Article:

Ricci, P., García-Collado, M.I., Narbarte Hernández, J. et al. (3 more authors) (2018) Chronological characterization of medieval villages in Northern Iberia: A multi-integrated approach. European Physical Journal Plus, 133 (9). 375. ISSN 2190-5444

https://doi.org/10.1140/epjp/i2018-12233-5

Chronological characterization of Medieval Villages in Northern Iberia:

A multi-integrated approach⋆

Paola Ricci[1,a], Maite Iris García-Collado[2], Josu Narbarte Hernández[2], Idoia Grau Sologestoa[2], Juan Antonio Quirós Castillo[2], and Carmine Lubritto[1]

[1] University of Campania "Luigi Vanvitelli", Department of Environmental Science and Technology, Via Vivaldi 43, 81100, Caserta, Italy

[2] Universidad del Pais Vasco/Euskal Herriko Unibertsitatea, UPV/EHU, Department of Geography, Prehistory and Archaeology, C/Tomás y Valiente s/n, 01006 Vitoria-Gasteiz, Spain

Abstract. Defining the occupation sequence of medieval rural farming sites in Northern Iberia is complicated, since they feature low density of stratigraphic relationships and few finds and because of the intensive agricultural activities developed there during the last few decades. This paper presents the chronological characterization of the medieval village of Zornoztegi, located in the Basque Country, in the province of Alava. At this site, dwellings extend over an area of approximately two hectares and consist mainly of negative structures excavated in the bedrock. Radiocarbon dating measurements carried out on 32 samples, together with mortar optical microscopic analyses and other information obtained from stratigraphic relationships, changes in the settlement organization and the study of material culture, allowed structuring and characterizing the occupation sequence of the site of Zornoztegi. Furthermore, Bayesian statistics was used to reduce the range of the calibrated dates and to refine the chronology of the sequence.

1 Introduction

During the last fifteen years, all across Southern Europe, extensive digging projects have allowed for the first time archaeological interventions in vast areas, uncovering new typologies of archaeological sites [1]. In particular, the recovery of abandoned medieval villages has brought peasant agency into the debate and has enabled the development of an "Agrarian Archaeology" based not only on the study of dwellings, but also on the cultivated areas and field systems [2]. These approaches are useful to study the formation and development of medieval villages and the transformation of historical landscapes [3, 4]. The construction of the occupation sequences of this type of sites cannot only be based on the stratigraphic sequence. Carver [5] defined these sites as poorly stratified sites, because although they extend over large territories, there are few vertical stratigraphic relationships, and alternate empty spaces (cultivated areas) with spaces full of structures (inhabited areas). Moreover, the mechanization of agricultural practices has turned them into cultivation fields, with the consequence that, in most villages in northern Spain, primary deposits have been removed. These sites are formed from negative structures, dug directly into the rock, filled with secondary deposits, consequently to establish the correct archaeological sequence it is crucial to combine different strategies, including radiocarbon dating, geoarchaeological analysis and archaeological studies [5, 6].

Radiocarbon dating is a field of interdisciplinary research in continuous development, with a profound impact on archaeology. As pointed out in [7], radiocarbon dating is a very complex process and starts well before the measurement takes place, so it is very important to realize the various stages of the process (investigation, sampling, treatments, measurements, analysis and interpretation) as accurately as possible.

Fig. 1. General view of early medieval occupation of Zornoztegi (Álava, Spain).

The aim of the present paper is to analyse the occupation sequence of the site of Zornoztegi, an abandoned village located in the Basque Country (Spain), occupied between the Chalcolithic and the medieval period. Using a multi integrated approach, based on radiocarbon measurements, archaeological and historical records, archaeobotanical and optical microscope analyses and a Bayesian statistic model, we are able to refine the chronological sequence of the site.

2 The archaeological site

The site of Zornoztegi is located 2.5 km north of the medieval town of Salvatierra-Agurain, in the east plain of Alava, in the Basque Country, Spain. Archaeological evidence showed that the first occupation of the site dated back to the Chalcolithic. After a long hiatus, it was again occupied in the Late Roman period. Written documents prove a continued occupation until the Late Middle Ages.

The existence of the abandoned village has been known at least since the 18th century. However, only after extensive removal of upper deposits, it was possible to uncover the site and to ascertain that it was made up of modest and poorly preserved structures, mainly negative elements excavated in the bedrock. Most of them were storage pits, post holes supporting domestic structures, as well as stockades, fences, pits and other constructions (fig. 1). Trenches and drains for different purposes and several cuts of difficult interpretation were also recorded. Especially relevant were the circular pits of different dimensions, which were interpreted as silos (storage pits) for underground storage of foodstuffs [8]. Originally these silos were 1–2 meters deep but at Zornoztegi only the bottoms could be registered, rounded and with depths between 80 and 10 cm, depending on the heterogeneous impact of the erosion processes caused by recent agrarian works. Wall structures were only uncovered in the northern sector of the residential area, where the basements of two Roman dwellings and the foundations of the parish church of St. Mary —demolished during the Late Middle Ages, when the site was abandoned— were recorded.

As a consequence of the post-depositional alterations in vast sectors of the village, most of the superficial archaeological deposits were lost and with them the stratigraphic relationships, essential to establish relative dating between the structures. Moreover, the scarcity of archaeological material (for example pottery) recovered at the site made the construction of the occupation sequence even more difficult, that for these reasons, the integration of radiocarbon dating, the spatial distribution of the structures and the analysis of the single finds became essential to investigate the complexity of this site.

3 Sampling strategy

The sampling strategy for radiocarbon dating was based on two main aspects: a) the analysis of the formative processes of the archaeological record, and b) the adequate choice of organic materials for dating. In this sense, it must be noted that most of the archaeological deposits uncovered at

Zornoztegi were secondary or tertiary assemblages employed as fillings for negative structures excavated in the bedrock.

The complete inventory of the structures recorded during the excavation included 35 silos, 150 postholes and several trenches and drains of diverse nature. All of them were filled with rubbish and heterogeneous deposits when they were not used any more. Primary deposits (levels of domestic use, wall structures, collapse levels, fireplaces) were only uncovered in the northern area of the site, in particular in the sector of the church of St. Mary and in the area of the Roman occupation. The negative structures were mostly filled in with a single deposit. This denotes the clear intention of filling them quickly when they were not useful any more. The abundance of domestic waste and building materials in their inside has allowed to infer the existence of central or individual dumping grounds, probably located at the edge of the domestic units. Furthermore, in this kind of rural settlement sometimes one can find fragments of a single artefact, frequently pottery, distributed within the fillings of more than one silos, sometimes at tens of meters distance. For example, at Aistra —a contemporary settlement 5 km northeast to Zornoztegi— fragments of a single handle made of antler were found in the fillings of different silos [9]. This is the final proof of the existence of such intermediate dumping grounds. As it has been demonstrated for other similar sites [10,11], we propose, that garbage management in rural areas entailed its deposit in peripheral zones. Then, these residues were used for a number of purposes (fertilization, constructive fillings, occlusion of negative structures, etc.). As reported in table 1, four primary (levels of domestic use, structures) and 28 secondary deposits (silos, postholes, agrarian fillings, other types of fillings) were sampled.

Taking into account the complex dynamics exposed above, it was considered that the most appropriate material for radiocarbon dating were archaeobotanical remains, because they have a short lifespan. Therefore, charred seeds (20 samples) were preferred to branch charcoals (11 samples), since seeds are considered “short-lived” samples, not affected by the old-wood process [12]. In particular, in early medieval contexts wheat seeds were chosen, whilst barley was preferred for the later contexts. These decisions were based on the abundance of each species [13] during different seasons. Regarding charcoal, the selection only discriminated small firewood, so as to avoid posts, beams or other timber used in construction, which could be much older. Finally, a sample of mortar from the northern wall of the nave of the church of St. Mary was also dated [14].

4 Material and methods

4.1 Archaeobotanical analysis

Soil samples were wet-sieved at the Laboratory of Archaeology at the University of the Basque Country. The total number of samples processed was 145, which corresponded to about 9815 litres of soil. However, in the end archaeobotanical materials from only 31 contexts were chosen for radiocarbon dating based on the type of storage pit and the diachronic distribution. The flotation was carried out with meshes sized 1 and 2mm, to collect the larger fractions, and 250 and 500 microns, to recover wild species too.

Almost all carpological and anthracological remains recovered at the site Zornoztegi are charred. They were identified from the reference collection at the University of the Basque Country, which consists of modern and ancient charred materials, and comparisons with the literature [15,16]. The determination was made with a binocular lens (Nikon SMZ 1500 110 increase) in the Archaeobotany Laboratory at the University of the Basque Country. The only two species that were selected for dating were *Triticum* (wheat) and, in its absence, *Hordeum* (barley).

The anthracological remains have been identified using the collection of modern woods at the University of the Basque Country, and through wood anatomy atlases [17,18]. The determination of the wood was achieved with an incident light microscope of different increases to recognize both the transverse and longitudinal sections. Finally, for uniformity, only *Quercus* (Oak tree) samples were selected for dating.

4.2 Sample preparation protocol for radiocarbon dating

The different preparation protocols that are applied to the samples (charcoal, seed, bone, mortar), dated by radiocarbon using Accelerator Mass Spectrometry (AMS) technique, are aimed to extracting the suitable organic fraction to be dated, and to minimizing the contamination from carbon that does not belong to the sample. This operation generally consists in scratching the sample surface and, if necessary, making an observation under optical microscope. Afterwards, the sample is treated with chemical reagents. The most suitable chemical protocol needs to be chosen according to the sample material and to the fraction to be extracted and dated.

For charcoal and seed samples a simple protocol, called acid-alkali-acid (AAA) protocol [19] is applied. It consists in a series of baths in acid and basic solution: the acid solution (hydrochloric acid 1M) dissolves carbonate residues. The role of the bath in alkaline solution (sodium hydroxide 0.1M) is to eliminate humic acids. Finally, a further bath in acid is necessary to remove traces of atmospheric CO2 entered in the solution in the previous step. Then samples are dried in an oven.

Concerning mortar samples, a new protocol called CryoSoniC [20] allowing 14C dating of mortar has been developed and tested [21]. Cryo2SoniC methodology was applied to suppress the C contamination in the analysed mortar samples by means of a sequence of physical separations: cryobreaking, ultrasonication, and centrifugation. This procedure is based on the experimental observation that binder carbonates are characterized by an easily breakable structure under a series of ultrasonic attacks. This main selection criterion results from the ultrasonication allowing the isolation of the binder signal from the unburnt limestone residuals by breaking the softer binder structure and originating a suspension of fine particles characterized by a slow sedimentation velocity and, hence, easily recoverable by means of centrifuging.

In detail, the Cryo2SoniC applied procedure was the following.

1) Cryogenical breaking: mortar pieces (~ 5 g) were submerged in liquid nitrogen until the achievement of thermal equilibrium and immediately transferred into an oven at 80 ◦C for several minutes. After repeating this freezing/thawing cycle three times, the mortars were broken by gentle hammering.

2) Size selection: The produced fragments (spanning a wide range of particle size) were sieved and only particles with size below 500 µm were selected and stored in a beaker and then deionized/decarbonated water (DDW) was added.

3) 1st ultrasonic selection: After complete sedimentation (~ 12 hr), the selected powder was ultrasonicated for 10min. DDW-containing suspended mortar particles were totally removed and transferred to a Falcon centrifuge tube. This fraction of binder represents the fraction potentially affected by dead carbon contamination (*susp* sand) due to the probable presence of very fine carbonaceous grains sands entering the suspension easily and before binder particles.

4) 2nd ultrasonic selection: Residual powder, decanted on the bottom of the beaker after the first sonic attack and the total removal of *susp* sand, underwent another ultrasonication for 30min in an excess of DDW. About 30mL of water was collected by siphoning and stored in another Falcon centrifuge tube, taking great care not to induce a new suspension of the sediments. This last fraction, according to our experimental experience, represents the suspension guaranteeing accurate dating (*susp*).

5) Centrifugation: The Falcon centrifuge tube containing *susp* carbonates, and the other containing the *susp* sand fraction, were centrifuged at 8.0 krpm for 5 minutes and oven-dried overnight (80 ◦C). After removal of all contaminations, the sample then needs to be converted to the chemical form suitable for the measurements, i.e. graphite, solid elemental carbon, and for this reason samples are purified using steel cryogenic lines [22]. In order to check the accuracy, reproducibility, and induced background of our procedure, several standards (OXII, IAEA C1, IAEA C2) and blanks (Aesar graphite) were prepared following the same procedure. Graphite samples, were measured by using a NEC 3MV - AMS facilities [23]. All measurements are expressed as 14C ages calculated according to Stuiver and Polach [24] and calibrated by using OxCal v 4.3.2 [25] and the IntCal13 calibration curve [26].

4.3 Characterization of mortar

The identification of mineralogical phases and the characterization of the aggregates are an important tool to collect clues about the presence of possible dating contamination sources of mortar samples [21]. For example, the presence of recrystallized calcite plays a primary role in the accurate determination of 14C ages of the studied samples, raising the risk of rejuvenation in the case of weathering, or ageing in the case of water table interactions. Other potentially dangerous identifiable features are calcination relics and biomicritic sand usage; their presence also leads to an ageing effect on the final dating. In our case a series of analyses (i.e., OM, and SEM-EDS) were performed on mortars.

4.4 Bayesian model

To use radiocarbon measurements for chronological purposes we need to use statistical methods for data calibration. Although the calibrated data ranges are accurate estimates of the dates of the samples, their interpretation can be sometimes difficult, especially in the case of non-Gaussian probability distributions (as in the case of radiocarbon dates). A great help comes from the Bayesian statistical approach, that permits to combine experimental results coming from scientific analyses together with the knowledge of an archaeological problem (prior information), in order to give coherent interpretations [27].

Bayesian analysis has proved to be very useful in archaeological research [28]. It is applied in two different classes of study. The first is that regarding single sites, where stratigraphic information is used to constrain samples relative to one another and in groups in order to give answer at archaeological issues almost on the scale of single generations. The second class are those studies in which radiocarbon dates from archaeological phases are analysed together, in order to better understand the chronology of regions or cultures [7]. Therefore, a Bayesian model, belonging to first-class studies, was created, in order to better relate the dating results with the other archaeological indicators available. This enabled reducing the calibration ranges, as well as understanding the duration of each occupation phase.

In the specific case, in order to reduce the uncertainty ranges of single radiocarbon dating, the Bayesian model is based (a priori information) on the sequences of events and occupation phases of the site, defined by the stratigraphy and the chronology provided by pottery, as described in [13,14]. The technique used to construct the Bayesian Model is a Markov Chain Monte Carlo (MCMC) sampling and has been applied using the software OxCal ver. 4.2.4 [25].

5 Results and discussion

In table 1 phase, context, laboratory code, type of material dated, type of deposit and radiocarbon age of the samples analysed are shown. Moreover, results of the radiocarbon dates just calibrated are compared to those resulting from the Bayesian model.

Table 1. List of radiocarbon dated contexts from Zornoztegi, indicating the material analysed and the nature of the deposits the sample comes from. Radiocarbon age (BP), calibrated age (AD, unless otherwise specified) and modelled ages (AD) are also reported. In the column “Phase”, “Indet” means “indeterminate phase”. In the column “Deposit type”, “Prim” means “primary deposit” and “Sec” means “secondary deposit”. In the column “Modelled date, 2(AD)”, “N/A” means “not applicable”.

leposit" and "Sec" means "secondary deposit". In the column "Modelled date, 2σ (AD)", "N/A" means "not applicable".

Phase	Context	Code	Material	Deposit type	Radiocarbon age (BP)	Calibrated date, 2σ (AD)	Modelled date, 2σ (AD)
1	1889	DSH1114	Charcoal	Sec: Filling	3965 ± 31	2573–2434 BC (86.1%), 2422–2402 BC (3.6%), 2308–2348 BC (5.6%)	N/A
2	4119	DSH1113	Charcoal	Sec: Silo	1878 ± 28	69–220 (95.4%)	N/A
3	4277	DSH1666	Seed	Sec: Posthole	1420 ± 46	551–671 (95.4%)	604–683 (95.4%)
3	4294	DSH1663	Seed	Sec: Posthole	1365 ± 37	605–711 (90.6%), 746–764 (4.8%)	628–688 (95.4%)
3	4229	DSH1671	Seed	Sec: Posthole	1312 ± 47	638–778 (92.7%), 792–804 (1.0%), 816–823 (0.5%), 841–861 (1.3%)	636–711 (95.4%)
4a	4243	DSH1926	Seed	Sec: Posthole	1247 ± 33	677–780 (67.9%), 787–876 (27.5%)	712–881 (95.4%)
4a	1647	DSH348	Charcoal	Sec: Silo	1284 ± 18	671–729 (58.0%), 736–769 (37.4%)	701–774 (95.4%)
4a	1744	DSH341	Charcoal	Sec: Silo	1224 ± 20	695–700 (0.8%), 710–745 (19.9%), 764–883 (74.7%)	724–743 (8.1%), 764–881 (87.3%)
4a	4234	DSH1672	Seed	Sec: Dump	1221 ± 25	695–701 (1.0%), 710–745 (17.1%), 764–885 (77.3%)	712–886 (95.4%)
4a	1738	DSH340	Charcoal	Sec: Silo	1218 ± 18	721–741 (10.0%), 766–882 (85.4%)	728–738 (3.3%), 766–882 (92.1%)
4a	1302	DSA731	Charcoal	Sec: Silo	1205 ± 21	732–735 (0.8%), 769–886 (94.6%)	769–885 (95.4%)
4a	1907	DSH1103	Seed	Sec: Posthole	1166 ± 23	778–901 (82.6%), 921–952 (12.8%)	773–902 (83.2%), 921–951 (12.2%)
4a	4103	DSH1110	Seed	Sec: Silo	1180 ± 23	771–895 (92.5%), 928–940 (2.9%)	771–895 (93.0%), 929–940 (2.4%)
4a	4201	DSH1678	Seed	Sec: Silo	1168 ± 81	684–999 (94.3%), 1004–1012 (1.1%)	730–991 (95.4%)
4a	1921	DSH1108	Seed	Sec: Posthole	1171 ± 61	690–750 (9.7%), 761–959 (85.7%)	727–745 (2.2%), 761–987 (93.2%)
4a	1606	DSH350	Seed	Sec: Silo	1115 ± 29	779–789 (1.0%), 871–998 (93.9%), 1005–1012 (0.5%)	779–789 (1.0%), 868–995 (94.4%)
4a	1638	DSH346	Seed	Sec: Silo	1066 ± 18	901–921 (9.5%), 950–1020 (85.9%)	900–923 (18.0%), 951–1016 (77.4%)
4a	1745	DSH339	Charcoal	Sec: Posthole	1027 ± 18	986–1026 (95.4%)	985–1024 (95.4%)
4a	1844	DSH1105	Seed	Sec: Filling	1057 ± 33	896–928 (15.0%), 941–1026 (80.4%)	895–929 (24.9%), 940–1018 (70.5%)
4a	1662	DSH343	Seed	Sec: Filling	1086 ± 27	894–930 (30.7%), 938–1015 (64.7%)	892–1003 (95.4%)
4a	4264	DSH1929	Seed	Sec: Posthole	1033 ± 44	893–1049 (86.8%), 1085–1124 (6.7%), 1137–1150 (1.9%)	893–931 (23.8%), 937–1022 (71.6%)
4b	1903	DSH1104	Seed	Sec: Posthole	827 ± 26	1166–1261 (95.4%)	1042–1088 (95.4%)
4b	1919	DSH1107	Seed	Sec: Posthole	907 ± 25	1036–1190 (94.5%), 1199–1203 (0.9%)	1027–1102 (95.4%)
4b	1949	DSH1111	Charcoal	Sec: Posthole	987 ± 26	992–1052 (57.6%), 1081–1152 (37.8%)	1016–1062 (79.0%), 1076–1115 (16.4%)
4b	1235	DSH1112	Charcoal	Prim: Level of domestic use	954 ± 24	1023–1059 (27.9%), 1065–1154 (67.5%)	1022–1109 (95.4%)
4b	1685	DSH338	Seed	Sec: Silo	944 ± 28	1026–1156 (95.4%)	1024–1105 (95.4%)
5a	1226	DSH2399	Mortar	Prim: Wall	978 ± 40	994–1155 (95.4%)	1072–1166 (95.4%)
5a	1776	DSH1106	Seed	Sec: Posthole	969 ± 22	1018–1054 (39.3%), 1079–1153 (56.1%)	1085–1155 (95.4%)
5a	1784	DSH1109	Seed	Sec: Agrarian filling	960 ± 23	1021–1059 (31.4%), 1065–1155 (64.0%)	1085–1156 (95.4%)
5b	4404	DSH1673	Seed	Prim: Level of domestic use	895 ± 27	1041–1108 (40.3%), 1116–1214 (55.1%)	1071–1216 (95.4%)
5c	1110	DSA735	Charcoal	Prim: Level of domestic use	757 ± 16	1228–1231 (1.1%), 1245–1282 (94.3%)	1222–1280 (95.4%)
Indet	4219	DSH1676	Charcoal	Sec: Posthole	1815 ± 27	127–256 (91.9%), 299–316 (3.5%)	N/A

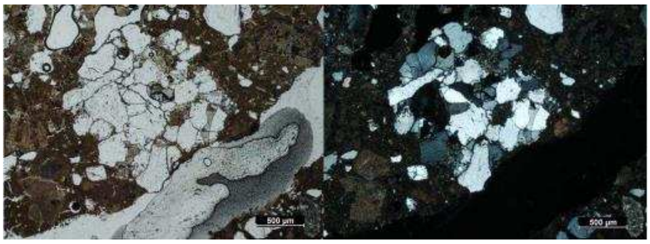

Fig. 2. Optical microscope images of mortar sample.

Table 2. Phasing of Zornoztegi.

Periods	Sub-periods
1. Large Chalcolithic domestic structure (ca. 2500 BC)	
2. Late Roman farm (4th–5th c.)	
3. Early Medieval farm (6th–7th c.)	
4. Early Medieval village (8th–11th c.)	Phase 4a, 8th–10th c.
	Phase 4b, 11th c.
5. High Medieval village (12th–13th c.)	Phase 5a, 1st half 12th c.
	Phase 5b, mid 12th–mid 13th c.
	Phase 5c, 2nd half 13th c.
6. Late Medieval abandonment (14th–16th c.)	

In fig. 2, the optical microscope images in transmitted light (parallel and crossed nicols) of the mortar sample (phase 5a, context 1226), are shown, in which the quartz nature of the aggregate is clear. Preliminary archaeobotanical results show a diversified production in order to avoid a specialization in the production of few seeds, which could put at risk the rural economy of Zornoztegi. The integration of leguminous plant and cereals, both in the summer and in winter time, is evident in particular between the 7th and 10th centuries, when the cultivation of *Triticum* (wheat) *Hordeum* (barley), *Setaria* (panic-grass) and *Panicum* (millet) became the most important taxa produced. Later, between 11th and 12th centuries, *Hordeum* cultivation seems to substitute the *Triticum* [29].

A preliminary occupation sequence was drafted based on four parameters: a) the stratigraphic relationships preserved; b) the diachronic transformation of the settlement morphology; c) the study of the archaeological finds, especially pottery; d) the dating of the single contexts by AMS. The combined use of all these indicators allowed us to identify six occupation periods ranging from the Chalcolithic to the Late Middle Ages (table 2). Unfortunately, because of the scarcity of stratigraphic relationships and the small number of archaeological assemblages found, it was not possible to establish accurate chronological limits between single periods and phases. In addition, the calibration curve for several periods of the sequence (in particular the time-lapse between the 8th and the 9th and between the 11th and the 14th centuries) is rather flat: this causes the chronological ranges obtained from the calibrations to be wide. In order to overcome these limitations a Bayesian model of calibration was built.

The Bayesian model, in its uniform-phases version, worked well because the excavation contexts were homogeneous and the stratigraphic sequence allowed establishing, with the utmost certainty, some useful bonds and discriminants to analyse the dating. These *terminus ante quem* (TAQ) and *terminus post quem* (TPQ) were essential for separating the different phases of occupation of the site. They are described in detail below, as their correct definition will condition the results of the whole model.

The boundary between periods 2 and 3 was based on two facts: i) the southbound physical movement of the residential areas, since period 3 buildings were located at the edge of the Roman occupation; ii) a clear change in the characteristics of the archaeological assemblages. Indeed, the houses of period 2 were built with mud walls on dry-stone bases and contained plenty of domestic material: pottery (especially Late Hispanic Terra Sigillata, TSHT), glass, animal bones, metals and coins. On the contrary, the dwellings of period 3 were built on postholes and the few fragments of pottery recovered from their fillings corresponded undoubtedly to the Late Antiquity and the Early Middle Ages.

The transition between periods 3 and 4 was even clearer. Indeed, there was a clustering and nucleation process of the settlement, that occupied the whole hill of Zornoztegi, covering an extension of 1.2 Ha. The changes were also evident in the material culture: many silos were organically built across the whole settlement and new types of dwellings were constructed, both on postholes and cut in the bedrock.

From the archaeological point of view, subphases 4a and 4b belong to the same phase 4, as there is a continuity in different areas of the inhabited area, but at the same time they differ from each other, because one observes the abandonment of some housing structures, the foundation of other new ones and the construction of a dump made on previous houses.

The passage between periods 4 and 5 was defined by a new change in the urban distribution of the village. The foundation of the parish church of St. Mary, north of the residential area, generated a new clustering process of the domestic units in its surrounding area and the abandonment of the residential and productive structures south of the hill. This zone was then transformed into a cultivation space by the deposition of a massive filling over the early medieval structures of period 4 [29].

Finally, the boundary between periods 5 and 6 was defined by the abandonment of all the dwellings and the progressive dismantlement of the parish church. This process must be related with the foundation in 1256 of the small town of Salvatierra, about 2.5 km south of Zornoztegi, by intervention of the King Alfonso X of Castile. The new town started absorbing the neighbouring villages as early as the second half of the 13th century, probably including the inhabitants of Zornoztegi.

The most relevant result obtained from the Bayesian model (fig. 3) was the confirmation of the chronological characterization initially hypothesised and the precise definition of the different periods extension. In particular,

1) For period 3, the results identified a very homogeneous chronological phase, beginning during the interval (552, 677) and ending within the time lapse (646, 735).

2) Period 4 started around the year 700 and extended for a long period. The Bayesian model estimated its start during the interval (680, 766) and its end during the 11th century (1032, 1116).

3) Period 5 started around the year 1100 (1047, 1136) and finished approximately two centuries later (1224, 1357).

Another important result achieved thanks to the Bayesian model (fig. 3) was the identification within period 4, which was initially very long (8th to 11th centuries), of two different phases, representing two different moments of occupation of the site. It must be noted, though, that it was not possible to extend these subperiods to all the archaeological contexts, because many of them (particularly postholes, silos and huts) were isolated and did not have stratigraphic relationships with any structure dated through radiocarbon, nor diagnostic archaeological evidence. Therefore, it was possible to distinguish phase 4a (contexts 1302, 1606, 1638, 1647, 1662, 1738, 1744, 1844, 1907, 1921, 4103, 4201, 4243, 4264) from phase 4b (contexts 1235, 1685, 1745, 1919, 1949). More precisely, the start of phase 4a could be contextualized within the interval (680, 766) and its end within the range (924, 1049). In the same way, start of phase 4b was situated within the interval (1000, 1100) and its end during the period (1032, 1116).

The start of phase 5, defined by the Bayesian model within the interval [1047, 1136], is very relevant too, since it was the moment when the parish church of St. Mary was built. This important constructive event implied the abandonment of two domestic structures (E5 and E6) from the previous period located exactly under the temple. The pottery and domestic materials found in both structures were very similar. The recovery of plenty of construction material (slabs and mortar) identical to those used in the church in the fillings of these underground structures indicates that both were contemporaneously destroyed to build the church. To date this event, a sample from an in situ level of domestic use from structure E5 (context 1235) and a mortar sample from the northern wall (context 1226) of the church were radiocarbon dated. The former gave a modelled calibrated interval of (1022, 1109), which places the use of structures E5 and E6 during the central decades of the 11th century. The later gave a modelled calibrated range of (1072, 1166) and situates the construction of the church during the first half of the 12th century.

Moreover, thanks to the Bayesian model it was possible to assign a precise chronological context to the large domestic structure E8 too. First, the radiocarbon dated postholes were assigned to phase 4a (contexts 1907 and 1921) or 4b (contexts 1919 and 1949) based on the pottery found in them. Then, the model was executed, performing excellent agreement and confirming the long duration of this structure, its reform probably along the 9th century and its abandonment during the central decades of the 11th century. The stability of this residential building contrasts with other domestic structures in the same site, which were rebuilt every one or two generations. In other sites [30, 31] the steadiness of this kind of dwellings has been considered a marker of high social status.

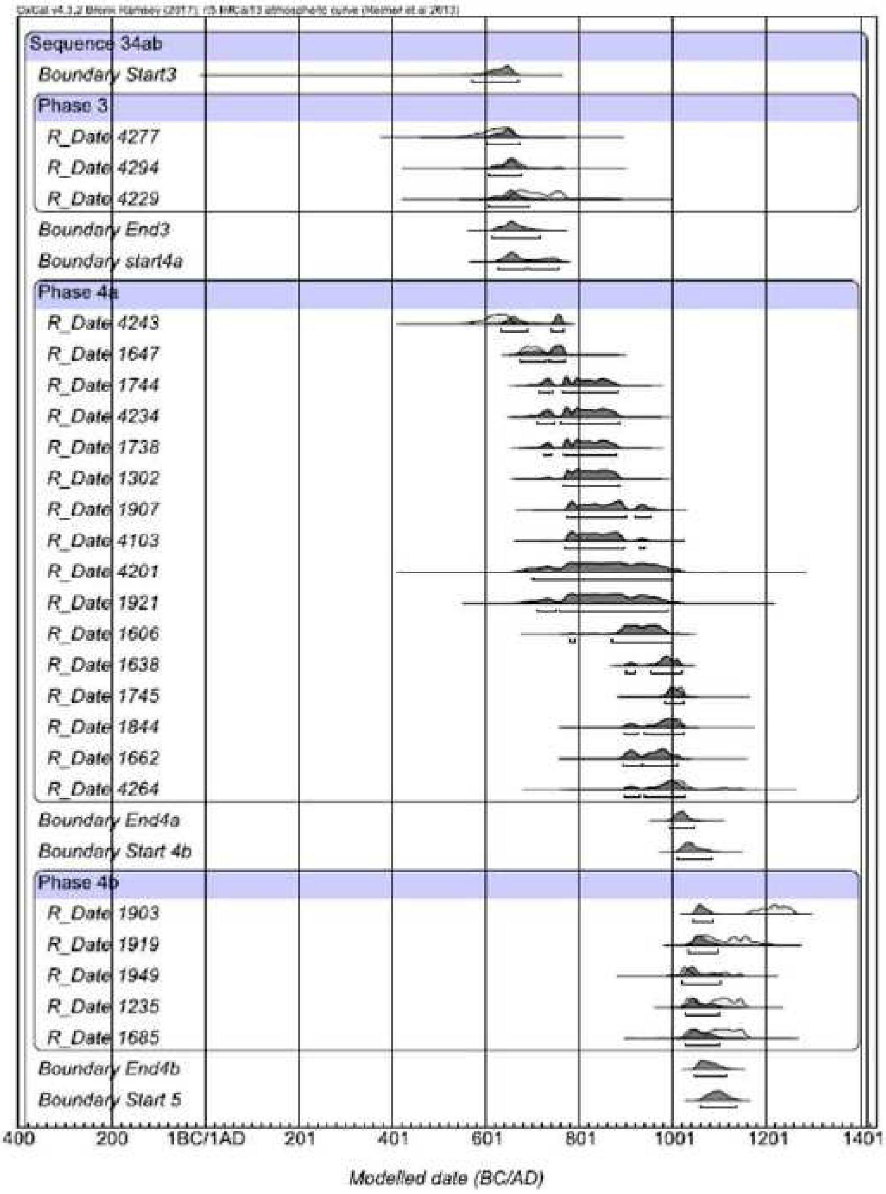

Fig. 3. Chronological characterization obtained from the Bayesian model.

Finally, the dating of the massive agrarian filling 1784 was assessed. It covered the big domestic structure E8 just analysed. Combining this stratigraphic information with the data from the radiocarbon dating of the agrarian filling itself (context 1784), a modelled calibration interval of (1085, 1156) was obtained for its arrangement. This leads to the conclusion that the functional transformation of the southern area of the site took place between the end of the 11th century and the first half of the 12th century, that is, virtually simultaneously to the construction of the church.

6 Conclusions

The application of the Bayesian statistics in the context of radiocarbon dating, allows to better define the intervals of dating, thanks to models that use in a combined way the information coming from historical, stratigraphic or typological investigations with those deriving from radiocarbon dating [31]. This method, therefore, forces archaeologists not to delegate the resolution of archaeological problems to the measuring laboratory, but, from the design of the excavation, to using an integrated approach between archaeological and archaeometric surveys [32].

However, it should be kept in mind that these models must be used carefully, depending on the type of site and its chronology, and the quality of the archaeological information acquired, with the aim of creating chronological models of remarkable precision and quality, as was done for example in British archaeological sites [27].

In particular, for medieval sites in the Mediterranean area, the generalized use of radiocarbon dating has not always come together with well-founded integrate chronological strategies, taking into account the limits and potential of the different datasets available. This is particular true for rural villages and burials without grave goods, that are among the most complex sites to date, because they are often poorly stratified and feature particular formation and post-depositional processes.

This paper presents an integrated approach to the analysis of the occupation sequence of this kind of poorly stratified sites, based on a Bayesian model built on the combination of data from the stratigraphical sequence, archaeobotanical analyses, optical microscopic measurements and radiocarbon dating. The application context was Zornoztegi, a rural site located in the Basque Country and spanning from the Chalcolithic to the Late Middle Ages. The objective was to overcome the comprehension issues of the chronology and occupation periods of these improperly so-called "non-stratified sites" [33]. In addition, these sites are commonly deeply altered by recent agricultural practices, and pottery and archaeological diagnostic materials are usually infrequent and rather fragmented. In this case, the shape transformations and the spatial articulation of the different structures set the boundaries between the archaeologically defined periods.

In the present work we succeeded in showing that, even in poorly stratified rural sites, very altered by recent agricultural practices and with a reduced number of archaeological materials, it is possible to construct a Bayesian chronological model, based on radiocarbon dates, and constraints provided from historical and archaeological information, which provide a reliable occupation sequence.

Acknowledgements

This study was supported by the project "Peasant agency and social complexity in North-Western Iberia in the medieval period" (Spanish Ministry of Economy, Industry and Competitiveness AEI/FEDER UE HAR2016-76094-C4-2R), the Research Group in Heritage and Cultural Landscapes (Government of the Basque Country, IT931-16) and the Group of Rural Studies (Unidad Asociada UPV/EHU-CSIC). MIGC is funded by the FPU PhD programme of the Spanish Ministry of Education, Culture and Sports (AP2010-5177).

References

1. J. Bofinger, D. Krausse (Editors), Large-scale Excavation in Europe: Fieldwork Strategic and Scientific Outcome (Archaeolingua, Budapest, 2012).

2. J.A. Quirós Castillo, Quat. Int. 346, 1 (2014).

3. H. Hamerow, Early medieval settlements: the archaeology of rural communities in Northwest Europe 400–900 (Oxford University Press, Oxford, 2002).

4. R. Francovich, R. Hodges, Villa to Village: The transformation of the Roman Countryside in Italy, c.400–c.1000 (Bristol Classical Press, London, 2003).

5. M. Carver, Archaeological Investigation (Routledge, New York, 2009) pp. 281–287.

6. M.B. Schiffer, Formation Processes of the Archaeological Record (University of Utah Press, Alburquerque, 1987).

7. C. Bronk Ramsey, Archaeometry 50, 249 (2008).

8. F. Sigaut, Tools Tillage 7, 3 (1988).

9. I. Grau Sologestoa, Quat. Int. 330, 97 (2014).

10. S. Foreman, J. Hiller, D. Petts, Gathering the people, settling the land: The Archaeology of a Middle Thames Landscape, Anglo Saxon to post-medieval (Oxford Archaeology, Oxford, 2002).

11. J.A. Quirós Castillo, Arqueología del campesinado medieval: la aldea de Zaballa (Universidad del País Vasco, Bilbao, 2012).

12. R.E. Taylor, Radiocarbon Dating: An Archaeological Perspective (Academic Press, London, 1987) p. 46.

13. I. Sopelana, L. Zapata, Primeros resultados de los estudios carpológicos del despoblado de Zornoztegi (Salvatierra-Agurain, Álava), in The Archaeology of Early Medieval Villages in Europe, edited by J.A. Quirós Castillo (Universidad del País Vasco, Bilbao, 2009) pp. 437–445.

14. J.A. Quirós Castillo, Arqueología de una comunidad campesina medieval: Zornoztegi (Álava) (Bilbao, 2018).

15. R.T.J. Cappers, R.M. Bekker, J.A.M. Jans, Digital seed atlas of the Netherlands (Barkuis Publishing & Groningen University Library, Groningen, 2013).

16. S. Jacomet, Identification of cereal remains from archaeological sites (Basel University, Basel, 2008) available on-line at: https://ipna.unibas.ch/archbot/pdf/.

17. J.G. Hather, The identification of the Northern European woods. A guide for archaeologist and conservators (Left Coast Press, Walnut Creek, 2000).

18. J.L. Vernet, P. Ogereau, I. Figueiral, C. Machado, P. Uzquiano, Guide d'identification des charbons de bois préhistoriques et récents. Sud-Ouest de l'Europe: France, Péninsule Ibérique et Îles Canaries (CRNS Editions, Paris, 2001).

19. W.G. Mook, H.J. Streurman, Proceedings of the Groningen Symposium 14C and Archaeology (PACT Publ., 1983) pp. 31–55.

20. F. Marzaioli, C. Lubritto, S. Nonni, I. Passariello, M. Capano, F. Terrasi, Anal. Chem. 83, 2038 (2011).

21. C. Lubritto, P. Ricci, C. Germinario, F. Izzo, M. Mercurio, A. Langella, V. Salvatierra Cuenca, I. Montilla Torres, M. Fedi, C. Grifa, Measurement 18, 362 (2018).

22. F. Marzaioli, G. Borriello, I. Passariello, C. Lubritto, N. De Cesare, A. D'Onofrio, F. Terrasi, Radiocarbon 50, 139 (2008).

23. F. Terrasi, N. De Cesare, A. D'Onofrio, C. Lubritto, F. Marzaioli, I. Passariello, D. Rogalla, C. Sabbarese, G. Borriello, G. Casa, A. Palmieri, Nucl. Instrum. Methods Phys. Res. B 266, 2221 (2008).

24. M. Stuiver, H.A. Polach, Radiocarbon 19, 355 (1977).

25. C. Bronk Ramsey, Oxcal software version 4.3.2., http://c14.arch.ox.ac.uk/oxcal/OxCal.html (2017).

26. P.J. Reimer, E. Bard, A. Bayliss, J. Warren Beck, P.G. Blackwell, C. Bronk Ramsey, C.E. Buck, H. Cheng, R. Lawrence Edwards, M. Friedrich, P.M. Grootes, T.P. Guilderson, H. Hafildason, I. Hajdas, C. Hatt´e, T.J. Heaton, D.K.L. Hoffmann, A.G. Hogg, K.A. Hughen, K. Felix Kaiser, B. Kromer, S.W.

Manning, M. Niu, R.W. Reimer, D.A. Richards, E.M. Scott, J.R. Southon, E.A. Staff, C.S.M. Turney, J. van der Plicht, Radiocarbon 55, 1869 (2013).

27. A. Bayliss, World Archaeol. 47, 677 (2015).

28. A. Bayliss, C. Bronk Ramsey, Pramatic Bayesians: a decade of integrating radiocarbon dates into chronological models, in Tools for constructing chronologies: tools for crossing disciplinary boundaries, edited by C.E. Buck, A.R. Millard (Springer, London, 2004) pp. 25–41.

29. J.A. Quirós Castillo, C. Nicosia, A. Polo-Díaz, M. Ruiz del Árbol, Quat. Int. 346, 56 (2014).

30. H. Hamerow, Siedl. Küstenforsch. Südlichen Nirdseegebiet 33, 59 (2010).

31. J.A. Quirós Castillo, Arqueol. Arquitect. (2017) https://doi.org/10.3989/arq.arqt.2017.019.

32. A. Bayliss, Radiocarbon 51, 123 (2009).

33. R. Aboal Fernández, X.M. Ayán Vila, F. Criado Boado, M.P. Prieto Martínez, M. Tabarés Domínguez, Trab. Prehist. 62, 165 (2005).