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The time of callaïs: radiocarbon dates and Bayesian chronological modelling

Bettina Schulz Paulsson, Serge Cassen, Carlos Rodríguez-Rellán, António Faustino Carvalho, Jean-Sebastien Vaquer, Miguel Molist Montaña, Josep Bosch Argilagós, Mònica Oliva Poveda

Abstract. Research on the provenance of rare green stone materials has produced new insights into the value systems of societies in western and central Europe between the 6th and 3rd millennia cal BC. This contribution presents the results of a Bayesian statistical analysis of 406 current available radiocarbon results from variscite and turquoise (*callaïs*) contexts in Europe, along with the results of provenance analyses, undertaken to investigate the fine-grained temporal pattern for the exploitation, circulation and deposition of *callaïs* artifacts.

Keywords: radiocarbon dates, Bayesian analysis, *callaïs*, variscite, turquoise, Europe.

Résumé. Les recherches sur la provenance des matériaux rares en pierre verte ont permis de mieux comprendre les systèmes de valeurs des sociétés d'Europe occidentale et centrale entre le VIe et le IIIe millénaire av. J.-C. Cette contribution présente les résultats d'une analyse statistique bayésienne de 406 résultats radiocarbones actuellement disponibles concernant des contextes de découverte de variscite et de turquoise (*callaïs*) en Europe, accompagnés des résultats d'analyses de provenance, entrepris pour étudier le schéma temporel détaillé de l'exploitation, de la circulation et des dépôts d'objets en *callaïs*.

Mots-clés : datations radiocarbones, analyse bayésienne, *callaïs*, variscite, turquoise, Europe.

Introduction

Recent provenience studies on *callaïs* and on artefacts of Alpine jades have produced new insights into the movement of these rare green minerals and the value system of Neolithic and Chalcolithic societies in western and central Europe. We used a Bayesian statistical approach and 406 current available radiocarbon results from variscite and turquoise (*callaïs*) find contexts in Europe, along with the results of provenance analyses, to investigate the fine-grained temporal pattern for the exploitation, circulation and deposition of *callaïs* artifacts [tabl. 1]. In a first important step, we critically reviewed these 406 dates, obtained from the 1960s to the present, assessing their quality and the reliability of the sample contexts. Several of the sample materials are problematic from a scientific point of view. Charcoal and wood samples have the possibility of an inbuilt age; human bone can be enriched with older carbon, if marine or riverine resources were an important part of the diet. Moreover, contamination of sample material could not be excluded for early radiocarbon dates, with insufficient or inadequate pre-treatment procedures. We classified the sample contexts according to their reliability and the stratigraphic relationship between the sampled material and the *callaïs* beads. Contexts were deemed to be reliable (“strong”) if there was a clear, direct relationship with the beads, as in the case of a bone from a single individual buried with *callaïs* beads. “Medium” contexts were those with a vertical or horizontal proximity, as in the case of dated human bone from a collective burial with successive interments, with *callaïs* beads present. Data from these contexts do not necessarily reflect the deposition of the greenstone artifacts and require some extra discussion. Finally, “weak” contexts exhibited no clear direct relationship with the beads. We therefore focused on analyzing radiocarbon dates from *callaïs* contexts rated as having a strong or medium reliability.

To build a chronological *callaïs* sequence that is as precise as possible, we adopted a Bayesian modelling approach using the program OxCal 4.1 (Bronk Ramsey, 2009a, b) and the IntCal09 calibration data (Reimer *et al.*, 2009). The Bayesian statistical method is now a well-established way to constrain the scatter

inherent in calibrated calendar dates, thereby tightening the chronology. We combined the radiocarbon dates with the archaeological information relating to stratigraphic contexts, associated cultural material, burial rites and funerary architecture. For some of the sites with available radiocarbon results and a suitable sequence we constructed single-phase or multi-phase models with phase boundaries. For the investigated regions of northern and southern France, Catalonia, western Spain and Portugal we established sub-regional multi-phase models, taking into account the culture-historical classifications of the incorporated sites. The results of Bayesian-modelled dates are given after convention in italics.

Most of the data employed here have been collated from research literature, some of it still unpublished or of variable quality in its presentation. Yet the available radiocarbon dates for *callaïs* contexts in Europe and the chronological models that we have produced allow us to discern trends in use, and to reconstruct a scenario for the exploitation and circulation of this precious greenstone mineral between 5500 cal BC and 2000 cal BC.

Northern France

For northern France we have analyzed 34 radiocarbon dates from 13 sites. Most of these dates have been obtained from graves containing variscite or turquoise beads (*callaïs*). The relation between the *callaïs* and the dated event is more or less reliable, as discussed further below. There are, however, general problems in dating funerary contexts – especially in north-west France – that must be considered. This region exhibits a distinctive sequence of Neolithic funerary monuments and an exceptional peculiarity and diversity of megalithic architecture. Many of these monuments are composed of multi-phased structures, which were renewed and extended over centuries, and organic material was frequently mixed up due to these secondary building activities. Settlement structures under grave monuments are common. For Brittany, there is very little bone material preserved in the acidic soil of the region. This makes it hard to determine when monuments were constructed and used, and when the *callaïs* was deposited. Most of the sample material is represented by unidentified charcoal with all its methodological problems, such as an inbuilt age and uncertain taphonomy. In west central France, there are other problems in using dated bone material from possible ossuaries to create a chronological classification of the monuments and of *callaïs* deposition in them (Schulz Paulsson, 2017, p. 85-87).

The earliest evidence for *callaïs* use in northern France comes from its easternmost part, at Plichancourt, Marne. Les Monts is an early Neolithic pit burial which contained one variscite pendant. Associated human bone has been dated to *5199-4847 cal BC (95.4%; 5076-4856 cal BC, 68.2%)* (fig. 6). The source for this variscite has been determined, with high reliability, as Encinasola in Spain (Herbaut, Querré, 2004, and see Querré, this volume).

The earliest reliable radiocarbon dates for *callaïs* contexts in north-western France fall some centuries later, and come from the Carnac mounds of Mont Saint-Michel, Er Grah and Tumiac. The construction sequence for the tumulus Mont Saint-Michel, as based on excavation reports of the 1860s and 1920s (Galles, 1862; Le Rouzic, 1932; Schulting *et al.*, 2009, p. 10), features as its initial phase a small, above – ground closed chamber, wholly dry stone – built, located under the centre of the eastern mound. To the south of this main chamber another small, but accessible, empty chamber is located. Either the main chamber or both chambers were first covered by a circular stone cairn and then by an elongated tumulus, before the whole structure was incorporated within the massive earth and stone mound which is visible today. In the eastern end of the final mound, a small north-east-oriented passage grave is located. Hearths and smaller stone structures attest to activities which took place on the site before the construction of the first elongated tumulus and the final mound. Furthermore, from Le Rouzic's excavations, a series of 21 smaller stone so-called cists around the two central chambers is recorded (Le Rouzic, 1932). From the chambers and these "cists" came small fragments of calcined bones. The bones from the main chamber

were identified as being human, while those from the cists are the remains of ruminants (Boujot, Cassen, 1998, p. 113; Schulting *et al.*, 2009, p. 770). In the whole complex, altogether 127 variscite artifacts have been found, of which 110 beads and pendants came from the central drystone-built chamber. The dating of the whole building sequence is insecure, with only five radiocarbon results. Four of the samples for radiocarbon dating were obtained from the central drystone chamber, with the fifth coming from the final mound. Two of the results from the main chamber were obtained from the same cremated human bone (namely GrA-20197, 5780±45 BP and UB-6869, 5845±38 BP) (Schulting *et al.*, 2009, p. 773). Combined, they indicate a calibrated date of 4777–4585 cal BC (95.4%; 4722–4616 cal BC, 68.2%) (fig. 1) The other two results from the chamber derive from single-entity charcoal samples. One is 4667–4363 cal BC (AA-42784; 5665±54 BP, 95.4%; 4580–4403 cal BC, 68.2%, Pétrequin *et al.*, 2002). The other, due to its excessively large standard deviation, is effectively unusable (SA-96; 5720±300 BP, Delibrias *et al.*, 1966). Since the main chamber is not accessible and the burial had been a single act, one should not expect a younger determination of the charcoal than for the bone samples from the main chamber, but there is a gap of around 200 years. Therefore, either this charcoal intruded into the chamber during the building of the first tumulus, or else the bone sample is contaminated. Therefore, it is not possible to demarcate the date of this first phase of activity, namely the burial and the deposition of the large callaïs in the main chamber, more precisely than 4777–4363 cal BC (95.4%; 4585–4403 cal BC, 68.2%). The latest result, obtained from a sample from the eastern passage grave filling, 4339–3631 cal BC (95.4%; 4235–3715 cal BC, 68.3%, GSY-89; 4980±150 BP) (Coursaget *et al.*, 1966; Cassen *et al.*, 2012) (fig. 1), relates to the later construction of the final mound and the passage grave.

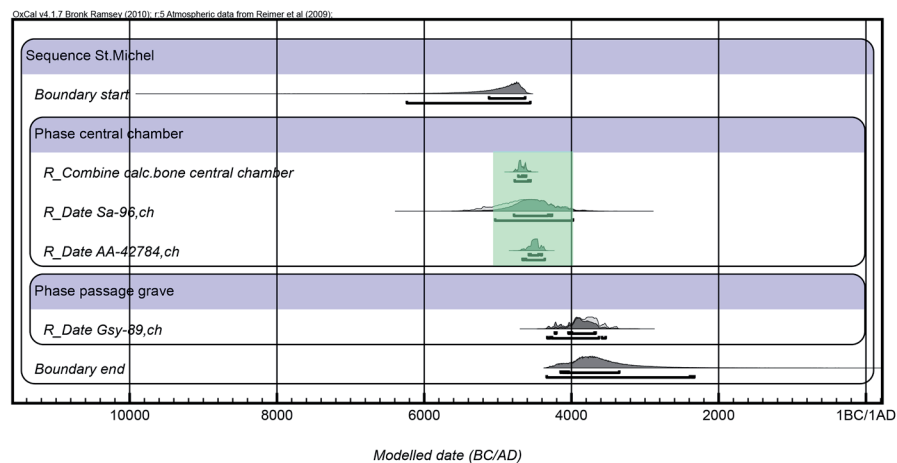


Fig. 1: Probability of the radiocarbon dates from the Carnac mound of Saint Michel in Carnac. Model agreement: Amodel: 95.4, Aoverall: 96.7.

Along with the Table des Marchands, the Grand Menhir, and the now-disappeared alignments of standing stones, the Carnac mound of Er Grah forms part of a cluster of Neolithic monuments in Locmariaquer, in the Morbihan (Le Roux *et al.*, 2006; Cassen *et al.*, 2009, p. 741-765). The 140m long, north-south-oriented monument was constructed in at least two phases and under the tumulus, a pre-monument settlement layer is documented, containing charcoal and Castellar-style artefacts (Cassen *et al.*, 2000, p. 327; 2009, p. 744) (figs. 3.23, 3.24). There are eight radiocarbon determinations available, some of which relate to this settlement layer under the tumulus and its immediate environs (Le Roux *et al.*, 2006, appendix; Cassen 2009, p. 751). Two radiocarbon results from organic residue – extracted from a Castellar sherd recovered at the level of the settlement surface under the tumulus (Lyx 56 (OxA), 4885±65 BP; Lyx 55 (OxA), 5650±50 BP) were excluded from the model. The method used to obtain these dates was experimental at the time.

The radiocarbon measurement exhibits either a « modern » intrusion or the method was not adequately developed. Another sample from the outer pavement was likewise excluded (Gif-7691; 5250±70BP), to keep the model constrained to the monument. The termini post quos radiocarbon results from the pre-monument activities hint at a time interval spanning at least 5461–4721 cal BC (95.4%; 5330–4790 cal BC, 68.2%) (fig. 2). The presence of lithic material belonging to the Châtelet arrowhead horizon, and a sample from a hearth (3) dated to 5461-5030 cal BC (95.4%; 5330-5070, 68.2%) are further evidence for an early Neolithic occupation of the place. Hearth 3 was cut by pit e4, which contained an ox bone which has been dated to 5036-4721 cal BC (95.4%; 4954-4790 cal BC, 68.2%). Stratigraphically, the pit is associated with the monument, as confirmed by the presence of material in the pit fill such as a middle Neolithic arrowhead and, in the upper fill, a complete Castelleic pot – a unique feature in the entire site (Le Roux, 2006, p. 192). Given this evidence, the ox bone clearly represents intrusive material, rather than dating the monument’s construction to the early 5th millennium, as had formerly been proposed (Cassen, 2009, p. 744).

In the northern part of the monument, a drystone chamber with 1m high side walls, a megalithic capstone and an entrance structure was documented (Boujot, Cassen, 1998, p. 112; Boujot, Cassen, 2000, p. 64; Le Roux, 2006). The monument was re-excavated in the eighties (Le Roux, 2006) and this investigation revealed anew the complexity of the building sequence. The grave chamber was covered by a round tumulus with a short entranceway, which was infilled either directly after the burial of the chamber’s occupant or somewhat later, in order to prevent the grave from being accessible. According to the excavators’ interpretation, the grave chamber, the round mound and the trapezoidal cairn represent a single phase of construction, Phase 1, with all the elements being built at the same time. Thus, the round tumulus just represents one part of this initial phase of construction. This phase is associated with early Castelleic material. In the chamber, a variscite pendant was found. The excavators have attributed two radiocarbon dates to this phase, but neither of the dated samples originated in the chamber. These two dates (hearth C, 1 A-8916, 5760±70BP and pit e13, A-8915, 5495±60BP) together calibrate to 4692-4269 cal BC (95.4%; 4603-4338 cal BC, 68.2%) (fig. 2).

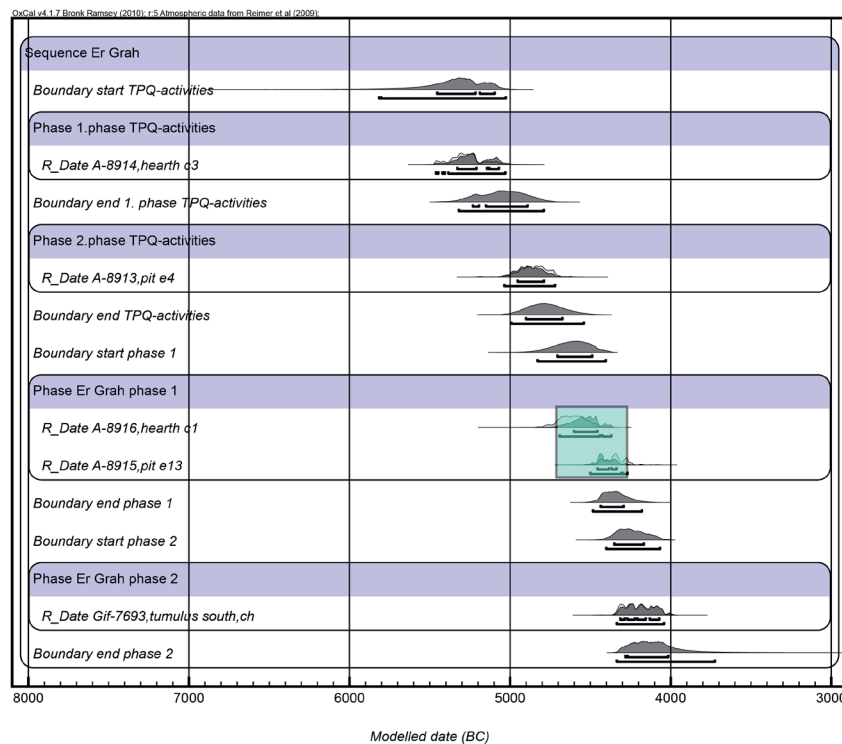


Fig. 2: Radiocarbon determinations from Er Grah. Model agreement: Amodel=79.2, Aoverall=80.1.

The building sequence of the circular Carnac mound of Tumiac (or Butte de César) near Arzon in the Morbihan is easier to understand. Tumiac is a monument with approximately 50m diameter and, at present, 15m high. The eastern part of the tumulus covered a cist measuring 3m x 2.4 m, mostly constructed from stone slabs but with drystone walling in its eastern third and at its entrance. The cist was closed and then covered, first by a round or a semi-circular stone cairn, and then by a final round earthen tumulus with no indication of any entrance or passage (Fouquet, 1862; Galles, 1878; Le Rouzic, 1935; Herbaut, Querré, 2004, fig. 3). According to the 19th century explorations (Malaguti, 1862; Cassen, 2011, p. 8), human remains belonging to one adult individual were discovered in the chamber. Accompanying this individual was a remarkable amount of jade and fibrolite artifacts and, with 251 *callaïs* beads and pendants, this constitutes the richest assemblage of stone grave goods in the Morbihan region. Four new radiocarbon dates are available, thanks to the European JADE2 research programme, directed by P. Pétrequin with E. Gauthier. One of these was obtained from a secure context, namely the wooden floor of the chamber. However, because this floor had been constructed using massive oak planks, we need to take into account the possibility of a significant old wood effect. We assumed an offset of 300 years (N(10, 300)), (fig. 3), which is the average for massive oak. The other two dates are from samples positioned quite close to each other and originating from sediments close to the chamber. From these dates, and assuming that the construction of the grave chamber and the burial of the individual occurred at the same time (or at least with no significant interval), the deposition of the *callaïs* is estimated to date to 4485-4332 cal BC (95.4%; 4450-4357 cal BC, 68.2%) (fig. 3).

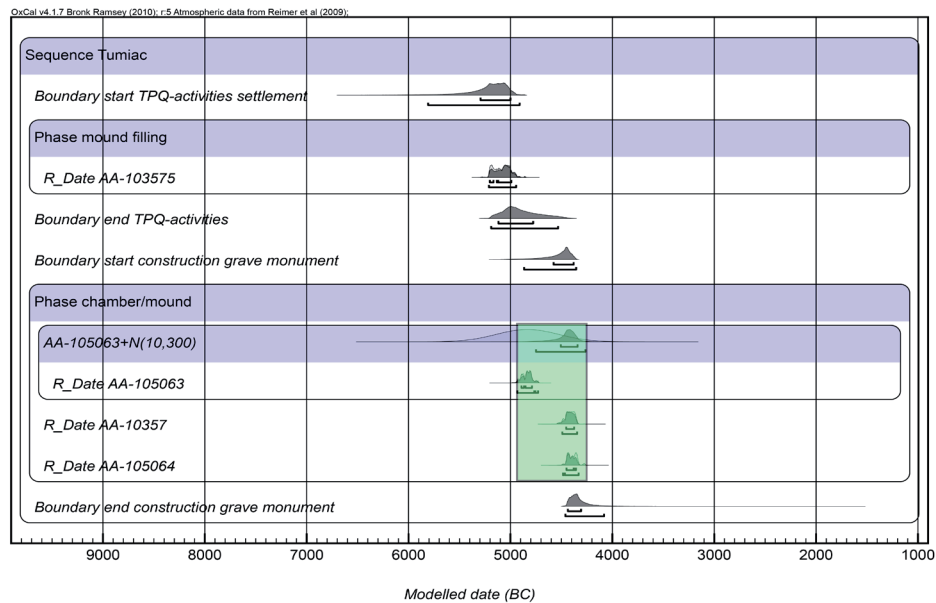


Fig. 3: Radiocarbon determinations from Tumiac. Model agreement: $A_{\text{model}}=84.6$, $A_{\text{overall}}=85.3$.

Contemporary with the Carnac mounds, there is a reliable context with variscite from north-east France, Replats at Aime, Rhône-Alpes (Cassen *et al.*, this volume). The cist contained one variscite bead. Two radiocarbon dates from human bones (Gely, 2005) suggest a date of 4585-4343 cal BC (95.4%; 4499-4368 cal BC, 68.2%) (fig. 6).

There are possible indications of an earlier use of *callaïs* artifacts in north-west France, in the form of earlier radiocarbon dates. However, none of these dates comes from a secure context, and in some cases there are additional problems with the poor quality of the dates. A variscite bead is documented from a pre-monument layer under the passage grave of Table des Marchands. There is just one radiocarbon

date available to date this layer (Ly-13083; 5930±45BP). This is from the foundation pit for the back stone of Table des Marchands (TDM)-a stele that had been erected prior to the passage grave and was subsequently incorporated into it: 4933-4714 cal BC (95.4%; 4846-4727 cal BC, 68.2%). A second date (Gif-7555; 5040±70BP) comes from a sample located outside the chamber (hearth F3, which is contemporary with the TDM cairn): 3971-3667 cal BC (95.4%; 3946-3774, 68.2%) (cf. Schulz Paulsson, 2017, fig. 3.41).

The passage grave of Kercado in Carnac contained 156 variscite beads. One radiocarbon date gained from a charcoal sample, unidentified as to species, is available, but it has a very large standard deviation: 5840±300 BP (SA-95, 5464-4055 cal BC, 95.4%; 5048-4368 cal BC, 68.2%).

The Petit Mont, a complex structure with several construction phases, is located further to the south in Arzon on the Rhuys peninsula (Lecornec, 1987, 1994; Giot, 2007, p. 107; Cassen, 2009, p. 752). Today, the final stone cairn measures 60m x 46m and is between 6m and 7m high. In its initial stage, a long and low mound was erected. The tomb associated with this mound has not been identified, so there is no access to it. The next phase is represented by a trapezoidal stone tumulus (cairn I). The tomb associated with this mound has not been excavated either, but its position is nevertheless visible from the top of the cairn; it had collapsed (Cassen, 2009). The third structure is a round stone cairn which covers at least two tombs, each orientated to the east (passage graves II and III). Altogether, 11 radiocarbon determinations from charcoal samples are available (Lecornec, 1994; Cassen, 2009, p. 752, fig. 3.44) (fig. 4). One radiocarbon result from the initial long barrow or tertre is calculated to c. 4420 cal BC (Gif-6844, 5650±70 BP; 4428-4348 cal BC, 68.2%; 4515-4333 cal BC, 95.4%). Since there is also a date from the old ground surface of c. 4530 cal BC (Gif-6846, 5600±70 BP, 4547-4427 cal BC, 68.2%; 4679-4387 cal BC, 95.4%), it is likewise possible that this charcoal originates from the pre-monument layer. A series of seven radiocarbon determinations is available from chamber II, passage II, passage IIIB, and from the eastern façade of the final mound. The construction of grave II, which is the earliest passage grave of the complex according to Lecornec (but not proven by the stratigraphy), is dated to 3944-3798 cal BC (95.4%, 3887-3817 cal BC, 68.2%). One result is available from the passage IIIB, indicating construction or use of grave III at 3882-3777 cal BC (95.4%; 3847-3803 cal BC, 68.2%). The date for a charcoal sample from the eastern façade suggests activities at the final tumulus cairn III c. 3670 cal BC (3760-3639 cal BC, 68.2%, 3808-3536 cal BC, 95.4%) (fig. 4). Chamber II produced clear Auzay-Sandun material, as did the entrance of IIIB, while from chamber IIIA only Late Castelic material was found, such as the fragment of a footed cup (*coupe-à-socle*) (Lecornec, 1987, fig. 21 to 25). A sequence of Auzay-Sandun to Castelic would be quite contradictory to the regional ceramic chronology. Thus, doubt is cast on Lecornec's hypothetical building sequence. Three variscite beads were found in chamber IIIA during the excavation by Galles and Cussé in 1865, and four further beads were collected during Lecornec's excavation; the variscite pendant was discovered behind chamber IIIA, at the base of the cairn I façade.

Further to the south and in the west part of Saint-Nazaire in Loire-Atlantique, four radiocarbon dates from charcoal samples from the grave complex Dissignac are at our disposal (L'Helgouach, 1990). A pre-monument layer is documented, with Middle Mesolithic and Early Castelic material (Cassen, 2004; Cassen, 2009, p. 755) and a variscite bead. Three of the dated samples originate from the pre-monument layers and are dated to 6230-3973 cal BC (95.4%; 5589-4274 cal BC, 68.2%) (fig. 6).

A later passage grave complex with radiocarbon dates and *callaïs* artifacts is Ile Carn in Ploudalmézeau (Giot, 1987, 2007, p. 42; Giot *et al.*, 1998; Sparfel, Pailler, 2009, p. 205-209). Ile Carn is a structure with three passage graves under a stone tumulus. Three variscite beads were found in a mixed burial layer with secondary depositions in the northern grave. Four radiocarbon dates, three of them with large standard deviations between ±150 and ±250, are available. One charcoal sample from the central chamber (Delibrias *et al.*, 1970, p. 431) provided a radiocarbon result of 4313-3811 cal BC (95.4%; 4226-3965 cal

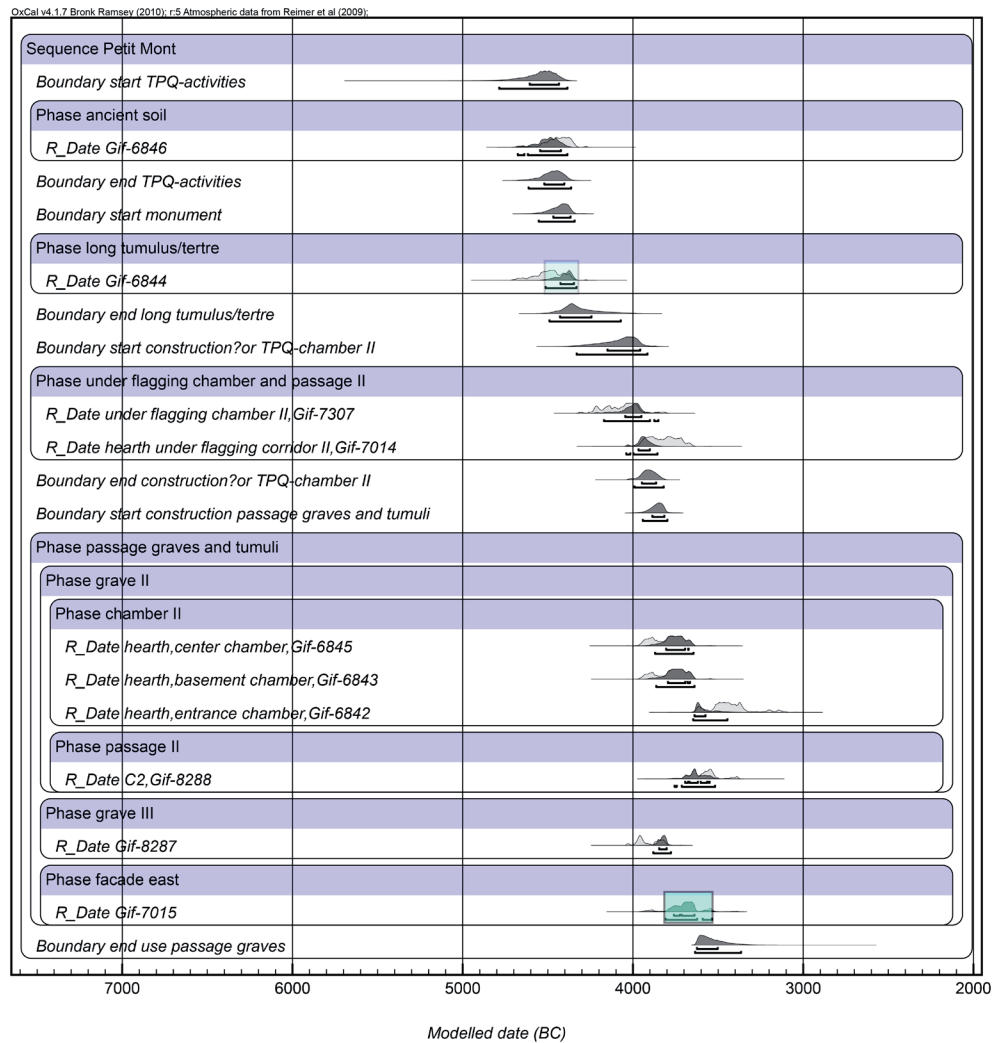


Fig. 4: Probability of the dates from the Petit Mont in Arzon. Model agreement: $A_{model}=74.4$, $A_{overall}=77.8$. The variscite artifacts are associated with passage grave III and possibly with the earlier long barrow/tertre.

BC, 68.2%; Gif-1968, 5230±75 BP) (fig. 6).

The chronology of the *callais* contexts in west-central France is even more complex and needs some closer consideration. We have radiocarbon dates from human bones from graves associated with variscite objects in the cemeteries of Les Chiron/Bougons, in Bougon. There is evidence, however, that these graves served partly as ossuaries (Chambon, 2003 ; Schulz Paulsson, 2017, p. 71-75), and because of that, the dates from the human bones cannot be taken as an indication of the construction of the graves or the use of the variscite found in them. The cemetery of Les Chiron/Bougons in Bougon near La-Mothe-Saint-Héray in Deux Sèvres comprises six monuments, A–F. These complexes, partly built in several phases, are round or long stepped drystone cairns, with altogether eight passage graves and two closed graves (Mohen, 1986; Mohen, Scarre, 2002). Variscite beads were found in chambers E1 and F2. The radiocarbon date from chamber E1 (Ly-966, 5800±230 BP) comes from one of the contexts that has been described as an ossuary. Moreover, it suffers from a large standard deviation and its use in dating the deposition of the variscite beads is therefore limited. The first stage of monument F is represented by the drystone passage grave F0 built at the southern end and covered by a round cairn. The monument was then possibly extended to the north with the megalithic passage grave F2 at its northern end. There are two dates from the megalithic passage grave F2 at the northern end of monument F: 4224–3289 cal BC (95.4%; 3894–3409 cal BC, 68.2%; Ly-967, 4790±220 BP) and 3941–3188 cal BC (95.4%, 3652–3352, 68.2%, Ly-968, 4440±230 BP) (fig. 5, fig. 6).

One result is available from a quarry on the level of chamber F2: 4362–4052 cal BC (95.4%; 4346–4174 cal BC, 68.2%) (fig. 5, Schulz Paulsson, 2017, p. 71-75). This is contemporary with the earliest of the later individuals in chamber F0 and it offers a possible construction date for chamber F2. The finds from the chamber comprised middle Neolithic Chasséen and late Neolithic material (Mohen, Scarre, 2002, p. 94).

Later *callais* occurrences are documented within the gallery graves of northern France. Radiocarbon

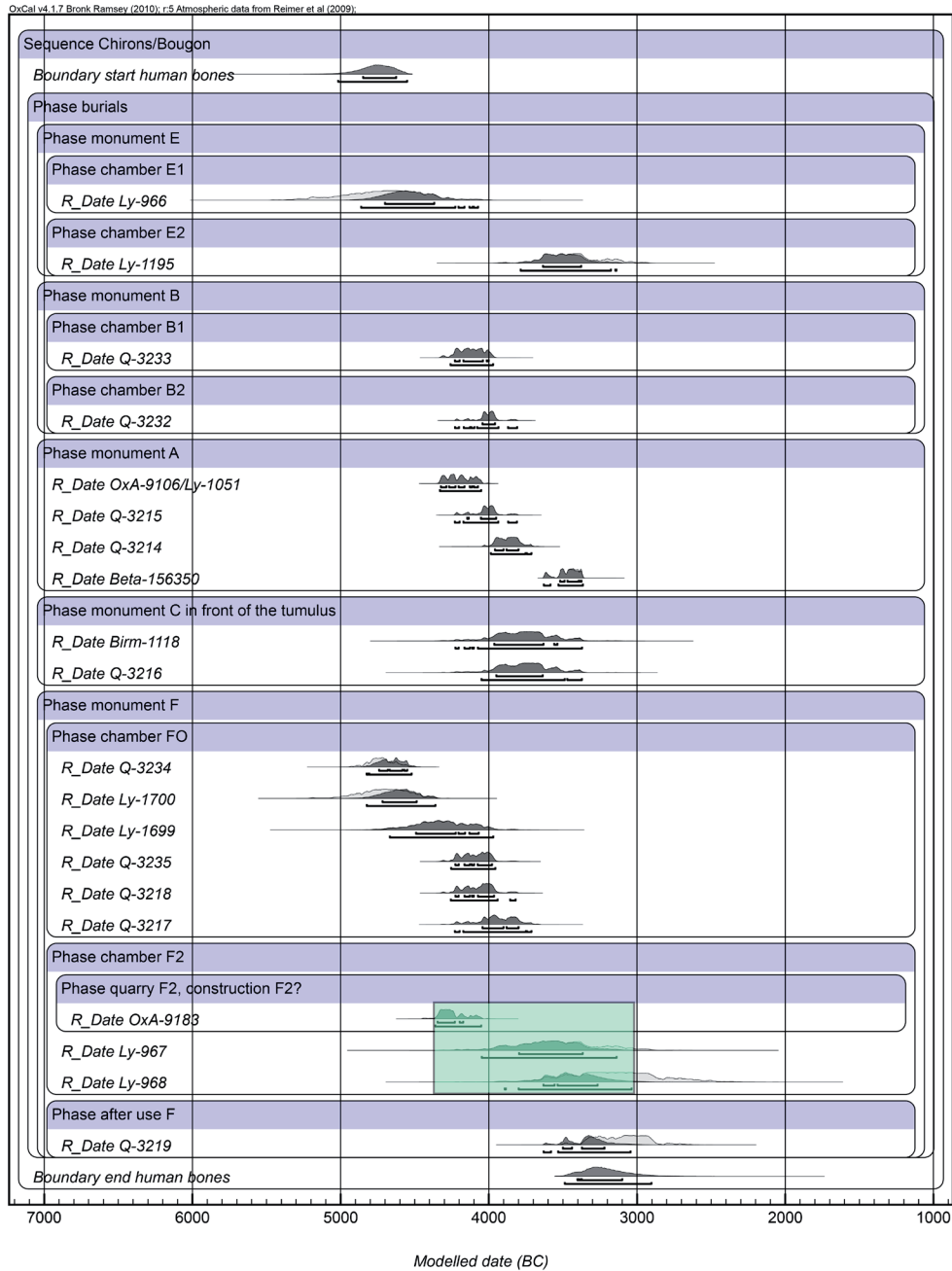


Fig. 5: Probability of radiocarbon determinations from monuments A-F, Chirons/Bougon. Model agreement: Amodel=96.4, Aoverall=94.5. The green bar marks the probability for the variscite deposition. The early dates from chamber E1 and F0 are, as discussed, likely to relate to secondary deposits of human remains (Schulz Paulsson, 2017).

results are available for the gallery graves (“*allées sépulcrales*”) found in the Paris Basin. These are similar to the megalithic gallery graves, but were built in wood and partly covered by megalithic capstones. From Porte-Joie in Eure, there is a subterranean gallery grave, featuring one stone-lined grave (*allée sepulcrale*) (pit XIV) and one timber-built gallery grave (tomb 1), formerly complete (Billard *et al.*, 1995; Chambon, Salanova, 1996; Billard, 2007, p. 145). Four radiocarbon results are available from tomb 1, including from human bone samples, with the earliest result *c.* 3120 cal BC (3264–2924 cal BC, 68.2%; 3331–2915 cal BC, 95.3%) and the last result from the Early Bronze Age, *c.* 1600 cal BC (1872–1325 cal BC, 68.2%; 2111–1092 cal BC, 95.5%) (cf. Schulz Paulsson, 2017, p. 91). The grave goods of these burials consist of one variscite bead, stone or bone beads, axe head pendants, two small gold plates, and leaf-shaped arrowheads.

La Butte Saint-Cyr in Val-de-Reuil is a gallery grave with an MNI of 109 individuals. Both sexes and all

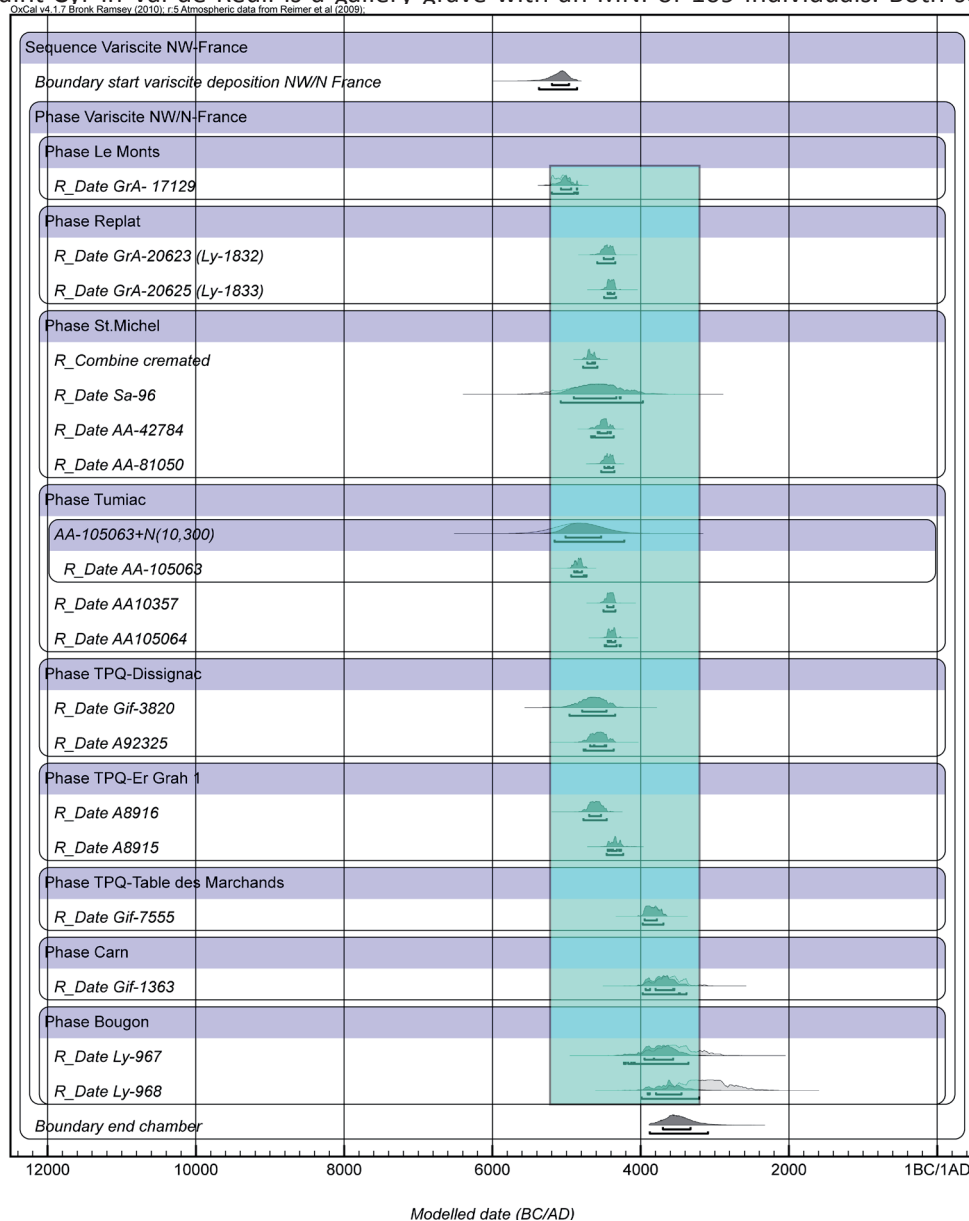


Fig. 6: Probability of all available radiocarbon dates for reliable callais contexts in northern France. Model agreement: Amodel=86, Aoverall=81.4.

ages, except for small children under two years of age, are represented. Four radiocarbon determinations from human bone are available, with the earliest result from c. 3370 cal BC onwards (Ly-123, 4690±90 BP; 3362–3101 cal BC, 68.3%; 3498–3016 cal BC, 95.4%) and latest result from c. 2690 cal BC (Ly-125; 2865–2621 cal BC, 68.2%; 2881–2505 cal BC, 95.4%). The grave goods consist of six variscite beads, SOM pottery, flint daggers, mussel shells, bear or bovid teeth, lignite beads and copper objects, including copper beads and two copper daggers (Billard *et al.*, 1995).

The significance of these dates is limited since so many individuals are buried and we do not know which one was associated with the deposition of the variscite bead.

Southern France

For southern France there are 25 radiocarbon dates relating to *callaïs* deposition. Four of these, with a standard deviation of over ±100, were excluded for the analysis. Around 15 of these dates are from funeral contexts, the remainder originating, as far as we know, in domestic contexts.

The radiocarbon results indicate that variscite artifacts circulated in southern France during the Early Chassey horizon, from 4309-4053 cal BC (95.4%; 4271-4067 cal BC, 68.2%) onwards (fig. 7). Potentially the earliest evidence for *callaïs* comes from grave 33 in Béziers, le Crès (Loison, Schmitt, 2009), where one bead is associated with a child. Three other graves (22, 29 and 33) within the Béziers funeral complex are dated to 4309-4045 cal BC (95.4%; 4271-4052 cal BC, 68.2%). Two more radiocarbon dates belonging to this time horizon are from human bones from a silo grave (Cugnaux, ZAC Agora, sept. 30) and from an underground pit (Cugnaux, ZAC Agora, sept. 13): 4258-3999 cal BC (95.4%; 4189-4045 cal BC, 68.2%). These graves are contemporary with another grave (Cugnaux, ZAC Agora, sept. 19) where one variscite bead was found (Marlière *et al.*, 2008). Further finds of variscite are associated with Chassey and Montbolo phase individuals buried at Toulouse, St. Michel-du-Touch and Villeneuve-Tolosane (La Terrasse), natural caves (Montou) and the enclosure at Carcassonne, Auriac.

In the final Neolithic Chassey period further *callaïs* artifacts are recorded from caves and inhumation graves dating to between 3904 and 3596 cal BC (95.4%; 3798–3631 cal BC, 68.2%). Excavations in the cave Grotte IV de Las Claousos in Auriac produced six *callaïs* beads (five of variscite, one of turquoise) (Guilaine *et al.*, 2015a), while the site at Villeneuve-Tolosane/ La Terrasse produced ten beads, of which six are from a funeral context (Vaquer *et al.*, 2008).

There is more evidence for the use of variscite ornaments in the early Chalcolithic horizon, 3444–3095 cal BC (95.4%; 3372–3161 cal BC, 68.2%) (fig. 7), again within caves (Saint-Jean et Saint-Paul, Grotte des Treilles; Blandas, Grotte des Pins; Boucoiran/Grotte du Chemin de Fer), a hypogeum (Roaix, Les Crottes), the megalithic graves of Béziers/ Cabrials and the dolmen de Laure-Minervois, Saint-Eugène.

There are some secure associations of variscite beads in closed Bell Beaker complexes, for example at Trèbes, le Mourral, but these lack radiocarbon dates. Their date can be estimated at c. 2500–2300 cal BC.

Catalonia

Altogether 56 radiocarbon dates are associated with variscite depositions in Catalonia. For the Bayesian analysis, it was necessary to exclude a large proportion of the dates (n=20): four of these are of low reliability regarding stratigraphy and context, while the others have a standard deviation of ±350 years. The latter are, however, considered in passing in the text. Twenty-six of the radiocarbon dates derive from funeral contexts and 30 are connected with the important variscite mine Can Tintorer in Gavá

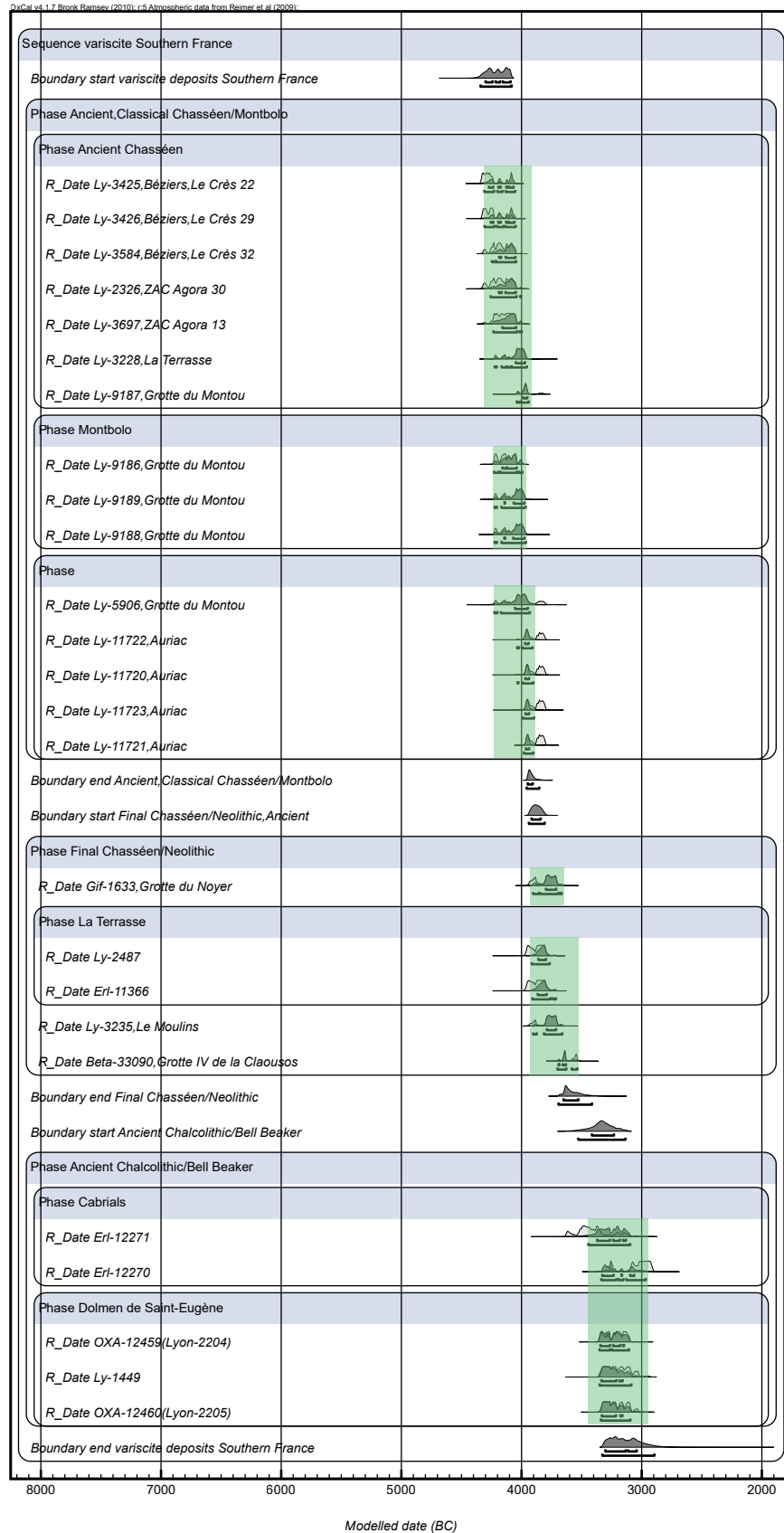


Fig. 7: Probability of all available radiocarbon dates from reliable variscite contexts in southern France. Model agreement: $A_{model}=68.8$, $A_{overall}=65.4$.

and the mining activities there. Provenance analyses have demonstrated that the raw material for the variscite artifacts in Catalonia originates in this mine.

In the early Neolithic/Epicardial/Postcardial horizons the earliest variscite depositions, comprising one to three beads, come from funeral contexts in natural caves such as Cova de l'Avellaner and Cova de Can Sadurní and date to 4741-4347 cal BC (95.4%; 4599-4363 cal BC, 68.2%) (fig. 8) onwards (Edo *et al.*, 2011). There is only weak evidence for earlier depositions: the date of 5920±180 BP (Gak-12933) from the Cova de l'Avellaner has an unacceptably large standard deviation. The same is true of the date of 5880±110 BP (Beta-61490) from charcoal from the Barranc d'en Fabra (sep 4) hypogeum (Baldellou, 1972). Moreover, the context of this date is insecure and no other hypogeum is known from this time horizon. The latest available reliable date for the cave depositions is from the Cova de Can Sadurní (OxA-15490; 5279±31BP; 4230-4101 cal BC, 68.2%; 4234-4048, 95.4% cal BC). For the middle Neolithic, variscite artifacts continued to be deposited in funeral contexts such as hypogea (Can Roqueta, Can Gambús, Bòbila Madurel) and cists (Pla del Riu de les Marçetes) (Carlús *et al.*, 2008; Gibaja *et al.*, 2010; Allières *et al.*, 2014). The mine activities at Gavà Can Tintorer date from 4036-3806 cal BC (95.4%; 3997-3848 cal BC, 68.2%) onwards. Gavà Can Tintorer is a Neolithic variscite mine and workshop for the manufacture of jewelry, situated on the coast of Catalonia. Mine shafts were dug into the schist and there are also traces of the extraction and working of the mineral from exterior areas. There are altogether 32 radiocarbon results for the mines available (Buxó *et al.*, 1991; Bosch, Estrada, 1994; Villalba *et al.*, 1998; Bosch, Borrell, 2009; Bosch, 2010). Eight dates were excluded from the analysis due to having excessive standard deviations. There is only one date (I-12.731, 5350±190BP; 4360-3969 cal BC, 68.2%; 4582-3714 cal BC, 95.4%) obtained from charcoal from mine 8, which suggests that mining started earlier here. However, this date cannot be accepted, even if the evidence from early Neolithic variscite depositions in general suggest early mine activities, since its standard deviation is excessive; and in any case, with unidentified charcoal there is always the potential danger of an inbuilt age. The mining activities in mines 16, 70, 6 and 5 seem to have started at 4041-3822 cal BC (95.4%; 3998-3595 cal BC, 68.2%). The radiocarbon dates for mines 7, 28, 84 and 90 suggest that variscite mining started there around 200 years later. The latest dates and the date for the end of the Gavà mines fall within the time interval 3645-3439 cal BC (95.4%; 3635-3439, 68.2%) (fig. 8). No reliable evidence exists for later variscite depositions during the final Neolithic in Catalonia. The charcoal sample for one date (Gif-6925; 4270±70BP), from a domestic cave (cova 120) with one variscite bead, comes from an insecure context.

Western Spain

Western Spain is the largest region considered in this work, with altogether 180 radiocarbon dates being associated with *callaïs* artifacts. For this analysis, 157 radiocarbon dates have been used, coming from moderately or strongly reliable contexts. Furthermore, this region has an important role to play in explaining the production and distribution of green beads, given that two of the three main variscite mines exploited during prehistory, namely Palazuelo (Zamora) and Encinasola (Huelva), are located there.

During the early Neolithic, the earliest variscite artifacts have been found in natural caves or collective burials. Among the reliable variscite contexts with available radiocarbon dates the Cueva de Chaves de Bastaras, in Aragón, and Paternanbidea in Navarra, deserve to be highlighted (Baldellou *et al.*, 2012). The early variscite there probably originates from the mines of Can Tintorer, in Gavà (Catalonia). This is also the case for those recovered in the similar context of Cueva del Moro de Olvena (*ibid.*). The variscite artifacts from Cueva de Chaves de Bastaras come from a layer (Ia) that contains charcoal and human bone. Four charcoal samples and one human bone were dated. The results are fairly consistent and hint at a time interval of 5346-4902 cal BC (95.4%; 5269-4983, 68.2%) (fig. 9). One charcoal sample had an earlier offset of c. 100 years and this potential inbuilt « old wood » age was corrected. Meanwhile, Paternanbidea

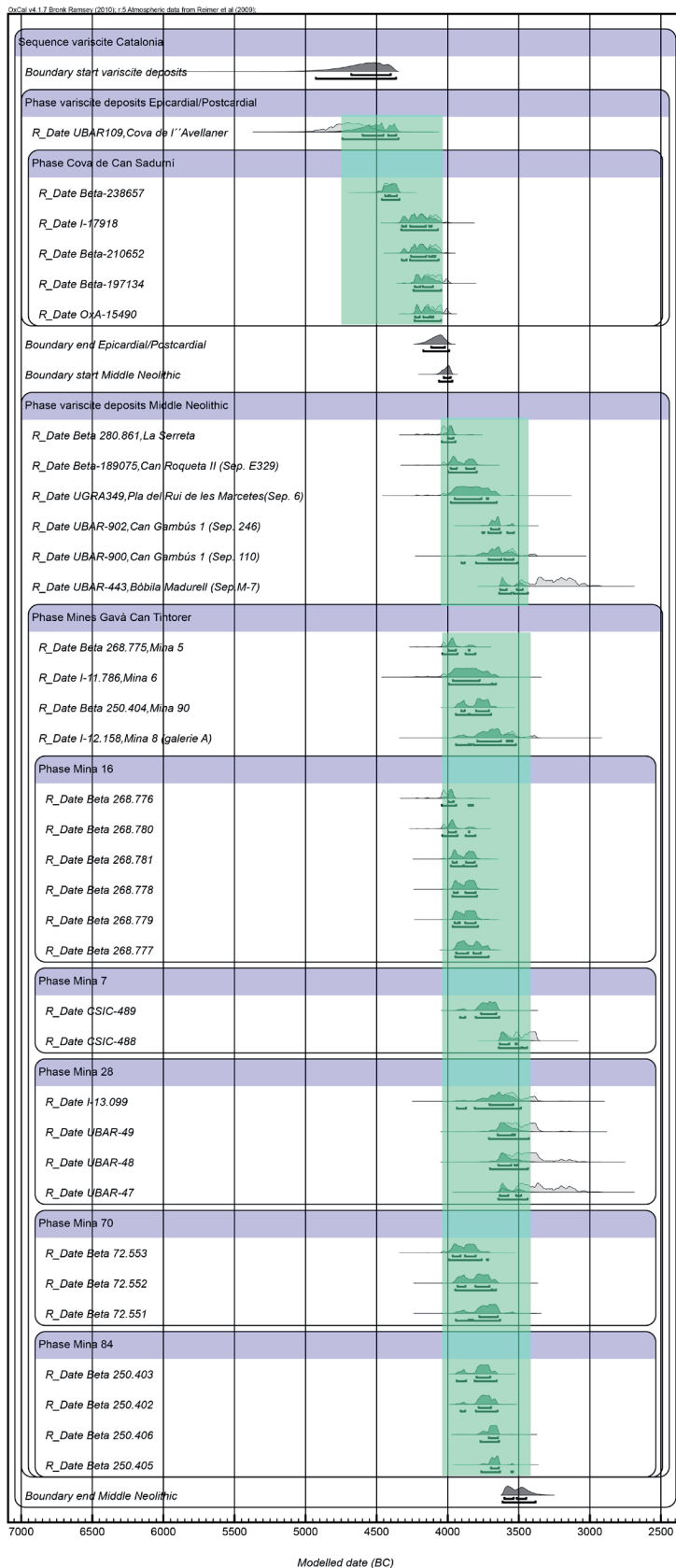


Fig. 8: Probability of all available radiocarbon dates from reliable variscite contexts in Catalonia. Model agreement: $A_{model}=86.9$, $A_{overall}=83.6$.

is a site where several pits containing collective burials have been recorded. Six dated human bones from Fosa 1 and 2 hint at a time interval of 5290-4802 cal BC (95.4%; 5223-4871 cal BC, 68.2%). A greenstone bead was associated with the skull of a child aged around one year recovered in Fosa 1 (García Gazoláz, 1998; Baldellou *et al.*, 2012).

After a hiatus of c. 700 years, variscite was again used as a raw material for beads and pendants and it became increasingly popular, to judge from the ornaments recovered from middle Neolithic graves, dating from 4187-3988 cal BC (95.4%; 4101-4046 cal BC, 68.2%) onwards. Several contexts with green beads also have radiocarbon sequences: this is the case with the mound of Fuentepecina 2, several megalithic graves (Tremedal de Montehermoso, San Martín and Chabola de la Hechicera), the collective burial El Miradero and also the tholos of La Sima II (Soria). The raw material for at least one of the variscite beads found in the Fuentepecina 2 (Burgos) mound suggests Can Tintorer (Gavà) as its source. The same origin is proposed for ornaments recovered from other sites in Burgos province, such as La Sima II, although this has not been yet confirmed analytically. Palazuelo has been identified for the first time as the source for the variscite beads found in the mound of Río Fortes (Ávila) (Estremera Portela, Fabián García, 2002). The only available radiocarbon date comes from charcoal from a burnt layer (Beta-164477, 4970±80 BP; 3951-3641 cal BC, 95.4%; 3909-3656 cal BC, 68.2 %). However, due to the heavily disturbed nature of this site and to the presence of grave goods of allegedly more recent date, we cannot exclude the possibility that the variscite was deposited during a

secondary re-use of the mound.

Another problematic context with variscite beads ascribed to the middle Neolithic is the megalithic grave of Alberite, Cadiz; the 110 variscite beads found there make this one of the largest occurrences of this material in the region. Three radiocarbon dates have been obtained: 4328–3661 cal BC (95.4%, 4255–3715 cal BC, 68.2%) (Beta-80602, 5320 ± 70 BP; Beta-80600, 5110 ± 140 BP, Beta-80598, 5020 ± 70 BP). All three come from charcoal samples from a « find at the base of the tomb », associated with a layer of ochre. Even if the hearth where some of the charcoal was recovered is partly interpreted as indicating the use of the interior of the grave (*e.g.* García Sanjuán *et al.*, 2011, 126), we have to take into consideration the possibility that it may instead relate to an earlier use of the site. In addition, the structure was partly destroyed by ploughing and it is possible that older charcoal found its way into the chamber as a result. Furthermore, this kind of architecture is associated with later periods, both in Andalusia and in other European regions. All in all, then, the evidence points towards this being a later grave form, with the dates being *termini post quos*.

The fact that most of the funerary contexts in question are collective graves involving successive burial episodes makes it much harder to determine the exact time of the variscite deposition. For the tholos of La Sima, three radiocarbon dates are available, from the bones of some of the 20 or so individuals buried there. Variscite beads, allegedly from the Can Tintorer mines, have been found among the grave goods (Rojo Guerra *et al.*, 2005). The dates hint at a time interval of 3765–3532 cal BC (95.4%; 3706–3541 cal BC, 68.2%). Meanwhile, in La Velilla—where an MNI of between 71 and 76 individuals has been identified — five dates are available, from human bones, rabbit bones and charcoal (Zapatero Magdaleno, 2015). These belong to the middle Neolithic, within a probability range of 3966–3365 cal BC (95.4%; 3786–3412 cal BC, 68.2%). However, we must bear in mind that such dates do not necessarily reflect that of the deposition of the variscite. There are far more individuals buried than have been dated and the variscite cannot be associated with any specific individual. Thus, variscite may have been deposited within a short time interval during the middle Neolithic, or else it may have belonged to individuals who were added to the monument later. There are eight more radiocarbon dates for human bones from La Velilla, and these belong to the late Neolithic and the early Chalcolithic periods, 3187–3011 cal BC (95.4%; 3121–3060 cal BC, 68.2%).

From the same horizon are two radiocarbon dates obtained from the rock-cut tomb Paraje de Monte Bajo (E2). These come from charcoal that was either connected to the construction of the grave or to the cremation of one of the 60 individuals found there. However, the reliability of these dates is not very secure; the same can be said of the identification of the green beads as being of variscite (Lazarich *et al.*, 2009).

The cave of San Juan ad Portam Latinam, in the Basque country, exhibits a sequence of radiocarbon results associated to a huge amount of human remains (with an MNI of 289), some of which would have been deposited inside the cave accompanied by a small number of green beads (Vegas Aramburu, 1999). Six dates obtained from human bones have produced a modelled range of 3211–3017 cal BC (95.4%; 3147–3049 cal BC, 68.2%).

Chabola de la Hechicera, also in the Basque country, is a passage grave displaying a sequence of deposition of human remains spanning the date range 3224–3009 cal BC (95.4%; 3139–3051 cal BC, 68.2%) (Fernández Eraso, Mujika-Alustiza, 2013). Again, we need to take into account the fact that this monument was used for a long time for burial, so the dates do not necessarily reflect the time when the green stone ornaments were deposited.

Although there is evidence for the circulation of variscite beads during the early and middle Neolithic, it

seems clear that, in western Spain, the most intense period for the production and distribution of these objects was the third millennium cal BC. Most of the radiocarbon sequences at our disposal belong to this time horizon, and they come from (*inter alia*) the tholoi of La Pijotilla 3 and El Sotillo, the settlements of Aldeagordillo, Camino de las Yeseras, la Teta, Cantera de las Hálagas, Las Peñas and Humanejos, the cave of San Juan ad Portam Latinam, the collective burial of El Tomillar, the rock-cut tombs of Valle de las Higueras, Castillejo del Bonete, cueva B and the passage graves of Trincones 1, Alto de la Huesera and Tres Montes. These dates cover a span of 3022-1872 cal BC (95.4%; 2988-1889 cal BC, 68.2%) (fig. 9).

Even though we do not yet have reliable dates for the mines in western Spain that would allow us to assert such a hypothesis, nevertheless the larger amount of variscite that was circulating during the third millennium cal BC may be an indication that both production centres in this area reached their peak production at that time. In this sense, and according to the provenance analyses conducted so far, the products from the Palazuelo and Encinasola mines seem to “corner the market” of western Iberia at that time, with the variscite from Gavà being almost absent from the archaeological record in the region.

Portugal

For Portugal, 37 sites with variscite ornaments are known, and there are over 100 radiocarbon results available. For the analysis only those dates from contexts with a medium or a strong reliability were used. This reduces the number to 41 determinations.

There is evidence for a potential early Neolithic phase in Portugal with variscite artifacts within a burial cave context, thus similar to the Spanish evidence. The Caldeirão cave in Estremadura is so far one of the very few early Neolithic contexts in Iberia with variscite artifacts and the only one with radiocarbon results available. Three variscite beads are documented. Radiocarbon results, obtained from two animal bones and a human bone, suggest a date range of 4989-4543 cal BC (95.4%; 4846-4622 cal BC, 68.2%) (fig. 10). However, since the cave has a long history of occupation, with funerary and settlement activity extending from the early Neolithic to the Visigoth period, we have to bear in mind that the beads may belong to a phase later than the early Neolithic. Indeed, the excavator’s ongoing re-analysis of the later prehistoric collections from this site suggests that they should be linked instead to its middle or late Neolithic occupation (J. Zilhão, pers. *inf.*; see Carvalho, this volume). Until a definitive study is published, however, we shall provisionally assume that the dates are a reliable indicator for the period of variscite use.

The same cannot be said for the Monchique Mountain, in the western half of the Algarve region. Here, some variscite beads were recovered in “proto-megalithic” cists during excavations in the 1940-50s. Although a relatively early date (5th millennium BC) has been proposed for the older examples of these monuments on the basis of typological analysis of grave goods (*e.g.* Silva 2008), there are no radiocarbon dates to confirm or refute this claim.

The more reliable middle Neolithic contexts with variscite artifacts and radiocarbon dates are limited to the passage graves of Areita 1 and the dolmen of Carapito 1, in northern Portugal. For Areita, there are two available dates for human bones from the basement of the chamber, namely 3976–3795 cal BC, 68.3%; 4037–3712 cal BC, 95.4% and GrN-18497, 4840±60BP (3695-3537 cal BC, 68.2%; 3756-3517 cal BC, 95.4%). Since there is a gap of *c.* 300 years between these dates and since the older result is somewhat isolated when compared to the other 76 radiocarbon dates on human bones from megalithic contexts in the western Iberian Peninsula, we have to consider the possibility that we are dealing with the practice of secondary burial, in order to explain such an old result (Schulz Paulsson, 2017). In other words, the individuals may have been allowed to decompose elsewhere before their remains were

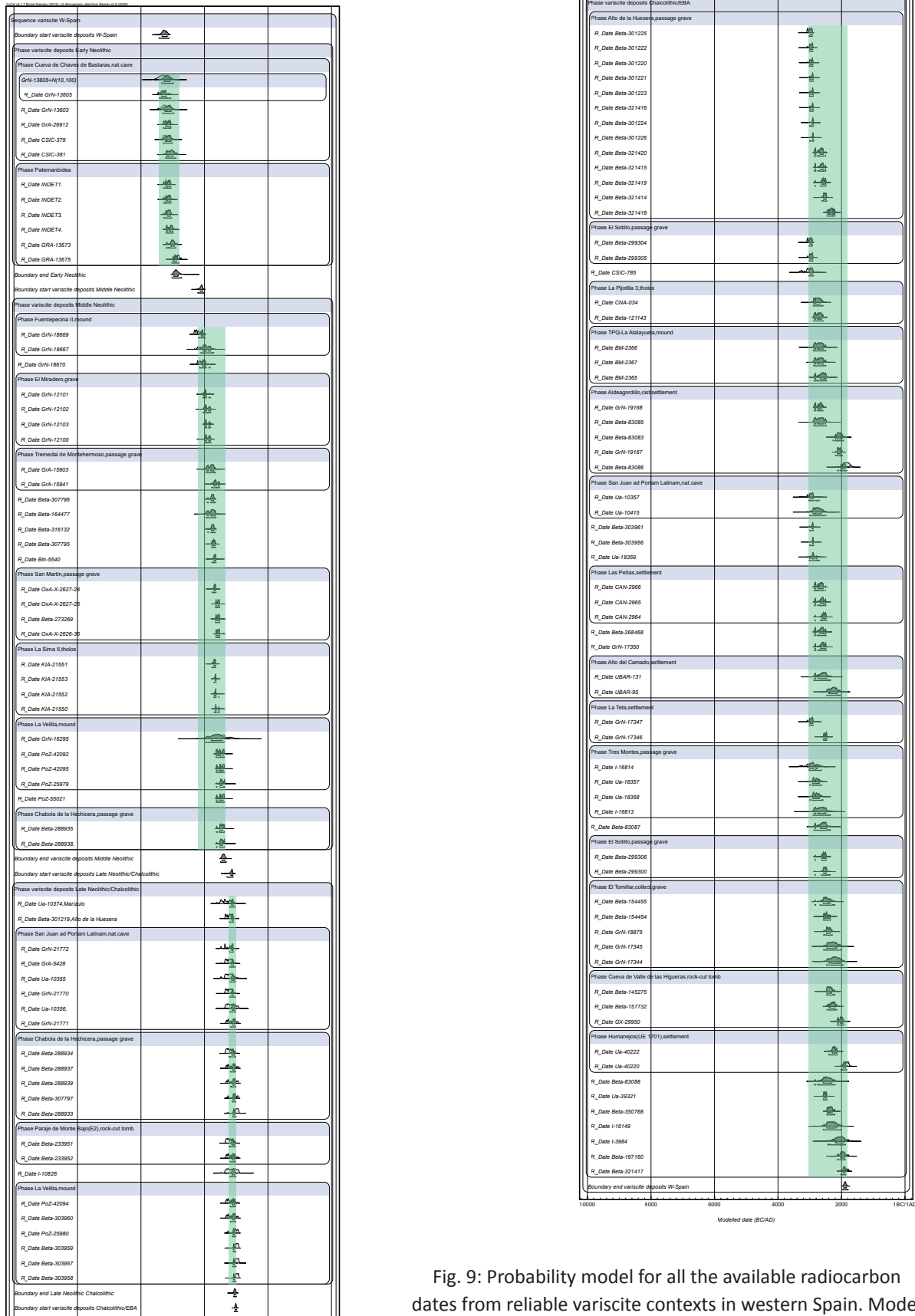


Fig. 9: Probability model for all the available radiocarbon dates from reliable variscite contexts in western Spain. Model agreement: Amodel=87.8, Aoverall=84.9.

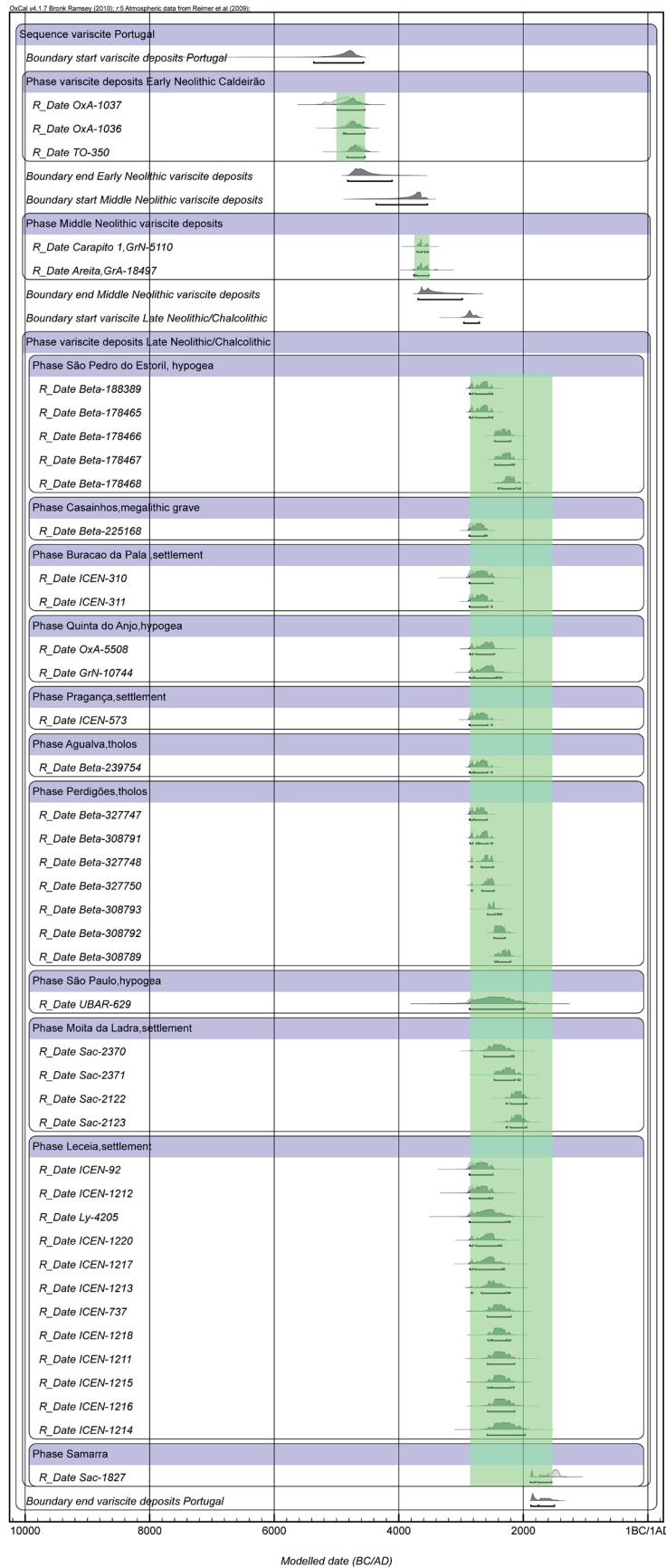


Fig. 10: Probability of all available radiocarbon dates from reliable variscite contexts in Portugal. Model agreement: Amodel=79.9, Aoverall=79.8.

transported into the dolmen—a possibility that has also been proposed for other graves in Portugal (Rocha, 2005) and elsewhere in Europe (e.g. in north-west France, Schleswig-Holstein and Ireland). According to this hypothesis, this early result would therefore represent a *terminus post quem* value and would not actually date the construction of the grave. Alternatively, the bone that produced this earlier date could have been contaminated, or else could have had a potential reservoir effect. Therefore, only the later of the two dates cited above can be regarded as a potential indicator of the date of variscite deposition.

Contemporary with this later date is that obtained from the dolmen of Carapito 1 (GrN-5110, 4850±40 BP; 3693-3540 cal BC, 68.2%; 3707-3530 cal BC, 95.4%), which indirectly reinforces the above conclusion.

After the middle Neolithic, the radiocarbon results suggest a hiatus of at least 800 years for the exploitation of, and trade in, variscite. The Chalcolithic is the period with the highest occurrence of variscite artifacts and the peak of variscite deposition in both domestic and funerary contexts. Thirty-five out of the 41 analysed radiocarbon dates are concentrated within the 2860-2220 cal BC (95.4%; 2834-2145 cal BC, 68.2%) date bracket. From this time horizon there are variscite artifacts found as grave goods in the hypogea of São Pedro do Estoril, Quinta do Anjo and São Paulo, the tholoi of Aqualva and Perdigões, and the megalithic grave of Casainhos. Between one and 37 beads are recorded from each of these contexts, the only known pendant being from Casainhos. A remarkable exception is the assemblage of 277 variscite beads from the Anta Grande do Zambujeiro in the Alentejo.

The Anta Grande de Zambujeiro is one of the largest megalithic graves in the Iberian Peninsula. Its grave goods indicate a long history of funerary use at this monument, with finds attributable to the 4th and 3rd millennia cal BC. There is only one radiocarbon result available (Beta-243693, 3910±40BP), which was excluded from the analysis since it is impossible to correlate it with the deposition of variscite. More than 150 idol-plaques (schist plaques, or “*placas de xisto*” in Portuguese) underline the chronological affiliation of the variscite artifacts to this time horizon (2860-2220 cal BC 95.4%; 2834-2145 cal BC, 68.2%) (cf. Schulz Paulsson, 2017, fig. 10.12). In the Alentejo region, idol-plaques are estimated to have been in use mostly during the first centuries of the 3rd millennium cal BC (Boaventura, 2009, 2011; Schulz Paulsson, 2017).

Large quantities of variscite beads are documented in other late Neolithic/Chalcolithic settlement contexts from north to south across the country, such as Pragança, Leceia, Moita da Ladra and Buraco da Pala.

All the variscite artifacts to have been identified in late Neolithic and Chalcolithic sites in Portugal appear to have been made using material from the Palazuelo and Pico Centeno mines (e.g. Odriozola *et al.*, 2010; Querré *et al.*, 2015). Two main conclusions can be drawn from the available evidence (and see Carvalho, this volume, for the quantitative data). One is the exclusivity of the source, as represented in each site—the only two exceptions being the passage grave of Anta Grande do Zambujeiro and the walled enclosure of Vila Nova de São Pedro, where material from more than one source has been found. The other is the overwhelming predominance of variscite deriving from the more distant source—Palazuelo de las Cuevas, in the Spanish province of Zamora, around 400 km to the north east—rather than from the nearest source, Pico Centeno (50-100 km to the east).

Conclusion

Our radiocarbon results suggest that variscite was exploited from the end of the 6th millennium cal BC, from deposits located in the Iberian Peninsula. We have found decisive support for long-distance contacts and for the circulation of this precious green mineral across the land and/or seaways, to northern France, from this early date. Used as jewellery, this green stone was deposited in simple graves or within caves or collective burials. Can Tintorer/Gavá is considered to be the raw material source for the early variscite finds from funeral

contexts in natural caves or collective funerary contexts in the Aragón and Navarra regions of north-eastern Spain (5346-4802 cal BC, 95.4%; 5269-4871 cal BC, 68.2%). These earliest variscite horizons are not, however, reflected by the currently-available dating sequence at the Can Tintorer/Gavá mines themselves, which suggest that exploitation started around the beginning of the fourth millennium BC (4036-3806 cal BC, 95.4%; 3997-3848 cal BC, 68.2%). Yet we should not rule out the possibility that variscite was exploited earlier at these mines, and that the dated activity relates to the expansion of early mine shafts during the peak of mining activities in the first half of the 4th millennium cal BC. Reliable evidence for the early use and long-distance circulation of variscite ornaments comes from the east of France, at Plichancourt/Marne, Les Monts, where an early Neolithic grave containing a variscite pendant has been dated to 5199-4847 cal BC (95.4%; 5076-4856 cal BC, 68.2%). Pico Centeno/Encinasola in Andalusia has been identified as the source of this variscite. Again, this early horizon of exploitation has not yet been reliably confirmed through radiocarbon dates from the mine itself. The Caldeirão cave in Estremadura, Portugal is another potential early Neolithic context with variscite artifacts dating from the first half of the 5th millennium cal BC.

The *callaïs* sequence for north-west France currently starts with the first phase of the Carnac mound, the Tumulus St. Michel, at 4777-4585 cal BC (95.4%; 4722-4616 cal BC, 68.2%). The end of the period when considerable amounts of *callaïs* were deposited corresponds to the end of the early Castelic horizon, around 4200 cal BC (cf. Schulz Paulsson, 2017, p. 38). Later deposits consist of single, or a few beads. The same can be said for west central France. Variscite artifacts were deposited singly or in small amounts in graves in later horizons from 4328-4047 cal BC (95.4%; 4313-4054 cal BC, 68.2%) onwards. Recent provenance analyses have revealed that Pico Centeno/Encinasola was the sole source for the raw material of these beads and pendants in northern France. The abundance of Andalusian variscite in Carnac monuments in Brittany is evidence for long-distance travel between these regions at that time and we have to take maritime routes into consideration. No contemporary Andalusian variscite artifacts of this early date has been found in the region of Encinasola and between the mines and the Morbihan. Within the same date range of 4741-4048 cal BC (95.4%; 4599-4101 cal BC, 68.2%) deposits of variscite artefacts have been recorded in the natural caves of Catalonia. In the Cova dels Ladres some 139 beads have been documented. This variscite had originated in the Can Tintorer/Gavá mines.

During the middle Neolithic variscite and turquoise beads were deposited in funerary contexts such as hypogea, cists and megalithic graves. This is the time of the peak of mining activities at the Can Tintorer Gavá mines (4041-3439 cal BC, 95.4%; 3998-3439, 69.2%). Most finds are of single beads, but in the Can Gambús cemetery near the mines some 620 beads have been found. For southern France the radiocarbon results indicate that variscite artifacts were circulating there from the early Chasséen horizon (4309-4053 cal BC, 95.4%; 4271-4067 cal BC, 68.2%) onwards. On the Iberian Peninsula away from the mining areas variscite ornaments were deposited in funeral contexts from 4187-3988 cal BC (95.4%; 4101-4046 cal BC, 68.2%) onwards. Where the source of the raw material for the ornaments has been identified, as at several sites in Burgos province, it has been the Can Tintorer/Gavá mines. The earliest recorded appearance of Palazuelo variscite is in the mound of Río Fortes (Ávila), but the early dates obtained from this site should be regarded with caution, given the post-depositional problems at this site as discussed above. Most of these sites provided only one or a few beads; an exception to this is a necklace with 13 variscite beads found in the passage grave of Areita, in northern Portugal.

In the Iberian Peninsula the number of variscite finds, and the reliability of associations with radiocarbon dates, increase as we approach the 3rd millennium BC – a time of peak production at both the Palazuelos and Pico Centeno mines. The Can Tintorer/ Gavá mines apparently lose their sub-regional importance at this time, and the Palazuelo and Pico Centeno provided almost all the variscite artefacts that have currently been identified in late Neolithic and Chalcolithic sites. Large numbers of variscite artifacts have been found in settlements and funerary sites, such as the 277 variscite beads in the Anta Grande do

Zambujeiro or the c. 300 documented in the artificial caves of Valle de las Higueras. According to the provenance analyses carried out so far, most of these sites seem to have variscite from only one of these two mines, namely Palazuelo de las Cuevas, in the Spanish province of Zamora; products from the nearer Pico Centeno mines are in the minority.

Appendice : List of the 406 current available radiocarbon results from variscite and turquoise (*callaïs*) find contexts in Europe used to construct the chronology/scenario outlined in the chapter, including detailed information. The radiocarbon dates for the complete radiocarbon sequences for Er Grah, Petit Mont, Table des Marchands and Les Chirons/Bougou are from Schulz Paulsson (2017).

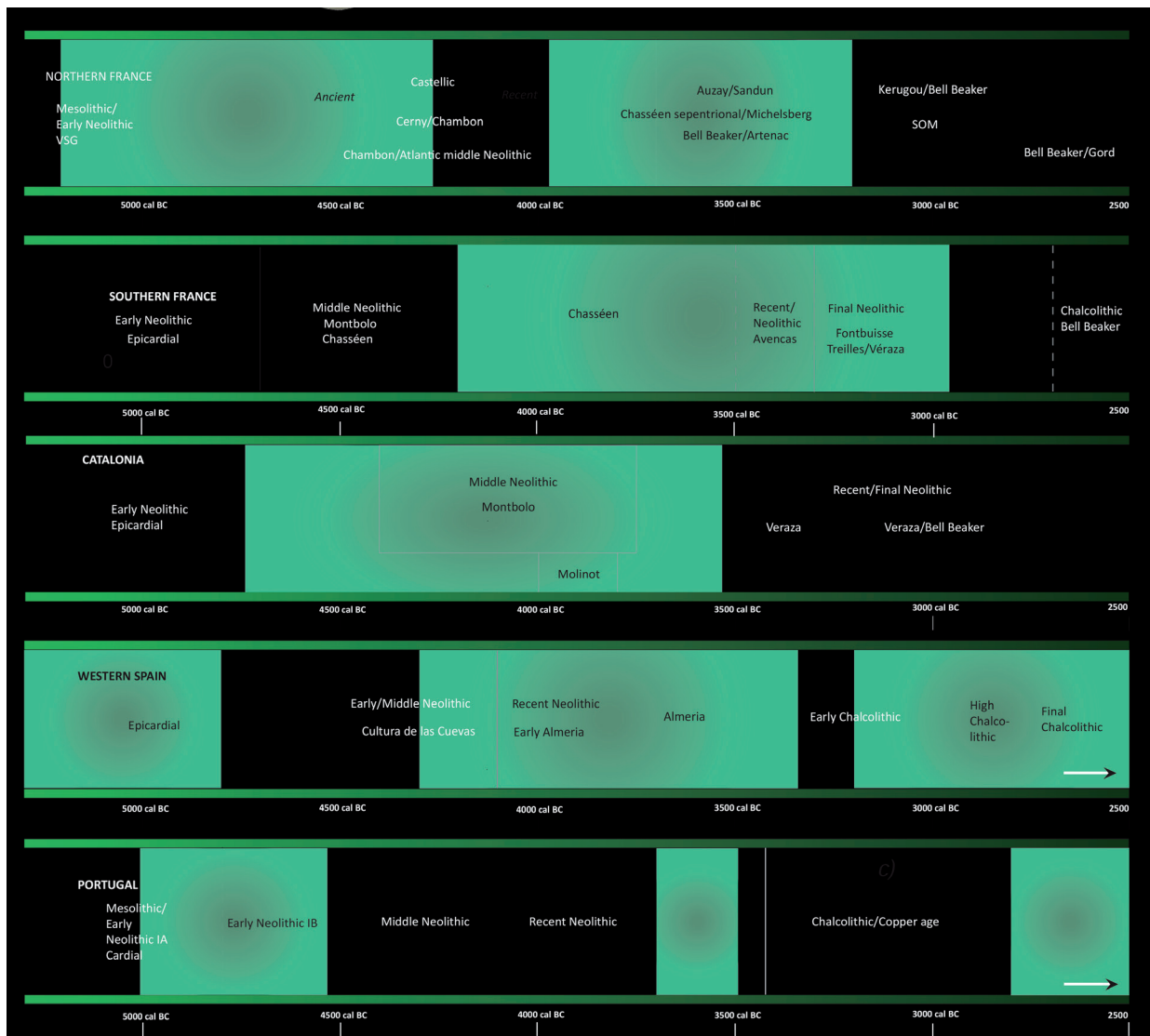


Fig. 11: Results from the Bayesian analysis of 406 radiocarbon dates for callaïs contexts in Europe. The date ranges for the circulation of callaïs in the different regions (green) are presented at 95.4% probability.

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