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**Geoarchaeology of mound structures:
A sedimentary micromorphological analysis of
Lapa da Meruje (Vouzela, Viseu)**



Faro 2021

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A sedimentary micromorphological analysis of
Lapa da Meruje (Vouzela, Viseu)

Dissertação de Mestrado em Arqueologia

Trabalho efetuado sob a orientação de:
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Faro, 2021

Declaro ser o autor deste trabalho, que é original e inédito. Autores e trabalhos consultados estão devidamente citados no texto e constam da listagem de referências incluída.

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Maio de 2023, Faro

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Acknowledgments

Gostaria de agradecer primeiramente aos meus dois orientadores, nomeadamente;

Ao Prof. Dr. António Faustino de Carvalho que não apenas escolheu orientar e auxiliar no desenvolvimento deste seminário, mas que tem vindo a ajudar de forma imensurável e acompanhar-me ao longo da minha fase académica.

Ao Dr. Carlos Duarte Simões por participar como orientador na elaboração deste seminário, mostrando sempre disponibilidade e generosidade ao longo do processo.

Em seguinte às duas entidades e todos os seus membros;

À Camara Municipal de Vouzela por todo o auxílio prestado, bem como fornecerem o material analisado e permitirem participar nos projetos de estudo e valorização do seu património.

Ao ICArEHB (*Interdisciplinary Center for Archaeology and the Evolution of Human Behaviour*) por permitirem utilizar os laboratórios bem como o suporte e auxílio de todos os seus membros.

Gostaria especialmente de agradecer à minha incrível família pelo amor, apoio e constante encorajamento que deram e continuam a dar ao longo deste tempo. Em particular, gostaria de destacar o suporte dos meus pais, pois são eles que todos os dias me direcionam para o caminho do sucesso.

À minha espetacular, Maria Beatriz, pelo suporte, amor e carinho que mostras a cada dia. És um verdadeiro pilar da minha vida, com isto quero dizer que...também te amo incondicionalmente.

A todos os meus colegas e amigos, que me acompanharam pela minha jornada académica, bem como pessoal. Espero também acompanhá-lo nas suas jornadas da vida.

Keywords: Beira Alta; Lafões; Megalith; Middle Neolithic; Micromorphology

Abstract:

The occurrence of an ample number of megalithic monuments in the historical region of Lafões, presents itself as a consequence of the increased human activity on the landscape, having this notable growth marked during Neolithic period. From this point, the present work focuses on a geoarchaeological approach, in order to obtain an insight on possible land use before the building of megaliths, as well as the construction phases and of use of these funerary structures.

To answer these problems a sedimentary micromorphological analysis was carried out, also adding a better understanding of both the stratigraphy and construction methods of a particular megalithic monument. This was conducted by obtaining samples from the Neolithic dolmen of Lapa da Meruje (one of the few dolmens to have been target of consistent archaeological work), by means of understanding site formation processes through the analysis of thin sections, under a petrographic microscope.

Through the use of this method, it was possible to understand the extent of the violation that occurred in the funeral chamber. On the other, preserved areas of the monument revealed the origin of the sediments used for the construction of the monument and the filling of the funerary chamber (in prehistoric times), these being most likely of local origin. Furthermore, several elements within the thin sections led to the possibility of having occurred the practice of vegetation clearance activities previous to the construction of the funerary structure, as well as a layer attributed to preparation practices for the construction of the dolmen.

Resumo:

A ocorrência de um amplo número de monumentos megalíticos na região histórica de Lafões, localizada na Beira Alta, apresenta-se como consequência do aumento da atividade humana na paisagem, tendo este notável crescimento sido marcado durante o período do Neolítico. Como resultado vários trabalhos têm vindo a ser publicados sobre o megalitismo desta região, particularmente quanto à sua grande variabilidade arquitetónica e espólio funerário. Estes trabalhos viram o seu começo ainda nos inícios do século passado, destacando-se A. de Amorim Girão com a sua obra publicada, intitulada as “*Antiguidades pré-históricas de Lafões*” (1921), que por sua vez estabelece a primeira referência científica destes monumentos pré-históricos.

A partir deste ponto, o presente trabalho centra-se numa abordagem geoarqueológica, de forma a obter uma compreensão sobre o possível uso do solo antes da construção dos megálitos, bem como as fases de construção e de utilização destas estruturas funerárias.

Para responder a estas problemáticas foi realizada uma análise de micromorfologia sedimentar. Este método baseia-se na observação e interpretação detalhada de amostras sedimentares intactas e orientadas utilizando um microscópio petrográfico para identificar a sua organização interna, de modo a compreender os processos de formação dos depósitos, simultaneamente distinguindo processos antrópicos bem como naturais. Neste caso de estudo, adicionalmente adquirindo também uma melhor compreensão tanto da estratigrafia como dos métodos construtivos de um determinado monumento megalítico.

Esta foi realizada a partir da obtenção de amostras de sedimento em bloco do dólmen Neolítico da Lapa da Meruje (um dos poucos dólmenes a ter sido alvo de trabalhos arqueológicos consistentes), através da compreensão dos processos de formação do sítio com base na análise de blocos vindos dos depósitos da mamoa e da câmara.

Desde 2016 tem se feito trabalhos de escavação de forma contínua na Lapa da Meruje, revelando vários aspetos do monumento, como as suas características arquitetónicas. Trata-se de

um monumento de grandes dimensões, constituído por uma câmara e um corredor comprido (irregular) que leva a um átrio exterior. Foram ainda registadas gravuras pré-históricas nos esteios da câmara e do corredor. Estas escavações permitiram compreender as várias fases de ocupação do sítio, sintetizando na sua fundação no Neolítico Médio e o seu selado ainda em época pré-histórica (na passagem para o Calcolítico). Por último foram encontradas marcas de clara violação, resultado da sua utilização na Idade Média e outras feitas posteriormente pela sondagem realizada por A. Girão nos inícios do séc. XX.

Posto isto, por meio da utilização da micromorfologia, foi possível compreender a extensão destas violações ocorridas na câmara funerária, no qual foram removidos os sedimentos do preenchimento pré-histórico (datados ao Neolítico) pelas comunidades medievais, dada pela presença de cerâmica deste período. Porém não foram identificadas marcas desta violação em níveis próximos da base. Estes sedimentos remexidos teriam sido depositados imediatamente na parte exterior da câmara, na qual numa fase posterior, de estagnação do uso da câmara (ou pelo menos utilizada com pouca frequência), estes foram (re)depositados na câmara através de processos localmente coluviais, dada pela presença de agregados arredondados, bem como a mistura de materiais de várias épocas.

Por outro lado, áreas preservadas do monumento revelaram a origem dos sedimentos utilizados para a construção do monumento e o preenchimento da câmara funerária (em tempos pré-históricos), sendo estes provavelmente de origem local. A matriz dos sedimentos do interior da câmara consiste de areias graníticas (compostas principalmente por micas), juntamente com uma grande quantidade de matéria orgânica. Os sedimentos utilizados para o preenchimento da câmara funerária apontam parcialmente para uma fonte semelhante à dos depósitos da mamoa. Vários elementos encontrados nas lâminas delgadas que conduzem à possibilidade de terem ocorrido práticas de limpeza de vegetação anteriores à construção da estrutura funerária, justificado pela presença de uma forte componente de matéria orgânica (fina e amorfa) misturada nos sedimentos. Para além desta foram encontrados vários elementos vegetais como fragmentos de carvão (alguns com a estrutura interna conservada), fitólitos correspondendo a espécies gramíneas.

Para além da estrutura pétreia interior, a mamoa também revelou ser mais complexa do que aparenta a uma primeira vista pela sua heterogeneidade estratigráfica. Esta não se apresentava como uma acumulação simples, resultado de um único evento de despejo (o que normalmente é considerado) mas constituída por camadas atribuída a práticas de preparação para a construção do dólmen. Pela presença de seixos de rio imbricados na base da mamoa, suportados por sedimentos que parecem ter vindo do terraço fluvial de onde o monumento foi construído, com a adição de material arqueológico cerâmico. O nível que cobria estes clastos foi distinguido pela sua matriz mais arenosa (em comparação com o nível acima), levando à possibilidade da sua origem como vindas do terraço fluvial alterado. A cerâmica incorporada nestes sedimentos poderia estar relacionada com rituais de preparação do dólmen. Contudo não é claro a que ponto a cerâmica teria sido incorporada, pois poderia já estar incorporada, podendo ter vindo do topo das vertentes da bacia onde possíveis ocupações poderiam estar localizados. A camada superior pela sua (facilmente distinguível pela sua coloração negra) pela sua coloração preta e possui uma microestrutura massiva bem como alto grau de bioturbação, com a presença de marcas deixadas por insetos e plantas. Estas comunidades neolíticas teriam obtido esses sedimentos orgânicos de um solo superficial ou/e horizontes de solo próximos à superfície. Estes mostram características de pertencerem a solos que se desenvolvem sob áreas florestadas. Pela sua forte componente orgânica terão vindo de solos húmidos que se desenvolvem sob áreas florestadas. Estas possivelmente terão vindo de depósitos no fundo do vale, erodidos das vertentes da bacia.

Em suma, este seminário expõe uma série de problemáticas envolventes à Lapa da Meruje, bem como ao megalitismo de Lafões na sua generalidade, relativos aos impactos que estas construções teriam no meio ambiente envolvente, no entanto a utilização de métodos adicionais em trabalhos futuros (como o uso da geoquímica) poderá vir a confirmar as hipóteses levantadas com o uso da micromorfologia. Adicionalmente a conclusão da escavação da câmara aprofundará a compreensão do uso do monumento.

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1. Introduction

The notable increase of activities that impact the environment and soils, such as vegetation clearance on account of human action, seemingly develop in parallel with the appearance and use of Prehistoric megalithic tomb structures, additionally linked to agropastoral practices (THOMAS, 2012). These large stone and earthen structures are found distributed throughout the Portuguese territory, occupying diverse topographic locations and environments, from coastal strips and planar regions to high mountainous areas. Even at smaller scales this diversity is vast as seen in the region in study— Lafões (located in the heart of the Beira Alta) is overall characterized as a mountainous region and displays an enormous geomorphological diversity. This translates itself into propitious areas for the establishment of populations which consequently comes to show the immense archaeological potential. Since the discovery of the Lafões megalithism at the beginning of the 20th century by Amorim Girão a systematic study has been carried out that has highlighted the particular characteristics of this megalithic group such as a substantial architectural variability (MOITA, 1966).

Despite the large number of monuments that have come to provide a considerable amount of information, the majority of the knowledge rarely transcends the study of the artefactual remains contained within these tumuli or the architecture of the internal structures, not including the earthwork. Since only the internal structures gain prominence in megalithic studies, little is known about the earthen structures, which are normally considered as a simple sediment accumulation into a pile, resulting from a single dumping event. However, the creation of earthen mound structures seems to be more complex than they first seem to appear, and having been strongly suggested that these may play an important role in the ritual nature of these archaeological sites (KIDDER & SHERWOOD, 2016). The creation of mound structures is just one of the problems related to these types of sites, since there is scarce knowledge of previous occupations of the spaces currently occupied by megalithic monuments and/or activities elaborated before the construction of these funerary and votive sites. This “transparency” of these archaeological sites may be influenced regarding the high acidity of the soils which creates poor conservation conditions resulting in a lack of organic remains (namely bone material) and in turn leading to insufficient data on the use of the interior of the monuments.

To better understand general patterns of implantation of these monuments and the overall framework of the region’s megalithism, a project that aimed to investigate and enhance existing sites and monuments in the municipality of Vouzela (Lafões) was started. Among Vouzela’s megalithic group is the Dolmen of Lapa da Meruge that is the main focus of this project due to its good state of conservation was incorporated in this project. Furthermore, a previous study of its artefact assemblage and the morphology of the structure places chronologically this monument

in one of the earliest megalithic constructions of the region. Based on these characteristics, Meruje has been one of the first megalithic monuments to be studied, which, for this reason, has been the object of constant reviews.

The conditions stated above prompted the use of soil micromorphology for the study of the sedimentary deposits found at Lapa da Meruje. The methodological approach was established based on excavation work previously elaborated at the site and field observations.

The use of the soil micromorphology has been a viable method in obtaining results, especially related to site-specific questions, such as a better delimitation of the stratigraphic sequence and construction techniques. Recent works have carried out geoarchaeological research at megalithic sites using this particular method (ADEWUMI, 2019; GKOUMA et al., 2021; RAMSTEIN et al., 2022), nevertheless, in a global view there are still few works on micromorphology applied to megalithic contexts and even less in granitic settings and mountainous regions.

The present work looks to understand the relationship of the funerary world and its implantation in the landscape by means of an micromorphological approach applied to the specific site of Lapa da Meruje via the samples obtained from two different areas of the dolmen — the mound and the interior of the funerary chamber. While the sample from the mound could give an insight on its building and of previous land use before the construction of the tomb, the chamber samples could lead to a better understanding on the use of the megalith as well as the post-chronological phase(s).

2. Delimitation of the study area and regional integration

The dolmen of Lapa da Meruje is located in the centre north of Portugal, within the historical region of Lafões, whose geographical characteristics, mainly orographic and climatic, give it a marked identity. This region in turn is integrated within a larger territorial unit, the Beira Alta province. In the 19th century the administrative unit of Lafões was altered, resulting in the current segmentation composed by the municipalities of Oliveira de Frades, São Pedro do Sul and Vouzela. Lapa da Meruje is located in the latter, which has not only as limits São Pedro do Sul to the North and Oliveira de Frades to the West and Southwest, but also the municipalities of Tondela and Águeda in the South and Viseu covering the Eastern side (fig.1).

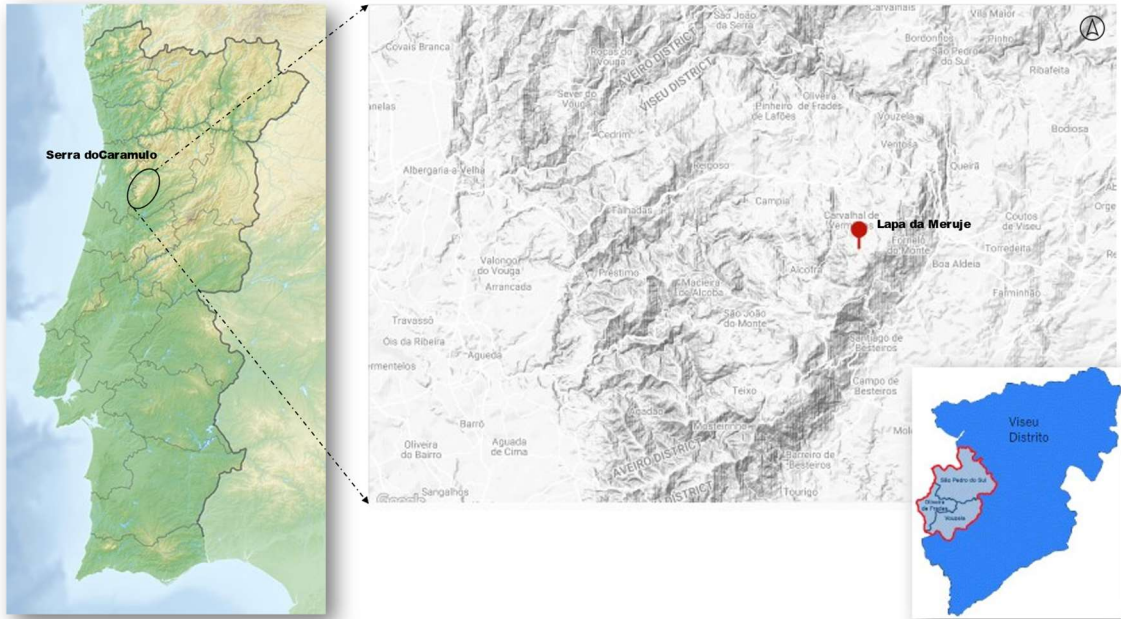


Figure 1 – Geographical location of the Caramulo mountain range within the Portuguese territory and delimitation of the region of Lafões, in the district of Viseu.

2.1. Geomorphology

Lafões is situated on the westernmost sector of the Beira Alta region, between two distinct geomorphological units that compose this latter major region. While the eastern side of the region is composed by the Central Highlands, namely by the Estrela mountain range, in contrast the West side leads to a group of mountain ranges, orientated from NNE to SSW, forming a barrier that divide the hinterland from the coastal regions. Due to their geographical location these were appropriately designated as Western Mountains, being composed by three main units, from North to South: Montemuro, Gralheira and Caramulo. Both the Gralheira Massif and Caramulo form gateway ranges which are transversely cut by the River Vouga (GIRÃO, 1921; CARVALHO, 1930)- (fig.1). From the meeting point between these two mountainous areas to the coast, it is seen an intensification of ramifications of water courses, in the form of tributaries or even streams, spreading from this point on. These also act as a physical limit to another historical region known as Beira Litoral,

Focusing on the Caramulo, where the archaeological site under study is located, this mountain range presents itself as one of the key features of Lafões, as it plays a large role into various aspects such as topography, climate, vegetation cover, among others that establish the regions' landscape (which will be detailed described below). It is a dominant landmark of the Lafões region, being NE-SW orientated, with its highest point being the Caramulinho (1074 m above sea level; hereafter a.s.l.). Both mountain sides of the Caramulo show discrepancies, as the

western flank exhibits a gradual ascent, forming a moderately sloped surface, while in contrast the eastern incline is an abrupt descent (RIBEIRO, 2006; CEISCaramulo, s.d.). The resistance offered by different geologies that make up the Caramulo towards erosion effects can be clearly seen along the mountain ridges and various high points, alternating between rounded peaks in schistose areas and sharper/pointed peaks with the granitoid rocks. The majority of the Caramulo is comprised of a predominant granitic landscape, which in turn is affected by a high level of several weathering affects, primarily mechanical. From these processes the appearance of boulder fields becomes a common sight (Fig. 2). These can be explained by the occurrence of colluvial processes (given the steep slopes) such as runoffs, consequently “(...) favouring the exploitation of diaclases/joints and giving rise to spheroidal type disjunctions (...)” (RIBEIRO, 2006, p. 9; REBELO, 1991).

Within this mountain setting other orographic elements are also well marked, namely the occurrence of plateaux's. Located at several altitudes, these consist of flattened platforms, corresponding to old erosion surfaces, having been severely affected by slope processes, like solifluction. They are related to “(...) testimonies of stability phases in the fluvial incision process (...)” (RODRIGUES & GOMES, 2020, p. 84). To better clarify the reason for this topography it must be understood that the Beira Alta integrates the western border of the Iberian Massif. This results in one of the most notable characteristics that is the high number of fractures that occur within this geological unit, one of which affect the region in study, referring specifically to the Régua-Verin-Penacova and the Vilariça fault (RAMOS & PEREIRA, 2020). This rectilinear fracture creates a valley, of which was attributed the name Riba-Má or Ribamá, from which the Vouga river runs through. The fractures that resulted characteristic of the Massif are clearly seen with the Caramulo. Its southeasternmost part shows a small paleolake, given by an extensive basin (CARVALHO, 1930). This refers to area known today as Vale de Besteiros.



Figure 2 – View of the basin and Lapa da Meruje from the (a) south-east, immediately after the forest fires of 2017 and (b) south-west, post referred event.

2.2. Geology and soils

Lafões integrates a large geological unit known as the Iberian Massif (RAMOS & PEREIRA, 2020), which is subdivided into several tectonic-stratigraphic domains, where the region in study is incorporated in the Central Iberian Zone / Schist-Greywacke Complex (MEDINA, 1988, 1996). Geologically, this translates into a predominance of granitic rocks, along with mica schists, phyllites, corneal rocks, musket schists (andalusite and cordierite) and amphibolite base rocks (see Fig. 3). Within the domain of the granitic rocks and granodiorites, these present a “fairly uniform mineralogical-petrographic constitution, seeming to belong to the greatest extent to the coarse to medium grained porphyroid granite, being likewise also known more or less extensive patches of non-porphyroid granite of medium coarse or fine grain” (FONSECA, 2018, p. 13: original in Portuguese). In the case of the area of Vouzela, two-mica granite, with different granulometry, differentiated between fine to medium grained; medium-grained and medium to coarse grained, being the last two of porphyroid tendency cover the area (see Fig. 3). Other lithologies also outcrop in the region, some of which are metamorphic in nature, highlighting schists and quartzite (REBELO, 1992, p. 17). Since the Caramulo range displays both well marked sectors of either schist or granites, in given areas these two rock formations merge forming a contact metamorphism (MEDINA, 1988). Within these same areas of the metamorphic rocks, greywackes can also be identified, alongside numerous quartz veins.

As most of the region is composed by siliceous terrains, the predominant type of soils that compose Lafões region are classified Cambisols, being possible to distinguish humic cambisols associated with luvisols (schists), humic cambisols (schists) and humic cambisols (eruptive rocks) (ALMEIDA, 2009; RIBEIRO, 2006; SANTOS, 2008), this last one predominant on the higher areas of Caramulo (ALMEIDA, 2009). Once, that the soils are composed by granites and schists along with sands and sandstone, means that the large majority of soils are extremely acid, leaving poor conservation conditions of archaeological materials, like bones (WEINER, 2010).

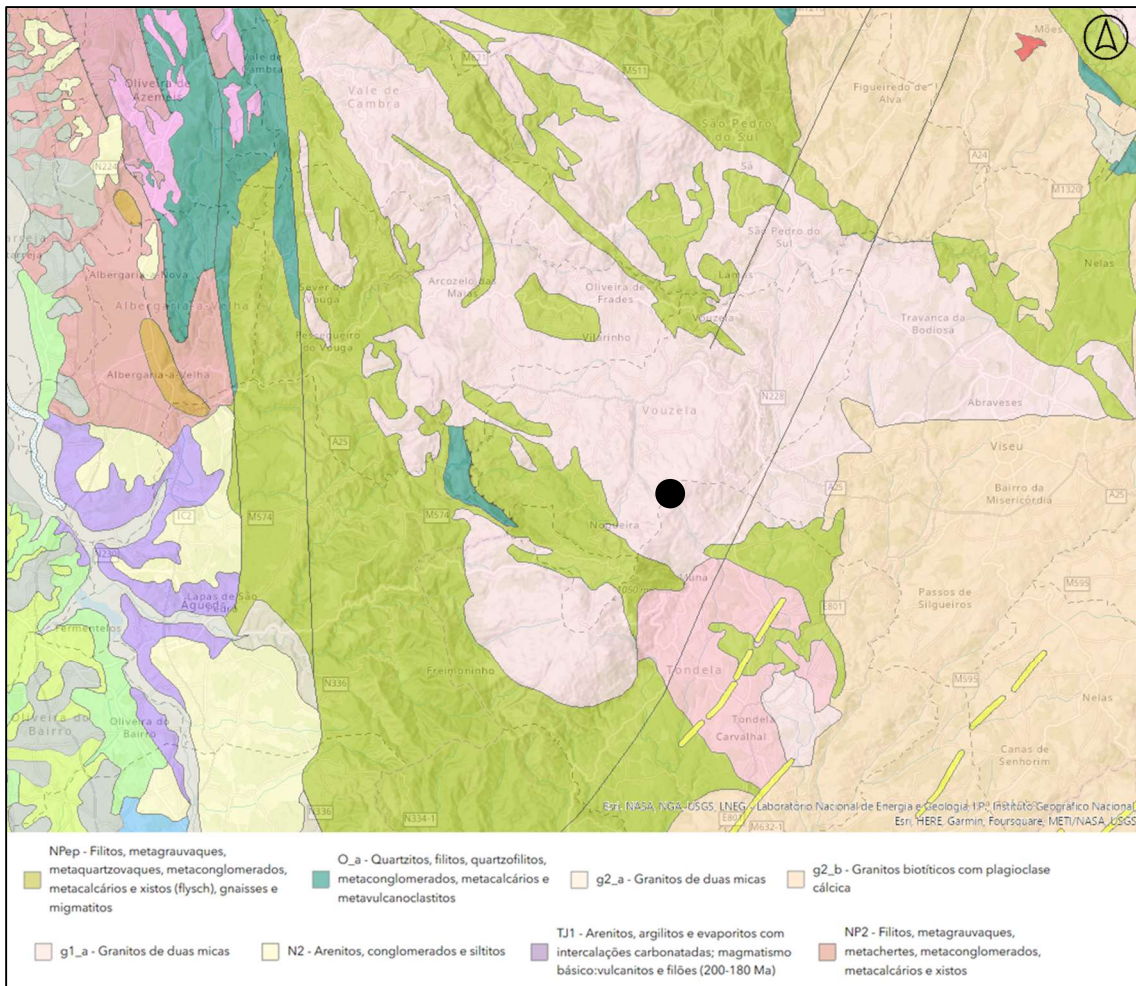


Figure 3 – Partial localization of the study area with location of Meruje (black dot), scale 1:2 888 95 — adapted from “Carta Geológica de Portugal, scale 1:1 000 000”, (source: LNEG).

2.3. Climate

Despite the large input of several factors that reflect on the region’s climate, within a general framework Lafões can be inserted in a typical Mediterranean climate (MORA & VIEIRA, 2020) though in this case with a strong Atlantic influence. This is characterized by a dry climate during the Summer months and the increase of precipitation levels during cold season “(...) with average temperatures of 14-18 °C and generally no average monthly temperatures below 0 °C” (ALMEIDA, 2009, p. 48). Once again, the surrounding mountain ranges play an important part in defining the region’s climate, being the Caramulo one of these, that displays a large variability due to its somewhat parallel orientation to the Atlantic. This creates a barrier to the large Atlantic air masses from the West that affect the continent, creating a discrepancy of both sides of the mountain. On the West side the precipitation levels are much higher, as a result from these humid coastal climates, leaving the East side a drier climate, similar to that of interior regions. Precipitation levels exceed 1200 mm per year (ALMEIDA, 2009, p. 50; MORA & VIEIRA, 2020, p. 38; SANTOS, 2008). Given the alternation between two types of environments, one of coastal

nature that exhibits constant values and another which is closer to inland environments, thus displaying large discrepancies in its thermal amplitudes, it is possible to further categorize the region as sub-Atlantic.

2.4. Hydrographic networks

Inserted in the hydrographic basin of River Vouga, a high number of water courses can be observed in the region, being heavily influenced by the geological features of the terrain, such as the numerous fractures found in a granitic cover or “deformations suffered by flattening surfaces” (RIBEIRO, 2006, p. 11). The main river being the Vouga, it plays an important role since it connects the coastal region to the inland areas, from which during its traverse through the region of Lafões several smaller tributaries affect the territory in study, especially in the settlement of populations. Vouga originates in the Lapa mountain range, traversing 148 km before branching out into channels and giving rise to the formation of the Ria de Aveiro, a large coastal lagoon, after passing the Gralheira and Caramulo gateway (SANTOS, 2008). Over its course three main sections that are well marked can be identified (or rather three large hydro-morphological units): Alto Vouga, Médio Vouga and Baixo Vouga (Upper, Middle, and Lower Vouga, respectively), these divisions being assigned according to the different characteristics of the river, such as morphology, climate, and hydrological regime (Agência Portuguesa do Ambiente, 2015). The region in study is located in the middle course, where the subordination of the river by the surrounding landscape leads to the formation of “tight V-shaped” valleys. This is clearly evidenced by the passing of the Vouga between the Caramulo and Gralheira, as mentioned above. Several important tributaries disperse from the Vouga River “(...) among which the most important and that pass over the region in question are the Alfusqueiro, Teixeira, Mau, Águeda and Sul rivers” (GIRÃO, 1921; Agência Portuguesa do Ambiente, 2015; SANTOS, 2008). Several surface waterlines cover the municipality of Vouzela, the most important ones consist of the Zela, Troço, Alfusqueiro, Alcofra, Couto, and Ribamá streams (PMDFC-Vouzela, 2020). Lapa da Meruje is fully inserted in the drained basin by the Couto River (Fig. 4).

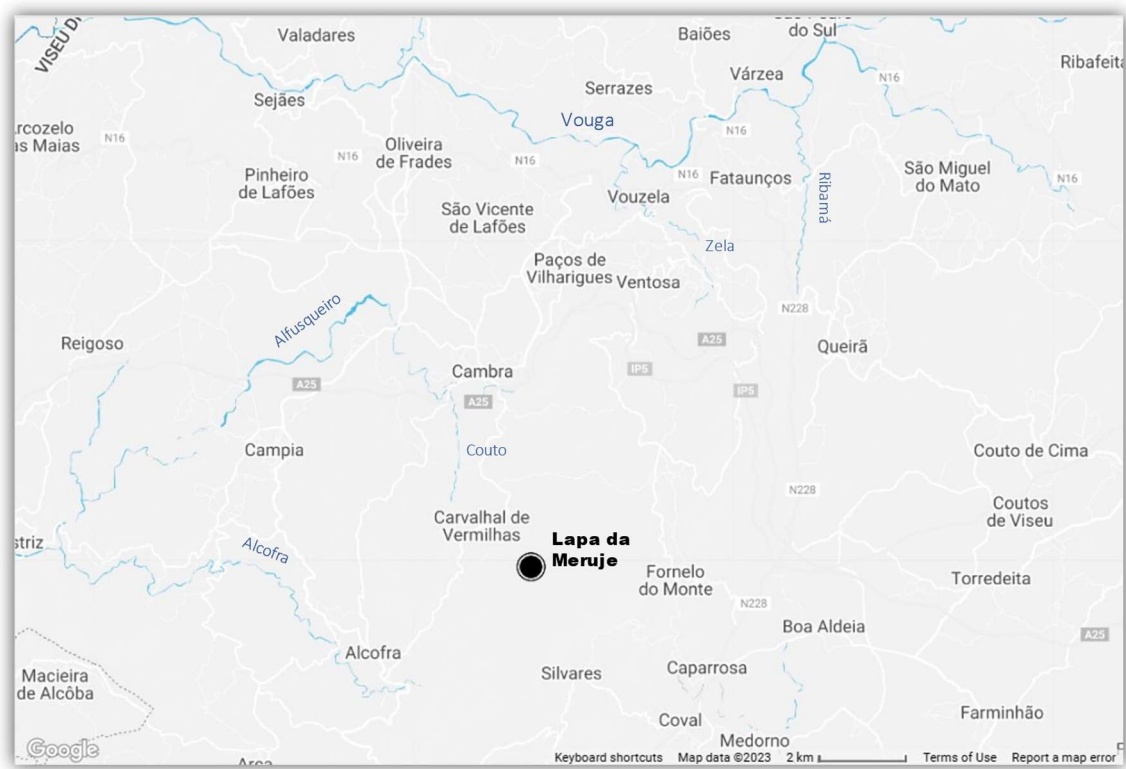


Figure 4 – Main water lines in the region under study and location of Lapa da Meruje.

Underground water lines also circulate throughout the region (SANTOS, 2008), as a major fault system cuts through Lafões, referring to the Régua-Verin-Penacova (MEDINA, 1988; 1996; RAMOS & PEREIRA, 2020; GOMES, 2007), crossing from NNE to SSW. The section that cuts through the town of São Pedro do Sul, designated as the Ribamá fault, leads to the occurrence here of thermo-mineral springs (GOMES, 1999). Some of these can be exemplified with the Roman, Medieval and modern baths at the São Pedro do Sul hot springs. For the case of this last area, the formation of hot springs it is not only tied into the appearance of fractures, but also from the different geological composition of the granites.

2.5. Vegetation

All the previous elements play into the vegetation cover of the Lafões landscape, having predominantly a forest type, but other environments can be identified such as the heath/scrub and aquatic/riverside areas (ALMEIDA, 2009; RIBEIRO, 2006). Large arboreal species compose the tree stratum, which can be evidenced mainly through the presence of deciduous oak trees, along with others such as alder (*Alnus glutinosa*), ash (*Fraxinus angustifolia*), betula (*Betula celtibera*) or other mostly closer to permanent water lines, like willow (*Salix atrocinera*). As already discussed, the Caramulo mountain range creates two differentiated climates, which in turn is reflected by the appearance of two types of distinguished autochthonous oak. For the Western

flank, it is predominated by the so-called alvarinho oak (*Quercus robur*), as it displays an Atlantic climate, while the Eastern side, having a more continental climate, that is preferred by the black oak (*Quercus pyrenaica*) (MONTEIRO-HENRIQUES et al., 2021). In (sub)mountainous areas are dominated by maritime pine (*Pinus pinaster*) and eucalyptus (*Eucalyptus*), a modern introduction (SANTOS, 2008). In the case of shrubs, the bulk of it is composed by several species of gorse, namely the arnal gorse (*Ulex europaeus* subsp. *latebracteatus*), *Genista falcata* (gorsegadanho), common broom (*Cytisus multiflorus*) or *Genista hystrix*, amongst others (MONTEIRO-HENRIQUES et al., 2021). For the areas located in larger elevations are best represented by the appearance of rockroses (*Cistetum ladaniferi*) and white Spanish broom (*Cytiso multiflora*) (*idem*, 2021).

3. State of the Art

3.1. The megalithism of Lafões

The interest in the megalithic monuments of Portugal, specifically in the Beira Alta region, started in the mid-19th century and developed further in the early 20th century. The existence of mounds of variable sizes, located throughout the landscape, was the key factor for the beginning of their study by various investigators. This also marked the start of the interest of the mortuary practices associated to the Neolithic period, which resulted in the publishing of various works about this subject. This brought into light a wide variety of megalithic architectures throughout the Beira Alta region. These consist of mounds that cover burial tombs, mainly characterized by collective inhumation practices. New forms of funerary practices like incineration will make their appearance in later periods, like the late Bronze Age. Megaliths represent one of the aspects that characterize the likely emergence of complex societies in the Neolithic, which can be associated with a possible legitimization of a given territory, utilizing these constructions to distinguish groups or to establish a relation and/or frontiers between these. This defines the Middle Neolithic, comprising the first three quarters of the 4th millennium BC.

The first monument that was targeted for archaeological work in the Lafões region was the dolmen of Pedra da Arca, better known today as Anta de Espírito Santo de Arca, located in the municipality of Oliveira de Frades. The antiquity of the site was already acknowledged, having been first referenced in the *Diccionario Geografico* (in 1747) by the priest Luís Cardoso, that mentions the monument and its relation to the practice of pagan religions. Other references of this monument include the *Corografia Portuguesa* by priest António Carvalho da Costa (1650-1715) – (GIRÃO, 1921, p. 44). Yet it's first scientific mention would be made in the late 19th century by José Leite de Vasconcelos (1898), published in the journal *O Archeólogo Português*.

Shortly after this publication, a study on a larger scale, presenting itself as the first to develop the subject of megalithic constructions extensively of Lafões was due to Aristides de Amorim Girão [1985-1960], who established the first profile of the region's remote past. This work also makes reference to several archaeological excavations aimed at the region's megalithic monuments carried out by this investigator. This publication, intitled "*Antiguidades pré-históricas de Lafões*" (GIRÃO, 1921), constitutes the first archaeological register of the region's megalithic constructions. However, it didn't limit itself to the description of archaeological sites, addressing a wide range of topics, in order to explain the establishing of past societies in the region. By describing a detailed contextualization of the region, portraying its orographic and hydrographic features, and adding more minute elements, like the etymology of the words that gave rise to the name's places in the region, it exposed it's complete identity. One aspect of this work that stands out, is the reference to certain monuments that were lost or that were destroyed, prior to this work.

During the middle of the 20th century, other authors would publish new finds on the megalithism of Lafões. This is the case of three investigators that surveyed the Vouga river basin, from the Atlantic shore to more inland areas, further upstream in the inner part of the Marginal Massif. This was elaborated by Luís de Albuquerque e Castro, together with Octávio da Veiga Ferreira and Abel Viana (CASTRO et al., 1956). These researchers also carried out systematic excavation work in the Antelas dolmen (CASTRO et al., 1957), which allowed a careful description of the dolmen's architecture and artefactual assemblages, as well as a survey of its art and its state of conservation. Located also in Oliveira de Frades, this was first mentioned in the publication by A. Girão, who referred to the monument as the "*painted dolmen of Antelas*". Given the importance of the paintings and their excellent state of conservation, it underwent restoration work along with further archaeological field work between 1993 and 1995, carried out by Domingos Cruz (1995). This marks one of the main research questions related to megalithism—the beginnings of megalithic art. All these works, especially the one by A. Girão, constituted an initial base of studies on the subject for the research of the following archaeologists.

Later works were published that address this issue on a broader, regional scale. This is the investigation carried out by Irisalva Moita. Her work focused on a more systematic approach to the study of dolmenic constructions, entitled "*Características predominantes do grupo dolménico da Beira Alta*" (MOITA, 1966). The publication presented the question of the architectural evolution of the megalithic constructions in the western Iberian Peninsula, especially in the mentioned region. This was achieved by a comprehensive register of megalithic monuments, that are located within the various municipalities that compose the Beira Alta region, also referencing previous works on the monuments. A strong focus is made on the Lafões sites, though all suggests that this researcher has never visited this region.

The dolmenic monuments of the Beira Alta region also where the subject of study by the Leisner couple since the 1930s, who reviewed the megalithic monuments already documented, resulting in the posthumous publication by Vera Leisner in 1998 of her work “*Die Megalithgräber der Iberischen Halbinsel*” (LEISNER, 1998). As with other previously mentioned works, this makes use of material already published by A. Girão when it refers to the Lafões territory, which constituted an important basis for this work, especially in the register of monuments that have since disappeared or been altered. This was also valid for the short syntheses, like the one published by João Luís Cardoso (1999). In this article the author proceeds to systematize (and update) the information already published, creating a very complete inventory of the megalithic monuments of Vouzela. The cataloguing utilized the entries presented by Leisner (1998), however it only reaches a total of 24 monuments, since two menhirs (Fataunços and Bicão dos Conqueiros)¹ and the mound of Monte Cavallo, also mentioned by A. Girão, are not counted (ANASTÁCIO, 2019). Lapa da Meruje is not mentioned in Cardoso’s (1999) work because it was thought to belong to the neighbouring municipality of Tondela (see below). On this same year it was also published the “*Carta Arqueológica do Concelho de Vouzela*”, integrating other types of archaeological sites, namely from historical periods (MARQUES, 1999). The two last works on Lafões megalithism that provided an update and systemization of the existing dolmens, derived respectively from a master’s thesis (ANASTÁCIO, 2019) and from recently carried out excavations (CARVALHO et al., 2021a).

Works on individual sites also contributed for the comprehension of the Lafões megalithism, as is the case on the dolmen of Casa da Orca da Malhada do Cambarinho/ Malhada do Cambrinho, that refers to a mountain basin where exists a cluster of megalithic monuments. The mentioned megalith was excavated and classed by A. Girão in his publication as a “gallery dolmen”, that is a type of dolmen where the burial chamber is not architectonically distinguishable from the passage. This particular megalith was later re-excavated in 1993 by Pedro Sobral de Carvalho and colleagues (CARVALHO et al., 1993), who were able to state that the only surviving part is the passage, the chamber having been destroyed in the past.

As of October of 2017, when a large wave of wildfires broke out, severely affecting the region’s landscape by destroying its hitherto thick vegetation cover (fig. 2a) and thus allowing for the discovery of new archaeological sites, marked a new chapter of archaeological investigation in the Lafões region. These wildfires offered “very favourable soil visibility conditions (...), which allowed to increase the number of sites (...) which could thus constitute a very relevant case-study in the region” (CARVALHO & CARVALHO, 2018, p. 37: Portuguese original). This gave rise to a drastic turning point on then ongoing survey tasks, altering the field strategies in

¹ These were not accounted for on purpose as they are not funerary monuments.

order to systematically cover the entire territory of Lafões. This change in priorities and field methodologies took place in Vouzela and Oliveira de Frades (respectively, REAL et al., 2019; CARVALHO et al., 2022), but not at São Pedro do Sul, the three modern-day municipalities that form the Lafões region. Fruit of these projects a new line of archaeological interventions on megalithic monuments occurred, throughout the region in question.

The excavations that took place in more recent years have come to put in view the complexity of cultural/ritualistic and funerary phenomena related to the regional megalithic phenomenon. One of the most remarkable phenomena in this regard is the observation that Neolithic monuments seem to mark central areas around which, in later periods, small inhumation mounds, dated to the Chalcolithic, and incineration cists, from the Bronze Age, were subsequently built. Other new monuments have also been identified, as is the case of so-called “monumentalized outcrops” (CARVALHO & CARVALHO, 2018; CARVALHO et al., 2022), cultural places attributed to the late Bronze Age.

All the previously mentioned excavation seasons were part of a project entitled LAFÕES (“*Estudo do património histórico-arqueológico de Vouzela*”), having taken place between 2016 and 2019. The core objectives of this project viewed an archaeological investigation and preservation of the heritage in the municipality of Vouzela (REAL et al., 2017, 2019). Among other objectives (the project had a general focus on a diachronic perspective of the Vouzela’s past and heritage), it aimed at “(...) not only to discover new sites but also to excavate selected mounds and dolmens, especially the endangered ones, employing minimally intrusive excavation strategies” (CARVALHO et al., 2021, p. 167).

The need for a new project was inevitable, given the amount of work and data accumulated in the above-mentioned project, for the continuation of the study of the megaliths. Duly titled MEGA Lafões (“*Megálitos, Espaços, Gentes e Ambiente. Manifestações tumulares pré e proto-históricas da região de Lafões, Viseu*”), it incorporated several objectives, from new excavations to expanding the previous database, all under a coherent regional approach to the Lafões evidence as a whole. Since the time of Girão’s (1921) work, this is the first encompassing research on the region’s megalithism. From this it even facilitates the management of the territory by local municipalities, including and its protection from the destructive consequences of farming and forestry by allocating resources and establishing municipal regulations to the protection of megaliths and later burial mounds. And this became possible because there is now a more detailed and precise knowledge of archaeological sites and their distribution in the landscape (CARVALHO et al, 2021; CARVALHO et al., 2022; SOARES, 2021).

3.2. State of investigation on Lapa da Meruje

Located on the northwest slope of the Caramulo, at 925 m altitude, the dolmen of Lapa da Meruje, its surrounding environment, and the monument's state of conservation at the time of the discovery, was described adequately by A. Girão as the following:

“The situation of this monument, right in the centre of a basin with a slightly depressed bottom, where the mound covered by vegetation stands out surrounded by a wreath of small elevations, in which the granite stands sometimes assumes very capricious shapes, is one of the most interesting that we know. The dolmen is still well preserved despite the fact that several stones were diverted from the gallery and presenting clear evidence of violation in the burial chamber” (GIRÃO, 1921, p. 47: Portuguese original).

Currently, additional information can be provided about the site itself, such as its construction on an interfluvial platform within the basin, formed by the confluence of two streams. As it was correctly referenced by A. Girão, the basin is surrounded by granite formations (tors), which in turn creates several water runoff streams, marked around the site. Additionally, as this area is made of granitic outcrops, these also provided part of the material utilized to construct the monument. The landscape has been heavily altered, especially with the establishment of a reservoir built in the late 1990's (Fig. 5).

Both the projects of LAFÕES and MEGA Lafões took in mind Lapa da Meruje as the perfect monument for systematic archaeological interventions, having so far been the target of various archaeological excavation seasons. Like most of the megalithic monuments in Lafões, it was discovered by A. Girão in 1917 and made known for the first time in the previously mentioned volume “*Prehistoric Antiquities of Lafões*” (GIRÃO, 1921). Additionally, in the year of its discovery, a survey was also conducted in the form of an archaeological dig, carried out by Girão himself.

New excavation work was commenced in 2016, followed by two more excavation seasons, in 2017 and 2018 (CARVALHO, 2018a), and a third one in 2021 of very limited extension. Taking advantage of the excavation work done by Girão as a starting point, these new excavations established modern methodologies and different objectives, having these allowed to relocate and reassess the 1917's excavations, as well as identifying and understanding the re-use events that would have occurred in the past (see below). The excavations revealed a complex architecture beneath the large mound, composed essentially by the previously known chamber along with a passage. This led to unravelled additional structures that were not visible before

excavation, particularly a forecourt, as well as a in depth comprehension of the previously known structures, referring particularly to the chamber and passage areas (Fig. 5c and d).

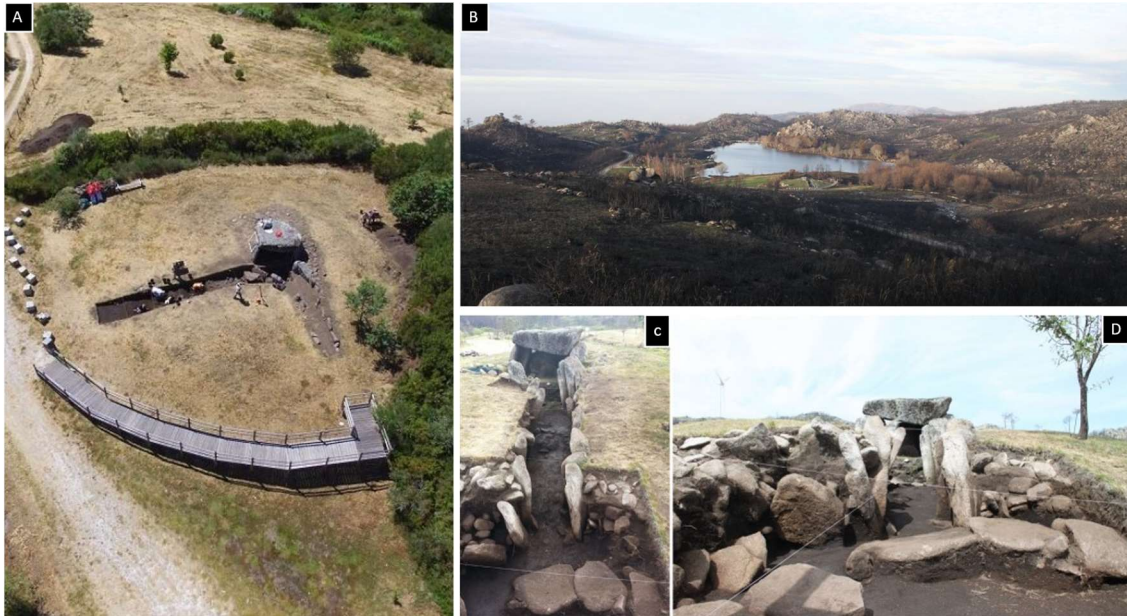


Figure 5 – (a) Aerial view of the excavation, during the 2016 season, showing the burial chamber and corridor surrounded by the well-preserved mound. (b) General view of the landscape of Lapa da Meruje after the fires of October 2017 and the monument within the basin. (c and d) View of the general architecture, being distinguishable a forecourt that leads to the chamber through a long corridor (CARVALHO, 2018a).

By opening a section in the southern part of the mound, a better understanding of the stratigraphic record of the earthen structure was achieved. This indeed was important as it revealed three main architectural components of the dolmen's construction. Such elements refer to a stone carapace that originally covered the whole monument. Still related to the mound, an outer stone ring (made of vertically aligned small slabs) was identified around the edges of the mound to contain the mound's earth and smaller blocks. The mound itself is an earthen structure made of black coloured sandy-clay sediments and a buttress made of large blocks around the chamber and the connection area with the passage. The burial chamber, that is, the area of the final deposition of the dead, had already been tested by Girão in a small area (Fig. 6). It corresponds to a large polygonal-shaped chamber, with a size of around 3x3m, composed of seven vertical slabs, making it a large sized dolmen, still preserving its thick, heavy capstone. The entrance into the monument would be done by a forecourt at open air, tiled with large granitic slabs. The forecourt would be the stage for a first phase of the process of deposition of the dead in their final resting place. As with the entrance, this area was also sealed intentionally with blocks and sediment, giving this act the designation of “condemnation structure”. The chamber and the forecourt are both connected by a long passage, of approximately 9 m (Fig. 5a). This was also excavated, and still contained, in its basal part, prehistoric, undisturbed levels. On two sections of

the corridor there are evidenced bottlenecks, starting with one formed by the slabs of the entrance, followed by a second one before the access to the chamber, forming a vestibule.

Though the architecture and the grave goods placed its foundation during the Middle Neolithic, it would show evidence of reuse in later periods. The chamber was the most affected, not only by the test done by Girão in 1917, but also by a reuse of this space during the Middle Ages. Indeed, the appearance of pottery from this period (dated more specifically to the 12th century AD) strongly suggests the use of the dolmen as a shelter for shepherds or farmers in this time period. Within the "condemnation structure", the sedimentary and rocky deposit that sealed this area, there were fragments of large flint blades that point to the Late Neolithic/Chalcolithic, thus indicating that the monument was sealed at some point during the 4th-3rd millennia BC transition.

Over the course of the excavations a careful analysis of the stone slabs was taken into regard, in order to look for megalithic art, engraved and/or painted. This approach was also prompted by the existence of modern motifs, of historical times, carved into the upper surface of the dolmen's capstone, as well as other possible symbolic representations from various periods, located inside the chamber. This megalithic art was examined in 2019 through the use of so-called morphological residue model (M.R.M.). Only selected monoliths were chosen for this preliminary analysis. The M.R.M. method displayed an array of graphisms that were previously unseen by the naked eye. In four monoliths located in various parts of the corridor it was possible to identify little, shallow concavities, parallel lines, as well as other depictions of hard interpretation (CARVALHO, 2019). Certain monoliths presented polished surfaces, which raises the possibility of having been prepared for paintings that would have not survived. In surveys before 2019, documentation of engravings had already been done in the chamber's capstone. Certain engravings—such as so-called "cup-marks"²—do not necessarily correspond to the Neolithic. Others are today recognized as the "game of *alquerque*". This last engraving is appointed to Medieval or Modern times and are related to the use of the monument as a shelter or meeting point for shepherds.

The last intervention will consist of a rehabilitation project (CARVALHO & COSTA, 2021, p. 104: Portuguese original), having as main objectives, to "(...) intervene in the architecture of the monument in order to guarantee its structural stability and assess the possibility of providing the visiting public their circulation within it." This is due to the 2023 field season of excavations.

² These are found throughout prehistoric times extending to modern day periods, making it difficult to pinpoint the conception of this artistic production.

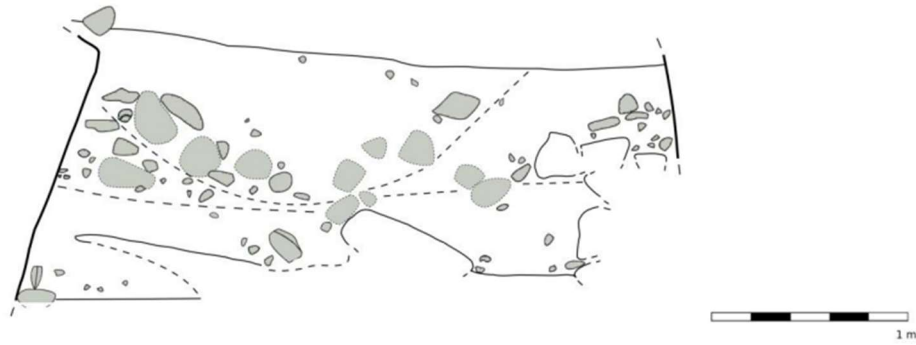


Figure 6 – Stratigraphic profile M-O22, obtained from the dolmen chamber (Unpublished; 2017 excavations).

3.3. Geoarchaeological approaches to megalithism

When reading the archaeological record, archaeologists are aware that the context under study inevitably comprises a series of processes of geological nature. As a direct result, new forms of reading the archaeological record, that aim to distinguish natural processes from anthropic activities, have been gaining more impact. The incorporation of specific study areas within geology like pedology for the study of soils, petrography for the analysis of the geological composition of artefacts and materials, or sedimentology, that focuses on sedimentary deposits for the reconstruction of archaeological contexts, or even paleoenvironmental conditions (ANGELUCCI, 2003a; GOLDBERG & MACPHAIL, 2006, GOLDBERG & ALDEIAS, 2018, MACPHAIL et al, 1990; GOLDBERG, 1980), among various others, offered a resolution of questions related to earth sciences within the archaeological sites. As a way to reconstruct the environmental context or to understand site formation processes related to human activity, geoarchaeology presents itself as a means of understanding the processes of formation and post-depositional changes that affected archaeological deposits as well as artefacts. In short, Geoarchaeology is “(...) the scientific discipline that, using concepts and techniques from Earth Sciences, aims to solve archaeological problems” (ANGELUCCI, 2003a, p. 36: Portuguese original). This scientific area has proven to provide strong results towards various questions and/or complementing more classical methods.

Geoarchaeological approaches had frequently been applied to prehistoric contexts. Within the large and diversified types of archaeological sites in a prehistoric timeline, the use of geoarchaeology in megalithic contexts can be highlighted. When referring to megaliths, it is invoked large monuments built of stone, utilized for ritual and mortuary practices, covered by anthropogenic accumulations or put more simply, a “mound”. The internal structure of these earthen structures (also known as *tumuli*) can differ. Although the construction of such structures

expands over a long period of time, it is usually considered that “(...) the same general principles of site formation occur” (GOLDBERG & MACPHAIL, 2006, p. 231). The application of geoarchaeological techniques to these mounds have allowed to obtain more in-depth knowledge of the construction of these structures as well as the activities practiced by the communities that constructed them, through the analysis of deposits and depositional/post-depositional processes that affect them (GOLDBERG & MACPHAIL, 2006; KARKANS & GOLDBERG, 2019; KIDDER & SHERWOOD, 2016). The following case studies establish a brief outline of geoarchaeology methods and their extent that have been applied to megalithic monuments. It should be mentioned that several works that focus on this type of structures refer to the use of geophysical methods, as way to detect them. Although this method can be integrated in geoarchaeology (CARDOSO, 1996), it will not be discussed, since this work focuses on addressing issues of the sedimentary, pedological, mineralogical and stratigraphical nature.

Having said this, the adoption to interdisciplinary approaches to geoarchaeology are commonly applied in the study of raw material procurement, applying methods that not only are achieved by comprehending the physical properties of the materials by means of petrography, but also by identifying distinct chemical record of individual sources by way of chemical analysis (TYKOT, 2004). With this material provenance studies play a role in specializing to determine procurement range in relation to the original source deposits of raw materials, leading to the understanding of the mobility of people and further grasp of exchange networks that may have taken place. From here the mobility of people and objects has been one of the main focuses for archaeologists, having it be one of the aspects that marks the Neolithic, seen by the means of the transport of exogenous artefacts and building materials, closely related to population or group mobility. When it comes to megaliths, many works focus on the relationship between rock types and the available quarries, thus marking the distribution of dolmens and their source materials within the geological landscape.

Among the classical examples within this timeperiod is the Stonehenge enclosure (PEARSON et al., 2020). While it its known that this construction does not constitute a funerary purpose, it shows the application of the method to a megalithic structure.

This was first erected in the Late Neolithic (c. 3000-2500 BC, in Britain), having been utilized until the Early Bronze Age (c. 2200-1600 BC). Through geochemical and petrographic analysis, this one construction showed a variety of building materials brought to the site from various locations. The results showed the extent of large networks, where the prime building material, bluestones³, came from both short and large range distances, evidencing contacts

³ The term ‘bluestone’ refers to a wide range of different rock types, of bluish or grey tonalities, which include rhyolites, dolerites, among others. This can also be perceived as a term for “foreign” materials that specifically compose the Stonehenge site.

between populations, from western Wales and local areas within the Salisbury Plain. This would not necessarily consist of a need for the building materials, but most likely as a symbolic act (PEARSON et al., 2020).

Similar to Stonehenge, material provenance studies have also been conducted towards the comprehension of the Southwestern megalithism of the Iberian Peninsula. Within the Portuguese territory, case studies like the ones conducted in the Alentejo and the Estremadura regions can illustrate this. Both included in their studies an ample group of megaliths. The dolmens of Freixo, at Redondo, in Middle Alentejo (BOAVENTURA et al., 2020), totalized in seven, while the other was an archaeopetrographic study of four dolmens located in the Upper Ribatejo (MOLEIRO, 2015). A detailed mapping of the geological surroundings of each site and a lithological characterization of the dolmen slabs, would contextualize for a geochemical characterization of these geological materials that compose the dolmens and the outcrops. It was quickly established that in both case studies the source outcrops that provided raw material for the construction of the dolmens were located not only in the vicinity of the archaeological sites, but also at further distances. The link between the materials and the constructions was not clearly established, namely as for “why” these populations resorted to different sources, leading to the conclusions that these could have been related to the immediate availability of the material or to aesthetic/symbolic reasons. In addition, the data supported that most of the stone slabs were from an endogenous origin. Apart from the difficulty of interpreting the data, other problems arise when readings obtained from the artifacts match several source deposits or even intra-source variability that occurs in the deposit(s), as these might also have different measured values (TYKOT, 2004). This was not the case for these case studies.

Other than building materials, the grave goods found in these constructions also evidenced external sourcing. The acquisition of raw material for the manufacture of handheld artefacts has a greater extension of sourcing areas, either due to exchange networks or to mobility. While referring to material provenance, it is inevitable to refer that these studies were also applied to artefacts exhumed from Lapa da Meruje and Antelas (CARVALHO et al., 2018b), having as the main objective to find out where the flint objects were “brought in from”. For this particular case study, the use of X-Ray Fluorescence analysis was applied. Additionally, the methodological approach for this group of objects went further than geochemical analysis, having also looked at the functionality and typology of these lithic tools that consisted of an assemblage of flint geometrics and bladelets. Between Lapa da Meruje and Antelas there are clear differences, despite the geographical and temporal proximity perceived through this geoarchaeological analysis, which “(...) made it possible to observe very contrasting techno-economic strategies, with manufactured sets, exclusively for incorporation in a funerary context and others previously used intensively. This double standard seems to reveal the existence of human groups with different

degrees of access to exogenous raw materials (...)” (CARVALHO et al., 2018b, p. 230: Portuguese original).

More in-depth methods within geoarchaeology were also applied for a better understanding of the context in which these funerary constructions were built. For this the identification of geochemical markers, by analysing the sediments that composed the structures (focusing on the mound), would also shed some light on the various utilization phases and activities that occurred at the site, along with the identification of anomalies. This was the case for both the Mamoia 1 das Madorras, Sabrosa (JUAN-TRESSERRAS, 1994), and the *tumuli* of Senhora da Ouvida, Castro Daire (SILVA, 1999). Located in the north of Portugal, in a similar granitoid (with predominant biotite and feldspar) setting to Lapa da Meruje, the results were obtained from an extensive geoarchaeological approach, again starting with a characterization of the stratigraphy that composed the mound as a first step. A thorough general description of the profile, that composed these sites was conducted, using sedimentology parameters, such as colour, granulometry and densitometry, later comparing to each other. The Mamoia 1 das Madorras focused on understanding the formation of the paleo-soil, on the moment corresponding to the construction of the megalith. The comparison between modern day paleo-soils, and the ones existing during the time of construction of megaliths, pose as a contribute for reconstruction and evolution of the landscape. The comprehension of the mound as a study object takes it to a different dimension, of the state of conservation of the monument, and the level of decay of the materials that compose it.

Also, by analysing the phytoliths that are incorporated within the sediment, a paleo-vegetation reconstruction was achieved (JUAN-TRESSERRAS, 1994, p. 244). Seeing the vegetation within each level can be related to a certain environmental condition, in which the predominance or retraction of a given plant species can be seen. For the case of Mamoia 1 das Madorras, the existence of *Quercus robur* and *pyrenaica*, would be related to the existence of a forest cover with a higher humidity level, during the time of construction of the monument (JUAN-TRESSERRAS, 1994, p. 245). The understanding of the environmental conditions in a certain period, has great importance, since these also affect the development of soils. The pH of a soil can be influenced from certain activities, such as burning. For the *tumuli* of Senhora da Ouvida, a necropolis possessing a total of 25 constructions of various dimensions, the identification of anomalies in the (natural) development of soils were inferred as resulting from a human intervention (SILVA, 1999, p. 178). A geochemical analysis was conducted on samples from the sites. The conclusions from evaluating several chemical elements from the base of the monument saw the inexistence of major differences in values where identified, being similar to the local geological context. Regarding the existence of charcoal on the base of the monument, it is unclear whether it relates to on site burning, or if these would have come from external sources,

furthermore, being difficult to put in a chronological sequence, as these were specified if this layer of charcoal pre-dates the monument. Along with this, high levels of Cu were put forward as a possibility of the existence of copper artefacts. The low levels of calcium and P₂O₅ (phosphorus pentoxide) do not support this hypothesis, also having similar values to the local baseline, concluding that would be related to some other activity (SILVA, 1999, p. 178).

Most of these studies to megaliths focus on the underlying structures or soils, leaving aside the mound structure itself. This last element is truly integrated only when a whole study of monument is done, but in this case limited to a macroscopic description of the sediments that compose each stratigraphic layer, not a micromorphological one.

3.4. Micromorphology in the archaeological record, particularly in megalithic contexts

In recent years the use of sedimentary micromorphology has progressively come to gain more acknowledgement within the geoarchaeological studies, and its application in answering a wide range of archaeological questions. This method consists in the study of thin sections under the petrographic microscope, created from orientated, undisturbed samples from a sedimentary context (COURTY et al, 1989), effectively taking an intact part of the archaeological site, being later analysed in the laboratory preserving the original geometric arrangement of the sediments and soils components. This technique of geoarchaeology looks at sediments and/or soils as a way to reveal their formation and identifying mechanisms responsible for its genesis and the causes for the alteration of archaeological deposits, being possible to distinguish between natural causes from anthropic activities (MACPHAIL et al., 1990). Due to the finer scale that this method can achieve, a better understanding of the stratigraphic layers, along with establishing a clear link between layers, subsequently results in a more precise sense of the formation processes and post-depositional alterations. Various archaeological contexts have resorted to the use of micromorphology, to answer particular questions of an archaeological nature (ANGELUCCI, 2003b; NICOSIA & STOOPS, 2017; BRONNIKOVA, 2016).

Archaeological sediments preserve data which through micromorphology can be decoded to answer several questions, as briefly describe below – for example directed at archaeological artefacts that are embedded in archaeological soils (see topic I), which may extend to the understanding of activities linked to these objects (see topic II). More importantly the context (referencing in this case to specifically to archaeological sites) presents itself of high importance, as they preserve both artifacts and activity indicators (see topic III). While in sheltered archaeological sites (caves and rock shelters) or buried archaeological sequences there is a greater

preservation of sedimentary deposits, in the case of open-air sites the preservation is usually obscured by surface processes that usually occurred after the abandonment of archaeological sites. Micromorphology then becomes the way to reconstruct the archaeological context. Obtaining data aimed at paleoenvironmental is useful in the reconstruction of climatic and environmental changes that occurred during the duration of archaeological sites (see topic IV). In certain cases, the environmental changes reconstructed from anthropogenic sediments can be correlated with changes by humans in the environment, through various forms such as changes in land use among others (see topic V).

(I) Often, the incorporation of archaeological material in sedimentary deposits translates to artifacts produced and/or modified by human action. With micromorphology presents itself as powerful tool in the identification of archaeological materials, that may otherwise not be detected in the field or materials not usually dismissed as “artefacts” which could be of plant and animal origin such as excrement or mineral components, as previously referred with the study of raw material.

(II) As mentioned, archaeological objects may derive from certain activities, giving a insight of the technological knowledge behind these and in turn are great, indicators for reconstructing the cultural context in which it was developed. Such activities require a technological knowledge, which in turn are great indicators for reconstructing the cultural context in which it was developed. The construction of earthen structures presents the clearest example of this. The Laona tumulus (GKOUMA et al., 2021), an anthropogenic mound marking the Cypriote landscape, was identified as the subject of a geoarchaeological analysis, being the primary objective the comprehension of potential source materials, as well as techniques and equipment that were utilized for mound-building. Results showed a sequence of construction phases, as well as a large range of geological materials. From the results obtained, a series of hypotheses could be put forward in relation to the specific cultural context it was built in. It was clear that the construction of the monument (including its mound) was a result of premeditated planning that integrated a series of cultural patterns and rules. This is clearly evidenced given the properties of specific building materials, seen from the use of gypsum along with anthropogenic materials (such as pottery). This would be a means for the maintenance along with specific techniques for the application of these materials.

(III) Yet, to better understand these questions, the case study mentioned above started by establishing a reconstruction of the sequence of depositional and post-depositional processes involved in the site formation. In many cases anthropic activities that are undertaken at a given site may have a huge impact on the soil development, as well as conservation and alteration of

sediments that contain archaeological materials. Following two case studies that show similarities with mound covered structures, such similarities can be seen in major accumulation processes, as dumping and compaction can present as two features found in both, or the remobilization of sediments after the construction of such structures. For the sites of Cabeço da Amoreira (ALDEIAS & BICHO, 2016), at Muge, and Poças de São Bento (SIMÕES et al., 2017) at the Sado river valley the application of micromorphology presented as an indispensable tool for a better understanding of accumulation of midden deposits, which in the case of the former, has led to mound formation. Within these two sites several occupation floors were identified, along with areas of primary deposition meaning simple tossing events and secondary deposition, related to remobilization processes.

As for cases of mound structures, other works that followed a similar methodology applied at Laona obtained a well detailed history of Mycenaean chamber tombs (KARKANAS et al, 2012), that focused mainly on the earthwork structure. With the application of micromorphology, it brought to light a new dimension that otherwise would go unnoticed. By applying this method, a finer stratigraphic development was identified. This study focused on a large group of Mycenaean chamber tombs. A total of six tombs were studied, composed by constructions from the sites at Ayia Sotira in conjunction with one more in Barnavos. With monuments from two different sites, it would give an insight to the formation processes in chamber tombs. These revealed useful to identify constructed floors, where certain tombs possessed the original floor, while others presented subsequent re-openings. Other alterations that had occurred in these tombs are related to the collapse of the structure or backfilling events.

At other sites in the Beira Alta mountainous territory, like the Penedo dos Mouros, Gouveia (SIMÕES et al., 2020), research aimed at looking to comprehend the utilization of a rock-shelter. This was first utilized during the Early/Middle Neolithic and is one of the few sites in the Beira Alta region that revealed possible early pastoral practices. Again, the objective was to comprehend the stratigraphic contacts of the sedimentary record and identifying post-depositional processes. In this case, it was clear that periods when the site was unoccupied it was being left to be targeted by weathering effects. Several other information could be obtained, such as the case of the appearance of burnt bone, ash and microcharcoal, allowing for possible assumptions on practices that occurred at the site, especially anthropogenic combustion. Also, from the study of these deposits the paleoenvironmental conditions related to the Neolithic period could be addressed, being the main factor the erosion of surrounding soils, which might have had an anthropic origin.

(IV) This shows another facet of micromorphology, which is that at a larger scale it can also achieve a paleoenvironmental reconstruction, having as a central question the understanding of the natural environment.

(V) Recently in the Alto Ribatejo sub-region, the megalithic monument of Anta 1 de Vale da Laje, in Tomar (ADEWUMI, 2019) has come to exemplify the anthropic impact on the environment, not only because of the existence of a funerary monument but also acquiring additional information with the use of micromorphology, related to manipulation of the surrounding environment at a larger scale. A greater importance is added to this site, given that this megalithic structure is comparable to Lapa da Meruje, as both show similar structure, being covered by a tumulus, possesses a common architectural typology, such as a large chamber associated to corridor, all constructed using large slabs. It was possible to distinguish changes in soil structure, identifying three different phases, that correspond to periods before, during and after the construction of the megalithic monument. Within each phase clear markers could be seen, as the first phase was related to clearance activities in order to create arable land, as well as cultivation activities (ADEWUMI, 2019, p. 40). The second and third phases relate to the construction of the monument followed by its abandonment after collapse. The monument would show later human presence after the abandonment period, corresponding to the Bronze Age. This author proposes, based on the results obtained, a continuous use of the area for cultivation and clearance activities, until the final abandonment of the monument (ADEWUMI, 2019, p. 41). The relationship of human communities with the environment in which they are integrated produce marks. This is seen when looking into modifications of subsistence strategies, land-use changes, or the abandonment of settlements. This is especially seen throughout prehistoric periods, where the increasing alteration of the landscape may be due to human action for example during the transition from hunter-gathering to the practice of agropastoral activities. Examples derived from these new activities leave clear marks, highlighting forest clearance.

The shift in social organization marked by the monumentalization of funerary spaces and the introduction of pastoral/agricultural activities characterize the Neolithic in the western European landscape. Regarding geoarchaeological research, few projects have been done that were particularly aimed at the comprehension of these Neolithic constructions. Although the megalithic phenomenon has a broad impact on the South-West and West of the Iberian Peninsula, when compared to the number of works elsewhere, Portugal presents a lack of sedimentary micromorphology studies on archaeological contexts. Likewise, in the Beira Alta region few micromorphology works have been executed on megalithic constructions, even though the richness of these sites in the region.

4. Objectives

Maintaining as the central question the comprehension of the megalithic phenomenon, this thesis aims to understand the regional megalithism of Lafões, within a geoarchaeological approach focused on reconstructing of the building dynamics at the dolmen of Lapa da Meruje, the environmental conditions and human occupations that existed at the time of building, and the post-depositional alterations, both natural and human.

Identification of sedimentary indicators, starting by the establishing of the matrix (microfabrics and microstructures), provides a first step to distinguish deposition as well as erosion phases, allowing the degree of alteration that these may have provoked on the monument to be observed. Alongside this, an insight to distinguish between natural and anthropic activities, related to the mound's construction and utilization phases, leads to establish the lifespan of the monument. Due to the finer scale that this method can achieve, a better understanding of the stratigraphic layers can be obtained. From these, specific secondary objectives can also be established:

- To determine the soil forming processes and sedimentary sourcing of the mound infill. This presents the first step to distinguish anthropic activities from natural processes, as well as understand the factors that affect soil development, in every sampled area of the dolmen.
- To explain the meaning of a layer with a large frequency of charcoal fragments, along with quartz flakes and plain potsherds, below the mound structure. This level dates to before the construction of the funerary structure, and its analysis will lead to understanding the settings for the construction of the dolmen.
- On the same line of the previous objective, the comprehension of anthropogenic activities, i.e., the use strategies of the monument, focusing on the funerary/ritual practices that took place in the funerary chamber.

5. Materials and methods

From the profiles that result from the 2016 to 2018 excavations at the site, a total number of five samples were obtained. Three of these come from the mound, while for the chamber area, two were collected. Only three were analysed for the purposes of the present work. All the samples were removed in the field, in the form of undisturbed oriented blocks of sediment. Gypsum plaster was used to form a cast, to maintain the block's original form, for their later conversion into thin sections. These sedimentary blocks incorporate several stratigraphic unit's (Fig. 6). No off-site

sampling was conducted in order to obtain control samples, due to the high degree of alteration of the landscape—the location of a dam next to the monument, and recent dumping of exogenous gravelly deposits in the surface around the monument, to prepare the space of visits, that buried remaining natural deposits or soils that might have existed. The field descriptions of the stratigraphic profiles, from which the samples were removed, were done using the suggested guidelines from Goldberg & Macphail (2006).

The fabrication of thin section consists of removing all humidity and its impregnation with resin. The next step refers to its cut into small manageable thin block sections, which are individually smoothed and mounted on a glass slide. Finally, they are polished to the required thickness. This process was ordered at the laboratory Terrascope (Troyes, France). The analysis of the thin sections was carried out by the author utilizing a petrographic microscope under a cross-polarized light (XPL) and plane-polarized light (PPL) at magnification between x2,50 and 400x. The thin section descriptions followed the methodology and terminology established by Courty et al. (1989) and Stoops (2021), also adding other references for establishing the sizes of the sedimentary components (GOLDBERG & MACPHAIL, 2006).

A geographical and lithological contextualization of the archaeological site had been previously established to provide a better perception of natural alterations that occurred in the region and consequently to the site. It may reveal certain conditions explaining the location of the site and assess preservation questions, leading to the careful choice of methodological approaches to the monument. For the interpretation of the thin sections several manuals were used (COURTY et al., 1989; NICOSTA & STOOPS, 2017; STOOPS, 2010; KARKANAS & GOLDBERG, 2019; GOLDBERG & MACPHAIL, 2006; ADAMS et al, 1984).



Figure 7 – Topographic layout of Lapa da Meruje (adapted from CARVALHO, 2018a). Stratigraphy of the sampled profiles in both the chamber (top image) and the mound (bottom image).



Figure 8 – Details of profiles, with contacts and layers designations annotated, located in the mound (A) and the chamber (B).

5.1. Field description

The description of the several sedimentary units identified in the field is given in the tables 1 and 2 below, divided in the areas of Mound and Chamber (Fig.7).

Mound

Unit	Width	Description	Additional information
O	0	Layer corresponding to vegetation cover, directly above the stone carapace.	
1	±31-35cm	Compact layer of very dark colour (blackish brown) rich organic matter, large amount of clay with some silt, appearing overall massive and homogeneous. The lower contact is neat and tabular.	Presence of prehistoric pottery.
2	±20cm	Compact layer, composed of a silty sand matrix of quartz, showing a greyish-brown colour containing some unsorted clasts of up to ~10cm. The lower contact is marked by the presence of imbricated rounded pebbles	Presence of prehistoric pottery.

Table 1. Field description of mound

Chamber

Unit	Width	Description	Additional information
0	0	Layer of vegetation cover	–
1	±40-50cm	Sediment composed of heterogenous sand and silt. Quarzitic very coarse sand and gravel, very porous and loose.	Probable backfill from the excavation by A. Girão (see above)
2	±50-60cm	Fine and homogenous sediment, composed of loamy sand. Compact and dark coloured, given the organic material in its composition.	Presence of adornment elements (beads).

Table 2. Field description of chamber

5.2. Micromorphological analysis

Under the microscope, all thin section exhibited the basic components described in Table 3 below.

Component	Description and comments
Quartz	Dominant, angular to rounded grains of quartz. Size ranges from silt/ fine sand to fine gravel. Frequent 30-50% of the coarse mineral fraction.
Feldspar	Sizes ranges from fine sand to fine gravel. Shapes are rounded to angular. Frequent 30-50% of the coarse mineral fraction. Plagioclase and alkali feldspars were distinguished by their optical diagnostic characteristics. Both plagioclase and k-feldspars exhibit varying degrees of weathering, slightly predominating fragments with an advanced degree of weathering.
Biotite	Sizes ranges from fine sand to fine gravel, flake morphology. Common (16-30%) of the coarse mineral fraction.
Muscovite	Sizes ranges from fine sand to fine gravel, flake morphology. Few (5-15%) of the coarse mineral fraction. 20-30 % of the fine mineral fraction.
Charcoal	Coarse fragments that range from dusty to ~3mm. Their abundance is 5-15% Internal structure overall well preserved.
Organic fine material	Matrix component composed by amorphous organic fine material, with a dark coloration (black/ brownish), with signs of burning and humification.
Biogenic components	Fungal <i>sclerotia</i> , fresh roots in state of decomposition. Other organic tissues. Rare silica phytoliths.

Table 3. List and description of the basic sedimentary components identified in thin sections from Dolmen da Lapa da Meruje

Layer	Sample	Microstructure	Voids	C/f _{μm} limit	C/f _{μm} ratio	C/f relative distribution pattern	Coarse material	Fine material	Pedofeatures	Organic material	Other fine components
Mound 1	LMR-M2	-Massive microstructure.	chamber; channels	c/f _{μm} limit: 63	c/f _{5μm} ratio: 2/4; 1/4	-Porphyric -Open porphyric; -Unsorted	-Subangular to angular grains of quartz; subangular platy felspar, angular flakes of biotite and muscovite. All sized from silt to fine gravel. All unsorted (~1%) -Mica and quartz. Silt and fine sand	-Dark amorphous organic material. Cristalitic <i>b-fabric</i> (micas). - Dark brown undifferentiated b-fabric	Excrement Infilling	Roots; large charcoal fragments; <i>sclerotia</i> ; micro-charcoal	-
Mound 2	LMR-M1	-Massive granular microstructure. -Crumb microstructure.	Discreet weakly separated compound packing voids	c/f _{μm} limit: not applicable	c/f _{5μm} ratio: not applicable	-Close coarse enaulic; -Unsorted	-Subangular to angular grains of quartz; subangular platy felspar, angular flakes of biotite and muscovite. -Mica silt to fine sand. Quartz from silt to large clasts	(dark) Brownish amorphous material. Cristalitic <i>b-fabric</i> (micas)	-	charcoal fragments, <i>sclerotia</i> ; micro-charcoal	-
Chamber 1	LMR-C1	-Crumb microstructure with compound packing voids. -Coated-grain microstructure	-compound packing voids; -Tunnels & chambers	c/f _{μm} limit: 63	c/f _{5μm} ratio: 2/2	-Close fine enaulic; -Single spaced fine enaulic,	<i>Idem</i> ; massive organic material aggregates; commonly the clasts exhibit a coating of organic material.	Dark amorphous organic material. Cristalitic <i>b-fabric</i> (micas);	Organic material aggregates	Roots; charcoal fragments; <i>sclerotia</i> ; micro-charcoal	-
Chamber 2	LMR-C1	-Medium separated granular microstructure. -Highly separated granular microstructure. - massive microstructure	Idem	Idem	c/f _{5μm} ratio: 3/4	-Porphyric	Idem	Idem	Organic material aggregates	Idem	Phytoliths (<1%)

Table 4. Micromorphological description of identified microstructures and related features of each layer.

The sedimentary components found within the thin sections correspond to a typical granitoid environment, in which its composition predominates, quartz, feldspars (plagioclase and alkali feldspars) and micas (muscovite, and biotite) which vary in size (fig. 9b-i). These are constituted by medium to very fine sand (see table 4.1. in STOOPS, 2021) with a high quantity of organic material incorporated, all presenting a random distribution (table 2). The large majority of the coarse fraction ($\pm 30-40\%$) is composed by subangular to angular grains, consisting of gravel, which largely vary in size, from fine to coarse gravel and also including large river clasts at the foundation level (fig. 8a). These also present a high to low degree of sphericity. The fine fraction ($\pm 20\%$) consists of two main elements, composed of a mineral and an organic fraction. The mineral portion in its larger extent is made up of loose grains of micas (biotite and muscovite), seen by a cristallitic *b-fabric* (fig. 9c and 10c-e), also including in this composition feldspars, due to weathering that leads to formation of micas. Some amount of clay is also included in the matrix, having it hard to quantify given that contained in a matrix composed mostly of organic fine material. The organic part is comprehended by the noticeable abundance of unsorted dark amorphous material, furthermore the appearance of darker areas corresponds to a larger concentration of organic material. The amount of dark organic material seems to increase in the upper level of the thin section LMR-C1 correspondent to the chamber area (fig. 10a [upper layer]). Other basic organic components could also be identified, namely micro-charcoal (fig. 10d; 11a) and charcoal fragments (fig. 12a and b). These charcoal fragments also greatly differ in size, starting from the already mentioned micro-charcoal to large sized, majority showing a conserved internal structure. While the larger fragments are found to be subangular, the smaller ones seem to be rounded, indicating reworking, or trampling and rounding of objects is most probably due to transportation. Other organic tissues are also well represented in all thin sections (fig. 14a-b; 12b), where some did not show any sign of charring, however in turn displayed a red tonality related to an advanced decomposition state (fig. 13). Part of the organic constituents refer to the presence of sclerotia and other associated fungal tissues (fig.14b), where in certain instances moderately concentrated. Embedded within the organic micromass it is possible to observe some phytoliths, although rare (fig.13).

Sedimentary Microstructures

All three thin sections display similar arrangement patterns, where four main microstructures are identified. These consist of granular, crumb and massive microstructures, along with a coated grain microstructure. Overall, microstructures seem to be randomly distributed throughout the thin sections, exhibiting proportionate quantity of each and coexist evenly, with exception of the coated-grain microstructure that is only found in the top layer (unit 1) of the chamber deposit. Each microstructure showed the following characteristics:

Granular microstructure amounts to spheroidal granules, mostly without with extinction limits, of a dark/ yellowish in coloration, sized between silt and fine sand, with dark elements consisting of organic material and microcharcoal. Several differentiations can be seen in within these as a presence of a closely packed granular microstructure, medium separated granular microstructure, and a highly separated granular microstructure (figure 10b).

As the name suggests, the crumb microstructure (figure 9f) refers to a crumbly like structure, comprised of small aggregates with diffuse limits and more or less spheroidal shapes, with little to no internal porosity (figure 9f). The aggregates are sized from fine sand/ silt to fine gravel, also small to large sized clastic inclusions are also seen. The void space in this microstructure presents themselves as weakly accommodated or do not accommodate each other. The aggregates are made up of organic dark brownish isotropic amorphous organic material, admixed with mica silt/ fine sand and fine clay. These also show compound packing voids.

A massive microstructure (figure's 9b-d; 9h; 11a) is easily differentiated from the previous two has there are no separated peds with non or few visible voids. The void spaces within this microstructure, contain both chamber and channels.

Finally, coated-grain microstructural features can be seen in the form of well-rounded coatings around clasts, composed mainly of fine amorphous dark organic material (figure 10b). This definition has not been formally defined; however, several works have mentioned the occurrence of such pedological features, (NIEUWENDAM et al, 2012; BERTRAN & TEXIER, 1999; SIMÕES et al., 2020). It possesses similarities to a “intergrain micro-aggregate microstructure”, referred by Stoops (2021, p. 84) however differentiated by the large grains coated with a large, well-rounded layer of fine organic matter.

In terms of post-depositional features, the presence of intrusive pedofeatures can be identified in the form of infillings, caused by voids left by microfauna and post filling of this cavity (figure 9b).

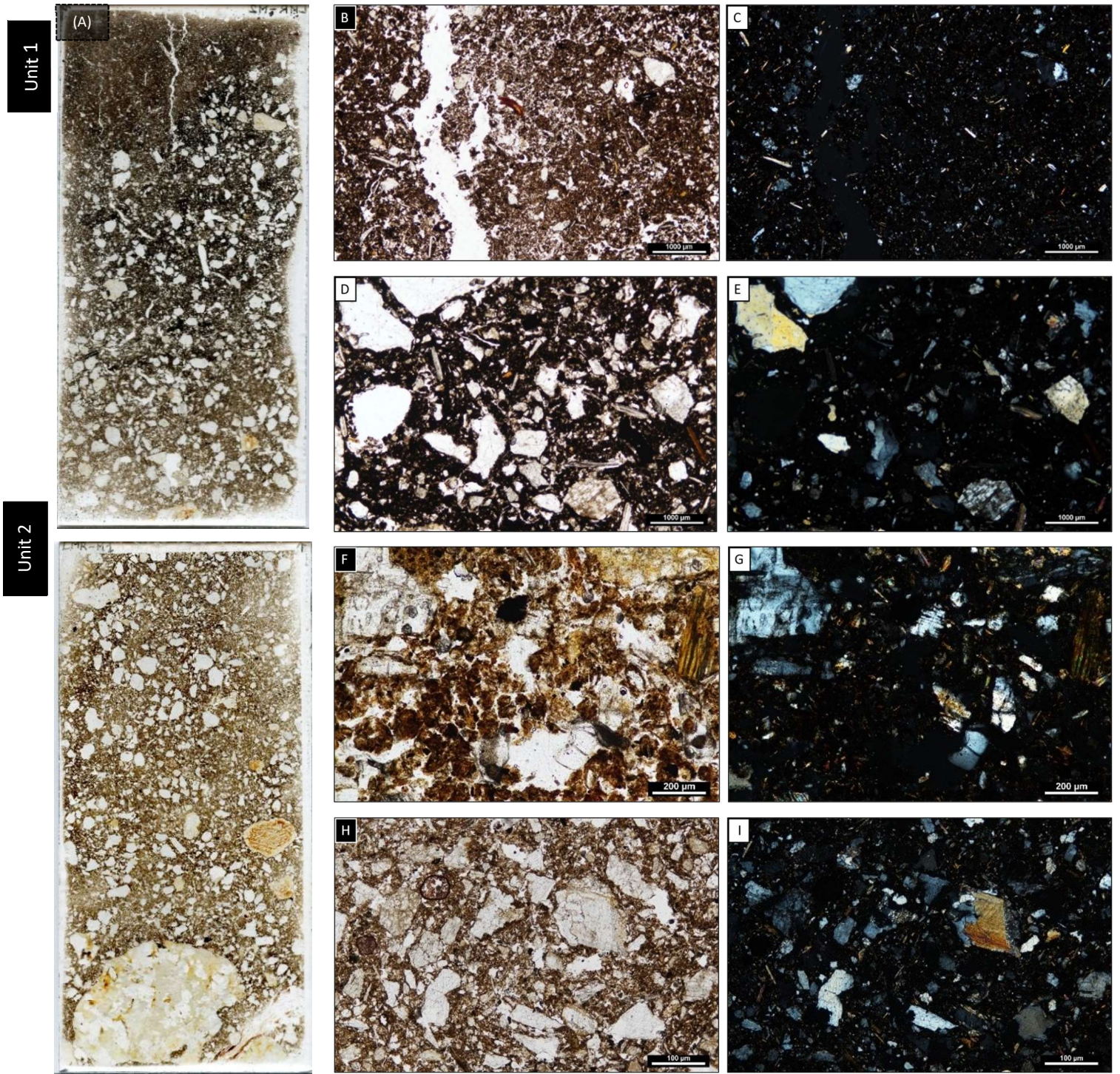


Figure 9 – (a) Flatbed scan of thin sections LMR-M1 (below) and LMR-M2 (above). (b) Unit 1, Sample LMR-M2: Channels porosity; being observable a bioturbation features as root channel and void left by an insect, filled by the sedimentary matrix, PPL. (c) Same as b, XPL: Layer composed of fine fraction, with micas silt/ sand and organic material. (d) Unit 2, LMR-M2: Massive microstructure, with porphyric c/f related distribution. The finer fraction is composed of dark organic isotropic material. (e) Same XPL. (f) Granular microstructure, PPL. (g) Same in XPL, easily identifiable rock components. (h) Massive microstructure, PPL. (i) Same in XPL, Large fraction Gravel Rock components with angular/ subangular morphology

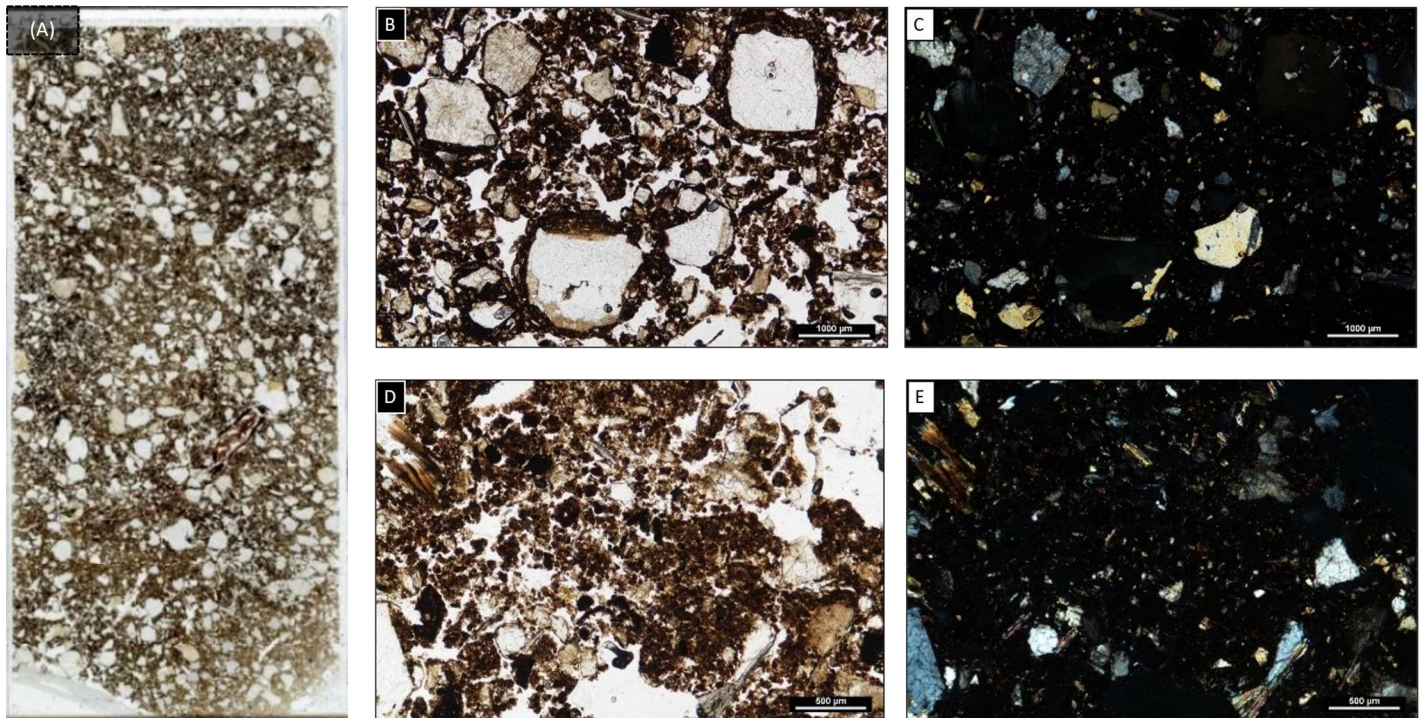


Figure 10 – (a) Flatbed scan of thin section LMR-C1 (b) Visible large mineral fragments with coated with organic dark amorphous material. PPL (c) Same XPL. (d) Crumb microstructure, with small fragments of charcoal in its composition. (e) cristallitic *b-fabric*, XPL

6. Interpretation and Discussion

6.1. Sediment source and accumulation

Based on the microstructures and the degree of weathering of the mineral components identified in the studied thin sections suggest that slope dynamics played a large part in the sediments found at the site. Although it is clear that the sediments were deposited at the site by human action, it is possible to presume the origin of the original deposits based on some of their characteristics. Has it stands there is the strong possibility that the sediments most likely originated from the granite slopes that surround Lapa da Meruje. Having said this, it is not easy to associate such features to a particular erosion and/or deposition mechanisms as these may result in similar microfacies, also the original microstructures may be altered on the behalf of post-depositional processes (BERTRAN & TEXIER, 1999, p. 118). Colluvial deposit present several characteristics associated to slope wash and/or grain flows justified by the presence of rounded aggregates (figure 9f). Additionally, the upper mound level and the chamber demonstrated an open porphyric *c/f* related distribution, within a massive microstructure, composed of a crystallitic *b-fabric* and poorly sorted coarse materials, has features present themselves as general characteristics, associated to either debris flow deposits and earth flows, as well as the basal

matrix-rich layer of grain flow deposits (BERTRAN & TEXIER, 1999, p. 118). Similar processes may have occurred at the site, referring particularly to slope processes, given the incorporation of anthropic material in their matrix, which is common in these types of deposits (KARKANS & GOLDBERG, 2019). Archaeological artefacts, such as pottery fragments, were not found in the thin sections, nevertheless, were identified in the field. More importantly, the sedimentary materials seemed to be considerably rolled, given their overall roundness of the microstructural aggregates. Mineral clastic components seem to also support a slope origin of the sediments, as they show overall subangular rock fragments and in certain cases the rock fragments present weathered features (MUCHER et al, 2010, p. 38-39; COURTY et al, 1989, p. 158-159). Similar characteristics also apply to run-off and debris flow, as “(...) they fill erosional hollows which incise the slopes” (TEXIER & MEIRELES, 2003, p. 147). Once again contributing to the origin of the sediments from the surrounding hills.

With exception of the feldspars that are mainly affected by weathering effects (BRAGA et al., 2002; BEGONHA & BRAGA, 2002; TABOADA, & GARCIA, 1999) inherited from its original source, the majority of the clastic components in the thin sections exhibit a low degree of weathering, possibly due to finding themselves sealed in the deposits of the chamber/ mound, reminding that this last one as a carapace.

The clastic fraction and other fine elements are embedded in fine dark organic matter, which is found in several layers and is most likely composed from redeposited A-horizons of surface soils (STOOPS, 2010, p. 387). Furthermore, it can be deduced that these sediments that compose the archaeological structure may have originated from local ranker type soils, that can be found at the Serra do Caramulo (TEXIER & MEIRELES, 2003) and developed over granitic bedrocks. The characteristics of these ranker type soils seem to appear in the analysed thin sections that will be addressed further below.

It has been established the nature of the soils found in these areas, which are referred to as rankers, from which most likely made use of the base of a ranker soil, since these present “their base is emphasised by a pavement composed of pebbles and boulders 5 to 50 cm in diameter” (TEXIER & MEIRELES, 2003, p. 144). In both cases the origin of the sediments does not nullify the final objective for which they serve, that is the creation of a stable surface for the construction of the monument.

7.2. Post-depositional features

A significant level of reworking of the sediments by soil fauna and root activity lead to appearance of several chamber and channels voids, within a massive microstructure, seen in unit 1 of the chamber. These seem to be the main factors of soil development in the in the top unit of the mound, whose abundance and expression is notability increase compared with the lower levels of the mound. The recorded fabric type in which present as the one of the major contributors leave large pedological features for it is seen in the form of compaction features or faunal coatings around voids and other materials (COURTY et al., 1989). The reasoning for the massive microstructure, may stem from this high degree of bioturbation, as it's been identified that in certain cases "(...) when vertical movements are very intense, the action of soil fauna results in complete homogenization and destruction of original soil or sedimentary fabrics" (COURTY et al., 1989, p. 142).

It has been well established that bioturbated sediment consist of a "post sedimentary feature reflecting *in situ* biological activity" (LISÁ et al., 2013, p. 144), again evidenced in this case by soil channels and rounded vaughs with sharp compacted boundaries, to have maintained their shape (COURTY et al., 1989, p. 144), left by fauna and roots structures. Alongside side these were the appearance of certain faunal voids, in the form of infillings, that is voids with sharp external boundaries containing soil material. This strongly suggests that the bioturbation took place after the mound was constructed, as this would constitute stable conditions. Despite observing various elements of *in situ* bioturbation, it is likely that the deposited sediment had already contained several bioturbation agents, advocating the hypothesis of their origin from topsoil horizons. A high concentration of sclerotia can further support this point.

All these processes seem to derive from humification. Bioturbation agents lead to the homogenisation of the soil/ sediment profiles, destroying previously existing sedimentary fabrics (COURTY, 1989, p. 142). The process of humification refers to break down of large organic constituents leading to the formation of humid horizons, by means of chemical and mechanical, having as main biological agents, from macro to microfauna and more importantly microbial activity (COURTY, 1989, p. 147).

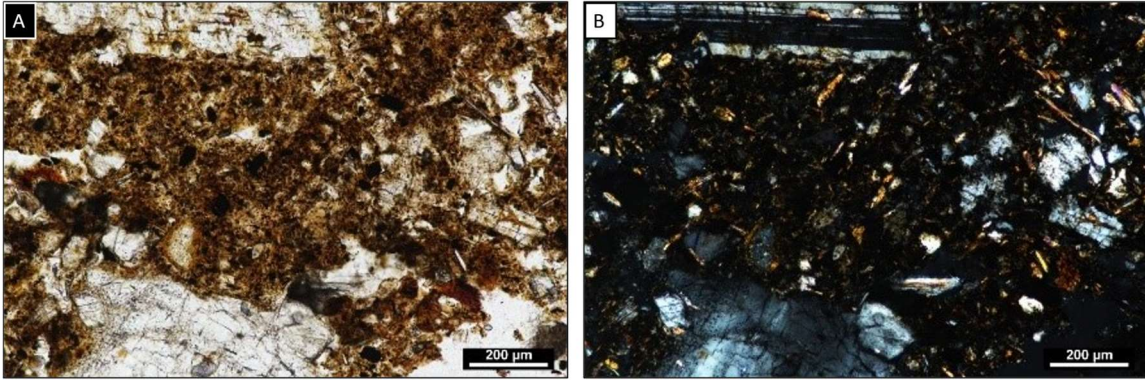


Figure 11 – Sample LMR-M1; layer 1 (a) Massive microstructure. Microcharcoal also incorporated in the matrix. Alteration of feldspars *Note that certain fragments show clear degradation on the rims. (b) Same (XPL), again alteration of feldspars, giving speckled b-fabric.

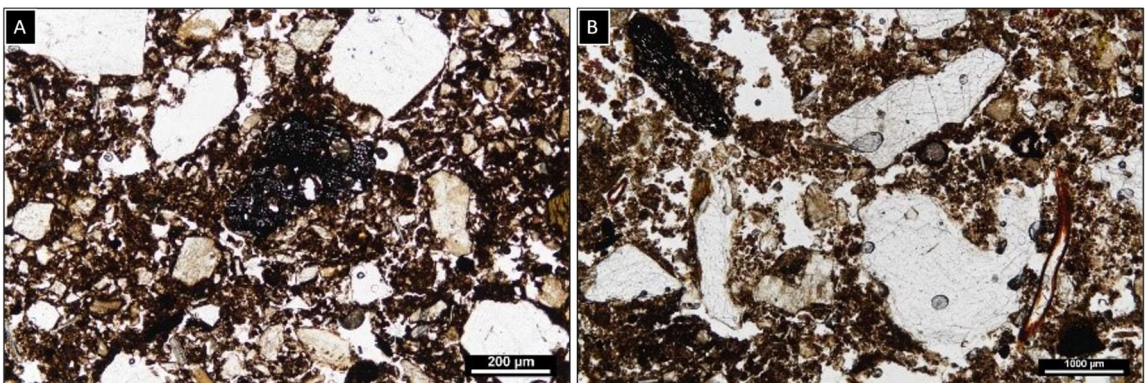


Figure 12 – Sample LMR-C1: (a and b) Examples of charcoal fragments; with visible charred cellular structure (of angiosperm). Sedimentary mass with small sized charcoal fragments (microcharcoal); (PPL).

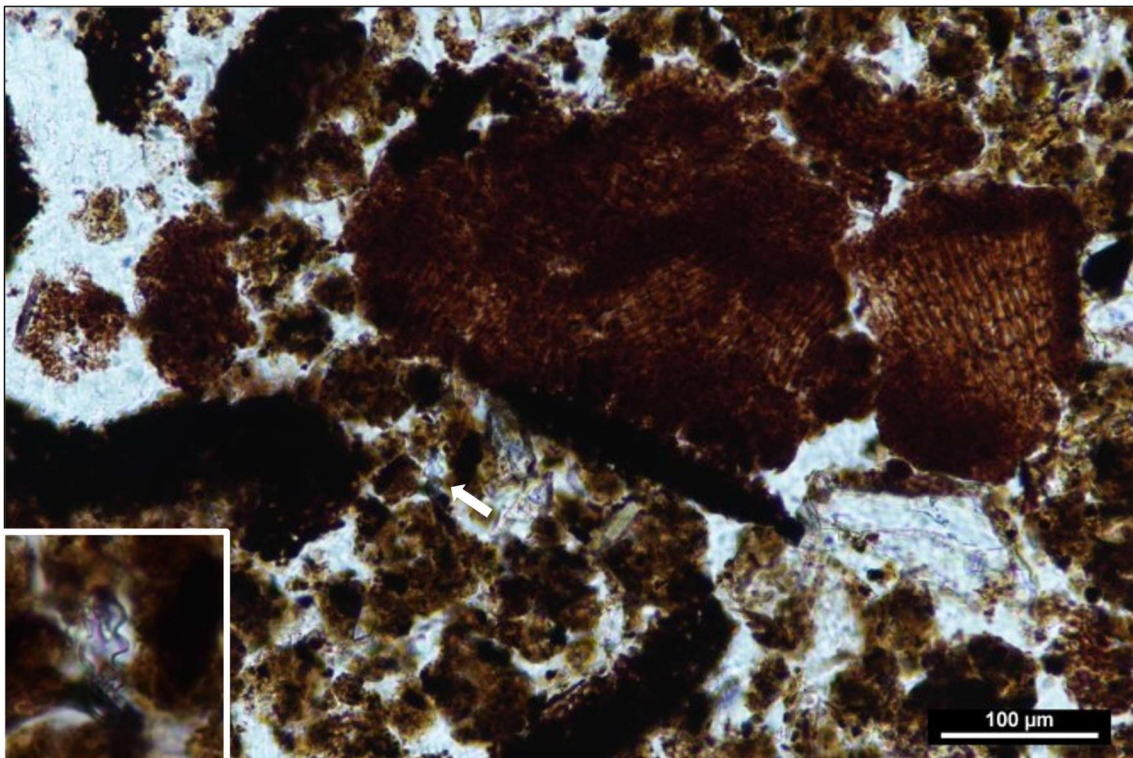


Figure 13 – Sample (LMR-C1): Examples of plant tissues with internal structure in anatomical connection. Small isolated phytolith; correspondent to grasses species; loose in the sedimentary mass; marked with an arrow (PPL).

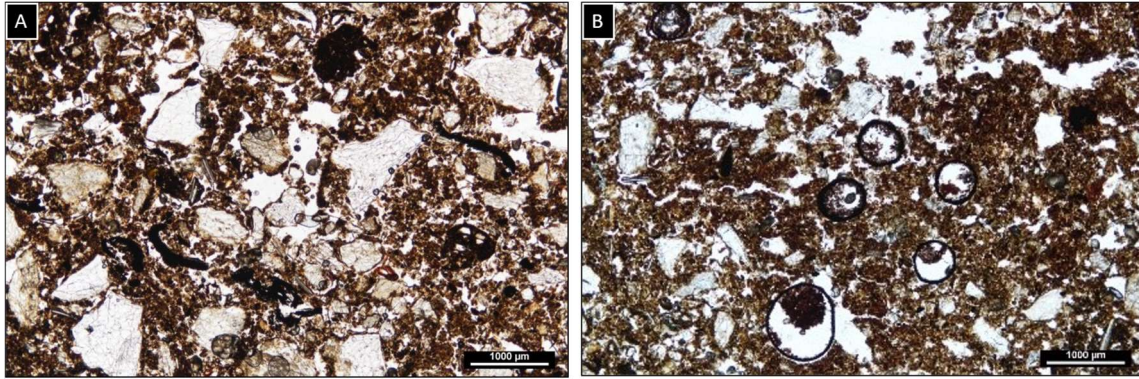


Figure 14 – Sample (LMR-C1): (a) Charred husk components; PPL. (b) example of fungal material, high concentration of *sclerotia*; PPL.

6.3. Construction of the monument

Several aspects of the mound revealed it to be a complex structure. According to our results, the internal stone structure was not covered with simple accumulations created by a single dumping event. Starting with the basal level of the mound, this is a layer composed of granitic sandy gravel, with pottery and charcoal incorporated. Its bottom was found to have imbricated, rounded clasts, being distinguishable from the rest of the mound as these correspond to river pebbles. The appearance of these river pebbles suggests two possibilities.

The first may be related the prior construction of a floor made through the careful placement of small river clasts, where prior activities of the ritual nature would have taken place, related to the founding of the monument itself. Alternatively, this pebbly layer could possibly correspond to use of a pre-existing ancient fluvial terrace definitively abandoned by the river, creating a stable surface for the implementation of Meruje.

This layer of imbricated pebbles is supported and covered by a sandy deposit. This constitutes a first level of sediment accumulation or even as a further reinforcement to the previous pebbles level. As the sediments composition utilized for this purpose are those of loam with a lower content of fine organic matter, these sediments were obtained most likely from a riverside source (BROWN, 1997), which would perfectly fit the fluvial terrace, or a pre-existing fluvial terrace that was manipulated. Some parallels can be correlated with the data retrieved from Barca do Xerez de Baixo, in the middle Guadiana valley (ANGELUCCI, 2006). The site consisted in an early Holocene human occupation, having been found layers corresponding to the Epipalaeolithic, situated on an alluvial terrace of the mentioned river. Thin sections showed overall sediments composed of sand to silt sized components, with a brownish-yellow coloration, displaying several microstructures (chitonic, gefuric and porphyric). The presence of bone, charcoal micro-fragments, lithic artefacts (flakes), and organic matter dispersed in the fine material constituted the sedimentary alluvial matrix that were seen in the thin sections. It's clear that human inputs were critical for the development of these soil profiles and for maintaining

sable occupational floors. Equally other depositional processes would be in play like sloping effects and the geomorphological positioning of the site, given the proximity of the Guadiana River.

Regarding Lapa da Meruje anthropic elements, particularly the inclusion of pottery in the sediments establish the practice of activities at the site, however it is unclear at what point was the pottery added. This leads to difficulties of interpretation about the origin of the sediments. It could be argued that the pottery would already be incorporated into the sediment's, being later dislocated from their original source, however this seems less likely as the pottery did not show to be rounded. In addition, no associated sedimentary structures were identified at the microscopic level, that could indicate a fluvial deposition such as bedding or sorted laminations. The inclusion of pottery in this layer could correspond to the practice of dolmen preparation rituals in which frame it could have been incorporated into the manipulated sediments.

Similar geoarchaeological features match the ones found at the sites of Vau, Bispeira and Rodo (MONTEIRO-RODRIGUES & GOMES, 2020), all three situated on small terraces/platforms, on the river valley of the Vouga and Teixeira rivers. Geoarchaeological studies carried out at these sites revealed the existence of colluvium deposits, containing rounded clasts within a silty-sand matrix and the presence of artifacts in good conservation conditions, all of them affected by slope related processes. The comparison that can be drawn between the sediments at these sites and the ones found at Meruje, share similar erosion and deposition mechanisms that lead to the formation of slope deposits and could be placed in a period affected by an environment of low energy deposition. One more the sediments show the correct conditions for the construction of the dolmen, during a period where the river flow would be stable.

The upper layer, that constitutes the bulk material utilized to construct the earthen structure, is easily distinguishable by its black coloration and possesses a massive microstructure with a high degree of bioturbation. Under the microscope the conformation of this sediment is being primarily composed of organic matter. The existence of reddish decomposing organic tissue, abundant fungal tissues, and the almost total absence of mineral coarse components, may relate to the use of highly organic soils, having these been sourced from a topsoil or/and a near-surface soil horizons (STOOPS, 2010, p. 370; BRIGGS, 2004; ZAIETS & POCH, 2016). Based on the identified characteristics, these may correspond to an A-horizon, or an admixture of A-horizons from different locations, that are primarily composed by soil decomposing organic matter. Given several elements, particularly the advanced degree of decomposition and the presence of a large quantity of soil organic matter, we can classify this sediment material as humus. The categorized humus found at the site best fits into Mor, "consisting predominantly of well preserved, though often fragmented, plant remains with few excrements" (STOOPS, 2010, p. 383). In addition, this type of humus develops under deciduous forest of conifers, where the soils present a high level of acidity, favouring its development (STOOPS, 2010, p. 383). However, it can also be classified

as Amphimull, as these also develop under forest and “appearing in Mediterranean, eutrophic environments where humification is not complete due to a seasonal water deficit or other factors” (ZAIETS & POCH, 2016, p. 83). It is difficult to categorize the seen organic matter based on few characteristics, nevertheless different types of A-horizons may be determined based on the quantification of organic matter incorporated in them, as horizons with Mull and Amphimull are recognized for having higher soil organic matter in contrast with the coarse components found in these (ZAIETS & POCH, 2016, p. 91). “In contrast, Blazejewski et al. (2005) found that infillings were the least common pedofeatures rich in organic matter found in the subsurface horizons of hydric riparian (streamside) soils and the few that were observed were directly below A-horizons or buried surface horizons” (STOOPS, 2010, p. 387; KODESOVA, 2007). To sum up it is likely that earths that make up the body of the mound come from natural organic deposits either forested or turf-like environments yet is it unclear whether these were sourced within the Meruje basin or somewhere else around the Caramulo, where this type of organic deposits develop.

Other funerary structures have been seen to use soil organic matter for construction purposes, as is the case for the archaeological site of St. Albans on the outskirts of London. This saft tomb, utilized “turf” as the main building material, obtained from removing the top layer of a local soil profiles, that are composed of brown earth enriched in organic matter (MACPHAIL et al., 1998, p. 637). This particular material was utilized to create the mound structure in a similar manner to Lapa da Meruje, as both possess similar sedimentary structures, seen by the massive and packing voids microstructure. Among these microstructures while the fine fraction is composed of fine amorphous organic matter, with marks of biological activity, the coarse fraction of mineral grains sandy silt to a sandy loam soil, sometimes with gravel. The presence of charcoal of variable sizes. was also identified, being visible in all samples (MACPHAIL et al., 1998, p. 630).

Although the layers found in the mound structure at first sight seem to be homogenous (macroscopically) as they exhibit a dark coloration, due to their composition of mainly by organic matter, still show abrupt contact between them, making it clear that these well-defined (microscopically) layers amount to a quick construction of the monument. With the practical inexistence of certain textual pedofeatures or at least being unclear, such as clay coatings, as these are indicative of mechanical soil disturbance, leading to a lacking vegetation cover of the soil surface and leaving the soil surface exposed (DEÁK et al, 2017, p. 241), could also indicate the covering of the monument within a short period. Another question that is raised is the use of different sediments, putting forward the possibility of a careful selection of the building materials, given their properties paired with particular construction techniques (KARKANS & GOLDBERG, 2019, p. 219). Such parallels can be seen with other mound structures like the tumulus of Laona, in Cyprus, as the sediments were composed essentially of marls for the construction of the mound (GKOUMA et al., 2021). It's not by chance that this community

utilized marls, as this particular raw material retains moisture and reducing the plasticity, and a higher level of compaction, originating a sturdier structure, as the authors argue. Paired with the choice of this raw material, the alternation of the size between large blocks with the addition of red soils, due to these possessing a fine material with a granular structure, “(...) served a geotechnical, stability purpose, (...) enhancing the cohesion of the sediments (GKOUMA et al., 2021, p. 13). Again, the question of stability takes centre stage when addressing the use of materials and construction techniques, as the main goal is to achieve maximum maintenance of the construction (GKOUMA et al., 2021, p. 14).

Anthropogenic materials incorporated in the mound filling, in the form of rolled pottery, leads to the possibility of the presence of human occupation in the surroundings, more particularly at the top of the basin where occupations date to later historical periods is attested. This paired with the particular use of sediments that develop under forested areas and the strong presence of charcoal may relate to practices predating the monument, referring to vegetation clearance activities, discussed below.

6.4. Vegetation clearance activities

The practice of vegetation clearance activities would have been the first step for the construction of a monumental space. All sediment samples were found to contain carbonized plant remains, putting forward the possibility of anthropogenic combustion activities, that occurred at and/or around the site. Charcoal is one of these representative elements found throughout all stratigraphic units, appearing in the form of both large fragments, some of which have a well-preserved internal structure, while others constitute part of the finer fraction, due to their smaller proportions (microcharcoal). It has been discussed that the production of large fragments derives from the burning of woods in contrast microcharcoal is associated to grass vegetation (DEÁK et al., 2017, p. 235). Based on a brief analysis plant remains structures a deduction of the vegetation cover that surrounded the archaeological site may be attempted. The process of combustion leads to the shrinking of plant structures (CANTI, 2017, p. 141), leaving an increased difficulty to identify plant species, nevertheless it appears that the charcoals found in the thin sections are possibly derived from hardwoods (Angiosperms), as these show the presence of a porous cellular structure (SCHWEINGRUBER, 2007) as observed in the transversal section of a wood fragment and further justified by the arrangement of the pores, as these show bands of both earlywood and latewood vessels. The earlywood is easily distinguishable as the rows of pores are organized in a compact manner, with a larger number of pores while in contrast latewood vessels are less dense, composed of pores several sized pores, dendritic orientation (SCHOCH et al., 2004). These are,

however, tentative hypotheses, and an anthracological study must be undertaken to correctly identify these charcoals.

Among the charcoal, various other organic components incorporated in the sediment were also identified, particularly organic material of red coloration with an intact internal structure correlative to decomposing organic tissue, falling in the category of leaves, shrubs, or small grasses, as the tissues look to be palisade cells (ISMAIL-MEYER, 2017). Like the charcoals, these could also support clearance activities. However, these do not show enough data to clearly support such events, and the possibility of having been derived from natural fires cannot be ruled out.

Case studies on paleo-environmental reconstruction of nearby areas can give a relatively good idea of the prehistoric bioclimatic framework in the region, especially through the archaeobotanical studies. In the region only the bottom-valley Prehistoric sites of Vau and Bispeira 8 have published evidence. Palynological analysis and study of plant macro remains were applied to these sites, in order to understand the exploitation of plant resources. Both sites possess similar taxa with significant presence of large tree specimens, particularly oaks and pines, amongst several shrub species of the family Leguminosae (OLIVEIRA et al., 2020, p. 155). However, variations can be noticed with the occurrence of rarer species in certain sites, of which the Vau site presents itself as a good example, where other species like *Acer* sp., *Corylus avellana*, *Juniperus* sp., *Olea europaea*, *Populus* sp., *Rhamnus/Phillyrea*, *Salix* sp. and *Ulmus* sp. have been found (OLIVEIRA et al., 2020, p. 155), possibly given microclimates and a heavy influence of small variations of the site's geomorphology. This study also concludes that throughout the Holocene it is noted the advances and retreats of the forested zones, as well as the variation of taxa levels of each species and in later periods due to possible human action (OLIVEIRA et al., 2020, p. 159). Other case studies on paleo-environment that are comparable to that of Caramulo show similar results within the relevant chronologies, in the 6th-3rd millennia BC time span. Pollen values for the Aboboreira, Passos and Freita mountain ranges, in north-western Portugal, seem to present "[...] *pine woods on the poor soils of interfluves, marcescent woodland on areas with richer soils, and Pyrenean oak (Quercus pyrenaica) forest covering the mountain slopes*" (AURA et al., 1998, p. 89), also showing fluctuations of the forest cover as a result of alternating periods of aridity (SANCHES; 2003, RODRIGUES et al, 2006).

Such settings, that is the existence of forested areas, would correspond perfectly in the environment surrounding the study area, given by plant materials (mainly charcoal) incorporated on the sediments of Meruje. Charcoal fragments may derive from clearing by burning from forested areas around the basin where habitational sites could exist. Penedo dos Mouros, located in foothills of Estrela Mountain, presents itself as a comparable case, as the sediments that filled the rock-shelter were indicative of being transported on account of colluvial processes, already rich in pyrogenic material (SIMÕES et al., 2020, p. 16).

Other plant-related elements were also observed in the thin sections of Lapa da Meruje, such as the presence of phytoliths, recognized as being from small grasses and burnt husk/chaff components (protective casing of the seeds), derived from undergrowth vegetation.

Alongside the phytoliths, a high level of fungal sclerotia is also found in all thin sections, thus further supporting this possibility, as fungal material can appear regularly in association with pasture fields (TENTE & SIMÕES, 2017, p. 23), however without clear evidence, this cannot be said for sure for the Lapa da Meruje case. For the region in question where these types of soils develop, a large input of fungal elements is seen, particularly the sclerotia in acidic soils (BALDOCK & NELSON, 2000, p. 67). In the work of Texier and Meireles (2003), particularly for the Caramulo, it is mentioned the existence of soils rich in carbonised organic matter, dating from the Paleolithic and arguing that natural wildfires favour the erosion of rankers and therefore the formation of slope deposits where these botanic elements can be found.

6.5. Chamber infilling and post-Prehistoric use

With the partial excavation of the dolmen's chamber, it was inferred that the original prehistoric sediments would have been partially removed during the 12th century AD, as the oldest disturbance levels were found to have medieval potsherds, typologically attributed to this chronology; likewise, it was also possible to acknowledge that Girão's testing in 1917 was confined to the post-medieval (re)filling of the chamber, which is the reason why he said he found "nothing worth noting" (CARVALHO, 2018a, p. 208). However, the lower, Neolithic levels in the chamber were shown to be relatively well preserved in their original context, as observed in the testing adjacent to Orthostat 14 in 2021 (A.F. Carvalho, pers. inf.). This was further emphasised by the field data through macroscopic visible subtle contrast of sediments within the conserved level, as its top contained a higher concentration of organic matter that could be seen through a subtle coloration difference (Fig. 7b).

Micromorphological data supports this view and adds new information. While the preserved prehistoric layer is found to exhibit a somewhat porous massive microstructure and in certain areas a medium separated granular microstructure, the disturbed layer is easily distinguishable by having microstructures with a higher porosity, as seen by the presence of highly separated granular microstructure and crumb microstructure with compound packing voids. The coated grain microstructure is also observed in these latter deposit, alongside rounded aggregates. The rounded coatings, composed of both silt and organic material, likely result from rolling downslope mechanisms, reminding of a colluvial origin. Possible arguments that justify the presence of such sedimentary products is that they would have been deposited inside the chamber from the outside. These sediments would belong to the original filling of the chamber, which in

the post-Medieval use of the monument would have got back into the chamber as a result of surface runoff and debris flows promoted by the impact of rainwater (STOOPS, 2010, p. 38) and continuous human presence in the area. Such processes would indicate that the site (chamber) remained open for a long period after its medieval use, leading to a stability phase where the monument most likely wasn't used or at least was used less frequently.

Early Bronze Age inhumation graves at the cemetery of Weiden am See, in Austria, suffered similar processes with the reopening and removal of internal contents of several graves by looters, as slumping was identified as lateral effect of part of the refilling of the graves (ASPOCK & BANERJEA, 2016, p. 805). Thus, parallels can draw in both the Bronze Age graves and Lapa da Meruje, as during the intervention the original filling of both funerary structures dug out, piled up on the side to later be part of post loot sealing.

The presence of rounded aggregates may lead to a different interpretation of the revolved sediment, as being a result of a Neolithic infill in order to wedge the chamber slabs, especially duo to their positioning, located next to a slab.

In contrast to the disturbed level, the conserved prehistoric filling, shows to be homogeneous, as mentioned above. This homogeneity of the older sediments could possibly be explained by a constant and long use of the chamber during the Neolithic or a single sealing event. The presence of bioturbation elements, mainly root channels and rounded voids left behind by microfauna (associated with the crumb microstructure) may reinforce this idea, as untouched soils and sediments lead to the development of soil fauna activity (HELEN, 2003, p. 12). Sclerotia where also incorporated in the deposit's matrix, once again as found in the mound, but at a closer look their internal structure showed to be badly preserved which reveals its relative antiquity, most likely having been already part of the original source of the sediments.

Regarding the origin of the sediments that filled the funeral chamber, they point to a similar source as those of the mound deposit (layer 1), this is derived possible topsoil horizons, in particular the upper layer, since it bears a large quantity of organic matter mixed with a mica-rich sand/silt with several reoccurring elements, for instance charcoal fragments and decomposing plant tissues, derived from topsoil horizons.

In the lower deposit of the chamber (layer 2), intact plant structures of reddened decomposing plant material look to be larger and maintained their internal structure (with visible tissues), in comparison to the mound. This is due to a low level of remobilization, or even these being archaeological materials, derived from maintenance clearing of the funeral chamber by burning. It seems that the enrichment in diverse plant and fungal tissues, both charred and uncharred, can be associated to the anthropogenic infilling of the chamber recurring to materials rich in these type of perishable materials.

7. Conclusion

Having been undertaken a micromorphological approach to the dolmen of Lapa da Meruje, this allowed for a in depth understanding of the sedimentary profiles present at the site and their relationship with several research questions regarding depositional activities and post-depositional processes that occurred throughout the lifespan of the monument between its building in the early 4th millennium BC and its first archaeological testing in 1917.

The overall results indicated that the human presence in the mountain basin where the dolmen is located would have started with its construction in the Middle Neolithic period, not having been identified any preceding human activities. The only possible exception is the find of a few decontextualized lithic artefacts brought to the surface in 2020, when the nearby lake bottom was dredged during consolidation works at the dam; these however seem to date to pre-Neolithic time periods (A.F. Carvalho, pers. inf.), therefore left behind by hunter-gatherer groups with little, if any important impacts on the local landscape.

The sediments that make up both the mound and the infilling of the funerary chamber strongly point to a local origin, due to being composed of mica sands and gravel, heavily weathered and reworked. This supports that the prehistoric communities would have sourced the material from the base of the surrounding slopes. Moreover, given the abundance of burnt plant material (particularly charcoal from wood species) and other elements (such as husks and sclerotia) in the studied sediments related to soils that develop under forested areas, it suggests that vegetation clearance activities, most likely aimed at the construction of the dolmen.

Data showed that activities to prepare the monument took place prior to the assembly of the orthostats and their covering by the mound. This is evidenced by a layer composed of highly abundant burnt plant material and pottery accumulated over a surface composed of river pebbles, the latter possibly anthropogenically modified over a pre-existing fluvial terrace. The construction of the monument on a fluvial terrace would provide natural flat surface and stability.

The application of micromorphology also allowed for a somewhat detailed understanding of post-use events of the dolmen's funerary chamber. Reconstruction of the cultural sequence indicated that, after the sealing of the passage and forecourt in the Late Neolithic–Chalcolithic transition (4th–3rd millennia BC), the chamber would have remained untouched until its reopening at some point during the Medieval period. The removed deposits would have been located immediately on the exterior, scattered all over the (top of the) mound. The post-medieval abandonment consisted of a stability phase where these sediments would flow back into the chamber through slope effects (*colluvium*), bringing small-sized Neolithic artefacts (e.g., microliths) along with them. These deposits would again be disturbed with the 1917 excavations by A. Girão.

The addition of other methods (such as geochemical analysis) may present themselves as a possibility to enrich the micromorphological results obtained in this work and solve these problems. With this statement, with the use of micromorphology it was possible to provide information on the paleoenvironmental conditions immediately before and at the time of construction, strongly suggesting the existence of an incising fluvial network and possible forested areas at the site. Ongoing charcoal analyses for a paleoenvironmental reconstruction may confirm this statement.

Also, the complete excavation of the chamber, which is due in September 2023, will surely lead to the complementation of the data already obtained, especially in what regards the first use of the chamber in Neolithic times.

As final consideration, it is important to state that, from its beginnings to the present day, several works have been carried out with a view of understanding the megalithism of Lafões as a whole and have produced strong results on this topic. However, questions still remain regarding the history of each (individual) monument and the impact of the surrounding environment in which these are inserted. This work allowed to understand that communities in late Prehistory started to choose spaces (that weren't used before) for funerary constructions. This implied site preparation rituals raises the possible existence of residential occupations in the vicinity of the monuments. These megaliths are complex constructions, that demonstrate a clear choices regarding construction materials and a well-established prior planning. Although many monuments in the region have suffered looting, it is still possible to obtain information by employing alternative methods such as systematic sediment micromorphology analyses. It is hoped that the Lapa da Meruje may serve as an example for other monuments in the region.

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