Moving into the Metal Ages: The Social Importance of Metal at the End of the Neolithic period in France

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Abstract:
This article, focused on a number of areas in Continental France, tries to evaluate the impact of metal production and its consumption on communities dating from the end of the Neolithic and the Early Bronze Age.
Few metal discoveries have been made in the northern half of France. However, it is in the Paris Basin that the oldest metal objects have been discovered so far (second half of the 4th mill. BC). The region was exclusively a "metal consumer" during the whole 3rd mill. BC, and the use of metal in the Paris Basin remained a secondary phenomenon which had little or no effect on the mutation of the local cultural groups.
In contrast to the Paris Basin, the southern half of France could count on a wide range of copper ore resources. The mining and metallurgical district of Cabrières-Péret in Languedoc developed its activities over a long period, starting during the late 4th mill. BC and declining at the end of the 3rd mill. BC. The study of this mining district reveals an integrated production site where zones for the extraction of the raw material were closely associated with metallurgical areas. The micro-region around Cabrières-Péret developed a cultural and economic activity particularly dynamic during this period, in which metal played an important role. Metal was therefore probably considered as having a high social value in that specific area.
Other models of copper production are known in Languedoc and the southern border of the Massif Central, such as the Al Claus settlement, a site featuring a small scale and occasional copper production, within the living units. Moreover, the study of the Neolithic metal objects discovered in Languedoc indicates that the diffusion was essentially local. These two facts, the Al Claus model and the local diffusion of copper objects, support the hypothesis of a multipolar production of copper, an alternative to the Cabrières model, where output of metal on social change was probably very low.
At the end of the 3rd mill. BC, a decline in metal production seems to have occurred on the southern border of the Massif Central. At the same time, *ie* the beginning of the Early Bronze Age, an increase in the exploitation of copper resources in the French Alps is to be noticed. Thus, the mining and metallurgical site of Saint-Véran (Hautes-Alpes) developed a specific high-yield metallurgical process similar to the one which spread over the whole Alpine zone throughout the Bronze Age.
According to an evolutionary interpretation, the Cabrières / Al Claus / Saint-Véran models can be used to represent the passage from the Neolithic to the Bronze Age. This schema however implies that the phenomena succeeded each other in a defined period and in the same area. Does the model remain valid when the cultural areas are not connected and the phenomena not associated in time? The answer is quite obviously in the negative.

This study focuses on a number of areas in Continental France (the Paris Basin, the southern border of the Massif Central, Languedoc, and the Southern Alps), and is based on recently established data in the fields of archaeology and archaeometallurgy. We have tried to evaluate the role and the position occupied by metal production and its consumption in communities of the third millennium before our era.

The term "Chalcolithic" has been interpreted in various ways; it can refer to a technological phase related to the first appearance of metallurgy, or to the emergence in Europe of unequal,

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[1] This article is a slightly modified version of Carozza and Mille 2007. The translation into English is by Janice Abbott.

hierarchical societies. By associating the notion of Chalcolithic (which we shall identify as the progression from the last Neolithic societies to the first Metal Ages communities) with that of social complexification, (which we identify on the basis of evidence of the evolution of social organisations), we have attempted to determine whether there was a cause-effect relationship between the appearance of metallurgy and the evolution of social organisations. Before going into the details of our research study, we shall first outline the conceptual framework.

The weight of past research

By deciding to focus our study on metal uses we have opted for a "technological" interpretation of the term "Chalcolithic" covering a number of different aspects, including raw material production, the shaping of metal into objects or the simple consumption of already fashioned metal objects[2]. In this article we shall not employ the term Chalcolithic in its chronological usage when describing the end of the Neolithic period in France. We have divided the latter into three phases: the Recent Neolithic, the Final Neolithic and the Early Bronze Age.

We have gone into detail concerning the notion of social complexification, since we consider it to be fundamental to the debate, and we have analysed this concept in the light of archaeological and archaeometallurgical data**.** The notion of social complexification is well known to archaeologists; it is derived from various theories on the classification of societies proposed by Anglo-American anthropologists (Service 1962; Johnson and Earle 1987). These similar, though complementary, theories suggest that societies evolved from the « simplest » of egalitarian communities into state-controlled structures embodying - in Fried's terminology - the most complete or "complex" type of social organisation. (Fried 1967). As recently pointed out by Alain Testart (Testart 2005), such propositions are based on an evolutionary approach, and have been favourably received by the archaeological community, on the ground that they postulate an ordered, progressive increase in the hierarchical organisation of society, a theory considered as "compatible" with the march of History.

This approach is based on the idea that societies evolve from the very simple to the ultra complex, an idea which has been criticised by social anthropologists. Archaeologists on the other hand, confronted as they are with material evidence which is not always very explicit, have been more reserved in their reactions. Alain Testart has clearly identified the danger of adopting an exaggeratedly evolutionary approach, with its attendant implicit value judgements concerning the notions of 'simple' and 'complex'. Although we adhere in part to Testart's position and agree with the social anthropological movement which accords more importance to structure, we have to admit that archaeologists often lack the data necessary for determining social structures. In proposing an alternative model, or at least in making this contribution to the debate, as we shall now attempt to do, we are well aware how difficult it is to go beyond a simple description of material data, the transient signs of past social organisations.

Archaeologists can refer to a number of factors when trying to assess the nature of social change. Types of habitat, funeral practices, and territorial organisation constitute one group of factors, techniques and the exploitation of resources, another. The description of

[2] Metallurgy covers three principal areas of activity: extractive metallurgy (smelting), the elaboration of alloys, and the metalworking process (shaping metal into objects). The extraction and preparation of ore (crushing and enrichment) belong to the area of mineralurgy.

metallurgical *chaînes opératoires* is of course important, but the crucial question is how they can be integrated into the whole range of technical, cultural and environmental variables. In passing, it is interesting, and indeed somewhat ironic to note that the development of inter-disciplinary approaches tends to make technological approaches - which initially appear so simple - systematically more complex.

The emergence of metallurgy: simple to complex?

Those technical innovations thought to have had decisive social implications for man's history are invariably seen within an evolutionary framework; metallurgy is no exception to this rule. The initial stages of metallurgy in Europe are now well understood, and it is a well accepted fact that they originated in south-eastern Europe. It has been proved that the first collection of copper ore took place on the borders of the Black Sea at the end of the sixth millennium and the beginning of the fifth millennia B.C. in the Balkans. By this period, Middle Neolithic communities already had considerable experience of mining, and they were equipped with the technical know-how for extracting native copper and copper carbonates. The production of copper by pyrometallurgy, i.e. the use of high temperature processes, coincided with the important mining activity of the Early Chalcolithic Age (middle of the fifth millennium B.C). This phenomenon is illustrated by the Bulgarian necropolis of Varna (Karanovo culture), where gold necklaces and bracelets were found lying alongside massive objects made from copper (shaft-hole axes). Metallurgy subsequently spread to the Carpathian Basin, Hungary, Poland and central Germany. It was not until 3800-3500 B.C that it reached the Alps, the Swiss plateau – notably in the Pfyn culture – and northern Italy.

The schema generally accepted and discussed in the literature is that of a primo-metallurgy divided into three stages spread out over time. It can be summarised in the following way: the production of metal from native copper, which by definition excludes all extractive metallurgy processes, is believed to have first appeared in Anatolia in the seventh millennium (Early Neolithic). Pyrometallugy for extracting copper from carbonates would have first appeared in Europe in the Carpathian-Balkan era during the sixth and fifth millennia, and in the Alpine arc and the South of France during the fourth and third millennia BC. The exploitation of copper ore sulphides (in particular chalcopyrite), which are considered as more difficult to smelt because they are polymetallic, would not have appeared in western Europe until the middle of the Bronze Age.

The combination of technical models (evolutionary) and historical models (diffusionist) has led to a correlation between the complexity of *chaînes opératoires* - determined by the type of copper ore smelted - and the high level of social organisations, as shown by the increase in social inequalities. According to this hypothesis, native copper metallurgy required no particular knowledge – a theory which, incidentally conveniently ignores the fact that certain techniques need to be set up for fashioning objects - and extractive metallurgy for carbonated ores only required the setting up of simple *chaînes opératoires*. Metallurgy for the exploitation of copper sulphides on the other hand, involving the delicate operation of separating copper from iron, constituted the most complex process of all.

The increase in the complexity of extractive metallurgical processes has often been related to the nature of available resources, a theory which suggests that the natural stratification of copper resources justifies the model. According to this theory, metallurgical techniques were adapted to available resources. In primo-metallurgy only superficial formations were worked, the native copper was exploited until it was completely exhausted, and only crudely hammered objects were fabricated from such copper. The theory also suggests that the exploitation of copper carbonates (the alteration of facies of deposits easily accessible to prehistoric miners) came later and necessarily involved the mastery of extractive metallurgy. Finally, according to this hypothesis, it was not until the Bronze Age that more developed mining and metallurgical techniques permitted the exploitation of sulphidic polymetallic ores which were found at deeper levels.

The idea that complex *chaînes opératoires* were essential for the exploitation of copper sulphide ores is derived more from the treatise "*De Re Metallica*" published by Agricola in 1556, than from any real description of the processes used at the end of the Neolithic and during the Bronze Age (Agricola 1556). In fact, a determinist socio-interpretative model lies behind this convenient schema, linking technical complexity with social complexity. Christian Strahm's notion of "Metallikum", which combines technical and social signs, is clearly inspired from this model and offers an interpretative grid which has been widely used in archaeological studies (Strahm 1982 ; 2005).

Metal without metallurgy in the northern half of France

Few metal discoveries attributable to the Neolithic period have been made in the Paris Basin. The most recent inventory lists only 48 metal objects (Mille and Bouquet 2004)[3]. Study of the inventoried objects showed that the region was exclusively "a metal consumer". Attested metallurgical activities did not begin until the middle of the Bronze Age, and even then concerned only metalworking processes, that is the fabrication of objects, as, for example, at Fort-Harrouard, where alloys were produced and subsequently shaped into objects (Mohen 1990). The Paris Basin is a vast sedimentary zone totally lacking in any copper resources, and extractive copper metallurgy (the transformation of ore into metal) was never practised there. Neolithic copper most certainly came to northern France in the form of objects which had already been manufactured.

However, this rarity does not mean that copper appeared late - quite the contrary in fact, for it is in the Paris Basin that the oldest metal objects so far discovered in France have been found. When the aforementioned inventory was being drawn up, a most surprising discovery was made, that of a group of personal ornaments of a particular type - sheet-metal copper beads. The 26 beads made up more than half of the inventoried objects. Nearly all of them can be attributed to the Recent Neolithic, with however, differing degrees of certainty depending on the context of the discoveries (collective burials). It is interesting to note that these objects were heavily concentrated in the region of the hypogea in the area of the Marne, but what we really need to discuss in detail is the most spectacular find of a necklace made from 9 beads in sheet-metal copper, discovered in the collective burial of Vignely "la Porte aux Bergers" (Seine-et-Marne).

This burial alley was recently excavated by a team under the supervision of Yves Lanchon (Allard *et al.* 1998). It consisted of a small alley completely built of wood. Radiocarbon dating carried out on a piece of charcoal discovered in the hole where one of the wooden posts had been placed indicates that the alley can be dated to about the thirty-fourth century B.C., (unpublished data provided by Y. Lanchon: Ly 9401 : 3517-3357 cal. B.C.). One of the

[3] This inventory was conducted within the framework of the collective research program: « *Le 3e millénaire dans le Centre-Nord de la France : définitions et interactions des groupes culturels* », Augereau *et al.* 2004.

interesting facts concerning the collective burial site of Vignely is that it was used for only a relatively short space of time. The anthropological study concluded that the ten burials were carried out over a few decades (Chambon 1999). Individual number 7, a child about 5 years old, was found wearing a necklace composed of nine copper beads and a turitella pendant (fig. 1). The beads are not cylindrical but « barrel-shaped », and it has been estimated that they were originally 20 to 25 mm long, 13 to 15 mm in diameter, and were made from thin sheet metal of a 0.3 to 0.4 mm regular thickness (fig. 1). Each bead must have weighed about 3 grams; this would give a total of 25 to 30 grams of metal for the whole necklace. Radiocarbon analysis of a sample of the child's bones fully confirmed the conclusions advanced by the anthropological study that the burial site had only been used for a short time: Ly-2682 (GrA) : 4590 ± 40 BP, i.e. 3499-3123 cal. BC, with two peaks of greater probability in 3360 and 3475 B.C. From the direct dating of the child wearing the necklace it was possible to obtain an extremely precise relative dating for the metal objects – a quite exceptional research find for the period under consideration.

Except for a few rare examples found on the east bank of the Rhône, no similar sheet-metal beads have been discovered in the South of France, (Arnal *et al.* 1974 ; Barge-Mahieu 1995). The Vignely beads are in any case too old to have come from southern France, since the first metallurgical activities in the Languedoc region go back to the extreme end of the fourth millennium, whereas the long-distance distribution of corresponding productions does not seem to have begun before the middle of the third millennium. On the other hand, items of personal decoration made from a sheet of copper are frequently encountered in central and northern Europe from the end of the fifth millennium and up to the middle of the third millennium (Ottaway 1973; Bartelheim *et al.* 2003), fig. 2. In these metal-producing regions, shapes were not limited, as in the Paris Basin, to beads. Crescent-, disc-, and trapeze-shaped pendants, rings, and numerous different kinds of spirals were also found. The sheet-metal beads discovered in the Paris Basin therefore clearly belong to a tradition which, by the fourth millennium was already firmly established over a large area, extending from central Europe to Scandinavia.

The other copper objects discovered in the Paris Basin fit in perfectly with the metal items found elsewhere in France at the end of the Neolithic period; (for western France, see Briard and Roussot-Larroque 2002; for Provence, see Lemercier 2005; and for the Languedoc region, see Ambert and Carozza 1996). They include two flat "archaic" shaped axes, seven daggers, two Palmela points, two awls, and seven heavy beads (Mille and Bouquet 2004). The contexts of these discoveries are in general not very helpful and contribute little to the establishment of a chrono-cultural attribution of the objects. All come either from collective burial sites or from isolated discoveries, with the exception of the tanged dagger from Wallers « Aremberg » (North Pas-de-Calais region) found in an individual Bell Beaker burial, and two beads from Ouroux-sur-Saône (Saône-et-Loire) discovered in a Final Neolithic settlement. However, the daggers and the two Palmela points are typical of the Bell Beaker period. There is no doubt at all that the heavy beads are similar to those made in the south of France and discovered in large quantities in the dolmens on the west bank of the Rhone. If we widen our study to a larger geographical area, we can try to determine the period during which the heavy beads from the Midi circulated. Radiocarbon dates of horizons associated with the objects and beads discovered at Ouroux-sur-Saône in Saône-et-Loire (Thevenot 1973), at Artenac in Charente (Bailloud *et al.* 2008) and at Charavines in Isère (Bocquet *et al.* 1976) all converge to the second half of the third millennium. We therefore suggest that the seven heavy beads discovered in the Paris Basin should be attributed to the Final Neolithic in this region, i.e. 2700-2200 B.C.

It is well established therefore that copper objects were circulating throughout the Paris Basin from the second half of the fourth millennium and during the whole of the third millennium. It would be no exaggeration to suggest that from this period onwards, every man, woman and child living in the region was aware of the existence of metal. Does this mean that the arrival of copper in the Paris Basin provoked profound social changes? The answer is quite obviously in the negative. The sheet-metal beads are part of a more general Recent Neolithic phenomenon featuring the use of rich ornaments made from materials originating from different places: calcite, amber, variscite, lignite and other hard stones, bone, stag antler wood, shell (Polloni *et al.* 2004). Copper does not seem to have been valued more than these other materials; this seems to be shown clearly by the Vignely necklace, in which the pendant, a simple turitella, takes pride of place in the centre of the necklace, with the copper beads simply acting as framing ornaments. The production of personal ornaments during the Recent Neolithic in the Paris Basin implies that several supply routes had been set up, including one which brought in sheet-metal beads from central and northern Europe.

No decisive modification took place during the Final Neolithic. Supply circuits changed, and the copper beads used in certain ornaments came henceforth from the South of France. The range of objects made from metal widened to include weapons (daggers), and tools (awls and probably a few flat axes). Except for a few very particular cases[4], it is clear that these objects never totally supplanted stone tools. But it also seems obvious that daggers and flat axes - objects requiring dozens and even hundreds of grams of copper - now constituted important power symbols. Although the use of metal in the Paris Basin remained a secondary phenomenon which had no effect on the mutation of Neolithic cultural groups, there is no doubt that the possession of a fine object in metal was one of the outward signs of the increasing social ranking which characterised the societies of the period.

The emergence of metallurgy in the South of France

In contrast to the Paris Basin, the southern half of France could count on a wide range of copper resources (fig. 3), some of which were probably never exploited during protohistoric times, possibly because they were not particularly rich (Leblanc 1999). The distribution of the deposits is irregular. Most are grouped on the southern border and along the major faults of the Massif Central. Copper resources may also have been exploited in the Pyrenees, the Corbières, and on the edges of the Maures and the Alps. These deposits, which are rarely isolated, were formed in varying geodynamic contexts and at different periods, and constitute metallogenic provinces. The latter can be characterised according to the combination of chemical elements enclosed within the copper ores. The association of antimony and silver for example is typical of fahlerz (polymetallic sulphides) from Late Hercynian formations, whereas nickel-arsenic compositions are typical of Alpine ophiolite sulphide mineralisations. In order to establish the provenance of the metal from which an object is made, the relationship between the ore and the metal needs to be reconstituted, a difficult operation (Mille and Bourgarit 2000). Nevertheless, the features typical of early metallurgical processes can be of help when trying to establish a provenance: few or no mixtures (no use of flux, no production of alloys, little or no recycling) and a high ration of residual impurities in the copper: all of these constitute geochemical markers of the ore. However, the presence of the

[4] Such as a some finishing work by pressure flaking made during the fabrication of flint tools, which, it would seem, could only have been carried out by pressing down on the object with a copper point (information from J. Pellegrin).

antimony/silver combination in an object for example, does not constitute sufficient evidence for establishing the provenance of the object. It might at most indicate that the object was produced in the metallogenic late Hercynian province of the Massif Central. But this does not necessarily mean that the metal came from Cabrières; in fact it is certain that other mining sectors were also operating. In order to discover the other mining districts in this vast province, it is necessary to prospect for them, but we also need to widen our study of the objects in question. Such a study must take into account factors like the specific typological and technological features of the objects, typological diffusion maps, the presence or absence of more specific geochemical markers, and the isotopic composition of the lead. Such an approach will be attempted in the third and last part of this article.
The archaeological and archaeo-metallurgical research studies carried out over the last ten years in the South of France show that the Languedoc region and the southern edge of the Massif Central constitute key areas for our understanding of the role played by metallurgy in societies at the end of the Neolithic. Both social and technological approaches have much to contribute to the theoretical debate. With the end of the Neolithic period and the appearance of metallurgy, ways of exploiting raw material did not evolve in any significant way. Even if our knowledge of the Neolithic copper mines in Europe is still very limited, it is clear that mining techniques were inherited from previous periods. Minerals were extracted from vast pits - a good example being the Bronze Age mining site of Great Orme in Great Britain (Dutton *et al.* 1994). The manner in which mining was conducted depended on the nature of the substratum and the mineralisations (dip of the ore veins, discontinuous strata, aquifer level etc.) Miners and quarrymen used rudimentary but effective stone tools, such as picks, hammers, sledge-hammers, and wedges. Like the miners of the Middle Neolithic they used firesetting to fracture the surrounding rock (Castaing *et al.* 2005).
Finally, early metallurgists active at the end of the Neolithic period in the South of France succeeded in developing or adapting processes and methods for extracting metal from copper ores and for shaping the resulting metal into objects.

<u>The mining and metallurgical district of Cabrières-Péret (Hérault)</u>

In contrast to other regions in southern France, Central Languedoc is a favourable geographical area where metal production is known to have been practised from the beginning of the third millennium B.C. Research by Paul Ambert and his team in the mining district of Cabrières (Hérault) revealed that mining activities and extractive metallurgy were both conducted in the area (Ambert *et al.* 1982 ; Ambert *et al.* 1983 ; Ambert *et al.* 1985 ; Ambert and Barge 1991 ; Espérou 1993 ; Ambert *et al.* 1998 ; Ambert and Carozza 1996 ; Bourgarit and Mille 1997 ; Ambert *et al.* 2002 ; Bourgarit *et al.* 2003a ; 2003b ; Ambert *et al.* 2005 ; Bourgarit and Mille 2005). The district of Cabrières is situated at the east end of the Montagne Noire and groups together several mining sectors (fig. 4) which developed around Pioch-Farrus (Pioch-Farrus 1 and 4, la Vierge), La Roussignole, and the site of Les Neuf Bouches de Vallarade.

Mine and metallurgical zone; the example of the sites of Pioch Farrus 4 and of Roque-Fenestre

The excavations conducted in 1999 at Pioch-Farrus 4 showed that prehistoric mining activity had been carried out on the site, and also provided clues as to how such activity had been organised (Carozza 2005). Signs of prehistoric extraction included the suspended domes on the wall of the shaft leading to the Roman mine. When the shaft was unearthed, a number of well-conserved signs of exploitation were observed (fig. 5). One of the observations of our research was that during Antiquity exploitation was not limited solely to underground seams but also included all surface areas – even the smallest veins.. Mineralisations were completely exploited right down to the base of the fault. This mining activity disturbed archaeological deposits left previous to Antiquity and transformed the areas mined during prehistory (fig. 5). We decided to analyse the traces of ancient exploitation in the hope that this might help us reconstitute a map of the prehistoric mine. We noted a clear distinction between the zones exploited during the prehistoric period (where the wall surfaces were smooth or slightly roughened) and those worked during Antiquity (in this case the surfaces were covered with small marks left by picks or metal tools). A map was drawn up showing the two types of surface treatment, roughened or pick-marked, and from this map we were able to deduce the shape of Neolithic mines.

Study of the walls in the parts mined during prehistory revealed that the roughened zones were coalescent and formed cavities over the domes. These domes, which have been discovered in all the prehistoric mining sites in the district of Cabrières resulted from the use of stone tools and firesetting (Castaing *et al.* 2005). Each dome represents a stage in the exploitation of the mine. The succession of domes points to a corresponding succession of mining campaigns which probably followed each other fairly closely in time. Examination of the round, coalescent shapes shown on the map revealed furthermore the existence of a veritable network, since intersections were also discovered (fig. 5). The existence of this complex network suggests that the mine was exploited in a reasoned and coherent way that closely followed the layout of the mineralisations. Although some extraction probably took place in the open air, certain mineralised quartz deposits were exploited by means of digging galleries and shafts as early as Late Prehistory. The galleries we unearthed at Pioch Farrus 4, which are fifteen metres long and more than six metres deep, are evidence of a veritable mining strategy and a collective long-term effort.

The transport of materials for fire-setting, the making of tools, the removal of debris, and the separation of minerals from the gangue with which they were closely mixed, were all long and fastidious operations. Although these tasks were carried out by a small number of individuals, they were not just isolated opportunist actions but rather the result of a group effort. Ditches for smelting the mineral were discovered at Roque-Fenestre, just a few hundred metres from the Pioch Farrus 4 mine (Espérou 1993; Ambert and Barge 1991). The fact that the mining site and the smelting zone were probably contemporary means that we were able to study how the different phases of the *chaîne opératoire* spanning the mining to metallurgical stage had been managed. The model we propose shows that the different phases of ore extraction and smelting were conducted in specialised areas separated from each other geographically – even if the distance between them was not that great. Excavations conducted at Roque-Fenestre show that the tools used by the metallurgists included mallets, grinders, “cupula stones”, anvils, and a bovine scapula employed as a shovel or scoop. Analysis of the contents of the ore-treatment ditch revealed a succession of stratigraphic units containing materials left over from mineralurgical operations (breaking up and crushing, sorting, and enrichment of the ore etc). The ore-treatment ditch also contained debris more or less directly linked with metallurgical activities (charcoal, slag, etc.).The nature of the sedimentation suggested that the ditch had been flooded. Other layers are more specifically composed of sand residues left over from the treatment of the ores. This ditch seems to have been a treatment area where the ore was broken up, sorted, and washed. Secondary deposits, consisting mainly of domestic refuse (e.g. pottery) and some metallurgical refuse (small pieces of slag and copper droplets) prove that a periphery activity linked with the smelting of ore into metal was conducted in the area (Bourgarit and Mille 1997). In short, the artefacts discovered at Roque Fenestre indicate that extractive metallurgical activity was practised in direct proximity to the Pioch Farrus 4 mine.

The metallurgical zone of La Capitelle du Broum at Péret

Results from the excavations now being conducted by Paul Ambert and his team on the site of La Capitelle du Broum at Péret suggest a model where the mining site was closely associated with a metallurgical zone for smelting the ores (Ambert *et al.* 2005).

The site of La Capitelle is in a favourable position; it occupies an unusually flat sector in the heart of the metallurgical and mining district of Cabrières-Péret. Various discoveries made during the excavations suggest that metallurgical activities were conducted on the site. The most important of these discoveries was the existence of hollows, some of which are rubefied and contain copper impregnations, associated with a layer of earth containing a high density of tools and residues, including slag, copper droplets and ore. It would seem that extractive metallurgy was practised on the La Capitelle site from the very beginning of the third millennium B.C. (Bourgarit *et al.* 2003a). The Neuf-Bouches mines are situated just a few hundred metres away. One of the revelations of these excavations was that there was a close association between the mining zone and the smelting area at the La Capitelle site – as at the Pioch-Farrus 4 and Roque-Fenestre sites. The existence of this link reinforces the organised and collective nature of the metallurgical activity practised by these still predominantly agro-pastoral communities of the Final Neolithic. The discovery of buildings made of double-facing dry-stone walls confirms the non-opportunist character of metallurgical activity in the mining district of Cabrières-Péret (Ambert *et al.* 2002). Although excavators have established a close link between these buildings and the Fontbouisse culture, it should be remembered that the use of stone does not constitute a chrono-cultural sign (Carozza 2005). In this particular regional context, stone architecture can also be linked with influences from the Grands Causes zone, and more specifically with human groups indirectly linked with the Treilles cultural group.

The Smelting Process at Cabrières-Péret

Hundreds of metallurgical remains, consisting of small fragments measuring on average 0.5 cm^3 were discovered during the various excavation campaigns on the La Capitelle du Broum site. Following analysis of these remains it has been possible to propose a model for the smelting processes conducted on the site (Bourgarit *et al.* 2003a; Bourgarit and Mille 2005). During the study, heated debris were first distinguished from other types of debris. The non-heated debris consisted of small fragments of quartz with little copper mineral content - indeed the low copper content probably explains why they had been thrown away. Three types of heated debris were distinguished: first, partially vitrified and low density (< 2.7) slag, secondly, fragments of matte consisting of copper sulphide with a density ranging from 2.7 to 4, and finally metallic copper droplets (fig. 6A). The elemental composition of the debris showed that the smelted ore consisted, at least in part, of tetrahedrite, a copper sulphide rich in antimony and silver $(Cu, Fe, Ag)_{12}Sb_4S_{13}$. This seems to indicate that the first Languedoc metallurgists knew how to smelt sulphide based copper ores, the exploitation of which until now, was thought to have begun much later. This discovery makes nonsense of the previously held theory that metallurgical techniques evolved slowly from the simple (native copper and copper carbonates) to the complex (sulphurated mineral)

The *chaîne opératoire* used for smelting this complex ore into metal was clearly very rudimentary. This is shown by the primitive nature of the slag (heterogeneity, partially melted mineral inclusions etc.), typical of initial metallurgical phases (Bourgarit 2007), which lead to extremely high residual copper-contents (more than 10 % in weight). The nature of the pyrometallurgical "reactors" also suggests that the processes were very simple; they were not real furnaces in the usual sense of the word, but simple bowl-shaped hollows where a fire could be lit. Does this mean that the *chaîne opératoire* was so simple that it only consisted of one stage? This indeed was suggested by the analysis of the slag pieces found in the ditches at Roque-Fenestre (Bourgarit and Mille 1997; 2001). However, following the discovery of matte fragments - a classic product of copper sulphide extractive metallurgy - around certain metallurgical hearths at La Capitelle du Broum, a second hypothesis can now be envisaged, that of a more elaborate *chaîne opératoire* consisting of a first phase where a semi-manufactured product – the matte – was produced, and then a second separate phase where the matte was converted into metal (Bourgarit *et al.* 2003a, Bourgarit and Mille 2005). This second hypothesis is reinforced by the fact that the process it describes is exactly the same as the one used during the nineteenth century A.D. on the island of Luzon in the Philippines (Zschoke and Preuschen 1932). At Luzon, once the matte had been produced, it was progressively converted into metal by repeatedly melting it in an oxidising atmosphere.

The Capitelle du Broum site is exceptionally well preserved, and this has greatly helped in the reconstitution of how extractive metallurgical activity was organised spatially. The result is that we now have a much deeper understanding of how the metallurgical process functioned in its entirety. We now know that the ore was complex, and that although it was smelted in a rudimentary way – i.e. the organisation was relatively simple and yield fairly mediocre –the activity was quite clearly an established, organised one.

Chronology of the Cabrières mining district

To conclude this section we shall now propose a chronology for the mining operations and metallurgical production conducted in the mining district of Cabrières-Péret. A chronological and cultural approach can be sketched out, based on the numerous dates established for different mining and metallurgical zones in the district. If all the dates are taken into consideration (fig. 7), the period of time covering the different occupations can be placed between the thirty-third and nineteenth century B.C. If we take the risk of working with 1 sigma and add together the probability peaks, the period of occupation of the Cabrières mining district can be limited to the millennium between 3100 and 2100 B.C. The pottery discovered on the different metallurgical sites fits in perfectly with this schema and corresponds to the Final Neolithic groups in the Hérault valley (Carozza 2005). If we keep strictly to the measurements, the most ancient occupations of the horizons of the metallurgical zone of the Capitelle du Broum at Péret and a mining debris pile at Pioch Farrus 448 can be dated to the late fourth and early third millennia B.C. We have fewer dates for the third millennium B.C., but we do have one group of dates which is concentrated in the period between the twenty-ninth and twenty-fifth centuries, and another group in the period between the twenty-fifth and twenty-second centuries B.C. The latter group concerns certain horizons at La Capitelle du Broum and Pioch Farrus 4. Given the large difference between these dates, those obtained for the Roque-Fenestre ditches differ slightly from this model - at least for one of them. Taken together, the dates indicate that the exploitation of copper resources in the Cabrières district developed over a long period, starting at the very beginning of the third millennium B.C. Dates for the twenty-third to the twenty-second centuries B.C. show however that there was a decline in metal production. On a regional level, this period coincided with a major rupture in the material culture and the ways in which the territory was occupied (Carozza 2005).

An example of domestic metallurgy: the Final Neolithic settlement of Al Claus (Tarn-et-Garonne)

Numerous copper objects corresponding to the Final Neolithic have been found in the regions of North Albigeois and Bas-Quercy (fig. 8). Most can be linked to funerary contexts, and in particular to the megalithic ensembles of this karstic zone. If we compare the distribution of copper objects found in these contexts with the distribution of copper mineralisations we see that the two phenomena can probably be related (fig. 9). The hypothesis of a regional metallurgy activity based on the exploitation of resources from the Villefranche-de-Rouergue fault has already been postulated a number of times (Servelle and Servelle 1991, Pajot *et al.* 1996), but no real proof supporting the theory had been advanced until the discovery of the Al Claus site (Carozza 1998).

One of the specific features of the open-air settlement of Al Claus in the Aveyron Valley is that numerous artefacts linked with metallurgical activities have been discovered there (fig. 10). The site consists of a group of buildings with a wooden framework, associated with combustion structures consisting of small stone-floor hearths and large circular pits filled with limestone blocks fractured by thermal shock. The pits were grouped outside the buildings and determined large open areas. The Al Claus settlement is particularly interesting since the circulation levels are well-conserved. This is shown by the objects discovered there, consisting principally of numerous potsherds showing signs of alteration resulting from heating. The fragments measure between 5 and 30 square centimetres and come principally from medium- to large-sized ovoid vessels. Nearly 1600 pottery fragments - all more or less deformed as a result of being heated - were found concentrated in a small area of several square metres around three small pits filled with combustion products. The inside surfaces of the potsherds show signs of significant alteration from heating, and in some cases bear traces of a substance resembling slag. Other objects discovered at Al Claus, including a tuyere fragment, a small mortar and several hammers indicate that the area was a metallurgical site. The date obtained for one of the hollows (3855±45 BP i.e. 2448-2175 B.C.) suggests that the site can be dated to a period of the Final Neolithic contemporary with the Bell Beaker phenomenon. It should be noted however, that no Bell Beaker objects have so far been discovered inside the settlement or in the surrounding area.

After analysing the slag residue found on the internal surface of the potsherds, we were able to describe the *chaîne opératoire* (Carozza *et al.* 1997; Mille and Bourgarit 1998), fig. 6B. The potsherds are made of clay tempered with huge quantities of quartz and micaschist, a clay identical to the one used for the domestic pottery found on the site. It would seem that the good refractory properties due to the quartz and micaschist association were fortuitous and not intentionally planned. These vessels were domestic objects, and it was only when they had become too old to be used for cooking that they were recycled and employed for metallurgical purposes. A net temperature gradient shows that the pots were heated by placing combustible material inside them. The slag residues consist of crystallised magnetite and fayalite in a vitreous gangue. This double crystallisation indicates that the temperature rose to above 1100°C. The presence of copper-iron sulphides, small nuts of copper rich in antimony or tin, and micro-globules of gold and silver, shows that the ore at Al Claus was different from the one used at Cabrières; at Al Claus, it might have been chalcopyrite $CuFeS_2$. A number of factors suggest that the clay pots found at Al Claus were used for smelting operations - and not refining activities[5]. The main argument for this is the systematic fragmentation of the pots. The latter had to be broken to extract the product of metallurgical activity – a procedure unnecessary when the metal is simply melted, but inevitable when ore is transformed into metal with the attendant production of slag.

We only understood the advantages of using a vase furnace as a smelting reactor when we conducted an experimental reconstruction of the process (fig. 11). One of the main difficulties is to provide a sufficient quantity of oxygen so that the sulphur in the mineral can be evacuated. By using a vase furnace and stirring the liquid phase with a wooden stick, the aeration can be considerably improved (Bourgarit *et al.* 2002). At the Al Claus site metallurgical production was occasional and integrated within domestic activities. Furthermore, it did not lead, as at the Cabrières-Péret site, to the development of a territory entirely devoted to mining and extractive metallurgy.

We shall now consider the case of Saint-Veran. Although this site was more or less contemporary with Al Claus, it follows a very different model, one typical of the very beginning of the Early Bronze Age.

The Bronze Age mining and metallurgical complex of Saint -Véran

The mining and metallurgical complex of Saint-Véran is situated in Haut-Queyras (Hautes-Alpes). Here, as at Cabrières, separate sites devoted to ore extraction and metallurgical activities were concentrated in the same small area (fig. 12). The numerous research studies conducted by Pierre Rostan and his team in the heart of the complex have provided a considerable amount of information concerning the mining activities of Saint-Véran, and the Pinilière rock-shelter (Rostan *et al.* 2002). Bruno Ancel's research into the history of the mining site draws attention to the complexity of the site (Ancel 1999). Hélène Barge's study of the metallurgical workshop of La Cabane des Clausis (Barge 1999) has greatly added to our knowledge of the context of protohistoric metal production in south-eastern France (Barge *et al.* 1998a; 1998b).

Mining activities and raw material

The deposits at Saint-Véran are of a sedimentary exhalative type created by submarine hydrothermal sources. They are now tilted vertically, have a pseudo-veined appearance resulting from Alpine tectonics, and are distributed over a steep slope between 2600 and 2250 metres high. Two roughly parallel veins can be seen on the surface about twenty metres from each other. The quartzites which accompany the mineralisations are spread along a distance of about one kilometre up to the Longet valley. These two veins were exploited in ancient times. The west vein is about 490 m long for a drop of 40 metres; the east vein is 650 m long for a drop of over 70 metres. The production has been estimated at about 2,000 tons of ore (Rostan *et al.* 2002).

The ore sought after was bornite (Cu_5FeS_4), a sulphide containing 63 % of copper in weight**.** Bornite from Saint-Véran has a massive form, and contains practically no macroscopic inclusions (Rostan *et al.* 2002). Native copper was found underground during modern mining

[5] Refining: Operation in which metallic copper is melted to purify it by oxidising its impurities.

works, and it was probably also exploited in ancient times. However, the nature of the metallurgical debris dating from the Bronze Age, and the *chaînes opératoires* which they imply are only related to bornite.

It is not easy to form a precise idea of the topography and extension of the mining works conducted at Saint-Véran. This is not because twentieth century mining operations modified the underground areas, but is quite simply due to the fact that many areas were filled in at some point in the past and few are now accessible. However, in the zone called "Trenches of the Ancients", a trench was opened for ore extraction (fig. 13). A group of finds related to a prehistoric mining phase, consisting of narrow extraction galleries formed as a result of the removal of ores, was found at a depth in the 'eastern" vein.

Timbering and the remains of planks used in the working of the mine or for stocking mining waste were also discovered. On the basis of a date obtained for a sample taken from a wooden beam of the eastern column, it has been possible to date these workings to the Early Bronze Age (AA.27533 3635±80 BP, i.e. 2300-1750 BC). Other dates link certain materials to later phases of the Bronze Age, *ca.* 1000 B.C.

The extraction galleries are between 1.2 and 1.5 m wide. Areas measuring no more than 40 cm wide are interspersed with others that can be up to 3 m wide. The layer of massive ore, which in certain parts reaches up as high as 20 cm, was positioned between the tender chloritoschist of the wall and the quartzite of the roof. This means that the mining was very selective with a low volume of host rock. The chloritoschists formed mining waste measuring less than a centimetre; this granulometry indicates that they had been treated mechanically. Tools adapted to each type of digging were found, including green-rock and eclogite hammers for the compact quartzite, and green-rock picks for the sulphide ore. Goat-horn picks provided with handles were used for working the chloritoschists. The pieces of larch-wood, planks and supports found on the site indicate that propping techniques were employed. Other specifically mining artefacts were discovered, such as fragments of shovels, and torches made from bunches of sticks, which were carried with a fork-like instrument.

Pierre Rostan has suggested that firesetting might have been used for attacking particularly compact quartzite, a theory backed up by the observation that thermic changes had occurred in the quartzites and that a sodic amphibole - the riebeckite associated with them - had been partially melted (Rostan *et al.* 2002).

Depth work probably stopped not because the resources of the mine were exhausted, but because the miners were unable to ensure a gravitational flow of water in the mine. The fact that there was no aquifer circulation on the surface or underground during the winter freeze probably facilitated extraction works. Metallurgical activities on the other hand were carried out in the open air during the warmer seasons of the year. During the twentieth century AD the working of the mine was organised along these lines.

The metallurgical site of La Cabane des Clausis

A number of archaeological remains linked with metallurgical activities have been discovered on the site of the old Cabane des Clausis, situated on a platform about 350m down from the mining zone (Barge 1999). The first finds - in the form of a multiphase heap consisting of charred remains (charcoal and cinders) mixed in with slag - appeared in the ruins of the

Cabane (a kind of shepherds' shelter which has since been restored). These deposits contained sandy material alternating with layers rich in combustion products. The existence of a modern foundation ditch for the Cabane des Clausis in this area meant that it has not been possible to establish the stratigraphic link between the waste materials and the combustion structure. The dates obtained for the charcoal from the deepest of these horizons are compatible with the Early Bronze Age (3760±65 BP, i.e. 2555-2029 cal. BC).

The extension of excavations to the whole of the terrace revealed the existence of a complex metallurgical site. The terrace is formed of different layers containing various quantities of combustion products and debris left over from the metallurgical treatment of the ore. In the absence of any combustion structure directly linked to this zone, the artefacts and products found on the site probably resulted more from activities such as crushing ores. The tools - consisting essentially of hammers, cupula stones and mortars - were used for ore enrichment and the crushing of slag and smelting products. The numerous fragments of clay tuyeres which were also discovered have a very particular shape: they are small, conical, and gradually become thicker and flare out at the end. They have a very small opening no more than 0.3 cm in diameter, with no apparent slag residue. Similar fragments were unearthed in the Pinilière shelter next to the protohistoric mine, and in various other places in the valley. Pottery objects, probably for domestic use and provided with a ribbon handle and fingered strips, or decorated with bands, can be linked with the Early Bronze Age. The numerous dates obtained within the archaeological horizons support this hypothesis.

Slag and the metallurgical process

During the excavation of the metallurgical zone of the Cabane des Clausis, more than a hundred kilos of slag were unearthed. Alain Ploquin analysed these fragments and made an estimate of their original shape (Ploquin 1997). They did not resemble the small heterogeneous droplets measuring a couple of centimetres found at Cabrières, but were more like flat slabs between 10 and 20 cm in diameter and between 1.5 and 2.5 cm thick (fig. 6C). These slabs are identical to the *plattenschlacke* type, which have so far only been found in the Austrian and Trent Alps from the Middle Bronze Age onwards (Bourgarit *et al.*, in press). The slabs are very dense (3.5) and contain relatively little copper (between1 and 10 %). Since they are very homogeneous and contain sodium, riebeckite might have been added as a flux. Another particularly striking feature of these slabs is that the parts in contact with the upper surface of the slag exhibit a prismatic structure (fig. 6C). This structure indicates that at the end of the smelting operation, water was thrown over the slabs to cool them as rapidly as possible. We can reasonably assume that the slag was cooled in order to free the furnace as quickly as possible so that it could be used for another smelting operation.

We thus have ample evidence that there were significant mining works at the Saint-Véran site, that the metallurgists had mastered the technique of producing slag of standardised shape and composition, and finally that they seem to have wanted to shorten the length of the operation. All these factors indicate that this district might very well be the oldest known example of large-scale copper production in Western Europe (Bourgarit *et al.*, in press).

Dating the Saint-Véran metallurgical district

Numerous dates have been obtained for the Saint-Véran mining works and the metallurgical zone of La Cabane des Clausis; we shall here only discuss those relating to the period under consideration (Barge *et al.* 1998a). Other factors suggest that attempts may have been made in the final phase of the Bronze Age and the beginning of the Iron Age to re-exploit the site. It seems that it was not possible to reach the submerged deposits with the mining techniques available. The dates obtained in different horizons on the La Cabane des Clausis site cover the period extending from the second half of the twenty sixth century B.C. to the eighteenth century B.C. (fig. 14), thus covering the whole of the Bell Beaker phase, i.e. the extreme end of the Neolithic, and the Early Bronze Age. If we add the dates and their range of probability per half century together, we find that the period between the twentieth and the twenty-fourth centuries B.C is preponderant. From a cultural point of view, objects do not help clarify our perception of the situation. The importance of the Italic region has however been underlined by Pierre Rostan and Maurizio Rossi (Rostan *et al.* 2002). The discovery of petroglyphs near Saint-Véran representing a personage and two Remedello type daggers (with a hilt, and a triangular shaped blade) are of particular interest. The Oullas shelter in the upper valley of Ubaye (Alpes-de-Haute-Provence), about 6 km from the metallurgical zone of Saint-Véran, is evidence of the important cultural influence exercised by the Italic complex. The mining site of Saint-Véran is indeed only 3 kilometres from the present border between France and Italy, and the Longet pass at an altitude of 2700 m was a wide open door to the Val Varaita (Cuneo).

The role of metal in the transformation of societies at the end of the Neolithic in France

Towards the end of the Neolithic period, in the last centuries of the fourth millennium B.C., societies underwent fundamental changes on economic, cultural and symbolic levels. Christian Strahm studied these socio-economic changes, with particular reference to central Europe, and developed a model which emphasises the role played by metal production. On the basis of techno-economic and social characteristics which may, or may not have resulted from the introduction of intensive metallurgy, he distinguished two successive stages, by proposing that a "Metallikum" stage followed the Chalcolithic stage (Strahm 1982). This approach is based in turn on an evolutionary approach assuming progressive increase in social complexity, as modelised by Anglo-Saxon anthropologists.

The same model was recently applied to describe the situation in Continental France (Strahm 2005). Strahm's definition of the Chalcolithic stage corresponds to Johnson and Earle's "Big Man" societies, whereas his Metallikum stage concerns more hierarchical societies, in which the organisation of metal production is controlled by a centralised political entity. Two features distinguish his model of the Metallikum stage: social division of labour, and a *chaîne opératoire* in which all stages, from ore extraction to metal production, are conducted on the same site. This type of social organisation can be compared with the chiefdoms of Service's model, or the elementary stage of Johnson and Earle's classification. In short, according to Christian Strahm, the passage from the Chalcolithic to the Metallikum stage signified the advent of chiefdom type societies. However, this kind of approach can only be considered valid if it is based on an analysis of *all* markers, and not just metal objects. Furthermore, as we shall try to show in the next part of this article, there are no signs that society evolved from a Chalcolithic to a Metallikum stage in the south of France; in Languedoc the Chalcolithic stage was not followed by a Metallikum stage, and there is nothing to prove that the Metallikum stage of Saint-Véran was preceded by a Chalcolithic stage.

If our analysis is to be workable, we need to re-examine the difficult question of the emergence of metallurgy in the Languedoc region. Strahm suggests that metallurgy did not appear independently in the Languedoc region, but spread there from Italy at the end of the fourth millennium (Strahm 2005); this however, poses the question of why this metallurgy "forgot" to begin during the same period in Provence, a region which had abundant copper resources and which constituted an almost unavoidable communication link between Italy and Languedoc.

Why produce, and for whom?

The introduction of metal in Continental France was predominantly symbolic and had little real impact in economic terms. Most of the metal objects discovered are personal ornaments such as beads and pendants made from a very small amount of metal. Most were found in funerary contexts and they become frequent from the end of the fourth millennium and the beginning of the third millennium B.C. in contexts dating to the Recent and Final Neolithic. Although the chronological resolution is often insufficiently precise to permit discussion of this point, it would seem that the use of metal increased in the south of France in the middle and last phases of the Final Neolithic (2800-2400 B.C.). Domestic equipment did not basically change, but copper awls and small burins were added to the range of small tools made from bone and flint. As for heavier tools, the few flat copper axes that have been found were probably not all used in a functional way. Studies of domestic contexts clearly show that most tools were still made from polished stone. Copper axes do not seem to have appeared until the last phase of the Final Neolithic, and were probably more emblematic than functional. The same can be said for daggers, which had an obvious symbolic value.

This rapid review of the subject shows that the innovation of metal consumption at the end of the Neolithic had very limited consequences. Metal objects did not replace those made from stone or bone. Copper completed the range of raw materials used in the fabrication of objects. On the other hand, the means of acquiring metal and the ways in which it was consumed were very different from those associated with stone. During the third millennium B.C., areas with no flint or other siliceous rock but which possessed copper ore resources, now had at their disposal a raw material of high "symbolic" value.

The consumption of metal does not seem to have provoked major economic and social changes in the agro-pastoral communities living at the end of the Neolithic. However, we can suppose that copper-producing regions and the human groups associated with them developed in certain specific ways. The stone material found in the Al Claus settlement (Tarn-et-Garonne) - such as the fragment of a dagger made from Grand-Pressigny-type flint - point to the existence of long-distance exchange routes. The same diversity of raw materials can be seen on a regional scale in the funerary remains unearthed in the megalithic ensembles in Bas-Quercy, some of which included metal objects. In addition to the Grand-Pressigny type blades made from Turonian flint, the raw materials suggest that contacts of varying importance and frequency existed with other regions - Aquitaine, Languedoc and Provence. Studies show that metal production on the Al Claus site was domestic and integrated with the living units, and that output was low. Metallurgical activities were conducted away from the areas directly containing the copper resources, suggesting that production was opportunist and related to medium and long-distance exchange networks for raw materials. The hypothesis of multipolar production is implied by the wide distribution of mineral-bearing zones along the Villefranche-de-Rouergue fault. In contrast, the model for the mining district of Cabrières-Péret reveals an integrated production site where zones for the extraction of the raw material were closely associated with metallurgical areas. The density of finds, even if they are admittedly spread over a long period, show the systematic nature of the exploitation of zones rich in minerals and indicate that metal was considered as having high social value. Although it was indeed part of a general phenomenon affecting the whole region, the particular cultural and economic dynamism in the middle valley of the Hérault during the phase dating from the end of the Neolithic was specific to that area. The special characteristics of the distribution of copper objects in eastern and central Languedoc show the diversity of metal consumption practices.

Notwithstanding the inherent bias of all archaeological documents, the enumeration and spatial distribution of copper objects from Languedoc presented by Xavier Gutherz and Luc Jallot gives an idea of how metal was produced and used in the region (Gutherz and Jallot 2005). The corpus for central and eastern Languedoc (the Hérault, Gard and Ardèche departments) covers more than 1,400 objects, distributed very unequally (fig. 15). Numerous objects were found on the edge of the Cévennes, with the occasional concentration of objects in certain areas, such as in the Gard caves at Rouquette in Saint-Hillaire-de-Brethmas, (59 beads, 15 awls and 1 axe), at Miguro in Corconne (402 beads) and at Enquissé in Sainte-Anastasie (1 axe, 1 awl and 125 beads). These concentrations can for once be correlated to the exploitation of local resources. On the other hand, it has to be admitted that very few objects have been found in the coastal region, and in central Languedoc around the mining and metallurgical area of Cabrières-Péret, even though production is known to have existed in these places. This difference might be due to a sampling problem, and to the fact that funerary ensembles are under-presented in central Languedoc, as mentioned, though not endorsed, by Xavier Gutherz and Luc Jallot. Although we share this point of view we feel that the small number of metal objects noted by these authors in the coastal region of eastern Languedoc is less relevant. Luc Jallot and Xavier Gutherz correlated the surface area of excavated sites with the number of objects discovered on them, and in their conclusions emphasised the significant imbalance between coastal and inland zones (Gutherz and Jallot 2005). Their conclusion however can be questioned on the ground that site surface area is not an adequate measuring value. We are simply not using the same scale of measurement when we compare results from the partial excavation of several thousand square metres of extensive flat open country in a coastal zone, with those from the intensive excavation of small dry-stone domestic units and burial pits contained within a limited space inland.

To reach a more balanced assessment we would need to take into consideration the contexts and the volume of material actually excavated. This method reduces the difference between the geographic zones under consideration, without modifying the established facts. It suggests that there were two economic models operating at the same time, one where metal production and consumption were regulated along domestic lines - such as the type described for the region around the Villefranche-de-Rouergue fault in Bas-Quercy - and a second model featuring a more centralised type of production, where ore exploitation and metallurgical activities were conducted within the same small area.

The diffusion of the metal objects produced in the Languedoc region and the southern border of the Massif Central

In the first part of this article we reviewed the two models of copper production so far identified in the South of France, *i.e.* the Cabrières model of a small specialised metallurgical mining district, and the Al Claus model featuring a site where metallurgical activities was probably more occasional and conducted inside the settlement. We also identified the types of manufactured objects produced on these sites - mainly ornaments (beads and pendants), arms (daggers), and tools (awls, flat axes). In our research we focussed particular attention on the diffusion of objects; we analysed the scale of the diffusion, and studied whether objects were produced for local consumption, or for long-distance diffusion via exchange networks, as was the case for contemporary stone objects (for example the Grand-Pressigny blades, Mallet *et al.* 2004). The social impact of metallurgical activities associated with long-distance exchange, would have been far greater than those associated with the production of objects for local use. The ability of the group to establish a network of long-distance relationships would have depended almost entirely on the quantity of copper objects they could produce. This would have been a factor leading to social complexification.

Two methods can be used to analyse the nature of diffusion: we can analyse the distribution of objects. For this we can refer to published inventories and distribution maps (Arnal *et al.* 1974; Barge 1982; Lemercier 2005; Gutherz and Jallot 2005), and we can study the elemental composition of the metal from which objects were made. The copper from which the objects were made generally contained two impurities, antimony and silver - a factor which made the identification of the copper much easier. The statistics published by Jean-Luc Espérou on this subject are very revealing (fig. 16): of the 453 objects analysed two thirds contain copper with a high content of both antimony and silver **(**Espérou 1998).

The distribution of objects produced in the South of France has rarely been compared with the elemental composition of the metal from which the objects are made. This is particularly unfortunate, since on the few occasions that the comparison has been made, the results have been very encouraging [we refer in particular to the work of Georges Costantini on the nature of metal productions of the Grands Causses (Costantini 1991), that of Benoît Mille on the provenance of Artenac beads (Mille 2008), and of Jean-Luc Espérou for his demonstration of the relationship between typology, place of discovery and metal composition (Espérou 1998)]. It is not easy to go beyond these first attempts, mainly because of the lack of detailed information in the inventories, especially concerning typology. It is nevertheless interesting to assemble, and where possible complete the available data.

In our description of the situation in northern France we referred to the question of long-distance diffusion of copper objects originating in the South of France. This diffusion occurred at a relatively late date (around the middle of the third millennium) and only concerned a small number of objects. As expected, the elemental composition of the metal from which such objects are composed parallels the typology: the majority of these objects are made of copper rich in antimony and silver (Mille and Bouquet 2004).

The middle-distance circulation of metal objects is on the other hand very surprising; the distribution map of copper beads from Languedoc and Provence is extremely instructive, for it gives the impression that the Rhône acted as an impassable barrier. Whereas thousands of beads have been found to the west of the river, only a few dozen have been discovered in Provence. There is of course the unlikely explanation that late Neolithic cultural groups in Provence were not interested in metal, but the imbalance should probably be seen more as the first indication that the distribution of Languedoc productions was essentially local.

An analysis of the distribution of objects in the zone where they were produced (Languedoc, southern border of the Massif Central and the Grands Causses) appears to corroborate this first indication.

We first turned out attention to a series of beads which have a very particular shape, for the perforation is narrower in the centre than on the periphery. Apart from 6 beads discovered in the Artenac caves at Saint-Mary in Charente (Mille 2008), the other known examples were found in the South of France. Edward Sangmeister analysed 22 beads of the type from the South of France (Sangmeister 1971). Only two of them were made from copper containing no detectable impurities; the others contained the antimony-silver combination. It is possible to locate 19 examples; these beads can be divided, both chemically and geographically, into two groups (fig. 17). The beads in the first group contain antimony-silver (with or without arsenic) and were found concentrated in the Garrigue region of the Gard and Hérault. The second group concerns a small number of beads found dispersed over the Grands Causses, containing lead as well as antimony and silver.
We learn two important lessons from this map. First, the diffusion of objects was mainly local; on the basis of the elemental composition of the metal from which they are made the two groups of beads are mutually exclusive. Secondly – and this is a logical consequence of the first lesson - we can now detect the existence of new centres of metallurgical production indirectly by comparing the maps showing the distribution of objects, with the elemental composition of the metal. This map opens the possibility of two new mining districts, apart from Cabrières. The first was probably situated in the contact zone between the garrigues of the Gard and Hérault, and produced a copper with an elemental composition which unfortunately can not be distinguished from Cabrières copper (although analysis of the isotopic composition of the lead might resolve this problem). The second district, where beads contained the triple association of antimony, silver and lead, was centred in the Grands Causses zone.

This model of metal production destined principally for local consumption has been confirmed on other sites, as brilliantly demonstrated in Georges Costantini's remarkable identification of the metal productions of the Treilles cultural group (Costantini 1991). In his study of the distribution of claw- or tongue-shaped pendant, he showed that they were only found in the Causses area. The tubular beads with a swelling in the middle are concentrated in Quercy and in south Aveyron. To further test this model, we examined available analyses concerning the elemental composition of metal for the Quercy region. The sample was composed of 32 pieces: 15 beads, 4 pins, 4 pendants, 4 flat axes, 3 buttons, 1 awl and 1 dagger. From a formal point of view, this group of objects may not be considered satisfactory for describing a regional metallurgy (non synchronous objects). However, the analysis of the impurities contained within the copper proved to be very significant (fig. 18). Antimony and silver appear almost systematically. Of course this combination is not sufficiently discriminating, since it is contained in practically all the mineralisations of the major faults and the southern border of the Massif Central. However, two other elements - arsenic and nickel – also appear in the impurities. This is very interesting, since small deposits of nickel-rich copper, formed by contact with the remains of the Palaeozoic ophiolites of the Massif Central, are to be found in the neighbouring Najac zone (Leblanc 1999). Finally, we observed that the same group of objects contained a significant percentage of lead and bismuth. This last association points to a specific late-Hercynian mineralisation, known as the Salsigne sub-type (Leblanc 1999)[6]. The results of these elemental analyses seem to indicate that objects were acquired locally. This in turn might mean that in certain cases several production centres were in competition with each other.

[6] As its name suggests, this mineralisation is above all typical of the mining sector of Salsigne (to the west of Montagne Noire). But other occurrences of this type have been observed in different sectors of the Massif Central.

There is a strong correlation in the South of France between the distribution of objects dated to the very beginning of the Metal Ages and the presence of copper resources (fig. 3); this might indicate a model where production and consumption were integrated, and where long-distance diffusion was not the main objective.

<u>The impact of metal at the end of the Neolithic in France</u>

If we pose the question of the nature of the role played by metal in the transformation of societies at the end of the Neolithic in the south of France, we are tempted to reply rather provocatively that it played no role at all! When the model proposed for the Carpathian-Balkan region is compared with the situation in the South of France, we see that the magnitude and importance of social evidence in the two regions are totally different. Once this is established, we are still faced with the question of how societies in France changed at the end of Neolithic and the role played by metallurgy in this change.
The French examples discussed in this article establish a clear distinction between metal-importing zones and those which both produced and used metal. Although the oldest metal objects discovered in France come from the Paris Basin, it is now an established fact that the consumption of metal in this area in the fourth and third millennia B.C. was principally symbolic.

In the South of France the typological features of objects - especially ornaments such as beads - reinforces the hypothesis that metal objects were produced locally in the areas where they were used. Elemental composition analyses also reinforce this theory and suggest that we should be more circumspect concerning the hypothesis that metal objects produced in the south were diffused over wide geographical areas. The same analyses point to the geographic diversity of the provenances of copper. The Grands Causses, the Cévennes, and Bas-Quercy were all cultural areas where metal objects produced locally from accessible mineralisations circulated. The very few objects circulating outside these networks were probably obtained as a result of rare exchanges.

This observation suggest that metal was of no great importance in the transformation process of societies at the end of the Neolithic.

The multiplication of regionalised production units during the first half of the third millennium B.C. could reflect the rapid diffusion of metallurgical techniques along the southern border of the Massif Central. However, the concentration of numerous metal objects within certain archaeological sites, such as the Gard caves is linked to particular local uses which did not result in copper becoming commonplace in society.

The impact of metal on the societies of the end of the Neolithic can only be seen in small regions where there was a relatively important metallurgical activity. We have shown that throughout the Final Neolithic a strong correlation exists between socio-cultural change and the exploitation of copper resources in the middle valley of the Hérault, on the borders of the mining and metallurgical district of Cabrières (Carozza 2005). This process can be seen more specifically in the way the ground was occupied, by the ranking of types of settlement and by the ostentatious role of fortifications (fig. 19 and 20). Without falling into the simplistic research trap of binary causality links, we can say that between 3200 and 2400 B.C., a complex mutation process accompanied the rationalised exploitation of copper resources in the district of Cabrières (Hérault).

During the third millennium B.C. a multipolar development of metallurgy closely integrated with cultural changes occurred on the southern border of the Massif Central. The exploitation of potential mineral deposits points to an important link between the consumption of metal objects and the presence of copper resources. This simple observation shows that metal, and even more metallurgy, played a role in the process of change within societies in this area during the Final Neolithic. This phenomenon occurred over a period of time, but did not continue to evolve after the end of the Final Neolithic.

There was indeed a decline in metal production at the end of the third millennium. Absolute chronological data are admittedly insufficient, but the few we have indicate that the mining and metallurgical sites of the Cabrières district operated until the end of the third millennium B.C. (fig. 21) and then came to a complete halt at the beginning of the Bronze Age. The dates obtained in the Alpine zone for the mining and metallurgical site of Saint-Véran (Hautes-Alpes) suggest that metal production was carried out there in the second half of the third millennium and the very beginning of the second millennium B.C. A number of arguments, including the low number of objects found in the surrounding area and the geochemical incompatibility between the ore and metal circulating in Provence, suggest that we should link the site of Saint-Véran with similar developments occurring in northern Italy rather than with what was happening at the same time in southern France. The site of Saint-Véran developed a specific, high-yield metallurgical process of integrated production, similar to the one which spread over the whole of the Alpine zone throughout the entire Bronze Age.

The increase in the exploitation of copper resources in the Alpine zone in about the twenty-third century B.C., seems to have occurred at the same time as the rapid decline in the exploitation of resources on the southern borders of the Massif Central. This displacement of the production zones reflects two phenomena. The first is related to the importance of cultural changes and points to the increasing importance of the Rhone and Alpine zones during the Early Bronze Age. The second reflects the link between metal production and consumption on the one hand, and social change on the other. The fact that there was a halt in the exploitation of mineralised zones in Languedoc and on the southern borders of the Massif Central, and that very few metal objects have been found in these regions, seems to indicate that metal no longer played as important role there as previously.

In conclusion, we need to return to the theoretical aspect of the problem, *i.e.* the role played by metal in the increasing complexity of societies.

The schema developed by Christian Strahm, and since followed by many other scholars of the Neolithic period, proposes two types of production systems: on the one hand the Chalcolithic model where production was conducted essentially by small domestic units and where yields were low, and on the other hand, the Early Bronze Age model (Metallikum), associated with more hierarchical societies, where production activities were controlled by a centralised political power.

According to an evolutionary interpretation, this schema can be used to represent the passage from the Neolithic to the Bronze Age. The schema however implies that the phenomena succeeded each other in a defined period and in the same area. Does the model remain valid when the cultural areas are not connected and the phenomena not associated in time?

The data presented reveals that an evolutionary type scenario cannot be defended with respect to France, once we distinguish production from the consumption of metal goods. In the southern half of France, the most striking phenomenon remains the development of production activity of a symbolic kind, which accompanied - but not in any monopolistic way - the stages marking the transformation of societies in the Final Neolithic (fig. 20). In the Early Bronze Age this phenomenon did not lead to a change in the way production was conducted, in other words production did not start to use new methods and improved *chaînes opératoires*. On the contrary the phenomenon led to the abandonment of ore extraction, an activity which was subsequently taken over by other cultural areas such as the Alps and the Iberian Peninsular. If we are to understand the mechanisms of change, and more specifically if we want to evaluate the issue of increasing complexity– in both technological and social domains, we need to analyse separately each of the different social, technological and environmental parameters.

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Figure captions :

Figure 1: The collective burial of Vignely, La Porte aux Bergers (Seine-et-Marne, France):
Above : A 5 year-old child wearing a copper beads necklace and a turitella pendant, © INRAP, Y. Lanchon.
Below: Detail of the necklace, © C2RMF, B. Mille.

Figure 2: The different types of copper ornaments encountered in Northern Europe at the end of the Neolithic period, from Ottaway 1973. a,b beads; c,d tubes; e,f pendants; g crescent-shaped sheet copper; h,i,j spiral rings and rings; k,l,m spiral cylinders; n spectacle spirals; o discs.

Figure 3: South of France, distribution map of copper ore resources (in black) and copper objects dating from the end of the Neolithic and the beginning of the Bronze Age (in grey). 1: Cabrières-Péret mining district (Hérault). 2: Al Claus settlement (Tarn-et-Garonne). 3: Saint-Véran mining district (Hautes-Alpes). From Ambert and Carozza 1996; Arnal *et al.* 1974; Barge *et al.* 1998a; Costantini 1984; Gutherz and Jallot 2005; completed with unpublished data.

Figure 4: Location of the main mining sites and metallurgical workshops in the Cabrières-Péret mining district (Hérault, France), from P. Ambert, infography by A. Burens.

Figure 5: Prehistoric ore extraction in the Pioch Farrus 4 mine at Cabrières-Péret. The rounded shapes are dated to the Final Neolithic. The extraction scheme is shown superimposed on the general view of the mine: extraction followed the mineralised veins in open air trenches or parallel galleries. Excavation by L. Carozza, photography by P. Druelle, infography by L. Carozza.

Figure 6: Cross section of slags dating from the Final Neolithic and the Early Bronze Age.
A: A slag typical of the La Capitelle site in the Cabrières-Péret mining district (Hérault), © C2RMF, D. Bourgarit. This slag is characterised by its low density (< 2.7), its heterogeneity and high residual copper content.
B: Slag residue adhering to the internal surface of an Al Claus potsherd (Tarn-et-Garonne), © C2RMF, B. Mille. The internal wall of the pot was partially vitrified as a result of heating. Analysis of the slag residue indicates the probable smelting of chalcopyrite.
C: Fragment of a *plattenschlacke* discovered at Saint-Véran (Hautes-Alpes), © C2RMF, E. Burger. The high homogeneity of the slag and the prismatic structure of the zone in contact with the upper surface is of particular interest.

Figure 7: Compilation of the available radiocarbon dating carried out on the different sites of the mining district of Cabrières-Péret (Hérault, France).

Figure 8: Metal objects discovered in the "Grotte du Four", Caylus (Tarn-et-Garonne, France), from Clottes 1974.

Figure 9: Distribution map of copper objects dating from the end of the Neolithic period and discovered in Bas-Quercy and along the Villefranche-de-Rouergue fault. Copper mineralisations are indicated in grey.
<u>Lot</u>: 1, grotte de Marsa, Beauregard.

Tarn-et-Garonne: 2, dolmen du Pech de la Crabe 1, Saint-Projet ; 3, Caylus ; 4, grotte du Four, Caylus ; 5, dolmen de Poussou, Caylus ; 6, dolmen de Saint-Amans, Caylus ; 7, Claus de Faret, Montalzat ; 8, Lamarre, Caussade ; 9, dolmen de Peyrelevado-Finelles, Septfonds ; 10, dolmen de Moussac, Septfonds ; 11, les Cloutets, Monteils ; 12, dolmen de la Bartalbenque, Septfonds ; 13, dolmen des fonds, Septfonds ; 15, dolmen du Frau de Cazals ; 16, dolmen de Brétou 2, Cazals ; 17, dolmen de Brétou, Cazals ;18, dolmen du Frau, Saint-Antonin-Noble-Val ; 19, dolmen de Pécoupet, Saint-Antonin-Noble-Val ; 20, grotte de la Nogairède, Espinas ; 21, dolmen du Bosc, Saint-Antonin-Noble-Val ; 22, dolmen de Cluzet à Saint-Antonin-Noble-Val ; 23, dolmen de Teulières, Cahuzac-sur-Vère ; 25, Al Claus, Varen ; 26, dolmen de Gabach, Saint-Antonin-Noble-Val.
Tarn: 24, grotte Mazuc, Penne ; 27, dolmen de la Peyre, Vaour ; 28, dolmen de Peyresseco, Roussayrolles ; 29, dolmen de la Gazelle, Vindrac ; 30, dolmen de Cayrou, Alos.

Figure 10: The Neolithic settlement of Al Claus, Tarn-et-Garonne, France, reconstruction of the smelting *chaîne opératoire*, based on the excavation data. Infography by A. Burens.

Figure 11: Scale 1 metallurgic reconstruction of the smelting activity as deduced from the metallurgical debris discovered at Al Claus, Tarn-et-Garonne, © A. Burens.

Figure 12: Location of the Saint-Véran archaeological sites.

Figure 13: The Early Bronze Age mine “Trench of the Ancients”, © C2RMF, B. Mille.

Figure 14: Compilation of the available radiocarbon dating carried out on the different sites of the mining district of Saint-Véran, Hautes-Alpes, France.

Figure 15: Distribution map of the copper objects dating from the end of the Neolithic period and discovered in Eastern Languedoc and in the *Grands Causses* area, from Gutherz and Jallot 2005.

Figure 16: Impurities associated with the copper from Neolithic artefacts discovered in the South of France, diagram drawn up following data in Espérou 1998. The number of artefacts and the corresponding percentage are indicated in brackets.

Figure 17: Distribution map of those beads which have a narrowing perforation and which have been analysed. Document drawn up following Sangmeister 1971 (for the recognition of the bead type), Junghans *et al.* 1974 (for the analyses), and Arnal *et al.* 1974 (regarding the location of the objects). The Sb-Ag group is concentrated between the Gard and Hérault rivers, while the Sb-Ag-Pb group is only found in the *Grands Causses* area, infography by B. Mille.

Figure 18: Histogram of the elementary metal composition of 32 copper objects discovered in Bas-Quercy. The density of grey is function of the number of corresponding analyses. Antimony and silver are to be found systematically. Arsenic and nickel on the one hand, lead and bismuth on the other hand are also often associated with the Sb-Ag couple.

Figure 19: Beginning of the third millennium B.C. Development of metallurgical activities and of the initiation of mining extraction in the Cabrières mines. Hierarchisation of habitat: small open units contrast with fortified settlements, infography by L. Carozza.

Figure 20: Middle of the third millennium B.C. The development of numerous fortified settlements could reflect the stage when economic competition increased and when social control over territory intensified, infography by L. Carozza.

Figure 21: Comparison of the histograms obtained from radiocarbon dating of the mining and metallurgical districts of Cabrières-Péret (Hérault) and Saint-Véran (Hautes-Alpes).