Megaliths and Geology

Edited by

Rui Boaventura, Rui Mataloto
and André Pereira

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Megálitos e Geologia

MEGA-TALKS 2

19-20 November 2015 (Redondo, Portugal)

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Archaeopress Access Archaeology

Archaeopress Publishing Ltd
Summertown Pavilion
18-24 Middle Way
Summertown
Oxford OX2 7LG

www.archaeopress.com

ISBN 978-1-78969-641-7
ISBN 978-1-78969-642-4 (e-Pdf)

Financial support for the meeting Mega-Talks 2 has been provided by the project *Moving megaliths in the Neolithic* (PTDC/EPH-ARQ/3971/2012), funded by FCT (Fundação para a Ciência e a Tecnologia, Portugal) and the Municipality of Redondo (Portugal).

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Introduction

Megaliths and Geology: a journey through monuments, landscapes and peoples

This book is the result of the MegaGeo project, under the direction of Rui Boaventura, with the purpose of analysing the raw material economy in the construction of megalithic tombs in multiple territories, showing the representation of several prehistoric communities that raised them and their relationship with the surrounding areas.

Following the meeting of the previous year, it was decided to hold MegaTalks 2, wich brought together national and international experts who have developed work related to Megalithism and Geology, in its various perspectives, from the funerary depositions to the raw material construction of the tombs, as indicators of mobility and interaction with the surrounding physical environment.

Since the original meeting, held in Redondo on 19-20 November 2015, there have been several changes in the alignment of discussion and participants involved. However, the core of the analysis, regarding Megalithism and Geology, has not changed..

The alignment of the contributions sought a generically regional organisation, either in a national scale, or later in a peninsular and a European scale.

The volume opens with the presentation of a case study developed within the MEGAGEO project in the megalithic nucleus of Freixo (Redondo, Portugal) coordinated by R. Boaventura, Patrícia Moita and J. Pedro. This paper presents the analysis of the raw material of several clusters of megalithic tombs in Freixo region (Redondo, Alentejo). Broadly speaking, there was an exploration of proximity, most likely opportunistic, but in which other criteria were taken into account in the selection of the supports for the construction of monuments.

The following two contributions focus on the work carried out on the Megalithism of Beira Baixa (Central Portugal). João Luís Cardoso's work presents a general perspective on the Megalithism of this region, highlighting the documented architectural diversity, indicating structural polymorphism, contradicting linear development interpretations. The mobility of raw materials is understood essentially from the viewpoint of votive depositions in a funerary context, documenting contacts and circulation with the closest geographical regions, such as Estremadura and Alto Alentejo.

The next contribution, under the coordination of João Caninas, but using an extensive team, presents a novel investigation of Megalithism in the region of Proença-a-Nova, as well as Beira Baixa, Portugal. It is a set of works in progress revealing a diverse and complex reality that indicates contacts and circulation of goods and people at an interregional level, especially lithic artefacts. Concerning the raw material economy, there is a use of the raw material available locally, although one of the slabs may have a more distant source, more than 10 km away.

In the following chapter, Marco Andrade focuses his analysis on the raw materials of the votive objects deposited in megalithic contexts, trying to understand their sources of lithic supply, and thus seeking mobilities and circulation in the upper Alentejo's pre-history (Southern Portugal). This work presents us with a very in-depth perspective on the wide range of interaction in the upper Alentejo region for the purposes of amortization of votive objects in megalithic contexts, allowing us to understand the complexity of circulation and supply.

José António Linares brings us an innovative and detailed perspective on a region whose peculiar Megalithism has long been known. For the Sierra de Huelva (Southwest Spain), this author brings us a careful assessment of each monument and each group of tombs, which allowed him to verify the presence of a very fine and diverse knowledge of the territory and its potential. This knowledge was used for the construction of complex structures, where the different geological elements were carefully selected in response to the physical and ideological needs that presided over the construction of the tombs. The micro-analysis carried out for the Los Llanetes group, made it possible to emphasize the relevance of the Phyllite blocks. Simultaneously, the gathering and using of different types of stone for the construction of complex tumuli showed a clear chromatic and textural combination, evidencing all the effort to build the structure.

Heading north, towards the Douro River basin in Northern Spain, the work of Cristina Tejedor and Manuel Rojo present a chrono-typological perspective on the tombs of this wide and diverse region. The region presents a very different reality from the previous areas, marked by the polymorphism of the megalithic monuments that were only a small part of a diverse funerary architecture, with whom shares concepts and common cosmogonies. Architectural polymorphism, even if dependent on local developments and different diachronic processes, seems to be clearly rooted in this wide region. Despite this diversity, there is a use of essentially local raw materials, although this sometimes requires a few kilometers journey. This fact does not prevent the use of a diverse set of lithologies that allow a certainly significant chromatic combination that, in some situations, may be mimicking the landscape in which it fits, thus seeking to incorporate the geological elements of a certain landscape identity.

Following a long-time precursor line of research, Chris Scarre points out that there is a huge European affinity between Megalithism and its relationship with Landscape, an ancestral landscape certainly distinct from the current one. Thus, the author underlines the clear emergence of Megalithism in landscape contexts previously dominated by the large concentrations of stones, whether endogenous or dragged, as is the northern areas affected by glacier advance and retreat. In these landscapes of abundant stone and rock outcrops, the action of building the tombs from the local stones reinforces its connection to a territory and to the creation of a Landscape.

Mike Parker Pearson brings us a greater example of Megalithism and Geology, Stonehenge, due to its long researched history, to which is now added an important set of new data. The geological origin of the sarsen and bluestones has long motivated extensive studies and analyses, with the origin of the latter being well defined to the west, in the Preseli Mountains of Wales. However, a number of recent studies have allowed for the investigation into the specific origin of extraction such as Carn Goedog or Craig Rhog-y-felin, where ancient traces of these same works have been documented. Following this new data, it is believed possible that the bluestones were initially implanted in another stone circle, close to the extraction area. In a later moment, when it seems that a period of West-East rapprochement and union was developing, the bluestones of these ancient Welsh monuments would have been moved for the construction of Stonehenge, an area that seems to have had specific geological and historical characteristics. Stonehenge was an identity monument of that union, where the geological elements present would act as a mark of the ancestors. Different studies seem to prove that this displacement would have been accompanied by the installation of new people from the West in the Stonehenge region, being able to go back the different origins of the communities, even to the first Neolithic settlers.

At the end of the book, the results of the extensive investigation in Swedish Megalithism, in particular in the interior region of Falbygden, give us a very similar perception to the one documented on the opposite end of Europe, where we started this volume. Karl-Göran Sjögren's work shows us how the Megalithism of the Falbygden region adapts in a very particular way to the geological pre-existences, using them in a very structured way and as a reflection of the surrounding Landscape, which they somehow mimetize. However, some choices, even in local stones, or as a result of the dragging action of glaciers, are clearly due to options that are not merely functional or structural, but rather seem to respond to symbolic perceptions inherent in certain geological choices. In this way it is believed that there are recurring choices of raw materials, all local or locally available, for the construction of specific components of the tombs, such as the slabs of the chambers or the cover stones, which are not determined by their physical characteristics or robustness. Another vector of analysis is the ability of local groups to aggregate workforce to build such a large number of monuments. Despite the lack of data, the occupation sites would not have had a large enough population needed for the construction of the monuments and, therefore, their construction should imply the aggregation of different groups, regional or not. The monument would emerge as a greater symbol of group identity, but also as an impeller of social dynamics and sense of intergroup competition in the region, representing the capacity of regimentation and cohesion of the groups that built them, even at a long distance. Geological choices, even on a local basis, seem to represent identity discourses that justify the diversity of choices. The various strontium isotope studies carried out on the populations buried in Falbygden show that a quarter of the population would be allochthonous making clear the establishment of broad networks of solidarity with more remote regions.

As an epilogue, it is important to underline some aspects. This work was born from the will and vision of Rui Boaventura, who organised it in the last moments of his life, making clear that, instead of the closed Portuguese context, Megalithism at European level was once more in a very dynamic moment, structured in areas of multilinear research, where pressing issues of the study of European Prehistory were combined, from mobility to questions of identity, including the foundation of Neolithic Landscapes.

In this respect, the connection between Megalithism and Geology, whether in its structural aspects, in raw material economics, but also identity or symbolic aspects, is assumed as a multidisciplinary research line that needs to continue to be deepened and diversified, like Rui well knew.

Rui, you will continue to be one of the foundation stones of our Megalithism. May the Slab be with you!

Moving megaliths in the Neolithic - a multi analytical case study of dolmens in Freixo-Redondo (Alentejo, Portugal)

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Abstract: In this work a multi-disciplinary and multi-analytical approach was developed with the aim of better understanding the effort and selection criteria involved in the search for slabs used for the construction of dolmens during the Neolithic. Nine dolmens within a strip with ~15x10 km^2 on south Portugal (Freixo, Alentejo region), within magmatic and metamorphic geological basement were studied. Based on their chronology and geographic positioning the dolmens studied were systematized as follows: dolmens of the Freixo Group (7), dolmen of Godinhos (1) and dolmen of Candeeira (1). The work developed consisted of an intensive geological survey associated with a sampling protocol. These data combined with the results obtained through microscopy and whole-rock geochemistry on samples from dolmens and outcrops allow us to infer some conclusions about distances involved. The nearest exposures were not used as the unique collection site. Although the distances from dolmen to nearest outcrops varies between 150 m and 780 m the complete match including size, shape, petrography and geochemistry was obtained for several dolmens providing for group of Freixo, distances between 800 and 3500 m, the dolmen of Godinhos use very local material ~350 m, and for dolmen of Candeeira, a local provenance of 170 m was established based on singular macroscopic features. Other nearby, available lithology (gabbro) and with compatible size was deprecated due to other reasons than functional.

Keywords: Neolithic; Provenances; Multidisciplinar-Mulianalytical; Archaeometry; Dolmens

Movendo megálitos no Neolítico - um caso de estudo multi-analítico de dolmens no Freixo-Redondo (Alentejo, Portugal)

Resumo: Desenvolve-se aqui uma perspectiva multidisciplinar e multianalítica, com o objectivo de melhor compreender o esforço e os critérios de seleção envolvidos na procura de lajes utilizadas para a construção de dólmens durante o Neolítico. Foram estudados nove dólmens numa faixa com ~ 15x10 km^2 no sul de Portugal (Freixo, região do Alentejo), com um substrato geológico magmático e metamórfico. Os dólmens estudados foram sistematizados da seguinte forma: dólmenes do Grupo Freixo (7), dólmen de Godinhos (1) e dólmen de Candeeira (1), com base na cronologia e posicionamento geográfico. O trabalho desenvolvido consistiu num levantamento geológico intensivo associado a um protocolo de amostragem. Estes dados, combinados com os resultados obtidos através de microscopia e geoquímica da rocha total em amostras de dólmens e afloramentos permitiram inferir algumas conclusões sobre as distâncias envolvidas. Os afloramentos mais próximos não foram usados como o único local de análise. Embora as distâncias de um dólmen aos afloramentos mais próximos variem entre 150 m e os 780 m, a associação perfeita, incluindo tamanho, forma, petrografia e geoquímica, foi obtida para vários dólmens tendo-se obtido para o grupo do Freixo distâncias entre 800 e 3500 m, para o dólmen de Godinhos, que usa muito material local, ~ 350 m, e para o dólmen da Candeeira, uma procedência local de 170 m foi estabelecida com base em características macroscópicas singulares. Outras litologias disponíveis nas proximidades (gabro) e com tamanho compatível foram preteridas devido a outras razões que não funcionais.

Palavras-chave: Neolítico; Proveniências; Multidisciplinar-Multianalítico; Arqueometria. Dólmens

1. Introduction

Dolmens are the most conspicuous remains of the populations of mainly the 4^{th} millennium BCE. These tombs are impressive not only for their monumentality, but also because of the socioeconomic investment they represent for Neolithic communities who built it. Although dolmens have been studied for their funerary content and typologies, an interdisciplinary approach toward the geological characterization and sourcing of stones used in these constructions has not received enough attention from researchers. In fact, as highlighted by Thorpe *et al.* (1991) little attention has been paid in published discussions of megaliths to the relationship between rock types and the geological sources utilized. When studied, most archaeological analyses are limited to brief description of rock types of slabs and geological settings and whether they were the same. When a megalith is found to be made of non-local stones origin this is usually highlighted but rarely and thoroughly investigated. When rigorous geological identification is conducted for specific dolmens, rarely is any attempt made to verify if there are similar patterns of slab selection on neighbouring dolmens and what relationship it might have with its geological background.

Previous works (Kalb, 1996; Kalb & Höck, 1996; Boaventura, 1999-2000; 2000) demonstrated a tendency for the use of local (1-2 km) stones, mainly in small- to middle-size dolmens (approximately 1-2 m high and 2-4 m long by 2 m wide). In larger tombs there were a few cases of megaliths sourced to outcrops at greater distances (6-8 km). The proximity and cost/benefit of slab extraction as well as its transport and erection could explain the selection of local stones, but the need for more suitable stones (that were larger or flatter), might explain the use of more distant sources. Nevertheless, the intrinsic and phenomenological qualities of certain rocks or geological contexts may have also influenced community's choices, as much as the prestige and power that those endeavours would give to its members.

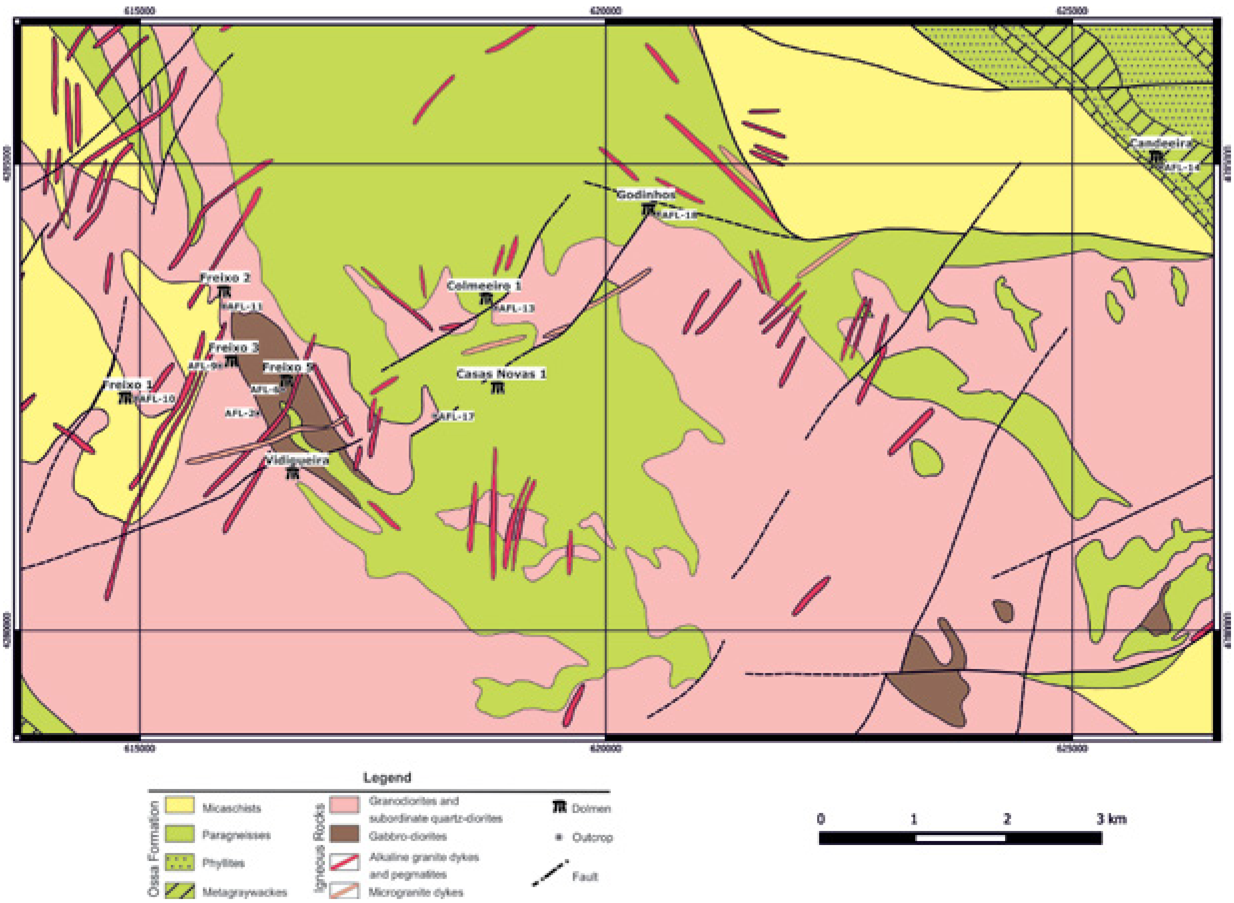

Figure 1 – Geological map adapted from Carvalhosa et al. (1987). Dolmens and outcrops of the Freixo-Redondo studied in this work.

In this work an integrated geo-archaeological approach is applied to systematically establish the relationship between the distribution of nine dolmens in the Freixo-Redondo area (Alentejo region, South Portugal, Fig. 1), and their source materials within the geological landscape. In this sense several data (archaeological information, field data, petrographic observation and elemental geochemistry) from slabs and probable outcrop sources, are presented and discussed. It is implied the comparison of dimension/geometry between dolmen slabs and blocometry from outcrops that might have been selected as the source of raw materials. Within that frame of results, it is the main goal of this work to establish a minimum distance necessary to carry heavyweight stone blocks for the erection of megalithic tombs that should reflect the effort of a community involved in such endeavour.

2. Methodology

In order to achieve the goals of this work it was initially developed a geological field survey using the cartography from Laboratório Nacional de Energia e Geologia at 1:50.000 scale (Carvalhosa *et al.*, 1986); this work embraces in a first approach the lithological characterization of dolmen slabs and mapping of geological surroundings for probable sourcing. The preliminary lithological classification of megaliths was non-destructive and comprised an in loco observation by hand magnifying lenses. These observations were in certain cases affected or precluded by rock surface weathering due to climatic and/or biological processes, which limits an accurate observation and classification. In these cases, a small-scale sampling by drilling was needed. Additionally, and besides this situation's samples were taken by drilling to have the opportunity to acquire a set of petrographic/geochemical data not attainable in another way.

The selection of outcrops source that were probably the site for slabs extraction was achieved by considering several features such as mesoscopic lithological characterization (at outcrop/hand sample scale), joint surfaces, morphology and dimensions of blocks/outcrop as result from weathering and faulting (Fig. 2). Another important characteristic for the selection of the outcrop source was the evidences of absence of blocks, that is to say voids of compatible sizes as slabs (Fig. 2). Whenever it was verified the presence of several hypotheses the studied outcrop was the one that is nearest the dolmen - the Nearest Mesoscopically Compatible Outcrop (NMCOutcrops).

Figure 2 – Example of an outcrop (AFL-10) with lithological and morphological macroscopic features compatible with the nearest dolmen slabs. The absence of blocks (i.e. negative) agrees with its use as for the production of raw material.

The drilling campaign followed a defined protocol, approved by national heritage institution - Direção Geral do Património Cultural. The slabs were sampled (Fig. 3) on hidden surfaces with a drill core (2.5 cm diameter; 5-6 cm long) leaving a hole which was subsequently mitigated by a restorative conservative procedure (Fig. 4).

The geological samples from NMCOutcrops were processed following specific laboratory requirements for polished thin sections and geochemical analyses. The subsequent detailed characterization of the rock specimens includes petrographic characterization and elemental whole rock geochemistry. The drilled samples from the dolmens were processed in the same way as those from the outcrops.

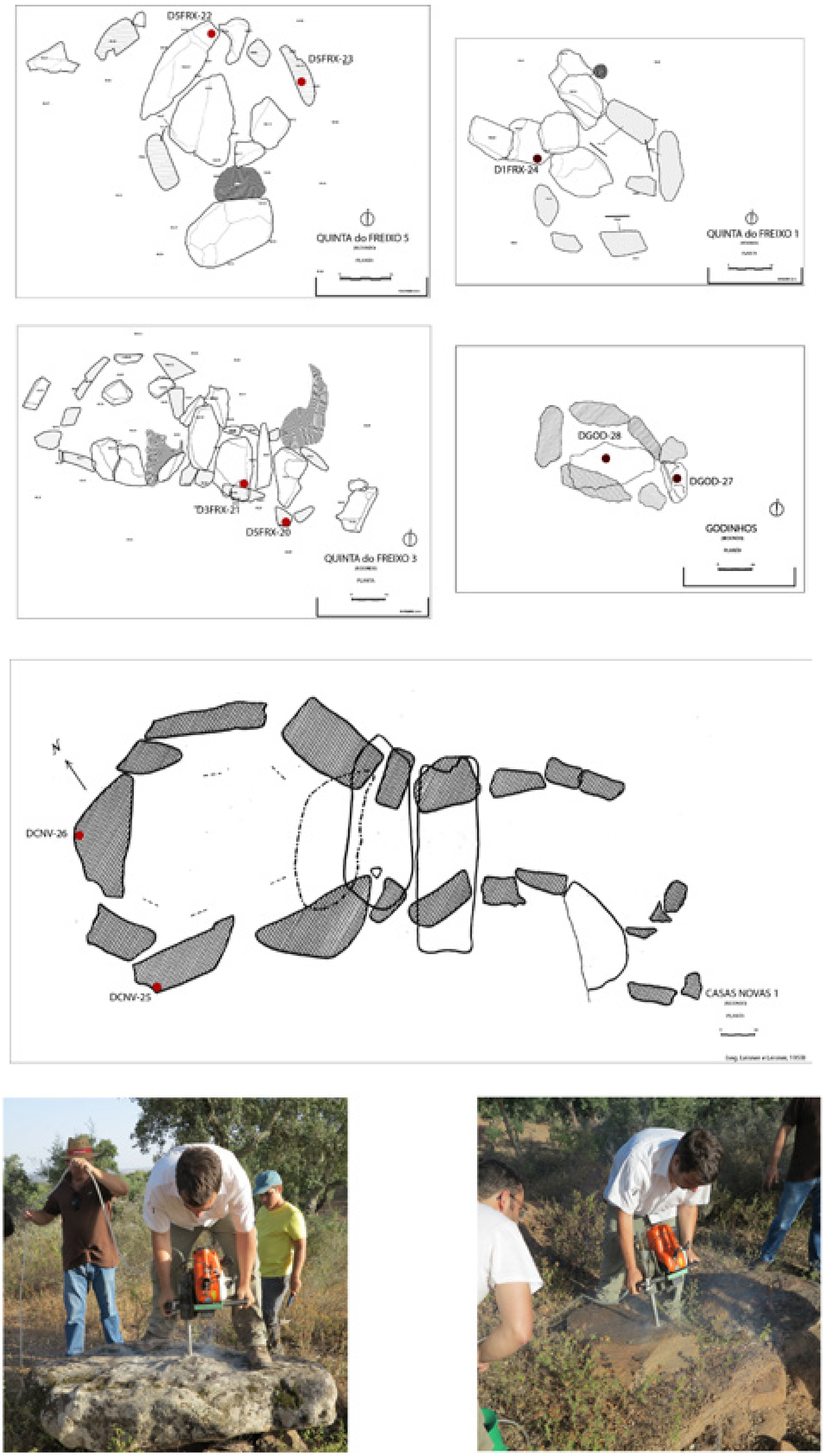

Figure 3 – Map of dolmens with sampling location

A refined petrographic and geochemical characterization of geological materials were performed in dolmen and outcrop samples. The obtained data are presented and discussed in the following points. As a remark, all the data were gathered in a SIG data base and used for geo integrated analyses (Nogueira *et al.*, 2015).

Figure 4 – Dolmen sampling by drilling and mitigation by restorative conservative procedures.

3. Archaeological context

There is a concentration of dolmens along the outskirts of Ossa mountain, either on its Northern and Southern borders (Calado & Mataloto, 2001; Mataloto *et al.*, 2015; Mataloto *et al.*, 2017). Within a set of 33 dolmens, 9 dolmens from the Freixo-Redondo area were selected (Tab. 1, Fig. 5); the group of Freixo with 7 dolmens (Quinta do Freixo 1, 2, 3 and 5, Vidigueira, Casas Novas 1 and Colmeeiro 1), Godinhos and Candeeira. Their choice was the result of the archaeological context, geographical dispersion and the type of lithological bedrock implantation. The Freixo dolmens present a geographical and typological coherence that allows us to clearly isolate them as a regional cluster, composed, however, by small groups aggregated by landscape units, which usually present some internal diachrony.

Early in the 19th century three dolmens from Redondo were identified (Cartailhac, 1878) and soon after became National Heritage: dolmens of Candeeira, Colmeeiro 1 and Vidigueira. Despite this early attention, the region only had its first attempt of systematic inventory with the German researchers Georg and Vera Leisner (1959) that visited the region in 1945-46. Nevertheless, although plans and pictures have been taken, no site excavations were conducted. By the end of the 20th century the list of tombs was expanded, namely with the dolmens from group of Quinta do Freixo (Calado & Mataloto, 2001), and in the past decade several dolmens have been studied in more detail (Mataloto & Rocha, 2007; Mataloto & Boaventura, 2009; Mataloto *et al.*, 2015; Mataloto *et al.*, 2017). This made possible to verify that small megalithic tombs, such as Godinhos, have been erected during the middle and second half of the 4th millennium BCE, and bigger megalithic structures followed those with more standardized plans despite the variation in size - varying from small, middle and large size (Mataloto *et al.*, 2015). Most of the latter tombs seems to have been erected during the second half of the 4th millennium and possibly in transition to the next millennium BCE, as might be the case of Quinta do Freixo 4 (Mataloto *et al.*, 2015).

The dolmens from group of Freixo are related with the small village of Freixo, located half way between Évora and Redondo towns, on the southern border of the Ossa mountain range (Fig. 1). Within this area 7 dolmens were considered; Quinta do Freixo 1, 2, 3 and 5, Vidigueira, Casas Novas 1 and Colmeeiro 1.

Table 1 – Typological features of the studied dolmens. (*Age based on typology; ** Dolmens size: small ~0,5 m high; medium 1-1,5 m high; large 1,5-2 m high; very large higher than 2 m; *** Number of slabs with each lithology.)

Dolmen	Age *	Size **	Corridor/ Cover	# Slabs Chamber	Bedrock	Preserved Slabs Chamber ***
Quinta do Freixo 1	3500 BCE 3rd Millenium	Medium		7	Micaschist	Granodiorite (7)
Quinta do Freixo 2	3500 BCE 3rd Millenium	Medium		7	Granodiorite	Granodiorite (7)
Quinta do Freixo 3	3500 BCE 3rd Millenium	Medium		7	Granodiorite	Granodiorite (7)
Quinta do Freixo 5	3500 BCE 3rd Millenium	Medium		7	Gabbro-diorite	Granodiorite (5) and Quartz-Diorite (1)
Colmeeiro 1	3500 BCE 3rd Millenium	Medium	Yes/ Yes	7	Paragneiss	Granodiorite (7)
Casas Novas 1	3500 BCE 3rd Millenium	Very Large	Yes / Yes	7	Paragneiss	Granodiorite (7)
Vidigueira	3500 BCE 3rd Millenium	Very Large	Yes inc / Yes	7	Granodiorite	Granodiorite (7)
Godinhos	3500 BCE -3250 BCE 3rd Millenium	Small		6	Gneiss and Migmatites	Muscovite-Granite (4) and Gneiss-Migmatite (2)
Candeeira	3500 BCE 3rd Millenium	Large	Yes inc / Yes	7	Phylite	Porphyroblastic-Schist (7)

The largest and better-preserved dolmen from group of Freixo is Casas Novas 1. Although is missing the capstone, still maintains all chamber slabs and lintel, as well as the passage slabs and lintels. Vidigueira and Colmeeiro 1, although well preserved, being the only dolmens of the area with the capstones, are slightly smaller in comparison with Casas Novas 1. From the remaining dolmens, only the Quinta do Freixo 1 is fairly complete, the dolmens of Quinta do Freixo 2, 3 and 5, although with sufficient plan information o allow its classification, have suffered partial destructions.

This group can be subdivided in two models of location: an immediate one to the plain, exactly in the transition between the hills that precedes the elevations of Ossa mountain (Vidigueira, Freixo 1, 2, 3 and 5), and another one composed by dolmens embedded in the valleys, further away from the plain (Casas Novas, Colmeeiro 1). Thus, while the first one is located in flat areas, and with open landscapes, the latter is on small elevations overlooking small water lines, and with more limited horizons. However, in architectural terms, and in spite of the variation in size, they present great homogeneity, with polygonal plants of seven slabs and middle size corridors. The dolmen of Godinhos is isolated from others known until present and has an intermediate location between the dolmens from group of Freixo and the dolmen of the Candeeira (Fig. 1). As mentioned above this dolmen seems to represent an early type of tomb, followed by more common type of polygonal chamber tombs, varying in size (small, medium and large). However, dolmen of Godinhos presents already some standard characteristics: chamber made with slabs covered by a capstone, opening to the rising sun and been all covered by a structured mound with a peripheral "kerb".

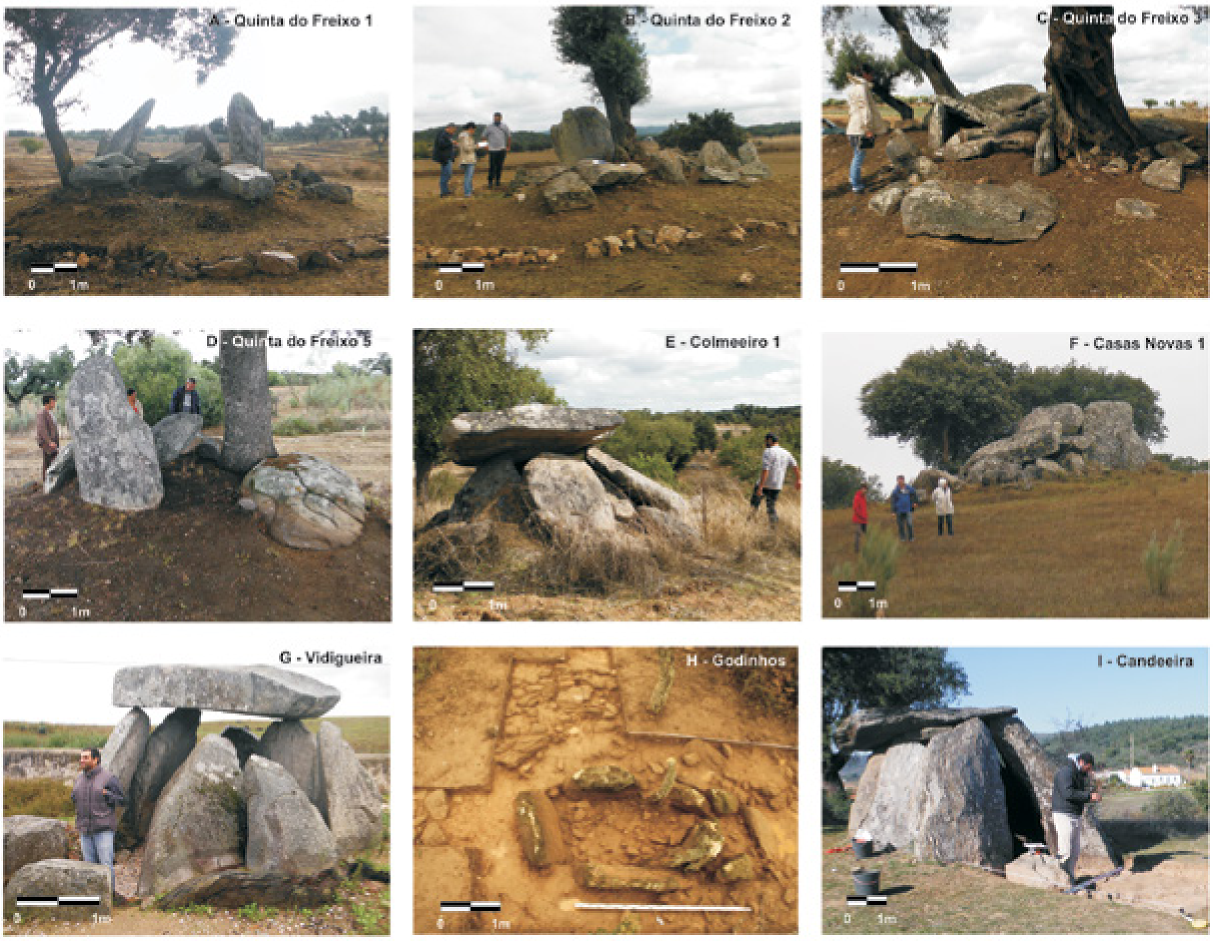

Figure 5 – Selected dolmens for this study, from Freixo-Redondo área: A) Quinta do Freixo 1, B) Quinta do Freixo 2, C) Quinta do Freixo 3, D) Quinta do Freixo 5, E) Colmeeiro 1, F) Casas Novas 1, G) Vidigueira, H) Godinhos and I) Candeeira.

The dolmen of Candeeira is nowadays sort of isolated on the immediate outskirts of the mountain, around 6.6 km north of Redondo town (Fig. 1). However ancient reports point to the existence of other similar structures at the Convento da Serra premises (Leisner & Leisner, 1959: 160). It is likely the first dolmen to be drawn in Redondo, around 1867, and two decades later again together with dolmens of Vidigueira and Colmeeiro 1 (Boaventura *et al.*, 2014). The singularity of a hole on the headstone called the attention of national and international researchers - although likely a mediaeval operation, the chronology of this feature is still open to discussion. Based on the typology of the tomb, with seven chamber slabs and a short passage, and presenting the capstone still, it is plausible to admit the erection of the structure at the second half of the 4th millennium BCE that is, contemporaneous with dolmens from group of Freixo.

Given the available information from the dolmens mentioned above, it was possible to establish a generic chronology for them: besides Godinhos earlier chronology, erected around middle and second half of the 4th millennium BCE whereas the other studied dolmens, based solely on its typologies seem to have been erected at least during the second half of the 4th millennium BCE.

4. Geological setting and outcrops availability

The dolmens of Freixo-Redondo area are implanted in the Portuguese sector of the Ossa-Morena Zone, one of the major NW-SE geotectonic divisions of the Iberian Variscan Belt. The Freixo-Redondo area comprises metamorphic and igneous rocks that are structurally controlled by the Redondo Antiform (Carvalhosa *et al.*, 1986).

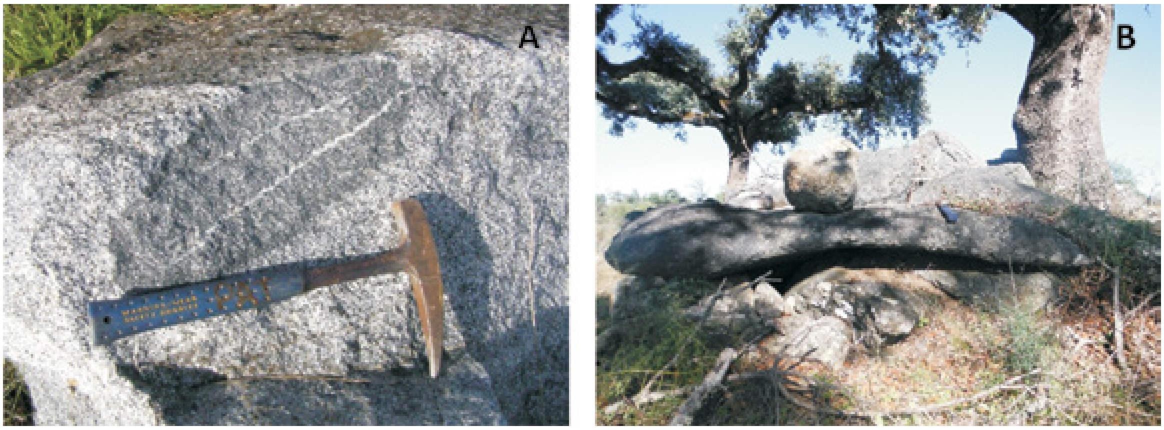

Figure 6 – Examples of outcrop features: A) macroscopic features used to establishment of provenances such as mafic microgranular enclave within granodiorite; B) gabbro-diorite tabular block.

The metamorphic rocks belong to the Ossa Formation unit mainly composed of paragneisses, micaschists and phyllites, with subordinate metagraywacke intercalations. Planar and linear fabrics are present in those lithologies. Also, most of their lithological limits have the typical NW-SE orientation present in Ossa-Morena Zone and are in agreement with regional scale structures in Iberian Variscan Belt.

Paragneisses display a NW-SE foliation with vertical dipping and alternating layers of quartz-feldspar and biotite, while micaschists and phyllites develop a NW-SE schistosity. In particular the quartz-feldspathic nature of the paragneisses provide rare, usually very weathered, small and tabular slabs. Micaschists and phyllites, with great amounts of phyllosilicates are also suitable to weathering and do not provide or provide scarce and very weathered outcrops. In fact, due to his mineralogical constitution (mainly muscovite) the micaschists and the phyllites are very fragile and usually just slightly emerge in the surface. Although not differentiated in cartography the paragneisses unit also includes anisotropic and deformed levels of gneiss-migmatites and small bodies of muscovite-granites. Due to their mineralogical and structural features this lithologies provide very weathered and scarce outcrops.

The igneous rocks correspond mainly to the granodioritic Redondo massif, an irregular NW-SE elongated pluton with approximately 10-15km long that enclose a NW-SE elliptic gabbro-diorite body with 2.5 km long. The Redondo massif intruded the Ossa Formation and was responsible for the development of a contact metamorphism aureole in the surrounding pre-existent metamorphic rocks. It produced metamorphic recrystallization and macroscopic appearance of porphyroblast phases, like andalusite in phyllites. This lithology presents a silica enrichment with develops silica veins which probably contributes for preservation of some outcrops that enables them to provide metric and tabular blocks. The Freixo-Redondo area is also characterized by a profusion of granitic dykes, with variable orientation without/or limited cartographic representation.

Especially prominent in the field relations are the interactions of granodiorite with the gabbro-diorite intrusion; these two melts interacted before cooling and crystallization which is manifested by interpenetration between the two rock types as well by the presence of rounded mafic microgranular enclaves (Fig. 6). This type of relations (mingling of magmas) provided macroscopic fingerprints that can be related with the proximity to limits of the gabbro-diorite.

In the studied area the plutonic rocks are better preserved than the metamorphic being the dominant lithology a granodiorite: it is a light-coloured medium size grained where the mafic minerals correspond mainly to biotite and occasionally to hornblende. Typically exhibits rounded mafic granular enclaves and angular metamorphic enclaves. The granodiorite provides some large outcrops with fracturing patterns that originated metric rounded to tabular blocks. The gabbro-diorite is very coarse grained, sometimes with cumulated textures and provide very fresh tabular blocks (~1 m length).

5. Dolmens and outcrops features

The geological survey in the area allows to identify/select and geo-reference the outcrops (Tab. 2) that have mesoscopic (outcrop scale) and blocometry compatibility with the slabs from the dolmens. Most of the selected outcrops exhibited evidences of extraction of raw material such as negative structures (Fig. 2), that is a clear absence of stone blocks and/or more recent extraction (roman, medieval/modern) activity by notch marks. Outcrop identification fieldwork with respective GPS-location made possible to locally redraw the cartographic geological limits of the studied area (*e.g.* AFL-2, 12, 13). Upon selection of outcrops by the above mentioned criteria these were sampled according with the nearest proximity to the dolmen (NMCOutcrops). In most of cases, the NMCOutrops (Tab. 2) are at a visual distance, between 20-310 m away from the dolmen. In this way minor distances were obtained, although not denying the hypothesis that more distant outcrops were used. Currently, besides the dolmen of Quinta do Freixo 5, there are no clear and unequivocal outcrops under the dolmens, suggesting that the implantation of slabs is in soil horizon. Nevertheless, it was not the object of this work to control the soil thickness and the deep of the alveoli.

5.1. Dolmens from group of Freixo

Several dolmens from group of Freixo (Quinta do Freixo 2, 3, 5, Vidigueira) stands out in the area dominated by interaction between two types of igneous rocks - granodiorite and gabbro-diorite - and the bedrock correspond to one or other (Tab. 1). The dolmens of Colmeeiro 1 and Quinta do Freixo 1 are associated with the geologic limits between granodiorite-paragneisses and granodiorite-micaschists respectively. The dolmens of Casas Novas 1 Colmeeiro 1 lies over the paragneisses whereas the dolmen of Quinta do Freixo 1 is implanted over micaschists (Tab. 1).

Granodiorite is ubiquitous in the dolmen slabs from group of Freixo (Tab. 1). In fact, within this group almost all the preserved slabs have a similar granodioritic composition between monuments. This granitoid variety has typically a light colour (i.e. dark minerals such as biotite and hornblende are less than 15-20% of modal composition) and it is medium to coarse grained. Some small differences between them include grain size variations, proportions between mafic phases (dark minerals), as well as the presence of quartz veins and enclaves. These variations are also observed in the outcrops.

Dolmens of Quinta do Freixo 1, 2, 3 and 5, and Colmeeiro 1 have smaller slabs, when compared with Vidigueira and Casas Novas 1 megalithic tombs – approximately half the size. Thus, for the smaller-middle size dolmens there are more outcrops availability that covers the requisites mentioned in methodology. The selected outcrops for a more detailed comparison with slabs from dolmens of Quinta do Freixo 1, 2, 3 and 5, and Colmeeiro 1 are 20-180m apart (Tab. 2) and exhibit blocks size of more than 1,5-2 m long and 1 m wide.

Table 2 – Distances between dolmens and Nearest Mesoscopically Compatible Outcrops (NMCOutcrops).

Dolmen			NMCOutcrop				Distance (m)
Ref.	Coordinates		Ref.	Coordinates		Lithology	
	Latitude	Longitude		Latitude	Longitude		
Quinta do Freixo 1	38,683861	-7,679611	AFL-10	38,683500	-7,678250	Granodiorite	125
Quinta do Freixo 2	38,696667	-7,667528	AFL-11	38,691750	-7,668083	Granodiorite	240
Quinta do Freixo 3	38,687303	-7,666806	AFL-9	38,686750	-7,668000	Granodiorite	120
Quinta do Freixo 5	38,684778	-7,659806	AFL-6	38,684861	-7,659667	Gabbro-diorite	20
			AFL-7	38,683278	-7,659139	Granodiorite	180
Colmeeiro 1	38,692675	-7,634889	AFL-13	38,693722	-7,633778	Granodiorite	150
Casas Novas 1	38,688420	7,593319	AFL-17	38,681760	-7,642060	Granodiorite	780
Vidigueira	38,676422	-7,659564	Not identified				
Godinhos	38,702692	-7,615100	AFL-18	38,700278	-7,613750	Muscovite-Granite	300
			AFL-18	38,699917	-7,615611	Gneiss-Migmatite	
Candeeira	38,704353	-7,553539	AFL-14	38,703278	-7,554889	Porphyroblast-Phyllite	170

Regarding the dolmens with bigger size slabs, Casas Novas 1 and Vidigueira, the possibilities of outcrop sourcing are reduced. In the case of dolmen of Casas Novas 1 an extensive outcrop (AFL-17; Fig. 1) near the Freixo stream, southeast from the dolmen, present blocks with sizes similar to those in the dolmen as well as evidences of extraction.

As in the remaining dolmens, Vidigueira tomb also has granodioritic slabs. Nevertheless, this dolmen stands out not only by the size of the slabs but also for the profusion of enclaves (black rounded globules) as well for the quartz veins with few centimetres thickness. The presence of mafic micro-granular enclaves in the slabs of dolmen of Vidigueira is geologically compatible with its implementation near the limit between the gabbro-diorite and the granodiorite. Unfortunately, this dolmen was erected between the edge of the village, nearby a farmstead house and a crop field with no outcrops within a radius of 1km. Although no outcrops were observed these could have existed and are presently hidden under farm infrastructures. (Fig. 1).

The dolmen of Quinta do Freixo 5 is the only that was erected over the gabbro-diorite bedrock and exhibit different lithologies (Tab. 1). One of the preserved slabs is darker (dioritic affinities) whereas the others correspond to granodiorites. Located over the gabbro-diorite bedrock, the dolmen was erected away from the concentration of available basic outcrops but above a later intrusion of a pegmatitic dyke.

5.2. Dolmen of Godinhos

The preserved slabs from dolmen of Godinhos correspond to gneiss-migmatite and muscovite-granite lithologies. The slabs are very weathered and are relatively small, which agrees with the size of the available outcrops in the area. There are two gneiss-migmatite slabs, the head slab and one other, that have a heterogeneous appearance with felsic (mainly quartz and feldspar minerals) igneous layers alternating with metamorphic mica-rich layers. The other slabs including one of the probable capstone, are made of muscovite-granite that is also very weathered. They are light coloured (yellowish due to alteration) without mafic minerals reflecting the different geological processes of formation of this granite when compared with granodiorite.

Around the dolmen of Godinhos the outcrops of gneiss-migmatites are rare. They have an orientation parallel to the NW-SE anisotropy of the rock. At a distance of approximately 300 m, it was identified an outcrop presenting adequate size blocks. The muscovite-granites outcrops were not found. Nevertheless, this lithology can be found as abundant blocks, boulders and as sand in the soil associated with blocks of paragneisses, gneiss-migmatites and micaschists. It is not surprising that muscovite-granites do not constitute significant outcrops due to the strong alteration as well to the fact that they occur as small "pouches", without cartographic representation. It is important to note that these two lithologies present in the dolmen of Godinhos as well in the outcrops are not individualized in the Ossa Formation unit (Carvalhosa *et al.*, 1986), both are included in the unity of the paragneisses.

5.3. Dolmen of Candeeira

The chamber slabs and capstone of dolmen of Candeeira correspond to andalusite-porphyroblast phyllite. This singular lithology is characterized by the growth of andalusite crystals over the mica schistosity, projecting in the surface. The slabs are very identical within each other but displaying slight variations in size and abundance of andalusite crystals. The andalusite-porphyroblast phyllite is a relatively fragile/soft rock due to their large proportion of phyllosilicates (muscovite, sericite).

Around the dolmen (4-5 m to west and south) there are small outcrops that slightly emerge from the soil. However, although constituted of schist they do not have andalusite crystals. More to the south (170 m) a protuberant outcrop (AFL-14) constituted by andalusite- porphyroblast phyllite, with quartz veins, was selected for sampling. Regarding the size and fractures of the outcrop, it would have been possible the extraction of large blocks as those used in the dolmen of Candeeira.

6. Petrographic analysis

The microscopic petrography allows the identification and quantification of mineralogy present in the rock. Not only the main mineralogy, but also accessory mineralogy as well as textural relations between the different mineral phases. The aim of this type of analysis is to identify unique petrographic features that might be identified in samples of slabs and outcrops. It were analysed 30 thin sections representing outcrops and slabs, whose main features are presented on Tab. 3 and Fig. 7. In what concern the dolmens of Colmeeiro 1, Vidigueira and Candeeira, classified as National Heritage Monuments, no samples were taken because of its very distinctive macroscopic mineralogy/texture and fragility of the slabs. Moreover, considering the same archaeological and geological features between the dolmens of Quinta do Freixo 2 and 3 to reduce the impact of sampling and preclude the duplication of data only the dolmen of Quinta do Freixo 3 was sampled.

Table 3 – Main petrographic feature of samples from dolmens and outcrops.

OUTCROP																
Field Ref.	AFL-2	AFL-2	AFL-6	AFL-8	AFL-9	AFL-10		AFL-11			AFL-13			AFL-17	AFL-18	
Sample ID	FRX-2	FRX-2	FRX-5	FRX-6	FRX-7	FRX-8	FRX-9	FRX-10	FRX-11	FRX-12	FRX-13	FRX-14	FRX-15	FRX-17	FRX-18	FRX-19
Rock Type	Grd	Grd	Gb-Drt	Grd	Hb-Grd	Hb-Grd	Hb-Grd	Qz-Drt	Qz-Drt	Qz-Drt	Grd	Grd	Grd	Grd	Gns-Mig	Msc-Gr
wt %																
SiO_2	61,31	61,31	48,10	61,74	61,71	61,43	60,41	48,41	58,32	48,17	60,18	61,31	61,02	61,83	70,01	74,26
Al_2O_3	17,95	17,95	17,04	17,70	18,11	17,53	17,73	19,83	18,71	20,15	18,17	18,23	18,11	17,05	15,49	14,13
Fe_2O_3	6,04	6,04	10,51	5,78	4,92	5,62	6,19	9,64	6,66	10,05	5,93	6,17	6,26	5,40	6,36	0,66
MnO	0,09	0,09	0,17	0,09	0,07	0,11	0,11	0,20	0,12	0,20	0,10	0,10	0,10	0,09	0,18	0,03
MgO	2,45	2,45	7,41	2,28	2,91	2,55	2,92	5,35	2,99	6,24	2,39	2,44	2,51	2,22	1,76	0,11
CaO	4,99	4,99	8,72	4,82	5,54	4,64	5,50	9,86	6,12	9,39	5,22	4,87	5,05	4,47	0,13	0,33
Na_2O	2,91	2,91	2,65	2,98	2,92	3,13	3,11	2,47	3,19	2,49	3,15	2,87	2,91	2,88	0,30	2,61
K_2O	2,80	2,80	1,52	2,83	2,35	2,89	2,50	1,31	2,26	1,72	2,48	2,60	2,76	2,77	2,31	4,95
TiO_2	0,71	0,71	1,07	0,69	0,60	0,63	0,65	1,16	0,77	0,91	0,65	0,71	0,76	0,65	0,60	0,06
P_2O_5	0,23	0,23	0,26	0,20	0,23	0,19	0,20	0,24	0,23	0,21	0,27	0,22	0,23	0,19	0,04	0,07
LOI	1,52	1,52	3,05	1,08	1,12	1,43	1,00	1,69	1,11	1,42	0,93	1,08	1,02	1,05	1,53	1,30
ppm																
Y	10,60	10,60	30,00	8,30	6,50	21,40	26,70	50,10	22,60	33,70	12,60	17,40	16,80	13,00	16,80	8,60
Zr	181,00	181,00	93,00	151,00	176,00	145,00	143,00	134,00	156,00	111,00	170,00	171,00	226,00	168,00	83,00	24,00
Nb	8,60	8,60	4,90	8,90	5,20	7,40	10,50	7,40	7,90	4,70	12,60	8,20	10,00	11,70	10,70	11,50
La	34,30	34,30	18,40	15,40	4,98	30,10	34,00	20,60	22,90	16,40	44,80	16,60	75,00	39,50	38,40	6,99
Ce	81,80	81,80	46,60	29,00	10,80	60,70	66,80	58,40	48,70	44,10	78,60	32,70	150,00	75,20	74,00	11,20
Pr	7,44	7,44	6,47	3,30	1,50	6,89	7,68	8,91	5,81	6,30	9,08	3,73	16,50	8,20	8,35	1,29
Nd	27,30	27,30	30,50	13,30	7,15	27,10	30,00	44,40	24,70	29,50	32,80	15,50	60,90	29,90	30,40	4,30
Sm	4,54	4,54	7,30	2,65	1,55	5,27	6,21	11,00	5,07	7,21	5,02	3,41	9,78	4,98	5,83	0,92
Eu	1,41	1,41	1,63	1,18	0,93	1,22	1,22	2,15	1,28	1,59	1,24	1,14	1,49	1,11	0,98	0,37
Gd	3,14	3,14	6,17	2,10	1,24	4,12	5,11	9,81	4,44	6,26	3,52	2,76	6,19	3,40	4,23	0,90
Tb	0,43	0,43	1,01	0,31	0,19	0,65	0,86	1,66	0,76	1,12	0,44	0,51	0,80	0,52	0,65	0,21
Dy	2,31	2,31	5,73	1,61	1,10	3,85	4,96	9,10	4,16	6,47	2,38	3,17	3,66	2,76	3,48	1,47
Ho	0,38	0,38	1,12	0,27	0,20	0,75	0,94	1,74	0,76	1,22	0,46	0,62	0,64	0,50	0,65	0,27
Er	1,05	1,05	3,06	0,66	0,63	2,06	2,75	4,99	2,22	3,38	1,31	1,74	1,60	1,32	1,78	0,77
Tm	0,16	0,16	0,42	0,08	0,09	0,30	0,45	0,74	0,32	0,48	0,19	0,26	0,20	0,20	0,28	0,13
Yb	1,17	1,17	2,61	0,53	0,59	1,91	2,77	4,87	2,00	3,01	1,22	1,63	1,16	1,35	1,83	0,85
Lu	0,20	0,20	0,43	0,10	0,09	0,28	0,37	0,69	0,31	0,49	0,19	0,24	0,18	0,19	0,25	0,12
Hf	4,20	4,20	2,20	3,20	3,80	3,20	3,60	3,20	3,40	2,50	4,40	3,60	4,90	4,00	2,20	0,80
Ta	0,70	0,70	0,42	0,98	0,57	0,64	0,80	1,51	0,49	0,30	0,57	0,76	0,78	1,08	0,95	2,29
Th	10,10	10,10	2,42	4,08	0,49	7,67	9,06	2,15	3,98	1,03	11,00	6,38	21,40	11,20	12,10	3,05

DOLMEN								
Field Ref.	Freixo-1	Freixo-3		Freixo-5		C. Novas1	Godinhos	
Sample ID	D1FRX-24	D3FRX-4	D3FRX-20	D5FRX-22	D5FRX-23	DCNV-26	DGOD-27	DGOD-28
Rock Type	Grd	Hb-Grd	Grd	Qz-Drt	Grd	Grd	Gns-Mig	Msc-Gr
wt %								
SiO_2	64,45	65,30	63,55	49,92	67,54	63,52	51,96	74,99
Al_2O_3	16,70	16,56	17,09	18,78	15,60	17,43	25,00	14,40
Fe_2O_3	4,96	4,59	4,16	10,53	3,55	4,66	9,82	0,98
MnO	0,10	0,09	0,08	0,17	0,06	0,09	0,15	0,08
MgO	1,97	1,81	1,75	4,92	1,46	1,82	1,59	0,15
CaO	3,76	4,12	4,06	8,82	3,46	4,55	0,15	0,42
Na_2O	3,26	3,03	3,38	1,94	3,18	3,46	0,73	2,73
K_2O	2,56	3,34	2,80	2,07	2,51	2,51	5,82	5,39
TiO_2	0,54	0,49	0,56	1,08	0,38	0,51	1,12	0,07
P_2O_5	0,18	0,15	0,15	0,19	0,20	0,20	0,14	0,14
LOI	1,38	0,91	0,98	1,36	0,94	0,82	2,79	1,12
ppm								
Y	23,50	21,70	13,50	32,80	16,00	16,40	37,30	15,50
Zr	140,00	134,00	122,00	105,00	110,00	157,00	165,00	28,00
Nb	10,30	6,20	8,00	8,60	9,30	9,40	18,80	16,00
La	55,30	13,30	30,60	16,70	88,40	43,20	62,50	5,77
Ce	110,00	26,30	58,40	40,30	164,00	82,70	119,00	11,50
Pr	11,90	3,56	6,74	5,83	17,30	8,82	14,10	1,33
Nd	43,30	14,60	25,30	27,50	60,40	31,90	53,70	5,07
Sm	7,36	3,50	4,82	7,08	8,74	5,64	10,80	1,36
Eu	1,10	0,99	1,09	1,62	1,19	1,05	2,02	0,23
Gd	4,61	3,30	3,36	6,25	5,09	3,68	7,45	1,65
Tb	0,73	0,60	0,48	1,06	0,70	0,56	1,25	0,38
Dy	3,97	3,64	2,65	6,48	3,52	3,12	6,92	2,52
Ho	0,81	0,71	0,50	1,20	0,61	0,56	1,36	0,49
Er	2,45	2,13	1,44	3,53	1,45	1,67	3,92	1,39
Tm	0,41	0,35	0,21	0,54	0,15	0,31	0,59	0,23
Yb	2,62	2,22	1,26	3,33	0,81	2,34	3,73	1,37
Lu	0,39	0,35	0,18	0,48	0,11	0,39	0,53	0,23
Hf	3,60	3,10	3,20	2,80	3,50	3,70	4,40	1,10
Ta	1,12	0,95	0,86	0,55	1,24	0,99	1,42	3,29
Th	23,60	4,78	7,98	2,35	24,20	9,86	20,90	3,87

Grd: Granodiorite; Gb-Drt: Gabbro-Diorite; Hb-Grt: Horneblende-Granodiorite; Qz-Drt: Quartz-Diorite; Gns-Mig: Gneiss-Migmatite; Msc-Gr: Muscovite-Granite

6.1. Dolmens from group of Freixo

The granodiorite present in the dolmens from group of Freixo, has a typical plutonic igneous texture – (hypidiomorphic medium to coarse grained). The light colour of the rock - leucocratic - is the result of dominant presence of felsic minerals over mafic minerals. As main mineralogical felsic phases exhibit plagioclase, quartz and ±K-feldspar, whereas biotite is the main mafic phase occasionally accompanied by hornblende. Allanite, apatite and zircon are accessory phases usually in minute amounts. Chlorite is present in some samples due to later low-temperature mineralogical reactions. The dolmen samples are usually not weathered and as consequence plagioclases are well preserved without or with vestigial sericitization. One of the minerals used as reference/comparison between granodiorites (dolmens and outcrops) was the hornblende. This mineral is an amphibole with green colour under transmitted polarized light and exhibits a typical prismatic section (diamond shape). Its size on average is between 200 and 500 µm.

Petrographic analysis show both differences and similarities between pairs of dolmens and NMCOutcrops. All the petrographic features on dolmens and outcrops are compatible and expected at the scale of the granodiorite intrusion, related with their genesis, evolution and crystallization. The petrographic diversity results from differences in texture, for example, whether there is anisotropy (mineral alignment) or quartz recrystallization, but mainly observed by the abundance (modal composition) of mafic phases such as biotite and hornblende.

It was observed a clear match between dolmen samples of Casas Novas 1 and its NMCoutcrop (samples DCNV-25 and DCNV-26 from dolmen with sample FRX-17 from outcrop AFL-17) that is all samples present similar isotropic texture as well biotite as the only mafic mineral phase.

The sample from dolmen of Quinta do Freixo 3 (D3FRX-4) and NMCoutcrop (sample FRX-7 from outcrop AFL-9) have strong similarities where in this case both amphibole and biotite are present with similar volumetric amounts. On the other hand, the sample D3FRX-20 does not present amphibole in its modal composition and does not match with the petrography observed in NMCoutcrop. This observation suggests different sources of material, that is, different outcrops, for a single dolmen.

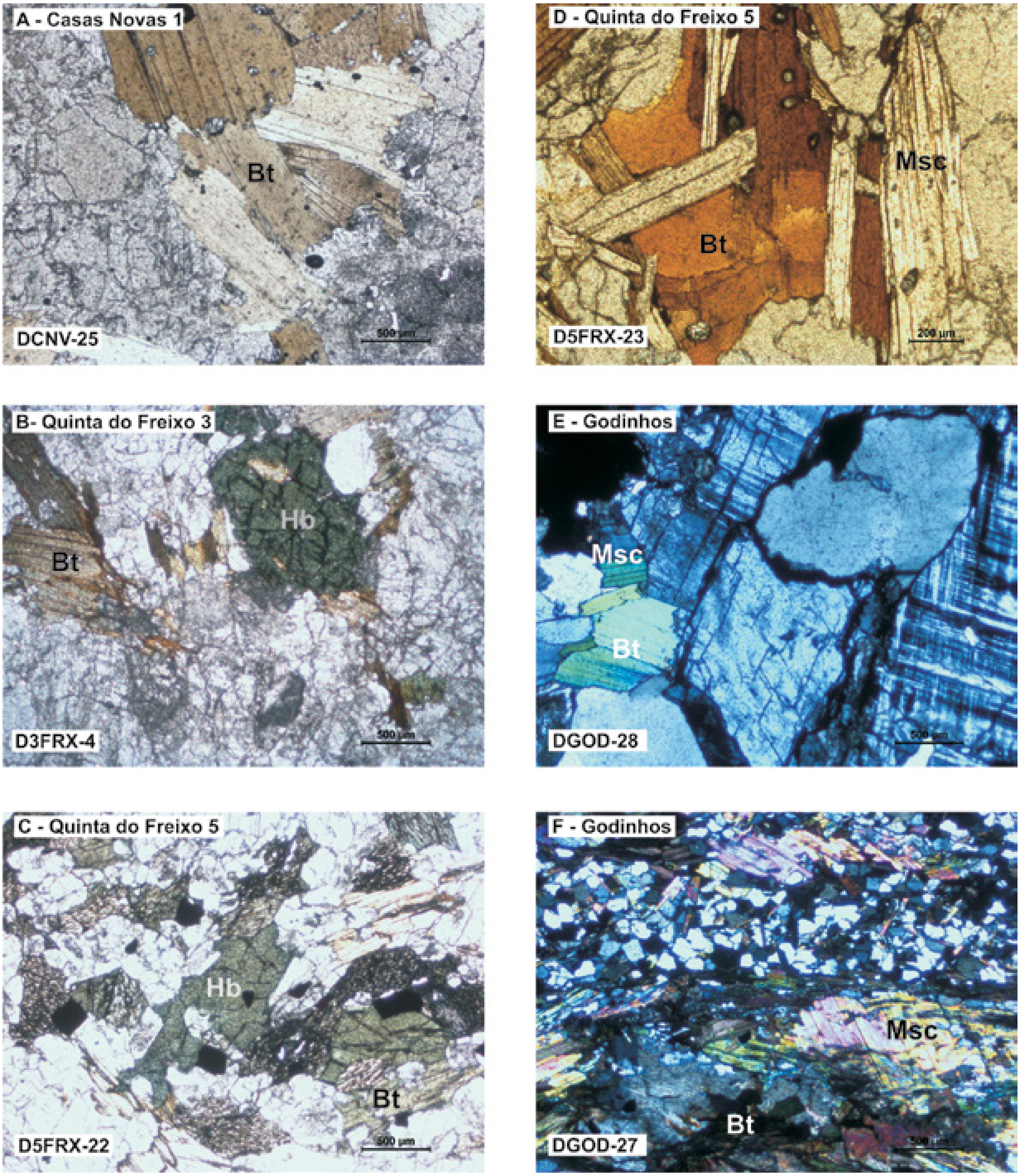

Figure 7 – Microphotographs of samples from dolmens showing main mineralogical and textural features. Bt – Biotite, Hb – Hornblende, Msc – Muscovite. Images with parallel (A, B, C, D) and crossed (E, F) Nicols.

The outcrop selected for sampling near dolmen of Quinta do Freixo 1 (AFL-10) with clear evidences of exploitation (Fig. 2) would not have been the place for the provenance of the sampled slab (D1FRX-24). In fact, the outcrop samples (FRX-8 and FRX-9 from outcrop AFL-10) show hornblende and biotite as the main mafic mineral phases within an isotropic texture and these features contrast with the anisotropic texture (mineral alignment) and absence of hornblende (Fig. 7) in dolmen sample.

The petrographic features of the gabbro-diorite sample (FRX-5), from NMCOutcrop (AFL-6), enclose the presence of plagioclase, hornblende and subordinate pyroxene within a hypidiomorphic medium grained texture. Although dark at mesoscale and similar to quartz-diorite, sample from dolmen Quinta do Freixo 5 (D5FRX-22), does not correspond to the same lithology. In terms of texture as well modal composition the mafic mineral phases (biotite and hornblende) represent 30 to 40% of modal composition in quartz-diorite. Regarding the other sample from the same dolmen (D5FRX23), the presence of muscovite in their granodioritic paragenesis inviable the match with the granodiorite (FRX-6) sampled from the NMCOucrop (AFL-8) where this accessory mineral phase was not observed.

The exercise of confronting the petrography of the dolmens lithologies with more distant outcrops provided similarities. For example, the granodiorite sample from dolmen Quinta do Freixo 3 (D3FRX-20) it is not compatible with the hornblende-granodiorite from the nearest outcrop (AFL-9), but match with the granodiorite outcrops AFL-2 (at 757 m; sample FRX-2) and AFL13 (at 3000 m, samples FRX-13, 14 and 15). Other example is the sample D5FRX-22 from dolmen Quinta do Freixo 5 that matches with the hornblende-rich diorite outcrops AFL-10 (at 1600 m; sample FRX-10), AFL-11 (1100 m; sample FRX-11) and AFL-12 (2400 m; sample FRX-12).

6. 2. Dolmen of Godinhos

As mentioned before dolmen of Godinhos slabs have different lithologies – muscovite-granite and gneiss-migmatite as building material. The muscovite-granite found in dolmen of Godinhos has an anatetic nature and exhibits a medium grained allotriomorphic texture, mainly composed by quartz and K-feldspar (microcline). These are followed in volume amount by muscovite and biotite as accessory phases. Also, vestigial amphibole can be observed. The most intense alteration in this lithology, observed in both samples (dolmen sample DGOD-28 and sample FRX-19 from outcrop AFL-18) is specially expressed on plagioclase by formation of clay minerals.

The gneiss-migmatite samples (DGOD-17 from dolmen and FRX-18 from outcrop AFL-18), are very heterogeneous presenting a well-developed planar fabric that consists in the alternation of micaschist (biotite within a lepidoblastic texture) and granite (quartz and feldspar within a granoblastic texture) layers.

7. Geochemistry

It was selected 24 samples (16 from outcrops and 8 from dolmens) for geochemical analyses at the Activation Laboratories - ACTLABS (Canada) using the lithium metaborate/tetraborate fusion for ICP and ICP-MS. The data for major and trace elements from analysed samples are presented in Tab. 4.

Within the cartographic unit of granodiorite, it is verified that despite being a cartographically homogeneous body there is, as also observed in petrography, a compositional variability (Fig.8) where, namely, the MgO varies considerably between 1.46 and 6.24 wt%.

For a better comparison between samples (dolmen and NMCOutcrop) it was adopted the chondrite-normalized (Sun & McDonough, 1989) multi-element diagram (Fig. 9) that compare simultaneously the abundances of a set of trace elements, with different geochemical behaviour. The outcome geochemical patterns result from the modal composition and represent for each sample elemental ratios.

Table 4 – Major and trace element composition of samples from dolmens and outcrops. (Grd: Granodiorite; Gb-Drt: Gabbro-Diorite; Hb-Grt: Horneblende-Granodiorite; Qz-Drt: Quartz-Diorite; Gns-Mig: Gneiss-Migmatite; Msc-Gr: Muscovite-Granite; Qz: Quartz; Hb: Horneblende; Plg: Plagioclase; Alk: Alkaline Feldspar; Bt: Biotite; Pyr: Pyroxene; Epd: Epidote; Msc: Muscovite)

Sample			Mineralogy (%)			Texture
	ID	Rock type	Qz	Feldspar	Accessory phases	
Outcrops	FRX-2	Grd	20	Plg ± Alk	Bt	Hypidiomorphic
	FRX-5	Gb-Drt	-	Plg	Hb + Pyr ± Bt	Hypidiomorphic
	FRX-6	Grd	25	Plg ± Alk	Bt (± Epd)	Hypidiomorphic
	FRX-7	Hb-Grd	30	Plg ± Alk	Bt ± Hb	Hypidiomorphic
	FRX-8	Hb-Grd	20	Plg ± Alk	Bt ± Hb	Hypidiomorphic
	FRX-9	Hb-Grd	15 - 20	Plg ± Alk	Bt ± Hb	Hypidiomorphic
	FRX-10	Qz-Drt	5 - 10	Plg ± Alk	Hb ± Bt	Hypidiomorphic
	FRX-11	Qz-Drt	15	Plg ± Alk	Bt + Hb	Hypidiomorphic
	FRX-12	Qz-Drt	10 - 15	Plg ± Alk	Hb + Bt	Hypidiomorphic
	FRX-13	Grd	25	Plg ± Alk	Bt	Hypidiomorphic
	FRX-14	Grd	25	Plg ± Alk	Bt	Hypidiomorphic
	FRX-15	Grd	20 - 25	Plg ± Alk	Bt	Hypidiomorphic
	FRX-17	Grd	25 - 30	Plg ± Alk	Bt	Hypidiomorphic
	FRX18	Gns-Mig	(Qz + Plg) 50 - 70		Bt + Msc	Layered-Granoblastic-Lepidoblastic
	FRX-19	Msc-Gr	30 - 40	Alk	Msc	Alotriomorphic
Dolmens	D1FRX-24	Grd	25 - 30	Plg ± Alk	Bt	Hypidiomorphic
	D3FRX-4	Hb-Gd	20 - 30	Plg ± Alk	Bt ± Hb	Hypidiomorphic
	D3FRX-20	Grd	25 - 30	Plg ± Alk	Bt	Hypidiomorphic
	D5FRX-22	Qz-Drt	20 - 30	Plg ± Alk	Bt + Hb	Hypidiomorphic
	D5FRX-23	Grd	30 - 40	Plg ± Alk	Bt (± Msc)	Hypidiomorphic
	DCNV-26	Grd	20 - 25	Plg ± Alk	Bt	Hypidiomorphic
	DGOD-27	Gns-Mig	(Qz + Plg) 50 - 70		Bt + Msc	Layered-Granoblastic-Lepidoblastic
	DGOD-28	Msc-Gr	30 - 40	Alk	Msc + Bt	Allotriomorphic

The profile of the granodiorites presents roughly a similar structure; this is a general pattern with an enrichment of more incompatible elements (on the left) compared to the less incompatible elements (on the right). This distribution is truncated by the negative anomalies for the elements Nb-Ta and Ti more and less pronounced.

As in the petrographic analysis, similarities and differences were found for elemental geochemistry for samples from dolmens and respective NMCoutcrops. The petrographic match verified for the dolmen of Casas Novas 1 (sample DCNV-26) is corroborated by the geochemistry (Fig. 9a) of sample FRX-17 from the NMCOutcrop (AFL-17 at 750 m distance) with a clear overlap of the multi-elements diagram.

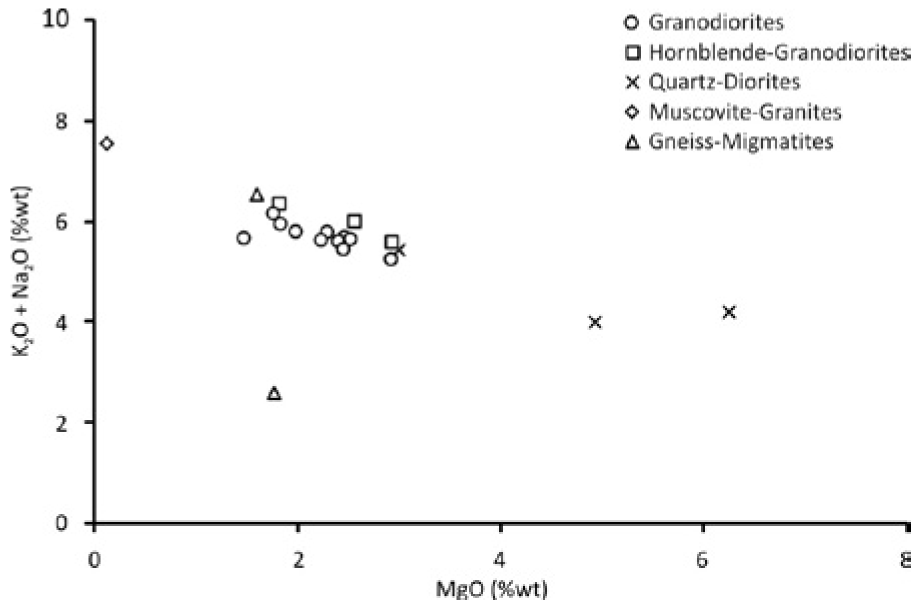

Figure 8 – Projection of dolmens and outcrops analyses for major elements (alkalis and magnesium) highlighting geochemical variability.

On the other hand, the petrographic correspondence verified in the pair D3FRX-4 (from dolmen of Quinta do Freixo 3) and FRX-7 (NMCOutcrop AFL-9) is contradicted by the geochemistry of the outcrop sample that shows an anomalous pattern regarding all the other samples from granodioritic intrusion (Fig. 9b). Nevertheless, that hornblende-granodiorite sample is geochemically and petrographically compatible with FRX-8 and FRX-9 samples from outcrop AFL-10 (1000 m distance). For the same dolmen Quinta do Freixo 3 the other studied sample (D3FRX20) should be related with the granodiorite from outcrop AFL-2 (sample FRX-2 at 750 m distance) because of its similar geochemical patterns.

As also deducted from petrography, the granodiorite sample D1FRX-24 from dolmen of Quinta do Freixo 1, cannot be related with the hornblende-granodiorites samples FRX-8 and FRX-9 from the NMCOutcrop AFL-10 (150 m distance). Nevertheless, the advanced hypothesis based on petrography for the provenance of sample D1FRX-24 echoes in the geochemistry with a good match of the multi-elemental diagrams (Fig. 9c); the sample D1FRX-24 that does not match with its NMCOutcrop, can be related with the granodiorite samples from outcrop AFL-2 (sample FRX-2 at 1600 m distance), outcrop AFL-13 (sample FRX-15 at 3200 m distance) or outcrop AFL-17 (sample FRX-17 at 4100 m distance) with similar petrographic features and multi-elemental patterns.

For the dolmen of Quinta do Freixo 5 where it was observed the more mafic lithology (quartz-diorite: D5FRX-22) other source than the NMCOutcrop is required; in fact, the quartz-diorite samples FRX-11 and FRX-12 from outcrop AFL-11 (1000 m distance) have petrographic features and multi-elemental patterns (Fig. 9d) similar with the above mention dolmen sample. Still for this dolmen, the granodioritic slab sample (D5FRX-23), it is not compatible with the nearby granodioritic outcrop (sample FRX-6 from outcrop AFL-8 at 330 m distance). Still this slab can be related with the granodiorite sample FRX-15 (Fig. 9d) from the outcrop AFL-13 that is further away (2500 m distance), but geochemically and petrographically similar.

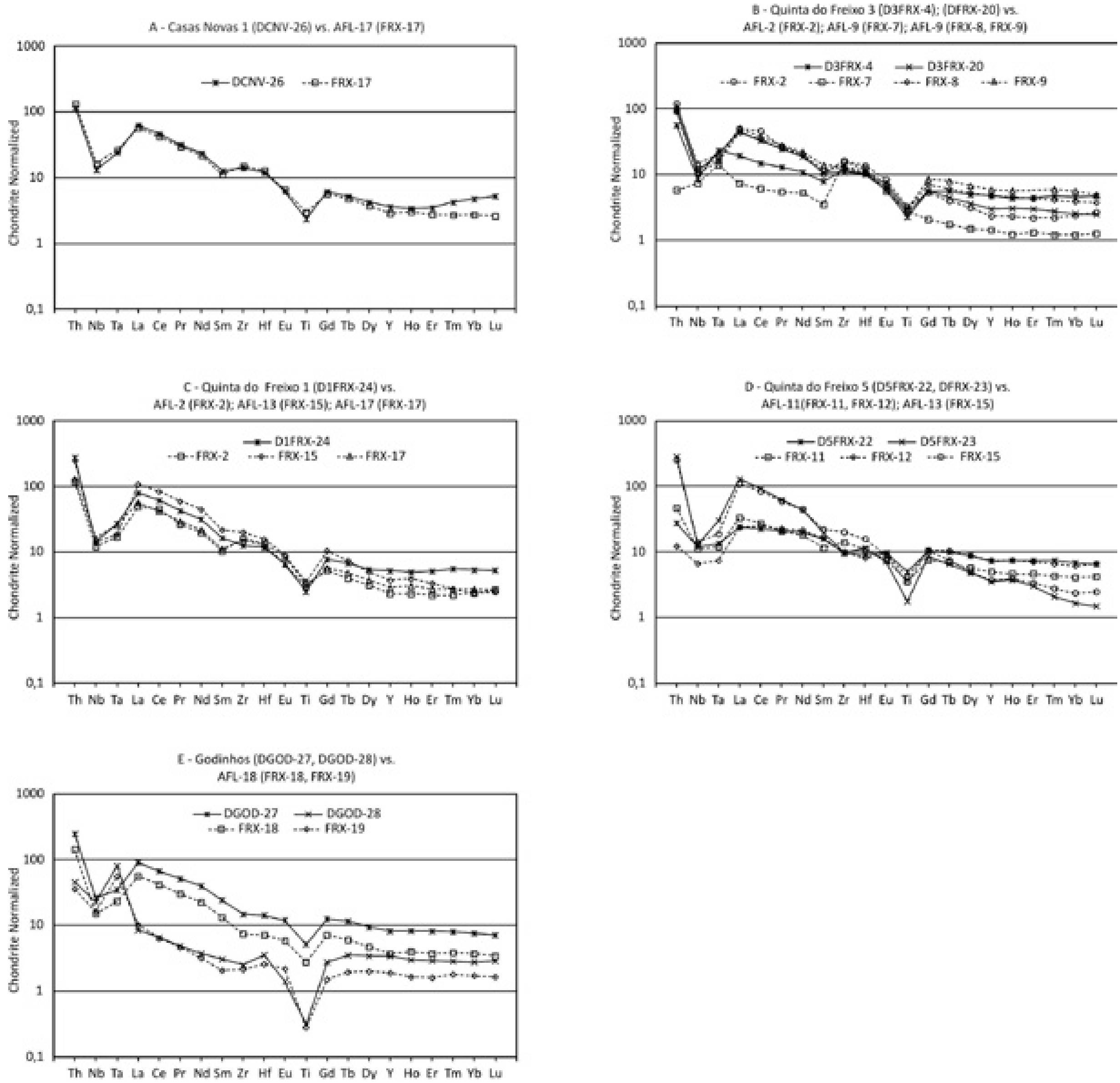

Figure 9 – Multi-elemental diagrams for dolmens and outcrops samples. A) dolmen of Casas Novas 1 vs AFL17, B) Dolmen of Quinta do Freixo 3 vs AFL-2, AFL-9 and AFL-10; C) Dolmen of Quinta do Freixo 1 vs AFL-2, AFL-13 and AFL-17; D) Dolmen of Quinta do Freixo 5 vs AFL-11, AFL-13; E) - Dolmen of Godinhos vs AFL-18.

The geochemical signature of the muscovite-granite is distinct from that of the granodiorite, namely in the positive anomaly in Ta and the most pronounced negative anomaly in Ti, both associated with impoverished multi-element profiles. The multi-element profiles of muscovite-granites for the dolmen of Godinhos (DGOD-28) and for sample FRX-19 from NMCOutcrop AFL-18 are similar (Fig. 9e) but diverging only in the Heavy Rare Earth Elements which may be justified by the presence of cryptocrystalline accessory mineral phases (in minute quantities).

Due to the heterogeneity (macro and microscopically) of the gneiss-migmatites, it is difficult to expect an overlap of the profiles. However, the parallelism for the data from the dolmen of Godinhos (sample DGOD-27) and the NMCOutcrop AFL-18 (sample FRX-18) establishes a clear relation between these samples, pointing to a probable local provenance around 300 m.

8. Discussion

The studied dolmens in this work (group of Freixo, Godinhos and Candeeira) are located in the Freixo-Redondo area (Alentejo region) with a low population density where the landscape should not have undergone major changes until the present time. It is dominantly an agricultural region with a small anthropogenic impact and in thus we can assume a topographic preservation as well a maintenance of outcrops availability. Some of them present evidence compatible with their use as a supplier of raw material, but the presence of notched marks reverts to more recent periods of use. However, the negatives of stone blocks are timeless and can be interpreted, or at least speculated, as Neolithic use. At distances less than ~300 m from the dolmens, usually at a visual distance, it is possible to identify a NMCoutcrop that has sizes and mesoscopic features compatible with the slabs.

Regarding the dolmens from group of Freixo, the slabs are broadly considered as granodiorites (rarely quartz-diorites) but it was verified some differences; namely in mesoscopic features (*e.g.* enclaves, quartz veins and dimensions of the slabs), petrography (mineralogical composition such as presence or absence of amphibole, and texture such as anisotropy) and geochemistry (major and trace elements). In this sense and although they are in a relatively circumscribed area there should not have been a single place – outcrop – that would supply the raw materials for the slabs of all dolmens.

Also, the variability found in a single dolmen, as in the case of the dolmen of Quinta do Freixo 5, points to provenance of slabs from different outcrops. This data agrees with what was observed by Pedro *et al.* (2015) in the Monforte area (northeast Alentejo region). Without constraints of size or shape the communities would have use a naturally fractured outcrops and single extraction of (partially) loosened blocks, followed by exploitation of more distant outcrops.

The mesoscopic geological monotony found in the slabs and outcrops was not reflected on the variability, however tenuous, from petrography and geochemistry. The conjunction of the presented data for the dolmens from group of Freixo highlights as shown in Table 5, that the NMCOutcrops were not always the suppliers for the studied slabs. Not denying the hypothesis of a very local provenance, in fact, the data obtained points to considerably higher distances.

As an exception, the dolmen of Casas Novas 1 stands out not only for its monumentality but also for its edification in a small hill. The petrographic and geochemical similarity between samples of dolmen and NMCOutcrop allowed to establish a correlation between both. Bedrock materials were not used, but rather large granodiorite slabs that outcrops at 780 meters down-hill associated with a marked slope.

In the case of dolmen of Vidigueira, the macroscopic characteristics are very typical. In this sense it is important to weigh the impact of sampling (even reduced and mitigated) with the added data that will come from it. In this case, sampling seemed unnecessary since the macroscopic comparison will always provide good information. The dimension of the slabs requires an outcrop(s) with a fracturing pattern that provides large blocks. Moreover, the slabs have frequent mafic microgranular enclaves and quartz veins. Thus, and fundamentally due to the dimension of the slabs a compatibility with the wide outcrop that occurs along the banks of the Freixo stream (AFL -17 and around) was verified. If the supply-outcrop is not covered under the existing construction around the dolmen, a considerable effort was required with a provenance of about 2000 m increased by topographical irregularities.

Table 5 – Inferred distances by matching petrography and geochemistry or mesoscopic-features.

Dolmen		**Outcrop**	**Dolmen - Outcrop**
Ref.	**Sample ID**	**Reference**	**Distance compatible (m)**
Quinta do Freixo 1	D1FRX-24	AFL-2	1600
		AFL-13	3200
		AFL-17	4100
Quinta do Freixo 3	D3FRX-4	AFL-10	1000
	D3FRX-21	AFL-2	750
Quinta do Freixo 5	D5FRX-22	AFL-11	1000
	D5FRX-23	AFL-13	2500
Colmeeiro 1	Not sampled	AFL-17	1350
Casas Novas 1	DCNV-26	AFL-17	780
Vidigueira	Not sampled	AFL-17	2000
Godinhos	DGOD-27	AFL-18	300
	DGOD-28		
Candeeira	Not sampled	AFL-14	170

The basement for dolmen of Colmeeiro 1 correspond to weathered paragneisses not used as building material. Immediately around metamorphic rocks, the granodioritic outcrops doesn't show morphological features of its use as a supplier and present incompatible huge rounded blocks. So, for the provenance of materials of dolmen of Colmeeiro 1 a more southeast outcrop should be invoked; taking into account the survey of the rare outcrops around the dolmen the occurrences that border the Freixo stream (AFL17 at 1350 m) appear as the most probable.

Despite the availability of granodiorites near the dolmen of Godinhos, for its construction there was the option of using different lithologies (muscovite-granites and gneiss-migmatites) that appear to the north of the dolmen. As mentioned, the muscovite-granite, which in the geologically surveyed area does not crop out, have a petrographic and geochemical affinity with the sample taken from the dolmen. The same match occurs with samples of gneiss-migmatites. This match was obtained with proximal sampling at a looking distance. On the contrary of the dolmens from Quinta do Freixo the slabs of dolmen of Godinhos are smaller and weathered which agrees with a higher facility of extraction from the surrounding lithologies.

Figure 10 – Detail of mesoscopic features of andalusite-porphyroblast phyllite used as slabs in dolmen of Candeeira.

In the case of dolmen of Candeeira, the material chosen for the slabs not only has a very fragile constitution, but also its mesoscopic characteristics are very distinctive. The bedrock of dolmen consists of schists as observed in the slabs but without the presence of porphyroblasts. Further south (170 m) and downhill there is an outcrop compatible with the slab sizes that additionally, as observed in slabs, shows the development of andaluzite crystal overgrowing over a strongly foliated matrix (Fig. 10).

Although gabbros naturally provides blocks of dimensions and forms compatible with those verified in the smaller dolmens, as a matter of fact, they were not used as a building material. We cannot ignore the hypothesis that there are dolmens to be discovered or excavated with this material, but with the available data to date one can only speculate and defend aesthetic reasons since the functionality would be similar to the granodiorite slabs.

The differences found especially for dolmens from group of Freixo, are tenuous and in some cases can be explained only by a geological variability that can even occur at the outcrop scale. With very different lithologies associated to significant differences in petrography and geochemistry such as the Monforte area (Pedro *et al.*, 2015) due to lack of hypothesis, the bonds become easier to establish. In this sense for the dolmens from group of Freixo, Godinhos and Candeeira there is no irrefutable data to attributes any outcrop as an unequivocal source of raw material for the production of slabs. To overcome this difficulty, one could think of a more extensive sampling, but an invasive sampling should not bring greater certainties. On the other way, an excavation campaign on some of more promising identified outcrops such as AFL-14 for dolmen of Candeeira or AFL-17 for dolmen of Casas Novas 1 would bring valuable proofs of use during Neolithic ages. Moreover, some of the smallest quarry/outcrop can no longer exist due to their full exploitation or modern activity.

The macroscopic features associated to a good awareness of outcropping geology have proved to be a major and important aspect to be taken into account for the establishment of provenances. On geological monotonous regions such as Freixo-Redondo area, sampling can be used to refine some aspects but quite never as an irrefutable proof of match/dis-match: because of the geologic variability at outcrops and small size of dolmen samples can biased data. Also, the unique texture of phyllite from dolmen of Candeeira or the muscovite-granite and gneiss-migmatite from dolmen of Godinhos, which variations are not represented in the cartography of the studied area (Carvalhosa *et al.*, 1986) are examples of the good knowledge of field.

With the engineering skills to raise up the stones went the capability to move them to the site, with Stonehenge the best-known example of an apparent long-distance transportation. While for Stonehenge (England), an apparent long-distance transportation was established (Thorpe & Williams-Thorpe, 1991) for the Freixo-Redondo area (Alentejo region, Portugal) the predominance of much smaller distances is obtained. These observations agree with Boaventura (2000) that favours a pragmatic attitude of Neolithic communities in the search of the appropriate slabs for construction.

The order of magnitude of the values obtained for this study (less than 4 km) are in agreement and within the radius usually attributed to these megalithic buildings of about 5 km (Thorpe *et al.*, 1991; Jiménez *et al.*, 2017; Vicens *et al.*, 2010). Moreover, contrary to Jiménez *et al.* (2017), the data obtained do not suggest the existence of a single quarry that would provide the generality of the blocks but rather the use of several outcrops dispersed throughout the area.

9. Conclusions

For the studied dolmens - group of Freixo, Godinhos and Candeeira - it were identified nearest mesoscopically compatible outcrops, that is, at mesoscale are compatible with the slabs from megaliths. The distances from dolmen to mentioned outcrop varies between 150 m (*e.g.* dolmen Quinta do Freixo 1) and ~780 m (*e.g.* dolmen Casas Novas1). Through field, petrographic and multi-elemental geochemical obtained data, it is noticed that almost never, the nearest ones were not used as unique collection site. The mesoscale characteristics, coupled with an exhaustive recognition of geology, have proved to be a fundamental tool in establishing provenances.

As observed in other areas of Monforte area (Alentejo region) dolmens were built with slabs from different outcrops. The complete match including size, shape, petrography and geochemistry was obtained for several dolmens providing for group of Freixo, distances between 800 and 3500 m. The oldest dolmen (Godinhos) use very local material and shorter distances (~350 m). The more weathered characteristic of geological materials makes them easier to quarry. For the dolmen of Candeeira, a local provenance of 170 m was established based on singular macroscopic features.

It is not possible to attribute a reason for one's provenances to the detriment of another outcrop. It could be related to the immediate availability of the material (loosened blocks) but nevertheless, the gabbro-diorites in the area were not chosen, at group of Freixo, for building purposes. Apparently for aesthetic/symbolic reasons since this lithology occurs as loosened blocks and presents similar sizes/ shapes to those found in medium dolmens of granodiorite. Confirmation of the use of certain outcrops by communities from the Neolithic period will be possible through excavation work.

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Funerary megalithism in the south of Beira Interior: architectures, spoils and cultural sequences

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Abstract: In this study, we present the main results obtained during the archaeological survey of a vast area in the south of Beira Interior, in the region of the International Tagus river, followed by the excavation of the most representative and best preserved funerary megalithic monuments. It was possible to identify several types of monuments and to relate these with the artefact findings, and then to develop a model to explain the architectonic succession of funerary megalithic monuments in the region. It was also possible to observe some constructive particularities in some of these monuments, herein summarized.

Keywords: International Tagus river; megalithic tombs; cultural sequence.

Megalitismo funerário do sul da Beira Interior: arquitecturas, espólios e sequências culturais

Resumo: Neste trabalho apresentam-se os principais resultados obtidos no âmbito da prospecção sistemática de uma vasta região do sul da Beira Interior, região do Tejo Internacional, seguida da escavação dos monumentos megalíticos funerários mais representativos e em melhor estado de conservação. Desta forma, foi possível identificar diversos tipos arquitectónicos, relacionando-os com os respectivos espólios, fundamentando um modelo para a sucessão arquitetónica regional do megalitismo funerário. Foi igualmente possível a observação de particularidades arquitectónicas ou estruturais em alguns destes monumentos, as quais serão também sumariamente apresentados.

Palavras-chave: Tejo internacional; megálitos funerários; sequência cultural.

1. History of investigations

Until recently, the south of Beira Interior, in the region of the Internacional Tagus river, as far as the richness of its megalithic archaeological heritage was concerned, has remained largely unknown. In fact, considering the pioneer explorations carried out by Francisco Tavares de Proença Júnior in the Urgueira dolmen, in Vila Velha de Ródão, as well as in other megalithic monuments, of which he would only report existence (Proença Júnior, 1910); all those explorations did not have the follow-up they deserved. Félix Alves Pereira only occasionally became interested in the subject. To him is owed the exploration of the Anta Grande de Medelim, which he published in 1934 (Pereira, 1934). Georg and Vera Leisner, in their inventory of the Portuguese dolmens (Leisner & Leisner, 1956), mark only three, west of Rosmaninhal, and another one, near the extinct village of Alares; a panorama that has not changed in Vera Leisner's recently published posthumous works (Leisner, 1998).

In the second half of the century, only three other monuments were excavated, by O. da Veiga Ferreira and D. Fernando de Almeida. Especially relevant was the excavation of the important dolmen of Granja de S. Pedro, Idanha-a-Velha (Almeida & Ferreira, 1958, 1959, 1971).

Nevertheless, it was highly likely that yet a large number of dolmens had been left unidentified in the region, according to the approximately 90 dolmens surveyed by the Leisner in the neighboring region of Proença-a-Nova (Kalb, 1990). There was no reason why that situation should not be the case also in the adjacent region.

2. Recent works

Systematic prospecting work carried out on the ground since the 1970s to the present time by the Alto Tejo Studies Association has fully confirmed the above assumption. Thus, in an area naturally limited to the South by the International Tagus river, at East by the Erges river and at West by the Aravil river, more than ninety dolmens have been recognized so far, which remained totally unpublished. About sixty-five are in the region of Rosmaninhal, while about twenty-five are in the region of Malpica do Tejo/Monforte da Beira. The vast majority are in good conservation conditions. This was partly due to the low population density of the region and the type of land use. In fact, the holm oaks (*montado*) dominates the region, often with centuries-old specimens. The extensive cereal cultivation practices, especially of wheat, which was important until the early 1960s, are still carried out by traditional, non-mechanized methods, which also explains the good conservation conditions of these monuments.

Systematic archaeological cartography of the region that had already been carried out should also be pursued by excavations, which ought to be planned in the medium/long term, allowing for the acquisition of full knowledge about the most important monuments, along with other actions, in view of characterizing the housing component of these communities.

For now, only reference to the funerary component will be made here. This is by far the bestknown aspect, as it is likely that the builders of these megaliths have had an itinerary economy, essentially based on silvo-pastoral activities.

This paper will also not address the nonfuneral megalithic heritage, which integrates several menhirs and cromlechs already known in the region, nor the artistic component, represented by several rock panels, often found in the proximity of the megalithic monuments. These elements obviously make part of the same and indivisible reality, which will merit an integrated study.

3. Geo-environmental aspects. Implantation of monuments

The area of distribution of the remarkable megalithic structures, which has gradually been defined, corresponds, from the geological point of view, to a substrate consisting of outcrops of the pre-Ordovician greywake/shist complex, integrated in the Rosmaninhal Formation, with turbiditic characteristics (Oliveira, 1992). These rocks are, in turn, covered by detrital deposits, essentially arkosic conglomerates, of more or less reddish color depending on the degree of oxidation they present, and preserved on the top of the platforms cut by erosion. Their age was fixed in the Eocene or the Oligocene (Oliveira, 1992). Finally, we can observe, mainly on the slopes and adjacent low zones, deposits constituted by vast mantles of quartz and quartzite gravels, resulting from the dismantling of the Paleozoic reliefs, and whose age can be set in the transition from Pliocene to Quaternary: these are the *rañas*, typical from semi-arid climate, and formed by torrential discharges, which periodically impacted the region at that time.

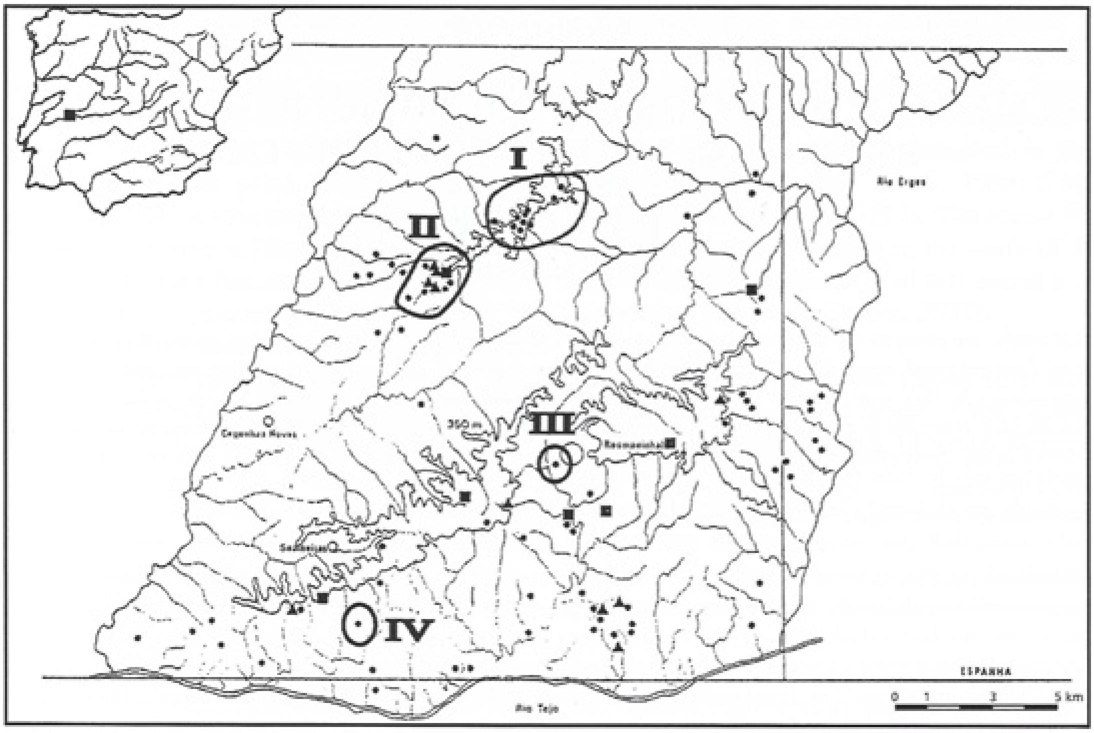

Figure 1 – Geographical location of the *nuclei* of monuments studied in the region of the International Tagus river. Circles: megalithic monuments and *tumuli*; squares: habitational remnants (large elements of handheld millstones); triangles: menhirs', enclosures and engraved rocks. The closed lines indicate the megalith *nuclei* investigated: I - Amieiro, with five excavated monuments (Amieiro 1, 2, 3, 5 and 8). II - Couto da Espanhola, with 2 monuments excavated. III - Dolmen of Cabeço da Forca. IV - Dolmen of Poço do Chibo.

The nine dolmens explored (Fig. 1) are distributed according to two main patterns. In some cases, they are concentrated on the top of platforms that constitute the major axes of the landscape compartmentalization, forming true megalithic necropolis, from which vast areas can be seen. Some of the monuments from two of these platforms have been exploited to this day. One is the Couto da Espanhola platform, at an altitude of around 300 meters and a NE-SW general orientation. In this platform, seven dolmens were mapped, of which two were better preserved, and showed greater architectural differences. The other is the Amieiro platform, at a slightly higher elevation (360-370 meters) and with an identical orientation. In this platform, eight dolmens were identified, of which three were explored, according to their state of conservation and the diversity of their architectures. In some cases, the distance between these monuments is less than 100 meters, so that they can be seen from each other, constituting *nuclei* within the necropolis that they integrate. Still, in general, the distance between the monuments is higher, in the range of 200 to 250 m, although from any of these places one can generally recognize the location of the nearest one. In other cases, monuments occur more or less isolated in the landscape. This is the case of the Poço do Chibo dolmen, which is implanted in a lower zone.

4. Architectural aspects and funerary rituals

The results obtained from the excavations that have been carried out since 1993 in the International Tagus region, have already given rise to several contributions, among which one can highlight the study published in 2003 (Cardoso, Caninas & Henriques, 2003). Based on the nine megalithic monuments excavated, we can be summarized the information as follows:

1 – The landscape would have been punctuated, in a very evident and intentional way, by megalithic graves. Such evidence is confirmed by the existence of a coating in all funerary mounds (*tumuli,* in Portuguese*, mamoas)* without exception, made of blocks of milky quartz, a characteristic which, in fact, greatly facilitates their current identification on the ground. This was not just a simple coating: the armor of quartz blocks, tightly fitted together, extended in depth, and really gave the mounds the status of *cairns*. Therefore, there was a clear intention of giving visibility to all these sepulchers, instead of dissimulating them in the landscape. Even monuments that were implanted in low zones, such as the Poço do Chibo dolmen, where nothing would make one suppose they existed, presented the *mamoa* coated in this way (Fig. 2).

Figure 2 – *Cairn* of the dolmen of Poço do Chibo, constituted by large blocks of milky quartz coming from a nearby quartz vein. Photo by J. L. Cardoso.

2 – The presence of a relatively scarce number of dolmens in the two platforms hitherto studied in more detail configures the preference given to them, as real necropolises, over hundreds of years. However, the construction of new monuments would have been an exceptional act in the daily lives of the agro-pastoral communities that were established here in the 4th and 3rd millennium BC. If, at present, their number seems to be excessive, this is because the time factor is often ignored, as well as the remarkable population potentially installed here, in the course of hundreds of years. In fact, the presence of this noteworthy population is further justifiable given the excellent conditions for a pastoral economy, involving the mobility of these people.

3 – It is important to discuss and value the differences in architecture and artifacts found in monuments that are sometimes a few hundred meters distant from each other, as in the case of the dolmens (*antas*) 6 and 2 of Couto da Espanhola, both fully explored. Thus, while the small dolmen 6 has a plant devoid of a corridor, having been built after an originally closed monument (Fig. 3); dolmen 2 corresponds, in

its turn, to a large polygonal chamber monument, with a very long corridor (Fig. 4). Such architectural differences can be reconciled with the differences pointed out in terms of the spoils there found. In dolmen 6, considering the lithic spoils, and in addition the polished stone artefacts, there were only scarce geometrics and *lamellae*.

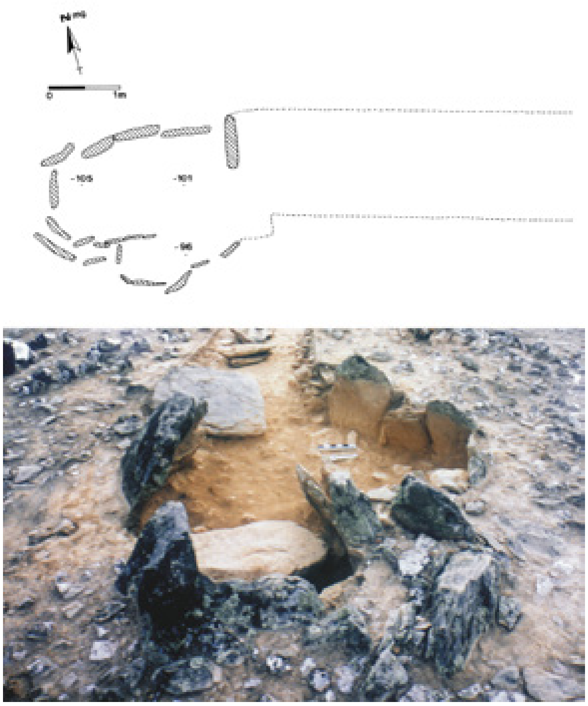

Figure 3 – Plant and general view of the dolmen 6 of Couto da Espanhola, of small dimensions, evidencing two phases of construction, with the transformation of a closed monument into an open structure, during the Middle Neolithic. Photo by J. L. Cardoso.

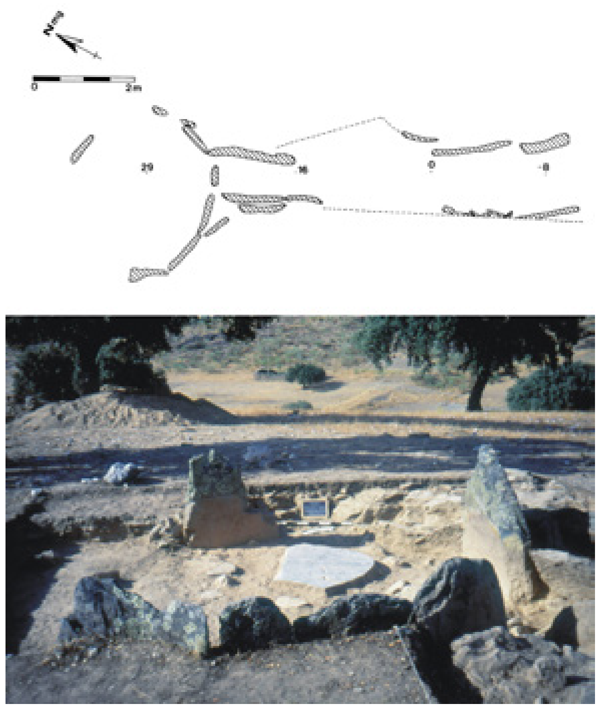

Figure 4 – Plant and general view of dolmen 2 of Couto da Espanhola, evidencing a large monument with a polygonal chamber and a long corridor. Photo by J. L. Cardoso.

In this monument, ceramic specimens were entirely absent, very likely because of symbolic precepts (Cardoso, Caninas & Henriques, 1995), as it has been observed in other contexts of the Middle Neolithic, such as the cave of Lugar do Canto, Alcanena (Cardoso & Carvalho, 2008). On the contrary, in dolmen 2, the lithic industry is abundant, evidencing a remarkable set of arrowheads from different typologies (Fig. 5), thus corresponding to the phase of occupation from the Late Neolithic or even from the Chalcolithic (Cardoso, Caninas & Henriques, 1997a).

This reality seems to indicate that the beginning of regional megalithism occurred in the Middle Neolithic period, which can be placed between 4000 and 3500/3400 BC (Cardoso, 2015), and is represented by dolmen 6 of Couto da Espanhola. It also indicates that the construction of megalithic monuments became more common in the following centuries, extending until the end of the Chalcolithic, with the construction of the first individual graves, also known in the region.

4 – In these terms, it is necessary to discuss the issue of the polymorphism evidenced by the monuments. It is interesting to note that there are monuments of small dimensions and apparently archaic typology, with a horseshoe-shaped plan and devoid of corridor, such as the dolmen 8 of Amieiro (Fig. 6). This monument provided, along with geometrics, a single *lamella*, compatible with the Neolithic chronology attributed to dolmen 2 of Couto da Espanhola (Middle Neolithic), but also produced a concave-base arrowhead, recovered from inside the chamber, with a deeply reentrant base, clearly Chalcolithic (Fig. 8).

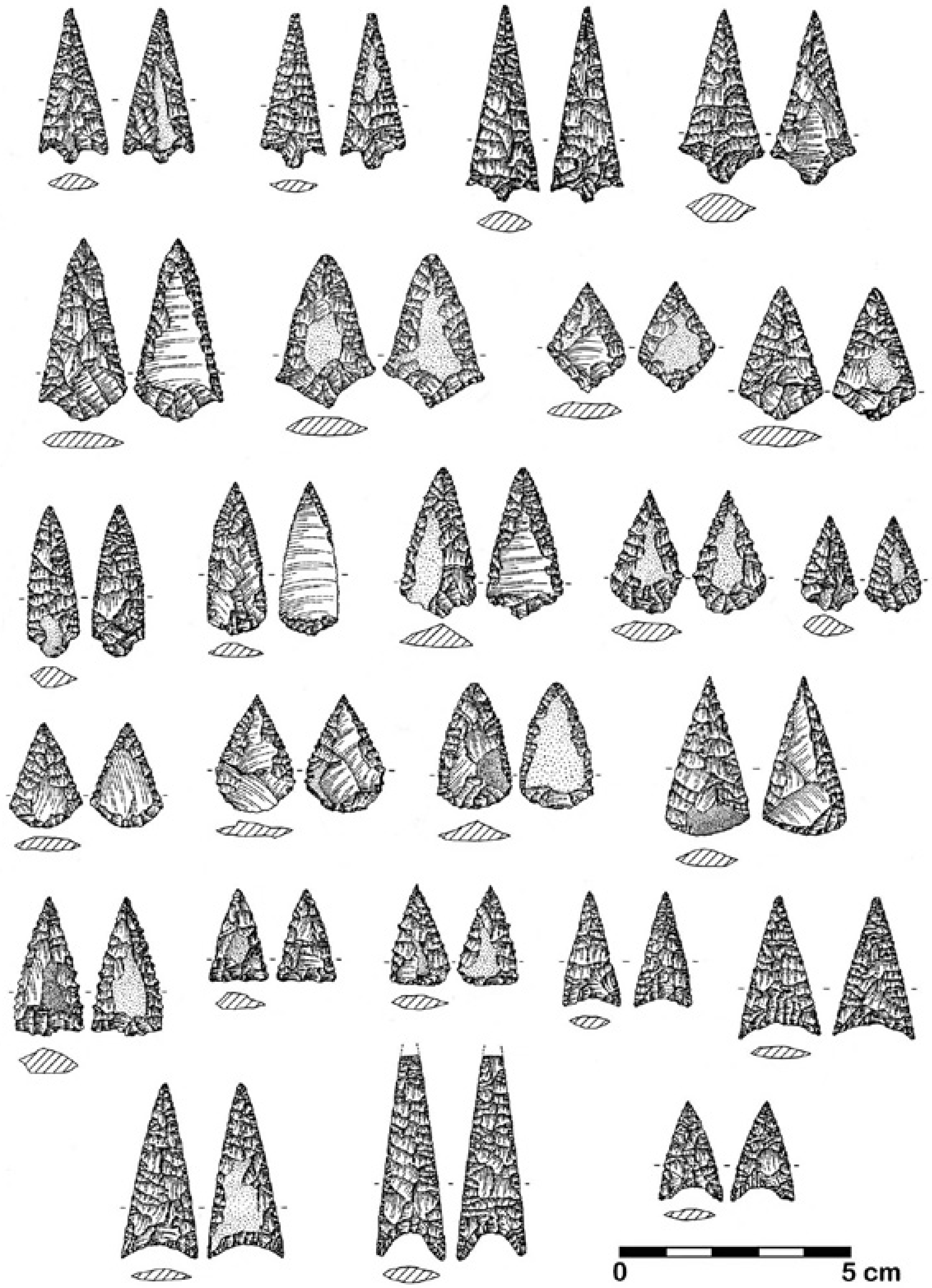

Figure 5 – Arrow points of flint from dolmen 2 of Couto da Espanhola. Drawings of B. L. Ferreira.

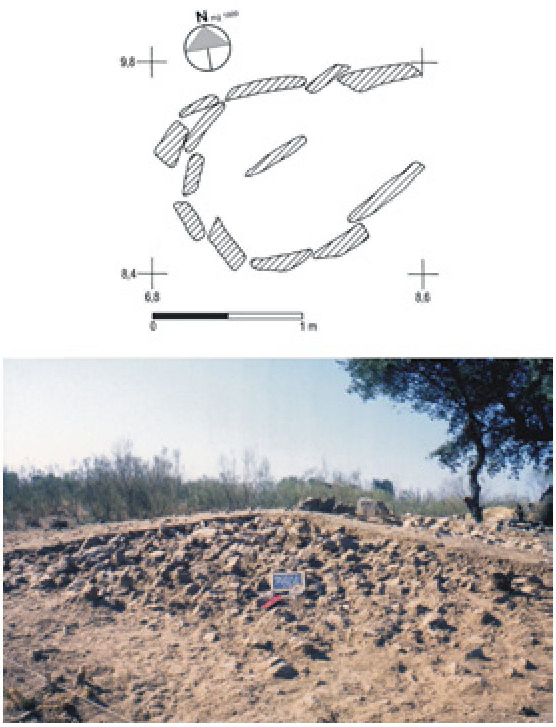

Figure 6 – Plant and general view of dolmen 8 of Amieiro, evidencing the *cairn*, very well preserved, consisting of blocks of milky quartz, originating from an existing quartz vein about 10 m away. Photo by J. L. Cardoso.

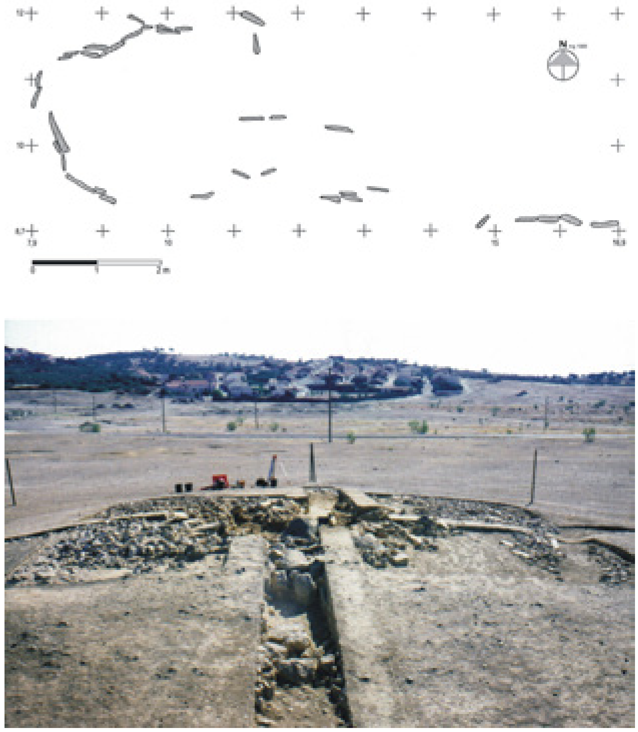

Figure 7 – Plant and general view of the Cabeço da Forca dolmen. The plant shows the *alveoli* of the slabs, almost all of them removed for various re-uses, leaving only the small wedges that served to fix them. Photo by J. L. Cardoso.

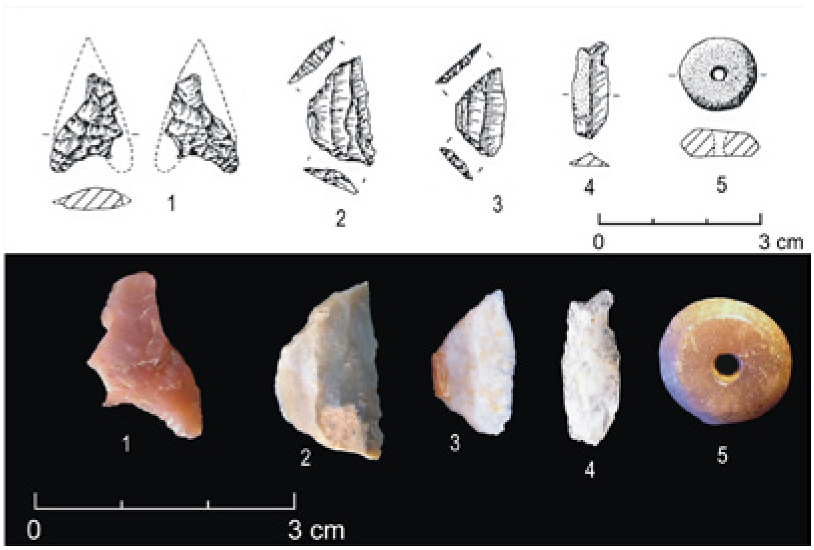

Figure 8 – Spoils from dolmen 8 of Amieiro. 1 - Chalcolithic arrow tip with thermic fractures in pink flint, collected at about 0.60 m depth in the chamber; 3 and 4 - Quartz lamella and chalcedony crescent, collected in the chamber at about 1.0 m depth; 3 - Grayish brown flint crescent, collected on the surface of the *cairn*; 5 - bead with cylindrical perforation, of rosy siliceous rock, collected at the surface of the *cairn*. Drawings by B. L. Ferreira. Photos by J. L. Cardoso.

This reality points to two alternatives.

The first alternative corresponds to the eventual survival of the small graves in the late period of megalithism, a subject recently discussed in an exemplary way for another geographical area, Central Alentejo (Mataloto, Andrade & Pereira, 2016/2017).

The second alternative refers to the reuse of the monument, centuries after its first funeral occupation. Given the smallness of the chamber, it would only be possible to perform one burial at a time. Belonging to the eventual more modern burial, one flatbottomed vase has been found, provided with a ribbon wing that departs from the edge. This hypothesis was confirmed in other nearby monuments, such as dolmen 2 of Amieiro, where a copper dagger with riveted handle, from the Bronze Age, was found. Another example is dolmen 5 of Amieiro, which also corresponds to a small horseshoe-shaped monument devoid of corridor. Nevertheless its apparently archaic architecture, this monument produced two arrowheads, a flint blade and a engraved schist plaque of remarkable dimensions, indicating the Late Neolithic, with no element of the spoils suggesting the Middle Neolithic. In this case, there is a clearer possibility that this small megalith had been built during the Late Neolithic.

The possibility that some of the great monuments with an "evolved" plant predate the Late Neolithic is also supported by the material evidence. This is the case of the Cabeço da Forca dolmen. Despite its considerable size, its polygonal chamber and long corridor (Fig. 7), and the abundant collection of polished tools collected, this dolmen did not contain any elements of the most evolved phase of the Neolithic period, as arrow points and could thus be integrated in the Middle Neolithic period. This would relegate the origins of the megalithic polymorphism to the beginning of the phenomenon itself, at least in the region under study.

A single monument of Chalcolithic typology was recognized. This is the dolmen 3 of Amieiro, whose chamber consists of nine narrow orthostats (Fig. 9). There follows a corridor, sealed by a transversally placed slab separating it from an open-air *atrium*, delimited on either side by orthostats of diminishing heights, and accompanying the pendant of the *tumulus* (Fig. 10). On the whole, the architecture of this monument evokes that of the country's southern *tholoi*, which are unknown in the region. The scarce material recovered, is from the Chalcolithic, corresponding to a lanceolate Palmela point, of evolved typology.

5 – Regardless of their respective typology, these structures invariably show orthostats of local origin or, at most, available only a few hundred meters away. However, the size of the schist or greywake slabs, rarely exceeding one meter in length, is always significantly smaller from the dimensions of those that characterize the granite slabs of the dolmens from other geographic areas. With such dimensions, it was not possible to construct large dolmens, such as those in the granitic regions of Beira Alta and Alto Alentejo. This explains the small height not only of the chambers, but also of the corridors of these monuments, which in most cases would have had only a ritual function. It would be an impractical task to crawl through these long and narrow spaces, sometimes more than 8 meters in length, as it is the case of the corridor of dolmen 2 of Couto da Espanhola, whenever a new burial in the chamber was intended; even more considering the additional difficulty of having to carry along the bodies to be buried. For the most part, the same observation applies to dolmen 2 of Amieiro (Fig. 11).

Thus, in order to carry out subsequent burials, it would be necessary to directly access the chambers of the dolmens, by partial or complete removal of their respective cover. This operation was greatly facilitated by the absence of large roof slabs, for which no trace was found. The covering of the chambers of these monuments would thus be secured with timber and branches, on which the elements of the *mamoa* would be settled and that were easy to remove.

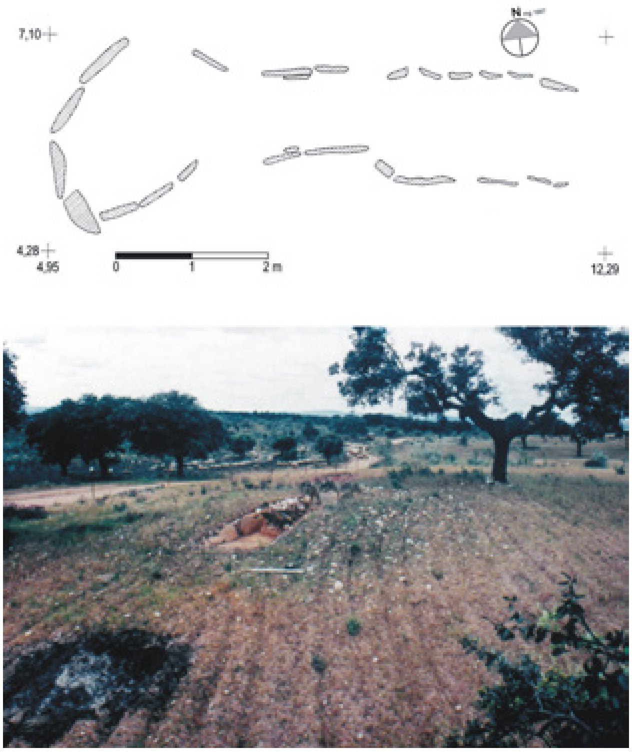

Figure 9 – Plant of Amieiro 3 and its implantation in the landscape, corresponding to a large platform formed by coarse tertiary deposits. Photo by J. L. Cardoso.

Figure 10 – Frontal view of the *atrium* (originally open-air) of Amieiro 3, sealed with two large slabs placed transversely and separating it from the corridor under the monument's *tumulus*. Photo by J. L. Cardoso.

What has been said so far does not invalidate, however, that in some cases the corridor could be functional. In dolmen 3 of Amieiro, the presence of two large imbricated slabs was recognized, sealing the dolmen, and separating it from the outside of the monument, where, as mentioned above, a small entrance *atrium* could be found, laterally delimited by orthostats of decreasing height. This is, however, an odd situation.

It should be noted that the modest dimensions of orthostats limited only the height of the monuments, but not their horizontal development. This is proved by the existence of the two great dolmens already mentioned, the dolmen 2 of Couto da Espanhola and the dolmen of Cabeço da Forca.

In addition to schist and greywake orthostats, large quartz blocks were exceptionally used, taken from near veins, sometimes of large dimensions, observed at the ground in the vicinity of some monuments, like Poço do Chibo. These blocks make up part of the constructive apparatus of this monument of diminutive dimensions, having a maximum length of about 4 meters and a corridor with a little more than 2 meters in length. This monument, with a sub-circular chamber and comparatively long corridor, definitively embodies the independence between the architectural typology and the raw material used in the construction of such structures (Fig. 12).

6 - The orientation of four out of the five excavated sepulchers with a corridor (Couto da Espanhola 2, Cabeço da Forca, Amieiro 2 and Amieiro 3) varies between 100 and 110 degrees; the only exception is the dolmen 2 of Couto da Espanhola, oriented to Southeast (135 degrees). This pattern coincides perfectly with that observed for the dolmens of Reguengos de Monsaraz, as reported by Leisner, whose

results were inventoried by V. Gonçalves (1992: 40). Of the 69 dolmens recorded, 35 had exactly the same orientation, immediately followed by the dolmens oriented to the Southeast (10 cases). The preference for the corridors' orientation to this quadrant relates to the azimuths of the sunrise, from which comes the Light and the Life, daily reaffirmed (Gonçalves, 1992: 51).

Figure 11 – Plant and general view of Amieiro 2. Note the small width of the corridor, impracticable for effective use as a way of accessing the chamber of the monument, for the purpose of performing burials. Photo by J. L. Cardoso.

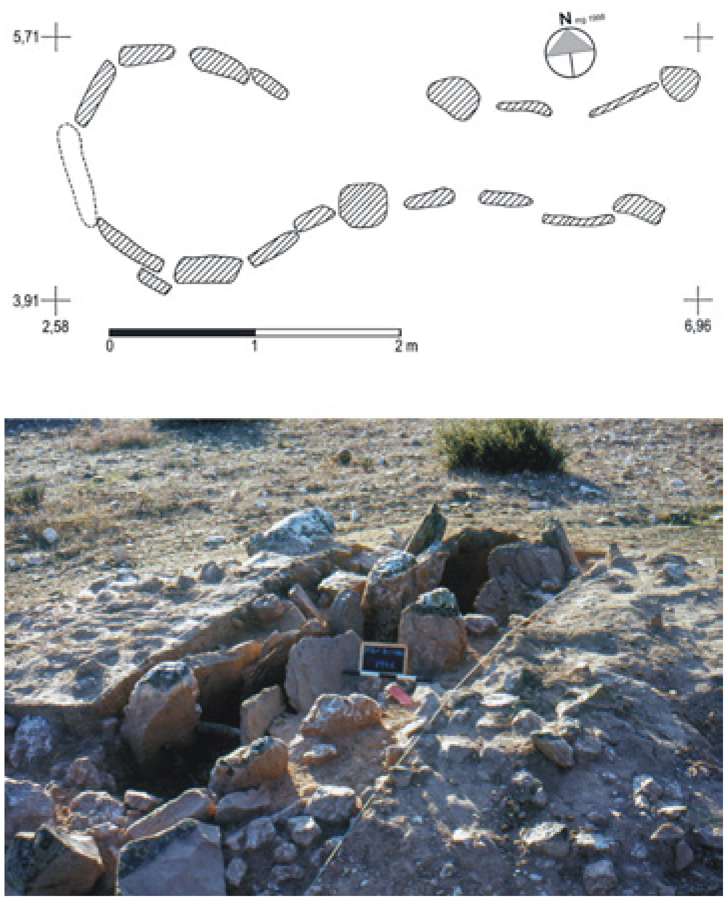

Figure 12 – Plant of the Poço do Chibo dolmen, of small dimensions, and general view of the monument; notice the large blocks of quartz used in its construction. Photo by J. L. Cardoso.

7 – In the funerary contexts investigated, the ritual deposition of objects would be usual. This was only evidenced in one situation corresponding to two axes, deposited side by side, but necessarily without handle, and placed against the left side wall of the corridor of the dolmen 2 of Amieiro, in a space intentionally compartmentalized by a slab placed perpendicular to one of the lateral supports (Fig. 13).

8 – Two slabs of shale placed on the floor of the monuments, one recognized in the chamber of dolmen 2 of Couto da Espanhola (Fig. 14), and another in the corridor of the dolmen 3 of Amieiro, would act as beds on which the corpses would have been deposited, probably lying on their side with arms and legs flexed, given the dimensions of those elements. This possibility, with parallels in other similar monuments from our territory, is reinforced, in the case of the first dolmen, by the concentration of remains that have been collected on the said slab.

Figure 13 – Two axes ritually placed side by side, along the left side of the corridor of Amieiro 2, in a space delimited by a small slab placed transversally. Photo by J. L. Cardoso.

Figure 14 – Large schist slab placed horizontally on the chamber of the Couto da Espanhola dolmen, used as basement for a funerary deposition. Photo by J. L. Cardoso

Figure 15 – Fire structure built in the chamber of Amieiro 3. Photo by J. L. Cardoso.

9 – Rituals of fire were identified in dolmen 3 of Amieiro. It is a small pavement made of small blocks, essentially of quartz, with an elliptical contour, built at the bottom of the monument's chamber, and functioning as the basement for a fireplace (Fig. 15). Santos Rocha, when studying dolmen monuments in the region of Figueira da Foz, noticed the practice of fire in their interior. Other examples could also be pointed out. In fact, fire would play a double role. Besides its role as a symbolic element, purifying and regenerating the souls of the deceased, it would also have a much more practical function, eliminating the pestilent air necessarily existing in the unventilated space of the interior of a collective sepulcher. This would have been an indispensable action, possibly involving the burning of aromatic plants, whenever there was the need to carry out a new deposition.

This fireplace could also be related to rituals of partial cremation of the corpses, as it was observed by Jorge Oliveira (Oliveira, 1997), in a megalithic monument of the Serra de S. Mamede, Portalegre, to cite only a geographically close example.

10 – One of the narrower monuments – the dolmen 8 of Amieiro – had a smooth stele of greywake, standing vertically in the interior of the chamber and in the direction of its length. This stele was similar to the supports that define the monument, though of lower height (Fig. 16). Such a stele would not, therefore, serve to support the cover, an unnecessary structure having in mind the small span of the chamber ceiling. It could, however, be useful in separating the mortuary space, with a purpose that presently elude us.

11 – After the construction of dolmen 5 of Amieiro, a cystoid grave, of subrectangular tendency, was built in the periphery of the pre-existent *tumulus*. As usual, this *tumulus* corresponds to a *cairn* of blocks of quartz strongly fitted together (Fig. 17).

This grave contained only a fragment of a decorated schist plaque and a bell-beaker fragment with pseudoexcised decoration. This finding seems to be of great interest, since it defines the immediate stage after the construction of the last megalithic collective graves, when burials were already being made in individual graves, only now documented in the region (Amieiro 5b). However, the memory of the graves of the "ancestors" led to this grave being built on the periphery of the dolmen, located in the central area of the *mamoa* (Amieiro 5a). On the other hand, the occurrence of a bellbeaker fragment with pseudo-excised decoration – the first finding of this nature in the region – evokes the affinities with the Iberian Meseta, where such decorative patterns are characteristic of the Ciempozuelos' Group .

Figure 16 – View of the small chamber of Amieiro 8, containing a stele of greywake. Photo by J. L. Cardoso.

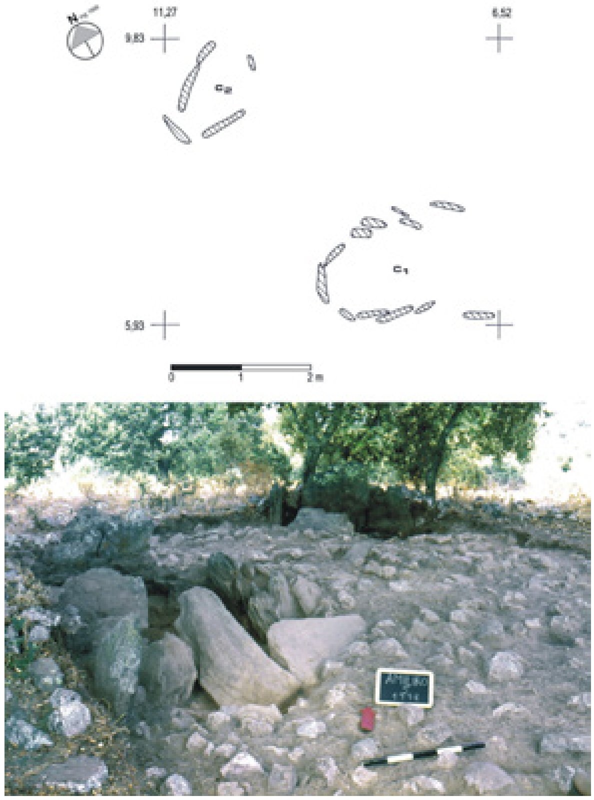

Figure 17 – Plant of the Amieiro dolmen 5, and general view of the monument in the foreground, showing the respective *cairn*, where, in the background, the cist of the Late Chalcolithic (Montelavar Horizon), can be seen, built in the periphery of the *cairn*. Photo by J. L. Cardoso.

5. Raw materials: the origins and circulation of the respective artifacts

The recovered pieces were made essentially of two raw materials: amphibolithic schists for the production of polished stone artifacts; and flint, which takes on importance for being the almost exclusive material used in the production of chipped stone artifacts. While the first rock could be obtained both in the Alto Alentejo and in Beira Alta, flint would have its preferential origin in the Portuguese Estremadura, its occurrence in this region being explained in view of its commercialization along the Tagus valley and its tributaries on the right bank. Thus, the region would receive inflows from various geographical areas, with which it would have maintained economic links, made possible by the existing natural circulation routes: one route, from the coast to the interior, through the Tagus valley, penetrating into the Iberian Meseta, from where in turn, the bell-beaker fragment of Ciempozuelos style had been brought; and another route, north-south oriented, flowing in both directions, thus explaining the occurrence of the typical Alentejo shale plate, collected in dolmen 5a from Amieiro (Fig. 18).

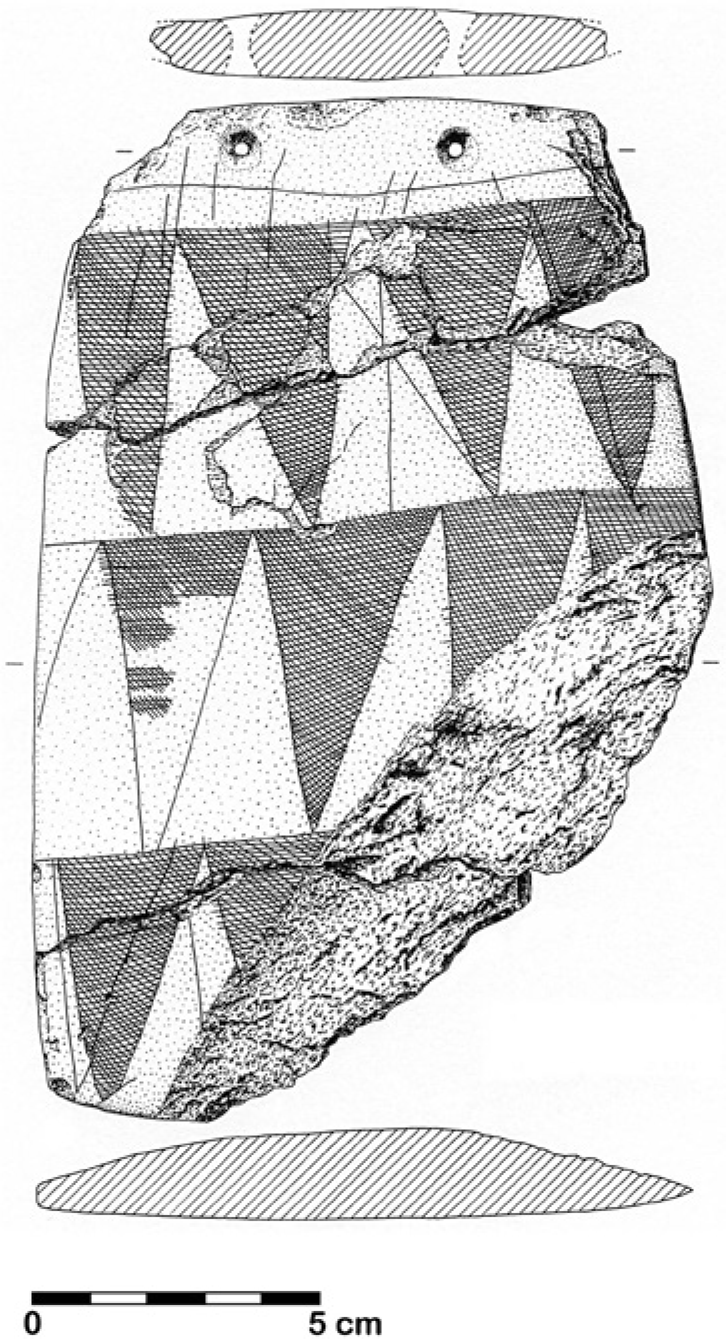

Fig. 18 – Engraved schist plaque of Amieiro 5. Drawing by B. L. Ferreira.

6. Towards the establishment of a sequence in regional megalithism

The origin of megalithism in the region can be placed in the Middle Neolithic, and corresponds to the construction of monuments, either closed or open, either small or large, either devoid of corridors or, on the contrary, showing long corridors. These are followed in the Late Neolithic by monuments that would continue to embody the same architectural duality, although the spoils are now different. In fact, the construction during the Final Neolithic period of small monuments identical to those previously built in the Middle Neolithic period seems to be a reality, along with their reuse in the course of the Chalcolithic, or even in more modern times.

It should therefore be stressed that this was not a simple, linear evolution, from the simple to the complex, and from the small to the large – far from it. Monuments of different typologies would have coexisted and would have been built during a period of about 1000 years.

There is, in fact, a monument of large dimensions, comparable to that of the dolmen 2 of Couto da Espanhola, the dolmen of Cabeço da Forca, where, contrary to what was observed of the former dolmen, no single arrowhead was collected, nor any ceramic production was found, but where a small geometric was identified. This suggests that the construction of large monuments in the region, such as that in the Lisbon area, based on the dates obtained (ca. 3500-3400 BC, see Boaventura, 2009) could still ascend to the transition of the Middle to the Late Neolithic. If this is to be so, the funerary polymorphism would be observed in the region from the very beginning of the megalithic phenomenon.

Finally, in the course of the Chalcolithic period, the last dolmens are built, represented by the Amieiro 3, which is closely related to the architecture of the Chalcolithic *tholoi* of southern Portugal. The cycle would be closed in the Late Chalcolithic (Montelavar Horizon) with the construction of the first individual graves, represented in the region by the cist that was built on the outskirts of the Amieiro dolmen 5 and containing a fragment of a bell-beaker vessel with pseudo-excised decoration.

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A look at Proença-a-Nova's Megalithism (Beira Baixa Intermunicipal Community, UNESCO Global Geopark Naturtejo, Portugal)

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Abstract: Knowledge about funerary Megalithism at Proença-a-Nova's municipality area was present through 95 records in the inventory organized by Georg and Vera Leisner, but these researchers hadn't the opportunity to further develop their study. The AEAT – Associação de Estudos do Alto Tejo started in the 1970's a project of systematic field recognition, which, until this date, allowed the identification of almost thirty monuments, much less than the number registered by the German researchers. These findings are part of a broader group of monuments, if one takes into consideration the territory forming part of the Beira Baixa Intermunicipal Community (Castelo Branco, Oleiros, Penamacor, Proença-a-Nova, Idanha-a-Nova, and Vila Velha de Ródão). Since 2012, archaeological excavations are being conducted at three megalithic tombs of Proença-a-Nova (Cão do Ribeiro, Cimo do Vale de Alvito, and Cabeço da Anta), in the frame of the CAPN – Campo Arqueológico de Proença-a-Nova, a study to be carried on in the following years under the same institutional framework, but also as part of a new research program, the Mesopotamos Archaeological Project. CAPN is promoted together by the AEAT and the Proença-a-Nova's Town Council and have as its partners the universities of Alcalá de Henares, Évora, Coimbra, and Oporto, through several of their research centers, private companies, and the UNESCO Naturtejo Geopark. The work done so far at Proença-a-Nova monuments yielded very interesting results concerning the knowledge of the processes and materials used in the construction of these megalithic tombs, still requiring further evaluation but already showing both variability and standardization of their architectural features.

Keywords: Funerary megalithism; Proença-a-Nova Archaeological Field Camp (CAPN); County of Proença-a-Nova

Um olhar sobre o megalitismo de Proença-a-Nova (Comunidade Intermunicipal da Beira Baixa, Geoparque Naturtejo, Portugal)

Resumo: O conhecimento acerca do megalitismo funerário do concelho de Proença-a-Nova ganhou destaque no inventário elaborado por Georg e Vera Leisner com 95 monumentos, mas estes investigadores não tiveram oportunidade de aprofundar o seu estudo. A partir dos anos 70 do séc. XX, a Associação de Estudos do Alto Tejo iniciou pesquisa de campo sistemática que conduziu à identificação, até ao momento, de quase três dezenas de monumentos, um número muito inferior ao estabelecido pelos investigadores alemães. Estes achados enquadram-se num conjunto mais alargado de monumentos, considerando a região abrangida pela actual Comunidade Intermunicipal da Beira Beixa (Castelo Branco, Oleiros, Penamacor, Proença-a-Nova, Idanha-a-Nova e Vila Velha de Ródão). De 2012 até ao momento foram iniciados trabalhos de escavação arqueológica em três sepulturas megalíticas de Proença-a-Nova (Cão do Ribeiro, Cimo do Vale de Alvito e Cabeço da Anta) no âmbito do Campo Arqueológico de Proença-a-Nova (CAPN), modalidade que terá continuidade nos próximos anos, enquadrada no projecto de investigação Mesopotamos - *Povoamento entre o 5º e o 1º milénio AC entre os rios Tejo e Zêzere na actual Beira Baixa.* O CAPN que é promovido pela Associação de Estudos do Alto Tejo e o Município de Proença-a-Nova tem sido organizado em parceria com as universidades de Alcalá de Henares, Algarve, Évora, Coimbra, Porto) e respectivos centros de investigação, com empresas do sector privado e o Geopark Naturtejo. Os trabalhos executados nos monumentos de Proença-a-Nova têm fornecido resultados, ainda em avaliação, mas com muito interesse para o conhecimento dos processos e materiais utilizados na construção daqueles monumentos funerários, evidenciando variabilidade e padronização das respectivas arquitecturas.

Palavras-chave: Megalitimso funerário; Campo Arqueológico de Proença-a-Nova (CAPN); Município de Proença-a-Nova

1. Introduction

Proença-a-Nova is a municipality located in the interior center of Portugal (Fig. 1), with a territorial area of 395 square kilometers, forming part of the Beira Baixa Intermunicipal Community along with the municipalities of Castelo Branco, Idanha-a-Nova, Oleiros, Penamacor, and Vila Velha de Ródão. It is enclosed by a vast natural amphitheater, anchored in the westernmost section of the Iberian Central System, open to the East and the South. This region is structured by several parallel faults, defining a tectonic stairway expressed by three steps. From the Northwest to the Southeast, the degree of altimetric variation explains the environmental, climatic, and biotic variability that we can observe, for instance, at Oleiros, the highest territory, included in the Central Horst System, in the western part of the region, and at Idanha-a-Nova, which belongs to the most eastern and less elevated block. Political and geographical factors have contributed to the isolation of this region, transitional between the North and the South of Portugal, and to the preservation of archaic forms of rural life (Mattoso, Daveau & Belo, 2010). Curiously, its megalithic heritage, not showing the monumentality intrinsic to the constructions made of granite, scarce in this territory, is probably one of the less known and published and less known among the different regions of Portugal.

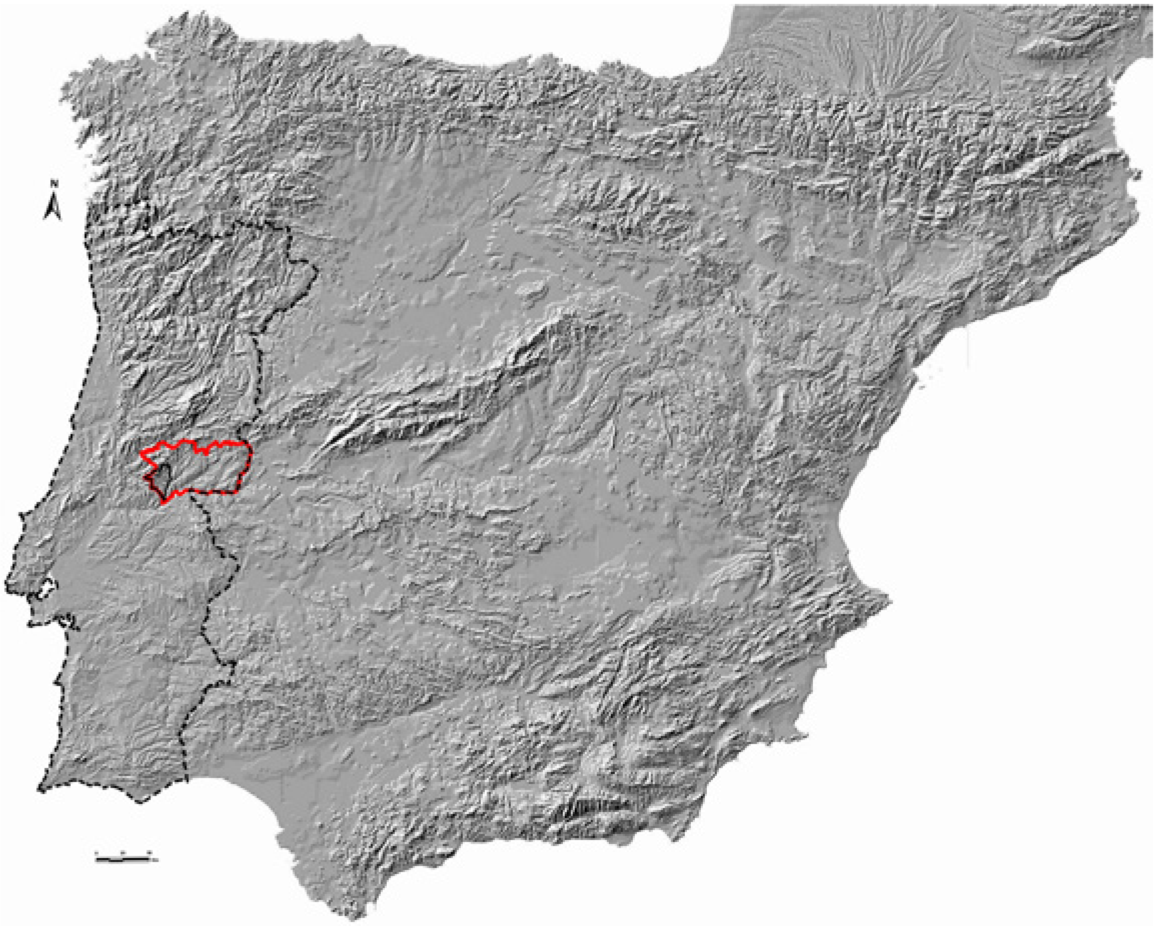


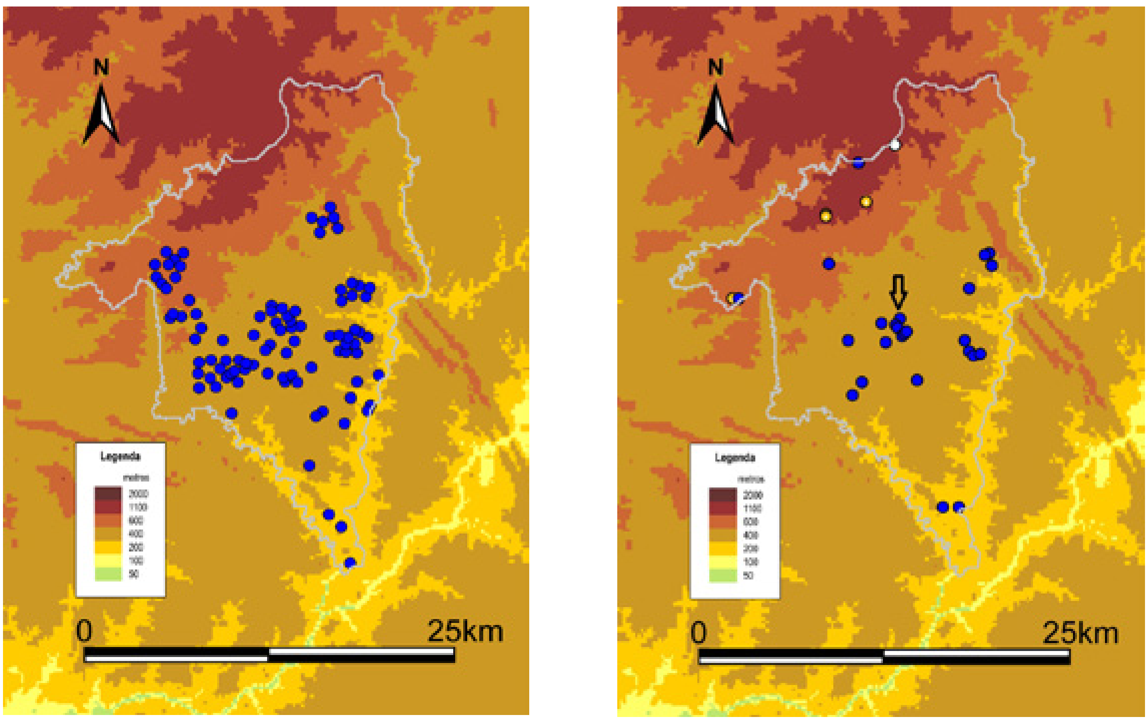
Figure 1 – The municipality of Proença-a-Nova (black continuous line) in the study area (red line) and its location relatively to the Portuguese territory (black dashed line). Map credits: http://ricardocosta.com.

Proença-a-Nova has adapted its administrative boundaries mostly to striking geographic accidents, with no noticeable continuity gaps. It is confined in almost the totality of its perimeter by incised river valleys that drain into the Tagus, the most important river in western Iberia, and, in the North and Northwest, by a section of the Iberian Central mountain range. This is a territory dominated by a plateau gently sloped to the Southeast, severely cut by the river system. The geologic setting is formed mainly by metasedimentary rocks of the Beiras Group, dating from the Neoproterozoic (610 to 542 Ma), not being preserved the Cenozoic intramountain siliciclastic deposits (50 to 1 Ma), still abundant in the eastern area of the region under investigation.

2. The history of the investigation

Attention toward funerary megalithism in the territory of Proença-a-Nova gained momentum with the inventory of supposedly 95 dolmens (*anta*, in vernacular Portuguese) by Geog Leisner (Fig. 2A) in the first half of the twentieth century, an inventory posthumously published by Vera Leisner under the editorial organization of Philine Kalb (Leisner, 1998). Unfortunately, these researchers did not get further in the investigation of this megalithic heritage, contrasting to what they did with notable success in other regions of Portugal, particularly in the Beira Alta and Alentejo.

Georg Leisner's work was recently revised under the scope of the organization of the municipal archaeological heritage inventory, which, contrary to what was displayed at *Die Megalithgräber*, could only confirm 28 occurrences (Fig. 2B), not all coincident with those proposed previously. Moreover, the fieldwork could not corroborate the possibility of existence of megalithic tombs in the majority of the 95 *loci* mapped by the German archaeologists. We think Georg Leisner, following information given by local inhabitants, might have inventoried the location of a lot of hypothetical tombs, which he could not verify, but reproduced in the 1956 edition of *Die Megalithgräber* (Leisner & Leisner, 1956, taf. 70).



A B

Figure 2 – Map of megalithic tombs in the municipality of Proença-a-Nova: (A) following Leisner (1998); (B) current distribution, following the work of the AEAT. The arrow points to the location of Moitas group (Cão do Ribeiro, Cimo do Vale de Alvito and Cabeço da Anta).

Georg Leisner, maybe accompanied by his wife, visited some of the monuments of Proença-a-Nova and left the plans of five orthostatic structures — Chã das Vargens, Covão do Ribeiro, Vale de Alvito, Moita da Galinha, and Portela da Lameira (Leisner, 1998, taf. 77-78) — and a photograph of one of them — Covão do Ribeiro (Leisner & Leisner, 1956, taf. 57). The plans of Covão (also Cão) do Ribeiro, Vale de Alvito, and Moita da Galinha correspond very accurately to the conditions of preservation we found those monuments when our research in the region started in the last quarter of the twentieth century.

Before Georg and Vera Leisner, Francisco Tavares de Proença Jr., the forerunner of archaeological investigation in the region of Castelo Branco (Henriques & Caninas, 2004), pointed out the existence of six megalithic tombs in the vicinity of Proença-a-Nova (Proença Júnior, 1910), but did not leave any substantive data about them. Between 1904 and 1907, he probably excavated at least 15 tombs in the municipalities of Vila Velha de Ródão, Castelo Branco, and Idanha-a-Nova, but only one was published, the Anta da Urgueira (Proença Júnior, 1909). His escape from Portugal after the establishment of the republican regime and succeeding premature death may have contributed to the loss of the fieldwork notebooks with the information concerning the excavations done at the other sites. Artifacts recovered during the excavations are currently cured by the regional museum that carries his name (Ferreira, 2004).

Throughout the third quarter of the twentieth century, Octávio da Veiga Ferreira, who was by then working at the Roman city of Egitania (municipality of Idanha-a-Nova), seized the opportunity to excavate nearly a dozen monuments (Cardoso, 2008), a work that was only published in the form of a few small reports. The longer report refers to a tomb at Granja de São Pedro (Almeida & Ferreira, 1971).

From the last quarter of the twentieth century until the present day, the study of the megalithic phenomenon widened and became consolidated in the framework of the AEAT[1] activities with the development of a continuous programme of archaeological inventory in the five municipalities of the Beira Baixa Intermunicipal Community, complemented, so far, with the excavation of about 20 monuments (Henriques, Caninas & Chambino, 1993; 2008; Cardoso, Caninas & Henriques, 2003; Caninas, Henriques & Cardoso, 2011; Caninas *et al.,* 2014). This work led to a first outline of a model of chronological evolution of Megalithism in the region, placed between the fifth and the third millennium BC (Cardoso, Caninas & Henriques, 2003), in despite of the absence of absolute dates and being solely based in the variability of architectural solutions and findings, which resulted from the excavation of ten monuments located in the southern sector of Idanha-a-Nova, in the International Tagus area. For that reason, this chronological outline, the only one made until the date for the region, should not be generalized nor used outside the subregional set for which it was built (Rosmaninhal, Idanha-a-Nova).

The results from the research promoted by the AEAT are presented in a palimpsest of almost 300 occurrences with an asymmetrical distribution throughout the study area (Fig. 3). We think this distribution is conditioned by two main factors related to the paths followed by the investigation and the historical use of the soil: concentration of points at the meridional zone, by the Tagus river, between Vila Velha de Ródão and Oleiros, due to a greater incidence of the archaeological work; a higher degree of destruction of monuments at the lower lands corresponding to the central and septentrional zones of Idanha-a-Nova and Castelo Branco, with larger agricultural potential and effective land-use, where the voids are also in accordance with a smaller frequency of the research effort.

However, we can recognize a sort of ubiquity in the distribution of these megalithic tombs, which indicates an extensive occupation of the territory, beginning with the Neolithic, from the ridges of the Central System, at 1,000 meters of altitude, in the Oleiros territory, to the banks of the Tagus river,

[1] AEAT – Associação de Estudos do Alto Tejo (Upper Tagus Study Association).

below 100 meters a.s.l., in Vila Velha de Ródão. This distribution corresponds to placements on very diversified geological and geomorphological settings (Caninas, 2012). In the recorded set, almost all the monuments display the use of metasedimentary rocks (*vulgo* schist and greywackes) as the raw material for both orthostatic structures and mound lithic substructures, which stands for the prompt usage of materials available in the vicinity of the places where the monuments would be built. Thus, it is uncommon the incorporation of granitoid rocks into those constructions.

Other kind of monuments, as menhirs and cromlechs, are nearly absent in this region, in contrast to what we can see at the Alentejo, particularly at the adjacent district of Portalegre (Oliveira & Oliveira, 2000). The most notable cases correspond to the presence of two monoliths at Granja de São Pedro mound (Almeida & Ferreira, 1971) and to the reuse of other two, where some engraved depictions were made during the Late Bronze Age, such as the examples of São Martinho, Castelo Branco (Monteiro & Gomes, 1978), and Corgas, Fundão (Banha, Veiga & Ferro, 2009). On the other hand, we consider very doubtful an interpretation as cromlechs attributed to the lithic enclosures of Fonte Fundeira, Castelo Branco, and Couto da Espanhola, Idanha-a-Nova, and to the displaced set of menhirs from Couto de Santa Marina, Idanha-a-Nova (Henriques, Caninas & Chambino, 1993).

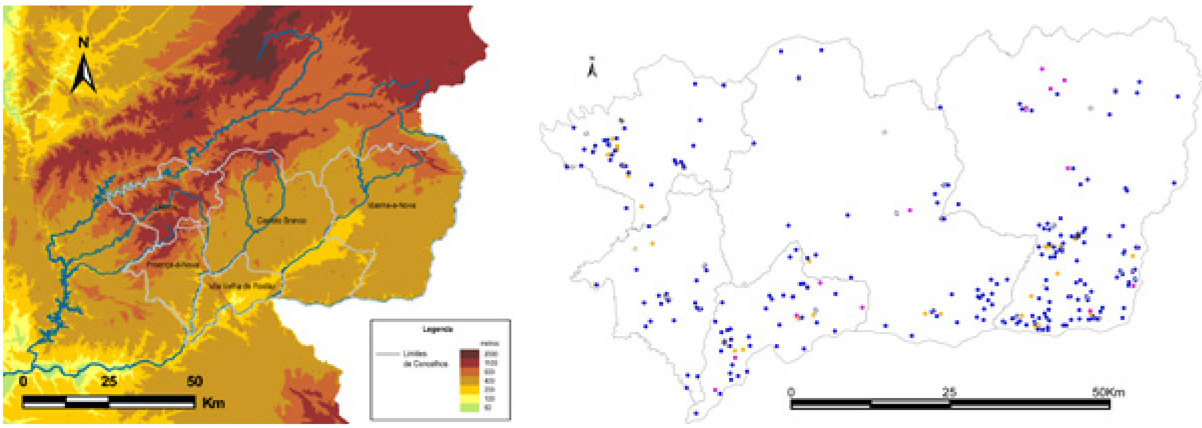


Figure 3 – Hypsometric map with the location of megalithic tombs and mounds at the municipalities of Castelo Branco, Idanha-a-Nova, Oleiros, Proença-a-Nova, and Vila Velha de Ródão (source: AEAT). Map credits: http://www.guiadeportugal.pt.

The characterization of Late Prehistoric occupation of this region, especially the one dating from the fourth and third millennium BC, by correlating the pattern of distribution of megalithic tombs with the dispersal of residential sites and open-air graphical-symbolic expressions, is enhanced by the preservation of a series of settlement traces on Cenozoic detrital formations (Henriques, Caninas & Chambino, 2008), namely at Vila Velha de Ródão (Caninas, Henriques & Osório, 2017), where we can find also a vast complex of open-air rock art by the Tagus river (Gomes, 2010).

This reality gains regional significance, having the Tagus river as an axis, with the continuity of the megalithic network into the neighbouring regions of Cáceres, Spain (Bueno *et al.*, 2006), North Alentejo (Oliveira, 1998; 2008), and Upper Ribatejo (Scarre *et al.*, 2011), and, in the context of a graphical, schematic, and polymorphic universe, shared by different types of depiction (engraving and painting) and sites (Bueno, Balbín & Barroso 2009; 2011), including, alongside open-air rock outcrops, engraved and painted representations in megalithic tombs (Bueno *et al.*, 2006) and painted depictions in rock shelters located in the quartzite mountain ranges of San Pedro (Bueno *et al.*, 2006), São Mamede (Oliveira & Oliveira, 2012), Zimbreira (Cardoso, 2003), and Talhadas (Henriques *et al.*, 2011; Henriques, Pereira & Caninas, 2017).

3. The most recent research at Proença-a-Nova

Three of the Proença-a-Nova's dolmens referred by Georg Leisner (Fig. 2B), Cão do Ribeiro (altitude: 368 meters a.s.l.), Cimo do Vale de Alvito (371 meters a.s.l.), and Cabeço da Anta (386 meters a.s.l.) are under study since 2012 (Henriques *et al.,* 2016). Excavation campaigns have been included in the scope of the Proença-a-Nova Archaeological Field Camp (CAPN) and have benefited from the commitment and support of the town council. The selection of these monuments was determined by scientific and public valuation goals. Concerning the scientific purposes, it was determinant the relative proximity of the megalithic tombs, their placement on a well delimited plateau, their distribution around the source of São Gens stream, and the possibility of being part of a larger necropolis associated to a potential settlement not yet identified, but we assume could have been located in the area of Moitas airfield. With the second objective, we intended to qualify the public understanding concerning these monuments, which are now part of a walking trail promoted by the town council (PR1 – History in the Landscape).

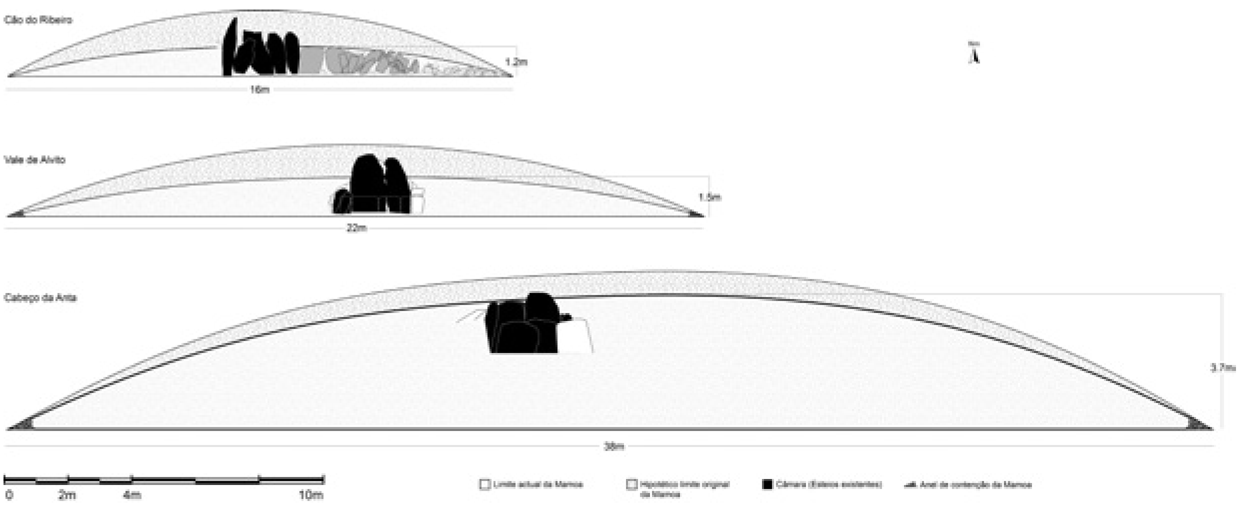


Figure 4 – Relative size of Cão do Ribeiro, Cimo do Vale de Alvito, and Cabeço da Anta mounds, with a comparison between the current and estimated heights of each mound and a schematic representation of the orthostatic substructures.

These monuments present very diverse magnitudes (Fig. 4), and it was possible to document a direct correlation between mound sizes and their topographic prominence: Cão do Ribeiro is located in the southern slope of a hillside and shows a narrower range of vision than the other two tombs, situated on hilltops. The degree of preservation of both their orthostatic structures and mounds are also very different: Cabeço da Anta, the largest monument of the region, is the best preserved. While there are evident volumetric differences, all three monuments seem to respond to the same construction pattern, with orthostatic substructures (chamber and differentiated corridor in both plan and height), peripheral and covering substructures, all built with local metasedimentary rocks and using clay as the main constituent of the mounds. Moreover, this feature was highlighted by Georg and Vera Leisner (1951, 32). However, we should mention that Cabeço da Anta's corridor has not yet been exposed and Cão do Ribeiro's peripheral containment ring was not identified, maybe because it was previously destructed by modern agricultural work. Cão do Ribeiro lies some 1,000 meters from Cimo do Vale de Alvito and 1,200 meters from Cabeço da Anta. The distance between Vale de Alvito and Cabeço da Anta is 400 meters.

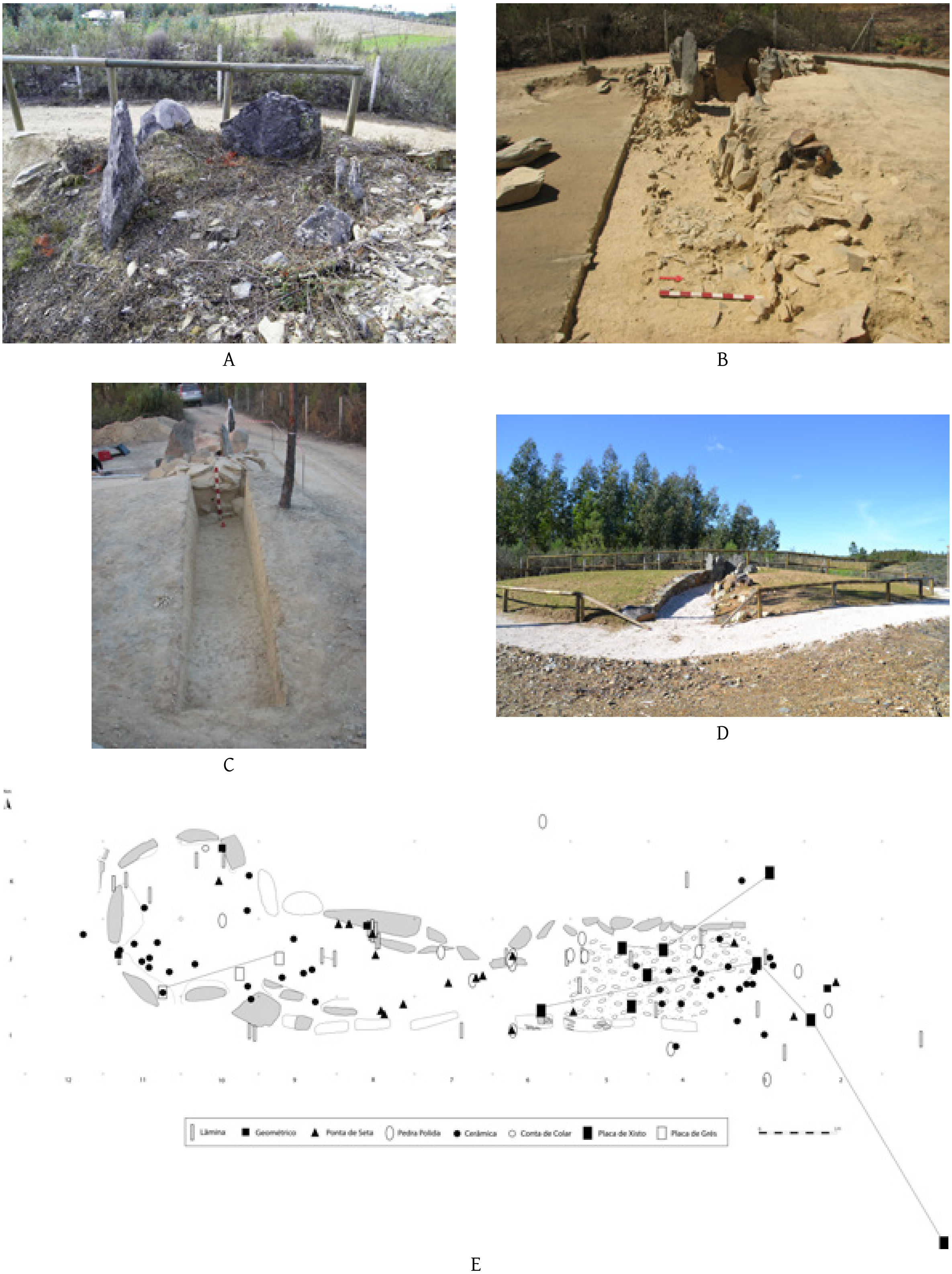
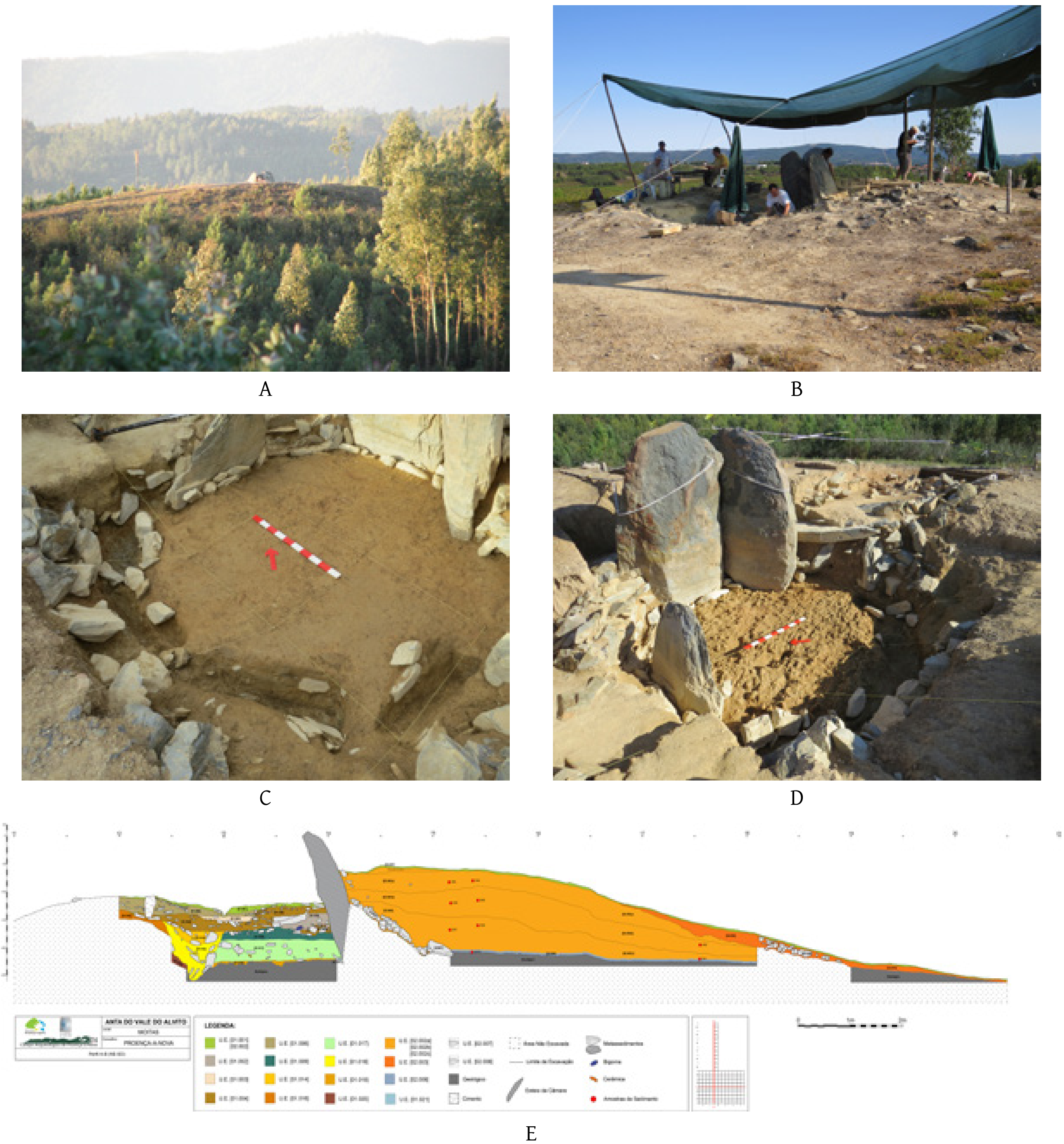


Figure 5 – Cão do Ribeiro: A. Before the excavation; B. During the excavation; C. A view of the sampling trench; D. After partial reconstruction; E. Plan showing the distribution of artifacts. From left to right: blade, geometric microlith, arrowhead, polished stone implements, pottery, necklace bead, engraved schist plaque, and sandstone plaque.



A B C D E

Figure 6 – Vale de Alvito: A. A panoramic view of the monument; B. At the beginning of the excavation; C. A moment of the excavation with the delimitation of disappeared slab sockets; D. The chamber at the end of its excavation; E. Stratigraphic section between the chamber and the periphery of the mound at the end of the excavation.

Excavation work was already concluded at Cão do Ribeiro, but not at Cimo do Vale de Alvito neither Cabeço da Anta, from which we just have a fractional knowledge of their structural and ritual characteristics, especially Cabeço da Anta, whose excavation at the chamber did not reach yet the lowest levels of sedimentation and provided only a reduced amount of archaeological artifacts. The three yearly archaeological excavation campaigns at Cabeço da Anta were preceded by geophysical diagnosis (Electrical Resistivity Tomography, Ground Penetrating Radar, and Magnetometer, under the direction of António Correia), because we considered these techniques could be helpful as a first guidance for the excavation and, additionally, could be cross-checked by the results of the excavation itself.

The excavation of Cão do Ribeiro (Fig. 4 and 5) revealed a seven-slab small chamber with a surrounding buttress, associated to a medium sized passage or corridor separated from the periphery by an elongated atrium, whose floor was a flat stone paved ritual structure made of rounded pebbles. This orthostatic set, built with metasedimentary rocks, was wrapped by a mound made entirely of clay and best preserved in its northeast quadrant. We concede that agricultural practices could have contributed to the destruction of the monument's peripheral containment ring and, if ever existed, mound covering stone structures. The owner of the land made some earthmoving work at the southeast side of the monument, which resulted in the removal of the mound clay in that sector and the dismantling of the south line of the passage and atrium slabs.

Beyond the mentioned structural characteristics, the excavation of Cão do Ribeiro provided very valuable information on the funerary rituals, materialized through the positioning of an assorted series of lithic and ceramic artifacts (Fig. 5E), still under study, most of them found *in situ*, in the passage and atrium areas. In this regard, we should mention the concentration of pottery sherds at the atrium, chamber, and the passage area adjacent to the chamber; polished stone artifacts were found mostly at the end of the passage and the atrium, where all the schist plaque fragments were also recovered. By contrast, all sandstone plaque fragments came from the chamber. In the group of knapped stone artifacts, arrowheads were distributed predominantly in the passage area, whereas blades were ubiquitous inside the orthostatic structure. Presences at the chamber may indicate the last or final depositions and the atrium could have played a function of condemnation of the monument or a place for secondary inhumations. Most probably with a different meaning, geometric microliths were deposited at some of the sockets of the chamber's slabs.

In 2013, when the excavation started, the monument of Cimo de Vale de Alvito (Fig. 4 and 6) displayed a funerary chamber reduced to two complete slabs, the same as previously represented by the German archaeologists (Leisner, 1998), and a well well-preserved mound, but slightly reduced in its height due to erosion and showing a few depressions originated from the extraction of clay for building purposes. At the external surface of one of the slabs, two circles engraved by percussion were still visible.

Using the same methodology adopted at Cão do Ribeiro, the excavation was focused on the inside of the orthostatic structure and on a sampling trench covering all the radius of the mound. The excavation of the inside of the chamber is already finished, reaching the bedrock. This procedure allowed us to know that the chamber was built with eight slabs and reinforced by a strong stone buttress. Besides the two complete monoliths already known, the excavation brought to light the remains of two additional slabs and the sockets cut in the bedrock for the other four orthostats. These were probably extracted in the last hundred years. A quite diversified set of artifacts, predominantly very fragmented pottery, was collected in the lower level of the chamber's deposits. The passage, already identified in the area of its intersection with the chamber, is apparently well preserved and its excavation will start in the years to come.

The sampling trench revealed that the mound is currently reduced to a core made solely of clay and a stone peripheral containment structure surrounding it. In a similar way to the case of Cão do Ribeiro, no planar lithic substructure in a covering or intermediary position inside the mound has been documented. These kinds of substructures could have disappeared by erosion or agricultural exploitation of the land. As a matter of fact, the gap we can observe between the top of complete chamber slabs and the summit of the mound, in the central area of the monument, reflects a significant loss of mound mass that, besides the clayey fraction, could have contained the mentioned stone covering/reinforcing substructures.

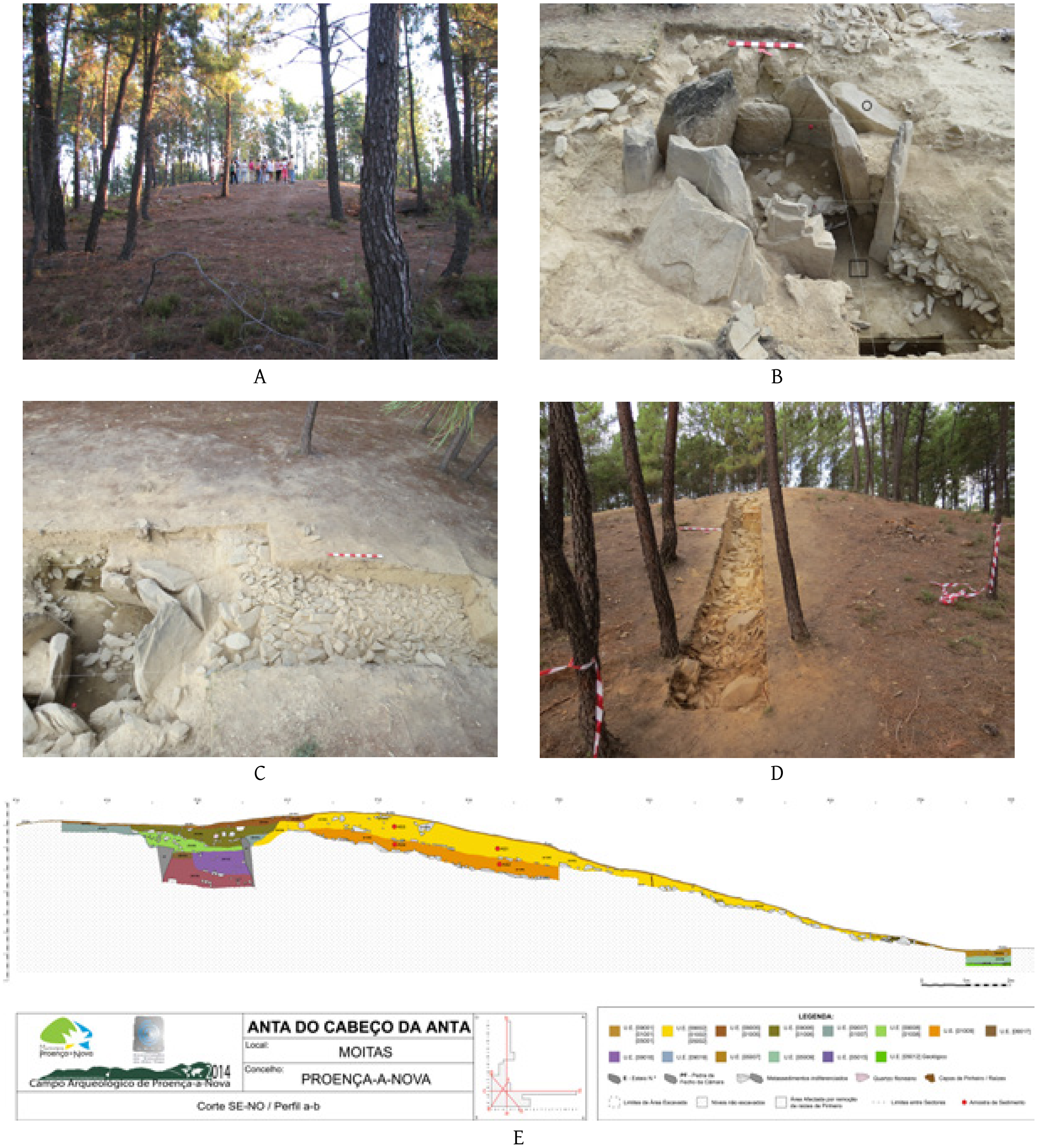


Figure 7 – Cabeço da Anta: A. A view of the mound; B. A view of the chamber's excavation; C. Stone structure adjacent to the chamber; D. One of the sampling trenches; E. Stratigraphic section between the chamber and the periphery of the mound (NW-SE), during its excavation.

Work done at Cabeço da Anta (Fig. 4 and 7) during the excavation campaigns of 2013, 2014, 2015 and 2016 led to the characterization of several substructures, to a great extent due to the fact this monument was much better preserved than Cão do Ribeiro and Cimo do Vale de Alvito. The excavations revealed a nine-slab funerary chamber with just one of them being absent (position noted with a square symbol in Fig. 7B). At the eastern side of the chamber, we could identify a block we consider the closing slab of the gap existing between the top of the chamber and the top of the passage (noted with a circle symbol in Fig. 7B), suggesting that the passage is positioned to the East (not yet visible). In so far, we recovered just a few archaeological artifacts and, albeit the excavation has reached two meters deep (counted from the top of the highest slab), the bottom levels of the chamber, with potential funerary depositions, are still to be attained.

The mound is very well preserved both in plan and height, being slightly higher than the top of the largest slab. A few sampling trenches were opened in the mound, especially two radial trenches with orthogonal directions covering all the mound, from the chamber to the periphery. Despite this planimetric cover, the excavation was not very deep, with the exception of the chamber area. The research has documented an extensive use of clay, but with a more complex vertical structuration than the observed at the other two monuments (Fig. 7E), and the inclusion of planar stone substructures very close to the top of the mound (Fig. 7C and 7D).

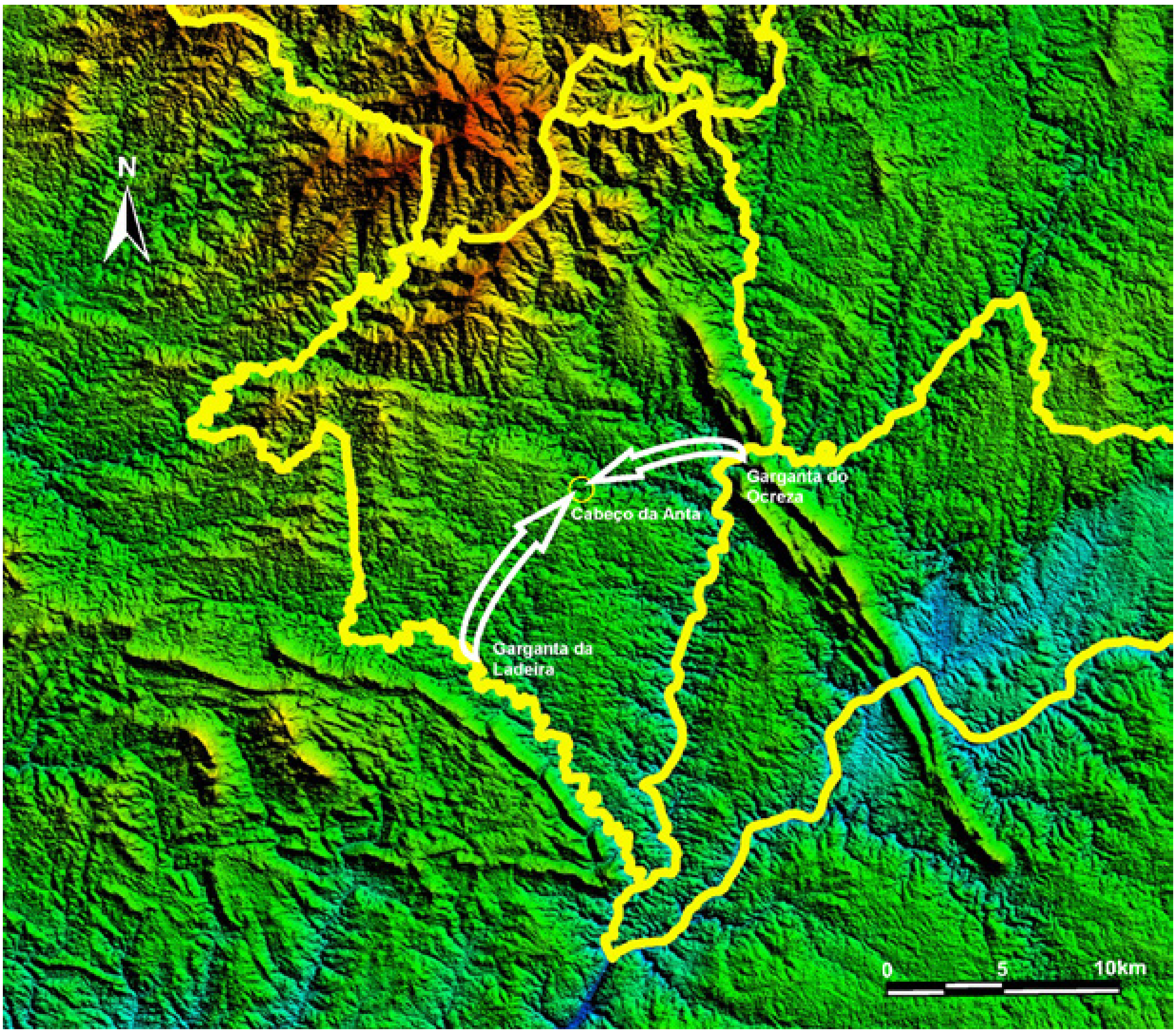


Figure 8 – Cabeço da Anta: hypothetical origins and routes of transportation for the metaquartzite slab registered at the funerary chamber (representation on a DTM produced by Hugo Pires).

The excavation of one of the trenches all the way down to the bedrock may reveal a more heterogeneous stratigraphy than what was perceived until now, and such knowledge may contribute to recover important information about the original composition of the more eroded mounds. As in the case of Vale de Alvito, mound's stone peripheral markers appeared at the end of both orthogonal trenches. Likewise Cão do Ribeiro and Cimo do Vale de Alvito, in the construction of Cabeço da Anta metasedimentary rocks were used almost exclusively (42,9% metapelites; 40,8% metagreywackes; 6,1% metarenites; N= 49), identical to those available locally, and we registered a very scarce presence of hydrothermal vein quartz. The majority of the clasts is angular, of heterogeneous sizes, being present rare rounded pebbles of fluvial origin, as well as weathering patina and cortex alterations, which are typical of clasts accumulated in river terraces and subject to subsequent edaphoclimatic processes. However, one of the chamber slabs, a metaquartzite with sedimentological features that enable to relate it with the upper beds of the Armorican Quartzite Formation,, which, in this region, occurs in the Talhadas and Águas Quentes ridges (Fig. 8), could have had a more distant origin, of at least 11 kilometers, what is suggestive of a further demanding construction project.

4. Concluding remarks

The current state of development in the investigation of the megalithic tombs of Cabeço da Anta, Cimo de Vale de Alvito, and Cão do Ribeiro, three related but dimensionally well differentiated neighboring monuments, does not allow the publication of substantive and representative results on these funerary architectures and associated rituals in the territory of Proença-a-Nova. As a matter of fact, the study of the internal funerary structures is still underway in the first two monuments and has been finished only at Cão do Ribeiro. The analysis of the set of artifacts recovered at the latter tomb will be concluded very shortly, a set that includes, as a novelty, several geometric incised schist plaques and fragments of others made of sandstone. The finding of incised plaques north of the Tagus, alongside those from Charneca das Vinhas (Caninas, Henriques & Cardoso, 2011) and Cabeço d'Ante (still unpublished), in Vila Velha de Ródão, and the structure 1 of Amieiro 5 (Cardoso, Caninas & Henriques, 2003), in Idanha-a-Nova, has altered the former view that defended its total absence in the region of Castelo Branco (Kalb, 1987).

However, some relevant information about the construction features of these monuments has already arisen from the fieldwork carried out until the present date, namely the intensive use of clay in the elaboration of the mounds that covered the megalithic structures, a trait also noticed in the middle of the twentieth century (Leisner & Leisner, 1951) and documented by us in other areas of the Intermunicipal Community, like Vila Velha de Ródão (Caninas, Henriques & Cardoso, 2011) or Idanha-a-Nova (Cardoso, Caninas & Henriques, 2003).

The follow-up of these monuments archaeological investigation, especially at Cabeço da Anta, the largest and best preserved one, reinforced by complementary physical, chemical, archaeometric and paleoenvironmental studies, some already initiated, will contribute decisively to the characterization of these tombs and the rituals performed there in the Past, to the knowledge of the construction techniques, of the materials used and their provenance, and to an approach to this territory's prehistoric settlement network, for which we don't know any dwelling site at the moment.

Acknowledgements

The materialization of this archaeological research, structured around the Proença-a-Nova Archaeological Field Camp (CAPN), including the systematic inventory and study of archaeological sites, has only been possible due to the commitment and support given by the Proença-a-Nova Town Council, through the presidents João Paulo Catarino and João Lobo, the vice-president João Manso and the technical staff led by Isabel Gaspar and António Sequeira.

The success of the excavations was not achievable without the support of the owners of the land parcels where the monuments were located, namely José Adelino Ribeiro Cristóvão, Diamantino Ribeiro Cristóvão, Helena Fernandes Lopes, José Luís Cardoso Dias and António de Jesus Lourenço.

We want to acknowledge also the CAPN partners, in particular the universities of Alcalá de Henares (Spain), Algarve, Coimbra, Évora and Oporto, the research centers CHAIA, Hercules, ICT and CTA, the Municipality of Almada and several private companies (EMERITA, EDF EN, Procesl, Rotation, Superfície, TPF Planege, TTerra and VISA Consultores).

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From matter to essence. Sourcing raw materials for the votive artefacts of the megalithic communities in Ribeira da Seda (North Alentejo, Portugal): a preliminary approach.

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Abstract: This paper presents some preliminary readings about the procurement of raw materials for the production of votive artefacts by the megalithic communities in the area of Ribeira da Seda (North Alentejo, Portugal). A macroscopic analysis of the artefacts collected in megalithic monuments in the study area (pottery, flaked stone artefacts, polished stone artefacts, votive plaques, adornment elements, metallic artefacts, ground stone artefacts) allowed to evidence a relative diversity of the used materials – most of which, in percentage terms, corresponds to locally or regionally available raw materials, in the Ossa-Morena Meta-Volcanic Zone, reflecting the optimized maintenance of abiotic resources. Extra-regional raw materials, such as flint, have statistically lower values when comparing only the types of raw material, indenpendently of the artefacts category and number; however, if we compare the number of artefacts *per se*, we note a marked weight of exogenous materials (for flaked stone artefacts, for instance, nearly 2/3 are produced on flint). This shows a constant procurement of this raw material, which is also associated with the presence of exotic materials (such as amber and ivory), framing the area of Ribeira da Seda in the wide interaction diagrams of the megalithic communities of the 4th and 3rd millennia BCE in Southwestern Iberia.

Keywords: Megalithic communities; Neolithic-Chalcolithic; North Alentejo; Raw material sourcing.

Da matéria à essência. *Aprovisionamento de matérias-primas para os artefactos votivos das comunidades megalíticas da Ribeira da Seda (Norte Alentejo, Portugal): uma abordagem preliminar.*

Resumo: Este trabalho apresenta algumas leituras preliminares sobre o aprovisionamento de matérias-primas para a produção dos artefactos votivos pelas comunidades megalíticas da área da Ribeira da Seda (Alto Alentejo, Portugal). Uma análise macroscópica dos artefactos recolhidos em monumentos megalíticos da área em estudo (recipientes cerâmicos, artefactos de pedra lascadas, artefactos de pedra polida, placas votivas, elementos de adorno, artefactos metálicos, artefactos de pedra afeiçoada) permite evidenciar uma diversidade relativa dos materiais utilizados – sendo que a maioria, em termos percentuais, corresponde a matérias-primas disponíveis local ou regionalmente na zona de Ossa-Morena, reflectindo a manutenção optimizada dos recursos abióticos. As matérias-primas extra-regionais, como o sílex, têm valores estatisticamente baixos quando se comparam exclusivamente os tipos de matéria-prima, independentemente das categorias e número de artefactos; no entanto, se compararmos o número de artefactos *per se*, nota-se um peso acentuado das matérias-primas exógenas (nos artefactos de pedra lascada, por exemplo, perto de 2/3 são produzidos em sílex). Evidencia-se assim a procura constante de matérias-primas siliciosas, à qual se associa igualmente a ocorrência de matérias exóticas (como o âmbar e o marfim), incluindo a área da Ribeira da Seda nos amplos esquemas de interacção das comunidades megalíticas dos 4º e 3º milénios a.n.e. no Sudoeste peninsular.

Palavras-chave: Comunidades megalíticas; Neolítico-Calcolítico; Alto Alentejo; Aprovisionamento.

1. Research Background

It is well known the diversity of components of the votive sets of the Megalithism of Southwestern Iberia, region in which the area of Ribeira da Seda is included. This diversity of elements is obviously reflected in the diversity of raw materials needed to produce them. However, this has always been a study subject in someway neglected, with the provenance analysis summarized to the origin of orthostats, and only applied so far in just a few published cases, such as Vale Rodrigo (Dehn *et al.*, 1991; Kalb, 1996 and 2013) and Rabuje (Boaventura, 2000). Recently, this issue has major developments with the work carried out under the project *MEGAGEO – Moving Megaliths in the Neolithic: Geology Sourcing of Dolmen Slabs in Central-South Portugal* (directed by R. Boaventura) (for instance, see Boaventura & Moita, 2012; Nogueira *et al.*, 2015; Pedro *et al.*, 2015).

In the same way, in the scope of the project *New Technologies Applied to the Study of Mobility and Exchanges: Green Beads and Decorated Pottery with White Inlays from the 5th to the 2nd millennium BCE in the Iberian Peninsula* (directed by C. Odriozola, R. Villalobos García, R. Boaventura and A. C. Sousa), intensive studies have been developed in the framework of the provenance definition of raw materials used for adornment elements (for the case of megalithic contexts in Southwestern Iberia, see Linares Catela & Odriozola Lloret, 2011; Odriozola & Linares Catela, 2012; Odriozola *et al.*, 2010 and 2012).

In the general context of the Neolithic and Chalcolithic in Souterwestern Iberia, it is also necessary to point out the work conducted under the project *Mobility and Interaction in South Portugal Recent Prehistory: the Role of Aggregation Centers* (directed by A. C. Valera), which also contemplates, with the ditch enclosure of Perdigões as a case study, the definition of raw materials provenance – highlighting till the present date the case of ivory, limestone and malacological elements, including the ones collected in the adjacent funerary contexts (Valera *et al.*, 2015; Dias *et al.* 2017; Valera & André, 2016-2017; see also the case of green stones used in adornments at Perdigões in Odriozola *et al.*, 2010).

These studies, which mainly deal with material culture or other material elements of the archaeological record, can be complemented by the strontium isotopes analyses carried out so far in the context of several research projects regarding burial sites, confirming the circulation of people and animals (and therefore ideas and artefacts) between the Portuguese Estremadura and Alentejo during the Neolithic and Chalcolithic (Hillier *et al.*, 2010; Waterman *et al.*, 2013; Lillios *et al.*, 2014; Carvalho, 2014; Carvalho *et al.*, 2016).

Under the MEGAFRONT project (*Megalithism and Megalithic Communities in the Area of Ribeira Grande*) and the GEOM-RS research vector (*Geometries of the Megalithic Territory in the Area of Ribeira da Seda*), whose main objective is to define and characterize the Megalithism and the megalithic communities on the left bank of Ribeira da Seda (North Alentejo, Portugal), the identification of the possible provenance areas of the essential raw materials used for the production of artefacts was considered as vitally important, in addition to the techno-typological gauging of the votive artefacts collected from the studied megalithic monuments, with the perspective of a more rigorous characterization of the interaction diagrams of the Late Neolithic and Chalcolithic communities in Southwestern Iberia.

In this regard, some observations are advanced here, based on an empirical analysis of these materials in terms of their geological features. The data presented here are obviously not definitive and result only from a macroscopic examination of artefacts and objects. Rather it is a preliminary approach to the issue of raw material procurement, in terms of their seriation and the indication of probable provenance areas, thus establishing the conceptual basis for more detailed analyses. Either way, the data collected so far are considered to be enough to understand the regional diversity, suggesting extensive exchange networks covering the entire Southwestern Iberia during the 4th and 3rd millennia BCE.

2. Megalithism and megalithic communities in the area of Ribeira da Seda, on a bird's wing flap

In the area of Ribeira da Seda there are about three hundred references to megalithic monuments, included in the municipalities of Avis, Alter do Chão, Fronteira, Sousel, Monforte, Crato, and in part of the municipalities of Mora, Estremoz and Elvas (Andrade, 2009 and 2013).

They are included in what is commonly referred as *Megalithic Group of North Alentejo*, mainly characterized by the monuments of the areas of the Sever basin and Crato (Oliveira, 1998; Parreira, 1996). One can perceive here an interesting diversity in architectural terms, being this polymorphism probably explained by chronological and cultural factors. In fact, one can recognize here from the small simple monuments («proto-megalithic» type) to the large complex monuments with a differentiated Chamber and Corridor. No *tholos*-type monuments were identified so far in this region.

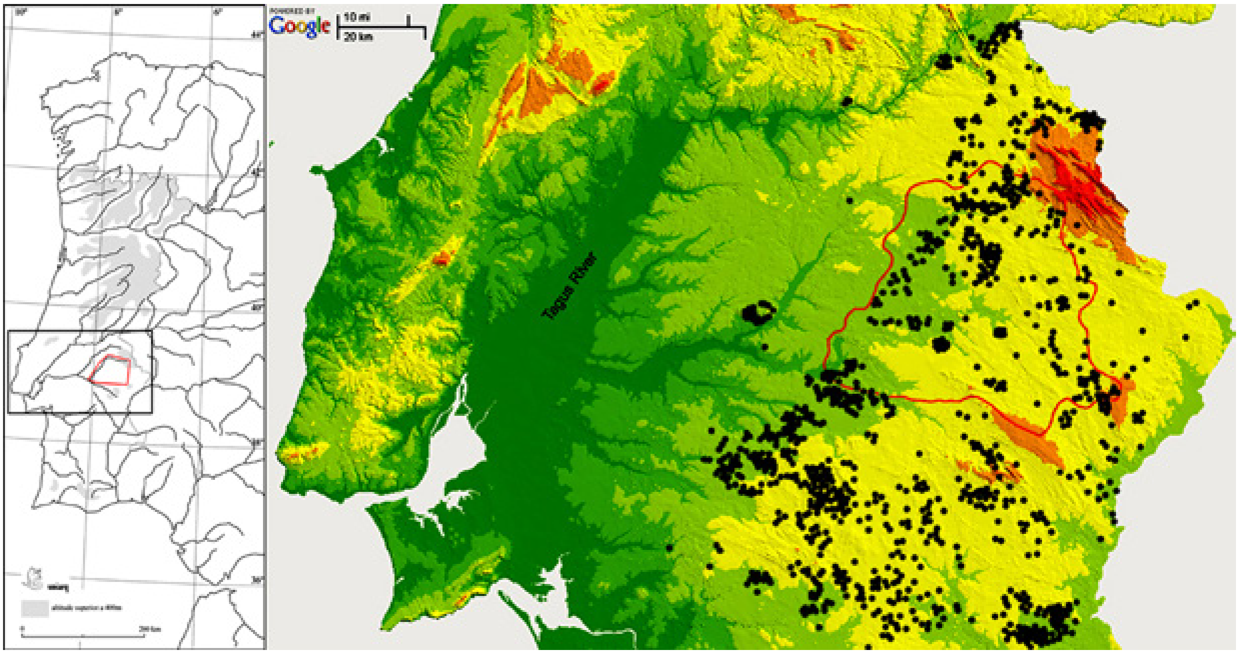


Figure 1 – Megalithic monuments in North Alentejo and Central Alentejo. The area of Ribeira da Seda (its hydrographic basin) is indicated by the red line. Cartographic base: Google Maps, 2013.

Some monuments have been the subject of recent excavation works, such as those of the Coudelaria de Alter do Chão (Várzea Grande, Soalheira and Horta; Oliveira, 2006), the clusters of Rabuje, Enxara and Lacraus (Boaventura, 2006; Mataloto *et al.*, 2016-2017) and the small elongated monument of Condes (Rocha & Alvim, 2015). The availability of contextualized votive sets and associable radiocarbon dates disclosed by these recent works allows to serialize the construction and use of the megalithic monuments in the area of Ribeira da Seda, although with caution due to the scarcity of the sample.

In the general context of the Megalithism of Southwestern Iberia, two generic chrono-cultural levels are recognizable (Boaventura, 2011; Boaventura & Mataloto, 2013). The first, marked out between the second and the last quarter of the 4th millennium BCE, is characterized by small simple «proto-megalithic» monuments or small monuments with a short Corridor, with votive sets consisting of scarce pottery, geometric armatures, small non retouched flint blades and polished stone artefacts (mostly axes with circular cross-section and adzes); the second moment, marked out between the last quarter of the 4th millennium and the mid-3rd millennium BCE, is characterized by monuments with a differentiated Chamber and Corridor, of medium and large size, sometimes with a long Corridor, with votive sets constituded by abundant and diversified pottery, bifacial lithic artefacts (arrowheads, spearheads, daggers and halberds), large retouched flint blades, votive plaques (engraved schist plaques and sandstone plaques, plain or carved with anthropomorphic motifs) and polished stone artefacts (mostly axes with rectangular cross-section and a larger number of adzes).

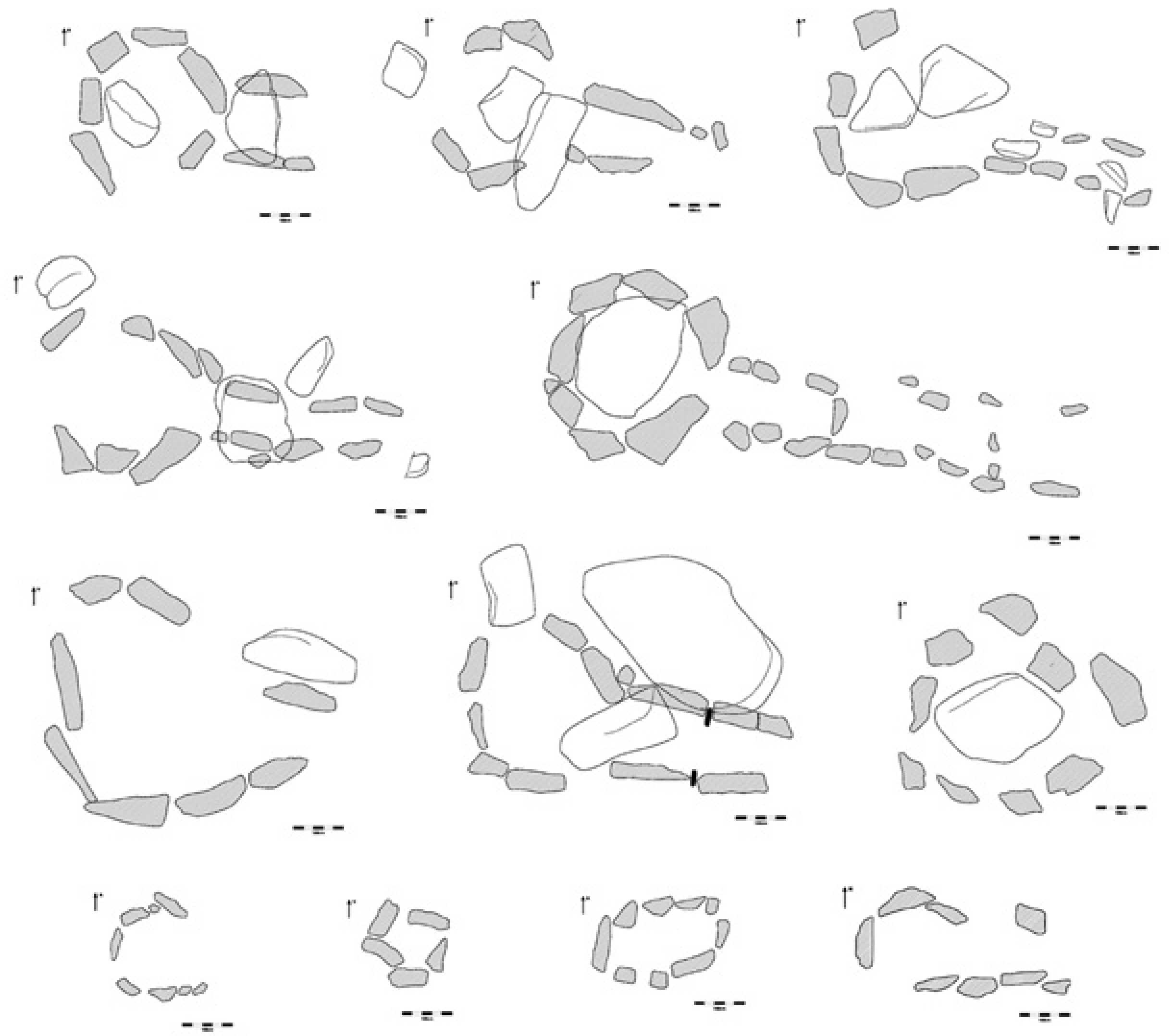


Figure 2 – Examples of the architectural diversity of megalithic monuments in the area of Ribeira da Seda.

Both chrono-cultural levels are represented in the area of Ribeira da Seda. Considering only the monuments that have absolute dates (excluding the ones with only relative dates based on the characteristics of the collected materials), the first moment is represented in Rabuje 5 (Boaventura, 2006), a small tomb originally with a simple Chamber («cistoid» type) to which a Corridor seems to be added slightly after its building (Mataloto *et al.*, 2016-2017); the votive set is not very diversified, consisting of flint bladelets, geometric armatures and few polished stone artefacts – which is compatible with the result of the radiocarbon date obtained from a sample of *Arbustus unedo* charcoal, centered around the mid-4th millennium BCE (Beta-191133: 4650±50 BP).

The second moment is represented in the monuments of Capela (Odriozola *et. al.*, 2017) and Horta (Oliveira, 2006), two medium-sized tombs with a differenciated Chamber and Corridor (from medium to long in lenght); the votive sets are diversified (including arrowheads, votive plaques and abundant pottery with typical forms of this chronological stage), consistent with the radiocarbon dates obtained from human bone samples, whose results are statistically arranged between the last quarter of the 4th millennium (CNA-3543: 4532±30 BP for Capela and Beta-194313: 4390±50 BP for Horta) and the second quarter of the 3rd millennium BCE (Beta-194313: 4190±50 BP for Horta).

Table 1 – Radicarbon dates for megalithic monuments of the area of Ribeira da Seda, recalibrated in 2017 using the program Calib 7.0.1 (© M. Stuiver & P. J. Reimer, 2013), with the IntCal13.14c calibration curve (Reimer *et al.*, 2013, *Radiocarbon* 55: 4). 2σ result with 95,4% probability.

Monument	Lab Reference	Sample	Date BP	Cal BC 2σ	Bibliography
Rabuje 5	Beta-191133	Charcoal – *A. unedo*	4650±50	3630-3343	Boaventura, 2006
Capela	CNA-3543	Human bone – *humerus*	4532±30	3361-3104	Odriozola *et al.*, 2017
Horta	Beta-194313	Human bone	4390±50	3325-2900	Oliveira, 2006
Horta	Beta-194312	Human bone – *calcaneus*	4190±50	2898-2627	Oliveira, 2006

3. The votive artefacts

In the several hundred of megalithic monuments counted in the area of Ribeira da Seda, about 50 of them have known archaeological sets. About 800 individual registers of artefacts and objects, distributed by the different established categories, compose these sets, housed in several national museums and analysed in the context of the projects MEGAFRONT and GEOM-RS. This value does not account for archaeological materials collected in settlements, not included in this particular study but also under analysis in the context of the projects mentioned above.

Materials and Methods

In terms of cataloging and analysis, the artefacts collected in megalithic monuments of the area of Ribeira da Seda were serialized in the following categories: *Pottery*, *Flaked stone artefacts*, *Polished stone artefacts*, *Votive plaques*, *Adornment elements*, *Metallic artefacts* and *Ground stone artefacts*.

All available artefacts were individually described, assessing their specific morphological and techno-typological characteristics.

In order to ascertain the petrographic features of the multiple raw materials, the flaked stone artefacts and polished stone artefacts, as well as the pastes of pottery elements (in order to define the components of their temper), were macroscopically analysed using a Leica MZ6 binocular stereomicroscope (45x magnification). These analyses sought to define potencial sourcing areas based on the information available in the *Portuguese Geological Chart* and on the comparison with geological samples (mainly flint and amphibolites) collected and firstly analysed in the scope of other research programmes.

Macrophotographs were obtained using a Veho VMS-001 USB microscope, with 45x and 200x magnification, both in geological and archaeological samples.

Pottery

Obviously, from a perspective of optimization of efforts, one can suggest the local sourcing of clays required for the production of the pottery vessels included in the votive sets of these communities.

This proposal is ratified in some ways by the evaluation of the minerals composing the temper of votive pottery, mostly referring to quartz grains (from sub-rounded to angular), feldspar and muscovite, and minoritarily, biotite, hematite, iron oxides – which generally matchs to the local geology (obviously, geo-chemical analyses are requiered to confirm this hypothesis).

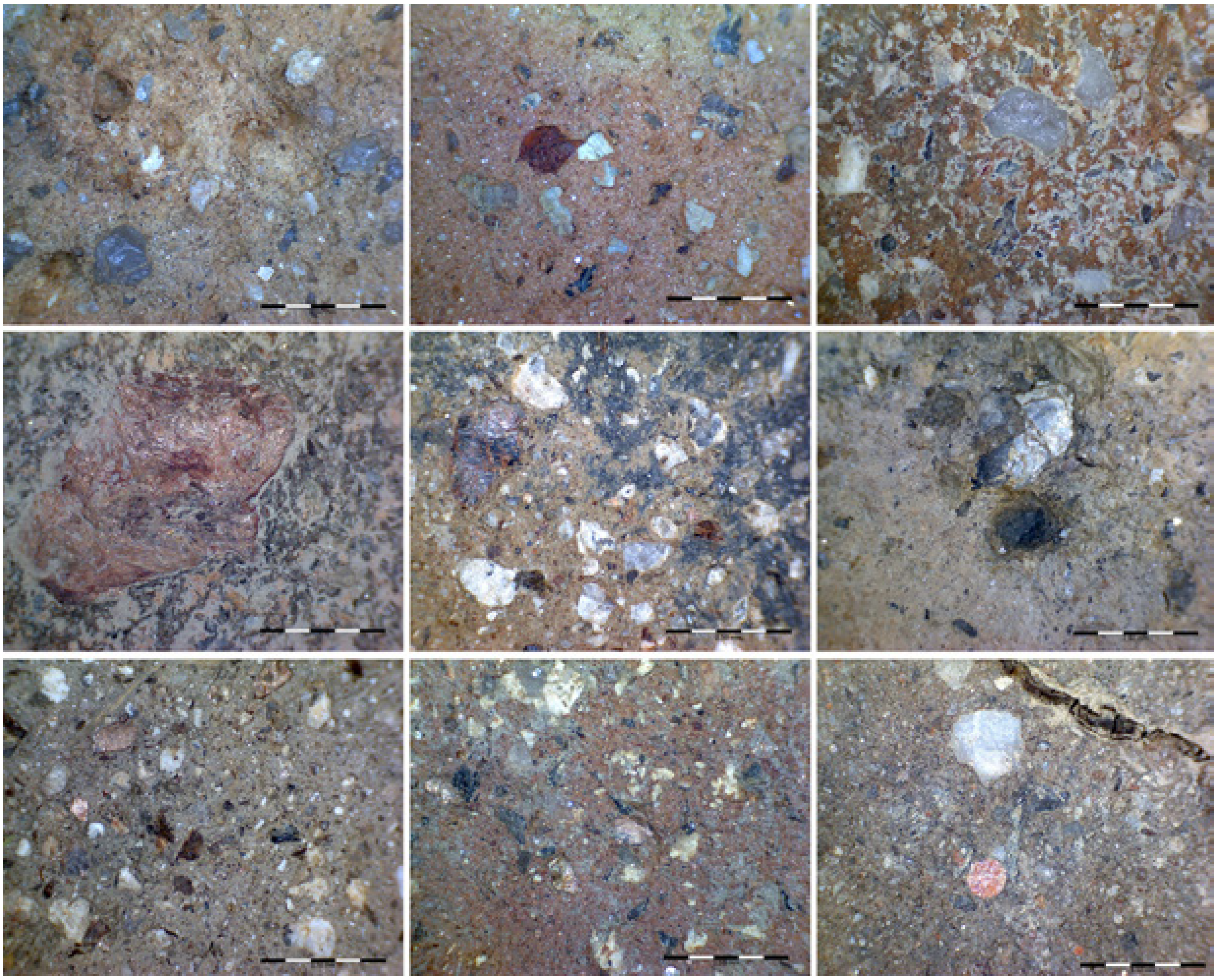


Figure 3 – Macroscopic aspect (x50) of the ceramic pastes of pottery collected in megalithic monuments in the area of Ribeira da Seda, being evident the presence of quartz grains (angulous and sub-rounded), feldspar, muscovite, biotite, iron oxides and hematite. The scale corresponds to 2,50 mm.

Flaked stone artefacts

The set of flaked stone artefacts is diversified, not only in terms of typology of the artefacts themselves but also in terms of the raw materials used in their manufacture. Techno-typologically, the presence of blades, bladelets, bifacial points (arrowheads and spearheads), geometric armatures and bladelet cores can be highlighted. The raw materials used in their production can be serialized as follows:

- Blades: flint, opaline and rhyolite;

- Bladelets: flint, hyaline quartz and milky quartz;

- Bifacial points (arrowheads and spearheads): flint, silcrete, opal (?), opaline, siliceous schist, phyllite, lydite, hyaline quartz and milky quartz;

- Geometric armatures: flint, chalcedony, opaline, milky quartz;

- Bladelet cores: flint, hyaline quartz.

Thus, one can perceive an interesting variety in the raw materials used, apparently not directly dependent of the artefact type.

Regarding flint, several procurement sources can be distinguished by a macroscopic analysis. Flint is generally of good quality, fine-grained, presenting scarce internal flaws. It is from opaque to semi-translucent, with a wide range of shades. The *mudstone* texture is a homogeneous feature in the set, and it is possible to observe some exceptionally rough areas that may correspond to micro and macro-quartzic zonings, as well as few poorly preserved bioclastic remains. These characteristics are typical of the Cenomanian silicifications (Cretaceous) of the Portuguese Estremadura, where flint can be found in secondary position on Miocenic deposits (cf. Aubry *et al.*, 2014; Matias, 2016). Thus, it is possible (according to certain particular features) to recognize flints from the Estremadura Limestone Massif and adjacent drainage basins, namely from Azinheira or Amieira-Arruda dos Pisões (Rio Maior) and Caxarias or Pederneira (Ourém) – the latter not so well represented and mainly used in the production of blades and some few geometric armatures. One single element, an arrowhead collected in the dolmen of Capela, appears to have been produced using Cenomanian flint from the Lisbon peninsula area, which occurs in primary and sub-primary position on the Cretaceous formations found around the Lisbon Volcanic Complex (areas of Loures-Odivelas-Amadora, Monsanto-Campolide-Alcântara, Oeiras and Sintra). Nevertheless, this attribution is not categorical, only based, besides the particular petrographic features, on the post-knapping weathered surfaces that normally characterises this type of greenish gray flint. In fact, flint with similar characteristics are also present in the area of Rio Maior (together with the typical red or brownish red flint, although in smaller amounts); therefore more detailed analyses are required to substanciate this ascription.

Only two elements, two blades collected in the dolmens of Talha 2 and Outeirões 3, seem to correspond to Oxfordian flint (Jurassic) from Tomar area (respectively Agroal and Sabacheira; cf. Aubry *et al.*, 2014; Matias, 2016); however, given the intense thermic changes presented by the blade of Talha 2, it is not possible to defend this hypothesis with certainty without more detailed analyses. However, this classification is obvious in the case of the blade from Outeirões 3, even if based only on a macroscopic evaluation.

A particular type of opaque, grayish flint, with heterogenic textures (from *mudstone* to *wackestone-packtone*), is widely used in the production of the small blades and geometric armatures found in monuments attributable to the second half of the 4th millennium BCE, sometimes in roughly identical proportions to the Cenomanian flint (like in Talha 3). It presents some petrographic features apparently similar to those from Oxfordian contexts – however, it does not match exactly to any of the silicifications with this geological age recognized so far in Western Iberia (cf. Aubry *et al.*, 2014; Matias, 2016). Therefore, its precise source must still be defined.

Another element should be mentioned, collected in the dolmen of Nossa Senhora da Conceição dos Olivais. Although it corresponds to a monument located outside the limits of the hydrographic basin of Ribeira da Seda, it is located near de ridgeline between this watercourse and Ribeira da Tera, thus being territorially associable. In this monument, within the set of arrowheads produced almost exclusively in Cenomanian flint, one can find an element distinguished by its characteristics. It corresponds to a

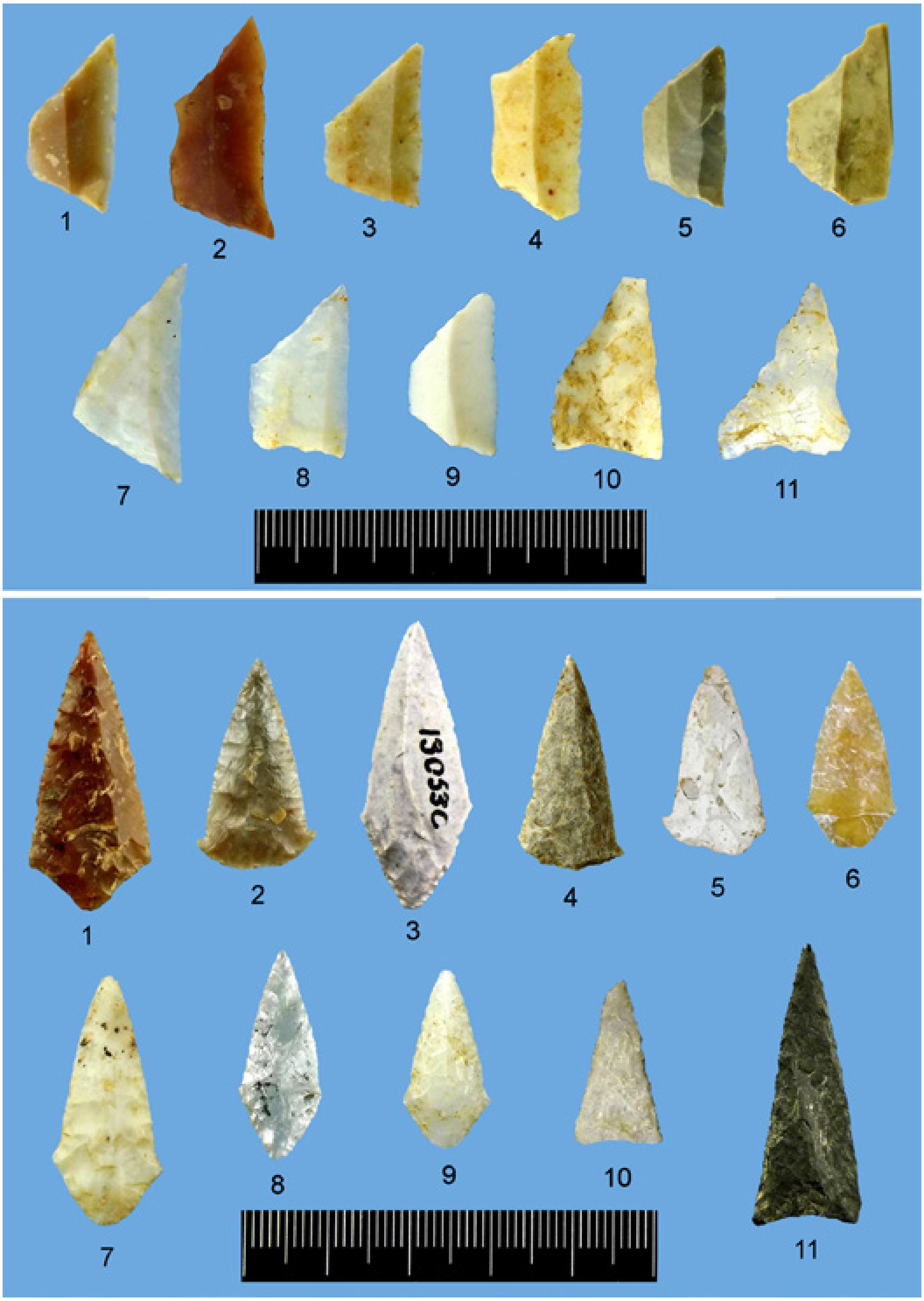


Figure 4 – Top: examples of the variability of geometric armatures collected in megalithic monuments in the area of Ribeira da Seda: Cenomanian flint from Rio Maior (1-2), Cenomanian flint from Ourém (3-4), opaque gray flint from undetermined source (5-6), chalcedony (7-8), opaline (9) and milky quartz (10-11). Bottom: examples of the variability of arrowheads collected in megalithic monuments in the area of Ribeira da Seda: Cenomanian flint from Rio Maior (1-2), Cenomanian flint possibly from the Lisbon area (3), oolitic flint (4), silcrete (5), opal? (6), opaline (7), hyaline quartz (8), milky quartz (9), phyllite (10) and lydite (11).

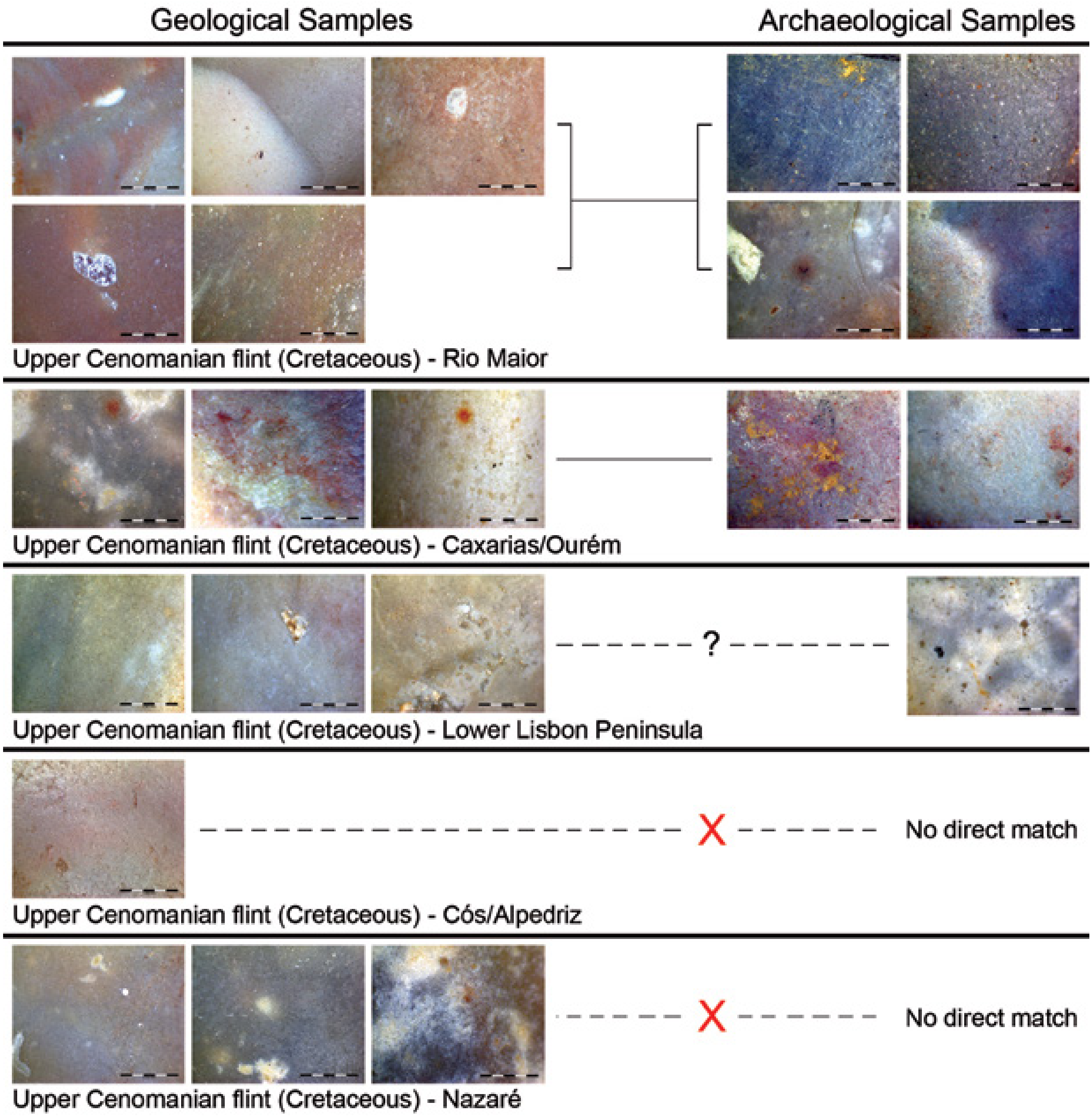


Figure 5 – Macroscopic comparison (x50) between geological samples (Cretaceous) and archaeological samples of flint collected in megalithic monuments in the area of Ribeira da Seda (blades, geometric armatures and arrowheads). The scale corresponds to 1 mm.

fine-grained flint, with *packstone-grainstone* texture and a high density of ooids composing its structure. It presents petrographic features similar to those found in the Jurassic silicifications of the Middle Sub-Betic range between Malaga and Granada (cf. Ramos Millán *et al.*, 1993; Martínez Fernandéz *et al.*, 2006; Morgado & Lozano, 2011; Morgado Rodríguez *et al.*, 2011). Although instances of oolitic limestone are known in Western Iberia (namely in the Estremadura Limestone Massif and Western Algarve), the presence of silicifications in these formations has not been confirmed so far.

Regarding chalcedony, although it is known to occur in limestone contexts of the Portuguese Estremadura and of the coastal region of Alentejo, it is possible to consider perhaps its presence (not confirmed) in secondary mineralizations in the context of closer igneous rocks (the volcanic-sedimentary complex of Estremoz, for instance). The same can be also mentioned for the case of opal (?) and opaline.

Silcrete is also available in the adjacent drainage basins of the Estremadura Limestone Massif, on Miocenic deposits, together with the Cenomanian flint.

All other raw materials are locally and regionally available; in fact veins and masses of rhyolites, siliceous schists, phyllite, lydite and quartz are mapped in the whole area of the North Alentejo, in Precambrian, Cambrian, Ordovician, Silurian and Devonian contexts.

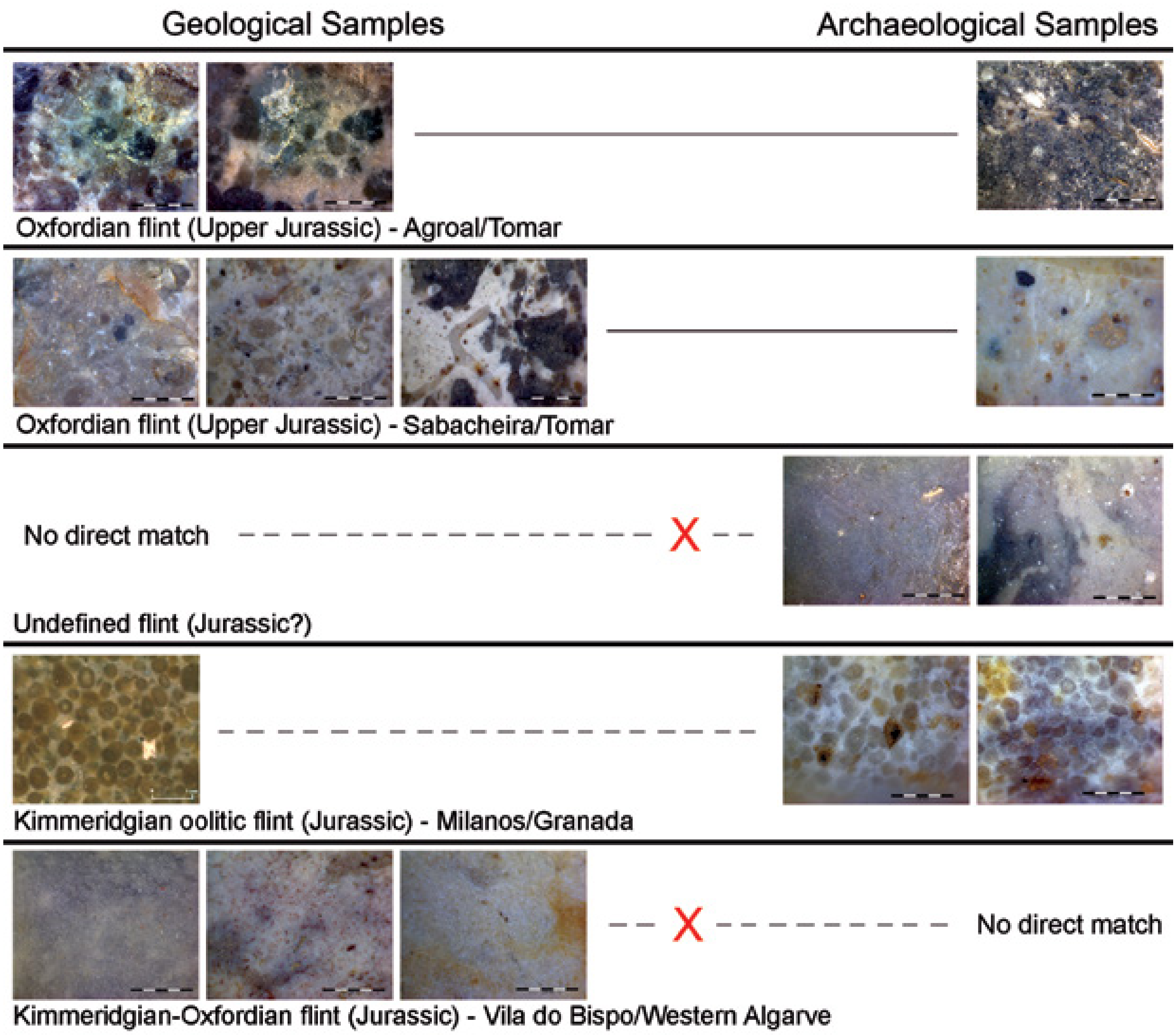
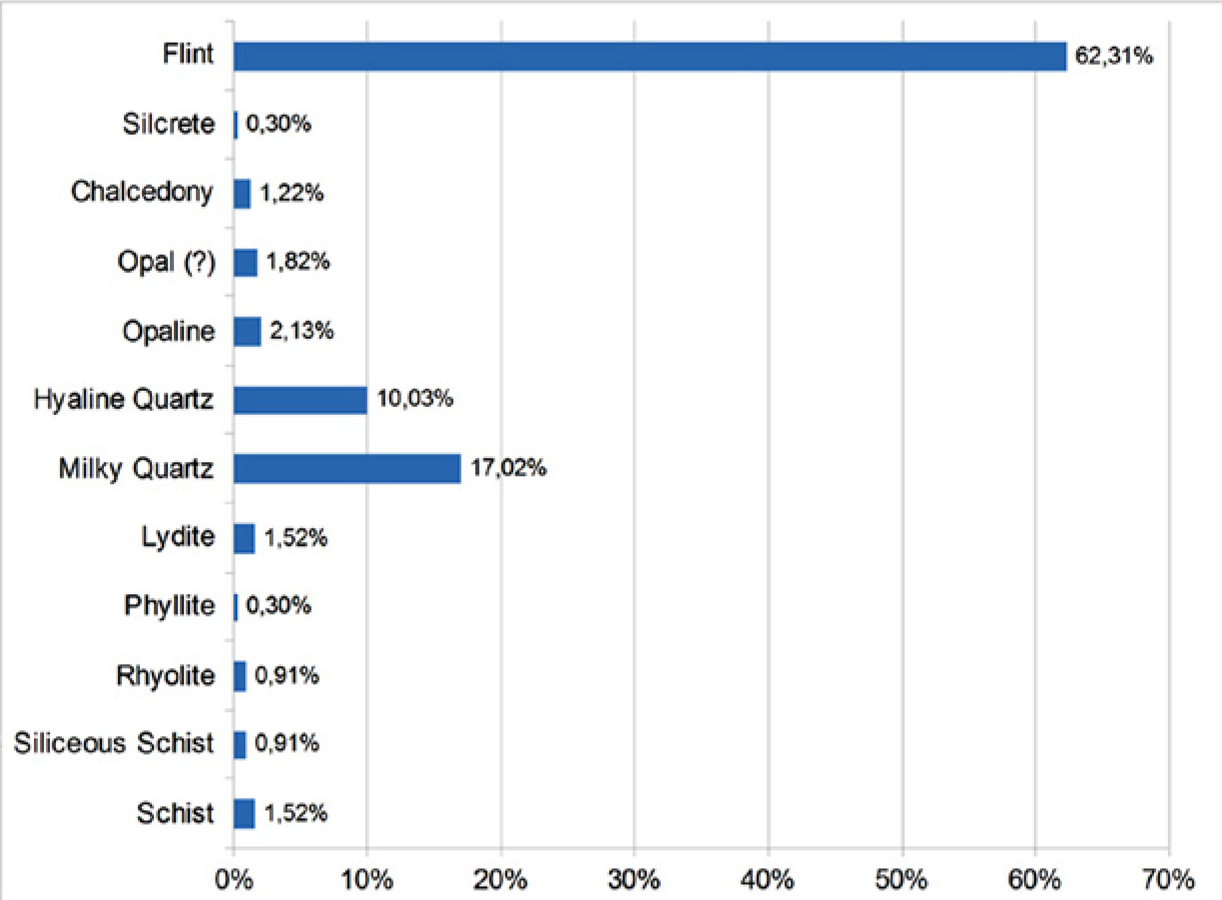


Figure 6 – Macroscopic comparison (x50) between geological samples (Jurassic) and archaeological samples of flint collected in megalithic monuments in the area of Ribeira da Seda (blades, geometric armatures and arrowheads). Macrophotograph of the oolitic flint from Granada after Morgado Rodríguez et al., 2011, fig. 5.4. The scale corresponds to 1 mm.

Chart 1 – Percent *ratio*, by raw material, of flaked stone artefacts (geometric armatures, arrowheads, blades and bladelets) in the area of Ribeira da Seda.



Polished stone artefacts

The polished stone tool set, including axes, adzes and chisels, is mostly produced in amphibolite (or other derived metamorphic rocks, such as amphibolic gneiss and amphibolic schist). Their local and regional availability is well-known in the areas of Abrantes, Gavião, Montargil, Ponte de Sor, Avis, Campo Maior, Mora, Pavia, Arraiolos, Montemor-o-Novo, Évora and Viana do Alentejo, being therefore easy to access these materials.

Axes produced with microgranites-diorites or dolerites are also known, although in a statistically reduced number. These raw materials are also locally and regionally available, in the areas of Avis, Alter do Chão and Crato, in the form of masses and veins in different geological settings.

Other artefacts, mainly adzes, are produced in sillimanite (fibrolite). The definition of its origin is complex; although, its procurement can be propose in not too distant areas, being mapped occurrences of sillimanite veins on metamorphosed sedimentary formations in the areas of Montargil, Campo Maior and Arraiolos. In the same way, an adze of amphibolic rock from the dolmen of Capela presents an embedded sillimanite vein, allowing to perceive that the enclosing rock of this alumino-silicate mineral will be amphibolite (or rather amphibolic gneiss).

A mild, metamorphic rock type, of microcrystalline trend, designated as «green schist» or «weathered filonian basalt» and used in the produtction of adzes during the 4th millennium BCE, may correspond to vulcanites from volcanic-sedimentary contexts. It may be locally available in Silurian and Cambrian contexts in the areas of Avis, Sousel and Alter do Chão, or regionally available in the foothills of the Anticline of Estremoz.

A single artefact presents distinct raw material, corresponding to an adze from the dolmen of São Lourenço 1, produced in siliceous schist. It can be obtained from Banded Iron Formations (BIF) of Precambrian age, possibly also locally or regionally available in the foothills of the Anticline of Estremoz or in the Syncline of Terena.

Figure 7 – Top left: adze of siliceous schist (BIF?) from the dolmen of São Lourenço 1 (Crato). Top right: sillimanite adzes from dolmens of the areas of Fronteira and Avis. Bottom: Adze of amphibolic rock from the dolmen of Capela (Avis), with a small sillimanite vein near the edge (indicated by the arrows).

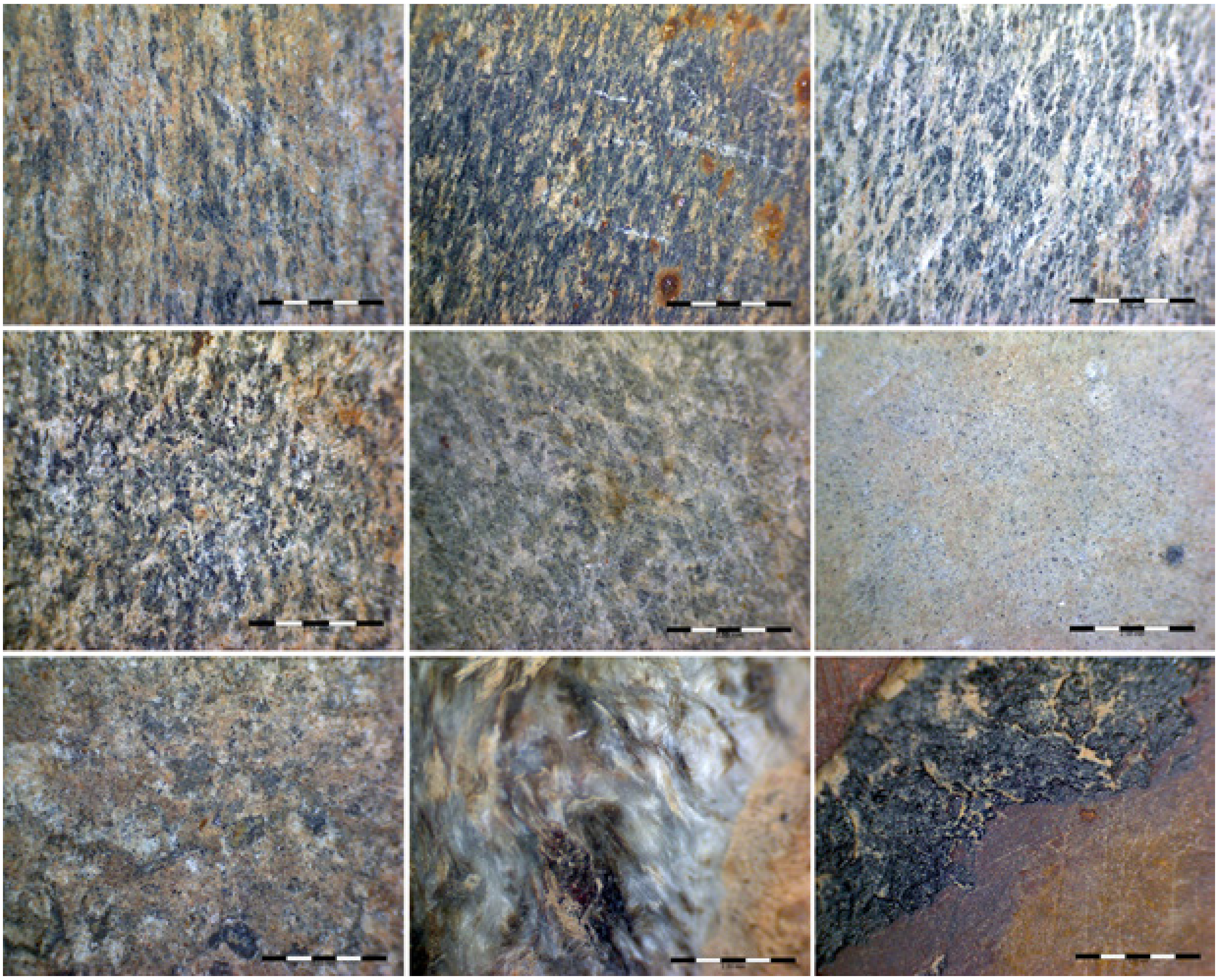


Figure 8 – Macroscopic aspect (x50) of polished stone tools collected in megalithic monuments in the area of Ribeira da Seda. The last four correspond to dolerite, microgranite-diorite, sillimanite and siliceous schist (BIF?), the others correspond to amphibolite or derived amphibolic rocks. The scale corresponds to 2,50 mm.

Votive plaques

Votive plaques, one of the main elements that characterize the Megalithism of North and Central Alentejo (and generally of Southwestern Iberia) are produced in slate, chloritic schist, amphibolic schist, serpentinite, mica-schist and sandstone.

Once again their availability is local and regional. Slate is available, for instance, in Silurian contexts in Pavia; chloritic schist is also available in the Silurian contexts of Pavia and in the Precambrian contexts of Portalegre; amphibolic schist is available in the areas indicated above about the polished stone artefacts; serpentinite is available in the basites and ultrabasites (gabbro) of the Prehercynian contexts of Sousel and Portalegre; mica-schist is available in Montargil, Ponte de Sor, Pavia and Arraiolos, in Cambrian, Ordovician and Silurian contexts; sandstone is found abundantly in the Miocene and Pliocene contexts of the Tertiary filling of Tagus and Guadiana Rivers, in the areas of Castelo de Vide, Montargil, Ponte de Sor, Portalegre, Avis, Sousel, Campo Maior, Mora, Pavia and Montemor-o-Novo and in Devonian-Silurian contexts in Marvão and Assumar.

Figure 9 – Votive plaques collected in megalithic monuments in the area of Ribeira da Seda (Ordem 1, Avis): slate, serpentinite (with weathered surfaces), amphibolic schist and sandstone.

Adornment artefacts

This category includes artefacts such as necklace beads, pendants and «hair pins», produced with several types of raw materials.

Beads present a relative variety of raw materials: slate (the most common), chloritic schist, amphibolic schist, serpentinite, mica-schist, ceramic, amphibolite, sillimanite, steatite, talc and green stone (mainly muscovite, variscite being rare and resumed so far to the dolmens of Ordem 1 and Capela). All the above listed raw materials are locally or regionally available, excluding (so far) the variscite of extra-regional procurement. Pendants are produced on green stones and schist, sometimes recycling fragments of engraved schist plaques.

Since this is a matter currently under study within the project *New Technologies Applied to the Study of Mobility and Exchanges* mentioned above (including, in the study area, the dolmens of Ordem 1 and Capela), it will be useless to advance major considerations about their provenance, using the sources indicated above for the votive plaques (since the raw materials are essentially the same, with regard to slate, chloritic schist, serpentine, amphibolic schist, mica-schist and sillimanite).

One can also found bone beads, especially one of African savannah elephant ivory collected in the dolmen of Capela (Schuhmacher *et al.*, 2009). The «hair pins», some with grooved detachable head, are exclusively manufactured in bone.

The amber element from the dolmen of Capela does not necessarily correspond to a necklace bead. It is a small, apparently unworked nodule. However, it can be assumed that it is likely a component of an adornment object, complemented with an undetermined attachment/suspension implement. Its analysis revealed that it might be Sicilian simetite (Odriozola *et al.*, 2017).

Metallic artefacts

Occasionally, metallic artefacts are included in funerary sets, possibly related to later uses of the monuments, during the second half of the 3rd millennium BCE – as attested in Assobiador 2, Ordem

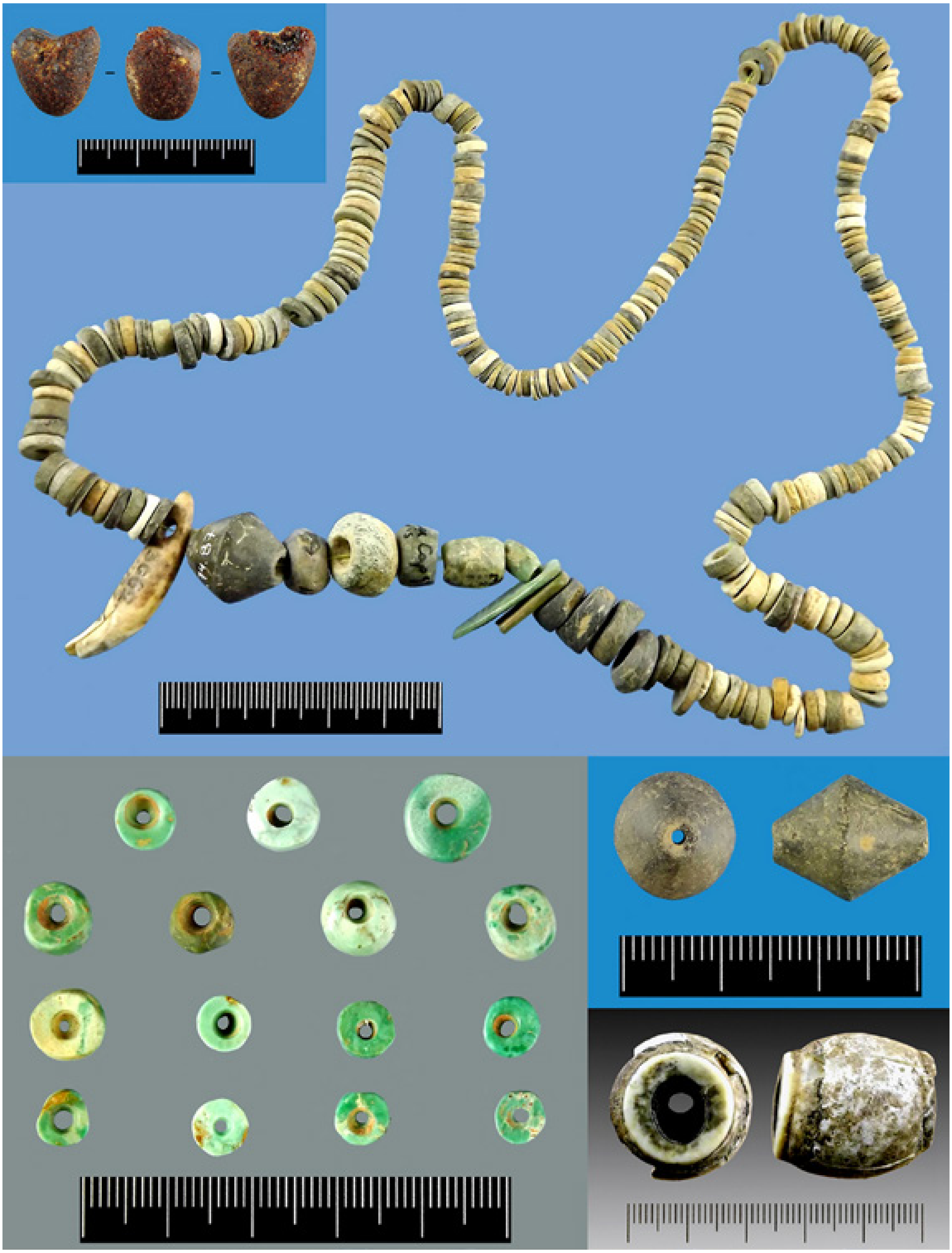


Figure 10 – Top: examples of the variability of adornment elements collected in megalithic monuments of the area of Ribeira da Seda; several types of schist, serpeninite, amphibolite, talc, green stone (muscovite), bone (including a *canis* sp. perforated canine) from the dolmen of Capela (Avis). Top left: Small amber nodule from the dolmen of Capela (Avis). Bottom left: Green stone beads (muscovite and variscite) collected in the dolmen of Ordem 1 (Avis). Bottom right (top): Ceramic bead from the dolmen of Espadanal (Estremoz). Bottom right (bottom): Large ivory bead of African savannha elephant from the dolmen of Capela (Avis).

1, Entreáguas 1, Passarinhos 1 and possibly in Torre do Ervedal 3, monuments in wich copper points, daggers, blades and awls were collected. It may be suggested the local acquisition of the raw materials necessary for the manufacture of these artefacts, with copper occurences being mapped in the areas of Monforte, Alter do Chão and Fronteira, in Cambrian contexts.

Ground stone artefacts

The presence of millstone elements is common in megalithic monuments in Alentejo, being present in the area of Ribeira da Seda both querns and handstones. They are produced on local igneous rocks, such as the ubiquitous diorite, gabbro, granite and granodiorite.

Polishers and grinders are also known in votive contexts, using local metamorphic rocks as raw material, mainly gneiss.

Other ground stone artefacts, of occasional use such as hammers and anvils, use quartz, quartzite and hornfels as support. The use of pebbles for these artefacts makes it possible to defend their local procurement, being these pebbles largely available in the watercourses beds or in the Tertiary and Quaternary terraces of the banks of Ribeira da Seda.

4. Some remarks on local, regional, extra-regional and hyper-regional procurement of raw materials by the megalithic communities of the area of Ribeira da Seda

As mentioned above, the data presented herein are based only on a macroscopic analysis of the raw materials used in the production of votive artefacts by the megalithic communities in the area of Ribeira da Seda and its confrontation with the information available on the *Portuguese Geological Chart*. Thus, it must be taken only as a preliminary approach to this issue, establishing the conceptual basis for further detailed analyses.

Extending the scheme proposed by J.-M. Geneste (1991) for the hunter-gatherer communities, as already suggested for the case of Nossa Senhora da Conceição dos Olivais (Boaventura *et al.*, 2014-2015), the following scales of immediate analysis are proposed for the megalithic communities of Southwestern Iberia, considering the mobility patterns of the Neolithic and Chalcolithic communities:

Local procurement – up to 10 km radius;

Regional procurement – between 10 and 50 km radius;

Extra-regional procurement – over 50 km radius.

Obviously, the definition of these scales is based on linear theoretical criteria, and therefore their application sould be relativized, depending on several factors. First of all, the natural boundaries must be taken into account – in this case, the Ossa mountain range and the Estremoz Limestone Massif (and, a bit further away, the course of the Tagus and Guadiana Rivers), acting as obvious conditioners of transitability. Subsequently, it should be noted that movements of herds, hunting expeditions or other small-scale logistical maneuvers could cover distances of more than 10 km (and even of more than 50 km). However, these movements are always assumed to be «local» activities (in which just few days could pass between the departure and arrival to the settlement base), having as indirect repercussion the occasional sourcing of raw materials (and their consequent transport to the residential area). Similarly, we can find raw materials from areas located way over the 50 km radius, even over 100 or 200 km; in such cases they are regarded as of hyper-regional origin, considered as exotic materials.

Obviously, it can be discussed if it were whether raw materials or finished products to be traded; however, this is not the place to deepen such matter. In any case, the provenance areas would be the same, and that is the issue that truly concerns us here. Nevertheless, and as a small contribution for this debate, it should be noted that the occurrence of workshops near the raw material sources, specifically in the cases of flint and variscite (as further mentioned), could favour the second hypothesis.

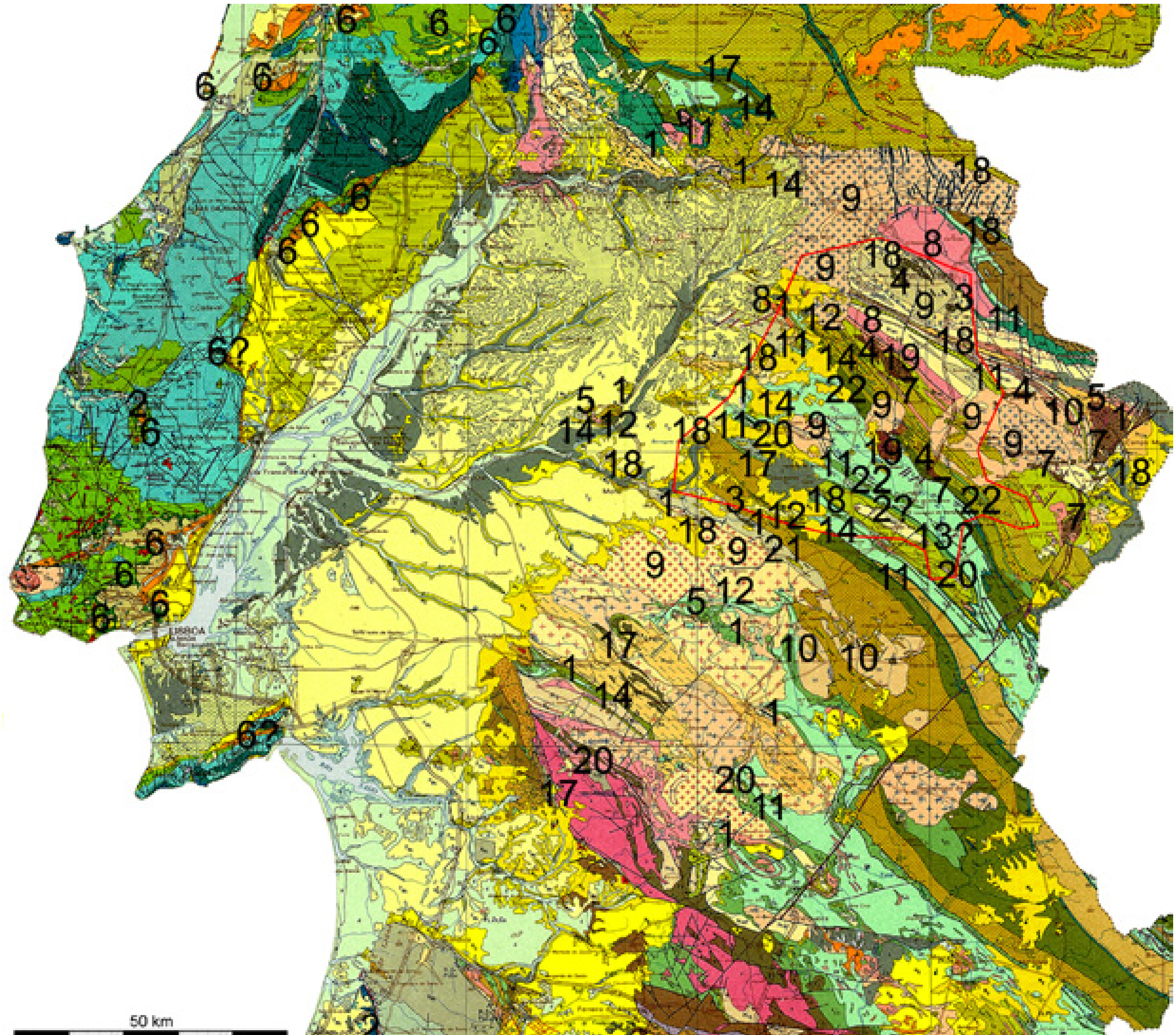


Figure 11 – Possible procurement sources of raw materials used in votive artefacts in the area of Ribeira da Seda. Note that the points do not necessarily correspond to the original procurement sources, but only to the indication of geological contexts in which raw materials can be found. 1: Amphibolite and amphibolic rocks; 2: Chalcedony; 3: Chloritic schist; 4: Diorite; 5: Fibrolite (sillimanite); 6: Flint; 7: Gabbro; 8: Gneiss; 9: Granite; 10: Granodiorite; 11: Lydite; 121: Mica-schist; 13: Opal (?) and Opaline; 14: Phylite; 15: Quartz; 16: Quartzite; 17: Rhyolite; 18: Sandstone; 19: Serpentinite; 20: Siliceous schist; 21: Slate; 22: Vulcanites. The area of Ribeira da Seda (its hydrographic basin) is indicated by the red line. Cartographic base: *Portuguese Geological Chart*, scale 1:500000, 1992.

Taking into account the above mentioned, and independently of their category or number, the vast majority of raw materials used in the production of artefacts by the megalithic communities of Ribeira da Seda are mostly of local or regional origin (from the Davos-Morena Meta-Volcanic Zone), with extensive occurrences mapped in the region of North and Central Alentejo. Their availability is thus immediate, revealing no major investment in obtaining raw materials for the production of votive artefacts, reflecting an educated use and an optimized maintenance of abiotic resources.

One can only point out flint, as well as silcrete, chalcedony, opal (?) and opaline, as exogenous raw materials – excluding, in this context, the cases of variscite, amber and ivory used in adornment elements, with an obvious hyper-regional origin (Odriozola *et al.*, 2010, 2012, 2016 and 2017; Schuhmacher *et al.*, 2009; Valera *et al.*, 2015). However, for chalcedony, opal (?) and opaline, one can perhaps propose their potential local or regional presence as secondary mineralizations in volcanic-sedimentary complexes, as mentioned above.

Regarding flint, and as such, the petrographic features allow to point out as probable procurement sources the areas of the Estremadura Limestone Massif and adjacent drainage basins, referring mainly to flint of Cenomanian contexts, with a statistically irrelevant presence of flint from Oxfordian contexts and excluding the grayish, opaque flint from undefined source (cf. Aubry *et al.*, 2014; Matias, 2016 about the description of these flints). The region of Rio Maior (Azinheira and Amieira-Arruda dos Pisões, for instance) and the regions of Ourém (Pederneira and Caxarias) and Tomar (Agroal and Sabacheira) can be highlighted as probable provenance areas, over 120 km from the central area of the hydrographic basin of Ribeira da Seda. Although other potencial sourcing areas with the same features are available, we highlight those ones due to the occurrence of extensive Late Neolithic and Chalcolithic flint workshops directed towards the production of bifacial tools and large blades, particularly in Rio Maior and Ourém (Zilhão, 1994 and 1997; Forenbaher, 1999; Andrade *et al.*, 2014; Andrade & Matias, 2013).

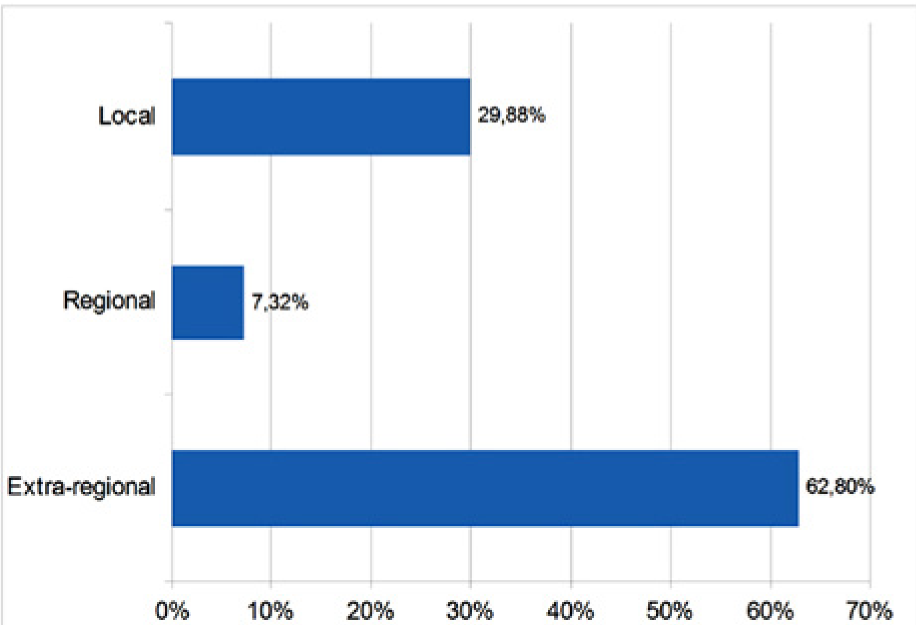
The case of the opaque, gray flint is particularly interesting. Although its specific provenance area has not been rigorously determined yet (still to be compared with Jurassic flint occurrences in the Montejunto and São Luís mountain ranges, the latter on the Setúbal peninsula), its relevance lies on the fact that it seems to have been used in the production of blades and geometric armatures only during the 4th millennium BCE, in roughly identical proportions to Cenomanian flint. Apparently, it was no longer used in the production of blades and arrowheads during the 3rd millennium BCE, when these artefacts are manufactured almost exclusively in Cenomanian flint. Therefore, its use could be regarded as a possible indicative of a specific chronological level.

The same can be pointed out for the metamorphic rock (possibly vulcanites) used in the production of adzes during the 4th millennium BCE, apparently no longer used (or used in insignificant amounts) in the production of votive adzes during the 3rd millennium BCE. Either way, in both cases, these readings should be carried out with some caution, with more detailed petrographic analyses and a greater overall acknowledgement of the archaeological sets being required. It should be noted that these observations are based (though not exclusively) on the specific case study of the area of Ribeira da Seda – but apparently also confirmed in the case of the megalithic clusters of Deserto and Barrocal das Freiras (Montemor-o-Novo), currently under study within the project *OMEGA – The Origins of Megalithism in Central Alentejo*, directed by the author in collaboration with V. S. Gonçalves (Gonçalves & Andrade, in press).

It should be also mentioned the curious apparent absence of flint from the Cenomanian contexts of the Lower Estremadura (area of Lisbon peninsula), only documented, although without absolute certainty, in one single element in the area of Ribeira da Seda (an arrowhead from the dolmen of Capela). Whereas this type of flint is extensively and almost exclusively used by the local Neolithic and Chalcolithic communities in the Lisbon area, it seems that it has not been transacted to Alentejo, which contrasts with the already attested introduction of amphibolites from Alentejo in Lisbon peninsula (as discussed below). Thus, considering the recognized extension of the inter-regional relations of these same communities, the absence of flint from Lisbon is not so easily explained.

The circulation of flint from the Portuguese Estremadura to the Alentejo, as roughout blocks or as finished products, is included in extensive exchange networks outlined since at least the Early Neolithic, intensifyed during the consolidation of stable peasant communities of the Late Neolithic and Chalcolithic. As evidence of the extent of these exchange networks, one can recall the presence of oolitic flint from the areas of Malaga and Granada where extensive mines/workshops can be found, which are also oriented towards the production of bifacial tools and blades, such as La Venta, Valle de los Gallumbares or Malaver (Ramos Millán *et al.* 1993; Aguayo & Moreno, 1998; Martínez Fernandéz *et al.* 2006; Lozano *et al.*, 2010; Morgado & Lozano, 2011; Morgado Rodríguez *et al.*, 2011). The presence of artefacts produced using this type of flint in Alentejo and in the adjacent area of the Spanish Extremadura (Nocete *et al.*, 2005; Cerrillo Cuenca, 2009; Morgado Rodríguez *et al.*, 2011; Boaventura *et al.*, 2014-2015; Mendonça & Carvalho, 2016; Valera & André, 2016-2017; Cardoso *et al.*, 2018) is proof enough of its large-scale geographical circulation (of over 450 km). However, as the arrowhead from Nossa Senhora da Conceição dos Olivais shows (Boaventura *et al.*, 2014-2015), not only the large bifacial tools and blades were exchanged – as usually defended (Nocete *et al.*, 2005).

Chart 2 – Percent *ratio* of flaked stone artefacts (geometric armatures, arrowheads, blades and bladelets) produced with local, regional and extra-regional (including oolitic flint) raw materials in the area of Ribeira da Seda. Althought without absolute certainty, chalcedony, opal (?) and opaline were considered in the set of regional available raw materials.



Although exogenous raw materials (mainly flint) can be statistically considered as a minority when comparing exclusively the type of raw material, their presence is solid when comparing the number of artefacts *per se*. In fact, arrowheads and geometric armatures are produced mainly in flint, corresponding the local raw materials (phyllite, lydite, quartz) to lower values in percentage terms (nearly 1/3). However, raw material does not seem to influence the typology of artefacts; so, the preferential use of one or other material can not be explained by cultural factors, but only by their availability. Anyway, this preferential use of flint for the production of bifacial points and geometric armatures indicates a constant procurement of this exogenous raw material.

As a counterpart, the area of Ribeira da Seda is one of the potential areas that would supply the Portuguese Estremadura in amphibolic rocks during the Neolithic and Chalcolithic (Cardoso & Carvalhosa, 1995; Lillios, 1997). In fact, this raw material is here abundantly available in both the exposed outcrops and in detached blocks present in the fluvial deposits of Ribeira da Seda and subsidiary watercourses. Furthermore, a possible quarry of amphibolic rocks was identified in the area of Torre de Palma (Monforte), spatially related to the Chalcolithic settlement of Pombal (R. Boaventura; personnal information). Similarly, one can also mention the «supply» of the schists required for the production of votive plaques, absent in the geological context of the Portuguese Estremadura.

Moreover, it must be said also, in the context of these reciprocal exchange relationships, that organized mining instances of local raw materials for «exportation» (such as those known for flint supplying in the Portuguese Estremadura, for instance) are not known in this area so far. Indeed, amphibolic rocks (as well as quartz, quartzite and lydite) can be found in secondary deposits spread throughout this area, detached from the original outcrop, presenting therefore an immediate accessibility.

The presence of exotic raw materials of hyper-regional origin, such as variscite, ivory and amber (as well as the oolitic flint discussed above), allows to integrate the area of Ribeira da Seda into long-distance trade diagrams, encompassing the development processes of social complexity since the late 4th millennium BCE onwards.

Regarding variscite, and according to the analyses conducted under the project *New Technologies Applied to the Study of Mobility and Exchanges*, two provenance areas are known for the green beads integrating the votive sets of the megalithic communities in Southwestern Iberia. The first one is located in Palazuelo de las Cuevas (Zamora, about 400 km from the central area of the hydrographic basin of Ribeira da Seda); a second one is located in Pico Centeno (Ensinasola, Huelva; about 150 km from a central area of the hydrographic basin of Ribeira da Seda). Both these instances are spatially associated with mines and workshops oriented towards the production of variscite beads (Odriozola & Villalobos-García, 2015; Odriozola *et al.*, 2016; Villalobos García & Odriozola, 2016a and 2016b).

The comparison between the data from Anta Grande do Zambujeiro and Perdigões suggests a sourcing in Palazuelo de las Cuevas during the 4th millennium BCE and a sourcing in Pico Centeno during the 3rd millennium BCE, revealing a hypothetical shift in the variscite supply strategies between the Neolithic and the Chalcolithic in Southwestern Iberia (Odriozola *et al.*, 2010 and 2012).

The integration and importance of this mineral in long-distance exchange networks is precisely evidenced by the introduction of Iberian variscite in Brittany, possibly as early as the mid-5th millennium BCE (Querré *et al.*, 2012). As a return, one could mention the presence of axes of Breton influence in Iberia (Fábregas Valcarce *et al.*, 2011; Pétrequin *et al.*, 2012). In the specific case of the area of Ribeira da Seda, it should be mention in this context the perforated flat axe, of Cangas type (a Tumiac type variant), produced in sillimanite, collected in Ervedal and clearly inspired on the Breton models (Andrade, 2014).

In relation to ivory, basically from African savannah elephant in the Southwestern edge of Iberia (as attested in the case of the bead from dolmen of Capela), it must be recognized that it comes from a «mobile» source. In this regard, it was considered the distance to the nearest potential acquisition area, namely the African side of Gibraltar Strait (about 500 km from the central area of the hydrographic basin of Ribeira da Seda).

Although the current northern natural boundary of the African savannah elephant distribution coincides with the sub-Saharan zone of the Sahel, reaching the Southern area of Mali and Senegal (more than 3000 km from the central area of the hydrographic basin of Ribeira da Seda), its occurrence in North Africa during the 3rd millennium BCE could be possible, based on some archaeographic data. Therefore, a sea route from the Atlantic coast of Morocco is suggested for its introduction in Iberia (Schuhmacher *et al.*, 2009, p. 994; Schuhmacher & Banerjee, 2012), being its introduction in Alentejo carried out from the Portuguese Estremadura (Schuhmacher & Banerjee, 2012; Valera *et al.*, 2015, p. 408-409). However, in this assumption, one must consider the direction of the Canarian current, which runs from North to South along the Northwestern African coast, making the sea-crossing to Iberia (*via* Atlantic) relatively difficult with rudimentary navegation methods.

Therefore, land routes (even if possibly following the African coastline) to the Gibraltar Strait can also be admitted, and from here directly introduced to the Southwestern Iberia (together with ostrich egg-shells).

It is accepted that ivory could be traded on its raw form into the Iberian context – as demonstrated by the identification of a workshop in Valencina de la Concepción (in this case, with a large percentage of Asian elephant ivory, after Nocete *et al.* 2013) or by the presence of unworked pieces included in the votive sets of Alcalar 4 or Perdigões (Schuhmacher *et al.*, 2009; Valera *et al.*, 2015), indicating a local management of this raw material.

Regarding amber, recent analyses carried out within the scope of the project *New Technologies Applied to the Study of Mobility and Exchanges* (Odriozola *et al.*, 2017), updating some previous readings (such as those expressed in Murillo-Barroso & Martinón-Torres, 2012, for instance), allowed to attest that the elements using this fossil resin present in Iberia between the Neolithic and Early/Middle Bronze Age basically correspond to Sicilian simetite (over 2000 km from the central area of the hydrographic basin of Ribeira da Seda).

Two routes can be admitted for the introduction of Sicilian amber in Iberia: a first one by the North shore of the Mediterranean, along the French coast towards the Northeastern Iberia, replicating the paths of the obsidian from the Tyrrhenian Sea during the Early Neolithic (Vaquer, 2007; Binder *et al.*, 2012; Lugliè, 2012; Gibaja Bao *et al.*, 2013; Freund & Batist, 2014; Terradas *et al.*, 2014) but with a wider geographical reach; another one by the Southern shore of the Mediterranean, *via* North Africa, meeting the ivory routes in the area of the Gibraltar Strait, entering Iberia by the Southwest.

The geographical dispersion of Sicilian amber in Iberia, from Catalonia to Algarve in a period between the Late Neolithic and the Early/Middle Bronze Age (Odriozola *et al.*, 2017), could precisely favor the first hypothesis. Also, if we admit a maritime route, the direction of the dominant currents in the Mediterranean, running towards West along the European coast and in the opposite direction along the African coast, allows us to support a diffusion path by the North side of that sea.

It is generally assumed that the large-scale dissemination of exotic materials such as ivory and amber would take place mainly with the affirmation of the Chalcolithic complex societies – especially the relations with North Africa, that currently seem to have occurred in moments prior to the second half of the 3rd millennium BCE (as suggested in Harrison & Gilman, 1977). However, the presence of such materials in the dolmen of Capela, in the inland of Alentejo, associated with a votive set that will not advanced further than the last quarter of the 4th millennium BCE or the first of the 3rd (corroborated by the result of the radiocarbon date) may suggest its distribution, even if occasionaly, in moments prior to the advent of the archaeometallurgic communities.

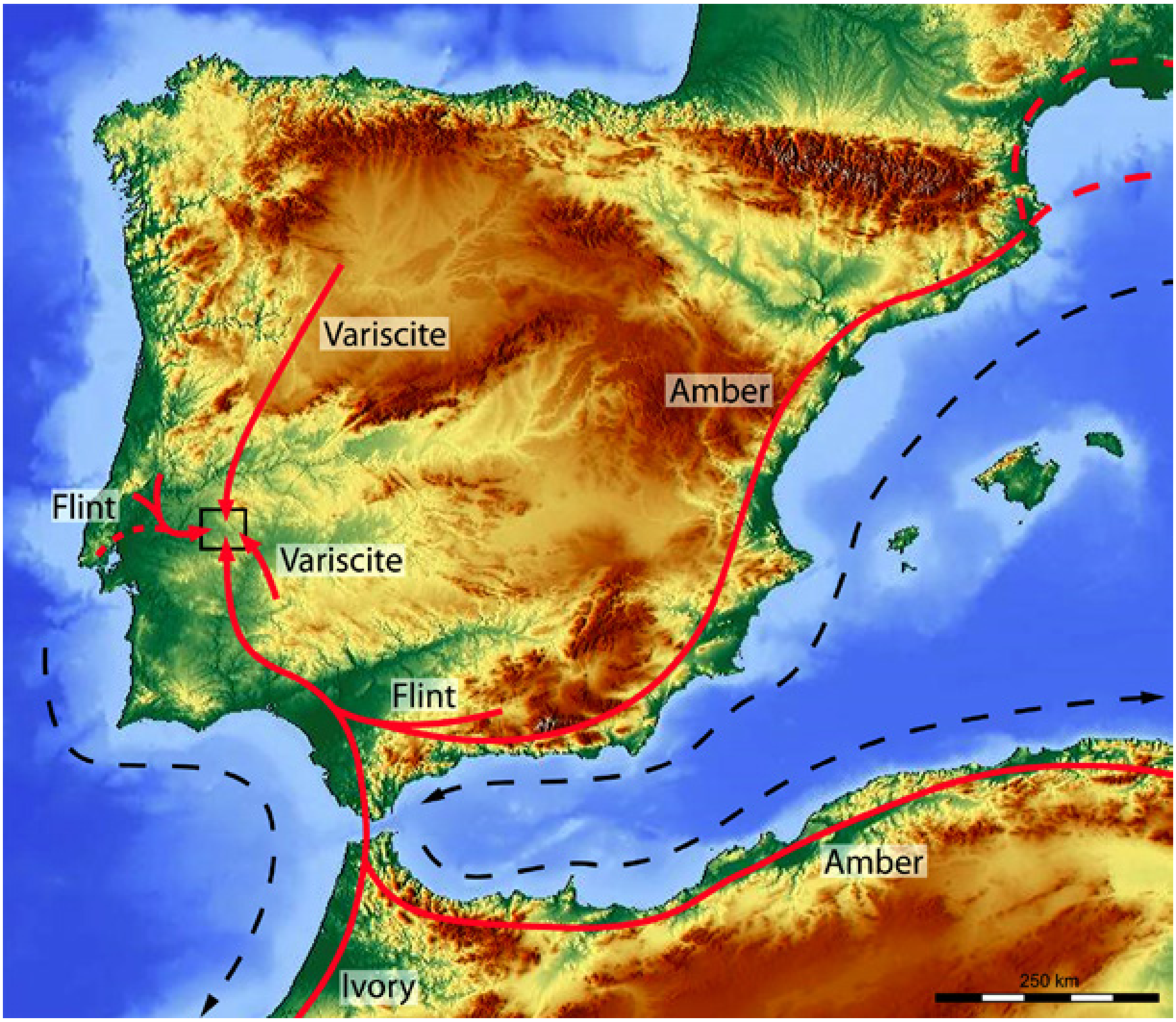


Figure 13 – Theoretical routes for the introduction of extra- and hyper-regional raw materials in the area of Ribeira da Seda. The black dashed lines indicate de main sea currents. Cartographic base: Google Maps, 2016.

Obviously, one can not suggest direct links between the megalithic communities of the area of Ribeira da Seda (and, in general, of Southwestern Iberia) and the communities from the provenance areas of the distinct raw materials – in some cases, more than 2000 km away.

These direct relations can only be suggested in the case of the Portuguese Estremadura – according to, in addition to the well-recognized exchanges of raw materials mentioned above (such as flint and amphibolite, and even copper), the techno-typological and morphological similarities of the artefacts collected in both areas (Thomas, 2010; Sousa & Gonçalves, 2012). This fact is particularly evident in the set of votive plaques from Lapa da Galinha, a burial cave located in the Estremadura Limestone Massif, with remarkable affinities (in terms of iconography and imagetics) with the votive plaques collected in megalithic tombs in North Alentejo (Gonçalves *et al.*, 2014).

These closed-scale inter-regional relations between Alentejo and Estremadura are equally substanciated by the recent strontium isotopes analyses performed on individuals from Middle Neolithic, Late Neolithic and Chalcolithic burial sites in the latter region – namely, Algar do Bom Santo, Cabeço da Arruda 1 and Cova da Moura (Hillier *et al.*, 2010; Waterman *et al.*, 2013; Lillios *et al.*, 2014; Carvalho, 2014;

Carvalho *et al.*, 2016). The results show that at least part of the community buried therein is originally from Alentejo, which indicates an evident and direct circulation of people between both regions during the 4th and 3rd millennia BCE.

Table 2 – Relation between relative distance and main travel time (in straight hours by foot) of extra and hyper-regional raw materials localities (over 100 km radius), excluding the ones that could be locally or regionally avalilable (such as chalcedony). Calculations *via* Google Earth (2017) in relation to a central area of the hydrographical basin of Ribeira da Seda.

Raw-materials	Locality	Distance	Travel time
Cenomanian flint (Cretaceous)	Campolide and Alcântara, Lisbon	≈160-170 km	≈31-38 h
Cenomanian flint (Cretaceous)	Azinheira and Amieira-Pisões, Rio Maior	≈135-140 km	≈28-29 h
Cenomanian flint (Cretaceous)	Pederneira and Caxarias, Ourém	≈135 km	≈28 h
Oxfordian flint (Jurassic)	Agroal and Sabacheira, Tomar	≈120 km	≈25 h
Oolitic flint (Jurassic)	Malaga and Granada	≈445-470 km	≈92-97 h
Variscite	Ensinasola, Huelva	≈150 km	≈31 h
Variscite	Palazuelo de las Cuevas, Zamora	≈400 km	≈83 h
Amber	Sicily, *via* Iberia	≈2250 km	≈307 h
Amber	Sicily, *via* North Africa	≈2650 km	≈473 h
Ivory (North African elephant)	North Africa	>500 km	>96 h

For the other regions, a scheme of indirect relations seems to be much more feasible, considering the sometimes excessively long distances between the areas of origin and the areas of destination. What is left to be defined is effectively the identity of the agents of these exchanges in the various poles of this vast territory, including the area of Ribeira da Seda on extensive exchange networks outlined throughout the Southwestern Iberia during the Late Neolithic and Chalcolithic, framed in the consolidation processes of stable ancient peasant communities.

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Construction materials of the monuments of Los Llanetes group, El Pozuelo cemetery (Huelva, Spain). Selection, exploitation and provenance of stone blocks.

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Abstract: This study deals with the selection, exploitation and provenance of the lithologies used in the construction of the megalithic monuments of the Los Llanetes group, El Pozuelo cemetery. For this, a geoarchaeological research has been developed focused on the systematic study of the geological environment, the outcrops and the construction materials of the architectures, determining the strategies and techniques for acquisition, transport and use of phyllite, slate, quartz and andesite. These lithologies were obtained from the diverse supply areas and quarries located in the surrounding environment, at a distance that oscillates between 0-350 linear meters with respect to the monuments.

Keywords: Geoarchaeology; Dolmens; Quarries; Supply areas; Phillyte

Materiais de construção dos monumentos do grupo Los Llanetes, Necrópole de El Pozuelo (Huelva, Espanha). Seleção, exploração e proveniência de blocos de pedra.

Resumo: Este artigo aborda a selecção, exploração e procedência das litologias empregues na construção dos monumentos megalíticos do grupo de Los Llanetes, do conjunto de El Pozuelo. Com este objectivo, desenvolveu-se uma investigação geoarqueológica centrada no estudo sistemático do meio geológico, nos aflormentos e nos materiais de construção das arquitecturas, tendo-se determinado as estratégias e as técnicas de captação, transporte e uso de filito, xisto, quartzo e andesito. stas litologias foram obtidas em diversas áreas de aprovisionamento e pedreiras localizadas no meio envolvente próximo, a uma distância que oscila entre 0-350 m lineares em relação aos monumentos.

Palavras-chave: Geoarqueologia; Dolmens; Pedreiras; Áreas de aprovisionamento; Filito

1. Megalithic architectures and geology of the province of Huelva

The province of Huelva is located in the southwest of the Iberian Peninsula (Fig. 1). It occupies a strip of the Atlantic façade that stands out in megalithism of Western Europe due to the quantity and diversity of architectures of different chronologies. Its territory is delimited to the north by the Sierra Morena, to the south by the Atlantic Ocean, to the east by the Guadalquivir River and tributaries, and to the west by the water courses of the Guadiana and Chanza rivers, tributary to the previous one.

It is one of the areas of greatest quantity and diversity of megalithic monuments in western Andalusia (Linares Catela, 2011a). Its formal and constructive variability is very contrasted, given the highlighted architectural polymorphism. Thus, very differentiated monuments are presented, distinguishing three groups: 1) individual standing stones (menhirs) or forming groups of standing stones (circles and alignments) representative of a pre-funerary or non-funerary megalithism originated in the V-IV millennia BC (Linares Catela, 2010a); 2) funerary architectures erected in stone, the dolmens of the IV-III millennia BC and the corbelled vaulted tombs (*tholoi*) of the III millennium BC (Cerdán *et al.*, 1952; Leisner & Leisner, 1956, 1959; Cabrero, 1985, 1986; Piñón Varela, 1986a, 1986b, 1987, 2004; Nocete *et al.*, 2004; Linares Catela, 2010b; Linares Catela & García Sanjuán, 2010); 3) subterranean architectures, the hypogea (rock-cut tombs) of the III millennium BC (Linares Catela & Vera Rodríguez, 2015). The extraordinary formal diversity and constructive techniques of the models of the dolmens are remarkable, distinguishing between simple chamber monuments (trapezoidal, rectangular or "cistoid"), covered galleries and monuments of multiple chambers in the same mounds, whose highest concentration occurs in the region of the eastern Andévalo (Linares Catela, 2011b, 2016).

The megalithic architectures are distributed and present in all the geological units of the province: Ossa-Morena Zone, Southportuguese Zone, Guadalquivir Basin and Litoral Strip, which correspond in a generic manner to the geographical regions: Sierra, Andévalo-Cuenca Minera, Condado-Tierra Llana and Costa. The observation of the territorial implantation and distribution of the architectural forms in the different geological environments allows us to propose certain binding elements between the models of monuments (their architecture and building technique), the geological formations (lithology and type of outcrop) and the source of the raw materials (Fig. 2).

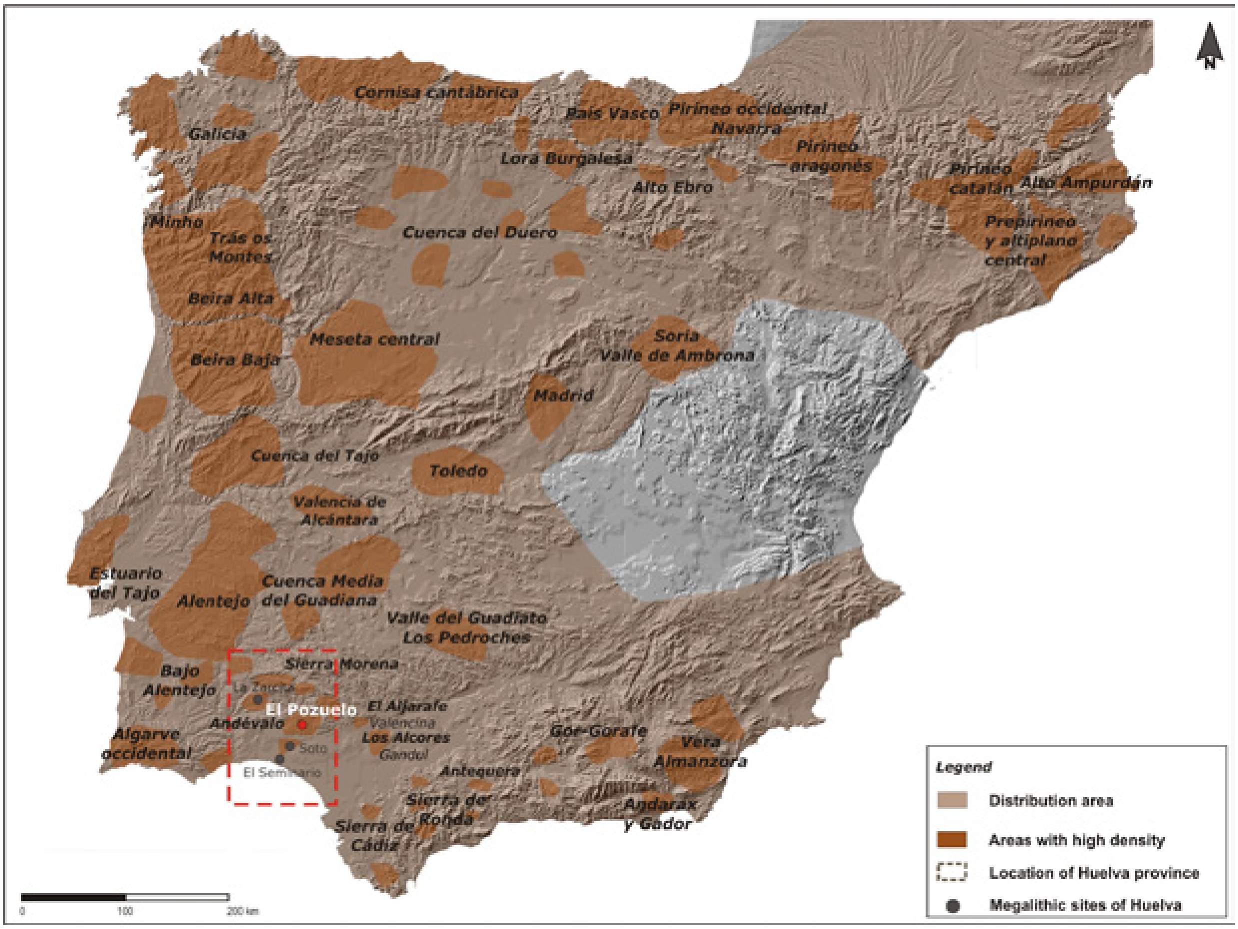

Figure 1 – Location of the Huelva area in the context of the Iberian Peninsula megalithism.

In a general way, it is observed that the raw materials used for the construction of the different megalithic monuments come mostly from the nearby local geological environment. Most of the standing stones are located in areas where appear granite, slate, greywaque or basic volcanic rocks in a massive form outcrops or in detached blocks of great size and material consistency. The architectures of dolmens are usually located in sites where there are massive rock outcrops likely to be extracted, provisioned and carved as regular supports for the formation of orthostats, highlighting especially the following lithologies: phyllite, greywaque, riodacite, granite and calcarenite, which occur in the Sierra, Andévalo and northern fringe of the Tierra Llana. The *tholoi* occur in various areas of the province, mainly concentrated where slate formations are predominant that fracture into thin and regular slabs that allow the construction of the walls by masonry or slabs of cladding and false domes. The hypogea, for the moment, have only been documented in the area of the Estuary of Huelva, in the necropolis of El Seminario, where the tertiary sandy loams allow the development of subterranean architectures as well as corbelled vaulted tombs excavated partially in the substratum.

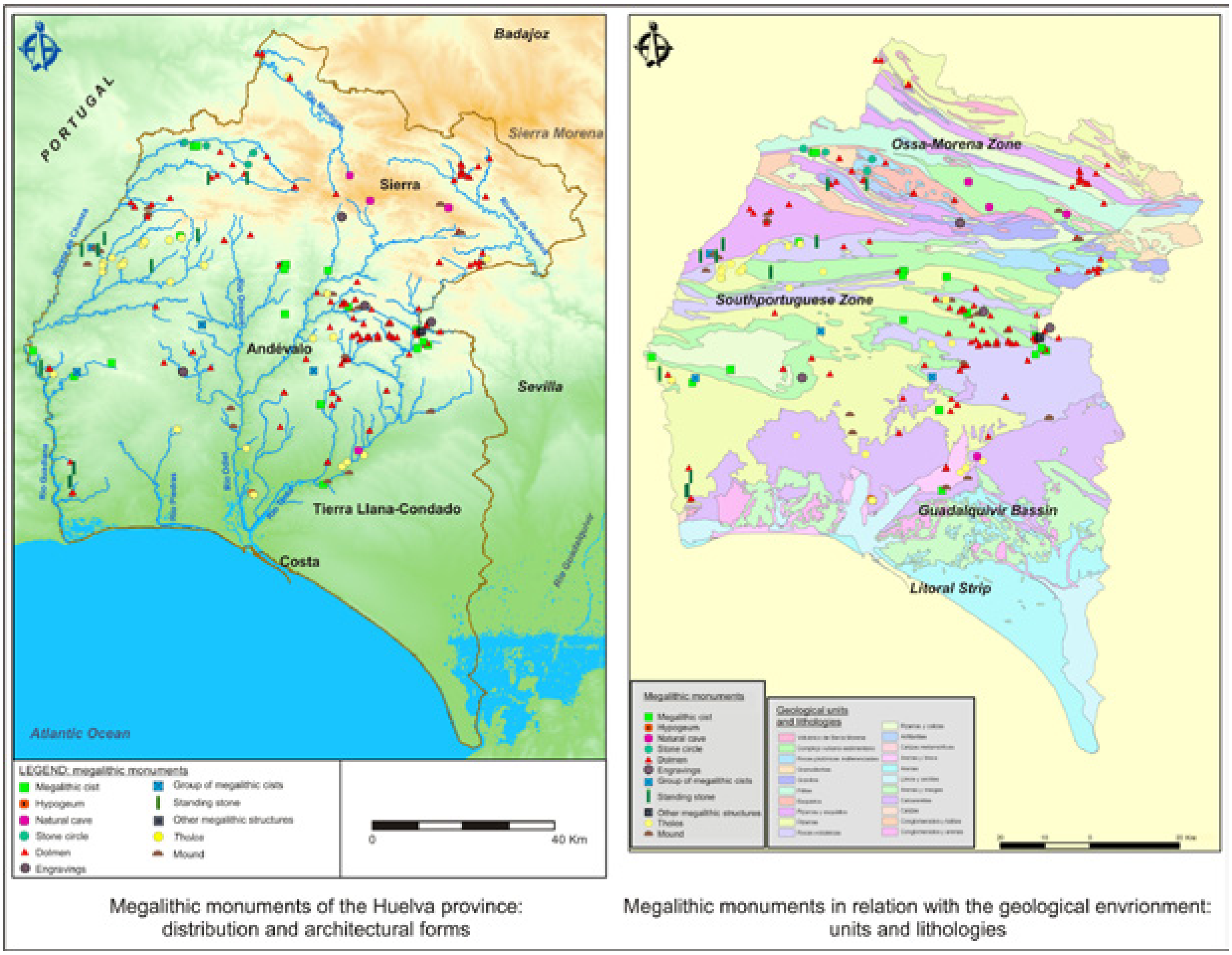

Figure 2 – Megalithic monuments of the Huelva area in relation to the geological environment.

2. Theoretical considerations and research methodology

2.1. Selection, exploitation and provenance of materials

The construction of megalithic monuments would require a set of works and technical operations, subject to the conceptual approach that would be carried out in each architectural project (Laporte, 2010, 2015, 2016). The construction were executed in an interrelated manner, with a spatial articulation and sequence of works that can be understood as an «*chaîne opératoire*» (Pelegrin *et al.*, 1988) or as a construction process subject to planning (Dehn, 2016), which would depend on the design, shape and size of the monument, as has been verified and analyzed in several megalithic monuments in western France (Laporte *et al.*, 2014; Cousseau, 2016). Each architectural project has its own construction process, which would be conditioned by the form or constructive model that was executed and by the technological knowledge of each group. However, in general, there may be a group of common works for the building of the megalithic architectures:

- Fitting-out of the field and the site;

- Selection and exploitation of raw materials;

- Transport;

- Transformation and technical treatments of materials;

- Construction: placement and arrangement of materials.

Through the integral knowledge of the constructive sequence it is possible to know the rules, methods and techniques that determine each construction work. Each architectural model must have its own construction process, carrying out the constructive actions in an stablished order by the previous approaches of the conception or architectural project, as we have shown in the case of the Los Llanetes group (Linares Catela, 2019, in press).

Specifically, the selection and exploitation of lithic raw materials, subject matter of analysis of this paper, would depend on a set of variables, highlighted in other studies:

- The availability and accessibility of the materials, predominantly prioritizing stones from the local environment by the appropriate shapes and sizes, located at a relatively short distance (Scarre, 2009). However, in the great ritual centers composed of monumental architectures raw materials were procured from outcrops of greater distances, exploited by properties, sizes, visual qualities or symbolic values, from several kilometers away, in case of stone circles of Stones of Stennes and Ring of Brodgar, whose sandstone quarries (Vestra Fiold, Staneyhill & Houton) were located at a distance of 3-6 km (Richards *et al.*, 2013), or the dolmen of Soto, with quarries and supply areas of greywaque, sandstone and calcarenite more than 5 km (Linares Catela & Mora Molina, 2015: 107; Linares Catela & Mora Molina, 2018: 125). In other monuments, some materials come from far sources, involving the transport of long distances, case of the monuments of the Brú na Boinne, built with lithologies of between 3-40 km (Cooney, 2000: 136), or Stonehenge, with materials coming from 30 km to 160-240 km (blue stones from the Preseli Hills area) used for the construction (Parker Pearson *et al.*, 2011, 2016);

- The qualities, visual properties and symbolic attributes of certain lithologies, in case of quartz, for its texture and color, causing a greater visual impact of the constructions in the landscapes in which they were built (Jones, 1999; Trevarthen, 2000; Cummings, 2002);

- The aesthetic of rocks, as has been found in the megalithic group of Belas in the Lisbon region. Thus, for the construction of the tombs of Pedra dos Mouros, Monte Abraão and Estria certain types of rocks were selected from the local geological environment by the morphology of the surfaces, being arranged with an intentional aesthetic pattern in the funerary chambers, highlighting the recurrent use of limestones with ichnfossils in the slabs and the backstones (Cardoso & Boaventura, 2011);

- The visual connection between the raw materials and the megaliths, especially with the rocky outcrops more prominent in the landscapes, some of them with rock engravings, configuring monumental symbolic landscapes (Bradley, 1998, 2000; Tilley, 1996);

- The strong identity and connection between the stone blocks used in funerary chambers and geographical areas of origin (Giot, 1987; Richards, 1996; Scarre, 2004; Le Goffic, 2009);

- The reuse of old standing stones and steles-menhirs in funerary architectures due to their high symbolic value, as documented in numerous monuments of the French Brittany (L'Helgouach, 1983, 1996; Le Roux, 1985), the British Isles (Richards, 1996; O'Sullivan, 2009; Robin 2010) and the Iberian Peninsula (Bueno *et al.*, 2007, 2015, 2016), which can be interpreted as the stones of the ancestors (Bueno *et al.*, 2014);

- The work technique and constructive tradition of the groups around specific lithologies, in the case of the phyllites in El Pozuelo cemetery (Linares Catela, 2016).

This set of elements would imply that each group developed some forms of selection and exploitation of specific raw materials. In a generic way, two basic strategies can be distinguished:

1) The supply of blocks and stones on the surface, detached from the rocky outcrops, until they cause the clearing or disappearance of the same (Scarre, 2009: 11-14), as is common in many models of monuments;

2) The opening of quarries, in which different exploitation methods were articulated with massive movements of stones: extraction faces, trenches and large ditches. Quarries can be located in three different sites: a) open quarries in the same construction site; b) quarries placed in the immediate vicinity; c) quarries from distant areas, generally corresponding to monuments of great construction scale and landscape presence.

Traditionally it has been conceived that most constructions used "rough stones" or "megalithic blocks", generally not being worked or transformed after their acquisition or extraction, standing out the rude, spontaneous and primitive character of the architecture. However, the use of the raw materials can indicate two crucial aspects: a) the existence of selection strategies for materials with a technical expertise in the systems of supply of the large stones of the outcrops and extraction in quarries, namely a mental approach to the «*chaîne opératoire*» ("operational chain") to be developed for its use, a conception of the type of block to be obtained / extracted and the function as a constructive element, as has been demonstrated in the standing stones that form the alignments of Carnac (Mens, 2008, 2013); b) a symbolic and cultural meaning of the raw blocks, thus linking the megalithic architecture with the landscape, with complex codes and meanings (Tilley, 1994, 1996; Scarre, 2004, 2009).

2.2. Methodology of study and analysis

The study was conducted using a geoarchaeological methodology aimed at determining the selection criteria, forms of exploitation and provenance of the materials used in the construction of the Los Llanetes group. The methodology is based on a series of geoarchaeological studies:

- Geotechnical characterization of the type of substratum of the site and of the stone supports;

- Lithological identification and characterization of the units and materials of the local geological environment of the surroundings of the monuments, making a detailed geological cartography;

- Lithological characterization of vertical stone supports and other construction materials, through three combined analyzes: a) petrography (macroscopic and mineralogical study of thin sheet by optical microscope); b) structural geology (study of foliations, discontinuities or cleavages); c) morphology of the materials;

- Determination of the sources areas of provenance (supply zones and quarries of the surroundings of the monuments) through a set of works: geoarchaeological prospecting, geological cartography, comparative petrographic study between the supports and the outcrops, structural geology comparative study between the stone supports and the source areas;

- Planning of transport routes from the source areas to the construction sites through the study of the orography of the place: topography and geomorphology.

3. El Pozuelo cemetery. Location, geological environment and composition.

The megalithic cluster of El Pozuelo (Zalamea la Real) is located in the peneplain area of the southern ridge of Sierra Morena, characterized by a geomorphology in which small mountain ranges alternate with mounds and abrupt topography elevations with softer areas composed by hills, plateaus and valleys. This area is moderately dissected by the river basin of the Tinto River, with abundant tributaries of differentiated range: streams, creeks and ravines. It is framed in the southeastern end of the Iberian Pyrite Belt, the northernmost structural and paleogeographic domain of the Southportuguese Zone (ZSP), according to the classic zonation of the Iberian Massif (Mantero *et al.*, 2007). The Iberian Pyrite Belt is formed by three large units or lithostratigraphic formations: Slate and Quartzite Group (PQ Group), Volcanic-Sedimentary Complex (CVS) and Culm Group (Donaire *et al.*, 2009). El Pozuelo cemetery is territorially developed in a contact zone between the units of the PQ Group, with predominance of slates, ochre slate and white quartz outcrops, and the CVS, where appear dark slates, green phyllite and intermediate volcanic rocks (andesite, hialoclastite and andesite epiclastite) (Fig. 3).

The megalithic cluster consists of thirteen monuments organized spatially in three compact groups separated equidistantly: Los Llanetes, El Riscal-La Veguilla and Los Lomeritos, distributed in different geomorphological units (mounds, hills and hillocks) of the valleys of two tributary streams from the right bank of the upper basin of Tinto River (Agua Fría ravine and Los Pinos stream), occupying a total length of 5 km. The cluster stands out for the architectural diversity, compositional variety, structural plurality and spatial complexity, confirming various forms of funerary monuments: single chambers (dolmens 8, 9, 10 and 11), elongated chambers / covered galleries (dolmen 4), ben chamber/passage (dolmen 9), dual chambers (dolmens 1, 2 and 3), multiple chambers (dolmens 5, 6, 7 and 13). Due to its territorial presence and architectural features, it is the most outstanding megalithic complex in the eastern Andévalo region and one of the most unique in the south of the Iberian Peninsula (Linares Catela, 2017).

In the previous investigations of the El Pozuelo cemetery it had been proposed that the lithologies selected, exploited and manufactured as orthostats and capstones corresponded to two lithologies of the local geological environment: porphyry slate (Cerdán, 1951: 163; Cerdán *et al.*, 1952: 14; Leisner & Leisner, 1956: 65, Gómez Ruiz, 1978: 22; Cabrero, 1985: 210) or slate (Piñón Varela, 1986c, 1987; Piñón Varela, 2004: 790; Cano & Vera de Orueta, 1988: 23; Nocete *et al.*, 1999: 26; Nocete *et al.*, 2004: 52-53). However, after the geoarchaeological study of the Llanetes group and the recognition of all the monuments of the El Pozuelo cluster it can be argued that the predominant and most used material for orthostatic constructions is phyllite, although the slate is the rock that appears in a majority in the environment. Other lithologies used in the construction of the monuments were various types of slate, basic volcanic (pillow and sills) and intermediate (andesite) rocks, quartzite and white quartz.

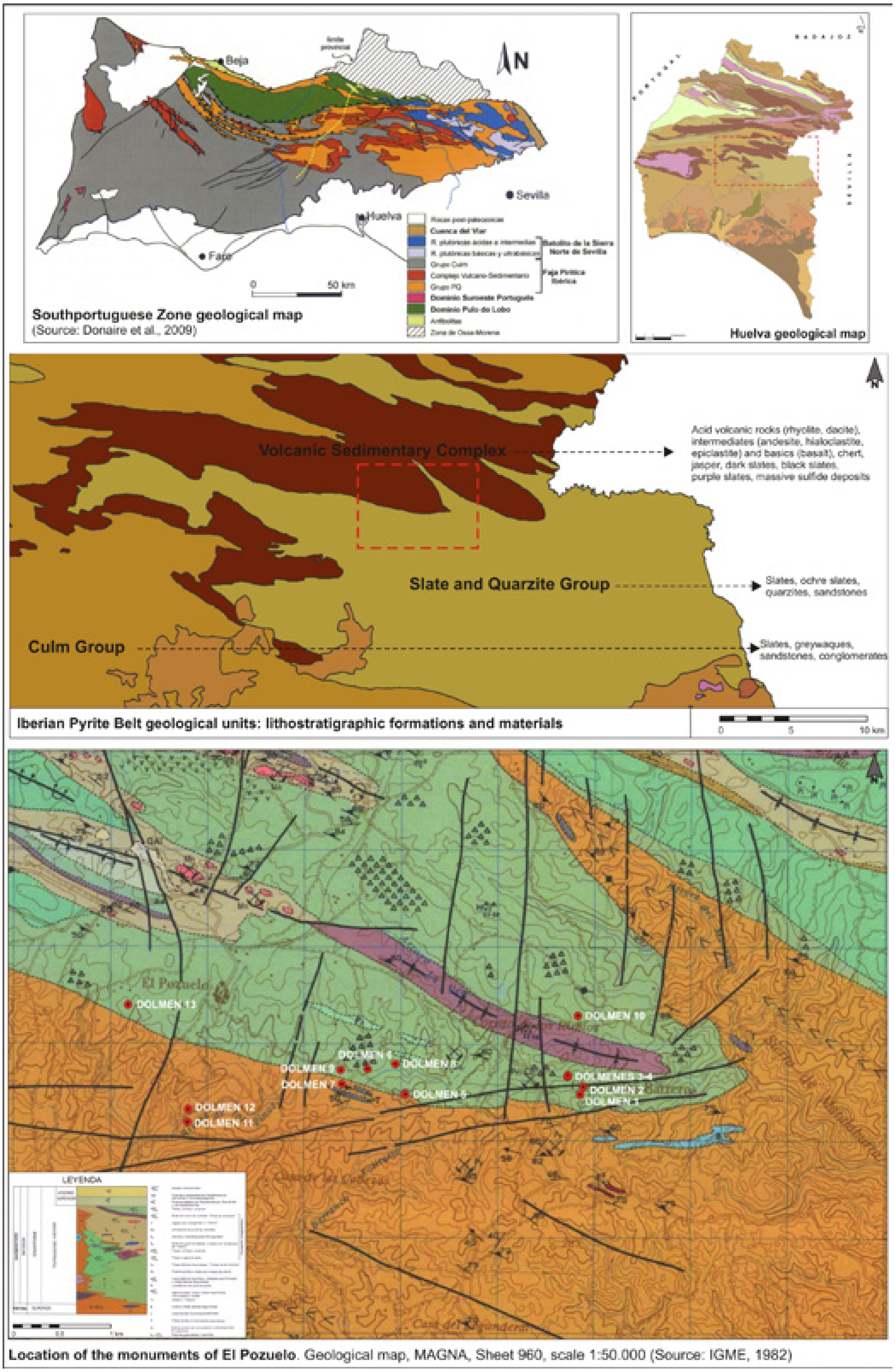

Figure 3 – Situation of the of El Pozuelo cemetery in the geological context of the Southportuguese Zone and local environment.

4. Los Llanetes group

4.1. Site, architectures and construction materials

The Llanetes group is located at the head of the Agua Fría ravine, tributary of the Manzano stream, very close to the Chinflón copper mines. It is formed by four monuments distributed in binary form, distant between 100-150 linear meters one group with respect to the other. The monuments 1-2 are located in the highest areas of two hills of the unit of relief more projected towards the east, being a geomorphological unit of higher altitude and visual prevalence, than the subgroup of the monuments 3-4, located in a promontory of the southeast slope of the Chinflón summit, on a location of smooth topography to the west of the previous subgroup. The topography of the site is abrupt, irregular and variable, given the intense deformation and folding of the materials during the Hercynian Orogeny, in which there are hills and elevations that form mountainous foothills with a northwest-southeast direction, in case of the Chinflón summit to the north, Cabezo de la Cebada to the northeast and Cabezo de la Canaria to the southeast, being units with steep slopes (greater than 30% of gradient), which alternate with other smaller and less pronounced elevations, plateau morphologies and softer topographies, where the monuments are located.

Each monument has a particular morphology, product of its constructive history throughout the IV-III millennia BC, highlighting the carrying out of the architectural projects of the dolmens with dual chambers (monuments 1, 2 and 3) and the elongated chamber dolmen-covered gallery (monument 4). For the construction of the monuments, four basic lithologies were used: green phyllite, slate (greenish-gray, brown, dark and red), white quartz and andesite, as well as the clays and earths from the sites (Linares Catela, 2016; 2017).

The phyllite was the main raw material used in the construction of the monuments, in spite of being the farthest rock with respect to the sites of the monuments. It is the only lithology available in the local geological environment present in large blocks and around it is feasible to develop a controlled technical workstone. Its exploitation required the articulation of collective work strategies and a collective and cooperative labour for the supply, transport and transformation in relation to the construction processes. It was used in most architectural elements, highlighting its transformation, manufacture and use as orthostats, stelae, pillars, shoring slabs, capstones, kerb slabs, blocks and slabs of the mounds, pavings and structures masonry external. Around this lithology a sophisticated technology was developed for the manufacture of the vertical supports (orthostats, pillars, stelae, jambs) and horizontal (capstones), taking advantage of the optimal morphological properties, fracturing qualities and geomechanical conditions (resistance and hardness). It is the only suitable lithology in the environment that is presented in medium and big stone blocks, being possible to transform them into supports of rectangular, trapezoidal, oval and pseudo-cylindrical shapes. The study of the technological traces of the vertical supports makes it possible to highlight the existence of a regular technical labour and an operational chain («*chaîne opératoire*») of various basic treatments: a) lateral roughing by direct percussion to regularize the edges and profiles; b) fine carving by direct percussion of the upper extremity in the case of the orthostats and pillars for uniform support of capstones; c) homogeneous treatment of the surfaces by continuous hammering by direct percussion, continuous and fine pecking by indirect percussion, discontinuous continuous picketing with hammer and chisel.

The slates of the PQ Group and CVS were used in multiple constructive elements: mounds, pavings, external structures, etc. Generally, the slabs were used rough, after their surface supply or quarry extraction, taking advantage of the natural morphology of elongated and rectangular slabs detached and extracted from the outcrops by their fracturing according to the foliation planes. The slate, in addition, constitutes the base substratum for the construction of the monuments, which was continuously modified according to the execution of the various architectural projects given the discontinuities (foliations and clefts), conditions of penetration, high fracturing and low mechanical resistance, which enabled the development of excavation works, rock cutting, regularization, grading, etc. The monuments 1-2 were erected on the substratum of slates of the PQ Group. Monuments 3-4 were built on a base promontory of dark slate of the CVS.

The red slate was used as ornamentation elements of the leveling platform and external pavement together with the white quartz in monument 3, for its peculiar qualities of reddish color, brightness and oxidized texture, being an aesthetic and / or symbolic material, emerge next to copper mineralizations of green color (malachite).

The andesite, due to its material properties and formal characteristics, is a lithology that was used as a filling for tumular masses, packing stones, external pavings, formation of structures with masonry, as well as the elaboration of work instruments (hammers and picks), for its great hardness and resistance, like the dolerite.

The cobbles and pebbles of white quartz were used as construction material for the sizes, morphologies, qualities of hardness and appearance (brightness and texture), being recurrently used as packing stones and filling of the foundation ditches, given their good material conditions, and as visible external elements and of ornamentation, being frequent in the pavings, elements of spatial demarcation of the entrances of the façades (monument 4) and mounds. In this regard, the use of three transformed quartz blocks that appear linearly on the northeast side of monument 1 as architectural devices stands out, being very notable for their size, morphology, visibility, colour and brightness.

4.2. Geological environment

The Llanetes Group is located in the contact zone between the units of the Slate and Quartzite Group (PQ Group), and the Volcanic-Sedimentary Complex (CVS). The diversity of lithologies with their particular petrographic characteristics of this area had not been identified, studied and mapped in detail in conventional geological studies, with maps of scale 1/50000 (sheet 960 of the IGME, published in 1982) or 1/25000 (IGTE map, edited in 1999).

Therefore, its adequate research has demanded a systematic lithological study and the accomplishment of an exhaustive geologic cartography of the surroundings of the Los Llanetes, elaborated to scale 1/2000, mapping an area of 12 km^2 (Fig. 4). This, together with the geoarchaeological study and the archaeological excavations, has allowed to characterize of the materials used in the architectures, identify the supply areas and quarries, locate the source of each lithology, determine the potential transport routes and establish the selection criteria in relation to the material properties, transformation and manufacturing techniques.

The materials of the PQ Group, of Upper Devonian Age, make up the basal unit of the geological sequence. In the environment of the group of Llanetes three lithologies are presented: slate, metasandstone (sandstone and/or greywaque) of the Mata Amarilla site and white quartz.

The slates form stratigraphic units of great continuity, forming very extensive and visible outcrops of great depth, occurring in kilometric extensions without interruptions of other outcrops. These slates are of variable colours, ranging from grayish green to light brown (light olive gray 5Y 5/2, grayish green 10GY 5/2, dark yellowish orange 10YR 6/6). They surface in a stratigraphic sequence of alternating layers, with succession of green slates, with a greater representation in the area, and ochre slates, circumscribed to the area of Charco del Lobo. The slate is the majority lithology of the PQ unit, as in the

CVS, appearing massively in rocky crests or detached blocks.

The white quartz appears in superficial phyllonian outcrops in the areas of the faults, the result of contact metamorphism in old levels of sandstones, with WNW-ESE orientation. In the slate outcrops, structures of the mesoscopic S-C type are presented, composed of veins of white quartz of order centi-decimeter (20 to 50 cm), with a vertical schistosity, with criteria of inverse failure and southern vergence. Quartz is a massive rock, , of translucent white colour, formed almost exclusively by medium and coarse-grained of silicon dioxide.

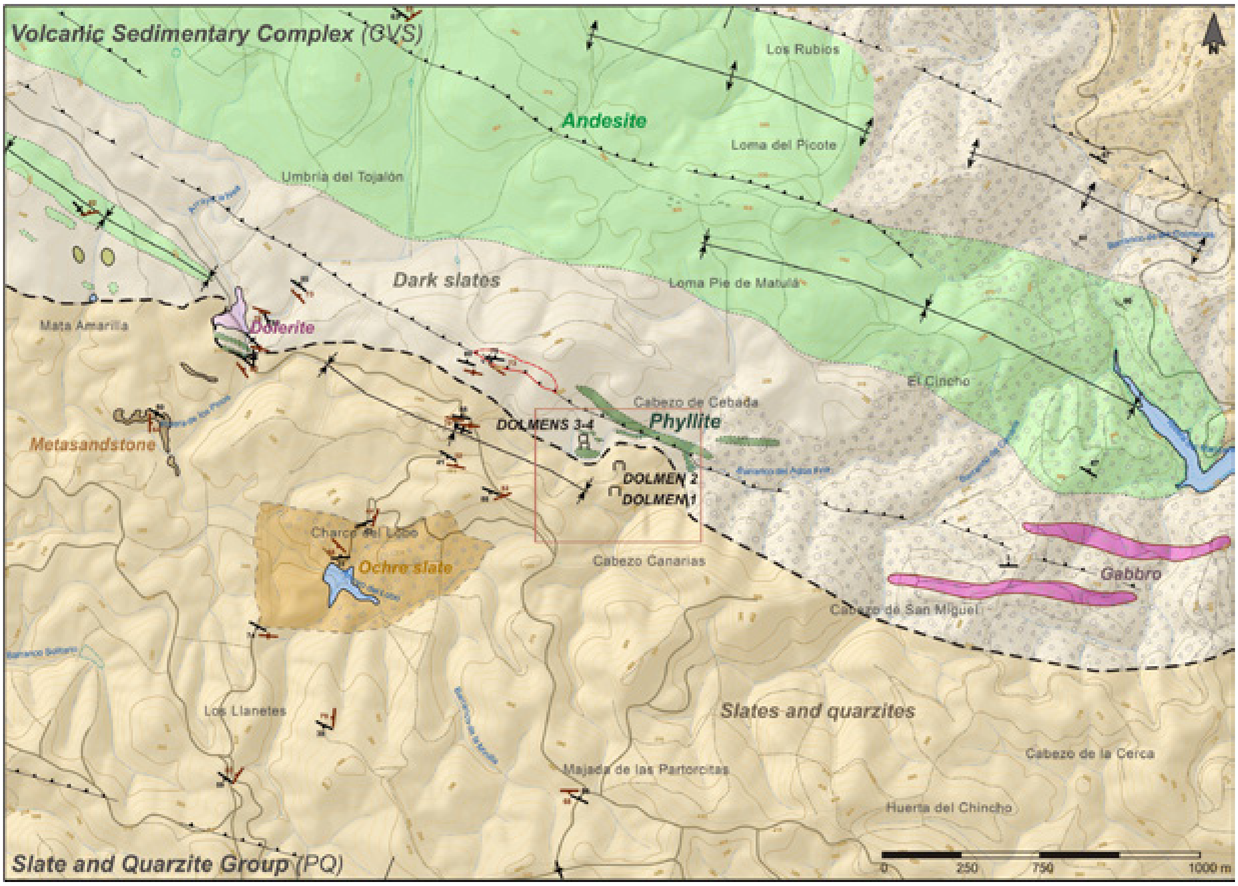

Figure 4 – Geological map of the Los Llanetes area. Monuments and lithologies.

The materials of the CVS, overlying the PQ Group, are of Late Famenian Age - Late Visense. In the El Pozuelo Synclinory intermediate volcanic rocks (andesite, andesitic hialoclastite and epiclastite) are present, together with slates, phyllite and intrusive igneous rocks (dolerite and gabbro). In this geological unit stand out the massive outcrops of andesite, a volcanic rock beige-brown to greenish (grayish orange 10YR 7/4, ligtht olive brown 5Y 5/6, pale blue green 5 BG 7/2) of macrocrystalline texture, formed by elongated phenocrysts of plagioclase and amphiboles of dark tonalities. This lithology develops as a large massive strip to the north of the Los Llanetes group, distant to 550 linear meters. In the same way, this rock is located, in a secondary position, in the ravines where this formation takes place, evidencing the presence of medium blocks and cobbles of globular morphologies, highlighting the intersection of streambed of the Agua Fría and the La Canaria, 350 m east-northeast with respect to the monuments, with abundant material dragged from the Loma Pie del Matulá.

The CVS slates appear in formations with a lateral or kilometric continuity. Two types of slates are presented: dark slates and red slates. The dark slates appear in the form of crests of varying sizes, with northwest-southeast orientation, the most outstanding being those present on the slopes of the Chinflón summit. These dark slates are presented in different tonalities of brown, green and gray (moderate yellowish brown 10YR 574, light olive gray 5Y 5/2, grayish green 10GY 5/2), having a fundamentally microcrystalline texture, not being able to observe the mineralization macroscopically.

The red slate is analogous to the previous ones, but subjected to a moderate and intense contact metamorphism, which originated an enrichment of copper carbonates and iron oxides, providing the rock with its outstanding red colouring (dark reddish brown 10R 3/4). This slate appear in a philonian outcrop in a northwest-southeast direction, forming a strip 300 m long and 50 m wide, which develops in the extreme west and the southeast slope of the Chinflón summit, 800 m distant from the site of the megalithic architectures.

In the geological environment has been identified and mapped several outcrops of phyllites, which develop in the flanks of a fold of thrust with a direction N110-130E and a high dip, generally to the north, adopting the shape of *boudins*. They concentrate on two fundamental areas. The first zone is a point outcrop located at the head of the Los Pinos stream, being composed of two parallel strips of northwest-southeast orientation of 100 m in length and 20 m in width, being visible in the bed of the fluvial course. This outcrop is 1,1 km west of the Llanetes group. The second zone corresponds to an irregular strip of 500 m and 50 m of maximum width, with a northeast-southeast direction, which runs parallel to the thrust fold, extending from the southern slope of the Chinflón summit to the intersection of the beds of the ravines of Agua Fría and La Canaria. In this strip, diverse types of outcrops with differentiated morphologies occur intermittently on the surface.

The phyllite is a low grade metamorphic rock of metapelite origin, developed from clay sedimentary rocks (pelites). They are rocks of light colours, predominating grayish-green tones (greenish gray 5GY 6/1), microcrystalline matrix and fine grain texture, composed of mineralizations of the quartz-feldespathic type. This rock has been deformed mainly by the hercynian fold, acquiring a generalized slaty that is disrupted by the original stratification of the rock. It presents a polyphase deformation of up to four families of discontinuities or foliations according to the tectonic evolution of the zone.

4.3. Provenance of materials: supply areas and quarries

The identification of the supply areas and quarries of the various materials has been possible through the excavation of the external areas of the monuments and the carrying out of a systematic geoarchaeological exploration of the environment, focused on the recognition of the mapped rock outcrops, the study of the lithologies and the analysis of the remains derived from the acquisition and extraction of the exploited materials (Fig. 5).

The supply areas are the sites where natural blocks are found on the surface, detached from the rocky outcrops, which have been selected and obtained by their morphological and structural qualities for their use, without specifying the use of extraction techniques. In these areas, blocks, slabs and boulders of varying sizes are dominant. On the contrary, the quarries have generated a notorious modification of the outcrops by the development of diverse extractive techniques: in block, in quarry faces or in trench. The quarries are recognized by the existence of one or more extraction fronts, as well as by the presence of fractured blocks and stone tools associated with the extraction processes: mallets, hammers, picks or chisels.

Each lithology (phyllite, slate, andesite and white quartz) presents some peculiarities in terms of selection strategies, exploitation, transport and technical treatments.

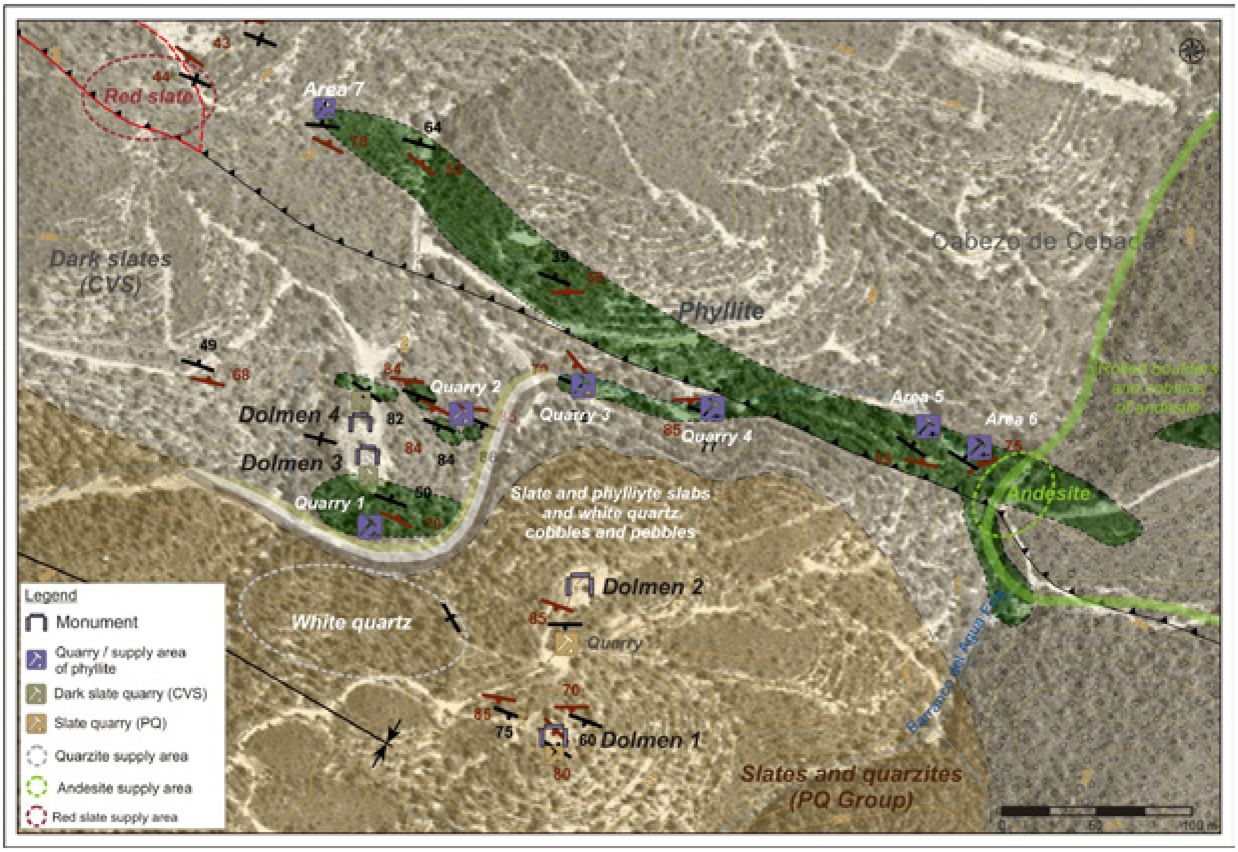

Figure 5 – Quarries and supply areas for the construction materials of the Los Llanetes group.

<u>Slates</u>

The slates of the PQ Group make up the lithological base of the hill where the monuments 1 and 2 are located. In the space between the two dolmens there is a quarry developed around massive crest slate of step morphology, with direction 90-110º S, up to 1-1,20 m high (Fig. 6). This outcrop has very wide diaclases that form the outline of the slate blocks in the outcrop, favoring the detachment and the extraction of medium and small blocks and slabs. This quarry was subjected to intense extractive activity, as denoted by the exploitation area of 18,50 m in length by 16,50 m in width (250 m^2), in relation to the construction of monuments 1 and 2. Slabs and blocks were transported manually from the quarry, given the proximity and average weight of the supports (less than 50 kg), up to the areas of the construction works, being used in multiple constructive elements. The dolmen 1 is located 38 linear meters to the south, having to have moved on the northern slope of the site, where there is an average upward gradient of 25%. The dolmen 2, 20 m northeast of the quarry, has a flat topography, with an average upward gradient of 5%, being its most comfortable displacement, being the main slate supply source.

At the site of dolmen 1, 4 m south, there was another slate quarry, which had to be exploited in several phases of the monument. This quarry has an extraction front with southwest-northeast direction (73º NE), reaching 8 m in length, 4 m in width and 0,50 m in height.

The dark slates of the CVS constitute the base of the rocky substratum where the megalithic monuments 3-4 were built. The dark and light brown slates were one of the main raw materials used, exploited by two ways: a) opening of quarries in the same place of the site, one on each side of the dolmens (Fig. 7); b) supply of blocks detached on the surface and in a secondary position in the bed of the Agua

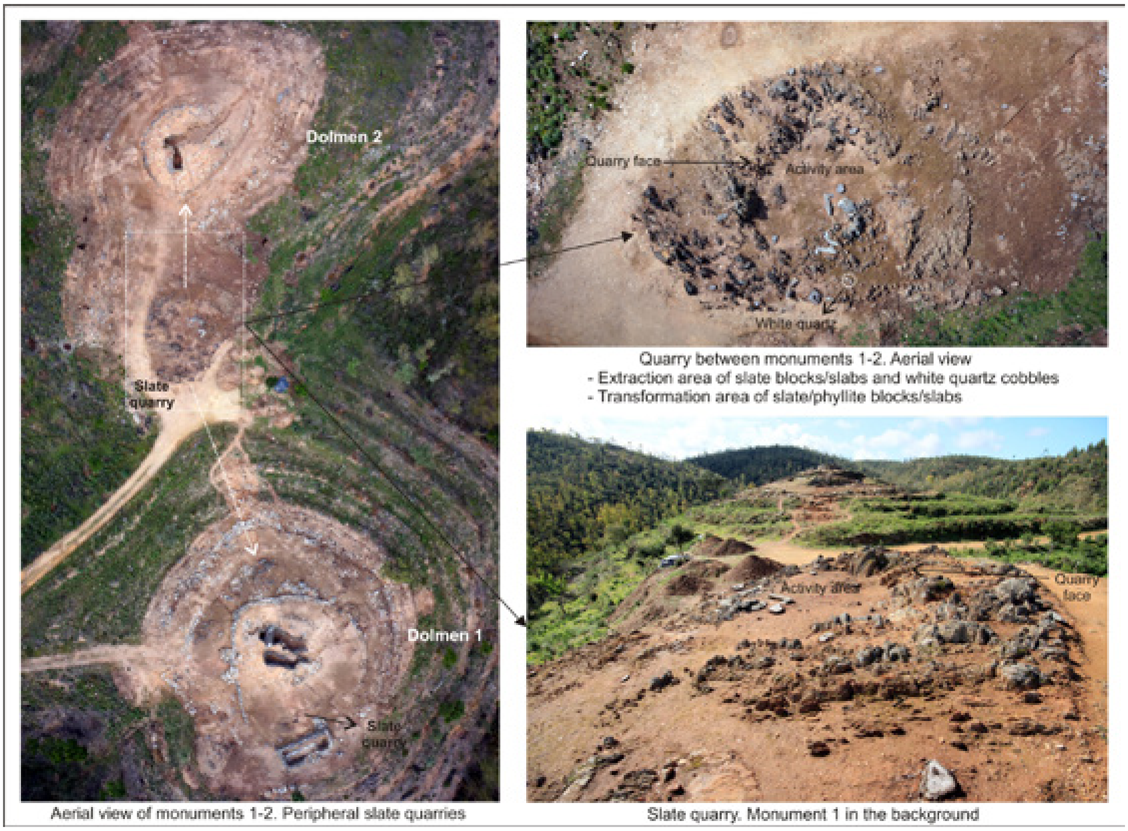

Figure 6 – Slate quarries peripheral to monuments 1-2.

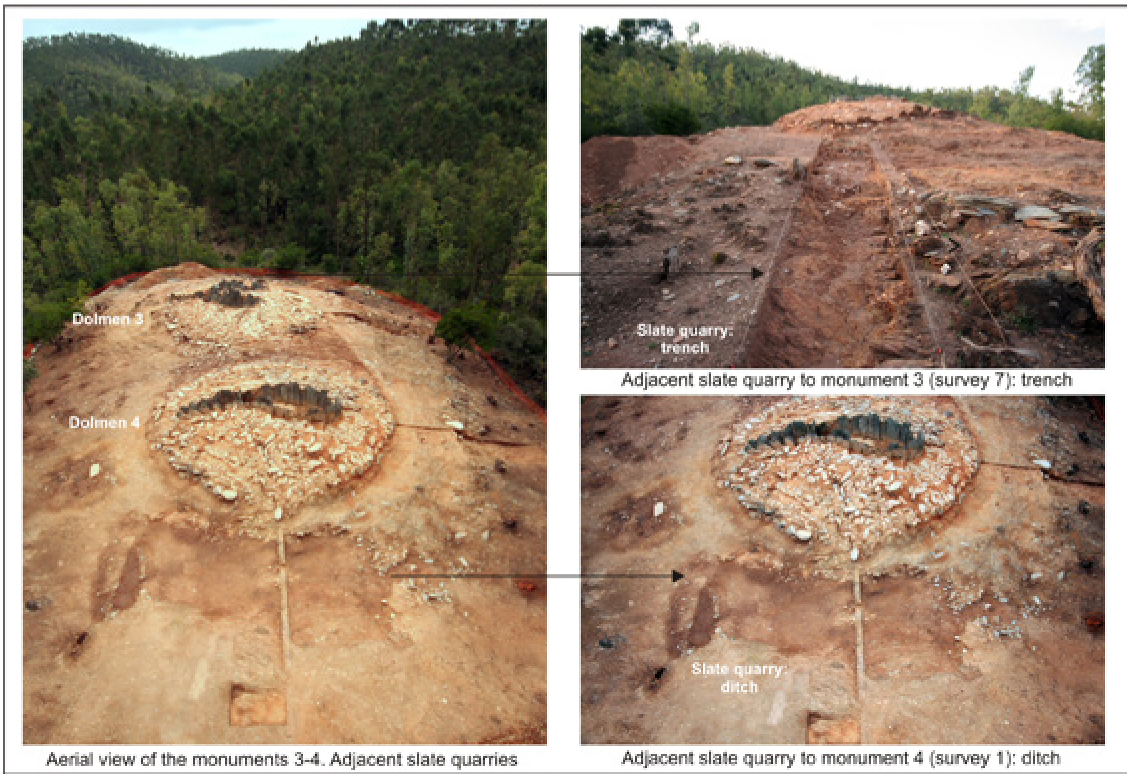

Figure 7 – Slate quarries adjacent to monuments 3-4.

Fría ravine. Thus, next to monument 4, immediately to the north, a quarry with east-west orientation was opened, with surface dimensions of 17 m in length, variable width of 12-14 m and an estimated maximum depth of 0,70 m, being able to a volume of material of 75 m^3 has been extracted. Similarly, a section of the slate quarry has been found south of monument 3. It is a trench of 5 m in length, 3,50 in maximum width in the central section and 2 m in the extraction front of the intermediate zone, with a variable depth ranging from 0,50 to 1,20 m on the front, defining an extraction volume of at least 11 m^3 in the documented space. From these quarries, blocks and slate slabs of medium and small sizes had to be extracted, mostly used raw in the constructive elements of the tumulus (leveling/support platform and mounds) and external elements attached (paving, structures and altars).

The red slates come from the philonian outcrop of the Chinflón summit, developed at 800 m from the site of the megalithic monuments and in a secondary position at the source of the Agua Fría ravine, next to the megaliths.

<u>Phyllites</u>

In the mapped outcrops of phyllites have been identified four quarries and three supply areas, concentrated in two areas: strip northeast of the group and hill where the dolmens 3-4, in a radius of distance of between 50-350 m respect to the monuments. From these exploitation areas were obtained stone blocks of diverse morphologies (*boudins*, lenticular and in barrel form) and sizes that were later transformed and manufactured in the activity areas located in the same sites, previously to their placement as constructive elements (Fig. 8).

Quarries 1 and 2 are located on the promontory where the dolmens 3-4 were built. Quarry 1 is located on the south side. It is developed around a continuous outcrop of medium size, 80 m long and 30 m wide, with the presence of prominent *boudins* ridges. It is developed in a metamorphism zone of contact between the materials of the CVS and PQ Group, alternating layers of phyllites with slates of decimetric sizes, with a subverticalized disposition of between 65-85º of the blocks. The quarry 2 is located on the eastern slope, exploiting small discontinuous superficial outcrops and linear ridges 10-20 m long, 3 m wide and around 1 m high, with a marked vertical arrangement (c. 90°). In these outcrops, were developed quarrying activities: extraction of lenticular blocks. Quarries 3 and 4, located in the bed of the Agua Fría ravine, developed around massive outcrops of greater dimensions. In this area, the phyllites appear in step form, with rectangular profiles and vertical sections (c. 80-90º) and slightly rounded edges. These outcrops, with northwest-southeast orientation, with vergence to the south and with marked foliation lines, stand out vertically from the ground between 1-3,5 m. These geological conditions propitiated the development of an intense extractive activity of great elongated and slender lenticular blocks, according to the volume of stone exploded, the remains and the residues on the surface. From the quarry 3 elongated lenticular blocks and thin sections were regularly extracted, according to regular foliation lines (15-30 cm thickness) of the outcrop on the extraction front of up to 1,5 m in height. The quarry 4 has two vertical extraction fronts up to 3,5 m high, highlighting the regularity of the fracture planes of the rock, with average intervals of 20 cm, forming an exploitation area of 15 by 10 m.

Zones 5, 6 and 7 were exploited mainly as supply areas of blocks on the surface, obtaining rolled supports of various morphologies detached from the outcrops scattered along the bed of the Agua Fría ravine (areas 5-6) and on the slope of the Chinflón summit (area 7).

The transport routes of the phyllite blocks had to contemplate three potential transit zones: the Agua Fría ravine, the western slope of the dolmens promontory 3-4 and the watercourse to northwestern of the dolmens 1-2. These three areas of circulation have a favorable topography, with slopes of 5 to 20% of gradient, lower than the surrounding relief units, being the natural crossing areas. The total linear routes would range from 30 m to 365 m, depending on the distance from the supply area or quarry with the construction site, with ramps being carved into the substratum at the sites of monuments 1 and 3-4 (Fig. 9).

Figure 8 – Quarries and supply areas of phyllite in the surroundings of the Los Llanetes.

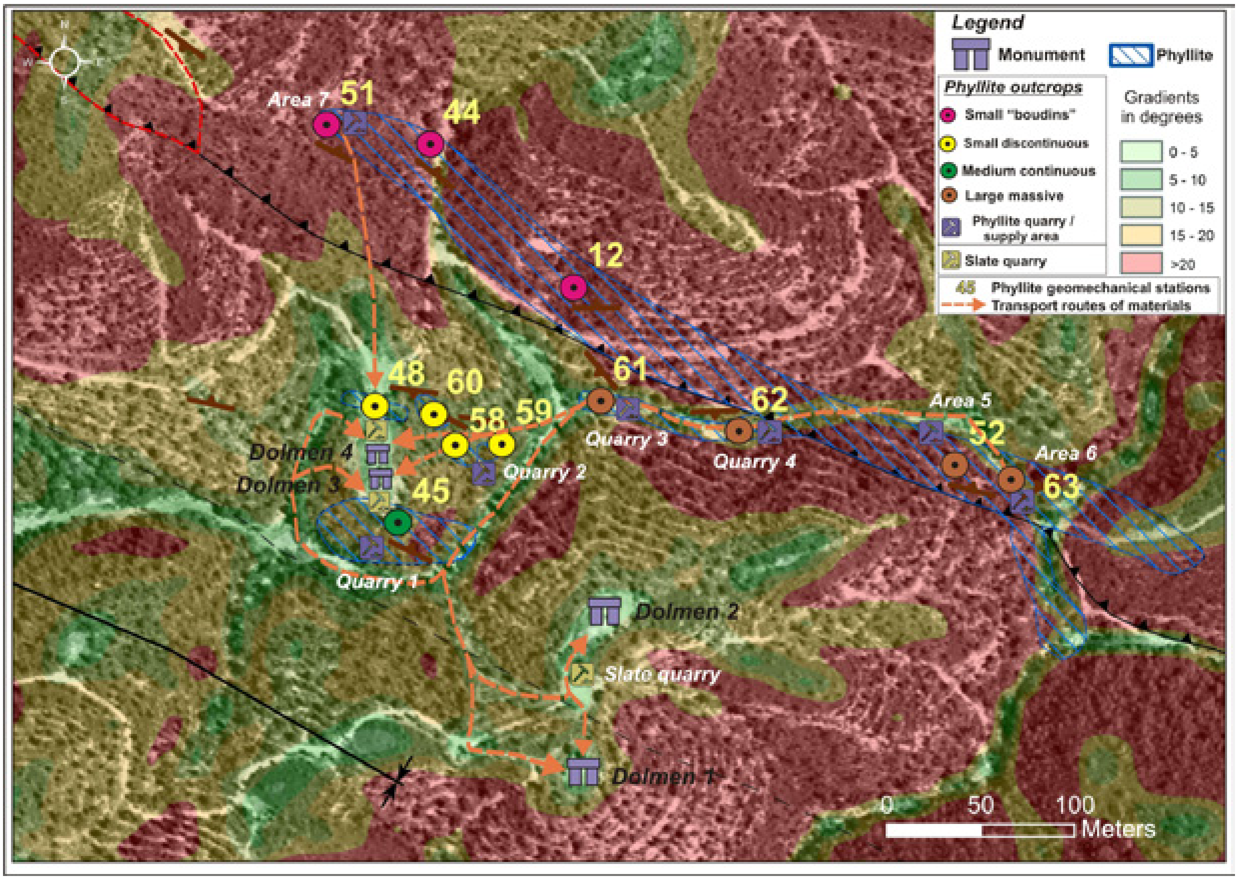

Figure 9 – Transport routes of construction materials.

Andesite

The andesite blocks were procured from the water courses located 350 m northeast-east of the site of the architectures: Agua Fría ravine and La Canaria ravine (Fig. 10). From the bed of these two ravines were obtained blocks of globular morphologies (boulders and cobbles) that were used in rough for the formation of tumular masses, pavings, masonry walls and as tools.

White quartz

The blocks, cobbles and pebbles of white quartz come from three supply areas: a) the northern slope of the hill where monuments 1-2 are located, where there are abundant blocks of 20 cm detached from isolated levels of the host rocks (slates of PQ Group); b) bed of the Agua Fría ravine, with a high concentration of secondary blocks of different sizes and polyhedral morphologies; c) the slate quarry between the dolmens 1-2, where there are veins of white quartz with polyhedral blocks between 5-15 cm on each side. These zones are within a radius of distance very close to the monuments, between 40-65 m in a straight line for the dolmens 3-4 and 105-135 m in a straight line for the dolmens 1-2. These materials being used together with other lithologies in different external sectors of the monuments (Fig. 10).

The slate slabs and blocks of andesite and white quartz would be transported by the same displacement zones as the phyllite blocks, in their final sections of the routes.

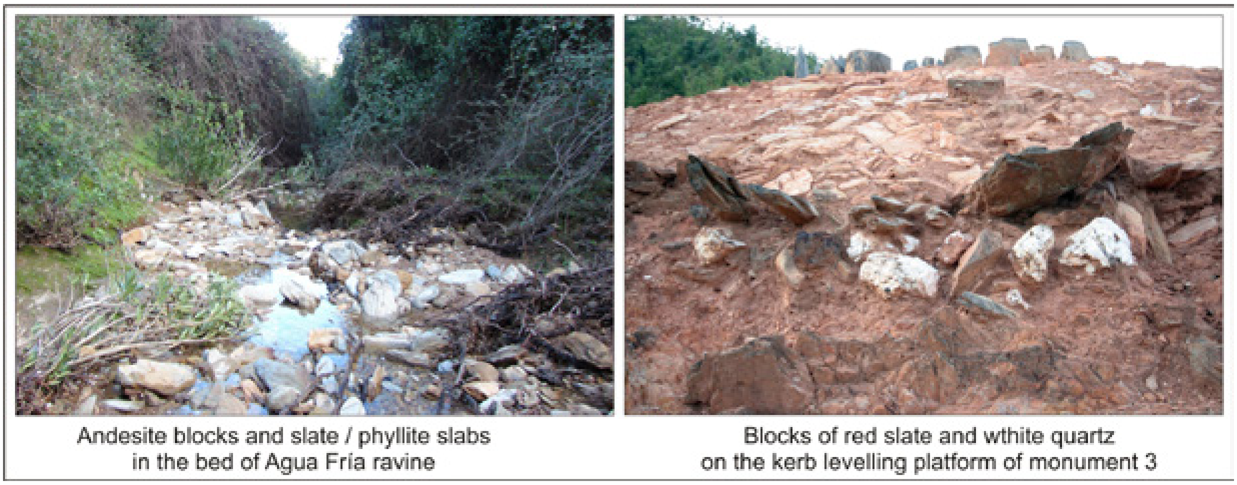

Figure 10 – Boulders and cobbles of andesite in the bed of the Agua Fría ravine and other lithologies: slates and phyllites (left). Quartz blocks and red slate slabs in the monument 3 (right).

5. Conclusions

The type of geological formation, the availability and accessibility of raw materials must be elements to be considered in order to explore the criteria that the communities of the Recent Prehistory had to carry out in terms of the choice of the sites, the architectural forms to be built in the sites and the construction processes operated in each architectural project.

In general, for the El Pozuelo cemetery it would be possible to maintain that there is a correlation between the location of the monuments and the presence of phyllites. Thus, in the surroundings of El Riscal-La Veguilla group we have documented several outcrops of phyllites next to the course of the riverbed of Los Pinos stream, with a variable distance of between 50-300 linear meters, which has also shown detached blocks and quarries with exploitation systems analogous to those documented in Los Llanetes group. Besides, a locational pattern can be observed regarding the selection of the construction site of the largest monuments, architectural complexity and development of building projects (dolmens 1, 2, 3 and 4 of Los Llanetes, dolmens 5, 6 and 7 of El Riscal-La Veguilla, dolmen 13 or Martín Gil), since these are located on or in the immediate vicinity of the contact zone between these two geological formations: PQ Group and CVS. From these sites it was feasible to transport short distances from the blocks of phyllites obtained on the surface or by extraction in quarries.

The place selected for the location of the Llanetes monuments had to be directly related to the availability of lithic raw materials in the local geological environment suitable to be used as building materials: phyllites, slates, white quartz and andesite. These raw materials were obtained through their supply in surface or extraction in quarries, in a radius of 50-350 m linear distance, transported, used in the rough or transformed by various technical treatments in order to be arranged as building materials in the execution of the various architectural projects.

For the construction of the monuments several types of rocks were used, which were selected by several factors:

- For its material and mechanical qualities suitable as building materials, in all the lithologies used. Especially noteworthy is the phyllite, being the only lithology that allows the acquisition and manufacture of large stone blocks for the construction of orthostatic architectures covered under mound, in addition to possessing peculiar morphological properties (slender and elongated supports), colour (gray-green/ bluish-grayish) and texture (roughness), according to the creation of the internal architectural spaces;

- For the existence of a local technical tradition and an "architectural style" of megalithic monuments around a raw material: the phyllite;

- Visual properties (colour, brightness and texture), in the case of white quartz and red slates, being visible materials from external spaces;

- Symbolic values, case of white quartz and red slatesas well as recycled phyllite stelae.

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An approach to the Megalithic Architectures in the Douro Basin: some chrono-typological remarks and examples about the use of different lithologies

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Abstract: Despite the seeming uniformity of the Megalithic ritual in the inner Iberian Peninsula, it displays a wide variety of features, especially regarding the morphology and architectural types of monuments. The present paper examines the possible existence of diachronic sequences in the development of Megalithic architecture, both at the local level and throughout the studied territory, considering the absolute chronology and the material culture associated with each type of building. Moreover, the paper proposes different phases in the Megalithic constructive practices in light of a Bayesian statistical analysis of the available absolute dates. Finally, it offers some examples of the use of stones of different provenance and various textures and colours in the same Megalithic monument.

Keywords: Megalithism; Douro Basin; Megalithic architectures; Chronometric analysis; Provenance and lithology studies

Uma abordagem às Arquitecturas Megalíticas na Bacia do Douro: algumas observações crono-tipológicas e exemplos sobre o uso de diferentes litologias

Resumo: Apesar da aparente uniformidade do ritual megalítico no interior da Península Ibérica, este apresenta uma grande diversidade de características, nomeadamente quanto à morfologia e os tipos arquitectónicos dos megálitos. Neste trabalho estuda-se a possibilidade de existirem sucessões diacrónicas em relação ao desenvolvimento da Arquitectura Megalítica, não só no âmbito local mas também em todo o território de estudo em geral, tendo em conta quer as datações absolutas quer os achados materiais que estão ligados a cada um dos modelos construtivos megalíticos. Propõem-se, também, diferentes fases para a construção dos megálitos, baseadas nas análises de estatística bayesiana desenvolvidas sobre as datas de radiocarbono disponíveis para este tipo de eventos. Por outro lado, apresentam-se alguns exemplos documentados no território de estudo do emprego de litologias de distinta origem e de pedras de diferentes texturas e cores num mesmo monumento.

Palavras-chave: Megalitismo; Bacia do Douro; Arquitecturas megalíticas; Análises cronométricas; Estudos de proveniência e litologia

1. Introduction

The present work is divided into two different sections. The first one will offer a chrono-typological approach to the development of the megalithic phenomenon in the Douro Basin, specifically with regard to its wide diversity of morphological and architectural features. In this sense, we will introduce some diachronic sequences of the Megalithic architectural development at the local level, which will be examined later by means of the statistical analysis of the available absolute dates for the construction and first-use events of megaliths throughout the studied territory. Our purpose is to test the hypotheses regarding the existence of a chronological determinism in connection with the building size and typology of megalithic monuments and to assess, in turn, the idea that megalithic architectural structures grew ever more complex with the passing of time.

The second part will consider some telling examples included in the few studies on lithology and stone provenance that focus on this geographical area. In order to deepen into the topic of the provenance of the raw material used in building this kind of monuments, we have chosen a study case taken from the megalithic phenomenon in the province of Salamanca (López-Plaza *et al.*, 2008). The study offers an in-depth analysis of lithological factors in the building features of monuments, of the distance from the quarries, of the possible transportation routes and, even, of the hierarchical relations among megaliths according to the position they occupy and of the higher or lower degree of lithic diversity used in their construction. Moreover, the present work tries to show how interesting may be the analysis of one of the most forgotten variables in the studies of Megalithism, the colour. In this sense, as a case study, we will present an example from the Ambrona Valley (Soria), where there are evidences of the use of stones of different colours in the same monument (Rojo *et al.*, 2005, 2013). This example will allow us to explore the symbolic function of such peculiarities in the social relationships and mindsets of the groups using these megaliths.

2. The Megalithic phenomena in the Douro Basin: some remarks about its geographical distribution

The Douro Basin covers the upper part of peninsular Central Plateau, both in Spain and Portugal, as well as the Portuguese littoral platform (Fig. 1). It is the largest peninsular watershed with 98,073 square kilometers (according to the Douro Hydrographic Confederation; http://www.chduero.es/). The Douro river, the third longest river of the Iberian Peninsula, has 897 km from its birth (at the Picos de Urbión, in the province of Soria) to its Atlantic estuary, near the Portuguese city of Porto. Administratively, this geographic area is characterized by the presence of the border between the two countries. In fact, 572 km of the river run through Spanish territory, while 213 km do it through Portuguese lands. The remaining 112 km mark the Spanish-Portuguese border in the region called 'International area of the Douro River'.

The megalithic phenomenon in the Douro Basin shows a very regular and even distribution (Delibes, 1995: 64), which clashes with the traditional view of this territory as a 'megalithic blank' with some exceptions, such as the well-known centers in Salamanca and in the Beira Alta region, and some scattered monuments in the province of Burgos (Bellido, 1993). Regarding distribution, archaeological evidence seems to point towards a balance between the northern and southern parts of the basin, with important megalithic centers documented on both sides (Fig. 2). In the northern area, the Serra de Aboboreira group in the Porto district stands out, as well as those belonging to the La Lora region in Burgos, to the Benavente y Los Valles area in Zamora or to the Serra do Alvão necropolis in Vila Real. In the South, the megalithic groups of the Tormes Middle Valley and of the Ciudad Rodrigo-Campos de Azaba y Argañán, both in the province of Salamanca, or the monumental areas of Serra da Nave or Nossa Senhora do Monte, in the district of Viseu, would be the most renowned examples. More recent findings are the significant monumental groups documented at the two ends of the basin: on the one hand, in the littoral platform, both in the North and South of the Douro River (in the Porto and Aveiro

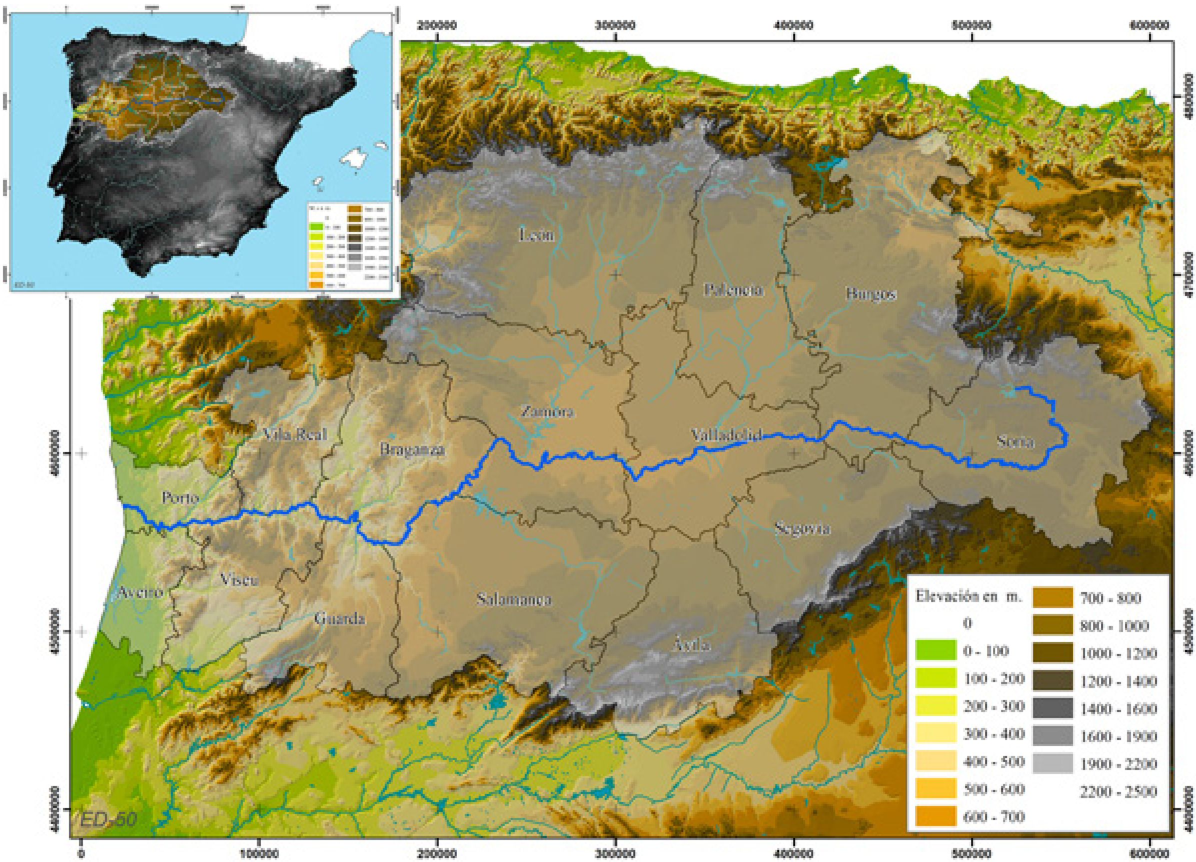

Figure 1 – Location of the Douro Basin in the Iberian Peninsula and the political-administrative frame of the Spanish provinces and Portuguese districts that are part of that territory.

district respectively), and, on the other and, in the Valle de Ambrona megalithic centre (in the southeast corner of the province of Soria). However, despite the increase of fieldwork and the incorporation of new findings during the last years, there are still places characterized by the paucity or total absence of this type of structures, such as the provinces of León-Ávila-Segovia, the sedimentary lands of the central part of the basin (provinces of Palencia and Valladolid mainly) or the Trás-os-Montes e Alto Douro region, especially in the surroundings of the Raya/Raia, a term which refers to the Portuguese-Spanish border.

Many authors have tried to explain the absence of uniformity in the distribution of megaliths from different perspectives, resorting to topographic and geological causes, such as the lack of raw material for the construction of this type of buildings in some regions. In this regard, while the areas with a granite-schist substrate (such as the western half of the valley) would be characterized by the relatively easy access to raw materials, such access would be far more complicated in the sedimentary lands of the central basin due to the lack of stone (López-Plaza, 1982: 1). However, this hypothesis is currently outdated as a result of the finding of some megaliths in these areas. Other explanations suggest reasons of a more symbolical or ideological sort, like the rejection by the local groups of the Megalithism, a burial rite that did not fit their mindset, and the use of other burial methods, probably linked to specific local traditions (Delibes *et al.*, 1992: 12). Nevertheless, this hypothesis would not explain the absence of megaliths in specific areas, since the fact that there might have been other ritual and funerary methods does not mean they were the only ones. In fact, the coexistence of megalithic tombs and other funerary customs at the same moment in time has been documented in other peninsular regions (Carvalho, 2016; Boaventura & Mataloto, 2013: 91; Díaz-Zorita *et al.*, 2012; Fernández-Crespo & De La Rúa, 2016). Other reason could be the destruction of the megalithic monuments due to both natural and anthropic causes. In this regard, it could be argued that the areas with fewer documented manifestations usually boast fertile lands close to drinking sources and therefore have gone through intense human intervention throughout history, linked to agricultural labours, as well as to the occupation of strategic places. Besides, as already mentioned above, since we are dealing with regions lacking stone outcrops, it is probable that most architectural elements of these constructions were reused by later populations in other edifications (Bellido, 1993: 189).

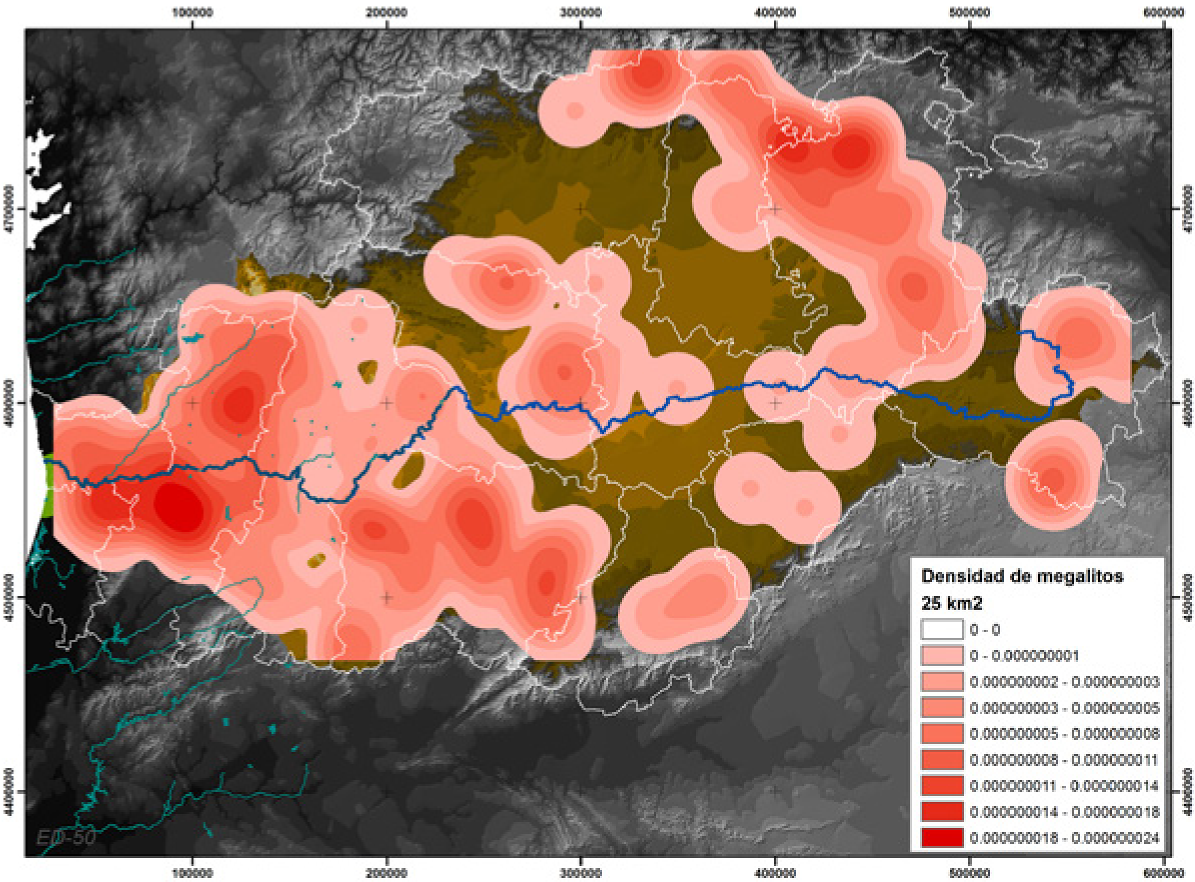

Figure 2 – Estimated densities of the presence of the megalithic monuments in the Douro Basin (Tejedor-Rodríguez, 2018).

Moreover, the imbalances observed in the geographical distribution of megaliths could derive in part from elements not related to the megalithic reality, but rather closely related to the development of the 'megalithic research'. Studies have traditionally focused on the largest and well-known centers since more than half a century ago, neglecting other isolated and scattered findings. Additionally, there has always been an obsession for the search of the classic dolmenic model (represented by the 'passage grave'), discarding in turn other manifestations of megalithic nature not considered as such by the academic world until recent times (Pereira-da-Silva, 1993: 117). Thus, regions apparently without megaliths may present a different reality, showing alternative, not so monumental, architectural models, but with the same ritual and burial patterns. In this sense, the documented image of the distribution of Megalithism in the Douro Basin would not reflect a 'historic reality', but an 'archaeological reality' (Fabián, 1995: 125).

3. The Megalithic Architecture in the Douro Basin: a polymorphic reality

Despite the seeming uniformity of the Megalithic ritual in the Douro Basin, it displays a large diversity of features, especially regarding the morphology and architectural types of monuments. The progress of the research during recent years has revealed a wide variety of sizes and types of megaliths, in contrast with the traditionally predominant theory of the 'Passage grave' as the one megalithic model existing in the studied territory. As mentioned above, for decades studies have focused on the existence of large structures (mainly 'Passage graves' and in some cases 'Single chambers'), leaving aside other manifestations associated to more recent chronologies (to the 2nd or even 1st millennium BC), due to their different architectural features and their limited monumentality. This is the main reason behind the overrepresentation of the 'Passage graves' in relation to the rest of the megalithic buildings.

However, as a result of the research developed in the last decades, the diversity in megalithic architecture has been proved beyond doubt and, already in the 1980's, the morphological differences were defined by Professor Víctor Oliveira Jorge in his studies about Megalithism in northern Portugal using the concept of 'megalithic polymorphism' (Jorge, 1983-1984). Usually, all megalithic architectures follow the same constructive design, which is configured by a central burial space covered by a barrow of stone and/or soil. In many cases, this basic model is completed with a small access or a corridor of different lengths and, sometimes, with secondary architectural elements like an atrium, an intratumular corridor, a peristalith, peripherical circles or surrounding rings, among others. Thanks to the statistical analysis of this diversity, it is possible to distinguish six architectural models in the megalithic phenomenon of the Douro Basin (Tejedor-Rodríguez, 2018): 'Passage grave', 'Single chamber', 'Single chamber with short vestibule', 'Simple barrow' and two specific types exclusive to this territory, the 'Redondil' and the 'Lime-kiln tomb' (Fig. 3 and 4):

- 'Passage Grave' (Fig. 3C): it is the most common and best known megalithic model in the Iberian Peninsula. In the studied territory, this type shows a circular or polygonal chamber and a corridor of variable length, whose structure is made of large orthostats arranged either vertically or horizontally. The systems of covering are usually unknown, although there are some documented roof remains in corridors, which would be formed by mid-sized stone slabs arranged perpendicularly over the passage walls;

- 'Single chamber' (Fig. 3E): it has the same characteristics of the passage graves, except for the absence of the corridor. This constructive model could be opened (if a small access opening was present) or completely closed, a feature very difficult, or even impossible, to identify in many cases;

- 'Single chamber with a short vestibule' (Fig. 3B): this model is halfway between the 'Passage graves' and 'Single chambers'. This type of monument is opened because it has a clear access; yet, due to its short length, it cannot be considered as a real corridor, but rather as a simple vestibule. Usually this access features two orthostats arranged horizontally, on its larger side, facing each other;

- 'Simple barrow' (Fig. 3A): this type of tomb shares the monumental and tumular aspect, but it does not exhibit the typical colossal stone architecture. Usually, these structures have been interpreted as simple closed burial sites, where the funerary deposits would take place in a single event in which the bodies and grave goods would be arranged in an enclosed space and then covered with a mound (Delibes, 2010: 24). However, other hypotheses propose that these tombs were actually open 'dead houses' used during a brief time span, where the dead were deposited in a small pit protected by now lost stone walls or even wooden structures. When its funerary use was finished, these fragile buildings would be dismantled and its burial area covered by a barrow, the main architectural feature that identifies this type of megalithic monuments (Rojo *et al.*, 2015: 42-44). This proposal has been reinforced thanks to the finding of negative structures in some tombs (such as postholes, pits...), which could have served as support elements of buildings. These non-dolmenic megaliths, so abundant in the studied territory and sometimes called 'para-megalithic' structures (Galán-Saulnier, 1984-1985: 64-65), were not traditionally regarded as belonging to the megalithic phenomenon for its small size and little monumentality. In fact, up until the last few decades (Delibes & Rojo, 2002; Palomino, 1989; Rojo, Kunst *et al.*, 2005; Sanches, 1987; Sanches *et al.*, 1987; etc.), academic research did not pay attention to such manifestations, which were considered structures of a later period such as the Bronze Age or even the Iron Age. This type of megalith is still underrepresented in specialised literature. In our view, this does not make justice to the reality of the megalithic phenomenon in the Douro territories;

Figure 3 – Examples of different megalithic architectural types documented in the Douro Basin: A-'Simple barrow' of La Tarayuela (Soria); B-'Single chamber with a short vestibule' of Fonte Coberta (Vila Real); C-'Passage grave' of El Teriñuelo de Aldeavieja (Salamanca); D-'Redondil' of La Velilla (Palencia); E-'Single chamber' of Carapito I (Guarda).

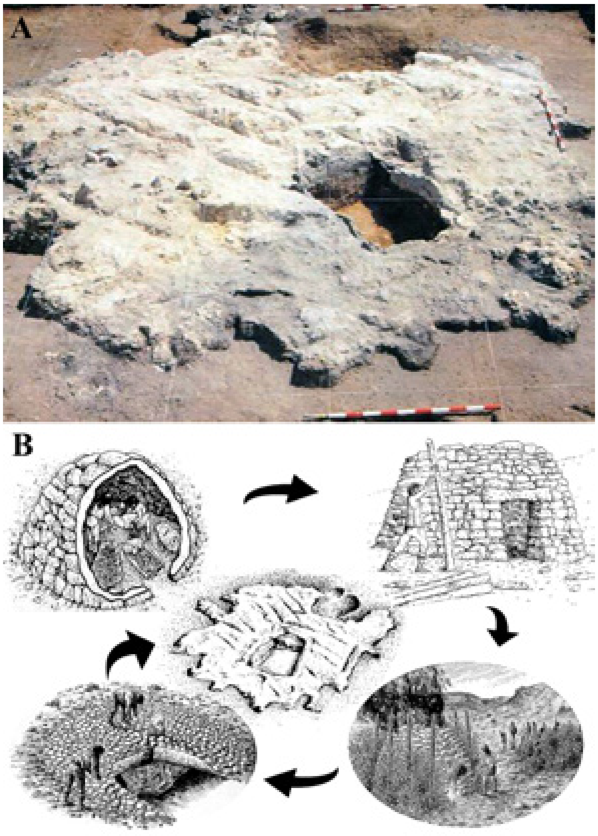

Figure 4 – A-State of conservation of the megalithic tomb of La Peña de la Abuela (Ambrona, Soria) before its excavation. B-Recreation of the 'building-use-closure' cycle of the site: building and use phases (top left), preparation for the closure process (top right), the burning (bottom right), the 'tumulation' (bottom left) and the image of the site state before its excavation (center) (Rojo *et al.*, 2010; drawings by Luis Pascual-Repiso).

- 'Redondil' (Fig. 3D): this is the name used to define some manifestations with many megalithic elements (grave goods, collective funerary deposits, chronology...), but whose architecture is very different, except for the presence of a mound (Delibes, 1995: 65; Delibes *et al.*, 1987: 183-185; Galán-Saulnier, 1984-1985). The chambers of these constructions are formed by orthostats laying on their largest side and forming a circular space, which would overlap to make a baseboard. The finding of clay remains, both in the peripheral area and also within the ossuaries, leads us to think that the original walls and cover were made with this raw material (Palomino & Rojo, 1997: 253; Zapatero, 2015: 98-99). These tombs could have a corridor. This model is located in a specific area of the Douro Basin, mainly in the sedimentary lands of the central basin, where raw materials for constructing conventional dolmenic tombs were very scant (Bellido, 1993: 183; Delibes & Del Val, 1990: 56). Therefore, the populations would have chosen an alternative constructive model based on the accessible resources in their nearest environment. This apparently accurate interpretation was gradually outdated due to the finding of megaliths of this type composed by large stone blocks, which could have been perfectly placed in an upright position following the 'canonical design' (Delibes, 2010: 20). Therefore, the 'Redondil' would not be an architectural alternative conditioned by the lithological elements, but a voluntarily chosen option linked to certain traditions or symbolic values, which additionally may have solved some obstacles such as the lack of stone (Delibes, 1995: 65);

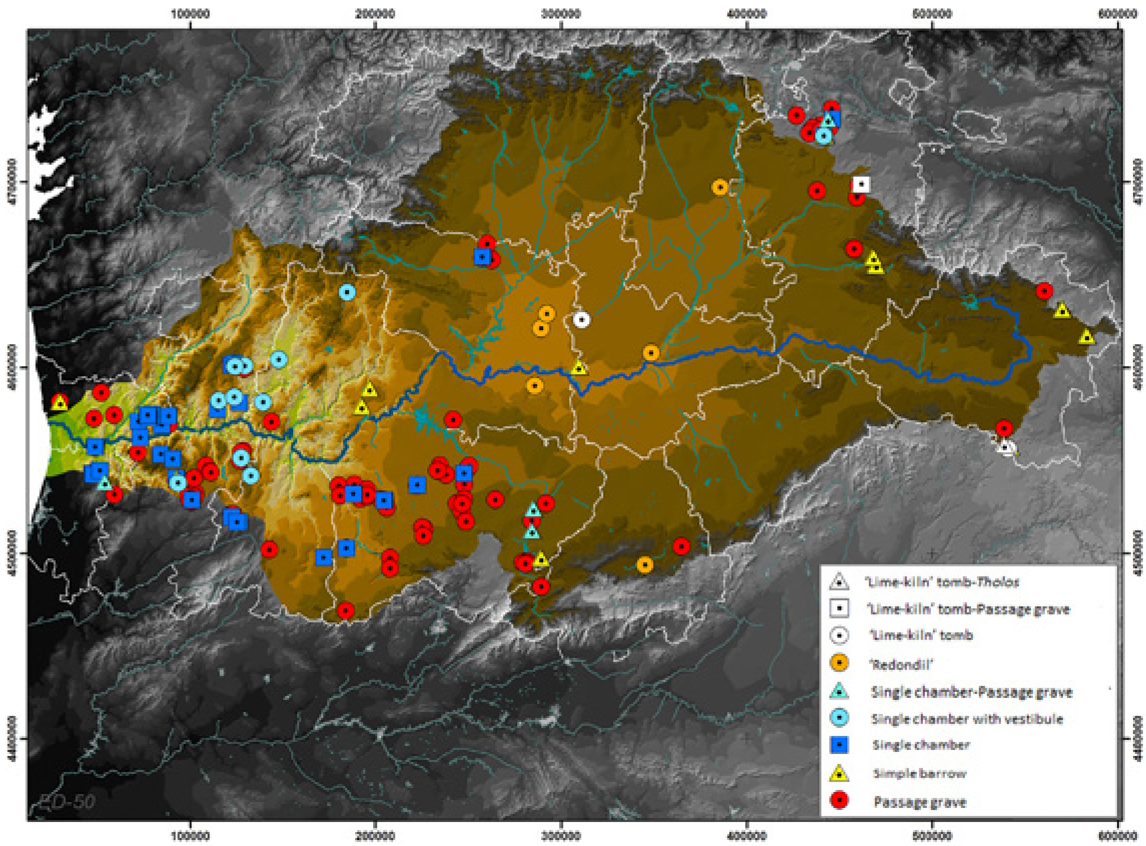

Figure 5 –Distribution map of the megalithic monuments documented in the Douro Basin according to their architectural type.

- 'Lime-kiln tomb' (Fig. 4): nowadays, the clearest evidence of these megaliths, which could be defined as simple barrows for its external appearance, is the huge crust of quicklime that seals off the collective burial (Fig. 4A). Thanks to the development of an interesting Experimental Archaeology

> Project carried out in 1999 (Rojo, Kunst *et al.*, 2005: 9-23, Annex 2; Rojo *et al.*, 2010), it was confirmed that the production of a lime crust of such a size was intentional and planned. Since the moment of its construction, users knew the way in which the tomb had to be sealed, because certain essential conditions had to be accomplished while building it. The original structure would have a false dome shape, such as a tholos, that would be made completely of flat pieces of limestone in order for the structure to be transformed, once its ritual and funerary use was finished, into a quicklime through an intentional big fire that would melt the whole content and seal the burial. Finally, it was covered by a dirt and stone mound, thus monumentalising the site for eternity (Fig. 4B).

All these architectural types are present in the studied territory, with the exception of some singular models whose findings, to date, are limited to specific areas of the Douro Basin (Fig. 5). This is the case of the 'Redondiles' and the 'Lime-kiln tombs' (marked in the map with the orange and white symbols respectively), which have been documented in the center and eastern regions of the Valley. In particular, lime-kiln tombs are limited to the far eastern area of the Douro valley (provinces of Burgos and Soria), although there is an isolated example in Valladolid. This, in our view, might be due, alongside social and cultural factors, to purely lithological reasons, since limestone is required to build this type of tomb, and limestone is fairly abundant in those areas, while quite scarce in the western half of the basin, where schists and granites predominate. On the other hand, 'Single chambers with vestibule' are located, with some exceptions (two sites in Burgos), in the far western region of the basin, in Portuguese territory (Bragança, Vila Real and Viseu districts). In this case, the only possible explanation is to pose a building pattern with a marked local nature.

3.1. Evolutionary hypotheses as an explanation for the 'megalithic polymorphism'

Many interpretative proposals have attempted to account for this polymorphic situation. One of the most accepted hypothesis proposes an evolutionary typological sequence to explain this variety; accordingly, there would be a progressive replacement of simple types by more complex and monumental architectures. This idea is mainly based on the association of each architectural type with its absolute dates and the presence/absence of some characteristic elements of the material culture.

In this regard, several studies have been carried out at the local level in the studied territory. In this paper, we will focus on and compare two proposals that are the result of significant research projects and fieldworks and that provide a suitable systematisation of the 'megalithic polymorphism' by taking into account absolute dates. They focus on two well-known megalithic centers, located at the extremes of the Douro Basin: the Serra de Aboboreira, in the district of Porto, and La Lora, in the Northeast of the province of Burgos.

The chrono-typological sequence proposed by professors Germán Delibes and Manuel Rojo to study the development of Megalithism in La Lora region establishes four types of megalithic structures (Fig. 6A) that occasionally overlap in time (Delibes & Rojo, 2002: 25). The emergence of different types is part of a process by which more complex structures substitute simpler ones. The oldest architectures would be the 'Small non-dolmenic barrows', dated to the end of the 5th millennium cal. BC, which contain a small ossuary and lack clear internal demarcations. According to the researchers, these structures would be part of the stage of 'the burial monumentalisation before Megalithism' (Delibes & Rojo, 2002: 23). Then, around 4000 cal. BC, the 'Single dolmens under barrow' appeared. They are polygonal chambers formed by horizontal orthostats, supported on peristalithic rings, and covered by vegetation or wood. These structures are not completely closed because sometimes they have a vertical entrance like a hatch. The 'Dolmens with simple access' overlap in time with the previous type. Such dolmens present both innovative features (as the presence of a corridor or the circular shape of the chambers) and archaic elements (like the elongation of the chamber or the horizontal orthostats in the chamber and in the passage). Their mounds can reach a diameter of fifteen meters. At last, the 'Large Passage graves', whose chambers, almost completely circular, are formed by many vertical orthostats, developed between 3700 and 3200 cal. BC. The corridors are long and the mounds can reach a diameter of twenty five meters and a height of two and a half meters.

The chrono-typological model proposed for the megalithic group of Serra de Aboboreira (Cruz, 1995: 82-89) displays a lower degree of diversity and there are some significant differences with the previous one. In any case, both examples can be compared because their diachronic sequences are very similar. In this proposal, the oldest dates (4450-3700 cal. BC) are associated with the architectural type of the 'Single dolmens under barrow'. It features small polygonal opened or enclosed chambers, peristalithic rings and soil mounds covered by a stone level. The 'Fossas under barrows', which could be identified as the 'Simple barrow' model, would be somewhat more recent (4000-3650 cal. BC). At last, the 'Passage grave', whatever the length of its corridor, is present during the second half of the 4th millennium cal. BC (3600-3100 cal. BC).

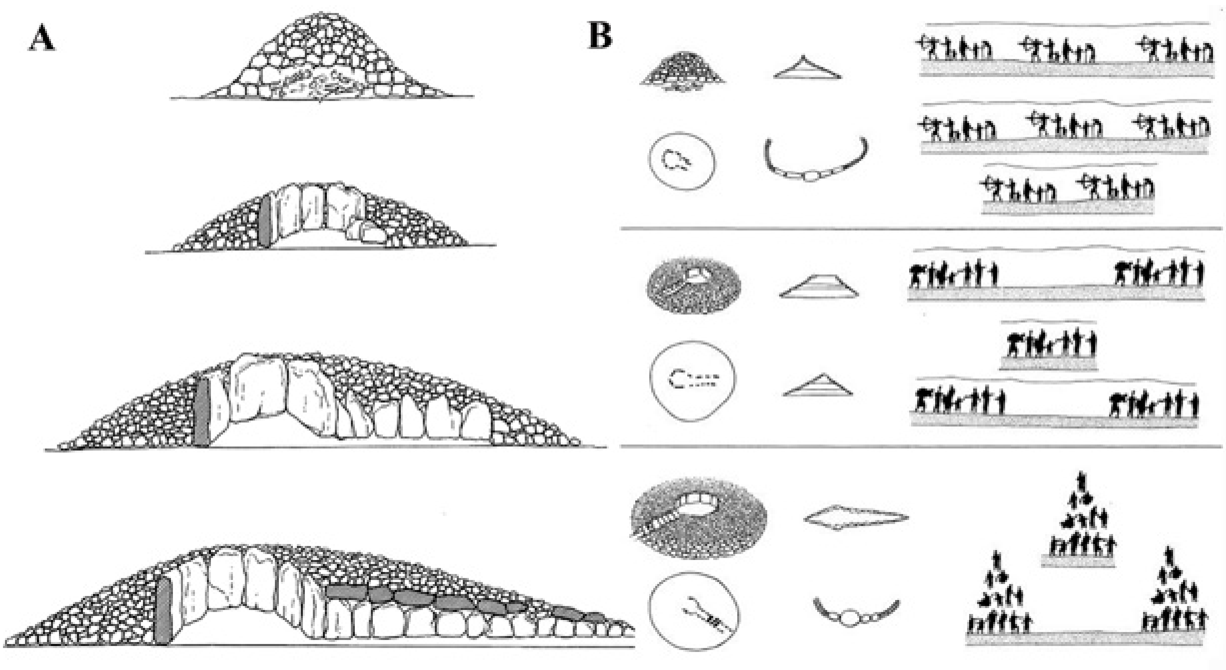

Figure 6 – A-Schematic sequence of the 'megalithic polymorphism' documented in the La Lora region (Burgos): 'small non-dolmenic barrows', 'simple dolmens under small barrows', 'dolmens with simple access' and 'large passage graves'. B-Development of the relationships between the different megalithic architectures, grave goods and population aggregation models according to the researchers (Delibes & Rojo, 2002).

The 'megalithic polymorphism', as well as the associated chrono-typological sequences explained above, show that many different megalithic burials were built during the 4th millennium cal. BC and that, regardless of their differences, all of them convey the same idea of collectivity and monumentality. From an evolutionary approach, which interprets this fact in terms of a diachronic substitution of simple forms with more complex and monumental ones, the diversity could be the result of the socioeconomic development and the gradual process of population aggregation of different groups (Fig. 6B) or, perhaps, of different ideological or religious responses to the needs of their rituals, rather than the effect of the greater architectural skills of the builders of megaliths or the adoption of foreign influences and building models (Delibes & Rojo, 2002: 1).

Accordingly, the hypothesis of the 'Megalithisation in two phases' (Delibes, 1995: 66; Delibes & Rojo, 2002: 31-33) proposes the existence in the megalithic development of an early period characterized by small, very numerous and scattered constructions of a large typological diversity. Later, toward the mid-end of the 4th millennium cal. BC, the most usual models, such as the 'Passage graves', spread throughout the territory (Fig. 6B). The location of megaliths in strategic places, from where transit routes and other resources could be controlled, has led to consider its role as possible territorial markers. Therefore, each group would legitimate its 'right' to make use of the lands, already occupied by its ancestors (Renfrew, 1976), in a context of demographic pressure and growing competition for the land. On the basis of this idea, the first phase of the megalithic activity would be linked to small groups, scattered throughout the territory, whose still poor technological capabilities would force them to be itinerant and search for new fertile lands. Thus, the small megaliths would have worked as territorial markers of the resources controlled by each group. Later, the populations would begin to cultivate larger areas, thus being able to reduce the frequency of their movements. Consequently, its 'catchment area', though smaller, would have a larger amount of recourses, and, meanwhile, whereas the number of megaliths would be lower, their size would grow, being the territorial reference of the 'catchment area' of each group. Besides, the increase of farmlands, the development of technological tools and the subsequent rise in crop productivity resulted in a growing need to concentrate and aggregate the population in order to get more manpower (Delibes & Rojo, 2002: 31-33). In this regard, the different groups would gather for their own benefit, leading to the creation of cohesive and strong communities, which would need symbols in their environment to congregate around and to reinforce their ties. Thus, the funerary dimension of the megaliths was losing its significance as it acquired new roles closely linked to their status as ritual centers. In this sense, what at first were simple tombs became ceremonial monuments with a complex meaning and functioning (Delibes & Rojo, 2002: 9). Therefore, following these evolutionary hypotheses, the ever greater monumentalisation of both architecture and landscape must be linked to the phenomenon of a gradual larger social complexity and, perhaps, to the phenomenon of an increasingly differential access to resources, in an inevitable path to the growing hierarchical character of society (Delibes & Rojo, 2002: 13).

3.2. What do the 14C dates and chronometric analysis tell us about this?

These chrono-typological hypotheses based on an evolutionary approach have been refuted using different kinds of evidence (Bueno, 2000: 64; Bueno *et al.*, 2010: 162-168; Jorge, 2000: 363). On one hand, several cases of the 'evolved types', such as the 'Passage graves', have been documented at the beginning of the 4th millennium cal. BC and, therefore, they would be contemporaries of simpler architectural models, such as the 'Single chambers' or the 'Simple barrows' (Bueno, 2000: 64-70; Cruz, 1995: 105). On the other hand, these simplified structures appear sometimes associated with some characteristic elements of an 'advanced Megalithism' and, so, their construction must have taken place in more recent dates (Bueno *et al.*, 1999: 156-157). Based on this evidence, other interpretative proposals argue that the 'megalithic polymorphism' did not result from the simple substitution of architectural models throughout time. The possible existence of many different purposes and needs since the earliest Megalithism and, consequently, the appearance of different constructive models adapted to them must be taken into account in order to explain the polymorphous reality (López de Calle & Ilarraza, 1997: 319). In this regard, it is perfectly reasonable to argue that there is not one, but many reasons, to account for the variety of burials among different groups. Therefore, the presence of simple and more complex and/or alternative megalithic constructions in the same territory could be interpreted in terms of contemporaneity and synchronism in some cases, and in terms of a diachronic sequence in others (Blas-Cortina, 1995: 72).

In an attempt to somehow clarify the question of the possible existence of a chronological determinism regarding the polymorphism of megalithic monuments in the Douro Basin, a detailed analytical study of available radiocarbon dates has been carried out. To that end, we have carried out several statistic studies of a selected sample of 14C dates (Fig. 7), in connection either with the "building event" of

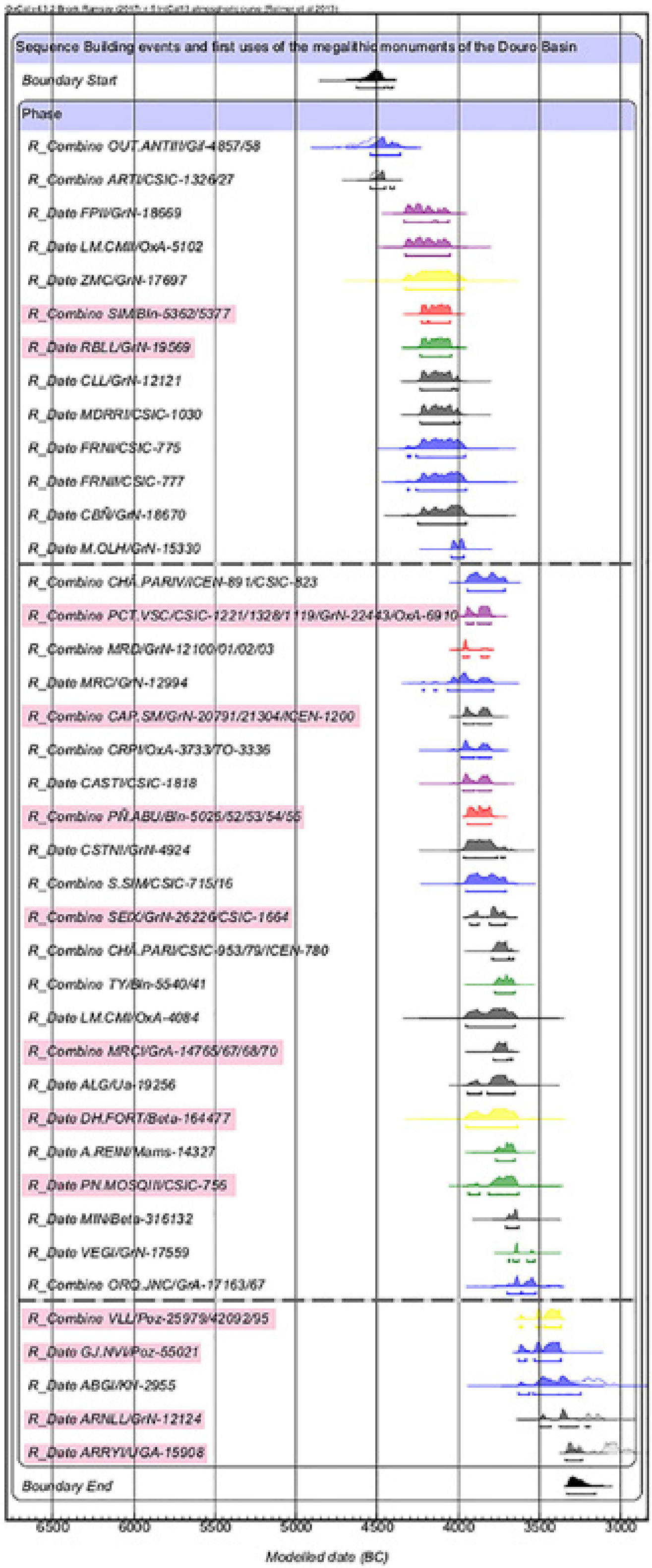

Figure 7 – Bayesian chronological model of *Phase* type made on a selection of radiocarbon dates available for the 'building events' or other practices that took place at the foundational use phase of the megalithic monuments. Each architectural type has been marked with a different colour on the graph: gray-'Passage grave', purple-'Single chamber with a short vestibule', blue-'Single chamber', green-'Simple barrow', yellow-'Redondil' and red-'Lime-kiln tomb'.

the monument or with some practices that took place at a foundational use phase (such as "closing events" or "early funerary uses"). All dates whose archaeological context of provenance was ill-defined or vague (for instance, all samples taken from paleosols or most of them coming from "pre-building fire events"), as well as dates with a standard deviation of 100 or higher have been discarded. The final total sample of our study consists of 69 dates from 40 different megaliths.

After individually analysing and calibrating each date, several Bayesian statistical analysis have been applied, since they allow for the incorporation of aprioristic information of archaeological nature to the study, such as the relation between the sample and the stratigraphic sequence or its connection with certain items of material culture. When applying this analytical approach, both calibrated and modelled dates have been included, thus offering the opportunity to identify, with far more precision, some aspects of the development of the megalithic phenomenon in the studied territory and to determine its chronological boundaries with a higher degree of probability. Moreover, in the case of dates proceeding without doubt from the same event, we have implemented the date combination analysis. The use of these analytical tools has allowed us to simplify the analysis and to obtain a more precise image of the time sequence, since they reduced the level of statistical uncertainty due to the error of classical calibrations -sometimes exceedingly large-. All analysis and graphs included in this paper have been done with OxCal v4.3.2, available online (http://c14.arch.ox.ac.uk/), applying the IntCal13 calibration curve (Reimer *et al.*, 2013).

The main goal of this analysis has been to determine, with the highest level of precision, the chronology of the development of the megalithic building activity in the Douro Basin and, in light of the results, to try to infer the possible existence of a chronological determinism with regard to the presence of a given architectural type. The Bayesian Phase estimation is the most appropriate analytical tool for this type of study, since it does not require a preset chronological order in the sample of dates to analyse (in this case, there is not even a clear stratigraphic sequence of dates; Bayliss & Bronk-Ramsey, 2004: 35-36; Bronk-Ramsey, 2009). The resulting model, which we present in the following pages, has an acceptance rate over 60%, both with regard to the agreement with the general model (Amodel: 88.4%) and to each one of the analysed data (Aoverall: 88.3). Therefore, it must be taken as a valid model to offer some further interpretations.

The first conclusion to be inferred from the results of the Phase analysis is that the construction of megalithic monuments in the Douro Valley spans through a very large period of time, from the middle-end of the 5^{th} millennium to the end of the 4^{th} millennium cal. BC (Fig. 7). However, as we shall see, some nuances apply to this first remark.

Thanks to a more detailed analysis of this dataset, at least two different moments of 'constructive activity' can be established (marked on the graph by a broken line): the first one would span from the end of 5^{th} millennium cal. BC to the first centuries of the 4th millennium cal. BC and the second stage would extend along the first half of the 4th millennium cal. BC (Fig. 7). A third phase, that would cover the second half of the 4^{th} millennium cal. BC, might be identified, but most 14C dates included in it, except in the case of the 'Single chamber' of Abogalheira I, have in fact an ante-quem value (the dates that are not directly linked with 'construction' or 'foundational use' events, but with other practices such as remodelings, reuses, manipulations of the remains or, even, closure rituals, have been highlighted on the graph -Fig. 7-). Therefore, it is very probably that the construction of these megaliths took place several years before. These results do not mean that no megalith was built since then, because we must take into account that the data refer only to the 'construction' and 'foundational use' events of the monuments that have been dated. However, it seems safe to say that, from the second half of the 4th millennium cal. BC on, the megalithic constructive practice experiences a significant fall.

The analysis of the variable 'architectural type' in this dataset does not show a clear behavioural pattern (each architectural type has been marked with a different colour on the graph -Fig. 7-: gray-'Passage grave', purple-'Single chamber with a short vestibule', blue-'Single chamber', green-'Simple barrow', yellow-'Redondil' and red-'Lime-kiln tomb'). In fact, all architectural types and their foundational use cycles (including some 'closure events' as in the case of La Sima or El Rebolledo, among others) are presented at the first moments of the megalithic activity. On one hand, several cases of 'evolved types', such as 'Passage graves', have been documented at the beginning of the 4^{th} millennium cal. BC and, therefore, they would be contemporaries of simpler architectures such as the 'Single chambers" or 'Simple barrows'. Furthermore, one of the more recent 'construction events' that has been documented corresponds to a simple type: the 'Single chamber' of the mamoa of Abogalheira I (Fig. 7). It is noteworthy that all the 'Lime-kiln tombs' included in this analysis appear among the oldest dates in the sequence, particularly when considering that in most cases such dates come from 'closing events' and, therefore, their construction would be earlier. Thus, it seems possible to assert that this specific architectural type is limited to the earliest stages of megalithic building activity in the studied territory (Rojo *et al.*, 2010: 253-256).

Therefore, it is not possible to support a chrono-typological interpretative model for the whole studied territory, on the basis of the increasing complexity of structures throughout the time. Further studies carried out in other geographical regions, which have implemented the same type of Bayesian analytical approach to the megalithic dataset, have reached similar conclusions (Boaventura & Mataloto, 2013: 89-97; Whittle *et al.*, 2007: 125-131, 142). However, other statistical analysis performed on data from the detailed study of the material culture, the archaeological contexts and the practices developed in the megaliths (Tejedor-Rodríguez, forthcoming) show that, from the middle of the 4th millennium on, the megalithic activity focused on the larger architectures, while in the rest experienced a significant decrease. Thus, it could be suggested that, although there are no chronological differences with regard to the construction moment of each architectural type (which apparently are contemporaries), there are some variations with regard to its diachronic use, since the larger monuments took a more prominent role over time to the detriment of smaller and less monumental structures. Perhaps, this fact was due to ritual or ideological aspects and this evidence could reflect changes in both the functionality and the socio-symbolic meaning of megalithic monuments.

In any case, this general interpretation does not invalidate the possible existence of local chrono-typological sequences, as in the case of the two proposals above presented. Therefore, although it is not possible to establish a diachronic pattern of different behaviours regarding the choice of architectural types throughout the territory of the Douro Basin, that does not prevent such behaviour from taking place as result of the cultural tradition of some populations or the specific needs of the ritual developed at each time.

4. The lithological matter in the Megalithic Architecture of the Douro Basin: some examples and remarks

In the second part of this paper, we will discuss some questions about the provenance and lithology of raw materials.

When analysing the various constructive elements of megalithic monuments (orthostats, mounds...) and the grave goods placed in them, archaeologists use a series of different parameters, from their typology and distribution to the raw materials they are made of, the provenance of such material, their exceptional character in the archaeological record and, even, the possible meaning of their colours.

There is an increasing number of examples of megaliths whose raw materials come from distant places, notwithstanding the presence of nearby good stone quarries for building them. It seems obvious that this choice was motivated by symbolic and/or cultural factors and not by practical reasons. Consequently, all attempts to find the evidences that may have played a special role determined by the symbolic meaning of the megalith, whether on account of its chromatic features or on account of some other reasons such as the orientation and distribution of raw materials within the monument, the longer or shorter distance of provenance or their possible relationship with different elements of the surrounding landscape, are of particular significance.

In the field of megalithic studies, research about different aspects of lithology has multiplied in recent years; the works included in the present volume are a clear proof of it. In this particular area, English-speaking literature (Jones, 1999; Jones & MacGregor, 2002; Lynch, 1998; Parker-Pearson *et al.*, 2011 & 2015; Scarre, 2002 & 2004; Tilley, 1996; etc.) and French-speaking literature (Cassen *et al.*, 2013; Gouezin *et al.*, 2013; Guyodo & Mens, 2013; etc.) stand out. Likewise, there are some noteworthy works in this regard devoted to the Iberian Peninsula. Most of them focus, on the one hand, on the study of raw material provenance and of the distance to these sources, and, on the other hand, on the role played by some selected building elements in questions such as the visibility and monumentality of megaliths or, even, on their role as symbolic references in the surrounding landscape (Aranda *et al.*, 2017; Criado *et al.*, 1994; Forteza *et al.*, 2008; Kalb, 2011; Nogueira *et al.*, 2015; Pedro *et al.*, 2015; Wheatley & Murrieta, 2008; etc.).

However, very few works deal with these questions in the studied territory and, normally, they offer some general references and very simple proposals, such as the local provenance of the stones. Next, we will focus on two specific case studies that stand out over the rest, since they reveal an obvious intention in the choice of orthostats and of other constructive elements.

4.1. Different provenances, the same megalithic focus: some study cases in the province of Salamanca

The first case is the study led by Prof. Socorro López-Plaza, from the University of Salamanca (López-Plaza *et al.*, 2008). In this work fifteen monuments and around 130 orthostats were analysed, taking into account their measures, weight and minimum transportation distance, in order to study two main questions: the relevance of lithological features in the architecture of megaliths and the distance to the quarries and the possible transport routes. In this paper, we will stand out two study cases, each one located at one end of the province (Fig. 8), where archaeologists found evidence of transport over long distances: the dolmen of La Hurtada (marked with a red circle on the map) and the megalithic group of Villarmayor (marked with a blue circle on the map).

The dolmen of La Hurtada is located in the village of Villar de Argañán, in the Southwest of the province of Salamanca. This megalithic monument was already documented at the beginning of the 20th century by C. Morán, who noted that just three large granite slabs were still preserved in situ on the western side of the chamber (Morán, 1931: 40). Besides, he also pointed out that no remains of a corridor were found. The three orthostats are granitic stones, with a porphyritic texture and a biotite composition, a type of material that is not present in the surrounding area, where limestone and metapelite predominate. Therefore, the builders had to walk several kilometers to obtain the slabs for the monument.

The most probable route would be the one going from the South-Southwest to the North-Northeast one (marked with a black arrow on the map -Fig. 9A-), considering the possible use of water streams and the lack of major obstacles, such as embedded valleys. This route presents a very slight slope without rocky formations and covers a distance of about five kilometers.

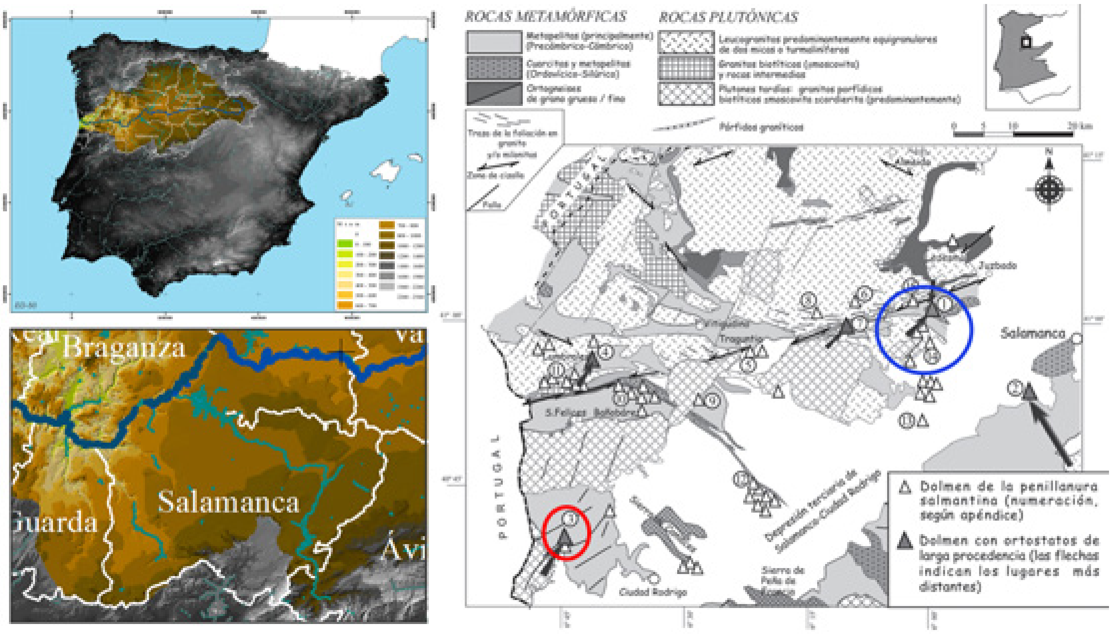

Figure 8 – Location of the two case studies on the use and provenance of different lithologies in a same megalithic group in the province of Salamanca and map of the geological characterization and the megalithic monuments documented in the region (López-Plaza *et al.*, 2008). Both case studies are highlighted: red circle-dolmen of La Hurtada and blue circle-the megalithic group of Villarmayor.

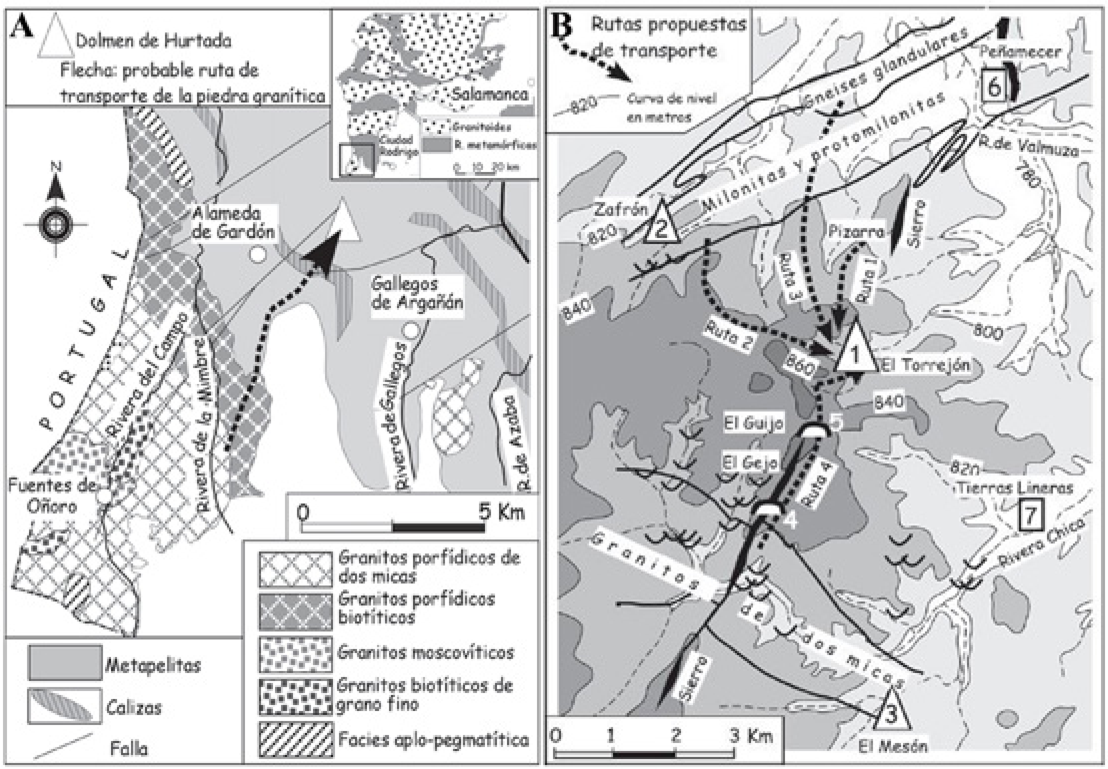

Figure 9 – A-Possible outcrop origin and transport route of the orthostats of the dolmen of La Hurtada. B-Location of the different monuments and settlements that are part of the megalithic group of Villarmayor and possible pathways from the different otucrops to the dolmen of El Torrejón (López-Plaza *et al.*, 2008).

The second case is related to the megalithic group of Villarmayor, consisting of small 'Simple barrows' and 'Single chambers' (such as El Guijo de las Navas mounds) and 'Passage graves' (such as Zafrón, El Mesón or El Torrejón). In light of the material culture, all these types of megaliths seem to be contemporary, but their location in the landscape, architecture and lithology are clearly different. The dolmen of El Torrejón, the biggest one, is located in the middle of the megalithic group. It is a 'Passage grave', whose subcircular chamber only preserves in situ one of its slabs on the southern side, while the rest of orthostats were found knocked down. Thanks to the archaeological evidences, it has been possible to find out that the chamber was composed of fourteen orthostats. Meanwhile, the corridor has remained mostly unchanged, with nine slabs in situ on its northern wall and more than ten on the southern one, all of them arranged horizontally and supported on the natural substrate (Arias, 1989: 400-401).

Most monuments of the megalithic group of Villarmayor are composed of local granite and quartz (as in the case of El Guijo mound), but El Torrejón shows seven different lithological types (López-Plaza *et al.*, 2008: 116-122, Tabla 1): quartzite, three different kinds of granite, schist, glandular gneiss and, above all, milky quartz (the material of sixteen orthostats of the corridor). It should be pointed out that while the corridor is mainly made with local quartz, the chamber displays a far greater diversity of materials. They do not only proceed from local sources; some have been brought from long distances. In fact, the glandular gneiss, with an anomalous texture, had to travel a significant distance.

Therefore, there seems to exist four different radial routes of arrival of raw materials (Fig. 9B), with transportation distances between twenty meters and four kilometers: the shorter distance for the local materials, such as the quartz, and the four kilometers or more for other stones, such as the glandular gneiss. This fact emphasizes the significance of the monument of El Torrejón as the axis of the megalithic group of Villarmayor (López-Plaza *et al.*, 2008: 120).

The use of different raw materials in the building of megaliths has been documented in some nearby examples, such as the chambers in the dolmens of El Teriñuelo de Aldeavieja, Linejo or La Ermita (Tejedor-Rodríguez *et al.*, 2017: 46-48) or the corridor in El Teriñuelo de Salvatierra, made out of quartz and slate (Santonja *et al.*, 1996: 19). Some other exceptional cases have been recorded outside the province of Salamanca, such as the mamoa of Castelo I, located in the district of Vila Real (Sanches *et al.*, 2005: 19-21), or the tholos of La Sima in the Soria province, that will be next the object of further attention (Rojo, García *et al.*, 2005: 685-686; 2013: 215-217, Fig. 2).

4.2. Colour and raw materials as references of a microcosm: the case of the Ambrona Valley (Soria)

Research on the use of different lithologies in megalithic constructions and on the reasons behind the choice of such stones -something that, as we mentioned above, has experienced a great advance in recent years- has shown that, among other aspects, the election of colour played an essential role (Jones, 1999; Jones & MacGregor, 2002). Several authors have proposed that, by using stones of different colours and their intentional arranging inside the megaliths according to some given patterns, the builders of the monuments tried to establish a link between the building and some natural elements of the surrounding area. Thus, the symbolic qualities and meaning attached to the landscape were conferred upon the megalith, and inversely, the stones used in the construction would carry the sacred potential suggested by the surrounding area (Scarre, 2002: 12).

The second study case presented in this paper refers to the Ambrona Valley, located in the province of Soria (Fig. 10; Rojo, Kunst *et al.*, 2005). It does not especially focus on the lithology and provenance of raw materials, because all of them come from local sources. Thus, the discussion aims to interpret the symbolic use of contrasting stones both in texture and colour, as well as their arrangement within the monument and their relation to the surrounding landscape. The megalithic monument of La Peña de La

Abuela, located in the village of Ambrona, is a 'lime-kiln tomb' dated by radiocarbon to the beginning of the 4th millennium cal. BC (Fig. 7). As we have explained above, this type of megalithic graves originally could have been a round corbelled tomb like a tholos, made with limestone blocks. Therefore, it is striking that in the interior of the collective ossuary there were sandstone cists containing some human remains, which were clearly segregated from the rest (Fig. 11A). After the burning of the tomb, it was monumentalized by the construction of a stone mound over the lime crust, crowned by a small menhir -that was later destroyed by modern ploughing- becoming in a reference point in the landscape (Rojo *et al.*, 2010: 256-257).

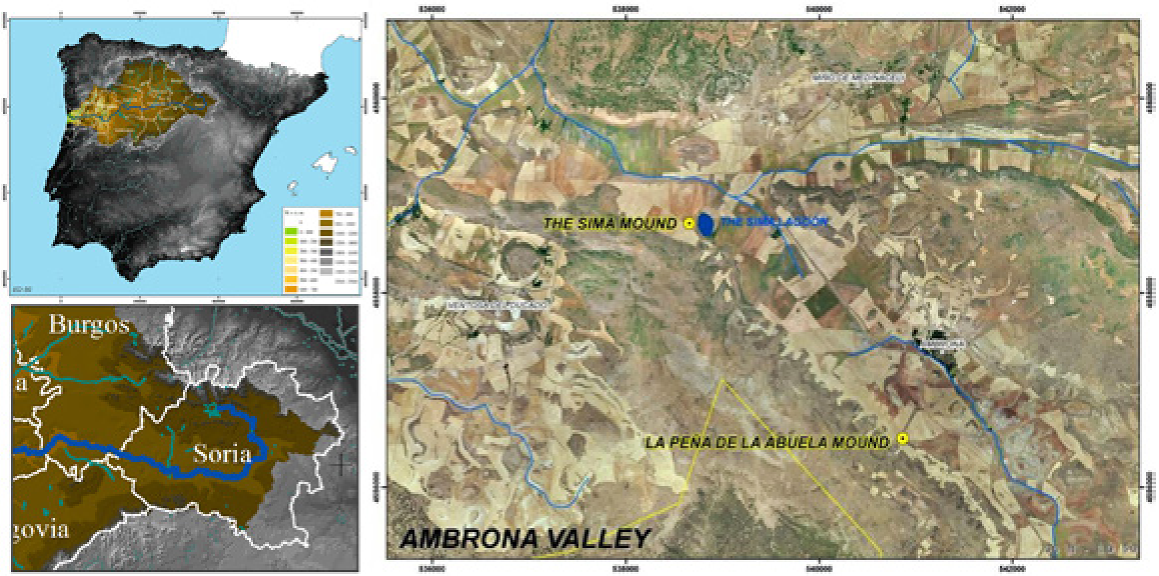

Figure 10 – Location of the two case studies on the use of different lithologies due to their different colour and/or texture features in megalithic monuments of the Ambrona Valley (province of Soria).

The monument of La Sima, located next to the La Sima Lagoon in the village of Miño de Medinaceli, is a complex burial monument with different phases of construction and use. At first, it was another 'lime-kiln tomb', contemporary of the site of La Peña de la Abuela, whose original internal structure was totally made of limestone. After its closing by fire, a new tomb was built on top of the resulting quicklime crust. In this case, it was an authentic stone tholos made of limestone and sandstone slabs that were arranged following a specific pattern (Fig. 12B). On the one hand, two sandstone geminated cists were documented inside the collective ossuary, as in the case of La Peña de la Abuela. On the other hand, while the sandstone slabs were placed at the back of the chamber, in front of the entrance, the limestone ones were positioned in both sides. Thus, the only wall of the tholos illuminated by sunlight was the one made of sandstone, leaving in darkness the rest of the tomb. Such a strong association between light and architecture has been also attested in other European megalithic areas (Bradley, 1989; Jones, 1999: 344-346).

Moreover, the stone mound of La Sima in its earlier phase was made with limestone stones, covered in some parts by reddish sandstone slabs (Fig. 11B) whose colour displayed a striking contrast with the bright white chamber (Rojo, García *et al.*, 2005: 684-685). Later, important changes took place because, due to a subsequent remodeling, the reddish slabs were covered by limestone blocks and some parts were destroyed, thus disappearing the chromatic contrast of the earlier phase between the mound and the chamber (Rojo *et al.*, 2013: 216). The studied territory provides some further examples of the combination of earth and/or stones of various colours, sizes and textures in the different layers or levels of megalithic tombs. Such is the case of some dolmens from Salamanca, like El Teriñuelo de

Aldeavieja or El Prado de la Nava, where a surface layer of slate partially covered the top of the mound (Tejedor-Rodríguez *et al.*, 2017: 46-48).

Therefore, the existence of specific patterns of combination of two types of local raw materials (red sandstone and white limestone) is documented in both megalithic monuments; however, its different use cannot be explained by architectural reasons. In this regard, this use of stones with different lithology and a clear chromatic contrast could be interpreted from two different viewpoints, one from 'Inside the Monument' and another from 'Outside the Monument'.

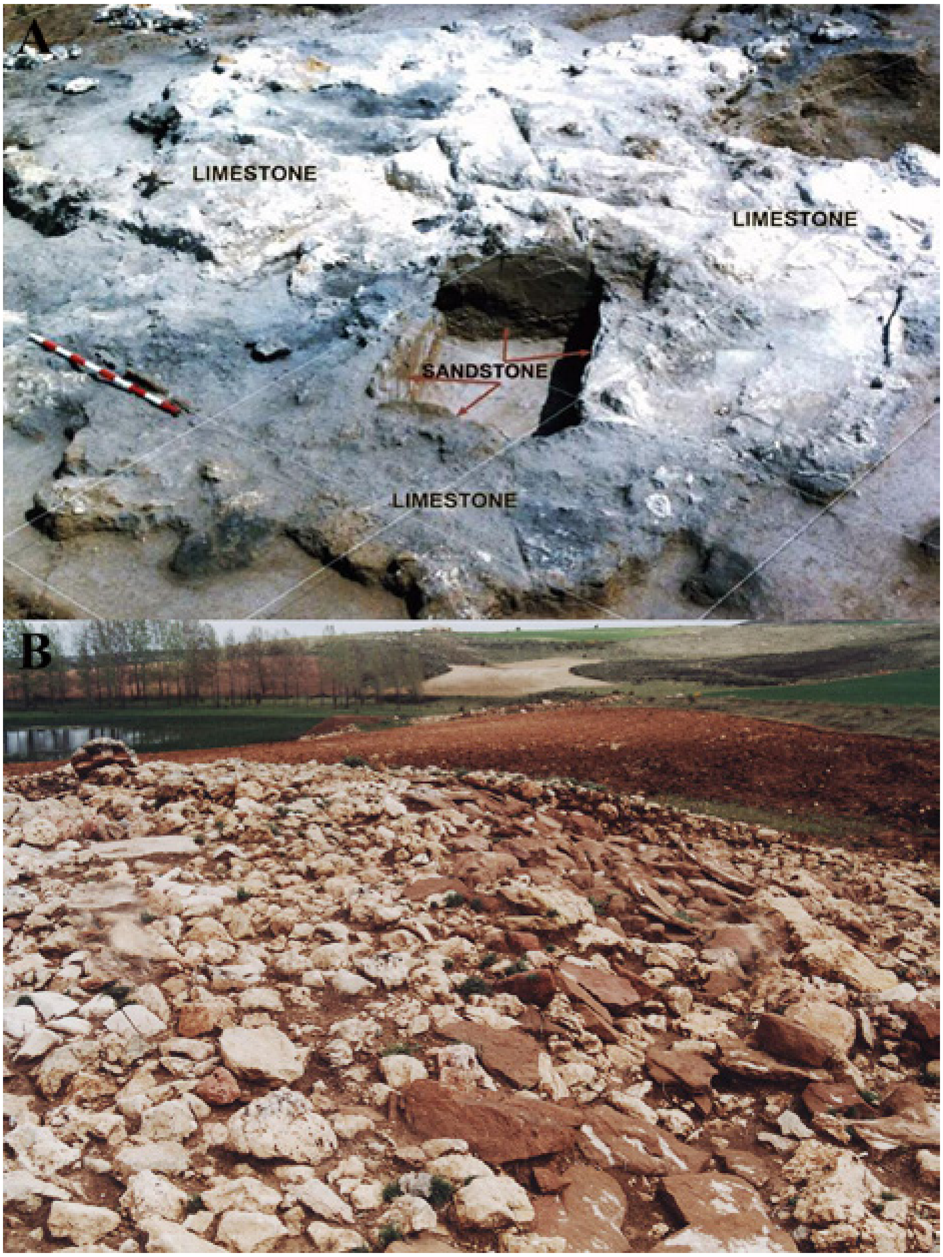

Figure 11 – A-Use of a combination of limestone and sandstone in the chamber of La Peña de la Abuela tomb: the limestone turned into a quicklime crust due to the burning ritual while the sandstone cist was preserved from the destruction. B-La Sima Mound in its earlier phase when reddish sandstone slabs were covering part of the mound made of limestone blocks.

The burial chambers of both megaliths were built with limestone, and the bright white colour would stand out against the surrounding environment. Thus, the pattern 'Inside the Monument' is determined by the chromatic contrast established between the original white colour of the limestone slabs of the chamber and the red of the sandstone cists placed inside the ossuary, and, similarly, between the different levels of the early stone mound in La Sima (Fig. 11). This fact has been interpreted considering the possible symbolism of the colour: the white colour might be an important symbolic reference to the presence of the ancestors' bones in the tombs, thus being the 'colour of death', while the red was the 'colour of life' -a reminiscence of the flesh and blood- in an attempt to endow with life the human bones (Jones, 1999: 347-348).

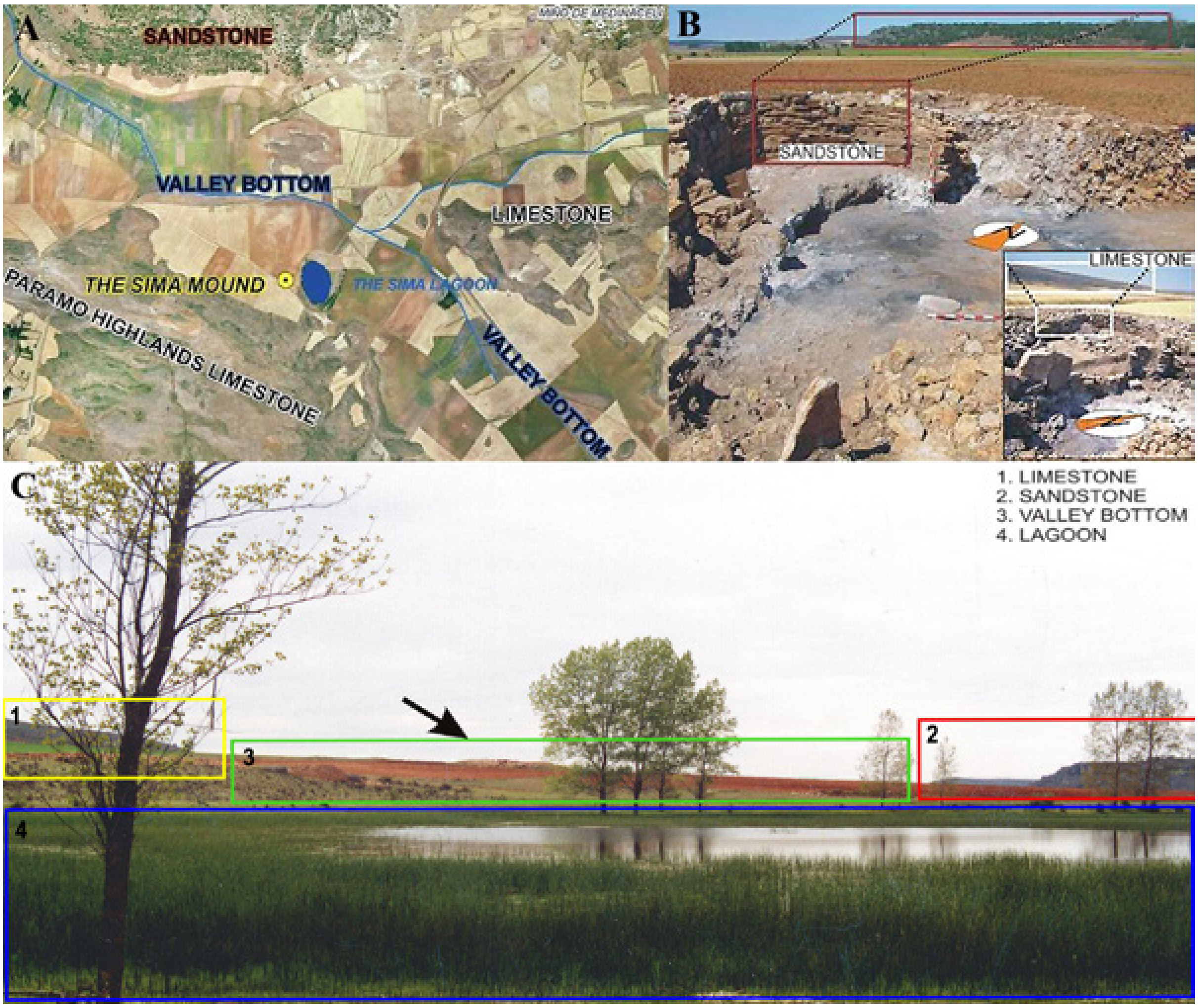

Figure 12 – A and C- Location of the different raw material outcrops and the three main geological features of the Ambrona Valley in the sourroundings of La Sima Mound. B-La Sima Mound as a schematic and symbolic model of the Ambrona Valley landscape according to the researchers (Morán, 2005 and Rojo *et al.*, 2013).

Additionally, the view from 'Outside the Monument' is determined by the aspect of the monuments with regard to the relationship between the raw materials they feature and the landscape. On the one hand, the sandstone and the limestone are easily accessible in the surrounding area (Fig. 12A). On the other hand, both megalithic monuments are located in the valley bottom, a place that provides visual control of rock outcrops, gathering together in a single place the three main geological features of the Ambrona Valley: valley bottom, limestone moorlands and sandstone outcrops (Fig. 12C; Morán, 2005: 418-419). The monument of La Peña de la Abuela, built on a small natural promontory from which it would have visual control of the valley, stands out not because of its size (it is short and only four and a half meters in diameter), but because of its bright white colour, understood as a permanent reference to the ancestors' presence in the landscape. Likewise, La Sima attracts our attention not only on account of its size (its mound could have reached between 20 and 25 meters in diameter), but also because the white limestone burial chamber contrasts with the reddish sandstone level of the barrow. Besides, the presence of a small lagoon, whose symbolism is likely to have influenced the location of this monument, provides it with a greater significance.

Finally, it is also noteworthy the curious arrangement of sandstone and limestone slabs in the chamber of the second phase of La Sima, as it follows a very singular pattern (Fig. 12B). In this regard, the wall sectors built with sandstone were clearly oriented toward the location of natural outcrops, in the northern area of the Valley. At the same time, the limestone slabs pointed to the moorlands, the source of this type of stone. Thus, the arrangement of the raw materials in the chamber seems to be an attempt to schematically reflect the main features of the natural landscape of the Ambrona Valley.

Analysing these examples, as well as many others, it seems obvious that the colour would have been perceived and, also, endowed with a symbolic significance in the context of the megalithic monuments.

5. Concluding remarks

To sum up, the statistical analysis of radiocarbon dates shows that it is not possible to establish a diachronic pattern of different behaviours regarding the choice of architectural types in the Douro Basin. In fact, this 'architectural polymorphism' was present from the first stages of the Megalithism in the studied territory and, also, it has been able to establish two clear phases of constructive activity (Fig. 7). This means that the 'megalithic polymorphism' is not related to some kind of diachronic substitution or evolutionary development of architectural models, but rather that it derives from sociocultural issues. However, this must not void the possible existence of chrono-typological diachronic sequences well-defined in some local areas, such as the models from Serra de Aboboreira and La Lora reveal. In these cases, we might face a behaviour conditioned by a given cultural tradition or by the specific needs of the ritual developed at each moment.

Furthermore, the stones used in the megalithic monuments of the Douro Basin usually show a local provenance, with some exceptions. However, an intentional selection of different stones in relation to their lithology or other features, such as their colour and texture, has been documented in many cases. The study cases included in the present paper are proof of it.

Some authors have viewed the use of stones with various colours and textures, brought from a shorter or larger distance, as the result of the desire by the builders of the megalithic structures to integrate "the monumental" and "the natural", concepts that in some cases may have been mixed up, taking as old or ancestral constructions some natural forms of the landscape (Cummings, 2002: 112; Scarre, 2002: 8-9). Many times, the monuments seem to imitate the natural shapes of their surroundings, in order to fit the landscape, up to the point that it becomes hard to differentiate them (Garrido *et al.*, 2012: 168). Thus, the attributes and sacred power of some special places, probably with mythological associations, would be released and transmitted to the monuments (Scarre, 2002: 12). Therefore, this phenomenon shows how strong symbolic links could have been established between the megaliths and the landscape.

It has been proposed that the presence of several textures and colours in the stones used in the building of megalithic monuments may also reveal or mean 'the catchment area of the communities who built and buried their dead in the tombs' (Scarre, 2004: 198). In this sense, megaliths could be considered as microcosms or omphaloi of the 'universe' of prehistoric groups (Morán, 2005: 422), which would reproduce schematically the world of the living in the 'afterlife' (Garrido *et al.*, 2012: 169).

Acknowledgements

We do not want to finish our paper without expressing a heartfelt word in remembrance of Rui Boaventura, who was behind our participation in the interesting meeting of Mega-talks, held in Redondo in November 2015. Moreover, his research has been an important inspiration for this work. We would also like to express our most sincere gratitude to Rui Mataloto, as well as to the other members of the organisation of the congress, for their kindness during or stay and for giving us the opportunity to enjoy the lovely village of Redondo.

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Geology, Landscape and Meaning in the Megalithic Monuments of Western and Northern Europe

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Abstract: The incorporation of megalithic blocks in so many of the Neolithic monuments of western and northern Europe provides a direct connection with geology and landscape. The blocks themselves were often taken from local outcrops or boulder fields, but occasionally longer distance transport was involved. Coupled with the careful arrangement of blocks, sometimes drawn from different sources, within an individual structure, a strong case can be made that the individual blocks, and the places from which they came, held special significance for these Neolithic communities. To better understand that significance it is essential to consider the nature and appearance of the landscapes in which these monuments stood, before subsequent clearances and cultivation. Not only would woodland cover have been considerably more extensive, but many of these landscapes would have been rich in natural stone in the form of outcrops, stone scatters, or spreads of glacial erratic blocks. Megalithic monuments may indeed have been responding to prominent visible features of the landscapes in which they were built.

Keywords: Neolithic monuments; landscapes; geology; outcrops and erratics; Carnac; Channel Islands; megalithic quarrying

Geologia, Paisagem e Significado nos Monumentos Megalíticos da Europa Ocidental e do Norte

Resumo: A incorporação de blocos megalíticos em muitos dos monumentos neolíticos do ocidente e do norte da Europa fornece uma conexão directa com a geologia e a paisagem. Os blocos em si eram muitas vezes retirados de afloramentos locais ou campos de grandes pedras, estando o transporte de longa distância ocasionalmente envolvido. Juntamente com a cuidadosa disposição dos blocos, por vezes extraídos de diferentes fontes, dentro de uma estrutura individual, pode-se argumentar que os blocos individuais e os lugares de onde vieram tiveram um significado especial para essas comunidades neolíticas. Para entender melhor esse significado, é essencial considerar a natureza e a aparência das paisagens em que esses monumentos se situavam, antes das desflorestações e cultivos subsequentes. Não apenas a cobertura florestal teria sido consideravelmente mais extensa, mas muitas dessas paisagens teriam sido abundantes em pedra na forma de afloramentos, pedras dispersas ou extensões de blocos glaciais erráticos. Os monumentos megalíticos podem, de facto, responder a traços visíveis proeminentes das paisagens em que foram construídos.

Palavras-chave: Monumentos neolíticos; paisagens; geologia; afloramentos e erráticos; Carnac; Ilhas do Canal; pedreiras megalíticas

The defining feature of a megalithic monument is the size of the blocks used in its construction, and the geology, quarrying and transport of those blocks has long attracted scholarly attention and speculation. Geological studies have become a routine component of megalithic studies in recent decades. This indeed was a focus of Rui Boaventura's earlier work (Boaventura, 2000a, 2000b; Cardoso & Boaventura, 2011), and more recently of his important MEGAGEO project.

The size and weight of the slabs very naturally led to questions about their origin. Initially, research focused on the pragmatics of their construction: how were the Neolithic builders able to quarry and transport these large blocks? Impressed by the dimensions and weight of the stones, early accounts attributed megalithic monuments to supernatural beings or processes. Some 17th century historians suggested that the hunebeds of Drenthe province in the northern Netherlands had been built by giants, and illustrated them accordingly (Bakker, 2010, 48). Legend held that the Carnac alignments of southern Brittany were Roman legionaries pursuing Saint Cornély (a third century pope) who were turned to stone (Mérimée, 1836: 117). Other standing stones, such as the Heelstone at Stonehenge and the Devil's Arrows at Boroughbridge in northern England, were popularly believed to be the work of the devil (Burl, 1991; Barclay, 1895: 11). A few early writers, dismissing the option of supernatural agency, alternatively suggested that megalithic standing stones were natural phenomena or that the megalithic blocks themselves were artificial compounds of sand, lime and other materials – a kind of prehistoric concrete (Camden, 1610: 701).

The reasons for choosing to use such large blocks have also been the subject of much discussion. Ethnographic accounts of recent megalithic traditions in south and southeast Asia link them to social prestige and aggrandisement (Hutton, 1921: 345-347; Adams, 2009). Monumentality is indeed a widespread feature of human social behaviour, and one that has left an indelible mark on the archaeological record, expressing as it does, "in a public and enduring manner the ability of an authority to control the materials, specialized skills, and labour required to create and maintain such structures" (Trigger, 1990: 127). The construction of an enduring structure from extravagantly large blocks will have furnished a visible index of prestige and power; the extraction and transport of the blocks themselves another. Dragging a large stone over several kilometres demanded organisation, technical knowledge and a substantial labour force.

There is more to megalithic monuments, however, than size and weight alone. The stones themselves were often left with minimal shaping or modification, as if the natural surfaces, colours and contours of the blocks had to be preserved. This drew comment from earlier British writers such as James Fergusson: "With the rarest possible exceptions, they preferred their being untouched by a chisel, and as rarely were they ever used in any properly constructive sense" (Fergusson, 1872: 40). By retaining the shape and surface of the original material an important visual link was maintained between the quarried block and the cliff, the outcrop or the erratic from which it was taken. That such a link was recognised by these early societies is highlighted by the way that stones from different and visually distinct sources are often incorporated in a patterned and intentional manner within a megalithic tomb or stone circle. This suggests that the sources themselves may have held special significance, a significance that went beyond their pragmatic function as providers of suitable blocks. Many of the sources may indeed have been conspicuous and symbolically important features within the landscapes of the megalith-building communities. The fact that similar relationships between megaliths and landscapes have been documented from Scandinavia to southern Spain provides intriguing support for the long-held belief that the megalithic traditions of western and northern Europe were underpinned by shared or overlapping ideologies and cosmologies.

1. Clearing landscapes, constructing monuments

A crucial consideration in seeking to understand the sourcing and transport of megalithic blocks is the character of the prehistoric landscapes before modern stone clearance. One issue is tree cover. Claims for long-distance intervisibility between megalithic monuments or between monuments and landscape features (*e.g.* Bergh, 1995; Cummings *et al.*, 2002; Roughley, 2004) are dependent upon the presence or absence of woodland cover. Even such open landscapes as those of Orkney today are known to have had significant areas of tree cover in the prehistoric past (Farrell *et al*., 2014). Palaeoecological study in northern Germany has concluded that the megalithic tombs of Krähenberg were embedded in a woodland landscape with only small forest openings (Sadovnik, 2014). Conversely, pollen and soil micromorphology in southern Brittany indicate a relatively open landscape during the 5th and 4th millennium BC, when the impressive Carnac mounds, stone rows and passage graves were being built (Marguerie & Marcoux, 2009). In regions such as northwest Iberia, the pattern is less clear, with human impact on forest cover already apparent in the mid-5th millennium, when the first passage graves were erected, but accelerating only in the 3rd millennium, after passage grave construction had ceased (Lillios *et al*., 2016: 145-147).

This regionally diverse evidence for the degree of tree cover is probably to be extended to the stoniness of the landscapes in which the first megalithic tombs were built. It is no surprise to observe that megalithic tombs were built mainly in areas where suitable large stones were locally available. In seeking to explain the origins of the megalithic tradition, indeed, the presence of loose blocks and outcrops may have provided not only a convenient source of raw material, but may also have provided inspiration for the tradition itself. In considering the link between megalithic monuments and stony landscapes, however, it is crucial to explore the way in which those landscapes have changed since the monuments were built. To some extent, indeed, the construction of megalithic monuments will itself have altered the original stony character of the locales in which they were built. This makes it all the more important to reconstruct, as far as possible, the presence of stone within those landscapes. Boulders, cliffs and outcrops will all have been significant components of pre-megalithic landscapes.

The stoniness of pre-megalithic landscapes must be considered on a region-by-region basis. In northern Europe (northern Germany, the Netherlands and southern Scandinavia) the relatively low-lying landscape of the North European plain consists mainly of boulder clay laid down by melting ice sheets. Trapped within the boulder clay are large numbers of glacial erratics that furnished the raw material for the megalith-builders of this region. This has long been recognised: "The stone blocks of which the hunebeds are constructed were unquestionably found in the immediate vicinity of the spots where they have been erected. They are water-worn and rounded boulders of granite or gneiss, which have been transported by a glacial sea moving southwards from Scandinavia, and scattered broadcast on the way" (Lukis, 1879: 49). Geologist Otto Gehl subsequently mapped the distribution of megalithic tombs in relation to a series of end moraines and surviving glacial erratics in Mecklenburg, demonstrating a spatial association between them (Gehl, 1972). In Drenthe province, too, in the northern Netherlands, tomb location can be tied directly to the presence of stonefields left where erosion had removed the boulder clay in which the glacial erratics were contained (Bakker & van Waateringe, 1988).

It is difficult today to appreciate the original appearance of these boulder-strewn landscapes. To do that, one must look beyond Europe to formerly glaciated regions with a shorter and less intensive history of agricultural clearance. One such is western Canada, where the Foothills Erratic Train of Alberta stretches 580 kms across the landscape. Even here, however, human action is rapidly depleting the boulder fields and it is likely that other erratic trains of similar scale may have been entirely removed by clearance of land for agriculture (Jackson, 2017).

Hence the landscape in which the megalithic tombs of the North European Plain were constructed was one strewn with glacial erratics, most of which have been removed, either to clear land for agriculture, or as raw material for building. The process of clearance became particularly intense from the 18th century but may have begun at a much earlier period: successive studies have revealed evidence of agriculture (in terms of plough marks or altered soils) beneath these megalithic tombs. The creation of arable fields would inevitably have involved the removal of erratic boulders (Midgley, 2008: 41).

In southern Britain, too, recent studies have revealed the interplay between stony pre-megalithic landscapes and the construction of megalithic monuments. Major stone circles appear today as prehistoric structures in carefully manicured settings of short-cropped grassland. That, however, is the end result of centuries of stone clearance. The dominant elements of megalithic sites in the Wessex region are composed of 'sarsen', a silicified sandstone formed from Tertiary sands that once covered the chalk downlands, and were locally hardened by silcrete formation to create sarsen boulders (Geddes & Walkington, 2005: 62-63). Natural processes of erosion, aided by human action, have subsequently destroyed or dispersed most of this stratum, leaving surviving boulder fields only in upland areas such as the Fyfield or Overton Downs, or in adjacent valley floors (Field, 2005) (Fig. 1). Mapping the original extent of sarsen distribution demonstrated that it had once reached as far as the South Downs and noted that large sarsen monoliths were still occasionally discovered hidden in sinkholes in the chalk (Bowen & Smith, 1977).

Figure 1 – Natural sarsen boulders at Lockeridge Down near Avebury, part of a once more extensive cover that has now largely been cleared. Photo: Chris Scarre.

In seeking to establish the origin of the sarsen monoliths employed for the construction of Stonehenge and Avebury, attention initially focused upon areas where blocks of sufficient size were still available today. As long ago as 1580, William Lambarde identified the Marlborough Downs as the probable area of origin (Chippindale, 1994: 37). The present restricted distribution, however, may not be a reliable guide to their availability in the 3rd millennium BC, when these impressive monuments were built. In addition to earlier agricultural clearances, there was extensive use of sarsen for building in the later 19th and 20th century. As Gillings and Pollard observe, this industry "completely reconfigured the stonescape within the Upper Kennet Valley and Marlborough Downs, with whole sarsen fields completely or largely worked out... The implication is that it is erroneous to regard the distribution of sarsens surviving today (where for example the largest stones are currently confined to the higher portions of the Marlborough

Downs) as a direct proxy for the character of the distribution 300 years ago, let alone 6000" (Gillings & Pollard, 2016: 541).

The uncertainty over the prehistoric extent of sarsen distribution in Wessex makes it difficult to identify the precise source of the stones, though it is likely to have been closer to the monuments than the current scatters of sarsen blocks suggest. The large numbers of surviving sarsens noted by earlier travellers testify however to the much greater abundance of this material in times past. Indeed, before clearance for agriculture and building stone, the entire landscape may have been littered with sarsen blocks of varying sizes. That would imply that the sites of Stonehenge and Avebury themselves may have had to be cleared of boulders before the monuments were laid out, and some of those stones might have been incorporated in the megalithic structures that were built on those sites (Field, 2005: 91). The construction of these stone circles may not only have required the bringing of stones from distant sources, but the removal of stones from their interiors.

In northwest France, in the Carnac area, the connection between the extensive stone rows and the natural blocks and outcrops around them drew comment from British visitor John Bathurst Deane in the 1830s. Bathurst Deane was convinced that the Kerzerho, Le Ménec, Kermario and Kerlescan alignments had originally been linked together and were the truncated remains of a single 12-kilometre stone setting. Prosper Mérimée countered by observing that there was simply no evidence that stone rows had ever linked the eastern end of Kerzerho to the western end of Le Ménec (an interval of no less than 5.5 kms) (Mérimée, 1836: 120-121). The proposal can be readily dismissed, but in searching for evidence to support his idea, Bathurst Deane had made careful inspection of the intervening terrain. The quantity of granite boulders he encountered between Kerzerho and Le Ménec led him to speculate that this "very remarkable bed of rocks . . . had the appearance of having been a quarry for the Dracontium. Some large stones were lying loose upon its surface, as if they had been prepared but never erected (Deane, 1834: 209) (Fig. 2).

What Bathurst Deane had observed in the 'bed of rocks' between Kerzerho and Le Ménec was the natural scatter of stone blocks that littered the surface of the Carnac landscape before modern clearances removed them. More recent study of another of the Carnac stone rows, Kerlescan, has identified in detail the process by which they were created. Careful analysis of the weathering patterns on the individual standing stones has revealed that some of these blocks may have been lying loose on the surface and the remainder could have been detached from the bedrock with relatively little effort. Furthermore, the variation in the size of the monoliths (smaller at the lower end of the slope, larger towards the upper end) was in direct relationship to the natural fracture patterns in the granite bedrock. Where the fracture lines were more widely spaced, the standing stones were correspondingly larger in size; as they grew close together towards the lower end of the stone row, the standing stones became progressively smaller (Sellier, 1991, 1995, 2013). This evidence suggests that the individual stones for the Kerlescan stone rows were taken from the immediate vicinity to where they stood, and that in building the stone rows, a natural landscape of boulders and small outcrops had been transformed into a cultural monument.

Similar studies by Emmanuel Mens have refined and expanded this methodology, applying it to another of the Carnac stone rows (Kermario) and to chambered tombs such as Mané Bras, Mané Bihan and Kerbourg (Mens, 2006, 2007, 2008, 2013). The implication is that entire outcrops have been dismantled for the construction of these tombs, and that the landscape we see today, is essentially a product of this and later human stone clearance.

Excavation in the Channel Islands provided direct evidence of stone clearance from a granitic landscape. The small island of Jethou has only a single surviving standing stone of prehistoric date, on the level summit of the island, although another lies fallen on the steep northeastern slope. The summit of the island today is divided by an impressive wall of upright 'megalithic' granite blocks (Fig. 3). It is possible that some of the blocks forming this wall may originally have been standing stones that were removed when the area was cleared for cultivation, perhaps when Jethou was a possession of the abbey of Mont-Saint-Michel from 1070 to 1416 (Johnston, 1981: 112). Within the now cleared area on the island summit, excavation uncovered the stumps of sockets for two (possibly three) embedded natural boulders. This suggests that the surface of the island, before clearance, was littered with natural granite boulders and presented an appearance very different from the open area that we see today (Scarre, 2016).

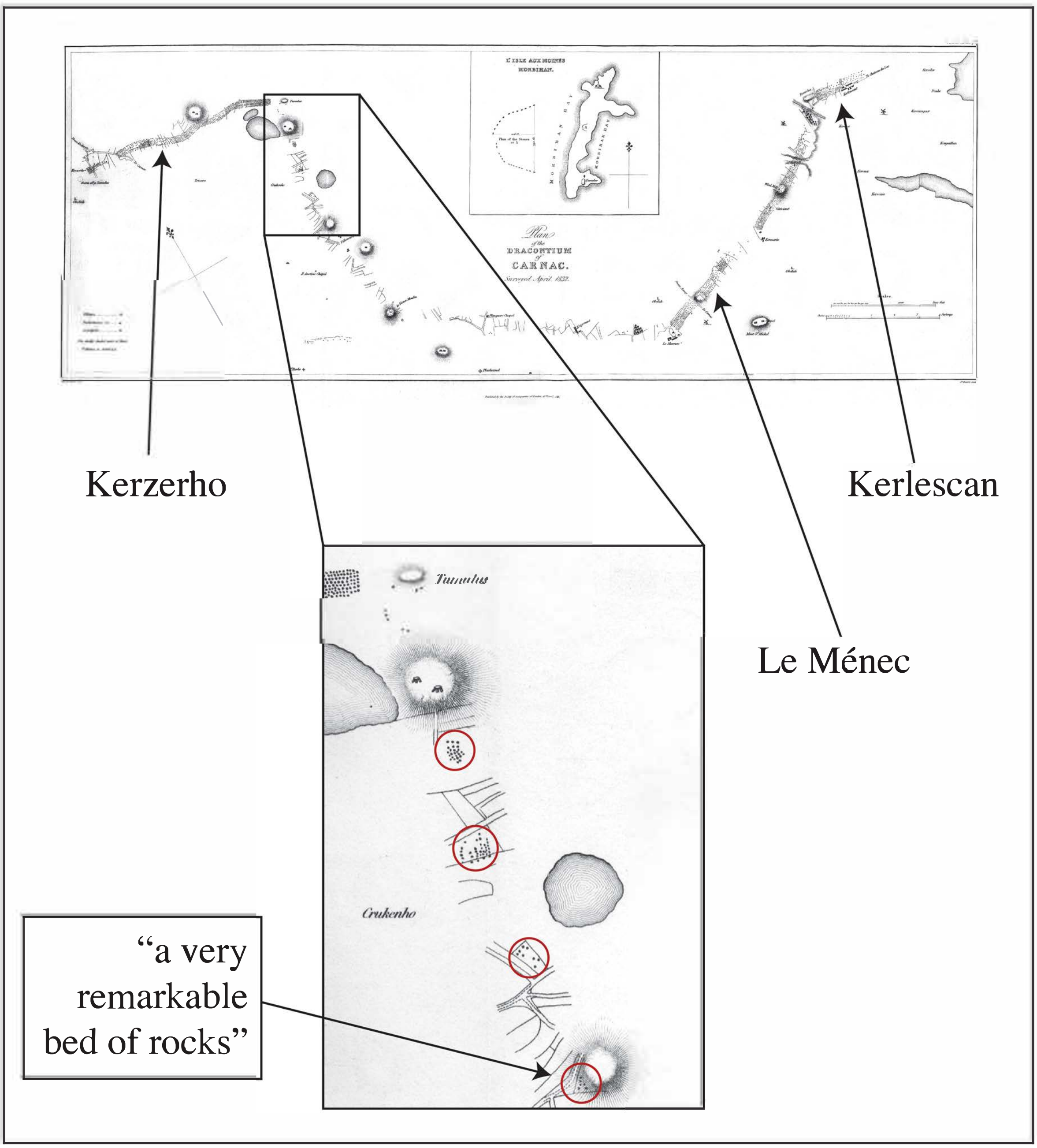

Figure 2 – Map of the Carnac alignments drawn by surveyor Murray Vicars, with (below) detail showing various stone scatters including the 'remarkable bed of rocks' described by John Bathurst Deane in his search for the missing elements that he believed had connected the Kerzerho stone rows to those of Le Ménec. From Deane, 1833

Figure 3 – Megalithic blocks on Jethou in the Channel Islands. Above, wall of megalithic blocks marking the edge of the open area on the summit of the island; below, hollows and fragments left by removal of earth-fast boulders from the middle of the open area. It is possible that the entire surface of the island was covered by granite blocks embedded in the eroded bedrock surface, and that some of those removed were used to construct the megalithic wall in the medieval period. Photos: Chris Scarre.

Granitic landscapes are a feature also of western Iberia where once again large numbers of megalithic monuments are encountered. Boulder fields still survive in Spanish Extremadura and some areas of the adjacent Portuguese Alentejo. As in Brittany, geological study of tombs and outcrops has shown the particular way in which the latter were dismantled for construction of the former, exploiting natural cleavage planes. The forms of the megalithic blocks often allow the manner of extraction to be deduced: small and medium sized capstones have a flat underside and a convex upper side, the latter with weathering that indicates that it was the original surface of the rock. Larger parallel-sided capstones could also have been extracted horizontally by exploiting natural cleavage planes. Orthostats were sometimes extracted from the lower part of the outcrop, in vertical position (Vortisch, 1999). Thus the tomb replicates in some degree the original position of its constituent megalithic blocks within the source outcrop. Once again, the inevitable conclusion is that the many megalithic tombs of the Central Alentejo replace an original landscape much richer in granite outcrops that were dismantled in order to build them.

2. Extracting the stones, constructing the tombs

Given that many of the pre-megalithic landscapes of western and northern Europe were littered with detached blocks and outcrops of various sizes, it is all the more significant that in most cases, megalithic monuments were built not of boulders that were already detached, but of blocks that were deliberately quarried. The quarries in question were invariably superficial, so that the materials were a visible feature of the landscape before they were extracted. This reinforces once again the link between landscape and megalithic, between natural and cultural. It also gives significance to the way in which blocks were sometimes drawn from different sources, and arranged within the structure of a monument in a way that may itself have had symbolic meaning. Thus on the Scottish island of Arran, the megalithic chamber of Carn Ban is constructed of two geologically distinct stone types: red sandstone and grey granite. These two materials, drawn from different areas of the island, are distributed in a structured and intentional fashion within the tomb; the capstones, for example, are of alternating geology (Jones, 1999).

Similar examples are to be found in other regions. In southern Sweden, the cluster of tombs in the Falbygden region likewise makes use of materials from different parts of the landscape. Orthostats are mainly of the sedimentary rocks (red limestone and sandstone) that constitute the underlying geology on which the tombs stand; capstones, by contrast, are igneous blocks from the nearby tablelands. Thus the vertical geology of the landscape (sedimentary lowlands vs. igneous uplands) is replicated in the structure of the tombs themselves. This may be highly symbolic (Tilley, 1996: 124), although equally, it draws on the mechanical qualities of the respective materials. The sedimentary rocks are easier to split and shape; the igneous materials provide more robust capstones capable of spanning the chambers with less risk of fracture.

In both of these cases, colour and texture may be significant. That could hold too at Pornic in northwest France. Blocks of white quartz were used to striking effect at the entrance to the passage tomb of Les Trois Squelettes (de Wismes, 1876). At neighbouring Les Mousseaux, a cairn containing two parallel passage tombs, the megalithic blocks are all tertiary sandstones, but differences in colour and texture are nonetheless perceptible and stones of different kinds are arranged within the passage tombs in a clearly patterned way (Scarre, 2004).

A similar practice was remarked by Rui Boaventura in his study (with João Luís Cardoso) of megalithic tombs in the Lisbon region. In the case of Pedra dos Mouros, Monte Abraão and Estria, at Belas, he observed the selective use of slabs with surfaces covered by ichnofossils, which came from some distance away and were arranged in an alternation between smooth and 'decorated' surfaces that suggested a concern with symmetry and aesthetics (Cardoso & Boaventura, 2011). In an earlier study, Boaventura had noted the employment of megalithic blocks of different geologies among the passage tombs of Rabuje in Alto Alentejo: pink granite and metamorphic schist from the local area, but one megalithic capstone (Rabuje 1) drawn from a distance of 8kms (Boaventura, 2000a, 2000b). There might be a pragmatic explanation, in the greater size of Rabuje 1, but symbolic considerations cannot be excluded. Geological study of the Vale de Rodrigo tomb group has documented a similar pattern of largely local stone sources complemented by occasional longer-distance transport (Dehn *et al*., 1991; Kalb, 2013)

The meaningful and structured use of geology, visible through contrasts of colour and texture, is hence a feature of Neolithic megalithic architecture throughout western and northern Europe. It is occasionally manifest also in stone shapes, most strikingly in the 'twin stones' found in Danish megalithic tombs. These consist of glacial erratics that have been split in two to give a pair of equivalent blocks with matching faces. Around 20% of Danish megalithic tombs have twin stones of this kind, and they are always placed within the structure in reference to each other: sometimes alongside, sometimes opposite, sometimes forming a corner. The intentional nature of the arrangement is clear, and implies that these matching stones had a special significance for the builders (Dehn & Hansen, 2000). Hence here again there is unmistakable evidence that the megalithic blocks were not used randomly but that their selection and their positioning were intensely meaningful to the communities who built them. The argument can of course be extended to the re-use of megalithic blocks – whether former standing stones, decorated stelae or dismantled from earlier chambers – about which there is now an extensive literature (*e.g.* L'Helgouach, 2007; Ard *et al*., 2016; Díaz-Guardamino, 2015; Bueno Ramírez *et al*., 2016).

Much of this significance must relate to the specific places from which the stones were derived. In only a few cases, however, have the megalithic quarries themselves been directly investigated. Excavated examples take us from Scotland to the Alentejo, including Vestra Fjold in Orkney and Na Dromannan in the Hebrides; Craig Rhos-y-felin and Carn Goedog in southwest Wales; L'Hirondelle, Rocher-Mouton and other sites in northwest France; and Murteiras in the Alentejo region of Portugal (Richards, 2013: 127-143, 248-251; Parker Pearson *et al*., 2015; Benéteau-Douillard, 2013; Mens, 2009; Calado, 2016). Among the most graphic is the quarry for the Menhir of Barrocal near Monsaraz in Alentejo, where a dramatic granite outcrop 300m away still bears the deep vertical scar left by the extraction of the monolith (Calado, 2016).

The majority of these quarries were associated with the construction of standing stones – either individual menhirs, or in the case of the Scottish and Welsh examples, stone circles. That may partly be a function of size, since many standing stones were larger than the orthostats and capstones used for the construction of chambered tombs (Calado, 2016). It raises the possibility of systematic differences between the quarrying of monoliths and the extraction of blocks for orthostats and capstones, although any such difference will only be confirmed when more examples have been investigated.

Even where quarrying evidence cannot be detected, the sources of megalithic blocks can sometimes be localised. The megalithic tombs at Cota near Viseu in Portugal drew their materials from an exposed granite surface 300m to the south. The connection is shown by the loose granite blocks at the northern end of this exposure, where the thickness of the natural slabs corresponds to those in the tombs and the perpendicular natural clefts and fissures produce blocks of a similar size (Dehn *et al*., 1991). At Barnenez in Brittany, the sources of several of the materials used for the megalithic blocks have been identified with more or less precision (Giot *et al*., 1995). Likewise, the megalithic blocks for the Menga chambered tomb at Antequera include breccias that can be traced to the cliffs of Cerro de la Cruz and Barrio de los Remedios, less than half a kilometre to the west (Carrión *et al*., 2009).

In a number of cases, megalithic tombs are built directly against outcrops or incorporate outcrops in their construction: in south Wales, in Galicia, on the isles of Scilly, or in northwest France (Cummings, 2002; Boado & Villoch Vázquez, 2000; Robinson, 2007; Scarre, 2011: 248-249). At Brécé in western Normandy, the outcrop itself appears to have been quarried into to accommodate one end of the burial chamber (Bouillon 1989). Whether these outcrops were quarried for orthostats or capstones is highly probable although not always established directly. At Guilliguy, however, on the northern coast of Brittany, the weathering pattern on one of the orthostats suggested that it had been taken directly from the neighbouring outcrop (Le Goffic & Peuziat, 2001).

The search for megalithic quarries today is of course severely compromised by quarrying in more recent periods, and by the spread of modern development. Some sources will have been worked out, while at others all traces of earlier working will have been erased. The evidence, nonetheless, is sufficient to demonstrate that in most cases, the megalithic blocks were derived from the vicinity of the locations where the tombs were built; in most cases within a range of 500 m, and almost invariably within a radius of 5kms. This is true not only for northwest Europe (Britain, northwest France and the Netherlands: Thorpe & Williams Thorpe, 1991), but for southwest Europe as well. The exceptions are nonetheless intriguing. Some involve still relatively modest displacements: the white granite capstone of Rabuje 1 brought from 8 kms, or the porphyritic granodiorite of Vale de Rodrigo from 7 kms (Boaventura, 2000a, 2000b; Dehn *et al*., 2001; Kalb, 2013). More spectacular is the long distance movement of the orthogneiss menhirs of southern Brittany, such as the "grande stèle de Runélo" ferried across several kilometres of open sea to Belle-Île, or the massive 300-tonne Grand Menhir Brisé quarried some 8-10 kilometres from the site where it now lies fallen and fragmented (Audouard & Large, 2013; Querré, 2006; Bonniol & Cassen, 2009). Then finally there is the long-distance transport of the Stonehenge bluestones, to be explained perhaps by their previous incorporation in a megalithic monument in southwest Wales that was subsequently transferred to Salisbury Plain (Parker Pearson *et al*., 2015).

3. Conclusions

Megalithic monuments by their nature draw attention to the geology of the settings in which they were built. The use of large blocks establishes a direct connection with the places from which those blocks were obtained. Understanding that connection inevitably demands an understanding of the Neolithic landscape. It is important, above all, to recognize how much those landscapes have been altered by the clearance of stones during subsequent millennia, and especially in recent centuries. This applies equally to the glaciated landscapes of northern Europe and the rocky promontories of the Atlantic façade, as well as to inland landscapes of Wessex and the Portuguese Alentejo. The ubiquity of stone cover provided an ample source of material, at least for the smaller megalithic elements; but it may also have played a fundamental role in the genesis of the megalithic tradition itself, drawing upon a pre-existing symbolism of special places within these rocky landscapes; a 'cult of stones'.

At a more detailed level, the connection between megaliths and their landscapes devolves to the issue of the individual blocks of stone. These prominent components may, in the case of chambered tombs, only have been visible while the construction project was in progress. Yet it is clear that blocks were intentionally chosen not only for their mechanical properties, but also because of their colour or texture, or because of the special significance of the places from which they were taken. It is this crucial insight which Rui Boaventura brought to the study of megalithic tombs in south-central Portugal: an insight that takes us beyond the pragmatics of megalithic construction to the deeper realm of symbolism and meaning. It is left now for others to continue that work.

Acknowledgements

I am grateful to Rui Boaventura and Rui Mataloto for their invitation to participate in the MEGAGEO programme, and for their hospitality in Portugal. The fieldwork on Jethou was undertaken with the permission and financial support of Sir Peter Ogden. I should also like to thank Manual Calado for a fascinating visit to the Menhir of Barrocal and the nearby outcrop from which it was taken; and to Jeff Veitch for assistance with Figure 2.

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Long-distance landscapes: from quarries to monument at Stonehenge

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Abstract: Stonehenge is famous for the distances moved by its stones, both sarsens and bluestones. In particular, the bluestones have their geological origins in West Wales, 225km away. Recent excavations at two of these bluestone sources – one for rhyolite and one for spotted dolerite – have identified evidence of megalith quarrying around 3000 BC, when Stonehenge's first stage was constructed. This remarkable movement of bluestones from Wales coincided with a decline in regional cultural distinctions between west and east, suggesting that building Stonehenge may have served to unify the Neolithic populations of Britain.

Keywords: Stonehenge; Megaliths; Bluestones; Quarrying; Neolithic

Paisagens longínquas: das pedreiras ao monumento em Stonehenge

Resumo: Stonehenge é famoso pelas distâncias percorridas pelas suas pedras, arenitos e pedras azuis. Em particular, as pedras azuis têm a sua origem geológica no ocidente do País de Gales, a 225 km de distância. Escavações recentes em duas dessas fontes - uma para riolito e outra para dolerito - identificaram evidências de extração de megálitos por volta de 3000 a.C., quando a primeira fase de Stonehenge foi construída. Este notável movimento de pedras azuis do País de Gales coincidiu com um declínio nas distinções culturais regionais entre o Ocidente e o Oriente, sugerindo que a construção de Stonehenge pode ter servido para unificar as populações neolíticas da Grã-Bretanha.

Palavras-chave: Stonehenge; Megálitos; Pedras Azuis; Pedreiras Neolítico

Stonehenge is unique amongst European prehistoric megalithic monuments for the distance moved by its stones (Fig. 1). Whereas the sarsens (blocks of silcrete weighing 4-30 tons) are likely to have come from 30 km away or even further (Parker Pearson, 2016), the smaller bluestones (a variety of igneous and sedimentary monoliths weighing 1-4 tons) were brought from west Wales to Salisbury Plain, a distance of at least 225 km as the crow flies (Fig. 2; Thomas, 1923; Atkinson, 1979; Parker Pearson *et al.*, 2011). Such distances are unparalleled for megalith-moving anywhere in Europe during the Neolithic or Chalcolithic; consequently, this extraordinary achievement demands explanation.

In contrast to many other megalithic monuments, the purpose of Stonehenge was not to erect a monument from the nearest available materials, but to bring specific stones across varying distances to a location which appears not to have been particularly favoured in terms of locally available stone resources (Fig. 3). It may be that the places of origin of these stones were an integral aspect of what was important about Stonehenge. By researching those origins we should come to a better understanding of what this iconic and unique monument was all about and how it helps our knowledge of prehistoric societies before the rise of early states.

Figure 1 – Stonehenge, viewed looking southwest towards the direction of midwinter solstice sunset (photo by Adan Stanford, Aerial-Cam Ltd.).

1. The Welsh bluestones at Stonehenge

Stonehenge's constructional sequence has been thoroughly reinterpreted since the threefold schemes of the 20th century (Atkinson, 1979; Cleal *et al.*, 1995). As a result of recent excavations and revisions of its stratigraphy, it is now understood as a sequence of five stages spanning the 3rd millennium BC and the first half of the 2nd, during Britain's Late Neolithic (c. 3000-2500 BC), Chalcolithic (c. 2500-2200 BC) and Early Bronze Age (c. 2200-1600 BC; Darvill *et al.*, 2012). The large, dressed sarsens with lintels were erected in Stonehenge's Stage 2 (modelled as 2620-2480 BC) as the horseshoe of five trilithons and the outer ring of lintelled uprights. The bluestone pillars are now thought to have been arranged in a double arc or circle between the trilithons and the sarsen ring, in a setting known as the Q & R Holes within Stage 2.

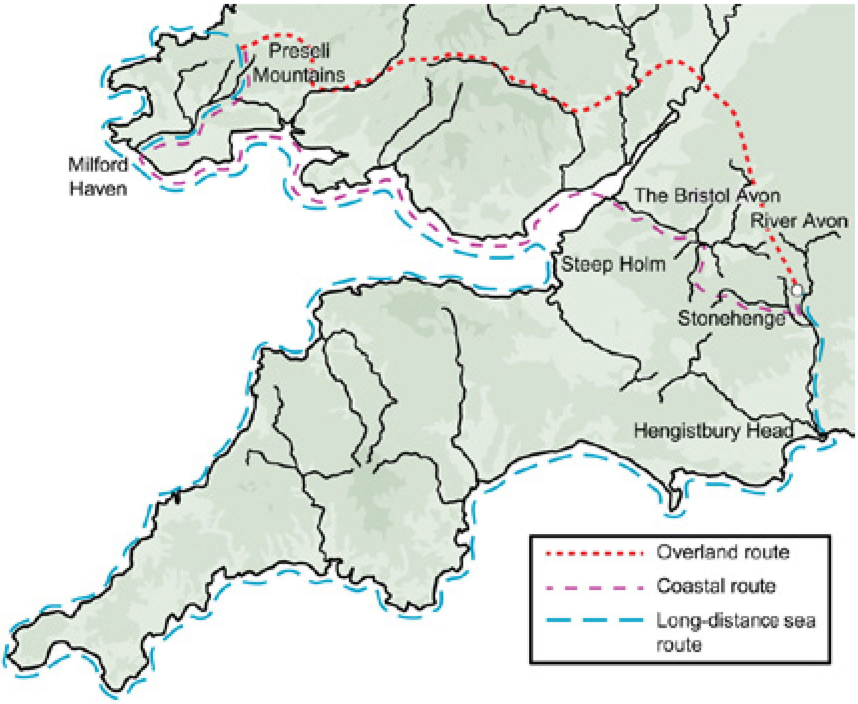

Figure 2 – Suggested routes for transporting the bluestones to Salisbury Plain; the route from Preseli to Milford Haven can now be ruled out for bluestones from Carn Goedog and Craig Rhos-y-felin (drawn by Irene de Luis).

Yet there is evidence that the bluestones were already present at Stonehenge in Stage 1, when the monument was first constructed in 3000-2920 BC. This first stage consisted of a banked and ditched circular enclosure with a variety of cut features interpreted as pits, postholes and emptied stoneholes (Fig. 4). Some of the stoneholes within the centre of the monument and outside its northeast entrance may have held sarsen monoliths. In addition, the circle of 56 Aubrey Holes inside the bank may well have held the bluestones during Stage 1.

Although Richard Atkinson was convinced from his excavation of two Aubrey Holes that they had merely been pits, the earlier excavator William Hawley concluded that 'there can be little doubt that they once held small upright stones' (Hawley, 1921: 30-31). Hawley excavated 32 Aubrey Holes and observed instances in which the basal chalk at the bottom of pits had been crushed under pressure that could only come from a stone upright, and in which the sides of the pits had been crushed during removal of standing stones. He also observed that cremation burials had been placed against the stones and in their 'packing' fills, before the stones were withdrawn, and also placed in Aubrey Holes after stones had been removed. Re-analysis of the depths and diameters of the Aubrey Holes reveals that they have the same dimensions as stoneholes in Stonehenge's later stages that contain bluestones (Parker Pearson *et al.*, 2009: fig. 8).

Stonehenge was by no means the first megalithic monument in the British Isles to incorporate a solstice alignment. Newgrange passage tomb in Ireland was built a few centuries earlier (c. 3300-2900 BC) and the rays of the midwinter-solstice sunrise famously shine down its long entrance passage (O'Kelly, 1982;

Hensey, 2015). Newgrange and its neighbouring passage tomb at Knowth incorporate rocks that are not from their immediate environs. Whilst the large kerb stones, passage stones and roof stones of greywacke come from Clogher Head, some 5 km away on the coast, other raw materials were gathered from further afield. Quartz blocks were brought from the Wicklow Mountains, some 70 km to the south, whilst granodiorite, gabbro, siltstone and granite stones probably came from up to 80 km to the north (Cooney, 2000: 136-138). The greywacke kerb stones weigh generally less than a ton, and the other rock types must have been brought in as basket-loads of cobbles and small blocks.

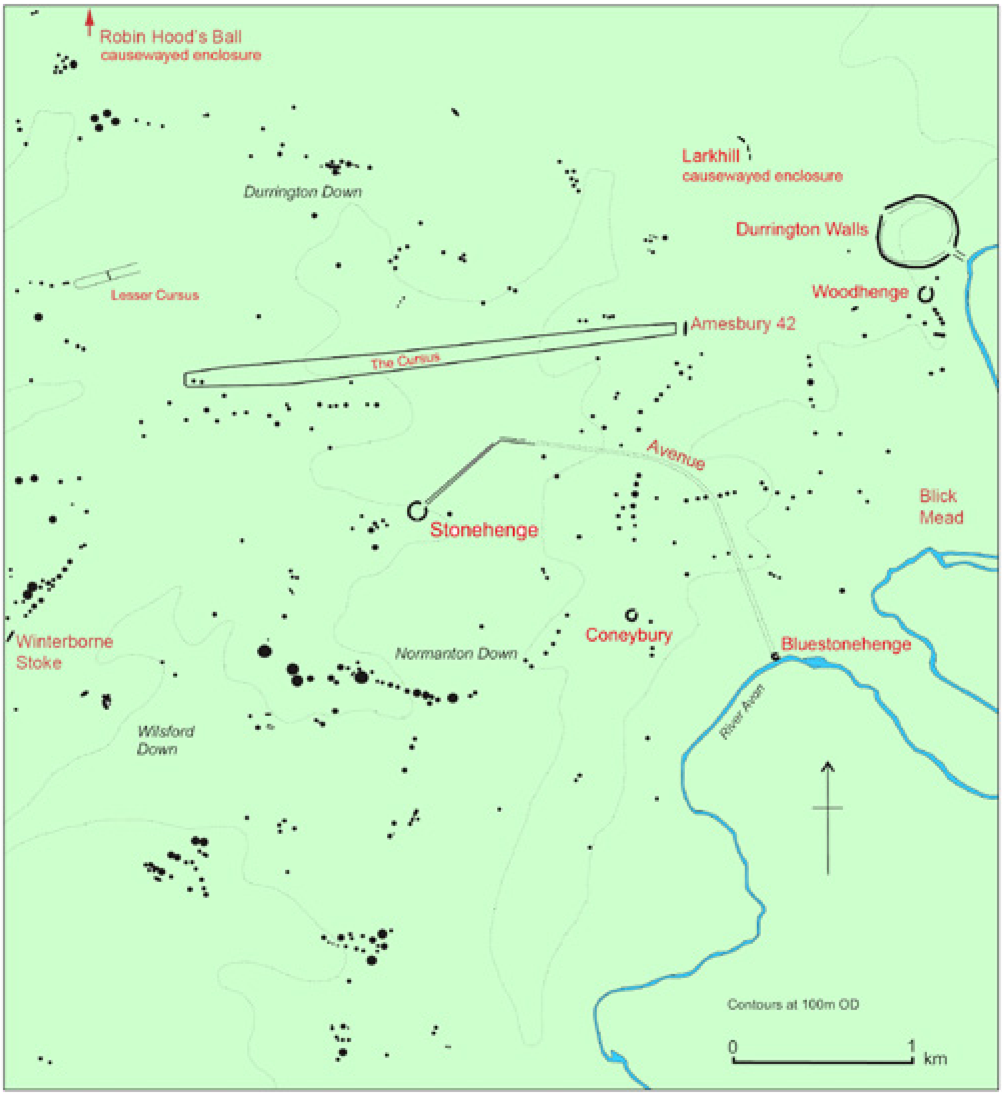

Figure 3 – The Stonehenge environs (drawn by Josh Pollard).

There was no shortage of stone materials within 5 km - 10 km to build the large, complex passage tombs of the Bend in the Boyne from local materials, so the importation of stones from long distances is likely to have been a deliberate and symbolic act. The various types of stone, especially quartz, may well have had a significance and colour that the builders sought. They may also have embodied a sense of place from their different origins, literally and metaphorically constructing the tombs out of the substance of far-off domains brought together into a single home for the ancestors whose cremated remains were placed inside.

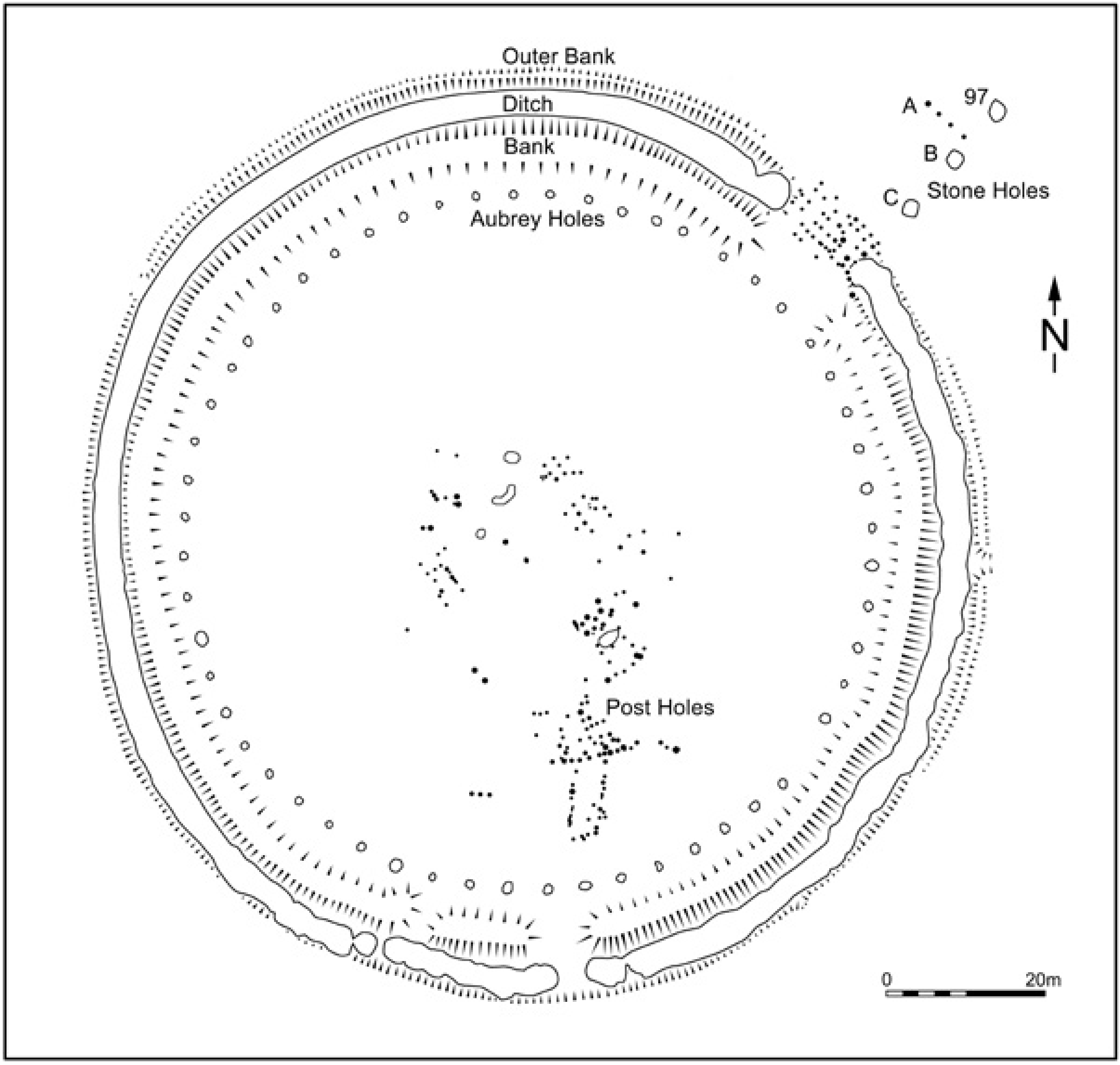

Figure 4 – Stonehenge Stage 1, 3000-2620 BC; the bank and ditch were constructed in 3000-2920 BC, around the same time as the Aubrey Holes (drawn by Irene de Luis)

2. Sources of the bluestones

Recent geological research into the geochemistry and petrography of Stonehenge's bluestones (by Richard Bevins and Rob Ixer) has revealed that they constitute at least 13 different types of rock (Table 1). All of these are likely to originate within the Fishguard district of Pembrokeshire, west Wales, with the possible exception of the Altar Stone, so-called because of its recumbent position inside the horseshoe of trilithons (Fig. 5). The Altar Stone is a 5 m-long monolith of Devonian Old Red sandstone from the enni Beds of south Wales, possibly even from the Brecon Beacons, 110 km east of the Fishguard district (Ixer & Turner, 2006). This corrects a previous, erroneous association of this stone with the Cosheston Beds near Milford Haven on the south coast of Wales.

Table 1 - Rock types of the Stonehenge bluestones and their geological sources.

Rock types	Source	Stonehenge stone
Spotted dolerite Group 1	Carn Goedog	Stones 33, 37, 49, 65, 67
Unspotted dolerite Group 2	Cerrigmarchogion or Craig Talfynydd	Stones 45, 62
Spotted dolerite Group 3	Carn Breseb, Carn Gwfry, outcrop near Carn Alw or outcrop w of Carn Ddafad-las	Stones 34, 42, 43, 61
Spotted dolerite ungrouped	Most likely Mynydd Preseli	Stones 31, 32, 35a, 35b, 36, 39, 41, 44, 47, 61a, 63, 64, 66, 68, 69, 70, 70a, 70b, 71, 72, 150
Rhyolite Groups A-C	Craig Rhosyfelin	Stones 32d & 32e
Rhyolite Group D	?Fishguard Volcanic Group	No stone identified; from debris only
Rhyolite Group E	?Fishguard Volcanic Group	Stone 48
Rhyolite Group F	?Fishguard Volcanic Group	Stone 46
Rhyolite Group G	?Fishguard Volcanic Group	Stone 40
Volcanics Group A	?North Pembrokeshire	Stones 32c, 33e, 33f, 40c, 41d
Volcanics Group B	?Fishguard Volcanic Group	Stone 38
Sandstone (Devonian)	Senni Beds, South Wales	Stone 80 (Altar Stone)
Lower Palaeozoic Sandstone		Stone 40g, 42c

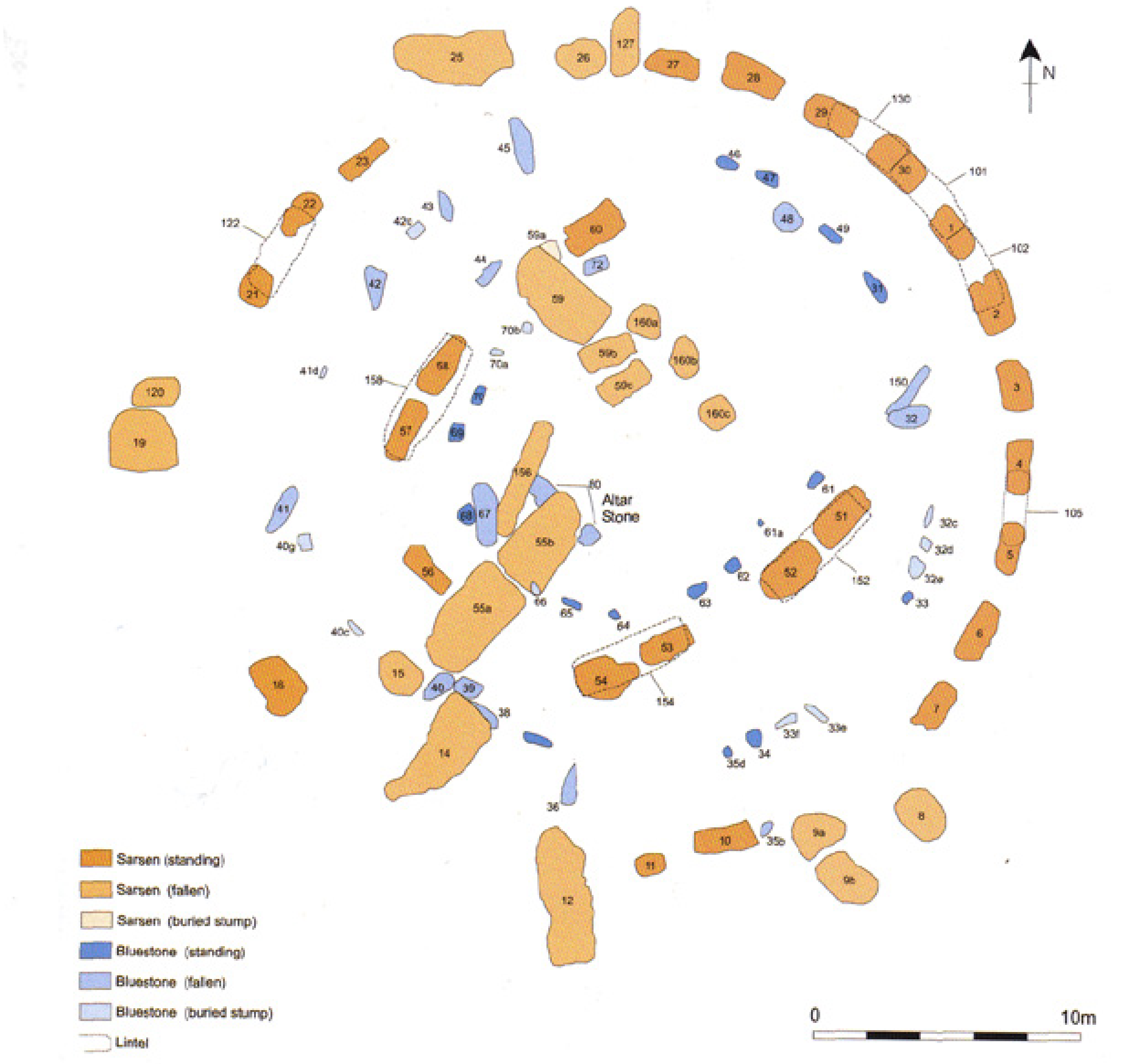

Figure 5 – Plan of Stonehenge's stones, showing the locations of the bluestones (© English Heritage).

Four of Stonehenge's types of bluestone have been more closely provenanced to source, all in the area of Mynydd Preseli and the lowland to the north (Fig. 6). One of these is a group of rhyolites (Rhyolite Groups A-C; Ixer & Bevins, 2011), pinpointed to the stream-side outcrop of Craig Rhos-y-felin within the Brynberian valley, a tributary of the River Nevern on the north side of Preseli (Fig. 7). Another is unspotted dolerite (Dolerite Group 2; Bevins *et al.*, 2013), derived from outcrops along the Cerrigmarchogion ridge that forms the central east-west spine of these hills, 4 km south of Craig Rhos- y-felin. The main source of the spotted dolerites (Dolerite Group 1 and possibly Group 3; Bevins *et al.*, 2013) is Carn Goedog, an outcrop halfway up the north flank of Preseli, just east of Cerrigmarchogion and 3 km south of Craig Rhos-y-felin. Finally, dating of palynological microfossils in Stonehenge's Lower Palaeozoic Sandstone rocks links them to Lower Palaeozoic metasediments to the north of Preseli (Ixer *et al.*, 2017).

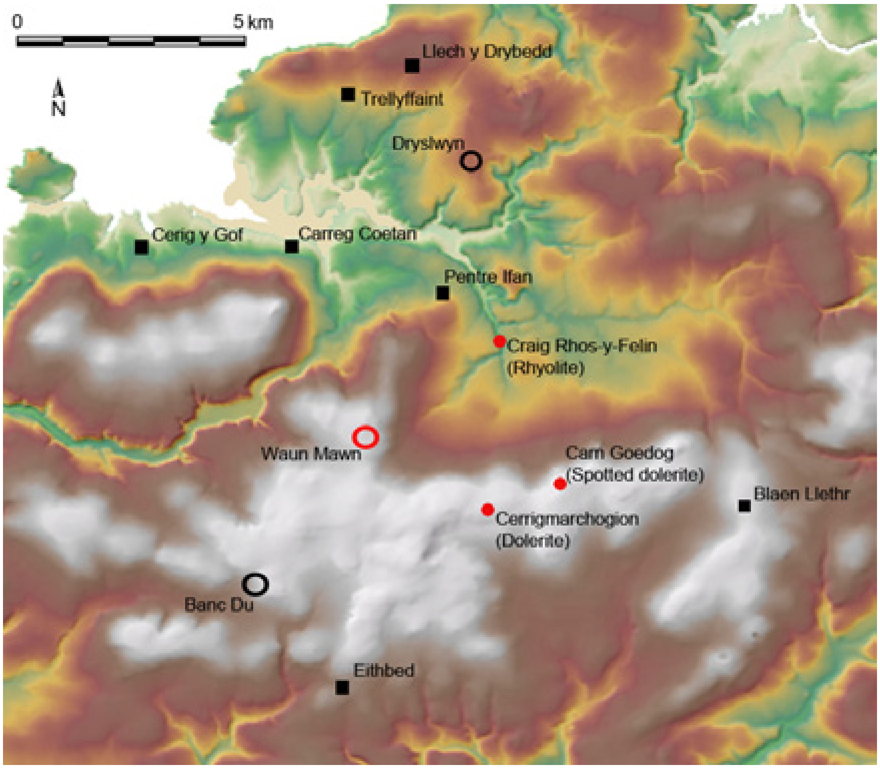

Figure 6 – The locations of Craig Rhos-y-felin and Carn Goedog within the watershed of the Nevern valley, Pembrokeshire, Wales; Neolithic dolmens are black squares and enclosures are black circles (drawn by Mike Parker Pearson).

Figure 7 – Known sources of Stonehenge bluestones in Preseli (yellow) and prehistoric sites (red) in their vicinity (from Google Earth).

For a hundred years now, geologists and archaeologists have known that Stonehenge's spotted dolerite derives from the Preseli hills (Thomas, 1923). Yet until recently, it was assumed that most or all of the spotted dolerite monoliths (of which there are 29) came from Carn Meini (also known as Carn Menyn), the most impressive of the outcrops, lying 2km southeast of Carn Goedog. Bevins et *al*.'s geochemical re-analysis of the 12 spotted dolerite monoliths at Stonehenge that have been sampled now reveals that five of them (Dolerite Group 1) can be sourced to Carn Goedog, and another four can be sourced to Carn Goedog or its vicinity (Dolerite Group 3). The recent provenancing of these various dolerites, rhyolites and sandstones found at Stonehenge restricts the distribution of their sources on current evidence to an area that may be no larger than 5 km east-west by 5 km north-south against the north flank of the Mynydd Preseli. However, a number of bluestone lithologies remain to be sourced with confidence.

3. Carn Goedog megalith quarry

Between 2011 and 2016, archaeological excavations were carried out at two outcrops revealed by geochemical and petrographic analysis to be sources of Stonehenge's bluestones. Excavations at Carn Goedog were commenced in 2014 with three test trenches along the north side of the outcrop, the only part with access to tall pillars suitable as standing stones (Parker Pearson *et al.*, 2019). The circumstances of formation of these dolerite pillars, with their characteristic white spots, some 482 million years ago were such that the magma cooled slowly to form tall, thin pillars separated from each other by narrow joint planes best exemplified by those on Carn Goedog's north side.

Test trench 1, the most easterly of the three trenches at Carn Goedog, revealed the most promising deposits and stratigraphy, commencing with a buried soil covered by flat slabs which had been laid, mostly with their fresh faces uppermost, to form an artificial platform. Roundwood charcoal of Pomoideae and *Corylus avellana* from this buried soil between and beneath the stone slabs yielded radiocarbon dates ending in 3020-2880 BC. Later activity here dated principally to the medieval period when the area was used as a seasonal settlement (*havod*), and the post-medieval period when the western part of the outcrop was quarried. Fortunately, this later quarrying had not extended into the eastern area with Neolithic deposits.

In 2015 and 2016, Trench 1 at Carn Goedog was extended to reveal not only the extent of the stone-slabbed platform but also its 1 m-high drop onto surrounding subsoil, a stone-filled, 11 m-long ditch (dating to 3020-2880 BC) beyond the southern edge of the platform, and a layer of upcast from the ditch spread on its southern side (Fig. 8).

On the north face of the outcrop, immediately above the platform (and unaffected by later quarrying which was marked by a 'skirt' of broken blocks further west) was a series of embayments or niches from which multiple pillars had been entirely removed, leaving no trace of any such pillars at the foot of the outcrop. Roundwood charcoal of *Corylus avellana* from the base of sediments in one niche included one piece with a date of 2125-1906 BC, suggesting that pillars had been removed from this niche by *c.* 2000 BC or earlier.

Acidic soils in west Wales prevent the survival of bone and antler, in addition to wood and other organic materials. Consequently, most of the expected material culture of Neolithic megalith-extraction – wooden wedges to insert into joint planes (and to expand when wet), antler and wooden hammers to drive in the wedges, and ropes to manoeuvre the pillars – cannot be expected to survive. The only finds from Carn Goedog were of stone: among the finds was a flint blade beside the ditch and several wedge-shaped blocks of sandstone with batter damage on both the blade and the head end. One of these wedges also exhibited a 'skid mark' caused by contact with a harder stone (Fig. 9).

Figure 8 – The excavation of Carn Goedog in 2016 (north is at the top); in front of the outcrop where pillars were removed is the stone platform, the stone-filled ditch and, closer to the camera, the upcast from the ditch (photo by Adam Stanford, Aerial-Cam Ltd.).

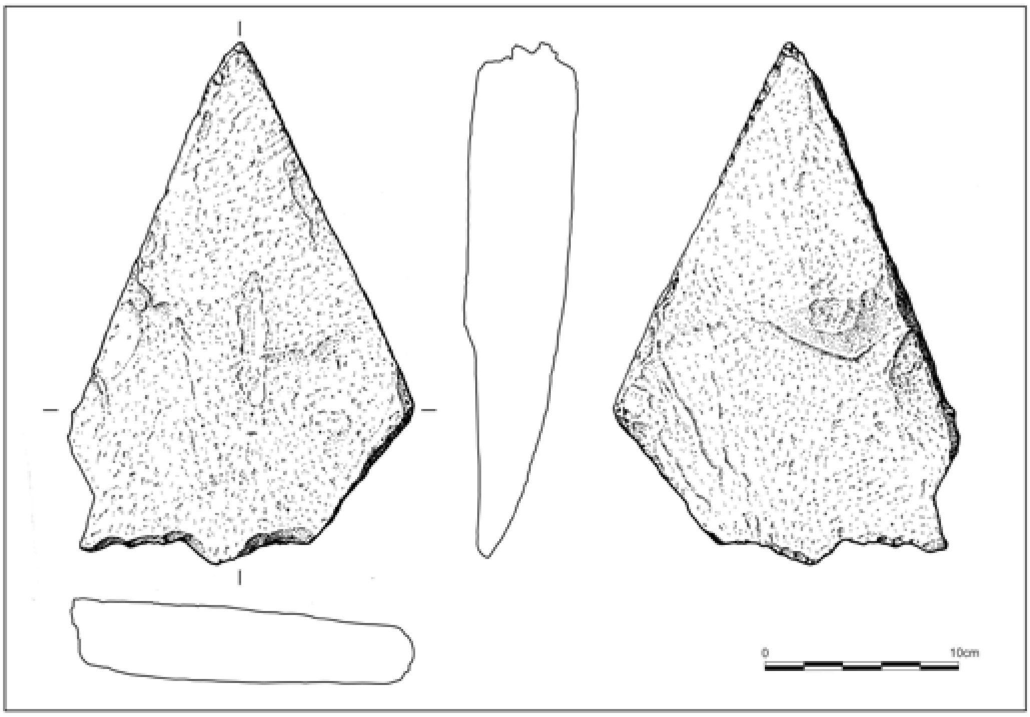

Figure 9 – A wedge-shaped stone tool found at Carn Goedog, from the spread upcast sediment beside the ditch (drawn by Irene de Luis).

4. Craig Rhos-y-felin megalith quarry

Extensive geological sampling of acid volcanic outcrops in the Fishguard district has led to the identification of Craig Rhos-y-felin as the source of foliated Rhyolites A-C among Stonehenge's bluestones. It is possible that all three of these types are actually derived from a single monolith, as yet unidentified but thought to be either or both Stones 32d and 32e (see Cleal *et al.*, 1995: 226, figs 120 and 141). More specifically, the variable petrography of the rock along the edges of the outcrop has resulted in a close match between Stonehenge Rhyolite C and just one particular location on the rock face. Thanks to this fortunate diversity along the sides of the outcrop, it is possible to ascertain the precise position where a monolith was removed and taken eventually to Stonehenge (Fig. 10). That position is visible as an embayment or niche for a pillar *c.* 2.5 m high x *c.* 0.4 m wide and *c.* 0.4 m thick (Parker Pearson *et al.*, 2015). As at Carn Goedog, the rock's formation has a strong jointing pattern which produces natural pillars which will have made extraction, through exploitation of pre-existing joint planes and the strong orthogonal foliation, an easy task.

Figure 10 – The outcrop at Craig Rhos-y-felin under excavation (viewed from the northwest): 1 a prone 4m-long monolith; 2 a threshold slab; 3 an artificial platform; 4 the recess left by the extracted monolith; 5 an orthostat beside the prone monolith; 6 an orthostat beside the recess of the removed monolith; 7 a Neolithic hearth; 8 a Neolithic occupation area; 9 Early Mesolithic hearths; 10 the lower platform and revetment; 11 the location of the close match for Stonehenge 'rhyolite with fabric' (photo by Adam Stanford, Aerial-Cam Ltd.).

The foot of the outcrop was occupied at various times in the past: an Early Mesolithic hearth, a Neolithic hearth, and an Iron Age open-air occupation area were located in close proximity to this niche. The Neolithic hearth and its associated remains of burnt stones, a flint flake and rhyolite flakes, lay just 2 m from the niche. Two radiocarbon dates on carbonised hazelnut shells from this deposit provide dates of 3500–3120 BC and 3620–3360 BC (Parker Pearson *et al.*, 2015: table 1).

Evidence of quarrying-related activities includes two artificial platforms, one just 4 m north of the outcrop and formed of sediment (associated with Early Bronze Age megalith quarrying activity), and another formed of two large, flat slabs held back by remnants of a drystone revetment wall from the edge of a prehistoric palaeochannel. This second, lower platform is 4.3 m E-W x 3.5m N-S, up to 0.3 m deep, and made up of sediment and vertically pitched stones. A rhyolite end-scraper was recovered from its fill. The platform provided a vertical drop of 0.9 m to the base of the palaeochannel and a 2 m-wide x 0.2 m-deep hollow way containing wood charcoal dating to 3270-2910 BC (Parker Pearson *et al.*, 2019). Like the stone platform at Carn Goedog, we suspect that the lower platform at Craig Rhos-y-felin operated as a 'loading bay' where a monolith could be somersaulted onto a waiting wooden sledge and then slid away from the quarry by people pulling on ropes.

5. Where did the monoliths go from the bluestone quarries?

Although there have been theories that the bluestones were fetched from their outcrops directly to Stonehenge, perhaps because of supposed properties of healing (Darvill & Wainwright, 2008) or acoustics (Devereux & Wozencroft, 2013) of the stones themselves, there is a line of thought that it was the monument, rather than its individual stones, that was significant. If that were the case, the bluestones may have formed a pre-existing Neolithic stone circle in Preseli, this monument being dismantled and taken to Salisbury Plain to be erected at Stonehenge.

The first account of why Stonehenge was built comes from Geoffrey of Monmouth who wrote in *c.* 1136 that the wizard Merlin built Stonehenge out of a stone circle that he and his men brought from Ireland. The circle, known as *Chorea Gigantum* ('the dance of the giants'), was supposedly built by giants on Mount Kilaurus. According to Geoffrey, Merlin wanted this monument moved to Salisbury Plain to commemorate Britons massacred by Saxons because the stones had healing properties.

In 1923, Herbert Thomas was the first geologist to conclude that the bluestones had been carried to Salisbury Plain not by glaciers but by human agents. He also surmised that 'the removal of a venerated stone circle from Preseli to Salisbury Plain' was the reason for their transport some 240 km (Thomas, 1923: 258). Yet no trace of a dismantled stone circle had been recognised in the area of the megalith quarries, even though, in general, distances moved between quarry and monument in Neolithic and Chalcolithic western Europe were no more than a few kilometres (see other contributions to this volume). There are several extant stone circles in the Preseli region (Darvill & Wainwright, 2003) but their small sizes and generally short megaliths make them most likely to date to the Early Bronze Age than to the Neolithic. Similarly, the five henges known in the region are small and likely to date to after 2800 BC on the basis of their forms (Darvill & Wainwright, 2016: 113-114).

Since 2011, the Stones of Stonehenge Project, led by the authors of this paper, has explored other sites in the Preseli area to find out if they were monuments contemporary with the megalith quarries and whether they might have once included standing bluestones. Excavations in 2012-2013 of a suspected henge at Castell Mawr (Gibson, 2012: 117) revealed no trace of any Neolithic remains amongst the largely Iron Age features of this hillfort (Parker Pearson *et al.*, 2017). A henge-like ditched circular enclosure at Bayvil Farm turned out in 2014 to be a Late Bronze Age ringfort (Parker Pearson *et al.,* 2018), and a circular enclosure at Felindre Farchog was revealed on excavation in 2015 to be an early medieval cemetery (Casswell *et al.*, 2016). A suspected passage tomb and henge at Pensarn were found on excavation in 2016-2017 to be an Early Bronze Age burial cairn and an Iron Age enclosure

The only suspected candidate for a dismantled stone circle in the Preseli hills is an arc of dolerite pillars at Waun Mawn, *c.* 4 km west of the bluestone outcrops (Grimes, 1963: 150, fig. 36).

Located on a natural saddle at 310 m OD with views to the sea and to the eastwards sweep of the Preseli hills, these four stones (only one of which is still standing) form an arc which is all that is left of a robbed-out stone circle (Fig. 11). Six sockets, from standing stones removed in antiquity, were excavated in 2018, revealing the circle's diameter of 110 m. Not only is Waun Mawn the sole circle in Preseli with standing stones comparable in size to those at Stonehenge but it is also the third largest stone circle in Britain. Additionally, its diameter of 110 m is the same as Stonehenge's Stage 1 circular enclosure (Cleal *et al.*, 1995: 67). Together with a Neolithic causewayed enclosure at Banc Du, a Neolithic palisaded enclosure at Dryslwyn, and seven Neolithic dolmens (Darvill & Wainwright 2016; see Fig. 6), it forms a major ceremonial complex within the Preseli hills.

Figure 11 – Waun Mawn dismantled stone circle, looking southwest. The four remaining pillars are in the lower right of the picture. Another six empty stone sockets were found around the circle's perimeter (photo by Adam Stanford, Aerial-Cam Ltd.).

6. Mobility and contact between Stonehenge and the west of Britain

The bluestones are not the only evidence of contacts between west Wales and Salisbury Plain. Earlier Neolithic stone axes of Group VIII (Cummins, 1979: fig. 4a) originated in west Wales, and are found throughout south Wales and eastwards into southern England. This demonstrates a network of movement and exchange that was in place before the bluestones were moved.

Styles of monuments and ceramics also changed in their distributions after the Early Neolithic (*c.* 4000-3400 BC). Whereas ceramic styles had been regionalised between east and west (Darvill, 2010: fig. 33), Middle Neolithic impressed ceramics known as Peterborough Ware are found right across southern Britain (Ard & Darvill, 2015). Similarly, Early Neolithic funerary monuments reveal something of an east-west split, with oval barrows, round barrows, timber mortuary structures and pit graves in the east, and simple passage graves and – to a lesser extent – portal dolmens in the west (Darvill, 2010: fig. 37). During the Middle Neolithic, a Scottish-derived monument type – the cursus – was adopted throughout Britain (Loveday, 2006; Brophy, 2015). This was followed in the final centuries of the fourth millennium BC by the first henges, known as 'formative' henges because their banks were placed outside their ditches rather than inside them, as was the case after c. 2800 BC (Burrow, 2010). Llandygai henge A (Lynch & Musson, 2004) and Castell Bryn Gwyn (Wainwright, 1962) are examples of formative henges in north Wales, similar to examples in southern England: Stonehenge stage 1 (Cleal *et al.*, 1995; Darvill *et al.*, 2012); Flagstones, Dorchester (Healy, 1997); Priddy circles, Somerset (Lewis & Mullin, 2010); and Norton, Hertfordshire (Fitzpatrick-Matthews, 2015: 71-74).

The changes in ceramics and monument styles suggest a growing commonality of material culture throughout southern Britain across the east-west divide that had been a feature of the Early Neolithic. In addition, people moved too. Strontium isotope analysis of tooth enamel reveals that many individuals buried at or around Stonehenge had ratios consistent with growing up on the Silurian/Devonian rocks of south and west Wales and/or north Devon. Evidence for migration from west to east is found in the Stonehenge landscape as early as 3630-3360 BC, the same period as the cursuses were built; an adult male buried in a single, primary grave beneath Winterbourne Stoke long barrow, less than 2 km from Stonehenge, has strontium isotope ratios consistent with growing up in western Britain (Alistair Pike pers. comm.). A proportion of those people cremated and buried at Stonehenge during *c.* 3000- 2400 BC also have strontium isotope ratios consistent with origins in the far west of Britain (Snoeck *et al.*, 2018). A single adult human tooth from Durrington Walls, dating to c. 2500 BC, has similar likely origins. During the Beaker period and Early Bronze Age (*c.* 2450-1500 BC), more than a third of all migrants to the Wessex chalklands around Stonehenge – some nine individuals – have strontium isotope ratios that imply they came from Silurian/Devonian areas of the West (Parker Pearson *et al.*, 2016).

7. Ancestors and stones

These trends towards greater commonality in material styles and increasing human mobility between east and west in the Middle Neolithic are just part of a wider range of evidence for social transformations across the transition *c.* 3400 BC between the Early Neolithic and the Middle Neolithic. Violence and even warfare were present during the Early Neolithic up to *c.* 3400 BC with a major focus in the area between south Wales and southwest England on the one hand and Stonehenge on the other (Mercer, 1999; Schulting & Wysocki, 2005). With evidence for violence less evident than before, the Middle Neolithic (c. 3400–3000 BC) appears to have been the start of a population decline throughout Britain (Shennan et al., 2013), associated with woodland regeneration (Woodbridge *et al.*, 2014).

It was within this context of change that around 80 bluestone monoliths were transported to Salisbury Plain around 3000 BC. Just how to explain such a momentous and conspicuous feat of pointless bravado has defeated scholars unable to conceive of such large stones having any value greater than as unusual rocks. Gordon Childe considered this fantastic feat to 'illustrate a degree of political unification or a sacred peace' (Childe, 1957: 331) and the evidence gathered in recent decades would certainly be consistent with this interpretation. We can elaborate on Childe's hypothesis to suggest that the bluestones (and very possibly the cremated remains of some of the people buried with them at Stonehenge) were symbols of the ancestral origins of Neolithic groups in west Wales, combining their stones with the sarsens of southern and southeast England.

There is growing evidence that Stonehenge may have been an axis mundi, a centre of origin for the people of southern Britain. A large hunter-gatherer settlement at Blick Mead, 3 km east of Stonehenge, has the longest sequence of radiocarbon dates of any persistent place in the British Mesolithic, spanning the 8^{th}- 5^{th} millennia BC, and providing a long-term focus for movement within the region (Jacques & Phillips, 2014). Three monumental posts – almost unique for the European Early Mesolithic – were erected during the 8th millennium BC just 150 m from where Stonehenge would be built 5,000 years later (Allen & Gardiner, 2002). Their presence suggests that this was a special place long before Neolithic farmers, possibly connected with an unusual natural phenomenon discovered during excavations by the Stonehenge Riverside Project in 2008 (Allen *et al.*, 2016). The sockets for these 1 m-diameter wooden posts lie close to a geomorphological feature of parallel chalk ridges with unusually large parallel periglacial fissures running between them. This entirely natural earthwork is coincidentally aligned on the solstitial axis of midsummer sunrise/midwinter sunset. It was evidently recognised during the Neolithic because Stonehenge Stage 1 was placed at its southwest end and the ditches of the Stonehenge Avenue were cut against the outsides of the two ridges.

Stonehenge also appears to have been on a boundary between west and east during the Early Neolithic: not only were there differences in styles of ceramics and monuments on either side of Salisbury Plain and the Wessex chalkland, as discussed earlier, but this area also contains one of the highest densities of Early Neolithic causewayed enclosures. Causewayed enclosures are interpreted as gathering sites where people came from different regions to feast and exchange (Mercer & Healy, 2008; Whittle *et al.*, 1999). More than half of British causewayed enclosures are located within a 30-mile wide corridor extending from the south coast to the Wash on the east coast. If cursuses, henges and stone circles were also places of gathering during the Middle-Late Neolithic, then this same corridor also attracted people from their home ranges in the river valleys on either side.

This movement of people and their ancestral stones to an *axis mundi* on Salisbury Plain, thereby creating Stonehenge, could have constituted a religious and/or political union, or colonization by people of the west, or both. Analysis of ancient DNA is revealing the genetic origins of Neolithic farmers in Britain to lie in continental Europe. Also Neolithic farmers in Wales had different genetic admixtures from those in southeast Britain (Brace *et al.*, 2019). Such genetic differences could have been significant in defining separate ancestries for western and southeastern Neolithic populations within Britain.

Bringing ancestral bluestones to this *axis mundi* from the far west could thus have served to unite the people of west and east in southern Britain around 2900 BC, after a thousand years of difference and even dispute between the two regions. Such differences may even have extended back to Neolithic farmers' origins within continental Europe; whilst farmers may have brought the farming package to southeast England from northern France (Whittle *et al.*, 2011), other farming communities may well have colonised western Britain and Ireland – including west Wales – from Brittany (Sheridan, 2010). If the bluestones represented the ancestry of the western British at Stonehenge then the sarsens – the solid geology first encountered by earliest Neolithic farmers settling in Kent and the Thames estuary (Whittle *et al.*, 2011) – could have represented ancestries of those in the east. Stonehenge's stones thus encapsulate and embody the potential places of arrival, foundation and establishment of the two main groups of Early Neolithic farmers into southern Britain.

Note

All cited radiocarbon dates are calibrated and given at 95% confidence. Full details of those from the Welsh quarries are already published (Parker Pearson et al., 2015; 2019).

Acknowledgements

Rui Boaventura kindly invited MPP to the Redondo conference on the spur of the moment, as we were departing Hamburg airport after a megalith conference in Kiel. Thanks also to Rui Mataloto who persevered with bringing these proceedings to publication after Rui's tragically premature death. We also thank our many colleagues and current and former students who have taken part in the Stonehenge Riverside Project and the Stones of Stonehenge Project which have taken our understanding of Stonehenge so much further that we knew possible. Finally, we thank the many agencies and land owners that have permitted us to carry out the surveys and excavations that have provided the data drawn on in this paper.

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Raw material and work force in Falbygden passage graves. Identity, competition and social dynamic.

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Abstract: In this paper, building material is investigated for the remarkable concentration of more than 250 passage graves in the small region of Falbygden in the inland of western Sweden. This concentration occurs on a likewise limited area of Cambro-Silurian sedimentary rocks, which is surrounded by Precambrian bedrock (mostly gneiss). Based on a compilation of rock determinations from various surveys of the tombs, it is shown that the material used for different parts of the construction is highly structured and probably results from the choice of particular materials based on perceived symbolic/ ideological properties, rather than physical or functional ones.

The choice of material for chamber uprights shows a marked correspondence with the local substrate on which the tombs are sitting. Roof blocks are mostly Precambrian ice-transported material, commonly encountered all over the region. Roof blocks of other material occur in some limited areas, and show a similar pattern as that of chamber uprights. Nothing in the spatial pattern indicates long distance transport, and it is suggested that the material used would have been available within a few hundred m from the tomb sites. As a choice between different materials would have been possible in most areas, it is suggested that the structured use of material is based not only on local availability but also on inherent symbolical properties ascribed to the rocks and the landscape.

Further, the weights of the largest blocks in the constructions are used for a discussion on minimum work forces necessary for transporting them. It is suggested that for most tombs, it would have been necessary to mobilize resources from a wider network than the local group. Likely, a competitive situation was at hand, several tomb building projects going on at the same time and competing for assistance and resources. Results from recent isotopic mobility studies suggest that social networks in fact involved groups well outside Falbygden, living in areas where no megaliths were built. Part of the explanation for this could be the inherent dynamic in the competition involved in demonstrative tomb building projects.

Keywords: Falbygden; Passage graves; Building material; Work force; Funnel Beaker culture

Matéria-prima e força de trabalho em sepulcros de galeria de Falbygden. Identidade, competição e dinâmica social
Resumo: Este artigo debruça-se sobre o material de construção do notável conjunto mais de 250 galerias cobertas na pequena região de Falbygden, no interior oeste da Suécia. Esta concentração ocorre em área igualmente limitada de rochas sedimentares Cambro-Silurianas, que é cercada por leito rochoso pré-cambriano (principalmente gnaisse). A partir de uma recolha de proveniências de litologias de várias propsecções em redor dos túmulos, demonstra-se que o material usado para diferentes partes da construção é altamente estruturado e provavelmente resulta da escolha de materiais particulares baseados em propriedades simbólicas / ideológicas, ao invés de físicas. ou funcionais.

A escolha do material para os esteios da câmara demonstra uma correspondência bem marcada com o substrato local no qual os sepulcros estão implantados. As lajes de cobertura são, na sua maioria, materiais transportados do gelo pré-câmbrico, comumente encontrados em toda a região. Coberturas

de outro material ocorrem em algumas áreas limitadas, e mostram um padrão semelhante ao dos esteios da câmara. Nada no padrão espacial indica transporte a longa distância, e sugere-se que o material usado estaria disponível a poucas centenas de metros dos locais dos túmulos. Como a escolha entre diferentes materiais teria sido possível na maioria das áreas, sugere-se que o uso estruturado do material se baseia não apenas na disponibilidade local, mas também nas propriedades simbólicas inerentes, atribuídas às rochas e à paisagem.
Por outro lado, os pesos dos maiores blocos nas construções são a base para uma discussão sobre as forças mínimas de trabalho necessárias para transportá-los. Sugere-se que, para a maioria dos túmulos, teria sido necessário mobilizar recursos de uma rede mais ampla do que o grupo local. Provavelmente, uma situação competitiva estava à mão: vários projectos de construção de túmulos acontecendo em simultâneo e competindo por assistência e recursos. Resultados de recentes estudos de mobilidade isotópica sugerem que as redes sociais de facto envolveram grupos bem fora de Falbygden, vivendo em áreas onde nenhum megálito foi construído. Parte da explicação para isso poderia ser a dinâmica inerente à competição envolvida em projectos de construção de túmulos demonstrada.

Palavras-chave: Falbygden; Sepulcros de galeria; Material de construção; Força de trabalho; Cultura de *Funnelbeaker*

1. Introduction

At least 525 dolmens and passage graves are known in Sweden, but especially in the south a large number of tombs have been destroyed during the last two centuries. These tombs were built ca. 3300-3000 BC cal., i.e. the transition between the early and the middle Neolithic periods, in the cultural setting of the Funnel Beaker (TRB) culture. The Swedish tombs occur in two distinct types of landscape (Fig. 1). In Scania, Halland and Bohuslän, they are found close to the coast. The second group of tombs is found in the inland area of Falbygden. Here, a concentration of at least 255 tombs coincides with one of the very few areas in the region where the bedrock consists of limestone and slate instead of Precambrian rocks. In the surrounding areas, no dolmens or passage graves were built, although TRB settlements are known all over the region. Eastern Sweden went through a largely different development from the early Middle Neolithic on, and only a few scattered megalithic monuments are known.

Falbygden has several distinctive features. The diabase-capped plateau mountains have characteristic profiles visible over large areas. The flat, limestone plateaus below them are fertile agricultural lands. The vegetation is different from that of the surrounding areas and contains several unusual species. Thus, the Falbygden landscape has a number of properties that set it off from the surroundings. In most directions, it is also clearly bounded.

2. Falbygden tombs

The Falbygden tombs show a regular pattern in their architecture (Figs 2, 3). The predominant type is the symmetrical, rectangular passage grave (only two dolmens are known). A limited number of tombs have other chamber forms, such as trapezoid, D-shaped, oval or round. In addition to the regularity, they are also large. Mean chamber length is about 9 m, and the largest tombs have chambers up to 16 m in length.

Roof block size varies considerably, but some blocks have been estimated at about 20 tons. Chambers are surrounded by stone and earth mounds, usually some 15–20 m in diameter, but examples up to 40 m occur.

In the period 1860–1900, a large number of chambers were excavated by scholars like Bror Emil Hildebrand, Oscar Montelius and Gustaf Retzius. Later, systematic surveys were carried out by Karl-Esaias Sahlström among others. The passage grave at Rössberga was excavated in 1962 (Cullberg, 1963), and from the 1980s on further excavations were carried out (Bägerfeldt, 1992; Persson & Sjögren, 2001; Sjögren, 2008, 2015).

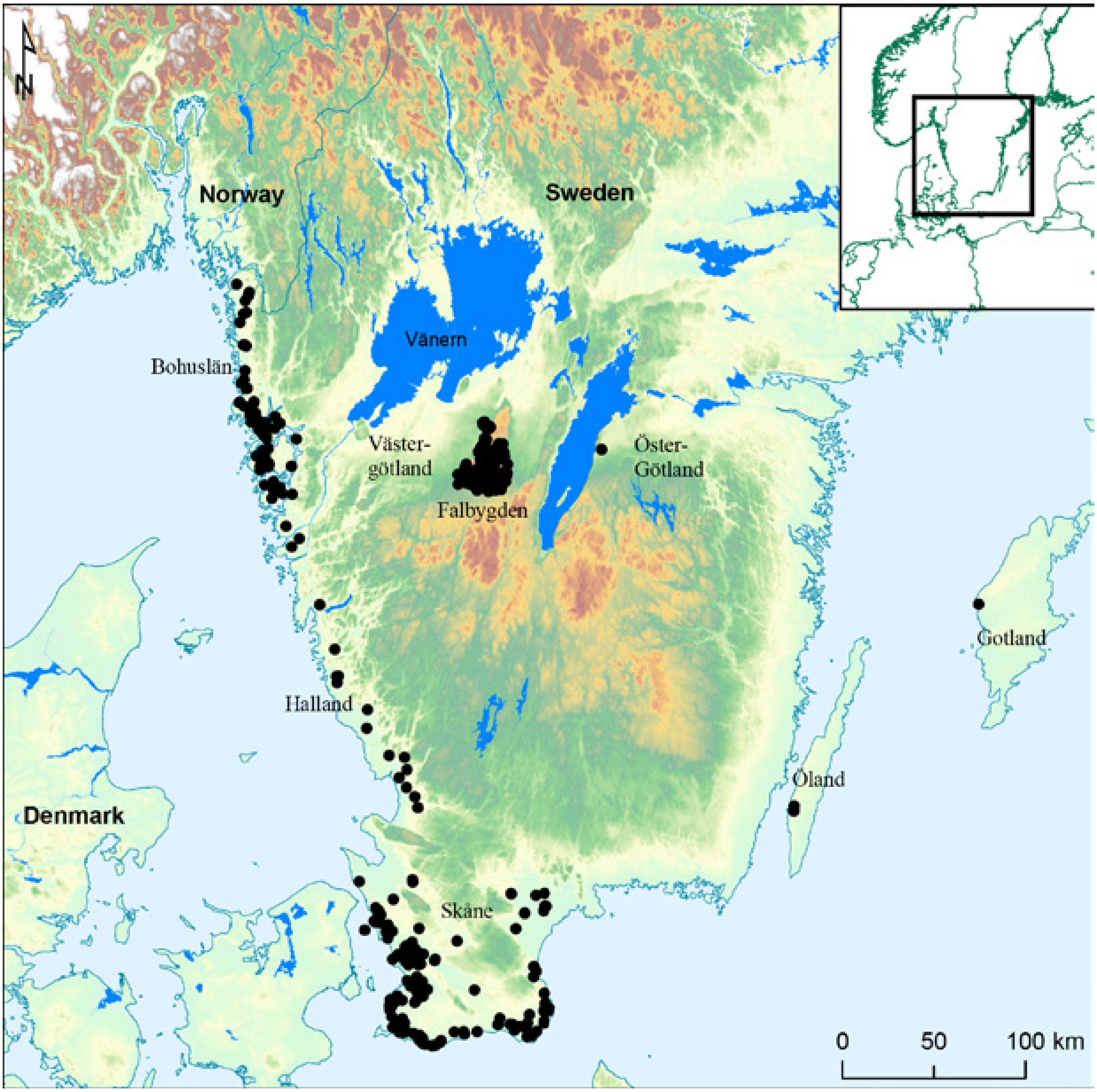
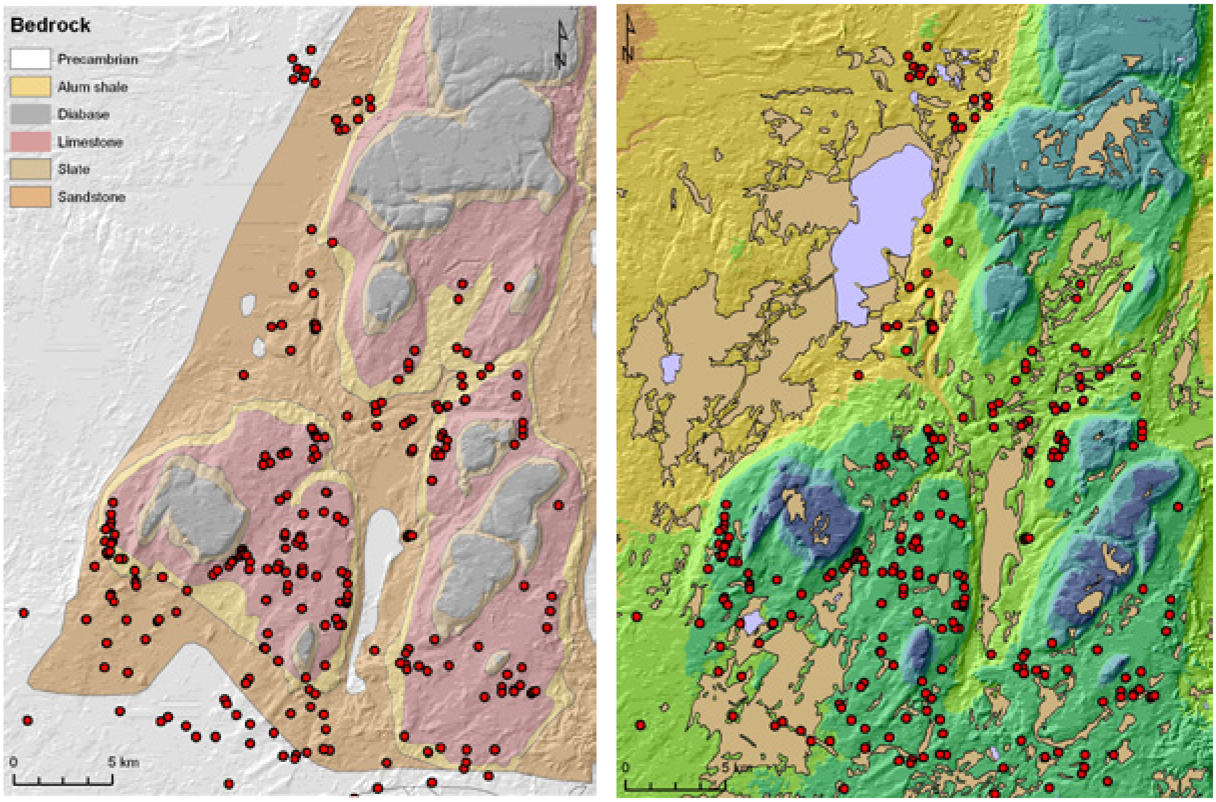


Figure 1 – Swedish dolmens and passage graves.

More recently, human and animal bones from the area have been subject to a number of scientific analyses, including aDNA, 14C dating, 13C and 15N isotopes, Sr isotopes etc. (*e.g.* Liden, 1995; Ahlström, 2009; Sjögren, 2003, 2015; Sjögren, Price & Ahlström, 2009; Hinders, 2011; Sjögren & Price, 2013; Skoglund *et al.*, 2014). Analyses of spatial patterning of the tombs have also been published (Sjögren, 2003; Axelsson, 2010).

Figure 2 – The passage grave "Ragvalds grav" in Karleby. This is the largest tomb in Falbygden, with a 16 m long chamber. The chamber uprights consist of limestone slabs while the roof consists of gneiss blocks.

Figure 3 – The passage grave "Gläshall" in Falköping town. This tomb has a massive limestone slab as roof, and is also one of the few where the keystone is of limestone.



A B

Figure 4 – The megalithic tombs in Falbygden in relation to geology (A) and to hydrology and topography (B).

As seen in Fig. 4, the megalithic tombs in Falbygden follow quite closely the extent of Cambro-Silurian bedrock. Only a few tombs are found outside this formation, mainly in the south. This is also the region where the landscape is less clearly bounded, mostly due to thicker deposits of moraine on top of the bedrock. In particular, the limestone plateaus seem to be favoured locations, and in many parts of the area the passage graves closely follow the edges of the limestone, forming linear arrangements (Fig. 4, Fig. 5).

3. Falbygden landscape

As noted above, the Cambro-Silurian area of Falbygden is distinctive from the surrounding Precambrian terrain in many respects, geologically, topographically and botanically. It is also clearly bounded in most directions, except to the south where the transition is more gradual. The flat-topped diabase mountains are visible over large distances and would have made natural orientation and reference points for a larger region.

The Cambro-Silurian bedrock is made up of a series of sedimentary rocks. The lowermost layer is sandstone, on top of which we find alum shale, limestone and slate. The mountain tops are covered by horizontal diabase layers. This gives the landscape a characteristic and in most areas easily recognizable stepped structure, where flat or slightly undulating limestone plateaus are interrupted by flat-topped mountains or by edges and slopes where alum shale and sandstone are exposed.

As Tilley (1991, 1996) noted, this vertical landscape zonation is in some way repeated in the choice of raw material in megalithic chambers. He writes: ”a very direct relationship between the megaliths and the landscape is apparent. The tombs are, in effect, the landscape in miniature”, and he continues: ”The up-down; high-low contrasts of the landscape are reflected in the very choice of building stones used to construct the tombs” (Tilley, 1991: 73-74; see also Tilley, 1996: 124). In this paper, I will reflect on and possibly extend this insight somewhat further.

Figure 5 – Aerial view from the south of the village Karleby in central Falbygden. The line of farms follows the limestone edge. To the left of it extends the limestone plateau with low ridges on which several passage graves are located, forming a line beyond the church. To the right of the farm houses a steep slope leads down to a terrace (alum shale level) on which several Neolithic settlements are located. Limestone would have been most easily quarried in the escarpment just to the right of the village. The distance to the passage graves from this supposed source is less than 100 m.

4. Raw materials

The rock types in Falbygden passage graves have been recorded in several surveys. The most detailed survey was made by Karl-Esaias Sahlström, who devoted much of his life to the archaeology of the region. He was also a trained geologist, and published detailed descriptions of the graves in a series of works (Sahlström, 1915, 1928, 1932, 1939). Further details can be found in a series of unpublished parish surveys as well as in the national register of antiquities. These data are summarized in Table 1 and Fig. 6. Raw material use in west Swedish megalithic tombs has previously been discussed in Sjögren (2003: 238 ff). The present paper constitutes a summary of this discussion.

From this table, it is clear that Tilley was right in suggesting that the choice of raw material is highly structured. Side stones in the chambers are primarily built by limestone slabs, with minor occurrences of gneiss/granite and sandstone. The opposite is true for the keystone (the innermost roof block in the passage, on which the middle chamber roof block usually rests). For this, diabase or gneiss/granite was predominantly used, with only marginal occurrence of limestone and sandstone.

The chamber roof, probably the most visible part of the construction, shows a somewhat more varied picture. Gneiss/granite is the most common and makes up about half of the registered blocks, while limestone and sandstone show lower frequencies. Together, they make up ca 1/3 of the registered roofs.

Schist is used in only one tomb, the Slutarp dolmen in the southern part of Falbygden, outside the Cambro-Silurian area. This material is found locally, as part of the Precambrian bedrock. Other rock types in the area, such as alum shale or slate, are too soft to use as structural elements. They have been used for other purposes, however, notably in dry stone walling filling up gaps between the side stones.

A functional explanation for this choice of material may be considered, since it is believed that limestone could not support the heavy load on keystones, or that they would crack if used for roofing. However, the occurrence of a number of tombs where sandstone and limestone were used both as keystones and for roofs, without any visible signs of collapse or cracking, renders such explanations less credible. Further, the load on chamber uprights must also in many cases be very large. Thus, physical properties of the rocks are not convincing explanations for the choice of material.

Table 1 – Rock types in different parts of the megalithic grave chambers in Falbygden. Data from Sjögren, 2003.

Type	Chamber	Keystone	Roof
Diabase	0	28	9
Gneiss/granite	21	44	65
Schist	1	0	1
Limestone	128	2	25
Sandstone	28	2	17
Mixed material	13	0	10
Sum	190	76	127

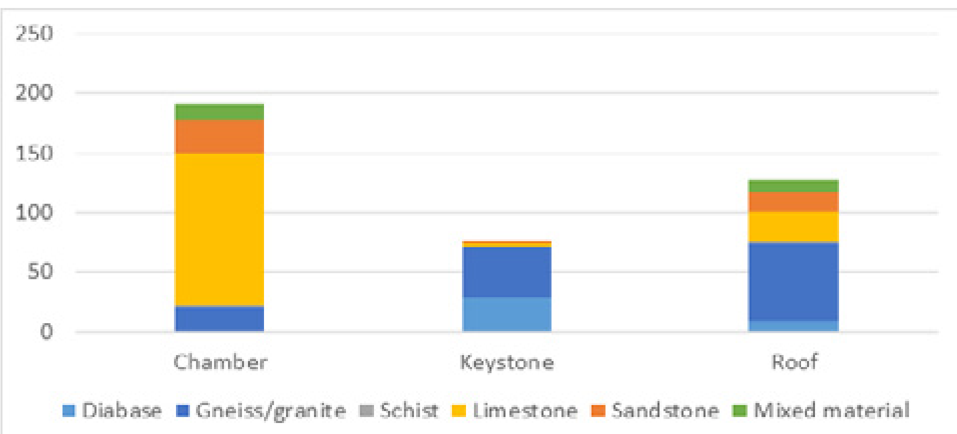


Figure 6 – Rock types in different parts of the construction.

5. Accessibility

As no Neolithic quarries have yet been located in the area, we have to proceed by considering the availability of the various rock types involved, in relation to the spatial pattern of material use revealed by the tombs themselves.

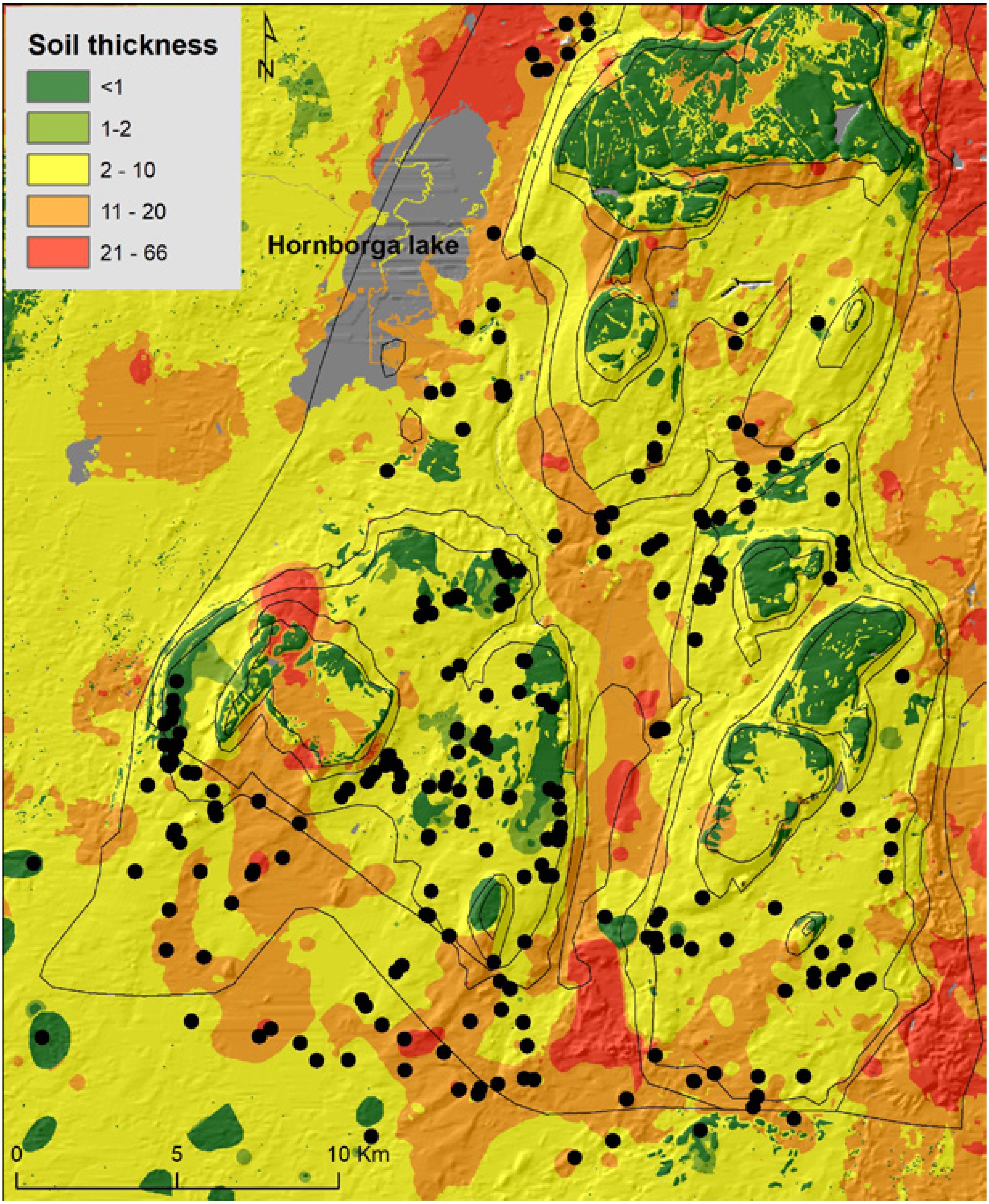


Figure 7 – Soil depth model, SGU.

As noted above, the sedimentary rocks in Falbygden are covered by late glacial ice-deposited material of various thickness, such as moraine or glacio-fluvial material. In some areas, the bedrock lies bare or is only covered by a few dm of soil, while in other areas the thickness amounts to 20 m or more. Over most of the area, a soil thickness of a couple of m is normal.

This governs the accessibility of the underlying bedrock and limits it to some rather restricted areas. In Fig. 7, a model of soil cover thickness is shown, produced from a generalization of data from drillings and cuttings by the SGU, the Swedish Geological Agency.

From this map, it seems that most of the tombs located on the limestone plateaus in fact are on or close to areas with thin soil cover (< 1m). This is accentuated when we take into account that many of them are also located close to the edges of the limestone, where this rock would have been most accessible and easiest to quarry. The limestone is divided up by natural fissures, both vertically and horizontally, so that once it is laid bare it would have been practicable to split off reasonably sized slabs by means of wooden poles or wedges. It should be mentioned that large enough limestone slabs are very rarely found in the moraine, as they would quickly have been split up and crushed by the pressure and movements of the ice.

The accessibility of sandstone, on the other hand, is much more restricted. As will be shown below, sandstone was mainly used in two small areas, one to the east of lake Hornborga and one in the southern part of Falbygden (Fig. 8). Access to sandstone would have been rather easy in the first of these areas, but in the southern area no obvious source can be seen. It is possible, however, that a very localized source has been missed by the soil thickness model.

As regards blocks of Precambrian rocks, these would have been readily available within short distances all over the landscape. Ice-transported gneiss blocks are still very common in the fields and stone field boundaries. Thus they would not have needed any special quarrying, and it can be supposed that the choices were largely governed by ease of transport, although it is not possible to show where a particular block actually came from.

Diabase blocks can also be found among the ice-transported material in the fields today, and it can be supposed that they were taken from nearby sites in the same way as the gneiss blocks. Alternatively, they could have been taken from the scree surrounding the diabase mountain tops. However, this appears less likely since these stones are generally much smaller in size, and are also different in shape (less rounded) than the blocks used for megalith construction.

With this background in mind, we will now look at the spatial pattern of rock types used in various parts of the passage graves: chamber wall, keystones, and roof blocks.

6. Chamber walls

Fig. 8 shows the chamber wall material, compared to the geological substrate. A clear picture emerges. Tombs located on limestone are primarily built of that material, with only isolated deviations. Two subgroups are dominated by sandstone chambers, as mentioned above. Both are located on sandstone substrate. In areas outside the limestone, such as the southernmost and northernmost parts, or with thick soil cover, such as the south-eastern area, chambers are built from more varied materials including Precambrian rocks. This also leads to a centre/periphery difference with central tombs made from limestone and more peripheral ones built from other material.

This pattern indicates that building material was not normally transported over any large distances. Consider for instance the two northernmost groups, separated by some 2 km. Only in the eastern of these groups does limestone predominate, while the western tombs are built of Precambrian rocks. The "sandstone group" slightly further south is also interesting, since two tombs to the north of these, closer to the limestone, were built of this material instead of sandstone.

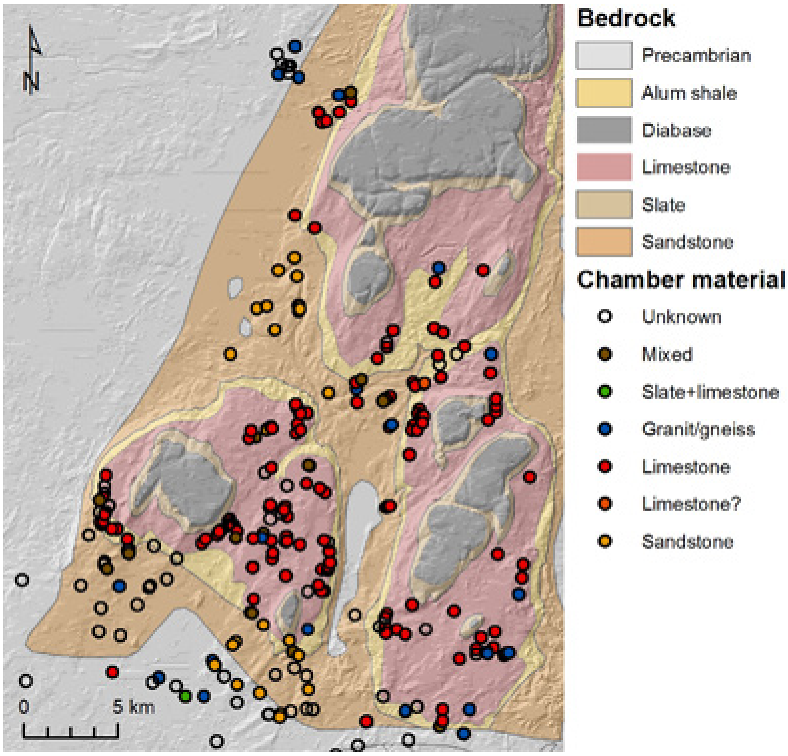


Figure 8 – Material in the chamber walls.

Thus, it would seem that limestone was normally chosen over other materials, if available within reasonable distance. The maximum distance for transporting limestone slabs seems to be in the order of 1-2 km, although the actual distances in most cases would probably have been smaller. In the case of Karleby (Fig. 3) limestone would have been accessible within less than 100 m, and the same applies to many other cases.

7. Roof blocks

The pattern of roof materials presents a very different picture (Fig. 9). The dominating material here is ice-transported blocks of gneiss/granite (in practice mostly gneiss). These are still to be found scattered over the landscape and would have been even more present in prehistoric time, before large scale clearing of the fields had been achieved. Therefore, we cannot expect availability of these blocks to show any spatial pattern. This is also reflected in the distribution of tombs with gneiss roofs, which occur all over the area.

This can also be said for the few chambers with diabase roof blocks. They do not occur close to the mountains but are instead scattered widely, with no discernible pattern.

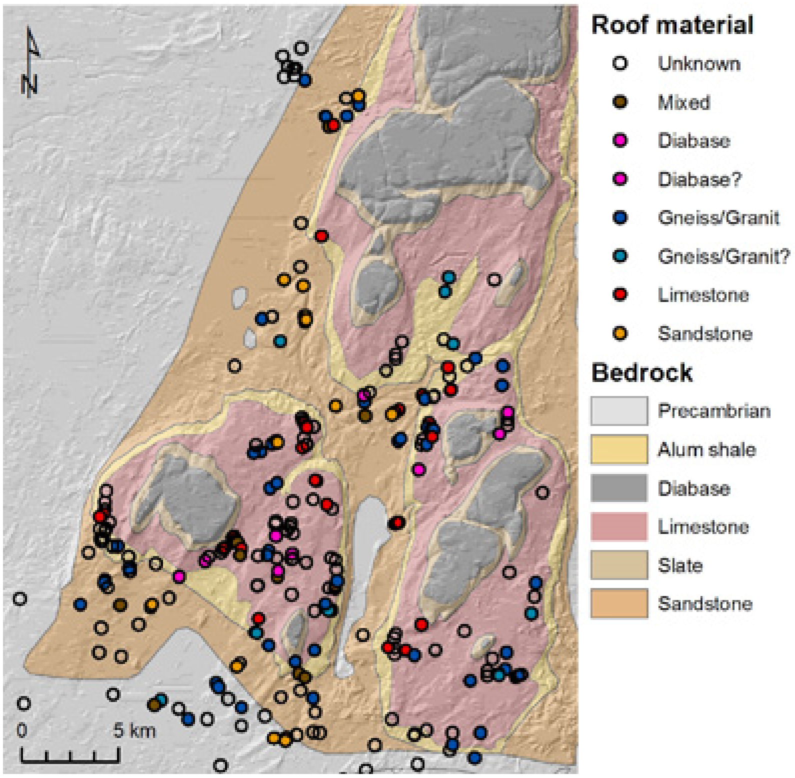


Figure 9 – Material in the chamber roof.

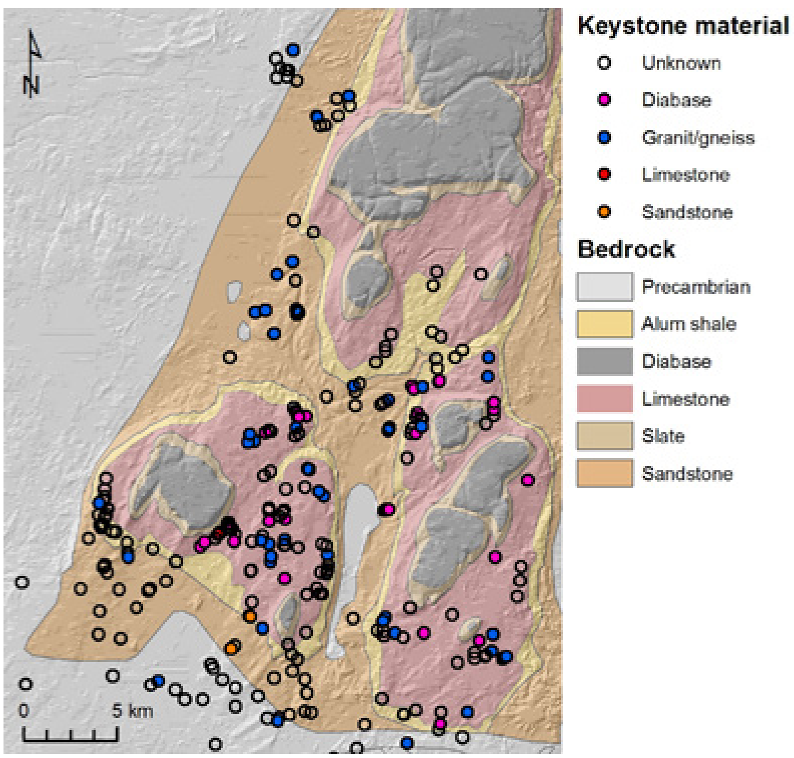


Figure 10 – Material used for keystones.

About a third of the tombs have sandstone or limestone roofs. These, on the other hand, are more spatially constrained and occur mainly in tombs located on the same kind of substrate, i.e. a similar pattern as seen in chamber uprights. Interestingly, many of the tombs with sandstone chamber walls also have roofs of this material, and strengthen the impression of two local groups mainly using sandstone. Limestone roofs are concentrated to the limestone plateaus in the central part of the region.

As for the chamber material, much of this spatial pattern could be attributed to constraints on accessibility in different subareas. However, there are hints that this kind of explanation is not sufficient. As noted above, ice-transported blocks occur over the whole are and would have been equally available for all groups. Availability can therefore not explain why some groups chose to use sandstone or limestone for roofing material. Apparently, they consciously chose particular materials over others, and we should probably think of this in terms of symbolic properties of rocks, possibly inherent in the landscape as Tilley suggests. Another factor may be the construction of local identities, using properties of the bedrock to connect themselves to the land.

8. The keystone

Fig. 10 shows the distribution of material used for keystones. Unfortunately, this is unknown for a large number of tombs, due to low visibility. They are completely dominated by gneiss/granite and diabase and the material shows no spatial patterning. This is to be expected, since this would have been ice-transported blocks, available locally at short distances. The very few instances of limestone (*e.g.* Gläshall in Falköping, see Fig. 3) and sandstone occur on these substrates, but are too few to lead to any far-reaching conclusions.

9. Roof blocks and work forces

Another constraining factor in the process of megalith building is of course the availability of labour power, in the form of human workforce or animal traction, or both. One particularly strategic moment is that of transport and manoeuvring of the largest blocks in the construction, which in the case of Falbygden would normally be one of the roof blocks. In Falbygden, the chambers are normally covered by 3-5 large blocks, of which the centre block, covering the keystone and the entrance of the passage into the chamber, is usually the largest.

Unfortunately, many tombs have been robbed of one or more of their roof blocks, and measurements are not available for all of them. For 66 tombs, however, it has been possible to calculate an estimate of the weight of the largest block (Fig. 11). These estimates range from ca 1 ton up to ca 20 tons, with peaks around 5, 10 and 16 tons (Sjögren, 2003: 246 ff).

Based on recent experiments and historical accounts, it can also be possible to suggest the minimum number of people or oxen needed to transport these blocks (data in Sjögren, 2003). The result of this exercise indicates that the smallest blocks could be transported by quite small groups, while quite large work forces (>75 people/>30 oxen) would be needed for the largest blocks.

Neolithic settlement systems are still insufficiently known in the area, but judging from a series of excavated settlements in Karleby (Englund & Sjögren, 1994; Sjögren 2003; Sjögren *et. al.*, 2019), the settlements seem to have been dispersed and of modest sizes. Settlement sizes of some 1-2 ha seem to be reasonable assumptions, leaving space for one or possibly two long houses. This to be regarded as rather small in comparison with some sites in Denmark and northern Germany (Skaarup, 1985: 367; Brozio, 2016; Hage, 2016). The population size at such a settlement is of course difficult to calculate, but it seems unlikely that the settlements known at present could have housed more than rather small populations, perhaps in the order of 10-15 people.

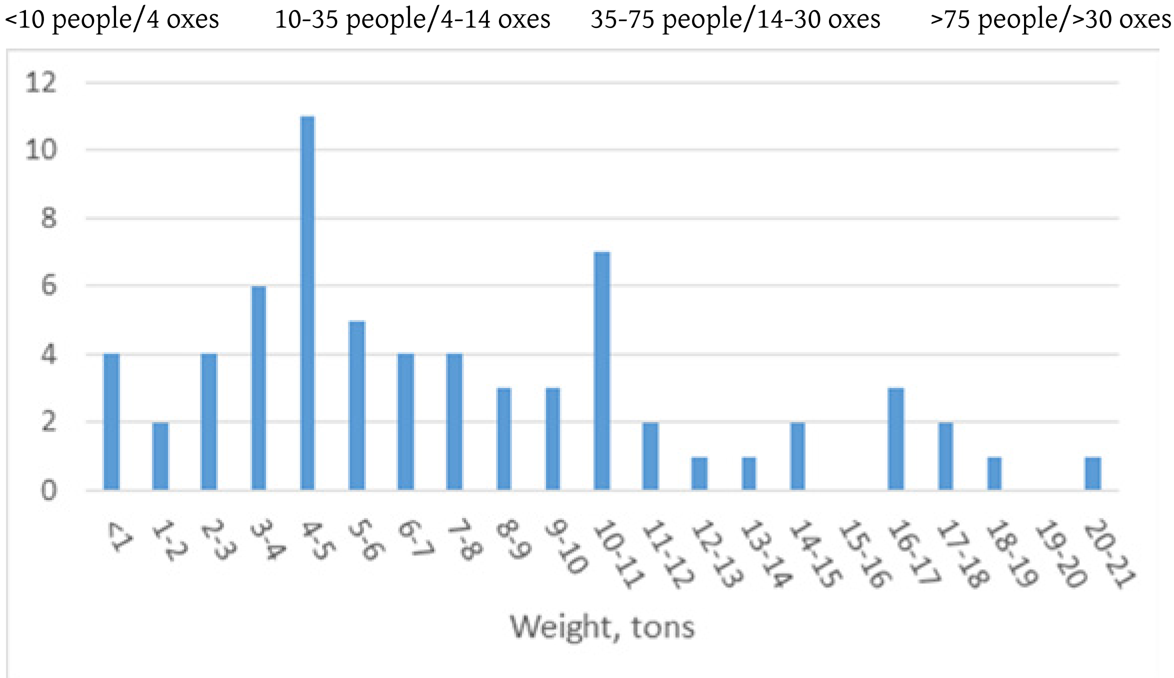


Figure 11 – Estimated weights of largest roof block for 66 passage graves in Falbygden. Data from Sjögren, 2003.

If we accept this as a reasonable estimate, it leads to the conclusion that a single settlement could rarely supply enough labour power to transport the roof blocks. In most cases, cooperation between two, or more probably several, settlements would be necessary. It is of course quite possible that social groups did not coincide with settlement groups, but this does not affect the argument that cooperation over larger areas was necessary. Further, it is likely that even more labour power would be needed at certain points, for instance when moving blocks upslope or placing them on top of the chamber uprights. If a normal group size is around 10-15 people, some 5 to 8 groups would need to be involved in transporting the blocks. This figure is only a minimum estimate of the numbers directly involved in block transport. To this should be added people involved in various supporting functions, bringing and preparing food, arranging and performing ceremonies and other socially necessary activities.

A further conclusion is that all except the smallest tomb projects necessitated the activation and mobilisation of a larger social network. Presumably, this would mean long periods of negotiation and planning, playing on factors such as clan or kinship ties, social obligations, relative social rank etc.

10. Conclusions

The data presented here do not support long distance transport of building material for any of the tombs in Falbygden. The tombs are constructed from material that was available locally, within short distances. The maximum distances involved can be estimated to less than ca 2 km, but in most cases suitable material could have been obtained within just a couple of hundred meters. Precambrian ice-transported blocks would have been available in nearby fields, just as diabase blocks, and would not have needed quarrying. Limestone and sandstone slabs could have been quarried from escarpments where they are exposed, or alternatively from areas with thin soil cover. No quarries have been located, however.

Further, there is a clear tendency for conscious selection of material to be used in different parts of the tombs. Chamber uprights are primarily built with limestone slabs, while Precambrian rocks are preferred for roof blocks, and diabase or Precambrian rocks for keystones. Functional explanations in terms of the hardness or durability of rocks are not sufficient, as noted above. Two other kinds of factors may be considered as governing the choice of material; one the one hand constrictions due to the availability of various materials, and on the other hand symbolic/ideological properties ascribed to the stones and the landscape they occur in.

The accessibility of raw materials is different for different kinds of stone. Precambrian gneiss/granite blocks as well as diabase blocks are scattered over the landscape as ice-transported blocks in the moraine. They are still a prominent feature of the landscape and would have been equally present in all parts of Falbygden (as well as outside it). The availability of limestone and sandstone, on the other hand, is spatially restricted and is constrained by soil cover depth and distance to escarpments/edges. From the data presented above, it is clear that there is a correspondence between material used for chamber walls on the one hand and the geological substrate a particular tomb sits on, on the other. To a lesser degree, this pattern is also visible for roof blocks, in that roofs not constructed by Precambrian rocks occur primarily in areas with accessible limestone or sandstone.

Thus, it seems that local availability of rocks plays a significant role. However, this is not the whole story. In addition to the rocks available in the local substrate, ice-transported Precambrian and diabase blocks would have been present in all areas of Falbygden. Therefore, the use of these for roof blocks and keystones but not for chamber uprights must involve a conscious choice, motivated not by necessity or physical properties but by more intangible properties ascribed to the rocks. The use of the very local material may have been a way of emphasising a very direct connection to the land, and thereby strengthening a connection between the living, the ancestors and the particular landscape of Falbygden.

A further limiting factor would have been the ability of different groups to mobilise human and/or animal work forces needed to carry out their various tomb building projects. In most cases, such projects were beyond the capacity of a local group and would have needed the assistance of a larger social network, mobilised through mechanisms such as kinship, alliances, debth, social obligations or other.

Given the large number of tombs and the limited period of time during which they were constructed (200-300 years, possibly less), it is highly likely that several building projects were going on or being planned at the same time. Several groups would then have been competing for assistance and resources, and the success of a particular building project would be a result from a combination of factors such as group size, economic resources, social standing, prestige, relative rank but also the ability to negotiate alliances with other groups and draw them into your own network. The measure of success would also be directly visible in the physical size and shape of the tomb.

In this regard, it is interesting to note that recent investigations, by means of strontium isotopes, into the geographic origins of people buried in Falbygden passage graves has shown that some 25% of them were not born and raised within the Cambro-Silurian area but in areas with more radiogenic, Precambrian bedrock. Most probably they came from the surrounding regions of western Sweden (Sjögren *et al.*, 2009). Even more dramatic, at least 50% of the cattle found on TRB settlements in Falbygden came from areas with Precambrian bedrock (Sjögren & Price, 2012). This suggests that the inherent dynamic in the process of tomb building led the people in Falbygden to forge and maintain relations with groups well outside the region where passage graves were built at all.

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