cases it is typically multi-modal.

The first problem implies the selection of the point estimate for the most probable date.

We have already discussed that so-called absolute dating is not as absolute as it seems and radiocarbon chronological estimates are always expressed in terms of probability estimated. Given that after calibration the confidence interval for the most probable date is irregular, asymmetric and in many cases multi-modal, which value will represent the best estimate of the true date? In fact, no single values can adequately describe the complex shape of a calibrated radiocarbon probability density function (Dehling & van der Plicht 1993; Buck et al. 1996; Bronk Ramsey 1999; Telford et al. 2004; Blaauw et al. 2007; Blockley et al. 2007). Telford and his group (Telford et al. 2004) analyzed eight estimates of the central tendency of a calibrated radiocarbon date: (1) the intercept between the BP raw estimation and the calibration curve (Stuiver & Reimer 1993), using the mean intercept if there is more than one intercept; (2) the median intercept (Seierstad et al. 2002), (3) the mode; (4) the median; (5) the weighted average or moment; (6) the weighted average of 2σ ranges using the range mid-points (extension of Bennett 1994); (7) the weighted average of 2σ ranges using the range mode; (8) the weighted average of 2σ ranges using the range intercept (mean intercept if more than one) or mid-point if no intercept in that range (Brown et al. 2002). When a single estimate must be used, a robust estimate such as the weighted average or median should be used and the method specified (Telford et al. 2004, p. 298).

In the light of such researches, we have decided to use the medians of the calibrated interval as a point estimate of the calendar date for each archaeological context. To minimize the effects due to the length and irregularity of standard error of radiocarbon estimates plus the effect of calibration intervals, we have screened off all dates with standard errors higher than the width of the time interval. Although very positive, however, such filtering of the “best” dates does not prevent that the median is in itself a bad estimate of a long interval of irregular probability. Therefore, we need other techniques that consider the full spectrum of underlying probabilities, and not a mere central point in an asymmetric interval. Such techniques are usually referred as summed probability functions (SPFs) or summed calibrated probability distributions (SCPDs). The advantage of the summing a group of estimates with different probabilities of being true, is to produce a new unique probability density function for a period hypothetically defined, which is the result of the sum of the individual confidence intervals. The obtained result should not be interpreted as an interval of time, but as the probabilistic distribution of the “best” estimate. Summed calibrated probability distributions (SCPD) have been used for several aims, like for instance, visualizing specific events like the temporal occurrence of radiocarbon dated variables (Gamble et al. 2005; Barceló 2008b; Steele 2010; Caracuta et al. 2012; Williams 2012; Wicks et al. 2014) or as an inference for demographic analysis (Turney et al. 2006; Ortman et al. 2007; Shennan & Edinborough 2007; Buchanan et al. 2008; Smith & Ross 2008; González-Sampériz et al. 2009; Oinonen et al. 2010; Peros et al. 2010; Tallavaara et al. 2010; Johnson & Brook 2011; Pesonen et al. 2011; Armit et al. 2013; Martínez et al. 2013; Miller & Gingerich 2013; Crombé & Robinson 2014).

In probability theory and statistics, the *cumulative distribution function* (CDF), or just *distribution function*, describes the probability that a real-valued random variable *X* with a given probability distribution will be found at a value less than or equal to *x*. In the case of a continuous distribution, it gives the area under the probability density function from minus infinity to *x*. The idea is to add the confidence intervals of radiocarbon estimated for all isotopic events from the same archaeological event (or a series of related archaeological events) (Gascó 1987; Mychzyńsky 2004). This method is based on the superposition of the relative probability density functions of the individual dates (Gascó 1985; Gascó 1987; Gascó & Binder 1983; Aitchinson et al. 1991; Évin et al. 1995; Mychzyńsky 2004; Michzyńska & Pazdur 2004; Bayliss et al. 2007). In this way, multi-modal and skew intervals are added to the estimate. Therefore, instead of an arithmetic sum, we produce a new probability density function which is the result of the superposition of the relative probability density functions of the individual dates (Gascó 1985; Gascó 1987; Gascó & Binder 1983; Aitchinson et al. 1991; Évin et al. 1995; Mychzyńsky 2004; Michzyńska & Pazdur 2004; Bayliss et al. 2007).
To understand how we obtain a summed probability function we can sum a hypothetical dataset composed of 10 random ^{14}C events. The figure 17 depicts calibrated intervals.

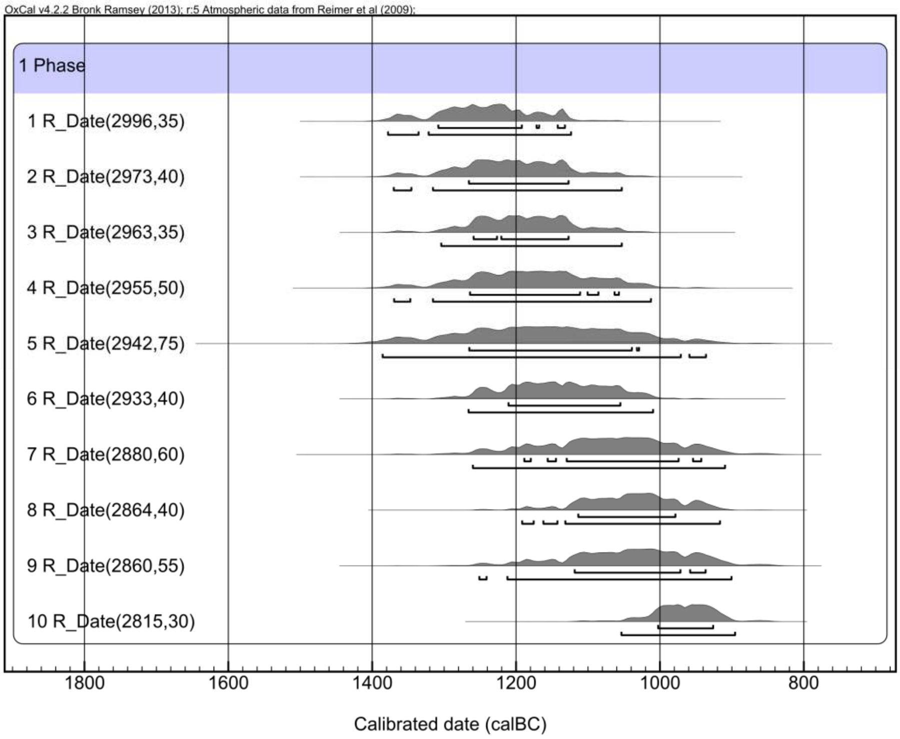

Fig. 17 – Dataset of 10 random ^{14}C dates (Software OxCal 4.2).

The absolute difference between the oldest sample (N. 1) and the newest one (N.10) is approximately 320 years. The problem is that such a difference is misleading because the confidence interval for the oldest dated event is so great that any point estimate within it can be used to calculate the difference.

Therefore, to add the respective confidence intervals $p_1(t)$ y $p_2(t)$ we may combine estimates:

$$r(t) = p_1(t)\, p_2(t)$$

or, in general terms,

$$r(t) = \prod_i p_i(t)$$

Different programs calculate this density function in a slightly different way (Fig. 18 and 19). Such differences are due to the algorithm of interpolation applied by the each software and for our type of analysis are meaningless

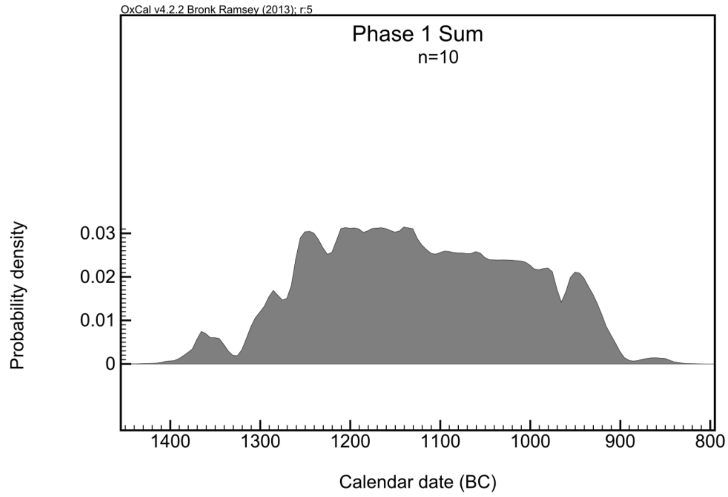

Fig. 18 – Summed probability function of the dataset at fig. 17 (Software OxCal 4.2).

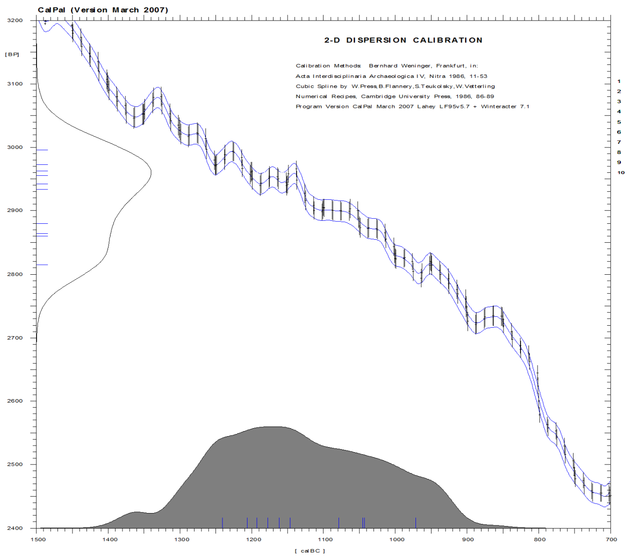

Fig. 19 – Summed probability function of the dataset at fig. 17 (Software CalPal).

Certain parts of the calibration curve are directly responsible of the peaks visible in the SPF plot (Gey 1980; Michczynski & Michczynska 2006; Thorndycraft & Benito 2006; Williams 2012; Kerr & McCormick 2014). It is relevant to remember that when the curve is steep we will obtain a small value for the standard error of the calibrated date and hence we have a fairly precise estimate of that value. Conversely, when the curve is flat, one will be much less confident of the value of it (Aitchison et al. 1991). Therefore, the areas whose effects are most relevant are the plateaus and the so called calendar age "step", as represented in fig. 20. The first ones produce a reduction of the peaks in summed probability plot because the plateaus convert a single date in a wide flat period.

The second ones generate step narrow peaks through superimposition of multiple dates (Williams 2012).

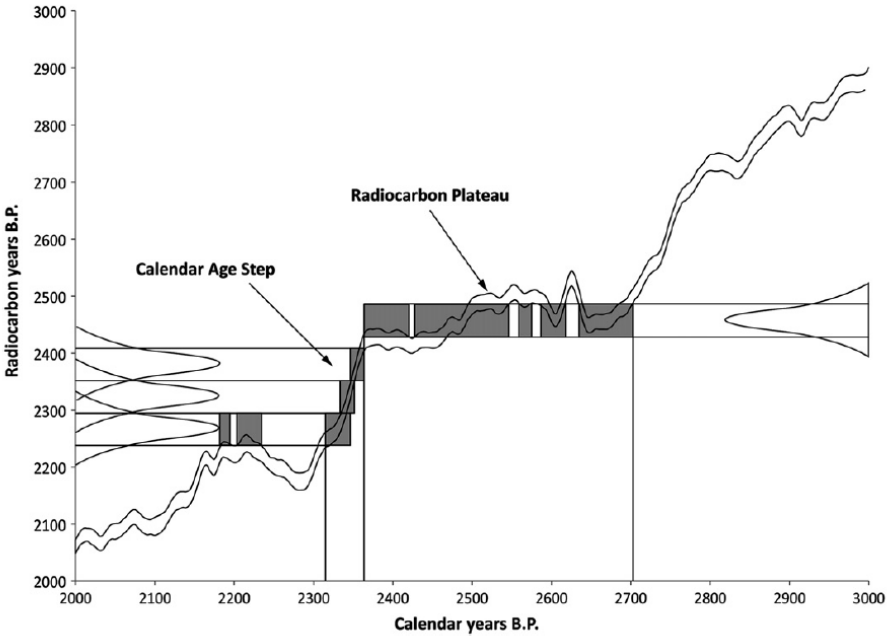

Fig. 20 – The effects of the radiocarbon calibration curve (IntCal09) on the summed probability plots. Each grey block corresponds to a radiocarbon date. The consequences of a plateau are represented on the right, whilst those ones of the calendar age steps on the left (Source: Williams 2012).

A straightforward approach in order to evaluate the confidence in SPFs distributions is to use the simulation techniques for proving the validity of the analysis (Chiverrell et al. 2011). In this respect, Johnson and Brook (2011) have tested the effects of complex population dynamics, like the processes of occupation of a site, the abandonments, the re-occupation, the foundation and the erase of archeological evidences due to post-depositional effects in Australia during the Holocene. Simulating the interaction of such variables through ten 1000 years intervals to the present, the authors show that "shifting site occupation across an archaeological landscape, together with the gradual loss of evidence of occupation at abandoned sites, can produce the appearance of increasing occupation towards the present when the true occupation density is constant" (Johnson & Brook 2011, p. 3752)

Another application of the modeling is to test null hypothesis of no relationship between the results obtained in the SCPDs and the effects of the calibration on the final outcome. Running a simulation with the same number of dates distributed in a random way in the analyzed time-span (the frequency is constant) we can check how particular section of the calibration curve, like calendar age steps and plateaus, could have conditioned our distributions.

4.3.2.1 The “Hallstatt disaster”

The Bronze Age-Iron age transition in Europe has been traditionally placed in the first half of the 1st millennium BC. As a result, in our research such a period deserves a particular attention, as it has been traditionally characterized by an apparent discontinuity between two different homogenous phases.

Regrettably, problems arise when we cope to calibrated radiocarbon dates located in this time-span. As a consequence of the calibration process in this part of the curve, the level of uncertainty in the confidence intervals of such dates is incredibly high.

With the term “Hallstatt disaster” the scientific community refers to the plateau located in the calibration curve between 760 and 420 cal BC (2500-2425 BP) (Fig. 21). The term is due to the chronological analogy to the Hallstatt society which developed in the late Bronze Age and the beginning of Iron Age in the northern part of the Alps (Austria).

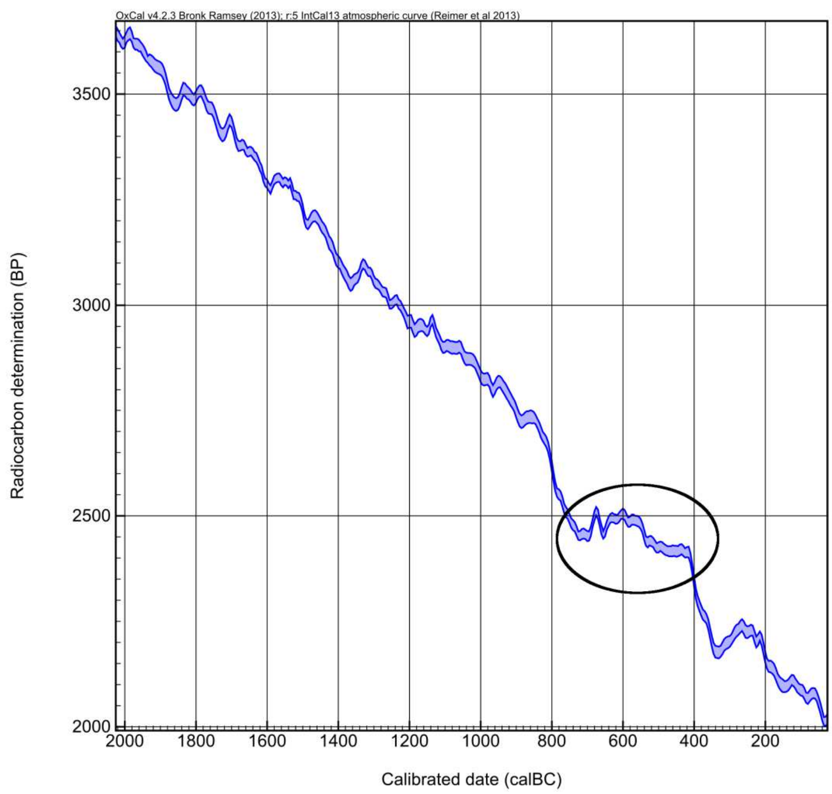

Fig. 21 – The Hallstatt Plateau in the IntCal13 calibration curve.

The flat shape of the calibration curve in this time-span is the result of the decrease, and hence the return to normal values, of the percentage of ^{14}C after a period characterized by an increase in the concentration of radiocarbon in the atmosphere, which is mirrored in the calibration curve as a sharp descent between 850 and 760 BC (2700-2450 BP) (Speranza et al. 2000). As asserted by many authors (Van Geel et al. 1996; Van Geel et al. 1998; Tinner et al. 2003; Dergachev et al. 2004; Van der Plicht et al. 2004; Swindles et al. 2007) the chronological range 850-760 BC is characterized by an abrupt increase of the amount of ^{14}C in the atmosphere and it corresponds chronologically to the boundary from Subatlantic to Subboreal (2800-2500 BP), which "has globally been identified as a time of marked climatic change. Stratigraphical, paleobotanical and archaeological evidence point to a change from a dry and warm to a more humid and cool climate in central and northwestern Europe" (Tinner et al. 2003). Several causes for explaining the deterioration of climatic conditions have been adduced. The main factor seems to be a decrease in solar activity and a drastic increase in the galactic cosmic ray intensity, associated with a pronounced displacement of the Earth magnetic field which took place around 2700 BP. As a consequence, the zonal circulation and cloudiness increased and this originates a cool effect with higher precipitation, which was accompanied by a fast and considerable rise of the groundwater table in Europe (Van Geel et al. 1998; Dergachev et al. 2004).

The effects of the plateau are clear when a radiocarbon date is calibrated, the uncertainty increases as we move into the flat section of the curve. Starting from the 750 cal BC the result of the calibration of the ^{14}C into calendar years is much more ambiguous than before, hence it does not correspond with a high precision to the archaeological date/event whose chronology we want to study. Some paradigmatic examples have been highlighted by Barceló (2008b). In fact, taking into account some dates from Catalan archaeological contexts we can clearly detect how the uncertainty increases. For instance, the radiocarbon date UBAR-830: 2760±40 BP (Can Roqueta II-E 265) have a calibrated interval quite narrow: 971-804 (2σ) and 902-827 (1σ) BC (Fig. 22).

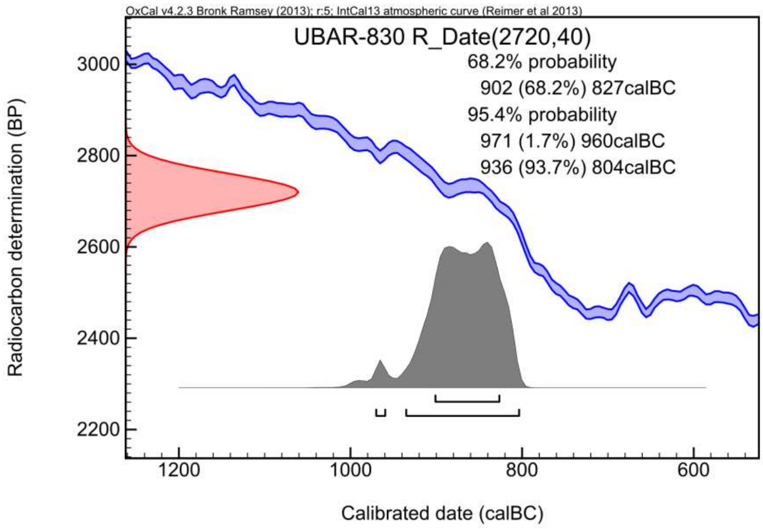

Fig. 22 - ^{14}C date from the structure 265 at Can Roqueta (Spain)

But as we get into the plateau the calibrated results are much more uncertain, the date KIA-24836: 2620±35 BP (Can Roqueta/Can Piteu-burial 466-1A), although it shows a shorter standard deviation compared to the previous date it has a larger uncertainty: 891-766 (2σ) and 818-789 (1σ) BC. The situation gets worse from 2570 cal BC. For example, the date Beta-98211: 2570± 40 BP (Barranc de Gàfols-US 44) has really ambiguous calibrated intervals: 814-547 (2σ) and 806-593 (1σ) BC (Fig. 23). The maxim uncertainty for the Catalan dates is reached with the date UBAR-90: 2360±60 BP from the stratigraphic unit 43 of the Aldovesta settlement which provides the 2σ calibrated interval 753-235 BC of more than 500 years (Fig. 24).

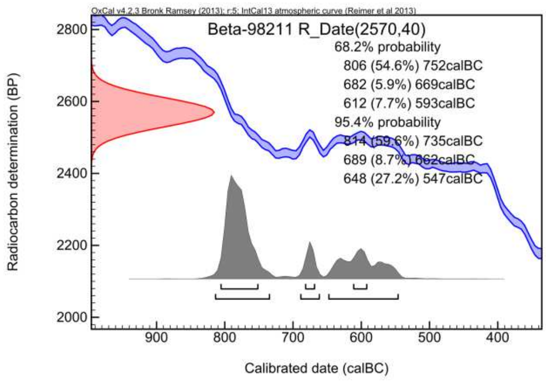

Fig. 23 - ^{14}C date from the US 44 at Barranc de Gàfols (Spain)

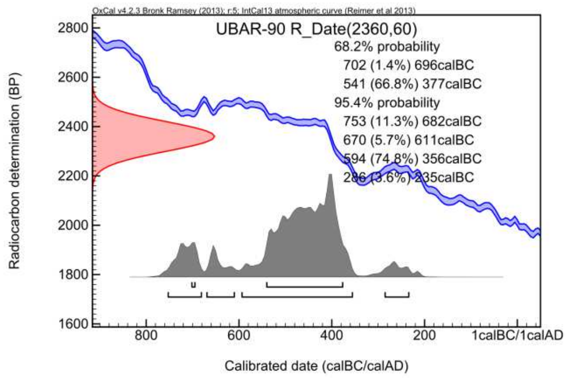

Fig. 24 - ^{14}C date from the US 43 at Aldovesta (Spain)

As an outcome we cannot take into account dates located in this section of the calibration curve and hence we have used as recent boundary for the time-span of our research the calendar age 750 BC.

4.3.3 Representativeness of a sample

We must take into account that the main source of uncertainty in radiocarbon dating is not so much the accuracy of the method, but the research endeavor itself. The possibility of erroneous measurements has been pointed out many times (Aitken 1990; Bowman 1990; Hedges and Pettitt 1999; Petchey & Higham 2000) but more important are problems in identifying the proper sample to be measured. Given the risk of believing that a measured sample is representative of the wrong archaeological context is not surprising that there is always the possibility of unexpected extreme outliers in a sequence of radiocarbon estimates. This is not, however, a serious problem if it can detect outliers either statistically or by filtering the data consistently. However, it should be noted that the possibility of unidentified erroneous data affecting the historical hypothesis should be tested.

4.3.3.1 Errors in the field

Too often archaeologists forget that the process for a reliable radiocarbon date starts in the field. As we have already mentioned the primary step is to understand what exactly we want to date. Therefore, in order to reduce as more as possible the error in the field it is important to distinguish what is the phenomenon (i.e. the depositional and archaeological events: use of a floor, destruction layer, period of activity of a fireplace, etc.) in which we are interested in. If the real object of dating is unknown, too many mistakes can be committed during the process. Frequently, in the archaeological literature, a radiocarbon date is used just to justify the general chronology of the archaeological sites and not as a powerful tool for getting a real sequence of different phases of the settlement. For that it is relevant to have a clear scheme of the stratigraphy of the analyzed area, in order to know exactly where the sample is taken and to which event that layer corresponds. Collecting samples from a clean section is a useful method for a good selection of the most appropriate ones. If we want to collect the sample directly from the archaeological surface of the excavation it is advisable to take care of their positions. In fact, charred seed, or charcoal found inside a structure or in a vessel has a higher probability to be *in situ* and therefore to be contemporary with the structure or with the vessel (Boaretto 2009). We should also take into account that preservation of charcoal is better in places like, for instance, under a group of stones or under a structure. In this case, synchronicity may not be absolutely reliable; anyway we can consider the date as a *terminus post quem* for the archaeological feature. This is why sample locations must be exactly documented and published accordingly. Whenever possible, the samples should be taken and published from a context holding objects that can be used in a typological sense in order to associate a conventional chronology with an absolute chronology in years given by the radiocarbon measurement (Stöckli 2009).

It is clear that a correct sampling is the primary step for a reliable estimate. We should not forget that frequently post-depositional processes can be caused by movements across the sedimentary matrix covering the archaeological material (Leonardi 1992b).

We suggest taking as a paradigmatic scheme for checking context reliability the approach published by the Dr. Elisabetta Boaretto in the Radiocarbon Journal (Boaretto 2009). First of all priority should be given to short-lived samples found *in situ*. In case of charred seeds it is advisable to find them as a cluster; in this case we have more guarantees that the deposition of the seeds was contemporary. Otherwise, if we collect seeds dispersed in the same layer we do not have secure information about the moment of deposition for each particular seed.

Another good sample is bone. Animal or human bones can be regarded as short-lived samples; the reason is that this material continually undergo remodeling, and thus the collagen in any given mature bone can be between a few years old and at most around 30 yr old (Boaretto 2009; Price et al. 2002). A good technique for the indication that the bone may contain collagen can be obtained in the field by dissolving a small amount of bone in acid and by visual inspection; if an insoluble organic suspension remains, then there is a high probability that collagen has been preserved. This, however, needs to be proved in the laboratory (Boaretto 2009). The precise location of bones in the sedimentary matrix is a source of information, too. For instance, bones in articulation should be preferred because they represent a material found *in situ*.

It is also relevant to take into account the way how the archaeologist has gathered the samples; in fact, he or she can actually be responsible for an introduction of error in the process. It is suggested to use aluminum paper for storing the sample after having collected it using metallic tools. It is advisable to keep away from touching the sample in order to avoid possible contamination. Furthermore, archaeologists should be aware that wet sieving can alter the PH of the samples and therefore the result of a radiocarbon dating (Rebollo et al. 2008).

As a general rule, it is suggested to adopt a microarchaeological approach in order to reduce the introduction of error in the field (Weiner 2010). The reliability of a radiocarbon date always corresponds to the reliability of the archaeological context. If the second variable is missing we could never have a precise and accurate radiocarbon date.

4.3.3.2 The “old-wood effect” and the “reservoir effect”

Another potential mistake in sample selection comes from the fact that the actually measured sample is older (or newer) than the most probable date for that archaeological context, given that the measured isotope event is not synchronous with the archaeological event. This problem happens when processing long-lived samples, the so called “old-wood effect” (Schiffer 1986; Bowman 1990; Ashmore 1999). As already pointed, when an archaeological sample is radiocarbon dated, the time-span between the dead of the live-being and the moment of measurement is calculated in terms of the residual ^{14}C remaining. Regrettably, the moment in which an organism stops exchanging radiocarbon with the atmosphere does not always coincide to the particular moment that we want to date. In case of long-lived samples, like wood or charcoal obtained by the combustion of wood, the radiocarbon date refers to the moment in which the plant was cut down or even to a previous moment during the life of the plant recorded in its inner structure made of growth rings. Hence, it is clear that those samples must have a value as *terminus post quem*, instead of an absolute estimate. In fact, the exact contemporaneity of the radiocarbon measurement and the calendarical date of the archaeological context cannot be asserted reliably. Moreover, in case of wood samples from architectural features of buildings, in which the organic material are well-preserved,-it is relevant to take into account the possible phenomena of use and re-use of the same wooden piles or beams during more than one construction phase. In such cases the isotopic events could be older tan the real archaeological event we want to date (Dean 1978; Schiffer 1986; Ashmore 1999).

As an outcome, the date of a long-lived sample implies an introduction of error in the final result and therefore we must be conscious of the possible “old wood effect” when a charcoal or a wood sample is analyzed. If this effect can be detected, in order to obtain a reliable date and to reduce as possible the uncertainty, the result should be corrected also through a comparison with the ^{14}C dates from short-lived samples gathered in the same archaeological layer.

We must be aware that the amount of ^{14}C in a tree trunk varies among their growth rings. Therefore, if a tree has lived 100 years before being cut and turned into firewood, we could find fragments of charcoal with 100 years of difference each other. The use of wood may have been contemporary but radiocarbon samples are not. On the other hand, the incidence of forest fires and human action explain that everywhere human activities occurred there is the possibility to find charcoal generated before that action, either by natural processes (fire), or by previous human action. Manning (1999) has estimated that in archaeological sites around the Mediterranean it can be found randomly some piece of charcoal which is about 50 years older or newer that the archaeological event we suppose to date. That estimate is based on the average life of the trees in that region.

A related trouble concerning the apparent contemporaneity between the isotope event and the archaeological deposition is the “reservoir effect”.

The ^{14}C exchange between the live-being and the environment depends on the source of absorption of the instable isotope when the organism was alive (Münnich et al. 1958; Stuiver & Braziunas 1993). If the exchange happens in a different environment from the atmospheric one the standard amount of radiocarbon present in the archaeological evidence is affected by variation of the percentage. This is the case of marine organisms, which exchange radiocarbon with the sea and not directly with the atmosphere. Between the concentrations of ^{14}C in a sample that has exchanged radiocarbon with the atmosphere and another from a marine context there is a difference of around 400 years. If the sample originates from the sea bottom such a difference can increase till 1800 years. This is why a different calibration curve is used for marine samples (Reimer et al. 2013).

Although this effect apparently does not affect directly the archaeological samples from terrestrial sites, it is relevant to highlight that the so called “reservoir effect” can also imply variations in the amount of radiocarbon in life beings whose subsistence base was mainly composed by fish and marine animals. Therefore, even if short-lived samples have a better value for building chronologies, we must be aware that the bone samples can be affected by this problem, hence, when it is detected the result of the radiocarbon dating should be corrected.

4.4 Dating historical events

Now, it is time to integrate the procedure and caveats of radiocarbon measurement with our explicit goal of dating history, taken into account the proper nature of radiocarbon measurement, the uncertainty of chronological estimates and the latent risk of making errors, both in measuring, in data selection and in data processing. We should take into account, however, that chronological uncertainty must be taken in a sense radically distinct from the familiar notion of risk error, from which it should be properly separated. The essential fact is that "risk" means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomena depending on which of the two is really present and operating. It will appear that a measurable uncertainty, or "risk" proper, as we shall use the term, is so far different from an no measurable one that it is not in effect an uncertainty at all (Knight 1921). In other words, we should look for ways for reducing the risk in chronological error, but also take into account that our chronological estimates are not absolute reference points, but probability intervals.

Historical periods are not observable entities. An historical period is an interval of time within which an undetermined number of single events happened. Such particular "historical" events should be understood in terms of the occurrence of social actions that were performed by someone who produced something somewhere and some-when. In general, the duration of a single historical period can be estimated in terms of the temporal extent of performed social actions (historical events). Of particular importance is the determination of the starting and final point of the historical period. We need to distinguish a particular discontinuity in the social actions that took place before and after those actions within the period.

That leads us to the fact that dating history should be understood as an analytical process involving formalisation and structuring of different data sets, in order to define events and their causal relations (Barceló 2005; Barceló, Bogdanović, Capuzzo 2012, 2013). We suggest an event-based chronological analysis, based on the principle that the event should be the analytical unit (Sewell 2005).

An event instance describes a state or a change in the state of specific object attributes and occurs at a specific time (Findler & Bickmore 1996; Doyle 2006). Therefore, we may define archaeological events as an expression of the fact that some percept at the archaeological site has some feature *f* in some space and temporal location *e*, that the perceived entity is in a state *s* and that the features defining state *s* of that entity are changing or not according to another space and temporal location *e'* (Barceló 2009). The fact that a vessel has shape *x*, and the fact that a lithic tool has texture *t* are events, because a social action has been performed at this spatial and temporal location (event), resulting in some artifact with, among other things, some specific shape and texture properties. The fact that "a pit has a specific shape", and the fact that "there are some animal bones inside that pit" are also events, because a social action was performed at this spatial and temporal location (event), resulting in a modification of the physical space: first the excavation of a pit, and then an accumulation of garbage items.

We are considering archaeological events as *processual events*. Here we use the term *processual* regarding the temporal and structural character of this category of events, not in sense of "processual archaeology" as it is used elsewhere (like in Lucas 2012: 182). Although a processual event happens in other time dimension, in no-experienced *historical time*, it has feedback impact on further social events and its relation with events in the social time is interactive. Processual events form a category without a given coherence; they should be defined by the sum of causally related social events. But, in the course of historical explanation, the processual event is defined only by the logical construction of the research questions, which setup all variables, as scale, content, time, etc. As a consequence of social (or natural) action, this event by itself does not produce any materiality. As a consequence of causal relation of lower level events, it should be explained in terms of the spatio-temporal location of social actions. Therefore, processual events must be understood as a generated by causal convergence of social events in wider space and/or time span.

If social events are inferred concepts, *archaeological events* are the result of observation, and happened in *archaeological time*. Between these two levels of events there is no feedback relation; archaeological events do not influence on the nature of the social event, but only on the probabilities of their discovery. An archaeological event is a palimpsest of *depositional events* which are remote consequences of direct social action; therefore we may describe the archaeological event as a meeting of depositional events and post depositional conditions.

Archaeological events are a palimpsest of lower-level events: the particular action that generated the location of such item at this particular place and moment. We call *depositional event* to these individual facts. One archaeological event can be composed of many different individual depositional events, with different calendar dates and different durations. Nor the calendar date nor the duration of a depositional event can be physically measured.

To understand the diversity and variability of archaeological events, we should understand that they may vary according three different dimensions: *space, time, quality* and *frequency*. According to an ordinary definition quality is a structurally undivided combination of indications, features of some substance or a thing revealed in a system of relations with other substances or things. *Frequency* should be defined in terms of the number of times some event took place, based on the *abundance* of observed material effects by unit of *space* and *time*. Without change in quality or frequency through time *and* across space, it is impossible to differentiate archaeological events. The key aspect is here the "*location* of quality/frequency changes". *Location* should be understood in its spatiotemporal signification. We understand by it, a characteristic of a concrete event that defines how the quality of the event has changed from state 0_1 to state 0_2 at two different places E_1 and E_2, and at two different moments of time T_1 and T_2. Therefore, when there is some regularity in the changes of quality of social action across space *and* time, we say that there is a certain degree of *dependence* between locations, and this dependence, is exactly what gives its appearance of unity to the archaeological site. "Location" can only be understood in functional terms, that is, according to what changes at each place and at each moment. Consequently, to understand what an archaeological event is, we require knowledge about how social action has changed, and about the specific changes generated by social and natural processes. In other words, our analysis of the spatiotemporal variation of archaeological events will remain incomplete if not coupled with an explanation based on the nature (human, animal or natural) of the event.

The probability of distinguished a particular archaeological event is necessarily related with the probabilities of detecting a *discontinuity* in archaeological space, that is, when the causative actions or formation process acting on neighboring locations are different. This discontinuity is the consequence of interfacial boundaries or contacts, which are the place where two different formation processes seem to join or to differentiate. In other words, social action variability with respect to distance is statistically measurable only within a finite *region* defined by some interfacial boundaries, which are in their turn the consequence of some discontinuities in the spatiotemporal variation of other archaeological features. This is the underlying supposition of spatial analysis in different disciplines (Groshong 1999). Where physical space is undifferentiated, the effects of social action cannot be asserted. We cannot explain the history of water in a lake, because water is spatially undifferentiated. However, if we can distinguish discontinuities along the basin lake perimeter, we can follow the geological transformation of this landscape. In the same way, we are able to define the temporality of social action only in terms of its observable spatial modifications. It is only when physical space (ground surface) has been modified as a result of human agency that we can speak about an archaeological site (Barceló et al. 2003, 2005).

A spatiotemporal discontinuity should be analyzed as the measured changes in value in the spatiotemporal variability of an archaeological event. The underlying idea is that changes in the topology of archaeological space allow us to determine changes in temporal ordering of archaeological events. Both are a consequence of the particular interplay between natural and social events across space and time. Therefore, an archaeological site should be considered as the result of successive and overlapping modification steps (both qualitative and statistical in nature). Therefore, we may define archaeological space as a sequence of finite states of a temporal trajectory, where an original entity -physical space, that is, ground surface- is modified successively, by accumulating things on it, by deforming a previous accumulation or by direct physical modification (building, excavation) (Barceló et al. 2003; 2005). The importance of observable discontinuities in physical space to archaeological characterization lies in the fact that they frequently influence the spatiotemporal variation of other social actions and natural events. Consequently, the spatiotemporal structure of archaeological sites depends very much on where and how different discontinuities are formed. In this sense, the variability of the material outcomes of some social actions and natural events seem to act as classifiers associated with discrete archaeological units with distinct boundaries.

However, no simple division of archaeological space into visually apparent regions will give us a temporal model of archaeological events (Barceló & Pallarés 1998). Spatiotemporal discontinuities are not necessarily visual features of the archaeological space. We are not interested in analyzing a spatiotemporal discontinuity in itself, but as a source of variation in the probability of social actions. It is of paramount importance then to describe not only the presence or absence of such discontinuities, but specially the physical and mechanical attributes that control their visual features (shape, size, texture, composition and location). After all, such discontinuities should be explained as the qualitative/frequency nature of observable changes in the physical space generated by social action, and their properties also explain how they influence the spatiotemporal location of other actions.

Below the level of the archaeological and depositional event, there is a single event which appears to be fundamental for the proper temporal ordering of higher level events. The *Isotopic event* which is just the date of the separation of certain substance which includes carbon of the source from which that carbon was obtained (Van Strydonck et al. 1999, p. 434), i.e. particular death event, measured by ^{14}C method. It is the only event whose location could be measured by exact methods.

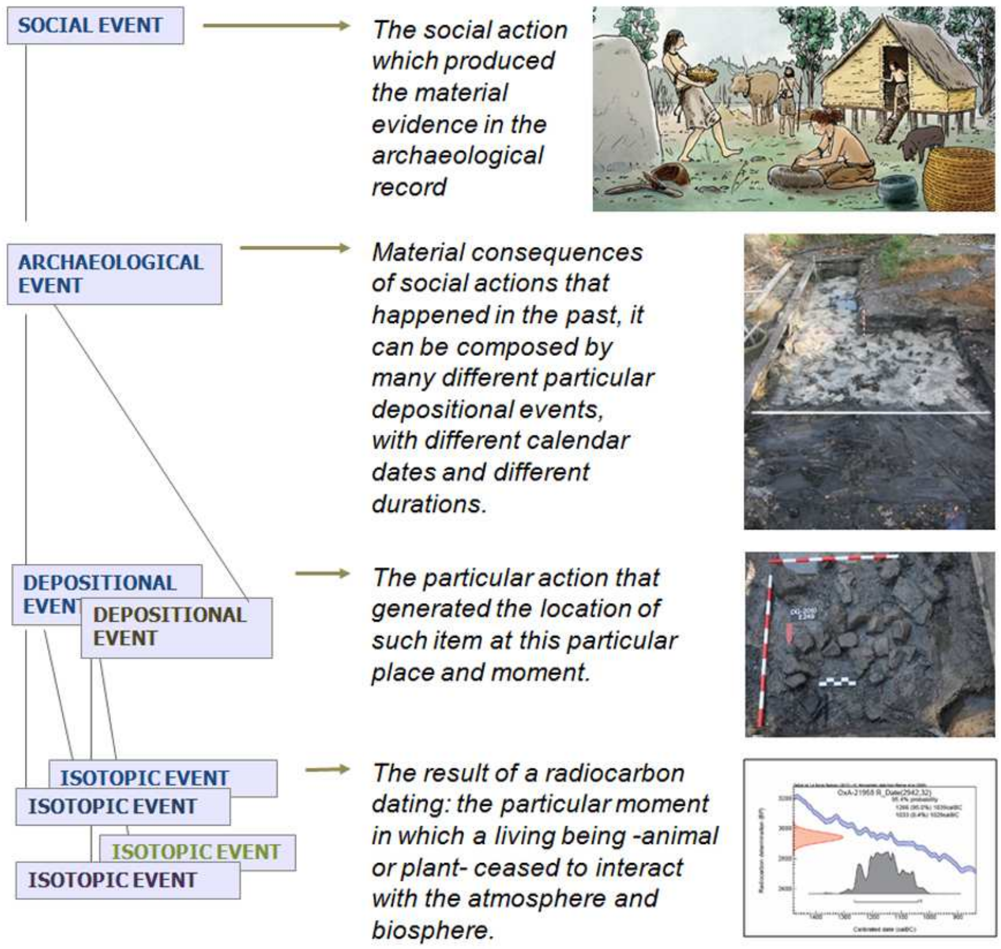

Fig. 25 – The architecture of our chronological inference chain, as proposed in Barceló, Bogdanović, Capuzzo 2012, 2013.

But a mere aggregation of particular and partial isotope events do not make a depositional event, nor an archaeological event provided the particular relationship between actions, agents and products is not taken into account. Instead, we should distinguish the possible occurrence of an isotopically determinable death event. It is the particular moment in which a living being -animal or plant- ceased to interact with the atmosphere and biosphere. We assume that the most probable calendar date of a depositional event will be the nearest possible to the isotopically measured calendar date of the isotopic event, with a standard error determined by the duration of the depositional event.

Each partial isotopic event was performed in a particular *sequence* in relation to other partial events. To know the particular order of an occurring social action within the temporal sequence we should measure the temporal distance between such particular event and a referential event (for instance, today). Consequently, a simple addition of calendar dates of particular events within a single period do not produce a consequent image of the time interval because of the influence of the possible overlapping of different particular events, and overlapping of different, although related trajectories.

Therefore, we should relate each isotopic event with corresponding depositional events, i.e. stratigraphic and taphonomic information of each dated sample. Defining context reliability is a fundamental step for obtaining a true relation between the radiocarbon probability intervals and the depositional event we are referring to. Nevertheless, calendar dates of isotopic events are not enough for building historical chronologies. A particular logical connection should be found within the isotopically determined calendar dates of all determinable death events within the same depositional event. The estimated calendar date and duration of all synchronous depositional events within the same archaeological event will be used to measure the date and duration of events higher in the hierarchy. The calculated calendar date and duration of all archaeological events within a single historical event should be used to compute an estimation of the initial and final position of events within the historical period.

In the light of such assumptions, to date history we propose following inference chain (Fig. 25):

Isotopic Event → *Depositional Event* → *Archaeological Event* → *Social Event*

To sum up, the starting point of the chain, as already mentioned, is represented by its basic unit, the ^{14}C date (isotopic event). Such a time span, in most cases, cannot correspond to the exactly moment we want to date. This is the main reason why we have to push to an upper level of our inference chain, which is represented by the depositional event. It can be defined as the particular action that generated the location of such item (for instance a fireplace, or a floor) at this particular place and moment. The date of the depositional event to be as more and precise as possible must be composed by more than one isotopic event. Higher than the depositional event is located the archaeological event, which correspond to the material consequence of social actions happened in the past and it can be composed by many different particular depositional events, with different calendar dates and different durations. On top of our chain we have the social event, i.e. the social action which produced the material evidence we can detect from the analysis of the archeological record. Such kind of structure implies that all the events, excluded the isotopic one, are an assemblage of punctual events with different durations.

Many times there is not enough information to define archaeological events from the description of temporally asynchronous depositional events. Although the relevance of spatial information has been argued early in the history of archaeology, main efforts were faithful to systematization of vertical disposition of layers and objects in order to establish relative chronologies. The key developments for spatial and temporal analysis in the method of archaeological excavation and recording are certainly the Kenyon method of phasing (Kenyon 1971) and the Harris principles of stratigraphy (Harris 1975, 1979). The phasing method, as well as the stratigraphy method concern strata as packages distinguished by sediment homogeneity and specific content. Each individual deposition episode is represented as a node in the graph, and relative chronological relations are shown as lines between the nodes.

Although events which have produced formation of layers have certain duration, the nodes in a Harris Matrix are points in a one-dimensional partial ordering, rather than time spans. Nodes organized in graph by the low of superposition may only describe three situations:

- something is later than, or earlier than something else
- there are no relationships between two,
- the two are contemporaneous.

On these assumptions Holst (2004) suggests that an accurate structural analysis of chronological consequences of different depositional events, can give us starting and end point of one event. Relating stratigraphic units in that way may not respond only to the law of superposition, but it may represent their causal relation. The possibility of representation of durations has to be represented by a new concept: “broadly contemporary”, which expand classification of chronological consequences.

Further developments of temporal reasoning have opened the door to new background knowledge for building chronologies. It has been suggested that events happen within “coherence volumes”, where all living and dead participants “meet” (Doerr et al. 2004). Causal relationships and event order information produce a temporal network, which in combination with absolute dates can fix “floating” events in one relative chronology.

History is not a simple succession of episodes on a timeline. It is a flow of events that origin consequences in other, posterior events. Spatial information cannot be transformed into temporal information in any simple nor formal way. We need additional information. This statement has been asserted in modern causal analysis (Shafer 1996; Pearl 2000; Sloman 2005), when it has been formally proved that to connect causally an event with another in the same historical trajectory, four conditions are necessary:

- one event should precede the next one in the trajectory, or be contemporary,
- when two events are independent, there should be a location in the graph representing the historical trajectory where both have their probabilities altered,
- one event tracks a second when the probability of the second is the same in any two graph locations where the first happens and the same in any two locations in the graph where the first fails,
- one event is a positive sign of a second if the probability of the second goes up whenever the probability of the first goes up, and goes down whenever the probability of the first goes down. The probability of the second is allowed to change arbitrarily when the probability of the first does not change at all.

The first condition can be archaeologically tested in a Harris/Holst diagram showing seriated temporal units, although without causal relation between them. The other conditions are much more difficult to analyze in the archaeological record. They are, however, necessary to find an estimation of calendar dates and duration of historical periods on the basis of their constituting events.

As an ordered sequence of related events, the specific chronology of the historical period should be calculated not only in terms of the chronology of the constituting historical events, but also in terms of the specific order or relationship between them. The chronological order depends on the specific ordering based on causal relations between related events within the same period.

Therefore, the process of dating should follow chronological inference chain, which begin with smallest unit, as it can be an *isotopic event*, i.e. the sample which provide us ^{14}C date interval. Relating it with an individual or collective action (for example flint knapping or house building) engaged directly with material transformation represented in a *depositional event*, and then discovering relation of individual actions to *archaeological event*, we can define space, time and content of *social event* which have generated material residues; to arrive finally to processual categories as social transitions, or technological shifts.

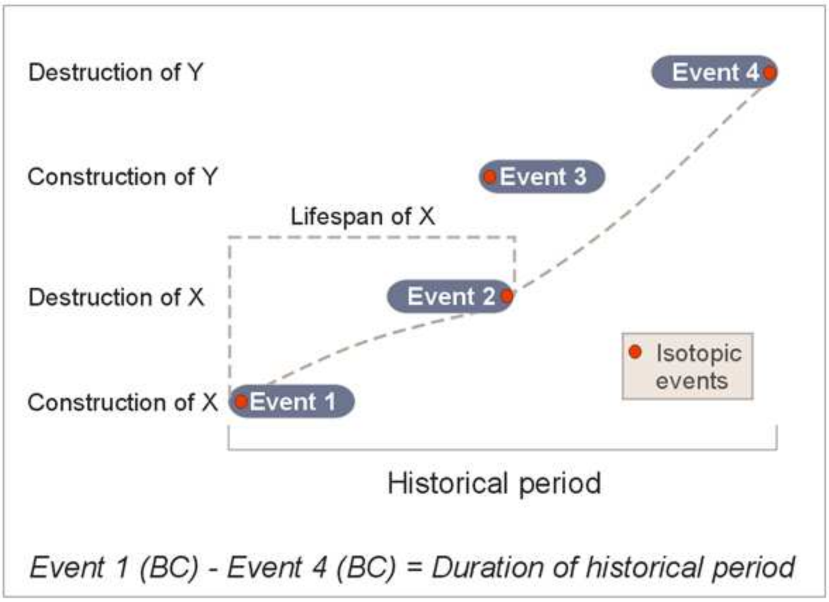

Fig. 26 – Way to describe duration of a historical period.

Although the duration of an historical period, or processual event, can be estimated in terms of the duration of performed social actions, a mere aggregation of events within a single period would be misleading if the particular relationship between actions, agents and products is not taken into account. Each partial event was performed in a particular *sequence* in relation to other partial events, and each one had a particular *duration*.

Duration ("running time", "lifespan") can be defined in terms of the difference between two consecutive points within the same trajectory. Such a trajectory is configured by the particular sequence relating the particular events. Nicolucci and Hermon (2014) follow this idea and suggest that the *duration* of an event is a mapping f from E to, which assigns a real number to an event. The duration measures the time-span of the event.
If there is a dating, the duration of an event can be computed:

$$f(e) = \sup(d(e)) - \inf(d(e))$$

There may exist events that are outside of the domain of the dating function, i.e. for which no dating is available, but having a duration; and events for which neither the dating nor the duration is available.
Note that in normal speech duration may refer to the time length of an event ("a duration of four years") but also to its time-span ("the war duration was from 1939 to 1945").
To know the particular order of an occurring social action within the sequence we should measure its *calendar date* (Fig. 26). Consequently, a simple addition of calendar dates of particular events within a single period do not produce a consequent image of the time interval because of the influence of the possible overlapping of different particular events, and overlapping of different although related trajectories. Of particular importance is the determination of the starting and final point of the Event. We need to distinguish a particular discontinuity in the social actions that took place before and after those actions within the period.
"One of the problems with much existing social archaeology is that it has tried to write a history of very generalized social institutions, made up of vague roles, when it has evidence in general not of roles but of practices" (Shennan 1993: 55 [in: Lucas 2012: 170])
Although we do not know what actions have produced what material consequences, we can relate the variability of observable features included in archaeological record, as location, shape, size, content, composition, and texture, with the variability of social actions through time and space. Consequently, we can infer the variability of social action from the variability of the archaeological record, and we can infer social organization from the variability of inferred social actions.

4.5 From theory to method. Estimating the duration of historical periods

The determination of the order of occurrence of past events is what we usually cal "chronology". It necessarily involves obtaining information to determine the *sequence* of these events. A *succession* can be defined as the dimensional representation of the relational structure of similarities/differences between events. In archeology spatial contiguity relationships are the most usual way of building archaeological sequences. The paradigmatic example is the Harris Matrix (Harris 1979; Trigg 1993; Sharon 1995, Herzog 1995, 2002, 2004; Blakham 1998; Estévez &Vila 2000; Roskams 2000; Holst 2001, 2004; Bibby 2002; Day et al. 2005; Barceló et al. 2005). Non-spatial continuity relationships can also be used to build a succession reflecting the pass of time. It is what we usually refer as "seriation": the more similar is the shape of two objects, or the more artifacts of the same type in the same context, the closer in time are their respective archaeological events (Ford 1962; Djindjian 1990; Barceló & Faura 1997; Buck & Sahu 2000; Baxter 2001, 2003; Mameli et al. 2002; O'Brien & Lyman 2002; Halekoh & Vach 2004; Lipo et al. 2006).

In any case, any ordering of archaeological events will give us information about the *duration* of such an event. The duration of an event is nothing more than an estimate of the difference between two consecutive turning points in the same sequence. For example, a S_n event may be older than other event S_{n+1}. If we have a proper estimate of the most probable date for each event, the difference between the oldest and the newest can be understood in terms of an estimation of this duration. If S_o is the proper date of an event of reference, whose date is well known,

$$\Delta t = (S_i - S_0) - (S_{i+1} - S_0)$$

A "historical period" is a qualitative range of time within which a number of events is assumed to have occurred, although generally, the type and form of the relationship between such events is unknown. Historical periods are constituted by an ordered series of events, defined in terms of the actions that took occurred. To be able to define this period, constituting events must be contiguous in space-time. The purpose of a chronological analysis is then to estimate the probability that some event (isotopic, depositional, archaeological, social) starts or ends at some particular moment of time (Doerr et al. 2004). Hence, the process of estimating the duration of an event actually involves the testing of a statistical hypothesis, rather than direct inference. The estimate of the duration should not be understood as a measure that summarizes the archaeological dating of the same event available, but as a test of the plausibility of the hypothesis that seeks to determine whether the events are different in time, and then considering the difference of such estimates as a measure of duration (Steel 2001; Bayliss & Bronk Ramsey 2004; Bayliss et al. 2007).

Whereas a cumulative probability density function, in the sense argued by Bronk Ramsey (2009) gives us a hint of continuity and discontinuity along an historical period, a standard histogram giving the *frequency of* dated archaeological contexts per time unit can give us a preliminary intuition of the duration of an historical period (Gascó 1985; Pazdur y Michzylska 1989; Aitchinson et al. 1991) (Fig. 27). Archaeological literature is full of confusions between counts and frequencies. For instance, counting the number of burials at a cemetery is not a measure of the *frequency* of burials, not of the number of repetitions of such a ritual practice in the past because different cemeteries have different extensions and temporal durations. The number of tools of a specific type found at a particular activity area is not a measure of the *frequency* of that archaeological type, because the probability of finding that type is different at different activity areas, and we cannot assume the homogeneity of the underlying process.

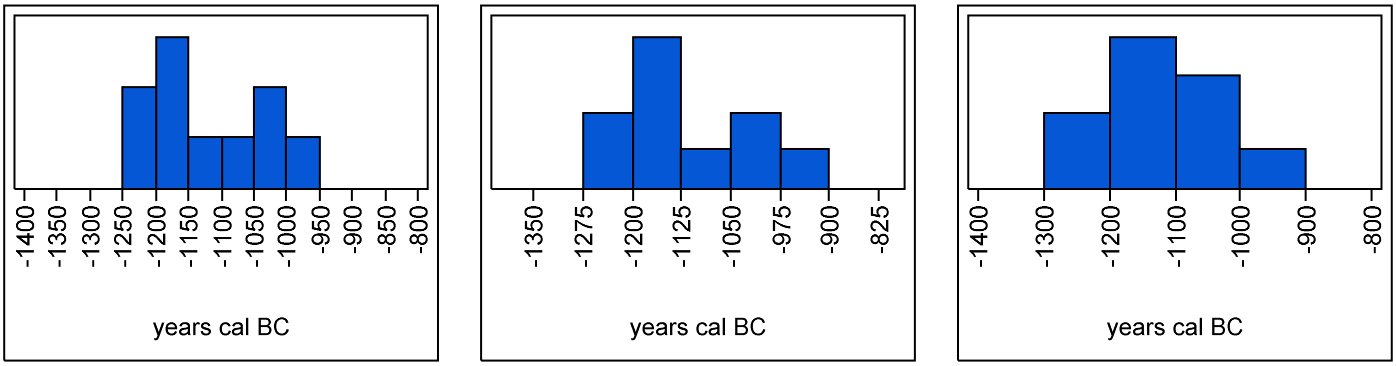

Fig. 27 – Histograms of frequency of the dates included in the dataset at fig. 17. The median values have been adopted. We have used time-spans of 50, 75 and 100 years.

The rationale of the method assumes that the number of dated archaeological contexts in a given time period can be expected to be monotonically related to the length of the time period, i.e. longer periods generate a stronger archaeological evidence which increases the probability that material suitable for radiocarbon dating is collected and analyzed (Surovell et al. 2009). Consequently observed peaks in an histogram of dates, as well as observed peaks and valleys in the SCPD may be taken as a signal of start and end events. The steepness of the slope of an increase or decrease may be indicative of the rapidity of the process of rise or fall. It would obviously be possible to examine patterns like these mathematically, but archaeological practice has generally been simply to examine probability distributions visually (Barceló et al. 2013). Chiverrell et al. (2011) warn of the fact that georeferenced radiocarbon databases incorporate multiple types of dated contexts with differing chronological relationships between the ^{14}C measurements and the dated events, with pre-dating, dating, or post-dating chronological control each displaying variable length temporal lags all mixed together in the same analysis.

More details about the problems remaining with this approach are covered in the chapter 7.

4.6 Bayesian analysis of radiocarbon measurements

When we want to define a historical period in a quantitative way what we have to identify is an interval of time within which an undetermined number of single events happened. One isotopic event (radiocarbon date) is not enough for describing it correctly. In fact, the duration of each event is enabled by many isotopic events, hence it is not punctual in time, but it is represented by a time-span which includes all the probabilities of the radiocarbon dates which make part of the depositional event and of the archaeological event too. As a consequence, we absolutely need to take into account a large amount of isotopic events, which has to be analyzed through statistical techniques in order to provide the correct answers to our questions. Therefore, dating an archaeological event means to restrict the region of coherence characteristic of that assemblage of isotopic events, defining the temporal boundaries. The degree of precision of each one of the single dates, like the duration of each event, is the main variable for the precision of the archaeological event. Theoretically, to restrict the uncertainty we could calculate the average of the dates of each specific event which forms the archaeological event. In this way we could correct the distortion caused by the uncertainty of the dates (Mychzyńsky 2004; Dolukhanov et al. 2005). However, this assumption is only valid when the dated samples are homogenous, i.e. they come from the same item, for instance the same bone or the same wooden feature. In this case the error characteristic of the archaeological event is normally distributed symmetrical, so the weighted average of the dates of different samples of the same event can be used as estimate the central trend of the archaeological event. Hence, assuming that the date of individual samples are in agreement, we could combine more than one date in order to produce a more accurate one, as their combination would provide a better estimate of the error associated with each date and the calibration process. As much dates of the same event, as greater the precision of the date would be (Long & Rippetau 1974).

Currently, datasets composed by a great amount of radiocarbon dates have been developed. Therefore, the necessity to take into account and to analyze a large number of ^{14}C dates is a fundamental stage in order to date correctly history. When we want to analyze such datasets we need statistical tools, which take into account any kind of information we have about for instance the contexts of provenience of the samples.

Currently, the most widespread approach to interpreting radiocarbon dated archaeological contexts in the Bayesian one. The fundamentals of such an approach are presents in the Bayes' theorem, which represents an important result in the mathematical manipulation of conditional probabilities. Two years after the death of the Reverend Thomas Bayes, an English mathematician and Presbyterian minister, his main work "An Essay towards solving a Problem in the Doctrine of Chances" was published (Bayes 1763). In this dissertation Bayes introduced the so called Bayes' theorem, which states the relation of probability between two or more elements as it is expressed in the formula:

$$P(A/B) = \frac{P(B/A)\,P(A)}{P(B)}$$

In which:

- *P(A)* is the probability of the event *A*
- *P(B)* is the probability of the event *B*
- *P(A/B)* is the conditional probability of *A* given *B*
- *P(B/A)* is the conditional probability of *B* given *A*

In such formula we can distinguish three main kinds of information; the first one is the posterior probability *P(A/B)* or the probability of a particular parameter set given the measurements and the prior, the second one is the prior information or the information about the parameters *P(A)* and *P(B)* that we have apart from the measurements, the third one *P(A/B)* and *P(B/A)* is the likelihood for the measurements given a set of parameters (Bayes 1763, Buck et al. 1996; Buck & Millard 2004; Bayliss et al. 2007; Bronk Ramsey 2009a). Therefore, through such an approach we can makes inferences based on the *a posteriori* probability distribution of the parameters as given by, which combines *a priori* probabilities for the parameters with the likelihood of the data (Buch & Millard 2004).

The most relevant source of information is represented by the prior information, or *a priori* information, using the Latin term. Its role is to force the final result to follow certain assumptions. Such constrains are based on the previous knowledge obtained on the problem that we want to solve before observations are made, in particular, it relates with the ordering of the data in case of radiocarbon dating. Consequently, through the term posterior or *a posteriori* information we refer to what is held after observations are made. Bayesian statisticians obtain posterior information by combining prior knowledge, a likelihood function and relevant data (Buck & Millard 2004).

But how can we apply it in the analysis of radiocarbon dated archaeological contexts?

In the Bayesian radiocarbon, this mathematical theory was introduced in order to define probability of success for cases in which the observed data are provided with qualitative or semi-qualitative information about the relative relationships between the samples and the expected results.

Currently, Bayesian approach is fundamental for the analysis of radiocarbon dates. In facts, it deals both to the process of calibration and to the treatment of a dataset composed of a large number of ^{14}C dates. In the first case it uses the information from the new measurement and information from the ^{14}C calibration curve. In the second case Bayesian statistics provides a coherent framework in which such analysis can be performed and is becoming a fundamental point for several radiocarbon dating researches. In fact, once calibrated ^{14}C dates have probability density functions which are not normally distributed density functions, as a consequence, many of the standard methods of classical statistics cannot be applied (Bronk Ramsey 2009a).

It is meaningful to remember that in archaeology “there are two main types of date information available to us in the study of chronology: calendar and relative” (Bronk Ramsey 2009a). The first one is represented by events whose absolute age is previously known by different sources (dendrochronology, documentary sources, etc.); the second one gives us information about the ordering of studied units. The relative one is directly connected to the analysis of the contexts and hence to the stratigraphic sequence of the archaeological site.

During the process of modeling a dataset of radiocarbon dates in order to build an age depth model thanks to the Bayesian statistical analysis we can introduce such prior knowledge in terms of the order of the dates in the sequence. It follows that the results of the models must accomplish these pre-established criteria and the dates which do not respect such criteria should be considered outliers, and the reason for a date to be an outlier must be accurate checked.

Nowadays, several tools are available in order to calculate the posterior probability distributions of an existing sequence of dates. The most widespread for analyzing ^{14}C dates is the software Oxcal 4.2 (http://c14.arch.ox.ac.uk/oxcal.html) elaborated by Christopher Ramsey and his team at the Oxford Radiocarbon Accelerator Unit.

The order of dates in the sequence can be obtained mainly in two possible ways, depending on the aim of the age-depth model we want to obtain.

According to a micro and semi-micro scale, like in a settlement the radiocarbon dates need to be linked to the observation in the archaeological stratigraphy and this will be our likelihood distribution of data. It follows that samples located in more recent stratigraphic units should provide more recent dates than sample collected from older strata in the sequence. In this first case our aim is to quantify the time boundaries of different strata (e.g. archaeological and depositional events) with ^{14}C dates. If we adopt a macro scale, like for instance for the study of a region, we can use phases composing the conventional chronology as a prior information. In this second case dates are ordered according to the typologically dated archaeological contexts; the aim is to quantify the boundaries between the various phases.

Furthermore, in the OxCal 4.2 Software we can also add another kind of prior information which deals with the location in time of our data, for instance a precise temporal value with the function of *terminus post quem* or *terminus ante quem* for the archaeological sequence, in English the “date before which” and the “date after which”. Such values constrain our data to be located in time before or after a particular past event took place. An example can be traced in the recent ^{14}C-dated eruption of Santorini (Thera) in Greece which spread a great amount of volcanic ashes in the Eastern Mediterranean. Such deposits, which were trapped in the archaeological record over a macro-area, can be currently used as a time-marker to define the chronological sequences of many sites. The event has been dated to the 17th c. BC in the Middle Bronze Age (LaMarche & Hirschboeck 1984; Hammer et al. 1987; Baillie & Munro 1988; Manning 1988, 1999; Manning et al. 2002; Hammer et al. 2003; Bronk Ramsey et al. 2004; Wiener & Earle 2014). Recently, a branch of olives that was buried in tephra in Santorini has provided the following date 1621-1605 BC for 1σ probability and 1627-1600 BC for the 2σ (Friedrich et al. 2006).

In any case, we need to build the model according to our understanding of the sequence and this is our prior distribution. In OxCal 4.2 the modeled distribution of the data is given as the posterior distribution with the calculated agreement indexes. Moreover, the modeling enables narrowing down the sometimes quite large ranges of dates, and makes relatively precise dates to each archaeological layer dated. This is actually one of the main advantages of the technique.

In the program we can introduce both the dates and the different available prior information, both relative and calendar. In case of calendar ages, such information is introduced in the software for the Bayesian chronological analysis as a probability density function, it represents the likelihood and the relative date information is the prior (Bronk Ramsey 2009a). However, as noticed by Ramsey (2009a), “ultimately the distinction is somewhat arbitrary and one can simple see the statistical method as a way of combining all of this information together”.

The result of the modeling produces a sequence of dates associated to an agreement index which establish the validity and the strength of the model. In OxCal 4.2 the agreement between the posterior distribution of the data and the prior distribution follow a convention, meaning that 60% is taken as the threshold for acceptance for the individual and overall agreement indices. If the agreement index is less than 60%, this means that the data do not fit the model and a re-evaluation of the data or of the model is needed. OxCal 4.2 provides agreements indexes both for the single radiocarbon dates and for the whole model with the indices A_{model} and the $A_{overall.}$

It deserves a particular attention the method used by the OxCal 4.2 software for defining the structure of a phase. It relates to the already expressed concept of event. Indeed, a phase can be seen as a depositional event, an archaeological event or a social event and it is described by two other events, a Start event which establishes the beginning of the phase and an End event for the finish of the phase, we can refer to these events as boundary events. “The type of group is defined by the type of boundary used. A simple Boundary at the start and end of a group defines a uniform phase. A Zero_Boundary is used to define the start or end of a group where the event rate has a ramped distribution. A Tau_Boundary can be used to define an exponentially distributed group and a pair of Sigma_Boundary statements, a normal distribution. The latter two types of group allow the events to spill beyond the dates of the boundaries themselves and allow the creation of models of processes that do not have definite start and end events" (Bronk Ramsey 2009a). An example of such a construction is represented in figure 28.

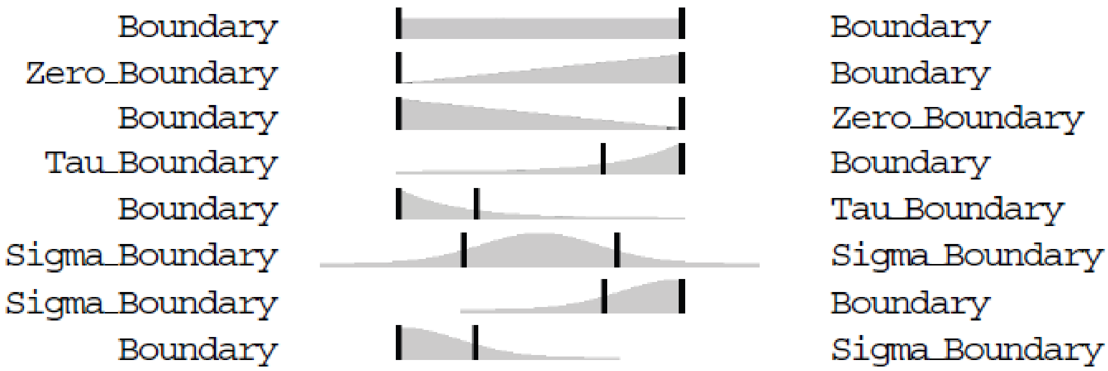

Fig. 28 – Structure of the events (phases) in OxCal 4.2. All the events are sandwiched between two boundaries and treated as a single group (Source: Bronk Ramsey 2009a).

The different types of boundaries imply different constraints on the radiocarbon dates included in each phase. Eventually, the program provides modeled values for the 1σ and the 2σ for both ^{14}C dates and boundaries.

The application of such a methodology on the European Bronze Age and Iron Age transition case study will be approached in chapter 6.

5 THE EUBAR DATABASE

5.1 Introduction

The last decades have been characterized by a growth in the amount of radiocarbon dates databases for European Prehistory. Many of them can be consulted on-line, like for instance the BANADORA (http://www.archeometrie.mom.fr/banadora/) developed by the CNRS, the *Université Claude Bernard* - Lyon 1 and the *Université Lumière* - Lyon 2, the RADON – Radiokarbondaten online (http://radon.ufg.uni-kiel.de/pages/home) (Hinz et al. 2012), the database of radiocarbon and stable isotopes measurements of the Royal Institute for Cultural Heritage in Brussels (IRPA-KIK) (http://c14.kikirpa.be/), the recent database of Archaeological Chronometry in Slovakia (http://www.c14.sk/) and the Database of Catalan Radiocarbon Dates developed by the Laboratory of Quantitative Archaeology of the Autonomous University of Barcelona and the Museum of Archaeology of Catalonia (http://www.telearchaeology.com/c14/). For the structure of the EUBAR database[7] we took as a model the Catalan database, which has the advantage of including information about the context and some particular classes of material remains associated with it.

The EUBAR database includes information about more than 1600 radiocarbon dates from every kind of archaeological context from a wide territory between the Ebro and the middle course of the Danube River. The area embraces the North-Eastern part of the Iberian Peninsula, Andorra, Southern France, Northern Italy, Switzerland, Liechtenstein, Austria and Southern Germany. In some punctual cases we have also introduced data from the neighboring territories, like Slovenia, Czech Republic, Northern Germany and Central Italy. The analyzed time span goes from 1800 to 750 BC, the end date is determined by the "Hallstatt plateau": a plane form on the calibration curve, caused by variations in solar activity, which debars us from taking into account dates between 750 and 400 because the results would be characterized by too large a time span, and so would not be useful for a statistical analysis (Van Geel et al. 1996; Van Geel et al. 1998;

[7] The EUBAR database can be looked up in the webpage http://www.telearchaeology.com/.

Speranza et al. 2000; Tinner et al. 2003; Dergachev et al. 2004; Van der Plicht et al. 2004; Swindles et al. 2007; Barceló 2008) (see chapter 4.3.2.1). Each entry of the database corresponds to a single radiocarbon date. Our challenge has been to collect lots of information about ^{14}C dated archaeological contexts, which were dispersed in different journals and monographs, many times the publications were in different languages according to the country of issue. Such a big source of data has been integrated in direct communication with the authors of data, who offered us the opportunity of developing a more up to date database.

5.2 Location in the physic space and in time

The location of the archaeological site from which the sample collected for the radiometric analysis originates is a primary issue in a database of radiocarbon dates. Regrettably, as we were not dealing with first hand data, but with data coming from a wide variety of excavations, in the majority of cases such kind of information is provided just in a qualitative way or it is even missing. Frequently, just a general location of the archaeological sites is reported in the references, often using photos which do not allow defining the exact location of the archaeological evidences in the territory. In light of this situation, an important issue of the database is the quantification not only of the concept of time but also of the space. Therefore, even though for each samples we have reported the position of the site in a qualitative way (municipality, province, district, canton, region and country), we have also marked the location using the geographic UTM coordinates in meters. When precise locations of the collected samples or at least of the site were lacking we employed published photos of the site together with the software Google Earth (Software: Google Inc. (2013). Google Earth, Version 7.1.1.1888) in order to define a correct position in space for the archaeological evidence. In the most unfortunately cases, in which just the radiocarbon date was edited with a general position according to qualitative information like the municipality of the archaeological site we tried to provide a location using the geographic coordinates of the municipality and the description of the deposit given in the bibliography. Such cases have been marked in the database; in fact the location is not truly reliable and should be associated to a standard error.

In each entry the location of the site/dated context was also reported according to the correspondent geographic regions. These values could be useful when exploring the data, for instance when want to visualize the dataset of a certain area characterized by a geographic homogeneity.

The z values (altitude) for the gathered samples were in most cases not given in the references, hence we did not include such values in the database.

Regarding the notion of time we have reported for each sample the radiocarbon date both in years BP with the associated standard deviation and in years cal. BC for the 1σ (68,2%) and the 2σ (95,4%) probabilities. The dates were all recalibrated using the last calibration curve IntCal13 (Reimer at al. 2013) and the software OxCal 4.2 (Bronk Ramsey 2009a). When the information about the conventional chronology of the context associated to the sample was provided by the references, it was reported in the entries. Four traditional chronological frameworks for the Bronze Age and the beginning of the Iron Age were considered: the Spanish chronology, the Southern French one, the Italian chronology and the chronological terminology adopted in north of the Alps regions (Switzerland, Austria and Germany) (see chapter 2). The year in which the samples were analyzed is also indicated in the database, when the exact year was absent in the references we used a time-span which embraces the period between the date of the excavation and that one of the references' publication.

5.3 Site, material and archaeological context

After the location in space and time of the radiocarbon dated archaeological site we presented the function of the site and its typology. In the EUBAR database every kind of archaeological context has been included. The majority of the samples originate from settlement area, followed by funerary contexts, mines, infrastructures (like bridges or routes) and cultural areas. For a small amount of samples such information was lacking. Then, among the large variability in the typologies of the sites we have specified the corresponding one for each ^{14}C dated archaeological site. In case of the funerary contexts the typology of the tomb and the funerary rite has been indicated.

The successive part of the entry relates to the analyzed material. As we already highlighted in the chapter 4 not all organic materials provide dates with the same degree of quality, therefore it is necessary to know from which kind of material the date originates. In the EUBAR database such information is correctly reported in each record, as well as the provenience of the samples, which is fundamental in order to check the context reliability and consequently the quality of the date. The critical analysis of each radiocarbon date, concerning the stratigraphic and taphonomic information of each sample has been an essential step in order to define the context reliability.

Regrettably, in the majority of the databases of radiocarbon dates few or no information about the materials associated to the dated sample is present. This represents a clear stumbling block for any research whose starting point are the radiocarbon dated archaeological features.

As an onset of such situation we decided to dedicate a large part of the EUBAR database to the description of the context associated to the radiocarbon sample, which represents the main and the most relevant part in the database. 35 variables which can be associated to the dated sample were selected. The majority of the values are indicated in terms of presence/absence of such variables. We took into account variables referring both to settlement and funerary contexts, and in particular we have used functional and economic typologies, in order to collect information about the society that created the analyzed archaeological record. The variables can be divided into two macro groups; the first one is composed of the social and economic factor, like the subsistence base, the settlement structure and the exchange networks; the second one is made up of pottery typologies characterized by macro scale diffusion.

5.3.1 The importance of social, cultural and economic variables

The aim of the EUBAR database is to collect information which can be useful in order to understand which kind of society left the traces documented in the archaeological record. The reconstruction of past social actions through the analysis of their material remains represents a main aim of our research. To achieve this goal it is of basic importance the presence of variables which can provide us information on this topic. In particular, in early complex societies like those who populated European territories during the Bronze Age and the beginning of Iron Age the necessity of taking into

account multiple factors relating to cultural, social and economic features in their correct space-time depth is an essential point for every kind of spatio-temporal analysis.
The first and the major variable included in the database relate to the funerary ritual. In particular, we have distinguished between inhumation and cremation burials. We have additionally reported information about the type of the tomb, including individual graves, double graves, multiple graves and princely burials. The study of funerary contexts, included in the so called archaeology of the death, is fundamental in order to reconstruct the societies of living beings (Saxe 1970; Binford 1971; Chapman et al. 1981; Tarlow & Nilsson Stutz 2013). In fact, we must remember, as Bradley (1989) pointed out that the treatments of the dead of a community are a result of the conscious and intentional decisions taken by living people. Hence, such decisions can reflect many aspects, like the status of the deceased *his* or *her* social position in life, the position of *his* or *her* kinship group, the richness of the group (Ruiz Zapatero 2004).
The second variable included in this group is represented by the settlement structure expressed through the *presence of traces of fortification*. According to several authors one of the main features of the analyzed period is a trend to a settlement concentration, which is the background for the rise of Iron Age historical towns, and also the diffusion on a large scale of fortified villages, which are a clear evidence of social tension (Kristiansen 1998b). In the EUBAR database we have distinguished among different types of fortification like, for instance, *walls of stones*, *palisade*, *ditch*, *embankment* and *natural fortification* due to the location of the site. Such categories cover a wide range of settlements typologies whose arise in Prehistoric Europe matches with the central and last phases of Bronze Age. In this framework we can cite two typologies in particular: the *Terramare* settlements in the Po Valley (Northern Italy) characterized by the presence of a earthwork encircled by a wide moat supplied with running water (Bernabò Brea et al. 1997), and the *castellieri*, developed in Istria, Dalmatia and neighboring areas, whose main feature were one or more walls of stones or a wooden palisade which rounded the settlements usually located on hills (Marchesetti 1903; Montanari Kokelj 2005; Bietti Sestieri 2009).
The third and the fourth variables relate to the subsistence base; they are a reflection of the type of economy carried out by the social group who inhabited the settlement. We have included in this group the *predominant domestic animal* and the *presence of agriculture*. The knowledge about the first one originates from the studies of the faunistic evidences collected in the archaeological record. The values adopted by this

variable are *cattle*, *pigs* and *sheep and goats* or the association of them. When provided by the references we have marked for the variable *predominant domestic animal* both the number of fragments (NF) and the minimum number of individuals (NMI). The variation over the time in the values of this variable can allow detecting changes in the economic subsistence base which can be caused by different factors that should be taken into account case by case. For example, the predominance of cattle remains in a settlement can be the result of an advanced agricultural economy, in which the cattle was employed not only as a supplier of meat and milk but also as source of labor force (Tecchiati et al. 2011).

Regarding the *presence of agriculture*, although for the Bronze Age it is widely accepted its diffusion we have marked its occurrence through either the presence of charred cereal remains in the archaeological context or the analysis of pollens.

The variables related to the production, the elaboration and the use of metals are another source of information about the economy carried out in the settlement. Metallurgical activities were performed in specialized areas which could be located in settlement areas or in places mainly dedicated to such a function (Giardino 1995, Krause 1999; Stöllner et al. 2003). The importance and the implications of the control of metallic sources and their network in Prehistoric Europe have been discussed in the chapter 3. For copper, bronze and iron we have indicated both their presence and their elaboration.

Finally, regarding the social, cultural and economic variables we have included in the database information about the exchange networks.

Starting from the Middle Bronze Age there are clearly evidences for the rise of a Mediterranean network of contacts between the eastern part and the western one, which brings materials and artifacts from the Aegean world and the Levantine coast to the Middle Europe. For instance, we may refer to the finds of Mycenaean ceramic coming from villages located in the Padan Plain[8] (Northern Italy) and dated to the 12th and 11th c. BC (Vagnetti 2002). More evidences for contacts even in a larger scale are the finds of two fragments of amber with a written text engraved in Mycenaean Linear B in the radiocarbon dated settlement of Bernstorf, in the municipality of Kranzberg, in Upper Bavaria (Germany) (Moosauer & Bachmaier 2000). On the light of such evidences it was important to include in the EUBAR database variables which allow us to detect

[8] Ceramic dated to Mycenaean IIIC were found in the settlements of Fondo Paviani, Fabbrica dei Soci, Castello del Tartaro, Frattesina, Montagnana.

circulation routes and exchanges in Prehistoric Europe. Therefore, we chose to mark the presence of *Greek* and *Phoenician pottery* as a useful indicator of such circulation on a macro scale. In the same category can be included all those variables gathered under the name of prestige objects, whose production and circulation required a constructed network and a political and economic base able to maintain alive such a complex system. Most of the selected variables in this category are metallic objects like: *swords, daggers, knives, arrowheads, spearheads, fibulas, pins, necklaces, earrings, bracelets, rings* and *axes*. Additionally, we have included the presence of precious materials like *amber* and *ivory*.

The last variable which can be comprised below this macro group is the presence of remains of horse's bones in the radiocarbon dated archeological context.

5.3.2 Archaeological and time markers

Archaeological types are, as David Thomas (1998) put it, the discipline's "basic units of classification...They are idealized categories artificially created by archaeologists to make sense of past material culture" (O'Brien & Lee Lyman 2002). They correspond to the necessity of ordering according to specific criteria the material remains produced by social actions which took place in the past. Among them, archaeologists have always been focusing the attention on some particular kinds of archaeological type, the so called fossil guides. Their short duration in time gives them a value of time marker. According to O'Brien and Lee Lyman (2002) chronological types should accomplish some requirements like a continuous distribution in time and "the period of time over which they occur should be fairly short. In other words, each type should have occurred only once, and it should have disappeared after a short life. Chronologically useful types cannot reappear at a later date". The main problem of using chronological types spread on a wide geographic area is the adoption of the concept of contemporaneity of the same elements located in different places, which does not take into account the possibilities of time gaps between the date of manufacture and the time of deposition. Such an approach has been criticized by several authors (Olivier 1999; Trachsel 2004; Arnold 2012) as explained in the chapter 2.2.

In the light of such considerations, in the last part of the EUBAR database we have included pottery typologies which are traditionally regarded as fossil guides and are also characterized by macro scale diffusion. The variables which form this section are: *handles with vertical expansion*, *fluted pottery*, *carinated cups* and *biconicals*. We have also included some peculiar ceramic decorations like, the *helicoidal ribs,* the *solar motive*, *meanders*, the *chevrons* and the *zig-zag*.

We describe in the details each variable in the following part of the chapter.

5.3.2.1 Vases with handles with vertical expansion

Under the name of *handle with vertical expansion* we have included different types of handles, which are characterized by a plastic expansion that exceeds in its verticality the edge of the ceramic vessel (Fig. 29). Such kind of handles is usually associated to tableware pottery and in particular to forms like the carinated cups. The diffusion of *handles with vertical expansion* covers a wide territory which includes Northern Italy, part of Switzerland, Southern France and the North-East of Iberian Peninsula. Due to the great amount and the extraordinary diversity that *handles with vertical expansion* present in the archaeological sites located in Northern Italy and dated to the Bronze Age, the origin of these types has been usually placed in such an area during the so called *Polada culture*; a material culture whose most relevant evidences are the lake dwelling settlements developed in the regions of Eastern Lombardy, Trentino, Western Veneto and neighbor areas) during the Early Bronze Age (Peroni 1996; Almagro Gorbea 1997; Espejo Blanco 2001-2002).

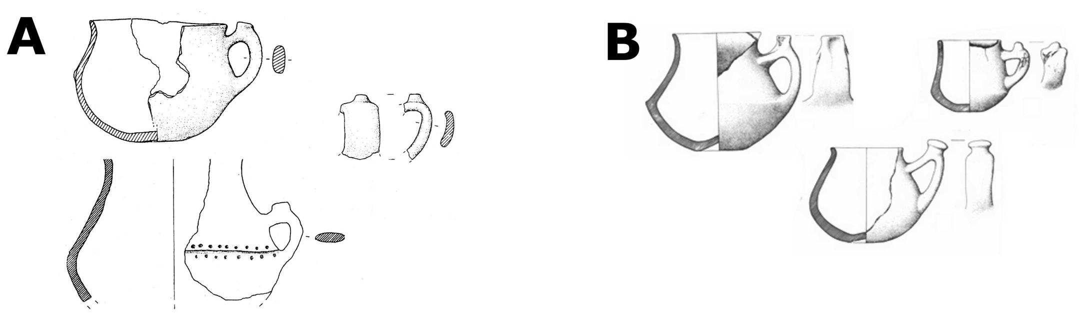

Fig. 29 – *Facies* of Polada, pottery with *handles with vertical expansion* originating from the settlements of Lavagnone (A) and Barche di Solferino (B) in Northern Italy (Source: Bietti Sestieri 2010).

The variability which characterizes types included in the category originating from

North Italian contexts can be appreciated in the figure 30. Such conventional names for the *handles with vertical expansion* types associated to radiocarbon dated archaeological contexts included in the EUBAR database were properly reported in each entry. It represents a relevant issue because a chronological value has been conventionally assigned to *handles with vertical expansion.* In particular, some typologies can be used as time markers, for instance the so called handle *ad ascia* is traditionally a fossil guide for the first phases of Middle Bronze Age in Northern Italy and the handle *cilindro-retta* for the Subapennine archaeological culture during the *Bronzo Recente* phase in Italian LBA (Cocchi Genick 2004; Cattani 2009b; Cattani et al. 2010; Cattani 2011; Desantis et al. 2011).

As we have mentioned before, such variable is characterized by macro scale diffusion. The presence of this kind of handles in the archaeological contexts located in Southern France (regions of Languedoc-Roussillon and Provence-Alpes-Côte d'Azur) can be explained by the exchanges networks between this area and the Subappenine one during the conventional phase *Bronze Final 2b* (Lachenal 2011a). Influences of the Apennine culture in the Southern France were especially intense during the Middle Bronze Age and the beginning of the LBA, as identified by many authors (Dedet 1985; Gascò 1992; Vital 1999; Vital 2004). Starting from the central phases of the LBA such contacts seem to be less frequent, although they are still present as it is attested from the fragments of Apennine pottery originating from the level associated to the *Bronze Final 2* materials in the Grotte Murée near Montpezat in Provence (Lagrand 1968; 1976; Lachenal 2011a).

The types *ad ascia*, *cilindro-retta* and *a corna* are also attested in several Bronze Age archaeological sites located in the North Eastern Iberian Peninsula, where they are gathered under the group traditionally named handles *de apéndice de botón* (Maluquer De Motes 1948; Barril Vicente & Ruiz Zapatero 1980; Alonso et al. 2002; Barceló 2008b; Carlús et al. 2008). This typology has been considered as a fossil guide for the *Bronce Medio* and the *Bronce Final* phases (Rovira 1978; Barril Vicente & Ruiz Zapatero 1980). As an explanation for their introduction in Spanish contexts, it is widely accepted that their presence is a result of trans-Pyrenean contacts motivated by a diffusion process from North Italian area and with the mediation of Southern French human groups (Almagro Gorbea 1997; Espejo Blanco 2001-2002; Barceló 2008b). A quite recent overview over this topic has been published in the journal Pyrenae (Espejo Blanco 2001-2002).

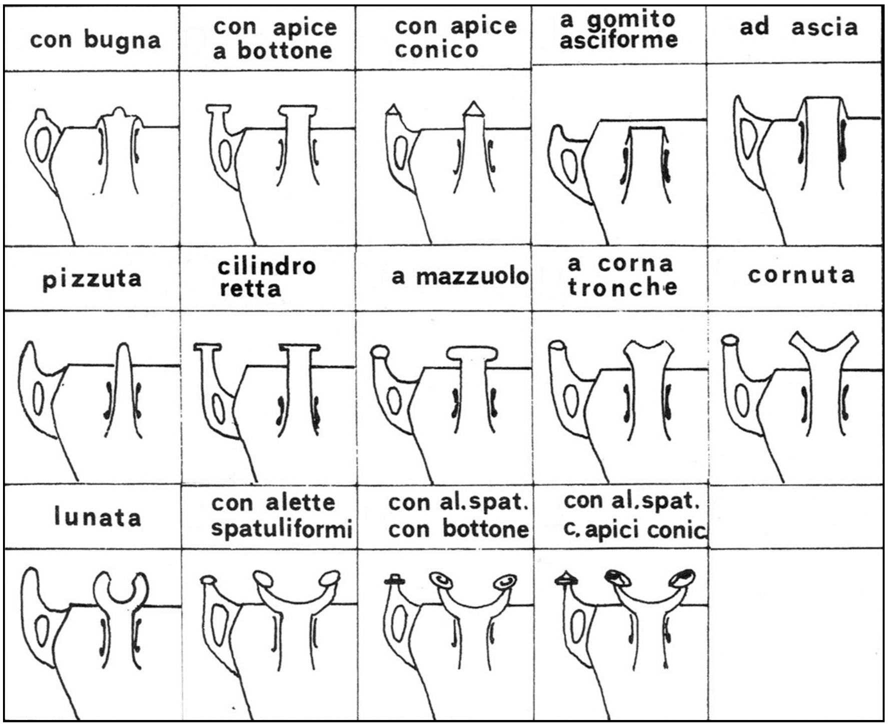

Fig. 30 – Most common types of *handles with vertical expansion* from North Italian archaeological contexts (Source: Guerreschi & Ceschin 1985).

5.3.2.2 Fluted pottery

Fluted pottery is a widespread kind of pottery characterized by a decoration which can cover either the external surface or the internal one. The technique for realizing this kind of decoration consisted in fluting the surface of pottery before its heating using a tool with a blunt point. Such a decoration takes different names in the different European country: in Spain it is called *acanalados,* in France *cannelures* or *décor cannelé*, in the German-speaking area *Kannelur* and in Italy *a grandi solcature*. The most problematic aspect dealing with this variable resides in its recognition. Frequently, the materials associated with the radiocarbon sample are not correctly described and the interpretation of drawings can lead to misunderstandings.

Regarding the decorative scheme pottery with large flutes present an extreme variability. The most common motive is perhaps horizontal large grooves in group of three decorating the upper part of tableware pottery, like *carinated cups*. Also the vertical large grooves, mainly in groups, are common. In particular in north Italian archaeological contexts many other types of decorative motives, which can be characterized by a certain complexity, are attested. Moreover, large grooves can also be present as a decoration usually with a cruciform motive on the base of vessels (see *solar motive*, onwards).

In Southern France the decoration with *cannelures* can be divided in two subcategories according to the dimension of the grooves, consequently it includes *cannelures larges* and *cannelures fines* (see Fig. 31 and 32, Lachenal 2010). In Eastern France and in the German urnfields of the Rhine Area such a decoration is typical for the period of *Bronzezeit D-Ha A1* (Sperber 1987; Mordant 1988; De Mulder et al. 2008), where it is considered as the privileged substrate for the diffusion of the RSFO group (Mordant 1988; Brun 1988; Lachenal 2011a). In Provence and in the neighboring territories this decoration is largely attested in particular during the *Bronze Final 2* phase, whilst in the North-Western Italian archaeological contexts it is attested since the *Bronzo Medio 2* phase (Vital 1999).

The chronological location in the LBA of the fluted pottery was already noticed in 1976 by Hänsel (1976), who stated that fluted pottery was "the only and proper pottery of the Hallstatt period". Nevertheless, it is important to highlight that this kind of decoration was also attested in the first phases of Bronze Age in the Carpathian area, even in a minor amount. In the Danube river basin this ornament is encountered from the Early Bronze Age onward and its Eneolithic genesis cannot be excluded; vessels decorated with vertical grooves were also characteristic of the Baden culture (Przybiła 2009). As far as concern the origin of such a ceramic decoration, some authors have tried to propose some hypothesis but no one of them have been widely accepted by the community of the archaeologists. For instance, a relation of this ornamentation with stylistic of metal vessel from the eastern Mediterranean was suggested among the possibilities (Przybiła 2009).

In the North-Eastern part of the Iberian Peninsula pottery decorated with *acanalados* has been traditionally regarded as a fossil guide for the LBA (Vilaseca 1954; López Cachero 2007). In particular, its introduction in this area has been conventionally associated with the adoption of cremation burials during the last phases of Bronze Age, a phenomenon traditionally regarded as an expansion from the Danube-Carpathian regions in Eastern Europe towards the Western districts (Schauer 1975; Ruiz Zapatero 1983; Sperber 1987; López Cachero 2007). According to a well diffused idea in the last century, that was inclined to join different events under the same process, these two phenomena were related to the same spreading model, which was the diffusion of the *Urnfield culture*. Indeed, in the Carpathian basin the development of the first stage of fluted pottery culture can be placed in the chronological range referred to as the transition between Bz D and Ha A1, which traditionally correspond to the 13th and the beginning of the 12th century BC in the period of the urnfield burials (Przybiła 2009). Nowadays, some studies are slowly changing this perspective, proving that a difference in time ranges can be recognized in the two diffusions (López Cachero 2007; Barceló 2008b; López Cachero 2008). For instance, for describing the diffusion on a large scale of the fluted pottery cultures in the Danube valley in the Carpathian region Gábor Szabo (1996) saw it a result of “homogenizing tendencies in pottery”, therefore not related to phenomena of massive migration, but to the diffusion of ideas (Przybiła 2009).

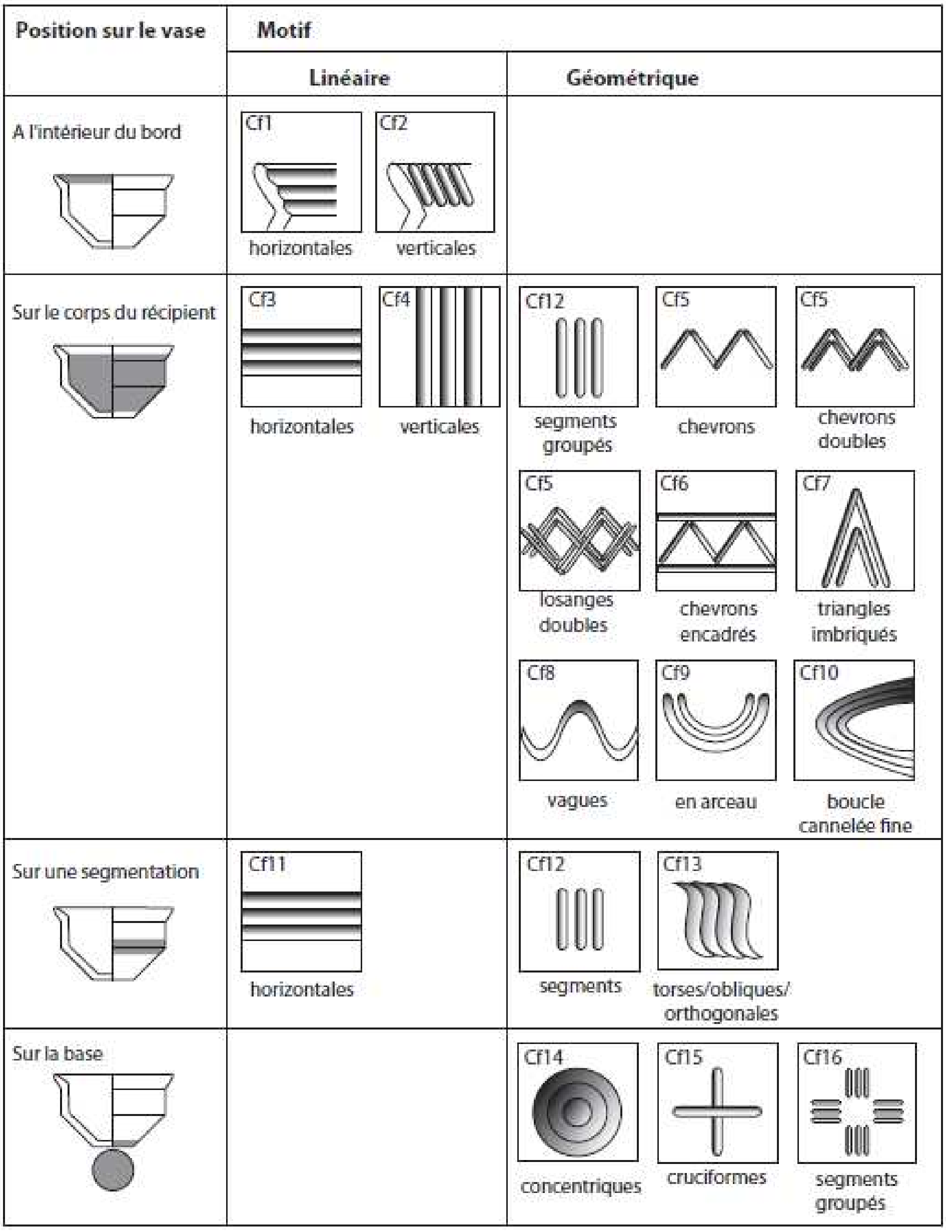

Fig. 31 – Types of decoration with *cannelures fines* from Southern France archaeological contexts (Source: Lachenal 2010).

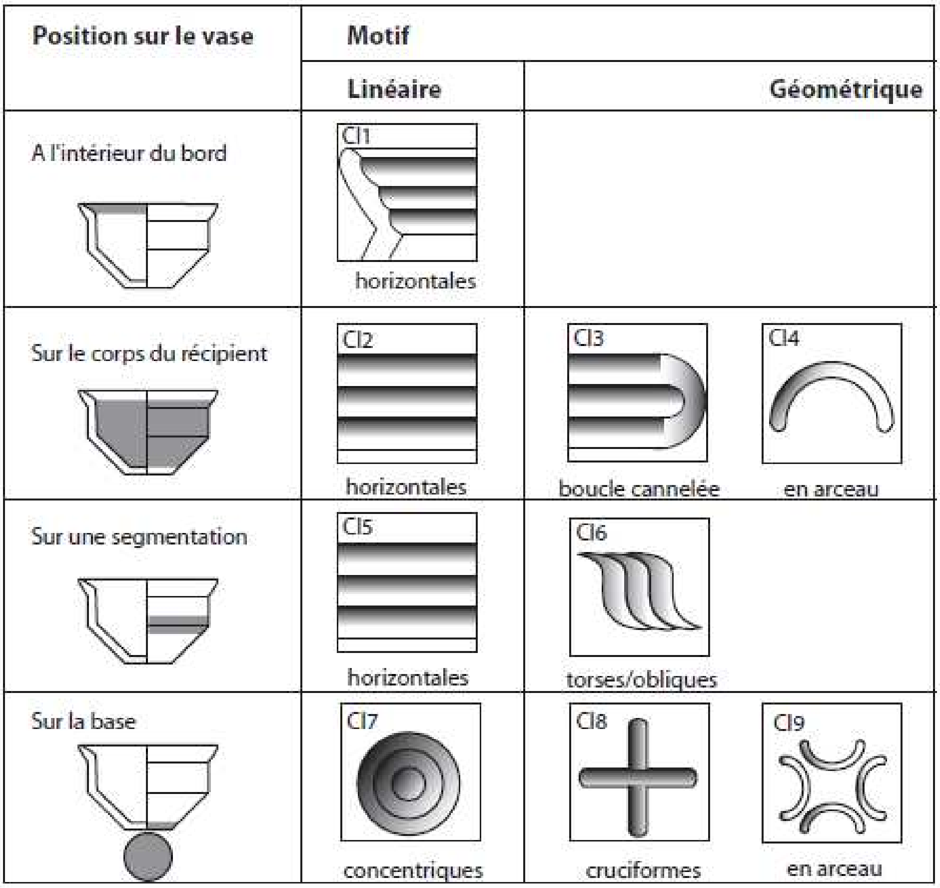

Fig. 32 - Types of decoration with *cannelures larges* from Southern France archaeological contexts (Source: Lachenal 2010).

5.3.2.3 Carinated cups

Among the tableware pottery we took into account a particular form of cup characterized by a large sharp bend (carina) located in the widest central part of the vessels. For such kind of bowls we have used the variable named *carinated cups*. These pots had probably a daily use and they were suitable to contain liquids, in fact the surface was made impermeable by polishing it, in order to reduce the porosity of the clay before the heating.

Within this group a large amount of variants are included especially based on the analysis of the width of the carina compared to that one of the rim and the minor or major develop of the body of the vessel above the carina. Although this variable does not have a so high chronological value as the previous ones, its wide diffusion over an area which includes the whole territory of the EUBAR database was a fundamental element for deciding to take into account this ceramic form. In this case, the research was addressed towards the detection of changes in frequency of such variable more than to the processes of diffusion.

Regarding North Italian contexts according to the typological studies carried on during the second half of the last century we can include in the category several types with their variants (Peroni 1971; Cocchi Genick 1998; Cocchi Genick 2004). According to Cocchi Genick the *carinated cups* are the most representative type of cups in the Italian LBA, their variety depends primary on the position of the carina in the body of the vessel as it can be easily detected in the figure 33 (Cocchi Genick 2004).

The main stumbling block in the identification of such variable, in particular among Italian sites, resides in the terminology used by the archaeologists, which is characterized by differences on a regional scale (Poesini & Agresti 2011, fig. 34). Such situation represents an outcome of the traditional typo-chronological studies carried out during the 20th century. Frequently the terms *ciotola carenata* and *tazza carenata* were employed in order to define forms similar between them, whose only differences were a generally narrower and deeper form in the *tazze carenate*, which are also characterized by the diameter on the rim usually equal o less than the diameter of the carina, by a generally smaller dimension and by the presence of a handle but not a *manico* (Cocchi Genick 1995, 2004). Moreover, due to the fragmentation of ceramic artifacts caused by post-depositional processes an unambiguous assignment to a unique type is frequently impossible to reach.

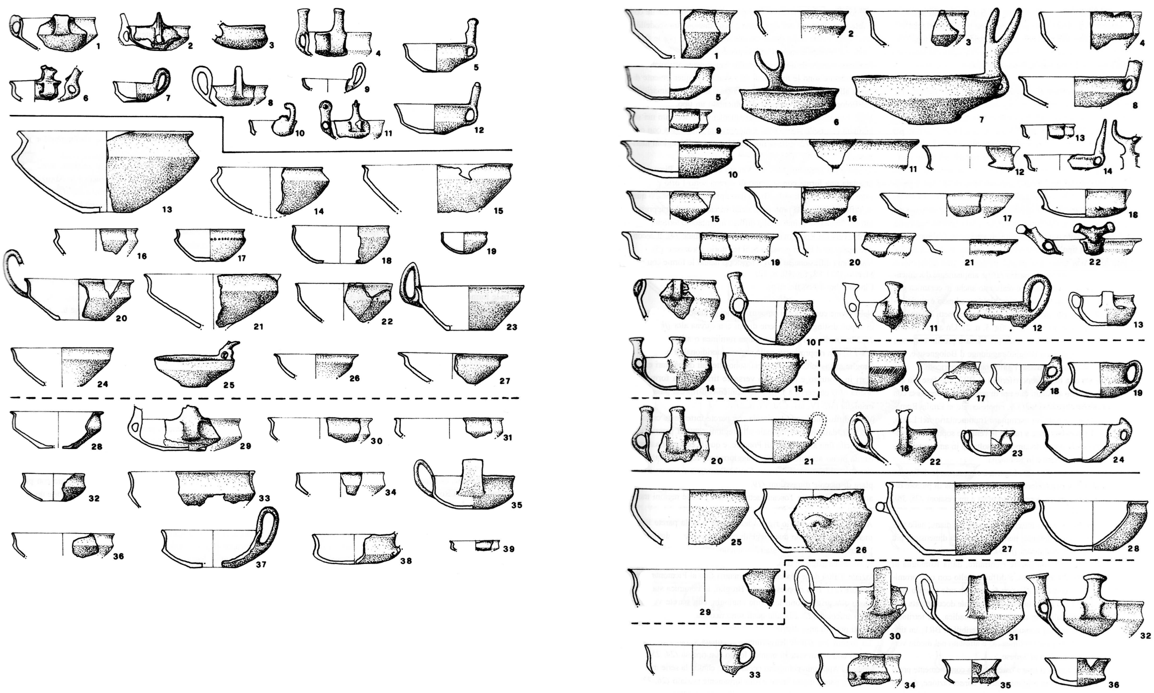

Fig. 33 –Types of *carinated cups* from LBA Italian archaeological contexts (Source: Cocchi Genick 2004).

SARTI, 2005	PARISE BADONI, 1980, 2000	PERONI, 1994	CARDARELLI et ALII, 1999	CÀSSOLA et ALII, 1999	BELARDELLI et ALII, 1999	NEGRONI CATACCHIO et ALII, 1999	BENTINI et ALII, 1999	BONGHI JOVINO, 2001	D'AGOSTINO-GASTALDI, 1988; GASTALDI, 1998
Forme molto basse	teglia	piatto per focacce	teglia		teglia				teglia
Forme basse	piattello	piatto			piattello		piatto	piatto/ciotola	piattello
		piattello su piede					coppa-piattello	piattello su piede	
	scodella	scodella	scodella	scodella	scodella	ciotola • ad orlo rientrante • troncoconica	scodella • a labbro rivolto all'esterno • a labbro rientrante • di copertura	scodella/ciotola/ coppa	scodella/ scodellone
		scodella/coppa su piede					coppa (su piede)		
		coppa			coppa (= kotyle)			tazza	
Forme medie		ciotola	ciotola	ciotola	ciotola	ciotola • carenata • a profilo ad S	scodella a labbro rivolto all'esterno	coppa/tazza	
	tazza	tazza bassa tazza-attingitoio	tazza	tazza	tazza	ciotola attingitoio	tazza	oriolo	tazza/attingitoio
	anforetta	tazza biansata	anforetta				tazza biansata	anforetta	anfora
Forme medie/ profonde	boccale	boccale	boccale		boccale	boccale	boccale	boccale/orciolo	boccale
	brocca/ brocchetta	brocca	brocca		brocca		brocca		brocca/brocchetta
	bicchiere/ olletta	bicchiere			bicchiere	vaso • ad olla • globulare • cilindrico	bicchiere	olla ovoide/olla globulare	bicchiere
Forme profonde	olla	olla	olla	olla	olla		olla/olletta	olla ovoide/olla ovoide-cilindrica/ olla ovoide-globulare/orciolo	olla/olletta monoansata
		urna/vaso a collo	vaso a collo	vaso a collo	vaso a collo distinto	vaso lenticolare	vaso a collo distinto	olla globulare	vaso biconico
	vaso biconico	urna/vaso a collo troncoconico e corpo biconico urna/vaso biconico	vaso biconico	ossuario biconico	vaso biconico	vaso biconico	biconico	olla biconica	
	brocca	orciolo	orciolo		orciolo				
	anfora	anfora			anfora	vaso ad anfora	anfora/anforetta		anfora
	dolio	dolio	dolio	dolio	dolio	dolio		olla doliaria	dolio/ziro

Fig. 34 – Summary table of the terminology current in use for the main pottery forms in the LBA- Early Iron Age in the Italian Peninsula (Source: Poesini & Agresti 2011).

5.3.2.4 Biconical vessels

Biconical vessel represents the second form included among the variables of the EUBAR database. A vessel is said to be biconical when the sides make a sharp, inward change of direction, as if two truncated cones were placed base to base (Fig. 35).

Although this particular form presents a large duration, during the LBA it is attested in funerary contexts with the function of urn for placing the ashes and the charcoals resulting from a process of cremation. In particular, in the Villanovan culture, which spread in Centro-Northern Italy during LBA, it represented one of the most outstanding features (Peroni 1996; Bietti Sestieri 2010).

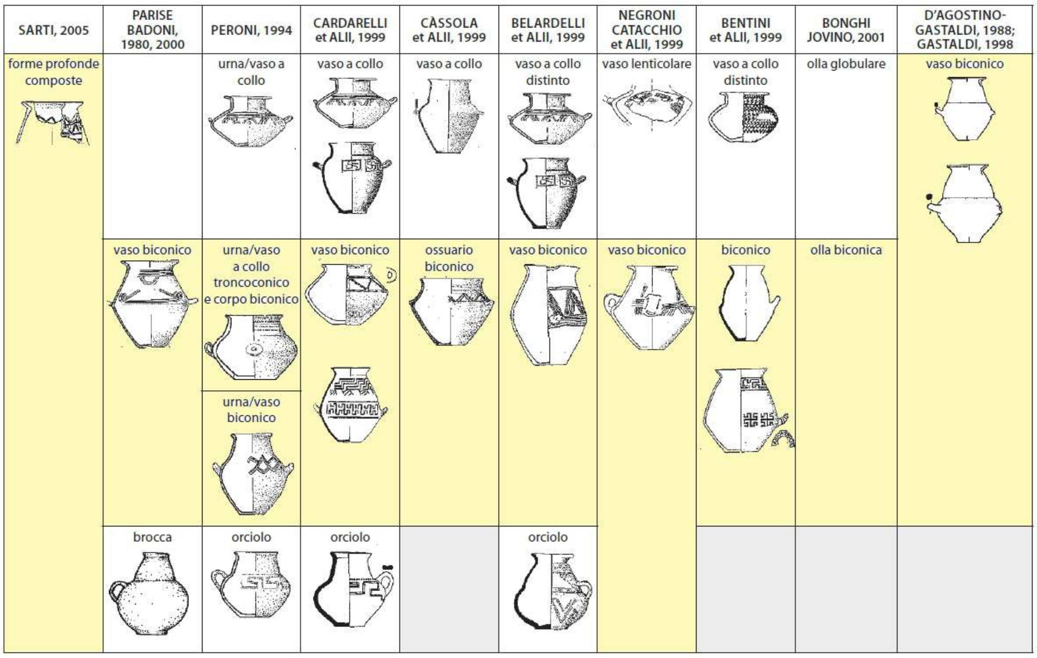

Fig. 35 – Summary table of the terminology and the forms of the biconicals originating from the LBA-Early Iron Age Italian contexts (Source: Poesini & Agresti 2011).

5.3.2.5 Decoration with helicoidal ribs

Among the decorations included in the EUBAR database the first one is a particular motive formed by helicoidal ribs located in the carina or in the bell of vessels (Fig. 36). Such a decoration presents a large diffusion in Protohistoric Europe and takes different names according to the countries. In the Iberian Peninsula archaeologists referred to it with the term *sogueado*, for the analogies with a thick rope (*soga* in Spanish); in France Carozza et al. (1996-1997, p. 61) named this motive *motif torsadé sur l'épaulament*, in

Italian contexts it is called *motivo a costolature elicoidali* (or *a turbante*), whilst in the German speaking area the term *Rand* (*Turbanrand*) is attested. We chose to include this decoration because it has been traditionally considered a ceramic feature of the *Urnfield culture*, attested in particular in the Danube-Balkans region and in Slovenia during the *Ha A1* phase (Leonardi 2010).

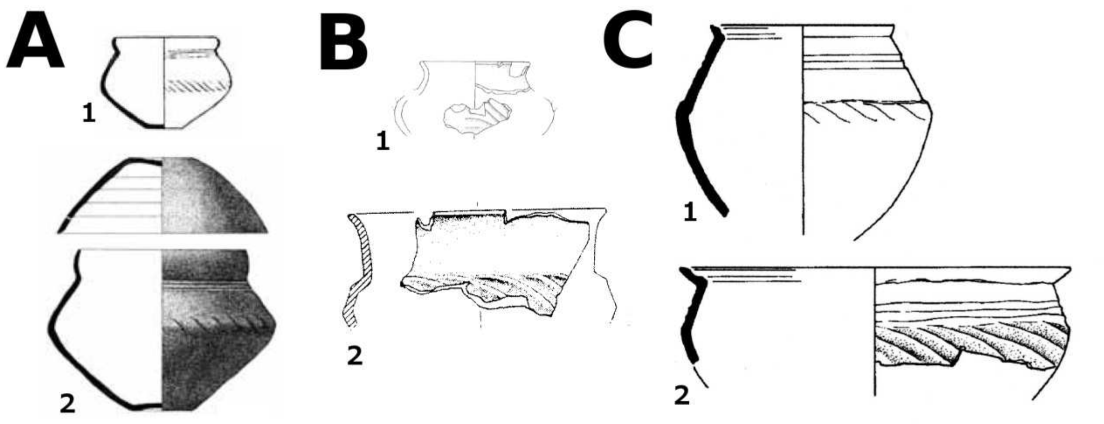

Fig. 36 –Decoration with helicoidal ribs from radiocarbon dated archaeological contexts located in NE Spain (A; 1-2: Can Missert), Northern Italy (B; 1: Gradiscje di Codroipo, 2: Caorle-San Gaetano) and Southern France (C; 1-2: Le Clot).

5.3.2.6 Decoration with solar motive

With the term *solar motive* we have included pottery with the external surface of the base decorated with a cross or a cruciform motive (Fig. 37). This kind of decoration was performed using different techniques, grooving or engraving the ceramic surface before its heating. The decoration is widely attested in archaeological context from *Terramare* settlements during the Middle Bronze Age (Bernabò Brea et al. 1997) and perhaps could represent a motive related to the element of the sun (Leonardi 2012). This and other kinds of kind of decoration linked to the sun will develop an ideology characterized by a pan-European solar cult, which spread over a macro-area in the in the last phases of Bronze Age (Bietti Sestieri 2010; Kristiansen 2010, 2011; Leonardi 2012).

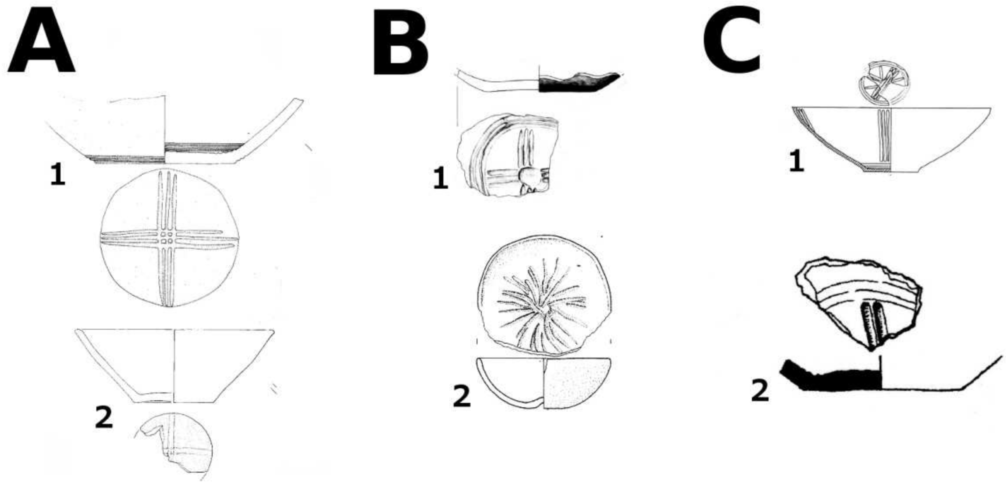

Fig. 37 –Decoration with *solar motive* from radiocarbon dated archaeological contexts located in the North of the Alps region (A; 1: Thunau am Kamp, 2: Birmensdorf-Wannenboden), Northern Italy (B; 1: Solarolo, 2: Noceto) and Southern France (C; 1: Grotte du Queroy, 2: Le Clot).

5.3.2.7 Decoration with meanders

Decoration with *meanders* is also reported in the EUBAR database. This kind of decoration was performed either grooving or engraving the exterior surface, and especially the bell, of vessels (Fig. 38). We have included in this variable several motives with different degrees of complexity, whose basic element can be represented by the motive of the Greek key. This decoration characterizes especially forms with great dimension, like for instance biconicals and urns employed for cremation burials.

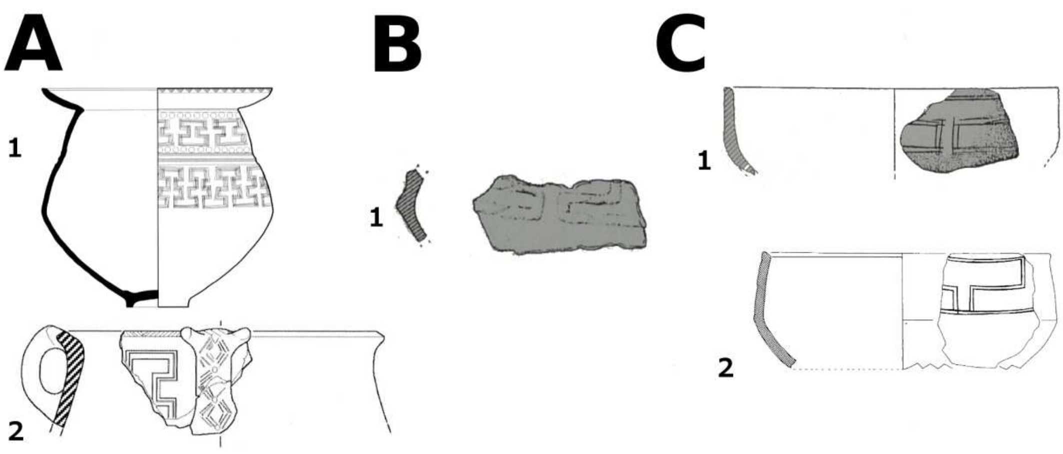

Fig. 38 –Decoration with *meanders* from radiocarbon dated archaeological contexts located in NE Spain (A; 1: Pi de la Lliura, 2: Can Roqueta II), Northern Italy (B; 1: Livorno-Stagno) and Southern France (C; 1: L'Abion, 2: Médor à Ornaison).

5.3.2.8 Decoration with *chevrons*

Decoration with *chevrons* is a widespread kind of decoration formed by a horizontal alignment of small triangles forming a band (Fig. 39). These triangles as well as their infill can be grooved or engraved. Their location is characterized by variability, they are attested both in the internal surface of vessel and in the exterior one. They are named in different way according the different languages: in Spanish *dientes de sierra*, in French *chevrons* (*triangles*) *hachurés*, in Italian *denti di lupo*.

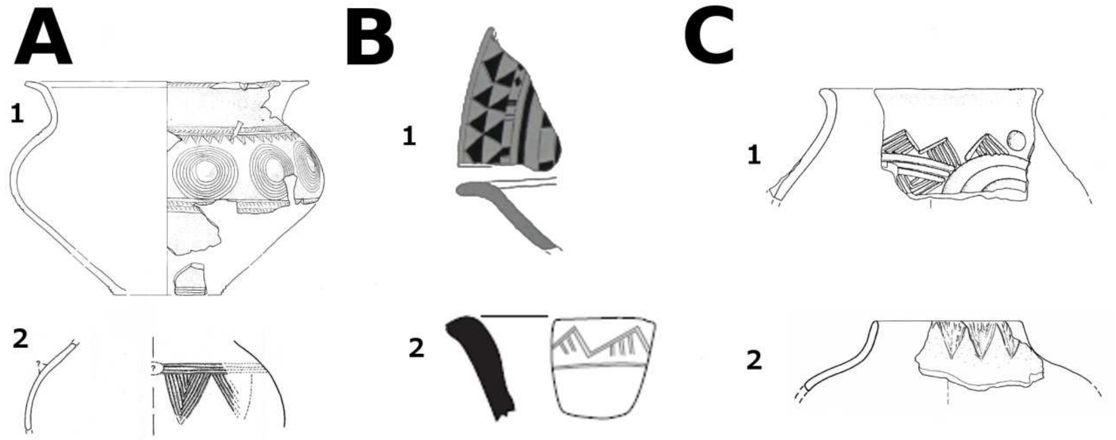

Fig. 39 –Decoration with *chevrons* from radiocarbon dated archaeological contexts located in the North of the Alps region (A; 1: Neftenbach II-Zürichstrasse 55, 2: Freienbach SZ-Hurden Rosshorn), Southern France (B; 1: Chatillon, 2: La Roumanine) and Northern Italy (C; 1: Monte Castellaccio, 2: Grotta dei Banditi).

5.3.2.9 Decoration with zig-zag

Decoration with *zig-zag* presents some analogies with the *dientes de sierra*, it can be grooved or engraved and it forms a decorative band which usually covers the exterior or interior surface of vessels (Fig. 40).

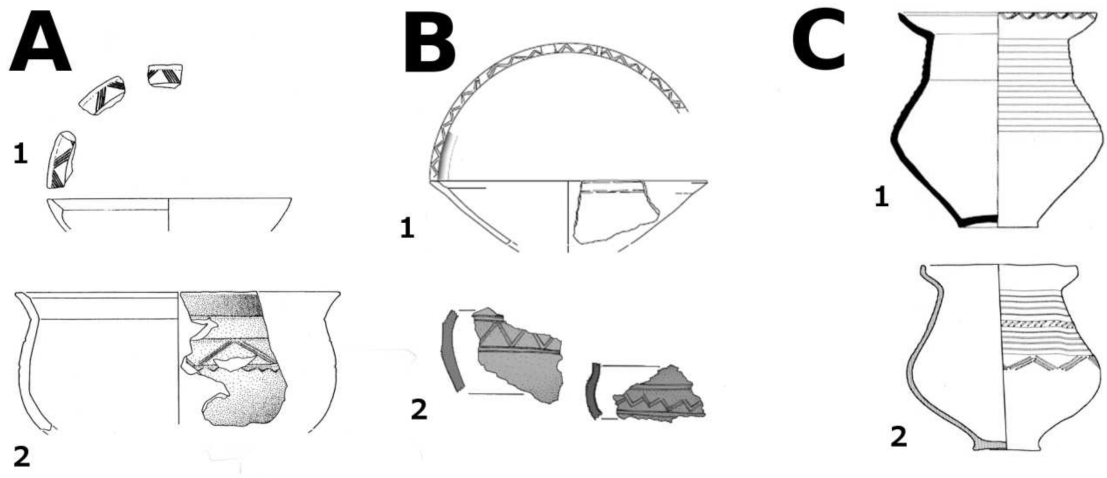

Fig. 40 –Decoration with *zig-zag* from radiocarbon dated archaeological contexts located in North of the Alps region (A; 1: Goldach SG-Mühlegut, 2: Münchenwiler-Im Loch 1), Southern France (B; 1: Le Bastidon, 2: Les Gandus) and NE Spain (C; 1: Pi de la Lliura, 2: Can Piteu-Can Roqueta).

5.4 The database: contents and preliminary inspection

The EUBAR database is currently composed of 1748 records, corresponding to 1748 isotopic measurements from 650 archaeological sites. The different countries are represented as it follows: 534 ^{14}C dates from 261 sites located in Southern France; 422 ^{14}C dates from 113 sites located in Switzerland; 221 ^{14}C dates from 91 sites located in Northern Italy; 274 ^{14}C dates from 114 sites located in the north-west of the Iberian Peninsula; 154 ^{14}C dates from 49 sites located in Austria; 132 ^{14}C dates come from 19 sites located in Southern Germany; 9 ^{14}C dates from 2 sites located in Liechtenstein; 2 ^{14}C dates come from one site located in Andorra.

The average is one dated site each 808 km^2. As we can observe in the Fig. 41 the spatial distribution of the data is not homogeneous. On the one hand, some area have been higher investigated, it is the case of the Swiss Plateau, or the areas surrounding important modern towns, where archaeological surveillance have been carried out in the last decades, like the neighbors of Barcelona and Lyon. On the other hand, areas like the mountains range systems of the Pyrenees and part of the Middle and Western Alps are characterized by a less amount of radiocarbon dated archeological sites. Doubtless the spatial distribution of collected data is strictly correlated to the amount of researches carried out in such an area. However, starting from the assumption that the process of choosing a sample to submit to radiocarbon dating is a stochastic process we can argue that the spatial distribution of ^{14}C dated sites would not be different from the already known archaeological evidence at the same time and space ranges.

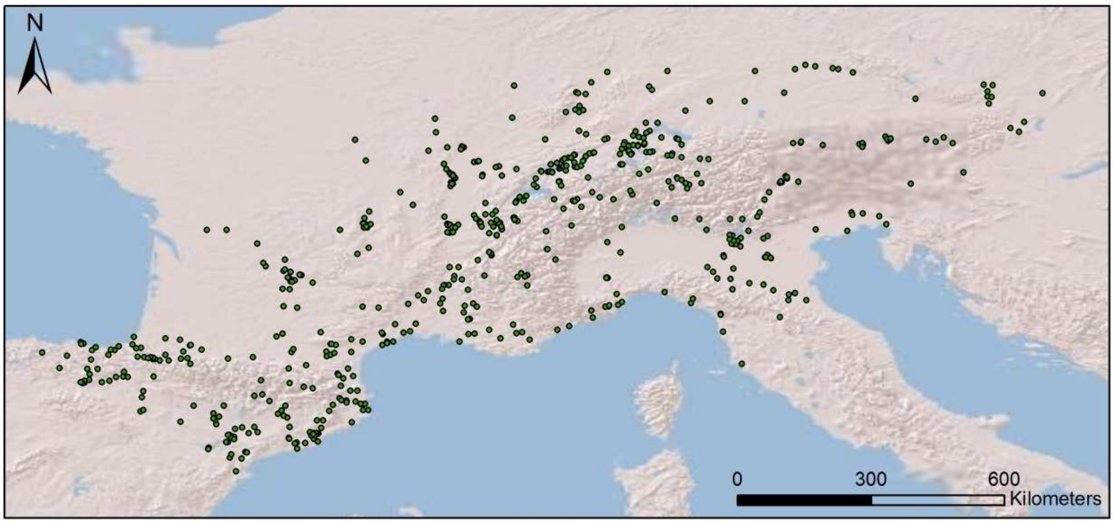

Fig. 41- Spatial distribution of data collected in the EUBAR database.

The distribution of dated per site is not homogenous as well. The average is less than 3 radiocarbon dates per site. For 54% of the archaeological sites we have only one ^{14}C date, for 19% two dates and for 9% three dates.

The most dated sites included in the database are the wooden piles of the ancient road of Freienbach SZ-Hurden Rosshorn with 81 measurements, the settlement of Padnal de Savognin in Swiss Canton of Grisons with 35 measurements and the south German settlement of Bogenberg with 29 measurements.

Collected data come from a large variety of archeological contexts (Fig. 42). The great majority of samples were collected in residential areas followed by funerary/ritual sites. Other kinds of context are also represented, like places where mining and smithing activities are attested, among them a large number of dates originate from the Hallstatt mines located in Austria. Sample collected from infrastructure (wooden bridges, channels for roads, agricultural ditches, etc.) have been also included in the database. Eventually, for a small amount of sample the information about the context was missing, either for a lack of information in the references or because they sample was collected associated to items (occasional objects) out of context.

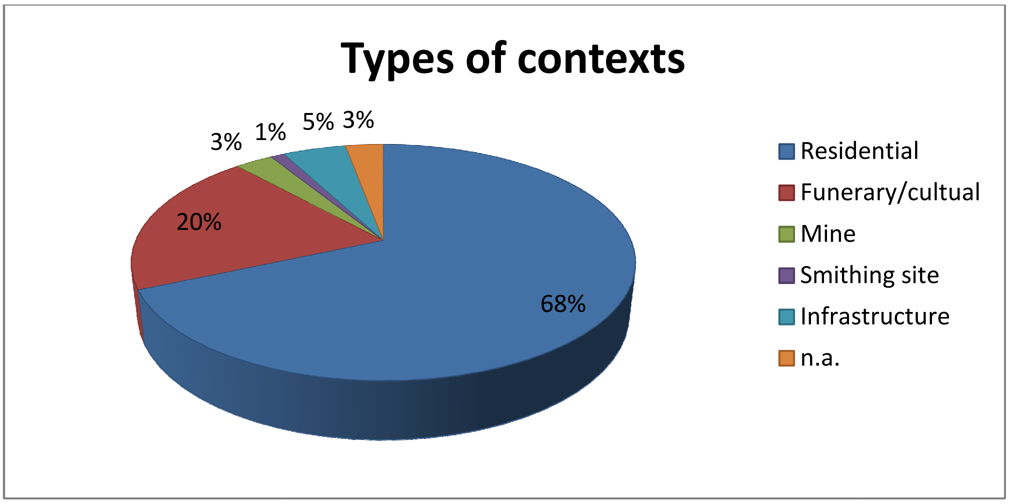

Fig. 42 – Types of contexts included in the EUBAR database.

Regarding the type of samples, submitted to radiocarbon dating, and therefore included in the EUBAR database, oldest samples were obtained with the traditional method of liquid scintillation counting developed by Libby. Half of the total amount of samples was dated through the AMS method, whose results are widely accepted to be more precise and accurate, as well as more expensive. In addition, we have to highlight that such kind of information is frequently lacking in the references.

Of the total amount of the samples, 61% of the dates come from long-lived samples like charcoal and wood, while short-lived-samples (mainly bones, followed by seeds) represent only 26% of the dataset (Fig. 43). Others samples were also dated, including carbonate, vegetal fibers and other not specified organic materials. For 12% of the sample we have not been able to retrieve such information.

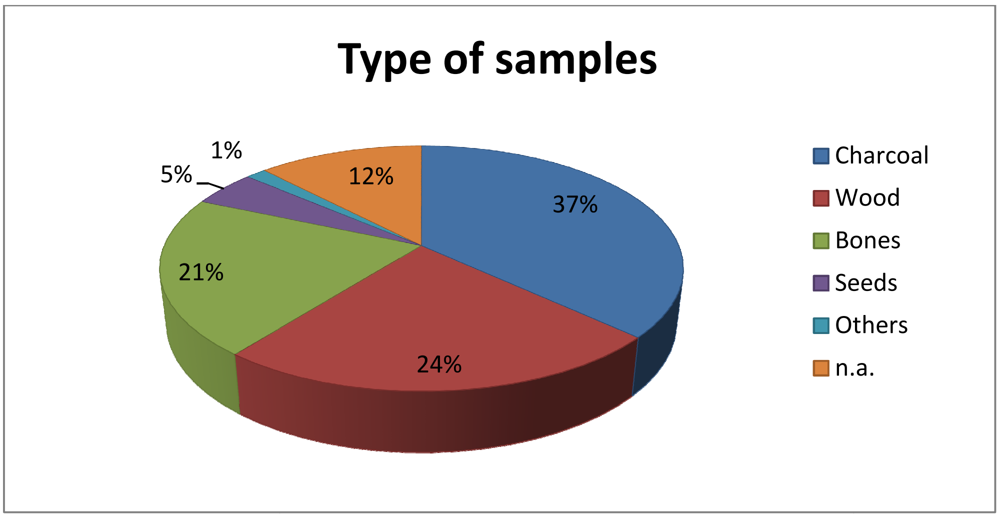

Fig. 43 – ^{14}C-dated samples included in the EUBAR database.

5.5 Testing the reliability of data: sample prescreening

In the previous paragraphs we have presented the EUBAR database, focusing on its structure. The backbone of the database is the analysis of the context associated to the radiocarbon sample, hence we have dedicated a particular care in defining which variable are useful in order to correctly describe the society which produced the material evidenced dated by the ^{14}C. The variables have been divided in two main groups; the first one gathers the variables useful for providing information about social, economic and cultural aspects whilst the second one includes the so called index fossils.

It is meaningful to remind that the accuracy and precision of ^{14}C dates depends first of all on the accuracy and precision of the related archaeological contexts, and on any degree of error introduced during their analytical processes, including sample preparation and measurement (Boaretto 2007; Regev et al. 2012). It is therefore important to verify whether the selected contexts from which the ^{14}C dates are recovered can be considered closed and well defined. In order to achieve this goal sample prescreening represents our primary stage. The collected information comes from different sources and has heterogeneous structure and form with different grades of quality. Therefore, it is necessary to formalize which dates can be considered reliable and consequently used for analysis. Due to the extreme variety of the sources from which archaeological data usually originates, the quality and completeness in the description of the published archaeological record can vary significantly. Regarding radiocarbon in particular, the exact location of the ^{14}C sample cannot be retrieved from the published material; hence, association with a given context is impossible to ascertain. In addition, problems related with the post-depositional process, like bioturbation, may affect the quality of the measured samples and thus should be detected during the archaeological excavation. These factors reduce the chronological value and quality of many of the collected samples, and are directly responsible for an increase in uncertainty.

As a result we have taken a particular care in order to check the context reliability, reported for each radiocarbon dated sample. Dates were classified as reliable if they follow a set of parameters that define their quality.

As we are not dealing with our own data, from our own excavations, the quality of published material is essential in order to test the validity of a radiocarbon date. The provenience of the sample used for dating should be explicitly marked, as also the association with an archaeological context described by diagnostic ceramic or metallic typologies. Nevertheless, often we deal with publications in which this kind of information is missing or unclear. If we had the date but no knowledge about the context, where the only we have is a date and a standard deviation, mainly because archaeological contexts are unpublished, we marked those dates as unreliable.

The second case is represented by publications with a lack of knowledge regarding the provenience of the sample or the description of the context. Frequently, the exact place where the sample was collected is unclear or is not reported in the publication. Is such situations, although the archaeological stratigraphy was clear and well-defined, we did not take into account those sites because it was not possible to associate the sample with one particular layer. Sometimes the date is artificially associated to the archaeological materials which are ordered according to a typological criterion (the so called horizons) and not in agreement with the archaeological stratigraphy. In such circumstances we did not take into account those samples.

In other cases, the lack of information regards the archaeological contexts that are reported fragmentarily due to various reasons: a bad publication, stratigraphic problems during the excavation, or missing context. The last case is frequent when the samples come from geoarchaeological prospections based on systematic sampling in open sections or from coring without excavating an open area.

The perfect situation is when the provenience of the sample is reported in the publication and all the materials found during the excavation are divided according to the stratigraphy. In such cases we have been able to correlate the sample with the material found in the same stratum, which should correspond to a single depositional phenomenon and hence to be contemporary.

Among all the well-defined contexts associated to the radiocarbon samples we used more specific criteria in order to assure the quality of the date. As a result, a flowchart which ordered all the archaeological contexts find in the literature was developed.

The first position belongs to bones in articulation from funerary context, like burials associated to well-defined ceramic or metallic typologies. Short-lived samples like bones or seeds should have a better value in the hierarchical scale due to their short duration; in fact their dates are characterized by a less error than long-lived samples. If the bone comes from a multiple tomb we must check to whom it corresponds and if the contemporaneity of the inhumations can be proved.

The second position is for short-lived sample, like for instance, seeds, found in a cluster in a well-defined archaeological layer defined by diagnostic pottery or metallic types. It is relevant that the sample comes from a cluster as a guarantee of an in loco feature. In fact, as already mentioned, a single seed can be affected by post-depositional processes which could change its initial position in the archaeological record. If the cluster of seeds comes from a pit we need to check to which layer of the pit it corresponds, in order to associate the archaeological material with the sample.

The third position corresponds to long-lived samples from secure stratigraphic layer and associated to clear object typologies. We can take as an example, charcoal from fireplaces located in an identified stratum or also charcoal found inside the funerary urn of a cremation burial. In this case a date from a bone sample should be preferred, but as often proved the collagen is not well-preserved in charred bones (Lanting et al. 2001; Olsen et al. 2013), hence usually the charcoals, which made part of the funerary pyre debris, are dated.

The fourth place belongs to wooden samples collected frequently in wet contexts, like for instance lake dwelling. Usually, the sample comes from a pile or another vertical element which made up the architecture of the settlement. The problems arise when we try to associate a vertical feature with a horizontal layer. This kind of association is actually quite difficult and hence it is not possible to correlate the archaeological material with the sample. In such cases the accuracy of the date cannot be tested and for that reason we just have information about the possible phases of construction of the settlement that can be compared with the ceramic or metallic typologies just according to a general chronology, but not with a high resolution.

We have marked as bad contexts samples gathered in the “infills”. As they are not closed contexts, we do not have any guarantee of the contemporary of the materials of such features, that could come from different places and therefore be the result of an accumulation of archeological remains of various chronologies.

6 REVIEW OF THE PERIODIZATION: BAYESIAN ANALYSIS OF ^{14}C-DATED ARCHAEOLOGICAL CONTEXTS FROM NORTHERN ITALY, SOUTHERN FRANCE AND THE NORTH-EAST OF IBERIAN PENINSULA

6.1 Introduction

The Bronze Age and Iron Age in Protohistoric Europe are often characterized by a qualitative division. Since the beginning of the discipline archaeologists have been trying to divide time into well-defined time spans, usually based on the typological analysis of human artifacts, in particular metallic objects and pottery. Such conventional periods or phases constructed from the archaeological record generally serve as the base for all archaeological study. Three main problems with such a chronological system are, first the lack of uniform acceptance of those phases among scholars, second the differences in the terminology used for defining phases, and third the amount of good quality contexts and the diligence given to ensuring context reliability remain low.

The result is a plurality of phases, which are defined differently from one country to another and from one school to another, and whose origins are rooted in the traditional studies carried out in each country over the 20th century. This approach represents a clear stumbling block for any research with a macro-scale geographic view. Moreover, the criteria adopted for correlating phases from different regions are frequently based on the presence/absence of archaeological materials with guide-fossil value.

In order to relate each archaeological phase to an absolute chronology, the radiocarbon dating technique and Bayesian statistical analysis represent a powerful tool (Buck et al. 1996; Bayliss et al. 2007; Bronk Ramsey 2009a). In the last few decades the increase of radiocarbon dated archaeological contexts for the Bronze Age and Iron Age has slightly improved the situation.

In this chapter we manage to highlight existing problems through a comprehensive review of all the available information from ^{14}C dated archaeological contexts in North-Eastern Spain, Southern France and Northern Italy during part of the 2nd and the beginning of the 1st millennium BC (1800-750 BC). We have also produced a model using data originating from the North of the Alps area, which corresponds to Switzerland, Austria and Southern Germany. Nevertheless, we have decided not to include it in this chapter due to problems of modeling in a reliable way ^{14}C dates from such a large area. Moreover, the absences in produced models of dendrochronological data, which cover a predominant role in the establishment of the North of the Alps chronology, prevent us to include these models in the chapter. Eventually, my knowledge of German language made more difficult to guarantee the same levels of reliability, which is the basic principle of the other Bayesian models.

6.2 Sites, contexts and sampling

The available information originates from the EUBAR database (see chapter 4).
The dataset used for this analysis is composed by a total of 872 radiocarbon dates, 221 come from 87 North Italian archaeological sites and 466 from 214 Southern French sites and 185 from 75 sites located in North-Eastern Spain. All the ^{14}C dates have been recalibrated using the software OxCal v. 4.2 (Bronk Ramsey 2009a) and the last calibration curve IntCal13 (Reimer et al. 2013). The datasets of Northern Italy and Southern France and relating references can be consulted from the webpage (http://www.radiocarbon.org/) as an online supplement of the Journal Radiocarbon (Capuzzo et al. 2014). The dates used for the analysis, including the outliers, are marked in bold.
The analyzed regions of Northern Italy are *Valle d'Aosta*, *Piemonte*, *Lombardia*, *Liguria*, *Trentino-Alto Adige/Südtirol*, *Veneto*, *Friuli-Venezia Giulia*, *Emilia-Romagna* and *Toscana*. In Southern France sampled regions include *Aquitaine*, *Midi-Pyrénées*, *Languedoc-Roussillon*, *Provence-Alpes-Côte d'Azur*, *Poitou-Charentes* (only the department of *Charente*), *Limousin*, *Auvergne* and *Rhône-Alpes*. In North-Eastern Spain the analyzed regions are Catalonia and Aragon (provinces of Huesca and Zaragoza). The distribution in space of collected data is not homogenous, the average is one radiocarbon dated archaeological site every 1186 km^2 (Fig. 44).

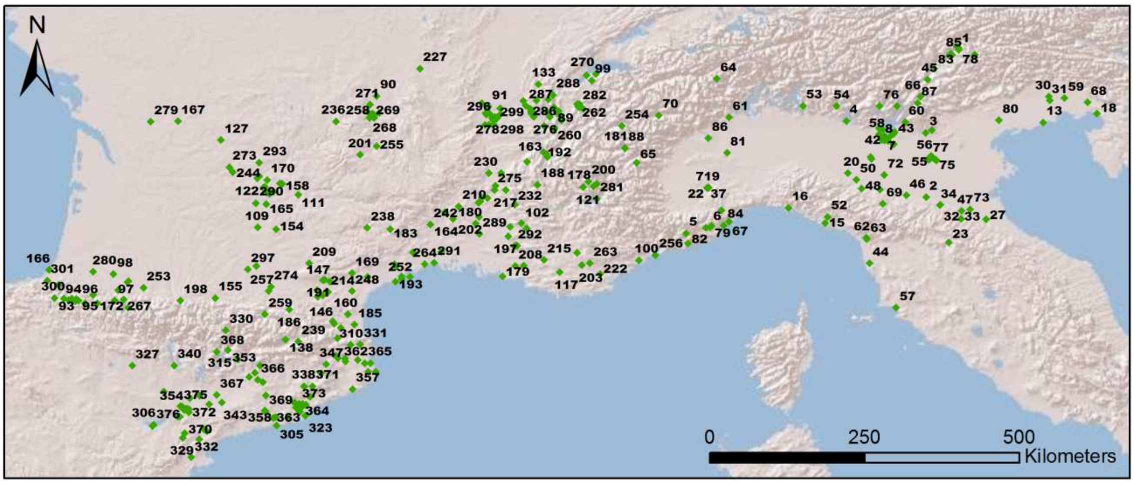

Fig. 44 - Map of the sites included in the dataset, the numbers correspond to the ID numbers of the dataset. Overlapping labels have not been reported.

6.3 Data analysis

6.3.1 Sample context prescreening

The accuracy and precision of ^{14}C dates depends first of all on the accuracy and precision of the related archaeological contexts, and on any degree of error introduced during their analytical processes, including sample preparation and measurement (Boaretto 2007; Regev et al. 2012). It is therefore important to verify whether the selected contexts from which the ^{14}C dates are recovered can be considered closed and well defined.

Due to the extreme variety of the sources, the quality and completeness in the description of the published archaeological record can vary significantly. Regarding radiocarbon in particular, the exact location of the ^{14}C sample is sometimes very difficult to find, or cannot be retrieved from the published material, hence, association with a given context is impossible to ascertain. In addition, problems related to the post-depositional process, like for instance bioturbation, affect the quality of the dated samples and thus should be detected during the archaeological excavation. These factors lower the chronological value and quality of many of the collected samples and are directly responsible for an increase in uncertainty.

In spite of such problems, to the best of our knowledge we collected all the available dates, recalibrated them, and identified the possible outliers by evaluating the archaeological record and using Bayesian modeling. As an outcome, this research represents a starting point for future studies and points to the necessity of enlarging the amount of ^{14}C dates from good archaeological contexts.

After the collection, the ^{14}C dates were selected for modeling based on a set of parameters that define the quality of the dates. As we were not dealing with first hand data, but with data coming from a wide variety of excavations, we were compelled to check context reliability as reported in the references. As a consequence, a sample prescreening was required (see chapter 5.3).

Initially, a distinction between long-lived samples (wood and wood charcoal) and short-lived samples (charred seeds and bones) was made. In the case of charred seeds a further distinction would be necessary based on the “amount” of seeds found together. This is related to the cluster vs. single seed. As the latter could more easily move by bioturbation between different layers/strata, a cluster of seeds would be of better quality for radiocarbon dating. Yet, this type of information was not available in the report and therefore we considered seeds, as short-lived, preferable for the chronology than wood charcoal. The date of the wood charcoal should be interpreted carefully, and in general charcoal samples represent a “*terminus post quem*” in relation to the dated event.

Of the total amount of the samples, 71% of the dates come from long-lived samples like charcoal and wood, while short-lived-samples (mainly bones, followed by seeds) represent only 25% of the dataset. For 37 samples such information is missing.

As a general rule, among the samples priority was given to ^{14}C dates recovered from *in-situ* cluster of carbonized seeds or bones in articulation associated to finds and contexts that have a primarily ceramic or metallic inventory (e.g. more than one type of diagnostic pottery or metal object) found *in-situ* (Boaretto 2009).

Other than these contexts, which might be rare, contexts with short or long-lived material were considered and analyzed, like destruction layers and installations (pits, metallurgical areas). On the other hand, fills and mixed contexts were avoided or rated low in the later analysis of the dates. Single short-lived materials, like a charred seed or a bone, are also of low importance due to the possibility of intrusiveness or residuality of the sample in relation to the context.

Errors can also be related to the preparation of the sample in the laboratory, a process which aims to separate the original carbon-bearing material from the extrogeneous carbon and to obtain a reliable date (Mook & Streurman 1983). Therefore, in order to control for uncertainty it is necessary to know the chemical pretreatment and to have details on the measurements of the samples. Regrettably, for many samples this information is lacking as it is not reported in the references. We therefore rely on the precision quoted by the lab as a paramater for the quality of the date.

For the analysis carried out in this paper we took into account only samples coming from archaeological contexts that could be described as monophasic from the analysis of metallic and pottery typologies. Hence, we discarded contexts which included more than one conventional phase. In the same way, materials divided into artificial archaeological horizons, rather than stratigraphically, were not considered reliable, as a clear association with the sample cannot be verified

6.3.1.1 Northern Italy

Although 221 ^{14}C dates were available, 170 samples were removed after prescreening, leaving 51 dates originating from 19 different sites.

In order to visualize the quality of the 51 samples retained for analysis, they have been represented in a plot (Fig. 45). We have used as a model the plot developed for the chronology of Early Bronze Age in the Southern Levant (Regev et al. 2012). The x-axis contains the archeological sites in alphabetic order, whilst the y-axis represents the chronology expressed in years BC.

Each bar corresponds to a ±1σ calibrated interval of a single radiocarbon date; the choice of using ±1σ calibrated range is for clarity. This has no influence in the Bayesian model applied to the final set of dates. The color corresponds with the conventional chronology as it is defined in the legend. The conventional chronological framework is shown on the right. It is clear that not all the data fit the traditional chronological framework proposed for North Italian regions, with dates from some sites showing large spread beyond the limits of the periods according to the conventional chronology (e.g. Santa Rosa di Poviglio).

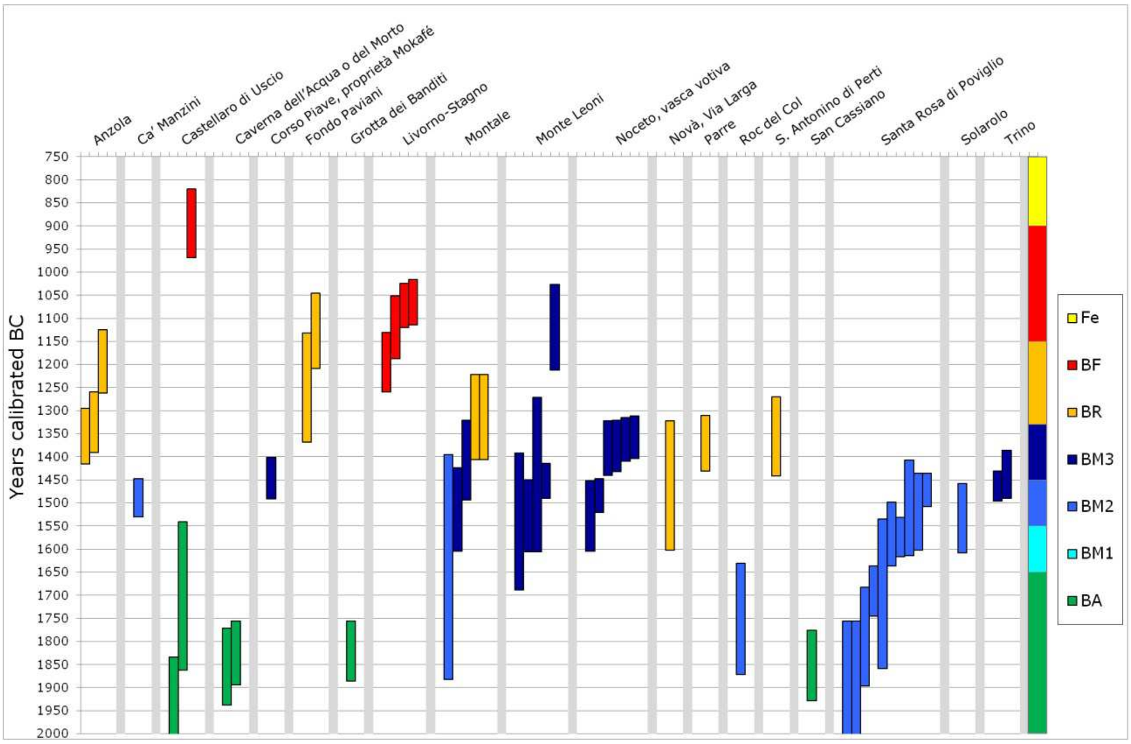

Fig. 45 - Filtered 1σ calibrated radiocarbon dates for the Bronze Age and the beginning of the Iron Age in Northern Italy with the corresponding archaeological phases as reported in the references. Each colored line represents one date.

The reasons for the rejection of dated samples are multiple. In some circumstances samples were collected during survey projects conducted for geo-archaeological campaigns. This is the case for the dates from the settlements of Castello del Tartaro, Fabbrica dei Soci, Perteghelle and three samples from Fondo Paviani, which were gathered during the *Alto-Medio Polesine-Basso Veronese Project* (Whitehouse 1993; 1994; 1997). Likewise, the samples from prehistoric features like agricultural ditches (Stanghelle Est) and infrastructure (Strada Meridionale su Argine) were not taken into account. In other sites (Lazise-La Quercia, Molina di Ledro, etc.) the samples originate from vertical wooden features in the settlement, and therefore the association with material objects is hard to obtain. These dates can be useful for defining the phases of building of a lake-dwelling, but they are not appropriate for our analysis. Other dates, like those from the Arano necropolis were not associated with archaeological materials, as the grave did not have funerary assemblages. Hence, although they represented short-lived samples we decided to reject them.

Eventually, dates that represented more than one archaeological phase were removed from the filtered dataset.

Nevertheless, most of the samples were eliminated due to publications, in which the information about the context was poor or even absent.

6.3.1.2 Southern France

From an original dataset of 466 dates, after the sample prescreening, we obtained 96 dates originating from 44 different sites (Fig. 46).

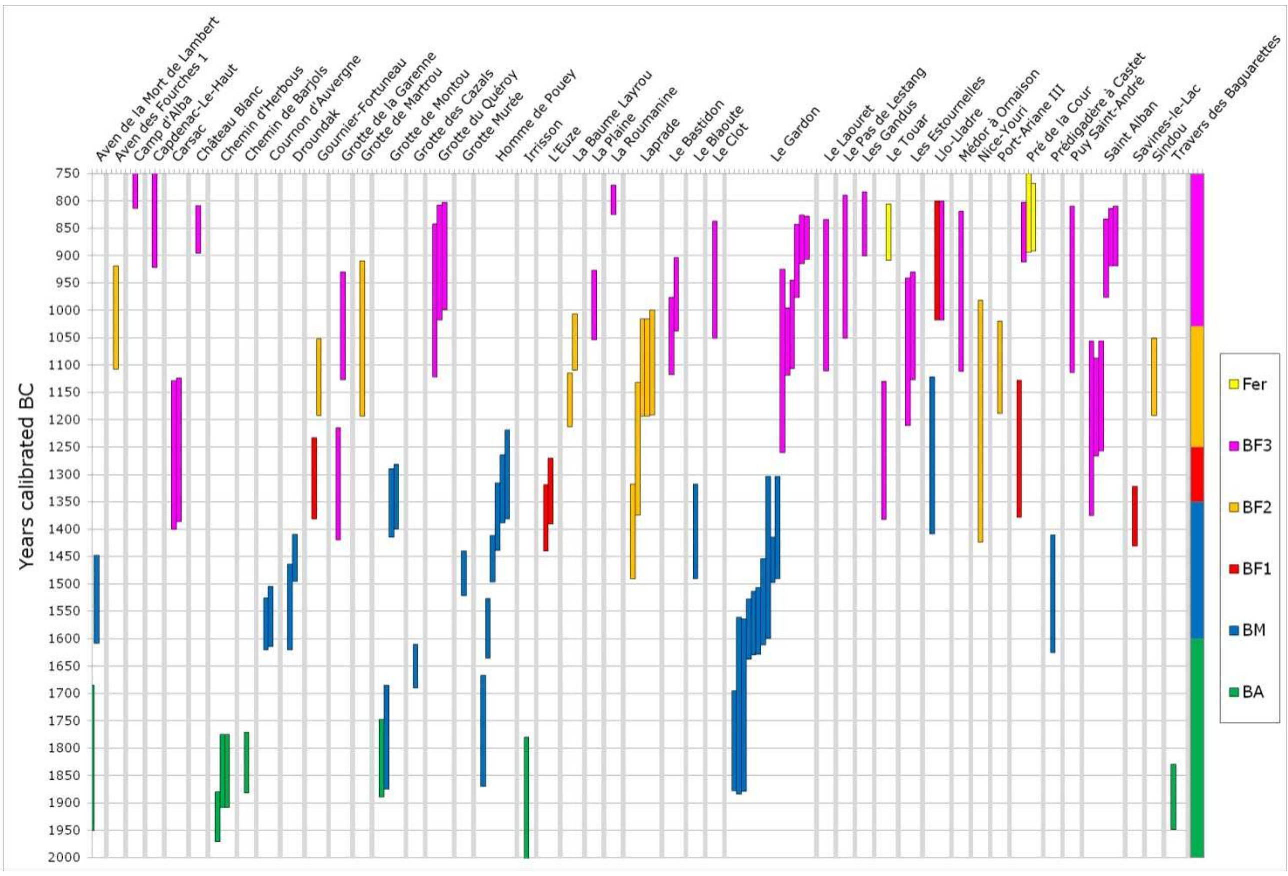

Fig. 46 - Filtered 1σ calibrated radiocarbon dates for the Bronze Age and the beginning of Iron Age in Southern France with the corresponding archaeological phases as reported in the references. Each colored line represents one date.

A large amount of dates were rejected in the filtering process because they derived from unpublished data, hence the information about the associated context was not available. Many such dates were included in the online database BANADORA (http://www.archeometrie.mom.fr/banadora/) developed by the CNRS, the *Université*

Claude Bernard - Lyon 1 and the *Université Lumière* - Lyon 2.

Other dates were not associated with pottery or metallic typologies with guide-fossil function or they were not of monophasic context, thus they were eliminated from the filtered dataset. As a general rule, the six criteria adopted for rejecting unreliable North Italian dates were valid also for Southern French archaeological contexts. The prescreening against the original dataset resulted in only few reliable dates derived from the six archaeological phases (*BA; BM*, *BF1*, *BF2*, *BF3*, *Fer*) following Hatt's division.

6.3.1.3 North-East of Iberian Peninsula

As a result of the sample prescreening, from an original dataset composed of 185 dates, 124 measurements from 44 archaeological sites were retained for the analysis (Fig. 47).

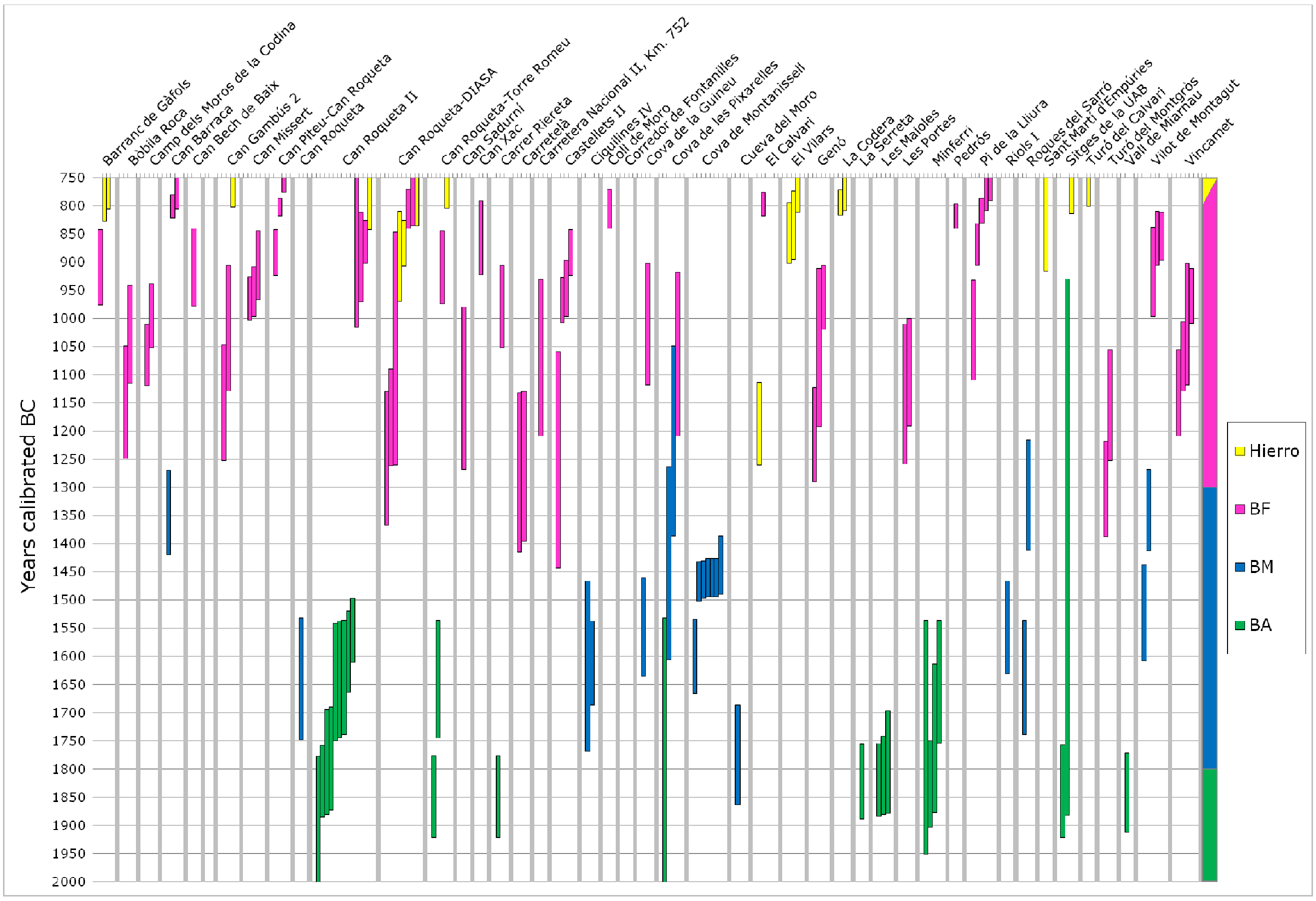

Fig. 47 - Filtered 1σ calibrated radiocarbon dates for the Bronze Age and the beginning of the Iron Age in the North-East of Iberian Peninsula with the corresponding archaeological phases as reported in the references. Each colored line represents one date.

Such dates were distributed in 4 conventional phases: *BA*, *BM*, *BF* and *Hierro*. We decided to include in the same phase *BF* the dates which were divided in the two subphases *BFa* and *BFb*, as reported in the Database of Catalan Radiocarbon Dates (http://www.telearchaeology.com/c14/). To reject dates we have adopted the same criteria used for North Italian and Southern French datasets.

6.3.2 Modeling methods (modeling Bronze Age and Iron Age transition)

The dates were analyzed according to the principles of statistical Bayesian analysis (Bayes 1763; Buck et al. 1996) using the software OxCal 4.2 (Bronk Ramsey 2009a), which calculates the posterior probability distributions of an existing sequence of dates.
Thanks to the association between the samples and the good contexts it was possible to build sequences of radiocarbon dates ordered according to the archaeological phase they belong to. This kind of information, called *a priori*, forms the parameters which condition our data and for this reason such an approach represents the backbone of our research.
This mathematical theory was introduced in order to define the probability of success for cases in which the observed data are provided with qualitative or semi-qualitative information about the relative relationships between the samples and the expected results (see chapter 4.6).
With the aim of detecting the radiocarbon time span of an archaeological phase we have ordered the samples according to the different conventional phases. In each phase the samples were distributed in a chronologic order, from oldest to youngest. If the resolution of the context was good, it allowed us to analyze also the sub phases of an archaeological phase. We managed to get into particular detail in phases characterized by a long time-span, like the Middle Bronze Age in Northern Italy (phases *Bronzo Medio 1*, *Bronzo Medio 2*, *Bronzo Medio 3*) and the Late Bronze Age in Southern France (phases *Bronze Final 1*, *Bronze Final 2*, *Bronze Final 3*).
The criteria for the analysis were adopted and followed as systematically as possible.
We have only presented dates that have had their reliability checked previously, according to the rules already mentioned. We ran two models (contiguous and sequential) for the same data in order to check variations in the results. In the contiguous models the software calculates the transitions between each phase and

provides this information according to the 1σ and 2σ probabilities. Slightly different are the sequential models, in which each phase has two boundaries, one for the start and the other for the end. The effect of those boundaries is a constriction of the dates in two limits. This could lead to the creation of chronological gaps among phases, whose causes can be related to the distribution of the dates included in the dataset. A great advantage of this modeling is that it enables the reduction of uncertainty by narrowing down the largest ranges of dates, caused by the presence of the plateau in the calibration curve (Reimer et al. 2013), and rendering relatively precise dates to each archaeological layer dated.

Wherever it was possible, two chronological models were run separately for each sample type, short-lived and long-lived. The results were then compared with each other in order to evaluate the possible differences in years caused by the “old-wood effect”.

Regrettably, just one multilayered site (Montale in Northern Italy) provided more than one reliable date for contiguous phases. We decided to run a model with these dates and check the results with the general sequence.

6.3.3 Definition, identification and removal of archaeological and analytical outliers from the sequences

An additional importance of the modeling is the identification of the outliers. A date can be defined as outlier when the agreement index appears as less than 60%. In such cases the confidence interval of the date does not statistically fit into the phase from which it originates. The reasons for data being defined as outlier were specified before they were removed from the sequence (Bronk Ramsey 2009b). It was not just the agreement index that was considered, we also took into account the type of sample and the context. As a general rule bones and seeds were preferred over wood and charcoal. Samples that appeared as outliers in the model were given additional consideration and a careful analysis was conducted in order to ensure the possible reason for their “unfitting” date. Although the earliest sample of the earliest phase and the latest one of the sequence were frequently characterized by a low agreement index, we did not consider them automatically as outliers (Regev et al. 2012).

After the identification, the outliers were removed one by one and the model was run

after each removal. The result can change after each removal, a date which was marked as an outlier in the previous model can increase the agreement index after the elimination of another date and hence be included in the model.
Dates with an agreement index of 55-60% were left in the sequence.

6.3.3.1 Northern Italy

The available dates from Northern Italian contexts after the sample prescreening were distributed into five archaeological phases (*BA*, *BM2*, *BM3*, *BR*, *BF*). Regrettably no reliable dates were left after the preselecting of the dates for the beginning of the Iron Age (*Fe* phase).
As the first phase of the Middle Bronze Age (*Bronzo Medio 1*) did not produce reliable dates we introduced it artificially into the OxCal 4.2 model using the *Interval* tool, which is used to calculate the time-span between two events in a sequence, without deciding *a priori* of a predetermined time duration for the missing phase.
In order to visualize in a simple way the distribution of short-lived samples in the sequence, they were marked with an asterisk in the models.
A contiguous model and a sequential one (Fig. 48 and 49) were run several times in order to create a reliable sequence. In both models, nine samples were characterized by a low agreement index and hence eliminated from the Bayesian analysis.
From the phase *Bronzo Medio 2* (*BM2*) five samples were removed. The first four samples are charcoal originating from the settlement of Santa Rosa di Poviglio in the Padan Plain (GX-16298; GX-16299; GX-15011; GX-14032). Although they came from a well-defined archaeological context they are slightly old for the archaeological phase they are supposed to belong to. As already noticed in the references (Cremaschi 2004), this can be due to an “old-wood effect” which could correspond to the intensive deforestation in evidence in the first phase of the *Terramare* settlement.
The date Beta-48687 collected at Roc del Col is also too old for the *BM2* phase; it could be attributed to an “old wood effect” as the dated sample is charcoal and was part of a of a 15mL sample sent to the laboratory, in which perhaps there were adult logs older than the dated context (Nisbet 2004).
From the phase *Bronzo Medio 3* (*BM3*) one sample (GrN-9274) from the dataset of the settlement of Monte Leoni was removed because it was too recent, as already observed

in the references.

The rest of the outliers were from the Late Bronze Age: two samples from the *Bronzo Recente* (*BR*) phase and one for the *Bronzo Finale* (*BF*) phase. The first two are a charred seed from the Novà, Via Larga site (GrA-5216) coming from the US 10 which is too old, and a charcoal from the US 8 collected in the Fondo Paviani settlement (LTL-5285) which on the contrary is too recent. The last date to be removed is charcoal from layer 2 of the Castellaro di Uscio settlement (Gif-7214), which is also too recent.

After the removal of analytical outliers 42 dates from 17 archaeological sites composed the contiguous and the sequential model.

We also modeled the stratigraphic sequence of the Montale settlement (Fig. 50) which provided five reliable ^{14}C dates: one for the *BM2*, two for the *BM3* and another two for the *BR*. The results agree with the general sequence proposed for Northern Italy.

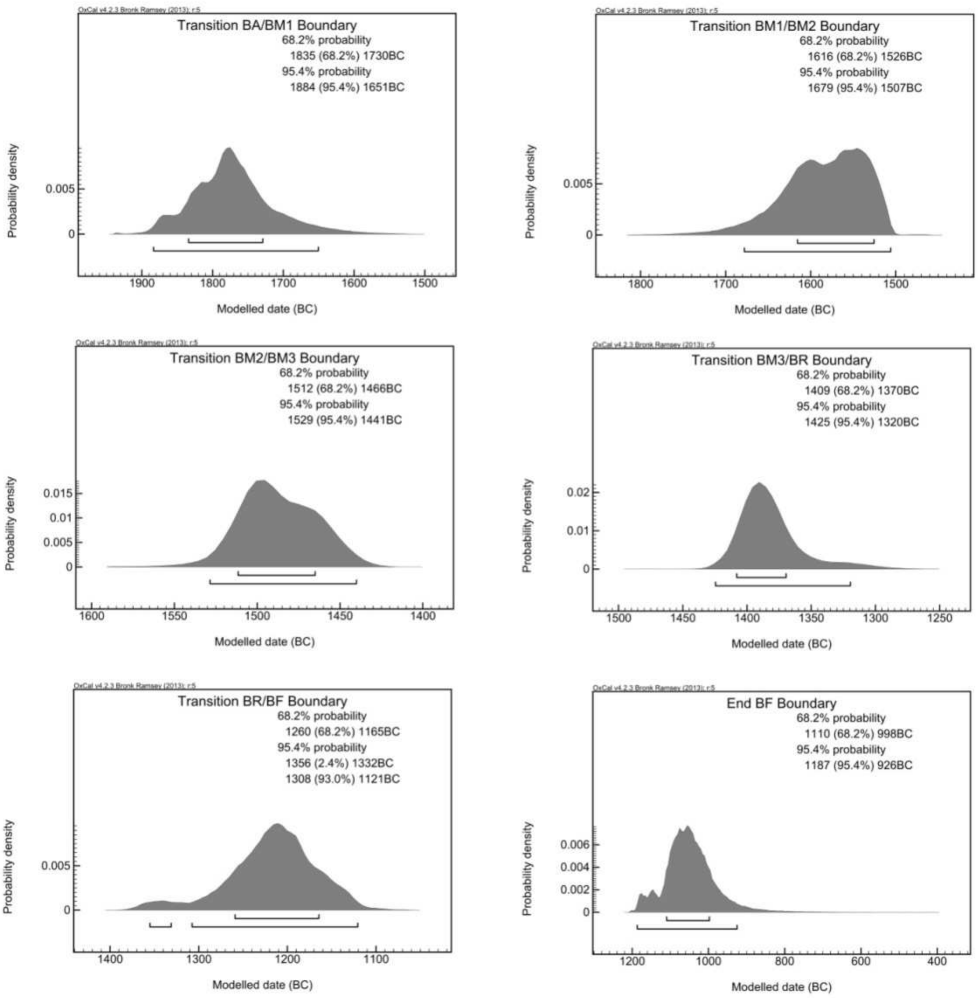

Fig. 48 - Transition boundaries of the contiguous model for archaeological contexts located in Northern Italy (A_{model}=122.4; $A_{overall}$=123.5).

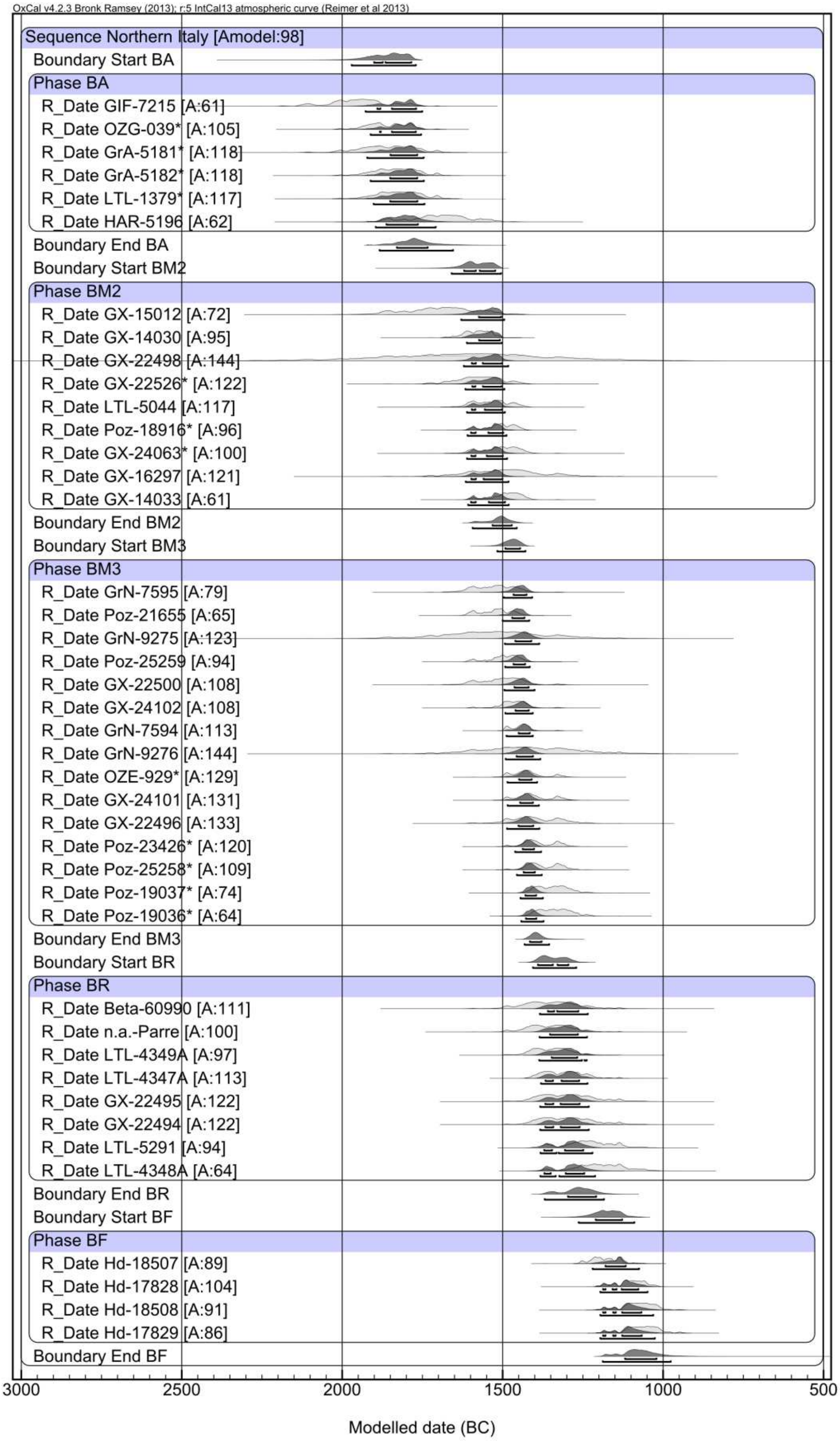

Fig. 49 - Sequential model for archaeological contexts located in Northern Italy (A_{model}=98.4; $A_{overall}$=96.1).

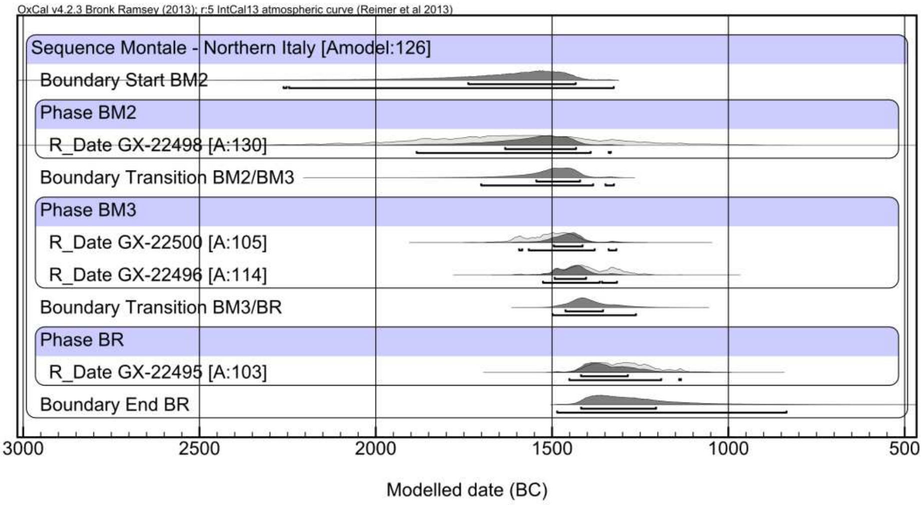

Fig. 50 - Contiguous model for the settlement of Montale located in Northern Italy (A_{model}=126.1; $A_{overall}$=126.2).

6.3.3.2 Southern France

Contiguous and sequential models (Fig. 51 and 52) were also created with the radiocarbon dates from archaeological sites in Southern France.

The outliers were mainly distributed in the last phases of Late Bronze Age (*BF1, BF2* and *BF3*). One date from charred seeds gathered at the settlement area of Llo (Gif-3744) is too old for the *Bronze Final 1* phase, as already noticed by the author (Campmajo 1983). It highlights the need to check the reliability among also short-lived samples. The sample (ARC-1618), which was collected in the Laprade settlement, is too old for the *Bronze Final 2* phase. It is the oldest date in the dataset of this site, which is made up by four other dates which fit correctly into the Bayesian model.

Nine dates obtained from charcoal samples were eliminated from the *Bronze Final 3* phase. Two samples collected in the village of Carsac (MC-2287; MC-2285) were removed for being too old for the archaeological contexts they belong to. One date from the layer C2d of the Grotte de la Garenne site (Ly-7184) is too old. Perhaps, it can be due to problems of contamination from the lower levels, in which materials typologically dated to the *BF2* was found (Carozza 1994). Furthermore, Lachenal (2011) inserts the date (Ly-7185) from the upper occupation layer C2c in the BF2 phase. It highlights the existence of disagreements in the chrono-typological chronological description of human artifacts. The sample collected from the settlement of Le Touar

(Ly-4542) is too old for the *BF3* phase maybe due to an old wood effect. Three dates (Ly-4743; Ly-5097; Ly-4686) from the site of Saint Alban seem to be slightly too old; in this case we cannot exclude a higher beginning of the *BF3* phase in the area of the site, in particular taking into account the marginal northern position of the settlement, located close to the Jura Mountains. Eventually, two dates were removed because too recent. The first one was collected at the site of La Roumanine (Ly-8244) and the second one originates from the necropolis of Camp d'Alba (Ly-7433).

As a result of this second selection with the removal of analytical outliers 85 dates from 41 archaeological sites composed the contiguous and the sequential model.

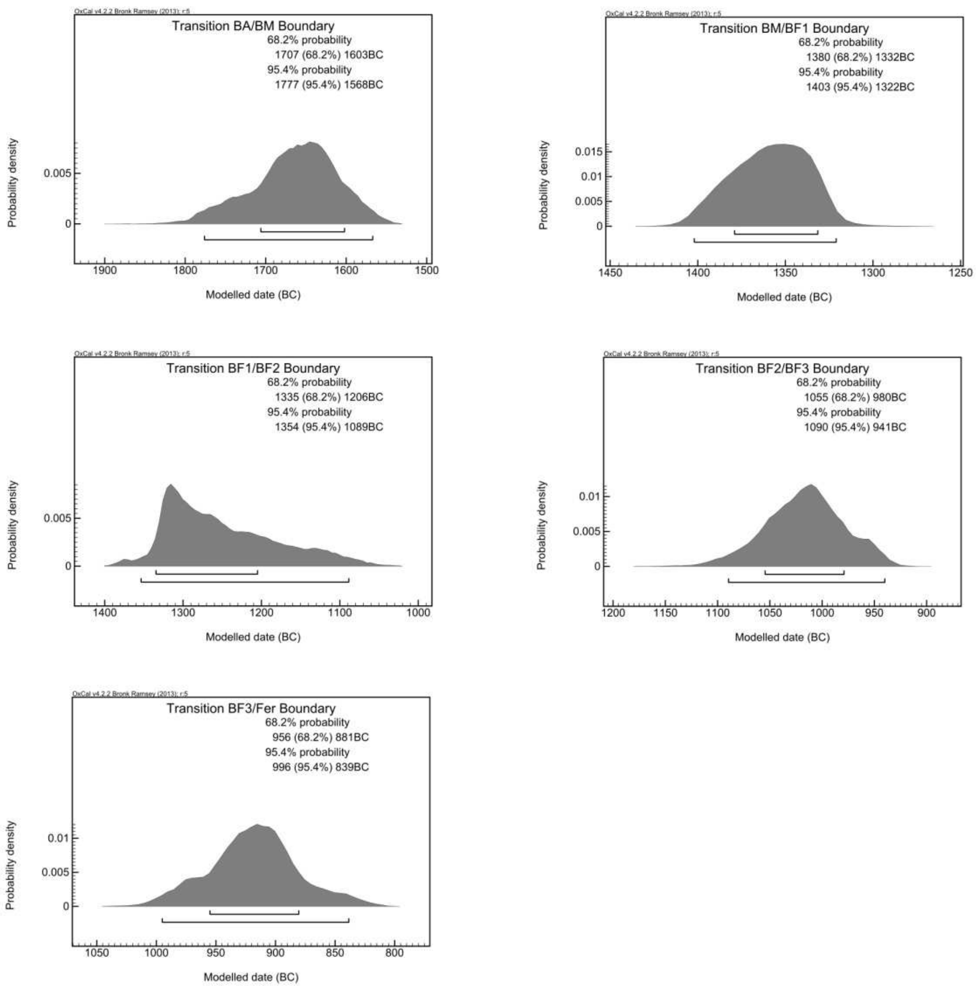

Fig. 51 - Transition boundaries of the contiguous model for archaeological contexts located in Southern France (A_{model}=145.7; $A_{overall}$=135.9).

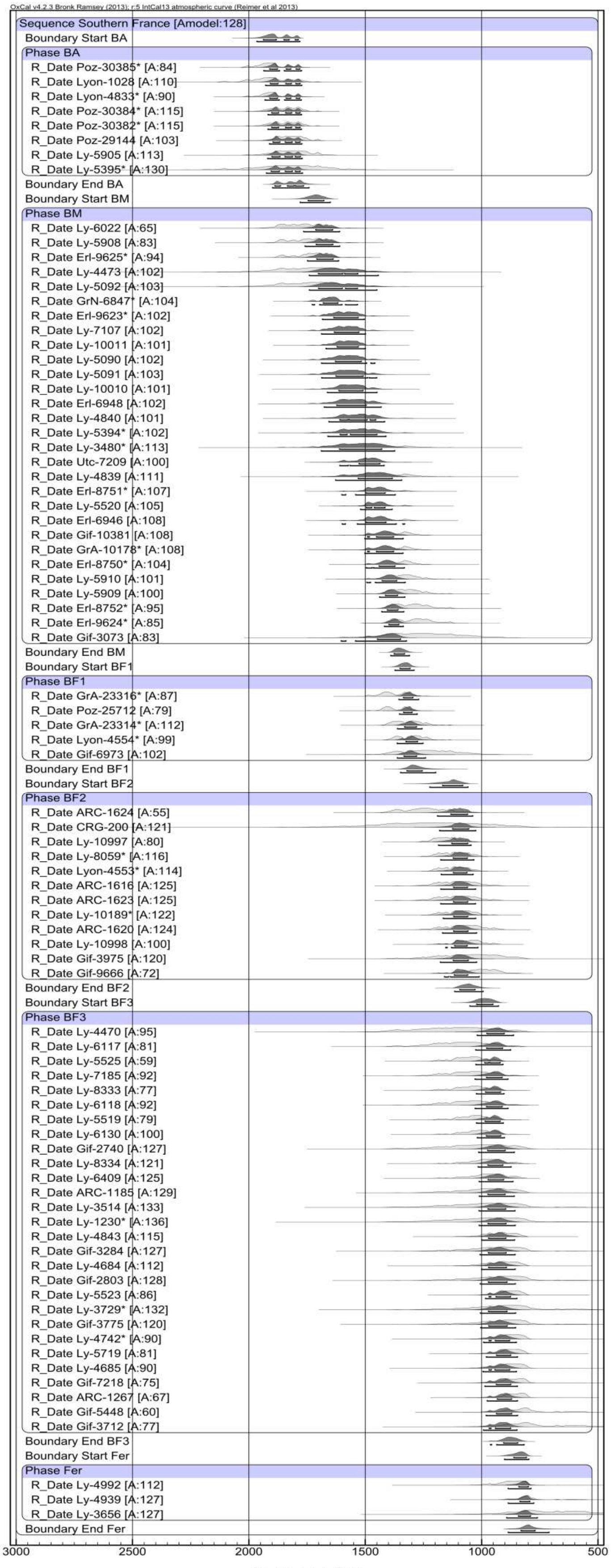

Fig. 52 - Sequential model for archaeological contexts located in Southern France (A_{model}=128.1; $A_{overall}$=102.1).

6.3.3.3 North-East of Iberian Peninsula

We did not manage to create reliable sequences with OxCal program using the 124 radiocarbon dates from archeological contexts located in the North-East of Iberian Peninsula. Therefore, it was impossible to create a contiguous and a sequential model using such a filtered dataset. In fact, dates overlap in many places and we could not detect a clear distinction between the different phases of the traditional chronological scheme. Furthermore, frequently large standard deviations are responsible of those phenomena of overlapping.

The absence of result is mainly due to the uncertainty in determining a reliable and solid traditional chronological framework for the North-East of Iberian Peninsula, as reported in the chapter 2.5. As a consequence, still nowadays, a univocal type-chronological seriation of the material culture is lacking among the scholars.

In the light of such a situation, the discussion of the results will be limited to the North Italian and the Southern French sequences.

6.4 Discussion

Through the Bayesian modeling with OxCal 4.2 (Bronk Ramsey 2009a) we produced two new chronological models for the Bronze Age in Northern Italy and Southern France (Fig. 53). During the process of prescreening of collected samples according to their chronological value, a large amount of dates were rejected, prior to start Bayesian modeling. Problems related to the sampling strategies still remain. In many cases the results of radiocarbon dating are used as a substitute for the chrono-typological analysis of human artifacts and when diagnostic pottery or metallic typologies are missing. Consequently, association between the two variables was frequently lacking and the selected dates were fewer than expected. Therefore, we decided to include in the models dates characterized by a large standard deviation (±100 years), although we are aware that it would be preferable to use dates with a shorter duration when available.

Another problem is the absence of ^{14}C dated multilayered sites. Separately modeling dates from contiguous layers in the stratigraphy of individual sites could have yielded different models for each site. Combining such information would have allowed us to detect a possible degree of overlap between cultural horizons and the existence of regional variations. However, sufficient research is currently lacking to test this theory.

When a sequence of phases is run the model manages to narrow the dates of the phase between the *Start Boundary* and the *End Boundary*. Such a process implies a possible creation of temporal gaps among archaeological phases. Analyzing the results of the sequential models, few discontinuities in times were detected in the models for Northern Italy and Southern France for the 1σ confidence intervals. We did not take into account, in any of the models, the values represented by the beginning of the first phase, which is the *Start Boundary* of the Early Bronze Age, or the end of the last phase represented by the *End Boundaries* of phases *Bronzo Finale* and *Fer*.

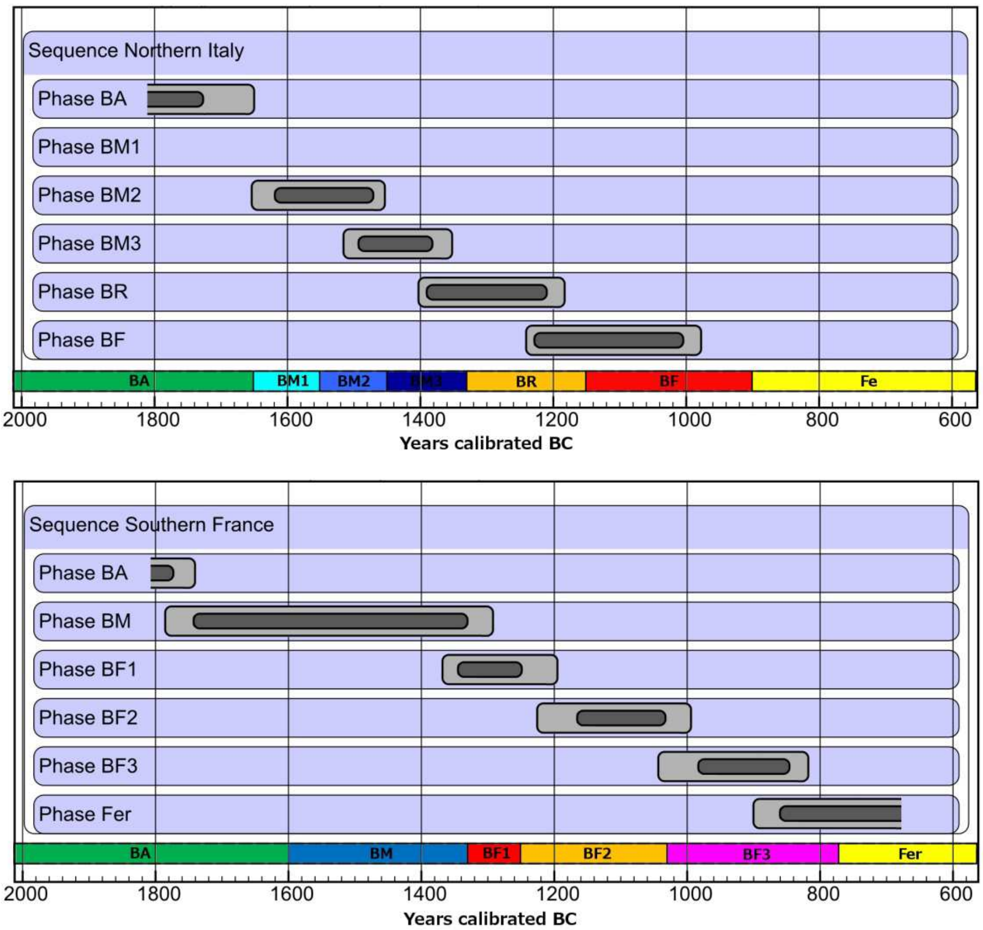

Fig. 53 - Results of the Bayesian modeling for Northern Italy and Southern France. Only the analyzed sub phases have been represented. The conventional chronology is shown above the x-axis. The ^{14}C scheme is a simplification of the results obtained through a sequentially phased Bayesian modeling: for the boundaries of each phase we chose the first value of the “Start Boundary” and the last value of the “End Boundary” for the 1σ probability (dark grey blocks) and for the 2σ probability (light grey blocks).

6.4.1 Northern Italy

Taking into account the limited numbers of ^{14}C dates for this period and the size of the region it must be stressed that these results points the need for further research and the necessity of an increase in the amount of dates from good archaeological contexts.

The results of the modeling must be considered as a first step toward a radiocarbon dated chronology for the Bronze Age in Northern Italy. The adoption of good sampling strategy for the future years can fill the lacks and improve the strength of the models.

Although we do not observe a relevant difference, more than 100 years, between the radiocarbon chronology and the conventional one it should be noted that both in the sequential model and in the contiguous model all the analyzed phases start and end before traditional dates proposed for these regions. It implies that the new radiocarbon chronology for the Bronze Age in Northern Italy is slightly higher than the conventional one. Regrettably, the number of short-lived samples is few; moreover they refer to the first three phases leaving a lack in the last two ones. As a consequence, we could not run a separate model for seed and bone samples. In any case the distribution of such samples in the phases does not suggest a problem related to an "old-wood effect" in the first three phases. The results obtained from statistical modeling of those samples collected from the Montale settlement are perfectly in agreement with the general radiocarbon chronological framework.

A debated topic, as already mentioned, is the beginning of the Iron Age in Northern Italy. Regrettably there are still only a few dates for this period and no reliable dates were selected for analysis. Moreover, problems related to the typological description of material culture must be underlined. In particular, there are still difficulties in the distinction of artifacts typologically dated the 10th c. BC from those of the 9th c. BC (Giovanni Leonardi, personal communication).

According to our models the end of the LBA (*BF*) is placed in the contiguous model in the interval 1110-998 BC for the 1σ probability and 1187-926 for the 2σ. It is dated between 1119 and 1021 BC for the 1σ probability and 1189-977 BC for the 2σ in the sequential model. Lamentably, these results cannot provide a compelling answer for the beginning of Iron Age in Northern Italy, since only one dated archaeological site for the *BF* phase is included and no Iron Age dates were inserted in the analysis in order to bracket the transition from the other side.

Concerning the discontinuity observed in the sequential model the main temporal gap is located between the phases BA and BM2. Its duration is ≈120 years taking into account the 1σ values of the more recent dates for the End Boundary of the Early Bronze Age and the beginning of the Start Boundary for the *Bronzo Medio 2* phase. This discontinuity is caused in part by the absence of a *BM1* phase. If we take into account the 2σ confidence intervals the gap disappears.

6.4.2 Southern France

In Southern France, the results obtained by the Bayesian modeling are in close agreement with the traditional dates proposed for the transitions among Bronze Age phases. There is remarkably solid agreement on the beginning of the *BF1, BF2* and *BF3* phases between the traditional and the radiocarbon chronologies. This demonstrates the reliability of filtered dates.

The distribution of short-lived samples in the sequence is quite homogenous among the different phases. As a result of this we could run a sequential model with bone and seed samples in order to test if a significant variation could be appreciated. The result showed that no differences can be detected; hence we can discard an “old-wood effect” in the analyzed data.

The most significant changes relate to the beginning of the Middle Bronze Age (*BM*) and the Iron Age transition. The *BM* phase seems to start ≈150 years before the date adopted in the conventional chronology. Also the transition to the Iron Age appears slightly higher in the ^{14}C model. In the contiguous model the transition between *BF3* and *Fer* is located in the interval 874-820 BC for the 1σ probability and 904-806 BC for the 2σ. These values are confirmed in the sequential model, in which the beginning of the Iron Age is dated within the interval 862-809 BC for the 1σ probability and between 902 and 798 BC for the 2σ probability. In any case, we have to highlight the problems of calibrating for the “Hallstatt plateau” whose beginning corresponds to the traditional date proposed for the start of Iron Age in Southern France, 775-750 BC (Janin 1992; Brun et al. 2009; Lachenal 2011). Moreover, only long-lived samples from two sites, Le Touar and Pré de la Cour, were selected for the *Fer* phase. In the future new dates from good archaeological contexts could improve the situation and reduce the uncertainty.

As was the case with the North Italian model, time gaps were detected in the sequential model of the radiocarbon chronology of Southern France for the 1σ confidence intervals. Such discontinuities are located between the three phases of Late Bronze Age *BF1*, *BF2* and *BF3*. These gaps disappear if we consider the 2σ values of the probability distributions.

7 FROM THE ALPS TO THE MEDITERRANEAN: A STATISTICAL ANALYSIS OF TEMPORAL CONTINUITIES AND DISCONTINUITIES

7.1 The study of population trends in the Bronze Age and in the Iron Age transition

Population trends of increase and decrease in the number of people represents a common denominator in prehistoric researches.

The possibility of detecting pattern and cycles for the 2^{nd} and the beginning of the 1^{st} millennia BC are a fundamental point in the works of Kristiansen (1998b).

The existence of cycles is a constant in long term processes. For the Nordic Bronze Age Kristiansen (1987; 1991; 1998b) detected regularities between burial and hoard deposition, based on comparative historical sequences from Denmark (Fig. 54). A peak in the amount of barrows and burial wealth has been detected by the author for the late Bronze Age, around 1200 BC. On the contrary, such event corresponds to a decrease in the number of hoards in the same regions. Axe and weapons appear in the previous period characterized by the logistic increase of burials.

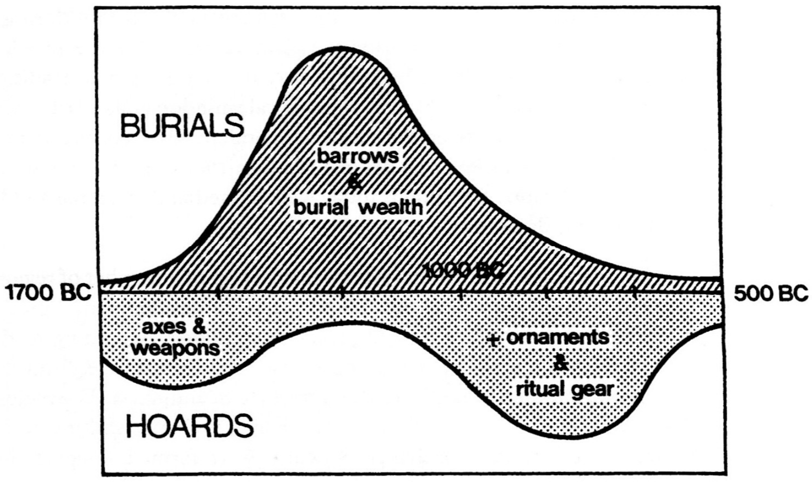

Fig. 54 – Ritual variation through time: patterns of investment in wealth deposition and monument construction during the Nordic Bronze Age (Source: Kristiansen 1998b).

The detection of cyclical regularities in the relationships between different modes of deposition in time and space was not only bounded to Nordic contexts.

A shift in the deposition of bronze hoards from east Central Europe (*HaA2-B1*) to Western Europe (*HaB2-3*) during the LBA (Furmanek & Horst 1982), in both areas the hoarding of personal prestige goods, weapons and ornament was preceded by a period of chiefly warrior burial (Wegner 1976; Bradley 1990). It is meaningful to highlight that Kristiansen (1998b) suggested that the Urnfield period was one on the most densely populated phase in the Prehistory. In the light of settlement size and the number of funerary contexts he detected a relevant enhance of population size in a large part of Europe, mainly in the period 1100/1000 BC. For instance, in Poland the number of necropolis of the Lausitz culture increase remarkably from the second period of Montelius (Stepniak 1986), at the end of the same period settlements located in the Swiss region around the main lake basins show a high density of population (Primas 1990). If the LBA is characterized by such a demographic growth the previous phase of the Late Early Bronze Age-beginning of the Middle Bronze Age shows a different trend with a low settlement density (Fig. 55). Such phenomena of increase and decrease in the number of settlement and as a consequence also of people have been traditionally correlated with climatic conditions (see chapter 3.6).

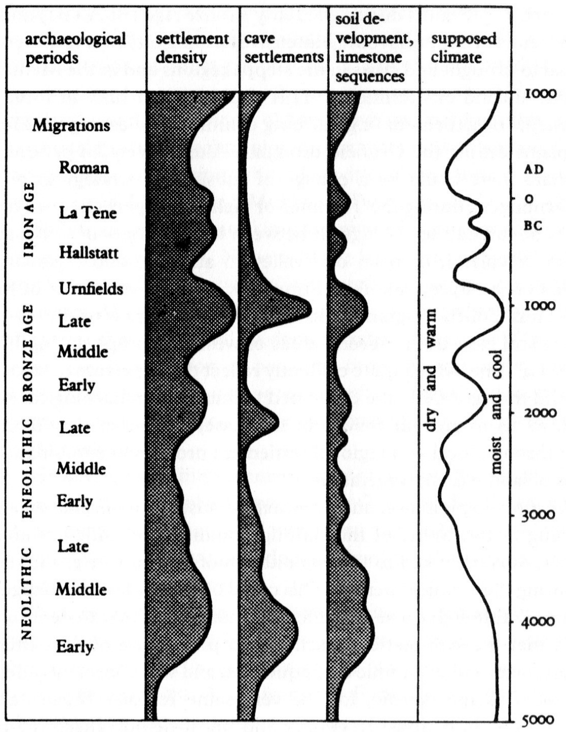

Fig. 55 – Correlation of settlement density number of cave settlements, soil development and supposed climatic change in Central Europe (Source: Kristiansen 1998b).

To strengthen Kristiansen's hypothesis, for the Bronze Age Zimmerman (2009, 2012) argued population densities in Central Europe between 0.6 and 1.8 persons per 100 km^2. The results were produced using geostatistical methods based on density of sites in the landscape (Zimmerman 2009). Adopting the idea of cycles, the author stressed the existence of cultural regularities from the Paleolithic onwards (Fig. 56). In his model the *Urnfield culture* would correspond to a moment with a high size of cooperating groups. Such a high degree of cooperation was probably promoted by an increase of population.

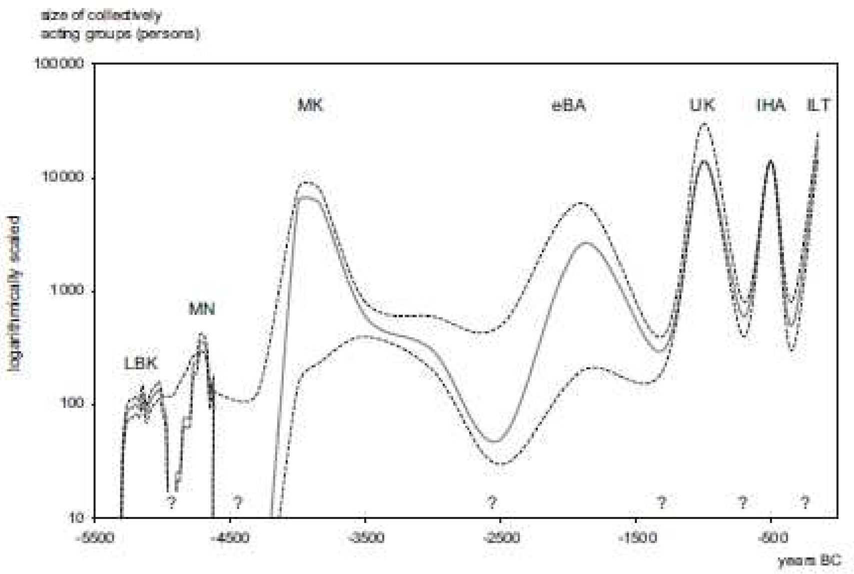

Fig. 56 - Cultural cycles from the Neolithic to the Iron Age in relation to the size of deliberately cooperating groups. The peak UK corresponds to the *Urnfield culture* (Source: Zimmermann 2012).

Eventually, for the time-span 2000-0 BC Kristiansen (1998b) stressed the presence of cycles regarding the funerary rite with the of chiefly burials and communal burials with a general trend of movement from east to west starting, in which a specific migration from west to east was argued for the period of *Tumulus Culture* (Fig. 57). Such cycle can be recognized also in other features like the settlement patterns and subsistence strategies.

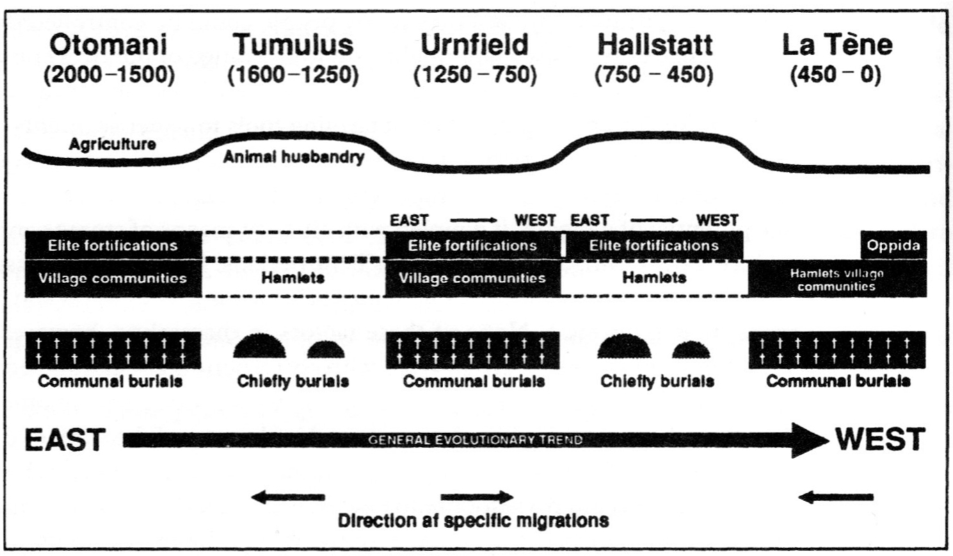

Fig. 57 – Schematic outline of the dominant trends in settlement, subsistence and burial ritual from 2000-0 BC in Central Europe Age (Source: Kristiansen 1998b).

In addition to Kristiansen's studies, the presence of cycles and a boom-and-bust pattern in the density of population have been recognized by other authors also for other periods. For instance, for the Neolithic period following the introduction of the agriculture, a series of demographic increases and decreases have been recently detected in various European regions by Shennan et al. (2013).

7.2 Temporal continuities and discontinuities in the EUBAR database

The methods for inferring past population structure, demographic variations and transitions, and population extinctions are various (Chamberlain 2009). Quantifying temporal continuities and discontinuities from archaeological data is an interdisciplinary endeavor that should incorporate findings from paleodemography, anthropology, paleogenetics, and human ecology (Housley et al. 1997; Gkiasta et al. 2003; Fort et al. 2004; Gamble et al. 2005; Mellars 2006; Shennan & Edinborough 2007; Hamilton & Buchanan 2007; Collard et al. 2010; Hinz et al. 2012; Shennan 2013). Several techniques have been used as a proxy for estimating the probable size of a human population based on archaeological data. Among them, we can mention the study of settlements' size, of house dimensions and site catchment areas, as well as the measurement of the rates of exploitation, consumption, and discard of raw materials and artifacts (Roper 1979; Schact 1981; Kolb 1985; Gallivan 2002). In this framework the "discard equation" or "Cook's law"[9] (published for the first time in Schiffer 1975, p. 840) is traditionally used to correlate the amount of discarded materials as a function of the duration of a site occupation, the size of the group who inhabited it and the rate at which materials were discarded. Also the analysis of funerary contexts and human skeletons has been used for estimating past population size. In fact, it is possible to infer age-specific mortality from assemblages of human skeletons remains (Katzenberg & Saunders 2008).

Moreover, in archaeology changes in the relative temporal frequency of dates or dated components are commonly interpreted to reflect changes in human demography based on the simple and reasonable assumption that as the number of people increases, so does the strength of their archaeological signal.

In our analysis we have decided to use the Summed Calibrated Probability Distribution (SCPD) of radiocarbon dates, which constitute the most widespread methodology for inferring population changes (Turney et al. 2006; Ortman et al. 2007; Shennan & Edinborough 2007; Buchanan et al. 2008; Smith & Ross 2008; González-Sampériz et al. 2009; Oinonen et al. 2010; Peros et al. 2010; Tallavaara et al. 2010; Johnson & Brook 2011; Pesonen et al. 2011; Armit et al. 2013; Martínez et al. 2013; Miller & Gingerich 2013; Crombé & Robinson 2014). For a review of such a methodology see chapter 4.3.2.

From the EUBAR database we have made a selection of radiocarbon dated archaeological contexts. First, we have refused ^{14}C dates from mines, like the large amount of dates (34) originating from the well known Halstatt mines, which could skew the final result of the Summed Probability Function. Then, in order to reduce the uncertainty, we have selected only radiocarbon measurements with a standard deviation less than 100 years. Eventually, 1443 dates were retained for the analysis.

Although not all archaeological events are similar, we assume that the original depositional events are comparable in that (Barceló, Capuzzo, Bogdanović 2013):

- Dated events correspond to random accumulations around social locations (residential, productive, and ritual)

[9] $T_D = St/L$ where T_D is the total number of artifacts discarded, S is the number of artifacts normally in use, t is the total period of use of the artifact type (expressed in units of time, such as months or years) and L is the uselife of the artifact (expressed in the same units of time as t).

- The nature of the accumulation was approximately the same,

Then,

- The amount of dated archaeological events for a single social event depends on the number of people generating the accumulation, the time during which the actions generated material effects observable archaeologically, and the social way of disposing garbage (Varien & Mills 1997, p. 143).

Consequently,

- Although we are not aware of the precise rate at which each material effect was socially produced at a specific moment, we assume the rates for the different kinds of material effects whose archaeological contexts have been dated are within a short variance,
- The probability that a social event happened in a short interval was proportional to the spatial extension or temporal duration of that event,
- The probability that a social event occurring in a short interval was independent of the events that occurred outside that interval, and
- The probability of more than one event in a sufficiently small interval is negligible.

In such conditions, we have generated different SPCDs for the 1443 ^{14}C measurements referring to 541 archaeological sites dated to the Bronze Age (Early, Middle and Late phases) and to the beginning of the Iron Age between the Ebro and the Danube rivers. As the analyzed period (1800-800BC) is much shorter than the time-spans usually adopted in SCPDs available in literature (Gamble et al. 2005; Turney et al. 2006; Ortman et al. 2007; Shennan & Edinborough 2007; Buchanan et al. 2008; Smith & Ross 2008; González-Sampériz et al. 2009; Oinonen et al. 2010; Peros et al. 2010; Steele 2010; Tallavaara et al. 2010; Johnson & Brook 2011; Pesonen et al. 2011; Williams 2012; Armit et al. 2013; Martínez et al. 2013; Miller & Gingerich 2013, among others), we have decided not to apply the correction for the postdepositional bias, which is suggested in Shennan and Edinborough (2007). In fact, we do not consider the existence of significant variations that could explain its adoption, in the intensity of post-depositional processes during the 2nd and the beginning of the 1st millennium BC on a large-scale in South-Western Europe.

Before a deeper filtration of the available information we have run a SCPD (Fig. X) with such a dataset using the IntCal13 calibration curve (Reimer et al. 2013) and the OxCal 4.2 software (Bronk Ramsey 2009a). We can explain the SCPD of 1443 radiocarbon dates from a large variety of archaeological contexts from Western Europe Bronze Age in terms of the absence of population growth during the period 1800–800 BC at a global scale, with peaks of higher frequency of human activities at 1500 BC and 800 BC (Fig. 58).

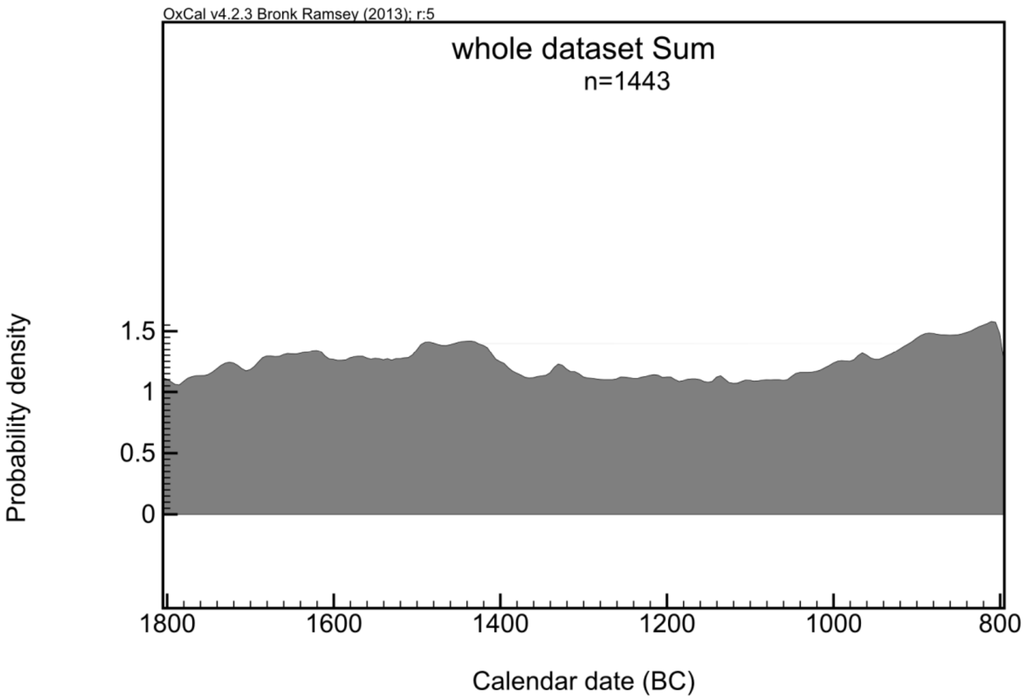

Fig. 58 – SCPD of 1443 radiocarbon dates included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2). Only a preliminary filtration has been applied to the dataset.

As in this graph a source of uncertainty can be recognized in the presence of some “overdated context”, we have decided to adopt a further sample prescreening. Therefore, when the information was available, we have combined dates from the same archaeological context, i.e. the same depositional event, using the toll “R_Combine” of the program OxCal 4.2, which function is to provide a pooled mean combining radiocarbon dates prior to the calibration (Bronk Ramsey 2009a). In this way, when we sum the results of combined contexts we obtain a more reliable SCPD, in which the representativeness of archaeological context is not altered. In fact, in the new SCPD graph (Fig. 59) each archaeological layer, as well as each grave, is represented by only one ^{14}C estimate. Obviously in this new distribution the number of analyzed dates will be lower than in the previous one, but the degree of quality in the representativeness of such data will be higher. The shape of the obtained SCPD is comparable with the previous one with peaks of supposed higher frequency of human activities at 1500 BC and 800 BC.

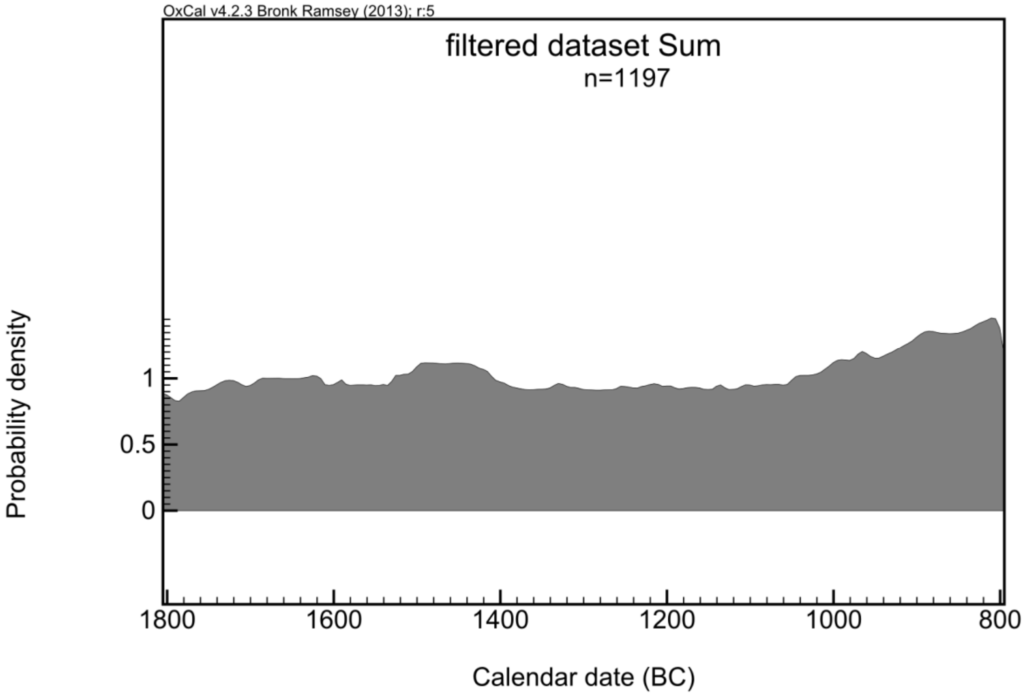

Fig. 59 – SCPD of 1197 radiocarbon dates included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2). We have filtered "overdated contexts" using the function "R_Combine" of OxCal 4.2 (Bronk Ramsey 2009a).

A problem relating to such an analysis is the presence and the sum of both funerary contexts and other contexts represented by settlements, ritual areas, productive districts and infrastructures. In order to avoid this noise we have decided to filter deeper our data, analyzing separately the two categories. Therefore, new SCPDs have been produced applying such a prescreening (Fig. 60 and 61). In the graph obtained using dates originating from settlements, although it is characterized by a slight positive trend the flat shape does not suggest major episodes of demographic increase or decrease in the time-span 1800-800 BC (Fig. 60). Nevertheless, for the funerary context our data shows a different temporal distribution compared to the settlement's one. In the SCPD including burials, both inhumation and cremation, two different patterns distinguished by a clear episode of discontinuity have been detected (Fig. 61). Before around 1400 BC the flat shape suggests a constant number of dated contexts, the number of funerary contexts decreases sensibly between 1420 and 1360 BC. After this discontinuity, the produced SCPD shows a positive trend with an increase in the number of contexts; such an increase is more pronounced in the last phases of the time-span. It is meaningful to highlight that the analysis of funerary contexts should not be interpreted as prove of demographic increase or decrease, but as an inference for the adoption of burials among the Bronze Age and the beginning of Iron Age communities. We will tackle in the details this issue in the following chapter.

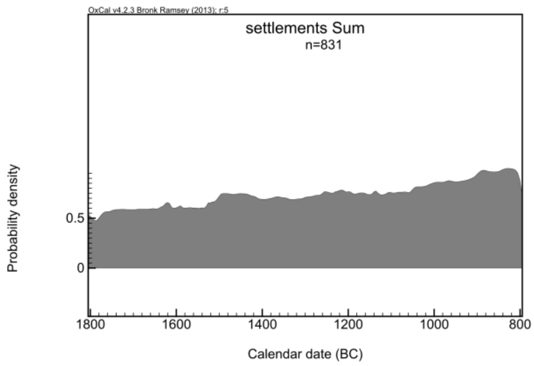

Fig. 60 – SCPD of 831 radiocarbon dates from settlements included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2). We have filtered “overdated contexts” using the function “R_Combine” of OxCal 4.2 (Bronk Ramsey 2009a).

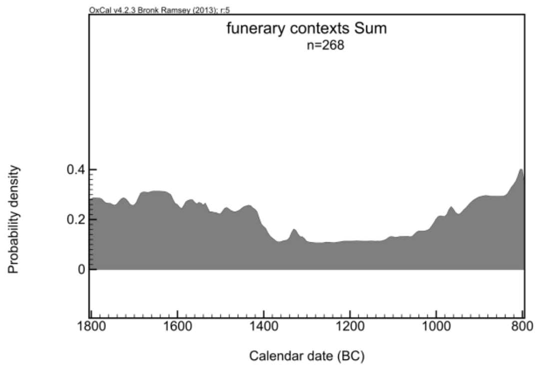

Fig. 61 – SCPD of 268 radiocarbon dates from funerary contexts included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2). We have filtered “overdated contexts” using the function “R_Combine” of OxCal 4.2 (Bronk Ramsey 2009a).

Eventually, we have simulated a set of radiocarbon dates with no chronological variation to test a null hypothesis of no relationship between the observed SCPD and the effects of that particular section of the calibration curve (Fig. 62). Through a generator of random numbers we have produced 1197 ^{14}C dates for the time-span 3550-2550 BP whose distribution does not correspond to a normal one. For the standard deviation we have adopted the media of the standard deviations of the original dataset. Then we have produced a SCPD graph with the OxCal 4.2 program (Bronk Ramsey 2009a).

Peaks in the observed distribution exactly coincide with irregularities in the calibration curve around 1500 and 800 BC (Fig. 63).

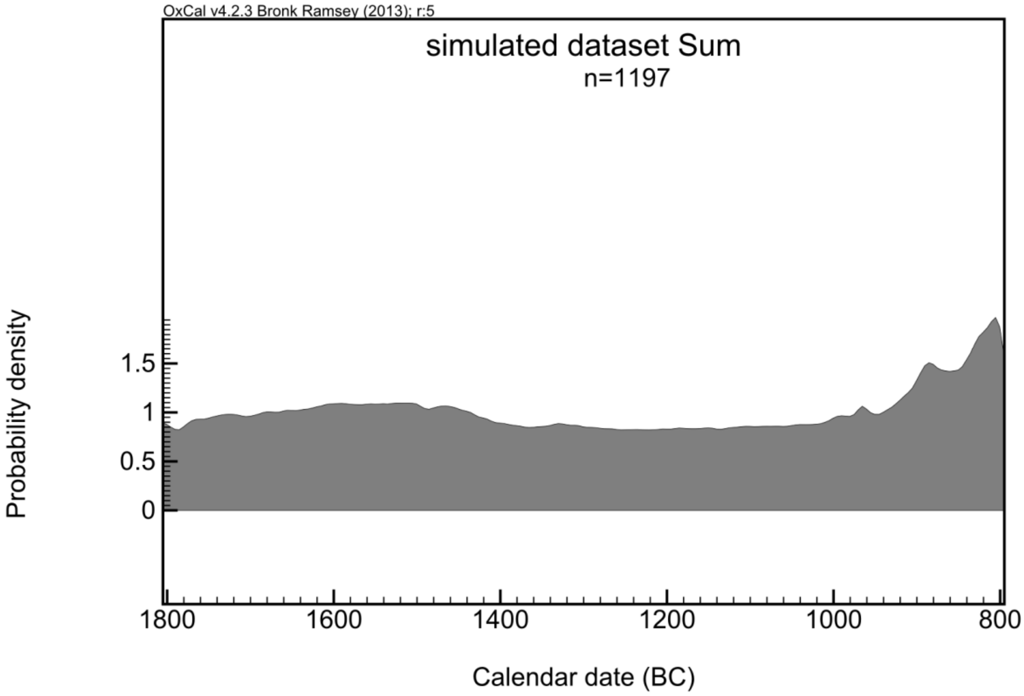

Fig. 62 - SCPD of 1197 simulated radiocarbon dates under the assumption of population uniformity: same number of dated archaeological contexts at each temporal bin. IntCal13 calibration curve (Software: OxCal 4.2).

This result should be interpreted in terms of the influence the calibration curve (IntCal13) on the kinds of inferences we can draw from temporal patterns in the observed frequency of dated archaeological contexts between 1800 and 800 cal BC from Danube to the Ebro valleys. Irregularities in the calibration curve explain both the peaks and the troughs in their curve as well as, or perhaps better than, demographic patterns can (Bamforth & Grund 2012; Chiverrell et al. 2011; Bleicher 2013; Barceló et al. 2013).

The risk that the shape of the SCPD be determined by the calibration curve as has been suggested in the last years (Bamforth & Grund 2012; Chiverell et al. 2011; Williams 2012; Bleicher 2013). The calibration curve was constructed by measuring the ^{14}C content of samples of known age. In times of high solar activity the slope of the calibration curve is steep, and conversely. So, as Bleicher (2013) correctly argued, the probability density function of any calibrated radiocarbon date is defined by three variables: first there is the true calendar age that, together with the error, gives the measured radiocarbon age pertaining to that calendar age. Then there is the uncertainty of the measurement that defines the range. Up to this point the posterior density function (pdf) has a Gaussian shape. This Gaussian pdf is then transformed using the calibration curve into something non-Gaussian, the shape of which is a direct function of the amount of ^{14}C in the atmosphere, which is to say that it is defined by solar activity. One effect is that the radiocarbon clock is quicker in times of high solar activity and slower in times of low activity. Consequently a higher activity normally results in a narrower calibrated range. Even within the range of a radiocarbon date the probability density is defined by the shape of the calibration curve. It might therefore be hypothesized that any SCPD of radiocarbon data will necessarily show similarities with the shape of the calibration curve (Bleicher 2013).

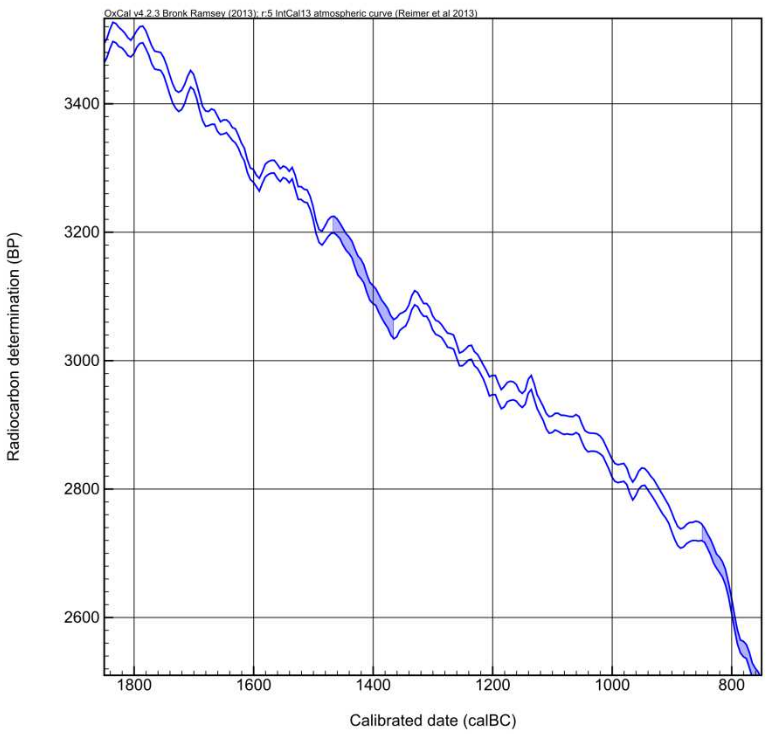

Fig. 63 – IntCal13 calibration curve. We can recognize two major irregularities, shown by two calendar age steps in the time-spans 1500-1380 BC and 860-700 BC. The effects of calendar age steps on SCPD are addressed in chapter 4.3.2.

In the light of the obtained SCPDs, on a macro scale we cannot in clearly episodes of population growth, nor for the last phases of the Early Bronze Age, neither for the LBA and the so called “Urnfield period”. The relevant enhance of population size in a large part of Europe, mainly in the period 1100/1000 BC cannot be distinguished in the analysis of the territory from the Ebro to the Danube River in its completeness.

The time-span 1800-800 BC on a macro scale is characterized by a linear trend in the demographic intensity, with the absence of boom and bust episodes or crisis events.

After having admitted the population stationarity during the Bronze Age and the Iron Age transition on a macro scale, it is important also to further analyze the estimates of population density at a more localized regional scale (Shennan 2013).
However, the reduced number of dated contexts (when dividing the dataset) prevents us deeper insights in this direction; we have chosen the regional area which produced the major number of radiocarbon dates. Therefore, we have analyzed 4 different geographic areas characterized by an internal homogeneity: the Swiss Plateau, the Padan Plain in Northern Italy, Southern French coast and the Massif Central. The obtained results must be considered only as preliminary and they could not be used directly as an evidence for demographic changes, but they need to be validated using other proxies. They could be useful to describe the space-time distributions of radiocarbon dated archaeological contexts. Like in the previous SCPDs also in the following ones we have refused contexts with a standard deviation grater that 100 years and we have combined multi-dated depositional events. The graphs show different patterns in different geographic regions (Fig. 64 and 65).

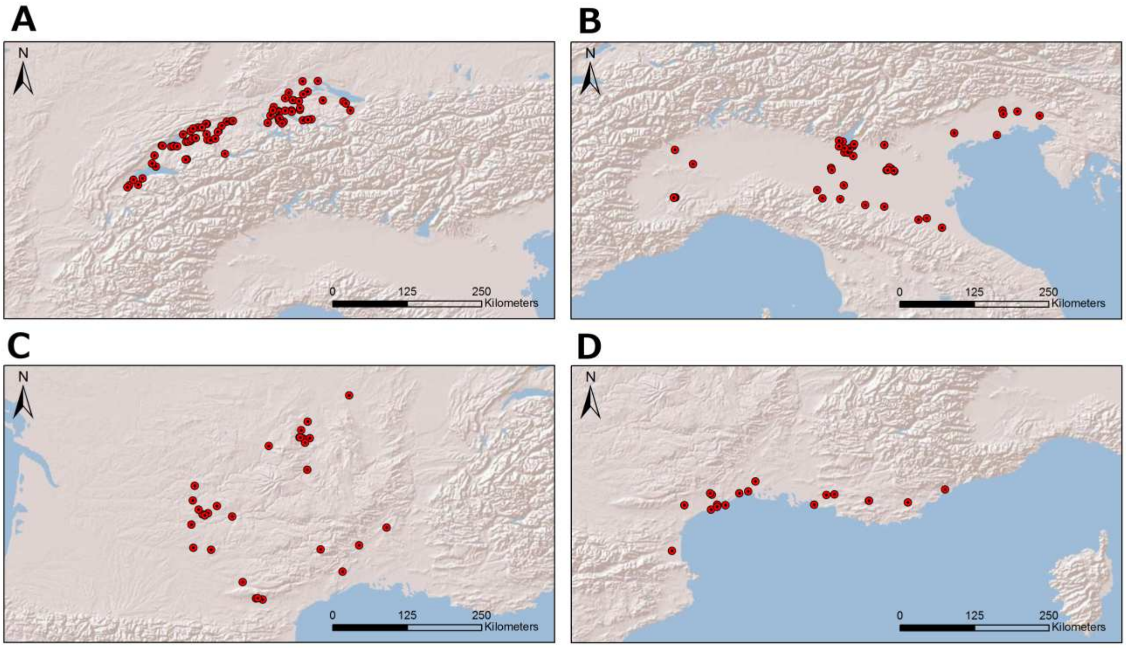

Fig. 64 – Archaeological sites included in the regional SCPDs. The Swiss Plateau (A), the Padan Plain (B), the Massif Central (C) and the French Mediterranean coast (D).

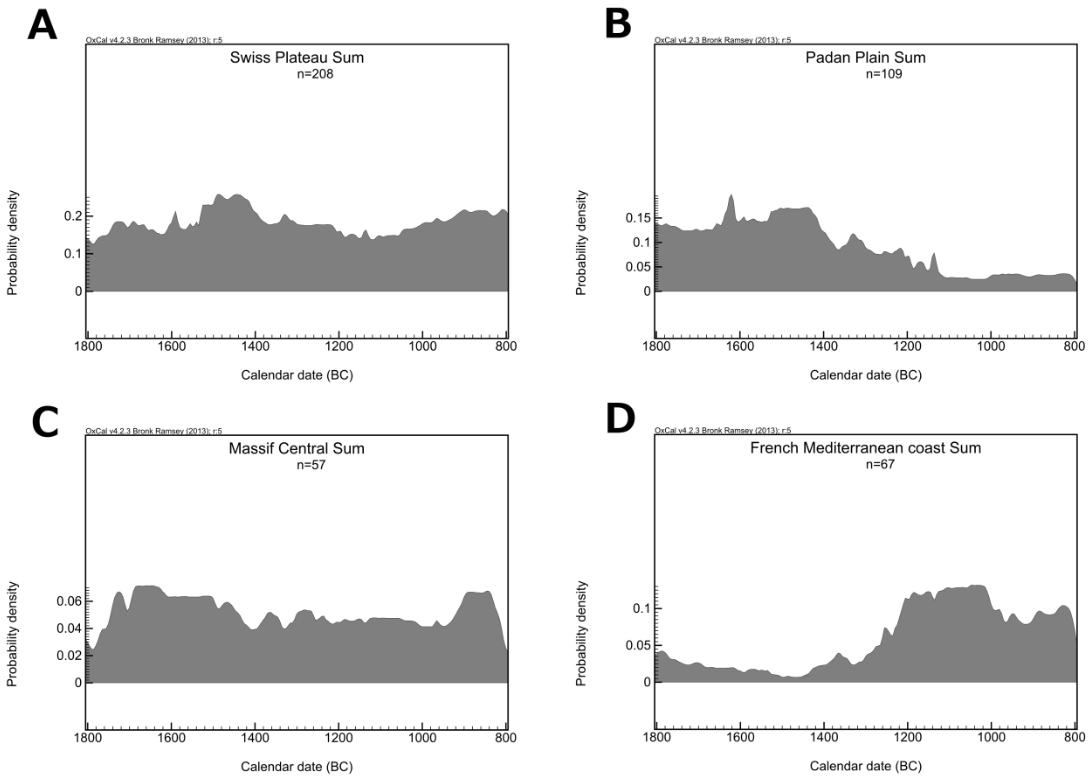

Fig. 65 – SCPDs of radiocarbon dates originating from the Swiss Plateau (A), the Padan Plain (B), the Massif Central (C) and the French Mediterranean coast (D). IntCal13 calibration curve (Software: OxCal 4.2).

The SCPD of 208 isotopic events gathered in the Swiss Plateau shows a quite flat shape with peak in the Middle Bronze Age, around 1500 BC (Fig. 64-65 A). It is relevant to highlight that the main phenomenon of abandonment evidenced in such a region is the end of the lake-dwelling system, which has been associated to episodes of climatic deterioration: the ^{14}C deviations in the atmosphere evidenced a positive correlation with the frequency of lake-side settlements in such a region (Magny et al. 2005; Billaud & Marguet 2007; Magny et al. 2007; Magny & Peyron 2008; Marguet et al. 2008). This event has been placed around 1520 BC (Menotti 2001). In the light of such assumptions the decrease in the number of ^{14}C dated archaeological contexts in the period around 1400 BC could be interpreted as a consequence of this phenomenon.

We also analyzed radiocarbon dates from sites located in the Padan Plain in Northern Italy (Fig. 64-65 B). The SCPD of 109 ^{14}C dates from 40 archaeological sites located the Po Valley shows a remarkable decrease in the number of dated contexts during the Late Bronze Age. The decrease begins around 1400 BC and follows constantly till the beginning of the Iron Age. It is meaningful to remember that at 3100 BP (1415/1311 2σ cal. BC) a decline of agricultural activities has been observed in the Po Valley (Valsecchi et al. 2006).

Such negative trend from Late Middle Bronze Age is confirmed by the archaeological evidences that highlight a phenomenon of abandonment whose early phases can be dated to the end of the 13th c. BC. One or more episodes of crisis lead to the end the "*Terramare*' system", which represented the main settlement network during the Middle Bronze Age in such an area. In the territories south of the Po River the archaeological record shows a lack in the demographic presence which continues till the beginning of the Iron Age (Bernabò Brea et al. 1997; Cremaschi et al. 2006; Mercuri et al. 2006, 2012; Cattani 2009; Cupitò et al. 2012).

For Southern France two SCPDs have been produced. The first one includes radiocarbon dated archaeological contexts located in the interior area of the Massif Central (Fig. 64-65 C). It is an elevated region consisting of mountains and plateau. The second one gathers sites located in a buffer zone of 40 km from the Mediterranean coast line.

It is relevant to note that the shape of the two graphs presents significant differences. The 57 dates from 33 archaeological sites of the internal region do not show relevant discontinuities in the amount of dated samples for the time-span 1800-800 BC. On the contrary, for the 67 dates from 18 archaeological sites located along the French coast the shape of the graph is significant different, with an increase of dated contexts from the last phase of Bronze Age (Fig. 64-65 D). In such a region the major phenomenon in the LBA is the expansion of the *Mailhacien culture* during the *Bronze Final 3b* phase, whose beginning is placed around 900 BC (Janin 2000; Giraud et al. 2003; Janin 2009). In our SCPD the increase is placed in the *Bronze Final 2* phase, therefore it does not seem to be correlated to the diffusion of *Mailhacien culture* on a wide area.

Regrettably, the low number of dates used for such an analysis does not allow considering them as an evidence of demographic growth. Therefore, with the available data we cannot address any hypothesis regarding a possible increase of population during the LBA in the Southern France Mediterranean facade.

7.2 Theoretical and Methodological remarks

If we assume that archaeological sites are formed in numbers that are exactly proportional to the size of population then, in the absence of any taphonomic alterations, the observed frequency of archaeological deposits or site n_t from each time interval t would provide an accurate proxy of relative population sizes at those times. This is the general reasoning behind standard archaeological interpretations of deposit or site frequency distributions.

In any case, to ensure the reliability of this kind of analysis we have adopted circumstance a sample prescreening. In fact, after the revision of the available literature we have developed some criteria in order to obtain a reliable result. First, it is relevant to check the representativeness of the dates; it means that the probability of having a dated sample related to a concrete period should correspond to the number of occupied sites in that period. Hence, if some sites or geographic areas have been less excavated and dated, then we cannot obtain a completely trustable picture of the archaeological reality (Shennan & Edinborough 2007).

Although radiocarbon dating should be a random action, in many cases archaeologists tended to “overdate” some particular archaeological site; we can refer for instance to the multilayered settlements. Therefore, large numbers of dates from individual sites might skew the overall dataset (Armit et al. 2013). An example is the discarted huge amount of radiocarbon dates from the salt mining context of Hallstatt in Austria during the Bronze Age. For this reason it is important to know the provenience of the dated samples as no individual sites should overly dominate the total amount of radiocarbon dates. In order to avoid the problem of having multiple dates from a given site-phase some authors (Shennan & Edinborough 2007; Miller & Gingerich 2013) suggest to use the “R_Combine” function from OxCal (Bronk Ramsey 2009a), which combines ^{14}C dates prior to calibration and provide as a result a pooled mean date for the site-phase. This rule has been correctly applied in multidated contexts included in previous SCPDs including the EUBAR dataset.

Another problem is the overrepresentation of some particular chronological period in the dataset. In some occasions archaeologists tended to date with a higher frequency sites from a well defined period. A paradigmatic example is the dataset of Neolithic houses in Ireland, where for a quite short chronological period characterized by visible monumental structures a large number of ^{14}C dates has been produced (Armit et al. 2013; McSparron 2013). This source of bias has not been detected for our data.

The third problem relates to the spatial distributions of data. The radiocarbon dates have a direct relation with the locations where the archeological excavations are carried on. Often, such places are not chosen randomly but they depend on the presence of already known archaeological site on the territory. Moreover, they are in particular conditioned by commercial and infrastructures projects. As a consequence, some regions can be characterized by a large number of radiocarbon dates whilst in others there is a lack in the archaeological knowledge. An example can be traced in Catalonia, where the metropolitan region of Barcelona is characterized by a large amount of dates for the Bronze Age; on the contrary, the Pyrenean region represents almost a missing area regarding human evidences during the Protohistory.

Another factor, which is responsible for an introduction of uncertainty, is represented by the post-depositional effects. In particular natural and geomorphologic processes could have modified the source of information, destroying part of the archaeological record and hence conditioning the representativeness of the available data. Concerning regional analysis it is relevant to take into account the existence of such phenomena and their intensity, which could be different from an area to another. With regard to this a difference among the human presence between inland and coastal sites of Patagonia (Argentina) during the latter six millennia was observed starting from the analysis of the radiocarbon record. The absence of evidences higher than 3500 BP, documented by ^{14}C dates in the inland area, was explained by a taphonomic bias caused by destruction or a massive burial of archaeological sites located in such a region (Martínez et al. 2013).

Over long timescales a distinctive hallmark of many radiocarbon frequency distributions is the presence of a positive, long-term curvilinear trend (e.g., Kuzmin & Keates 2005; Bryson et al. 2006; Peros et al. 2010).

Surovell and Brantingham (2007) have pointed out that a monotonic increase in the frequency of dates through time can be generated by a systematic taphonomic bias if (as may often be the case) the probability of archaeological site survival is negatively correlated with the age of the site (Fig. 66). This means that in the archaeological record "recent things overwhelmingly outnumber older things and the form of the function relating abundance is nonlinear" (Surovell & Brantingham 2007, p. 1868). Such explanation can be the main cause of the presence of the positive long-term curvilinear trend. According to Surovell et al. (2009) a possible measurement and then correction of this kind of bias could be obtained by comparing the age-distributions of dates on archaeological sites with those of dates on relevant geological contexts.

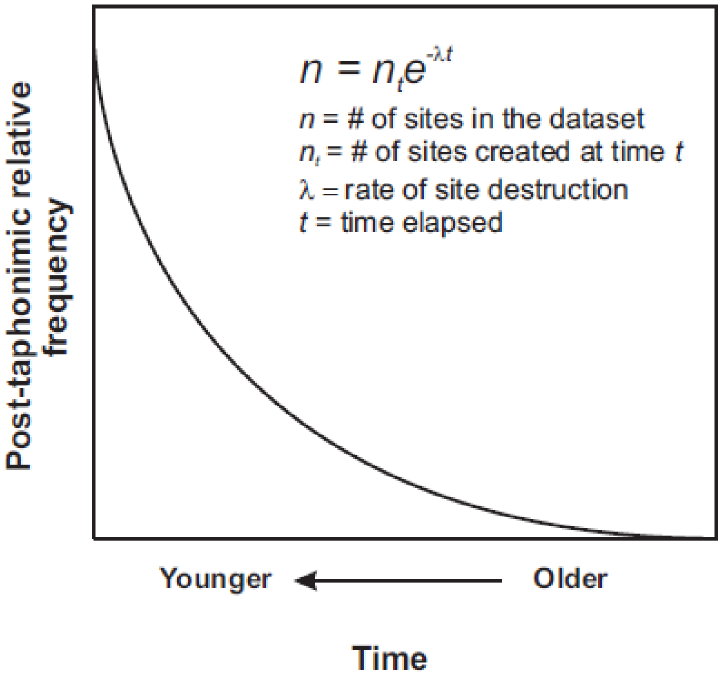

Fig. 66 – Effect of the postdepositional processes on the archaeological evidences (Source: Surrovell & Brantingham 2007).

The relationships between the SCPD and the effects of calibration have been already suggested (chapter 4.3.2). Various strategies have been employed in attempts to correct or to account for such a bias (Johnstone et al. 2006; Chiverell et al. 2011; Shennan et al. 2013). We tested the significance of fluctuations and autocorrelation in SCPDs by using computer simulation of ^{14}C dates generated under a null model of exponential increase in the SCPD through time as a result of population increase.

We could perhaps avoid these kinds of problems by analyzing radiocarbon datasets at fairly coarse chronological scales, examining patterns over intervals of time that are longer than the irregularities in the calibration curve, intervals like the 500 year blocks of time in Surovell et al. (2009) work. However, this effectively eliminates the possibility of seeing the kind of abrupt change.

Finally, a good way of proving the validity of the obtained results is to test them against a range of other proxies for human occupation, like for instance the knowledge produced by the analysis of the visible archaeological record as we have done in the regional analyses. As an example, the proxy data on population numbers provided by radiocarbon dating can be combined with estimates of fertility and migration in the construction of colonization models. There are many applications of those models (Housley et al. 1997; Gkiasta et al. 2003; Fort et al. 2004; Gamble et al. 2005; Mellars 2006; Shennan & Edinborough 2007; Hamilton & Buchanan 2007; Collard et al. 2010; Hinz et al. 2012; Shennan 2013).

As a consequence, extreme caution must be used in filtering our data and in interpreting temporal frequency distributions because the operation of simple taphonomic processes, sampling deficiencies and radiocarbon calibration effects can create patterns that mimic approximately those of exponential human population growth.

In addition, to guarantee the reliability of our analysis for demographic purposes we have to use a large dataset; as larger is the dataset as less the possible errors related to the sampling strategy will be. The reliability of the constructed SCPDs depends on the number of samples in analyzed sets. When the number of dates is too small, the gaps in the SCPDs reflect periods when samples have not been collected rather than necessarily indicating discontinuities in the demographic signal.

The working assumption of summed probability analysis is that a sufficiently large regional sample of radiocarbon dates will counteract any problems at the site level: that multiple small nonsystematic samples from a large assemblage of sites constitute a quasi-random sample of regional trends in occupation. If this is accepted, then it is crucial to determine the minimum number of radiocarbon dates for a robust and reproducible summed probability distribution (Williams 2012).

Many authors have focused on the minimum number of samples required for using dates as data (Michczynska & Pazdur 2004; Michczynska et al. 2007; Williams 2012). Michczynska and Pazdur (2004) applied Monte Carlo techniques to an artificial dataset and showed that the minimum number of radiocarbon dates required (keeping statistical fluctuations <50%) was reliant on the mean of the standard deviations reported for radiocarbon dates in the sample (laboratory error) (ΔT) and the span of the time series. For instance, with a time interval of 0-14.0 ka and $\Delta T = 115$ yr, the minimum number of dates is 200. For reliable results (with statistical fluctuations <20%), they concluded that 780 dates with a $\Delta T = 115$ yr is required (Michczynska and Pazdur, 2004; Michczynska et al., 2007). Williams (2012) suggests a minimum sample of 200-500 dates, hence, analysis based on less that these values should be treated as provisional and likely to change appreciably once larger datasets become available.

We have also to remind not to include in the analysis, ^{14}C dates with a too high standard error, which would introduce a high degree of uncertainty in the final result. In general, for a time span of one millennium we suggest to adopt as a common rule to refuse dates with a standard deviation equal or greater than 100 years.

Eventually, we need to stress that SCPDs are a useful tool not only to detect phenomena of decline, extinction, and hiatuses in settlement history, but they can also be used to model the diffusion in time of certain variables, as we have shown for the funerary rite. In OxCal 4.2 (Bronk Ramsey 2009b) the SCPD distribution does not relate to a single event but the elements within the sum are treated as a phase, in the sense the 95% range for the summed distribution gives an estimate for the period in which 95% of the events took place, and not the period in which one can be 95% sure all of the events took place. Hence, under the assumption that we consider the population of dated archaeological contexts representative enough, we can model continuities and discontinuities both for demographic intensity and for adoption of single variables as we are going to argue in the next chapter.

8 QUANTIFYING THE RATE OF ADOPTION OF "INNOVATIONS" IN WESTERN EUROPE DURING BRONZE AGE

8.1 The number of radiocarbon dates as an estimation of the number of adopters. Theoretical and methodological remarks

If a diffusion hypothesis for the adoption of cremation burials and specific pottery typologies in the 2nd and the beginning of the 1st millennium BC was true, we could distinguish between the relative earliness and lateness with which such innovations were adopted by human population living in the studied area, compared with other communities. As a consequence, shorter or larger temporal lags would be observed between first appearance of a particular kind of burial or typology and its general acceptance within a population. The length of such gaps can be analyzed in terms of the innovation's *rate of adoption*, defined as the relative speed in which members of a social system adopt an innovation or a change is produced. It is usually measured as the number of members of the system who adopt the innovation in a given time. Alternatively, the rate of adoption can also be measured as the length of time required for a certain percentage of the members of a system to adopt an innovation (Olshavsky 1980; Rogers 2003; Young 2009).

The precise way of quantifying this rate of adoption will depend on the nature of the model (Banks 1994). In a simple model (SI) there are two components or categories of social agents: those who have already changed and acquired the innovation ("adopters") and those who are going to change (potential adopters). In the general model (SIR) there is a third category: those who have changed initially but subsequently rejected the innovation and came back to the initial situation before adoption. In a more complicated general diffusion model (SEIR), a forth category may be included: those who have been exposed to the innovation but have not yet adopted it. That means to include a measure of the "resistance" to adopt any particular innovation, which in some cases can be assumed as be the inverse of the time lag between the first evidence of the innovation in an area, and the actual observation of change: the shorter a time lag, the lesser the resistance to change, and the lesser social influence needed to resistance.

Quantifying the number of adopters across time from archaeological data is an interdisciplinary effort that should include researches in various fields, like demography, anthropology, paleogenetics, and human ecology (Housley et al. 1997; Gkiasta et al. 2003; Fort et al. 2004; Gamble et al. 2005; Mellars 2006; Shennan & Edinborough 2007; Hamilton & Buchanan 2007; Collard et al. 2010; Hinz et al. 2012; Shennan 2013). Important questions that should be addressed before we can quantify the parts of a population adopting an innovation or changing their cultural features include the establishment of methods for inferring past population structure, the timing of the adoption or change, the relative importance of demographic variations, and the possibilities of alternative hypotheses like demographic transitions, colonization events, and/or population extinctions (Chamberlain 2009). We have addressed such topics in chapter 7.

In ideal conditions, the precise knowledge of the number of adopters compared with population size at each time step would be necessary. Nevertheless, we can estimate the rate of adoption of an innovation or change even in the case the size of the population is not entirely known. The *frequency* (counts per time unit) of archaeological contexts in which the presence of the innovation has been asserted can be used to estimate the number of adoptions, although such a number did not express reliably population size at the time of adoption.

We ground our approach on the assumption that the probability of dating a characteristic archaeological context should be binomially distributed. In probability theory and statistics, the *binomial distribution* is the discrete probability distribution of the number of successes in a sequence of *n* independent “yes/no” experiments, each of which yields success with probability *p*. In our case, we are looking for the probability a dated archaeological context had the innovation out of the number of dated archaeological contexts. In general, if the archaeological contexts where the presence of the attribute has been signaled (*X*) follows the binomial distribution with parameters *n* and *p*, the probability of finding exactly *k* contexts with that attribute in a total number of *n* dated archaeological contexts is given by the probability mass function:

$$f(k; n, p) = \Pr(X = k) = \binom{n}{k} p^k (1-p)^{n-k}$$

for $k = 0, 1, 2, ..., n$, where

$$\binom{n}{k} = \frac{n!}{k!\,(n-k)!}$$

is the binomial coefficient, hence the name of the distribution. The problem we are trying to solve is to calculate the probability of finding a properly dated archaeological context with a particular feature in a fixed number of dated archaeological observations with or without that feature. The formula can be understood as follows: we are interested in quantifying the number of contexts where the innovation has been already adopted (k successes, p^k) taking into account the number of sufficiently similar archaeological contexts where there is no evidence of such an adoption or related cultural change ($n - k$). Therefore, k can be approached considering $(1 - p)^{n-k}$, but we should take into account that the k archaeological events with the new cultural feature can occur anywhere among the n archaeological observations, and there are $\binom{n}{k}$ different ways of distributing k observations of a particular type in a set of n dated archaeological observations.

The reliability of this measure of the rate of adoption or cultural change can only be asserted assuming that the two exclusive events (there is evidence of cultural change/ there is no evidence of cultural change) are mutually independent, that is, the actual observation of a "new" cultural feature at one site does not affect the probability of observing such a feature at another site. Therefore, the proportion between well individualized and properly dated archaeological contexts in which evidence of a particular feature has been reliably asserted and equally well individualized and properly dated contexts without that feature can be understood in terms of the number of adopters of an innovation (the feature in question) provided:

- we are aware of the rate at which a finite population of archaeological contexts has been dated,
- the probability to observe a number of contexts with a particular feature in a time interval is proportional to the temporal duration of that interval,
- the probability that a context be classified as an instance of adoption of innovation is independent of the number of archaeological contexts so classified,
- the probability of simultaneous adoption of an innovation in the past is very low,

In the light of such assumption we can estimate the number of adopters trough the analysis of the number of radiocarbon dated archaeological contexts in which the adoption is present. The adopted methodology to analysis the frequency of dates includes Summed Calibrated Probability Distributions (SCPD) and the histograms of medians of calibrated ^{14}C dates (see chapters 4.3.2 and 4.5).

The same criteria in the use of SCPD as a proxy for demographic signal can be adapted also to inference phenomena of adoption of innovation.

Therefore, problems relating to overdated geographic areas and overdated archaeological sites can alter the reliability of the results. Therefore it is important to know the geographical and qualitative variability of dated archaeological events as no individual sites should overly dominate the total amount of radiocarbon dates.

In fact, when we have different numbers of dated contexts from different sites, large numbers of dates from individual sites might skew the overall dataset (Armit et al. 2013). For instance, at some cemetery we have dated two burials, and both radiocarbon dates are so similar that we can infer that both events were contemporary. At another cemetery we have not dated any single burial. At a third cemetery we have five radiocarbon estimates, but they are so different that there are no chances than any of them is contemporary with the other. According to the Binomial distribution assumptions, the probability of more than one simultaneous burial in a sufficiently small interval should be negligible, and not any simultaneous burials are expected to have occurred. Consequently, if we want to estimate the frequency of adoption of an innovation, we should reject the possibility of dating twice the same context, but we need to increase the probability of a point estimate using different isotopic events of the same archaeological context. After all, archaeological events are a palimpsest of depositional events, and those should be understood in terms of a heterogeneous aggregation of isotope events with probable different durations. As a consequence, the duration of the archaeological event is not equivalent to the duration of the originally dated isotopic events.

Another factor that may alter the representativeness of the number radiocarbon dates as an estimate of the proportion between the number of adopters and potential adopters lies in particular natural and geomorphologic processes that may have modified the source of information, destroying part of the archaeological record. As we have stressed for SCPDs for demographic analysis (chapter 7), several scholars (Surovell and Brantingham 2007; Surovell et al. 2009, Peros et al. 2010) have proved that a constant taphonomic rate often drives the emergence of an exponential functional form in the post-taphonomic frequency distribution of sites through time regardless of the initial frequency distribution of sites. When no bias occurs in sampling, every object in a population has an equal probability of being sampled (meaning discovered or excavated in archaeology). Bias occurs when portions of populations are more or less likely to be sampled for any reason. Some of the major biases impacting temporal frequency distributions of archaeological sites or deposits comprise research, discovery and the already mentioned taphonomic bias, including processes which destroy the archaeological and/or geological record.

The rationale of our approach assumes that the proportion of dated archaeological contexts with a particular feature considered to be something “new” in the history of that particular site is expected to be monotonically related to the proportion of adopters/potential adopters, i.e. the more agents began to use something, the stronger the archaeological evidence of such an use. In other words, we cannot estimate the proportion of adopters/potential adopters in the human population having lived in the past, but we can certainly estimate the proportion of adopters/potential adopters in the archaeological dataset. In this sense, the probability of having a dated sample from a context with a particular characteristic related to a particular time interval can be proved to correspond to the number of known occupied sites in that period, not to the number of people having lived in the past. This assumption implies that we consider the population of dated archaeological contexts representative enough. In specific cases in which such an assumption cannot be accomplished we will highlight the existence of such a problem directly in the text.

We consider that as important as the absolute number of available dated isotopic is the exhaustiveness of the archaeological dataset (dated and non dated contexts) and the proportion between the number of dated contexts with presence of the attribute (the “innovation”) and the number of dated contexts with a reliable absence of the attribute. We should remember that the absence of evidence is not necessary an evidence of an absence!

8.2 Growth, diffusion and the adoption of innovations across time

One of the most robust findings from over 3,000 studies in the diffusion of innovation literature is the *S*-shaped cumulative adoption curve, which is the plotted result of a cumulative adoption time path or temporal pattern of a diffusion process (Fig. 67) (Bass 1969; Casetti 1969)

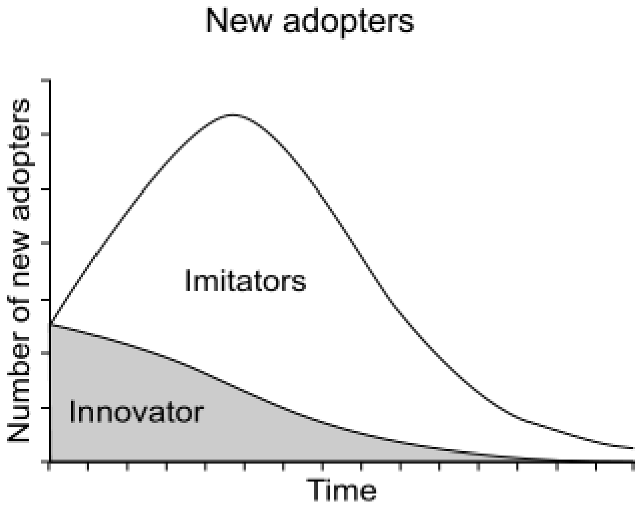

Fig. 67 – The model for forecasting the diffusion of new consumer products proposed by Frank Bass (Source: Bass 1969).

This vast literature contains data for the spread of an enormous variety of practices, technologies, and ideas in communities and countries throughout the world. These cases include the adoption of "innovations" such as hybrid corn among Iowa farmers, bottle-feeding practices among impoverished Third Worlders, new governance practices among Fortune 500 companies, chemical fertilizers among small-scale farmers, and the practice of not smoking among Americans. Typically, the cumulative adoption curve for the spread of these practices has an S-shape.

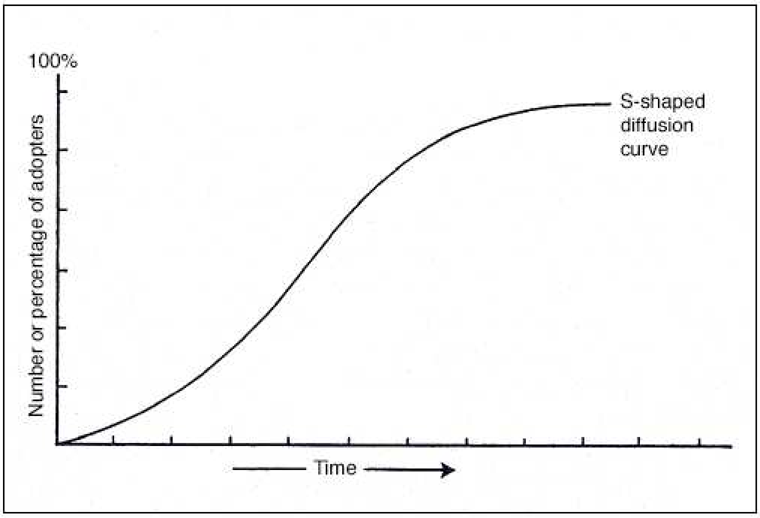

Fig. 68 – S-Shaped diffusion curve.

The S-shaped (sigmoid) adopter distribution rises slowly at first, when there are only few adopters in each time period (Fig. 68). The curve then accelerates to a maximum until half of the individuals in the system have adopted. Then it increases at a gradually slower rate as fewer and fewer remaining individuals adopt the innovation It is meaningful to highlight that although the diffusion pattern of the most innovations can be described in terms of a general S-shaped curve, the exact form of each curve, including the slope and the asymptote, can differ (Mahajan & Peterson 1985). In fact, the slope can be more or steep according to a rapid or a slow diffusion.

The time element of any diffusion process allows us to draw diffusion curves and to understand the dynamics of the innovation-decision process. Because time is required for innovations to be adopted by the members of a population and, depending on both internal and external factors, some innovations diffuse faster than others; one can reasonably define the concept of diffusion speed as a measure of how fast a particular innovation is adopted (Shinoara 2012). As Nieto et al. (1998) argued, the underlying hypothesis in diffusion models that are based on the logistical function is simple: the speed to which the total number of agent that adopt a new technology increases, depends on the number of agent that have already assimilated it and the potential number of firms that have not yet incorporated it. In other words, as fewer agents are left to adopt a new technology, the rate at which adoption occurs decreases. This produces the convex segment at the top of the S-curve that marks the inflection point from a rapid to a more gradual increase. The S-curve is produced in a setting where the population of agents is finite.

In terms of development, the S-curve describes a path of an initially slow performance increase followed by a rapid rise in performance that levels off as some physical limit of potential is approached (Altshuller 1984; Bowden 2004; Eriksson 1997; Nieto et al. 1998; Wedgwood et al. 2003). The S-shape of a typical development curve can be viewed as the result of the process of exhausting a 'solution space' of potential improvements: as the pool is explored and exploited there are fewer and fewer improvements remaining to be discovered, slowing the pace of improvement if the number of trials stays the same (Fig. 69). Again, the S-curve is produced in a setting where there is a finite potential for improvement.

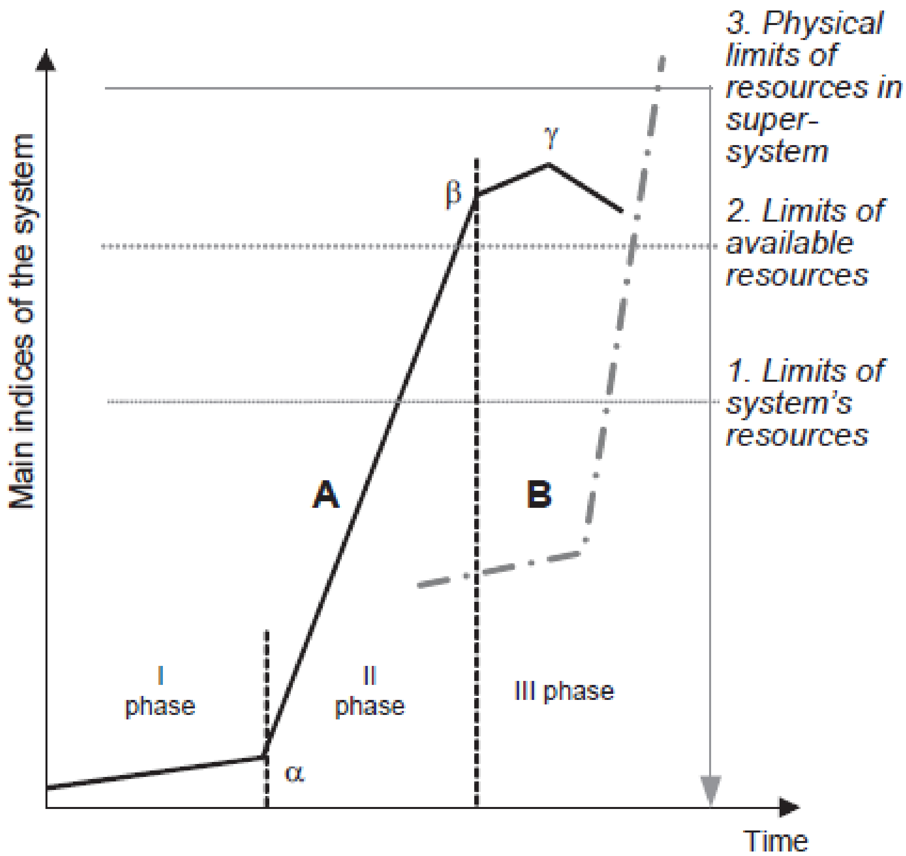

Fig. 69 – Styles S-curve of technical systems evolution and limits of resources (Source: Kucharavy & De Guio 2011).

According to standard accounts, the adoption of an innovation usually follows a normal, bell-shaped curve when plotted over time on a frequency basis. In particular, in such a process follows a number of rules, which allow us to distinguish four main stages (Fig. 70). The first one is the *primary st*ep, which corresponds to the beginning of the diffusion. At this temporal location, only a few individuals adopt the innovation in each time period, therefore diffusion introduces a new differentiation inside geographical space. This is the time span in which the role of the innovators is crucial for the further stages. A contrast is appearing between places where the event took place and other places. Soon the diffusion curve begins to climb, as more and more individuals adopt it in each succeeding time period. This is the second stage, which is called *expansion step.* In this phase the occurrence of the event takes place generating a gradual softening of the strongest contrasts between places. During the following step, that is called *condensation step*, the rate of penetration into the different places tends to become more homogeneous, while speeds of diffusion in the various places grow closer. In this stage the trajectory of the rate of adoption begins to level off, as fewer and fewer individuals remain who have not yet adopted the innovation. Finally, in the ultimate step, that is called saturation step, the penetration rate increases toward a maximum following an asymptotic curve. S-shaped curve reaches its asymptote, and the diffusion process is finished. This point can be interpreted as the maximum carrying capacity of the system. No more adopter can be included in the process.

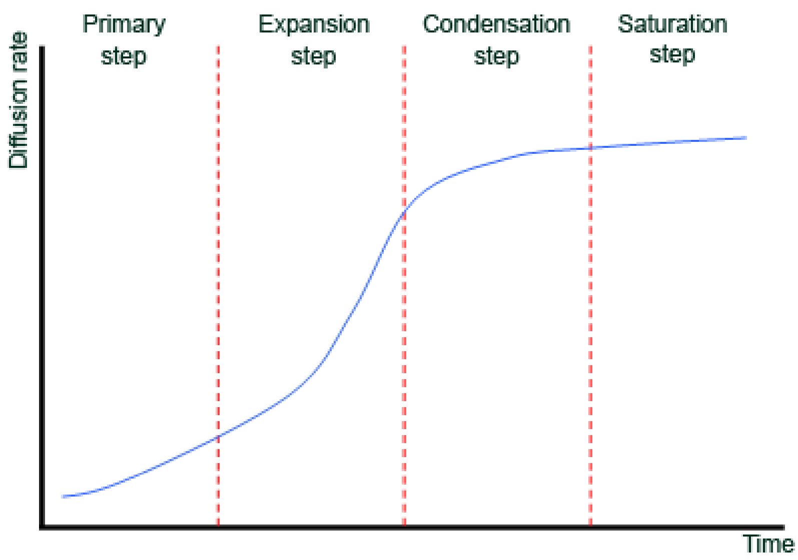

Fig. 70 – The four main stages in the adoption of innovation.

It is important to highlight that the S-shaped curve is constructed and plotted in two dimensions, representing the cumulative number of adopter occurring over time. The adoption process can also be drawn in a not cumulative way by a Gaussian (Fig. 71); these are just two different ways to display the same data. In both the cumulated frequency distribution and the normal distribution the points 1 and 3 correspond to the early and the late phases of the adoption process. In such phases, which are relatively stable regions, it is difficult to change the system (Rogers et al. 2005). On the contrary, the highest reactivity across all adopter groups is found at the critical mass inflection point, point 2 on the S-shaped diffusion curve. This is where cascades of change occur. The diffusion curve can be thought of as a smooth curve that passes through the step-up plateaus in systemic fitness thresholds. As the curve rises, certain thresholds are passed for adoption networks. These rising thresholds evoke adaptation (in the case of early adopters) or loss (for laggards). Critical mass is reached at the point where there are enough adopters that further diffusion becomes self-sustaining (Rogers 2003). At the height of the adoption curve, the fittest members of the social network have self-organized (adapted) to the higher plateau of fitness and adopted the innovation. Bifurcation, or decision, points have been passed on the way at step-like critical-mass thresholds. Unfit adopters, those without sufficient capability or inclination to adopt, have been precluded from participating in the adoption of the innovation. (Rogers et al. 2005). In such a process Rogers (2003) managed to quantify the amount and the role of agents which take place in the time span, from the innovators to the laggards.

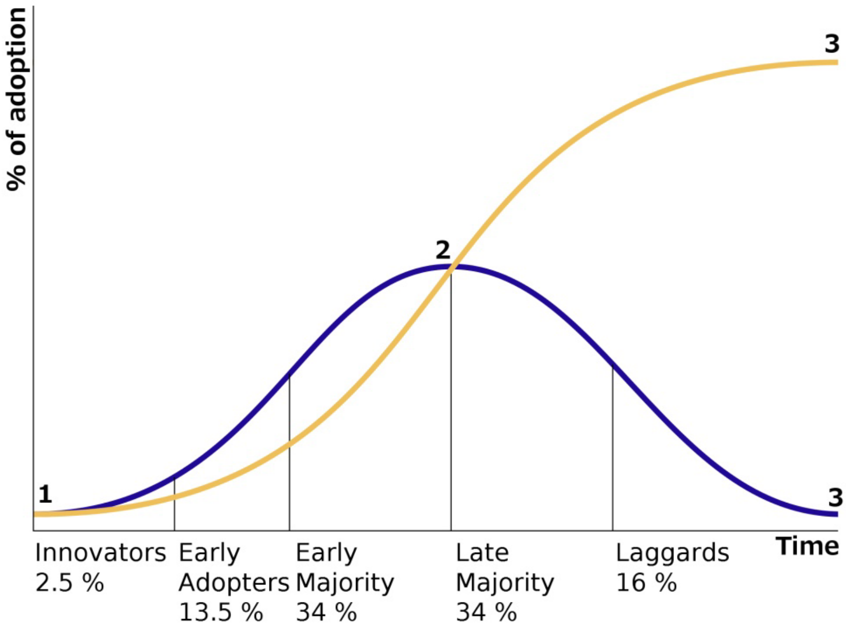

Fig. 71 – The diffusion of innovation according to Rogers (2003). The normal distribution is in blue and the cumulative frequency distribution is in yellow.

An important point in the S-shaped curve is the so called point of inflection (Fig. 72). It is the point where the curve changes from increasing faster to increasing slower. It also marks some symmetry for the curve, both for the population and for time. In fact, half of the people are accounted for below the point of inflection, and half are accounted for above that point. Moreover, half of time is accounted for the left of the point of inflection, and half of the time is accounted for the right of that point. This is a key point of interest because it is about where critical mass occurs, i.e. the point after which further diffusion becomes self-sustaining (Rogers 2003; Rogers et al. 2005). A continuing increase in the number of adopters, or synapses, or processing elements, increases the energy being processed in the local system at the inflection point. Until that point of critical mass is reached on the S-curve, the rate of increase in the number of adopters per time unit is nearly linear (Rogers et al. 2005).

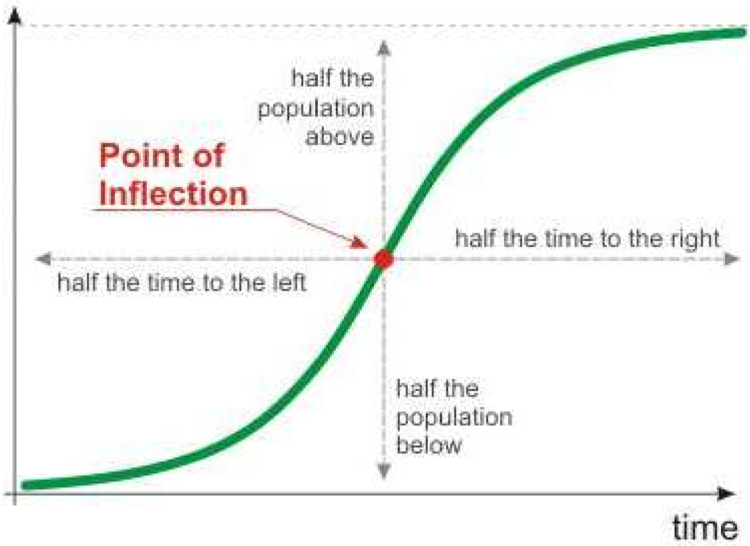

Fig. 72 – The point of inflection in the S-shaped curve (Source: www.nctm.org/resources).

The essential meaning of this function is "the rate of growth is proportional to both the amount of growth already accomplished and the amount of growth remaining to be accomplished". Understanding of that concept helps to catch part of the answer to the question: "Why does the S-curve approach possess forecasting powers?".

Casetti (1969) suggested this model based on the following postulates:

1. that the adoption of technological innovations by potential users results primarily from "messages" emitted by adopters;
2. that potential users have different degrees of "resistance" to change;
3. that within any region there are potential users with different degrees of "resistance";

4. that resistance is overcome by a sufficiently large repetition of messages. It can be shown that the dynamic interaction of these postulates causes the proportion of adopters to increase slowly at first, then rapidly, then slowly again until saturation is reached.

Moreover, according to Kucharavy and De Guio (2011) the forecasting power of the S-curve is due to the basic concept of limiting resources that lies at the basis of any growth process. In diverse areas, limiting resources are named in different ways: scarcest resources (geochemistry), restricted resources (economy), limitation of resources, resource constraint (theory of constraints), etc. In most cases, applying an S-curve for forecasting induces the correct measurement of the growth process that in turn can be applied to identify the law of natural growth quantitatively and to reveal the value of the ceiling (upper limits of growth) and steepness of the growth (slope of curve). Obviously, the more precise the data and the bigger the section of the S-curve they cover leads to a lower level of uncertainties. In other words, one can identify a more accurate ceiling and steepness with a larger data set. This effect causes some difficulties in applying an S-curve forecast for emerging technologies, which have not yet passed the "infant mortality" threshold (when the ratio of new to old technology has not reached 0.1).

The slopes and inflection points of any given development or diffusion curve are potentially affected by a number of other things. Conceptually, accordingly to Mahajan and Peterson (1985) it is possible to consider the effect of the communication channels, which can be of the following type: vertical, centralized, structured or formal. Accordingly to Young (2009), innovation is diffused through two channels: from the fonts internal to the group and/or from the fonts external to the group. The intensity of these sources determines the shape of the curve. The diffusion patterns of these models can be characterized in function of two mathematical properties: the symmetry of the adoption rate curve and the inflection point location relatively to the adopters accumulation.

Eventually, it is meaningful to highlight that the S-curve is innovation-specific and system-specific, describing the diffusion of a particular new idea among the member units of a specific system. The S-shaped curve describes only cases of successful innovation, in which an innovation spreads to almost all of the potential adopters in a social system. Many changes are not “successful”.

8. 3 Quantifying the adoption of a new funerary ritual

In order to understand the temporal distribution of different funerary rite, both inhumation and cremation, we have produced two SCPDs using radiocarbon dates included in the EUBAR database. We have filtered our dates not taking into account ^{14}C dates with a standard deviation greater than 100 years. Additionally, we have represented the frequency in time of these contexts using the histograms of the medians. In order to control problems relating to sample strategy, which could cause lack in the distributions of our data, we have chosen to adopt time lags of both 200 and 100 years.

The aim is to visualize over a macro-scale the possible differences between the two phenomena: the adoption of inhumation burials and that one of cremation burials. In the first stage we have analyzed together data originating from the whole territory included in the EUBAR database, from the Ebro to the Danube River.

First, we have summed 145 ^{14}C dates originating from 71 archaeological sites characterized by the presence of radiocarbon dated inhumation burials (Fig. 73). The result of the SCPD shows a negative trend in the number of inhumation burials for the time span 1800-800 BC. In particular, the decrease in the amount of contexts seems to be more pronounced at around 1400 BC, whilst in the second part of the rage, from 1400 to 800 BC the presence of inhumations reaches stability without significant fluctuations. Analyzing the same dataset adopted in the SCPD, we have produced two histograms with the medians of calibrated radiocarbon dates, as calculated by the software OxCal 4.2 (Bronk Ramsey 2009b). The same negative trend can be observed in the histograms of medians without any relevant difference between 200 and 100 time lags (Fig. 74 and 75).

Such results, which point the decrease in the frequency of inhumations for the time span 1800-800 BC, can be used as a proxy for a diminution of the number of adopters, who practiced the inhumation rite.

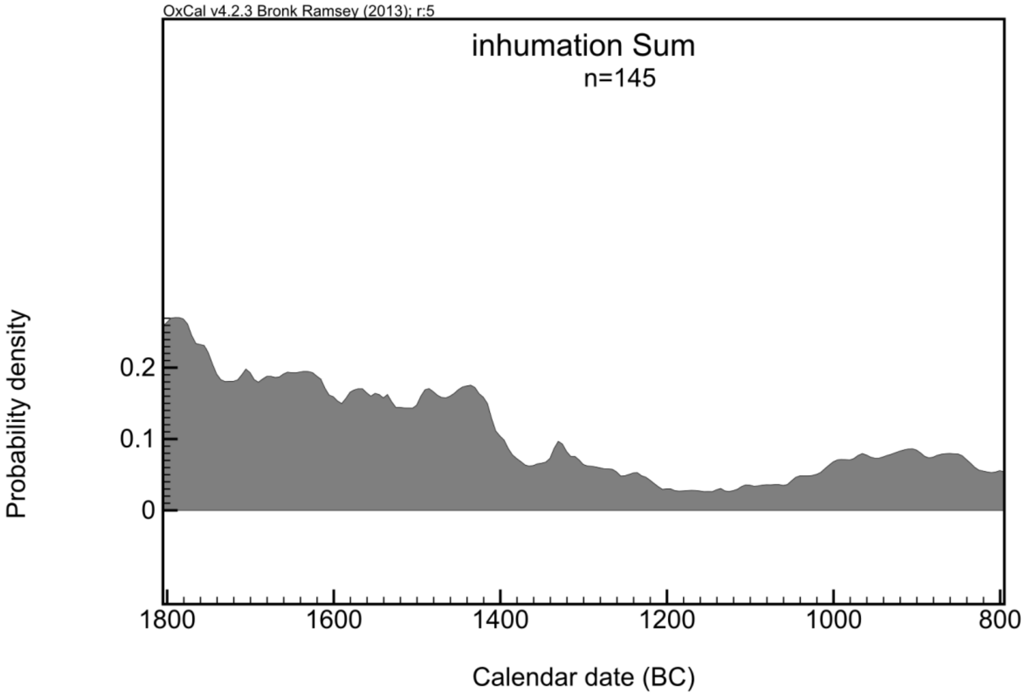

Fig. 73 – SCPD of funerary contexts included in the EUBAR database and characterized by the inhumation rite. IntCal13 calibration curve (Software: OxCal 4.2).

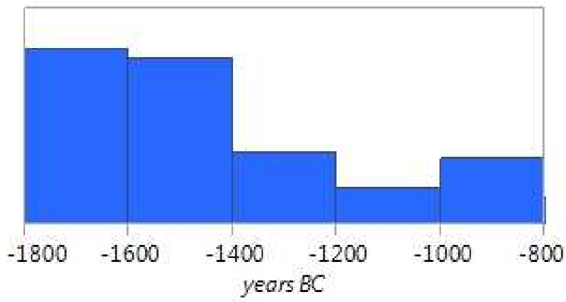

Fig. 74 – Histogram of funerary contexts included in the EUBAR database characterized by the inhumation rite. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

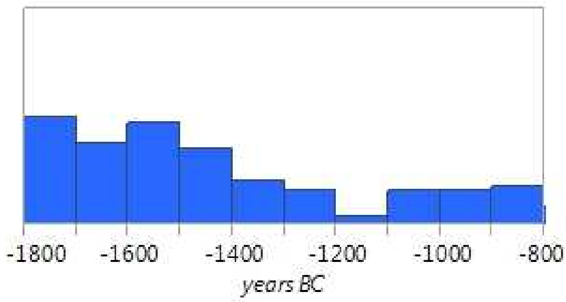

Fig. 75 – Histograms of funerary contexts included in the EUBAR database characterized by the inhumation rite. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

Second, we have summed 77 ^{14}C dates originating from 42 archaeological sites characterized by the presence of radiocarbon dated cremation burials (Fig. 76). The result of the SCPD shows an opposite trend compared to the inhumations' one. We can clearly observe a positive trend in the number of cremation burials for the time span 1800-800 BC. In particular, the increase seems to be more pronounced in the last part of the time span, which corresponds to the Late Bronze Age and the Iron Age transition. It is relevant to remember that the SCPD do not show the beginning of the phenomenon, in this case the adoption of cremation burials in the 2nd and the beginning of the 1st millennia BC, but it must be interpreted as a graphical visualization of the probability of recovering cremation burials in the analyzed time span. The fluctuations around 1400 BC could be a consequence of the calibration, as we have argued for other SCPDs in the chapter 7.

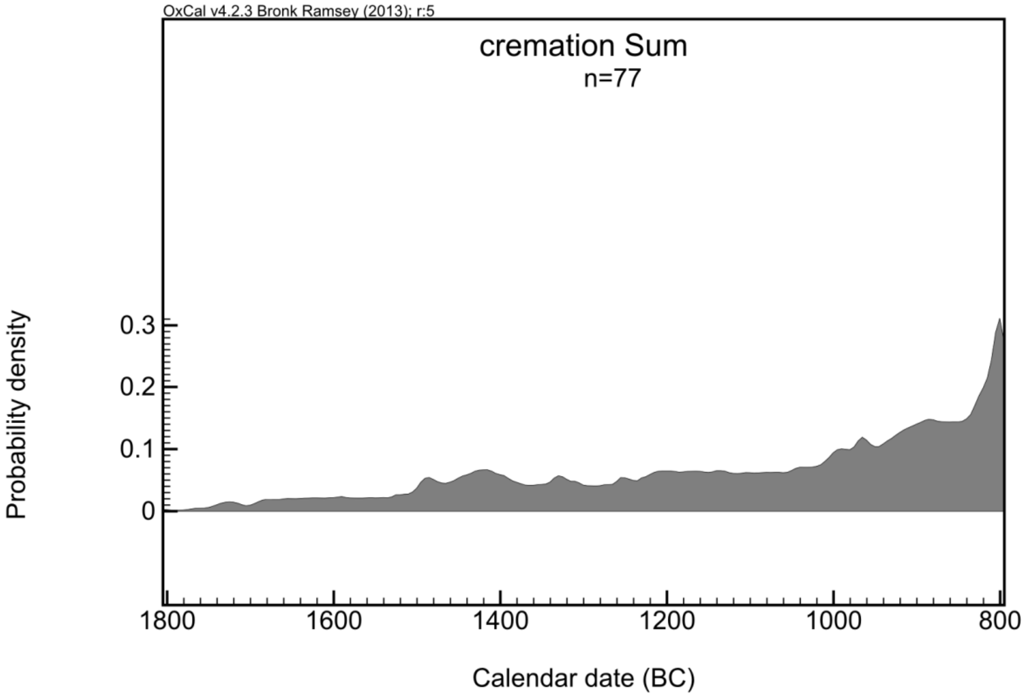

Fig. 76 – SCPD of funerary contexts included in the EUBAR database and characterized by the cremation rite. IntCal13 calibration curve (Software: OxCal 4.2).

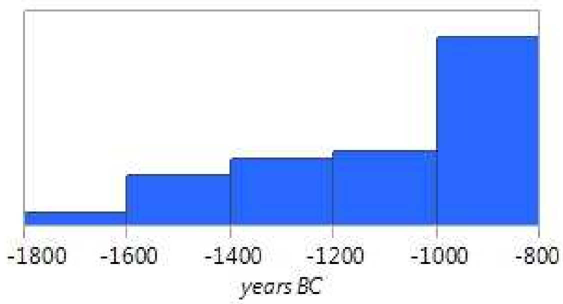

Fig. 77 – Histogram of funerary contexts included in the EUBAR database and characterized by the cremation rite. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

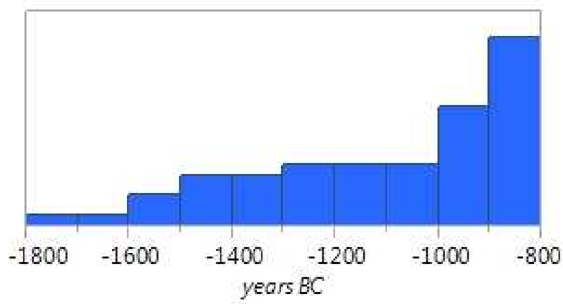

Fig. 78 – Histogram of funerary contexts included in the EUBAR database and characterized by the cremation rite. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

To strengthen the results obtained in the SCPD, using the same dataset we have produced two histograms with the medians of calibrated radiocarbon dates, as calculated by the software OxCal 4.2 (Bronk Ramsey 2009b) (Fig 77 and 78). The positive trend can also be observed in the histograms of medians. It is relevant to notice that in the histograms we cannot recognize the fluctuation around 1400 BC, the increase in the amount of ^{14}C-dated cremation burials is constant with no relevant differences between 200 and 100 time lags.

In order to analyze on a smaller scale the temporal distribution of cremation burials we have taken into account four main regions: the North-East of Iberian Peninsula, Southern France, Northern Italy and the north of the Alps region (Switzerland, Austria and Southern Germany). In spite of the low number of available dates per region we have been able to distinguish regional differences from the different SCPDs produced for the various territories (Fig. 79). The adoption of cremation burials seems to be placed earlier in the North of the Alps territories, where the phenomenon shows a positive trend as we move to the 800 BC. Regrettably, in Northern Italy the small number of dates affects the reliability of the obtained result. Therefore, the shown adoption of cremation burials in particular around 1600 and 1200 BC must be considered only as preliminary. The increase in the number of radiocarbon dated cremation graves in this area would shed light on the temporal distribution of the new funerary rite. In Southern France the probability of the adoption of cremation starts around 1500/1400 BC and it seems to increase in the analyzed time span. A similar pattern but with a later chronology can be recognized in the North-East of Iberian Peninsula, where the phenomenon reaches its maximum development around 800 BC.

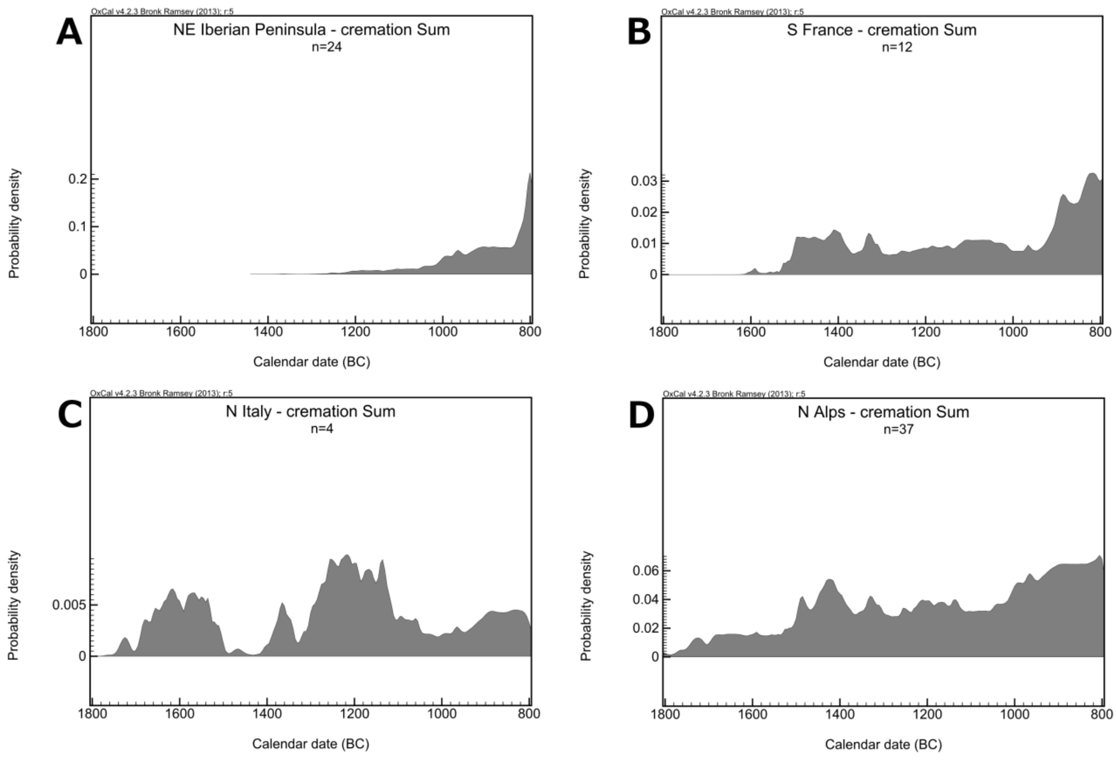

Fig. 79 – SCPDs of ^{14}C-dated cremation burials included in the EUBAR database from: the North-East of Iberian Peninsula (A), Southern France (B), Northern Italy (C), and the north of the Alps region (D). IntCal13 calibration curve (Software: OxCal 4.2).

To sum up, in the time span 1800-800 BC the adoption of cremation burial and the practice of inhumation rite are two different phenomena whose temporal distribution can be clearly distinguished. Our data show that on a macro scale, between the Danube and the Ebro River, the transition between the two phenomena can be placed at around 1220 BC (Fig. 80).

It follows that the lesser people were inhumated, the more people were cremated. It implies that the smaller the number of people practicing the inhumation rite, the higher the number of adopters of the cremation rite.

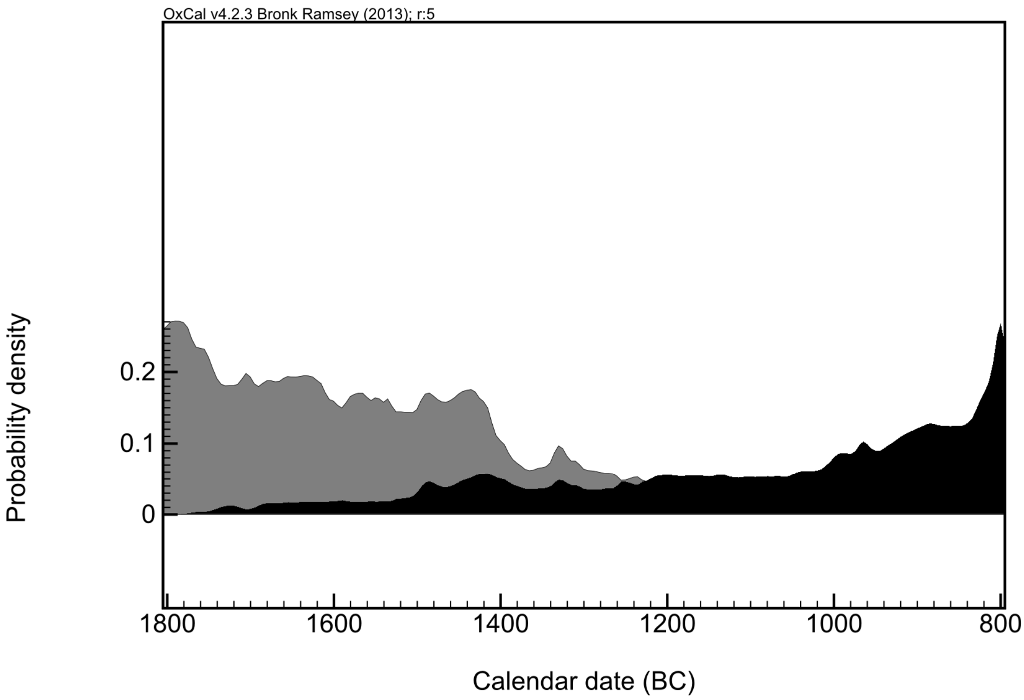

Fig. 80 – The transition from the practice of inhumation burial (in grey) to the adoption of cremation burials (in black). SCPDs of ^{14}C dates included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2).

8.4 Quantifying the adoption of new cultural elements

The adoption of cremation burials is not the only innovation which took place in the 2nd millennium BC in Prehistoric Europe. As we have explained in chapter 3 and 5 there are others cultural elements that were newly introduced along the time span 1800-800 BC. As we have demonstrated, for the funerary rite, the analysis of such variables regarding their temporal distribution allows us to infer episodes of continuities and discontinuities

in time over a macro scale.
In this paragraph we focus on the most outstanding ones among those included in the EUBAR database.

8.4.1 Fluted pottery

We started with the analysis of ^{14}C-dated contexts where fluted pottery was recovered in association with the sample submitted to dating. For a description of fluted pottery we refer the reader to the chapter 5.3.2.2
A SCPD using 213 radiocarbon dates from reliable contexts, included in the EUBAR database, was produced (Fig. 81). The graph shows an increase in the presence of fluted pottery across time. Although the probability of finding fluted pottery covers the whole time span, with low values in the first 100 years, the probability increases as we move to the Late Bronze Age. Indeed, the mode of the graph, which identifies the point with the highest probability for the presence of fluted pottery, is located in the time span 1000-900 BC.
We can recognize the same trend in the histograms of the medians of calibrated dates, obtained using the same dataset (Fig. 82 and 83).

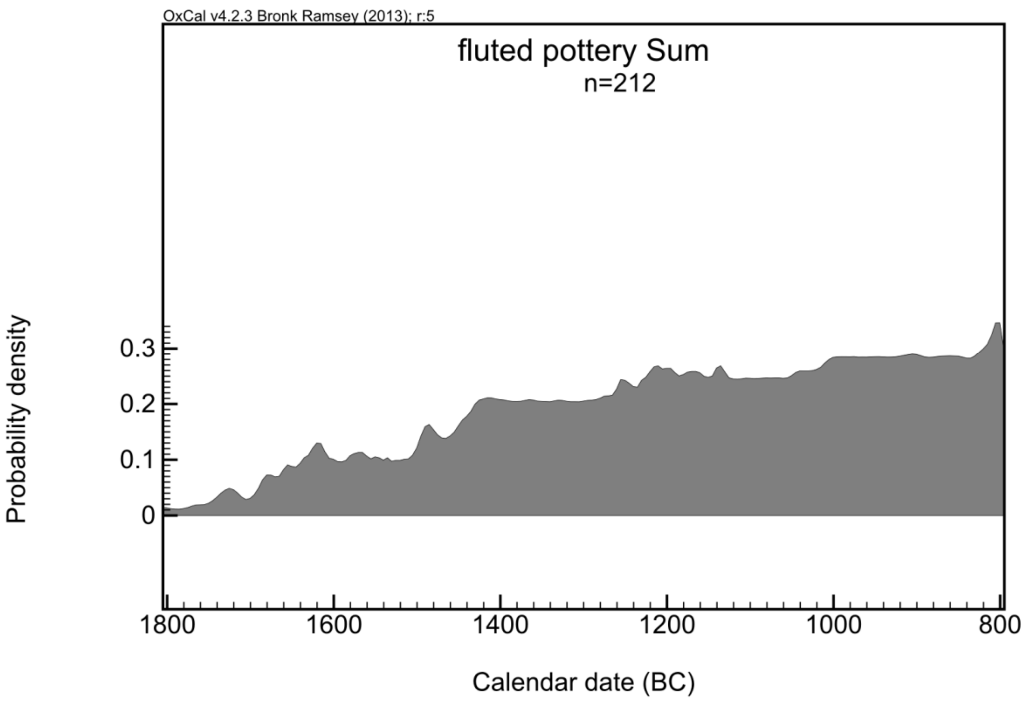

Fig. 81 – SCPD of contexts characterized by the presence of fluted pottery included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2).

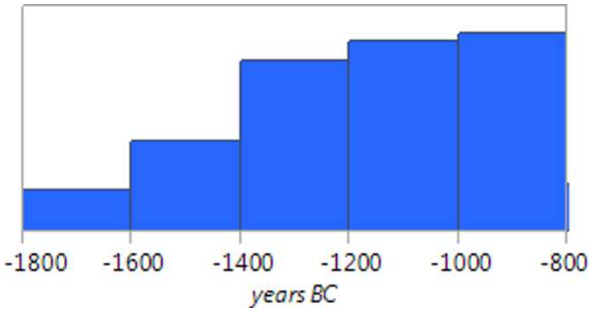

Fig. 82 – Histogram of contexts characterized by the presence of fluted pottery included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

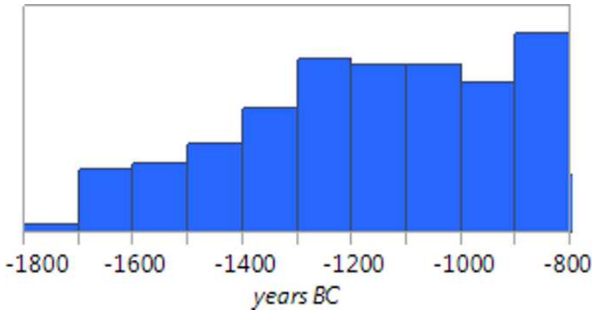

Fig. 83 – Histogram of contexts characterized by the presence of fluted pottery included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

Our results point that the adoption of fluted pottery is a clear phenomenon of innovation in the 2nd millennium BC. Although such a pottery decoration is attested since the Middle Bronze Age the number of adopters increases according to a constant rate in the time span 1800-800 BC.

Can the same global time pattern be recognized in different regional areas?

We have considered four main regions: the North-East of Iberian Peninsula, Southern France, Northern Italy and the north of the Alps region (Switzerland, Austria and Southern Germany). Through the analysis of SCPDs of these regions we can distinguish that the adoption of fluted pottery had different chronologies in different places (Fig. 84).

The area where this pottery was earlier adopted seems to be Northern Italy, where there is evidence for the presence of fluted pottery since the Middle Bronze Age. In fact, we are aware that such a decoration is largely frequent among pottery collected in the *Terramare* settlements in the Po Valley. In the north of the Alps territories this decoration is also attested since the Middle Bronze Age, but it is in the Late Bronze Age when it reaches its maximum diffusion. The major number of adopters seems to be around 1200 BC. Eventually, fluted pottery in Southern France and in the North-East of Iberian Peninsula are characterized by temporal distributions which have many features in common. Higher probabilities of recovering fluted pottery seem to be earlier in Southern France, where it is attested since around 1500-1400 BC and it reaches the maximum in the time span 1100-1000 BC. On the contrary, the SCPD of North-East of Iberian Peninsula shows that fluted pottery is attested slightly later in time, since the

Late Bronze Age. Its presence increases as we move to the Iron Age.

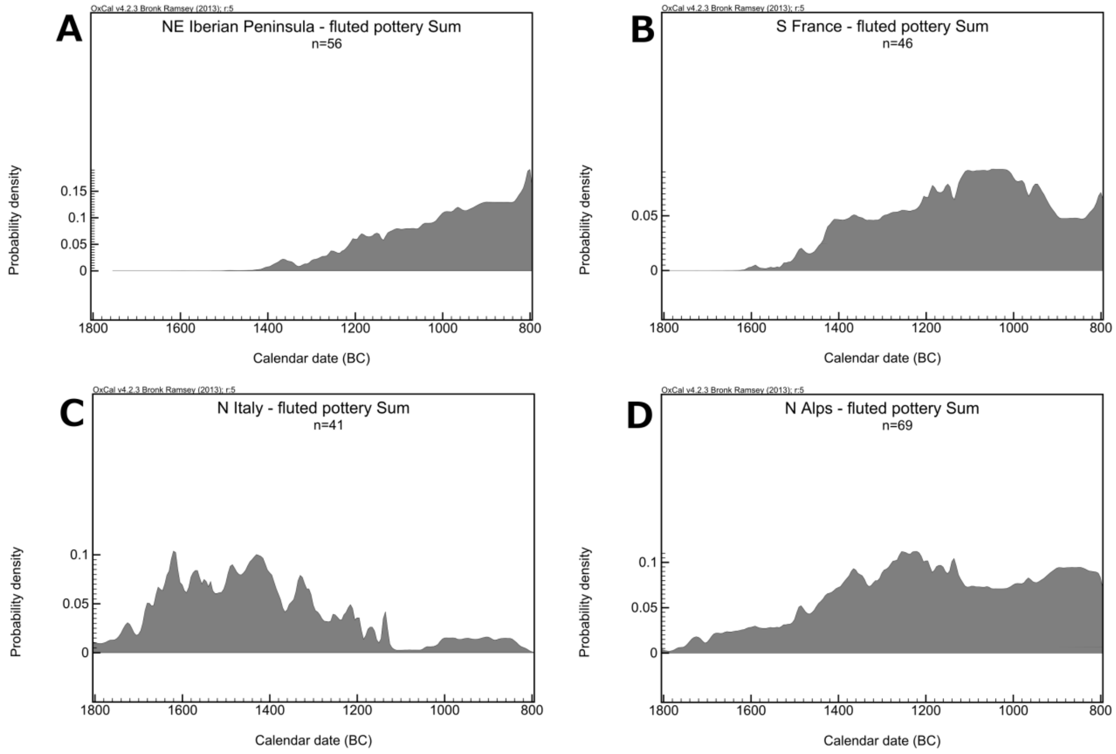

Fig. 84 – SCPDs of reliable contexts with fluted pottery included in the EUBAR database from: the North-East of Iberian Peninsula (A), Southern France (B), Northern Italy (C), and the north of the Alps region (D). IntCal13 calibration curve (Software: OxCal 4.2).

It should not surprise the parallelisms in the shape of the SCPD obtained for cremation burials, and those for fluted pottery. In fact, we should remember that the arrival of fluted pottery in the North-East of Iberian Peninsula has been traditionally associated to the arrival of the Urnfield burials. If we compare such graph with the SCPD of ^{14}C-dated cremation burials from the same region we can observe that the probability to recover fluted pottery in the North East of Iberian Peninsula started before the presence of cremation burials (Fig. 79A). Therefore, chronological differences allow us to assume that they represent two different and autonomous phenomena in this region.

8.4.2 Vases with handles with vertical expansion

The second pottery typology we have analyzed comprises handles with vertical expansion. As we have previously explained in the chapter 5.3.2.1 such a typology is distributed in Northern Italy, Southern Switzerland, Southern France and the North-East of Iberian Peninsula. This datum is confirmed by the spatial distribution of ^{14}C-dated archaeological contexts where handles with vertical expansion were recovered (Fig. 85).

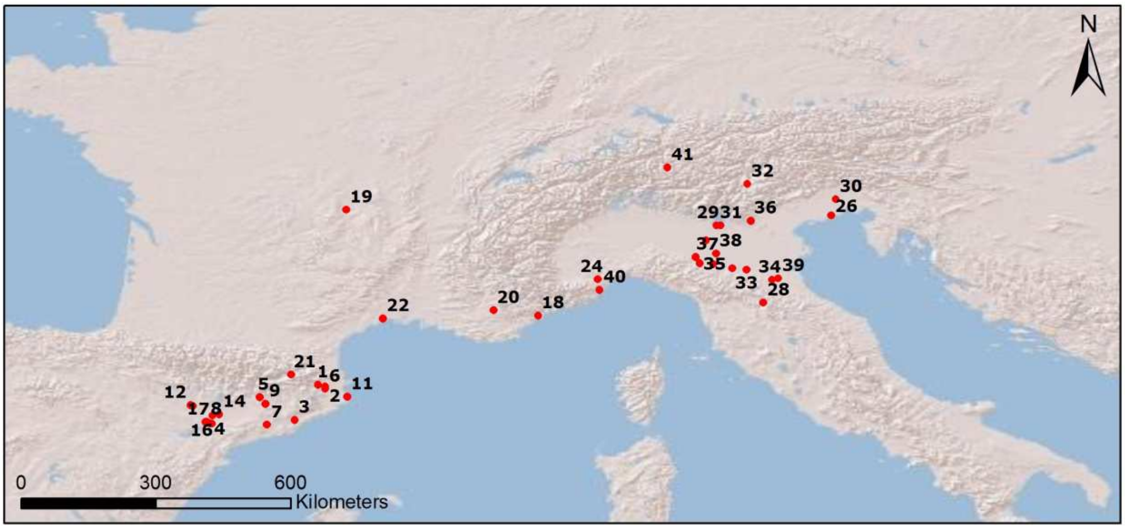

Fig. 85 – ^{14}C-dated contexts included in the EUBAR database and characterized by the presence of vases with handles with vertical expansion. The numbers correspond to: Bauma del Serrat del Pont (1),Can Barraca (2), Can Roqueta II (3), Carretelà (4), Clará (5), Cova d'en Pau (6), Cova de la Guineu (7), Cova de Punta Farisa (8), Dolmen de la Pera d'Ardèvol (9), Genó (10), La Fonollera (11), La Torraza I (12), Masada de Ratón (13), Roques del Sarró (14), Tozal de Macarullo (15), Vilot de Montagut (16), Vincamet (17), Aven de la Mort de Lambert (18), Cournon d'Auvergne (19), Grotte Murée (20), Llo-Lladre (21), Port-Ariane III (22), Anzola (23), Bric Tana (24), Ca' Manzini (25), Caorle-San Gaetano (26), Castellaro del Vhò (27), Dicomano (28), Frassino I (29), Gradiscje di Codroipo (30), Lavagnone (31), Magrè-Tolerait (32), Montale (33), Monte Castellaccio (34), Monte Leoni (35), Monte Madarosa (36), Noceto-vasca votiva (37), Santa Rosa di Poviglio-Villaggio Piccolo (38), Solarolo-via Ordiere (39), Villaggio di Castellari (40), Padnal de Savognin (41).

In order to analyze the frequency of such a variable in the time span 1800-800 BC we have summed calibrated dates from reliable samples archaeologically associated to handles with vertical expansion and included in the EUBAR database. We have obtained a SCPD of 78 radiocarbon dates from 29 sites (Fig. 86). The result points a higher frequency of the variable in the time span 1650-1400 BC on a macro scale. That is not surprising as the origin of this typology has been traditionally placed in the North Italian archaeological contexts of the *Polada* and *Terramare* cultures, dated to the end of the Early Bronze Age and the Middle Bronze Age. The amount of dated contexts slightly decreases as we move to the beginning of the Iron Age.

Such a temporal distribution is confirmed in the histograms of medians, both for 200 and 100 years time lags (Fig. 87 and 88).

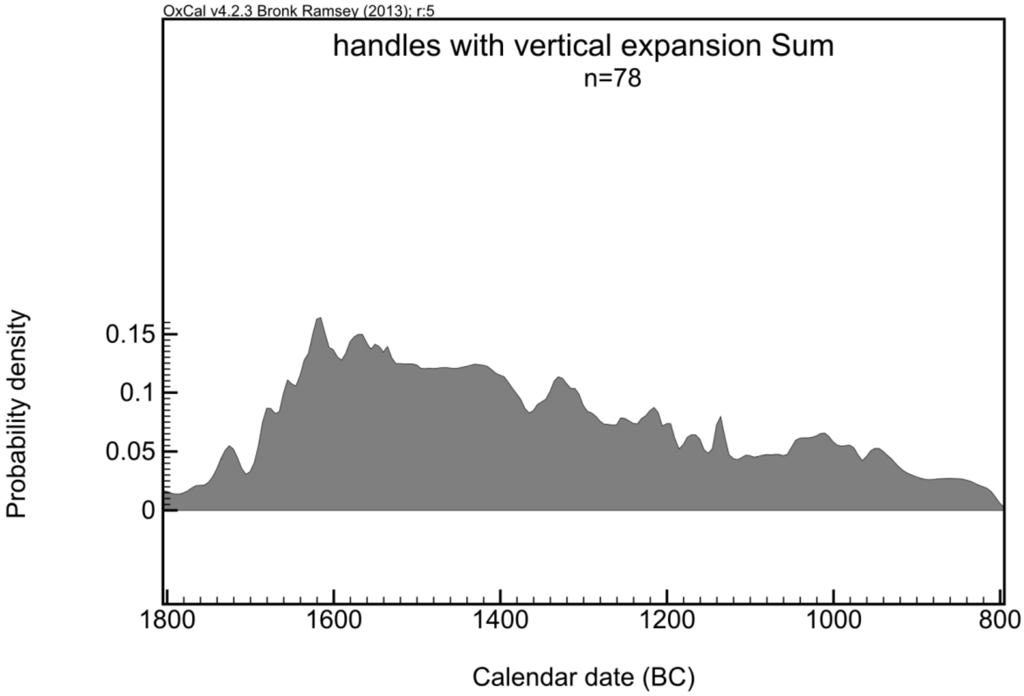

Fig. 86 – SCPD of contexts characterized by the presence of handles with vertical expansion included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2).

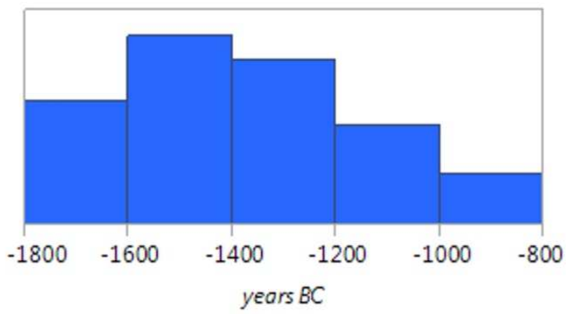

Fig. 87 – Histogram of contexts characterized by the presence of handles with vertical expansion included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

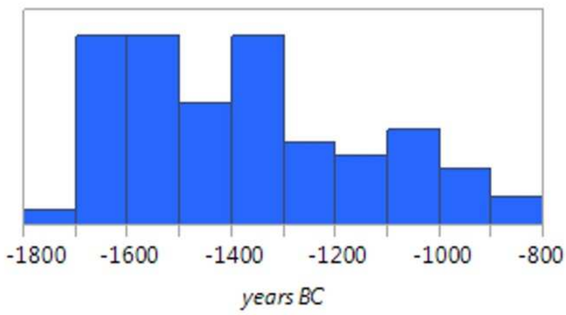

Fig. 88 – Histogram of contexts characterized by the presence of handles with vertical expansion included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

Nevertheless, when we analyze regional distribution we can recognize different time patterns in different territories. As for fluted pottery we have produced SCPDs for four main regions: the North-East of Iberian Peninsula, Southern France, Northern Italy and the north of the Alps region (Switzerland, Austria and Southern Germany) (Fig. 89). Regrettably, the amount of dates in some regions, like Southern France and Northern Alps, is too low, so obtained results must be taken into account only as preliminary. In any case we can distinguish that the Middle Bronze Age core of sites where pottery with vertical expansion handles have been found is located in Northern Italy. The same temporal distribution can be appreciated in the north of the Alps region represented only by the settlement of Padnal de Savognin in Southern Switzerland. In Southern France presence of such a variable seems to be placed both in the Middle Bronze Age and in the Late Bronze Age. On the contrary, in the North East of Iberian Peninsula handles with vertical expansion are concentrated mainly in the last phase of Bronze Age. However, we must be cautious with such results due to the small amount of contexts.

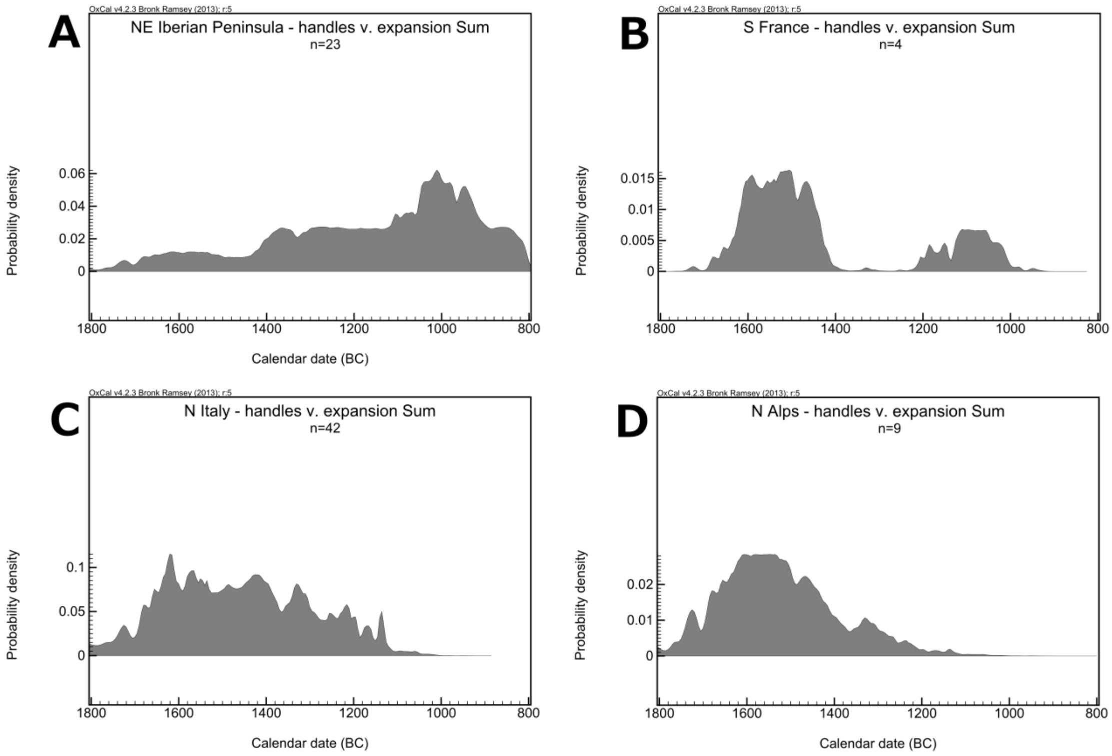

Fig. 89 – SCPDs of reliable contexts, included in the EUBAR database, where handles with vertical expansion were recovered from: the North-East of Iberian Peninsula (A), Southern France (B), Northern Italy (C), and the north of the Alps region (D). IntCal13 calibration curve (Software: OxCal 4.2).

8.4.3 Pottery with helicoidal ribs decoration

The decoration formed by helicoidal ribs located in the carina or in the bell of vessels has been traditionally linked to the *Urnfield culture* and considered as a time marker for the *Ha A1* phase (Leonardi 2010). See chapter 5.3.2.5. We decided to test such a hypothesis using data collected in the EUBAR database.

After having selected reliable contexts where such a variable was attested, we produced a SCPD using the 11 ^{14}C dates originating from 8 archaeological sites (Fig. 90). Additionally we analyzed the temporal distribution of such a pottery decoration using the histograms of the medians of calibrated dates (Fig. 91 and 92). Time lags of 200 and 100 years have been taken into account.

Despite of the small number of dates the results claim that the higher frequency must be placed in the time span 1250-1100 BC, which corresponds to the chronological range of the *Ha A1* phase. The more recent dates correspond to contexts located in the South-Western France and in Catalonia. It is interesting to note that the radiocarbon dated Catalan context where this variable has been attested is the necropolis of Can Missert (Terrassa), where a cremation burial in an urn decorated with *sogueado* was recovered.

Moreover, such a cemetery was linked to first arrival of *Urnfield culture* in the Catalan territory (Pérez Conill 2009), what could explain the later presence of pottery decorated with helicoidal ribs decoration in the region.

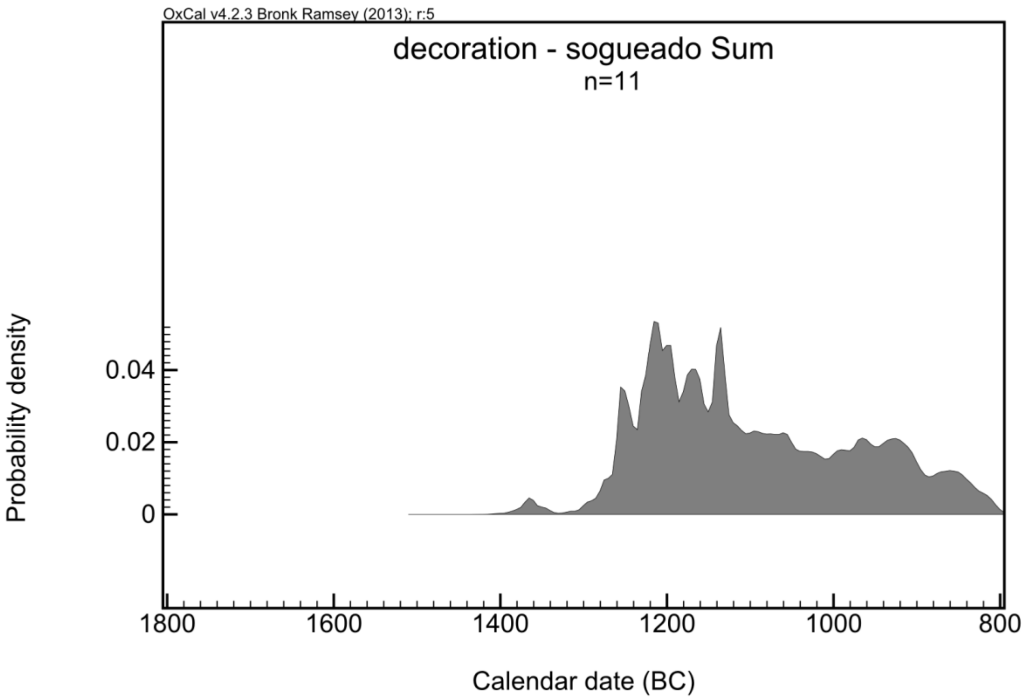

Fig. 90 – SCPD of contexts characterized by the presence of pottery decorated with helicoidal ribs included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2).

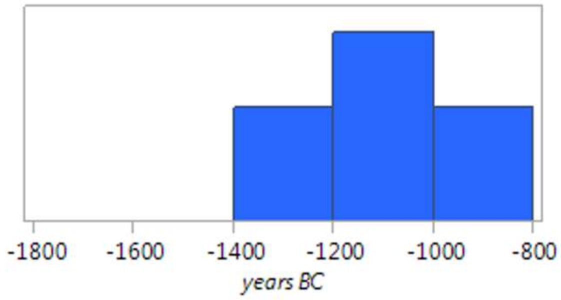

Fig. 91 – Histogram of contexts characterized by the presence of pottery decorated with helicoidal ribs included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

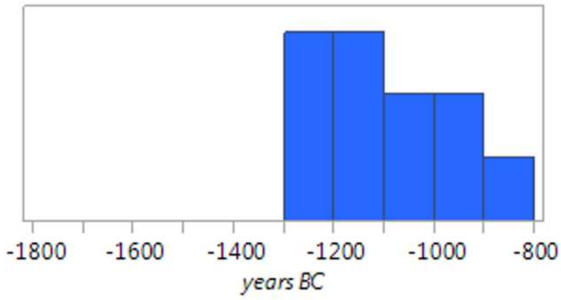

Fig. 92 – Histogram of contexts characterized by the presence of pottery decorated with helicoidal ribs included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

8.4.4 Biconical vessels

In order to analyze the temporal distribution of biconical vessels we have selected 146 ^{14}C dates from 64 sites where samples reliable associated to biconical vessels were recovered. Data originate from archeological contexts included in the EUBAR database. The SCPD (Fig. 95) as well as the histograms of medians (Fig. 93 and 94) obtained using such dataset are characterized by a homogeneous temporal distribution of the pottery typology in the time span 1800-800 BC. The distributions show that biconical vessels appear in a quite stable frequency in the analyzed chronological range, no episodes of discontinuity have been detected. The small peak around 1400 BC can be an effect of the calibration process as we have mentioned previously. The result highlights that the common biconical form of vessels cannot be used alone as a time marker (see chapter 5.3.2.4), nor characterize the new period.

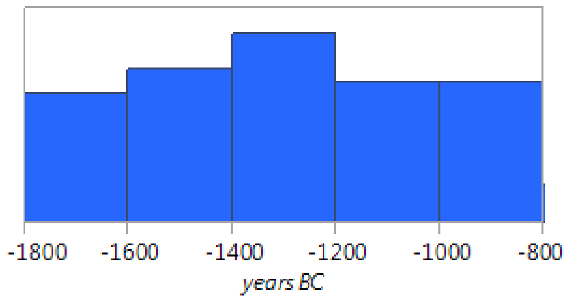

Fig. 93 – Histogram of contexts characterized by the presence of biconical vessels included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

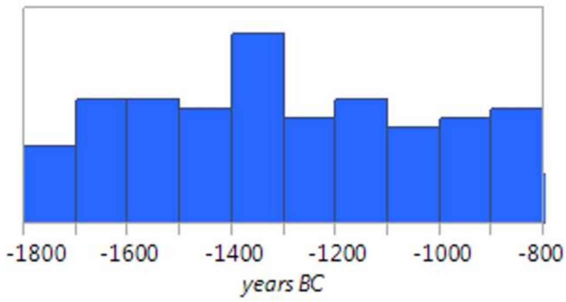

Fig. 94 – Histogram of contexts characterized by the presence of biconical vessels included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

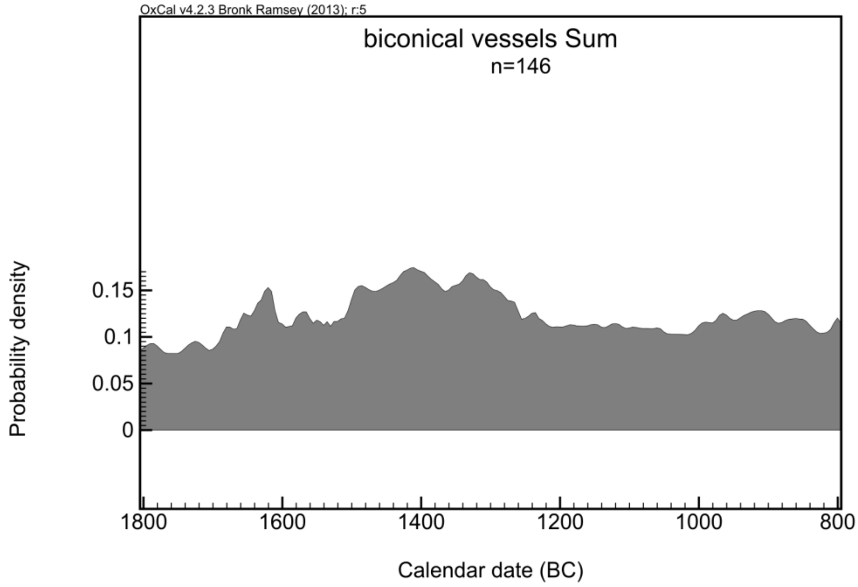

Fig. 95 – SCPD of contexts characterized by the presence of biconical vessels in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2).

8.4.5 Carinated cups

Carinated cups are another vessel form that we have been able to analyze. 197 ^{14}C dates from 85 archaeological sites included in the EUBAR database have been retained for the analysis.

The SCPD (Fig. 96) and the histograms of medians (Fig. 97 and 98) show a relative homogeneous temporal distribution (stationarity). The probability of recovering carinated cups is equally distributed in the whole time span 1800-800 BC. We can only detect a lower probability in the last phase of the Bronze Age. Regarding those results we need to highlight the major difficulties in identifying such a variable, for the problems already mentioned in the chapter 5.3.2.3. These relate mainly to the ambiguous terminology used to describe this vessel form and the problems of fragmentation, whose effects do not allow us to identify clearly this pottery typology.

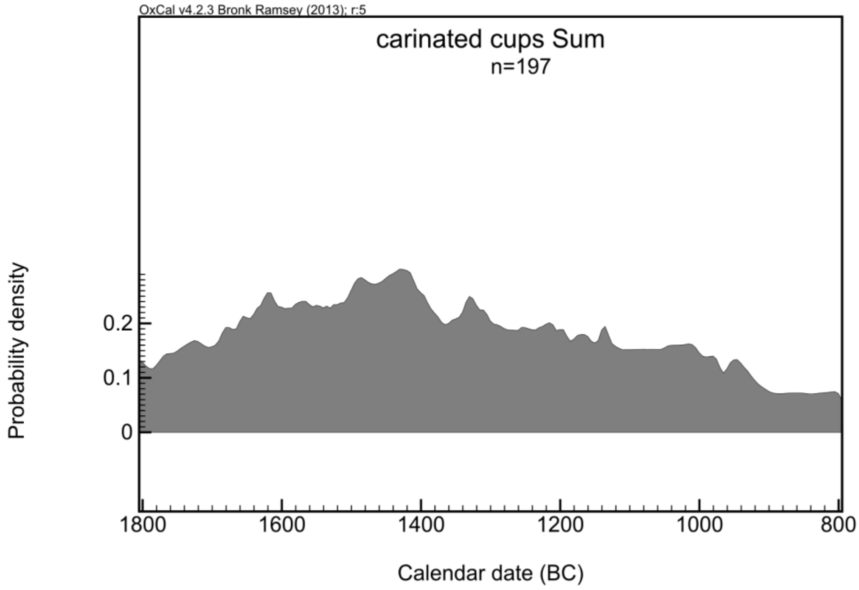

Fig. 96 – SCPD of contexts characterized by the presence of carinated cups included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2).

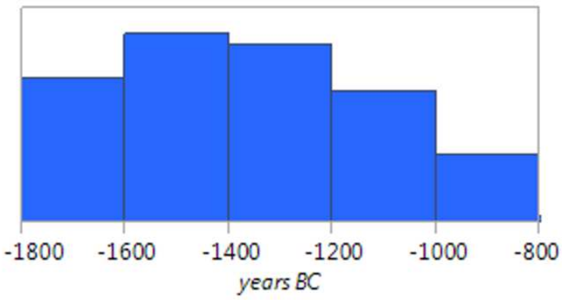

Fig. 97 – Histogram of contexts characterized by the presence of carinated cups included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

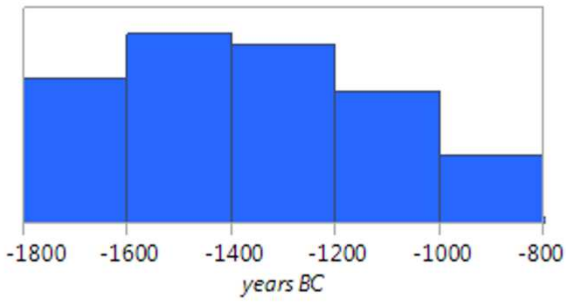

Fig. 98 – Histogram of contexts characterized by the presence of carinated cups included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

8.4.6 Daggers and knives

Among the metallic objects included in the EUBAR database we have decided to analyze daggers and knives together. The main difference among them is the number of blades: daggers have a double edged blade which is sharp on both sides; knives have only one side of the blade sharpened.

Regarding their function, Bronze Age daggers had mostly the utility of weapons although their use as a tool cannot be discarded; on the contrary Bronze Age knives were mainly used as tools. Regarding their chronology, knives represent an innovation of the Middle Bronze Age which spread quickly and with lasting effect across central Europe (Jockenhövel 2013).

Our aim was to test if possible different temporal patterns can be recognized on a macro scale between daggers and knives taking into account ^{14}C-dated archaeological contexts included in the EUBAR database.

We have started analyzing 58 radiocarbon dates from 14 sites where daggers where found in association with the dated sample. Regrettably the number of reliable archaeological contexts where daggers have been recovered is low.

Using such a dataset we have produced a SCPD (Fig. 99) and the histograms of medians (Fig. 100 and 101). The results point a decrease in the amount of daggers in the time span 1800-800 BC between the Ebro and the Danube River. The highest probability in the adoption of daggers seems to be placed in the Early and in the Middle Bronze Ages between 1800 and 1450 BC, whilst it is sensibly lower between 1200 and 800 BC.

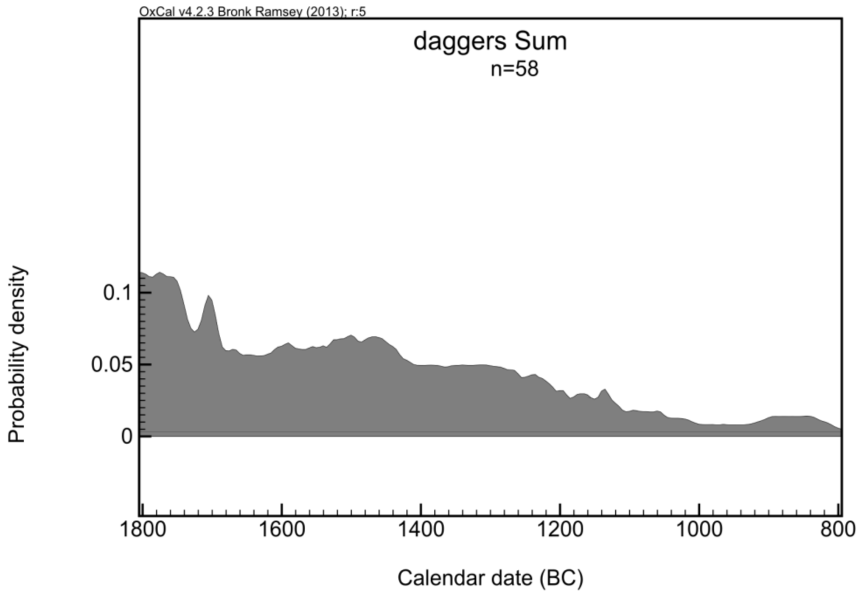

Fig. 99 – SCPD of contexts characterized by the presence of bronze daggers included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2).

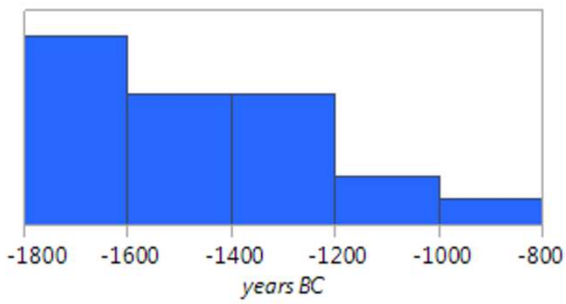

Fig. 100 – Histogram of contexts characterized by the presence of bronze daggers included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

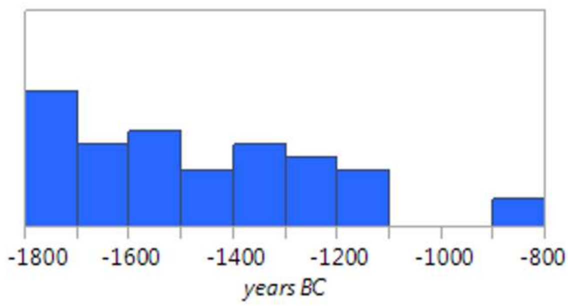

Fig. 101 – Histogram of contexts characterized by the presence of bronze daggers included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

Regarding knives we have retained for the analysis 41 radiocarbon dates originating from 18 archaeological sites. Using such a dataset we have summed the calibrated dates in order to obtain a SCPD (Fig. 102). In addition, we have analyzed the temporal distribution of knives using the histograms of medians (Fig. 103 and 104).

Results are in agreement with what expected. The probability of recovering knives in Bronze Age archaeological contexts is lacking in the first part of the time span 1800-800 BC. Our data shows that before 1600 BC such a tool was absent. From this moment on, the probability of finding knives is low till around 1300 BC, when it starts to increase. In the light of such results it is clear that: on the one hand the adoption of knives in the 2nd millennium BC is a clear phenomenon of adoption of innovation characterized by a constant positive trend between 1800 and 800 BC. In fact, the highest probability in the adoption of such a variable is located at the end of the time span. On the other hand, daggers present a completely opposite temporal distribution, with a negative trend in the same time span.

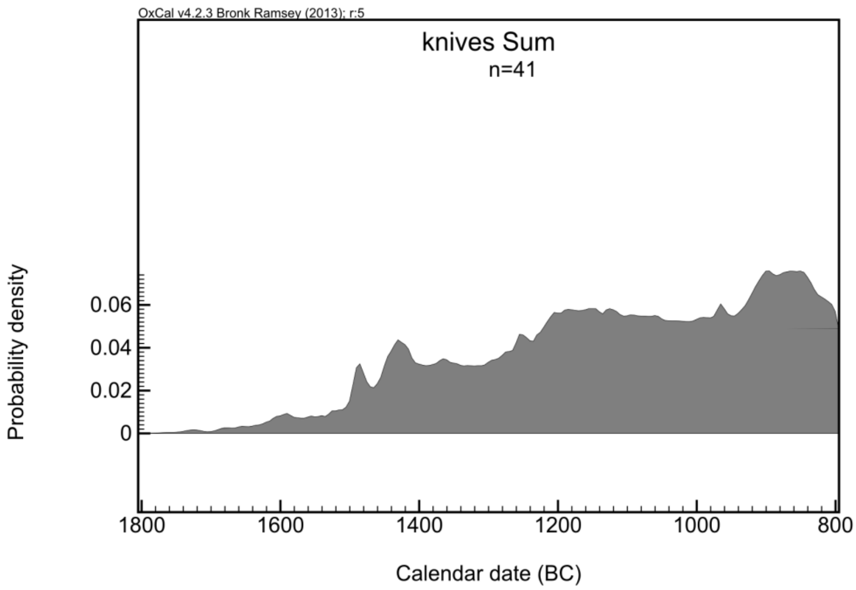

Fig. 102 – SCPD of contexts characterized by the presence of metal knives included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2).

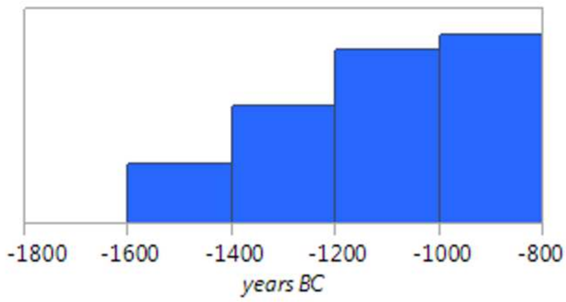

Fig. 103 – Histogram of contexts characterized by the presence of metal knives included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

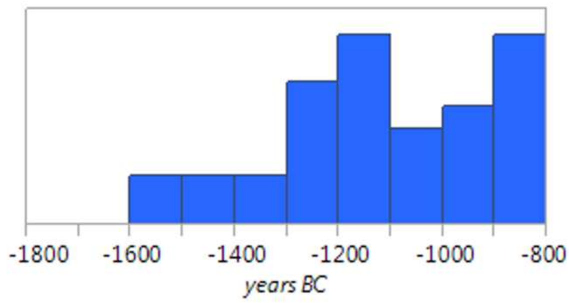

Fig. 104 – Histogram of contexts characterized by the presence of metal knives included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

8.4.7 Fortified settlements

Among social and economic variables included in the EUBAR database we decided to analyze a variable that provide information about the settlement structure between 1800 and 800 BC, i.e. the presence of traces of fortification. Therefore, we have summed 95 radiocarbon dates originating from 24 fortified settlements and we have produced histograms of medians using the same dataset.

The obtained SCPD (Fig. 105) as well as the histograms (Fig. 106 and 107) do not show relevant episodes of change in the frequency of such a variable in the studied chronological range. In particular, we cannot detect a relevant increase in the number of fortified settlements for the last phase of the Bronze Age in the territory comprised between the Ebro and the Danube River. The probability of the presence of fortified villages seems to be higher between 1800 and 1200 BC. However, we must be cautious with this result because only 24 sites for one millennium have been included in the analysis. Therefore, the study and the comparison with non ^{14}C-dated archeological sites could highlight problems of sampling in the available data.

Moreover, it is relevant to add that traditionally the increase of fortified settlements become clear in the *Ha C* phase, which is not included in the analyzed time span, as it corresponds to the Hallstatt plateau in the IntCal13 calibration curve.

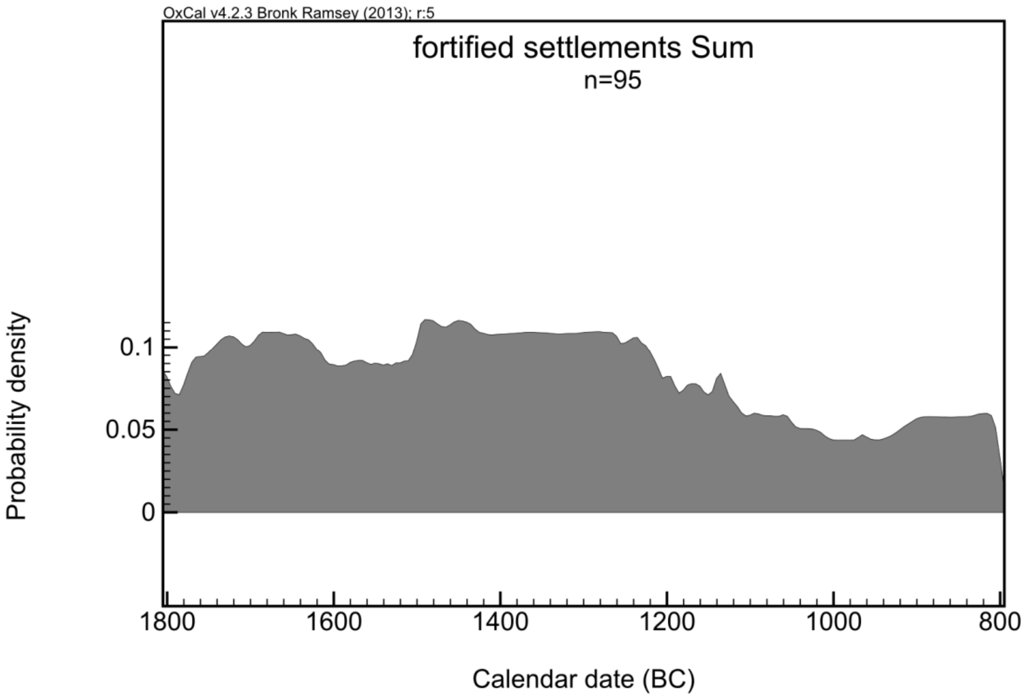

Fig. 105 – SCPD of ^{14}C dates from fortified settlements included in the EUBAR database. IntCal13 calibration curve (Software: OxCal 4.2). We have filtered "overdated contexts" using the function "R_Combine" of OxCal 4.2 (Bronk Ramsey 2009a).

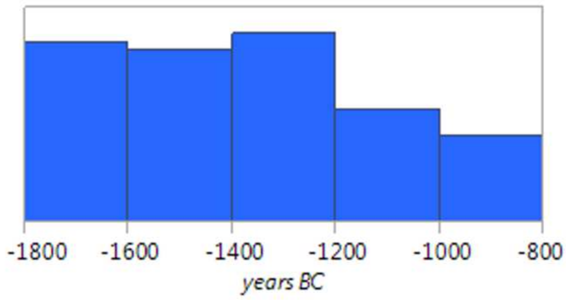

Fig. 106 – Histogram of fortified settlements included in the EUBAR. Medians of the calibrated radiocarbon dates. Time lags of 200 years.

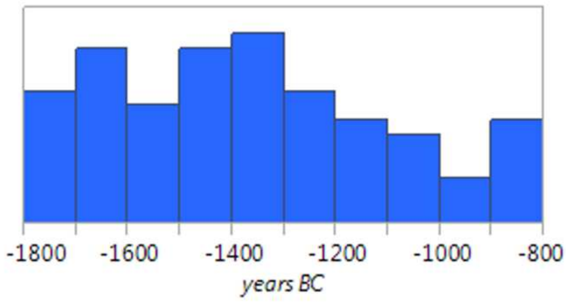

Fig. 107 – Histogram of fortified settlements included in the EUBAR database. Medians of the calibrated radiocarbon dates. Time lags of 100 years.

8.5 The classical logistic model of temporal growth

The regularity of systems' evolution, characterized by an initial slow change, followed by a rapid change and then ending in a slow change again are observed since statistical observation was established in the mid 18th century. Various scientists and researchers discovered, reinvented, and adapted the curves of nonlinear growth many times for different domains of knowledge. Therefore, S-shaped curves possess a lot of different names: Logistic curve, Verhulst-Pearl equation, Pearl curve, Richard's curve

(Generalized Logistic), Growth curve, Gompertz curve, S-curve, S-shaped pattern, Saturation curve, Sigmoid(al) curve, Foster's curve, Bass model, and many others.

To model the diffusion of innovation and thus determine the rate of growth in the number of users of an innovation and predicting their numbers in the future, one can use the mathematical theory of the spread of infections during an epidemic or the theory of information transfer (Kijek & Kijek 2010).

Using the theory of epidemiology, a fundamental model of innovation diffusion can be expressed by the differential equation:

$$\frac{dN(t)}{dt} = g(t)(m - N(t))$$

where:

- t is time
- $N(t)$ is the cumulative numbers of adopters at time t
- m is the ultimate ceiling of potential adopters
- $g(t)$ is the coefficient (rate) of diffusion.

This equation points out that the diffusion rate is a function of the number of the potential adopters who have not yet adopted the technology and the rate of diffusion. The rate of diffusion, $g(t)$, reflects the likelihood that potential adopters will adopt the innovation in some small interval of time around time t. The value of $g(t)$ depends on such characteristics of the diffusion process as the type of innovation, communication channels, time and the traits of the social system. Depending on the formula for the coefficient of diffusion, $g(t)$, there are three specific models of innovation diffusion (Kijek & Kijek 2010):

1. the external-influence model, where the coefficient of diffusion $g(t)$ is a constant p,
2. the internal-influence model, where the coefficient of diffusion $g(t)$ is $qN(t)$,
3. the mixed-influence model, where the coefficient of diffusion $g(t)$ is $p + qN(t)$.

The constant p in the external influence model is defined as the coefficient of innovation or external influence, emanating from the outside of a social system. Under such a premise, it can be assumed that p depends directly on communication regarding innovation, formulated by market agents, government agencies, etc., and aimed at potential users of innovation. This model is applicable to modeling the diffusion of innovation, where agents of the social system are relatively isolated, when formalized and hierarchical communications dominate the sphere of communication. This is the case of the classical Pearl-Venhurst model. Its equation is:

$$f(x) = \frac{1}{1 + e^{-x}}$$

Where e is Euler's number (e = 2.71828...)

The constant q in the internal-influence model, defined as the coefficient of imitation, reflects the interactions of prior adopters with potential adopters. Therefore, the decision by potential users to adopt an innovation depends directly on the information formulated by existing users. The internal-influence model is appropriate to characterize the diffusion of innovation when a social system is relatively small and homogenous and there is a need for legitimizing information prior to adoption. The specific form of this model is the well-known Gompertz law of mortality, which states the rate of mortality (decay) falls exponentially with current size.

$$y(t) = ae^{-be^{-ct}}$$

Where:

- a is the upper asymptote, since $ae^{be^{-\infty}} = ae^0 = a$
- *b*, *c* are positive numbers
- *b* sets the displacement along the *x* axis (translates the graph to the left or right)
- *c* sets the growth rate (*y* scaling)
- *e* is Euler's Number (*e* = 2.71828...)

Examples of uses for Gompertz curves include:

- Mobile phone uptake, where costs were initially high (so uptake was slow), followed by a period of rapid growth, followed by a slowing of uptake as saturation was reached.
- Population in a confined space, as birth rates first increase and then slow as resource limits are reached.

A final hypothesis is the mixed-influence model, developed by Bass (1969), which subsumes both of the previous models. For the mixed-influence model, the diffusion coefficient $g(t)$ is equal to $p + q\,N(t)$. In view of its great degree of generality, due to the accommodation of both internal and external influences, mixed-influence models are the most frequently employed in analyses. The mixed-influence model can be expressed using the following equation:

$$\frac{dN(t)}{dt} = \left(p + \frac{q}{m}N(t)\right)(m - N(t))$$

where:

- $N(t)$ is the cumulative number of adopters at time t
- m is the ceiling
- p is the coefficient of innovation
- q is the coefficient of imitation

Assuming $F(t) = N(t)/m$, where $F(t)$ is the fraction of potential adopters who have adopted the technology by time t, the Bass model can be restated as:

$$\frac{dF(t)}{dt} = \big(p + qF(t)\big)(1 - F(t))$$

The Richards' model (Richards 1959) is an empirical model developed for fitting growth data. Through the use of a shape parameter that enables the curve to stretch or shrink, the Richards model encompasses the Gompertz, Fisher–Pry and every other imaginable sigmoidal model (Banks 1994; Marinakis 2012)

The *Richards' function,* or also known as *generalized logistic function*, is an extension of the logistic function, allowing for more flexible S-shaped curves.

Its formula is:

$$Y(t) = A + \frac{K - A}{(1 + Qe^{-B(t-M)})^{1/T}}$$

Where:

- Y is weight, height, size, etc.
- t is time
- A is the lower asymptote
- K is the upper asymptote. If A=0 then K is called the carrying capacity. K-A=C
- B is the growth rate
- $T > 0$ affects near which asymptote maximum growth occurs
- Q depends on the value $Y(0)$
- M is the time of maximum growth if $Q = T$

When *T*=0, the model approximates an exponential growth function. When *T*=0.67, the model behaves like the von Bertalanffy. When *v* approaches 1, the model behaves like the Gompertz. When *T*=2, the model behaves like the Logistic model. In this later case, we may assume (Banks 1994; Sharif & Ramanathan 1981):

1. The population of potential adopters is limited (N) and remains constant with time;
2. All members of the population eventually adopt;
4. All adopters are imitators and adopt only after seeing another using the innovation;
5. The adoption rate is dependent only on the number who have adopted but also on the proportion of the maximum number of adopters that is still unrealized;
6. The probability of one pair of individuals meeting is the same that of any other pair meeting.

8.6. Fitting the the explanatory model to archaeological data

Predicting the number of archaeological artifacts at a specific moment of time is a fundamental concern in the study of the adoption of new tools, technologies and behaviors in ancient times. According to what we have considered in previous sections, one model often used to make such predictions is a geometric growth model which assumes that a population of artifacts grows by the same percentage every year. This is the classical frequency model by Ford (1962) and Bordes (1967). This is unrealistic in the long run because geometric growth models ignore issues such as function and production costs that limit the number of artifacts at each moment.

We prefer to work with probabilities instead of frequencies. We are not considering the growth in the quantity of objects, but the growth of the probability that those objects were in used, assuming that the more objects were in used, the higher the probability. Because no population grows without bounds, we have defined a *maximum* not in reference to a *carrying capacity*, but on the basis of the proportion of adopters. If everyone is using/producing the artifact or practicing the ritual, then the probability is 1.

Using summed probabilities for a specific calendar year, we are modeling the possible growth of different populations of tools, sites or burials considering the sequence *Nt*, where *Nt* is a period of validity (Barceló 2008b), defined statistically as the period of time that fulfills the condition that there is a calculable nonzero probability, and at any time interval included therein it contains at least one of the true dates. For the calculation of *Nt*, we must bear in mind that OxCal has summed different probability distributions: the more archaeologically dated samples have the same chronological interval, the higher the probability (N_t) of that particular calendar year. In this way, ours appears to be a binomial model including, in addition to the adopters and non-adopters, uncommitted members and members with varying degrees of receptivity to the innovation (Sharif & Ramanathan 1981).

In our case we cannot assume that the potential adopter population is fixed and does not change with time. On the other hand, we assume that this population was exposed to some changes and innovations continuously over time and that the members of the population made binary decisions either to adopt or not to adopt the innovations.

In the light of such assumption we have decided to analyze mathematically the adoption of some variables included in the chapter 8.3 and 8.4. We have chosen all those variables, whose SCPDs showed a positive trend in the time span 1800-800 BC, like cremation burials, fluted pottery and metal knives. For all these variables we have been able to detect an increase in their adoption on a macro scale. In addition, we have tested mathematically the possibility of a growth in the adoption of vases with handles with vertical expansion.

To tackle this issue we have curve fitted our modeled data obtained through SCPDs plots (Fig. 108). For this aim we have adopted generalized logistic curve (Richard's curve). Then we have analyzed the produced coefficients and parameter statistics in order to ensure the reliability of the process and to infer its causes (Fig. 109).

Among the obtained values we have to focus on the R-squared, also called coefficient of determination, which indicates how well data points fit the statistical model, in our case the generalized logistic curve. The possible values range from 0 to 1. We have obtained high values, above 0.89 for cremation burials, fluted pottery and metal knives. It means that the adoption of the three variables can be well explained by the generalized logistic curve. On the contrary, for vases with handles with vertical expansion the obtained value is 0.42, which proves that the model does not fit the data. In fact, the adoption of such a pottery typology is not characterized by a positive trend in the whole time-span 1800-800 BC as it has been evidenced also in the related SCPD and histograms (Fig. 86, 87 and 88). It follows that the Richard's function cannot be used to describe on a macro spatial and temporal scale the process of adoption of handles with vertical expansion.

It is relevant to observe that the results suggest different ratios of adoption among the three phenomena which fit the Richards' curve for the time span 1800-800 BC, i.e. the adoption of cremation burials, fluted pottery and metal knives.

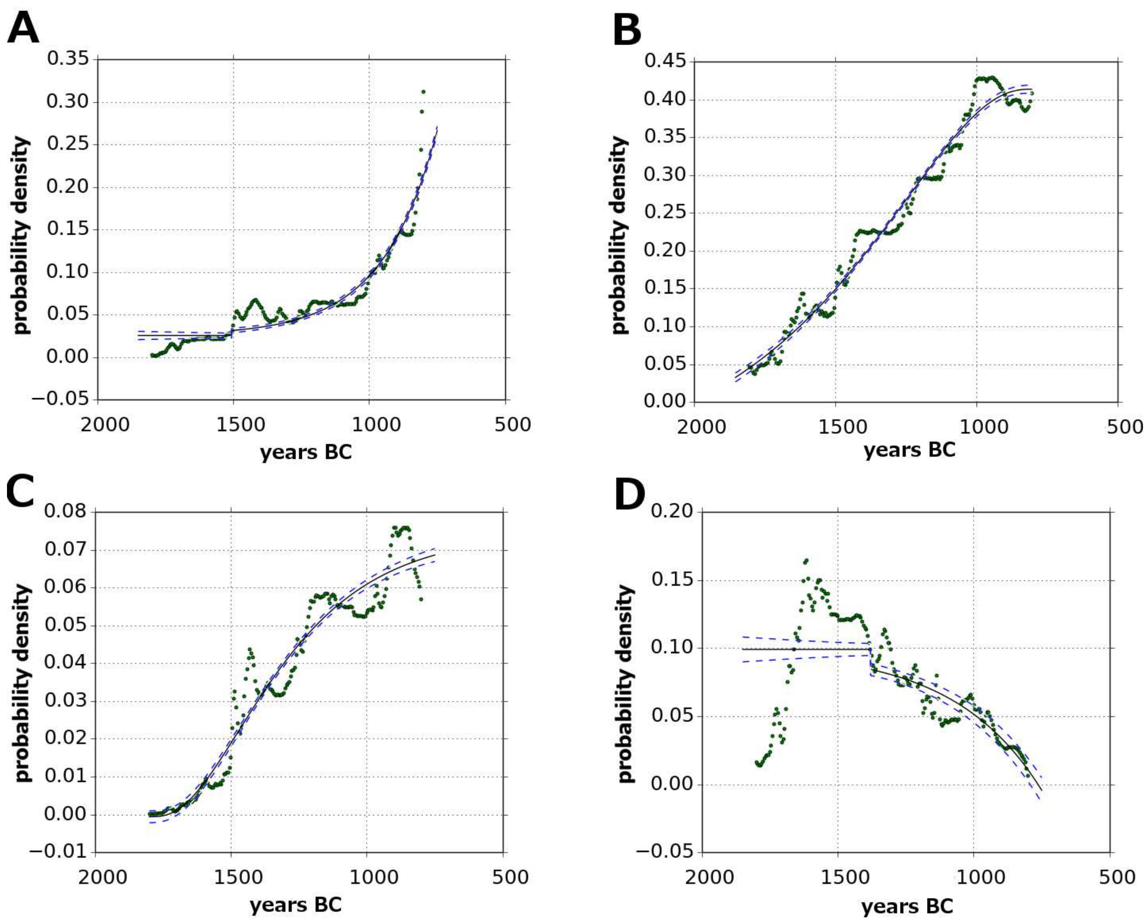

Fig. 108 – Generalized logistic distribution fitted to SCPDs data of: cremation burials (A), fluted pottery (B), metal knives (C), vases with handles with vertical expansion (D). The green dots represent the SCPDs, the black line the fitted curve and the dashed blue lines the 95% confidence interval. Analyzed time span goes from 1800 to 800 BC.

For cremation burials we can detect a slow rate of adoption in the early phases, when the role of innovators is predominant (Fig. 108A). Then the phenomenon is characterized by an exponential growth at least till 800 BC. It follows that the innovation spread fast starting from 1200/1100 BC. Historically, the increase in the rate of adoption can be an effect of the decrease in the number of inhumation burials starting from 1300/1200 BC, that we observed in the related SCPD (Fig. 73).

For fluted pottery we can distinguish a slight different generalized logistic curve (Fig. 108B). The obtained results show that the adoption of such a variable is defined by a fast rate from the early phases, with a rapid linear increase in the number of adopters.

Such a growth seems to stop and to reach the condensation/saturation step in the last range of the time span, between 950 and 800 BC. Therefore, apparently this period corresponds to late phases of the adoption process. Regarding the differences between the adoption of cremation burials and the adoption of fluted pottery, already suggested in the SCPDs, the generalized logistic curve fitted to our data strengthen the hypothesis of separated phenomena, with a much faster growth in the adoption of the new pottery decoration compared to that one of cremation rite.

Similarities with the process of adoption of fluted pottery can be traced in the temporal diffusion of metal knives between 1800 and 800 BC. The phenomenon is characterized by a rapid growth since the first phases with a linear increase in the majority of its process, at least till 1200/1100 BC when the process seems to reach the condensation step (Fig. 108C). It means that between 1200/1100 and 800 BC the rate of penetration into the different places tends to become more homogeneous and the trajectory of the rate of adoption begins to level off, as fewer and fewer individuals remain who have not yet adopted the innovation.

In cases of fluted pottery and metal knives obtained curves seem to display a single alternative shape, which Henrich (2001) calls an R-curve. In fact, R-curves lack the slow growth during the initial portion of the spread, which characterizes S-curves. R-curves begin at their maximum rate of growth (at $t = 0$) and then slowly taper off toward equilibrium.

Completely different seems to be the process of adoption of vases with vertical expansion (Fig. 108D). We can clearly recognize that such a phenomenon does not correspond to a unique homogeneous growth in the whole time span 1800-800BC. In fact, as we have already observed in the relating SCPD and the histograms of dates (chapter 8.4.2) the initial increase in the number of adopters of the new pottery typology is followed by a decrease in the temporal diffusion of such a variable. For this reason the generalized logistic curve is not suitable to describe such a phenomenon on a macro temporal and spatial scale.

The obtained results underline the main problem in the application of S-curves to the study of growing processes, which relates to its smooth and regular profile. In fact, compared to fieldwork data, logistic law rather appears as a mathematically ideality; it does not take into account the variability which can characterize phenomena of growth, diffusion and adoption of innovation. These phenomena never exhibit a so smooth and regular profile; on the contrary they are frequently defined by angled curves which directly correlated to the number of adopter. The lower number of susceptible adopters, the more angled the curve (Raynaud 2010).

As Raynaud (2010) argued the gap between the model and the real world lies in the assumption that societies are "well-mixed populations," assimilating the adoption of innovation to a random draw.

	cremation burials	fluted pottery	metal knives	h. with vertical expansion
Degrees of freedom (error)	196	196	196	196
Degrees of freedom (regression)	4	4	4	4
Chi-squared	0.0512928388262	0.0764412715217	0.00646427805195	0.184262672606
R-squared	0.898831217975	0.975211160543	0.944973656869	0.421461097538
R-squared adjusted	0.896766548955	0.97470526586	0.943850670275	0.409654181161
Model F-statistics	435.339131295	1927.6960081	841.482580021	35.6961194683
Model F-statistics p-value	1.11022302463e-16	1.11022302463e-16	1.11022302463e-16	1.11022302463e-16
Model log-likelihood	546.281013209	506.184366899	754.44262438	417.760491658
AIC	-5.38588072845	-4.98690912337	-7.45714054109	-4.10706956874
BIC	-5.30370896457	-4.90473735949	-7.37496877721	-4.02489780485
Root Mean Squared Error (RMSE)	0.0159746127611	0.019501405935	0.00567103053449	0.0302775447231
A	2.5373003945891787E-02	4.1352875698833352E-01	-5.944292684757050E-04	9.8958838218577816E-02
C	8.0162102831720450E-01	-5.0188241043145498E-01	7.5234369601290485E-02	-3.4537239793630929E+00
M	-5.1307732417899547E+02	-1.2413528268260436E+03	-1.4733407570311347E+03	3.6803992023307478E+02
B	7.1007543185630284E-01	-2.1888213827582137E-03	3.4432866496265451E-03	4.0337636263686605E-01
T	1.4377878650469259E+02	-3.8435341101060816E-01	-3.2528296832824266E-01	1.2985472259255670E+02

Fig. 109 – Table with the coefficients and fit statistics obtained from the generalized logistic distributions fitted to SCPDs data of cremation burials, fluted pottery, metal knives and vases with handles with vertical expansion.

8.7 Testing the reliability of the growth in the estimated probability of archaeological events across time

In archaeology, temporal frequency distributions are most commonly presented as summed calibrated probability distributions of ^{14}C dates (SCPDs) or histograms/frequency polygons of sites of calibrated or uncalibrated ^{14}C dates (see chapter 4.3.2 and 4.4). The resulting composite probability distribution is obtained by superposition of individual ^{14}C ages, represented by the confidence interval after calibration. For a SPCD, the height is expressed as intensity. Fluctuating intensities, which usually occur on time scales of centuries, enable the inference of changes of the investigated phenomenon. Mathematically what this approach does is to provide a frequency distribution modulated by the uncertainty on the calibrated date of the sample. This means that the technique attempts to provide a view of the spread of the actual calendar dates of the dated material in a phase, although, as this view is folded together with uncertainty caused by the statistical spread of the radiocarbon dates, "we are looking at it through blurred spectacles" (Bayliss et al. 2007). The "Sum" function in the OxCal software equates to an "OR" logical operator, which strictly means in the case of two radiocarbon ages that either one OR the other distribution might apply to the event in question. As Chiverrell et al. (2011) argued if this type of logical operation is applied to different events, then that distribution is folded together along with the uncertainty in those events and can give a misleading impression (Bronk Ramsey 2008).

A simple and linear cumulative frequency analysis of summed probabilities would assume that the number of social agents having adopted the innovation (or having culturally changed) is added from one time interval to the next. This can be a right assumption in modern market analysis, because the time-span is quite short (less than the life of a single person), and the agent retains the use of the innovation all along the studied period. This is clearly not the case in archaeology. We cannot add in the period 850-750 BC, archaeological contexts that had adopted the innovation in the period 1250-1150 BC, because of those people are dead when we arrive at the end of the studied period! Even more, we usually have evidence of a community having adopted an innovation at a particular moment, but we do not know whether the settlement was abandoned or not at the next moment.

The way of quantifying the rate of adoption of innovations or cultural change is different in archaeology than in other disciplines, dealing with shorter periods of time. Under most archaeological conditions, a positive curvilinear frequency distribution is expected to be produced by the ratio of site abandonment and taphonomic bias, although specific those rates will likely vary by time period, region, and material. Because positive nonlinear distributions are an expected outcome of the operation of a constant taphonomic process on the archaeological record, perhaps curvilinear functions (e.g., exponential, power, logarithmic, etc.) should be used as statistical null models when first attempting to detect if a demographic signal can even be identified over long time scales.

We suggest a non linear regression between the proportion of archaeological contexts of a particular kind and time can give us a preliminary intuition of the frequency of adoptions of innovations *per* time unit and the ratio of cultural change. In statistics, nonlinear regression is a form of regression analysis in which observational data are modeled by a function which is a nonlinear combination of the model parameters and depends on one or more independent variables. Standard regression models assume that those regressors have been measured exactly, or observed without error; as such, those models account only for errors in the dependent variables, or responses. Theoretically, the data should consist of error-free independent variables (time, in our case), *x*, and their associated observed dependent variables (the proportion of adopters/potential adopters at each time interval), *y*. If this is the case, then each *y* can be modeled as a random variable with a mean given by a nonlinear function $f(x,\beta)$.

However, in our case systematic error may be present in the assignment of an archaeological context to a time interval of fixed length because of the irregularity of the radiocarbon confidence interval after calibration. *Errors-in-variables models* or *measurement errors models* are regression models that account for measurement errors in the independent variables. In the case when some regressors have been measured with errors, estimation based on the standard assumption leads to inconsistent estimates, meaning that the parameter estimates do not tend to the true values even in very large samples. In non-linear models the direction of the bias is likely to be more complicated (Chesher 1991; Fuller 1987).

Michczyńska et al. (2007) stressed that when dates obtained from a larger territory are considered, and PDFs are constructed by adding up particular distributions, the influence of local effects can be eliminated, and information on changes derived from regional or global stimuli are highlighted. Even in the case the value of the summed radiocarbon probability density be plausible in terms of the frequency of archaeological events per time unit , we must decide how the statistical uncertainty inherent in each radiocarbon measurement affects the shape of the resulting curve, and hence the reliability of the estimate. It is important to take into account that statistical uncertainty is not a symmetrically distributed, and it is not independent for each measured sample. Therefore, as frequently mentioned we have the risk that the shape of the SCPD be determined by the calibration curve (Michczynska & Pazdur 2004; Chiverrell et al. 2011; Williams 2012; Bleicher 2013).

However, fluctuating intensities can have several other causes, which hamper the interpretation of ^{14}C histograms. These include (Stolk et al. 1994):

1. Overrepresentation of certain periods or areas due to preferential sampling (Geyh 1980). This can be avoided by a careful sampling program and a critical selection of radiocarbon ages.
2. An insufficient number of ^{14}C ages. When the data set used in ^{14}C histogram analysis is considered to be a random population, a minimum of 40 ^{14}C ages per

1000 ^{14}C yr is needed to meet statistical requirements (Geyh 1980; Shennan 1987; Stolk et al. 1989).

3. Non-linearity of the ^{14}C time scale in terms of calendar years, notably the effect of medium-term atmospheric ^{14}C variations (wiggles) (Geyh 1971; de Jong & Mook 1981).

We suggest ranking the calendar years according to their probabilities; it is easy to see that the shape of the resulting probability density function varies according to the different time-spans explored. We have already discussed the source of such a bias. The first one may be due to the choice of a point estimate conditioned by the shape of the calibration curve after the process of calibrating. To minimize this potential source of bias we have adopted the approach suggested by Telford et al. (2004) the median value of the calibrated interval. The second one, noticed by Surovell and Brantingham (2007), concerns the amount of "noise" that is a function of a small sample size and the choice of interval width.

Before using a histogram or a frequency polygon to measure the rate of adoption across time, three conditions should be checked independently:

- Given different time intervals of equal duration or spatial areas of equal spatial extension, the proportion of dated contexts/total number of archaeological observations should be approximately constant.
- The longer the historical period we have to study, the higher the quantity of dated contexts we need.
- The dating of a context has been obtained independently of the fact that there are previous dates for contemporary contexts.

9 THE ADOPTION OF “INNOVATIONS” IN WESTERN EUROPE DURING BRONZE AGE. THE PROBABILITIES OF SPATIALLY DEPENDENT DIFFUSION PROCESSES.

9.1 Characterizing expansive phenomena in historical research

Expansive phenomena in historical research have been traditionally related with the movement of people through space: invasions, migrations, colonizations, and conquests what gives us the appearance of an *expanding* population of men and women *moving* through space (and time). In recent times, however, expansive phenomena in historical research are not limited to the assumption of population movement but imply the movements of goods and/or ideas. According to Schumpeter (1934), to innovate is to introduce something new by *propagating* it in an environment, and generating irreversibilities in the evolution of this environment. In cultural anthropology and cultural geography, cultural diffusion, as first conceptualized by Alfred L. Kroeber in his influential 1940 paper *Stimulus Diffusion* (Kroeber 1940), or trans-cultural diffusion in later reformulations, is the spread of cultural items - such as ideas, styles, religions, technologies, languages etc. - between individuals, whether within a single culture or from one culture to another. It is distinct from the diffusion of innovations within a single culture. Inter-cultural diffusion can happen in many ways. Migrating populations will carry their culture with them. Ideas can be carried by trans-cultural visitors, such as merchants, explorers, soldiers, diplomats, slaves, and hired artisans. Technology diffusion has often occurred by one society luring skilled scientists or workers by payments or other inducement. Trans-cultural marriages between two neighboring or interspersed cultures have also contributed. Among literate societies, diffusion can happen through letters or books (and, in modern times, through other media as well).

In all such cases, the more complex the diffused innovation, the more influence its diffusion process will have on transformation of its propagation environment, as effects induced by its adoption will be all the more increased. Here what expands may be people, but also the number of goods or ideas through cultural transmission or information diffusion. As soon as time passes, farthest places begin to use previously unknown goods or ideas, increasing the distance between the place where the good or idea appeared for the first time, and the place where it is used anew.

The notion of *spatial diffusion thorough time* covers all processes that contribute to moves and to backlash effects generated in this space and that time by those movements. Therefore, the expansive nature of the historical phenomenon should be analyzed as an increase in the spatial distance between social agents resulting from some transformation in social ties (social fission), or a growth in the absolute number of agents. Contraction would be the reverse process; for instance, a decrease in distance between social agents as a result of an increase in social ties (social aggregation, social fusion). It brings about the intrinsic dynamic nature of the phenomenon, which refers to the idea of spatial change in a determined period of time.

Many attempts have been made to model the diffusion dynamics of expansive phenomena in particular by geographers, epidemiologists, demographists and botanists, but also by archaeologists and historians. Early results were obtained using diffusion or difference equation models (reviewed in Okubo & Levin 2001). A variety of other classes of models have subsequently been studied (e.g. individual-based models), showing that rates of expansion can be either linear or accelerating and that movement thorough space and time can be smooth or patchy depending on assumptions about individual movements, demography, adaptation and environmental structure (reviewed in Hasting et al. 2005). Our objective should be then to analyze where, when and why the chronology of the first occurrence of an event "varies from one location to another". In other words:

- how the spatial distribution of the values of some property *depends* (or "has an influence") over the spatial distribution of other(s) value(s) or properties,
- how the temporal displacement of the values of some property *depends* (or "has an influence") over the spatial distribution of other(s) value(s) or properties,
- how the temporal displacement of the values of some property *depends* (or "has an influence") over the temporal displacement of other(s) value(s) or properties,
- how the spatial distribution of the values of some property *depends* (or "has an influence") over the temporal displacement of other(s) value(s) or properties.

In this work, we refer to *expansive phenomena* as dynamical systems such that every location at some well specified underlying space has a distinctive behavior through time. As already stressed in the introduction of this thesis our definition comes from the mathematical concept of *expansivity*, which formalizes the idea of points moving away from one-another under the action of an iterated function.

The intrinsic dynamic nature of an expansive phenomenon refers to the idea of spatial change in a determined period of time. According to working domain, one can consider the following dynamic aspects of expansive phenomena:

- Geometrical changes of features over time (such as military expansions and political frontiers emergence).
- Positional changes of features over time (such as people migration).
- Change of features attribute over time (such as quantity of exchanged goods between connected areas in an Exchange network).
- Any combination of the above changes.

Expansive phenomena can be understood as the evidence of the increase of distance between spatial locations with time. Here we define *distance* as the difference between the values of any property at two (or more) spatio-temporal locations (Gattrell 1983). In our case, an expansion makes reference to objects corresponding to locations on the surface of the Earth (at least conceptually) with defined shortest path relations between all pairings. These are the minimum-cost routes for physical movement or virtual interaction between objects, where cost is interpreted generally. The shortest-path relations determine the measurement and analysis of geographic attributes. There are an infinite number of shortest-path relations that obey the metrics pace conditions of symmetry, non-negativity, and triangular inequality. The goal of analysis would be then to determine a meaningful relationship between difference-in-values (variance in the *quality* of social action) and difference-in-location (variance in spatiotemporal changes). This relationship, if it exists, is essentially a measure of how difference in value changed through time and space. Intuitively we expect any such relationship to show that variance increased as distance increased. In other words, we expect that in an expansive phenomenon, events spatially and temporally close together to have relatively small differences, and those further apart to have relatively large differences. "Everything will be related to everything else, but near things will more related than distant things" (Tobler's law). At greater distances, both in time and in space, as the sample become independent of each other, we expect the variance of the samples to oscillate about some constant value.

When relating the nature of expansive phenomena to Tobler's Law we make emphasis on the idea that over-coming space requires expenditure of energy and re-sources, something that nature and humans try to minimize (although not exclusively, of course). (Miller 2004). Spatio-temporal association does not necessarily imply causality, whereas expansivity really implies causality. Two things that are spatio-temporally associated may be involved in an expansive phenomenon, or there may be other hidden variables that cause the change through space and time. Although correlation is not causality, it provides evidence of causality that can (and should) be assessed in light of theory and/ or other evidence. Similar to spatial autocorrelation, spatio-temporal heterogeneity is not just a parameter drift to be corrected: it is information bearing since it reveals both the intensity and pattern of change.

A stricter evidence for expansive phenomena is interaction *in space* and *time*, or the movement of individuals, material, or information between two geographic locations *at the same time*. Spatio-temporal interaction is closely related to spatial autocorrelation: spatial interaction models are special cases of a general model of spatial autocorrelation. Similar to spatial autocorrelation, advanced techniques for spatio-temporal interaction and location choice modeling should recognize spatio-temporal heterogeneity. These effects result from individuals simplifying spatio-temporal choice problems by clustering or lumping choices together, often based on proximity in space and time.

When a social system *expands* through time, we can foreseen a certain degree of *dependence* between locations, and this dependence, is exactly what gives an appearance of unity to the process. When studying the expansion, what we are looking for are the causes of how the local value of some property has changed from state 0_1 to state 0_2 at two different points P_1 and P_2, and at two different moments of time T_1 and T_2. That means that "expansions" can only be understood in functional terms, that is, according to what changed at each place and at each moment. The change in *value* is also tightly linked with the change in *time* and in *space*. Without change in time it is impossible to imagine qualitative changes, it is an independent variable of the said interaction. There is space only, when the observer does not consider time, that is "dynamics". And we can speak of time as a generalization of changes and modifications in place. A pattern existing at one moment of time is the result of the operation of processes that have differential spatial impacts. The key aspect is here the "*location* of quality changes".

Consequently, when analyzing expansive phenomena we should take into account three supplementary basic spatio-temporal processes:

- A set of active entities produces a set of new entities (appearing passive entities) while consuming another set of components entities (disappearing passive entities). The *production* process is necessary to carry the systemic association between all involved entities and relate their simultaneous appearance and disappearance to the action of producers.

- A first set of entities creates a new set of entities of the same type. Such *reproduction* process is used to link parents and children even if the detailed mechanisms of life transmission remain unknown.

- The *transmission* process occurs when a set of receiver entities (passive) has its attributes modified by some contact with a set of transmitter entities (active). This kind of relationships has obvious applications in epidemiology and communication or may as well be used to model transmission of forces between moving balls over a billiard table.

Expansive phenomena in the social sciences can be described by combining this minimal set of general low-level evolution mechanisms (basic spatio-temporal processes) to define sequences, conjunctions, disjunctions or cycles of events (Claramunt et al. 1997).

Expansive phenomena can be classified into two groups that represent the characteristics of the spatial diffusion: spatially dependent and non-spatially dependent diffusion. In this chapter we are going to analyze the first one.

In the *spatially dependent diffusion* processes, it is assumed that the expansion is spatially continuous from one or several sources. Hence the notion of contagious expansion diffusion*:* where the expanding phenomenon has a source and diffuses outwards into new contiguous areas (Fig. 110).

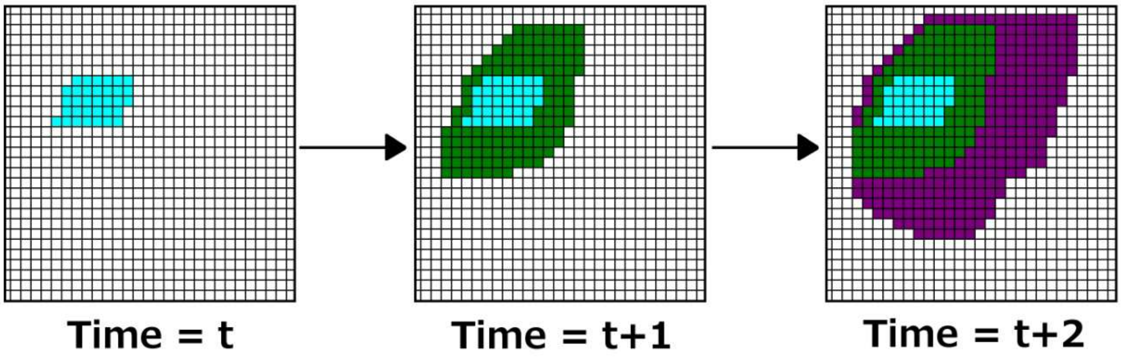

Fig. 110 –Spatio-temporal pattern of contagious expansion diffusion at successive moments of time.

In this framework it is possible a phenomenon of *relocation diffusion*, which implies that previous locations of items are replaced by new locations across time (Fig. 111). It is the case when the diffused element moves into new areas like migration. It could be interpreted as a movement or a travel in space.

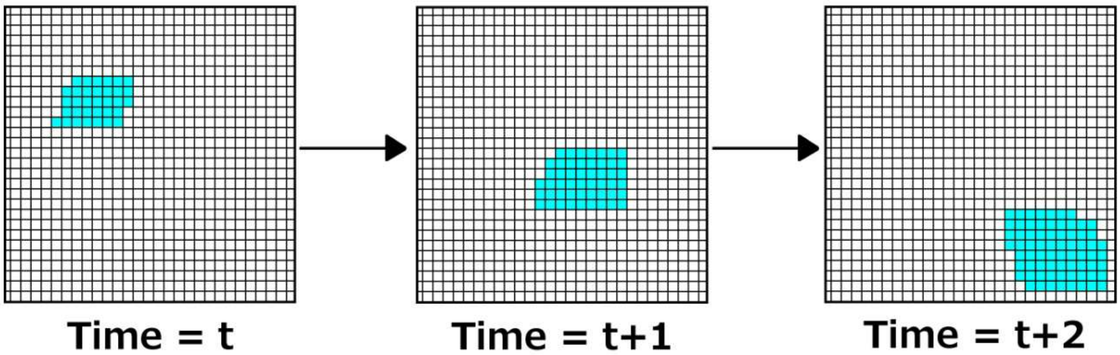

Fig. 111- Spatio-temporal pattern of contagious relocation diffusion at successive moments of time. The feature is moving throughout space.

In those cases, "space" is an active factor of the expansive phenomenon and not a passive container of movements. Its role can be simulated (Fig. 112):

- As an *isotropic plane surface*: space is simply considered as a homogeneous surface with thematic property distribution only ruled by Euclidian geometry (linear plane distance influencing accessibility, proximity and dependency).
- As an *isotropic skewed surface*: space is considered as a heterogeneous surface with each location influencing differently the distribution of thematic properties as well as the proximity and the accessibility. Space is modeled as a skewed

surface expressing an individual “isotropic friction rate” at each location. Distance is therefore no longer linear but symmetrical.

- As an *anisotropic skewed surface*: space is considered as a heterogeneous surface but with an individual “anisotropic friction rate” at each location. Distance is therefore no longer linear nor symmetrical.

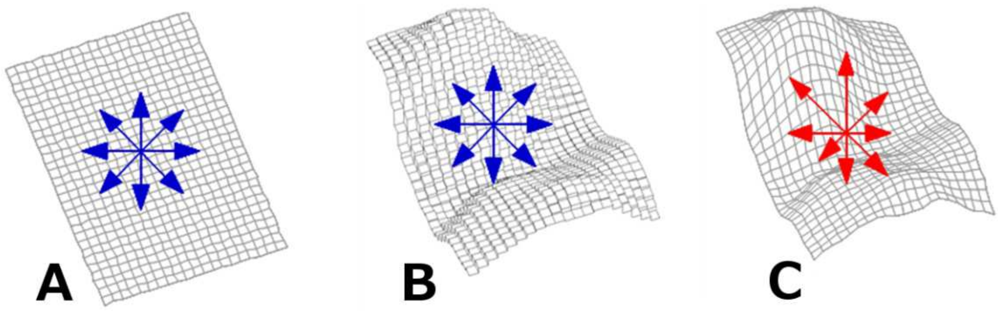

Fig. 112 – Three major levels of a model of space: *isotropic plane surface* (A), *isotropic skewed surface* (B) and *anisotropic skewed surface* (C).

To fully characterize *spatially dependent diffusion* processes, one should introduce a concept that characterizes the specific influence of locations in the diffusion process. In reality, space is analyzed as an environment with heterogeneous properties with respect to movement. Each place retains or favors a variable rate of movement with moving features. The concept of *friction* encompasses the overall specific properties of each location that influence the speed and the intensity of the diffusion process. *Friction* is considered as a barrier to the expansion process. Obviously, at each location and for each moment during the diffusion process, the permeability level of a barrier can vary:

- Absorbing barriers completely block a pulse of change or movement.
- Reflecting barriers will redirect the energy of diffusion toward different directions, such as a water body, for the expansion of a city.
- Permeable barriers absorb part of the energy but allow the rest to go through. Its effects will slow down the process in its local area of influence.

Local factors that usually act as barriers to the diffusion process may be of three types:

- Physical barriers that block or slow down the diffusion. They are physical properties of space such as the topography or the land cover. In this case we talk of the so called *frictions of space,* which refers to specific properties at any location in space whose effect can either slow down a movement or also increase the speed. In fact in Protohistoric Europe some physical barriers, like for instance rivers were not barriers but, on the contrary, they were frequently responsible for an increase in the rate of expansion.

- Cultural barriers can influence the diffusion of an innovation that spreads from individual acceptance. Linguistic, religious and political factors are typical cultural barriers to diffusion.

- Psychological barriers can be important for innovations involving individual acceptance in the process of diffusion. In this situation, individuals act as carriers in the diffusion process.

The starting point of our research, whose results are presented in this chapter, is a data structure consisting of a set of locations (s_1, s_2, etc.) in a defined 'study region', From the Ebro to the Danube Rivers, where a distinctive event (adoption of innovation) occurred at different moments of time. The purpose is to model the spatial trend linking differences in time for the adoption of the cremation burials, vases with handles with vertical expansion and fluted pottery. The theory about expansive phenomena over an isotropic space is exteded (Ammerman & Cavalli-Sforza 1984; Cavalli-Sforza et al. 2002; Gkiasta et al. 2003; Fort et al. 2004; Russell 2004; Pinhasi et al. 2005; Dolukhanovet al. 2005; Bocquet-Appel et al. 2009; Isern et al. 2012; Isern et al. 2014).
The most widespread model adopted in order to model expansive phenomena is the so called "wave of advance model" which assumed a logistic population growth and a random migratory movement to describe people movement over space and across time.
The two assumptions are included in the Fisher model (Fisher 1937), which was first created for describing the diffusion of some advantageous genes. The result was the developing of the already mentioned reaction-diffusion equation:

$$\frac{d\rho}{dt} = D\left(\frac{d^2\rho}{dx^2} + \frac{d^2\rho}{dy^2}\right) + a\rho\left(1 - \frac{\rho}{\rho_{max}}\right)$$

Variation of the population density over time

Diffusion $D = \frac{\langle\Delta^2\rangle}{4T}$

Reaction: logistic growth

Through the introduction of a time-delayed model such an equation has been recently improved for the description of expansive phenomena which took place in sedentary societies (Fort & Méndez 1999; Isern et al. 2012; Isern et al. 2014), see chapter 1.2. The introduction of a time-delayed reaction-diffusion equation implied a slower front speed in the wave of advance, due to the effects of the time delay.

The basic assumption for the identification of expansive phenomena is represented by the detection of a gradient of a scalar field. We use scalar fields to represent a geometric structure in which a scalar value is a single component that can assume one of a range of values. Therefore, a scalar field is a name we give to a function which takes in points in a two or three dimensional space (R^2 or R^3) and outputs real numbers. The gradient represents the rate of change of a function, which can be mathematically expressed by the derivative of a function of a real variable. It follows two major rules:

- Points in the direction of greatest increase
- Assumes 0 value at a local maximum or local minimum, due to the absence of increase

In our research we deal with space-time gradient. Identifying a variation in space, defined by geographic coordinates *x*, *y* and in time, measured by medians of calibrated ^{14}C dates for the adoption of cremation burials, pottery with handles with vertical expansion and fluted pottery allow to infer the existence of an expansive phenomenon for the analyzed variable. The gradient at any location points in the direction of greatest increase of a function, which, in our case, measures the temporal variability defined by radiocarbon estimates. Therefore, the gradient tells us which direction we need to move moved to reach a location where the variable (cremation burials, handles with vertical expansion and fluted pottery) appears with a more recent chronology. It is meaningful to highlight that the gradient does not give information about the geographic coordinates of the movement; it gives us the direction to move to find contexts where the adoption of innovation phenomenon took place later.

9.2 Modeling the first occurrence of cremation burials between 1800 and 800 BC in Protohistoric Europe

The purpose of this paragraph is to model the spatial trend linking differences in time for the adoption of the new burial practice of cremation during the Bronze Age. If such a function can be calculated, then by using observations of archaeological chronologies made at some locations, we will estimate the chronology of archaeological evidence at neighbor locations and the probabilities that a the new burial practice was adopted at some place at a specific time.

For a better comprehension of the phenomenon analyzed data originates from the EUBAR database and includes also ^{14}C-dated cremation burials from neighboring territories of Central Spain, Central France, Belgium, Central Germany and Czech Republic (Fig. 119).

Our preliminary results show that the first occurrence of a cremation burial is spatially auto-correlated because estimated chronologies at a distinct location are associated with the chronology of the same phenomenon at neighboring points. Dividing the hypothetical 2,354 km between the extremes of our study area into 20 intervals (117.7 km each), Moran's I index has positive values for neighboring cemeteries, and in most cases, negative values when distance increase. That means that chronology is spatially dependent at lower distances, and in some cases, at higher distances, such dependency is not easily detectable. The adoption of the new funerary ritual was then clearly not stationary because the intensity of chronological differences appears to be non-constant over the considered geographic space. Although more analyses are needed, we suggest that second-order intensity seems to be dependent on the vector difference, d (direction and distance), between spatial locations and not on their absolute locations, what makes reference to minimum-cost routes for physical movement or virtual interaction between social agents, where cost is interpreted generally. The expansion pattern is then much more complex than expected under a basic demic diffusion hypothesis.

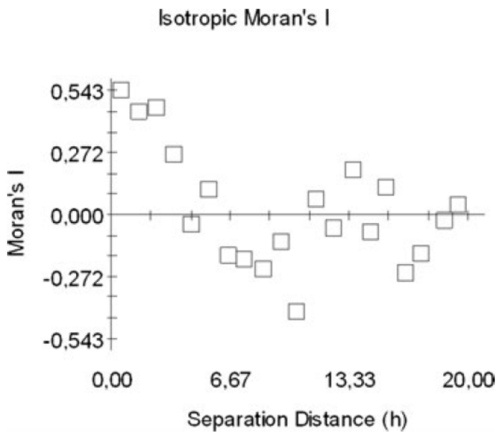

Fig. 113 – Spatial Autocorrelation results (Morans'I). Calculated using the GS+program (Gamma Design, Inc. http://www.gammadesign.com/).

In archaeology, it is usual to compute linear regression analysis between chronological estimates to describe the spatial directionality of the expansive process. A site is designated as the origin and its distance from each of the other sites computed; thereafter, the correlation between the distances and the ages of the other sites is measured. This procedure is repeated until all the sites have served as the origin. The final step of the method involves comparing the correlation coefficients. The site that yields the highest negative correlation coefficient when it is designated the origin is deemed to be the most likely center of origin (cf. for instance, Ammerman & Cavalli-Sforza 1984; Pinhasi et al. 2005; Hamilton & Buchanan 2007; Steele 2010; Buchanan et al. 2011; Collard et al. 2010a). However, our preliminary results show that the social space of Late Bronze Age was hardly uniform and boundless, because every spatial location had some degree of uniqueness relative to the other locations. This affects the spatial dependency relations and therefore the spatial process. Spatial heterogeneity means that overall parameters estimated for the entire system may not adequately describe the process at any given location. It is important to take into account that part of this irregularity and spatial heterogeneity is not a characteristic of the historical expansive phenomenon but to possible errors selecting the proper radiocarbon date for the "oldest" cremation burial in an area.

To be able to create an interpolated map of chronological estimates taking into account the non-stationarity and irregularity of the phenomenon under study we have calculated the semivariance of the adoption of the new burial practice of cremation from Danube to the Ebro valleys. We have used a kriging algorithm, without any edge interpolation to predict the value of the chronology across space according to a spatial lag relationship that has both systematic and random components. Kriging is based on the idea that the value at an unknown point should be the average of the known values at its neighbors; weighted by the neighbors' distance to the unknown point (Cressie 1993; Stein 1999; de Smith al. 2009; Mitchell 2009).

An important feature of kriging-based interpolation methods is that they rely on the semivariance among data. Semivariance is a property of a spatial distribution of values expressing the degree of relationship between locations. The semivariance is simply half the variance of the differences between all possible points spaced a constant distance apart. The semivariance at a distance d=0 will be zero, because there are no chronological differences between spatial locations that are compared with themselves. However, as cemeteries are compared with increasingly distant points, the semivariance of their chronology increases. At some distance, called the Range, the semivariance will become approximately equal to the variance of the whole spatial distribution itself. This is the greatest distance over which the chronology of a cremation burial is related to the chronology at another burial more distant. The range defines the maximum neighborhood over which control points should be selected to estimate a grid node, to take advantage of the statistical correlation among the observations. A plot of semivariances versus distances between ordered data in a graph is known as a semivariogram (Fig. 114). A variogram is usually characterized by three measures. The nugget refers to the variability in the field data that cannot be explained by distance between the observations.

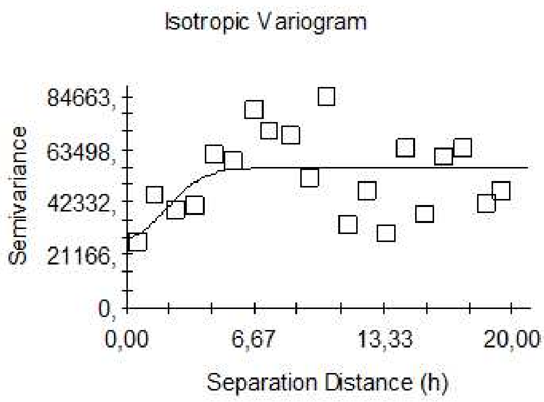

Fig. 114 - Second-order representation of radiocarbon dates for the Second Millennium first occurrence of cremation (Semivariogram). Calculated using the GS+program (Gamma Design, Inc. http://www.gammadesign.com/).

Many factors influence the magnitude of the nugget including imprecision in sampling techniques and underlying variability of the attribute that is being measured. In addition, the minimum spacing between observations can influence the nugget because if there are no observations located close to each other, it is impossible to estimate “close-range” spatial dependence. The sill refers to the maximum observed variability in the data. In theory, the sill corresponds to the variance of the data as normally estimated in statistics. The distance where the model first flattens out is known as the range; it is just the difference between the sill and the nugget, and represents the amount of observed variation that can be explained by distance between observations. Sample locations separated by distances closer than the range are spatially autocorrelated, whereas locations farther apart than the range are not. Our data show a small nugget and a large sill; the nugget effect disappears after lag 5, that means, an average distance of 885 km between cemeteries. Chronologies have much spatial dependence within such an area. Where spatial autocorrelation is present, semivariance is lower at smaller separation distances (autocorrelation is greater). This typically yields a curve like the one in Fig. 114.

We have interpolated the chronology at unknown spatial locations based on what we know from some locations (the list of georeferenced 57 radiocarbon estimates, Fig. 119), and the way they are related according to the previous semivariance (Fig. 114).

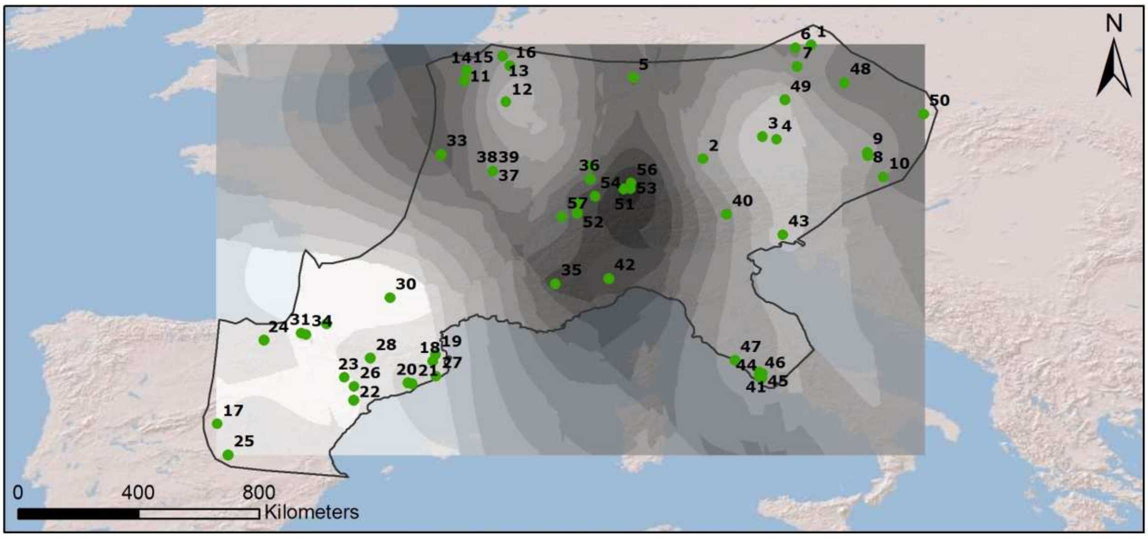

Fig. 115 - Visualizing spatial and temporal variations in the first occurrence of 2nd millennium cremation (medians of the calibrated radiocarbon dates). (Software: ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute). The numbers correspond to the ID numbers of the dataset at Fig. 119. Contours represent differences of 50 years.

We may infer the “expansive” nature of the historical phenomenon because a regular trend in the spatial probabilities of the first occurrence of cremation burials can be detected. The model allows identifying at what spatial locations a change in the estimated temporality of the archaeological event leads to a change in the probability of its causing action or process.

The obtained results suggest an expansion to explain the adoption of cremation burial practices during the second millennium BC. Radiocarbon estimates interpolation shows that oldest cremation burials should be located in the Western Alpine regions between Southern Switzerland and North-Western Italy (regions of Piedmont and Aosta Valley). In such an area the phenomenon took place around 1400 BC. It is meaningful to remember that the archaeological group Rhin-Suisse-France oriental (RSFO) is attested in those territories during the LBA. Its role in the spread of cremation burials was already suggested in chapter 3.3. From this region the phenomenon would have expanded to North, East, South and South-West. Western France, Northeastern Iberian Peninsula and Central Italy appear to be areas where the transformation took place nearly 500 years later, including also the possible adoption of cremations without urn. Regarding the adoption of cremation burial in the North-East of Iberian Peninsula we can detect two different patterns. The first one along the Mediterranean façade, where oldest cremation burials are placed close to the coast, hence it could indicate a possible maritime penetration as already argued by Rovira (Rovira i Port 1991). From this area the phenomenon would have expanded to the inner territories along the Ebro Valley. The second pattern is located in the Atlantic façade, where the adoption of cremation took place slightly later in time. These differences are in agreement with archaeological data which refers of an Atlantic Bronze Age culture, where cremation burials were mainly attested under cromlech structures and a Catalan Mediterranean facade where cremation burials were mainly in urn and characterized by strong influences from the Trans-Pyrenean region of Languedoc-Roussillon (see chapters 2.4, 2.5 and 3.3).

Nevertheless, instead of taking the map shown in Fig. 115 as a reliable “picture” of the expansive phenomenon in the 2nd half of the 2nd millennium BC, we should validate it. We need to have some idea of how well the model predicts the chronology of the first adoption of the new burial practice at unknown locations. For all points, cross-validation compares the measured and predicted values and plots a scatter plot of predicted values versus true values is given (Fig. 116).

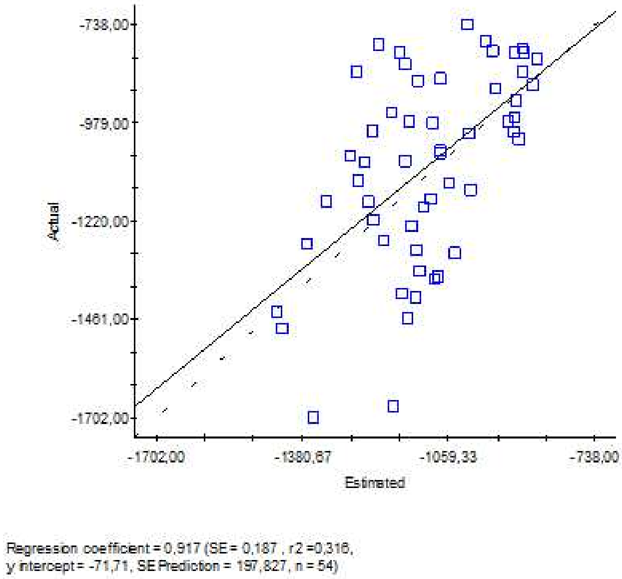

Fig. 116 - Cross-validating kriging chronological estimates at unknown spatial locations. Calculated using the GS+program (Gamma Design, Inc. http://www.gammadesign.com/).

Each point on the cross-validation graph represents a location in the input data set for which an actual and estimated value are available. The regression coefficient described at the bottom of the graph represents a measure of the goodness of fit for the least-squares model describing the linear regression equation. A nearly perfect fit has been obtained (0.917) and the best-fit line (the solid line in the graph above) coincides with the dotted 45° line on the graph. The standard error (SE=0.187, above) refers to the standard error of the regression coefficient; the r2 value is the proportion of variation explained by the best-fit line (in this case 31.6 %; it is the square of the correlation coefficient); and the y-intercept of the best-fit line is also provided. We can conclude that the model fits conveniently available data.

Our statistical results show that the expansive nature of the adoption of a new ritual during Late Bronze Age in Western Europe has a distinctive spatial gradient, which is characteristic both of demic diffusion and cultural transmission hypotheses. We can lead the analysis further by detecting significant chronological changes between neighboring cemeteries, suggesting the idea of non-stationarity, heterogeneity, and irregularity in the expansion. Hoffman and Richards (1984) have proposed that a good rule of thumb is to divide the data array into components at maximal concavities, which mathematically speaking, are the local minima of curvature. Formally, such a discontinuity in the spatial probabilities of the first occurrence of the studied event is defined as an observable edge in the first derivative of the mathematical function that describes the archaeological frequencies over space. This task can be approached by calculating the spatial gradient in the data array - that is, the direction of maximum rate of change of the perceived size of the dependent values, and a scalar measurement of this rate (Sonka et al. 1994; Palmer 1999; de Smith al. 2009). The spatial gradient associated with the first occurrence of cremation burial describes the modification of the density and the size of archaeologically measured values and so regularity patterns in spatial variation can be determined. It is calculated by finding the position of maximum slope in its intensity function (a graph of the value of time of first occurrence as a function of space). Thus, the intensity profile of spatial frequencies can be graphed as a curve in which the x-axis is the spatial dimension and the y-axis corresponds to time. Likewise, the directivity of such a probability gradient (or "aspect" of the scalar field) is simply the polar angle described by the two orthogonal partial derivatives.

We have calculated a gradient map showing the estimated direction of chronological changes (from locations with high chronologies to nearby locations with low chronologies) with arrow lines, which show the apparent nature of expansivity in the studied phenomenon (Fig. 117). The approach is based on the calculation of partial derivatives (or related functions) between the differences in chronology among locations at different distances to estimate "movement." In this case, it seems well attested the existence of some neighborhood effect (or contagious effect): the farthest a cremation burial has been discovered from the locations with highest chronologies, the lowest the chronology of the first adoption of the new burial practice. Interactions seem to be more frequent on nearest neighbors. As such, as time passes, the innovation potential gradually diffuses spatially.

To sum up, to the question "Was the first occurrence of cremation the result of an expansive process?" we should stress that our results from the carried analysis seem to suggest a positive answer. Was this "expansion" the consequence of demic expansion (people movements)? Our results give for the moment no conclusive answer. We postulate a statistically significant trend for early Urnfield sites to become younger with distance from the oldest ones somewhere in Northwestern Alps. The presence of a clear spatial gradient in initial dates of the first adoption of cremation burials in the southern part of our study area indicates that the phenomenon can be tentatively explained as an expansion. It was, by implication, fast. It is also an implication that the wave speed was determined more by unusually high exploratory mobility than by exceptionally rapid reproductive increase (i.e., there was a no evident population growth during the period). If we could assume that movement (of people, ideas, and/or goods) was equally likely in all directions and served to achieve uniform densities, regardless of local variation, we would conclude an average expansion speed of 0.6-1 km/ year (values calculated using a standard Fisher-KPP model), what is coherent in similar historical and geographical scenarios (Zimmermann et al. 2009).

Fig. 117 - Map showing the directivity of the 2nd millennium cremation adoption phenomenon (Software: Rockworks 16, Rockware, Inc.). The map contains small arrows at each grid node pointing down the gradient, that is, decrease in chronology: from places where cremations were older to places where such phenomenon appears to be more recent.

Eventually, we decided to test our model adding information retrieved from typologically dated cremation burials. In particular we choose to include data from those regions where the presence of radiocarbon dated cremation burials was lacking, like Southern France and Northern Italy (Fig. 120). Among the available contexts we chose for each region the first occurrence of cremation burials in the 2nd millennium BC. As a result we retained for the analysis 12 archaeological sites from Northern Italy typologically dated to *BM1*, *BM2*, *BM3* and *BR1* conventional phases; 10 sites from Southern France stylistically dated to phase *BF1*, *BF2a* and *BF3b*; and a date from South-Eastern Austria referring to a *BzD* cremation burial.

Due to the statistical nature of kriging interpolation we need to use a single value in order to represent each known point, therefore we took into account the medians of the 2σ calibrated probability intervals obtained for each conventional phase through the Bayesian modeling with OxCal 4.2, as explained in chapter 6.

The new interpolated model based both on ^{14}C-dated and typologically dated cremation burials for the Bronze Age included finally 80 different contexts (Fig. 118).

The results confirmed the existence of an expansive phenomenon for the spread of cremation burials. The area where the new rite appeared first would be located over a wide region including Northern Italy (the Po Valley) and Southern Switzerland. Future radiocarbon dates from North Italian funerary contexts where cremation rite is attested could strengthen the model, rejecting problems caused by the typological description of material culture.

Regarding Southern France typologically dated cremation burials introduced in the model are in good agreement with the east to west space-time diffusion pattern already detected in these regions.

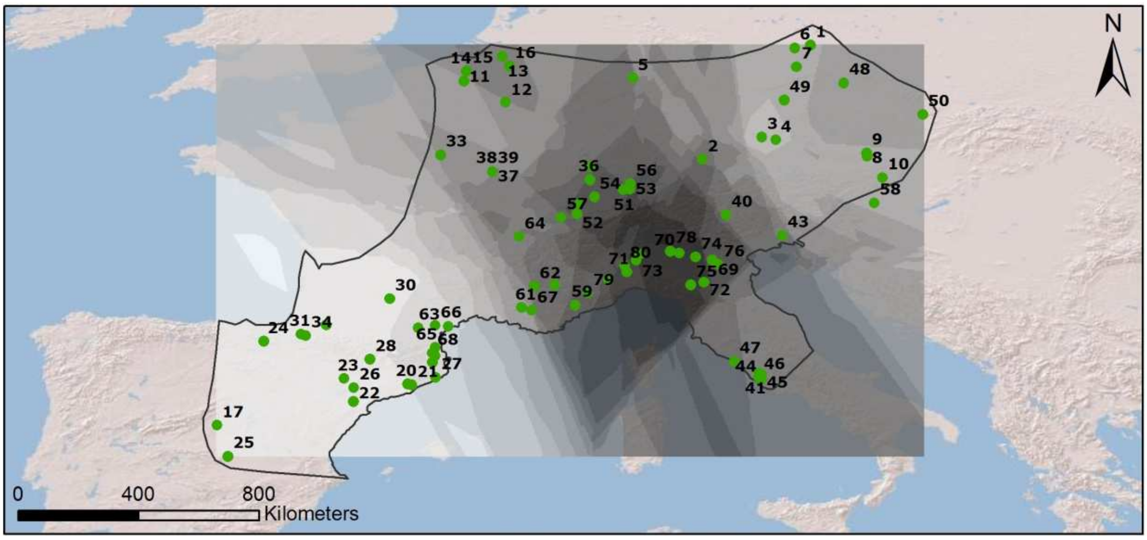

Fig. 118 - Visualizing spatial and temporal variations in the first occurrence ^{14}C and typologically dated cremation burials (medians of the calibrated radiocarbon dates and medians of conventional phases obtained from the Bayesian modeling). (Software: ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute). The numbers correspond to the ID numbers of the datasets at Fig. 119 and 120. Contours represent differences of 50 years.

ID	Site	Latitude	Longitude	Lab code	^{14}C Age BP	±σ	Median	Material and archaeological context
1	Altdöbern	51,652821	14,030812	Bln-3346	2690	50	-853	Unknown; grave 8
2	Hexenbergle	48,254602	10,806353	UZ-3556	2790	70	-953	Wood; burial mound 8
3	Kagers	48,916667	12,583329	BM-2991	2720	45	-870	Animal bone; grave 48
4	Künzing-Ost	48,833318	12,999994	BM-3027	2840	50	-1005	Animal bone; grave 220
5	Mainzlar	50,666667	8,733333	GrA-16041	3090	60	-1354	Human bone; burial mound 9
6	Rückersdorf	51,569941	13,565511	KIA-15666	3085	25	-1362	Charcoal; grave 16
7	Saalhausen 2	51,010465	13,615372	Not identified	3030	50	-1292	Unknown; grave 104
8	Franzhausen, S33 Kokoron	48,348096	15,722398	VERA-732	2931	50	-1143	Charcoal; *Pinus sp.* , grave 65
9	Hadersdorf	48,450135	15,716826	VERA-2069	2661	57	-833	Animal bone; grave 88
10	Pitten	47,712568	16,187493	VRI-93	3050	90	-1296	Charcoal; remains of the pyre, area 372
11	Blicquy	50,588374	3,684901	KIA-23752	3185	30	-1459	Human bone; grave F129
12	Louette Saint-Pierre	49,962117	4,927314	KIA-25593	2580	25	-785	Human bone; tumulus
13	Mezenstraat, Beerse	51,319233	4,836568	KIA-33613	2945	30	-1165	Human bone; at -63 cm from the surface
14	Paddestraat	50,872932	3,760283	KIA-20064	2920	30	-1119	Human bone; grave 18
15	Provinciebann	50,886047	3,770817	KIA-23751	2950	30	-1172	Human bone; grave 12
16	Tessenderlo	51,030555	5,047222	KIA-33615	2825	25	-976	Human bone; grave 43
17	Arroyo Butarque	40,338245	-3,681337	Beta-197521	2590	40	-781	Human bone; pit 1
18	Can Barraca	42,208637	2,748324	Beta-216833	2620	40	-801	Charcoal; grave 7, inside the urn
19	Can Bech de Baix	42,405218	2,827987	CSIC-242	2770	60	-923	Crystallized resin; grave 389, urn 15 of the C.4
20	Can Missert	41,56638	2,012233	KIA-35577	2815	30	-966	Human bone; urn 3581, Museo Episcopal de Vic
21	Can Piteu-Can Roqueta	41,53665	2,13832	KIA-24835	2755	30	-894	Human bone; urn 294-34B
22	Coll de Moro	41,0534	0,390811	GrA-23646	2630	50	-807	Human bone; tumulus, grave T42
23	La Codera	41,72466	0,110283	GrN-26966	2610	40	-795	Unknown; tumulus 6
24	Mendiluce	42,83974	-2,286687	CSIC-694	2700	60	-865	Charcoal; cromlech
25	Palomar de Pintado	39,417068	-3,361345	Beta-178469	2820	40	-975	Human bone; grave 76, inside the urn
26	Pedrós	41,458347	0,407092	OxA-13565	2657	37	-821	Charcoal; tumulus
27	Pi de la Lliura	41,763779	2,852027	Beta-136241	2850	40	-1016	Charcoal; urn E-15
28	Turó de la Capsera	42,304263	0,883157	UBAR-667	2835	55	-1000	Charcoal; tumulus 20, SU 2015
29	Cami Salié	43,316626	-0,416666	Ly-2242	2650	140	-807	Charcoal; tumulus 1, with urn
30	Camp d'Alba	44,109096	1,477133	Ly-7433	2575	50	-738	Charcoal; grave 79
31	Errotzaté 2	43,045831	-1,170259	Gif-3741	2680	100	-854	Charcoal; cromlech
32	Kastenwald	48,033326	7,450001	Ly-2054	2800	130	-998	Charcoal; tumulus 5, grave 5
33	La Croix de la Mission	48,385384	2,996810	GrA-17937	3130	50	-1407	Human bone; Str. 48, double cremation in urn
34	Millagate 5	43,009916	-1,030808	Gif-7559	2730	60	-885	Charcoal; mound-cromlech
35	Savines-le-Lac	44,525571	6,404869	Poz-25712	3115	30	-1397	Unknown; SU 102, grave
36	Sierentz	47,654520	7,454682	Ly-4208	2990	100	-1218	Charchoal; pit with cremation
37	Tumulus 2 de Vix	47,898687	4,537880	Ly-1431	2890	35	-1076	Human bone; tumulus 2, grave 1
38	Tumulus 6 de Vix	47,898687	4,537880	Ly-665	2685	40	-843	Human bone; tumulus 6, central grave
39	Tumulus de Chaume-lès-Baigneux	47,898687	4,537880	Lyon-1610	2985	55	-1222	Human bone; central grave
40	Ex Casa di Ricovero	46,603234	11,520332	ETH-25266	2960	45	-1185	Charcoal; individual burial in a pit
41	Foro di Cesare	41,894181	12,486691	Gra-16432	2920	60	-1126	Unknown; grave 1
42	L'Oasi	44,686034	8,006393	OZE-029	3012	47	-1267	Human bone; individual burial in a pit
43	Pozzuolo	45,988092	13,195239	UD-58	2700	100	-877	Charcoaal; grave 2
44	Roma, Quadrato	41,845227	12,586879	GrA-16423	2820	50	-979	Unknown; grave 2
45	S. Palomba	41,707568	12,576605	GrA-27028	2875	35	-1053	Unknown; grave 1
46	Trigoria	41,766800	12,479306	GrA-27025	2870	35	-1045	Unknown; grave 3
47	Villa Bruschi Falgari	42,240853	11,759284	GrA-23484	2885	45	-1072	Human bone; grave 103
48	Chodouny	50,533330	15,033328	P-1902	3080	60	-1343	Charcoal; grave 7
49	Manětín, Hrádek	50,016659	13,249995	P-1913	2630	60	-806	Charcoal; grave 164
50	Přáslavice, Dily pod dědinou	49,588368	17,392728	VERA-?	2990	40	-1232	Charcoal; grave 14, adultus individual in urn
51	Birmensdorf-Rameren	47,362281	8,446312	ETH-28490	3210	50	-1482	Charcoal; tumulus, grave 9
52	Bulle FR, Le Terraillet	46,631112	7,061908	Ua-24629	2950	40	-1171	Charcoal; tumulus
53	Fällanden-Fröschbach	47,369438	8,644476	UZ-3910	3400	60	-1702	Charcoal; grave 12, among the calcined bones
54	Koppigen, Usserfeld	47,135554	7,586912	ETH-26775/UZ-4914	3020	55	-1276	Charcoal; grave 1, individual burial in a pit
55	Murten-Löwenberg	46,938616	7,141140	B-4994	3380	50	-1674	Charcoal; tumulus 3, grave 11N.3
56	Neftenbach II (Zürichstrasse 55)	47,525379	8,660720	KIA-11173	3165	32	-1443	Charcoal; grave 8, sample 81
57	Vidy (Lausanne VD)	46,521682	6,594960	CRG-655	2870	70	-1058	Unknown; grave 2

Fig. 119 – First occurrences of ^{14}C-dated cremation burials in the 2nd and at the beginning of the 1st millennium BC in Europe.

ID	Site	Country	Latitude	Longitude	Phase	References
58	Lödersdorf	Austria	46,958486	15,946654	BzD	Jilg 2007; Lippert 2013
59	Ascros	France	43,919877	7,011786	BF2a	Lagrand 1968; Vital 1994; Lachenal 2007
60	Bel-Air	France	43,276623	3,224992	BF3b	Mazière et al. 2012
61	Buoux/Salen	France	43,83853	5,404909	BF2a	Muller et al. 1987; Vital 1990; Muller 2002
62	Champ-Crose	France	44,478243	5,782369	BF1	Vital 1990
63	Christol I	France	43,237647	2,322251	BF3b	Michel & Ropiot 2012
64	Grotte du Gardon	France	45,949996	5,333327	BF2a	Vital 1990
65	Las Canals	France	42,655079	2,826318	BF3b	Mazière 2012
66	Le Moulin/Grand Bassin I et II	France	43,306055	2,829317	BF3b	Taffanel et al. 1998, Mazière 2012
67	Nice/Youri	France	43,747923	5,714551	BF2a	Arnaud et al. 1987; Vital 1990
68	Vilanova	France	42,485235	2,739221	BF3b	Mazière 2012; Claustre 2013
69	Bovolone-Castello	Italy	45,253888	11,115000	BM3	Peroni 1963; Salzani 1985
70	Capriano del Colle	Italy	45,455870	10,122396	BM3	Simone Zompfi 2005b
71	Cascina Chiappona	Italy	44,895878	8,554203	BM2-3	Venturino Gambari et al. 1995; Gambari & Venturino Gambari 1998
72	Casinalbo	Italy	44,592570	10,852510	BM2	Cardarelli 1997; Cardarelli et al. 2003; Cardarelli & Pellacani 2004; Cardarelli et al. 2006
73	Gambolò	Italy	45,258895	8,845173	BM3	Simone 1990-1991
74	Madonna della Pieve	Italy	45,345000	10,604555	BM3	Zorzi 1960a
75	Montata	Italy	44,518489	10,455394	BM2	Tirabassi 1997; Cardarelli et al. 2003
76	Scalvinetto	Italy	45,122903	11,285105	BM3	Salzani 1994b; Salzani 2004
77	Scamozzina	Italy	45,428782	8,940760	BM2-3	Vannacci Lunazzi 1971
78	Urano d'Oglio	Italy	45,526120	9,853764	BM3	Simone Zompfi 2005a
79	Valdieri	Italy	44,275191	7,394849	BR1	Venturino Gambari 2008; Gambari & Venturino Gambari 2012
80	Vallare	Italy	45,084092	8,486410	BM1	Venturino Gambari & Villa 1993; Gambari & Venturino Gambari 1998

Fig. 120 – First occurrences of typologically dated cremation burials in the 2nd millennium BC. We have considered data from Southern France, Northern Italy and Southern Austria.

9.3 Modeling the first occurrence of vases with handles with vertical expansion between 1800 and 800 BC and from the Danube to the Ebro River

The introduction of vases with handles with vertical expansion is a clear phenomenon of innovation which took place in the 2nd millennium BC.

In chapter 5.3.2.1 we highlighted that the spatial distribution of such a variable includes a wide area which embraces Northern Italy, part of Switzerland, Southern France and the North-East of Iberian Peninsula. In chapter 8.4.2 and 8.6 we detected that on a macro scale the temporal probability distribution of such a pottery typology between 1800 and 800 BC does not follow a logistic growth, which implies that the number of adopters did not constantly increase in the analyzed time span. Nevertheless, in spite of the absence of a constant growth on a macro scale, adopting a regional perspective we were able recognize the existence of differences in time in different territories, as shown in the regional SCPDs (Fig. 89). Such result suggested the possibility of an expansive process for explaining the diffusion over a large area of such a pottery typology; therefore we decided to test such a hypothesis.

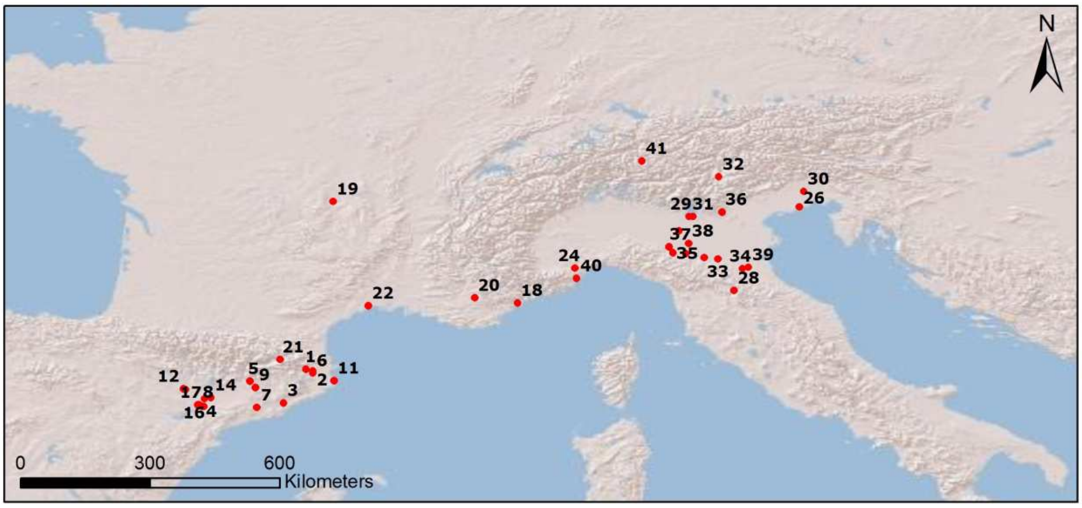

Fig. 85 – ^{14}C-dated contexts included in the EUBAR database and characterized by the presence of vases with handles with vertical expansion. The numbers correspond to: Bauma del Serrat del Pont (1),Can Barraca (2), Can Roqueta II (3), Carretelà (4), Clará (5), Cova d'en Pau (6), Cova de la Guineu (7), Cova de Punta Farisa (8), Dolmen de la Pera d'Ardèvol (9), Genó (10), La Fonollera (11), La Torraza I (12), Masada de Ratón (13), Roques del Sarró (14), Tozal de Macarullo (15), Vilot de Montagut (16), Vincamet (17), Aven de la Mort de Lambert (18), Cournon d'Auvergne (19), Grotte Murée (20), Llo-Lladre (21), Port-Ariane III (22), Anzola (23), Bric Tana (24), Ca' Manzini (25), Caorle-San Gaetano (26), Castellaro del Vhò (27), Dicomano (28), Frassino I (29), Gradiscje di Codroipo (30), Lavagnone (31), Magrè-Tolerait (32), Montale (33), Monte Castellaccio (34), Monte Leoni (35), Monte Madarosa (36), Noceto-vasca votiva (37), Santa Rosa di Poviglio-Villaggio Piccolo (38), Solarolo-via Ordiere (39), Villaggio di Castellari (40), Padnal de Savognin (41).

The first step was to select the first occurrence of the variable in homogenous spatial units. Therefore we made a selection among ^{14}C-dated archaeological contexts included in the EUBAR database where vases with handle with vertical expansion were recovered (Fig. 85).

From this dataset we retained for the analysis only oldest dates per region that originated from sample in a reliable association with the studied feature.

Then, using this discrete set of known points we interpolated our data using a kriging algorithm in order to produce a new map characterized by new data points for areas in which our data was lacking (Fig. 121). Additionaly, we have calculated a gradient map showing the estimated direction of chronological changes (from locations with high chronologies to nearby locations with low chronologies) with arrow lines (Fig. 122). The map suggests the apparent nature of expansivity in the studied phenomenon.

The obtained result allows inferring the "expansive" nature of the adoption of vases with handles with vertical expansion. A regular space-time gradient in the probabilities of the first occurrence of cremation burials can be detected. Regarding the directivity of the phenomenon we cannot detect a unique pattern from the Ebro to the Danube River. Interpolated dates suggest that older handles with vertical expansion should be located in North-Western Italy, in particular in a region including the Middle Po Valley. This result is not surprising since the origin of such a pottery typology has been traditionally placed in that area during the so called *Polada culture*; a material culture whose most relevant evidences are attested in Eastern Lombardy, Trentino, Western Veneto and neighbor areas during the Early Bronze Age (Peroni 1996; Almagro Gorbea 1997; Espejo Blanco 2001-2002; Bietti Sestieri 2010). The same chronology for the adoption of this innovation was detected also in neighboring region, as confirmed by the date from the sample collected in the site of Padnal de Savognin in Southern Switzerland and in the Ligurian coast. As expected our data follows the Tobler's law.

From Northern Italy handles with vertical expansion would have diffused both to the eastern and western territories.

Regarding the introduction of vases with handles with vertical expansion in the North-East of Iberian Peninsula analyzed data shows that oldest contexts are located in inner territories between the provinces of Lleida and Huesca, in the so called Segre-Cinca area from the names of the main rivers which cross such a region. On the contrary, the Catalan coast is characterized by more recent ^{14}C-dated archaeological contexts were this pottery typology was recovered. Such a result would suggest that the penetration took place through Trans-Pyrenean movements and not along the Mediterranean coast.

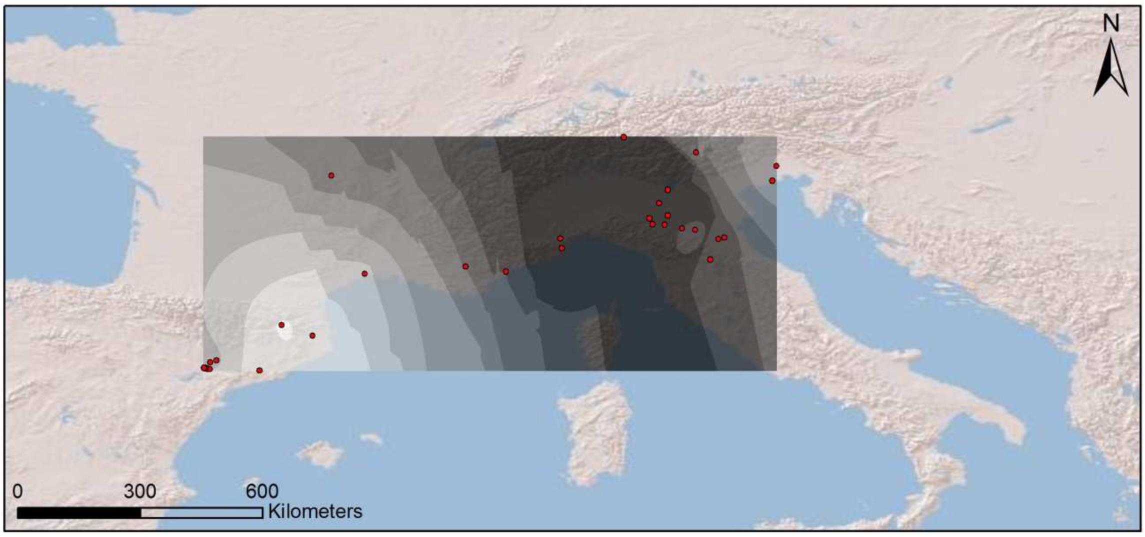

Fig. 121 – Visualizing spatial and temporal variations in the first occurrence of contexts characterized by the presence of handles with vertical expansion included in the EUBAR database (medians of the calibrated radiocarbon dates). (Software: ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute). Contours represent differences of 50 years.

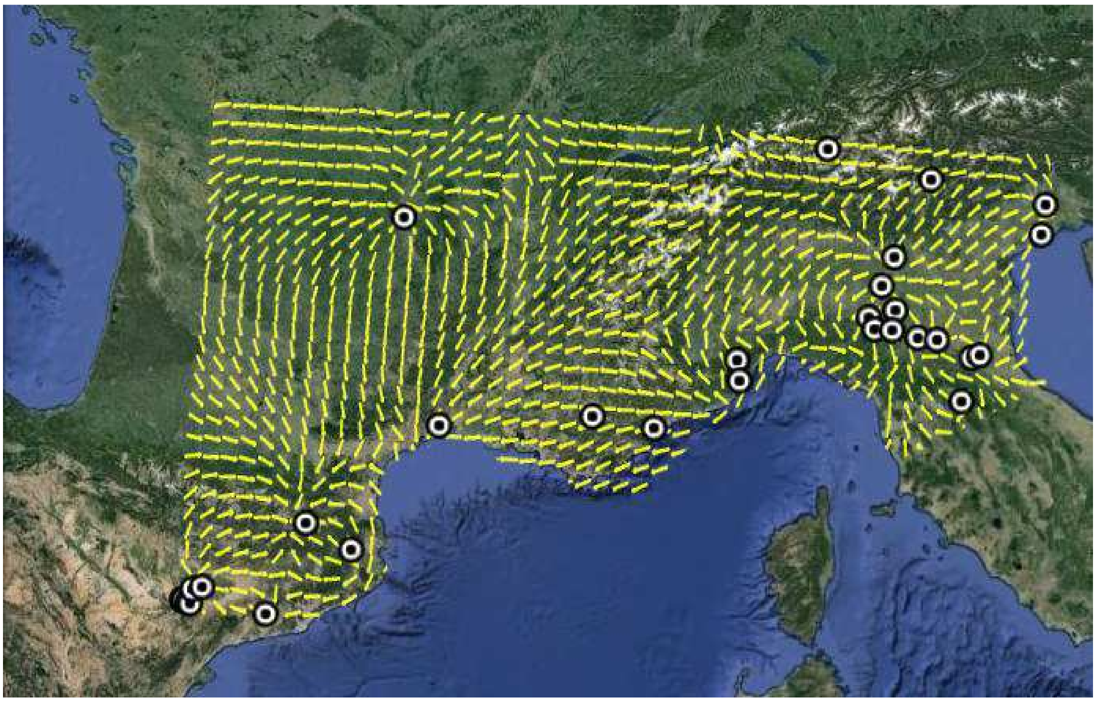

Fig. 122 - Map showing the directivity of the vases with handles with vertical expansion adoption phenomenon (Software: Rockworks 16, Rockware, Inc.). The map contains small arrows at each grid node pointing down the gradient, that is, decrease in chronology: from places where this typology was adopted first to places where such phenomenon appears to be more recent.

9.4 Modeling the first occurrence of fluted pottery between 1800 and 800 BC and from the Danube to the Ebro River

The latter variable we analyzed in this chapter is fluted pottery. Specifically, we want to test the possibility of an expansive phenomenon for the adoption of such a pottery decoration, observable through the existence of a space-time gradient in the area under study.

In the previous chapter we highlighted that both the SCPDs and the histograms suggested that this variable is characterized by a positive trend in the time span 1800-800 BC. The constant increase in the number of adopter was confirmed by the generalized logistic curve fitted to our data. Furthermore, local SCPDs drew attention to the presence of regional differences in the adoption of this pottery decoration. As we want to test is differences in time can correspond to differences in space according to a homogeneous space-time pattern we decided to test such a hypothesis.

Therefore, among data included in the EUBAR database we selected reliable archaeological contexts where fluted pottery appeared first according to the radiocarbon estimates. Hence, we used such data as an evidence for the first occurrence of the phenomenon.

Using a kriging algorithm we interpolated selected ^{14}C-estimates in order to obtain a new georeferenced map with values for unknown points. The result shows that in certain areas the adoption of fluted pottery took place earlier, for instance in Northern Italy, and in other the same pottery decoration is attested with a lower chronology. Nevertheless, we cannot recognize a regular and homogeneous space-time gradient among neighbor regions that could suggest an expansive phenomenon for describing the spread of fluted pottery. In particular we cannot distinguish the west to east pattern, from north of the Alps territories toward south-western districts, which has been traditionally proposed for the historical introduction of such a decoration in the North-East of Iberian Peninsula. On the contrary, in Switzerland and surrounding area the adoption of fluted pottery took place in a relative recent period, as already marked also in the North of the Alps SCPD (chapter 8.4.1, Fig. 84D).

In the light of such observations, we could not explain through a “wave of advance” model the adoption of fluted pottery between the Danube and the Ebro River in the 2nd and at the beginning of the 1st millennium BC.

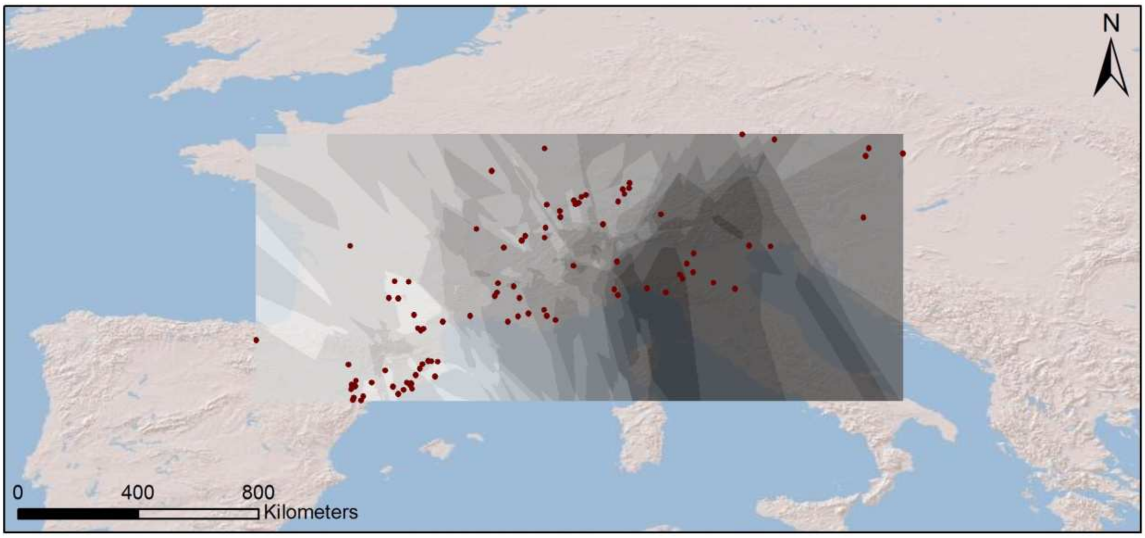

Fig. 123 – Visualizing spatial and temporal variations in the first occurrence of contexts characterized by the presence of fluted pottery included in the EUBAR database (medians of the calibrated radiocarbon dates). (Software: ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute). Contours represent differences of 50 years.

10 CONCLUSION AND FUTURE PERSPECTIVES

10.1 The historical problem

The historical problem developed in this thesis makes reference to the increase in Cultural Standardization at the end of Bronze Age in Europe, notably from the Alps to Northwestern Mediterranean. It is the historical phenomena known as *Urnfield culture*.

Many authors have suggested that around 1100 BC Europe was characterized by a shared tradition of burial rituals and a coherent religious system. In that scheme, both metal and ceramic productions are characterized by a high frequency of interactions between regions. It is assumed there was a rapid exchange of people, objects and ideas over large distances, which may have influenced in the formation of the cultural and linguistic map we know for later periods in history.

Thanks to palaeolinguist, genetic and archaeological data we have information about the spatial distribution of Iron Age Celtic peoples in Europe, but much less is known for the phases of formation of such a cultural group which should be located in last phases of Bronze Age. This period was explained at the beginning of 20th century in terms of successive invasions characterized by an East to West movement in which the leading role was held by the Urnfield warrior.

More popular nowadays are wave of advance explanatory models which may have involved or not the substitution of whole populations, as suggested by some genetic evidence and palaeolinguistic data.

Even more popular among modern scholars is the idea of Cultural Transmission, where new funerary practices and new pottery typologies can be regarded as adopted innovations. We understand culture as the information acquired from one individual to another through teaching, imitation, and other forms of social transmission. Therefore, Cultural Transmission can also be identified by multiple contacts and interactions between groups.

In order to understand Bronze Age early complex societies we need to focus on phenomena of spreading of people, objects and ideas over space and across time. Therefore, it has been essential to take into account a one millennium time span. A large temporal range allows detecting the beginning, the increase and in some cases also the end of such phenomena. It follows that our interest has been to isolate such historical events through the detection of discontinuities, quantified through the results of radiocarbon dating.

10.2 Archaeological evidence. Radiocarbon data

Indeed, an important matter of this work has been a constant effort dedicated to quantify problems and issues that are usually expressed in a qualitative way. The starting point has been the quantification of two basic concepts for every kind of space-time analysis, i.e. space expressed by geographic coordinates and time represented by the confidence intervals of calibrated ^{14}C dates. It follows that dealing with radiocarbon dates has been a basic point of this thesis.

^{14}C dates are a fashionable topic since the latter decades with a constant increase of publications and researches. Nevertheless such an increase of knowledge did not always correspond to a general improvement neither in the description of archaeological contexts associated with the radiocarbon sample nor in the posterior analysis of obtained dates. As Bayliss et al. (2007) stressed "a date is just a number - a radiocarbon date is just an expensive number". We could also add that a radiocarbon date is an expensive but a useful number. In this thesis we have proved that the amount of information we can infer from a radiocarbon dates dataset goes beyond the mere date, useful to confirm or to reject previous hypotheses.

A particular care from the field to the laboratory and specific skills are necessary to analyze correctly radiocarbon data. As we are dealing with probability density functions the treatment of radiocarbon dates requires statistical and mathematical knowledge. Hence, we have focused in particular on this field, showing how different techniques can help us to provide the most suitable answers to our questions. In fact, the main stumbling block in the way archaeologists deal with radiocarbon dates does not relate to radiocarbon dating itself, but to the interpretation of the results.

The backbone of this work has been the collection into the EUBAR database of ^{14}C dated archaeological contexts between the Ebro and the Danube River for the time span 1800-750 BC and the organization of this large amount of data in a homogeneous and coherent structure developed by the author. Making available to the archaeological community such a large set of radiocarbon dates together with archaeological information allow other researchers to test models proposed in this thesis and to produce others which might be better also with future additional high quality radiocarbon dates. Statistical tools to analyze radiocarbon estimates are varied; in this work we managed to present the most used ones like: Bayesian modeling, summed calibrated probability distributions (SCPDs), analysis of frequency with histograms, data interpolation with kriging, etc.

In particular, we have shown that each technique is closely linked to a specific question and it is functional to it. It follows that the main point is the question we want to answer and the hypothesis we need to test and to validate.

10.3 Testing the temporality of archaeological periods

According to the proposed framework in chapter 6 we have proposed a new chronological model based on Bayesian statistical analysis of ^{14}C dates from reliable archaeological contexts in Northern Italy and Southern France. For the North-East of Iberian Peninsula we have not been able to produce a reliable chronological model, this is mainly due to problems and errors relating to the traditional description of the material culture.

Trough the critical analysis of each sample concerning the stratigraphic and contextual information, we have given priority to selected archaeological contexts preferring quality instead of quantity.

Although the number of reliable dates for macro scale research remains low it has been possible to develop four different models with the software OxCal4.2 (Bronk Ramsey 2009a), two contiguous ones and two sequential ones.

Focusing on descriptive statistics our results have shown that the radiocarbon chronology of Northern Italy should be slightly higher than the conventional one, whilst that one of Southern France is confirmed by obtained models although a higher beginning of the Middle Bronze Age has been detected. In our model the transition from the *Bronze Ancien* to the *Bronze Moyen* phases in Southern France is located in the range 1707-1603 BC for the 1σ probability and 1777-1568 BC for the 2σ.

In both cases the results claim the absolute necessity of an increase in the amount of radiocarbon dates from selected archaeological contexts.

Through Bayesian modeling we have wanted to show that most of the disagreement between the different chronological frames was due to the low quality of the contexts and their associated dates. Our methodology, based on objective and independent parameter than the agreement of the date with our scheme, shows the importance of dating only good contexts in order to reduce the noise in the chronologies. In the future we hope that this work will set some rules for field work in relation to radiocarbon dating. Certainly improvement will come. We do not think that this is the final word, but we think that we have made some clarity in the subject.

10.4 Interpreting the spatio-temporal frequency of radiocarbon dated archaeological contexts

In chapter 7 and 8 we have focused on the study of frequency of radiocarbon dates, both through summed calibrated probability distributions (SCPDs) and histograms of medians.

Although the techniques are the same, they have been applied to test different hypotheses.

In Chapter 7 we have used radiocarbon dates as a proxy for detecting episodes of change and hiatuses in the demographic intensity between the Ebro and the Danube River for the time span 1800-800 BC. We chose to use 800 BC as the last term due to problems of calibration originated by the "Hallsttat plateau".

Traditionally Late Bronze Age is characterized by a phenomenon of demographic growth on a macro-scale, the result of these increase would be the diffusion over a macro scale of *Urnfield culture*. According to a wider perspective, reaction-diffusion models that analyze the spread of people over space and across time assume the existence of a logistic demographic growth. One or more episodes of population increase would have been the primary cause that made people spread.

Using data included in the EUBAR database we have produced different SCPDs in order to test such a hypothesis. First we have analyzed the whole dataset with only a preliminary sample prescreening, then we have filtered our data adopting more restricted criteria, like combining multi-dated contexts and modeling separately dates originating from settlements from those of funerary contexts. Our results agree in suggesting population stationarity during the time span 1800-800 BC between the Danube and the Ebro River. The presence of a long-term curvilinear positive trend shown by our SCPDs is a hallmark of many long-term radiocarbon frequency distributions (e.g., Kuzmin & Keates 2005; Bryson et al. 2006; Peros et al. 2010). It can be generated by a systematic taphonomic bias since (as may often be the case) the probability of archaeological site survival is negatively correlated with the age of the site (Surovell & Brantingham 2007). Moreover, small peaks observed in SCPDs are an effect of the calibration processes and therefore should not be interpreted as episodes of higher demographic intensity. To test a null hypothesis of no relationship between the observed SCPD and the effects of that particular section of the calibration curve we have simulated a set of radiocarbon dates with no chronological variation. The result has strengthened our assumption as peaks in the observed distribution exactly coincide with irregularities in the calibration curve around 1500 and 800 BC.

On the contrary, adopting a regional scale we can detect different patterns in different regions. It implies that continuities and discontinuities express locally with circumscribed episodes of crisis and demographic expansion.

In spite of the absence of population growth, in chapter 8 we have highlighted the existence of phenomena of growth in the temporal adoption of innovations, like cremation burials, fluted pottery, vases with handles with vertical expansion and metal knives. Using the same methodology adopted in chapter 7, i.e. SCPDs, we have focused on the phenomena of adoption of innovation which took place in the 2nd millennium BC in the area under study. Theory about adoption of innovation has been usually introduced by fields different from archaeology (Bass 1969; Casetti 1969; Olshavsky 1980; Mahajan & Peterson 1985; Banks 1994; Nieto et al. 1998; Rogers 2003; Rogers et al. 2005; Young 2009; Shinoara 2012; Kucharavy & De Guio 2011). Our aim has been to apply such a methodology to our case study.

The first phenomenon we have analyzed related to the religious and ritual world: it is the adoption of cremation funerary rite in the 2nd millennium BC. We have compared the temporal distribution of cremation burials with that one of inhumation burials. Both through SCPDs and histograms of median the results point that in the time span 1800-800 BC the adoption of cremation burial and the practice of inhumation rite are two different phenomena whose temporal distributions can be clearly distinguished. We have been able to fix on a macro scale the transition between the two phenomena at around 1220 BC.

It follows that the lesser people were inhumated, the more people were cremated. It implies that the smaller the number of people practicing the inhumation rite, the higher the number of adopters of the cremation rite. In addition, we have observed that locally the introduction of cremation burials is characterized by different pattern in different regions. Such a result stresses the possibility of an expansive phenomenon in order to describe the spatio-temporal diffusion of the new funerary rite. Hence, in chapter 9 we have tested such a hypothesis.

Selecting the first occurrence of the phenomenon and interpolating the medians of calibrated radiocarbon dates we have been able to detect a clear space-time gradient. The results stress that the adoption of cremation rite in the 2^{nd} millennium BC was not a random process, but followed a specific pattern. Our data suggest that it took place before in the Western Alpine area and in the Swiss Plateau around 1400 BC and from there it spread towards southern and south-western territories, where the occurrence of cremation burials took place in later phases according to the distance from the origin. Northeastern Iberian Peninsula and Central Italy appear to be areas where the transformation took place nearly 500 years later, including also the possible adoption of cremations without urn.

If we add to the model typologically dated cremation burials the area with oldest presences enlarges including part of the Po Valley in Northern Italy. For the model with only ^{14}C-dated cremation burials we have been able to calculate a spreading movement of 0.6-1 km/year; such a value is characteristic both of demic diffusion and cultural transmission hypotheses.

Regarding the adoption of cremation burial in the North-East of Iberian Peninsula we have detected two different patterns. The first one is placed along the Mediterranean facade, where oldest cremation burials are located close to the coast, therefore suggesting a possible maritime penetration. From this area the phenomenon would have expanded to the inner territories perhaps along the Ebro Valley. The second pattern is in the Atlantic facade, where the adoption of cremation took place slightly later in time. It is relevant to observe that these differences are in agreement with archaeological data which refers of an Atlantic Bronze Age culture, where cremation burials were mainly attested under cromlech structures and a Catalan Mediterranean facade where cremation burials were mainly in urn and characterized by strong influences from the Trans-Pyrenean region of Languedoc-Roussillon.

In this thesis we do not have modeled just one expansive process, but we have gone further managing to analyze the spatio-temporal distribution of other variables.

Among them vases with handle with vertical expansion are an innovation introduced in North Italian archaeological contexts during last phases of early Bronze Age and the Middle Bronze Age. Such a hypothesis has been confirmed by the spatial distribution of such a variable which showed a peak around 1600 BC and a decrease in the number of adopters in more recent phases. Nevertheless, in spite of such a decrease we have been able to model a phenomenon of expansion from the Po valley towards the North-East of Iberian Peninsula. The existence of a regular east to west space-time gradient is a signal of a specific directivity in the adoption of this pottery typology between the Po Valley and the Catalan area. Moreover, our data suggest that the penetration in the Iberian Peninsula took place through Trans-Pyrenean movements and not along the Mediterranean coast. In the future new radiocarbon dates from reliable archaeological contexts could strengthen this hypothesis or propose some new one.

A shared patrimony of pottery decoration and shapes characterizes European Late Bronze Age as an effect of the process of cultural standardization. Fluted pottery is one them as it is characterized by a macro scale spatial distribution. The analysis of ^{14}C-dated archaeological contexts from the Ebro to the Danube River has shown that the typology is attested with slightly different chronologies in different geographic areas. It is interesting to note that close regions have similar pattern for the temporal distribution of fluted pottery, as an effect of the Tobler's law according to which spatial proximity influences the process of adoption. It has been observed that the adoption of fluted pottery took place before in some regions, like in Northern Italy, and in a later phase in others, for instance in the Iberian Peninsula where fluted pottery is characterized by a more recent chronology. Nevertheless, we have not been able to detect a clear space-time gradient in our data, which implies that we cannot adopt a simple "wave of advance" explanation in order to describe the space-time diffusion of this pottery typology.

In this work we have also drawn the attention on the description of these processes of adoption of innovation through the analysis of the statistical properties of their temporal distribution between 1800 and 800 BC. Specifically, we have fitted our data to a generalized logistic curve, which is commonly adopted for describing processes of adoption of innovation. The results have showed that not all the variables spread at the same speed. The process of adoption of cremation rite was slow in the first phases and then it increases the rate reaching almost an exponential growth at least till 800 BC. On the contrary for artifacts like fluted pottery and metal knives our data have suggested a faster rate of adoption since the first phases, which implies that the innovation spread fast among people and was accepted by new adopters according to a linear trend.

10.5 Adoption of innovations and diffusion in Europe between 1800 and 750 BC

In the light of obtained results we can stress that we have been able to describe phenomena of adoption of innovations and diffusion in Protohistoric Europe. Through the analysis of radiocarbon dated archaeological contexts we have quantified flows, which could be referred to people, ideas and objects, between the Ebro and the Danube River in the 2nd and at the beginning of the 1st millennium BC. In this thesis we have focused in the descriptive statistics of such phenomena, which characterize Bronze Age complexity. In the future we could investigate why these phenomena took place.

In this framework, during the last months of developing of this work we have begun to study the possibility of distinguishing the temporally dependent but *non-spatially dependent diffusion* processes, where spatial proximity is not influencing the behavior of the diffusion because absolute location is not as important as relative position (a topological measurement). According to this idea, social groups can exist as personal and direct social ties that either link individuals who share values and belief or create impersonal, formal, and instrumental social links. In fact, spatially dependent processes do not explain in full the adoption of innovations because they are incapable of capturing individuals' motivations, or lack thereof, toward adopting an innovation. Such a model would presume that each individual who comes into contact with the innovation would automatically become an adopter. Although such an assumption is suitable for modeling phenomena such as the spread of diseases, a realistic model of innovation diffusion should somehow include factors related to cognition. It is important to realize that space and time are properties of the location of social acts, but they are not a *cause* in itself. It is a matter of basic methodological knowledge that the observation of two factual occurrences at two different but near points in space or time does not constitute a sufficient condition for the establishment of a causal relationship.

If *X* accepted innovation *A* around 1200 BC and a spatially neighbor group *Y* accepted the same innovation a “short” time later (for instance, less than 200 years after), a conclusion that *Y*'s decision was a consequence of *X*'s decision is a logical fallacy (Lindbladh et al. 1997). Two things that are spatially associated may be involved in a diffusion mechanism or there may be other hidden variables that cause the change through space and time. Spatio-temporal association does not necessarily imply causality, whereas adoption implies causality (Franzese & Hays 2006). In any case, although spatio-temporal dependence is not causality, it provides evidence of causality that can (and should) be assessed in light of theory and/or other evidence. Spatio-temporal heterogeneity is not just a parameter drift to be corrected: it is information bearing since it reveals both the intensity and pattern of change.

In the first chapters of this thesis we have presented the most diffused hypotheses regarding expansive phenomena in the 2nd and in the 1st millennium BC.

In the light of results produced by geostatistical modeling of collected data we can evaluate which ones are in agreement.

The first one is related to the demographic growth, as a basic condition for people movements. Radiocarbon evidence shows that this criterion is not accomplished for the period 1800-800 BC between the Ebro and the Danube River.

We have only detected a slightly positive trend analyzing ^{14}C-dates from settlement. Nevertheless, such an increase is not significant as it could be partially a result of the already mentioned taphonomic bias. Therefore we could stress that our data suggest a long-tem stationarity, which is in conflict with the traditional phenomena of population growth that should have characterized the LBA (Kristiansen 1998b; Zimmerman 2009, 2012). Such a demographic growth was interpreted as cause and an effect of the spread of *Urnfield culture* over a macro-scale in European territories. On the contrary our results highlight that on the one hand we do not have relevant episodes on change in the demographic intensity, which implies continuity on a macro-scale for the period 1800-800 BC, on the other hand we can clearly detect a growth in the adoption of the new funerary ritual characterized by the cremation of bodies. It is meaningful to stress that the increase toward the Iron Age in the probability of recovering cremation burials has to be interpreted as a growth in the number of adopters of the new funerary rite and not as a growth in the total amount of people that could hypothetically be adopters of the cremation rite.

Moreover, the statistical analysis of our data has suggested the existence of an expansive phenomenon for explaining the diffusion of cremation burials. Such an expansive process is associated with absence of population growth as argued before. This result is clearly in contradiction with the traditional "wave of advance" model that regards population logistic growth as a fundamental cause for explaining a process of demic diffusion. In our case such an assumption is not valid. It is relevant to argue that reaction-diffusion models were mainly applied to model prehistoric societies, like the Paleolithic and Neolithic ones. The level of complexity reached during Bronze Age and Iron Age transition implies that the "wave of advance" model is too simplistic to explain phenomena modeled in this thesis. We do not have only people movements; we have also circulation of objects, materials and above all ideas, which follow new rules different from one period to the other. The causes of studied flows of people, objects and ideas should be traced in the socio-cultural and economic structure of 2nd and beginning of 1st millennium BC society and not just in an episode of population growth.

Regarding the directivity of these flows through the geostatistical treatment of ^{14}C-dated data we have identified the existence of a general East to West pattern. This pattern has been confirmed not only for the diffusion of cremation burials but also for the pottery typologies likes vases with handles with vertical expansion. This result is partially in good agreement with the classical hypothesis for the diffusion of *Urnfield culture* which assumed a homogeneous East to West movement from the Danube-Carpathian regions to the North-East of Iberian Peninsula (Müller-Karpe 1959; Schauer 1975; Sperber 1987; Falkestein 1997; Kristiansen 1998b). In fact, in our model the origin of this gradient is placed in the North-Western Alps. It also true that an East to West gradient has been detected between the Western boundaries of studied area, which corresponds to the Vienna basin and the neighboring Czech territory, and South-Western Germany. However, North-Western Alpine area and the Swiss Plateau represent a major nucleus in the process. This result highlights the fundamental role covered by the Rhin-Suisse-France oriental (RSFO) groups (Brun 1984; Brun & Mordant 1989; De Mulder et al. 2008) in the process of spread of cremation burials.

The East to West gradient seems to be a major preferential flow of circulation. In fact such a gradient has been detected also for vases with handles with vertical expansion. In this second expansion we need to stress the importance of *Terramare culture* which represents a major archaeological group (Bernabò Brea et al. 1997; Bietti Sestieri 2010), whose evidences and effects, at least for the innovation introduced in pottery typologies and decorations, spread over an area much wider than its original territory.

As a conclusion for the period 1800-750 BC we can definitely exclude the existence of a West to East space-time gradient, like that one suggested as a possible hypothesis for the spread of Celtic people by Cunliffe and Koch (Cunliffe & Koch 2010; Koch & Cunliffe 2013).
Regarding the concept of transition, as reported in Sørensen and Thomas (1989) "The transition is an expression of change", we can conclude that in the analyzed time span we do not have detected just one transition. On the contrary, we are witnesses of episodes of introduction of new beliefs (the cremation rite), new fashions (expressed by new pottery typologies and decorations) and new tools (like metal knives). As an outcome, if we should choose a date to mark the major discontinuity which took place between the Danube and the Ebro River in the 2nd millennium BC due to its relevance we probably could take the change in the funerary rite from inhumation to cremation at around 1220 BC.

10.6 A suggested explanation of cultural standardization between 1200 and 750 BC

Our key theoretical assessment is to consider the emergence of ethnicity as a long-term process of group formation. Cultural standardization influences the updating of social identities and the possibilities of economic cooperation. We also consider this kind of standardization as a consequence of different forms of social interaction where cultural consensus may emerge. In this scenario aggregation of human groups also emerges affecting social reproduction by increasing both similarity in the long run and intergroup affinity.
We view the emerging complex of *Urnfield culture* as a process of reproducing identity from generation to generation. As a result, some people arrived to share some knowledge and some behaviors because they have learnt from the same people. However, what is learnt at birth and during childhood is progressively modified during life when interacting with other people with different knowledge, behaviors and believes. Social reproduction does not take place in an empty social world, but it should be built in the present through the social and political selection of prospective partners. What will be transmitted to the new generation is then different to what was learnt by

the individual, because:

- We change what we have learnt once inherited knowledge proves to be not useful or prone to contradictions.
- What we have learnt at childhood is usually a central tendency of what believed both parents. Given that the process of mating and selecting reproductive partner is socially and politically minded, the cultural consensus to be transmitted depends on the way such cultural consensus is built at the level of the reproductive unit, and hence on the social and political origins of the reproductive unit itself (“family”).

Both mechanisms are constructively contradictory. That is, ethnogenesis and identity formation emerge as result of the contradiction between social inertia (knowledge inheritance) and cultural consensus built during cooperation and labor exchange.

The key of our perspective is that any shared traits among social groups, their behavior, their beliefs, and their language, the products of their work and/or the material or immaterial results of their actions should be contingent to the social interaction process that generated those traits. In so saying, we follow a constructive approach to “ethnicity” and the study of cultural diversity. That means that the way Bronze Age people took economic, social and political decisions is what configured people clustering at different scales. In other words, the question is “*why* groups of people are the way they are” in terms of *how* they acted within a social aggregate their previous activity contributed to build. The complex interplay of social actions, people and the consequences of their actions explain the degree of cultural consensus and standardization by showing how social aggregation fit into a causal structure, that is to say, a vast network of interacting *actions* and *entities,* where a change in a property of an entity dialectically produces a change in a property of another entity.

Cultural standardization at the end of Late Bronze Age was probably the result in a change in the way social agents interacted in their economic and political activities. We assume that produced subsistence was dependent on local conditions of soil quality, water availability, etc., whose effects should be compensated using technology, which vary from agent to agent, and between time-steps, or increasing the quantity of labor. When subsistence production was insufficient because of local conditions, agents should ask other agents to share part of their surplus or some quantities of technology or even labor. Furthermore, technology loses its efficiency at each cycle, so it should be substituted from time to time. We assume that the only way to renovate technology is through exchange or robbery.

As any other society, Late Bronze Age communities were constituted by individuals connected to one another by overlapping arrays of social ties that together constitute a social network. Social interaction, and hence, the flow of people, goods and ideas, depended upon each agent's network of interpersonal contact or his network of social communication and that the configuration of this network is primarily dependent on the presence of various social barriers which may have impeded, diverted and channeled communications.

We hypothesize this change may be the result of the diffusion of a cultural standard. *Standard* is used here to refer to any individual elements incorporating specifications that feed the process of *compatibility* or cultural consensus. Consequently, instead of *assuming* that agents have common identity traits based on membership to an already existing "ethnic" group, agents may ask themselves as to the extent to which they "believe" they are similar to others in the neighborhood. The emergence of cultural consensus should be considered as a relevant property of a social system that enables social agents to "somehow go together" and makes them subject to a network effect. Agents use "cultural consensus" as an active *standardization* process to increase the probabilities of interacting with a communication partner. The theoretical bottom-line argument for standardization cultural processes is that the discrepancy between individual (at the level of the regions) and collective (at the level of the complete geographical area, network wide) gains leads to coordination problems. We could test whether social benefits of creating consensus (increasing the probability for exchange and decreasing the probability for conflict and robbery) are evolutionary sufficient for the diffusion of cultural standards. While the increased cultural similarity can lead to direct savings due to faster, more frequent and predictable communication, cultural consensus may also induce more strategic benefits: avoiding conflict and increasing the flow of goods, objects, materials and labor among culturally similar agents.

According to our hypothesis of cultural transmission and social identities building, asking for help in the particular economic, technological, social and political conditions of Late Bronze Age, from the Alps to the Mediterranean was mediated by the actual identity similarity and weighted by cost-distance. Cultural identity was in constant renegotiation and updating because agents calculated the percentage of consensus needed, depending on how much they need food or tools from others to survive. The more at risk they found themselves, the less tolerant to the others difference.

Agents survive thanks to the production of food, for which they need labor and technology. If they cannot survive, they also have the option of either asking for exchange or steal what others have accumulated, depending on the degree of cultural similarity. In both cases, food and tools travelling from agent to agent are negatively weighted in terms of cost-distances.

The theoretical bottom-line argument for considering the advantages of cultural homogenization lie in the assumption that the discrepancy between individual and collective gains leads to coordination problems. Increased cultural similarity can lead to direct savings due to faster, more frequent and predictable communication. Cultural consensus may also induce more strategic benefits, such as avoiding conflict and increasing the flow of goods and labor among culturally similar agents.

This is a global and theoretical model of the emergence of cultural standardization.

10.7 A computer model of Bronze Age diffusion and adoption of innovations

To understand what happened at this moment of European History we propose a computer simulation model defining *agents* as regions.

With Agent Based Modeling (ABM) we can create artificial societies based on archaeological data, observe how the agents interact in a virtual environment, analyze the parameters that affect the outcome of the simulation and then we can validate the result with real data (Epstein & Axtell 1996; Gilbert & Abbott 2005; Epstein 2006; Miller & Page 2007). This methodology is considered innovative and challenging for our discipline, whose aim is to understand human action in the past, which is by definition non-observable (Barceló 2009). A computer simulation should allow us to understand why a specific pattern of spatio-temporal dependence emerged when comparing the different cultural elements adopted and used by different groups of people during Bronze Age. For this sort of task, we, as programmers, should know and define what input conditions generate an increase in the probability of occurrence a change. Beyond a simple addition of individual random decisions, simulated social activity should be defined in terms of *dispositions* or *capacities* within a system of subjects, intentions, activities, actions and operations, some of them rational, others clearly indeterminate, impulsive or unconscious.

The starting point of the explanation of social systems by means of computer simulation is not the simulation of one particular system; in fact, the main purpose is to analyze social dynamics as a complex social system and hence to try to quantify the possible outcomes emerged from the different experiments preset on a computer platform (Gilbert & Conte 1995; Gilbert & Troitzsch 2005; Axelrod 1997; Axelrod & Cohen 2001).

The model architecture is based on 20 agents, which correspond to 20 different regions (Fig. 124). Each region constitutes a buffer zone around one agent and it has been calculated using Thiessen polygons. Each one defines an area of influence around the agent.

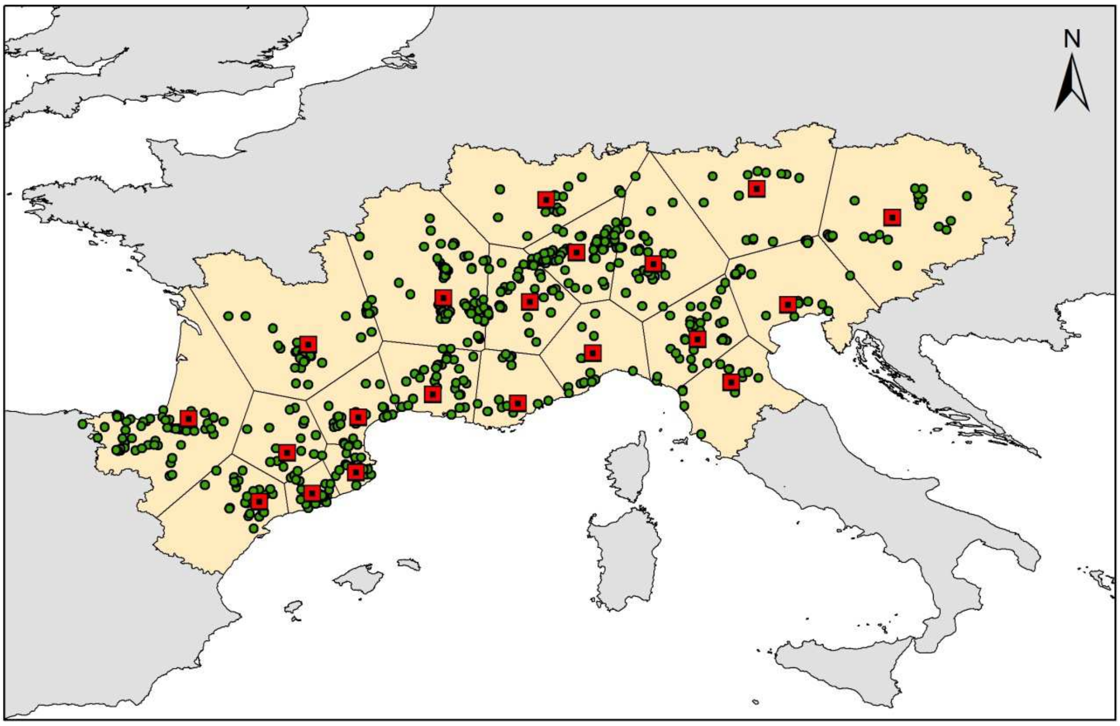

Fig. 124 – Map showing ^{14}C dated archaeological sites included in the EUBAR database (in green), 20 agents (in red) corresponding to 20 different geographic regions (in yellow) identified with Thiessen polygons (Software: ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute).

In the computer model, agents are defined in terms of their population, that is, the number of unit labor, cultural identity and the number of tools they have at each time step. Additional attributes and parameters are the amount of produced food, the surplus of food the agent can accumulate and the survival threshold, which depends on the number of labor units within the agent. Cultural identity has been defined in strict archaeological terms. It is a binary vector coding the presence/absence of idiosyncratic artifact types (Barceló et al. 2013; Del Castillo et al. 2014).

In this model each region is connected to other through cost-weighted distances, in such a way that there are no possibilities of random connection between them. Distances based in cost-weighted models try to define the least costly path to reach each known point using the path with least accumulated travel cost (Fig.125).

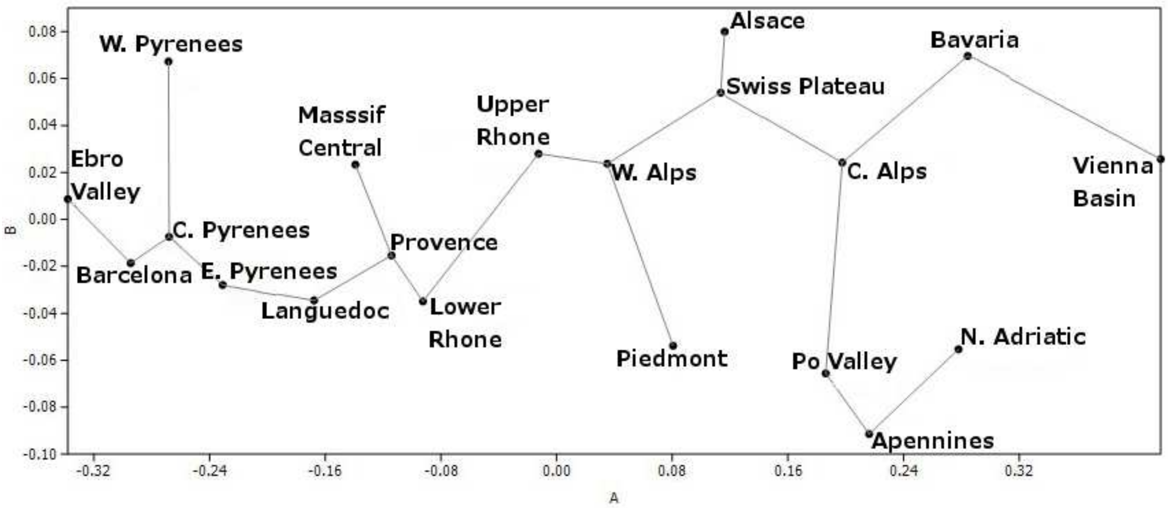

Fig. 125 – Cost weighted distances among the 20 agents represented in Fig. 124.

In the model agents are characterized by the following attributes:

- LABOR UNITS (l_i): (a Poisson distributed parameter counting the aggregated quantity of labor from all groups).
- SURVIVAL THRESHOLD ($\bar{e}_i$): Given that the survival of agents depends on the amount of food, a survival threshold should be calculated in terms of the quantity of calories all agents included in an agent that represents a regional group of local groups need to be able to live a season long (six months).
- IDENTITY: A vector.
- TECHNOLOGY (β_i): A parameter representing the aggregated efficiency of labor obtained when increasing the number of manufactured tools). It starts at 1 (lack of tools) and has not an upper maximum.

- ENERGY (e_i): Produced food, expressed in kilocalories.
- SURPLUS (s_i): The difference between energy produced and energy consumed. It is stored for later use.

In this simulation, SURVIVAL THRESHOLD and LABOR are fixed for all the simulation, although not any agent has the same values. The number of Labor units in an agent ("region") may vary from 100 to 1000 units. They are randomly assigned at start up. Survival threshold is a multiple of the number of labor units, assuming an individual needs an average of 730 kilocalories per year (2000 calories per day), and one time step (cycle or "tick") in the simulation roughly represents what an agent is able to do in six months, $\bar{e}_i = (365 * l_i)$ (Barceló et. al 2012).

Regarding the concept of identity we establish group identity in terms of perceived similarities in social activity. Our agents have an "identity", modeled somewhat following Axelrod cultural vectors (Axelrod 1984). It is important to take into account, nevertheless, that such identity vectors are not a surrogate of "culture", as in the classical Axelrod model. Culture is best understood as the expected variance of social activities between groups. Then it is not a list of attributes, but a measure of similarity. When similarity increases, cultural consensus emerges.

Values are inherited from parents at birth and they can be later modified when the agent integrates a social aggregation with other agents. In principle, such an identity vector can be perceived by all other agents, who interpret the social personality and group membership of agents which they interact in the present based on it. Different situations can be imagined where all or only a part of this identity vector is accessible to agents out of the group. That is, in many cases, agents are only partially aware of what identifies the "other". Cultural consensus does not exist as an explicit set of values, but should be built at each run time when agents with different identities agree to cooperate. It is then a process rather than a "label" or a set of values. It is the process of identity modification in terms of the statistical mode of identities of all agents that interact.

That is, our agents have a list of features represented by each agent's culture vector, that condition the way the agents interact, identify and cooperate with the other agents generating and defining different group identities in terms of the material culture their behavior generates. It is what each agent knows about the others, and has been represented as a list of features.

In the proposed ABM, simulation uses the following external parameters, which have to should be initiated at start-up (Barceló et al. 2010):

- INTERNAL CHANGE RATE (IRC). This is a random value (from 0 to 1, usually very small) defined in analogy to the probabilities of internal change (invention, mutation, catastrophe, sudden change).
- DEMOGRAPHIC VARIABILITY: A Poisson distribution of the number of labor units within each agent.
- LOCAL DIFFICULTY FOR PRODUCING FOOD (h_i): It is a Poisson distributed parameter counting the quality of soil and the availability of water and temperature at each time-step: the poorer quality of soils and the scarcer is water. This parameter is initiated at start up (a random number following a Poisson distribution whose λ is a free parameter selected by the user at the beginning of the simulation), and changes every time-step, in such a way that at odd cycles (warm season) it is the half that at regular cycles (cold season).
- NUMBER OF NEW TOOLS CREATED AT THE END OF A GIVEN CYCLE: A user selected number of agents, from specific locations (for instance, mining regions) produce a constant number of new tools at the end of each cycle.

In the simulation, virtual agents survive when they produce, exchange or steal enough food. They can be involved in three kinds of economic activities: agriculture-herding, exchange and robbery. Because agriculture is more productive and predictable, it is supposed to have increasing returns. Survival is also affected by diminishing marginal returns relative to the local difficulty to produce food (quality of soils, temperature and pluviometric variation, etc.) and the availability of labor and instruments. Agents should take the decision whether to ask for food or additional number of tools to culturally similar agents or steal food and tools by culturally different agents. Agents decide to exchange when they find themselves in a circumstance where they have not obtained enough resources for survival. To decide if an agent exchanges with another, we programmed each one observing the immediate neighborhood and evaluating their respective identities to know if they are “sufficiently” common. Each agent has its own IDENTITY, inherited at birth, learnt within the evolving group, modified all along the life of the agent and transmitted to the new generation.

We have not included demographic mechanisms in this simulation, because we are working at a very high scale, where the unit of analysis (the region) is assumed to have been constant over long periods of time. The effects of exchange and conflict on cultural homogeneity are the core of the simulation. But we are also studying cultural changes introducing new funerary practices and the adoption of new artifacts.

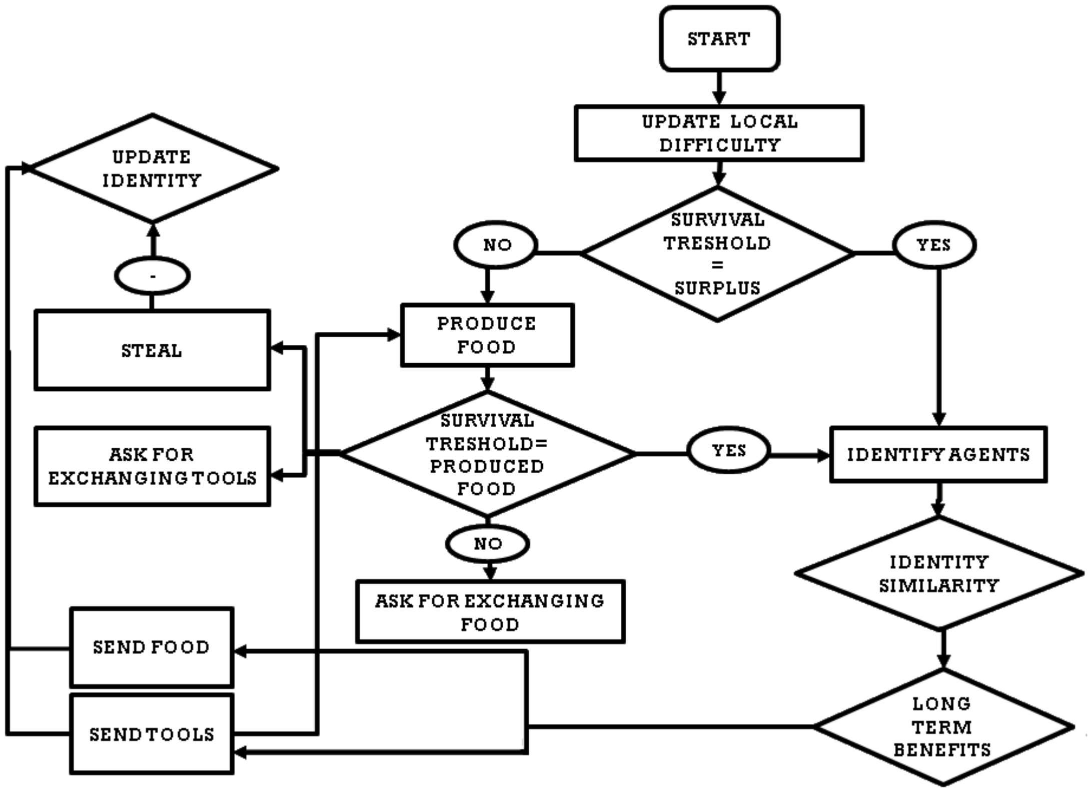

Fig. 126 - Process overview of the proposed ABM, sequence of operations.

The process overview is integrated by different agent's activities (Fig. 126). Surviving is the first process in the agent schedule at the beginning of a new time-step. Agents have a surplus from previous productive acts, and they produce food. Food produced and not consumed at the present time-step is converted into surplus. The number of tools experiment a reduction due to its constant use, in such a way that every two cycles, the number is reduced to a half. Tools can only be obtained through exchange or robbery.

When an agent needs food or tools and some degree of cultural consensus already exists between agents in this area (although they may be very far away), the decision whether exchange or not is taken according a variation of the Prisoner's Dilemma. If an exchange is decided, the half of the actual value of surplus or the half of the non-necessary tools is transmitted. The agent in need receives these quantities from all agents in the environment with a similarity in identity higher than a similarity threshold. The received quantities of food and tools are weighted negatively by the cost-distance separating them.

There are increasing returns to exchanges, i.e. agents have more chances of survival when helping others because if they help at this moment they will be helped later when they are in need. Production of food is also affected by diminishing marginal returns relative to the variations in the local difficulty of producing food and the effects of robbery (Barceló et al. 2012).

One agent steals another if 1) it is in need of food or tools, 2) they have appropriately dissimilar identities, that is to say, if some existing cultural consensus is below a critical threshold. Consequently, the current value of each agent identity vector influences the probabilities of cooperating or conflict within the current time-step. When exchange is successful, the current value of the identity vector changes adaptively to fit the newly built cultural consensus. That is to say, to decide if people in a region cooperated with people from another region without moving, we imagine each one observing the immediate neighborhood and evaluating the identity of other people in it. If their respective identities are "sufficiently" common, they decide to cooperate, and the probability of success in survival increases. If identities are too different, people do not cooperate there is a growing probability that they can enter in conflict stealing what they have produced and accumulated so far.

"Identity" is socially built by agents through a local imitation process. It evolves, changes and adapts to fit local features at the current time step. There are two main mechanisms for identity change.

1. Internal change, supposed to be random at the scale of a population.
2. Adaptive, trying to fit individual identity to collective identity if there is an economic advantage.

It is important to take into account that a cycle of the simulation, implies a six-month period, that is, a season. Food production gives different results owing to seasonal climatic variability.

In our model, the number of tools experiments a reduction due to its constant use, in such a way that every two cycles, the number is reduced to a half. Tools can only be obtained through exchange or robbery. However, a user selected number of agents, from specific locations have the chance to produce a constant number of new tools at the end of each cycle. Both the number of new tools and the agents that reproduce tools on their own (simulating regions which are rich on metal ores) are external parameters that can be selected by the user to experiment with different scenarios.

This is the architecture of the proposed model for diffusion processes and phenomena of adoption of innovation which took place in European Bronze Age. Eventually, it is meaningful to remember that models do not represent reality but rather our understanding of reality (Dürrwächter 2009). Hence, the results presented in this work are fundamental not only to construct the architecture of the model but also to validate it.

ACKNOWLEDGEMENTS

This Ph.D. thesis would not have been possible without the supports and the contribution of many persons.

First, I would like to thank my supervisor Juan Antonio Barceló, who made me to understand that different ways of making archaeology are possible: from a qualitative archaeology to a quantitative one. He managed to get the most difficult goal, to make me to hate mathematics a little less.

Thanks also to my co-supervisor Prof. Giovanni Leonardi, who let me start the Erasmus in Barcelona in the far 2007, without him probably I would not have started this work.

Special thanks go to Dr. Elisabetta Boaretto from the D-REAMS Radiocarbon Laboratory, Weizmann Institute of Science (Israel) for giving me the opportunity to touch with hand the interdisciplinary field of radiocarbon dating.

Thanks to the Prof. Javier López Cachero from the University of Barcelona for the suggestions and the useful comments to this work and to Dr. Enriqueta Pons from the Archaeological Museum of Catalonia in Girona for introducing me in the complex Catalan Late Bronze Age world.

I would like to thank also all the people who helped me in the difficult collection of the radiocarbon dates. Without them, the development of the EUBAR database would not have become reality. In particular, special thanks go to Dr. Peter Stadler from the Naturhistorishes Museum in Vienna and Prof. Gerhard Trnka from the Institute of Prehistoric and Historical Archaeology of the University of Vienna. I also want to acknowledge Dr. Franco Nicolis from the Archaeological Heritage Office of the Autonomous Province of Trento, Dr. Giovanni Tasca from the University of Udine, Dr. Maria Bernabò Brea director of the National Archaeological Museum of Parma and the librarian of the Archaeological Center in Lattes UMR 5140.

Mentioning my friends and colleagues, thanks to: Florencia for bringing an Argentine air, Vera for being always so kindly available, Hendaya for your positive energy, Katia for all the laughs, the long talks and the future projects. You all have created such a good environment in the Department.

Thanks also to my other friends Niccolò, Veronica, Francesco and Valentina for all the moments we spent together. In the next months I will be more present, I promise! Specially thanks to my close friend Elena, everything started in that far away 2004 and

ten years later we are still here supporting each other and enjoying past moments, present days, and I hope future days too.
Finally, I owe particular thank to Marco for being always present and for believing every day in me.

Let me thank all the other people that I have not mentioned here.

This research has been financially supported by the Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR) of the Generalitat de Catalunya, through my Ph.D grant, which I gratefully acknowledge.
It has also been supported by the following projects:

- *Experimentación y desarrollo de técnicas avanzadas de inteligencia artificial para la simulación computacional de la dinamica social y la evolución histórica* (HAR2009-12258, Spanish Ministry of Science and Innovation)
- *Etnicidad en el pasado. Un análisis causal de la etnogénesis en sociedades prehistóricas por medio de técnicas avanzadas de simulación computacional* (HAR2012-31036, Spanish Ministry of Science and Innovation)
- *Social and environmental transitions: Simulating the past to understand human behaviour* (CONSOLIDER-INGENIO 2010 CSD2010-0034, Spanish Ministry of Science and Innovation).
- *PADICAT. Patrimoni Arqueològic Digital de Catalunya* (RECER2010-05, RecerCaixa, Obra Social "La Caixa" i Associació Universitats Publiques de Catalunya).
- *AGREST, arqueologia de la gestió dels recursos socials i del territori (*2009SGR0734, AGAUR-Generalitat de Catalunya).

REFERENCES

(It includes EUBAR references)

ACHILLI A, OLIVIERI A, PALA M, METSPALU E, FORNARINO S, BATTTAGLIA V, ACCCETURO M, KHUSNUTDINOVA E, PENNARUN E, CERUTI N, DI GAETANO C, CROBU F, PALLI D, MATULLO G, SANTACHIARA-BENERECETTI AS, CAVALLI-SFORZA LL, SEMINO O, VILLEMS R, BANDELT H-J, PIAZZA A, TORRONI A. 2007. Mitochondrial DNA variation of modern Tuscans supports the near eastern origin of Etruscan. *The American Journal of Human Genetics* 80:759-68.

ACHOUR C. 2009. Ein mittelbronzezeitlicher Siedlungsplatz in Ebmatingen (Gem. Maur). *Archäologie im Kanton Zürich* 01:17-39.

ADAMI R, BONAZZA M, VARANINI GM, editors. 2005. *Volano. Storia di una comunità.* Rovereto (TN).

ADOLPHI F, GÜTTLER D, WACKER L, SKOG G, MUSCHELER R. 2013. Intercomparison of Radiocarbon Dating of Wood Samples at Lund University and ETH Zurich AMS Facilities: Extraction, Graphitization, and Measurement. *Radiocarbon* 55(2-3):391-400.

AGUSTÍ A, ALONSO N, GARCÉS I, JUNYENT E, LAFUENTE A, LÓPEZ JB. 2000. Una inhumación múltiple de perinatales en la fortaleza de Els Vilars (Arbeca, Lleida) y las prácticas de enterramiento en hábitat durante la 1a edad del Hierro en el valle del Segre (Cataluña). In: DEDET, GRUAT, MARCHAND, SCHWALLER PY, editors. Archéologie de la mort, Archéologie de la tombe au Premier Âge du Fer, Actes du XXIIe Colloque International de l'Association Française pour l'Etude de l'Age du Fer (Conques-Montrozier 1997). *Monographies d'Archéologie Méditerranéenne* 5:305-24.

AITCHISON T, OTTAWAY B, AL-RUZAIZA AS. 1991. Summarizing a group of ^{14}C dates on the historical time scale: with a worked example from the Late Neolithic of Bavaria. *Antiquity* 65:108-16.

AITKEN MJ. 1990. *Science-based dating in archaeology*. England.

ALARCOS BALLART A, GONZÁLEZ JIMÉNEZ R, MARTINÉZ RODRÍGUEZ P. 2006. Santa Digna III. Un hábitat del Bronze Final III al Vallès Oriental. *Cypsela* 16:161-75.

ALBANESE PROCELLI RM. 2000. Bronze Metallurgy in Protohistoric Sicily. The Stone Moulds. In: RIDGWAY D, SERRA RIDGWAY FS, PEARCE M, HERRING E, WHITE HOUSE RD, WILKINS JB, editors. Ancient Italy in its Mediterranean setting. Studies in honour of Ellen Macnamara. *Accordia Specialist Studies on the Mediterranean* 4:75-90.

ALBERTI A, DAL RI L, MARZOLI C, TECCHIATI U. 2005. Evidenze relative al X, IX, VIII sec. a.C. nell'ambito dell'alto bacino del fiume Adige (Cultura di Luco – Meluno). In: BARTOLONI G, DELFINO F, editors. *Oriente e Occidente: metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del Ferro italiana, Atti dell'Incontro di Studio (Roma, 30-31 ottobre 2003)*. Pisa. p 227-38.

ALBERTI ME, SABATINI S, editors. 2013. *Exchange networks and local transformation.*

Interaction and local change in Europe and the Mediterranean from the Bronze Age to the Iron Age.

ALBERT RM, MANGADO X, OLMEDO C, ORRI E, VARGAS A. 1997. *Memòria de l'excavació d'urgència de Santa Digna-El Pla de la Girada. Vilafranca del Penedès (Alt Penedès)*. Servei d'Arqueologia de la Generalitat de Catalunya.

ALBORE LIVADIE C, ORTOLANI F, editors. 2003. *Variazioni climatico-ambientali e impatto sull'uomo nell'area circum-mediterranea durante l'Olocene*. Bari.

ALCALDE G, MOLIST M, TOLEDO A. 1994. Procés d'ocupació de la Bauma del Serrat del Pont (La Garrotxa) a partir del 1450 a.C. *Publicacions eventuals d'arqueologia de la Garrotxa* 1. Museu Comarcal de la Garrotxa. Olot.

ALCAMO JC, VITAL J, BINTZ P. 2004. O*ccupations protohistoriques et historiques de la grotte de Coufin II à Choranche*. In: JOURDAIN-ANNEQUIN C, editor. *Atlas culturel des Alpes occidentales: de la Préhistoire à la fin du Moyen-Âge*. Paris. p 49.

ALDAY RUIZ A. 1992. Síntesis sobre la secuencia cultural Neolítico-edad del Bronce en el País Vasco. *Sancho el sabio: Revista de cultura e investigación vasca* 2:19-50.

ALESSIO M, ALLEGRI L, BELLA F, IMPROTA S, BELLUOMINI G, CALDERONI G, CORTESI C, MANFRA L, TURI B. 1978. University of Rome Carbon-14 dates XVI. *Radiocarbon* 20(1):79-104.

ALESSIO M, ALLEGRI L, IMPROTA S, BELLUOMINI G, CORTESI C, MANFRA L, TURI B. 1991. University of Rome Radiocarbon Dates XVII. *Radiocarbon* 33(1):131-40.

ALESSIO M, BELLA F, CORTESI C. 1964. University of Rome Carbon-14 dates II. *Radiocarbon* 6:77-90.

ALESSIO M, BELLA F, BACHECHI F, CORTESI C. 1965. University of Rome Carbon-14 dates III. *Radiocarbon* 7:213-22.

ALESSIO M, BELLA F, BACHECHI F, CORTESI C. 1967. University of Rome Carbon-14 dates V. *Radiocarbon* 9:346-67.

ALESSIO M, BELLA F, CORTESI C, GRAZIADEI B. 1968. University of Rome Carbon-14 dates VI. *Radiocarbon* 10(2):350-64.

ALESSIO M, BELLA F, CORTESI C, TURI B. 1969. University of Rome Carbon-14 dates VII. *Radiocarbon* 11(2):482-98.

ALESSIO M, BELLA F, IMPROTA S, BELLUOMINI G, CORTESI C, TURI B. 1971. University of Rome Carbon-14 dates IX. *Radiocarbon* 13(2):395-411.

ALESSIO M, BELLA F, IMPROTA S, BELLUOMINI G, CALDERONI G, CORTESI C, TURI B. 1973. University of Rome Carbon-14 dates X. *Radiocarbon* 15(1):165-78.

ALINEI M. 1998. *Towards an invasionless model of Indoeuropean origins: the continuity theory*. In: Papers from the EEA Third Annual Meeting at Ravenna 1997, vol. I Pre-and Protohistory. Oxford: BAR International Series 717. p 31-3.

ALINEI M. 2002. *Towards a generalised continuity model for Uralic and Indoeruopean* *languages*. In: The Roots of Peoples and Languages of Northern Eurasia IV (Oulu, 18.8-20.8.200). p 9-33.

ALMAGRO GORBEA M. 1977. El Pic dels Corbs, de Sagunto, y los Campos de Urnas del NE. de la Península Ibérica. *Saguntum* 12:89-141.

ALMAGRO GORBEA M. 1987. *La celtización de la Meseta: estado de la cuestión*. In: Actas del I Congreso de Historia de Patencia I. p 313-44.

ALMAGRO GORBEA M. 1991. *I Celti dell'Iberia*. In: MOSCATI S, HERMANN FREY O, KRUTA V, RAFTERY B, SZABÒ M, editors. I Celti, catalogo della mostra di Palazzo Grassi. Milano-Venezia. p 386-407.

ALMAGRO GORBEA M. 1992. El origen de los Celtas en la Península Ibérica. Protoceltas y Celtas. *Polis. Revista de idéas y formas políticas de la Antigüedad Clásica* 4:5-31.

ALMAGRO GORBEA M. 1994. "Proto-Celtes" et Celtes dans la Péninsule Ibérique. In: Actes du XVIe colloque de l'Association Française pour l'Etude de l'Age du Fer (Agen 1992). *Revue Aquitania* 12:283-96.

ALMAGRO GORBEA M. 1997. La Edad del Bronce en la Península Ibérica: periodización y cronología. *Saguntum* 30:217-29.

ALMAGRO GORBEA M, FERNANDEZ MIRANDA M, editors. 1978. *C-14 y prehistoria de la Península Ibérica*. Serie Universitaria 77. Fundación Juan March. Madrid.

ALMAGRO M. 1935. *El problema de la invasión céltica en España según los últimos descubrimientos*. Investigación y Progreso IX.

ALMAGRO M. 1952. *La invasión céltica en España*. Historia de España dirigida por Menendez Pidal, T. I, vol. II.

ALONSO N, GARCÉS I, JUNYENT E, LAFUENTE A, LÓPEZ JB, MIRÓ JM, ROS MT, ROVIRA MC. 1996. *L'assentament dels Vilars. (Arbeca, Les Garrigues): territori, recursos i activitats productives*. Gala 3-5:319-39.

ALONSO N, GENE M, JUNYENT E, LAFUENTE A, LÓPEZ JB, MOYA A, TARTERA E. 2002. *Recuperant el passat a la línia del Tren d'Alta Velocitat. L'assentament protohistòric, medieval i d'època moderna de El Vilot de Montagut (Alcarràs - Lleida)*. Lleida.

ALONSO N, JUNYENT E, LAFUENTE A, LÓPEZ JB. 1999. Chronologie des Ages des Métaux dans la basse vallée du Segre (Catalogne, Espagne) à partir des datations C14. In: EVIN J, editor. Actes du 3ème Congrès Internacional ^{14}C et Archéologie (Lyon, 6-10 avril 1998). *Mémoires de la Société Préhistorique Française* XXVI:287-92.

ALONSO N, JUNYENT E, LAFUENTE A, LÓPEZ JB. 2000. "La Fortaleza de Arbeca. El proyecto Vilars 2000". Investigación, recuperación y socialización del conocimiento y del patrimonio. *Trabajos de Prehistoria* 57(2):161-73.

ALTARA E. 1965. La Grotta "Serafino Calindri", Croara (Bologna). In: *Atti del VI Convegno Speleologia Emilia-Romagna (Formigine, settembre 1965)*. p 679-85.

ALTSHULLER GS. 1984. *Creativity as an exact science: the theory of the solution of inventive* *problems*. New York.

ALTUNA J, DE LA RUA C. 1989. Dataciones absolutas de los cráneos del yacimiento prehistórico de Urtiaga. *Munibe* 47:23-8.

ÁLVAREZ A, BACHILLER JA. 1996. La evolución del urbanismo en el Bajo Aragón durante los períodos del Bronce Final-Hierro Antiguo. In: Actas de la Taula Rodona: models d'ocupació, transformació i explotació del territori entre el 1600 i el 500 ane a la Catalunya meridional i zones limítrofes de la Depresió de l'Ebre (S. Feliu de Codines 1994). *Gala* 3-5:175-82.

ÁLVAREZ R, RAURET AM. 1996. El Neolítico Final en la cueva de les Pixarelles. In: *Actes del Ier. Congrés del Neolític a la Península Ibèrica, 1995-Rubricatum (Gavà), I.1*. p 439-45.

AMBERS J, BOWMAN S. 2003. Radiocarbon measurements form the British Museum: datelist XXVI. *Archaeometry* 45(3):531-40.

AMBERT P, AMBERT M. 1978. La grotte Tournié (Pardailhan, Hérault): stratigraphie et datations ^{14}C. *L'Anthropologie* 82(2):175-97.

AMBERT P, BARGE H. 1982. Les parures de la grotte Tournié à Pardailhan (Hérault). *Bulletin de la Société préhistorique française* 79(3):151-60.

AMBS R, WISCHENBARTH P. 1990. Metallverarbeitung in einer spätbronzezeitlichen Höhensiedlung bei Bellenberg (Schwaben). *Bayerische Vorgeschichtsblätter* 55:257-71.

AMMERMAN A. 1992. Pottery at Monte Leoni. *Rivista di Archeologia* XVI:5-24.

AMMERMAN A, BUTLER J, DIAMOND G, MENOZZI P, PALS J, SEVINK J, SMIT A, VOORRIPS A. 1976. Rapporto sugli scavi a Monte Leoni: un insediamento dell'età del Bronzo in Val Parma. *Preistoria Alpina* 12:127-54.

AMMERMAN AJ, CAVALLI-SFORZA LL. 1971. Measuring the rate of spread of early farming in Europe. *Man* 6:674–88.

AMMERMAN AJ, CAVALLI-SFORZA LL. 1984. *The Neolithic Transition and the Genetics of Populations in Europe*. Princeton. New Jersey.

ANDERSON J. 1973. Ideology in Geography: An Introduction. *Antipode* 5(1).

ANDERSON TJ, BOUYER M. 1994. Courgevaux FR, Le Marais 2. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 77:174.

ANDREE M, OESCHGER H, SIEGENTHALER U, RIESEN T, MOELL M, AMMANN B, TOBOLSKI K. 1986. 14C dating of plant macrofossils in lake sediment. In: STUIVER M, KRA RS, editors. Proceedings of the 12th International 14C Conference. *Radiocarbon* 28(2A):411-6.

ANDRESEN J, MADSEN T, SCOLLAR I 1993. Computing the past: CAA 92. In: *Proceedings of the 20th "Computer Applications in Archaeology" conference*. Aarhus.

ANGELINI B, BAGOLINI B. 1978. Riparo Gaban (Trento). *Preistoria Alpina* 16:239.

APELLANIZ JM, FERNANDEZ MEDRANO D. 1978. El sepulcro de galería segmentado de la Chabola de La Hechicera (Elvillar, Alava). Excavaciones y restauración. *Estudios de Arqueología* Alavesa 9:141-221.

APELLÁNIZ JM, NOLTE E, ALTUNA J. 1966. Excavación, estudio y datación por el C14 de la cueva sepulcral de "Kobeaga" (Ispaster, Vizcaya), con el estudio de la fauna. *Munibe* 18:37-62.

AQUILUÉ X, editor. 1999. Datacions per análisis de radiocarboni. In: AQUILUÉ X, editor. *Intervencions arqueològiques a Sant Martí d'Empúries (1994-1996). De l'assentament precolonial a l'Empúries actual, Empúries.* Monografies Emporitanes 9. Museu d'arqueologia de Catalunya- Empúries: p 653-4.

Archéologie et eutoroute A1: destins croisés. 25 années de fouilles en terres fribourgeoises, premier bilan (1975-2000) 2008. *Freiburger Archäologie/Archeologie fribourgoise* 22.

ARENAS JA. 1999. *La Edad del Hierro en el Sistema Ibérico Central, España*. Oxford: BAR International Series 780.

ARENAS JA. 2001-2002. Die Kelten in Hispanien: Schlüssel zu ihrer Identifikation und offene Fragen. *Veleia* 18-19:11-37.

ARIAS P, ALTUNA J, ARMENDÁRIZ A, GONZÁLEZ URQUIJO JE, IBÁÑEZ ESTÉVEZ JJ, ONTAÑÓN R, ZAPATA L. 1999. Nuevas aportaciones al conocimiento de las primeras sociedades productoras en la región cantábrica. In: Bernabéu J, Orozco T, editors. *Actas del II Congrés del Neolític a la Península Ibérica (Valencia, 1999). Saguntum. Papeles del Laboratorio de Arqueología de Valencia.* Extra 2. p 549-57.

ARMADA XL, HUNT MA, JUAN TRESSERRAS J, MONTERO I, RAFEL N, RUIZ J. 2005. Primeros datos arqueométricos sobre la metalurgía del poblado y necrópolis de Calvari del Molar (Priorat, Tarragona). *Trabajos de Prehistoria* 62(1):139-55.

ARMENDÁRIZ J. 1993-1994, San Pelayo (Arellano, Navarra). Campaña 1991. *Trabajos de Arqueología Navarra* 11:281-5.

ARMENTANO N, GALLART J, JORDANA X, LOPEZ JB, MALGOSA A, RAFEL N. 2006. La cova sepulcral de Montanissell (Sallent – Coll de Nargó, Alt Urgell): pràctiques funeràries singulars durant l'edat del bronze al Prepirineu. *Tribuna d'arqueologia* 2006:141-67.

ARMENTANO N, MALGOSA A. 2002. El jaciment de Can Filuà, dades per al món funerari de l'edat del bronze. In: *Pirineus i veïns al IIIer. mil·leni A.C. Homenatge al Professor Dr. Domènec Campillo: Actes del XII Col·loqui Internacional d'Arqueologia de Puigcerdà (Puigcerdà 2000).* p 681-8.

ARMENTANO N, MALGOSA A. 2004. Els enterraments de Can Ballarà (Terrassa). Una aproximació als rituals d'enterraments de l'edat del Bronze. *Terme* 19:75-85.

ARMIT I, SWINDLES GT, BECKER K. 2013. From dates to demography in later prehistoric Ireland? Experimental approaches to the meta-analysis of large 14C data-sets. *Journal of archaeological science* 40:433-8.

ARNAUD G, ARNAUD S, BUCHET L, DUBAR M, MULLER A. 1987. Sépultures protohistoriques à Nice (Alpes-Maritimes). La nécropole de Youri. *Bulletin Archéologique de Provence* 17:27-30.

ARNOLD B. 2012. Gender, temporalities, and periodization in Early Iron Age West-Central Europe. *Social Science History* 36(1):85-112.

ARTIGUES P, BRAVO P, HINOJO E. 2006. Excavaciones arqueològiques a Can Gambús 2, Sabadell: Vallès Occidental. *Tribuna d'arqueologia* 2006:111-40.

ASHMORE P. 1999. Radiocarbon dating: avoiding errors by avoiding mixed samples. *Antiquity* 73(279):124-30.

ATKINSON QD, NICHOLLS G, WELCH D, GRAY RD. 2005. From words to dates: water into wine, mathemagic or phylogenetic inference?. *Transactions of the Philological Society* 103(2):193-219.

AUBIN G, editor. 1997. *Sollières-Sardières, abri du Châtel*. *Gallia Informations* 1994-1:233-4.

AXELROD R. 1997. Advancing the art of simulation in the social sciences. In:CONTE R. HEGSELMANN R. TERNA P, editors. Simulating social phenomena. *Lecture Notes in Economics and Mathematical Systems* 456:21-40.

AXELROD R, COHEN MD. 2001. *Harnessing complexity: organizational implications of a scientific frontier*. Chicago.

AYALA G. 2000. *Saint-Priest (Rhône), Parc technologique de la Porte des Alpes. Mail Central: rue Minerve, Document Final de Synthèse.* AFAN. SRA Rhône-Alpes 2000.

AZZI CM, BIGLIOCCA L, GULISANO F. 1977. Florence Radiocarbon Dates III. *Radiocarbon* 19(2):165-9.

AZZI CM, GULISANO F. 1979. Florence Radiocarbon Dates IV. *Radiocarbon* 21(3):353-7.

BACHMANN H-G. 2003. Bunt- und Edelmetalle aus mitteleuropäischen Komplexerz-Lagerstätten: Fahlerz-Verhüttung von der Bronzezeit bis zur Rennaissance. In: STÖLLNER T, KÖRLIN G, STEFFENS G, CIERNY J. 2003. Man and Mining - Mensch und Bergbau. Studies in honour of Gerd Weisgerber on occasion of his 65th birthday. *Der Anschnitt* 16:25-35.

BADER C. et al. 1997-1998. Tiel I Kurzberichte über die Tätigkeit der Kantonsarchäologie 1997-1998. *Archäologie im Kanton Zürich* 15:11-50.

BADER C. et al. 1999-00. Tiel I Kurzberichte über die Tätigkeit der Kantonsarchäologie 1999-2000. *Archäologie im Kanton Zürich* 16:11-45.

BADER C. et al. 2001-02. Tiel I Kurzberichte über die Tätigkeit der Kantonsarchäologie 2001-2002. *Archäologie im Kanton Zürich* 17:11-56.

BADINI G. 1965. *Attività del Gruppo Speleologico Bolognese C.A.I. e dello Speleo-Club Bologna E.N.A.L. nel 1964 e nel 1965*. In: Atti del VI Convegno Speleologia Emilia-Romagna (Formigine, settembre 1965). p 15-25.

BADINI G, GRIMANDI P, ZUFFA G. 1964. La Grotta "Serafino Calindri". *Sottoterra* 3(9):19-28.

BAGOLAN M, LEONARDI G. 2000. Il Bronzo Finale nel Veneto. In: HARARI M, PEARCE M, editor. *Atti della giornata di studio "Il Protovillanoviano al di qua e al di là dell'Appennino" (Pavia 17 giugno 1995)*. Como. p 15-46.

BAGOLAN M, VANZETTI A. 1997a. Bassa Veronese: siti dell'età del Bronzo Medio, alcuni dei quali finiscono agli inizi del Bronzo Recente. In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997)*. Milano. p 356-7.

BAGOLAN M, VANZETTI A. 1997b. Bassa Veronese: siti dell'età del Bronzo Recente, che sovente iniziano nel corso del Bronzo Medio. In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997)*. Milano. p 357-60.

BAGOLINI B. 1972. Maso Pasquali - Riparo Gaban. In: *15° Riunione Scientifica dell'Istituto Italiano di Preistoria e Protoistoria Verona e Trento*. Guida all'escursione nel veronese e nel Trentino. p 91-4.

BAGOLINI B. 1980. *Riparo Gaban. Preistoria ed evoluzione dell'ambiente*. edizioni didattiche.

BAGOLINI B, TASCA G, TECCHIATI U. 1992. L'abitato di Sotcíastel (S. Leonardo in Badia, Bolzano). In: L'Età del Bronzo in Italia nei secoli dal XVI al XIV a.C. (Viareggio, 26-30 ottobre 1989). Firenze. *Rassegna di Archeologia* 10:630-1.

BAILEY GN. 2005. Concepts of time. In: RENFREW C, BAHN P, editors. *Archaeology: The Key Concepts*. London. p 268–73.

BAILEY GN. 2007. Time perspectives, palimpsests and the archaeology of time. *Journal of Anthropological Archaeology* 26:198-223.

BAILEY NTJ. 1950. A simple stochastic epidemic. *Biometrika* 37:193-202.

BAILEY NTJ. 1957. *Mathematical theory of epidemics*. New York.

BAILLIE MGL, MUNRO MAR. 1988. Irish tree rings, Santorini and volcanic dust veils. *Nature* 332:344–6.

BAILLIE MGL. 1998. Evidence for Climatic Deterioration in the 12th and 17th Centuries BC. In: HÄNSEL B, editor. *Mensch und Umwelt in der Bronzezeit Europas - Man and Environment in European Bronze Age, Abschlußtagung der Kampagne des Europarates: Die Bronzezeit: das erste goldene Zeitalter an der Freien Universität Berlin, 17.-19. März 1997*. Kiel. p 49-55.

BAILLY M, BESSE M, GISCLON J-L, HÉNON P, VÉROT-BOURRÉLY A. 1998. Le site d'habitat campaniforme de « Derrière-le-Château » à Géovreissiat et Montréal-la-Cluse (Ain): premiers résultats. In: D'ANNA A, BINDER D, editor. *Production et identité culturelle. Actualités de la recherche, Rencontres Méridionales de Préhistoire Récente, Actes de la deuxième session (Arles-Bouches-du-Rhône, 8-9 novembre 1996)*. Antibes. p 225-39.

BALDELLOU V, UTRILLA P. 1985. Nuevas dataciones de Radiocarbono de la prehistoria oscense. *Trabajos de Prehistoria* 42:83-95.

BALDEON A. 1983. Raíces en la Prehistoria. *Alava en sus manos* 18: 9-40.

BALISTA C. 1977. Studio sedimentologico preliminare della successione stratigrafica del Riparo Gaban (Trento). *Preistoria Alpina* 13:31-45.

BALISTA C. 2006a. I prelievi di campioni per datazioni C14 e per analisi polliniche eseguiti in corrispondenza della sezione nord-sud di Perteghelle B: i risultati ottenuti. *Padusa* XLII:74-5.

BALISTA C. 2006b. La “sezione est” di Perteghelle A e i prelievi di campioni per datazioni C14 e analisi polliniche. In: BALISTA C, DE GUIO A, VANZETTI A, BETTO A, DE ANGELI G, SARTOR F, editors. La fine dell’età del Bronzo ed i processi di degrado dei suoli innescati dai reinsediamenti della prima età del Ferro e dai deterioramenti climatici del sub-Atlantico al margine settentrionale delle Valli Grandi Veronesi (Il caso studio del sito di Perteghelle di Cerea-VR). *Padusa* XLII:66-7.

BALISTA C, CAFIERO F, DE GUIO A. 1997a. Castello del Tartaro. In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 240-5.

BALISTA C, CAFIERO F, DE GUIO A. 1997b. Fabbrica dei Soci. In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 246-9.

BALISTA C, CAFIERO F, DE GUIO A. 1997c. Fondo Paviani. In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 245-7.

BALISTA C, CANTELE G, LUCIANI M. 1990. Indagini geomorfologiche, stratigrafiche e dell’impatto agrario sul sito di Fondo Paviani. In: DE GUIO A, WHITEHOUSE R, WILKINS J, editors. Il progetto Alto-Medio Polesine-Basso Veronese: quinto rapport. *Quaderni di Archeologia del Veneto* VI:222-35.

BALISTA C, CANTELE G, LUCIANI M. 1992. Fabbrica dei Soci: la sezione sud, settembre-novembre 1990. Interventi multidisciplinari. In: DE GUIO A, WHITEHOUSE R, WILKINS J, editors. Il progetto Alto-Medio Polesine-Basso Veronese: quinto rapporto. *Quaderni di Archeologia del Veneto* VIII:183-4.

BALISTA C, DE GUIO A. 1990-1991. Il sito di Fabbrica dei Soci (Villabartolomea-VR): oltre la superficie…. *Padusa* XXVI-XXVII:9-85.

BALISTA C, DE GUIO A, VANZETTI A, BETTO A, DE ANGELI G, SARTOR F. 2005. Paleoidrografie, impianti terramaricoli e strade su argine: evoluzione paleoambientale, dinamiche insediative e organizzazione territoriale nelle Valli Grandi Veronesi alla fine dell’età del Bronzo. *Padusa* XLI:97-152.

BALISTA C, DE GUIO A, VANZETTI A, BETTO A, DE ANGELI G, SARTOR F, editors. 2006. La fine dell’età del Bronzo ed i processi di degrado dei suoli innescati dai reinsediamenti della prima età del Ferro e dai deterioramenti climatici del sub-Atlantico al margine settentrionale delle Valli Grandi Veronesi (Il caso studio del sito di Perteghelle di Cerea-VR). *Padusa* XLII:45-127.

BALISTA C, LEONARDI G. 1996. Gli abitati di ambiente umido nel Bronzo Antico dell’Italia settentrionale. In: COCCHI GENICK D, editor. *L'antica età del Bronzo in Italia, Atti del Congresso (Viareggio, 9-12 gennaio 1995)*. Firenze. p 199-228.

BALISTA C, LUCIANI M. 1992. Fabbrica dei Soci: la sezione sud, settembre-novembre 1990.

Quadro sinottico della stratigrafia. In: DE GUIO A, WHITEHOUSE R, WILKINS J, editors. Il progetto Alto-Medio Polesine-Basso Veronese: quinto rapport. *Quaderni di Archeologia del Veneto* VIII:184-6.

BAMFORTH DB, GRUND B. 2012. Radiocarbon calibration curves, summed probability distributions, and Early Paleoindian population trends in North America. *Journal of Archaeological Science* 39(6):1768-74.

BANDINI MAZZANTI M, MERCURI AM, ACCORSI CA. 1996. Primi dati palinologici sul sito di Monte Castellaccio (76 m s.l.m., 44°21'N 11°42'E, Imola-Bologna; Nord Italia) dall'età del Rame all'età del Bronzo. In: PACCIARELLI M, editor. *La collezione Scarabelli, Preistoria, II*. Casalecchio di Reno. p 158-74.

BANKS RB. 1994. *Growth and diffusion phenomena. Mathematical frameworks and applications*. Berlin.

BARANDIARÁN I. 1993-1994. Cueva de Berroberría (Urdax). Informe de las campañas de excavación V (1990), VI (1991), VII (1992) y VIII (1993). *Trabajos de arqueología Navarra* 11:243-7

BARANDIARÁN I., MARTÍ B., DEL RINCÓN M. Á., LUIS MAYA J. 1998. *Prehistoria de la Península Ibérica*. Barcelona.

BARANDIARÁN JM, FERNÁNDEZ MEDRANO D, APELLÁNIZ JM. 1964. Excavación del Dolmen de El Sotillo (Rioja Alavesa). *Boletín de la Fundación Sancho el Sabio* VIII(1-2):9-28.

BARBER K, LANGDON P. 2001. Testing the paleoclimatic signal from peat bogs—temperature or precipitation forcing?. In: *Abstracts, PAGES-PEPIII/ESF-HOLIVAR International Conference: Past Climate Variability Through Europe and Africa, ECRC/CERegE*. p 58-9.

BARBIER A, BOUDIN RC, CHAIX L, DELIBRIAS G, ERROUX J, LUNDSTRÖM-BAUDAIS K, PASSARD F, PÉTREQUIN A-M, PÉTREQUIN P, PICARD P, PININGRE J-F, RUTKOWSKI H, SÉNÉ G, URLACHER J-P, VUAILLAT D. 1981. La grotte des Planche-près-Arbois (Jura). *Gallia Préhistoire* 24(1):145-200.

BARBINA V, CALLIGARIS F, DEL FABBRO A, TURELLO A. 1984. Udine Radiocarbon Laboratory Date List II. *Radiocarbon* 26(2):293-6.

BARBUJANI G, BERTORELLE G, CHIKHI L. 1998. Evidence for Paleolithic and Neolithic gene flow in Europe. *American Journal of Human Genetics* 62:488-92.

BARCELÓ JA. 1991. *Arqueología, lógica y estadística*. Barcelona.

BARCELÓ JA. 1993. Automatic problimg solving in archaeology. *Archeologia e Calcolatori* IV:61-80.

BARCELÓ JA. 1999. Patriarchs, bandits and warriors. An analysis of social interaction in Bronze Agen South Western Iberian Peninsula. In: Eliten in der Bronzezeit. *Monographien des Römisch-Germanisches Zentralmuseum* 43:223-43.

BARCELÓ JA. 2001a. Técnicas de inteligencia artificial en arqueología. Su uso en el estudio de las formas de interacción social durante la Edad del Bronce. In: RUIZ-GALVEZ PRIEGO M, editor. *La Edad del Bronce, ¿Primera Edad de Oro de España? Sociedad, economía e* *ideología*. Barcelona. p 55-84.

BARCELÓ JA. 2001b. Virtual reality for archaeological explanation beyond “picturesque” reconstruction. *Archeologia e Calcolatori* 12:221-44.

BARCELÓ JA. 2005. Multidimensional Spatial Analysis in Archaeology. Beyond the GIS paradigm. In: *Reading the Historical Spatial Information in the World.Studies for Human Cultures and Civilizations based on Geographic Information System.* Kyoto: International Institute for Japanese Studies. p 47-62.

BARCELÓ JA. 2007. *Arqueología y estadística. Introducción al estudio de la variabilidad de las evidencias arqueológicas*. Bellaterra-Barcelona.

BARCELÓ JA. 2008a. La incertesa de les cronologies absolutes en arqueologia. Probabilitat i estadística. *Cypsela* 17:23-33.

BARCELÓ JA. 2008b. La seqüència crono-cultural de la prehistòria catalana. Anàlisi estadística de les datacions radiomètriques. *Cypsela* 17:65-88.

BARCELÓ JA. 2009. *Computational intelligence in archaeology*. Hershey-New York.

BARCELÓ JA, BOGDANOVIC I, editors. 2014. *Mathematics and Archaeology***.**

BARCELÓ JA, CAPUZZO G, BOGDANOVIĆ I. 2013. Modeling expansive phenomena in early complex societies: the Transition from Bronze to Iron Age in Prehistoric Europe. *Journal of Archaeological Method and Theory* 21(2):486-510.

BARCELÓ JA, CUESTA JA, DEL CASTILLO F, GALÁN JM, MAMELI L, MIGUEL F, SANTOS JI, VILÀ X. 2010. Patagonian ethnogenesis: towards a computational simulation approach. In: *Proceedings of the 3rd World Congress on Social Simulation*. Kassel. p 1-9.

BARCELÓ JA, DE CASTRO O, TRAVET D, VICENTE O. 2003. A 3D Model of an Archaeological Excavation. In: *The Digital Heritage of Archaeology. Computer Applications and Quantitative methods in Archaeology*. Heraklion: Hellenic Ministry of Culture. p 85-7.

BARCELÓ JA, DEL CASTILLO F. 2012. Ethnicity as cooperation. Hunter gatherers social dynamics from computer simulation models. In: *Proceedings of the 40th Conference on Computer Applications and Quantitative Methods in Archaeology*. Southampthon, UK.

BARCELÓ JA, DEL CASTILLO F, DEL OLMO R, MAMELI L, MIGUEL FJ, POZA D, VILA X. 2013. Social Interaction in Hunter-Gatherer Societies. Simulating the consequences of cooperation and social aggregation. *Social Science Computer Review*.

BARCELÓ JA, FAURA M. 1999. Time Series and Neural Networks in Achaeological Seriation. An example on early pottery from the Near East. In: *Archaeology in the Age of the Internet-CAA97***.** *Computer Applications and Quantitative Methods in Archaeology proceedings of the 25th anniversary conference*. University of Birmingham. p 91-102.

BARCELÓ JA, PALLARES M. 1998. Beyond GIS. The Archaeological study of social spaces. *Archeologia e Calcolatori* 9:47-80.

BARFIELD LH. 1968. Una nuova datazione assoluta per la stazione di Molina di Ledro. Considerazioni sulla cronologia della cultura di Polada. *Rivista di scienze preistoriche*

23(1):261-3.

BARFIELD LH. 1976. The cultural affinities of Bell Beakers in Italy and Sicily. In: *Glockenbecher Symposium (Oberried, 1974)*. p 307-22.

BARFIELD LH. 1977-1979. Carbon 14 dating. In: BARFIELD LH, BARKER GWW, CHESTERMAN JT, PALS JP, WOORRIPS A. Excavations at Monte Covolo, Villanuova sul Clisi, Brescia (1972-73), part II. *Annali del Museo di Gavardo* 13:74-5.

BARFIELD L. 1994. The Bronze Age of Northern Italy: recent work and social interpretation. In: MATHERS C, STODDART S, editors. *Development and decline in the Mediterranean Bronze Age*. Sheffield. p 129-44.

BARFIELD LH, BARKER GWW, CHESTERMAN JT, PALS JP, WOORRIPS A. 1977-1979. Excavations at Monte Covolo, Villanuova sul Clisi, Brescia (1972-73), part II. *Annali del Museo di Gavardo* 13:5-89.

BARFIELD LH, FASANI L. 1973. Problemi circa la fine del Neolitico e gli inizi dell'età del Bronzo nell'Italia settentrionale. In: *Atti della XV Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria (Verona-Trento, 27-29 ottobre 1972)*. p 181-90.

BARG F. 1987. *Der Westwall der Wehranlage Stillfried an der March (NÖ). Stratigraphie und stratigraphische Beziehungen zu 1969 – 1984 untersuchten Abschnitten im Wall- und Grabenbereich*. Dissertation zur Erlangung des Doktorgrades der philosophischen Universität Wien.

BARICH. B. 1975-1980. Insediamento di età del Bronzo nell'area di Lavagnone (Brescia). *Bullettino di Paletnologia Italiana* 82:71-116.

BARRIL VICENTE M, RUIZ ZAPATERO G. 1980. Las cerámicas con asas de apéndice de botón del NE. de la Península Ibérica. *Trabajos de Prehistoria* 37:181-219.

BARTHE JM, MARSAN G, DE VALICOURT E. 1985. La grotte de la Prédigadère (commune de Castet, P.A.). *Archéologie des Pyrénées Occidentales* 5:259-60.

BARTELHEIM M. 1998. *Studien zur böhmischen Aunjetitzer Kultur: Chronologie und chronologische Untersuchungen*. Bonn.

BARTELHEIM M. 2007. *Die Rolle der Metallurgie in vorgeschichtlichen Gesellschaften. Sozioökonomische und kulturhistorische Aspekte der Ressourcennutzung. Ein Vergleich zwischen Andalusien, Zypern und dem Nordalpenraum - The Role of Metallurgy in Prehistoric Societies. Socioeconomic and Cultural Aspects of the Use of Resources. A Comparison between Andalusia, Cyprus and the North Alpine Area*. Forschungen zur Archäometrie und Altertumswissenschaft 2.

BARTH FE, FELBER H, SCHAUBERGER O. 1975. Radiokohlenstoffdatierung der prähistorischen Baue in den Salzbergwerken Hallstatt und Dürrnberg-Hallein. *Mitteilungen der Anthropologischen Gesellschaft in Wi*en 105:45-52.

BARTH FE. 1993-1994. Ein Füllort des 12. Jahrhundert v. Chr. im Hallstätter Salzberg. *Mitteilungen der Anthropologischen Gesellschaft in Wien* 123-124:27-38.

BARTH FE. 1998. Bronzezeitliche Salzgewinnung in Hallstatt. In: HÄNSEL B, editor. *Mensch und Umwelt in der Bronzezeit Europas - Man and Environment in European Bronze Age, Abschlußtagung der Kampagne des Europarates: Die Bronzezeit: das erste goldene*

Zeitalter an der Freien Universität Berlin (17.-19. März 1997, Kiel). p 123-8.

BARTH FE. 2003. Hölzerne Konstruktionsteile aus dem spätbronzezeitlichen Salzbergwerk in Hallstatt, VB Gmunden, Oberösterreich. In: STÖLLNER T, KÖRLIN G, STEFFENS G, CIERNY J. 2003. Man and Mining – Mensch und Bergbau. Studies in honour of Gerd Weisgerber on occasion of his 65th birthday. *Der Anschnitt 16*:51-3.

BARTOLONI G, DELFINO F. 2005. *Oriente e Occidente: metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del Ferro italiana, Atti dell'Incontro di Studio (Roma, 30-31 ottobre 2003)*. Pisa.

BARTROLÍ R, CEBRIÀ A, MESTRES J, RIBÉ G. 1992. *La cova de la Guineu: ocupacions i usos d'una cavitat de la serra de Font-rubí (Alt Penedès) del 9.850 B.P. a l'època recent, Memòria de les campanyes realitzades en els anys 1988, 1989, 1990 i 1991*. Servei d'Arqueologia de la Generalitat de Catalunya.

BASS F. 1969. A new product growth model for consumer durables. *Management Science* 15(5):215–27.

BASSETTI M, DALMERI G, MOTTES E, NICOLIS F. 2008. La frequentazione delle alte quote nell'età del Bronzo. Il sito di Storo-Dosso Rotondo. In: MOTTES E, NICOLIS F, ZONTINI G, editors. *Archeologia lungo il Chiese. Nuove indagini della ricerca preistorica e protostorica in un territorio condiviso fra Trentino e Lombardia, Atti del 1° convegno interregionale (Storo, Teatro dell'Oratorio 24-25 ottobre 2003)*. Trento. p 107-27.

BATTAGLIA R. 1943. La palafitta del lago di Ledro nel Trentino. *Memorie del Museo di Storia Naturale della Venezia Tridentina* 7:3-63.

BAXTER MJ. 2001. Statistical modelling of artefact compositional data. *Archaeometry* 43:131-47.

BAXTER MJ. 2003. *Statistics in Archaeology*. London.

BAYLISS A, BRONK RAMSEY C. 2004. Pragmatic Bayesian: a decade of integrating radiocarbon dates into chronological models. In: BUCK CE, MILLARD AR, editors. *Tools for Constructing Chronologies. Crossing Disciplinary Baundaries*. London. p 25-41.

BAYLISS A, BRONK RAMSEY C, VAN DER PLICHT J, WHITTLE A. 2007. Bradshaw and Bayes: Towards a Timetable for the Neolithic. *Cambridge Archaeological Journal* 17(1 suppl.):1-28.

BEA D, DILOLI J. 2005. Elements de representació durant la Primera Edat del Ferro al curs inferior de l'Ebre: el recinte del Turó del Calvari (Vilalba dels Arcs, Terra Alta). *Revista d'Arqueologia de Ponent* 15:179-98.

BECKER B, KRAUSE R, KROMER B. 1989. Zur absoluten Chronologie der Frühen Bronzezeit. *Germania* 67(2):421-42.

BEECHING A. 1977. Le Boiron: una nécropole du Bronze final près de Morges (Vaud-Suisse). *Cahiers d'Archéologie Romande* 11.

BEECHING A, CORDIER F, BOUQUIN T. 1994. *Le Gournier - chantiers sud, la Roberte à Châteauneuf-du-Rhône (Drôme): fouille de sauvetage 1993-1994 et résumé des épisodes précédents, Rapport de l'ERA 36 du CNRS-CAP Valence*. Valence.

BELARDELLI C, GIARDINO C, MALIZIA A, editors. 1990. *L'Europa a sud e a nord delle Alpi alle soglie della svolta protourbana*. Treviso.

BELL C. 2006. *The evolution of long distance trade relationships across the LBA/Iron Age Transition on the Northern Levantine coast: Crisis, continuity, and change*. Oxford: BAR International Series 2574.

BELLODI L. 1971. Ricerche preliminari sull'abitato preistorico di S. Michele di Valestra (Reggio E.). *Atti Società dei Naturalisti e Matematici di Modena* 102:109-24.

BELLODI L. 1997. S. Michele di Valestra (RE). In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 369-70.

BELLODI L, BERTOLANI M, GRAZIOLI U, MANICARDI A, ROSSI A. 1979. *L'insediamenro preistorico di S. Michele di Valestra (RE)*. Formigine.

BELLWALD W. 1992. Drei spätneolithische/frühbronzezeitliche Pfeilbögen aus dem Gletschereis am Lötschenpaß. *Archäologie der Schweiz* 15(4):166-71.

BELLWOOD P. 1994. An archaeologist's view of language macrofamily relationships. *Oceanic Linguistics* 33:391-406.

BELLWOOD P. 1996. Phylogeny and reticulation in prehistory. *Antiquity* 70:881-90.

BENAMOUR P. 1993. Depuis 3000 ans avantm notre ère... Les Balmes à Sollières-Sardières, site d'altitude et passage obligé. In: La Savoie avant l'histoire: nouvelles recherches, nouveaux regards. *Mémoires et documents de la Société Savoisienne d'Histoire et d'Archéologie* 95:37-46.

BENAMOUR P. 1997. Sollières-Sardiéres. Grotte des Balmes. *Gallia Informations* 1996:233-4.

BENGUEREL S. 2006. Zur mittel- und spätbronzezeitlichen Besiedlung von Goldach SG-Mühlegut. *Jahrbuch Archäologie Schweiz* 89:87-135.

BENKOVSKY-PIVOVAROVÁ Z. 1991. *Das mittelbronzezeitliche Gräberfeld von Pitten in Niederösterreich. Ergebnisse der Ausgrabungen des Niederösterreichischen Landesmuseums in den Jahren 1967 bis 1973, Band 3. Ergänzungskatalog*. Mitteilungen der Prähistorischen Kommision, Österreichische Akademie der Wissenschaften 24. Wien.

BENKOVSKY-PIVOVAROVÁ Z. 2008. Zur bronzezeitlichen Siedlung Buhuberg in Waidendorf. *Študijné Zvesti Archeologického Ústavu SAV* 43:23-41.

BENNETT KD. 1994. Confidence intervals for age estimates and deposition times in late-Quaternary sediment sequences. *The Holocene* 4:337–48.

BENTINI L. 2002. L'abbandono in età protostorica di alcune cavità naturali del territorio di Brisighella. I casi della Grotta dei Banditi e della Tanaccia. In: MALPEZZI P, editor.

*Brisighella e val di Lamo*ne. Cesena. p 105-37.

BÉRATO J, DEGAUGUE F, KROL V, LEGUILLOUX M. 1999. Le Bastidon, Sillans-la-Cascade (Var). Un gisement de plein air du Bronze final IIIa en milieiu palustre. *Documents d'Archéologie Méridionale* 22:117-37.

BÉRATO J, MAGNIN F. 1989. *Le Touar, Les Arcs-sur-Argens (Var).* Un habitat de plaine du Bronze final II/IIIa et du premier Age du fer dans son environnement. *Documents d'Archéologie Méridionale* 12:7-40.

BÉRATO J, MAGNIN F, DUGAS F. 1990. Le Touar, Les Arcs-sur-Argens (Var). Note complémentaire. *Documents d'Archéologie Méridionale* 13:249-51.

BERGES M, SOLANILLA F. 1966. La cueva del Moro en Olvena (Huesca). *Ampurias* 28:175-90.

BERGLUND BE. 2003. Human impact and climate changes-synchronous events and a causal link?. *Quaternary International* 105:7-12.

BERMOND-MONTANARI G, RADMILLI A. 1954-1955. Recenti scavo nella Grotta del Farneto. *Bullettino di Paletnologia Italiana* 64:137-69.

BERNABÒ BREA M. 1997. Materiali dal sito di Monte Leoni (PR). In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 336-7.

BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. 1997. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano.

BERNABÒ BREA M, CREMASCHI M, editors. 2009. *Acque e civiltà nellle terramare. La vasca votiva di Noceto*. Milano.

BERTOLANI V. 1967. Relazioni di scavi effettuati negli anni 1965 e 1966 a S. Michele di Valestra (Reggio Emilia) e alla Grotta della Gaibola (Bologna). *Atti e Memorie della Deputazione di Storia Patria per le antiche Provincie modenesi* 10(2):209-13.

BERTONE A, FOZZATI L. 2006. Les palafittes de Viverone et le Bronze moyen de l'Italie nord-occidentale. In: HAFNER A, NIFFELER U, RUOFF U, editors. Die neue Sicht. Une nouvelle interprétation de l'histoire. The new view. Unterwasserarchäologie und Geschichtsbild. L'apport de l'archéologie subaquatique. Underwater Archaeology and the Historical Picture, Akten des 2. Internationalen Kongresses für Unterwasserarchâologie. Actes du 2e Congrès International d'Archéologie Subaquatique. Proceedings of the 2nd International Congress on Underwater Archaeology (Rüschlikon bei Zurich, 21-24 Oktober 2004). *Antiqua* 40:75-7.

BETTELLI M. 2002. *Italia meridionale e mondo miceneo. Ricerche su dinamiche di acculturazione e aspetti archeologici, con particolare riferimento ai versanti adriatico e ionico della penisola italiana*. Grandi contesti e problemi della Protostoria italiana 5. Firenze.

BIANCHIN CITTON E, MARTINELLI N. 2005. Cronologia relativa e assoluta di alcuni contesti veneti dell'età del Bronzo recente, finale e degli inizi dell'età del Ferro. Nota Preliminare. In: BARTOLONI G, DELFINO F, editors. *Oriente e Occidente: metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del Ferro italiana, Atti* *dell'Incontro di Studio (Roma, 30-31 ottobre 2003*). Pisa. p 239-53.

BIANCO PERONI V. 1970. *Die Schwerter in Italien /Le spade nell'Italia continentale*. Prahistorische Bronzefunde IV 1. Munchen.

BIBBY DI. 2002. *Permutations of the Multilinear Stratigraphic Sequence: Nature, Mathematics and Consequences*. Paper presented at the Workshop 7 "Archäologie und Computer" in Vienna. Powerpoint file on CD. Phoibos Verlag. Vienna 2003.

BICHET P, MILLOTTE J-P. 1992. L'Âge du Fer dans le Haut-Jura. Les tumulus de la région de Pontarlier (Doubs). *Documents d'Archéologie française* 34.

BIETTI SESTIERI AM. 1975. Elementi per lo studio dell'abitato protostorico di Frattesina di Fratta Polesine. *Padusa* XI:1-14.

BIETTI SESTIERI AM. 2000. Cronologia, periodizzazione. In: FRANCOVICH R, MANACORDA D, editors. *Dizionario di archeologia*. Bari.

BIETTI SESTIERI AM. 2009. L'età del Bronzo Finale nella Penisola Italiana. *Padusa* 2008:7-54.

BIETTI SESTIERI AM. 2010. *L'Italia nell'età del bronzo e del ferro. Dalle palafitte a Romolo (2200-700 a.C.)*. Urbino.

BIETTI SESTIERI AM., DE SANTIS A. 2008. Relative and absolute chronology of Latium Vetus from the Bronze Age to the transition to the Orientalizing period. In: BRANDHERM D, TRACHSEL M, editors. *A New Dawn for the Dark Age? Shifting Paradigms in Mediterranean Iron Age Chronology. L'âge obscur se fait-il jour de nouveau? Les paradigmes changeants de la chronologie de l'âge du Fer en Méditerranée, International union for prehistoric and protohistoric sciences, Proceedings of the XV World Congress (Lisbon, 4-9 september 2006), vol. 9, Session C35*. Oxford: BAR International Series 1871. p 119-33.

BIGLER B. 2005. Der Rhinsberg bei Eglisau, Kanton Zürich. Eine spätbronzezeitliche Höhenbefestigung. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 88:169-200.

BIGLER B. 2006. Neue Funde der Bronze- und Eisenzeit aus dem Kanton Zug. *Jahrbuch Archäologie Schweiz* 89:137-64.

BILLAMBOZ A. 1992. Bausteine einer lokalen Jahrringchronologie des Federseegebietes. *Fundberichte aus Baden-Württemberg* 17(1):293-306.

BILLAUD Y. 1995. *Sévrier, Les Mongetes (Haute-Savoie)*. Direction du Patrimoine, Sous-Direction de l'Archéologie. Bilan scientifique des centres nationaux.

BILLAUD Y. 1997. Les Mongets. *Gallia Informations* 1996:244.

BILLAUD Y. 1999. Laprade, Lamotte-du-Rhône (Vaucluse): un habitat de plaine à architecture de terre au Bronze final 2b. *Bulletin de la Société préhistorique française* 96(4):607-21.

BILLAUD Y. 2000. Mise en évidence d'aménagements du Néolithique ancien/moyen et du Bronze final dan le fleuve Charente à Saint Simon / l'Ile des Bois. In: BONNAMOUR L. 2000. *Archéologie des fleuves et des rivières*. Château-Gontier. p 132-5.

BILLAUD Y. 2002a. Laprade (Lamotte-du-Rhône). In: BUISSON-CATIL J, VITAL J, editors. Âges du Bronze en Vaucluse, Département de Vaucluse. *Notices d'Archéologie Vauclusienne* 5. *Travaux du Centre d'Archéologie Préhistorique de Valence* 4:176-88.

BILLAUD Y. 2002b. Laprade (Lamotte-du-Rhône, Vaucluse). L'âge du Bronze final 2b. In: Archéologie du TGV Méditerranée. Fiches de synthèse. Tome 2. La Protohistoire. *Monographies d'Archéologie Méditerranéenne* 9:504-20.

BILLAUD Y. 2008. Les stations littorales de l'âge du Bronze final: perception et évaluation d'un patrimoine subaquatique. In: JACQUET S, DOMAIZON I, POULENARD J, ARNAUD F, editors. *Autour du Lac du Bourget. Actes du colloque pluridisciplinaire (Le Bourget-du-Lac, 15-17 mai 2006).* Thonon-les-Bains. p 49-54.

BILLAUD Y, MARGUET A. 2006. Inventaire et diagnostic des sites immergés des lacs subalpins. In: RAMSEYER D, ROULIÈRE-LAMBERT M-J, editors. *Archéologie & érosion – 2. Zones humides en péril. Actes de la deuxième Rencontre Internationale (Neuchâtel, 23-25 septembre 2004).* Lonsle-Saunier: Centre Jurassien du Patrimoine. p 98-109.

BILLAUD Y, MARGUET A. 2007. Les installations littorales de l'âge du Bronze dans les lacs alpins français. État des connaissances. In: MORDANT C, RICHARD H, MAGNY M, editors. Environnements et cultures à l'âge du Bronze en Europe occidentale. Actes du 129e Congrès national des Sociétés Historiques et Scientifiques (Besançon, 19-21 avril 2004). Besançon. *Documents préhistoriques* 21:211-25.

BILLAUD Y, MARGUET A, SIMONIN O. 1992. Chindrieux, Châtillon (Lac du Bourget, Savoie). Ultime occupation des lacs alpins français à l'Âge du Bronze?. In: *Archéologie et environnement des milieux aquatiques: lacs, fleuves et tourbières du domaine alpin et de sa périphérie, Actes du 116e Congrès national des sociétés savantes (Chambéry, 1991).* p 277-310.

BINFORD L. 1971. Mortuary Practices: their study and potential. In: Approaches to the Social Dimensions of Mortuary Practices. *Memoirs of the Society for American Archaeology* 25:6-29.

BINTLIFF JL. 1997. Regional survey, demography and the rise of complex societies in the Ancient Aegean: Core-Periphery, Neo-Malthusian, and other Interpretive Models. *Journal of Field Archaeology* 24:1-38.

BLAAUW M. 2010. Method and code for "classical" age-modellling of radiocarbon sequences. *Quaternary Geochronology* 5:512-8.

BLAAUW M, CHRISTEN JA, MAUQUOY D, VAN DER PLICHT J, BENNETT JD. 2007. Testing the timing of radiocarbon-dated events between proxy archives. *The Holocene* 17(2):283-8.

BLACKHAM M. 1998. The unitary association method of relative dating and its application to archaeological data. *Journal of Archaeological Method and Theory* 5(2):165-206.

BLACKWELL PG, BUCK CE, REIMER PJ. 2006. Important features of the new radiocarbon calibration curves. *Quaternary Science Reviews* 25:408–13.

BLAIZOT F, FABRE L, WATTEZ J, VITAL J, COMBES P. 2004. Un système énigmatique de combustion au Bronze moyen sur le plateau d'Espalem (canton de Blesle, Haute-Loire). *Bulletin de la Société préhistorique française* 101(2):325-44.

BLAIZOT F, THIÉRIOT F. 2001. Un rituel original à la fin de l'âge du Bronze. Les inhumations en fosse des sites des Estournelles et de La Plaine à Simandres (Rhône). *Gallia Préhistoire* 42(2000):195-256.

BLANC C. 1982. Lons - Tumulus 2-3-4-5-6, informations archéologiques de la circonscription d'Aquitaine. *Gallia Préhistoire* 25(2):432.

BLANC C. 1994. Des tumulus ont-ils été érigés à l'Âge du Fer en Béarn?. *Aquitania* 12:147-163.

BLANC C. 2000. Archéologie protohistorique de la vallée d'Ossau (P.A.). Essai de synthèse. *Archéologie des Pyrénées Occidentales et des Landes* 19:7-27.

BLASCO MC. 1993. *El Bronce Final*. Madrid.

BLASCO MC., BARRIO J, PINEDA P. 2007. La revitalización de los ritos de enterramiento y la implantación de las necrópolis de incineración en la cuenca del Manzanares: La necrópolis de Arroyo Butarque. *Zona Arqueológica* 10(2):215-38.

BLEČIĆ KAVUR M. 2011. The fastest way to the Big Sea. A contribution to the knowledge about the influencee of the UFC on the territory of the northern Adriatic. In: GUTJAHR C, TIEFENGRABER G, editors. Beiträge zur Mittel- und Spätbronzezeit sowie zur Urnenfelderzeit am Rande der Südostalpen, Akten des 1. Wildoner Fachgespräches vom 25. bis 26. Juni 2009 in Wildon/Steiermark (Österreich). *Internationale Archäologie* 15:51-62.

BLEICHER N. 2013. Summed radiocarbon probability density functions cannot prove solar forcing of Central European lake-level changes. *The Holocene* 23(5):755-65.

BLOCKLEY SPE, BLAAUW M, BRONK RAMSEY C, VAN DER PLICHT J. 2007. Building and testing age models for radiocarbon dates in Late Glacial and Early Holocene sediments. *Quaternary Science Reviews* 26:1915-26.

BLOT J. 1976. Les Tumulus de Bixustia et de Zuhamendi III (Compte rendu de fouilles). *Munibe* 28:290.

BLOT J. 1977. Le cromlechs d'Errozaté (Compte rendu de fouilles). *Munibe* 29:77-85.

BLOT J. 1978. Le tumulus-cromlech de Méhatzé (Méhatzé V – Commune de Banca) (Compte rendu de fouilles). *Munibe* 30:173-88.

BLOT J. 1979. Les rites d'incineration en Pays Basque durant la protohistorire. *Munibe* 31:219-36.

BLOT J. 1984a. Les cromlechs d'Apatesaro I et Ibis (Compte rendu de fouilles). *Munibe* 36:91-7.

BLOT J. 1984b. Le tumulus d'Apatesaro IV (Compte-rendu de fouille). *Munibe* 36:99-104.

BLOT J. 1986. Le Tumulus-Cromlech de Zaho II (Compte rendu de fouille 1983) autorisation n.° 001546 programmée H 23. *Munibe* 38:97-106.

BLOT J. 1988. Le Tumulus d'Apatesaro V (Compte rendu de fouilles 1985). *Munibe* 40:89-94.

BLOT J. 1991a. Le cercle de pierres d’Urdanarre Sud 1 (Compte rendu de fouille 1989). *Munibe* 43:191-6.

BLOT J. 1991b. Le tumulus-chromlech de Millagate V (Compte rendu de fouilles 1987). *Munibe* 43:181-9.

BLOT J. 1992. Le tumulus Apatesaro VI (Compte-rendu de fouilles 1990). *Munibe* 43:57-63.

BLOT J. 1993. Le tumulus Urdanarre Nord 1 (Compte-rendu de fouilles 1991). *Munibe* 45:143-51.

BLOT J. 1994. Le cromlech Hegieder 7 (compte-rendu de fouille de sauvetage d'urgence autorisation n° 92-12). *Munibe* 46:133-41.

BLOT J. 1995. Contribution à l'étude des cercles de pierres en Pays Basque de France. *Bulletin de la Société Préhistorique Française* 92(4):525-48.

BLOT J. 1997. Le Baratze (cercle de pierres) Méatsé 11 (commune d' Itxassou, Labourd. PA). Compte rendu de fouille de sauvetage 1996 (Autorisation 96/56). *Munibe* 49:95-106.

BLUMEN W, editor. 1990. *Atmospheric processes over complex terrain.* Boston.

BLUMER R. 2005. Bulle FR, La Prila 2. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 88:326-7.

BLUMER R, SAUTEUR E. 2005. Bulle FR, La Prila 1. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 88:326.

BOARETTO E. 2007. Determining the chronology of an archaeological site using radiocarbon: minimizing uncertainty. *Israel Journal of Earth Science* 56(2-4):207-16.

BOARETTO E. 2009. Dating materials in good archaeological contexts: the next challenge for radiocarbon analysis. *Radiocarbon* 51(1):275-82.

BOCQUET A, PAPET N. 1966. La Grotte des Sarrasins, Seyssinet-Pariset (Isère). *Bulletin de la Société dauphinoise d'Ethnologie et d'Archéologie* 365-367:119-24.

BOISAUBERT JL, BOUYER M, ANDERSON T, MAUVILLY M, AGUSTONI C, MORENO CONDE M. 1992. Quinze années de fouilles sur le tracé de la RN1 et ses abords. *Archäologie der Schweiz* 15(2):41-51.

BOIS-GERETS J, BUARD J-F, NICOD P-Y, VORUZ J-L. 1991. La stratigraphie de la grotte du Gardon et son importance pour la chronologie du Néolithique et de l'Âge du Bronze. In: Actes des Rencontres Néolithique en Rhône-Alpes, Actualité de la Recherche, Université Lumière-Lyon III/URA 36 CNRS. Valence. Centre d'Archéologie Préhistorique. *Arenera* 6:55-73.

BONANI G, BEER J, HOFMANN H, SYNAL H-A, SUTER M, WOLFLI W, PFLEIDERER C, KROMER B, JUNGHANS C, MÜNICH KO. 1987. Fractionation, precision and accuracy in ^{14}C and ^{13}C measurements. *Nuclear Instruments and Methods in Physics Research B* 29(1-2):87-90.

BÖNISCH E. 1987. Ein jüngbronzezeitlicher Bestattungsplatz der Lausitzer Kultur von Altdöbern, Kr. Calau. *Veröffentlichungen des Museums für Ur- und Frühgeschichte Potsdam* 21:145-71.

BÖNISCH E. 1990. Das jungbronzezeitliche Gräberfeld der Lausitzer Kultur Saalhausen 2, Kr. Senftenberg. *Veröffentlichungen des Museums für Ur- und Frühgeschichte Potsdam* 24:63-169.

BÖNISCH E, WETZEL G. 1982. Die Gräberfelder der Lausitzer Kultur von Saalhausen, Kr. Senftenberg. *Ausgrabungen und Funde* 27:52-7.

BONNAMOUR L. 1965. Un habitat protohistorique à Ouroux-sur-Saône. *Gallia Préhistoire* XI:386-8.

BONNAMOUR L. 1968. Un habitat protohistorique à Ouroux-sur-Saône. *Gallia Préhistoire* VIII:110-2.

BONNAMOUR L. 1972. Première campagne de fouille sur le site protohistorique des Rives à Saint-Germain-du-Plain (Saône-et-Loire). *Comptes-rendu d'activités annuelles de l'Association Régionale pour le développement des recherches de Paléontologie et de Préhistorie et des Amis du Muséum de Lyon* 1972:34-7.

BONNAMOUR L. 1973a. Fouille d'un habitat de la fin de l'Age du Bronze à Epervans (Saône-et-Loire). *Revue archéologique de l'Est et du Centre-Est* XXIV(1):69-127.

BONNAMOUR L. 1973b. Saint-Germain-du-Plain (71), Habitat protohistorique des Rives. Fouille 1973. *Comptes-rendu d'activités annuelles de l'Association Régionale pour le développement des recherches de Paléontologie et de Préhistorie et des Amis du Muséum de Lyon* 1973:35-40.

BONNNAMOUR L. 1974a. Saint-Marcel-Epervans: La pièce au Loup. *Mémoires de la Société d'histoire et d'archéologie de Chalon sur Saône* 44:22-5.

BONNAMOUR L. 1974b. Trouvailles de la fin de l'Age du Bronze dans la Sâone, sur le site d'Ouroux-Marnay (S et L). *Bulletin de la Société préhistorique française* 71(6):185-91.

BONNAMOUR L. 1983. Dragage et archéologie dans la Saône, les dernières découvertes. *Archéologia* 174:38-43.

BONNAMOUR L. 1989. L'habitat bronze final du Gué des Piles à Chalon-sur-Saône (Saône-et-Loire). *Gallia Préhistoire* 31:159-89.

BONNAMOUR L. 1998. Bateaux de Saône: 3000 ans d'évolution. *Archaeonautica* 14:13-21.

BONNAMOUR L. 2000. *Archéologie des fleuves et des rivières*. Château-Gontier.

BONNET C, LAMBACH F, PLOUIN S. 2004. Le tertre II de Colmar-Riedwihr (Haut-Rhin): évolution d'un monument funéraire du bronze Ancien à La Tène A. *Bulletin de la Société préhistorique française* 101(3):547-94.

BONNET C, PLOUIN S. 1979. Nouvelles fouilles dans les terres du Kastenwald, Appenwihr VI. *Cahiers Alsaciens d'Archéologie d'Art et d'Historie* 1979:23-8.

BONNET C, PLOUIN S, LAMBACH F. 1981. Les tertres du Bronze moyen d'Appenwihr, forêt de Kastenwald (Haut-Rhin). *Bulletin de la Société préhistorique française* 78(10-12):432-71.

BOQUER S, GONZÁLVEZ L, MERCADAL O, RODON T, SÁENZ L. 1990. Les estructures del Bronze Antic-Bronze Mitjà al jaciment arqueologic de Can Roqueta (Sabadell, Vallès Occidental). *Arrahona* 7:9-25.

BOQUET A. 1976. *La grotte des Sarrasins à Seyssinet-Pariset*. Livret guide Excursion A9. IXème congrès UISPP. p 133-8.

BOQUET A. 1997. Le Crêt de Châtillon. *Gallia Informations* 1996:244.

BOCQUET-APPEL JP, NAJI S, VANDER LINDEN M, KOZLOWSKI JK. 2009. Detection of diffusion and contact zones of early farming in Europe from the space-time distribution of 14C dates. *Journal of Archaeological Science* 36:807-20.

BORDES F. 1967. Considerations sur la typologie et les techniques dans le Paléolithique. *Quärtar Volumen* 18:25-55.

BOREL L. 1973. La grotte des Sarrasins à Seyssinet-Pariset(Isère-France): les habitats des Âge des Métaux: analyse pollinique. *Belgiga Antica* 7:237-43.

BORRELLI P, DOMDEY C, HOELZMANN P, KNITTER D, PANAGOS P, SCHÜTT B. 2014. Geoarchaeological and historical implications of late Holocene landscape development in the Carseolani Mountains, central Apennines, Italy. *Geomorphology* 216:26-39.

BOSCH A, CHINCHILLA J, MERCADAL O, TARRÚS J. 1993. El paradolmen de Tafaina (Ventalló). *Cypsela* 10:33-50.

BOSCH GIMPERA P. 1919. *Prehistoria catalana*. Barcelona.

BOSCH GIMPERA P. 1921. Los celtas y la civilización céltica en la Península Ibérica. *Boletín de la Sociedad Española de Excursiones* 29.

BOSCH GIMPERA P. 1932. *Etnología de la Península Ibérica*. Barcelona.

BOSCH GIMPERA P. 1942. Two Celtic waves in Spain. *Proceedings of the British Academy* 26:1-126.

BOSCH GIMPERA P. 1944. *El poblamiento antiguo y la formación de los pueblos de España*. México.

BOTTO M. 2005. Per una riconsiderazione della cronologia degli inizi della colonizzazione fenicia nel Mediterraneo centro-occidentale. In: BARTOLONI G, DELFINO F, editors. *Oriente e Occidente: metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del Ferro italiana, Atti dell'Incontro di Studio (Roma, 30-31 ottobre 2003).* Pisa. p 579-628.

BOUBY L, BILLAUD Y. 2001. Économie agraire à la fin de l'âge du Bronze sur les bords du lac du Bourget (Savoie, France). *Comptes Rendus de l'Académie des Sciences Series IIA Earth and Planetary Science* 333:749-56

BOUBY L, FAGES G. 2005. Étude carpologique des réserves végétales de la grotte de Baume Layrou (Trèves, Gard). Aspects de la production agraire et fonction du site au Bronze final. *Documents d'Archéologie Méridionale* 28:45-60.

BOUBY L, FAGES G, TREFFORT M. 2005. Food storage in two Late Bronze Age caves of

Southern France: palaeoethnobotanical and social implications. *Vegetation History and Archaeobotany* 14(4):313-28.

BOUBY L, LEROY F, CAROZZA L. 1999. Food plants from late Bronze Age lagoon sites in Languedoc, southern France: reconstruction of farming economy and environment. *Vegetation History and Archaeobotany* 8:53-69.

BOURGEOIS J. 1989. *De ontdekking van nieuwe grondstoffen en de eerste metaalbewerkers in Temse en in het Waasland*. In: THOEN H, editor. *Temse en de Schelde. Van Ijstijd tot Romeinen*. Brussels. p 44-68.

BOUYER M, BOISAUBERT L. 1992. La nécropole de l'âge di Bronze de Murten/Löwenberg. *Archäologie der Schweiz* 15(2):68-73.

BOUZEK J. 1985. The Aegean, Anatolia and Europe: Cultural Interrelations in the Second Millennium B.C. *Studies in the Mediterranean Archa*eology 29.

BOWDEN MJ. 2004. Moore's Law and the technology S-curve. *Current Issues in Technology Management* 8(1):1-4.

BOWMAN S. 1990. *Radiocarbon Dating. Interpreting the Past*. Berkeley.

BOYCE AJ, KUCHEMANN CH, HARRISON GA. 1967. Neighbourhood knowledge and the distribution of marriage distances. *Annals of Human Genetics* 30:335-8.

BOYCE DS, PARKE D, CORRIE WJ. 1971. The identification of optimum production systems by network analysis, dynamic programming. *Journal of Agricultural Engineering Research* 16(2):141-5.

BOYD R, RICHERSON PJ. 1985. *Culture and the evolutionary process*. Chicago.

BRADLEY R. 1989. Comment on A. Cannon: The historical dimension in mortuary expressions of status and sentiment. *Current Anthropology* 30 (4): 448-449.

BRADLEY R. 1990. *The passage of arms: an archaeological analysis of prehistoric hoards and votive deposits*. Cambridge.

BRAMANTI B, THOMAS MG, HAAK W, UNTERLAENDER M, JORES P, TAMBETS K, ANTANAITIS-JACOBS I, HAIDLE MN, JANKAUSKAS R, KIND C-L, LUETH F, TERBERGER T, HILLER J, MATSUMURA S, FORSTER P, BURGER J. 2009. Genetic discontinuity between local hunter–gatherers and Central Europe's first farmers. *Science* 326:137-140.

BRAY PJ, POLLARD AM. 2012. A new interpretative approach to the chemistry of copper-alloy objects: source, recycling and technology. *Antiquity* 86:853-867.

BRÉHARD S. 2005. Exploitation des animaux domestiques et structuration de l'espace montagnard à l'Âge du Bronze: Llo (Cerdagne, Pyrénées-Orientales). *Anthropozoologica* 40(1):217-33.

BRIOIS F, CRUBÉZY E, CAROZZA L. 2000. La grotte Sindou (Lot): une sépulture familiale du Bronze final. *Bulletin de la Société préhistorique française* 97(4):553-9.

BROCHIER J-E, CLAUSTRE F. 2000. Le parcage des bovins et le problème des litières du Néolithique final à l'Âge du bronze dans la Grotte de Bélesta. In: GASCÓ J, CLAUSTRE

F, editors. 2000. *Habitats, économies et sociétés du Nord-Ouest Méditerranéen de l'Âge du Bronze au premier Âge du Fer, Actes du Colloque International, XXIVe Congrès Préhistorique de France (Carcassonne, 26-30 septembre 1994)*. Joué-lès-Tours. p 27-36.

BROCHIER J-L. 1992. *Les grottes de Pellebit-Courtinasse, Treschenu-Creyers, Drôme, Rapport de sondage, 1992*. C.A.P. de Valence. ERA 36 du CRA du CNRS.

BROMBACHER C, KLEE M, JACOMET S. 2005. *Münchenwiler – im Loch 1. Botanische Makroreste aus einer spätbronzezeitlichen Grube*. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6(B):559-68.

BRONK RAMSEY C. 1998. Probability and Dating. *Radiocarbon* 40(1):461-74.

BRONK RAMSEY C. 2008. *OxCal 4.0 Manual: online web resource*. Oxford.

BRONK RAMSEY C. 2009a. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1):337-60.

BRONK RAMSEY C. 2009b. Dealing with outliers and offsets in radiocarbon dating. *Radiocarbon* 51(3):1023-45.

BRONK RAMSEY C, MANNING SW, GALIMBERTI M. 2004. Dating the volcanic eruption at Thera. *Radiocarbon* 46(1):325-44.

BROWN LA. 1981. *Innovation Diffusion. A new perspective*. London.

BROWN S, BIERMAN P, LINI A, DAVIS PT, SOUTHON J. 2002. Reconstructing lake and drainage basin history using terrestrial sediment layers: analysis of cores from a post-glacial lake in New England, USA. *Journal of Paleolimnology* 28:219-36.

BRUN P. 1984. La Civilisation des Champs d'Urnes, étude critique dans le bassin parisien. *Documents d'Archéologie Française* 4.

BRUN P. 1989. L'entité 'Rhin-Suisse-France orientale': nature et evolution. In: BRUN P, MORDANT C, editors. Le groupe Rhin-Suisse-France orientale et la notion de civilization des Champs d'Urnes, Actes du colloque international de Nemours 1986. *Mémoires du Musée de Préhistoire d'Ile-de-France* 1:599-620.

BRUN P, CHAUME B, DHENNEQUIN L, QUILLIEC B. 2009. Le passage de l'âge du Bronze à l'âge du Fer ... au fil de l'épée. In: ROULIERE-LAMBERT M-J, DAUBIGNEY A, MILCENT P-Y, TALON M, VITAL J, editors. De l'âge du Bronze à l'âge du Fer en France et en Europe occidentale (X^{e} – VII^{e} siècle av. J.-C.). La moyenne vallée du Rhône aux âges du Fer, Actes du XXXe colloque international de l'A.F.E.A.F., co-organisé avec l'A.P.R.A.B. (Saint-Romain-en-Gal, 26-28 mai 2006). Dijon. *Revue Archéologique de l'Est* 27:477-85.

BRUN P, MORDANT C, editors. 1989. Le groupe Rhin-Suisse-France orientale et la notion de civilization des Champs d'Urnes, Actes du colloque international de Nemours 1986, *Mémoires du Musée de Préhistoire d'Ile-de-France* 1.

BRYANT D, FILIMON F, GRAY D. 2005. Untangling our past: Languages, Trees, Splits and Networks. In: MACE R, HOLDEN C, SHENNAN S, editors. *The evolution of cultural diversity: phylogenetic approaches*. p 69-85.

BRYSON RU., BRYSON RA, RUTER A. 2006. A calibrated radiocarbon database of late

Quaternary volcanic eruptions. *eEarthDiscussion* 1:123-4.

BUCH M, MARTÍ M, DÍAZ J, PARPAL A, CARLÚS X, VILLAFRUELA J. 1992a. *Informe de la destrossa dels treballs duts a terme entre el 3 d'agost i el 15 de setembre del 1992 a Can Filuà (Santa Perpètua de Mogoda)*. Servei d'Arqueologia. Departament de Cultura de la Generalitat de Catalunya.

BUCH M, MARTÍ M, DÍAZ J, PARPAL A, CARLÚS X., VILLAFRUELA J. 1992b. *Memòria d'excavació dels treballs duts a terme entre el 3 d'agost i el 15 de setembre del 1992 a Can Filuà (Santa Perpètua de Mogoda)*. Servei d'Arqueologia de la Generalitat de Catalunya.

BUCK CE, BLACKWELL PG. 2004. Formal statistical models for estimating radiocarbon calibration curves. *Radiocarbon* 46(3):1093-102.

BUCK CE, CAVANAGH WG, LITTON CD. 1996. *Bayesian approach to interpreting archaeological data*. Chichester (UK).

BUCK CE, CHRISTEN JA, JAMES GN. 1999. Towards Bcal: an on-line Bayesian radiocarbon calibration facility. In: EVIN J, editor. Actes du 3ème Congrès Internacional ^{14}C et Archéologie (Lyon, 6-10 avril 1998). *Mémoires de la Société Préhistorique Française* XXVI:113-7.

BUCK CE, KENWORTHY JB, LITTON CD, SMITH AFM. 1991. Combining archaeological and radiocarbon information: a Bayesian approach to calibration. *Antiquity* 65(249):808-21.

BUCK CE, LITTON CD, SMITH AFM. 1992. Calibration of radiocarbon results pertaining to related archaeological events. *Journal of Archaeological Science* 19(5):497-512.

BUCK CE, LITTON CD, SCOTT EM. 1994. Making the most of radiocarbon dating: some statistical considerations. *Antiquity* 68(259):252-63.

BUCK CE, MILLARD AR, editors. 2004. *Tools for constructing chronologies. Crossing disciplinary baundaries*. London: Springer.

BUCK CE, SAHU SK. 2000. Bayesian models for relative archaeology chronological building. *Journal of the Royal Statistical Society: Series C* 49(4):423.40.

BUISSON-CATIL J. 2002a. Aven des Fourches I (Sault). In: BUISSON-CATIL J, VITAL J, editors. Âges du Bronze en Vaucluse, Département de Vaucluse. *Notices d'Archéologie Vauclusienne* 5. *Travaux du Centre d'Archéologie Préhistorique de Valence* 4:139-50.

BUISSON-CATIL J. 2002b. Irrisson (Goult). In: BUISSON-CATIL J, VITAL J, editors. Âges du Bronze en Vaucluse, Département de Vaucluse. *Notices d'Archéologie Vauclusienne* 5. *Travaux du Centre d'Archéologie Préhistorique de Valence* 4:73-5.

BUISSON-CATIL J. 2002c. La Blaoute (Crillon-le-Brave). In: BUISSON-CATIL J, VITAL J, editors. Âges du Bronze en Vaucluse, Département de Vaucluse. *Notices d'Archéologie Vauclusienne* 5. *Travaux du Centre d'Archéologie Préhistorique de Valence* 4:119.

BUISSON-CATIL J, SAUZADE G. 1997. Le gisement Bronze final de l'aven des Fourches 1 à Sault. Contribution à l'étude fonctionnelle des cavités karstiques des plateaux de Vaucluse. *Documents d'Archéologie Méridionale* 19-20:7-31.

BUI THI M, COURTAUD P, DUMONTIER P, GIRARD M, MIRABAUD S, REGERT M. 2011. Analyses du contenu des vases déposés en contexte sépulcral au Bronze ancien et moyen dans les grottes de Droundak et Homme de Pouey (Pyrénées Atlantiques). In: *Actes 8 Rencontres Méridionales de Préhistoire Récente (Marseille, 7-8 novembre 2008)*. p 449-56.

BUNGE W. 1962. *Theoretical Geography*. Lund.

BYERS AM. 1991. Structure, Meaning, Action and Things: The Duality of Material Culture Mediation. *Journal for the Theory of Social Behaviour* 21:1-29.

BUCHANAN B, COLLARD M, EDINBOROUGH K. 2008. Palaeo-Indian demography and the extraterrestrial impact hypothesis. *Proceedings of the National Academy of Sciences* 105:11651-4.

CAILLAT P. 1984. La grotte du Phare: inventaire de la faune. *Bulletin de la Société préhistorique française* 81(10-12):355-6.

CAIRONI T, CATTANI M, DEBANDI F, GUERRA L, POLI V, RAVAGLIA M, VACCARI B. 2009. I materiali dell'abitato di Solarolo nel quadro del popolamento della Romagna e delle aree limitrofe tra la fine della media età del Bronzo e l'età del Bronzo recente. In: CATTANI M, editor. Atti della Giornata di studi "La Romagna nell'età del Bronzo" (Ravenna, Solarolo, 19 settembre 2008). *IpoTESI di Preistoria* 2(1):230-49.

CALLIGARIS F, COLONNELLO S, DEL FABBRO A, PERRONE S. 1991. Udine Radiocarbon Laboratory date list III. *Radiocarbon* 33(1):141-9.

CAMPBELL L. 1998. *Historical linguistics. An introduction*. Edinburgh.

CAMPMAJO P. 1983. *Le site protohistorique de Llo (Pyrénées Orientales)*. Perpignan.

CAMPMAJO P. 1986. Le Bronze Final I sur le site de Llo. In: *Actes del 6è Col·loqui internacional d'Arqueologia de Puigcerdà (Puigcerdà 1984)*. p 47-57.

CAMPOLO S. 2006. Découverte récente d'un dépôt de bronzes de l'âge du Bronze final à Savines (Hautes-Alpes). In: COUDENNEAU A, LACHENAL T, editor. *Espaces, techniques et sociétés de la Préhistoire au Moyen-Age: travaux en cours, Actes de la première table ronde des jeunes chercheurs en archéologie de la MMSH*.

CAMPOREALE G. 2010. L'età dei principi in Etruria. In: CELUZZA M, CIANFERONI GC, editors. *Signori di Maremma. Élites etrusche fra Populonia e Vulci, Catalogo della mostra (Museo Archeologico Nazionale, Firenze 2010)*. Firenze. p 21-34.

CANDUSSIO A. 1980. *Recenti scoperte preistoriche a Pozzuolo del Friuli*. Società Filologica Friulana. Udine. p 78-84.

CANN RL, STONEKING M, WILSON AC. 1987. Mitochondrial DNA and human evolution. *Nature* 325:31-6.

CAPUZZO G, BOARETTO E, BARCELÓ JA. 2014. EUBAR: A database of ^{14}C measurements for the European Bronze Age. A Bayesian analysis of ^{14}C-dated archaeological contexts from Northern Italy and Southern France. *Radiocarbon* 56(2):851-69.

CARACUTA V, FIORENTINO G, MARTINELLI MC. 2012. Plant remains and AMS: dating climate change in the Aeolian Islands (Northeastern Sicily) during the 2nd millennium BC.

In: BOARETTO E, REBOLLO FRANCO NR, editors. Proceedings of the Sixth Radiocarbon and Archaeology Symposium (Paphos, Cyprus, 10–15 April 2011). *Radiocarbon* 54(3-4):689-700.

CARANCINI GL, CARDARELLI A, PACCIARELLI M, PERONI R. 1996. L'Italia. In: BELARDELLI C, PERONI R, editors. *The Bronze Age in Europe and the Mediterranean, Absolute, relative and comparative chronological sequences, Colloquium XX, XIII Congresso dell'UISPP (Forlì, 8-14 September 1996)*. p 75-86.

CARDARELLI A. 1997. La necropoli di Casinalbo (MO). In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 688-96.

CARDARELLI A, CREMASCHI M, CATTANI M, LABATE D, STEFFE' G. 1997. Nuove ricerche nella terramara di Montale (MO). Primi risultati. In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 224-8.

CARDARELLI A, PELLACANI G. 2004. La necropoli di Casinalbo. In: COCCHI GENICK D, editor. *L'età del bronzo recente in Italia, Atti del Congresso Nazionale (Lido di Camaiore, 26-29 ottobre 2000)*. Viareggio (LU). p 111-20.

CARDARELLI A, SALVADEI L, SANTANDREA E, TIRABASSI J. 2003. Le prime grandi necropoli ad incinerazione in Italia: le necropoli terramaricole di Casinalbo (Modena) e Montata (Reggio Emilia). In: *Atti della XXXV Riunione Scientifica. vol. I*. p 299-322.

CARDARELLI A, LABATE D, PELLACANI G. 2006. Oltre la sepoltura: testimonianze rituali ed evidenze sociali dalla superficie d'uso della necropoli della terramara di Casinalbo. In: *Studi in Onore di Renato Peroni*. p 624-42.

CARLÚS X. 1999. La cabana del bronze inicial de la Vall Suau (Sant Quirze del Vallès, Vallès Occidental). *Limes* 6-7:19-39.

CARLÚS X, DIAZ J. 1995. El jaciment del Bronze Inicial de Can Ballarà (Terrassa, Vallès Occidental). *Terme* 10:38-45.

CARLÚS X, GONZALEZ J. 2008. Carrer de la Riereta, 37-37 bis: un nou assentament prehistòric al pla de Barcelona. Primers resultats. *Cypsela* 17:91-114.

CARLÚS X, LÓPEZ CACHERO FJ, OLIVA M, PALOMO A, RODRIGUEZ A, TERRATS N, LARA C, VILLENA N. 2007. Cabanes, sitges i tombes. El paratge de Can Roqueta (Sabadell, Vallès Occidental) del 1300 al 500 A.C., *Quaderns d'Arqueologia* 4. Museu d'Història de Sabadell.

CARLÚS X, LÓPEZ CACHERO FJ, TERRATS N, OLIVA M, PALOMO A, RODRIGUEZ A. 2008. Diacronia durant la prehistòria recent a Can Roqueta (Sabadell – Barberà del Vallès, Vallès Occidental) entre el VI i el I mil·leni cal ane. *Cypsela* 17:115-42.

CAROZZA L. 1990. L'habitat en grotte de la Garenne a Pech-Egos (Penne). *Archéologie Tarnaise* 5:67-90.

CAROZZA L. 1994. De l'Age du bronze a l'Age du fer en Albigeois. *Archives d'Ecologie Préhistorique* 13.

CAROZZA L. 1995. Aspects du Bronze final dans le bassin Audois et en Albigeois. In: *X Colloqui international d'arqueologia de Puigcerdà, hommage au professeur Jean Guilaine*. p 377-83.

CAROZZA L, BOUBY L, BALLUT C. 2006. Un habitat du Bronze moyen à Cournon-d'Auvergne (Puy-de-Dôme): nouvelles données sur la dynamique de l'Âge du Bronze moyen sur la bordure méridionale du Massif central. *Bulletin de la Société préhistorique française* 103(3):535-84.

CAROZZA L, GALOP D, MAREMBERT F, MONNA F. 2006. Quel statut pour les espaces de montagne durant l'âge du Bronze? Regards croisés sur les approches société-environnement dans les Pyrénées occidentales. *Documents d'Archéologie Méridionale* 28:7-23.

CAROZZA L, GEORJON C. 2006. La fin du Néolithique et les débuts de la métallurgie en Languedoc central: contrôle social du territoire et pratiques économiques entre 3200 et 2400 av. J.-C. dans la moyenne vallée de l'Hérault. In: Colloque interrégional sur le Néolithique n. 25 (Dijon, 20/10/2001). *Revue archéologique de l'Est* 25:215-37.

CAROZZA L, LAGARRIGUE A, PONS F. 1996-1997. Le mobilier des habitats Bronze final du Clot et de Lacaze-Haute (Castres, Tarn). *Documents d'Archéologie meridionale* 19-20:57-78.

CAROZZA L, MARCIGNY C. 2007. *L'âge du Bronze en France*. Tours.

CARTONNET M. 1984. Résumé de l'étude anthropologique des sépultures du Bronze ancien dans la grotte du Pic à Songieu (Ain). *Comptes-rendu d'activités annuelles de l'Association Régionale pour le développement des recherches de Paléontologie et de Préhistorie et des Amis du Muséum de Lyon* 1984:43-5.

CARTONNET M. 1985. La Grotte du Pic. *Gallia Préhistoire* 28(2):388-90.

CARTONNET M. 1986. La grotte sépulcrale du Pic à Songieu (Ain). *Études Préhistoriques* 17:17-22.

CASAS I GENOVER J. 2001. Mas Gusó-Puig Moragues (Bellcaire d'Empordà). Materials indígenes del período de transició Bronze-Ferro, importacions gregues i les seves imitacions occidentals. *Cypsela* 13:165-98.

CASETTI E. 1969. Why do diffusion processes conform to logistic trends?. *Geographical analysis* 1(1):101-5.

CASETTI E, SEMPLE RK. 1969. Concerning and testing of spatial diffusion hypotheses. *Geographycal analysis* 1:254-9.

CASSOLA GUIDA P, CORAZZA S, editors. 2004. Dai Tumuli ai Castellieri: 1500 anni di storia in Friuli (2000-500 a.C.). II. 2004. *Aquileia Nostra* LXXV:525-52.

CASSOLA GUIDA P, CORAZZA S, editors. 2005. Dai Tumuli ai Castellieri: 1500 anni di storia in Friuli (2000-500 a.C.). III. 2005. *Aquileia Nostra* LXXVI:345-60.

CASSOLA GUIDA P, CORAZZA S, editors. 2006. Dai Tumuli ai Castellieri: 1500 anni di storia in Friuli (2000-500 a.C.). IV. 2006. *Aquileia Nostra* LXXVII:297-314.

CASSOLA GUIDA P, CORAZZA S, FONTANA A, TASCA G, VITRI S. 2004. I castellieri arginati del Friuli. In: COCCHI GENICK D, editor. *L'età del bronzo recente in Italia, Atti del Congresso Nazionale (Lido di Camaiore, 26-29 ottobre 2000)*. Viareggio (LU). p 77-89.

CASSOLA P. 1980. Ricerche a Pozzuolo del Friuli. *Memorie Civici Musei Storia ed Arte* 2:148-65.

CASTANY J, GUERRERO L. 1985. La galeria catalana de La Pera. Ardèvol de Pinós. Solsonès. 1983-84. In: *Memòria arqueològica sepulcres megalítics del Solsonès. Servei d'Arqueologia de la Generalitat de Catalunya*. p 28-59.

CASTANY J, GUERRERO L, FÀBREGAS L. 2005. L'habitat prehistoric de les Portes (Lladurs, Solsonès). *Tribuna d'Arqueologia* 2004-2005:21-43.

CASTELLA D. 1995. Payerne VD, route de Bussy. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 78:202-3.

CASTELLA D, ESCHBACH F. 1994a. Payerne, Neyremont – Habitat préhistorique. Chronique des fouilles archéologiques 1993. *Revue Historique Vaudoise* 1994:211.

CASTELLA D., ESCHBACH F. 1994b. Payerne VD, Neyremont. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 77:178.

CASTRO PV. 1994. *La sociedad de los campos de urnas en el nordeste de la Península Ibérica. La necrópolis de El Calvari (El Molar, Priorat, Tarragona)*. Oxford: BAR International Series 592.

CASTRO PV, LULL V, MICÓ R. 1996. *Cronología de la Prehistoria Reciente de la Península Ibérica y Baleares*. Oxford: BAR International Series 652.

CATLING HW. 1968. Late Minoan vases and bronzes in Oxford. *Annual of the British School at Athens* 63:89-131.

CATTANI M. 2009a. Gli scavi nell'abitato di via Ordiere a Solarolo (RA) e il progetto di ricerca sull'età del Bronzo in Romagna. In: CATTANI M, editor. Atti della Giornata di studi "La Romagna nell'età del Bronzo" (Ravenna, Solarolo, 19 settembre 2008). *IpoTESI di Preistoria* 2(1):115-30.

CATTANI M. 2009b. L'ansa cilindro-retta come indicatore delle interazioni culturali nel Bronzo Recente. In: CATTANI M, editor. Atti della Giornata di studi "La Romagna nell'età del Bronzo" (Ravenna, Solarolo, 19 settembre 2008). *IpoTESI di Preistoria* 2(1):250-4.

CATTANI M. 2011. Contributo alla definizione della fase iniziale della media età del Bronzo in Italia centro-settentrionale: le impugnature con appendice ad ascia. *IpoTESI di Preistoria* 4(2):63-87.

CATTANI M, MARCHESINI M, MARVELLI S, editors. 2010. *Paesaggio ed economia nell'età del Bronzo, la pianura bolognese tra Samoggia e Panaro*. Bologna.

CATTANI M, MIARI M. 2010. La Romagna tra antica e recente età del Bronzo. In: *Atti XLV IIPP, Preistoria e protostoria dell'Emilia Romagna (Modena, 26-31 ottobre 2010)*. p 1-30.

CAVA A, BEGUIRISTAN MA. 1991-1992. El yacimiento prehistórico del abrigo de la Peña (Marañon, Navarra). *Trabajos de arqueología Navarra* 10:69-166.

CAVALLI-SFORZA LL. 1997. *Genes, pueblos y lenguas*. Barcelona.

CAVALLI-SFORZA LL. 2002. Demic diffusion as the basic process of human expansion. In: BELLWOOD P, RENFREW C, editors. *Examining the farming/language dispersal hypothesis*. Cambridge. p 79-88.

CAVALLI-SFORZA LL, EDWARDS AWF. 1967. Phylogenetic analysis: models and estimation procedure. *American Journal of Human Genetics* 19:233-57.

CAVALLI-SFORZA LL, MENOZZI P, PIAZZA A. 1993. Demic expansions and human evolution. *Science* 259:639-46.

CAVALLI-SFORZA LL, MENOZZI P, PIAZZA A. 1994. *The history and geography of human genes.* Princeton (NJ).

CAVALLO C. 2000. Analisi dei resti faunistici rinvenuti nel villaggio palafitticolo dell'Antica età del Bronzo (cultura di Polada) di Lagazzi Piadena (CR). In: *Atti del 2° Convegno Nazionale di Archeozoologia, Forlì*. p 231-9.

CEBRIÀ A. 2000. *La Cova de la Guineu (Font-rubí, Alt Penedès). Ocupacions i usos d'una cavitat de la Serra de Font-rubí (Alt Penedès) des del tardiglacial fins a l'era moderna. Memòria de les campanyes realitzades en els anys 1997-1998-1999*. Servei d'Arqueologia de la Generalitat de Catalunya.

CEBRIÀ A, BARTROLÍ R. 1997. *La Cova de la Guineu . Ocupacions i usos d'una cavitat de la Serra de Font-rubí (Alt Penedès) del tardiglacial fins a l'era moderna. Memòria de les campanyes realitzades en els anys 1997-1998 i 1999*. Servei d'Arqueologia de la Generalitat de Catalunya.

CERDEÑO ML, MARCOS F, SAGARDOY T. 2002. Campos de urnas en la Meseta Oriental: nuevos datos sobre un viejo tema. *Trabajos de Prehistoria* 59(2):135-47.

CHAIX L. 1990. *La faune d'Ayent-le-Château (Valais, Suisse; Bronze ancien et Bronze final). Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 73:44-6.

CHAMBERLAIN A. 2009. Archaeological Demography. *Human Biology* 81(2-3):275-86.

CHAPMAN R, KINNES I, RANDSBORG K, editors. 1981. *The archaeology of death.* Cambridge.

CHASE-DUNN C, HALL TD. 1991. *Core/periphery relations in precapitalist worlds*. Boulder.

CHASE-DUNN C, HALL TD. 1993. Comparing World-Systems: concepts and working hypotheses. *Social Forces* 71:851-86.

CHASE-DUNN C, HALL TD. 1997. *Rise and demise: comparing world-systems*. Boulder, CO.

CHASTEL J. 1988. Une structure de combustion de l'Âge du Bronze final à En Pierret, commune de Briord, Ain. In: Actes des rencontres protohistoriques de Rhône-Alpes. *Eléments de protohistoire rhodanienne et alpine* 1:125-30.

CHAUCAT C. 1984. La grotte du Phare de Biarritz premiers résultats. *Bulletin de la Société préhistorique française* 81(10-12):343-54.

CHAUCHAT C. 1987. Analyse palynologique du sédiment de l'une des cistes de la nécropole du col de Méatsé (Itxassou). *Bulletin du Musée Basque* 115:19-20.

CHAUME B. 2001. Vix et son territoire à l'Age du Fer. Fouilles du mont Lassois et environnement du site princier. *Protohistoire européenne* 6.

CHELLA P, GIANNICHEDDA E, LANZA R, OTTOMANO C. 1998. Novà – Via Larga. In: DEL LUCCHESE A, MAGGI R, editors. Dal diaspro al bronzo. L'Età del Rame e l'Età del Bronzo in Liguria: 26 secoli di storia fra 3600 e 1000 anni avanti Cristo. *Quaderni della Soprintendenza Archeologica della Liguria* 5:151-5.

CHESHER A. 1991. The effect of measurement error. *Biometrika* 78(3):451-62

CHILDE VG. 1929. *The Danube in Prehistory*. Oxford.

CHILDE VG. 1939 *The dawn of European civilization*. New York.

CHILDE VG. 1950. The Urban Revolution. *The Town Planning Review* 21(1):3-17.

CHIQUET P, de CEUNINCK G, VORUZ J-L. 2005. "L'affaire F 647...". In: MORDANT C, DEPIERRE G, editors. *Les pratiques funéraires à l'âge du bronze en France, Actes de la table ronde de Sens-en-Bourgogne (Yonne)*. Paris. p 81-101.

CHIVERRELL RC, THORNDYCRAFT VC, HOFFMANN TO. 2011. Cumulative probability functions and their role in evaluating the chronology of geomorphological events during the Holocene. *Journal of Quaternary Science* 26(1):76-85.

Chronologie. Archäologische Daten der Schweiz. Datation archéologique en Suisse 1986. Antiqua 15.

CICHOCKI O. 2003. Neue neolithische und Urnenfelderzeitliche Holzfunde aus dem Keutschacher See. *NAU (Nachrichtenblatt Arbeitskreis Unterwasserarchäologie)* 10:47-50.

CLARAMUNT C, PARENT C, THERIAULT M. 1997. *Design Patterns for Spatio-temporal Processes*. IFIP 2.6 Working Conference on Database Semantics, DS7.

CLARK JD, editor. 1982. *The Cambridge History of Africa, Volume I*. Cambridge.

CLARKE DL. 1968. *Analytical Archaeology*. Metheun, London.

CLARKE DL. 1977 *Spatial Archaeology*. London.

CLAUSTRE J. 2013. *La necropole de Vilanova à Ceret*. Association archéologique des Pyrénées-Orientales.

CLOP X, FAURA JM. 1995. *El sepulcre megalític de Les Maioles (Rubió, l'Anoia). Memòria definitiva dels resultats de l'excavació arqueológica*. Servei d'Arqueologia de la Generalitat de Catalunya.

CLOP X, FAURA JM. 2002. El sepulcre megalític de Les Maioles (Rubió, Anoia). Pràctiques funerarias i societat a l'altiplà de Calaf (2000-1600 cal ANE). *Estrat* 7. Centre d'Estudis Comarcal d'Igualada.

CLOTTES J. 1969. Le Lot Préhistorique, Inventaire Préhistorique et Protohistorique (des origines au premier âge du Fer inclus). *Supplémen au Bulletin de la Société des Etudes Littéraires, Scientifiques et Artistiques du Lot* XC (3-4).

CLOTTES J, CARRIÈRE M. 1979. Le gisement préhistorique de Capdenac-le-Haut. In: *La préhistoire du Quercy dans le contexte de Midi-Pyrénées, Congrès Préhistorique de France, XXIe Session (Montauban-Cahors, septembre 1979), vol. 1*. p 29-30.

CLOTTES J, CONSTANTINI G. 1976. Les civilisations de l'âge du Bronze dans les Causses. In: GUILAINE J, editor. *La préhistoire française, II*. Paris. p 470-82.

CLOTTES J, LORBLANCHET M. 1969. La grotte du Noyer (Esclaizels, Lot). (note préliminaire). In: *Congrès Préhistorique de France, IXIXe Session Auvergne*. Paris. p 145-64.

COCCHI GENICK D. 1992. La media età del Bronzo al Riparo Grande (Camaiore, Lucca). *Origini* 15:283-302.

COCCHI GENICK D, editor. 1995. *Aspetti culturali della media età del bronzo nell'Italia centro-meridionale*. Firenze.

COCCHI GENICK D, editor. 1996. *L'antica età del Bronzo in Italia, Atti del Congresso (Viareggio, 9-12 gennaio 1995)*. Firenze.

COCCHI GENICK D. 1998. *L'antica età del Bronzo nell'Italia centrale. Profilo di un'epoca e di un'appropriata strategia metodologica*. Firenze.

COCCHI GENICK D, editor. 2004. *L'età del bronzo recente in Italia, Atti del Congresso Nazionale (Lido di Camaiore, 26-29 ottobre 2000)*. Viareggio (LU).

COCCHI GENICK D, DAMIANI I, MACCHIAROLA I, PERONI R, POGGIANI KELLER R, VIGLIARDI A. 1992. 2. L'Italia centro-meridionale. In: L'Età del Bronzo in Italia nei secoli dal XVI al XIV a.C. (Viareggio, 26-30 ottobre 1989). Firenze. *Rassegna di Archeologia* 10:69-103.

COCCHI GENICK D, DAMIANI I, MACCHIAROLA I. 1993. Motivi decorativi del Bronzo medio preappenninico. *Rivista di scienze preistoriche* XLV:167-218.

COCKIN G, FURESTIER R, editors. 2009. *A8 Saint-Maximin/Chemin de Barjols à Saint-Maximin-la-Sainte-Baume (Var). Rapport final d'opération. Fouilles archéologiques préventives*. Mauguio. Oxford: Archéologie Méditerranée.

COLLARD M, BUCHANAN B, HAMILTON MJ, O'BRIEN MJ. 2010a. Spatiotemporal dynamics of the Clovis-Folsom transition. *Journal of Archaeological Science* 37(10):2513-9

COLLARD M, EDINBOROUGH K, SHENNAN S, THOMAS MG. 2010b. Radiocarbon evidence indicates that migrants introduced farming to Britain. *Journal of Archaeological Science* 37(4):866-70

COLLARD M, SHENNAN SJ, TEHRANI JJ. 2006. Branching versus Blending in Macroscale Cultural Evolution: A Comparative Study. In: LIPO CP, O' BRIEN MJ, COLLARD M, SHENNAN SJ. 2006. *Mapping Our Ancestors*. USA. p 53-63.

COLOMER A, PONS E. 1986. El primer nivell d'ocupació de la Fonollera (Torroella de Montgrí). In: *6è Col·loqui internacional d'Arqueologia de Puigcerdà (Puigcerdà 1984)*. p 79-86.

COM. SCI. C.A.I. di Modena, Gruppo Archeologico. 1970. Gli scavi a S. Michele di Valestra negli anni 1968 e 1969. *Emilia preromana* 6:49-50.

CONSCIENCE A-C. 2001. Frübronzezeitliche Uferdörfer aus Zürich-Mozartstrasse-eine folgenreiche Neudatierung. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 84:147-57.

CONVERTINI F, VITAL J, RODET-BELARBI I, MANNIEZ Y. 2010. Les occupations du site de terrasse de l'Euze à Bagnoles-sur-Cèze (Gard) du Néolithique final au Bronze final 1. *Bulletin de la Société préhistorique française* 107(2):291-329.

COOPER G, AMOS W, HOFFMAN D, RUBINSZTEIN DC. 1996. Network analysis of human Y microsatellite haplotypes. *Human Molecular Genetics* 5(11):1759-66.

CORAZZA S, SIMEONI G, ZENDRON F. 2006. *Tracce archeologiche di antiche genti. La protostoria in Friuli*. Montereale Valcellina (PN).

CORNAGGIA CASTIGLIONI O. 1967. Le piroghe preistoriche italiane. Problematica e inventario dei reperti. *Natura* 58:5-48.

CORTESI C, LEONARDI G. 1997. *New radiometric data on the Molina di Ledro lake-dwelling (excavation 1980 and 1983)*. Preistoria Alpina 33:133-8.

COURTAUD P, DUMONTIER P. 2010. La cavité sépulcrale de l'Homme de Pouey a Laruns (64): les aménagements funéraires dans une grotte de l'âge du Bronze. In: BEECHING A, THIRAULT E, VITAL J, editors. Économie et société à la fin de la Préhistoire, Actes des 7e Rencontres Méridionales de Préhistoire Récente tenues à Bron (Rhône), les 3 et 4 novembre 2006. *Documents d'Archéologie en Rhône-Alpes et en Auvergne* 34:347-58.

COURTAUS P, DUMONTIER P, ARMAND D, FERRIER C, HILD G. 2007. La grotte sépulcrale de Droundak. In: FOUÉRÉ P, CHEVILLOT C, COURTAUD P, FERULLO O, LEROYER C, editors. *Paysages et peuplements. Aspects culturels et chronologiques en France méridionale, Actes du VIe Rencontres Méridionales de Préhistoire Récente (Périgueux, 14-16 octobre 2004)*. p 191-210.

COURTIN J. 1975. Un habitat fortifié du Bronze ancien en basse-Provence: Le Camp de Laure, commune du Rove (Bouches-du-Rhône). *Bulletin du Musée d'Histoire Naturelle de Marseille* 35:217-40.

CRABOL D. 1986. L'Age du Fer en Cerdagne Française. In: *Actes del 6è Col·loqui internacional d'Arqueologia de Puigcerdà (Puigcerdà 1984)*. p 59-86.

CRADDOCK PT. 1995. *Early metal mining and production*. Edinburgh.

CRÉGUT-BONNOURE E. 2002. Aven du Vieux Chamois (Brantes). In: BUISSON-CATIL J, VITAL J, editors. Âges du Bronze en Vaucluse, Département de Vaucluse. *Notices d'Archéologie Vauclusienne* 5. *Travaux du Centre d'Archéologie Préhistorique de Valence* 4:135.

CREMA E. 2012. Modelling temporal uncertainty in archaeological analysis. *Journal of Archaeological Method and Theory* 19:440-61.

CREMASCHI M. 1997. Il sito d'altura di S. Michele di Valestra (RE). In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 285-6.

CREMASCHI M. 2004. Le datazioni radiocarboniche. In: CREMASCHI M, BERNABÒ BREA MA, editors. *Il villaggio della terramara di Santa Rosa di Poviglio. Scavi 1987-1992*. Firenze. p 693-702.

CREMASCHI M, BERNABÒ BREA MA, editors. 2004. *Il villaggio della terramara di Santa Rosa di Poviglio. Scavi 1987-1992*. Firenze.

CREMASCHI M, FERRARI P, PIZZI C, DI MARTINO S. 2006. La piccola terramara collinare di Ca' Manzini, Motta di San Bartolomeo (Codemondo, Reggio Emilia). *Padusa* XLII:7-23.

CREMASCHI M, PIZZI C. VALSECCHI V. 2006. Water management and land use in the terramare and a possible climatic cofactor in their abandonment: the case study of the terramara of Poviglio Santa Rosa (northern Italy). *Quaternary International* 151:87-98.

CREMONESI G. 1967. I materiali provenienti dal territorio di Vho conservati nel Museo Civico di Cremona. *Atti e Memorie della Società Toscana di Scienze Naturali* 74(2).

ČREŠNAR M. 2010. New research on the Urnfield period of Eastern Slovenia. A case study of Rogoza near Maribor. *Arheološki vestnik* 61:7-119.

CRESSIE N. 1993. *Statistics for spatial data*. New York.

CROMBÉ P, ROBINSON E. 2014. ^{14}C dates as demographic proxies in Neolithisation models of northwestern Europe: a critical assessment using Belgium and northeast France as a case-study. *Journal of Archaeological Science*.

CRUBÉZY E, LUDES B, POUJOL J, editors. 2004. Pratiques et espaces funéraires: Les Grands Causses au Chalcolithique. *Monographies d'Archéologie Méditerranéenne* 17.

CUBAS M, GARCÍA-HERAS M, MÉNDEZ D, DE PEDRO I, ZAPATA L, IBÁÑEZ JJ, GONZÁLEZ URQUIJO JE. 2012. La tecnología cerámica de los niveles IV y III en el yacimiento de Kobaederra (Cortézubi, Bizkaia). Aprovisionamiento y modificación de las materias primas. *Trabajos de Prehistoria* 69(1):51-64.

CUNLIFFE B. 2001. *Facing the Ocean: the Atlantic and its peoples.* Oxford.

CUNLIFFE B. 2003. *The Celts: a very short introduction*. New York.

CUNLIFFE B, KOCH JT, editors. 2010. *Celtic from the West: alternative perspectives from archaeology, genetics, language and literature*. Oxford.

CUPITÒ M. 2011. Micenei in Italia settentrionale. In: MARZATICO F, GEBHARD R, GLEIRSCHER P, editors. 2011. *Le grandi vie delle civiltà. Relazioni e scambi fra Mediterraneo e il centro Europa dalla preistoria alla romanità, Catalogo della Mostra*. Trento-Castello del Buonconsiglio. p 193-7.

CUPITÒ M, DALLA LONGA E, DONADEL V, LEONARDI G. 2012. Resistance to the 12th

century BC crisis in the Veneto Region: the case studies of Fondo Paviani and Montebello Vicentino. In: KNEISEL J, KIRLEIS W, DAL CORSO M, TAYLOR N, TIEDTKE V, editors. Collapse or continuity? Environment and development of Bronze Age human landscapes. *Universitätsforschungen zur prähistorischen Archäologie* 205:55-70.

CUPITÒ M, LEONARDI G. 2005. La necropoli di Olmo di Nogara e il ripostiglio di Pila del Brancón. Proposte interpretative sulla struttura e sull’evoluzione sociale delle comunità della pianura veronese tra Bronzo medio e Bronzo recente. In: ATTEMA P, NIJBOER A, ZIFFERERO A, editors. Communities and Settlements from the Neolithic to the Early Medieval Period, Proceedings of the 6th Conference of Italian Archaeology, Groningen, The Netherlands, April 15th-17th April 2003. *British Archaeological Reports* 1452(1):143-55.

CURA M, THOMMERET Y, GUILAINE J. 1975. Une datation C14 du dolmen de la Llanera (Solsona). *Pyrenae* 11:154-5.

CURDY P, DONATI B, LEUZINGER-PICCAND C, LEUZINGER-PICCAND U, SCHINDLER M, SPICHTIG N, ZAPPA F. 2000. Prospezioni archeologiche in alcune località dell'Alta Valmaggia. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 83:177-180.

CURRIE TE, MACE R. 2009. Political complexity predicts the spread of ethnolinguistic groups. *Proceeding of the National Academy of Sciences of the United States of America (PNAS)* 106(18):7339-44.

DAFFLON L, MAUVILLY M, RUFFIEUX M. 2009. Grandvillard FR, Fin de la Porta. *Jahrbuch Archäologie Schweiz* 92:277.

DAL RI L. 1985. Scavo di una casa dell’età del Ferro a Stufles-Stufels, quartiere di Bressanone (Stufles B). In: *Tutela dei Beni Culturali in Alto Adige* 1985. p 195-241.

DAL RI L. 1992. Note sull’insediamento e sulla necropoli di Vadena (Alto Adige). In: METZGER IR, GLEIRSCHER P, editors. *Die Räter - I Reti*. Collana della Comunità di lavoro regioni alpine (Arge-Alp). Bolzano. p 475-525.

DAL RI L, RIZZI G. 1992. Il colle di Albanbühel in Val d'Isarco (Bolzano). In: L’Età del Bronzo in Italia nei secoli dal XVI al XIV a.C. (Viareggio, 26-30 ottobre 1989). Firenze. *Rassegna di Archeologia* 10:626-7.

DAL RI L, TECCHIATI U. 1992, *L’insediamento di Tolerait in Val d’Adige (Bolzano)*. In: L’Età del Bronzo in Italia nei secoli dal XVI al XIV a.C. (Viareggio, 26-30 ottobre 1989). Firenze. *Rassegna di Archeologia* 10:628-9.

DAL RI L, TECCHIATI U. 2004. Una sepoltura ad incinerazione della cultura di Luco da Barbiano – Ex Casa di ricovero (Val d’Isarco, Bz). *Padusa* XL:171-89.

DAMMINGER F, SCHAUER P. 1998. Die Ausgrabungen auf dem Bogenberg, Lkr. Straubing-Bogen, Niederbayern. Resultate der Kampagnen 1997. *Vorträge des Niederbayerischer Archäologentages* 16:115-24

DAMMINGER F, SCHAUER P. 1999. Der Bogenberg in Niederbayern. Vorbericht über die Untersuchungsergebnisse der Jahre 1997-1998. *Archäologisches Korrespondenzblatt* 29:517-36.

DAMON PE. 1987. The history of calibration of radiocarbon dates by dendrochronology. In:

AURENCHE O, EVIN J, HOURS F, editors. *Chronologies in the Near East*. Oxford: BAR International Series 379. p 61-104.

DAUGAS JP, GILBERT A, RAYNAL JP. 1983. Premières sépultures du Néolithique ancien en Basse-Auvergne. *Bulletin de la Sociéte d'Anthropologie du Sud-Ouest* 18(1):44-52.

DAUGAS JP, TIXIER L. 1975. Premières observations sur la nécropole médiévale du Puy-Saint-André à Busséol (Puy-de-Dôme) et les niveaux protohistoriques. *Nouvelles archives du Musém d'histoire naturelle de Lyon* 13:29-38.

DAUMAS J-C, LAUDET R. 1981-1982. L'habitat du Bronze final des Gandus à Saint-Ferréol-Trente-Pas (Drôme). *Etudes Préhistoriques* 16:1-32.

DAVEAU I, editor. 2007. Port Ariane (Lattes, Hérault): construction deltaïque et utilisation d'une zone humide lors des six derniers millénaires. *Lattara* 20.

DAVID-ELBIALI M. 1987. Occupations en grotte à l'âge du Bronze récent/final en Haut-Valais (Grotte In Albon). *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 70:65-76.

DAVID-ELBIALI M. 1990. L'âge du Bronze en Valais et dans le Chablais vaudois: un état de la recherché. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 73:19-43.

DAVID-ELBIALI M. 1995. Genève-Parc de la Grange-Tente Botta: vestiges de la fin du Bronze final. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 78:164-8.

DAVID-ELBIALI M. 2009. Des femmes et des hommes dans l'arc alpin occidental entre le XIIe et le VIIe siècle av. J.-C. In: ROULIERE-LAMBERT M-J, DAUBIGNEY A, MILCENT P-Y, TALON M, VITAL J, editors. De l'âge du Bronze à l'âge du Fer en France et en Europe occidentale (X^{e} – VII^{e} siècle av. J.-C.). La moyenne vallée du Rhône aux âges du Fer, Actes du XXXe colloque international de l'A.F.E.A.F., co-organisé avec l'A.P.R.A.B. (Saint-Romain-en-Gal, 26-28 mai 2006). Dijon. *Revue Archéologique de l'Est* 27:343-60.

DAVID-ELBIALI M, DAVID W. 2009. À la suite de Jacques-Pierre Millotte, l'actualité des recherches en typologie sur l'âge du Bronze, le Bronze ancien et le début du Bronze moyen: cadre chronologique et liens culturels entre l'Europe nord-alpine occidentale, le monde danubien et l'Italie du Nord. In: ANNICK R, BARRAL P, DAUBIGNEY A, KAENEL G, MORDANT C, PININGRE JF, editors. *L'isthme européen Rhin-Saône-Rhône dans la Protohistoire. Approches nouvelles en hommage à Jacques-Pierre Millotte, Actes du colloque (Besançon, 16 -18 octobre 2006)*. Paris. p 311-40.

DAVID-ELBIALI M, DUNNING C. 2005. Le cadre chronologique relatif et absolu au nord-ouest des Alpes entre 1060 et 600 av. J.-C. In: BARTOLONI G, DELFINO F. 2005, editors. *Oriente e Occidente: metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del Ferro italiana, Atti dell'Incontro di Studio (Roma, 30-31 ottobre 2003)*. Pisa. p 145-94.

DAVID-ELBIALI M, MOINAT P. 2005. Le Bronze final de la Suisse occidentale: révision du cadre chronotypologique, grâce aux découvertes de la nécropole de Lausanne-Vidy (canton de Vaud, Suisse). *Bulletin de la Société préhistorique Française* 102(3):613-24.

DAVISON K, DOLUKHANOV P, SARSON G, SHUKUROV A. 2006. The role of waterways in the spread of the Neolithic. *Journal of Archaeological Science* 33(5):641-52.

DAY W, COSMAS J, RYAN N, VEREENOOGHE T, GOOL L, VAN WAELKENS M, TALLOEN P. 2005. *Linking 2D Harris Matrix with 3D Stratigraphic Visualisations: an integrated approach to archaeological Visualisations*. Paper presented at the CAA Conference 2005 in Tomar.

DEAN JS. 1978. Independent dating in archaeological analysis. In: SCHIFFER B, editor. *Advances in archaeological method and theory. Vol. I.* New York. p 223-55.

DE BEULE H. 2010. Phylogenetic relations and geographic distribution. *The Russian Journal of Genetic Genealogy* 1(2):56-71.

DE BEULE H. 2011. Origin, migrations and expansion of haplogroup I-L38 in relation to Haplogroup R1b. *The Russian Journal of Genetic Genealogy* 2(1):10-30.

DÉCHELETTE J. 1910. *Manuel d'archéologie prehistorie, celtique et gallo-romaine*. Paris.

DEDET B. 1985. Les gisements lagunaires à l'âge du Bronze final. In: DEDET B, PY M. 1985. L'occupation des rivages de l'étang de Mauguio (Hérault) au Bronze final et au premier Âge du Fer. Tome III. Synthèses et Annexes. *Cahiers de l'Association pour la Recherche Archéologique en Languedoc Oriental* 13:5-46.

DEDET B. 2001. L'archéologie funéraire de l'âge du Bronze dans le Sud-Est de la France (1995-2000). *Documents d'Archéologie Méridionale* 24:238-42.

DEDET B, GAUTHEY J. 1996-1997. La nécropole de Malausette (Soustelle, Gard) à l'Age du Bronze, aux VI^e^ et V^e^ siècles avant J.-C. *Documents d'Archéologie Méridionale* 19-20:89-142.

DEDET B, PY M, SAVAY-GUERRAZ H. 1985. L'occupation des rivages de l'étang de Mauguio (Hérault) au Bronze final et au premier Âge du Fer. Tome II. Sondages et sauvetages programmés (1976-1979). *Cahiers de l'Association pour la Recherche Archéologique en Languedoc Oriental* 12.

DEDET B, PY M. 1985. L'occupation des rivages de l'étang de Mauguio (Hérault) au Bronze final et au premier Âge du Fer. Tome III. Synthèses et Annexes. *Cahiers de l'Association pour la Recherche Archéologique en Languedoc Oriental* 13.

DEDET B., ROUQUETTE D. 2002. *L'habitat du Bronze final des Courtinals à Mourèze (Hérault): fouilles du C.R.A. des Chênes verts en 1961*. *Documents d'Archéologie Méridionale* 25:33-63.

DEDIU D. 2009. Genetic biasing through cultural transmission: Do simple Bayesian models of language evolution generalize?. *Journal of Theoretical Biology* 259:552-561

DE FINETTI B. 1974. *Theory of probability: a critical introductory treatment (Vol. 1)*. New York.

DEGER-JALKOTZY S. 2006. Late Mycenaean Warrior Tombs. In: DEGER-JALKOTZY S, LEMOS IS, editors. Ancient Greece: from the Mycenaean Palaces to the Age of Homer. *Edinburgh Leventis Studies* 3:151-79.

DE GROSSI MAZZORIN J. 1996. Archeozoologia delle "ossa di bruti" provenienti dagli scavi della stazione preistorica sul Monte Castellaccio presso Imola. In: PACCIARELLI M, editor. *La collezione Scarabelli, Preistoria, II*. Casalecchio di Reno. p 181-218.

DE GUIO A, WHITEHOUSE R, WILKINS J. 1990. Progetto Alto-Medio Polesine-Basso Veronese: quarto rapporto. *Quaderni di Archeologia del Veneto* VI:217-38.

DE GUIO A, WHITEHOUSE R, WILKINS J. 1994. Progetto Alto-Medio Polesine-Basso Veronese: settimo rapporto. *Quaderni di Archeologia del Veneto* X:115-30.

DE GUIO A, WHITEHOUSE R, WILKINS J. 1995. Progetto Alto-Medio Polesine-Basso Veronese: ottavo rapporto. *Quaderni di Archeologia del Veneto* XI:166-78.

DEHLING H, VAN DER PLICHT J. 1993. Statistical problems in calibrating radiocarbon dates. *Radiocarbon* 35(1):239-44.

DE JONG AFM, MOOK WG. 1981. Natural C-14 variations and consequences for sea-level fluctuations and frequency analysis of periods of peat growth. In: VAN LOON AJ, editor. Quaternary Geology: A Farewell to A. J. Wiggers. *Geologie en Mijnbouw* 60:331-6.

DEL CASTILLO MF, BARCELÓ JA, MAMELI L. 2013. Formalización y dinámica social: la simulación computacional en arqueología. *Atek Na* 3:35-73

DEL CASTILLO MF, BARCELÓ JA, MAMELI L, MIGUEL F, VILA X. 2014. Modeling mechanisms of cultural diversity and ethnicity in hunter-gatherers. *Journal of Archaeological Method and Theory* 21(2):364-84.

DELIBRIAS G, EVIN J, THOMMERET Y. 1982. Sommaire des datations ^{14}C concernant la préhistoire en France, II - Dates parues de 1974 à 1982, Chapitre VI: NÉOLITHIQUE: de environ 7000 BP à environ 4000 BP. *Bulletin de la Société préhistorique française* 79(6):175-92.

DELIBRIAS G, GUILLIER M-T. 1988. Gif Natural Radiocarbon Measurements XI. *Radiocarbon* 30(1):61-124.

DELIBRIAS G, GUILLIER MT, EVIN J, THOMMERET J, THOMMERET Y. 1976. *Datations absolues des dépôts quaternaires et des sites préhistoriques par le méthode du carbone 14*. In: *La Préhistoire Française. Tome I*. p 859-99. *Tome II*. p 1499-514.

DELIBRIAS G, GUILLIER M-T, LABEYRIE J. 1964. Saclay Natural Radiocarbon Measurements I. *Radiocarbon* 6:233-50.

DELIBRIAS G, GUILLIER M-T, LABEYRIE J. 1969. Gif Natural Radiocarbon Measurements III. *Radiocarbon* 11(2):327-44.

DELIBRIAS G, GUILLIER M-T, LABEYRIE J. 1970. Gif Natural Radiocarbon Measurements V. *Radiocarbon* 12(2):421-43.

DELIBRIAS G, GUILLIER M-T, LABEYRIE J. 1971. Gif Natural Radiocarbon Measurements VI. *Radiocarbon* 13(2):213-54.

DELIBRIAS G, GUILLIER M-T, LABEYRIE J. 1972. Gif Natural Radiocarbon Measurements VII. *Radiocarbon* 14(2):280-320.

DELIBRIAS G, GUILLIER M-T, LABEYRIE J. 1974. Gif Natural Radiocarbon Measurements VIII. *Radiocarbon* 16(1):15-94.

DELIBRIAS G, GUILLIER M-T, LABEYRIE J. 1982. Gif Natural Radiocarbon Measurements IX. *Radiocarbon* 24(3):291-343.

DELIBRIAS G, GUILLIER M-T, LABEYRIE J. 1986. Gif Natural Radiocarbon Measurements X. *Radiocarbon* 28(1):9-68.

DELLA CASA P. 2000. Mesolcina Praehistorica: Mensch und Naturraum in einem Bündner Südalpental vom Mesolithikum bis in römische Zeit. *Universitätsforschungen zur prähistorischen Archäologie* 67.

DELLA CASA P. 2013. Switzerland and the Central Alps. In: FOKKENS H, HARDING A, editors. *The Oxford handbook of the European Bronze Age*. Oxford. p 701-22.

DELLA CASA P, BASS B, FEDELE F. 1999. The Grisons Alpine Valley Survey 1995-97: methods, results and prospects of an interdisciplinary research program. In: DELLA CASA P, editor. Prehistoric alpine environment, society, and economy - Papers of the international colloquium PAESE '97 in Zurich. *Universitätsforschungen zur prähistorischen Archäologie* 55:151-72.

DELLA CASA P, FISCHER C. 1997. Neftenbach (CH), Velika Gruda (YU), Kastanas (GR) und Trindhøj (DK) - Argumente für einen Beginn der Spätbronzezeit (Reinecke Bz D) im 14. Jahrhundert v. Chr. *Prähistorische Zeitschrift* 72(2):195-233.

DEL LUCCHESE A. 1984. Resti di sepolture dell'Antica Età del bronzo nella Caverna dell'Acqua o del Morto (Finale Ligure – SV). *Preistoria Alpina* 20:155-68.

DEL LUCCHESE A. 1998. Bric Tana (Millesimo). In: DEL LUCCHESE A, MAGGI R, editors. Dal diaspro al bronzo. L'Età del Rame e l'Età del Bronzo in Liguria: 26 secoli di storia fra 3600 e 1000 anni avanti Cristo. *Quaderni della Soprintendenza Archeologica della Liguria* 5:108-14.

DEL LUCCHESE A. 2004. Il Bronzo Medio e il Bronzo Recente in Liguria (XVI-XII secolo a.C.). In: DE MARINIS RC, SPADEA G, editors. *I Liguri. Un antico popolo europeo tra Alpi e Mediterraneo*. p 117-21.

DEL LUCCHESE A, DE MARINIS R, GAMBARI F. 1992. 1. L'Italia Settentrionale. I. Italia Nord-occidentale. In: L'Età del bronzo in Italia nei secoli dal XVI al XIV a.C. (Viareggio, 26-30 ottobre 1989). Firenze. *Rassegna di Archeologia* 10:31-8.

DEL LUCCHESE A, ODETTI G. 1996. Nuovi dati sull'antica età del Bronzo nellla Liguria di Ponente. In: COCCHI GENICK D, editor. *L'antica età del Bronzo in Italia, Atti del Congresso (Viareggio, 9-12 gennaio 1995)*. Firenze. p 433-40.

DEL LUCCHESE A, ODETTI G. 1998. Il Finalese. In: DEL LUCCHESE A, MAGGI R, editors. Dal diaspro al bronzo. L'Età del Rame e l'Età del Bronzo in Liguria: 26 secoli di storia fra 3600 e 1000 anni avanti Cristo. *Quaderni della Soprintendenza Archeologica della Liguria* 5:90-3.

DEL LUCCHESE A, SCOTTI G. 2004. Il sito di S. Antonino di Perti e il Bronzo recente nel Finalese. In: COCCHI GENICK D, editor. *L'età del bronzo recente in Italia, Atti del Congresso Nazionale (Lido di Camaiore, 26-29 ottobre 2000)*. Viareggio (LU). p 457-62.

DE MARINI R.C. 1988. Liguri e Celto-Liguri. In: *Italia omnium terrarum alumna*. Milano. p 157-259.

DE MARINIS RC. 1991. I Celti golasecchiani. In: MOSCATI S, editor. *I Celti*. Milano. p 93-102.

DE MARINIS RC. 1994. Preistoria e protostoria nel territorio di Lecco. In: CASINI S, editor. 1994. *Carta archeologica della Lombardia. IV Provincia di Lecco*. p 50-6.

DE MARINIS RC. 1997. Le necropoli del Bronzo Medio e Recente nella Lombardia orientale e nel Veneto occidentale. In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 703-7.

DE MARINIS RC. 1999a. Il confine occidentale del mondo proto-veneto/paleo-veneto dal Bronzo Finale alle invasioni galliche del 388 a.C. In: *Protostoria e Storia del Venetorum angulus, Atti XX Convegno Studi Etruschi*. p 511-64.

DE MARINIS RC. 1999b. Towards a relative and absolute chronology of the Bronze Age in Northern Italy. *Notizie archeologiche bergomensi* 7:23-100.

DE MARINIS RC. 2005. Cronologia relativa, cross-dating e datazioni cronometriche tra Bronzo Finale e Primo Ferro: qualche spunto di riflessione metodologica. In: BARTOLONI G, DELFINO F. 2005, editors. *Oriente e Occidente: metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del Ferro italiana, Atti dell'Incontro di Studio (Roma, 30-31 ottobre 2003)*. Pisa. p 15-52.

DE MARINIS R, BIAGGIO SIMONA S, editors. 2000. *I Leponti tra mito e realtà*. Locarno

DE MARINIS RC, SPADEA G, editors. 2004. *I Liguri. Un antico popolo europeo tra Alpi e Mediterraneo.* Genova.

DE MARINIS RC, SPADEA G, editors. 2007. *Ancora su i Liguri. Un antico popolo europeo tra Alpi e Mediterraneo*. Genova.

DE MULDER G, LECLERCQ W, VAN STRYDONCK M. 2008. *Influence from the 'Group Rhin-Suisse-France Orientale' on the pottery from the Late Bronze Age urnfields in Western Belgium. A confrontation between pottery forming technology, 14c-dates and typo-chronology*. Oxford: BAR International Series 1861. p 105-15.

DE MULDER G, VAN STRYDONCK M, BOUDIN M. 2009. The impact of cremated bone dating on the archaeological chronology of the Low Countries. *Radiocarbon* 51(2):579-600.

DE MULDER G, VAN STRYDONCK M, BOUDIN M, LECLERCQ W, PARIDAENS N, WARMENBOL E. 2007. Re-evaluation of the late Bronze Age and early Iron Age chronology of the western Belgian urnfields based on ^{14}C dating of cremated bones. *Radiocarbon* 49(2):499-514.

DE REU J, DE MULDER G, VAN STRYDONCK M, MATHIEU BOUDIN M, BOURGEOIS J. 2012. ^{14}C dates and spatial statistics: modeling intrasite spatial dynamics of urnfield cemeteries in Belgium using case study of Destelbergen cemetery. In: BOARETTO E, REBOLLO FRANCO NR, editors. 2012. Proceedings of the Sixth Radiocarbon and Archaeology Symposium (Paphos, Cyprus, 10–15 April 2011). *Radiocarbon* 54(3-4):635-48.

DERGACHEV VA, RASPOPOV OM, VAN GEEL B, ZAITSEVA GI. 2004. The 'Sterno-Etrussia' geomagnetic excursion around 2700 BP and changes of solar activity, cosmic ray intensity, and climate. *Radiocarbon* 46(2):661-81.

DERGACHEV V, ZAITSEVA G. 1999. Archaeology and geophysical evidence of a 2400 year cycle in natural processes during the Holocene. In: EVIN AJ, OBERLIN C, DAUGAS JP, SALLES JF, editors. *^{14}C and Archaeology. 3rd International Symposium (Lyon 6-10 april 1998)*. Société Prehistorique Française. p 93-8.

DE SANTIS A. 2005. A Research Project on the Earliest Phases of the Latial Culture. In: ATTEMA P, NIBOER AJ, ZIFFERERO A, editors. *Papers in Italian Archaeology VI. Communities and Settlements from the Neolithic to the Early Medieval Period (Oxford 2005)*. p 156-163.

DESANTIS P, MARCHESINI M, MARVELLI S. 2011. *Anzola al tempo delle Terramare*. Bologna.

de SMITH MJ, GOODCHILD MF, LONGLEY PA. 2009. *Geospatial Analysis. A Comprehensive Guide to Principles, Techniques and Software Tools*. Leicester (UK).

DETRAIN L, MAZIÈRE F. 1997. Cazouls-lès-Béziers, La Roumanine. Etude deux fosses de la fin de l'Age du Bronze. In: *Etudes Archéologiques sur le tracé du gazoduc Artère du Midi, Document final de synthèse*. SRA Languedoc-Roussillon. Montpellier.

DHENNEQUIN L. 2005. *L'armement au Premier Âge du fer en Europe tempérée*. Thèse de doctorat. Paris. Université de Paris I Panthéon-Sorbonne.

DIAZ J, BORDAS A, POU R, MARTI M. 1995. Dos estructuras de habitación del neolítico final en el yacimiento de la "Bòbila Madurell" (Sant Quirze del Vallés, Barcelona). In: 1er Congreso de Arqueología Peninsular, (Porto 1993). *Actas dos Trabalhos de Antropologia e Etnologia* 35(1):17-30.

DIAZ J, VILLAFRUELA J. 1997. *Memòria de l'excavació arqueològica del jaciment del Bronze Inicial de La Serreta (Rubí, Vallès Occidental)(12-19 de novembre de 1996)*. Servei d'Arqueologia de la Generalitat de Catalunya.

Die ersten Bauern - Pfahlbaufunde Europas 1990. Forschungen zur Austellung im Schweizerischen Landesmuseum und zum Erlebnispark/Austellung Pfahlbauland in Zürich (28. April bis 30. September 1990). Schweizerisches Landesmuseum Zürich 1990.

Die Urnenfelderkulturen Mitteleuropas 1987. Symposium (Liblice, 21. - 25. 10. 1985). Archäeologisches Institut der Tschechoslowakischen Akademie der Wissenschaften. Praha.

DIECKMANN B. 1998. Siedlungen und Umwelt der Bronzezeit am Federsee und im westlichen Bodenseegebiet. In: HÄNSEL B, editor. *Mensch und Umwelt in der Bronzezeit Europas - Man and Environment in European Bronze Age, Abschlußtagung der Kampagne des Europarates: Die Bronzezeit: das erste goldene Zeitalter an der Freien Universität Berlin, 17.-19. März 1997*. Kiel. p 373-94.

DIEMER G. 1985. Urnenfelderzeitliche Depotfunde und neue Grabungsbefunde vom Bullenheimer: Ein Vorbericht. *Archäologisches Korrespondenzblatt* 15:55-65.

DIEMER G. 1995. Der Bullenheimer Berg und seine Stellung mi Siedlungsgefüge der Urnenfelderkultur Mainfrankens. *Materialhefte zur Bayerischen Vorgeschicht*e Reihe A 70.

DIEMER G, JANNSSEN W, WAMSER L. 1981, Ausgrabungen und Funde auf dem Bullenheimer Berg, Gemeide Ippesheim, Mittelfranken un Gemeinde Seinsheim, Unterfranken. *Das archäologishe Jahr in Bayern* 1981:94-5.

DILLON M, CHADWICK NK. 1967. *The Celtic Realms*. London.

DJINDJIAN F. 1990. *Méthodes pour l'archéologie*. Paris.

DOERR M, PLEXOUSAKIS D, KOPAKA K, BEKIARI C. 2004. Supporting chronological reasoning in archaeology. In: *Proceeding of the Computer Applications and Quantitative Methods in Archaeology Conference, CAA 2004 (Heraclion, Greece).*

DOITEAU S. 1992. Nouvelles données sur l'habitat et le premier Age du fer en Suisse occidentale. In: L'habitat et l'occupation du sol à l'âge du bronze en europe, Actes du colloque international de Lons-le-Saunier (16-19 mai 1990). *Documents préhistoriques* 4:313-25.

DOLUKHANOV PM. 2003. Archaeology and Languages in Prehistoric Northern Eurasia. *Japan Review* 15:175-86.

DOLUKHANOV P, SHURUKOV A, GRONENBORN D, SOKOLOFF D, TIMOFEEV V, ZAITSEVA G. 2005. The chronology of Neolithic dispersal in Central and Eastern Europe. *Journal of Archaeological Science* 32:1441-58.

DONAHUE DJ, JULL AJT, ZABEL R. 1984. Results of radioisotope measurements at the NSF-University of Arizona tandem accelerator mass spectrometer facility. *Nuclear Instruments & Methods in Physics Research Section B* 5(2):162-6.

DONNELLY M, FURESTIER R, editors. 2009. *A8 Saint-Maximin/Chemin d'Herbous à Saint-Maximin-la-Sainte-Baume (Var)*. Rapport final d'opération. Fouilles archéologiques préventives. Mauguio. Oxford: Archéologie Méditerranée.

DORE A. 2005. Il Villanoviano I-III di Bologna: problemi di cronologia relativa e assoluta. In: BARTOLONI G, DELFINO F, editors. *Oriente e Occidente: metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del Ferro italiana, Atti dell'Incontro di Studio (Roma, 30-31 ottobre 2003)*. Pisa. p 255-92.

DORIGO W. 1983. *Venezia origini*. Milano.

DOROT T, BLANC C. 1997. Résultats de la fouille du cercle de pierres du Lac Roumassot (Laruns, Pyr. Atlant.). *Archeologie des Pyrénées Occidentales et des Landes* 16:21-7.

DOYLE J. 2006. *Extending mechanics to minds. The mechanical foundations of psychology and economics*. Cambridge.

DRESCHER-SCHNEIDER R. 2010. Gletscherstände und bronzezeitliche Almnutzung in den Hohen Tauern und am Dachstein (Österreich). Ergebnisse palynologischer Untersuchungen. In: MANDL F, STADLER H, editors. Archäologie in den Alpen. Alltag und Kult. *Forschungsberichte der ANISA* 3:15-24.

DREWS R. 1995. *The End of the Bronze Age: Changes in Warfare and the Catastrophe of ca. 1200 B.C.* Princeton. New Jersey.

DUFRAIGNE J-J, GUILLET E, JALLET F. 2002. Les Pins (Aubais, Gard). Un établissement du début du Bronze ancient. In: *Pirineus i veïns al tercer mil·leni AC. De la fi del neolític a l'edat del bronze entre l'Ebre i la Garona, XII col·loqui Internacional d'Arqueologia de Puigcerdà (Puigcerdà 2000)*. p 245-60.

DU GARDIN C. 2003. Amber spacer beads in the Neolithic and Bronze Ages in Europe. In: BECK CW, LOZE IB, TODD JM, editors. *Amber in Archaeology. Proceedings of the Fourth International Conference on Amber in Archaeology (Talsi 2001).* Riga: Institute of the History of Latvia Publishers. p 180-97.

DUMÉZIL G. 1968. *Mythe et epopée I, L'idéologie des trois fonctions dans les épopées des peuples indo-européens*. Paris.

DUMONTIER P. 1999. La grotte d'Apons à Sarrance (Pyrénées-Atlantiques). Note préliminaire. *Bulletin de la Société préhistorique française* 96(3):444-7.

DUMONTIER P, COURTAUD P, FERRIER C. 2003. *La grotte plurielle de Droundak (Sainte-Engrâce, 64)*. Rapport de fouille programmée, Service régional de l'Archéologie. Bordeaux. p 150-1.

DUMONTIER P, THI MAI B, HEINZ C. 1997. Le dolmen sous tumulus nº 2 de Peyrecor et son paléoenvironnement à Escout (Pyrénées-Atlantiques). *Bulletin de la Société préhistorique française* 94(4):527-50.

DUMONT MA, MOYAT MP. 2005. Un habitat et un dépôt d'objets métalliques protohistoriques découverts dans le lit de l'Hérault à Agde (note d'information). *Comptes-rendus des séances de l'Académie des Inscriptions et Belles-Lettres* 149(1):371-94.

DUNN M, TERRILL A, REESINK G, FOLEY RA, LEVINSON SC. 2005. Structural phylogenetics and the reconstruction of ancient language history. *Science* 309:2072-5.

DÜRRWÄCHTER C. 2009. *Time, Space and Innovation: an Archaeological Case Study on the Romanization of the North-Western Provinces (50 BC to AD 50)*. Oxford: BAR Intenational Series 2011.

Dynamique du Bronze Moyen 1989. Actes du 113e Congrès National des Sociétés Savantes (Strasbourg 1988). Paris.

DZIĘGIELEWSKI K, PRZYBYŁA MS, GALWIK A, editors. 2010. *Migrations in Bronze and Early Iron Age Europe*. Prace Archeologiczne Studies 63. Krakow.

EBERLI U. 2008. B*irmensdorf-Wannenboden. Eine Siedlungsstelle der Spätbronzezeit*. Zürcher Archäologie 23.

ÉBRARD D. 1993. Architecture, stratigraphies et fonctionnements des dolmens I et II d'Ithé (Aussurucq, Pyrrénées-Atlantiques). In: Actes du colloque «Mégalithes du Sud-Ouest» (29 fév. 1992). *Bulletin de la Société d'Anthropologie de Sud-Ouest* XXVIII:151-78.

ECHALLIER J-C. 1988. Données analytiques sur le matériel céramique du site de Tonnerre (Mauguio). Compositions et provenances. *Archéologie en Languedoc* 1988 (1-2):9-13.

ECHALLIER J-C, LEGROS T. 1986. L'analyse pétrographique des poteries du Bronze final trouvées à Martigues (Bouches-du-Rhône). *Cahiers ligures de préhistoire et de protohistoire* 3:259-85.

EDER B, JUNG R. 2005. On the character of social relations between Greece and Italy in the 12th/11th cent. BC. In: LAFFINEUR R, GRECO E, editors. Emporia. Aegeans in the Central and Eastern Mediterranean. Proceedings of the 10th International Aegean Conference, 14-18 April 2004. *Aegaeum* 25:485-95.

EDO M, MILLÁN M, BLASCO A, BLANCH M. 1986. Resultats de les excavacions de la Cova de Can Sadurni (Begues, Baix Llobregat). *Tribuna d'Arqueologia* 1985-1986:33-42.

EHRICH RW, editor. 1992. *Chronologies in Old World Archaeology, Vol. I-II (Third Edition).* USA.

EMBLETON S. 1986. *Statistics in historical linguistics*. Bochum.

EPSTEIN JM. 2006. *Generative social science. Studies in Agent-Based Computational Modeling*. Princeton.

EPSTEIN JM, AXTELL R. 1996. *Growing artificial societies: social science from the bottom up*. Cambridge, MA.

EQUIP GUINEU 1994. *La Cova de la Guineu. Ocupacions i usos d'una cavitat de la Serra de Font-rubí (Alt Penedès) del 9850 BP a l'època recent. Memòria de les campanyes realitzades en els anys 1992-1993*. Servei d'Arqueologia de la Generalitat de Catalunya.

EQUIP MINFERRI 1997. Noves dades per a la caracterizació dels assentaments a l'aire lliure durant la 1ª meitat del II mil·leni cal BC: primers resultats de les excavacions en el jaciment de Minferri (Juneda, les Garrigues). *Revista d'Arqueologia de Ponent* 7:161-211.

EQUIP SARRÓ 2000. Les Roques del Sarró (Lleida, Segrià): Evolució de l'assentament entre el 3.600 cal a.n.e. i el 175 a.n.e. *Revista d'Arqueologia de Ponent* 10:103-73.

ERIKSSON LJ. 1997. How technology evolves. *Complexity* 2(3):23-30.

ERLANDSON JM, RICK TC, KENNETT DJ, WALKER PL. 2001. Dates, demography, and disease: cultural contacts and possible evidence for Old World epidemics among the Island Chumash. *Pacific Coast Archaeological Society Quarterly* 37(3):11-26.

ESCOLA M, VERGER-PRATOUCY J-C, MAYNARD G. 1998. Un tumulus du bronze ancien à Reyjade, commune de Nespouls (Corrèze). *Annales des rencontres archéologiques de Saint-Céré* 5:23-42.

ESPEJO BLANCO JM. 2000-2001. La cerámica con asas de apéndice de botón: un nuevo estado de la cuestión. *Pyrenae* 31-32:29-55.

ESTÉVEZ J, VILA A. 2000. Estratigrafías en contexto. *Krei* 5:29-61.

ÉVIN J, FORTIN P, OBERLIN C. 1995. Calibration et modes de représentation des datations radiocarbones concernant le Néolithique de l'est et du sud-est de la France. In: VORUZ J-L, editor. *Chronologies néolithiques: de 6000 a 2000 avant notre ère dans le Sud-Est de la France*. p 31-9.

EVIN J, LONGIN R, MARIEN G, PACHIAUDI CH. 1971. Lyon Natural Radiocarbon Measurements II. *Radiocarbon* 13(1):52-73.

EVIN J, LONGIN R, PACHIAUDI CH. 1969. Lyon Natural Radiocarbon Measurements I. *Radiocarbon* 11(1):112-7.

EVIN J, MARECHAL J, MARIEN G. 1983. Lyon Natural Radiocarbon Measurementes IX. *Radiocarbon* 25(1):59-128.

EVIN J, MARECHAL J, MARIEN G. 1985. Lyon Natural Radiocarbon Measurementes X. *Radiocarbon* 27(2B):386-454.

EVIN J, MARIEN G, PACHIAUDI CH. 1973. Lyon Natural Radiocarbon Measurements III. *Radiocarbon* 15(1):134-55.

EVIN J, MARIEN G, PACHIAUDI CH. 1975. Lyon Natural Radiocarbon Measurements V. *Radiocarbon* 17(1):4-34.

EVIN J, MARIEN G, PACHIAUDI CH. 1976. Lyon Natural Radiocarbon Measurements VI. *Radiocarbon* 18(1):60-88.

EVIN J, MARIEN G, PACHIAUDI CH. 1978. Lyon Natural Radiocarbon Measurements VII. *Radiocarbon* 20(1):19-57.

EVIN J, MARIEN G, PACHIAUDI CH. 1979. Lyon Natural Radiocarbon Measurements VIII. *Radiocarbon* 21(3):405-52.

FAGES G. 1981. Le gisement préhistorique et protohistorique de Baume Layrou. *Bulletin du Spéléo Club des Causses* 4:37-46.

FAGES G. 1982. Le gisement préhistorique et protohistorique de Baume Layrou. *Spelunca* 5:27-8.

FALKESTEIN F. 1997. *Eine Katastrophen- Theorie zum Beginn der Urnenfelderkultur*. In: ROEDER M, TERŽAN B, editors. *Χρόνος. Beiträge zur prähistorischen Archäologie zwischen Nord - und Südosteuropa. Festschrift für Bernhard Hänsel*. Internationale Archäologie. Studia Honoraria 1. Espelkamp. p 549-61.

FALQUET C, CORBOUD P, editors. 1995. *Prospection archéologique sur le tracé du Projet Rail 2000 entre Onnens (VD) et Vaumarcus (NE).* Genève.

FAUX DK. 2008. *A Genetic Signal of Central European Celtic Ancestry: Preliminary Research Concerning Y-Chromosome Marker U152*. 17 November 2008.

FARO CARBALLA JA, UNZU URMENETA M. 2006. La necropolis de la Edad del Hierro de El Castillo (Castejón, Navarra). Primeras valoraciones: campañas 2000-2002. *Complutum* 17:145-66.

FARWELL GW, GROOTES PM, LEACH DD, SCHMIDT FH. 1984. The accelerator mass spectrometry facility at the University of Washington: current status and an application to the ^{14}C profile of a tree ring. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* 5(2):144-9.

FASANI L, MARTINELLI N. 1994. Problemi relativi alle palafitte italiane alla luce della ricerca dendrocronologica. In: SKEATES R, WHITEHOUSE R. 1994. Radiocarbon Dating and Italian Prehistory. *Archaeological Monographs of the British School at Rome* 8:39-44.

FASANI L, MARTINELLI N. 1996. Cronologia assoluta e relativa dell'antica età del bronzo nell'Italia settentrionale (dati dendrocronologici e radiometrici). In: COCCHI GENICK D, editor. *L'antica età del Bronzo in Italia, Atti del Congresso (Viareggio, 9-12 gennaio 1995*). Firenze. p 19-32.

FASNACHT W. 1999. Prähistorischer Kupferbergbau im Oberhalbstein und dessen Spuren in der bronzezeitlichen Siedlung Savognin-Padnal (GR). In: DELLA CASA P, editor. Prehistoric alpine environment, society, and economy - Papers of the international colloquium PAESE '97 in Zurich. *Universitätsforschungen zur prähistorischen Archäologie* 55:267-76.

FAU G, GASCÓ J. 2001. *Histoire des fouilles et découvertes archéologiques à Roucadour (Thémines-Lot) 1925-2000***.** Association Racines, Alvignac (Lot).

FELBER H. 1970. Altersbestimmungen nach der Radiokohlenstoffmethode am Institut für Radiumforschung und Kernphysik V. *Mitteilungen des Instituts für Radiumforschung und Kernphysik* 614:62-76.

FELBER H. 1973. Altersbestimmungen nach der Radiokohlenstoffmethode am Institut für Radiumforschung und Kernphysik IX. *Anzeiger-Österreichische Akademie der Wissenschaften-Mathematisch-naturwissenschaftliche Klasse* 110(1-13):57-65.

FELBER H. 1979a. Vienna Radium Institute Radiocarbon Dates VIII. *Radiocarbon* 21(1):113-9.

FELBER H. 1979b. Vienna Radium Institute Radiocarbon Dates IX. *Radiocarbon* 21(2):298-305.

FELGENHAUER F. 1996. *Stillfried, Lebensraum des Menschen seit 30.000 Jahren. Archäologischer Fundplatz von internationaler Bedeutung, Objekt interdisziplinärer Forschung von bedeutendem Rang. Ergebnisse der Ausgrabungen und Forschungen 1969-1989.* FIST (Forschungen in Stillfried) 9/10, 1990-1992 (1996).

FERNÁNDEZ-ERASO J, MUJIKA-ALUSTIZA JA. 2013. La estación megalítica de la Rioja Alavesa: cronología, orígenes y ciclos de utilización. *Zephyrus* LXXI:89-106.

FERRARA G, FORNACA-RINALDI G, TONGIORGI E. 1961. Carbon-14 Dating in Pisa-II. *Radiocarbon* 3:99-104.

FERRARA G, REINHARZ M, TONGIORGI E. 1959. Carbon-14 Dating in Pisa-I. *Radiocarbon* 1:103-10.

FERRERUELA GONZALVO A. 1993. Aproximación a la carta arqueológica de la provincia de Zaragoza: término municipal de Leciñena. *Museo de Zaragoza, Boletín* 12:7-274.

FERUGLIO V, JAUBERT J, MAKSUD F, PEIRÉ J-F, FERRIER C, FONTUGNE M. 2006. Frayssinet-le-Gélat. Grotte de Combe-Nègre 2. In: *Bilan Scientifique 2003. DRAC Midi-Pyrénées, Service Regional de l'Archéologie*. p 116-8.

FINDLER NV, BICKMORE T. 1996. On the concept of causality and a causal modeling system for scientific and engineering domains, camus. *Applied Artificial Intelligence: an International Journal* 10(5):455-87.

FIORENTINO G, CARACUTA V, CALCAGNILE L, D'ELIA M, MATTHIAE P, MAVELLI F, QUARTA G. 2008. Third millennium B.C. climate change in Syria highlighted by carbon stable isotope analysis of 14C-AMS dated plant remains from Ebla. *Palaeogeography, Palaeoclimatology, Palaeoecology* 266(1-2):51-8.

FIORENTINO G, CARACUTA V, VOLPE G, TURCHIANO M, QUARTA G, D'ELIA M, CALCAGNILE L. 2009. The first millennium AD climate fluctuations in the Tavoliere

Plain (Apulia, Italy): new data from the 14C AMS-dated plant remains from the archaeological site of Faragola. *Nuclear Instruments and Methods in Physics Research B* 268(7-8):1084-7.

FISCHER C. 1993. Zinnachweis auf Keramik der Spätbronzezeit. *Archäologie der Schweiz* 16(1):17-24.

FISCHER C. 1993-1994. Ein Siedlungsplatz der Urnenfelder-, Hallstatt und Latènezeit in Fällanden-Fröschbach. *Archäologie im Kanton Zürich* 13:55-100.

FISCHER C. 1997. Innovation und Tradition in der Mittel- und Spätbronzezeit. Gräber und Siedlungen in Neftenbach, Fällanden, Dietikon, Pfäffikon und Erlenbach. *Monographien der Kantonsarchäologie Zürich* 28.

FISHER RA. 1937. The wave of advance of advantageous genes. *Annals of Eugenics* 7(4):355-69.

FIX GJ. 1975. Finite element models for ocean circulation problems. *SIAM Journal on Applied Mathematics* 29:371-87.

FOGOLARI G. 1983. *La palafitta di Molina di Ledro: stato dei lavori per la pubblicazione. Beni Culturali nel Trentino, interventi dal 1979 al 1983*. Trento. p 45-8.

FOHRENBAHER S. 1993. Radiocarbon dates and absolute chronology of the central European Early Bronze Age. *Antiquity* 67(255):218-56.

FOLKE S. 1972. Why a Radical Geography must be Marxist. *Antipode* 4(2):13-18.

FOLKE S. 1973. First Thoughts on the Geography of Imperialism. *Antipode* 5(3):16-20.

FONTANA A. 2006. Evoluzione geomorfologica della bassa pianura friulana e sue relazioni con le dinamiche insediative antiche. *Monografie Museo Friulano Storia Naturale* 47:1-288.

FONTANA A, MOZZI P, BONDESAN A. 2008. Alluvial megafans in the Venetian–Friulian Plain (north-eastern Italy): evidence of sedimentary and erosive phases during Late Pleistocene and Holocene. *Quaternary International* 189:71-90.

FORCADELL A, VILLALBÍ MM. 1991. *Memòria de l'excavació arqueològica d'urgència a Cova Cervereta. Vinallop-Tortosa (Baix Ebre)*. Servei d'Arqueologia de la Generalitat de Catalunya.

FORD JA. 1962. *A Quantitative Method for Deriving Cultural Chronology, Technical Manual I*. Pan American Institute. Washington.

FORENBAHER S. 1993. Radiocarbon Dates and Absolute Chronology of the Central European Early Bronze Age. *Antiquity* 67:218-220, 235-256.

FORMICOLA V. 1984. Qualche considerazione sui resti scheletrici umani rinvenuti nella Caverna dell'Acqua o del Morto (Finale Ligure – Savona). Scavi 1982-1983. *Preistoria Alpina* 20:245-8.

FORSTER P, ROMANO V, CALÌ F, RÖHL A, HURLES M. 2004. MtDNA Markers for Celtic and Germanic Language Areas in the British Isles. In: JONES M, editor. *Traces of Ancestry: Studies in Honour of Colin Renfrew*. p 99-111.

FORSTER P, TOTH A. 2003. Toward a phylogenetic chronology of ancient Gaulish, Celtic, and Indo-European. *Proceeding of the National Academy of Sciences of the United States of America (PNAS)* 100(15):9079-84.

FORT J, MÉNDEZ V. 1999. Time-delayed theory of the Neolithic transition in Europe. *Physical Review Letter*s 82:867-70.

FORT J, PUJOL T, CAVALLI-SFORZA LL. 2004. Paleolithic population waves of advance. *Cambridge Archaeological Journal* 14:53-61.

FORTUNATO L. 2011. Recontructing the History of Residence Strategies in Indo-European-Speaking Societes: Neo-, Uxori-, and Virilocality. *Human Biology* 83(1):107-28.

FOZZATI L. 1983. Viverone, lago di Bertignano. Recupero di una piroga monossile. *Quaderni della Soprintendenza Archeologica del Piemonte* 2:190.

FOZZATI L, BRESSAN F, MARTINELLI N, VALZOLGHER E. 2006 Underwater archaeology and prehistoric settlement in a great alpine lake: the case study of Lake Garda. In: HAFNER A, NIFFELER U, RUOFF U, editors. Die neue Sicht. Une nouvelle interprétation de l'histoire. The new view. Unterwasserarchäologie und Geschichtsbild. L'apport de l'archéologie subaquatique. Underwater Archaeology and the Historical Picture. Akten des 2. Internationalen Kongresses für Unterwasserarchäologie. Actes du 2e Congrès International d'Archéologie Subaquatique. Proceedings of the 2nd International Congress on Underwater Archaeology (Rüschlikon bei Zürich, 21-24 Oktober 2004). *Antiqua* 40:78-87.

FOZZATI L, FEDELE F. 1983-1984. Le “palafitte” del territorio piemontese: risultati e prospettive della ricerca. *Sibrium* 17:17-53.

FOZZATI L, GIOLITTO G. 1980. Lago di Viverone. *Preistoria Alpina* 16:157-9.

FOZZATI L, MARTINELLI N, EVANS SP. 1998. Le strutture palafitticole dei siti sommersi del lago di Viverone (TO-VC). In: *Atti IIPP XXXII*. p 197-200.

FRANCÈS J. 1993. Les estructures del Bronze antic del poliesportiu de la UAB: primers resultats. *Limes* 3:5-24.

FRANCÈS I FARRÉ J, PONS I BRUN E. 1998. L’hàbitat del Bronze final i de la primera edat del Ferro a la Catalunya litoral i prelitoral. *Cypsela* 12:31-46.

FRANCFORT HP. 1988. A propos de l’urbanisation du site de Shortughaï (Afghanistan). Une approche archéologique des transformations de l’économie de production. *Bulletin du Centre Genevois d’Anthropologie* 1:15-34.

FRANCOVICH R, MANACORDA D, editors. 2000. *Dizionario di archeologia*. Bari.

FRANK AG. 1993. Bronze Age World System Cycles. *Current Anthropology* 34:383-429.

FRANK AG, GILLS BK, editor. 1993. *The World System: five hundred years or five thousand?*. London.

FRANZESE R, HAYS J. 2006. *Spatio-temporal models for political-science panel and time-series-cross data*. Paper presented at the 23rd Meeting of the Society for Political Methodology.

FRASCOLI L. 1991. Der "Keltenwall" von Rheinau, Kt. Zürich - Die Grabung von 1989. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 74:7-42.

FREY O. 1995. The Celts in Italy. In: JANE GREEN M, editor. *The Celtic World*. London - New York.

FRIEDMAN J, ROWLAND MJ. 1977. Notes towards an epigenetic model of the evolution of "civilization". In: FRIEDMAN J, ROWLANDS MJ, editors. 1977. The *evolution of social systems*. London. p 201-78.

FRIEDRICH M, HENNING H. 1995. Dendrochronologische Untersuchungen der Hölzer des hallsttatzeitlichen Wagengrabes 8 aus Wehingen, Ldkr. Augsburg und andere Absolutdaten zur Hallstattzeit. *Bayerische Vorgeschichts-Blätter* 60:289-300.

FRIEDRICH M, HENNING H. 1996. A dendrodate for the Wehringen Iron Age wagon grave (778±5BC) in relation to other recently obtained absolute dates for the Hallstattt period in Southern Germany. *Journal of European Archaeology* 4(1):281-303.

FRIEDRICH WL, KROMER B, FRIEDRICH M, HEINEMEIER J, PFEIFFER T, TALAMO S. 2006. Santorini Eruption Radiocarbon Dated to 1627-1600 B.C. *Science* 312:548.

FRITZ A. 1999. 4000 Jahre menschliche Siedlungstätigkeit im Spiegel der Pollenanalyse. Ein Pollendiagramm vom Millstätter See. *Carinthia* I 189:43-52.

FRONTINI P, editor. 1997. *Castellaro del Vhò. Campagna di scavo 1995*. Scavi delle Civiche Raccolte Archeologiche di Milano. Como.

FRONTINI P, editor. 2001. *Castellaro del Vhò. Campagne di scavo 1996-1999*. Scavi delle Civiche Raccolte Archeologiche di Milano. Como.

FUCHS G. 1998. Die späturnenfelderzeitliche Höhensiedlung am Kulm bei Trofaiach (VB Leoben, Steiermark) - Ergebnisse der Grabungen 1997. *Archäologie Österreichs* 9(2):49-53.

FUCHS G. 2000. Die Höhensiedlung der späten Urnenfelderzeit am Kulm bei Trofaiach. Mit Beiträgen von Michael Friedrich, Alfred Galik, Jörg Obereder, Hubert Preßlinger und Hans-Peter Stika. *Fundberichte aus Österreich* 38:105-77.

FULLER WA. 1987. *Measurement error models*. Ames-Iowa.

FURMANEK V, HORST F, editors. 1982. *Die sozialökonomischen Entwicklung der Bronzezeitlichen Stämme in Mitteleuropa (eine übersicht)*.

GALATY ML. 2011. World-systems analysis and anthropology: A new détente?. *Reviews in Anthropology* 40.

GALLAY A. 1995. Les stèles anthropomorphes du site mégalithique du Petit-Chasseur à Sion (Valais, Suisse). *Notizie Archeologiche Bergomensi* 3:167-94.

GALLAY A. 1996. Le concept de cultura du Rhône: repères pour historique. In: MORDANT C, GAIFFE O, editors. *Cultures et sociétés du Bronze ancien en Europe, Actes du colloque de Clermond- Ferran 1992*. p 271-86.

GALLAY A, CHAIX L. 1984. Le site préhistorique du Petit Chasseur (Sion, Valais). 5. Le Dolmen MXI. *Cahiers d'Archéologie Romande* 31.

GALLAY A, OLIVE P, CARAZZETTI R. 1983. Chronologie C14 de la séquence Néolitique-Bronze ancien du Valais (Suisse). *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 66:43-73.

GALLIVAN MD. 2002. Measuring sendentariness and settlement population: accumulations research in the Middle Atlantic region. *American Antiquity* 67:535-57.

GAMBA C, FERNÁNDEZ E, TIRADO M, DEGUILLOUX MF, PEMONGE MH, UTRILLA P, EDO M, MOLIST M, R. RASTEIRO, CHIKHI L, ARROYO-PARDO E. 2012. Ancient DNA from an Early Neolithic Iberian population supports a pioneer colonization by first farmers. *Molecular Ecology* 21(1):45-56.

GAMBARI F. 2004. Le necropoli a cremazione nel quadro dell’età del Bronzo recente in Piemonte. In: COCCHI GENICK D, editor. *L'età del bronzo recente in Italia, Atti del Congresso Nazionale (Lido di Camaiore, 26-29 ottobre 2000).* Viareggio (LU). p 53-60.

GAMBARI FM, VENTURINO GAMBARI M. 1998. The introduction of cremation rites in north-western Italy. In: *Proceedings of the XIII congress, volume 4, (Forlì, 8-14 september 1996), International Union of Prehistoric and Protohistoric Sciences), Session 11: The Bronze Age in Europe and the Mediterranean*. p 243-8.

GAMBARI FM, VENTURINO GAMBARI M. 2012. Tombe monumentali a recinti nell’areale occidentale della cultura di Golasecca e nella Liguria interna piemontese: tipologia, ideologia costruttiva, rituali. In: ROVIRA HORTALÀ MC, LÓPEZ CACHERO FJ, MAZIÈRE F, editor. Les necròpolis d’incineració entre l’Ebre i el Tíber (segles IX-VI aC): metodologia, pràctiques funeràries i societat. *Monografies MAC* 14:305-20.

GAMBLE C, DAVIES W, PETTITT P, HAZELWOOD L, RICHARDS M. 2005. The Archaeological and genetic foundation of the European population during the Late Glacial: implications for “agricultural thinking”. *Cambridge Archaeological Journal* 15(2):193-223.

GARCÉS I, JUNYENT E, LAFUENTE A, LÓPEZ JB. 1997. *Vilars 2000. Una fortalesa ilargeta d'ara fa 2700 anys*. Ajuntament d'Arbeca i Universitat de Lleida.

GARCIA CASAS D. 2012. *Estudi de les pràctiques socials ramaderes d'alta muntanya pirinenca a través de les restes arquitectòniques. Una aproximació als modes de poblament pirinenc des del Neolíticfins als nostres diez*. Treball de final de màster, Departament de Prehistòria, Universitat Autònoma de Barcelona.

GARCÍA GAZÓLAZ J. 1998. Paternanbidea (Ibero, Navarra): un yacimiento al aire libre de la prehistoria reciente de Navarra. *Cuadernos de Arqueología de la Universidad de Navarra* 6:33-48.

GARCÍA GAZÓLAZ J. 2001. Excavaciones arqueólogicas en el abrigo del Padre Areso (Bigüézal, Navarra). Campañas de 1994-1995-1996. *Trabajos de Arqueología Navarra* 15:307-14.

GARCÍA GAZÓLAZ J, SESMA SEMSA J. 2005. Dispositivos de combustión durante la Prehistoria reciente en Navarra. *Munibe* 57:259-73.

GARCÍA GAZÓLAZ J, SESMA SEMSA J, TABAR SARRÍAS MI. 2001. La fosa sepulcral de la Saga (Cáseda, Navarrra). *Trabajos de arqueología Navarra* 15:115-22.

GARCIA JF, MESTRES JS, RAURET G. 1992. Comparing continental carbonates with other materials in dating a paleolake. *Radiocarbon* 34(3):619-25.

GARCIA MA. 1991. Grotte de Montespan. In: *Bilan scientifique de la région Midi-Pyrénées 1991, DRAC Midi-Pyrénées, Service Regional de l'Archéologie*. p 70.

GARCIA MA, DUDAY H. 1988. *Rapport de fouilles de la grotte de Montespan*. Archives du Service régional d'archéologie de Midi-Pyrénées, 1988-1991, 5 volumes.

GARDES P. 1993. Les urnes carénées de l'Age du Bronze Ouest-Pyrénéen français. Problèmes chronologiques. *Munibe* 45:133-41.

GARRO L. 2000. Remembering what one knows and the construction of the past: a comparison of cultural consensus theory and cultural schema theory. *Ethos* 28(3):275-319.

GASCÓ J. 1983a. Combustion d'orge et structure de conservation de l'Âge du Bronze à la grotte des Cazals (Aude). *Bulletin de la Société préhistorique française* 80(4):111-16.

GASCÓ J. 1983b. L'Age du Bronze Final à la Cauna de Matrou ou grotte de Villemaury (Mas-de-Cours, Aude). *L'Anthropologie* 87(1):99-112.

GASCÓ J. 1985. Histogrammes et dates radiocarbones. *Bulletin de la Société préhistorique français*e 82(4):108-11.

GASCÓ J. 1986. Contribution a l'étude des calendriers de datations absolues. *Revue archéologique de l'Ouest* suppl. 1:291-8.

GASCÓ J. 1987. Traitements graphiques des dates radiocarbone: application au Proche Orient. In: AURENCHE O, ÉVIN J, HOURS F, editors. *Chronologies du Proche Orient*. Oxford: BAR International Séries 379. p 21-37.

GASCÓ J. 1992. L'âge du Bronze moyen et récent en France méditerranéenne. In: *La Sardegna nel Mediterraneo tra il Bronzo medio e il Bronzo recente (XVI-XIII Sec. a.C.). Atti del III convegno di studi "Un millenio di relazioni fra la Sardegna e i paesi del Mediterraneo" (Selargius-Cagliari, novembre 1987)*. Cagliari. p 399-420.

GASCÓ J. 1996. Chronologie de l'âge du Bronze et du premier âge du Fer de la France continentale. In: RANDSBORG K, editor. Absolute Chronology. Archaeological Europe 2500-500 BC (Verona, April 20-23 1995). *Acta Archaeologica* 67:227-50.

GASCÓ J. 1998. Au terme de l'Age du Bronze en Languedoc occidental (France), le Bronze final IIIA. *Cypsela* 12:147-60.

GASCÓ J. 2000. *L'Age du Bronze dans la moitié sud de la France*. Tours.

GASCÓ J. 2001. La datation absolue de la Protohistoire du XXII^{e} au VIII^{e} siècle avant notre ère dans le sud de la France. *Documents d'archéologie Méridionale* 24:221-29.

GASCÓ J. 2004. La stratigraphie de l'Age du Bronze et de l'Age du Fer à Roucadour (Thémines, Lot). *Bulletin de la Société préhistorique française* 101(3):521-45.

GASCÓ J. 2006. Les pointes de flèches métalliques à la fin de l'Age du Bronze dans le sud de la France. *Cypsela* 16:147-59.

GASCÓ J. 2011. Geographie regionale de l'age du bronze en Languedoc. *Quaderns de prehistòria i arqueologia de Castell*ó 29:135-51.

GASCÓ J, BINDER D. 1983. Series de dates radiocarbone et représentation graphique. *Revue d'Archéométrie* suppl. 1983:76-84.

GASCÓ J, CAROZZA L. 1989. L'âge du Bronze moyen et ses dynamiques en Languedoc occidental. In: *Dynamique du Bronze Moyen en Europe occidentale 1989, Actes du 113e Congrès National des Sociétés Savantes (Strasbourg 1988)*. Paris. p 443-57.

GASCÓ J, CAROZZA L, FRY R, FRY S, VIGNE D, WAINWRIGHT J. 1996. *Le Laouret et la montagne d'Alaric a la fin de l'age du Bronze, Un hameau abandonné entre Floure et Monze (Aude).* Centre d'Anthropologie rurale, Toulousee, Archéologie en terre d'Aude. Carcassonne.

GASCÓ J, CLAUSTRE F, editors. 2000. *Habitats, économies et sociétés du Nord-Ouest Méditerranéen de l'Âge du Bronze au premier Âge du Fer. Actes du Colloque International, XXIVe Congrès Préhistorique de France (Carcassonne, 26-30 septembre 1994).* Joué-lès-Tours.

GASCÓ J, GUILAINE J. 1987. La chronologie de l'Age du Bronze dans le sud de la France. In: *Da Pré-Historia à Historia, Homenagem a Octavia da Veiga Ferreira*. Lisbonne. p 273-85.

GASCÓ J, GUILAINE J. 1989. Médor et la chronologie de la Fin de l'Âge du Bronze en Languedoc. In: GUILAINE J, VAQUER J, COULAROU J, TREINEN-CLAUTRE F, editors. *Médor Ornaisons. Archeologie et ecologie d'un site de l'age du cuivre, de l'age du bronze final et de l'antiquite tardive, Centre d'Anthropologie des Sociétés Rurales Toulouse*. Perpignan. p 217-23.

GASSLER A. 1982. Spätbronzezeitliche keramik vom Wittnauer Horn. *Archäologisches Korrespondenzblatt* 12:55-67.

GATRELL AC. 1983. *Distance and space: a geographical perspective*. Oxford and New York.

GAUCHER G. 1992. Les subdivisions du Bronze final. *Bulletin de la Société préhistorique française* 82(2):51-64.

GEBHARD R. 2000. Der Goldfund von Bernstorf - Zubehör eines Kultbildes der älteren Bronzezeit. Gemeinde Kranzberg, Landkreis Freising, Oberbayern. *Das archäologische Jahr in Bayern* 1999:22-4.

GENERA M. 1982. El Puig Roig del Roget. El Masroig. In: *Les excavacions arqueològiques a Catalunya en els darrers anys. Excavacions arqueològiques a Catalunya 1*. Generalitat de Catalunya. Departament de Cultura. Barcelona. p 215-7.

GENERA M. 1995. *El poblat protohistòric del Puig Roig del Roget. Memòries d'Intervencions Arqueològiques a Catalunya 17*. Generalitat de Catalunya.

GENERA M. 2007. *El jaciment prehistòric del Puig-Roig del Roget*. Servei d'Arqueologia de la Generalitat de Catalunya.

GEYH MA. 1971. Middle and young Holocene sea-level changes as a global contemporary events. *Geologiska Föreningens i Stockholm Förhandlingar* 93:679-92.

GEYH MA. 1980. Holocene sea-level history: case study of the statistical evaluation of ^{14}C dates. *Radiocarbon* 22(3):695-704.

GFELLER CHR, OESCHGER H, SCHWARZ U. 1961. Bern Radiocarbon Dates II. *Radiocarbon* 3:15-25.

GHIROTTO S, TASSI F, FUMAGALLI F, COLONNA V, SANDIONIGI A, LARI M, VAI S, PETITI E, CORTI G, RIZZI E, DE BELLIS G, CARAMELLI D, BARBUJANI G. 2013. Origins and evolution of the Etruscans' mtDNA. *PLoS ONE* 8(2): e55519.

GIARDINO C. 1995. *Il Meditterraneo Occidentale fra XIV ed VIII secolo a.C. Cerchie minerarie e metallurgiche*. Oxford: BAR International Series 612.

GIARDINO C. 2005. Metallurgy in Italy between the Late Bronze Age and the Early Iron Age: the coming of iron. In: ATTEMA P, NIJBOER A, ZIFFERERO A, editors. *Paper in Italian archaeology VI. Communities and settlements from the Neolithic to the Early Medieval Period, Proceedings of the 6th Conference of the Italian Archaeology held at the University of Groningen, Groningen Institute of Archaeology (The Netherlands, april 15-17, 2003)*. Oxford: BAR International Series 1452(I). p 491-505.

GIARDINO C, editor. 2011. *Archeometallurgia: dalla conoscena alla fruizione*. Atti del workshop (22-25 maggio 2006, Cavallino, Lecce). Bari.

GILBERT N, ABBOTT A. 2005. Introduction. *American Journal of Sociology* 110(4):859-63.

GILBERT N, CONTE R. 1995. *Artificial societies: The computer simulation of social life*.

GILBERT N, TROITZSCH KG. 2005. *Simulation for the social scientist*.

GILOT E. 1970. Louvain Natural Radiocarbon Measurements IX. *Radiocarbon* 12(2):553-8.

GIMBUTAS M. 1965. *Bronze Age cultures in Central and Eastern Europe*. The Hague.

GIMBUTAS M. 1977. The first wave of Eurasian steppe pastoralists into Copper Age Europe. *Journal of Indo-European Studies* 5:277-338.

GIOMI F, TRAVERSONE B. 1998. Trino Vercellese (VC), un insediamento della media età del Bronzo. In: *Atti IIPP XXXII*. p 201-13.

GIRAUD JP, CARRIÈRE M, CLOTTES J. 1988. La grotte du Noyer (Esclauzels, Lot). In: *Il y a 3500 ans... Les Tumulus de Haguenau et le Bronze moyen en Europe. Catalogue d'exposition (Haguenau, du 6 avril au 30 septembre 1988)*. Strasbourg. p 56-7.

GIRAUD JP, PONS E, JANIN T, editors. 2003. Nécropoles protohistoriques de la région de Castres (Tarn). Le Causse, Gourjade, Le Martinet. *Documents d'Archéologie Française* 94.

GIRAUD JP, VAQUER J. 1994. Un possible rebut de production céramique de l'Âge du Bronze moyen à Villeneuve-Tolosane (Haute-Garonne). In: BINDER D, COURTIN J, editor. *Terre cuite et société la céramique, document technique, économique, culturel, XIVe rencontres internationales d'archéologie et d'histoire d'Antibes (21-23 octobre 1993).* Juan-les-Pins. p 217-24.

GKIASTA M, RUSSELL T, SHENNAN S, STEELE J. 2003. Neolithic transition in Europe: the radiocarbon record revisited. *Antiquity* 77:45-62.

GLAUSER K, RAMSTEIN M. 2005. Herzogenbuchsee, Badwald. Rettungsgrabung 1998: spätbronzezeitliche Siedlungreste. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:71-3.

GLEIRSCHER P. 2006. Urnenfelderzeitliche Grabhügel und Siedlungen der älteren Hallstattkultur in der Steiermark. Zum Beginn der Hallstattkultur im Südostalpenraum. *Arheološki vestnik* 57:85-95.

GNEPF HORISBERGER U, HÄMMERLE S. 2001. Cham-Oberwil, Hof (Kanton Zug). Befunde und Funde aus der Glockenbecherkultur und der Bronzezeit. *Antiqua* 33.

GOLDENBERG G. 2004. Ein Verhüttungsplatz der mittleren Bronzezeit bei Jochberg (Nordtirol). In: WEISGERBER G, GOLDENBERG G, editors. Alpenkupfer - Rame nelle Alpi. *Der Anschnitt* 17:165-76.

GOLLNISCH-MOOS H. 1999. Ürschhausen-Horn - Haus- und Siedlungsstrukturen der spätestbronzezeitlichen Siedlung (Forschungen im Seebachtal 3). *Archäologie im Thurgau* 7.

GOMEZ J. 1978. La stratigraphie chalcolithique et protohistorique de la grotte du Quéroy à Chazelles (Charente). *Bulletin de la Société préhistorique française* 75(10):394-421.

GÓMEZ F, REY J, ROYO I. 1992. Estudio de los materiales del poblado neolítico de Riols I (Mequinenza, Zaragoza). Campaña de 1990. *Arqueología Aragonesa* 1990:47-53.

GOMEZ J. 1980. *Les cultures de l'Age du Bronze dans le bassin de la Charente*. Périgueux.

GOMEZ J. 1995. *Le Bronze Moyen en Occident. La cultura des Duffaits et la civilization des Tumulus*. L'Age du Bronze en France 5, Paris.

GOMEZ-PORTUGAL AGUILAR D, LITTON CD, O'HAGAN A. 2002. Novel statistical model for a piece-wise linear radiocarbon calibration curve. *Radiocarbon* 44:195-212.

GOMEZ J, KEROUANTON I, BOULESTIN B, BOURHIS J-R. 1991. La grotte du Quéroy à Chazelles (Charente) – Le Bronze final IIIb. *Bulletin de la Société préhistorique française* 88(10-12):341-92.

GOMPERTZ B. 1825. On the nature of the function expressive of the law of human mortality, and on a new mode of determining the value of life contingencies. *Philosophical Transactions of the Royal Society of London* 115: 513-83.

GONZÁLEZ JR, MEDINA J, RODRIGUEZ JI, MARKALAIN J, LARRÉGULA R. 1995. Les necròpolis tumulars al Pirineu occidental català. Estat de la question. In: *X Col·loqui Internacional d'Arqueologia de Puigcerdà – Cultures i Medi. De la Prehistoria a l'Edat Mitjana. (Puigcerdà i Osseja, 1994),* p 385-94.

GONZÁLEZ JR, JUNYENT E, MAYA JL, RODRÍGUEZ JL. 1983. Carretelà (Aitona, Segrià). *Arqueología* 82:173.

GONZÁLEZ MARCÉN P, LULL V, RISCH R. 1992. *Arqueología de Europa, 2250-1200 a.C. Una introducción a la "Edad del Bronce"*. Madrid.

GONZÁLEZ P, MARTÍN A, MORA R, editors. 1999. *Can Roqueta. Un establiment pagès* *prehistòric i medieval, Sabadell, Vallès Occidental*. In: *Excavacions arqueològiques a Catalunya 16*. Generalitat de Catalunya. Departament de Cultura. Barcelona.

GONZÁLEZ-SAMPÉRIZ P, UTRILLA P, MAZO C, VALERO-GARCÉS B, SOPENA MC, MORELLÓN M, SEBASTIÁN M, MORENO A, MARTÍNEZ-BEA M. 2009. Patterns of human occupation during the early holocene in the central Ebro basin (NE Spain) in response to the 8.2ka climatic event. *Quaternary Research* 71:121-32.

GÖRNER I. 2002. Bestattungssitten der Hügelbronzegräberzeit in Nord- und Osthessen. *Marburger Studien zur Vor- und Frühgeschiche* 20.

GOURICHON L. 2009. Etude archéozoologique. In: DONNELLY M, FURESTIER R, editors. *A8 Saint-Maximin/Chemin d'Herbous à Saint-Maximin-la-Sainte-Baume (Var)*. Rapport final d'opération. Fouilles archéologiques preventives. Mauguio. Oxford:Archéologie Méditerranée. p 90-8.

GRIEBL M. 1997. Siedlungsobjekte der Hallstattkultur aus Horn (Niederösterreich*). Mitteilungen der Prähistorischen Kommision* 31. Österreichische Akademie der Wissenschaften. Wien.

GRIFFITHS AJF, MILLER JH, SUZUKI DT, LEWONTIN RC, GELBART WM, editors. 2000. *An introduction to genetic analysis*. New York.

GROSHONG JRH. 1999. *3D Structural Geology: A Practical Guide to Surface and Subsurface Map Interpretation*. Berlin.

GROSS E, BLEUER E, DICK M, HARDMEYER B, RAST-EICHER A, RITZMANN C, RUCKSTUHL B, RUOFF U, SCHIBLER J. 1992. Zürich "Mozartstrasse". Neolithische und bronzezeitliche Ufersiedlungen. Band 2: Tafeln. *Berichte der Zürcher Denkmalpflege Monographien* 17.

GROSS E, BROMBACHER C, DICK M, DIGGELMANN K, HARDMEYER B, JAGHER R, RITZMANN C, RUCKSTUHL B, RUOFF U, SCHIBLER J, VAUGHAN PC, WYPRÄCHTIGER K. 1987. Zürich "Mozartstrasse". Neolithische und bronzezeitliche Ufersiedlungen. Band 1. *Berichte der Zürcher Denkmalpflege Monographien* 4.

GRUET AM. 1996. A nonparametric calibration analysis. *The Annals of Statistics* 24(4):1474-92.

GSTREIN P. 1988. Neuaufnahme eines vorgeschichtlichen Abbaues im Arthurstollen (Bergbau Mitterberg). *Mitteilungen der Gesellschaft für Salzburger Landeskunde* 128:425-38.

GSTREIN P, LIPPERT A. 1987. Untersuchung bronzezeitlicher Pingen am Hochmoos bei Bischofshofen, Salzburg. *Archaeologia Austriaca* 71:89-100.

GUBLER R. 2010. Spiez-Einigen, Holleeweg 3. Gräber am Übergang zwischen Früh- und Mittelbronzezeit. *Archäologie Bern/Archéologie bernoise* 2010:147-73.

GUÉLAT M, HONEGGER M, RENTZEL P. 1995. Nouvelles données sur la stratigraphie du site de Barmaz I (Collombey-Muraz VS). *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 78:131-44.

GUERRESCHI A, GHIRETTI A, GAMBARI FM. 1992. Archeologia all'Alpe Veglia. *Le Rive* 4-5:33-45.

GUERRESCHI G, CESCHIN N. 1985. Codice d’analisi della ceramica preistorica. 2ª Edizione riveduta e ampliata. *Padusa* XXI:3-54.

GUERRESCHI G, LIMIDO C. 1978. Alcune considerazioni sui materiali fittili provenienti dall'Isolone del Mincio (scavi Mirabella, Rittatore, Zorzi). Nota preliminare. *Annali Benacensi* 4:27-92.

GUERRESCHI G, LIMIDO C. 1982. Risultati preliminari dell'esame del materiale ceramico dell'Isolone del Mincio (Scavi Mirabella, Rittatore, Zorzi). In: *Studi in onore di F. Ritttatore Vonwiller 1/1*. Como. p 221-30.

GUERRESCHI G, LIMIDO C, CATALANI P. 1985. *L'insediamento preistorico dell'Isolone del Mincio (Volta Mantovana), scavi Mirabella, Rittatore, Zorzi 1955-1956*. Brescia.

GUIDI A. 2000. *Preistoria della complessità sociale*. Bari.

GUIDI A, WHITEHOUSE R. 1996. A radiocarbon chronology for the Bronze Age: the Italian situation. *Acta Archeologica* 67:271-81.

GUILAINE J. 1972. L’âge du Bronze en Languedoc occidental, Roussillon, Ariège. *Mémoires de la Société Préhistorique Française* IX. Paris.

GUILAINE J, ABELANET J. 1965. La céramique poladienne du Roussillon et du Bassin de l'Aude. In: *Actes del 4th Symposium de Prehistoria Peninsular*. Pamplona. p 138.

GUILAINE J, GASCÓ J. 1989. Médor et la chronologie de la fin de l'age du Bronze en Languedoc. In: GUILAINE J, VAQUER J, COULAROU J, TREINEN-CLAUSTRE F. 1989. *Ornaisons-Médor. Archéologie et Ecologie d'un site de l'Age du Cuivre, de l'Age du Bronze final et de l'Antquité tardive*. Perpignan. p 217-23.

GUILAINE J, LLONGUERAS M, MARCET R, PETIT MA, VAQUER J. 1982. Cova del Toll (Moià). In: *Les excavacions arqueològiques a Catalunya en els darrers anys, Excavacions Arqueològiques a Catalunya 1*. Generalitat de Catalunya. Departament de Cultura. Barcelona. p 150-2.

GUILAINE J, RANCOULE G, VAQUER J, PASSELAC M, VIGNE J-D, BARRIÉ P, COULAROU J, ERROUX J, FIRMIN G, KRAUSS-MARGUET I, MARINVALVIGNE M-C, MAZÉAS H, PICHON J, THOMMERET J, THOMMERET Y, VERNET J-L, ZAMMIT J. 1986. *Carsac. Une agglomération protohistorique en Languedoc*. Toulouse.

GUILAINE J, RANCOULE G, VIGNE J-D. 1986. Le fossé primitif ou fossé interne (point 17). In: GUILAINE J, RANCOULE G, VAQUER J, PASSELAC M, VIGNE J-D, BARRIÉ P, COULAROU J, ERROUX J, FIRMIN G, KRAUSS-MARGUET I, MARINVALVIGNE M-C, MAZÉAS H, PICHON J, THOMMERET J, THOMMERET Y, VERNET J-L, ZAMMIT J. 1986. *Carsac. Une agglomération protohistorique en Languedoc*. Toulouse. p 51-65.

GUILAINE J, VAQUER J, BARRIÉ P, COULAROU J. 1986. La structure n° 64 (ou structure du Belvédère). Unité d'habitation ou aire d'extraction d'argile. GUILAINE J, RANCOULE G, VAQUER J, PASSELAC M, VIGNE J-D, BARRIÉ P, COULAROU J, ERROUX J, FIRMIN G, KRAUSS-MARGUET I, MARINVALVIGNE M-C, MAZÉAS H, PICHON J, THOMMERET J, THOMMERET Y, VERNET J-L, ZAMMIT J. 1986. *Carsac. Une agglomération protohistorique en Languedoc*. Toulouse. p 33-50.

GUILAINE J, VAQUER J, COULAROU J, TREINEN-CLAUSTRE F. 1989. *Ornaisons-Médor.*

Archéologie et Ecologie d'un site de l'Age du Cuivre, de l'Age du Bronze final et de l'Antiquité tardive. Perpignan.

HAAK W, FORSTER P, BRAMANTI B, MATSUMURA S, BRANDT G, TANZER M, VILLEMS R, RENFREW C, GRONENBORN D, ALT KW, BURGER J. 2005. Ancient DNA from the first European farmers in 7500-year-old Neolithic sites. *Science* 310(5750):1016-8.

HAFNER A. 2001. Archäologische Belege der älteren Frühbronzezeit aus der Westschweiz. *Hemmenhofener Skripte* 2:155-64.

HAFNER A, HARB P. 2008. Inkwil BE/Bolken SO, Inkwilersee. Prähistorische Siedlungsreste. *Archäologie Bern/Archéologie bernoise* 2008:56-9.

HAFNER A, SUTER PJ. 2003. Vom Endneolithikum zur Frühbronzezeit: Wandel und Kontinuität zwischen 2400 und 1550 v. Chr. *Archäologisches Korrespondenzblatt* 33:325-44.

HÄGERSTRAND T. 1952. The propagation of innovation waves. *Lund studies in Human Geography Series B* 4:3-19.

HAJDAS I. 2009. Applications of radiocarbon dating. *Radiocarbon* 51(1):79-90.

HAHNEL B. 1986. Waidendorf – Buhuberg. Siedlung der Věteřovkultur. *Forschungen in Stillfried* 8.

HALEKOH U, VACH W. 2004. A Bayesian approach to seriation problems in archaeology. *Computational Statistics & Data Analysis* 45(3):651-73.

HALL TD, CHASE-DUNN C. 1993. The World-Systems perspective and archaeology: forward into the past. *Journal of Archaeological Research* 1:121-43.

HALL TD, KARDULIAS PN, CHASE-DUNN C. 2010. World-Systems analysis and archaeology: continuing the dialogue. *Journal of Archaeological Research* 19(3):233-279.

HAMILTON MJ, BUCHANAN B. 2007. Spatial gradients in Clovis-age radiocarbon dates across North America suggest rapid colonization from the north. *Proceeding of the National Academy of Sciences of the United States of America (PNAS)* 104(40):15625-30.

HAMMER CU, CLAUSEN HB, FRIEDRICH WL, TAUBER H. 1987. The Minoan eruption of Santorini in Greece dated to 1645 BC?. *Nature* 328:517-9.

HAMMER CU, KURAT G, HOPPE P, GRUM W, CLAUSEN HB. 2003. Thera eruption date 1645 BC confirmed by new ice core data?. In: BIETAK M, editor. *The Synchronisation of Civilisations in the Eastern Mediterranean in the Second Millenium BC II. Proceedings of the SCIEM 2000—Euroconference, Haindorf, 2001*. Vienna. p 87-94.

HÄNSEL B. 1976. Beiträge zur regionalen und chronologischen Gliederung der älteren Hallstattzeit an der unteren Donau. *Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer-Kulturraumes* 16.

HÄNSEL B, TERŽAN B, MIHOVILIĆ K. 2007. Radiokarbondaten zur älteren und mittleren Bronzezeit Istriens. *Praehistorische Zeitschrift* 82/1:22-50.

HARARI M, PEARCE M, editor. 2000. *Il Protovillanoviano al di qua e al di là dell'Appennino,* *Atti della giornata di studio (Pavia 17 giugno 1995)*. Como.

HARB C. 2009. Bronzezeitliche Steinsetzungen und weitere Fundstellen im Kronauer Amt. *Archäologie im Kanton Zürich* 01:177-225.

HARDING AF. 1987. Fernhandel in der Bronzezeit: Analyse und Interpretation. *Saeculum. Jahrbuch für Universalgeschichte* 38:297-311.

HARDING AF. 2003. *Sociedades europeas en la Edad del Bronce*. Barcelona.

HARDING AF. 2013. World Systems, Cores and Peripheries in Prehistoric Europe. *European Journal of Archaeology* 16 (3):378-400.

HARRIS EC. 1975. The stratigraphic sequence: A question of time. *World archaeology* 7:109-21.

HARRIS EC. 1979. *Principles of Archaeological Stratigraphy*. London.

HARRISON RJ. 1974. Ireland and Spain in the Early Bronze Age. *Journal of Society of Antiquaries of Ireland* 104:52-73.

HARTL D, JONES E. 2005. *Genetics: analysis of genes and genomes, 6th edition*. Sudbury (MA).

HARVEY D. 1971. *Explanation in Geography*. London.

HARVEY D. 1976. *Geografía y teoría revolucionaria*. Barcelona.

HARVEY D. 2003. *Espacios de esperanza*. Madrid.

HARVEY D. 2007. *Espacios del capital: hacia una geografía crítica*. Madrid.

HASENFRATZ A, SCHNYDER M. 1998. Das Seebachtal. Eine archäologische und paläoökologische Bestandesaufnahme (Forschungen im Seebachtal 1). *Archäologie im Thurgau* 4.

HASLER A. 2002. Ventabren - Château Blanc. Les installations de la fin de l'âge du Bronze. In: Archéologie du TGV Méditerranée. Fiches de synthèse. Tome 2. La Protohistoire. *Monographies d'Archéologie Méditerranéenne* 9:567-72.

HASTING A, CUDDINGTON K, DAVIES KF, DUGAW CJ, ELMENDORF S, FREESTONE A, HARRISON S, HOLLAND M, LAMBRINOS J, MALVADKAR U, MELBOURNE BA, MOORE K, TAYLOR C, THOMSON D. 2005. The spatial spread of invasions, new developments in theory and evidence. *Ecology Letters* 8(1):91-101.

HATT J-J. 1955a. Chroniques de Protohistorie, I. *Bulletin de la Société préhistorique française* 52(1-2):96-101.

HATT J-J. 1955b. Chroniques de Protohistorie, II. *Bulletin de la Société préhistorique française* 52(1-2):397-400.

HATT J-J. 1958. Chroniques de Protohistoire, IV. Nouveau projet de chronologie pour l’âge du Bronze en France. *Bulletin de la Société préhistorique française* 55(5-6):304-6.

HATT J-J. 1961. Chronique de Protohistoire V. Une nouvelle chronologie de l’Age du Bronze

Final. Exposé critique du système chronologique de H. Müller Karpe. *Bulletin de la Société préhistorique française* 58:184-95.

HAUPTMANN A, BEGEMANN F, HEITKEMPER R, PERNICKA E, SCHMITT-STRECKER S. 1992. Early copper produced in Feinan, Wadi Araba, Jordan: the composition of ores and copper. *Archeomaterials* 6(1):1-33.

HAUPTMANN A, BEGEMANN F, SCHMITT-STRECKER S. 1999. Copper objects from Arad: their composition and provenance. *Bulletin of the American Schools of Oriental Research* 314:1-17.

HAZELWOOD L, STEELE J. 2004. Spatial dynamics of human dispersals: Constraints on modelling and archaeological validation. *Journal of Archaeological Science* 31(6):669-79.

HEBERT B. 1995. Baubefunde in der mittelbronzezeitlichen Siedlung von Hörbing bei Deutschlandsberg, Steiermark. *Fundberichte aus Österreich* 34:301-3.

HEBERT B, KIENAST G, MANDL F, editors. 2007. Königreich-Alm Dachsteingebirge. 3500 Jahre Almwirtschaft zwischen Gröbming und Hallstatt. *Forschungsberichte der ANISA* 1.

HEBERT B, MANDL F, editors. 2009. Almen im Visier. Dachsteingebirge, Totes Gebirge, Silvretta. *Forschungsberichte der ANISA* 2.

HEDGES REM, HOUSLEY RA, BRONK RAMSEY CR, VAN KLINKEN GJ. 1993. Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 17. *Archaeometry* 35(2):305-26.

HEDGES R, PETTITT J. 1999. On the validity of archaeological radiocarbon dates beyond 30,000 BP. In: EVIN J, editor. Actes du 3ème Congrès Internacional ^{14}C et Archéologie (Lyon, 6-10 avril 1998). *Mémoires de la Société Préhistorique Française* XXVI:137-41.

HELLERSCHMID I. 2006. Die urnenfelder-/hallstattzeitliche Wallanlage von Stillfried an der March. Ergebnisse der Ausgrabungen 1969-1989 unter besonderer Berücksichtigung des Kulturwandels an der Epochengrenze Urnenfelder-/Hallstattkultur. *Mitteilungen der Prähistorischen Kommision Österreichische Akademie der Wissenschaften* 63. Wien.

HELMIG G. 1999. Basel BS, Neuhausstrasse 31. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 82:258-9.

HENNIG H. 1995. Zur Frage der Datierung des Grabhügels 8 "Hexenbergle" von Wehringen Ldkrs. Augsburg, Bayerisch-Schwaben. In: SCHMID-SIKIMIĆ B., DELLA CASA P, editor. Trans Europam. Beiträge zur Bronze- und Eisenzeit zwischen Atlantik und Altai. Festschrift für Margarita Primas. *Antiquitas 3* 34:129-45.

HENNIG H. 2001. Gräber der Hallstattzeit in Bayerisch-Schwaben. *Monographien der Archäologischen Staatssammlung München* 2.

HÉNON P. 1999. Structures domestiques et espaces villageois du V^{e} millénaire au VIII^{e} siècle avant notre ère. L'apport des fouilles de la "ZAC des Perches" à Saint-Priest (Rhône). Bilan documentaire. In: *Premières journées d'Histoire en Velin (Château de Saint-Priest, 20-21 novembre 1999)*. Saint-Priest. p 29-66.

HÉNON P, RAMPONI C. 2002. Saint-Priest, ZAC des Feuilly. In: *Bilan scientifique de la région Rhône-Alpes 2000, Ministère de la Culture et de la Communication, sous-direction* *de l'Archéologie*. Lyon. p 188-90.

HÉNON P. 2003. Exemples de fosses à pierres chauffantes protohistoriques du Bas-Dauphiné (Rhône et Isère, France). In: FRÈRE-SAUTOT M-C, editor. *Le Feu domestique et ses structures au Néolithique et aux Âges des métaux: actes du colloque de Bourg-en-Bresse et Beaune, 7-8 octobre 2000*. p 403-20.

HÉNON P, POUÉNAT P, COMBES P. 2000. *Espalem et Grenier-Montgon (Haute-Loire), nécropole tumulaire des Lacs, projet d'extension de la carrière de Blanchon*. Document final de synthèse de fouille d'évaluation archéologique, Clermont-Ferrand 17.

HENRICH J. 2001. Cultural Transmission and the Diffusion of Innovations: Adoption dynamics indicate that biased cultural transmission is the predominate force in behavioral. *American Anthropologist* 103(4): 992-1013.

HÉRITIER MA. 1997. Saou. Le Pas de Lestang. *Gallia Informations* 1996:79-80.

HERZOG I. 1995. Combining stratigraphic information and finds. In: WILCOCK J, LOCKYEAR K, editors. *Computer Applications and Quantitative Methods in Archaeology 1993*. Oxford: BAR International Series 598. p 109-14.

HERZOG I. 2002. *Possibilities for Analysing Stratigraphic Data*. CD of the Workshop "Archäologie und Computer". Vienna 2001.

HERZOG I. 2004. Group and Conquer - A Method for Displaying Large Stratigraphic Data Sets. In: *Enter the Past. The E-way into the Four Dimensions of Cultural Heritage. CAA 2003*. Oxford: BAR International Series 1227. p 423-6.

HIGHAM TFG, BRONK RAMSEY C, BROCK F, BAKER D, DITCHFIELD P. 2007. Radiocarbon dates from the Oxford AMS System: Archaeometry Datelist 32. *Archaeometry* 49(S1):S1–S60.

HILDEBRAND H. 1874. Sur les commencements de l’âge du fer en Europe. In: *Congrés internationale d’anthropologie et d’archéologie préhistorique* 2: 592.

HINZ M, FEESER I, SJÖGREN KG, MÜLLER J. 2012. Demography and the intensity of cultural activities: an evaluation of Funnel Beaker Societies (4200–2800 cal BC). *Journal of Archaeological Science* 39(10):3331-40.

HINZ M, FURHOLT M, MÜLLER J, RAETZEL-FABIAN D, RINNE C, SJÖGREN K.-G, WOTZKA H-P. 2012. *RADON - Radiocarbon dates online 2012. Central European database of ^{14}C dates for the Neolithic and Early Bronze Age*. www.jungsteinsite.de.

HOCK HE, JOSEPH BD. 2009. *Language history, language change and language relationship. An introduction to historical and comparative linguistics*. Germany.

HOCHULI S. 1991. Zur Datierung der früh- und mittelbronzezeitlichen Siedlungsstelle “Bleiche 2” bei Arbon TG. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 74:107-14.

HOCHULI S. 1994. Arbon-Bleiche. Die neolithischen und bronzezeitlichen Seeufersiedlungen. Ausgrabungen 1885-1991. *Archäologie im Thurgau* 2.

HOCHULI S, KÖNINGER J, RUOFF U. 1994. Der absolutchronologische Rahmen der Frühbronzezeit in der Ostschweiz und in Südwestdeutschland. *Archäologisches*

Korrespondenzblatt 24:269-82.

HODDER I. 1982. *Symbols in Action*. Cambridge University Press, Cambridge

HODDER I, ORTON C. 1990. *Análisis espacial en arqueología*. Barcelona.

HOFFMAN DD, RICHARDS W. 1984. Parts of recognition. *Cognition* 18:65-96.

HOGG A, PALMER J, BOSWIJK G, REIMER P, BROWN D. 2009. Investigating the interhemispheric 14C offset in the 1st millennium AD and assessment of laboratory bias and calibration errors. *Radiocarbon* 51(4):1177-86.

HOLDAWAY S, WANDSNIDER L, editors. 2008. *Time in archaeology: time perpectivism revisited*. Salt Lake City.

HOLMAN EW. 2004. Why are language families larger in some regions than in others?. *Diachronica* 21(1):57-84.

HOLMAN EW, WICHMANN S, BROWN CH, VELUPILLAI V, MÜLLER A, BAKKER D. 2008. Explorations in automated language classification. *Folia Linguistica* 42(2):331-54.

HOLM H. 2007. The new arboretum of Indo-European "Trees". Can new algorithms reveal the phylogeny and even prehistory of Indo-European?. *Journal of Quantitative Linguistics* 14(2):167-214.

HOLSTE F. 1962. *Zur Chronologie der südosteuropäischen Depotfunde der Urnenfelderzeit*. Marburg/Lahn.

HOLST MK. 2001. Formalizing fact and fiction in four dimensions: a relational description of temporal structures in settlements. In: STANCIC Z, VELJANOVSKI T, editors. Computing archaeology for understanding the past. Oxford. *British archaeological Reports* S931:159-63.

HOLST MK. 2004. Complicated relations and blind dating: formal analysis of relative chronological structure. In: BUCK CE, MILLARD AR, editor. *Tools for Constructing Chronologies. Crossing Disciplinary Baundaries*. London. p 129-48.

HÖPPNER B, BARTELHEIM M, HUIJSMANS M, KRAUSS R, MARTINEK K-P, PERNICKA E, SCHWAB R. 2005. Prehistoric copper production in the Inn Valley (Austria), and the earliest copper in central Europe. *Archaeometry* 47(2):293-315.

HORISBERG U. 2003. Die bronze- und hallstattzeitliche Foundstelle Baar ZG-Martinspark. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 86:55-113.

HOUSLEY RA, GAMBLE CS, STREET M, PETTITT P. 1997. Radiocarbon evidence for the late glacial human recolonization of Northern Europe. *Proceedings of the Prehistoric Society* 63:25-54.

HOWEY M. 2007. Using multi-criteria cost surface analysis to explore past regional landscapes: A case study of ritual activity and social interaction in Michigan AD 1200–1600. *Journal of Archaeological Science* 34:1830-46.

HUA Q, BARBETTI M, FINK D, KAISER KF, FRIEDRICH M, KROMER B, LEVCHENKO VA, ZOPPI U, SMITH AM, BERTUCH F. 2009. Atmospheric 14C variations derived from tree rings during the early Younger Dryas. *Quaternary Science Reviews* 28(25-

26):2982-90.

HUBER B, GIERTZ-SIEBENLIST V. 1998. Nachträge zur Dendrochronologie der "Wasserburg Buchau". In: Siedlungsarchäologie im Alpenvorland V. *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 68:87-9.

Hunley K, Dunn M, Lindstrøm E, Reesink GP, Terrill AH, Norton H, Scheinfeldt L, Friedlaender F, Merriwether D, Koki G, Friedlaender J. 2007. Inferring prehistory from genetic, linguistic, and geographic variation. In: FRIEDLAENDER JS, editor. *Population genetics, linguistics, and culture history in the southwest Pacific*. p 141-55.

HUNT-ORTIZ MA. 2003. *Prehistoric Mining and Metallurgy in South-West Iberian Peninsula*. Oxford: BAR International Series 1188.

IRIARTE CHIAPUSSO MJ. 2001. Un caso paradigmático de antropización del medio vegetal. El poblado de la Edad del Bronce de Puy Águila I (Bardenas Reales, Navarra). *Trabajos de Arqueología Navarra* 15:123-36.

ISAAC GR. 2004. The nature and origins of the Celtic languages: Atlantic seaways, Italo-Celtic and other paralinguistic misapprehensions. *Studia Celtica* 38:49-58.

ISERN N, FORT J, CARVALHO AF, GIBAJA JF, IBAÑEZ JJ. 2014. The Neolithic transition in the Iberian Peninsula: data analysis and modeling. *Journal of Archaeological Method and Theory* 21(2):447-60.

ISERN N, FORT J, VANDER LINDEN M. 2012. Space competition and time delays in human range expansions. Application to the Neolithic transition. *PLoS ONE* 7(12): e51106.

JACQUET P. 1995. *Intervention 94.8 « Bassins SNCF »*. Rapport d'intervention, Lyon, SRA/AFAN/Ville de Lyon/Courly. 2 vol.

JACQUET P, editor. 1998. Habitats de l'âge du Bronze à Lyon-Vaise (Rhône): les fouilles du boulevard périphérique nord de Lyon. *Documents d'archéologie française* 68.

JACQUET P, SPELLER A, HALITIM N. 1997. *Lyon, boulevard périphérique nord. Première partie: cadre et déroulement de l'opération. DFS de sauvetage archéologique programmé*. Lyon, SRA Rhône-Alpes/Service archéologique municipal.

JANIN T. 1992. L'évolution du Bronze final IIIb et la transition Bronze-Fer en Languedoc occidental d'après la culture matérielle et les necropolis. *Documents d'Archéologie Méridionale* 15:243-59.

JANIN T. 2000. Le groupe culturel Mailhac I en France méridionale: essai de définition et extension géographique d'apres l'étude des nécropoles du Languedoc occidental. In: GASCÓ J, CLAUSTRE F, editors. *Habitats, économies et sociétés du Nord-Ouest Méditerranéen de l'Âge du Bronze au premier Âge du Fer, Actes du Colloque International, XXIVe Congrès Préhistorique de France (Carcassonne, 26-30 septembre 1994)*. Joué-lès-Tours. p 167-74.

JANIN T. 2001. Sépultures, nécropoles, archéologie funéraire et sociétés de l'âge du Bronze dans le Sud-Ouest de la France: résultats récents, programmes et tendances. *Documents d'Archéologie Méridionale* 24:230-7.

JANIN T. 2009. Jean Guilaine, Mailhac et le Mailhacien. In: *De la Méditerranée et d'ailleurs. Mélanges offerts à Jean Guilaine*. Toulouse. Archives d'Écologie préhistorique. p 353-64.

JANIN T, BURENS A, CAROZZA L, BIRON M, CAROZZA J-M, CHARDENON N, GROS L, LAGARRIGUE A, MATILLA V, PRADAT B. 1997. *La nécropole protohistorique du Camp d'Alba à Réalville (Tarn-et-Garonne)*. Lattes - Toulouse.

JANKE R. 1993-1994. Prähistorische Funde aus Oberwinterthur. *Archäologie im Kanton Zürich* 13:317-26.

JANKOVITZ K. 1998-1999. Studio delle lamine in bronzo del ripostiglio di Pila del Brancón. *Padusa* XXXIV-XXXV:85-107.

JANSSEN W. 1991. Archäologische Burgenforschung in Franken. *Rostra Universitatis Wirceburgensis* IV. Würzburg.

JANSSEN W. 1993. Der Bullenheimer Berg. In: DANNHEIMER H, GEBHARD R, editors. *Das keltische Jahrtausend*. Mainz. p 75-82.

JACQUET P, BOUQUIN T, KUNTZ L, SIRVEN R. 2003. Fouille de fosses de combustion protohistoriques à Saint-Priest (Rhône, France). In: FRÈRE-SAUTOT M-C, editor. *Le Feu domestique et ses structures au Néolithique et aux Âges des métaux: actes du colloque de Bourg-en-Bresse et Beaune, 7-8 octobre 2000*. p 291-7.

JEANNET A. 1981. Un habitat du Premier âge du Fer à Jugy (S & L). *Mémoires de la Société d'histoire et d'archéologie de Châlon-sur-Saône* 50:27-41.

JENNINGS B. 2012. When the going gets tough...? Climatic or cultural influences for the LBA abandonment of circum-alpine lake-dwelling. In: KNEISEL J, KIRLEIS W, DAL CORSO M, TAYLOR N, TIEDTKE V, editors. Collapse or continuity? Environment and development of Bronze Age human landscapes. *Universitätsforschungen zur prähistorischen Archäologie* 205:85-99.

JOANNIN S, MAGNY M, PEYRON O, VANNIÈRE B, GALOP D. 2014. Climate and land-use change during the late Holocene at Lake Ledro (southern Alps, Italy). *The Holocene* 24(5):591-602.

JOCKENHÖVEL A. 1994. Raum und Zeit - Gliederung der Bronzezeit. In: JOCKENHOVEL A., KUBACH W, editors. *Bronzezeit in Deutschland. Sonderheft der Zeitschrift Archaologie in Deutschland*. Stuttgart. p 11-4.

JOCKENHÖVEL A. 2013. Chapter 40, Germany in the Bronze Age. In: FOKKENS H, HARDING A, editors. *The Oxford handbook of the European Bronze Age*. Oxford. p 723-45.

JOFFROY R. 1975. Vix: habitats et nécropoles. In: DUVAL P-M, KRUTA V, editors. *L'habitat et la nécropole à l'Âge du Fer en Europe occidentale et centrale, Actes du 1er colloque archéologique de la IVème section de l'Ecole Pratique des Hautes Etudes*. p 71-4.

JOHNSON CN, BROOK BW. 2011. Reconstructing the dynamics of ancient human populations from radiocarbon dates: 10000 years of population growth in Australia. *Proceedings of the Royal Society* 278:3748-54.

JOHNSTONE EC, MACKLIN MG, LEWIN J. 2006. The development and application of a database of radiocarbon-dated Holocene fluvial deposits in Great Britain. *Catena* 66:14-23.

JOLY J-L, BLAIZOT F, BELLON C, BONNET C, BROUILLAUD S, CONSTANTIN P, HORRY A, LALAI D, PLANTEVIN C, SAVAY-GUERRAZ S. 1999. *Vénissieux îlot D: DFS de sauvetage urgent.* DRAC Rhône-Alpes, Service Regional de l'Archéologie.

JONES RE, VAGNETTI L, LEVI ST, WILLIAMS J, JENKINS D, DE GUIO A. 2002. Mycenaean pottery from Northern Italy. Archeological and Archeometric Studies. In: *Studi Micenei ed Egeo-Anatolici* XLIV/2. CNR-Istituto di studi sulle civiltà dell'egeo e del Vicino Oriente. Roma. p 221-61.

JOVANOVIĆ B. 1986. Early metallurgy in Yugoslavia. In: MADDIN R, editor. *The beginning of the use of metals and alloys*. Cambridge. p 69-79.

JILG E. 2007. Young Bronze Age finds from Lödersdorf near Feldbach, Eastern Styria. In: TIEFENGRABER G, editor. Studien zur Mittel- und Spatbronzezeit am Rande der Sudostalpen. *Universitätsforschungen zur prähistorischen Archäologie* 148:117-23.

JUNG R, MEHOFER M. 2013. Mycenaen Greece and Bronze Age Italy: cooperation, trade or war?. *Archäologisches Korrespondenzblatt* 43(2):175-93.

JUNYENT E. 1982. Tossal del Molinet, El Poal. In: *Les excavacions arqueològiques a Catalunya en els darrers anys. Excavacions arqueològiques a Catalunya 1*. Generalitat de Catalunya. Departament de Cultura. Barcelona. p 256-7.

JUNYENT E. 1992. Els orígens del ferro a Catalunya. *Revista d'Arqueologia de Ponent* 2:21-35.

KAENEL G, KLAUSENER M. 1990. Quelques tombes à incinération du Bronze final (X[e] siècle av. J.-C.) à Vidy (Lausanne VD). *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 73:51-82.

KAISER K, KÜSTER M, FÜLLING A, THEUERKAUF M, DIETZE E, GRAVENTEIN H, KOCH PJ, BENS O, BRAUER A. 2014. Littoral landforms and pedosedimentary sequences indicating late Holocene lake-level changes in northern central Europe - A case study from northeastern Germany. *Geomorphology* 216:58-78.

KANIEWSKI D, PAULISSEN E, VAN CAMPO E, WEISS H, OTTO T, BRETSCHNEIDER J, VAN LERBERGHE K. 2010. Late second–early first millennium BC abrupt climate changes in coastal Syria and their possible significance for the history of the Eastern Mediterranean. *Quaternary Research* 74:207-15.

KARDULIAS PN, HALL TD. 2008. Archaeology and World-Systems Analysis. *World Archaeology* 40(4):572-83.

KARL R. 2010. The Celts from everywhere and nowhere, a revaluation of the origins of the Celts and the emergence of Celtic Cultures. In: CUNLIFFE B, KOCH JT, editors. *Celtic from the West: alternative perspectives from archaeology, genetics, language and literature*. Oxford.

KATZENBERG MA, SAUNDERS RS, editors. 2008. *Biological Anthropology of the Human Skeleton*. New York.

KEENAN DJ. 2012. *Calibration of a radiocarbon age*. Nonlinear Processes in Geophysics 19:345-50.

KELLER F. 1866. *The lake dwellings of Switzerland and other parts of Europe*. London.

KELLY RL, THOMAS DH. 2012. *Archaeology*. KY.

KENYON K. 1971. An Essay on Archaeological Technique: the Publication of Results from the Excavation of a Tell. *Harvard Theological Review* 64:271-9.

KERN D. 2001. Thunau am Kamp – Eine befestigte Höhensiedlung (Grabung 1965-1990). Urnenfelderzeitliche Siedlungsfunde der unteren Holzwiese. *Mitteilungen der Prähistorischen Kommision Österreichische Akademie der Wissenschaften* 41. Wien.

KERR TR, McCORMICK F. 2014. Statistics, sunspots and settlement: influences on sum of probability curves. *Journal of Archaeological Science* 41:493-501.

KIMMIG W. 1940. Die Urnenfelderkultur in Baden. *Römisch-Germanische Forschungen* XIV. Berlin.

KIMMIG W. 1951. Où en est l'étude de la civilization des champs d'urnes en France, principalement dans l'Est?. *Revue Archéologique de l'Est et du Centre-Est* II:65-81.

KIMMIG W. 1952. Où en est l'étude de la civilization des champs d'urnes en France, principalement dans l'Est? (suite). *Revue Archéologique de l'Est et du Centre-Est* III:7-19.

KIMMIG W. 1964. Seevolkerbewegung und Urnenfelderkultur. In: USLAR R, NARR KJ, editor. *Studien aus Alt-Europa* 1. p 220-83.

KING RC, STANSFIELD WD, MULLIGAN PK. 2006. *A dictionary of gen*etics. Oxford.

KIJEK A, KIJEK T 2010. Modelling of innovation diffusion. *Operations research and decisions* 3-4:53-68.

KLEMM S. 2003. Montanarchäologie in der Eisenerzer Alpen, Steiermark. Archäologische und naturwissenschaftliche Untersuchungen zum prähistorischen Kupferbergbau in der Eisenerzer Ramsau. *Mitteilungen der Prähistorischen Kommision Österreichische Akademie der Wissenschaften* 50. Wien.

KNIGHT FH. 1921. *Risk, uncertainty and profit*. Chicago.

KOCH JT. 2006. *Celtic Culture: a Historical Encyclopedia*. Santa Barbara, California.

KOCH JT. 2008. *Appendix A, O'Donnell lectures 2008*.

KOCH JT. 2009a. A case for Tartessian as a Celtic language. In: Acta Palaeohispanica X. *Paleohispanica* 9:339-51.

KOCH JT. 2009b. *Tartessian: Celtic in the South-West at the dawn of history*. Aberystwyth.

KOCH JT. 2013a. La fórmula epigráfica tartesia a la luz de los descubrimientos de la necrópolis de Medellín. In: Acta Palaeohispanica XI. *Palaeohispanica* 13:347-57.

KOCH JT. 2013b. Out of the flow and ebb of the European Bronze Age: heroes, Tartessos, and

Celtic. In: KOCH JT, CUNLIFFE B. 2013. *Celtic from the West 2: rethinking the Bronze Age and the arrival of Indo-European in Atlantic Europe*. Oxford.

KOCH JT, CUNLIFFE B. 2013. *Celtic from the West 2: rethinking the Bronze Age and the arrival of Indo-European in Atlantic Europe*. Oxford.

KOHL PL. 1987. The use and abuse of World Systems Theory: the case of the Pristine West Asian State. *Advances in Archaeological Method and Theory* 11:1-35.

KOHLER-SCHNEIDER M. 2001. Verkohlte Kultur- und Wildpflanzenreste aus Stillfried an der March als Spiegel spätbronzezeitlicher Landwirtschaft im Weinviertel, Niederösterreich. *Mitteilungen der Prähistorischen Kommission Österreichische Akademie der Wissenschaften* 37. Wien.

KOHLER-SCHNEIDER M. 2003. Contents of a storage pit from late Bronze Age Stillfried, Austria: another record of the "new" glume wheat. *Vegetation history and archaeobotany* 12(2):105-11.

KOLB CC. 1985. Demographic estimates in archaeology: contributions from ethnoarchaeology on Mesoamerican peasants. *Current Anthropology* 26:581-99.

KÖNINGER J. 2006. Bodman-Schachen 1: die frühbronzezeitlichen Ufersiedlungen (Tauchsondagen 1982–1984 und 1986), Siedlungsarchäologie im Alpenvorland VIII. *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 85.

KÖNINGER J. 2001. Frühbronzezeitliche Ufersiedlungen am Bodensee. Neue Funde und Befunde aus Tauchsondagen und Nachforschungen in neuen und alten Sammlungsbeständen. *Hemmenhofener Skripte* 2:93-116.

KOSSACK G. 1954. Studien zum Symbolgut der Urnenfelder- und Hallstattzeit Mitteleuropas. *Römisch- Germanishe Forschungen* 20. Berlin.

KOSSACK G. 1995. Mitteleuropa zwischen dem 13. und 8. Jahrhundert v. Chr. Geb. Geschichte, Stand und Probleme der Urnenfelderforschun*g*. In: Beiträge zur Urnenfelderzeit nördlich und südlich der Alpen. Ergebnisse eines Kolloquiums. *Römisch-Germanischen Zentralmuseums Mainz Monographien 35*:1-64.

KRAUSE R. 1996. Zur Chronologie der Frühen und Mittleren Bronzezeit Süddeutschlands, der Schweiz und Österreichs. In: RANDSBORG K, editor. Absolute Chronology. Archaeological Europe 2500-500 BC (Verona, April 20-23 1995). *Acta Archaeologica* 67:73-86.

KRAUSE R. 1999. Early Broze age metallurgy in the north alpine region and C14-dating (2300-1600 BC). In: EVIN J, editor. Actes du 3ème Congrès Internacional ^{14}C et Archéologie (Lyon, 6-10 avril 1998). *Mémoires de la Société Préhistorique Française* XXVI:183-88.

KRAUSE R. 2003. *Studien zur kupfer- undfruhbronzezeitlichen Metallurgie zwischen Karpatenbecken und Ostsee Leidorf*. Rahden/Westfalien.

KRAUSE R. 2005a. Bronzezeitliche Burgen in den Alpen. Befestigte Siedlungen der frühen bis mittleren Bronzezeit. In: HOREJS B, JUNG R, KAISER E, TERŽAN B, editors. Interpretationsraum Bronzezeit. *Universitätsforschungen zur prähistorischen Archäologie* 121:389-413.

KRAUSE R. 2005b. Settlement archaeology and prehistoric mining: a new interdisciplinary research project in the Alpine valley Montafon in Vorarlberg (Austria). *Preistoria Alpina* 39:211-8.

KRAUSE R. 2007. The prehistoric settlement of the inneralpine valley of Montafon in Voralberg (Austria). *Preistoria Alpina* 42:119-36.

KRAUSE R, OEGGL K, PERNICKA E. 2004. Eine befestigte Burgsiedlung der Bronzezeit im Montafon, Voralberg. Interdisziplinäre Siedlungsforschungen und Montanarchäologie in Bartholomäberg und in Silbertal. *Archäologie in Österreich* 15(1):4-21.

KRISMER M, VAVTAR F, TROPPER P, KAINDL R, SARTROY B. 2011. The chemical composition of tetrahedrite-tennantite ores from the prehistoric and historic Schwaz and Brixlegg mining areas (North Tyrol, Austria). *European Journal of Mineralogy* 23:925-36.

KRISTIANSEN K. 1978. The consumption of wealth in Bronze Age Denmark. A study in the dynamics of economic processes in tribal societies. In: KRISTIANSEN K, PALUDAN-MÜLLER C, editors. *New directions in Scandinavian Archaeology. Studies in Scandinavian Prehistory and Early History I*. Copenhagen.

KRISTIANSEN K. 1987. Center and periphery in Bronze Age Scandinavia. In: ROWLANDS M, LARSEN MT, KRISTIANSEN K, editors. *Centre and periphery in the Ancient World*. Cambridge. p 74-85.

KRISTIANSEN K. 1991. Chiefdoms, states and systems of social evolution. In: EARLE T, editor. *Chiefdoms-economy, power and ideology*. Cambridge.

KRISTIANSEN K. 1994. The emergence of the European World System in the Bronze Age: divergence, convergence and social evolution during the first and the second millennia BC in Europe. In: KRISTIANSEN K, JENSEN J, editors. Europe in the first millennium BC. *Sheffield Archaeological Monographs* 6:7-30.

KRISTIANSEN K. 1998a. A theorical strategy for the interpretation of exchange and interaction in a Bronze Age context. In: MORDANT C, PERNOT M, RYCHNER V, editors. *L'atelier du bronzier en Europe du XXe au VIIIe siècle avant notre Ère.* Paris. p 333-43.

KRISTIANSEN K. 1998b. *Europe before history*. Cambridge.

KRISTIANSEN K. 1999a. The emergence of warrior aristocracies in later European prehistory and their long-term history. In: CARMAN J, HARDING A, editors. Ancient *warfare. Archaeological perspectives*. Sutton. p 175-89.

KRISTIANSEN K. 1999b. Understanding Bronze Age weapon hoards. Observations from the Zalko and Vaja hoards, Northeastern Hungary. *Jósa András Múzeum Évkönyv*e XLI:101-7.

KRISTIANSEN K. 2001. *Europa antes de la Historia*. Barcelona.

KRISTIANSEN K. 2002. The tale of the swords - swords and swordfighters in Bronze Age Europa. *Oxford Journal of Archaeology* 21(4):319-32.

KRISTIANSEN K. 2009. Premieres aristocracies. Pauvoir et metal a l'age du Bronze, In: DEMOULE J-P. L'Europe. *Un continent redécouvert par l'archéologie*. p 73-83.

KRISTIANSEN K. 2010. The Nebra Find and Early Indo- European Religion. In: MELLER H, BERTEMES F, editors. Der Grif nach den Sternen. Wie Europas Eliten zu Macht und Reichtum kamen, 2 vols (Internationales Symposium in Halle (Saale), 16-21 February 2005. *Tagungen des Landesmuseums für Vorgeschichte Halle (Saale)* Band 5. p 431-7.

KRISTIANSEN K. 2011, Chapter 10. Constructing Social and Cultural Identities in the Bronze Age. In: ROBERTS BW, VANDER LINDEN M, editors. *Investigating archaeological cultures: material culture, variability, and transmission.* p 201-10.

KRISTIANSEN K. 2012. Bronze Age dialectics. Ritual economies and the consolidation of social divisions. In: KIENLIN TL, ZIMMERMANN A, editors. Beyond Elites. Alternatives to hierarchical systems in modeling social formations, Proceedings of the International Conference at the Ruhr-Universität (Bochum, Germany, October 22-24 2009). *Universitätsforschungen zur prähistorischen Archäologie* 215:381-92.

KRISTIANSEN K. 2013. Religion and society in the Bronze Age. In: CHRISTENSEN LB, HAMMER O, WARBURTON DA, editors. *The Handbook of Religions in Ancient Europe*. p 77-92

KRISTIANSEN K, LARSEN M, editors. 1987. *Centre and Periphery in the Ancient World*. Cambridge.

KRISTIANSEN K, LARSSON TB. 2005. *The rise of Bronze Age society. Travels, transmissions and transformations*. Cambridge.

KRISTINSSON A. 2010. *Expansions, competion and conquest in Europe since the Bronze Age*. Reykiavík.

KRISTINSSON A. 2012. Indo-European Expansion Cycles. *Journal of Indo-European studies* 40(3-4):365-433

KROEBER AL. 1940. Stimulus Diffusion. *American Anthropologist* 42(1):1-20.

KROMER B, MANNING SW, FRIEDRICH M, TALAMO S, TRANO N. 2010. 14C calibration in the 2nd and 1st millennia BC-Eastern Mediterranean Radiocarbon Comparison Project (EMRCP). *Radiocarbon* 52(3):875-86.

KRUTA V. 2000. *Les Celtes. Histoire et dictionnaire. Des origines à la Romanisation et au Christianisme*. Paris.

KUCHARAVY D, DE GUIO R. 2011. Application of S-shaped curves. *Procedia Engineering* 9:559-72.

KUDELA K, BOBIK P. 2004. Long-Term Variations of Geomagnetic Rigidity Cutoffs. *Solar Physics* 224(1-2):423-31.

KUKOČ S. 2010. Osvrt na spaljivanje pokojnika u liburnskom kulturnom kontekstu. A review of the cremation rite in the liburnian cultural context. *Prilozi Instituta za arheologiju u Zagrebu* 27:95-110.

KÜMMEL C. 2001. Frühe Weltsysteme. Zentrum und Peripherie-Modelle in der Archäologie.

Materialien zur Ur- und Frühgeschichtlichen Archäologie 4. Rahden.

KUZMIN YV, KEATES SG. 2005. Dates are not just data: paleolithic settlement patterns in Siberia derived from radiocarbon records. *American Antiquity* 70:773-89.

LACHENAL T. 2007. Relations transalpines à l'âge du Bronze: état des données pour la Provence. *Bulletin du Musée d'*anthropologie *préhistorique de Monaco* 39**:**17-27.

LACHENAL T. 2010. *L'age du bronze en Provence: productions ceramiques et dynamiques culturelles*. Thèse pour obtenir le grade de Docteur d'Aix-Marseille Universite, Directeur de Thèse Dominique Garcia.

LACHENAL T. 2011a. En marge du R.S.F.O.: styles céramiques de l'étape moyenne du Bronze final en Provencee. In: *Actes 8 Rencontres Méridionales de Préhistoire Récente (Marseille, 7-8 novembre 2008)*. p 157-76.

LACHENAL T. 2011b. Entre Alpes et Méditerranée. Productions céramiques et dynamiques culturelles de la fin de l'âge du bronze en Provence (X-IX siècles av. J.-C.). *Quaderns de prehistòria i arqueologia de Castelló* 29:231-67.

LACHENAL T, PÊCHE-QUILICINI K. 2009. Relazioni culturali nel Mediterraneo nord-occidentale durante il Bronzo medio. Contributo delle tipologie ceramiche. In: MELIS MG, editor. *Atti del Convegno Nazionale dei Giovani Archeologi. Uomo e territorio, dinamiche di frequentazione e di sfruttamento delle risorse naturali nell'antichità (Sassari, 27-30 Settembre 2006)*. p 141-8.

LACHENAL T, RÜCKER C. 2009. L'aven de La Mort de Lambert (Valbonne, Alpes-Maritimes) et les dépôts de vases en grotte à l'âge du Bronze en France méridionale. In: BONNARDIN S, HAMON C, LAUWERS M, QUILLIC B, editor. *Du matériel au spirituel: réalités archéologiques et historiques des "dépôts" de la Préhistoire à nos jours: actes des rencontres 16-18 octobre 2008*. Antibes. Association pour la Promotion et la Diffusion des Connaissances archéologiques. p 223-37.

L'âge du bronze en Europe et en Méditerrannée/The Bronze Age in Europe and the Mediterranean. Sessions générales et posters/General Sessions and Posters 2005, Actes du XIVème Congrès UISPP, Université de Liège, Belgique (2-8 septembre 2001). Oxford: BAR International Series 1337.

LAGIER-BRUNO L. 1969. Le géant des Chènes de la Balme. *Annales du Bugey* 56:54-66.

LAGRAND C. 1968. *Recherches sur le Bronze final en Provence méridionale*. Thèse de Doctorat, univ. d'Aix-en-Provence, 2 vol.

LAGRAND C. 1976. *Les civilisations de l'Âge du bronze en Provence: le Bronze final*. In: GUILAINE J, editor. La préhistoire française, les civilisations néolithiques et protohistoriques de la France, t. 2. Paris. p 453-8.

LaMARCHE VCJR, HIRSCHBOECK KK. 1984. Frost rings in trees as records of major volcanic eruptions. *Nature* 307:121-6.

LANTING JN, AERTS-BIJMA AT, VAN DER PLICHT J. 2001. Dating of cremated bones. In: Proceedings of the 17th International ^{14}C Conference. *Radiocarbon* 43(2A):249-54.

LANTING JN, VAN DER PLICHT J. 1999-2000. De ^{14}C-chronologie van de Nederlandse pre en protohistorie, III: Neolithicum. *Palaeohistoria* 41/42:1-110.

LANZREIN AN. 2009. Die befestigte Höhensiedlung Toos-Waldi von der Frühbronzezeit bis in die Spätantike. Mit Beiträgen von Stefanie Jacomet, Karl-Ernst Behre und Hansjörg Brem. *Archäologie im Thurgau* 15.

LAUPEN A. 1994. Münchenwiler, Im Loch. Sondierungen 1990/91 und Rettungsgrabungen 1992/93: Bronzezeitliche Fundstellen und römische Spuren. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 3A:60-2.

LAVIOSA ZAMBOTTI P. 1939. Civiltà Palafitticole lombarde e Civiltà di Golasecca. *Rivista Archeologia Comense* 119-120.

LAVIOSA ZAMBOTTI P. 1940. La ceramica della Lagozza e la civiltà palafitticola italiana vista nei suoi rapporti con le civiltà mediterranee ed europee. Cap. II, La ceramica tipo Polada. *Bullettino di Paletnologia Italiana* 4:120-64.

LAWN B. 1975. University of Pennsylvania radiocarbon dates XVIII. *Radiocarbon* 17(2):196-215.

LEALE ANFOSSI M. 1958-1961. Revisione dei materiali fittili e faunistici provenienti dagli scavi nella Grotta del Pertusello (Val Pennavaira, Albenga). *Quaternaria* 5:318-20.

LEALE ANFOSSI M. 1962. La scoperta dell’Arma di Nasino. *Rivista Ingauna e Intemelia* 17:53-5.

LEALE ANFOSSI M. 1974. L’Arma di Nasino (Savona). Gli strati con ceramica. In: *Atti XVI IIPP*. p 131-40.

LEBEDYNSKY I. 2011. *Gli Indoeuropei. Fatti, dibattiti, soluzioni*. Foligno (Pg).

LEFEVRE-LEHOERFF A. 1992. Les moules de l’Age du bronze dans la plaine orientale du Po: vestiges de mise en forme des alliages base cuivre. *Padusa* 28:131-243.

LEGROS T. 1982. *Les Salins de Ferrières, l'Abion: une phase de transition Bronze final-1er âge du Fer sur la commune de Martigues (B. du Rh.)*. Mémoire de Maîtrise, Aix-en-Provence.

LEGROS T. 1986. Les Salins de Ferrières et l'Abion à Martigues (Bouches-du-Rhône): deux noveaux gisements du Bronze final. *Cahiers ligures de préhistoire et de protohistoire Nouvelle série* 3:227-57.

LEO K. 1999. Gustaf Kossinna: 1858-1931. In: MURRAY T. *Encyclopedia of Archaeology: The Great Archaeologists: Volume I*. p 233-46.

LEONARDI G. 1973. *Materiali preistorici e protostorici del Museo di Chiampo (Vicenza)*. Collezioni e Musei Archeologici del Veneto. Venezia.

LEONARDI G. 1992a. Le prealpi venete tra Adige e Brenta tra XIII e VI secolo a.C. In: METZGER R, GLEIRSCHER P. 1992. *Die Räter. I Reti*. Bolzano. p 135-9.

LEONARDI G, editor. 1992b. *Processi formativi della stratificazione archeologica. Atti del seminario internazionale Formation Processes and Excavation Methods in Archaeology: Perspectives (Padova, 15-27 luglio 1991)*. Padova. Saltuarie del laboratorio del Piovego 3.

LEONARDI G. 2010. Premesse sociali e culturali alla formazione dei centri protourbani del Veneto. In: Roma 2008 - International congress of classical archaeology meetings between cultures in ancient Mediterranean. *Bollettino di archeologia on line* volume speciale F:23-35.

LEONARDI G. 2012. Il capo, il sole e il villaggio: spunti interpretativi sul rapporto tra iconografia e ideologia sociale dall'età del rame alla media età del bronzo. *Archeologia Veneta* XXX:30-51.

LEONARDI G, BIANCHIN CITTON E, BALISTA C, STABILE G. 1979. Ripresa degli scavi nellla palafitta di Molina di Ledro, Scavi 1980 - Nota preliminare. *Preistoria Alpina* 15:39-55.

LEONARDI G, CUPITÒ M. 2008. Il sito arginato dell'età del Bronzo di Fondo Paviani-Legnago. Notizia preliminare sulla campagna d'indagine 2007. *Quaderni di Archeologia del Veneto* XXIV:90-2.

LEONARDI G, ROSSI S, editors. 2005. *Archeologia e idrografia del Veronese a cent'anni dalla deviazione del fiume Guà (1904-2004). Il museo Archeologico di Cologna Veneta e le prime ricerche archeologiche nella pianura veronese. Atti della giornata di Studi "La necropoli del Fiume Nuovo" (Cologna Veneta 15 maggio 2004)*. Cologna Veneta.

LEROY F. 1999-2000. La Fangade, site submergé du Bronze final. *Bulletin de la Société d'Etudes Historiques et Scientifiques de Sète et sa région* 22-24:7-18.

LEROY F. 2001. Sites lagunaires du Languedoc au Néolithique et à l'âge du Bronze. In: *Actes des congrès nationaux des sociétés historiques et scientifiques. Nantes 1999*. p 229-39.

LEROY F. 2002. *L'Abion et les Salines de Ferrières, Martigues, Sondages archéologiques sous-marins du canal de Caronte*. Rapport d'étude.

LIBBY WF. 1962. Radiocarbon; an atomic clock. *Annual Science and Humanity Journal*:190-200.

LIBBY WF. 1963. Accuracy of Radiocarbon Dates. *Science* 140:278-80.

LIBBY WF, ANDERSON EC, ARNOLD JR. 1949. Age determination by radiocarbon content: world-wide assay of natural radiocarbon. *Science* 109(2827):227-8.

LICHARDUS-ITTEN M. 1999. L'age du Bronze en France à 2300 avant J.-C.?. *Bulletin de la Société préhistorique française* 96(4):563-8.

LIEGARD S, FOURVEL A. 2001. *R.C.E.A. Allier, Route Centre Europe Atlantique, Coulanges-les Fendeux, Document final de synthèse de l'opération archéologique de fouille préventive*. SRA d'Auvergne.

LINDBLADH E, LYTTKENS CH, HANSON BS, ÖSTERGREN P-O. 1997. The diffusion model and the social-hierarchical process of change. *Health Promotion International* 12(4):323-30.

LING J, STOS-GALE Z, GRANDIN L, BILLSTRÖM K, HJÄRTHNER-HOLDAR E, PERSSON P-O. 2014. Moving metals II: provenancing Scandinavian Bronze Age artefacts by lead isotope and elemental analyses. *Journal of Archaeological Science* 41:106-32.

LIPO CP, O' BRIEN MJ, COLLARD M, SHENNAN SJ. 2006. *Mapping Our Ancestors*. USA.

LIPPERT A. 2013. Brandbestattungen der Urnenfelderzeit in der Steiermark. In: LOCHNER M, RUPPENSTEIN F, editors. *Brandbestattungen von der mittleren Donau bis zur Ägäis zwischen 1300 und 750 v. Chr., Akten Des Internationalen Symposiums An Der Österreichischen Akademie Der Wissenschaften in Wien (11-12 Februar 2010)*. p 33-44.

LITTON D, LEESE MN. 1991. Some statistical problems arising in radiocarbon calibration. In: LOCKYEAR K, RAHTZ S, editors. *Computer applications and quantitative methods in archaeology 1990*. Oxford: BAR International series 565. p 101-9.

LLANOS A. 1972. Cerámica excisa en Alava y provincias limítrofes. *Estudios de Arqueología Alavesa* V:81-98.

LLANOS A. 1978. Bizkar. Nuevo yacimiento de depósitos en Hoyos. (Maestu-Alava). *Estudios de Arqueología Alavesa* 9:245-63.

LLANOS A, APELLÁNIZ JM, AGORRETA JA, FARIÑA J. 1975. El castro del castillo de Henayo (Alegría-Álava). Memoria de Excavaciones. Campaña de 1969-1970. *Estudios de Arqueología Alavesa* 8:87-212.

LLONGUERAS M, PETIT MA, MARCET R, GUILAINE J, THOMMERET JY. 1979-1980a. La Bòbila Madurell (San Quirze del Vallès, Barcelona), Noves dates de C14 a Catalunya. *Ampurias* 41-42:352-4.

LLONGUERAS M, PETIT MA, MARCET R, GUILAINE J, THOMMERET JY. 1979-1980b. Cova del Toll (Moià, Barcelona), Noves dates de C14 a Catalunya. *Ampurias* 41-42:347-51.

LOCHNER M. 1991. Studien zur Unrnenfelderkultur im Waldviertel (Niederösterreich). *Mitteilungen der Prähistorischen Kommision Österreichische Akademie der Wissenschaften* 25. Wien.

LOCHNER M, HELLERSCHMID I. *Ein Gräberfeld der jüngeren Urnenfelderkultur aus Franzhausen-Kokoron. Katalog und Abbildungen*. Version 02/epub, doi:10.1553/KatalogUFK.

LOCHNER M, HELLERSCHMID I. 2009. Sozialstrukturen im Gräberfeld Franzhausen-Kokoron, Niederösterreich. Eine Analyse anhand der Urnengrößen. *Archaeologia Austriaca* 93:23-32.

LOCHNER M, RUPPENSTEIN F, editors. 2013. Brandbestattungen von der mittleren Donau bis zur Ägäis zwischen 1300 und 750 v. Chr. Akten Des Internationalen Symposiums An Der Österreichischen Akademie Der Wissenschaften in Wien (11-12 Februar 2010).

LOCK G, MOLYNEAUX BL, editors. 2006. *Confronting scale in archaeology. Issues of theory and practice*. USA.

LOISON G. 1986. Orcet: Le Tourteix. *Gallia Préhistoire* 29(2):285-7.

LOISON G. 1991. Dallet, Machal. In: *Bilan scientifique 1991, DRAC Auvergne. Service Regional de l'Archéologie*. p 46-8.

LOISON G. 1992. *La genèse du Bronze ancien en Auvergne, identification d'un groupe regional. Pré-tirage du 117e Congrès national des societés historiques et scientifiques, CTHS*. Clermont-Ferrand.

LOISON G. 1993. Les dynamiques de peuplement et d'exploitation des milieux naturels de la fin du Néolithique au Bronze ancien en Basse-Auvergne. In: *Bilan scientifique. SRA Auvergne*. p 53.

LOISON G. 2003. L'Âge du Bronze ancien en Auvergne. *Archives d'Ecologie Préhistorique* 14.

LONG A, RIPPETEAU B. 1974. Testing Contemporaneity and Averaging Radiocarbon Dates. *American Antiquity* 39(2):205-15.

LÓPEZ A, FIERRO X, RIERA M. 2005. Resultats de les excavacions de 1997 a 2003 a l'oppidum del Turó del Montgròs, el Brull (Osona). In: *XIII Col·loqui Internacional d'Arqueologia de Puigcerdà (Puigcerdà 2003)*. p 141-62.

LÓPEZ A, ROVIRA J. 1982. L'assentament del Bronze Final del turó de Montgròs (el Brull, Osona). *Ausa (Vic)* X:187-92.

LÓPEZ CACHERO FJ. 1998. *Estudio de la habitación 2 de Genó, una aproximación al conocimiento del espacio doméstico de las comunidades de CC.UU antiguos en el Bajo Segre*. Tesis de licenciatura dirigida por José Luis Maya González y M. Àngels Petit i Mendizábal en la Universitat de Barcelona.

LÓPEZ CACHERO FJ. 2005. *La necrópolis de Can Piteu-Can Roqueta (Sabadell) en el contexto del Bronce Final y la Primera Edad del Hierro en el Vallès: estudio de los materiales cerámicos*. Tesis doctoral, Universitat de Barcelona.

LÓPEZ CACHERO FJ. 2006. *Aproximació a la societat del nord-est peninsular durant el bronze final i la primera edat del ferro. El cas de las necròpolis de Can Piteu-Can Roqueta (Sabadell, Vallès Occidental, Barcelona)*. Barcelona.

LÓPEZ CACHERO FJ. 2007. *Sociedad y economía en el Bronce Final y la primera edad del Hierro en el noreste peninsular: una aproximación a partir de las evidencias arqueológicas*. Trabajos de Prehistoria 64(1):99-120.

LÓPEZ CACHERO FJ. 2008. Necrópolis de incineración y arquitectura funeraria en el noreste de la Península Ibérica durante el Bronce Final y la Primera Edad del Hierro. *Complutum* 19(1):139-71.

LÓPEZ JB. 2000. *L'evolució del poblament protohistòric a la Plana Occidental catalana. Models d'ocupació del territori i urbanisme*. Lleida, Tesis Doctoral dirigida por el Dr. E. Junyent, Universitat de Lleida.

LÓPEZ JB, editor. 2001. Minferri en el context de l'edat del bronze a la plana occidental catalana. G.I.P (Grup d'Investigació Prehistòrica de la UdL). Colors de Terra. La vida i la mort en una aldea d'ara fa 4.000 anys. Minferri (Juneda). Lleida. *Quaderns de la Sala d'Arqueologia de l'I.E.I.* 1:13-40.

LÓPEZ JB, MALGOSA A, GALLART J, RAFEL N. 2005. Cova de Montanissell (Sallent - Coll de Nargó, Alt Urgell). Operació: "Senyora de les Muntanyes". *Cota Zero* 20:27-36.

LORRIO A, RUIZ ZAPATERO G. 2005. The Celts in Iberia: An Overview. *Journal of* *interdisciplinary Celtic Studies* 6:167-254

LOUIS R, LACROIX B. 1960. *Les Fontaines Salées*. Publication de la Societé des Fouilles Archéologiques de l'Yonne. Auxerre.

LOŽNJAK DIZDAR D. 2011. Graves of the Early Urnfield Culture in northern Croatia. Some remarks and questions. In: GUTJAHR C, TIEFENGRABER G, editors. Beiträge zur Mittel- und Spätbronzezeit sowie zur Urnenfelderzeit am Rande der Südostalpen, Akten des 1. Wildoner Fachgespräches vom 25. bis 26. Juni 2009 in Wildon/Steiermark (Österreich). *Internationale Archäologie* 15:37-49.

LUCAS G. 2005. *The Archaeology of Time*. London.

LUCAS G. 2008. Time and archaeological event. *Cambridge Archaeological Journal* 18(1):59-65.

LUCAS G. 2012. *Understanding the archaeological record*. Cambridge.

LULL V, MICÓ R, RIHUETE HERRADA C, RISCH R. 2013. Chapter 33, Bronze Age Iberia. In: FOKKENS H, HARDING A, editors. *The Oxford handbook of the European Bronze Age*. Oxford. p 594-616.

MACE R, HOLDEN C, SHENNAN S, editors. 2005. *The Evolution of Cultural Diversity: Phylogenetic Approaches*.

MACWHITE E. 1951. *Estudios sobre las relaciones atlánticas de la Península Ibérica en la Edad del Bronce*. Madrid.

MÄDER A. 2008. Die mittelbronzezeitlichen Gräber von Birmensdorf-Rameren. *Zürcher Archäologie* 24.

MÄDER A. 2009. Zwei spätbronzezeitliche Bestattungen in Neftenbach. *Archäologie im Kanton Zürich* 01:41-50.

MÄDER A, SORMAZ T. 2000. Die Dendrodaten der beginnenden Spätbronzezeit (Bz D) von Elgg ZH-Breiti. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 83:65-78.

MADDIN R. 2003. The beginning of the use of iron. In: STÖLLNER T, KÖRLIN G, STEFFENS G, CIERNY J. 2003. Man and Mining - Mensch und Bergbau. Studies in honour of Gerd Weisgerber on occasion of his 65th birthday. *Der Anschnitt* 16:309-18.

MAGGI R. 1990. *Archeologia dell'Apppennino Ligure. Gli scavi del Castellaro di Uscio: un insediamento di crinale occupato dal neolitico alla conquista romana*. Chiavari.

MAGGI R. 2004. L'eredità della Preistoria e la costruzione del paesaggio. In: DE MARINIS RC, SPADEA G, editor. *I Liguri. Un antico popolo europeo tra Alpi e Mediterraneo*. p 35-49.

MAGGI R, MARTINI F, SARTI L, editors. 1996. *Guide archeologiche. Preistoria e protostoria in Italia*. Genova.

MAGGI R, MELLI P, MACPHAIL RI, CRUISE GM, NISBET R, DEL SOLDATO M, PINTUS S. 1985. Note sugli scavi di Castellaro di Uscio (GE), 1981-1985. *Preistoria Alpina* 21:59-83.

MAGGI R, MELLI P, NISBET R. 1982. Uscio (Genova). Scavi 1981-82. Rapporto preliminare. *Rivista di Studi Liguri* XLVIII:193-214.

MAGGI R, NISBET R. 1991. Prehistoric pastoralism in Liguria. In: MAGGI R, NISBET R, BARKER G, editors. Archeologia della pastorizia nell'Europa meridionale, I. *Rivista di Studi Liguri* LVI:265-96.

MAGNY M, BÉGEOT C, PEYRON O, RICHOZ I, MARGUET A, BILLAUD Y. 2005. Habitats littoraux et histoire des premières communautés agricoles au Néolithique et à l'âge du Bronze: une mise en perspective paléoclimatique. In: DELLA CASA P, TRACHSEL M, editors. WES'04 - Wetland Economies and Societies. Proceedings of the International Conference in Zurich, 10-13 March 2004. Zurich : Musée Suisse. *Collectio* Archaeologica 3:133-42.

MAGNY M, BOSSUET G, GAUTHIER E, RICHARD H, VANNIÈRE B, BILLAUD Y, MARGUET A, MOUTHON J. 2007. Variations du climat pendant l'âge du Bronze au centre-ouest de l'Europe: vers l'établissement d'une chronologie à haute résolution. In: MORDANT C, RICHARD H, MAGNY M, editors. Environnements et cultures à l'Age du Bronze en Europe occidentale. Actes du 129e Congrès national des sociétés historiques et scientifiques (CTHS). Besançon, 19-21 avril 2004. Besançon, Presses universitaires de Franche- Comté. *Documents préhistoriques* 21:13-28.

MAGNY M, PEYRON O. 2008. Variations climatiques et histoire des sociétés à l'âge du Bronze au nord et sud des Alpes. In: GUILAINE J, editor. *Villes, villages, campagnes de l'âge du Bronze*. Paris. p 161-73.

MAHAJAN V, PETERSON RA. 1985. *Models for Innovation Diffusion*. Beverly Hills.

MAINI E, CURCI A. 2009. La fauna del sito di Solarolo Via Ordiere. Analisi preliminare del Settore 1. In: CATTANI M, editor. Atti della Giornata di studi "La Romagna nell'età del Bronzo" (Ravenna, Solarolo, 19 settembre 2008). *IpoTESI di Preistoria* 2(1):292-303.

MAISE C. 1998. Archäoklimatologie - Vom Einfluss nacheiszeitlicher Klimavariabilität in der Ur- und Frühgeschichte. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 81:197-235.

MALASPINA P, CRUCIANI F, NOVELLETTO A. 1998. Network analyses of Y-chromosomal types in Europe, northern Africa and western Asia reveal specific patterns of geographic distribution. *American Journal of Human Genetics* 63:847.

MALIZIA A. 1990. Definizione archeologica della fase Hallstatt B2: storia del problem*a*. In: BELARDELLI C, GIARDINO C, MALIZIA A, editors. *L'Europa a sud e a nord delle Alpi alle soglie della svolta protourbana*. Treviso. p 15-8.

MALLORY JP, ADAMS DQ. 1997. *Encyclopedia of Indo-European Culture*. London and Chicago.

MALUQUER DE MOTES J. 1948. La cerámica con asas de apéndice de botón y el final de la cultura megalítica del nordeste de la península. *Ampurias* IV:171-8.

MAMELI L, BARCELÓ JA, ESTÉVEZ J. 2002. The Statistics of Archeological Deformation Process. A zooarchaeological experiment. In: BURENHULT G, editor. *Archaeological informatics: pushing the envelope*. Oxford: BAR International Series 1016. p 221-30

MANDL F. 1995. Über 3000 Jahre alte Weidewirtschaft auf dem Dachsteinplateau. *Archäologie Österreichs* 6(1):42-6.

MANDL F. 2007. Das “Königreich” auf dem Dachsteingebirge. Dokumentationen. In: HEBERT B, KIENAST G, MANDL F, editors. Königreich-Alm Dachsteingebirge. 3500 Jahre Almwirtschaft zwischen Gröbming und Hallstatt. *Forschungsberichte der ANISA* 1:23-96.

MANDL F. 2009. Langkaralm und Lackenofengrube, Dachsteingebirge. Beiträge zur Geschichte der Alwirtschaft. In: HEBERT B, MANDL F, editors. Almen im Visier. Dachsteingebirge, Totes Gebirge, Silvretta. *Forschungsberichte der ANISA* 2:23-38.

MANDL F, STADLER H, editors. 2010. Archäologie in den Alpen. Alltag und Kult. *Forschungsberichte der ANISA* 3.

MANNING SW. 1988. The Bronze Age eruption of Thera: absolute dating, Aegean chronology and Mediterranean cultural interrelations. *Journal of Mediterranean Archaeology* 1:17-82.

MANNING SW. 1999. *A test of Time. The Volcano of Thera and the chronology and history of the Aegean and east Mediterranean in the mid second millennium BC*. Oxford.

MANNING SW. 2007. Why radiocarbon dating 1200 BCE is difficult: a sidelight on dating the end of the Late Bronze Age and the contrarian contribution. *Scripta Mediterranea* XXVII-XXVIII:53-80.

MANNING SW, BRONK RAMSEY C, DOUMAS C, MARKETOU T, CADOGAN G, PEARSON CL. 2002. New evidence for an early date for the Aegean Late Bronze Age and Thera eruption. *Antiquity* 76:733-44.

MANTEGARI G. 2010. *Cultural heritage on the semantic web: from representation to fruition.* Ph.D. dissertation. University of Milan.

MANYANÓS A. 1999-2000. Un estado de la cuestión de la celtización peninsular desde la complementariedad de un doble proceso. *Kalathos* 18-19:125-51.

MARAMBAT L. 1994. Environnement d'un cromlech de l'âge du fer, Hegieder 7 (Pays-Basque Nord). *Munibe* 46:143-4.

MARAMBAT L. 1995. Analyse palynologique du sédiment provenant de la ciste du cromlech Meatsé 8 (Pays Basque Nord). *Munibe* 47:211-3.

MARAMBAT L. 1997. Environnement du cromlech Méatsé 11. Medio ambiente en torno al cromlech Méatsé 11. *Munibe* 49:107-9.

MARCHESETTI C. 1903. *I castellieri preistorici di Trieste e della regione Giulia*. Trieste (reprint Trieste 1981).

MARCHESINI M, MARVELLI S. 2005. Analisi palinologiche su un campione di torba dal sito di Ponte Moro - Cerea (Verona, nord Italia). In: BALISTA C, DE GUIO A, VANZETTI A, BETTO A, DE ANGELI G, SARTOR F. 2005. Paleoidrografie, impianti terramaricoli e strade su argine: evoluzione paleoambientale, dinamiche insediative e organizzazione territoriale nelle Valli Grandi Veronesi alla fine dell’età del Bronzo. *Padusa* XLI:143-52.

MARCHESINI M, MARVELLI S. 2006. Ricostruzione del paesaggio vegetale e dell’ambiente dal Bronzo Finale alla prima età del Ferro nel settore centrale delle Valli Grandi Veronesi: risultati delle indagini palinologiche condotte nel sito di Perteghelle-Cerea (Verona, Nord Italia). In: BALISTA C, DE GUIO A, VANZETTI A, BETTO A, DE ANGELI G, SARTOR F. 2006. La fine dell'età del Bronzo ed i processi di degrado dei suoli innescati dai reinsediamenti della prima età del Ferro e dai deterioramenti climatici del sub-Atlantico al margine settentrionale delle Valli Grandi Veronesi (Il caso studio del sito di Perteghelle di Cerea-VR). *Padus*a XLII:113-25.

MARCHESINI S, editor. 2012. *Atti del convegno Matrimoni Misti: una via per l'integrazione tra i popoli, Verona-Trento, 1-2 dicembre 2011*.

MAREMBERT F, DUMONTIER P, DELFOUR G. 1999. Biarritz. Grotte du Phare. In: *Bilan scientifique 1998, S.R.A. d'Aquitaine*. p 118-20.

MAREMBERT FM, SEIGNE J. 2000. Un faciès original: le groupe du Pont-Long au cours des phases anciennes de l'Age du Bronze dans les Pyrénées nordoccidentales. *Bulletin de la Société préhistorique française* 97(4):521-38.

MARGUET A. 2000. L'habitat Bronze final immergé d'Ouroux-sur-Sâone: les données archéologiques de 1979 à 1982. In: BONNAMOUR L. 2000. *Archéologie des fleuves et des rivières*. Château-Gontier. p 183-94.

MARGUET A, BINTZ P, NICOD P-Y, PICAVET R, REY P-J, THIRAULT E. 2008. Éléments pour une histoire du peuplement nord-alpin français entre 10000 et 2700 ans BP. In: DESMET M, MAGNY M, MOCCI F,, editors. Du climat à l'homme: dynamique holocène de l'environnement dans le Jura et les Alpes. Actes du colloque GDR JURALP (Aix-en-Provence, 15-16 nov. 2007). Chambèry. *Cahiers de paléoenvironnement* 6:225-52.

MARIÉTHOZ F. 1997. Vufflens-la-Ville VD, En Sency. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 80:226.

MARIÉTHOZ F, MOINAT P. 1995. Vufflens-la-Ville VD, En Sency. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 78:204.

MARIÉTHOZ F, MOINAT P. 1996. Vufflens-la-Ville VD, En Sency. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 79:238-9.

MARIEZKURRENA K. 1979. Dataciones de radiocarbono existentes para la prehistoria vasca. *Munibe* 3-4:237-55.

MARIEZKURRENA K. 1990. Dataciones Absolutas para la Arqueología Vasca. *Munibe* 42:287-304.

MARINAKIS YD. 2012. Forecasting technology diffusion with the Richards model. *Technological Forecasting & Social Change* 79:172-9

MARTÍ M, POU R, BUCH M. 1995. Les estructures prehistòriques del jaciment de Can Filuà, Santa Perpètua de Mogoda (Vallès Occidental). *Limes* 4-5:29-44.

MARTÍN A. 1982. La Sorrera, Santa Eulàlia de Ronçana. In: *Les excavacions arqueològiques a Catalunya en els darrers anys. Excavacions arqueològiques a Catalunya 1*. Generalitat de Catalunya. Departament de Cultura. Barcelona. p 98.

MARTÍN A, MESTRES JS. 1996. Calibración de las fechas radiocarbónicas y su contribución al estudio del neolítico catalán. *Rubricatum* 1(2):791-804.

MARTÍN A, MESTRES JS. 2002. Periodització des de la fí del Neolític fins a l'Edat del Bronze a la Catalunya Sud-Pirinenca. Cronologia relativa i absoluta. In: *Pirineus i veïns al IIIer mil·leni A.C. Homenatge al Professor Dr. Domènec Campillo: Actes del XII Col·loqui Internacional d'Arqueologia de Puigcerdà (Puigcerdà 2000)*. p 77-130.

MARTÍN A, MIRET J, BLANCH RM, ALIAGA S, ENRICH R, COLOMER S, ALBIZURI S, BOSCH JM. 1988. Campanya d'excavacions arqueològiques 1987-88 al jaciment de la Bòbila Madurell-Can Feu (Sant Quirze del Vallès, Vallès Occidental). *Arrahona* 3:9-23.

MARTÍN A, MIRET J, BOSCH JM, BLANCH RM, ALIAGA S, ENRICH R, COLOMER S, ALBIZURI S, FOLCH J, MARTÍNEZ J, CASAS T. 1988. Les excavacions al paratge de la Bòbila Madurell i de Can Feu (Sant Quirze del Vallès, Vallès Occidental). *Tribuna d'Arqueologia* 1987-1988:77-92.

MARTÍN A, PONS E, SOLER N, NIETO FX. 1982. Noves datacions de ^{14}C. *Cypsela* IV:179-81.

MARTINEK K-P. 1996. Archäometallurgische Untersuchung zur frühbronzezeilichen Kupferproduktion und -verarbeitung auf dem Buchberg bei Wiesing, Tirol. *Fundberichte aus Österreich* 34:575-84.

MARTÍNEZ G, FLENSBORG G, BAYALA PD. 2013. Chronology and human settlement in northeastern Patagonia (Argentina): Patterns of site destruction, intensity of archaeological signal, and population dynamics. *Quaternary International* 301:123-34.

MARTINELLI N. 2001. Le indagini dendrocronologiche e le datazioni radiometriche. In: FRONTINI P, editor. *Castellaro del Vhò. Campagna di scavo 1996-1999*. Milano. p 215-20.

MARTINELLI N, KROMER B. 1999. High precision ^{14}C dating of a new tree-ring Bronze Age chronology from the pile-dwelling of Frassino I (Northern Italy). In: EVIN J, editor. Actes du 3ème Congrès Internacional ^{14}C et Archéologie (Lyon, 6-10 avril 1998). *Mémoires de la Société Préhistorique Française* XXVI:119-22.

MARTINELLI N, VALZOLGHER E. 2011. Date radiocarboniche dell'età del rame dall'Italia centrale e settentrionale: un bilancio critico. In: *Atti della XLIII Riunione Scientifica IIPP, L'età del Rame in Italia*. p 33-8.

MARTÍN AM. 2007. La crisis del siglo XII a.C. Pueblos del Mar y guerra de Troya ca. 1215-1175. *SPAL: Revista de prehistoria y arqueología de la Universidad de Sevilla* 16:93-154.

MARTÍN M. 1981-1983. *Memòria de les campanyes d'excavació de 1981 a 1983 a l'Illa d'en Reixac d'Ullastret*. Servei d'Arqueologia de la Generalitat de Catalunya.

MARTÍN MACHÍN P. 2006. *Can Barraca. Una necrópolis d'incineració de fa 2800 anys a Besalú (La Garrotxa).* Amics de Besalú i el seu comptat. Olot.

MARTY F. 2003. Projet collectif de recherche. Étang de Berre, faciès culturels du mobilier. In: *Bilan Scientifique 2002, DRAC PACA*. p 137-8.

MARZATICO F. 1997. L' industria metallurgica nel Trentino durante l'età del Bronzo. In:

BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 570-6.

MARZATICO F. 2012. Matrimoni misti nella preistoria: alcuni casi fra nord e sud delle Alpi. In: MARCHESINI S, editor. *Atti del convegno Matrimoni Misti: una via per l'integrazione tra i popoli (Verona-Trento, 1-2 dicembre 2011)*. p 79-92.

MARZATICO F, TECCHIATI U. 1998. The Bronze Age in Trentino and Alto Adige/Süd Tirol. *Preistoria Alpina* 34:27-60.

MARZATICO F, TECCHIATI U. 2002. L'età del Bronzo in Trentino e Alto Adige/Südtirol. In: *Atti della XXXIII Riunione Scientifica IIPP, Preistoria e protostoria del Trentino Alto Adige/Südtirol in ricordo di Bernardo Bagolini l, Trento 1997*. Firenze. p 45-92.

MASON P. 1996. *The early Iron Age of Slovenia*. Oxford: BAR International Series 643.

MAUVILLY M. 1995. Morat FR, Vorder Prehl 2-3. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 78:202.

MAUVILLY M, BOUYER M, BOISAUBERT JL. 1994. Münchenwiler 1988-93. Nouvelles données sur l'occupation de l'arrière pays moratois. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 3B:331-73.

MAUVILLY M, DAFFLON L, BUCHILLER C. 2006. Bulle FR, Le Terraillet. *Jahrbuch Archäologie Schweiz* 89:226.

MAXIMIANO A. 2007. *Teoría geoestadística aplicada al análisis de la variabilidad espacial arqueológica intra-site*. Tesis doctoral dirigida por el Dr. Juán Antonio Barceló Álvarez, Universidad Autónoma de Barcelona.

MAYA JL. 1985. Silos de la primera edad del hierro en la Universidad Autónoma de Barcelona. *Estudios de la Antigüedad* 2:147-218.

MAYA JL. 1990. Primera Edad del Hierro: los Campos de Urnas. In: ORTIZ D, editor. *Historia de España, vol 1*. Barcelona. p 296-377.

MAYA JL. 1992a. Aprovechamiento del medio y paleoeconomía durante las etapas metalúrgicas del nordeste peninsular. In: MOURE A, editor. *Elefantes, ciervos y ovicaprinos: economía y aprovechamiento del medio en la prehistoria de España y Portugal*. Santander. p 275-314.

MAYA JL. 1992b. Calcolítico y Edad del Bronce en Cataluña. In: UTRILLA P, editor. *Aragón/Litoral mediterráneo: intercambios culturales durante la Prehistoria. En homenaje a Juan Maluquer de Motes*. Zaragoza. p 515-54.

MAYA JL. 1998. El Bronce Final y los inicios de la Edad del Hierro. In: BARANDIARÁN I, MARTÍ B, DEL RINCÓN MÁ, MAYA JL. 1998. *Prehistoria de la Península Ibérica*. Barcelona. p 345-450.

MAYA JL, CUESTA F, LÓPEZ FJ. 1998. *Genó: Un poblado del Bronce Final en el Bajo Segre (Lleida)*. Barcelona.

MAYA JL, FRANCÉS J, PRADA A. 1991a. *Iª Campaña de excavaciones en la Balma de Punta Farisa*. *Arqueología Aragonesa* 1988-1989:95-8.

MAYA JL, FRANCÉS J, PRADA A. 1991b. IIª Campaña de excavaciones en la Balma de Punta Farisa (Fraga, Huesca). *Arqueología Aragonesa* 1988-1989:99-101.

MAYA JL, FRANCÉS J, PRADA A. 1992. Avance a las excavaciones en la Cova de Punta Farisa (Fraga, Huesca). *Revista d'Arqueologia de Ponent* 2:217-24.

MAYA JL, LÓPEZ FJ, GONZÁLEZ JR, JUNYENT E, RODRÍGUEZ JI. 2001-2002. Excavaciones (1981-1983) en el poblado de Carretelà (Aitona, Segrià, Lleida). *Revista d'Arqueologia de Ponent* 11-12:151-233.

MAYA JL, MESTRES JS. 1996. Approche a la chronologie de l'âge du Bronze et le premier âge du Fer dans la Péninsule Ibérique. In: RANDSBORG K, editor. Absolute Chronology. Archaeological Europe 2500-500 BC (Verona, April 20-23 1995). *Acta Archaeologica* 67:251-69.

MAYA JL, PETIT MA. 1986. El grupo del Nordeste. Un nuevo conjunto de cerámicas con Boquique en la Península Ibérica. *Anales de Prehistoria y Arqueología* 2:49-71.

MAYNARD G. 1989. Interventions sur le tumulus de Reyjade Ouest (inhumation de la fin du 1er âge du Fer) et le dolmen de la Maison des Gardes. *Bulletin de la Société Scientifique, Historique et Archéologique de la Corrèze* 111:49-53.

MAYR U. 2005. Triesen FL, Niggabünt (0953). *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 88:332.

MAYR U. 2006. Triesen FL, Niggabünt (0953). *Jahrbuch Archäologie Schw*eiz 89:230-1.

MAYR U. 2008. Triesen FL, Fürst Johannstrasse (0960). *Jahrbuch Archäologie Schweiz* 91:188-9.

MAZIÈRE F. 2001. L'occupation des sols dans la moyenne vallée de l'Orb à la fin de l'âge du Bronze. *Documents d'Archéologie Méridionale* 24:83-105.

MAZIÈRE F. 2012. Sépultures et nécropoles du Bas-Languedoc Occidental et du Roussilon (IXe-Ve s. av. J.-C.). Du geste observé aux rites supposes. In: ROVIRA HORTALÀ MC, LÓPEZ CACHERO FJ, MAZIÈRE F, editors. Les necròpolis d'incineració entre l'Ebre i el Tíber (segles IX-VI aC): metodologia, pràctiques funeràries i societat. *Monografies MAC* 14:173-208.

MAZIÈRE F, BLAIZOT F, DOMINGUEZ C, FOREST V. 2012. Nouvelles données sur la nécropole de Bel-Air à Vendres (Hérault, France). De la sépulture au complexe funéraire. In: ROVIRA HORTALÀ M.C., LÓPEZ CACHERO F.J., MAZIÈRE F, editors Les necròpolis d'incineració entre l'Ebre i el Tíber (segles IX-VI aC): metodologia, pràctiques funeràries i societat. *Monografies MAC* 14:271-80.

McCORMAC FG, BAYLISS A, BROWN DM, REIMER PJ, THOMPSON MM. 2008. Extended radiocarbon calibration in the Anglo-Saxon period, AD 395-485 and AD 735-805. *Radiocarbon* 50(1):11-7.

McMAHON A, McMAHON R. 2005. *Language Classification by numbers*. Oxford.

McSPARRON C. 2013. Irish rectangular Neolithic houses - a short lived phenomenon?. In: MCCLATCHIE M, SCHULTING RJ, WHITEHOUSE NJ, editors. *Living landscapes:*

exploring Neolithic Ireland in its wider context. Oxford.

MEDINA MORALES J, GONZÁLEZ PÉREZ J-R, VÀZQUEZ FALIP MP. 2012. La necrópolis del Turó de la Capsera (El Pont de Suert, Conca de Dalt). In: ROVIRA HORTALÀ MC, LÓPEZ CACHERO FJ, MAZIÈRE F, editors. Les necròpolis d'incineració entre l'Ebre i el Tíber (segles IX-VI aC): metodologia, pràctiques funeràries i societat. *Monografies MAC* 14:111-7.

MEINANDER CF. 1973. *Studies in the anthropology of the Finno-Ugrian peoples.* Helsinki.

MELLARS P. 2006. A new radiocarbon revolution and the dispersal of modern humans in Europe. *Nature* 439:931-5.

MENIN A. 1970. La Valle del Chiampo. *Il Chiampo* 43:10-4.

MENKE M. 1983. Ausgrabungen in der bronzezeitlichen Abschnittsbefestigung von Mörnsheim (Südliche Frankenalb). *Germania* 61:361-404.

MENOTTI F. 2001. *"The Missing Period": Middle Bronze Age Lake-Dwellings in the Alps*. Oxford: BAR Intenational Series 968.

MENOTTI F, editor. 2004. *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London

MENOTTI F, RUBAT BOREL F, KÖNINGER J, MARTINELLI N. 2012. Viverone (BI) - Azeglio (TO), sito palafitticolo Vi1-Emissario: indagini subacquee e campionamento dendrocronologico. *Quaderni della Soprintendenza Archeologica del Piemonte* 27:100-5.

MENOZZI P, PIAZZA A, CAVALLI-SFORZA LL. 1978. Synthetic maps of human gene frequencies in Europe. *Science* 210:786-92.

MERCURI AM, ACCORSI CA, MAZZANTI MB, BOSI G, CARDARELLI A, LABATE D, MARCHESINI M, TREVISAN GRANDI G. 2006. Economy and environment of Bronze Age settlements - Terramaras - on the Po Plain (Northern Italy): First results from the archaeobotanical research at the Terramara di Montale. *Vegetation History and Archaeobotany* 16:43-60.

MERCURI AM., BANDINI MAZZANTI M, TORRI P, VIGLIOTTI L, BOSI G, FLORENZANO A, OLMI L, MASSAMA N'SIALA I. 2012. A marine/terrestrial integration for mid-late Holocene vegetation history and the development of the cultural landscape in the Po valley as a result of human impact and climate change. *Vegetation History and Archaeobotany* 21:353-72.

MESTRES JS, RAURET G, GARCIA JF. 1991. University of Barcelona Radiocarbon Dates I. *Radiocarbon* 33:355-65.

MESTRES JS. 1999. La datació per radiocarboni. In: GONZÁLEZ P, MARTÍN A, MORA R, EDITORS. Can Roqueta. Un establiment pagès prehistòric i medieval, Sabadell, Vallès Occidental. In: *Excavacions arqueològiques a Catalunya 16*(annex 2). Generalitat de Catalunya. Departament de Cultura. Barcelona. p 329-35.

MESTRES JS. 2008. El temps a la prehistòria i el seu establiment a través de la datació per radiocarboni. *Cypsela* 17:11-21.

MEZZENA F. 1997. La valle d'Aosta nel Neolitico e nell'Eneolitico. In: *Atti della XXXI Riunione Scientifica IIPP*. Firenze.

MICHCZYŃSKA DJ, MICHCZYŃSKI A, PAZDUR A. 2007. Frequency distribution of radiocarbon dates as a tool for reconstructing environmental changes. *Radiocarbon* 49(2):799-806.

MICHCZYŃSKA DJ, PAZDUR AM. 2004. Shape analysis of cumulative probability density function of radiocarbon dates set in the study of climate change in the late glacial and Holocene. *Radiocarbon* 46(2):733-44.

MICHCZYŃSKI A. 2004. Problems of construction of a radiocarbon chronology for the time period 900-300 cal BC. In: SCOTT EM, ALEKSEEV AY, ZAITSEVA G, editor. *Impact of the environment on human migration in Eurasia, Proceedings of the NATO Advanced Research Workshop (St. Petersburg, 15-18 November 2003*). p 117-23.

MICHCZYŃSKI A, MICHCZYŃSKA DJ. 2006. The effect of PDF peaks' height increase during calibration of radiocarbon date sets. *Gechronometria* 25:1-4

MICHEL J, ROPIOT V. 2012. La nécropole du Bronze Final IIIb de Christol I à Carcassonne (Aude). In: ROVIRA HORTALÀ MC, LÓPEZ CACHERO FJ, MAZIÈRE F, editors. Les necròpolis d'incineració entre l'Ebre i el Tíber (segles IX-VI aC): metodologia, pràctiques funeràries i societat. *Monografies MAC* 14:255-70.

MILCENT P-Y. 2009. Le passage de l'âge du Bronze à l'âge du Fer en Gaule au miroir des élites sociales: une crise au VIII^e^ siècle av. J.-C.?. In: ROULIERE-LAMBERT M-J, DAUBIGNEY A, MILCENT P-Y, TALON M, VITAL J, editors. De l'âge du Bronze à l'âge du Fer en France et en Europe occidentale (X^e^ – VII^e^ siècle av. J.-C.). La moyenne vallée du Rhône aux âges du Fer, Actes du XXXe colloque international de l'A.F.E.A.F., co-organisé avec l'A.P.R.A.B. (Saint-Romain-en-Gal, 26-28 mai 2006). Dijon. *Revue Archéologique de l'Est* 27:453-76.

MILLER DS, GINGERICH JAM. 2013. Regional variation in the terminal Pleistocene and early Holocene radiocarbon record of eastern North America. *Quaternary Research* 79:175-83.

MILLER JH, PAGE SE. 2007. *Complex adaptive system. An introduction to computational models of social life*. Princeton.

MILLER P. 2004. Processing of written word and nonword visual information by individuals with prelingual deafness. *Journal of Speech, Langauge and Hearing Research* 47:990-1000.

MILLOTTE J-P. 1970. *Précis de proto-histoire européenne*. Paris.

MILLOTTE J-P. 2001. Sur le passage de l'Âge du Bronze à l'Âge du Fer dans le Massif jurassien: état de la question et perspectives. En complément à une ancienne datation d'un tumulus de Dompierre-les-Tilleuls. *Dialogues d'histoire ancienne* 27(1):33-80.

MIRABELLA ROBERTI M. 1956. Una palafitta fluviale a sud di Valeggio sul Mincio. In: *Atti del Convegno di studi rapporti scientifico culturali italo-svizzeri*. p 118.

MIRET J, BOQUER S. 2004. Bobila Roca (Sant Pere de Ribes, Garraf). In: *Jornades* *d’Arqueologia i Paleontología 2001. La Garriga. vol. 1*. p 348-58.

MITCHELL A. 2009. *The ESRI Guide to GIS Analysis (Vol. 2 Spatial measurements & Statistics)*. Redlands (CA).

MÖDLINGER M, PICCARDO P, KASZTOVSZKY Z, KOVÁCS I, SZŐKEFALVI-NAGY Z, KÁLI G, SZILÁGYI V. 2013. Archaeometallurgical characterization of the earliest European metal helmets. *Materials characterization* 79:22-36

MOLIST N, ROVIRA J. 1986-1989. L’oppidum ausetà del turó del Montgròs (el Brull, Osona). *Empúrie*s 48-50:122-41.

MONTANARI KOKELJ E, editor. 2005. *Carlo Marchesetti e i castellieri, 1903-2003, Atti del Convegno internazionale di Studi (Castello di Duino, 14-15 novembre 2003).* Trieste.

MONTELIUS O. 1885. *Om tidsbestamning inom bronsaaldern med sarskildt afseende paa Skandinavien. Kongliga Vitterhets Historie och Antiqvitets Akademiens Handlingaer 30/10*. Stockholm.

MONTELIUS O. 1889. Typologien eller utvecklingsläran tillämpad paa det menskeliga arbetet. *Svenska Fornminnesföreningens Tidskrift* 10:237-68.

MONTELIUS O. 1903, *Die typologische Methode. Die älteren Kulturperioden im Orient und in Europa 1*. Stockholm.

MONTÓN FJ. 2002. Ritual funerario en la I Edad Del Hierro. La necrópolis de la Codera. *Bolskan* 19:115-20.

MOOK WG, STREURMAN HJ. 1983. Physical and chemical aspects of radiocarbon dating, In: MOOK WG, WATERBOLK HT, editors. Proceedings, Groningen Symposium “14C and Archaeology”. *PACT* 8:31-55.

MOORE J. 1994. Putting anthropology back together again: the ethnogenetic critique of cladistic theory. *American Anthropologist* 96(4):925-48.

MOOSAUER M, BACHMAIER T. 2000. *Bernstorf – Die versunkene Stadt aus der Bronzezeit. Die befestigte Höhensiedlung der mittleren Bronzezeit bei Bernstorf (Gemeinde Kranzberg, Landkreis Freising)*. Stuttgart.

MORÁN M, GONZÁLEZ JR, PRADA A. 2002. Una sepultura en cista en la vall de Miarnau (Llardecans, Lérida). *Bolskan* 19:37-51.

MORDANT C. 1988. De la céramique cannelée à la production Rhin-Suisse-France orientale (RSFO). La rupture IIa-IIB dans le bassin Parisien. In: BRUN P, MORDANT C, editors. Le groupe Rhin-Suisse-France oriëntale et la notion de la civilisation des Champs d’Urnes. *Mémoires du Musée de Préhistorie d’Ile-de-France* 1:591-8.

MORDANT C. 2013. Chapter 32, The Bronze Age in France. In: FOKKENS H, HARDING A, editors. *The Oxford handbook of the European Bronze Age*. Oxford. p 571-93.

MORDANT C, DEPIERRE G, editors. 2005. *Les pratiques funéraires à l'âge du bronze en France, Actes de la table ronde de Sens-en-Bourgogne (Yonne, 10-12 juin 1998*). Paris.

MORDANT C, PERNOT M, RYCHNER V, editors. 1998. *L'atelier du bronzier en Europe du XXe au VIIIe siècle avant notre ère. Actes du colloque international Bronze '96, Neuchâtel et Dijon*. Paris.

MORLEY A, ROSENTHAL Y, DEMENOCAL P. 2014. Ocean-athmosphere climate shift during the mid-to-late Holocene. *Earth and Planetary Science Letters* 388:18-26.

MOSCATI S, HERMANN FREY O, KRUTA V, RAFTERY B, SZABÒ M, editors. 1991. *I Celti, catalogo della mostra di Palazzo Grassi*. Milano-Venezia.

MÖSLEIN S. 2001. Die Straubinger Gruppe – Zur Frühbronzezeit in Südostbayern. *Hemmenhofener Skripte* 2:17-30.

MOTTA F. 2000. La documentazione epigrafica e linguistica. In: DE MARINIS R, BIAGGIO SIMONA S, editors. *I Leponti tra mito e realtà, Vol. II*. Locarno. p 181-222.

MOTTES E, NICOLIS F. 2004. Storo – Dosso Rotondo (Trento): un sito di alta quota dell'età del Bronzo in Valle del Chiese. *Annali del Museo di Gavardo* 19:81-8.

MOTTES E, NICOLIS F, ZONTINI G, editors. 2008. *Archeologia lungo il Chiese. Nuove indagini della ricerca preistorica e protostorica in un territorio condiviso fra Trentino e Lombardia, Atti del 1° convegno interregionale (Storo, Teatro dell'Oratorio 24-25 ottobre 2003)*. Trento.

MOUCHA V. 1963. Die Periodisierung der Úněticer Kultur in Böhmen. *Sborník ČSSA* 3:9-60.

MOURANT AE, KOPEC AC, DOMANIEWSKA-SOBCZAK K. 1976. *The distribution of the Human Blood Groups and other Polymorphism*s. Oxford.

MOYA A, LÓPEZ JB, LAFUENTE A, REY J, TARTERA E, VIDAL A, EQUIP VINCAMET 2005. El Grup del Segre-Cinca II (1250-950 cal. a.n.e.) a les terres del Baix Cinca: el poblat clos de Vincamet (Fraga, Osca). *Revista d'Arqueologia de Ponent* 15:13-58.

MUJIKA ALUSTIZA JA. 1994. Monumento megalítico de Aitxu (Ataun-Idiazabal). *Arkeoikuska* 3:178-82.

MÜLLER A. 2002. Salen (Buoux). In: BUISSON-CATIL J, VITAL J, editors. Âges du Bronze en Vaucluse, Département de Vaucluse. *Notices d'Archéologie Vauclusienne* 5. *Travaux du Centre d'Archéologie Préhistorique de Valence* 4:192-9.

MÜLLER J, BERNBECK R. 1996. Prestige und Prestigegüter aus kulturanthropologischer und archäologischer Sicht. In: MÜLLER J, BERNBECK R, editors. Prestige -Prestigegüter - Sozialstrukturen. Beispiele aus dem europäischen und vorderasiatischen Neolithikum. *Archäologische Berichte* 6:1-27.

MÜLLER A, BOUVILLE C, LAMBERT L. 1987. Les stèles provençales du Bronze final. *Association d'Histoire et d'Archéologie du Pays d'Alp* 18:1-10.

MÜLLER-KARPE H. 1959. Beiträge zur Chronologie der urnenfelderzeit nördlich und südlich der Alpen. R*ömisch-Germanisches Forschungen* 22.

MÜLLER-KARPE H. 1974. Zur Definition und Benennnung chronologischer Stufen der Kupferzeit, Bronzezeit und älteren Eisenzeit. *Jahrbericht des Instituts für Vorgeschichte der Universität Frankfurt a.M.* 1:7-18.

MÜLLER S. 1897**.** *Vor Oltid*. Kobenhavn.

MUNILLA CABRILLANA G, GRACIA ALONSO F, BERGADÀ I ZAPATA MM, CUBERO CORPAS C. 1993. Un conjunto de estructuras de combustión en la H.88/21 del poblado protohistórico del Alto de la Cruz (Cortes de Navarra). *Pyrenae* 24:141-50.

MÜNNICH KO, ÖSTLUND HG, DE VRIES HL. 1958. Carbon-14 Activity during the Past 5,000 Years. *Nature* 182:1432-3.

MUÑOZ AM. 1971. Dos nuevas fechas de C-14 para sepulcros de fosa. *Pyrenae* 7:157.

MUÑOZ AM. 1972. Análisis de Carbono-14 sobre muestras recogidas por el Instituto de Arqueología de la Universidad de Barcelona. *Pyrenae* 8:147-50.

MUÑOZ SALVATIERRA M, BERGANZA E. 1997. *El yacimiento de la cueva de Urratxa III (Orozko, Bizkaia*). Bilbao.

MURBACH-WENDE I. 2001a. Cazis-Cresta, ein bronze- und eisenzeitlicher Siedlungsplatz. *Hemmenhofener Skripte* 2:117-24.

MURBACH-WENDE I. 2001b. *Die frühbronze- bis eisenzeitliche Keramik der Siedlung Cazis-Cresta (GR): eine Entwicklungsgeschichte über 1500 Jahre*. Bern.

MURRAY C. 1996. Frasses FR, En Bochat. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 79:234.

MURRAY C, EYER E. 1998. Lully FR, La Faye 5.2. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 81:273.

MURRAY T, editor. 1999. *Time and archaeology*. New-York.

MUTTI A, ROSSI MG. 1992. La terramara di Castione dei Marchesi (Parma). In: L'Età del Bronzo in Italia nei secoli dal XVI al XIV a.C. (Viareggio, 26-30 ottobre 1989). Firenze *Rassegna di Archeologia* 10:648-9.

MUTTI A, ROSSI MG, PROVENZANO N, ROTTOLI M. 1988. La terramara di Castione dei Marchesi. *Studi e Documenti di Archeologia* V.

NADAL J, SOCIAS J, SENABRE MR. 1994. El jaciment neolític de Pou Nou-2 de Sant Pere Molanta (Olèrdola). *Gran Penedès* 38:17-9.

NADAL J, ORRI E, ESTRADA A. 2007. Estudi de les restes faunístiques procedents del jaciment de Santa Digna - el Pla de la Girada (Vilafranca del Penedès). *Del Penedès* 14:27-33.

NAYSMITH P, SCOTT EM, COOK GT, HEINEMEIER J, VAN DER PLICHT J, VAN STRYDONCK M, RAMSEY CB, GROOTES PM, FREEMAN S. 2007. A cremated bone intercomparison study. *Radiocarbon* 49(2):403-8.

NELSON NC. 1909. Shellmounds of San Francisco bay region. *American Archaeology and Ethnology* 7:309-56.

NELSON DE, VOGEL JS, SOUTHON JR, BROWN TA. 1986. Accelerator radiocarbon dating at SFU. In: STUIVER M, KRA RS, editors. Proceedings of the 12th International Radiocarbon Conference (Trondheim, Norway, June 24-28, 1985). *Radiocarbon* 28(2):215-22.

NETTLE D. 1999a. Is the rate of linguistic change constant?. *Lingua* 108(2-3):119-136

NETTLE D. 1999b. *Linguistic Diversity*. Oxford.

NETTLE D. 1999c. Using social impact theory to simulate language change. *Lingua* 108:95-117

NEUBAUER F, LIPS A, KOUZMANOV K, LEXA J, IVĂŞCANU P. 2005. 1: subduction, slab detachment and mineralisation: the Neogene in the Apuseni Mountains and Carpathians. In: BLUNDELL N, ARNDT PR, COBBOLD C, HEINRICH D, editors. Geodynamics and Ore Deposits Evolution in Europe. *Ore Geology Reviews* 27:13-44.

NEUDERT C. 2004. Rund um den Weltenburger Frauenberg - Zentrum und Umland einer bronzezeitlichen Höhensiedlung. *Vorträge des Niederbayerischer Archäologentages* 22:83-110.

NEUGEBAUER JW. 1994. *Bronzezeit in Ostösterreich*. Wissenschaftliche Schriftenreihe Niederösterreich 98/99/110/101. St. Pölten-Wien.

NEUGEBAUER C, NEUGEBAUER JW. 1996. *Gemeinlebarn. "Leute, die bei Grabhügeln wohnen..."*. Wien.

NEUMAIER J. 1995. Los Campos de Urnas del sudoeste europeo desde el punto de vista centroeuropeo. *Revista d'Arqueología de Ponent* 5:53-80.

NEUMAIER J. 2006. Mito, artesanía e identidad cultural: los "campos de urnas" peninsulares y languedocienses a la luz de elementos" italianizantes": a propósito del paradigma de los urnenfelder" norte" y" sur" entorno del 1300-700 arq. ane. *Quaderns de prehistòria i arqueologia de Castelló* 25:147-66.

NICHOLS J. 1997. Modeling ancient population structures and movement in linguistics. *Annual Review of Anthropology* 26:359-84.

NICHOLS J. 2008. Language spread rates and prehistoric American migration rates. *Current Anthropology* 49(6):1109-17.

NICOLIS F. 1996. Strutture e riti funebri. L'Italia settentrionale. In: COCCHI GENICK D, editor. *L'antica età del Bronzo in Italia, Atti del Congresso (Viareggio, 9-12 gennaio 1995)*. Firenze. p 337-44.

NICOLUCCI F, HERMON S. 2014. Chapter 14. Time, chronology and classification. In: BARCELÓ JA, BOGDANOVIC I, editors. 2014. *Mathematics and archaeology*.

NICOUD C, THIÉROT F, VITAL J. 1989. Le site fluvial protohistorique des Barlières a Serrières-de-Briord (Ain). In: *L'homme et l'eau au temps de la Préhistoire, Actes du 112e Congrès national des sociétés savantes (Lyon, 1987)*. p 67-102.

NIEDERSCHLAG E, PERNICKA E, SEIFERT TH, BARTELHEIM M. 2003. The determination of lead isotope ratios by multiple collector ICP-MS: a case study of Early Bronze Age artefacts and their possible relation with ore deposits of Erzgebirge. *Archaeometry* 45(1):61-100.

NIETO M, LOPÉZ F, CRUZ F. 1998. Performance analysis of technology using the S curve model: the case of digital signal processing (DSP) technologies. *Technovation* 18(6–7):439-57

NIJBOER AJ, VAN DER PLICHT H. 2008. The Iron Age in the Mediterranean: recent radiocarbon research at the University of Groningen. In: BRANDHERM D, TRACHSEL M, editors. *Proceedings of the XV World Congress (Lisbon, 4-9 September 2006), International Union for Prehistoric and Protohistoric Sciences, A New Dawn for the Dark Age? Shifting Paradigms in Mediterranean Iron Age Chronology*. Oxford: BAR International Series 1871. p 103-18.

NIJBOER A. J, VAN DER PLICHT H, BIETTI SESTIERI AM, DE SANTIS A. 1999-2000. A High chronology for the Early Iron Age in central Italy. *Paleohistoria* 41-42:163-76.

NISBET R. 1994. Alcuni aspetti dell'ambiente umano nelle Alpi Cozie fra quinto e quarto millennio BP. In: BIAGI P, NANDRIS J. 1994. Highland zone exploitation in Southern Europe. *Monografie di Natura Bresciana* 20:259-71.

NISBET R. 2004. Alcune considerazioni sulla Preistoria del Pinerolese: Roc del Col nel contesto alpino. In: BERTONE A, FOZZATI L, editors. *La civiltà di Viverone. La conquista di una nuova frontiera nell'Europa del II Millennio a.C.* Candelo (BI). p 109-24.

NOCETE F. 1989. *El Espacio de la Coerción. La Transición al Estado en las Campiñas del Alto Guadalquivir (España) 3000-1500 a.C.* Oxford: BAR International Series 492.

OBERLIN C, LEROY F, GUIBAL F. 2004. High precision 14C dating of a Bronze Age tree-ring chronology from the pile-dwelling settlement of Montpenedre, Herault, southern France. In: HIGHAM T, BRONK RAMSEY C, OWEN C, editors. *Radiocarbon and Archaeology, Proceeding of the 4th Symposium (Oxford, 9-14 April 2002).* p 193-200.

OBERRAUCH H, NIEDERWAGNER G. 2010. Archäologische Prospektion im hinteren Passeiertal (Südtirol). In: MANDL F, STADLER H, editors. Archäologie in den Alpen. Alltag und Kult. *Forschungsberichte der ANISA* 3:167-98.

OBRECHT J, GUTZWILLER P. 2007. Die Loppburg - eine befestigte Höhensiedlung. Resultate der Ausgrabungen von 2001 in einer vermeintlich mittelalterlichen Burg. *Antiqua* 42.

O'BRIEN W. 2004. *Ross Island. Mining, metal and society in early Ireland*. Galway.

O'BRIEN MJ, BENTLEY RA. 2011. Stimulated variation and cascades: two processes in the evolution of complex technological systems. *Journal of Archaeological Method and Theory* 18:309-37.

O'BRIEN MJ, LEE LYMAN R. 2002. *Seriation, stratigraphy, and index fossils. The backbone of archaeological dating*. New York.

O'BRIEN MJ, LEE LYMAN R. 2003. *Cladistics and archaeology*. Utah.

ODETTI G. 1998. Loano. Tomba di età campaniforme e villaggio dell'età del Bronzo in località Castellari. In: DEL LUCCHESE A, MAGGI R, editors. Dal diaspro al bronzo. L'Età del Rame e l'Età del Bronzo in Liguria: 26 secoli di storia fra 3600 e 1000 anni avanti Cristo**.** *Quaderni della Soprintendenza Archeologica della Liguria* 5:84-9.

OINONEN M, PESONEN P, TALLAVAARA M. 2010. Archaeological radiocarbon dates for studying the population history in eastern Fennoscandia. *Radiocarbon* 52(2):393-407.

OKUBO A, LEVIN SA. 2001. *Diffusion and ecological problems, Modern perspectives*. New York.

OLAETXEA C. 1991. Tres nuevos poblados de la Edad del Hierro en la Protohistoria de Gipuzkoa. *Munibe* 43:175-80.

OLAETXEA C. 1995. Sondeo estratigráfico en el poblado de Moru (Elgobar, Gipuzkoa). *Munibe* 47:199-201.

OLIVIER L. 1999. The Hochdorf 'princely' grave and the question of the nature of archaeological funerary assemblages. In: MURRAY T, editors. *Time and Archaeology*. London. p 109-38.

OLSEN J, HEINEMEIER J, HORNSTRUP KM, BENNIKE P, THRANE H. 2013. "Old wood" effect in radiocarbon dating of prehistoric cremated bones?. *Journal of Archaeological Science* 40:30-4.

OLSEN J, HORNSTRUP KM, HEINEMEIER J, BENNIKE P, THRANE H. 2011. Chronology of the Danish Bronze Age based on ^{14}C dating of cremated bone remains. *Radiocarbon* 53(2):261-75.

OLSHAVSKY R. 1980. Time and the Rate of Adoption of Innovations. *Journal of Consumer Research* 6:425-8.

OLSON EA, BROECKER WS. 1958. Sample contamination and reliability of radiocarbon dates. *Transactions New York Academy Sciences Series II* 20:593-604.

OLSSON I. 1960. Uppsala Natural Radiocarbon Mesurements II. *Radiocarbon* 2:112-28.

OLSSON I. 1986. Radiometric methods. In: BERGLUND B, editor. *Handbook of Holocene Paleoecology and Palaeohydrology*. Chichester. p 273-312.

ONKAMO P, KAMMONEN J, PESONEN P, SUNDELL T, MOLTCHANOVA E, OINONEN M, HAIMILA M, ARJAS E. 2012. Bayesian spatiotemporal analysis of radiocarbon dates from eastern Fennoscandia. In: BOARETTO E, REBOLLO FRANCO NR, editors. Proceedings of the Sixth Radiocarbon and Archaeology Symposium (Paphos, Cyprus, 10–15 April 2011). *Radiocarbon* 54(3-4):649-59.

OREN ED, editor. 2000. *The Sea Peoples and their world: a reassessment*. Philadelphia.

ORTEGA VALCÁRCEL J. 2004. La Geografía para el siglo XXI. In: ROMERO J, NOGUÉ J. 2004. *Geografía Humana. Procesos, riesgos e incertidumbres en un mundo globalizado.* Barcelona. p 25-53.

ORTMAN SG, VARIEN MD, GRIPP TL. 2007. Empirical Bayesian methods for archaeological survey data: an application from the Mesa Verde region. *American Antiquity* 72(2):241-72.

O'SHEA JM. 2011. A river runs through it: landscapes and the evolution of Bronze Age networks in the Carpathian Basin. *Journal of World Prehistory* 24:161-74.

OTTAWAY BS. 1973. Dispersion diagrams: a new approach to the display of 14C dates. *Archaeometry* 15(1):5-12.

OTTE M. 1995. Diffusion des langues modernes en Eurasie préhistorique. *Comptes Rendus de l'Académie des Sciences de Paris* série II 321:1219-26.

OTTOMANO C, STARNINI E. 1998. Castellaro di Pignone. In: DEL LUCCHESE A, MAGGI R, editors. Dal diaspro al bronzo. L'Età del Rame e l'Età del Bronzo in Liguria: 26 secoli di storia fra 3600 e 1000 anni avanti Cristo. *Quaderni della Soprintendenza Archeologica della Liguria* 5:167-9.

OZANNE J-C. 1993. L'Abri du Châtel à Sollières. *Mémoires et documents de la Société savoisienne d'histoire et d'archéologie* 95:79-84.

OZANNE J-C, AYROLLES P. 1997. Sollières-Sardiéres. Abri du Châtel. *Gallia Informations* 1996:234.

PACCIARELLI M. 1996a. Il villaggio dell'età del Bronzo di Monte Castellaccio: dall'analisi dello scavo alle ricostruzioni planimetriche de economico-ambientali. In: PACCIARELLI M, editor. *La collezione Scarabelli, Preistoria, II*. Casalecchio di Reno. p 132-47.

PACCIARELLI M. 1996b. Le ceramiche dell'età del Bronzo di Monte Castellaccio. In: PACCIARELLI M, editor. *La collezione Scarabelli, Preistoria, II*. Casalecchio di Reno. p 221-81.

PACCIARELLI M. 2005. ^{14}C e correlazioni con le dendrodate nordalpine: elementi per una cronologia assoluta del Bronzo Finale 3 e del primo Ferro dell'Italia peninsulare. In: BARTOLONI G, DELFINO F, editors. *Oriente e Occidente: metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del Ferro italiana, Atti dell'Incontro di Studio (Roma, 30-31 ottobre 2003)*. Pisa. p 81-90.

PACCIARELLI M. 2009. Osservazioni sul giacimento del Bronzo Antico della Grotta dei Banditi. In: CATTANI M, editor. Atti della Giornata di studi "La Romagna nell'età del Bronzo" (Ravenna, Solarolo, 19 settembre 2008). *IpoTESI di Preistoria* 2(1):75-83.

PAGEL M. 2009. Human language as a culturally transmitted replicator. *Nature Reviews Genetics* 10:405-15.

PALMER S. 1999. *Vision Science: Photons to phenomenology*. Cambridge, MA.

PARAZZI A. 1981. Stazione dei Lagazzi fra Vho e S. Lorenzo Guazzone. *Bullettino di Paletnologia Italiana* 18:1-33.

PARE C. 1996. Chronology in Central Europe at the end of the Bronze Age. In: RANDSBORG K, editor. Absolute Chronology. Archaeological Europe 2500-500 BC (Verona, April 20-23 1995). *Acta Archaeologica* 67:99-120.

PARE C, editor. 1997. *Metals make the world go round: The supply and circulation of metals in Bronze Age Europ*e. Oxford.

PARE C. 1998. Beiträge zum Übergang von der Bronze- und Eisenzeit in Mitteleuropa. Teil I - Grundzüge der Chronologie imÖsttlichen Mitteleuropa (11.- 8. jahrhundert v.Chr.). *Jahrbuch der Römisch-Germanischen Zentralmuseum Mainz* 45(1):293-433.

PARE C. 2008. Archaeological periods and their purpose. In: LEHOËRFF A, editor. *Construire* *le temps: histoire et méthodes des chronologies et calendriers des derniers millénaires avant notre ère en Europe occidentale, Actes du XXXe colloque international de Halma-Ipel (CNRS, Lille 3, MCC, 7-9 décembre 2006)*. p 69-84.

PARNELL AC, HASLETT J, ALLEN JRM, BUCK CE, HUNTLEY B. 2008. A flexible approach to assessing synchroneity of past events using Bayesian reconstructions of sedimentation history. *Quaternary Science Reviews* 27:1872-85.

PAULI L, editor. 1980. *Die Kelten in Mitteleuropa, Salzburger Landesaustellung 1980 im Keltenmuseum Hallein Österreich*. Salzburg.

PEAKE R, DELATTRE V. 2005. L'apport des analyses ^{14}C à l'étude de la nécropole de l'âge du Bronze de "La Croix de la Mission" à Marolles-sur-Seine. *Revue archéologique du Centre de la France* 44:5-25.

PEARL J. 2000. *Causality*. Cambridge.

PEARSON GW. 1987. How to cope with calibration. *Antiquity* 61:98-103.

PEÑALVER IRIBARREN X. 2001. El Bronce Final y la edad del Hierro en la Euskal Herria Atlántica: cromlechs y castros. *Complutum* 12:51-71.

PEÑALVER X. 2005. *Orígene*s. Tafalla.

PEREIRA SIESO J, RUIZ TABOADA A, CARROBLES SANTOS J. 2003. Aportaciones del C-14 al mundo funerario carpetano: la necrópolis de Palomar de Pintado. *Trabajos de Prehistoria* 60(2):153-68.

PÉREZ B. 2007. Pratiques et rituels funéraires dans les Alpes méridionales françaises du Bronze Final au début du Haut Empire: un premier bilan. *Preistoria Alpina* 42:49-61.

PÉREZ CONILL J. 2009. Aportació a l'estudi de la necròpolis d'incineració de Can Missert de Terrassa (Vallès Occidental). *Terme* 24:177-88.

PANYUSHKINA IP. 2012. Climate-induced changes in population dynamics of Siberian Scythians (700–250 BC). *Geophysical Monograph Series* 198:145-54.

PARIBENI ROVAI E, ARANGUREN B. 1996. Fondo di capanna in località Poggio Fornello (Follonica, Grosseto). In: COCCHI GENICK D, editor. *L'antica età del Bronzo in Italia, Atti del Congresso (Viareggio, 9-12 gennaio 1995)*. Firenze. p 572-3.

PERINI R. 1971. Depositi di Romagnano-Loc. *Preistoria Alpina* 7:7-106.

PERINI R. 1975-1980. La successione degli orizzonti culturali dell'abitato dell'età del Bronzo nella torbiera del Lavagnone (com. Desenzano del Garda e Lonato). *Bullettino di Paletnologia Italiana* 82:117-66.

PERINI R. 1983. Der Frühbronzezeitliche Pflug von Lavagnone. *Archäologisches Korrespondenzblatt* 13:187-95.

PERONI R. 1963. L'età del Bronzo Media e Recente tra l'Adige e il Mincio. *Memorie del Museo Civico di Storia Naturale di Verona* XI:49-104.

PERONI R. 1971. *L'antica età del bronzo nella Penisola Italiana, I: L'anticà età del bronzo*. Firenze.

PERONI R, editor. 1979. *Il Bronzo Finale in Italia, Atti XXI Riunione Scientifica IIPP (Firenze 21-23 ottobre 1977)*. Firenze.

PERONI R. 1980. *Il bronzo finale in Italia*. Bari.

PERONI R. 1990. Trent'anni dopo. In: BELARDELLI C, GIARDINO C, MALIZIA A, editors. *L'Europa a sud e a nord delle Alpi alle soglie della svolta protourbana*. Treviso. p 11-4.

PERONI R. 1995. Stand und Aufgaben der Urnenfelderforschung in Italien. In: Beiträge zur Urnenfelderzeit nördlich und südlich der Alpen. Ergebnisse eines Kolloquiums. *Römisch-Germanischen Zentralmuseums Mainz Monographien* 35:225-37.

PERONI R. 1996. *L'Italia alle soglie della storia*. Roma-Bari.

PEROS MC, MUNOZ SE, GAJEWSKI K, VIAU AE. 2010. Prehistoric demography of north America inferred from radiocarbon data. *Journal of Archaeological Science* 37:656-64.

PESONEN P, KAMMONEN J, MOLTCHANOVA E, OINONEN M, ONKAMO P. 2011. Archaeological radiocarbon dates and ancient shorelines - resources and reservoirs. In: *Proceedings of the seminar "The Sea Level Displacement and Bedrock Uplift" (Pori, Finland, 10–11 June 2010). Posiva Working Report 2011*-07. p 119-29.

PETCHEY F, HIGHAM T. 2000. Bone Diagenesis and Radiocarbon Dating of Fish Bones at the Shag River Mouth Site, New Zealand. *Journal of Archaeological Science* 27(2):135-50.

PETIT MA. 1985. *Contribución al estudio de la Edad del Bronce en Cataluña (Comarcas del Moianès. Vallès Oriental. Vallès Occidental. Maresme. Barcelonès y Baix Llobregat).* Tesis doctoral leida en la Universidad Autónoma de Barcelona.

PETIT MA. 1990. Les primeres etapes de l'Edat del Bronze al Vallès. *Limes* 0:23-30.

PÉTREQUIN P, URLACHER JP, VUAILLAT D. 1969. Habitat et sépultures de l'âge du Bronze final à Dampierre-sur-le-Doubs (Doubs). *Gallia Préhistoire* XII(1):1-35.

PETRIE FWM. 1899. Sequences in prehistoric remains. *Journal of the Anthropological Institute* 29:295-301.

PETROSINO N, PUTZ U. 2004. Archäologische und archäobotanische Untersuchungen an einem bronzezeitlichen Gefäßdepot aus Sinzing, Lkr. Regensburg. *Beiträge zur Archäologie in der Oberpfalz und in Regensburg* 6:151-72.

PHILLIPS P, FORD JA, GRIFFIN JB. 1951. *Archaeological survey in the Lower Mississipi Valley, 1940-1947*. Peabody Museum of Archaeology and Etnology, Papers 25.

PICAVET R. 1988. La Sépulture collective de Comboire, Claix, Isère. In: *Actes des rencontres protohistoriques de Rhône-Alpes. Eléments de protohistoire rhodanienne et alpine 1*. p 113-9.

PICAVET R. 1990. La Sépulture collective de Comboire, Claix, Isère. In: *Actes du VIème Colloque International sur les Alpes dans l'Antiquité (Annecy, Haute-Savoie, 23-24 septembre 1989). Bulletin d'études préhistoriques et archéologiques alpine*s. p 29-34.

PICAVET R. 1991. Le site de la Grande Rivoire à Sassenage (Isère). In: Actes des Rencontres Néolithique en Rhône-Alpes, Actualité de la Recherche, Université Lumière-Lyon

II/URA 36 CNRS, Valence, Centre d'Archéologie Préhistorique. *Arenera* 6:83-9.

PICAVET R. 1997. Sassenage. La Grande Rivoire. *Gallia Informations* 1996:127-8.

PICAZO MILLÁN JV. 2005. El poblamiento en el Valle Medio del Ebro durante la Prehistoria reciente: zonas y procesos. *Revista d'Arqueologia de Ponent* 15:97-117.

PICCOLI A. 1982. Saggio esplorativo nell'insediamento perilacustre di Castellaro Lagusello (MN). In: *Studi in onore di Ferrante Rittatore Vonwiller, parte prima, preistoria e protostoria, vol. II*. Como. p 443-85.

PINGEL V. 2001. Die Bronzezeit im Norden der Iberischen Halbinsel. In: BLECH M, KOCH M, KUNST M, editors. *Hispania Antiqua: Denkmäler der Frühzeit*. Mainz. p 171-92.

PINHASI R, FORT J, AMMERMAN AJ. 2005. *Tracing the origin and spread of agriculture in Europe*. PLoS Biol 3(12):e410.

PINHASI R, THOMAS MG, HOFREITER M, CURRAT M, BURGER J. 2012. The genetic history of Europeans. *Trends in Genetics* 28(10):496-505.

PLASSOT ME. 1997. George-de-Loup. *Gallia Informations* 1996:193.

PLAZA S, CALAFELL F, HELAL A, BOUZERNA N, LEFRANC G, BETRANPETIT J, COMAS D. 2003. Joining the Pillars of Hercules: mtDNA sequences show multidirectional gene flow in the Western Mediterranean. *Annals of Human Genetics* 67:312-28.

PLÜSS P. 2011. Die bronzezeitliche Siedlung Cresta bei Cazis (GR): die Tierknochen. *Collectio Archaeologica* 9.

POESINI S, AGRESTI A. 2011. Per una tipologia della ceramica preistorica: nuove metodologie per lo studio delle produzioni del Bronzo Finale e del Primo Ferro. *Rassegna di Archeologia* 223(A):83-96.

POGGIANI KELLER R, BAIONI M, MAGRI F. 1999-2000. ISEO (BS). Area ex Resinex. Insediamento della tarda età del Bronzo. *Notiziario della Soprintendenza Archeologica della Lombardia*:41-6.

POGGIANI KELLLER R, RAPOSSO B. 1998. Aspetti della tarda età del bronzo nella Lombardia occidentale: il sito di Parre (BG), proprietà Botti. In: *Atti IIPP XXXII*. p 393-7.

POGGIANI KELLER R, RAPOSSO B. 2004. Il sito di Parre (Bergamo) nel quadro della tarda età del Bronzo della Lombardia prealpina. In: COCCHI GENICK D, editor. *L'età del bronzo recente in Italia, Atti del Congresso Nazionale (Lido di Camaiore, 26-29 ottobre 2000*). Viareggio (LU). p 443-8.

PONS E. 1977. La Fonollera (1° y 2° campañas de Excavación 1975-1976). *Serie Monográfica* 1. Museu d'Arqueologia de Catalunya-Girona.

PONS E. 1984. L'Empordà, de l'edat del bronze a l'edat del Ferro (1100-600 a.C.). *Sèrie monogràfica* 4. Centre d'investigacions Arqueològiques de Girona.

PONS E. 1999. Algunes observacions sobre les datacions de ^{14}C de Sant Martí d'Empúries. In: AQUILUÉ X, editor. Intervencions arqueològiques a Sant Martí d'Empúries (1994-1996). De l'assentament precolonial a l'Empúries actual, Empúries. *Monografies*

Emporitanes 9:655-6.

PONS E. 2003. De l'edat del bronze a l'edat del ferro a Catalunya: desplaçaments, estades i canvi cultural. *Cota Zero* 18:106-30.

PONS E, GRAELLS R, VALLDEPÈREZ M. 2010. La formación de las sociedades protourbanas en en NE de la Península Ibérica a partir de los contextos funerarios (1100-550 ANE cal.). In: *Proceeding of the XV Congress of the International Union for Prehistoric and Protohistoric Sciences (Lisbon, 4-9 september 2006).* Oxford: BAR International Series 2124. Oxford: Archeopres. p 47-60.

PONS E, SOLÉS A. 2002. Pi de la Lliura (Vidreres). Primers avenços sobre la necròpolis d'incineració del bronze final (1100-950 aC). *Quaderns de la Selva* 14:61-93.

PONS E, SOLÉS A. 2008. *La necròpolis d'incineració del Pi de la Lliura (Vidreres) ara fa 3000 anys.* Ajuntament de Vidreres.

POOLE M. 2003. *Le dépôt D 2388 de l'âge du Bronze final de la Z.A.C. des "Feuilly" à Saint-Priest (Rhône)*. Mémoire de Maîtrise d'histoire de l'art et d'archéologie. Université de Bourgogne.

POPOVTSCHAK M, ZWIAUER K. 2003. Thunau am Kamp – Eine befestigte Höhensiedlung. Archäobotanische Untersuchungen urnenfelderzeitlicher bis frühmittelalterlicher Befunde. *Mitteilungen der Prähistorischen Kommision Österreichische Akademie der Wissenschaften* 52. Wien.

POWELL TGE. 1958. *The Celts*. Norwich.

PRADES H, GROUPE ARCHÉOLOGIQUE PAINLEVÉ, DEDET B, PY M. 1985. L'occupation des rivages de l'étang de Mauguio (Hérault) au Bronze final et au premier Âge du Fer. Tome I. Les recherches du Groupe Archéologique Painlevé (1969-1976). *Cahiers de l'Association pour la Recherche Archéologique en Languedoc Oriental* 11.

PRANGE M, AMBERT P. 2005. Caractérisation géochimique et isotopique des minerais et des métaux base cuivre de Cabrières (Herault). In: AMBERT P, VAQUER J, editors. Actes du colloque international: La prèmiere métallurgie en France et dans les pays limitrophes. *Mémoires de la Société Préhistorique Française* XXXVII:71-81.

PREMO LS, SCHOLNICK J. 2011. The scale of social learning affects cultural diversity. *American Antiquity* 76(1):163-76.

PRICE TD, BURTON JH, BENTLEY RA. 2002. The characterization of biologically available strontium isotope ratios for the study of prehistoric migration. *Archaeometry* 44(1):117-35.

PRIEN R. 2005. Archäologie und Migration. Vergleichende Studien zur archäologischen Nachweisbarkeit von Wanderungsbewegungen. *Universitätsforschungen zur prähistorischen Archäologie* 120.

PRIMAS M. 1990. *Die Bronzezeit im Spiegel ihrer Siedlungen, Die ersten Bauern I. Phahlbaufunde Europas, Band I Schweiz*. Zürich.

PRIMAS M. 1992. Neue Forschungsansätze. In: PRIMAS M, DELLA CASA P, SCHMID-

SIKIMIĆ B. 1992. Archäologie zwischen Vierwaldstättersee und Gotthard. Siedlungen und Funde der ur- und frühgeschichtlichen Epochen. *Universitätsforschungen zur prähistorischen Archäologie* 12:240-8.

PRIMAS M. 2001. Settlement archaeology in the Rhine Valley - Objectives, fieldwork and first results. In: BITTMANN F, editor. DFG-Graduiertenkolleg 462 "Paläoökosystemforschung und Geschichte". Beiträge zur Siedlungsarchäologie und zum Landschaftswandel, Ergebnisse zweier Kolloquien in Regensburg 9. -10. Oktober 2000 und 2. -3. November 2000. *Regensburger Beiträge zur prähistorischen Archäologie* 7:127-41.

PRIMAS M. 2008. Bronzezeit zwischen Elbe und Po. Strukturwandel in Zentraleuropea 2200-800 v. Chr. *Universitätsforschungen zur prähistorischen Archäologie* 150.

PRIMAS M, DELLA CASA P, SCHMID-SIKIMIĆ B. 1992. Archäologie zwischen Vierwaldstättersee und Gotthard. Siedlungen und Funde der ur- und frühgeschichtlichen Epochen. *Universitätsforschungen zur prähistorischen Archäologie* 12.

PROBST E. 1996. *Deutschland in der Bronzezeit. Bauern, Bronzegießer und Burgherren zwischen Nordsee und Alpen*. München.

PRODÉO F. 1999. Montaut, Nicol Vieux. In: *Bilan Scientifique 1999, DRAC Midi-Pyrénées, Service Regional de l'Archéologie*. p 214.

PRZYBIŁA S. 2009. *Intercultural contacts in the western Carpathian area at the turn of the 2nd and the 1st millennia BC*. Warszawa.

PUGIN C. 1992. Des fosses-foyers rectangulaires de l'âge du Bronze à Sion VS. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 75:148-54.

PUTZ U. 2002. Archäologische Untersuchungen auf dem Bogenberg, Niederbayern I. Ausgrabungsschnitte und Funde. *Regensburger Beiträge zur prähistorischen Archäologie* 8(1-2).

PUTZ U. 2007. Die Befestigungsphasen auf dem Bogenberg in Bezug zu seinem Umfeld. *Bericht der Bayerischen Bodendenkmalpflege* 47-48:65-78.

PYDYN A. 1999. *Exchange and cultural interactions. A study of long-distance trade and cross-cultural contacts in the Late Bronze Age and Early Iron Age in Central and Eastern Europe*. Oxford: BAR International Series 813.

PY M. 1985. Sauvetage programme sur le gisement de Tonnerre I (Mauguio, Hérault). In: DEDET B, PY M, SAVAY-GUERRAZ H. L'occupation des rivages de l'étang de Mauguio (Hérault) au Bronze final et au premier Âge du Fer. Tome II. Sondages et sauvetages programmés (1976-1979). *Cahiers de l'Association pour la Recherche Archéologique en Languedoc Oriental* 12:49-120.

PY M. 1990. Culture, économie et société protohistoriques dans la région nimoise. *Collection de l'École Française de Rome* 131.

PY M. 2007. La céramique du premier âge du Fer de Port Ariane (VIIe s. av. n. è.). In: DAVEAU I, editor. Port Ariane (Lattes, Hérault): construction deltaïque et utilisation d'une zone humide lors des six derniers millénaires. *Lattara* 20:405-19.

QUILLIEC B. 2003. *L’épée atlantique: échanges et prestiges au Bronze final*. Paris, Thèse de doctorat, Université de Paris I - Panthéon-Sorbonne.

QUILLIEC B. 2004. L’épée atlantique: échanges et prestiges au Bronze final. *Bulletin de la Société préhistorique française* 101(2):379-382.

RAFEL N. 1991. *La necrópolis del Coll de Moro de Gandesa. Els materials*. Tarragona.

RAFEL N, ARMADA XL. 2008. Sobre la cronologia de la necròpolis del Calvari del Molar i l’horitzó funerari del bronze final-I edat del ferro a l’Ebre. Noves datacions absolutes. *Cypsela* 17:149-59.

RAGHET J. 1974-1975. Savognin GR, Padnal, Grabung 1971, 1972, 1973. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 58:41-2.

RAGHET J. 1976. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Grabungen 1971 und 1972. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 59:123-79.

RAGHET J. 1977. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Die Grabungskampagne von 1973. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 60:43-101.

RAGHET J. 1978. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Grabung 1974. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 61:7-63.

RAGHET J. 1979. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Grabung 1975. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 62:29-76.

RAGHET J. 1980. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Die Grabungskampagne 1976. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 63:21-75.

RAGHET J. 1981. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Grabung 1977. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 64:27-71.

RAGHET J. 1982. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Grabung 1978. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 65:23-68.

RAGHET J. 1983. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Grabung 1979. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 66:105-60.

RAGHET J. 1984. Die bronzezeitliche Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). Grabung 1980. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 67:21-60.

RAGHET J. 1986a. Die wichtigsten Resultate der Ausgrabungen in der bronzezeitlichen Siedlung auf dem Padnal bei Savognin (Oberhalbstein GR). *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 69:63-103.

RAGHET J. 1986b. L'âge du Bronze dans les Grisons. In: Chronologie. Archäologische Daten der Schweiz. Datation archéologique en Suisse 1986. *Antiqua* 15:80-90.

RAGHET J. 1998. Bivio GR, Stalveder, nördlich Guet da Beiva. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 81:279.

RAHMSTORF L. 2011. Re-integrating 'Diffusion': The spread of innovations among the Neolithic and Bronze Age societies of Europe and the Near East. In: WILKINSON TC, SHERRATT S, BENNET J, editors. *Interweaving Worlds: Systemic Interactions in Eurasia, 7th to 1st Millennia BC*. Oxford. p 100-19.

RAMOS AGUIRRE M. 2007. Cortecampo II (Los Arcos) y Osaleta (Lorca, Valle de Yerri). In: *La tierra te sea leve. Arqueología de la muerte en Navarra*. p 93-6.

RAMOS AGUIRRE M. 2009. Arqueología en la Autovía del Camino. *Trabajos de Arqueología Navarra* 21:5-119.

RAMSTEIN M. 2005a. Kernenried, Holzmühle. Dokumentation 1998: bronzezeitliche Brandgrube. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:74-5.

RAMSTEIN M. 2005b. Köniz-Niederwangen, Stegenweg. Rettungsgrabung 1999: bronzezeitliche Siedlungreste und römische Gebäude. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:75-6.

RAMSTEIN M. 2005c. Koppigen, Usserfeld. Rettungsgrabungen 1999: spätbronzezeitliche Gräber. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:76-7.

RAMSTEIN M. 2005d. Meikirch, Magazingebäude. Rettungsgrabung 1999 und Publikation 2004: bronzezeitliche Grube. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:79.

RAMSTEIN M. 2005e. Meinisberg, Scheidwege. Rettungsgrabung 2000: bronzezeitliche Brandgruben und Wege/Strassen. Archäologie im Kanton Bern/Archéologie dans le canton de Berne 6A:80-91.

RAMSTEIN M. 2005f. Münchringen, Mooswald. Mittelbronzezeitliche Grube. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6B:537-46.

RAMSTEIN M. 2005g. Münchringen, Mooswald. Rettungsgrabung 1997: mittelbronzezeitliche Grube. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:91.

RAMSTEIN M. 2005h. Pieterlen, Vorem Holz 1. Grabung 1998: prähistorische Siedlungreste. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:79.

RAMSTEIN M, BROMBACHER C. 2005. Thunstetten, Längmatt. Rettungsgrabungen 1999-2002: eisenzeitliche Werkgruben. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:153-63.

RAMSTEIN M, BROMBACHER C, BÜTTIKER-SCHUMACHER E, FREY-KUPPER S, KLEE M, MAGGETTI M, RÜTTIMANN D, ULRICH-BOCHSLER S. 2005. Ipsach-Räberain. Spätbronzezeitliche Siedlungen und römischer Gutshof. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6B:569-614.

RAMSTEIN M, CUENI A. 2005. Koppingen-Usserfeld. Spätbronzezeitliche Gräber. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6B:547-58

RAMSTEIN M, DESCHLER-ERB S. 2005. Pieterlen, Under-Siedebrunne 3. Rettungsgrabung 1998: prähistorische Siedlungreste. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:102-9.

RANCOULE G, GUILAINE J, VAQUER J, PASSELAC M, VIGNE J-D, ZAMMIT J. 1986. Les structures du 1er Age du Fer. In: GUILAINE J, RANCOULE G, VAQUER J, PASSELAC M, VIGNE J-D, BARRIÉ P, COULAROU J, ERROUX J, FIRMIN G, KRAUSS-MARGUET I, MARINVALVIGNE M-C, MAZÉAS H, PICHON J, THOMMERET J, THOMMERET Y, VERNET J-L, ZAMMIT J. 1986. *Carsac. Une agglomération protohistorique en Languedoc*. Toulouse. p 71-5.

RANCOULE G, GUILAINE J, VIGNE J-D. 1986. Autres points d'implantation à vestiges du bronze final. In: GUILAINE J, RANCOULE G, VAQUER J, PASSELAC M, VIGNE J-D, BARRIÉ P, COULAROU J, ERROUX J, FIRMIN G, KRAUSS-MARGUET I, MARINVALVIGNE M-C, MAZÉAS H, PICHON J, THOMMERET J, THOMMERET Y, VERNET J-L, ZAMMIT J. 1986. *Carsac. Une agglomération protohistorique en Languedoc*. Toulouse. p 67-70.

RANDSBORG K. 1991. Historical implications. Chronological studies in European Archaeology c. 2000-500 B.C. *Acta Archaeologica* 62:89-109.

RANDSBORG K, editor. 1996. Absolute Chronology. Archaeological Europe 2500-500 BC (Verona, April 20-23 1995). *Acta Archaeologica* 67.

RANKIN HD. 1987. *Celts and the classical world*. London.

RASSMANN K. 1993. Spätneolithikum und frühe Bronzezeit im Flachland zwischen Elbe und Oder. *Beiträge zur Ur- und Frühgeschichte Mecklenburg-Vorpomm*erns 28.

RASSMANN K. 1996. Zum Forschungsstandt der absoluten Chronologie der frühen Bronzezeit in Mitteleuropa auf der Grundlage von Radiokarbondaten. In: RANDSBORG K, editor. 1996. Absolute Chronology. Archaeological Europe 2500-500 BC (Verona, April 20-23 1995). *Acta Archaeologica* 67:199-209.

RATEL R. 1970. Le tumuls à incinération de Chaume-les-Baigneux (Côte d'Or). *Revue archéologique de l'Est et du Centre-Est* XXI(1-2):181-99.

RAURET AM. 1987. La seqüència estratigràfica de la cova de les Pixarelles (Tavertet, Osona). *Tribuna de Arqueologia* 1986-1987:59-68.

RAURET AM, MESTRES JS, GARCÍA JF. 1989. Relation between cultural and ^{14}C ages from a Bronze Age site stratigraphy of the Pixarelles Cave, Catalonia, Spain. In: MOOK WG, WATERBOLK HT, editors. 1989. *Proceedings of the Second International Symposium ^{14}C and Archaeology (Groningen, 1987).* p 395-402.

RAYNAUD D. 2010. Why do diffusion data not fit the logistic model? A note on network discreteness, heterogeneity & anisotropy. In: MEMON N, ALHAJJ R, editors. *From sociology to computing in social networks: theory, foundations and applications*. p 81-96.

REBOLLO NR, COHEN-OFRI I, POPOVITZ-BIRO R, BAR-YOSEF O, MEIGNEN L, GOLDBERG P, WEINER S, BOARETTO E. 2008. Structural characterization of charcoal exposed to high and low pH: implications for ^{14}C sample preparation and charcoal preservation. *Radiocarbon* 50(2):289-307.

REDING C. 2002. Altstätten SG, Bürg. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 85:285-6.

REGEV J, de MIROSCHEDJI P, GREENBER R, BRAUN E, GREENHUT Z, BOARETTO E. 2012. Chronology of the Early Bronze Age in the Southern Levant: new analysis for a high chronology. In: BOARETTO E, REBOLLO FRANCO NR, editors. Proceedings of the Sixth Radiocarbon and Archaeology Symposium (Paphos, Cyprus, 10–15 April 2011). *Radiocarbon* 54(3-4):525-66.

REY P-J, TREFFORT J-M, de LARMINAT S. 2012. Le site néolithique et protohistorique du Châtelard de Bourg-Saint-Maurice (Savoie). Habitat perché et zone sépulcrale au pied du col du Petit-Saint-Bernard, dans leur contexte alpin. *Bulletin de la Société préhistorique française* 109(4):731-65.

REIM H. 1997. Frühbronzezeitliche Gräber und Funde im Neckartal um Rottenburg. In: *Goldene Jahrhunderte. Die Bronzezeit in Südwestdeutschland.* Stuttgart. p 98-101.

REIMER PJ, BAILLIE MGL, BARD E, BAYLISS A, BECK JW, BERTRAND CJH, BLACKWELL PG, CAITLIN EB, BURR GS, CUTLER K, DAMON PE, EDWARDS RL, FAIRBANKS RG, FRIEDRICH M, GUILDERSON TP, HOGG AG, HUGHEN KA, KROMER B, McCORMAC G, MANNING S, BRONK RAMSEY C, REIMER R, REMMELE S, SOUTHON JR, STUIVER M, TALAMO S, TAYLOR FW, VAN DER PLICHT J, WEYHENMEYER CE. 2004. IntCal04 Terrestrial Radiocarbon Age Calibration, 0–26 cal kyr BP. *Radiocarbon* 46(3):1029-58.

REIMER PJ, BAILLIE MGL, BARD E, BAYLISS A, BECK JW, LACKWELL PG, BRONK RAMSEY C, BUCK CE, BURR GS, EDWARDS RL, FRIEDRICH M, GROOTES PM, GUILDERSON TP, HAJDAS I, HEATON TJ, HOGG AG, HUGHEN KA, KAISER KF, KROMER B, MCCORMAC FG, MANNING SW, REIMER RW, RICHARDS DA, SOUTHON JR, TALAMO S, TURNEY CSM, VAN DER PLICHT J, WEYHENMEYER CE. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0-50,000 years cal BP. *Radiocarbon* 51(4):1111-50.

REIMER PJ, BARD E, BAYLISS A, BECK JW, BLACKWELL PG, BRONK RAMSEY C, BUCK CE, CHENG H, EDWARDS RL, FRIEDRICH M, GROOTES PM, GUILDERSON TP, HAFLIDASON H, HAJDAS I, HATTÉ C, HEATON TJ, HOFFMANN DL, HOGG AG, HUGHEN KA, KAISER KF, KROMER B, MANNING SW, NIU M, REIMER RW, RICHARDS DA, SCOTT EM, SOUTHON JR, STAFF RA, TURNEY CSM, VAN DER PLICHT J. 2013. IntCal13 and Marine13 radiocarbon age calibration curves, 0-50,000 years cal BP. *Radiocarbon* 55(4):1869-87.

REIMER PJ, BROWN TA, REIMER RW. 2004. Discussion: reporting and calibration of post-bomb ^{14}C data. *Radiocarbon* 46(3):1299-1304.

REINECKE P. 1899. Studien zur Chronologie des ungarlandischen Bronzealters. I. Teil. Prahistorisches aus Ungarn und den Nachbarlandern. *Beiblatt der Ethnologischen Mitteilungen aus Ungarn* 1(1).

REINECKE P. 1900. Brandgraber vom Beginn der Hallstattzeit aus den ostlichen Alpenlandern und die Chronologie des Grabfeldes von Hallstatt. *Mitteilungen der Anthropologischen Gesellschaft Wien* 30:44-52.

REINECKE P. 1902. Zur Chronologie der 2. Halfte des Bronzealters in Sud- und Norddeutschland. *Korrespondenzblatt der deutschen Gesellschaft fur Anthropologie,* *Ethnologie und Urgeschichte* 33(3):17-32.

REINECKE P. 1965. *Mainzer Aufsätze zur Chronologie der Bronze- und Eisenzeit*. Bonn.

RENAULT S, BOURHIS J-R, FOREST V, MAGNIN F, MARGARIT X, MISTROT V, THIÉBAULT S, VIGNE J-D, WEYDERT N. 1996-1997. Les niveaux de l'Age du bronze du Mourre de la Barque à Jouques (Bouches-du-Rhône). Première analyse du mobilier et reconstitution paléoenvironnementale. *Documents d'archéologie Méridionale* 19-20:33-56.

RENDU C, CAMPMAJO P, DAVASSE B, GALOP D, CRABOL D. 1996. *Premières traces d’occupation pastorale sur la montagne d’Enveig.* Perpignan. p 35-43.

RENFREW C. 1987. *Archaeology and language: the puzzle of Indo-European origin*. London.

RENFREW C, BAHN P. 1998. *Arqueología. Teorías, métodos y práctica*. Madrid.

RENFREW C, BOYLE K. 2000. *Archaeogenetics: DNA and the population Prehistory of Europ*e. Cambridge.

REY F, SCHWÖRER C, GOBET E, COLOMAROLI D, VAN LEEUWEN JFN, SCHLEISS S, TINNER W. 2013. Climatic and human impacts on mountain vegetation at Lauenensee (Bernese Alps, Switzerland) during the last 14,000 years. *The Holocene* 23:1415-27.

REY J. 1988. Yacimientos prehistóricos en las proximidades de Monflorite (Huesca). *Bolskan* 5:87-116.

REY J. 1991. Informe de las excavaciones realizadas en Ciquilines IV (Monflorite, Huesca). *Arqueología Aragonesa* 1986-1987:131-3.

REY P-J, TREFFORT J-M, DE LARMINAT S. 2012. Le site néolithique et protohistorique du Châtelard de Bourg-Saint-Maurice (Savoie). Habitat perché et zone sépulcrale au pied du col du Petit-Saint-Bernard, dans leur contexte alpin. *Bulletin de la Société préhistorique française* 109(4):731-65.

RICCI M. 1998a. Alta valle Argentina. In: DEL LUCCHESE A, MAGGI R, editors. Dal diaspro al bronzo. L’Età del Rame e l’Età del Bronzo in Liguria: 26 secoli di storia fra 3600 e 1000 anni avanti Cristo. *Quaderni della Soprintendenza Archeologica della Liguria* 5:58-62.

RICCI M. 1998b. *Apricale (IM). Il tumulo n. 1 di Pian del Re*. In: DEL LUCCHESE A, MAGGI R, editors. Dal diaspro al bronzo. L’Età del Rame e l’Età del Bronzo in Liguria: 26 secoli di storia fra 3600 e 1000 anni avanti Cristo. *Quaderni della Soprintendenza Archeologica della Liguria* 5:63-5.

RICCI M. 2004. *Il Tumulo N. 1 di Pian del Re presso Apricale, in Provincia d’Imperia*. In: BERTONE A, FOZZATI L, editors. *La civiltà di Viverone. La conquista di una nuova frontiera nell’Europa del II Millennio a.C.* Candelo (BI). p 105-8.

RICHARDS FJ. 1959. A flexible growth function for empirical use. *Journal of Experimental Botany* 10(2):290-301.

RICHARDS M, CÔRTE-REAL H, FORSTER P, MACAULAY V, WILKINSON-HERBOTS H, DEMAINE A, PAPIHA S, HEDGES R, BANDELT HJ, SYKES B. 1996. Paleolithic and Neolithic lineages in the European mitochondrial gene pool. *American Journal of Human*

Genetics 59(1):185-203.

RICK JW. 1987. Dates as data: an examination of the Peruvian preceramic radiocarbon data. *American Antiquity* 52:55-73.

RIEDEL A. 1975. La fauna del villaggio preistorico di Isolone della Prevaldesca. *Bollettino del Museo Civico di Storia Naturale di Verona* 2:355-414.

RIEDEL A. 1976a. La fauna del villaggio preistorico di Barche di Solferino. *Atti del Museo Civico di Storia Naturale di Trieste* 29:215-318.

RIEDEL A. 1976b. La fauna del villaggio preistorico di Ledro. *Studi Trentini di Scienze Naturali* 53:3-120.

RIEDEL A. 1998. Archäozoologishe Untersuchungen an der Knochenfunden aus der Větěrov-Kultur von Böheimkirchen (Niederösterreich). Annalen *des Naturhistorischen Museums in Wien* 99(A):341-74.

RIEDEL A. 2002. *La fauna dell'insediamento protostorico di Vadena - Die Fauna der vorgeschichtlichen Siedlung von Pfatten*. XC pubblicazione del Museo Civico di Rovereto. Rovereto.

RIEDEL A, RIZZI J. 1995. La fauna della media età del Bronzo di Albanbuhel. In: Atti del 1° Convegno Nazionale di Archeozoologia. *Quaderni Padusa* 1:171-83.

RIEDEL A, TECCHIATI U. 1999. I resti faunistici dell'abitato d'altura dell'antica e media età del Bronzo di Nössing in Val d'Isarco (com. di Varna, Bolzano). *Atti dell'Accademia Roveretana degli Agiati* VII(IXB):285-327.

RIEHL S, BRYSON RA, PUSTOVOYTOV KE. 2008. *Changing growing conditions for crops during the Near Eastern Bronze Age (3000–1200 BC): the stable carbon isotope evidence*. *Journal of Archaeological Science* 35(4):1011-2.

RIESER B, SCHRATTENTHALER H. 1998-1999. Urgheschichtlicher Kupferbergbau im Raum Schwaz-Brixlegg, Tirol. *Archaeologia Austriaca* 82-83:135-79.

RIGERT E. 2003. Eschenbach SG, Neuhaus, Bürstli, Balmenrainstrasse. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 86:211.

RIGERT E, SCHINDLER MP. 2002. Der Bau der Schweizerischen Hauptstrasse H8 zwischen Jona und Schmerikon. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 85:7-22.

RIND MM. 1999. Höhenbefestigungen der Bronze- und Urnenfelderzeit. Der Frauenberg oberhalb Kloster Weltenburg I/1-2. *Regensburger Beiträge zur prähistorischen Archäologie* 6.

RIND MM. 2006. Höhenbefestigungen der Bronze- und Urnenfelderzeit. Der Frauenberg oberhalb Kloster Weltenburg II/1-2. *Regensburger Beiträge zur prähistorischen Archäologie* 16.

RIND MM. 2008. Der Einfluss des prähistorischen Menschen auf die Kulturlandschaft im Kelheimer Raum. In: Festgabe 40 Jahre Lehrstuhl für Vor- und Frühgeschichte der Universität Regensburg 1968-2008. *Regensburger Beiträge zur prähistorischen*

Archäologie 20:395-407.

RINGE DA. 1992. On calculating the factor of chance in language comparison. *Transaction of the American Philosophical Society* 1992:1-110.

RITTATORE E. 1954. Contributi di recenti ricerche paletnologiche in Italia. *Origines*:131-44.

RITTATORE VONWILLER F. 1963. La cultura di Canegrate ed il problema dei Campi d'Urne in Italia. In: *Studi in onore di A. Pedro Bosch-Gimpera*. Mexico. p 385-93.

ROBERTS BW, UCKELMANN M, BRANDHERM D. 2013. Chapter 2. Old father time: the Bronze Age chronology in Western Europe. In: FOKKENS H, HARDING A, editors. *The Oxford handbook of the European Bronze Age*. Oxford. p 17-46.

RODANÉS JM. 1991. Investigaciones arqueológicas en el Bajo Cinca: campañas de excavación de 1989/1990 en el poblado de la Edad del Bronce de Masada de Ratón (Fraga, Huesca). *Bolskan* 8:165-99.

RODANÉS JM. 1992a. Datación absoluta de los niveles inferiores del yacimiento de Masada de Ratón (Fraga, Huesca). *Boletín del Museo de Zaragoza* 11:5-12.

RODANÉS JM. 1992b. Del Calcolítico al Bronce Final en Aragón. Problemas y perspectivas. In: UTRILLA P, editor. *Aragón/Litoral mediterráneo: intercambios culturales durante la Prehistoria. En homenaje a Juan Maluquer de Motes*. Zaragoza. p 491-513.

RODANÉS JM. 1992c. Masada de Ratón (Fraga, Huesca). Campaña de 1990. *Arqueología Aragonesa* 1990:63-5.

RODANÉS JM, MONTÓN F. 1990. *Los yacimientos de la Edad del Bronce de Masada de Ratón y Zafranales (Fraga, Huesca). Estado actual de las investigaciones*. CEP de Monzón-Ayuntamiento de Fraga. Fraga.

RODANÉS JM, SOPENA MC. 1998. *El Tozal de Macarullo (Estiche, Huesca): el Bronce Reciente en el Valle del Cinca*. Monzón. Centro de Estudios de Monzón y Cinca Medio.

RODANÉS JM, REY J. 1991. Excavaciones arqueológicas en Masada de Ratón (Fraga, Huesca). Campaña de 1989. *Arqueología Aragonesa* 1988-1989:91-4.

ROGERS EM. 1962. *Diffusion of innovations*. New York.

ROGERS EM. 2003. *Diffusion of innovations (5th ed.)*. New York.

ROGERS EM, MEDINA UE, RIVERA MA, WILEY CJ. 2005. Complex adaptive systems and the diffusion of innovations. *The Innovation Journal: The Public Sector Innovation Journal* 10(3):1-26.

ROMNEY AK. 1999. Culture consensus as a statistical model. *Current Anthropology* 40:103-15.

ROMNEY AK, BOYD JP, MOORE CC, BATCHELDER WH, BRAZILL TJ. 1996. Culture as shared cognitive representations. *Proceeding of the National Academy of Sciences of the United States of America (PNAS)* 93:4699-4705.

ROMNEY AK, WELLER SC, BATCHELDER WH. 1986. Culture as consensus: A theory of culture and informant accuracy. *American Anthropologist* 88:313-38.

ROM W, GOLSER R, KUTSCHERA W, PRILLER A, STEIER P, WILD EM. 1998. AMS C14 dating of equipment from the iceman and of spruge logs from the prehistoric salt mines of Hallstatt. *Radiocarbon* 41(2):183-97.

RONCO D. 1994. Un campione di popolazione dell'età del Bronzo di Paradiso di Laorca (Lecco): paleobiologia. In: CASINI S, editor. *Carta archeologica della Lombardia. IV Provincia di Lecco*. p 81-90.

ROOTSI S, MAGRI C, KIVISILD T, BENUZZI G, HELP H, BERMISHEVA M, KUTUEV I, BARAĆ L, PERICIĆ M, BALANOVSKY O, PSHENICHNOV A, DION D, GROBEI M, ZHIVOTOVSKY LA, BATTAGLIA V, ACHILLI A, AL-ZAHERY N, PARIK J, KING R, CINNIOĞLU C, KHUSNUTDINOVA E, RUDAN P, BALANOVSKA E, SCHEFFRAHN W, SIMONESCU M, BREHM A, GONCALVES R, ROSA A, MOISAN JP, CHAVENTRE A, FERAK V, FÜREDI S, OEFNER PJ, SHEN P, BECKMAN L, MIKEREZI I, TERZIĆ R, PRIMORAC D, CAMBON-THOMSEN A, KRUMINA A, TORRONI A, UNDERHILL PA, SANTACHIARA-BENERECETTI AS, VILLEMS R, SEMINO O. 2004. Phylogeography of Y-Chromosome haplogroup reveals distintc domains of prehistoric gene flow in Europe. *The American Journal of Human Genetics* 75(1):128-37.

ROPER DC. 1979. The method and theory of site catchment analysis: A review. In: SCHIFFER MB. 1979. *Advances in Archaeological Method and Theory, v. 2*. New York. p 119-40.

RÖPKE A, KRAUSE R. 2013. High montane-subalpine soils in the Montafon Valley (Austria, northern Alps) and their link to land-use, fire and settlement history. *Quaternary International* 308-309:178–189.

ROSKAMS S, editor. 2000. *Interpreting Stratigraphy. Site evaluation, recording procedures and stratigraphic analysis*. Oxford: BAR International Series 910.

ROSSER ZH. ZERJAL T, HURLES ME, ADOJAAN M, ALAVANTIC D, AMORIM A, AMOS W, ARMENTEROS M, ARROYO E, BARBUJANI G, BECKMAN G, BECKMAN L, BERTRANPETIT J, BOSCH E, BRADLEY DG, BREDE G, COOPER G, CÔRTE-REAL HBSM, DE KNIJFF P, DECORTE R, DUBROVA YE, EVGRAFOV O, GILISSEN A, GLISIC S, GÖLGE M, HILL EW, JEZIOROWSKA A, KALAYDJIEVA L, KAYSER M, KIVISILD T, KRAVCHENKO SA, KRUMINA A, KUČINSKAS V, LAVINHA J, LIVSHITS LA, MALASPINA P, MARIA S, MCELREAVEY K, MEITINGER TA, MIKELSAARA-V, MITCHELL RJ, NAFA K, NICHOLSON J, NØRBY S, PANDYA A, PARIK J, PATSALIS PC, PEREIRA L, PETERLIN B, PIELBERG G, PRATA MJ, PREVIDERÉ C, ROEWER L, ROOTSI S, RUBINSZTEIN DC, SAILLARD J, SANTOS FR, STEFANESCU G, SYKES BC, TOLUN A, VILLEMS R, TYLER-SMITH C, JOBLING MA. 2000. Y-Chromosomal diversity in Europe is clinal and influenced primarily by geography, rather than by language. *American Journal of Human Genetics* 67:1526-43.

ROUDIL J-L. 1974. Languedoc-Roussillon. *Gallia Préhistoire* 17(2):629-64.

ROUDIL J-L, DEDET B. 1993. Les débuts du Bronze final dans les gorges de la Cèze (Gard). I-La grotte du Hasard à Tharaux. *Documents d'Archéologie Méridionale* 16:111-62.

ROUQUEROL N. 2004. Du Néolithique à l'Âge du bronze dans les Pyrénéen centrales françaises. *Archives d'Ecologie Préhistorique* 16.

ROUSSOT-LARROQUE J. 1984. Peyzac-le-Moustier: La Roque-Saint-Christophe. *Gallia*

Préhistoire 27(2):279-80.

ROUVINEZ F. 1998. Marin NE-Le Chalvarie: Habitat de l'âge du Bronze moyen. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 81:59-118.

ROVIRA J. 1978. La penetració cultural en el Bronze Final de les influències norpirinenques a l'interior a l'interior de Catalunya i el seu impacte. In: *Actes del XII Col·loqui Internacional d'Arqueologia de Puigcerdà (Puigcerdà 1976)*. p 69-82.

ROVIRA I PORT J. 1991. Reflexiones sobre los primeros campos de urnas en la Península Ibérica: una arribada marítima. *Cuadernos de prehistoria y arqueología castellonenses* 15:157-72.

ROVIRA J, SANTACANA J. 1980. Reflexiones sobre "economía" prehistórica aplicada a los grupos culturales del este peninsular: el modo doméstico de producción. *Información Arqueológica* 33-34:48-52.

ROWLANDS M, LARSEN MT, KRISTIANSEN K, editors. 1987. *Centre and periphery in the Ancient World*. Cambridge.

ROYO JI. 1986a. El yacimiento de Los Castellets de Mequinenza y su necrópolis tumular de inhumación e incineración. (Mequinenza, Zaragoza). *Arqueología Aragonesa* 1984:47-51.

ROYO JI. 1986b. Los Castellets de Mequinenza (Zaragoza). Cuarta campaña de excavaciones arqueológicas. *Boletín del Museo de Zaragoza* 5:401-3.

ROYO JI. 1987. La necrópolis tumular de Los Castellets de Mequinenza (Zaragoza). Campaña de 1985. *Arqueología Aragonesa* 1985:71-5.

ROYO JI. 1991. Los Castellets de Mequinenza (Zaragoza). Trabajos realizados en 1986. *Arqueología Aragonesa* 1986-1987:145-8.

ROYO JI. 1992. Estudio de materiales de Los Castellets de Mequinenza. Campaña de 1990. *Arqueología Aragonesa* 1990:81-7.

ROYO JI. 1996. Ritual funerario y cultura material en las necrópolis tumulares de Los Castellets de Mequinenza (Zaragoza): Una aportación al estudio del Bronze Final/Hierro I en el N.E. Peninsular. *Gala* 3-5:93-108.

ROYO JI, FERRERUELA A. 1983. Noticia preliminar sobre la necrópolis de inhumación e incineración de Los Castellets (Mequinenza, Zaragoza). *Boletín del Museo de Zaragoza* 2:211-9.

ROZANSKI K, STICHLER W, GONFIANTINI R, SCOTT EM, BEUKENS RP, KROMER B, VAN DER PLICHT J. 1992. The IAEA ^{14}C Intercomparison Exercise 1990. *Radiocarbon* 34(3):506-19.

RUBAT BOREL F. 2006. Il Bronzo Finale nell'estremo Nord-Ovest italiano: il gruppo Pont-Valperga. *Rivista di scienze preistoriche* 56:429-82.

RÜCKER C. 1997. Un cas de parodontite aiguë juvénile observé dans une population de l'Âge du Bronze (aven Mort de Lambert). In: BUCHET L, editor. *L'enfant, son corps, son histoire, actes des septièmes journées anthropologiques de Valbonne, 1-3 juin 1994*. Antibes. p 281-92.

RÜCKER C. 2011. *Aven de la Mort de Lambert. Un acte de prévention à l'âge du bronze*. *Actes de la Société française d'histoire de l'art dentaire* 16:69-74.

RUFFIEUX M, MAUVILLY M. 2003. La nécropole hallstattienne de Düdingen/Birch et l'occupation pré-et protohistorique du secteur. *Cahiers d'Archéologie Fribourgeoise/Freiburger Hefte für Archäologi*e 5:1-16.

RUIZ GÁLVEZ M. 1979. El Bronce Antiguo en la fachada atlántica peninsular. *Trabajos de Prehistoria* 36:151-72.

RUIZ GÁLVEZ M. 1984. *La Península Ibérica y sus relaciones con el Círculo Cultural Atlántico*. Madrid.

RUIZ-GALVEZ PRIEGO M. 1992. La novia vendida: orfebrería, herencia y agricultura en la protohistoria de la Península Ibérica. *SPAL: Revista de prehistoria y arqueología de la Universidad de Sevill*a 1:219-51.

RUIZ-GALVEZ PRIEGO M, editor. 2001. *La Edad del Bronce, ¿Primera Edad de Oro de España? Sociedad, economía e ideología*. Barcelona.

RUIZ ZAPATERO G. 1978. Las penetraciones de Campos de Urnas en el País Valenciano. *Cuadernos de Prehistoria y Arqueología Castellonense* 5:243-55.

RUIZ ZAPATERO G. 1983. Sociedad y economía en la cultura hallstática. *Revista de arqueología* 31:6-14.

RUIZ ZAPATERO G. 1985. *Los Campos de Urnas del NE. de la Península Ibérica*. Madrid.

RUIZ ZAPATERO G. 1995-1997. El poder de "los celtas": de la Academia a la Política. *O Arqueólogo Português* Série IV 13-15:211-32.

RUIZ ZAPATERO G. 1997. Migration revisited: urnfields in Iberia. In: DÍAZ-ANDREU M, KEAY S, editors. *The archaeology of Iberia: the dynamics of change*. London-New York. p 158-74.

RUIZ ZAPATERO G. 2001. Las comunidades del Bronce Final: enterramiento y sociedad en los campos de urnas. In: RUIZ-GALVEZ PRIEGO M, editor. *La Edad del Bronce, ¿Primera Edad de Oro de España? Sociedad, economía e ideología*. Barcelona. p 257-88.

RUIZ ZAPATERO G. 2004. Casas y tumbas. Explorando la desigualdad social en el Bronze Final y Primera Edad del Hierro del NE de la Península Ibérica. *Mainake* 26:293-330.

RUIZ ZAPATERO G. 2006. The Celts in Spain. From archaeology to modern identities. In: RIECKHOFF S, editor. *Celtes et Gaulois, l´Archéologie face à l´Histoire, I: Celtes et Gaulois dans l'histoire, l'historiographie et l'idéologie moderne. Centre archéologique européen*. Bibracte. p 197-218.

RUIZ ZAPATERO G. 2010. Roma conquistó la Gallia…y Astérix y Obélix conquistaron el mundo. Desenmarañando a los Celtas. In: CRUZ CARDETE M, editor. *La antigüedad y sus mitos. Narrativas históricas irreverente*s. Madrid. p 97-114.

RUIZ ZAPATERO G, LORRIO AJ. 1999. Las raíces prehistóricas del mundo celtibérico. In: ARENAS JA, PALACIOS MV, editors. *El origen del mundo celtibérico. Actas de los encuentros sobre el origen del mundo celtibérico (Molina de Aragón 1998)*. p 21-36.

RUSSELL TM. 2004. *The spatial analysis of radiocarbon databases: the spread of the first farmers in Europe and of the fat-tailed sheep in Southern Africa*. Oxford.

RUSSELL T, STEELE J. 2009. A geo-referenced radiocarbon database for Early Iron Age sites in sub-Saharan Africa: initial analysis. *Southern African Humanities* 21:327-44.

RYCHNER-FARAGGI A-M. 1998. Avenches VD-En Chaplix, structures et mobilier d'un site de la fin du Bronze final et du Hallstatt ancient. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 81:23-38.

RYCHNER-FARAGGI A-M. 1999. Faoug VD-Derrière-le-Chaney, Structures et mobilier d'un site hallstattien. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 82:65-78.

RYCHNER-FARAGGI A-M, WOLF S. 2001. Cendre d'os et céramiques hallstattiennes à Onnens VD-Le Motti. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 84:171-6.

RYCHNER V. 1995. Stand und Aufgaben dendrochronologischer Forschung zur Urnenfelderzeit. In: Beiträge zur Urnenfelderzeit nördlich und südlich der Alpen. Ergebnisse eines Kolloquiums. *Römisch- Germanischen Zentralmuseums Mainz Monographien* 35:455-87.

RYCHNER V, BÖHRINGER S, GASSMANN P. 1996. Dendrochronologie et typologie du Bronze final dans le région de Neuchâtel (Suisse): un résumé. In: RANDSBORG K, editor. Absolute Chronology. Archaeological Europe 2500-500 BC (Verona, April 20-23 1995). *Acta Archaeologica* 67:307-14.

RYCHNER V, RUOFF U. 1986. L'âge du Bronze sur le Plateau suisse. In: Chronologie. Archäologische Daten der Schweiz. Datation archéologique en Suisse. *Antiqua* 15:73-9.

ŠABATOVÁ K, VITULA P. 2002. Přáslavice. Díly pod dědinou, Kousky a kukličky (II). Pohřebiště a sídliště z doby bronzové (katalog). *Archaeologiae Regionalis Fontes* 4.

SAINTY J, JEUNESSE C, SCHNEIDER ML, RAPP J. 1974. Découverte de deux fours de potiers de l'époque hallstattienne à l'Ouest de Strasbourg. *Cahiers Alsaciens d'Archéologie d'Art et d'Historie* 18:13-21.

SAJANTILA A, LAHERMO P, ANTTINEN T, LUKKA M, SISTONEN P, SAVONTAUS ML, AULA P, BECKMAN L, TRANEBJAERG L, GEDDE-DAHL T, ISSEL-TARVER L, DIRIENZO A, PÄÄBO S. 1995. Genes and languages in Europe: an analysis of mitochondrial lineages. *Genome Research* 5:42-52.

SALZANI L. 1985. *Preistoria e Protostoria nella media pianura veronese*. Oppeano (Verona).

SALZANI L. 1989. Fratta Polesine, Frattesina. *Quaderni di Archeologia del Veneto* V:66-8.

SALZANI L. 1994a. Nogara. Rinvenimento di un ripostiglio di bronzi in località “Pila del Brancón”. *Quaderni di Archeologia del Veneto* X:83-94

SALZANI L. 1994b. Necropoli dell’età del Bronzo a Scalvinetto di Legnago (VR). Campagne di scavo 1991 e 1994. *Padusa* 30:107-31.

SALZANI L. 1998. Nuovi dati sul ripostiglio della Pila del Brancón. *Quaderni di Archeologia del Veneto* XIV:66-71.

SALZANI L. 2004. La necropoli di Scalvinetto (Legnago): nuove ricerche. *Bollettino del Museo Civico di Storia Naturale di Verona* 28:67-84.

SALZANI L. 2005a. Corte Lazise (Villabartolomea, Prov di Verona). *Rivista di Scienze Preistoriche* LV:525.

SALZANI L. 2005b. Le necropoli dell'età del Bronzo all'Olmo di Nogara. *Memorie del Museo di Verona* 2. Verona.

SALZANI L. 2006. L'area votiva di Corte Lazise a Villa Bartolomea (Verona). Nuovi rinvenimenti e considerazioni generali. *Quaderni di Archeologia del Veneto* serie speciale 2:25-34.

SALZANI L, VAGNETTI L, JONES RE, LEVI ST. 2006. Nuovi ritrovamenti di ceramiche di tipo egeo dall'area veronese: Lovara, Bovolone e Terranegra. In: *Atti della XXXIX Riunione Scientifica "Materie prime e scambi nella preistoria italiana", Istituto Italiano di Preistoria e Protostoria (Firenze, 25-27 novembre 2004)*. p 1145-57.

SALZANI L, EVANS S, FOZZATI L. 1991. Peschiera. Palafitta dell'età del Bronzo nel lago di Frassino. Campagne di scavo 1989-1990. *Quaderni di Archeologia del Veneto* VII:105-22.

SAMPIETRO ML, CARAMELLI D, LAO O, CALAFELL F, COMAS D, LARI M, AGUSTÍ B, BERTRANPETIT J, LALUEZA-FOX C. 2005. The Genetics of the Pre-Roman Iberian Peninsula: A mtDNA Study of Ancient Iberians. *Annals of Human Genetics* 69:535-48.

SÁNCHEZ JE. 1981. *La geografía y el espacio social del poder*. Barcelona

SÁNCHEZ JE. 1991. *Espacios, economía y sociedad*. Madrid.

SANDARS NK. 1978. *The Sea Peoples: Warriors of the ancient Mediterranean, 1250-1150 B.C.* London.

SANDOZ G, THIÉROT F, VITAL J. 1993. Le site protohistorique de la Raze de la Dame à Communay (Rhône). *Documents d'Archéologie Méridionale* 16:163-91.

SANMARTI J, BELARTE MC, SANTACANA J, ASENSIO D, NOGUERA J. 2000. L'assentament del bronze final i primera edad del ferro del Barranc de Gàfols (Ginestar, Ribera d'Ebre). *Arqueomediterrània* 5.

SANTOS C, FREGEL R, CABRERA VM, ÁLVAREZ L, LARRUGA JM, RAMOS A, LÓPEZ MA, ALUJA MP, GONZÁLEZ AM. 2014. Mitochondrial DNA and Y-Chromosome structure at the Mediterranean and Atlantic façades of the Iberian Peninsula. *American Journal of Human Biology* 26:130-41.

SANTOS M. 1974. Geography, Marxism and underdevelopment. *Antipode* 6(3):1-9.

SANTOS M. 1977. Society and space: social formation as theory and method. *Antipode* 9(1):3-13.

SANTOS M. 2000. *La naturaleza del espacio: técnica y tiempo, razón y emoción*. Barcelona.

SARTI L. 1980. L'insediamento dell'età del Bronzo di Dicomano (Firenze). *Rivista di scienze preistoriche* 35:183-247.

SAULE M. 1983. Fouille de sauvetage d'un tumulus à Audéjos (P.A.). *Cahiers du Groupe Archéologique des Pyrénées Occidentales* 3:29-34.

SAULE M, MARSAN G. 1985. Datation du tumulus d'Audejos (P.A.). *Archéologie des Pyrénées Occidentales* 5:258-9.

SAUZADE G, BUISSON-CATIL J, BIZOT B. 2003. Le Dolmen de l'Ubac et son environnement immédiat (Goult, Vaucluse). In: *Temps et espaces culturels du 6° au 2° millénaire en France du sud, Actes des 4èmes Rencontres Méridionales de Préhistoire Récente (Nîmes, 28-29 octobre 2000)*. p 335-46.

SAUZADE G, VITAL J. 2002. La Rouyère (Le Beaucet). In: BUISSON-CATIL J, VITAL J, editors. Âges du Bronze en Vaucluse, Département de Vaucluse. *Notices d'Archéologie Vauclusienne* 5. *Travaux du Centre d'Archéologie Préhistorique de Valence* 4:121-6.

SAXE AA. 1970. *Social dimensión of mortuary practices*. Ph.D. thesis, University of Michigan (Pubblished by University Microfilm, Ann Arbor, 1973).

SCHACT RM. 1981. Estimating past population trends. *Annual Review of Anthropoogy* 10:119-40.

SCHAER A. 2003. Untersuchungen zum prähistorischen Berbau im Oberhalbstein (Kanton Graubünden). *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 86:7-54.

SCHAEREN G. 1993-1994. Höhensiedlungen der Bronzezeit und der Hallstattzeit auf dem Furtbüel bei Russikon. *Archäologie im Kanton Zürich* 13:153-92.

SCHAER A, GLAUSER R. 2007. Spreitenbach AG, Willenacher IKEA (Spr.0006.1). *Jahrbuch Archäologie Schweiz* 90:150-1.

SCHAER A, SCHÖNENBERGER A. 2008. Boswil AG, Eibolde (Bsw.007.2). *Jahrbuch Archäologie Schweiz* 91:172-3.

SCHAER A, WÄLCHLI D. 2008. Frick AG, Königsweg (Fic.007.2). *Jahrbuch Archäologie Schweiz* 91:175-6.

SCHALK E. 1998. Ores, mining and metal production in the western Carpathians and their association from the Bronze Age until the Medieval period. In: HÄNSEL B, editor. *Mensch und Umwelt in der Bronzezeit Europas - Man and Environment in European Bronze Age, Abschlußtagung der Kampagne des Europarates: Die Bronzezeit: das erste goldene Zeitalter an der Freien Universität Berlin, 17.-19. März 1997*. Kiel. p 257-60.

SCHAMBERGER E. 2006. *Die bronzezeitlichen Siedlungsreste aus Vorwald, Gem. Wald am Schoberpass, Steiermark*. Diplomarbeit der Historisch Kulturwissenschaftlichen Fakultät der Universität Wien.

SCHAMBÖCK P. 1994. Rechteckige Feuerstellen um 2800 Jahre B.P. *Archäologisches Korrespondenzblatt* 24:41-7.

SCHAUB M, BÜNTGEN U, KAISER KF, KROMER B, TALAMO S, ANDERSEN KK, RASMUSSEN SO. 2008. Lateglacial environmental variability from Swiss tree rings. *Quaternary Science Reviews* 27(1.2):29-41.

SCHAUER P. 1975. Beginn und Dauer der Urnenfelderkultur in Südfrankreich. *Germania* 53:47-63.

SCHERER T, WIEMANN P. 2008. Freienbach SZ-Hurden Rosshorn: Ur- und frühgeschichtliche Wege un Brücken über den Zürichsee. *Jahrbuch Archäologie Schweiz* 91:7-38.

SCHIFFER MB 1975. Archaeology as behavioral science. *American Anthropologist* 77(4):836-48.

SCHIFFER MB. 1986. Radiocarbon dating and the “old wood” problem: the case of the Hohokam chronology. *Journal of Archaeological Science* 13(1):13-30.

SCHIFFER MB. 1987. *Advances in Archaeological Method and Theory, vol. 11*. Arizona, Tucson.

SCHIFFER MB. 2008. Transmission processes: A behavioral perspective. In: O’BRIEN JM, editor. *Cultural transmission and archaeology: Issues and case studies*. Washington. p 102-11.

SCHILMAN B, BAR-MATTHEWS M, ALMOGI-LABIN A, LUZ B. 2001. Global climate instability reflected by eastern Mediterranean marine records during the Late Holocene. *Palaeogeography, Palaeoclimatology, Palaeoecology* 176(1-4):157-76.

SCHILZ F. 2006. *Molekulargenetische Verwandtschaftsanalysen am prähistorischen Skelettkollektiv der Lichtensteinhöhle.* Dissertation zur Erlangung des Doktorgrades der Mathematisch-Naturwissenschaftlichen Fakultäten der Georg-August-Universität zu Göttingen.

SCHINDLER M. 1998. Alt St. Johann SG, Vorder Selun-Muelten und Seeli. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 81:266.

SCHINDLER M. 2001. Grabs SG, Garschella. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 84:211.

SCHINDLER M, RIGERT E. 2001. Jona SG, Wagen-Erlen. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 84:212.

SCHMIDHEINY M. 2011. Zürich “Mozartstrasse”. Neolithische und bronzezeitliche Ufersiedlungen. Band 4: Die frühbronzezeitliche Besiedlung. *Monographien der Kantonsarchäologie Zürich* 42.

SCHMIDL A, KOFLER W, OEGGL-WAHLMÜLLER N, OEGGL K. 2005. Land use in the eastern Alps during the Bronze Age - An archaeobotanical case study of a hilltop settlement in the Montafon (Western Austria). *Archaeometry* 47(2):455-70.

SCHMID-SIKIMIĆ B. 1992a. Ausgrabungen auf dem Renggpass (NW). In: PRIMAS M, DELLA CASA P, SCHMID-SIKIMIĆ B. 1992. Archäologie zwischen Vierwaldstättersee und Gotthard. Siedlungen und Funde der ur- und frühgeschichtlichen Epochen. *Universitätsforschungen zur prähistorischen Archäologie* 12. p 255-78.

SCHMID-SIKIMIĆ B. 1992b. Die Siedlung auf dem Flüeli bei Amsteg (UR). In: PRIMAS M, DELLA CASA P, SCHMID-SIKIMIĆ B. 1992. Archäologie zwischen Vierwaldstättersee und Gotthard. Siedlungen und Funde der ur- und frühgeschichtlichen Epochen. *Universitätsforschungen zur prähistorischen Archäologie* 12. p 279-306.

SCHNEIDER M. 1991. *Charred plaint remains from Late Bronze Age Stillfried (Lower Austria)*. In: International Workgroup for Paleoethnobotany, 8th Symposium, Nitra, Nové Vozokany-1989. *Acta Interdisciplinaria Archaeologica* VII:295-7.

SCHOPPER F. 1993. Das Urnenfelderzeitliche Gräberfeld von Straubing-Kagers. *Jahresbericht des Historischen Vereins für Straubing und Umgebung* 95:59-210.

SCHOPPER F. 1996. Zu Radiokarbondatierungen mittelbronzezeitlicher bis früheisenzeitlicher (ca. 1600-500 v. Chr.) Funde in Mitteleuropa. In: RANDSBORG K, editor. Absolute Chronology. Archaeological Europe 2500-500 BC (Verona, April 20-23 1995). *Acta Archaeologica* 67:211-8.

SCHOPPER F. 1995. Das Urnenfelder- und Hallstattzeitliche Gräberfeld von Künzing, Lkr. Deggendorf (Niederbayern). *Materialen zur Bronzezeit in Bayern* 1.

SCHORTMAN EM, URBAN PA. 1987. Modelling interregional interaction in Prehistory. In: SCHIFFER MB. 1987. *Advances in archaeological method and theory, vol. 11*. Arizona, Tucson. p 37-95.

SCHORTMAN EM, URBAN PA, editors. 1992. *Resources, power and interregional interactions*. USA.

SCHORTMAN EM. 1989. Interregional interaction in prehistory: the need for a new perspective. *American Antiquity* 54(1):52-65.

SCOTT EM, COOK GT, NAYSMITH P. 2010. *The Fifth International Radiocarbon Intercomparison (VIRI): an assessment of laboratory performance in stage 3*. Radiocarbon 52(3):859-65.

SCOTTI G. 1998a. S. Antonino di Perti (Finale Ligure, SV). In: DEL LUCCHESE A, MAGGI R, editors. Dal diaspro al bronzo. L'Età del Rame e l'Età del Bronzo in Liguria: 26 secoli di storia fra 3600 e 1000 anni avanti Cristo**.** *Quaderni della Soprintendenza Archeologica della Liguria* 5:100-2.

SCOTTI G. 1998b. S. Antonino di Perti, un sito d'altura della tarda età del Bronzo della Liguria di Ponente. In: *Atti IIPP XXXII*. p 405-8.

SEIERSTAD J, NESJE A, DAHL SO, SIMONSEN JR. 2002. Holocene glacier fluctuations of Grovabreen and Holocene snow-avalanche activity reconstructed from lake sediments in Grøningstølsvatnet, western Norway. *The Holocene* 12(2):211-22.

SEIFERT M. 1996. Der archäologische Befund von Zug-Sumpf. In: SEIFERT M, JACOMET S, KARG S, SCHIBLER J, KAUFMANN B. *Die spätbronzezeitlichen Ufersiedlungen von Zug-Sumpf, Band 1: Die Dorfgeschichte*.

SEIFERT M. 2000. Das spätbronzezeitliche Grab von Domat/Ems - Eine Frau aus dem Süden?. *Archäologie der Schweiz* 23(1):76-83.

SENABRE MR, SOCIAS J, NADAL J. 1994. *Pou Nou-2 (Olèrdola, Alt Penedès). Memòria de l'excavació d'urgència, abril-juny 1993*. Servei d'Arqueologia de la Generalitat de Catalunya.

SESMA J. 1995. Diversidad y complejidad: poblamiento de Navarra en la Edad del Bronce. *Cuadernos de arqueología de la Universidad de Navarra* 3:147-84.

SESMA J, BIENES CALVO JJ, ERCE DOMÍNGUEZ A, FARO CARBALLA JA, RAMOS AGUIRRE M. 2009. La cerámica de estilo Cogotas I y los ciclos culturales en las postrimerías de la edad del Bronce en Navarra. *Cuadernos de Arqueología Universidad de Navarra* 17:39-83

SESMA J, GARCÍA J. 1995-1996. Excavación de urgencia en los yacimientos de depósitos en hoyo de Aparrea (Biurrun) y la Facería (Tiebas). *Trabajos de Arqueología Navarra* 12:293-7.

SESMA J, GARCIA ML. 1993-1994. Monte Aguilar (Bardenas Reales de Navarra). Campañas de 1990-1991. *Trabajos de Arqueología Navarra* 11:276-9.

SESMA J, GARCÍA J, TABAR MI. 2007. La Saga (Cáseda). Una sepultura colectiva de la Edad del Bronce. In: *La Tierra te sea leve. Arqueología de la muerte en Navarra*, p 89-92.

SEWELL WH. 2005. *The logics of history: social theory and transformation*. Chicago (IL).

SHAFER G. 1996. *The art of causal conjecture*. Cambridge (MA).

SHARIF MN, RAMANATHAN K. 1981. Binomial Innovation Diffusion Models with Dynamic Potential Adopter Population. *Technological Forecasting and Social Change* 20:63-87.

SHARON I. 1995. Partial order scalogram analysis of relations - a mathematical approach to the analysis of stratigraphy. *Journal of Archaeological Science* 22(6):751-67.

SHENNAN I. 1987. Global analysis and correlation of sea- level data. In: DEVOY RJN, editor. *Sea surface studies. A global view*. London. p 198-230.

SHENNNAN S. 1987. *Quantifying archaeology*. Edinburgh.

SHENNAN S. 1993. After social evolution: a new archaeological agenda?. In: YOFFEE N, SHERRATT A, editors. *Archaeological theory: who sets the agenda?*. Cambridge. p 53-9.

SHENNAN S. 1995. Bronze Age copper producers of Eastern Alps. Excavation at St. Veit-Klinglberg. *Universitätsforschungen zur prähistorischen Archäologie* 27.

SHENNAN S. 2001. Trends in der Bevölkerungszahl in Mitteleuropa 4000-1500 v. Chr. Und ihre Bedeutung/Trend in the population size of Central Europe 4000-1500 BC and their significance. In: LIPPERT A, SCHULTZ M, SHENNAN S, TESCHLER-NICOLA M, editors. *Mensch und Umwelt während des Neolithikums und der Frühbronzezeit in Mitteleuropa*. pp. 97-103.

SHENNAN S, editor. 2009. *Pattern and process in cultural evolution*. Berkeley.

SHENNAN S. 2013. Demographic continuities and discontinuities in Neolithic Europe: evidence, methods and implications. *Journal of Archaeological Method and Theory* 20(2):300-11.

SHENNAN S, DOWNEY SS, TIMPSON A, EDINBOROUGH K, COLLEDGE S, KERIG T, MANNING K, THOMAS MG. 2013. Regional population collapse followed initial agriculture booms in mid-Holocene Europe. *Nature Communications* 4:2486.

SHENNAN S, EDINBOROUGH K. 2007. Prehistoric population history: from the Late Glacial to the Late Neolithic in Central and Northern Europe. *Journal of Archaeological Science* 34(8):1339-45.

SHERRAT A. 1993a. What would a Bronze-Age World System look like? Relations between temperate Europe and the Mediterranean in Later Prehistory. *Journal of European Archaeology* 1(2):1-57.

SHERRAT A. 1993b. “Who are you calling peripheral?” Dependence and independence in European Prehistory. In: SCARRE C, HEALY F, editors. *Trade and exchange in Prehistoric Europe*. Oxford. p 245-55.

SHERRAT A. 1994. Core, periphery and margin: perspectives on the Bronze Age. In: MATHERS C, STODDART S, editors. *Development and decline in the Mediterranean Bronze Age*. Sheffield. p 335-45.

SHERRAT S, SHERRAT A. 1993. The growth of the Mediterranean economy in the early first millenium BC. *World Archaeology* 24:361-78.

SHINOARA K. 2012. Space-time innovation diffusion based on physical analogy. *Applied Mathematical Sciences* 6:2527-58.

SHOTTON FW, BLUNDELL DJ, WILLIAMS RG. 1968. Birmingham University Radiocarbon Dates II. *Radiocarbon* 10(2):200-6.

SHUMPETER J. 1934. *The theory of economic development*. Cambridge, Massachusetts.

SIECK WR. 2010. Cultural network analysis: method and application. In: SCHMORROW D, NICHOLSON D, editors. 2010. *Advances in Cross-Cultural Decision Making*. p 260-9.

SIMONE L. 1990-1991. La necropoli della tarda età del Bronzo di Gambolò (PV). *Sibrium* XXI:89-147.

SIMONE ZOMPFI L. 2005a. Urago d’Oglio (BS). Necropoli ad incinerazione dell’età del Bronzo. *The Journal of Fasti Online*:www.fastionline.org/docs/2005-40.pdf.

SIMONE ZOMPFI L. 2005b. Capriano del Colle (BS). Tombe ad incinerazione dell’età del Bronzo. *The Journal of Fasti Online*:www.fastionline.org/docs/2005-39.pdf.

SIMON P, VITAL J. 1982. Le tumulus n° 10 de Laurie (Cantal). *Comptes Rendus d'Activités Annuelles. Association Régionale de Paléontologie, Préhistoire et des Amis du Muséum Lyon* 20:51-5.

SIMONI L, CALAFELL F, PETTENER D, BERTRANPETIT J, BARBUJANI G. 2000. Geographic Patterns of mtDNA Diversity in Europe. *American Journal of Human Genetics* 66(1):262-78.

SKEATES R, WHITEHOUSE R. 1994. Radiocarbon Dating and Italian Prehistory. *Archaeological Monographs of the British School at Rome*. 8.

SLOMAN S. 2005. *Causal models*. Oxford.

SMITH CA. 1976a. Exchange system and the spatial distribution of elites: the organization of stratification in agrarian societies. In: SMITH CA. *Regional Analysis.* New York. p 309-

74.

SMITH CA. 1976b. *Regional Analysis*. New York.

SMITH MA. 1957. A study in urnfield interpretations in Middle Europe. *Zephyrus: Revista de prehistoria y arqueología* 8:195-239.

SMITH MA, ROSS J. 2008. What happened at 1500-1000 BP in central Australia? Timing, impact and archaeological signatures. *The Holocene* 18(3):387-96.

SOLOW AR. 1997. *Estimating settlement time.* Radiocarbon 39(3):351-4.

SONKA M, HLAVAC V, BOYKLE R. 1994. *Image processing, analysis, and machine vision*. London.

SOPENA MC. 1996. La Edad del Bronce en el Ésera-Cinca medio. *Bolskan* 13:217-38.

SOPENA MC. 1998. Estudio geoarqueológico de los yacimientos de la Edad del Bronce de la comarca del Cinca Medio (Huesca). *Bolskan* 15.

SOPENA MC, RODANÉS JM. 1992. Excavaciones arqueológicas en el Tozal de Macarullo (Estiche, Huesca). Informe preliminar. *Bolskan* 9:117-32.

SOPENA MC, RODANÉS JM. 1994a. El Tozal de Macarullo (Estiche, Huesca). Campaña de excavaciones de 1991. *Arqueología Aragonesa* 1991:103-9.

SOPENA MC, RODANÉS JM. 1994b. Fechas de c14 del poblado de Tozal de Macarullo (Estiche, Huesca). *Cuadernos de CEHIMO* 21:7-23.

SORDOILLET D. 2009. Géoarchéologie de sites préhistoriques. Le Gardon (Ain), Montou (Pyrénées-Orientales) et Saint-Alban (Isère). *Documents d'archéologie française* 103.

SØRENSEN ML, REBAY KC. 2005. Interpreting the body. Burial practices at the Middle Bronze Age cemetery at Pitten, Austria. *Archaeologia Austriaca* 89:153-75.

SØRENSEN MLS, THOMAS R, editors. 1989. *The Bronze Age - Iron Age transition in Europe: Aspects of Continuity and Change in European societies c. 1200-500 B.C.* Oxford: BAR International Series 483.

SPECIALE C, ZANINI A. 2012. Alcune osservazioni sul tabù delle armi nelle necropoli ad incinerazione dell'età del Bronzo in Italia settentrionale. In: ROVIRA HORTALÀ MC, LÓPEZ CACHERO FJ, MAZIÈRE F, editors. Les necròpolis d'incineració entre l'Ebre i el Tíber (segles IX-VI aC): metodologia, pràctiques funeràries i societat. *Monografies MAC* 14:417-23.

SPERANZA A, VAN DER PLICHT J, VAN GEEL B. 2000. Improving the time control of the Subboreal/Subatlantic transition in a Czech peat sequence by 14C wiggle-matching. *Quaternary Science Reviews* 19(16):1589-604.

SPERBER L. 1987. Untersuchungen zur Chronologie der Urnenfelderkultur im nördlichen Alpenvorland von der Schweiz bis Oberösterreich. *Antiquitas 3* 29.

STACUL G. 1970. Esplorazioni archeologiche nel Carso Triestino. *Umana* 19:29-30.

STACUL G. 1972. Il Castelliere C. Marchesetti presso Sliva, nel Carso triestino (Scavo 1970).

Rivista di scienze preistoriche 27(2):145-62.

STADLER P. 1999. Aktueller Stand der Absolutdatierung der verschiedenen Gruppen des urgeschichtlichen Bergbaus und eines Blockbaus in Hallstatt aufgrund der ^{14}C-Daten. *Annalen des Naturhistorischen Museums in Wien* 101(A):69-80.

STADLER P, DRAXLER S, FRIESINGER H, KUTSCHERA W, PRILLER A, ROM W, STEIER P, WILD EM. 2000. *Absolute Chronology for Early Civilisations in Austria and Central Europe using ^{14}C Dating with Accelerator Mass Spectrometry*. Status of the Austrian Science Fund Project P12253-PHY.

STEELE J. 2010. Radiocarbon dates as data quantitative strategies for estimating colonization front speeds and event densities. *Journal of Archaeological Science* 37(8):2017-30.

STEEL D. 2001. Bayesian statistics in radiocarbon calibration. *Philosophy of Science* 68(3):S153-64

STEEL L. 2013. *Materiality and consumption in the Bronze Age Mediterranean*. New York.

STEIN ML. 1999. *Statistical Interpolation of spatial data: some theory for kriging*. New York.

STEINER H, editor. 2010. Alpine Brandopferplätze. Archäologische und naturwissenschaftliche Untersuchungen/Roghi votivi alpini. Archeologia e scienze naturali. *Forschungen zur Denkmalpflege in Südtirol/Beni culturali in Alto Adige-Studi e ricerch*e V.

STEPNIAK TP. 1986. *Quantitative aspects of Bronze Age metalwork in Western Poland. Long-distance exchange and social organization*. Oxford: BAR International Series 317.

STERNBERG M. 2004. La pêche à l'âge du Bronze: les données archéoichtyofauniques de l'Abion (Martigues, Bouches-du-Rhône) et de Tonnerre I (Mauguio, Hérault). *Documents d'Archéologie Méridionale* 27:171-96.

STEUER H. 1999. Handel II. Archäologie und Geschichte. *Reallexikon der Germanischen Altertumskunde* 13:502-93.

STIG SØRENSEN ML, REBAY-SALISBURY KC. 2008, The impact of 19th century ideas on the construction of “urnfield” as a chronological and cultural concept: tales from Northern and Central Europe. In: LEHOËRFF A, editor. *Construire le temps: histoire et méthodes des chronologies et calendriers des derniers millénaires avant notre ère en Europe occidentale, Actes du XXXe colloque international de Halma-Ipel (CNRS, Lille 3, MCC, 7-9 décembre 2006)*. p 57-67.

STIFTER D. 2008. *Old Celtic Languages*. available at http://www.univie.ac.at/indogermanistik/download/Stifter/oldcelt2008_2_lepontic.pdf.

STJERNQUIST B. 1985. Methodische Überlegungen zum Nachweis von Handel aufgrund archäologischer Quellen. In: DÜWEL K, JANKUHN H, SIEMS H, TIMPE D, editors. Untersuchungen zu Handel und Verkehr der vor- und frühgeschichtlichen Zeit in Mittel- und Nordeuropa, I, Methodische Grundlagen und Darstellungen zum Handel in vorgeschichtlicher Zeit und in der Antike. *Abhandlungen der Akademie der Wissenschaften in Göttingen Philologisch-Historische Klasse III* 143:56-83.

STÖCKLI WE. 2009. Contradictions in the relative chronology: archaeological and radiocarbon dating. *Radiocarbon* 51(2):695-710.

STOLK A, HOGERVORST K, BERENDSEN H. 1989. Correcting ^{14}C histograms for the non-linearity of the radiocarbon time scale. *Radiocarbon* 31(2):169-77.

STOLK A, TÖRNQVIST TE, HEKHUIS KPV, BERENDSEN HJA, VAN DER PLICHT J. 1994. Calibration of ^{14}C histogram: a comparison of methods. *Radiocarbon* 36(1):1-10.

STÖLLNER T, CIERNY J, EIBER C, BOENKE N, HERD R, MAASS A, RÖTTGER K, SORMAZ T, STEFFENS G, THOMAS P. 2006. Der Bronzezeitliche Bergbau im Südrevier des Mitterberggebietes. Bericht zu den Forschungen der Jahre 2002 bis 2006. *Archaeologia Austriaca* 90:87-137.

STOS-GALE ZA, GALE NH. 1994. The origin of metals excavated on Cyprus (Chapter 3). In: KNAPP B, CHERRY J, editors. *Provenance studies and Bronze Age Cyprus: production exchange and politico-economic change*. Madison. p 92-122 and 210-6.

STOS-GALE ZA, GALE NH. 2009. Metal provenancing using isotopes and the Oxford archaeological lead isotope database (OXALID). *Archaeological and Anthropological Sciences* 1(3):195-213.

STOS-GALE ZA, MALIOTIS G, GALE NH, ANNETTS N. 1997. Lead isotope characteristics of the Cyprus copper ore deposits applied to provenance studies of copper oxhide ingots. *Archaeometry* 39(1):83-123.

STUIVER M, BRAZIUNAS TF. 1993. Modelling atmospheric ^{14}C influences and ^{14}C ages of marine samples to 10,000 BC. *Radiocarbon* 35(1):137-89.

STUIVER M, PEARSON GW. 1986. High-precision calibration of the radiocarbon time scale, AD 1950-500 BC. *Radiocarbon* 28(2B):805-38.

STUIVER M, PEARSON GW. 1993. High-precision bidecadal calibration of the radiocarbon time scale, AD 1950-500 BC and 2500-6000 BC. *Radiocarbon* 35(1):1-23.

STUIVER M, REIMER PJ. 1993. Extended 14C database and revised CALIB 3.0 14C age calibration program. *Radiocarbon* 35(1):215-30.

STUIVER M, REIMER PJ, EDOUARD B, WARREN BECK J, BURR GS, HUGHEN KA, KROMER B, McCORMAC G, VAN DER PLICHT J, SPURK M. 1998. IntCal98 radiocarbon age calibration, 24,000-0 cal BP. *Radiocarbon* 40(3):1041-83.

STUIVER M, REIMER PJ, REIMER RW. 2005. *CALIB 5.0.2html*. http://calib.org.

SUROVELL TA, BRANTINGHAM PJ. 2007. A note on the use of temporal frequency distributions in studies of prehistoric demography. *Journal of Archaeological Science* 34(11):1868-77.

SUROVELL T, BYRD FINLEY J, SMITH GM, BRANTINGHAM PJ, KELLY R. 2009. Correcting temporal frequency distributions for taphonomic bias. *Journal of Archaeological Science* 36(8):1715-24.

SUTER M, BALZER R, BONANI G, HOFMANN H, ANDREE J, MORENZONI E, NESSI M, WOLFLI WM, BEER J, OESCHGER H. 1984. Precision measurements of 14C in AMS some results and prospects. *Nuclear Instruments & Methods* B5:117-22.

SUTER PJ. 1985. Neue absolute datierte Fundkomplexe aus dem Raume Zürich - Ein Beitrag zur Chronologie des Neolithikums in der Schweiz. *Archäologisches Korrespondenzblatt*

15:431-43.

SUTER PJ. 1994. Münchenwiler BE, Im Loch. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 77:178.

SUTER PJ. 2005a. Ostermundigen, Dennikofe. Rettungsgrabung 2002/03: bronze- und eisenzeitliche Siedlungreste. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:96-9.

SUTER PJ. 2005b. Studen, Studenwald/Waldhaus. Dokumentation 1998: spätbronzezeitliche Feuerstelle. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 6A:110.

SUTER PJ, FRANCUZ J, VERHOEVEN P. 1996. Der bronzezeitliche Einbaum von Erlach-Heidenweg. *Archäologie der Schweiz* 16(2):53-5.

SWADESH M. 1972. *The origin and diversification of languages*. London.

SWINDLES GT, PLUNKETT G, ROE HM. 2007. A delayed climatic response to solar forcing at 2800 cal. BP: multiproxy evidence from three Irish peatlands. *The Holocene* 17(2):177-82.

SYDOW W. 1996. Eine frühbronzezeitliche Fundstelle am Buchberg, Gem. Wiesing (Tirol). *Fundberichte aus Österreich* 34:567-73.

SZABÓ G. 1996. A Csorva-csoport és a Gáva-kultúra kutatásának problémái néhány Csongrád megyei leletegyüttes alapján. Forschungsprobleme der Csorva-Gruppe und der Gáva-Kultur aufgrund einiger Fundverbände aus dem Komitat Csongrád. A Móra Ferenc Múzeum Évkönyve *Studia Archaeologica* II:9-109.

TAFFANEL O, TAFFANEL J, JANIN T. 1998. La nécropole du Moulin à Mailhac (Aude). *Monographies d'Archéologie Méditerranéenne* 2. Lattes.

TALLAVAARA M, PESONEN P, OINONEN M. 2010. Prehistoric population history in eastern Fennoscandia. *Journal of Archaeological Science* 37(2):251-60.

TALMA AS, VOGEL JC. 1993. A simplified approach to calibrating 14C dates. *Radiocarbon* 35(2):317-22.

TARLOW S, NILSSON STUTZ L, editors. 2013. *The Oxford handbook of the Archaeology of Death and Buria*l. Oxford.

TARRUS J. 1987. El megalitisme de l'Alt Empordà (Girona): els constructors de dòlmens entre el Neolític Mitjà i el Calcolític a l'Albera, Serra de Roda i Cap de Creus. *Cota Zero* 3:36-54.

TARRÚS J, BOSCH A. 1990. Els nivells postglacials de la cova d'En Pau (Serinyà, Pla de l'Estany). *Cypsela* VIII:21-48.

TARRUS J, CASTELLS J, CHINCHILLLA J, VILARDELL R. 1985. Noves datacions de RC-14 obtingudes recentment i procedents de jaciments arqueològiques de les comarques gironines. *Cypsela* V:173.

TASCA G, editors. 2009. Gradiscje di Codroipo. Campagna di scavo 2009. *Notiziario della Soprintendenza per i Beni Archeologici del Friuli Venezia Giul*ia 4.

TAYLOR RE, SOUTHON J. 2013. *Reviewing the Mid-First Millennium BC 14C “warp” using 14C/bristlecone pine data. Nuclear Instruments and Methods in Physics Research B* 294:440-43.

TECCHIATI U. 1998a. *Il “castelliere” Nössing: un insediamento d'altura dell'antica e media età del bronzo in Val d'Isarco (BZ).* Tesi di Dottorato di Ricerca in Archeologia, Consorzio Universitario di Pisa, Firenze e Siena.

TECCHIATI U, editor. 1998b. *Sotćiastel. Un abitato fortificato dell’età del bronzo in Val Badia*. Bolzano.

TECCHIATI U, FONTANA A, MARCONI S. 2011. Indagini archeozoologiche sui resti faunistici della media-recente età del Bronzo di Laion-Wasserbühel (BZ). *Annali del Museo civico di Rovereto* 26:105-31.

TELFORD RJ, HEEGAARD E, BIRKS HJB. 2004. The intercept is a poor estimate of a calibrated radiocarbon age. *The Holocene* 14(2):296-8.

TEMPLE C. 2010. *Tracing Celtic Origins*. http://colintemple.com/papers/temple-tracing_celtic_origins.pdf.

TERŽAN B. 1999. An outline of the Urnfield Culture period in Slovenia. *Arheološki vestnik* 50:97-143.

THORNDYCRAFT VR, BENITO G. 2006. The Holocene fluvial chronology of Spain: evidence from a newly compiled radiocarbon database. *Quaternary Science Reviews* 25(3-4):223-34.

THIÉRIOT F. 2005. Le mobilier céramique de l'Âge du Bronze final III des sites des Estournelles et de la Plaine à Simandres (Rhône). *Bulletin de la Société préhistorique française* 102(2):417-38.

THIÉRIOT F, TREFFORT J-M, HÉNON P. 2009. *Nouvelles données sur l’évolution de la céramique de la fin de l’âge du Bronze au premier ge du Fer entre Alpes et Jura*. In: ROULIERE-LAMBERT M-J, DAUBIGNEY A, MILCENT P-Y, TALON M, VITAL J, editors. De l’âge du Bronze à l’âge du Fer en France et en Europe occidentale (X^{e} – VII^{e} siècle av. J.-C.). La moyenne vallée du Rhône aux âges du Fer, Actes du XXXe colloque international de l’A.F.E.A.F., co-organisé avec l’A.P.R.A.B. (Saint-Romain-en-Gal, 26-28 mai 2006). Dijon. *Revue Archéologique de l’Est* 27:**299-315.**

THOMAS D. H. 1998. *Archaeology. 3rd edition*. Forth Worth, Texas.

THRANE H. 1958. Ein Depotfunde der jüngeren Bronzezeit von Mandemark auf Møn. *Acta Archaeologica* 29:111-30.

TIEFENGRABER S. 2007a. Archäeologische Untersuchungen in einer prähistorischen Almhütte im Königreich - Tiefkar. In: HEBERT B, KIENAST G, MANDL F, editors. Königreich-Alm Dachsteingebirge. 3500 Jahre Almwirtschaft zwischen Gröbming und Hallstatt. *Forschungsberichte der ANISA* 1:97-108.

TIEFENGRABER S. 2007b. Zum Stand der Erfoschung der Mittel- und Spätbronzezeit in der Steiermark. In: TIEFENGRABER G, editor. Studien zur Mittel- und Spätbronzezeit am Rande der Südostalpen. *Universitätsforschungen zur prähistorischen Archäologie* 148:67-113.

TIMBERLAKE S. 2009. Copper mining and production at the beginning of the British Bronze Age. In: CLARK P, editor. *Bronze Age connections. Cultural contacts in Prehistoric Europe*. Oxford. p 94-121.

TINNER W, LOTTER AF, AMMANN B, CONEDERA M, HUBSCHMID P, VAN LEEUWEN JFN, WEHRLI M. 2003. Climatic change and contemporaneous land-use phases north and south of the Alps 2300 BC to 800 AD. *Quaternary Science Reviews* 22(14):1447-60.

TIRABASSI J. 1997. La necropoli della Montata (RE). In: BERNABÒ BREA M, CARDARELLI A, CREMASCHI M, editors. *Le Terramare. La più antica civiltà padana, catalogo della mostra (Modena 1997).* Milano. p 685-7.

TIXIER L, VITAL J. 1985. Observations sur trois fosses du Bronze Final 3 découvertes au Puy Saint-André de Busséol (Puy-de-Dôme)/Observations following the discovery of three Late Bronze Age 3 pits from Puy Saint-André de Busséol (Puy-de-Dôme). *Revue archéologique du Centre de la France* 24(1):17-34.

TCHÉRÉMISSINOFF Y, CAZES J-P, GILABERT C, DUCHESNE S, LACHENAL T, LAGARRIGUE A, MARET D. 2010. Nouvelles sépultures individuelles du Bronze ancien dans le sud de la France: contextes et problématiques. *Bulletin de la Société préhistorique française* 107(2):331-352.

TOBLER W. 1970. A computer movie simulating urban growth in the Detroit region. *Economic Geography* 46(2):234-40

TOLEDO A, de PALOL P. 2006. La necròpolis d'incineració del Bronze final transició a l'edat del Ferro de Can Bech de Baix, Agullana (Alt Empordà, Girona). Els resultants de la campanya d'excavació de 1974. *Serie Monogràfica MAC* 24.

TOLEDO A, PONS E. 1982. Estat de la qüestió de l'Edat del Bronze a les comarques de la Garrotxa i del Ripollès. *Ausa* X(102-104):165-86.

TOMASI G. 1965. Una ulteriore campagna di scavi alla palafitta di Ledro. *Natura Alpina* 16(4):129-30.

TOMASI G. 1982. Le palafitte del Lago di Ledro. *Natura Alpina* 29:1-41.

TORNOS F, CASQUET C, RELVAS JMRS. 2005. Transpressional tectonics, lower crust decoupling and intrusion of deep mafic sills: a model for the unusual metallogenesis of SW Iberia. *Ore Geology Reviews* 27(1-4):133-63.

TORNOS F, INVERNO CMC, CASQUET C, MATEUS A, ORTIZ G, OLIVEIRA V. 2004. The metallogenic evolution of the Ossa-Morena Zone. *Journal of Iberian Geology* 30:14-181.

TRACHSEL M. 2004. *Untersuchungen zur relativen und absoluten Chronologie der Hallstattzeit*. Bonn.

TREFFORT J-M. 1999. Kunheim « Les Résidences des Tilleuls». In: *Bilan Scientifique Régional d'Alsace*. p. 87.

TREFFORT J-M. 2000. Le site de Roche Noire à Montagnieu (Ain): rapport de fouilles et synthèse des résultats 1996-2000. In: *DRAC Rhône-Alpes, Service Regional de l'Archéologie*.

TREFFORT J-M. 2005. La fréquentation des cavités naturelles du Jura méridional au Bronze final: état de la question, nouvelles données et perspectives. *Bulletin de la Société préhistorique française* 102(2):401-16.

TREFFORT J-M, DUMONT A. 2003. Les structures de combustión protohistoriques du site de Roche Noire à Montagnieu (Ain, France). In: FRÈRE-SAUTOT M-C, editor. *Le Feu domestique et ses structures au Néolithique et aux Âges des métaux: actes du colloque de Bourg-en-Bresse et Beaune, 7-8 octobre 2000*, pp. 477-91.

TREFFORT J-M, NICOD P-Y, EXCOFFIER-BUISSON R. 2001. La Balme à Gontran à Chaley (Ain): du Néolithique moyen au haut Moyen Âge dans une cavité du Jura meridional. *Revue Archéologique de l'Est* 50:53-118.

TRIGG JR. 1993. The seriation of multilinear stratigraphic sequences. In: HARRIS E, BROWN MR, BROWN GJ, editors. 1993. *Practices of archaeological stratigraphy*. London-San Diego. p 250-73.

TRUCCO F, DE ANGELIS D, IAIA C. 2001. Villa Bruschi Falgari. Il sepolcreto villanoviano. In: MORETTI SGUBINI AM, editor. *Tarquinia etrusca. Una nuova storia*. Roma. p 81-93.

TRUCCO F. 2006. Considerazioni sul rituale funerario in Etruria meridionale all'inizio dell'età del ferro alla luce delle nuove ricerche a Tarquinia. In: VON ELES P, editor. *La ritualità funeraria tra età del ferro e orientalizzante in Italia*. Roma. p 95-102.

TSCHURTSCHENTHALER M, WEIN U. 1996. Kontinuität und Wandel eines alpinen Heiligtums im Laufe seiner 1.800-jährigen Geschichte. *Archäologie Österreichs* 7(1):14-27.

TURNEY CSM, BAILLIE M, PALMER J, BROWN D. 2006. Holocene climatic change and past Irish societal response. *Journal of Archaeological Science* 33(1):34-8.

TUZAR J. 1998. *Die ur- und frühgeschichtliche Besiedlung der Heidenstatt bei Limberg, NÖ*. Dissertation an der Geisteswissenschaftlichen Fakultät der Universität Wien.

UHLICH J. 2007. More on the linguistic classification of Lepontic. In: *Gaulois et celtique continental. Études réunies par Pierre-Yves Lambert et Georges-Jean Pinault. École pratique des hautes études. Sciences historiques et philologiques. III. Hautes études du monde gréco-romain 39*. Genève. p 373-411.

UNDERHILL PA, MYRES NM, ROOTSI S, METSPALU M, ZHIVOTOVSKY LA, KING RJ, LIN AA, CHOW C-ET, SEMINO O, BATTAGLIA V, KUTUEV I, JÄRVE M, CHAUBEY G, AYUB Q, MOHYUDDIN A, MEHDI SQ, SENGUPTA S, ROGAEV EI, KHUSNUTDINOVA EK, PSHENICHNOV A, BALANOVSKY O, BALANOVSKA E, JERAN N, AUGUSTIN DH, BALDOVIC M, HERRERA RJ, THANGARAJ K, SINGH V, SINGH L, MAJUMDER P, RUDAN P, PRIMORAC D, VILLEMS R, KIVISILD T. 2009. Separating the post-Glacial coancestry of European and Asian Y chromosomes within haplogroup R1a. European Journal of Human Genetics 18(4):479-84

UNDSET I. 1882. *Das erste Auftreten des Eisens in Nordeuropa*. Hamburg.

URBAN O. 1994. Keltische Höhensiedlungen an der mittleren Donau vom Linzer Becken bis zur Porta Hungarica. 1. Der Freinberg. *Linzer Archäologische Forschungen* 22.

URBAN T. 1993. Studien zur mittleren Bronzezeit in Norditalien. *Universitätsforschungen zur prähistorischen Archäologie* 14.

VÁCZI G. 2013. Cultural connnections and interactions of Eastern Transdanubia during the Urnfield period. *Dissertationes Archaeologicae* 3(1):205-30.

VAGNETTI L. 1979. Un frammento di ceramica micenea da Fondo Paviani (Legnago). *Bollettino del Museo Civico di Storia Naturale di Verona* VI:599-610.

VAGNETTI L. 2002. Ceramiche di tipo miceneo dal territorio veronese e dall'area padana. In: ASPES A, editor. Preistoria veronese: contributi e aggiornamenti. *Memorie del Museo Civico di Storia Naturale di Verona 2 seri*e V:134-6.

VALENTE TW. 1996. Social network thresholds in the diffusion of innovations. *Social Networks* 18:69-89.

VALSECCHI V, TINNER W, FINSINGER W, AMMANN B. 2006, Human impact during the Bronze Age on the vegetation at Lago Lucone (northern Italy). *Vegetation History and Archaeobotany* 15:99-113.

VALZOLGHER E. QUARTA G. 2009. Date radiocarboniche AMS dal Riparo di Peri (Dolcé, Verona). Commento e analisi bayesiana. *Bollettino del Museo Civico di Storia Naturale di Verona* 33:85-113.

VALZOLGHER E, MEADOWS J, SALZANI P, SALZANI L. 2012. Radiocarbon dating of the early Bronze Age cemetery at Arano, Verona, northern Italy. In: BOARETTO E., REBOLLO FRANCO NR, editors. Proceedings of the Sixth Radiocarbon and Archaeology Symposium (Paphos, Cyprus, 10-15 April 2011). *Radiocarbon* 54(3-4):483-503.

VAN DER PLICHT J. 2004. Radiocarbon calibration – past, present and future. *Nuclear Instruments and Methods in Physics Research B* 223-224:353-8.

VAN DER PLICHT J, BRUINS HJ, NIJBOER AJ. 2009. The Iron Age around the Mediterranean: a high chronology perspective from the Groningen Radiocarbon Database. *Radiocarbon* 51(1):213-42.

VAN DER PLICHT J, JANSMA E, KARS H. 1995. The "Amsterdam Castle": a case study of wiggle matching and proper calibration curve. *Radiocarbon* 37(3):965-8.

VAN DER PLICHT J, MOOK WG. 1987. Automatic radiocarbon calibration: illustrative examples. *Palaeo-historia* 29:173-82.

VAN DER PLICHT J, VAN GEEL B, BOHNCKE SJP, BOS JAA, BLAAUW M, SPERANZA AOM, MUSCHELER R, BJÖRCK S. 2004. The Preboreal climate reversal and a subsequent solar-forced climate shift. *Journal of Quaternary Science* 19(3):263-9.

VANDKILDE H. 2007. *Culture and change in central European Prehistory. 6th to 1st millenium BC*. Aarhus (Denmark).

VAN GEEL B, BOKOVENKO NA, BUROVA ND, CHUGUNOV KV, DERGACHEV VA, DIRKSEN VG, KULKOVA M, NAGLER A, PARZINGER H, VAN DER PLICHT J, VASILIEV SS, ZAITSEVA GI. 2004. Climate change and the expansion of the Scythian culture after 850 BC: a hypothesis. *Journal of Archaeological Science* 31:1735-42.

VAN GEEL B, BUURMAN J, WATERBOLK HT. 1996. Archaeological and palaeoecological indications of an abrupt climate change in The Netherlands, and evidence for climatological teleconnections around 2650 BP. *Journal of Quaternary Science* 11(6):451-60.

VAN GEEL B, VAN DER PLICHT J, KILIAN MR, KLAVER ER, KOUWENBERG JHM, RENSSEN H, REYNAUD-FARRERA I, WATERBOLK HT. 1998. The sharp rise of $\Delta^{14}C$ ca. 800 cal BC; possible causes, related climatic teleconnnections and the impact on human environments. *Radiocarbon* 40(1):535-50.

VANDKILDE H. 1996. *From Stone to Bronze. The Metalwork of the Late Neolithic and Earliest Bronze Age in Denmark*. Aarhus.

VAN STRYDONCK M, BOUDIN M, HOEFKENS M, DE MULDER G. 2005. 14C-dating of cremated bones, why does it work?. *Lunula. Archaeologia Protohistorica* 13:3-10.

VAN STRYDONCK M, NELSON DE, CROMBÉ P, BRONK RAMSEY C, SCOTT EM, VAN DER PLICHT J, HEDGES REM. 1999. What's in a 14C date. In: EVIN J, OBERLIN C, DAUGAS J-P, SALLES J-F, editors 3rd International Symposium 14C and Archaeology. *Mémoires de la Société Préhistorique Française* 26:433-48.

VANNACCI LUNAZZI G. 1971. *Necropoli della Media e Tarda età del Bronzo nella Lombardia occidentale*. Como.

VAN ZEIST W, GUILAINE J, GASCÓ J. 1983. L'orge du Bronze Moyen de la grotte des Cazals (Sallèles-Cabardès, Aude). *Bulletin de la Société préhistorique française* 80(4):117-8.

VAQUER J, GANDELIN M, REMICOURT M, TCHÉRÉMISSINOFF Y. 2008. *Défunts néolithiques en Toulousain*. Toulouse.

VARIEN MD, MILLS BJ. 1997. Accumulations research: problems and prospects for estimating site occupation span. *Journal of Archaeological Method and Theory* 4(2):141-91.

VEGAS JI. 1988. Revisión del fenómeno de los cromlechs vascos. *Estudios de Arqueología Alavesa* 16:235-444.

VENTURINO GAMBARI M, editor. 1995. *Navigatori e contadini. Alba e la valle del Tanaro nella Preistoria*. Alba.

VENTURINO GAMBARI M, editor. 2004. *Alla conquista dell'Appennnino: le prime comunità delle valli di Curone, Grue e Ossona, catalogo dell'esposizione (Brignano-Frascata, 23 aprile 2004 – 2 ottobre 2005).* Torino.

VENTURINO GAMBARI M, editor. 2008. *Ai piedi delle montagne. La necropoli protostorica di Valdieri*. Alessandria.

VENTURINO GAMBARI M, CERRATO N, OTTOMANO C. 2004. Alba, loc. San Cassiano (nuova piscina comunale). Sepoltura dell'antica età del Bronzo e strutture d'abitato della prima età del Ferro. *Quaderni della Soprintendenza Archeologica del Piemonte* 20:174-6.

VENTURINO GAMBARI M, GIARETTI M, OBERTI R. 1995. Alessandria, loc. Cascina Chiappona. Rivenimento di sepoltura della media età del Bronzo. *Quaderni della Soprintendenza Archeologica del Piemonte* 13:302-3.

VENTURINO GAMBARI M, PEROTTO A, LUZZI M, ZAMAGNI B, GIARETTI M. 1995.

Alba. Scavi nell'area delle necropoli e degli abitati preistorici. *Quaderni della Soprintendenza Archeologica del Piemonte* 13:334-7.

VENTURINO GAMBARI M, VILLA G. 1993. Casale Monferrato, fraz. S. Germano, loc. Vallare. Rinvenimento sepolture della media età del Bronzo. *Quaderni della Soprintendenza Archeologica del Piemonte* 11:199-203.

VERHOEVEN P, SUTER PJ, FRANCUZ J. 1994. Erlach - Heidenweg 1992. Herstellung und Datierung des (früh)bronzezeitlichen Einbaumes. *Archäologie im Kanton Bern/Archéologie dans le canton de Berne* 3B:313-29.

VERHULST PF. 1838. Notice sur la loi que la population suit dans son accroissement. *Correspondance Mathématique et Physique* 10:113-21.

VERNESI C, CARAMELLI D, DUPANLOUP I, BERTORELLE G, LARI M, CAPPELLINI E, MOGGI-CECCHI J., CHIARELLI B, CASTRI L, CASOLI A, MALLEGNI F, LALUEZA-FOX C, BARBUJANI G. 2004. The Etruscans: a population-genetic study. *The American Journal of Human Genetics* 74(4):694-704.

VERNET JL, PACHIAUDI C, BAZILE F, DURAND A, FABRE L, HEINZ C, SOLARI ME, THIEBAULT S. 1996. Le $\delta^{13}C$ de charbons de bois préhistoriques et historiques méditerranées, de 35000 BP a l'actuel. Premiers résultats. *Comptes Rendus de l'Académie des Sciences Paris* 323(2a):319-24.

VICENTE RODANÉS JM, PICAZO MILLÁN JV. 2001. Bronce Final y primera Edad del Hierro en Aragón. *Caesaraugusta* 75(1):273-312.

VIÉ R. 1987. Fouille d'un tumulus de l'Age du Bronze: le tumulus TIB.11 à Ibos (Plateau de Gere, H.-P.). In: Les hommes et leurs sépultures dans les Pyrénées Occidentales, depuis la préhistoire. Catalogue d'exposition. *Archeologie des Pyrénées Occidentales* 7:61-73.

VIÉ R. 1995. *Le tumulus 1 de la Tory à Avezac-Prat-Lahitte*. Association Gustave Mauran. Archives départementales. Tarbes. p 39-45.

VIGNAUD A. 1998. La nécropole néolithique du Camp del Ginèbre de Caramany (Pyrénées-Orientales). In: GUILAINE J, VAQUER J, editor. *Tombes, nécropoles, rites funéraires préhistoriques et historiques, séminaires du Centre d'anthropologie de Toulouse*. École des hautes Études en Sciences sociales. p 19-29.

VIGNEAU H, ANDERSON T-J. 1996. Châbles FR, Le Péchau. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 79:233.

VILAIN R. 1966. Le gisement de Sous-Balme à Culoz (Ain) et ses industries microlithiques. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon* 13:220.

VILASECA S. 1943. El poblado y la necrópolis prehistóricos de Molá (Tarragona). *Acta Arqueológica Hispanica* I.

VILASECA S. 1947. El Campo de Urnas de Les Obagues de Montsant y la evolución de la cultura de las Urnas en el SW. de Cataluña. *Archivo Español de Arqueologia* 20.

VILASECA S. 1954. *Nuevos yacimientos tarraconenses de cerámica acanalada*. Reus, Instituto de Estudios Tarraconenses "Ramon Berenguer IV" Centro Comarcal de Reus. Sección de Arqueología e Historia 2.

VINATIÉ A. 1995. *Sur les chemins du temps du pays de Massiac:15000 ans d'histoire de la fin du Paléolithique à l'aube du Moyen Âge*. Société d'Archéologie et d'Histoire. Massiac.

VINATIÉ A, DAUGAS J-P. 1972. La fouille du tumulus n° 21 du champ de tumulus de Lair à Laurie (Cantal). In: *Congrès préhistorique de France (Auvergne, 6-14 juillet 1969)*. Paris. p 348-54.

VINATIÉ A, DAUGAS J-P. 1975. Contribution à l'étude des tumulus cantaliens: nouvelles observations sur le champ de tumulus de Lair, commune de Laurie (Cantal). *Revue de la Haute-Auvergne* 45:115-30.

VITAL J. 1989. La dynamique du Bronze moyen dans la vallée du Rhône: nature et impact des courants culturels exogènes. In: *Dynamique du Bronze Moyen 1989*. Actes du 113e Congrès National des Sociétés Savantes (Strasbourg 1988). Paris. p 305-29.

VITAL J. 1990, *Nouvelles considérations sur les incinérations Bronze final de la nécropole de Champ-Crose à Chabestan (Hautes-Alpes) et sur les modes funéraires dans les Alpes occidentales du XIVe au XIe siècle avant J.-C.*, en “Bulletin de la Société Préhistorique Française”, 87, n. 8, pp. 250-256.

VITAL J, editor. 1993. Habitats et sociétés du Bronze final au Premier Âge du Fer dans le Jura. Les occupations protohistoriques et néolithiques du Pré de la Cour à Montagnieu (Ain). *Monographie du CRA* 11.

VITAL J. 1994. Céramique, métal, culture. « Moutons noirs » de la typologie et mobilité. Quelques exemples de l’Âge du Bronze rhodanien et leur interprétation. In: COURTIN J, editor. *Terre cuite et société. La céramique, document technique, économique, culturel, Actes des XIVe rencontres Internationales d’Archéologie et d’Histoire d’Antibes (Antibes, 1993)*. Juanles-Pins. p 381-93.

VITAL J. 1999. Identification du Bronze moyen-récent en Provence et en Méditerrannée nord-occidentale. *Documents d’Archéologie Méridionale* 22:7-115.

VITAL J. 2001. Actualités de l’âge du Bronze dans le Sud-Est de la France: chronologie, lieux, économie, mobiliers. *Documents d'Archéologie Méridionale* 24:243-52.

VITAL J. 2002. Occupations du Campaniforme et du Bronze ancien à Espeluche-Lalo (Drôme). In: Archéologie du TGV Méditerranée. Fiches de synthèse. Tome 2. La Protohistoire. *Monographies d'Archéologie Méditerranéenne* 9:442-6.

VITAL J. 2004. Le début du Bronze final en Provence et dans le sud-est de la France. In: COCCHI GENICK D, editor. *L'età del bronzo recente in Italia, Atti del Congresso Nazionale (Lido di Camaiore, 26-29 ottobre 2000*). Viareggio (LU). p 550-1.

VITAL J. 2007a. Le mobilier céramique du Bronze final. In: DAVEAU I, editor. Port Ariane (Lattes, Hérault): construction deltaïque et utilisation d’une zone humide lors des six derniers millénaires. *Lattara* 20:377-88.

VITAL J. 2007b. Les fouilles 1981-1987 dans la grotte de la Chauve-Souris à Donzère (Drôme): Visées initiales, problématiques actuelles, premières caractérisations chrono-culturelles, implications pour le Sud-Est de la France et le domaine circum-alpin. In: FOUÉRÉ P, CHEVILLOT C, COURTAUD P, FERULLO O, LEROYER C, editors. Paysages et peuplements. Aspects culturels et chronologiques en France méridionale, Actes du VIe Rencontres Méridionales de Préhistoire Récente (Périgueux, 14-16 octobre 2004). Chancelade. *Préhistoire du Sud-Ouest* 11:257-92.

VITAL J, BERGER J-F, BROCHIER J-L. 2011. L’architecture et les occupations du Bronze final 1 et du Bronze final 2b du site du Gournier, secteur de Fortuneau, à Montélimar (Drôme). Gallia Préhistoire 53:203-87.

VITAL J, BINTZ P, ALCAMO J-C, BILLARD M, CAILLAT B, LAGRAND C, GRUNWALD C, STORDEUR D, THIEBAULT S. 1991. Les occupations protohistoriques et historiques des sites du Cirque de Choranche (Isère). *Gallia Préhistoire* 33:207-67.

VITAL J, BOUBY L, JALLET F, REY P-J. 2007. Un autre regard sur le gisement du boulevard périphérique nord de Lyon (Rhône) au Néolithique et à l'Age du bronze: secteurs 94.1 et 94.8. *Gallia Préhistoire* 49:1-126.

VITAL J, BROCHIER J-L, DURAND J, PROST D, REYNIER P, RIMBAULT S, MAAMAR HS. 2002. La séquence holocène et les occupations des âges des Métaux de Roynac – Le Serre 1 (Drôme). In: Archéologie du TGV Méditerranée. Fiches de synthèse. Tome 2. La Protohistoire. *Monographies d'Archéologie Méditerranéenne* 9:411-26.

VITAL J, CONVERTINI F, LEMERCIER O, editors. 2012. *Composantes culturelles et premières productions céramiques du Bronze ancien dans le Sud-Est de la France. Résultats du Projet Collectif de Recherche 1999-2009*. Oxford: BAR International Series 2446.

VITAL J, VORUZ J-L. 1984. L'habitat protohistorique de Bavois-en-Raillon (Vaud). *Cahiers d'Archéologie Romand*e 28.

VOGEL JS, NELSON DE, SOUTHON JR. 1987. ^{14}C background levels in an accelerator mass spectrometry system. *Radiocarbon* 29(3):323-33.

VOGEL JS, NELSON DE, SOUTHON JR. 1989. Accuracy and precision in dating microgram carbon samples. *Radiocarbon* 31(2):145-9.

VOGEL JS, OGNIBENE T, PALMBLAD M, REIMER P. 2004. Counting statistics and ion interval density in AMS. *Radiocarbon* 46(3):1103-9.

VOGEL JS, SOUTHEN JR, NELSON DE, BROWN TA. 1984. Performance of catalytically condensed carbon for use in accelerator mass spectrometry. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* 5(2) :289-93.

VORUZ J-L. 1985. Le site terrestre de Sous-le-Pin à Saint-Sorlin-en-Bugey (Ain). Âge du Bronze final: rapport de découverte. In: *DRAC Rhône-Alpes, Service Regional de l’Archéologie*.

VORUZ J-L. 1990. La stratigraphie de la grotte du Gardon. *Bulletin du Centre Genevois d'Anthropologi*e 2:125-7.

VORUZ J-L. 1991. Archéologie de la grotte du Gardon (Ain), rapport de fouille, 1985-1990. *Document du département d’anthropologie et d’écologie de l’université de Genève* 17:329.

VORUZ J-L, editor. 1993. *La grotte du Gardon à Ambérieu-en-Bugey (Ain). Rapport de fouilles 1993. Département d'Anthropologie, Université de Genève, Société préhistorique rhodanienne*. Ambérieu-en-Bugey.

VORUZ J-L. 1996. Chronologie absolue de l'âge du Bronze ancien et moyen. In: MORDANT C, GAIFFE O, editors. 1996. *Cultures et sociétés du Bronze ancien en Europe, 117éme Congrès National des Sociétés Historiques et Scientifiques. Clermont-Ferrand 27-29 octobre 1992*. p 97-164.

VORUZ J-L. 1997. Ambérieu-en-Bugey. Grotte du Gardon. *Gallia Informations* 1996:7-11.

VORUZ J-L, PERRIN T, SORDOILLET D. 2004. La séquence néolithique de la grotte du Gardon (Ain). *Bulletin de la Société préhistorique française* 101(4):827-66.

VORUZ J-L, TREFFORT J-M, STAHL GRETSCH L-I, GUILLET J-P. 1999. Le Site protohistorique de Saint-Alban à Creys-Pusignieu (Isère): une belle stratigraphie du bronze final IIIA au Hallstatt ancien. In: BEECHING A, VITAL J, editors. Préhistoire de l’espace habité en France du Sud. Actes des 1res rencontres méridionales de Préhistoire récente (Valence, 3-4 juin 1994). *Travaux du Centre d'archéologie préhistorique de Valence* 1:269-86.

WAHL J, PRICE TD. 2013. Local and foreign males in a late Bronze Age cemetery at Neckarsulm, south-western Germany: strontium isotope investigations. *Anthropologischer Anzeiger* 70(3):289-307.

WAINSCOAT JS, HILL AV, BOYCE AL, FLINT J, HERNANDEZ M, THEIN SL, OLD JM, LYNCH JR, FALUSI AG, WEATHERALL DJ, CLEGG JB. 1986. Evolutionary relationships of human populations from an analysis of nuclear DNA polymorphisms. *Nature* 319(6053):491-3.

WALL E. 1998. Archäologische Federseestudien. Untersuchungen zur Topographie, Hydrologie und Chronologie der vorgeschichtlichen Siedlungen am Federseemoor. In: Siedlungsarchäologie im Alpenvorland V. *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 68:11-76.

WALLERSTEIN I. 1974. *The Modern World-system. I, Capitalist Agricolture and the Origins of the European World –Economy in the Sixteenth Century*. New York-London.

WALSH K, MOCCI F, COURT-PICON M, TZORTZIS S, PALET-MARTINEZ J-M. 2005. Dynamique du peuplement et activités agro-pastorales durant l'âge du Bronze danss des massifs du Haut Champsaur et de l'Argentierois (Hautes-Alpes). *Documents d’Archéologie Méridionale* 28:25-44.

WALSH K, MOCCI F, PALET-MARTINEZ J. 2007. Nine thousand years of human/landscape dynamics in a high altitude zone in the southern French Alps (Parc National des Ecrins, Hautes-Alpes). *Preistoria Alpina* 42:9-22.

WANNER H, HOLZHAUSER H, PFISTER C, ZUMBÜHL H. 2000. Interannual to century scale climate variability in the European Alps (Die Klimavariabilität im europäischen Alpenraum auf der Zeitskala von Jahren bis Jarhunderten). *Erdkunde* 54(1):62-9.

WEDEKIN CH. 1994. *Die prähistorische Höhensiedlung “Burg” bei Schwarzenbach, VB Wr. Neustadt. Die Ergebnisse der archäologischen Untersuchung der Wallbefestigung in den Jahren 1992 und 1993*. Diplomarbeit Zur Erlangung des Magistergrades der Philosophie eingereicht an der Geisteswissenschaftlichen Fakultät der Universität Wien.

WEDGWOOD J, CHADHA B, STAVASH J, EDEN J, CORTESE A. 2003. *Genetic programming approaches to composable simulation*. Lockheed Martin Advanced Technology Laboratories. SISO Simulation Interoperability Workshop. Orlando, Florida.

WEGNER G. 1976. *Die vorgeschichtlichen Flussfunde aus dem Main und aus dem Rhein bei Mainz*. Kallmuntz.

WEIHS A. 2004. *Der urnenfelderzeitliche Depotfund von Peggau (Steiermark)*. Universitätsforschungen zur prähistorischen Archäologie 121.

WEINBERGER S. 2008. *Warfare in the Austrian Weinviertel during the Early Bronze Age*. Wien.

WEINER S. 2010. *Microarchaeology. Beyond the Visible Archaeological Record*. Cambridge.

WEISGERBER G, GOLDENBERG G, editors. 2004. Alpenkupfer - Rame nelle Alpi. *Der Anschnitt* 17.

WEITZEL T, BEIMBORN D, KÖNIG W. 2006. A unified economic model of standard diffusion: the impact of standardization cost, network effects, and network topology. *MIS Quarterly* 30:489-514.

WELLER SC. 2007. Cultural Consensus Theory: Applications and Frequently Asked Questions. *Field Methods* 19(4):339-68.

WELLS PS. 1982. C14-Bestimmungen von der Siedlung Landshut-Hascherkeller in Niederbayern. *Archäologisches Korrespondenzblatt* 12:357-62.

WELLS PS. 1984. *Farms, villages, and cities. Commerce and urban origins in Late prehistoric Europ*e. London.

WELLS PS. 2002. The Iron Age. In: MILISAUSKAS S, editor. *European Prehistory: a survey*. New York.

WENINGER B. 1997. Studien zur dendrochronologischen Kalibration von archäologischen 14C-Daten. *Universitätsforschungen zur prähistorischen Archäologie* 43.

WENINGER B, EDINBOROUGH K, CLARE L, JÖRIS O. 2011. Concepts of probability in radiocarbon analysis. *Documenta Praehistorica* XXXVIII:1-20.

WENINGER B, JÖRIS O. 2004. Glacial radiocarbon age calibration: the CalPal program. In: HIGHAM T, BRONK RAMSEY C, OWEN C, editors. *Radiocarbon and Archaeology, Proceeding of the 4th Symposium (Oxford, 9-14 April 2002)*. p 9-15.

WESSELKAMP G. 1993. Die bronze- und hallstattzeitliche Grabhügel von Oberlauchringen, Kr. Waldshut. *Materialhefte zur Vor- und Frühgeschichte* 17.

WESTERDAHL C, editors. 2006. *The significance of portages*. Oxford: BAR International Series 1499.

WEWERKA B. 1998. Rettungsgrabungen beim Bahnhof von Hadersdorf am Kamp. In: Bericht zu den Ausgrabungen des Vereins ASINOE in den Projektjahren 1997 und 1998. *Fundberichte aus Österreich* 37:264-79.

WEWERKA B. 2001. Thunau am Kamp – Eine befestigte Höhensiedlung (Grabung 1965-1990). Urnenfelderzeitliche Siedlungsfunde der oberen Holzwiese. *Mitteilungen der Prähistorischen Kommision Österreichische Akademie der Wissenschaften* 38. Wien.

WHITE A. 2008. A developmental perspective on technological change. *World Archaeology* 40(4):597-608.

WHITE A. 2013. An abstract model showing that the spatial structure of social networks affects the outcomes of cultural transmission processes. *Journal of Artificial Societies and Social Simulation* 16(3):9.

WHITEHOUSE R. 1993. Datazioni radiocarboniche da Fabbrica dei Soci (Villabartolomea-VR). In: DE GUIO A, WHITEHOUSE R, WILKINS J, editors. Progetto Alto-Medio Polesine-Basso Veronese: sesto rapporto. *Quaderni di Archeologia del Veneto* IX:175-6.

WHITEHOUSE R. 1994. Radiocarbon dates from Fondo Paviani (VR). In: DE GUIO A, WHITEHOUSE R, WILKINS J, editors. Il progetto Alto-Medio Polesine-Basso Veronese: settimo rapporto. *Quaderni di Archeologia del Veneto* X:126.

WHITEHOUSE R. 1997. Radiocarbon dating and the Alto-Medio Polesine-Basso Veronese Project. In: DE GUIO A, WHITEHOUSE R, WILKINS J, editors. Il progetto Alto-Medio Polesine-Basso Veronese: nono rapporto. *Quaderni di Archeologia del Veneto* XIII:165-7.

WICKS K, PIRIE A, MITHEN SJ. 2014. Settlement patterns in the late Mesolithic of western Scotland: the implications of Bayesian analysis of radiocarbon dates and inter-site technological comparisons. *Journal of Archaeological Science* 41:406-22.

WIENER MH, EARLE JW. 2014. Radiocarbon dating of the Theran eruption. In: TYKOT RH, editor. Proceedings of the 38th International Symposium on Archaeometry (May 10th-14th 2010, Tampa, Florida). *Open Journal of Archaeometry* 2:5265.

WILLIAMS AN. 2012. The use of summed radiocarbon probability distributions in archaeology: a review of methods. *Journal of Archaeological Science* 39(3):578-89.

WILSON JF, WEISS DA, RICHARDS M, THOMAS MG, BRADMAN N, GOLDSTEIN DB. 2001. Genetic evidence for different male and female roles during cultural transitions in the British Isles. *Proceeding of the National Academy of Sciences of the United States of America (PNAS)* 98(9):5078-83.

WIRTH S. 2005. De nouvelles sépultures dans la Vallée du Lech inférieur. Contribution à la connaissance des pratiques funéraires au Bronze Final en Bavière du sud. In: MORDANT C, DEPIERRE G, editors. *Les pratiques funéraires à l'âge du bronze en France, Actes de la table ronde de Sens-en-Bourgogne (Yonne)*. Paris. p 305-20.

WOLF C. 1998. Neue Befunde zur Siedlungsstruktur der westschweizerischen Frühbronzezeit: erste Ergebnisse der Ausgrabungen in den neolithischen und bronzezeitlichen Seeufersiedlungen von Concise-sous-Colachoz (VD). In: HÄNSEL B, editors. *Mensch und Umwelt in der Bronzezeit Europas - Man and Environment in European Bronze Age, Abschlußtagung der Kampagne des Europarates: Die Bronzezeit: das erste goldene Zeitalter an der Freien Universität Berlin, 17.-19. März 1997*. Kiel. pp. 541-556.

WOLF C, BURRI E, HERING P, KURZ M, MAUTE-WOLF M, QUINN D, WINIGER A. 1999. Les sites lacustres néolithiques et bronzes de Concise VD-sous-Colachoz: premiers résultats et implications sur le Bronze ancien regional. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschicht*e 82:7-38.

WOLF JJ. 1978. La contribution de l'archéologie à l'histoire de Sierentz et de sa region. *Annuaire de la Société d'Histoire Sundgauvienne* 1978:140-60.

WOLFLI W, BONANI G, SUTER M, BALZER R, NESSIE M, STOLLER C, BEER J, OESCHGER H, ANDRE M. 1983. Radioisotope dating with thye ETHZ EN tandem accelerator. *Radiocarbon* 25:745-54.

WYBRUNNE A. 2010. Fundmaterial einer hallstattzeitlichen Siedlunge. *Archäologie Bern/Arquéologie bernoise* 2010:199-220.

WYSS R. 1993. Prähistorische Kupfergewinnung in den Schweizer Alpen. *Zeitschrift für Schweizerische Archäologie und Kunstgeschichte* 50(3):195-212.

WYSS R. 2002. *Die bronzezeitliche Hügelsiedlung Cresta bei Cazis, Ergebnisse der Grabungen von 1943 bis 1970. Band 1. Teil I. Die Siedlungen. Teil II. Die Kleinfunde (ohne Keramik)*. Archaeologische Forschungen, Herausgegeben vom Schweizerischen Landesmuseum Zürich.

YÁÑEZ C, BURJACHS F, JUAN-TRESSERRAS J, MESTRES JS. 2001-2002. La fossa de Prats (Andorra), un jaciment del bronze mitjà al Pirineu. *Revista d'Arqueologia de Ponent* 11-12:123-50.

YARRITU MJ, GORROTXATEGI X. El megalitismo en el Cantabrico Oriental. Investigaciones arqueológicas en las necrópolis megalíticas de Karrantza (Bizkaia), 1979-1994. La necrópolis de Ordunte (Valle de Mena, Burgos), 1991-1994. *Cuadernos de Sección. Prehistoria-Arqueología* 6:155-98.

YIZHAQ M, MINTZ G, COHEN I, KHALALLY H, WEINER S, BOARETTO E. 2005. Quality Controlled Radiocarbon Dating of Bones and Charcoal from the early Pre-Pottery Neolithic B (PPNB) of Motza (Israel). *Radiocarbon* 47(2):193-206.

YOFFEE N. 1979. The decline and rise of Mesopotamian civilization: an ethnoarchaeological perspective on the evolution of social complexity. *Antiquity* 44:5-34.

YOUNG HP. 2009. Innovation diffusion in heterogeneous populations: Contagion, social influence, and social learning. *The American economic review* 99(5):1899-924.

ZANINI A, editor. 1997. *Dal bronzo al ferro. Il II millennio a. C. nella Toscana centro-occidentale. Exhibition catalogue Livorno*. Pisa.

ZANINI A, MARTINELLI N. 2005. New data on the absolute chronology of the late Bronze Age in central Italy. In: *L'âge du bronze en Europe et en Méditerrannée/The Bronze Age in Europe and the Mediterranean. Sessions générales et posters/General Sessions and Posters 2005, Actes du XIVème Congrès UISPP, Université de Liège, Belgique (2-8 septembre 2001)*. Oxford: BAR International Series 1337. p 147-55.

ZAZZO A, SALIÈGE J-F, LEBON M, LEPETZ S, MOREAU C. 2012. Radiocarbon dating of calcined bones: insight from combustion experiments under natural conditions. In: BOARETTO E, REBOLLO FRANCO NR, editors. Proceedings of the Sixth Radiocarbon and Archaeology Symposium (Paphos, Cyprus, 10–15 April 2011). *Radiocarbon* 54(3-4):855-66.

ZIMMERMANN A. 1996. Zur Bevölkerungsdichte in der Urgeschichte Mitteleuropas. In: CAMPEN I, HAHN J, UERPMANN M,, editors. Spuren der Jagd - Die Jagd nach Spuren. Festschrift Hansjürgen Müller-Beck. *Tübinger Monographien zur Urgeschichte* 11:49-61.

ZIMMERMAN A. 2009. Estimations of population density for selected periods between the

Neolithic and AD 1800. *Human Biology* 81(2-3):357-80.

ZIMMERMAN A. 2012. Cultural cycles in Central Europe during the Holocene. *Quaternary International* 274:251-8.

ZOPPI U, FULCHERI E, GAMBARI FM, HUA Q, LAWSON EM, MICHELETTI CREMASCO M, VENTURINO GAMBARI M. 2001. The Copper Age in northern Italy. *Radiocarbon* 43(2B):1049-55.

ZORZI F. 1940. La palafitta di Barche di Solferino. *Bullettino di Paletnologia Italiana* 4:41-82.

ZORZI F. 1960a. Le tombe a cremazione scoperte sotto il colle di Madonna della Pieve (Cavriana). *Sibrium* V:81-3.

ZORZI F. 1960b. Preistoria Veronese. Insediamenti e Stirpi. In: *Verona e il suo Territorio vol. 1*. Verona. p 73-153.