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LETTER

Building Materials of Neolithic Tombs in Alava, Northern Spain

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Abstract: Fifty-two Neolithic tombs (dolmens) were grouped into megalithic stations that are mostly located on lithotecto from which the building rocks were removed. In six dolmens, there were no clues found to explain the presence of allochthonous stones, except perhaps in one of them, where rocks were selected to cause colour contrast. The morphology of the slabs, of chambers and corridors, showed no evidence of carving. The angularity of the tumulus blocks indicates that some were collected from the surface and others were manually fragmented. The identification of the construction materials in Neolithic dolmens with elemental geological features provides information on the building process, adding valorisation to the prehistoric monuments and enabling their reconstruction.

Keywords: Lithotype, Size, Sphericity, Manufacture, Geological features, Building materials.

1. INTRODUCTION

Neolithic megaliths, built between 7000 and 3500 BP, are the oldest preserved buildings on Earth thanks to the use of stones as building materials. Further possible older structures built with other materials have not survived. The distribution of megalithic architecture is very wide, ranging from Korea to Atlantic Europe, where the highest densities of prehistoric buildings are situated.

Megalithism is characterized by the use of large stones and the absence of mortar. The three basic megalithic structures are menhirs, tumuli, and dolmens. The menhir, also known as Neolithic monolith, is the most basic structure, but its function is unknown. The tumulus or mound is an accumulation of rocks, usually with a circular pyramidal shape or conic and a sepulchral function. The dolmen is the most complex megalith and represents the first conserved structure that defines a volume. It consists of a tumulus under which there is a chamber, with or without an access corridor. Three types of dolmens have been distinguished on the Iberian Peninsula based on the type of wall that supports the large slabs of the cover: orthostats, imbricated slabs, and masonry [1]. The dolmen's function was as a collective pantheon.

Alava is a province of about 3000 km^2 in the Basque Country, northern Spain (Fig. **1**). In 1831 the study of its megaliths began with the discovery of the Eguilaz dolmen, the first to be recognized as a prehistoric burial site in Spain [2]. Afterwards, two archaeological catalogues were published describing more than 170 Neolithic buildings [3, 4], 85 of which were considered to be dolmens. Of these 85 catalogued dolmens, 26 are not included in the present study because they could not be located or have been destroyed, or because they do not occur in Alava. Another 7 presumed dolmens are now considered tumuli. In short, in this study a total of 52 dolmens are taken into account (Table **1**).

The average dimensions of the Alavesian dolmens are 2.16 m in height and 17.5 m in diameter, ranging between 0.5 and 4 m in height and 5 and 64 m in diameter. The dolmens are located between 511 m and 1141 m above sea level and occur mainly on horizontal surfaces and never on summits or hills. Except for three dolmens with orthostatic walls, all the others have walls made of imbricated slabs. The number of burials in each dolmen can be very high, and they were

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used for long periods. For example, in Los Llanos dolmen (Fig. **1**), up to 100 individuals have been detected, ranging in burial ages from 4015 ± 215 BC to 2675 ± 225 BC [5], which represents 1350 years of use. According to published dates, the Alavesian dolmens were used between 6000 BP and 3000 BP [6].

Table 1. Neolithic dolmens of Alava analysed.

NAME	Megalithic Station	X	Y	Z	Substratum Lithology	Slabs Lithology	Displacement	Blocks Lithology	Displacement
Alarán	Gorbea	522832	4761475	944	Albian sandy clays	?	?	Albian sandstones	200
Gambidea	Gorbea	511166	4765710	907	Albian sandy clays	?	?	Albian sandstones	
Ollargan	Aramayona	530039	4769872	797	Albian sandy clays	?	?	Albian sandstones	
Aguiñaran	Elguea-Urquilla-Alzania	560481	4749471	972	Albian sandy clays	Albian sandstones	> 250	Albian sandstones	0
Artaso	Elguea-Urquilla-Alzania	548176	4756474	1038	Albian sandy clays	Albian sandstones	< 500	Albian sandstones	< 500
Larrasoil	Elguea-Urquilla-Alzania	554891	4751429	946	Albian sandy clays	Albian sandstones	0	Albian sandstones	0
Urkitzako Lepoa	Elguea-Urquilla-Alzania	551075	4755259	1143	Albian sandy clays	Albian sandstones	0 - 100	Albian sandstones	0
Alto de Lejazar	Guibijo	503253	4754076	844	Coniacian limestones	Coniacian limestones	0	Coniacian limestones	0
Ataguren	Guibijo	505608	4751420	803	Coniacian limestones	Coniacian limestones	0	Coniacian limestones	0
Lejazar meridional	Guibijo	503327	4753774	843	Coniacian limestones	Coniacian limestones	0	Coniacian limestones	0
Los Cotorricos I	Guibijo	503442	4750178	873	Coniacian limestones	Coniacian limestones	< 500	?	?
SB-32	Badaya	511559	4750395	816	Coniacian limestones	Coniacian limestones	0	Coniacian limestones	0
Arrizacen	Encía-Iturrieta	558979	4744050	1052	Paleocene sandstones	Paleocene limestones	> 150	Miocene calcareous conglom.	0
Gaztelamendi	Encía-Iturrieta	552912	4738999	1046	Paleocene marl limestones	Paleocene limestones	0	Paleocene limestones	0
Gaztalamendi II	Encía-Iturrieta	552783	4738888	1032	Paleocene marl limestones	Paleocene limestones	0	Paleocene limestones	0
Igurita	Encía-Iturrieta	559581	4741575	1022	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
Itaida N	Encía-Iturrieta	559161	4740165	967	Paleocene limestones	Paleocene limestones	0	Pal. limestones and Miocene conglom.	0 y > 150
Itaida S	Encía-Iturrieta	558640	4739593	1009	Miocene calcareous conglom.	Paleocene limestones	> 150	Miocene calcareous conglom.	0
Larragorri	Encía-Iturrieta	554716	4738839	1025	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
Legaire N	Encía-Iturrieta	559312	4743245	1013	Dissolution clays	Paleocene limestones	> 500	Paleocene limestones and clays?	?
Legaire S	Encía-Iturrieta	559103	4742943	1009	Dissolution clays	Paleocene limestones	> 250	Paleocene limestones and clays?	?
Morube	Encía-Iturrieta	558333	4737333	1077	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
Portillo de Kortagaina	Encía-Iturrieta	554953	4736394	1070	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
Puerto de Alangua I	Encía-Iturrieta	552797	4739356	1069	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0

(Table 1) contd.....

NAME	Megalithic Station	X	Y	Z	Substratum Lithology	Slabs Lithology	Displacement	Blocks Lithology	Displacement
Puerto de Alangua II	Encía-Iturrieta	552875	4739254	1070	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
San Juan	Encía-Iturrieta	549268	4739336	1023	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
Santa Teodosia I	Encía-Iturrieta	552610	4734949	1040	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
Santa Teodosia II	Encía-Iturrieta	552547	4735516	1044	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
Santa Teodosia III	Encía-Iturrieta	552518	4735247	1036	Paleocene limestones	Paleocene limestones	0	Paleocene limestones	0
Las Campas de Oletar	Ayala	490962	4766408	554	Coniacian marls	Conianian marl limestones	250 ?	Conianian marl limestones	250 ?
Las Campas E	Ayala	488554	4766371	537	Coniacian marls	?	?	Conianian marl limestones	250 ?
Las Campas W	Ayala	488506	4766351	534	Coniacian marls	Conianian marl limestones	250 ?	Conianian marl limestones	250 ?
Gurpide N	Cuartango	508513	4750732	579	Coniacian marls	Coniacian limestones	500 - 1000	Coniacian limestones	< 100
Gurpide S	Cuartango	508577	4750682	576	Coniacian marls	Coniacian limestones	500 - 1000	Coniacian limestones	< 100
San Sebastian N	Cuartango	508498	4751139	584	Coniacian marls	Coniacian limestones	500 - 1000	Coniacian limestones and boulders	> 250
San Sebastian S	Cuartango	508384	4750934	587	Coniacian marls	Coniacian limestones	500 - 1000	Coniacian limestones	< 100
Laurimendi	Zuya	515555	4754443	646	U. Cretaceous marl limestones	U. Cretaceous marl limestones	> 500	U. Cretaceous marl limestones	> 100
La Llana de Vitoriano	Zuya	514863	4755069	615	Keuper clays	U. Cretaceous marl limestones	> 500	U. Cretaceous marl limestones	> 100
Eguilaz	La Llanada	554285	4745843	606	U. Cretaceous marls	U. Cr. limestones and Alb. sandston	> 3000 - 5000	U. Cretaceous marls	0
Escalmendi	La Llanada	529535	4747541	509	U. Cretaceous marls	?	?	U. Cretaceous marls	0
Kurtzebide	La Llanada	520451	4753850	570	U. Cretaceous marls	U. Cretaceous marl limestones	0	?	?
Sorginetxe	La Llanada	550818	4742076	622	U. Cretaceous marls	Paleocene limestones	> 3000	?	?
La Lastra	Bayas	502246	4732021	532	Miocene sandy clays	Miocene sandstones	> 100	Miocene sandstones	> 100
La Mina	Bayas	502075	4732800	582	Miocene sandy clays	Miocene sandstones	> 100	Miocene sandstones	> 100
Alto de la Huesera	Rioja Alavesa	535613	4713104	610	Miocene sandy clays	Miocene sandstones	> 100	Mioc. sandstones and U. Cr. limestones	< 100 y > 3000
El Encinal	Rioja Alavesa	538337	4713354	595	Miocene sandy clays	Miocene sandstones	> 200	Miocene sandstones	> 200
El Montecillo	Rioja Alavesa	527478	4711360	511	Miocene sandstones and clays	Miocene sandstones	0	Mioc. sandstones and U. Cr. limestones	0 y 4500
El Sotillo	Rioja Alavesa	531031	4713544	613	Miocene sandy clays	Miocene sandstones	> 200	Mioc. sandstones and U. Cr. limestones	0 y > 2000
La Chabola de la Hechicera	Rioja Alavesa	536642	4712896	595	Miocene sandy clays	Miocene sandstones	> 150	Miocene sandstones	> 150

(Table 1) contd.....

NAME	Megalithic Station	X	Y	Z	Substratum Lithology	Slabs Lithology	Displacement	Blocks Lithology	Displacement
Layaza	Rioja Alavesa	528479	4714228	670	Miocene sandy clays	Miocene sandstones	> 200	Mioc. sandstones and U. Cr. limestones	> 200 y > 1000
Los Llanos	Rioja Alavesa	538371	4715807	681	Miocene sandstones and clays	Miocene sandstones	> 250	Miocene sandstones	> 250
San Martin	Rioja Alavesa	533312	4712247	570	Miocene sandy clays	Miocene sandstones	> 250	Mioc. sandstones and U. Cr. limestones	> 250 y > 2500

?: not visible.

The rock types used in the Alavesian historical monuments have been determined in the previous works [7 - 10] and they mainly consist in Palaeocene and Upper Cretaceous limestones and, Miocene and Albian sandstones. In this study, the rocks used in Neolithic dolmens are identified for the first time, with special attention to the lithology, size, and morphology of the materials, and the implications of these characteristics.

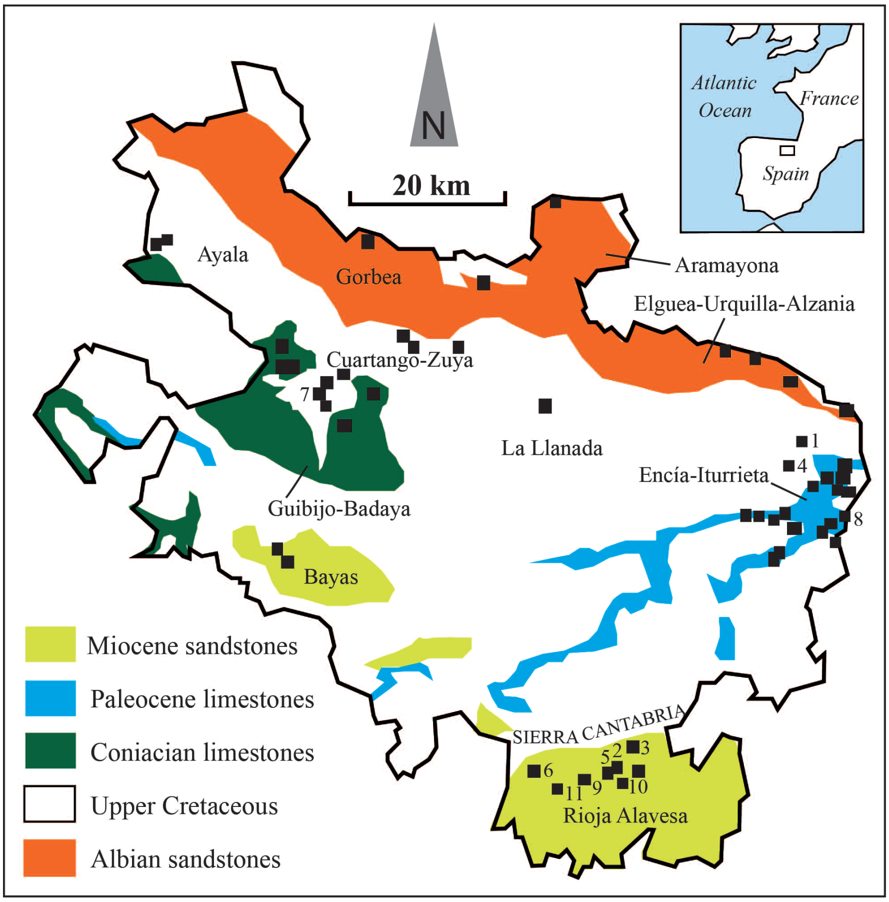

Fig. (1). Geographic and geological locations in Alava. Distribution of lithotectos, megalithic stations and dolmens cited in the text. 1: Los Llanos; 2: La Chabola de la Hechicera; 3: Sorginetxe; 4: Eguilaz; 5: Alto de la Huesera; 6: Layaza; 7: San Sebastian N; 8: Itaida N; 9: El Sotillo; 10: San Martin; and 11: El Montecillo.

2. BUILDING UNITS AND SIZES OF MATERIALS

The rocks used in each building unit differ markedly in size (Fig. **2a**). A conventional particle-size classification has been used to describe the tumuli, which mainly corresponds to the 'block' size. In describing the chambers and corridors, the slabs are referred with their corresponding measures. Each size reflects different functions in the construction: the blocks and smaller elements were used to construct the tumulus while the slabs defined the void volume within the dolmen. In addition, the difference in size implied a different handling. In fact, tumulus blocks were manageable by a single operator, while the chambers and corridors slabs required several workers, animals, or mechanical devices currently unknown.

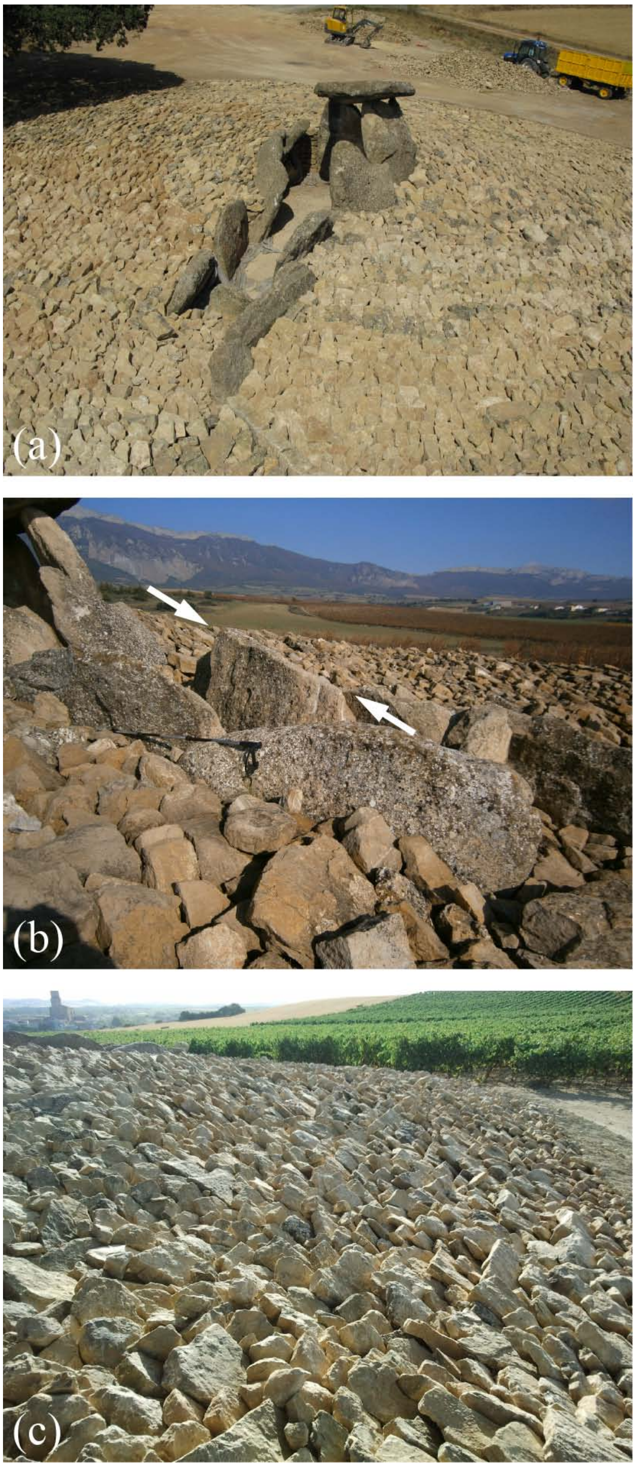

Fig. (2). La Chabola de la Hechicera. (a) Dolmen with corridor. See different sizes of stones in chamber, corridor and tumulus. (b) Fractured edges of the corridor slabs. (c) Restored blocks with sharp edges and imbricated structure as in the subjacent original tumulus.

3. METHODOLOGY

The rocks that constitute the monumental buildings constructed in Alava in all the historical periods until 1900 have been identified, including those of the Cathedral of Santa Maria [11] and the 487 churches in the diocese of Vitoria [7]. Spatio-temporal associations between the lithologies and the artistic periods have been defined [8] and interesting Romanesque lithological combinations have been described [9]. There are several articles on the building materials used in prehistoric times [12 - 14], and one specifically addresses the geological features of the Alavesian menhirs [15]. All these researches have contributed to the present study.

In Alava, the main lithotypes or rocks that were used in the constructions are Albian and Miocene sandstones, and Coniacian and Paleocene limestones (Fig. **1**). Their petrographic, mechanical, and durability characteristics have been described previously [11]. These lithotypes are distributed in the lithotectos or geological bodies represented on geological maps. The identification of lithotypes and lithotecto distributions has enabled the discovery of many kinds of ancient quarries [16].

In this study, the dolmens were localized using published catalogues [3, 4]. Later, the materials were identified, their sizes were measured and their morphologies determined. Rock identification and allocation to a lithotype were accomplished by visual inspection. After that, the related lithotecto was localized on the geological map. If the dolmen was not over lithotecto, the minimum distance between the Neolithic monument and the nearest corresponding outcrop was measured on map.

The measurements of the chamber and corridor slabs were made directly. The particle sizes of the blocks of the tumuli were estimated by photographs, in which the diameters of the blocks were measured and the average values calculated.

The morphologies of the rocks were defined by three parameters: shape, sphericity, and roundness. The ‘shape’ was determined from the axial relationships of height, width, and thickness, defining four types: discoid, spherical, tabular, and elongate [17]. The ‘sphericity’ is the degree of approximation to a sphere. The shape and sphericity are related to the original block extracted from the quarry. The ‘roundness’ refers to the curvature or sharpness of edges and corners. A Powers graph [18] was employed to determine the sphericity and roundness. Roundness, or its opposite term, ‘angularity’, indicates the degree of erosion and is important to know the origins of rocks. If the edges are rounded, it follows that the rock surface has been exposed for a long time. Conversely, if the roundness index for a given rock type is very low, it has originated from mechanical fracturing. In this study, rounded blocks were interpreted as having been collected directly from the ground surface and angular blocks as having been obtained using manual fragmentation. This approach has been validated by comparing rocks collected from the surface and others extracted mechanically [19].

4. MEGALITHIC STATIONS AND LITHOTECTOS

The Alavesian megalithism is grouped into stations based on geographic units. In turn, these stations correspond to geomorphological units that are defined by the lithological substrate. Therefore, the megalithic stations rest on litho-morphological units characterized by a common lithology, so when a megalithic station is cited, it indirectly indicates the lithology of the substrate. In other words, the distribution of megaliths is related to the lithology. Therefore, the megalithic stations differentiated in the published catalogues [3, 4] overlap the lithotectos previously delimited with geological mapping (Fig. **1**). Exceptionally, two of the fifty-two studied dolmens lie on substrates with no building material around.

5. CHAMBER AND CORRIDOR SLABS

5.1. Lithology

Generally, the rocks used in a dolmen belong to the megalithic station itself and were transported within the lithotecto. There are two unique dolmens in La Llanada (Fig. **1**): Sorginetxe (Fig. **3**) and Eguilaz (Fig. **4**), where no rocks suitable for megalithic slabs are available, requiring the building material to be transported. Both dolmens rest on a substrate of Upper Cretaceous marl-limestone.

Fig. (3). Dolmen of Sorginetxe. Note the structural fracture along joints. Rounded fractured edges indicate antiquity.

In the Sorginetxe dolmen, the chamber is built of Paleocene limestone. The nearest outcrop of this rock is 3 km away, so this is the minimum distance to be covered to transport the slabs. In the Eguilaz dolmen, all of the slabs are Paleocene limestone, with the only exception of Albian sandstone. Ten limestone slabs, weighing 1000-11000 kg, were transported at least 3 km, and the sandstone block of 4500 kg was transported for more than 5 km. This observation was made by Barandiaran [20] based on the lithology and was corroborated petrographically by Vegas *et al.* [21]. It is unknown why a slab of Albian sandstone was transported at least 5 km if there were Paleocene limestones available at a short distance of 3 km.

5.2. Morphology

The morphology of the slabs was determined by the type of source rock. Because the Alava area is dominated by sedimentary rock, the dimensions of the slabs are related to the layer of provenance. The thickness of the slab corresponds to the thickness of the source layer, and the other two dimensions, height and width, are limited by the joint system [13]. In general, the predominant shape of the slabs is tabular.

After several thousand years, part of the dolmen structure was exposed to sub-aerial conditions and the slabs eroded. So, in general, the slabs were very rounded. However, some slabs show sharp corners, as evidence of mechanical fracturing. Two kinds of fractures have been differentiated, one which is related to the structure of the dolmen and the other related to external source with or without intentionality.

Structural fractures arise from overloading. For example, the Sorginetxe dolmen contains a broken slab that failed along joint surfaces (Fig. **3**). The fracture surface has rounded edges, indicating that it is an old fracture, but its age cannot be determined. Another example of a structural fracture can be seen in the dolmen of Alto de la Huesera (Fig. **5a**). A force analysis suggests that the fragmented slab suffered overload caused by the asymmetry of the structure [14]. The slab, instead of rotating, was fractured, forming a window in the chamber. The edges of the fractured surface are sub-rounded, so it is an old fracture.

Fig. (4). Dolmen of Eguilaz. All slabs are Paleocene limestone, except for one of Albian sandstone, indicated by the star.

The fractures on the tops of the slabs in the walls of some chambers and corridors are more-or-less conchoidal, with sharp edges. At La Chabola de la Hechicera (Fig. **2b**), these surfaces are explained as having been carved to level the covers or capstones of the corridor [22]. In the Layaza dolmen, the tops of almost all the chamber slabs appear to have been retouched (Fig. **6**). In both cases, it is possible that the rocks were originally carved on their top edges, but have also been broken during more recent agricultural activities. In either case, the fractured surfaces are angular, indicating that they are not very old.

The ages of the dolmens must be considered when interpreting the origins of the fractured surfaces of the slabs. Most of them were built before the use of metal tools, so the only tools used were stone maces, most likely ophites [23]. No marks made by metallic tools have been observed. In short, it is difficult to prove that the slabs of the chambers and corridors have been retouched or intentionally carved. Furthermore, although the fracture surfaces are recognizable, it is difficult to determine their ages, and they may originate from a post-Neolithic period.

6. TUMULUS BLOCKS

6.1. Lithology

The rocks of the tumuli are almost always from the same megalithic station, suggesting that the closest building materials were chosen. However, there are some exceptions that require further investigations.

At the Cuartango megalithic station, most tumular blocks are angular fragments obtained by manual fracturation of the local Coniacian limestone, but in the dolmen of San Sebastian N (Fig. **1**), there are some alluvial sandstone boulders, transported by at least 250 m. A cause to explain the presence of these boulders is that the effort required to fracture and place the underlying Coniacian limestone was similar to that required to collect, transport, and place the superficial alluvial boulders.

A similar case is the dolmen of Itaida N in Sierra de Entzia (Fig. **1**). Part of the tumulus is composed of angular fragments obtained by manual fracturation of the local Paleocene limestone, whereas other blocks are boulders of a Miocene conglomerate that occurs 150 m away. It is likely that the effort required to obtain and transport the Paleocene limestone fragments was similar to that required for the surface collection and transport of the Miocene boulders, thereby explaining their presence. Therefore, in these tumuli, the selected rocks are consistent with the principle of minimal effort.

Fig. (5). Dolmen of Alto de la Huesera. (a) Fracture plane in a slab. (b) Blocks of the tumulus. The white blocks are Upper Cretaceous limestone from colluvium of Sierra Cantabria, located 3 km away. The ochre blocks are local Miocene sandstone.

In Rioja Alavesa, the dolmens of Alto de la Huesera, Layaza, El Sotillo, San Martin, and El Montecillo Fig. (**1**) are built mainly of the local Miocene sandstone. However, in the tumuli, there are also Upper Cretaceous limestone blocks from the colluviums of the Sierra Cantabria (Fig. **1**). The volumetric proportion of limestone ranges from about 30% in the Alto de la Huesera to 1% or less in El Montecillo. Although the building material for these dolmens was available close by, the limestone blocks were moved by at least the following distances: Layaza, 1 km; El Sotillo, 2 km; San Martin, 2.5 km; Alto de la Huesera, 3 km; and El Montecillo, 4.5 km. In Alto de la Huesera (Fig. **5b**), the strong presence (up to 30%) of white limestone could be explained as an intention to create a strong colour contrast between the tumulus and the ochre tones of the surrounding countryside. However, in other dolmens, the anomalous presence of white limestone is difficult to explain. Therefore, if the principle of minimal effort is not applicable, it seems that some meaning or value was attributed to the building materials used that we cannot interpret today.

6.2. Size

Most tumuli are built with centimetre-to-decimetre-sized blocks, which could be handled by a single operator. In six tumuli, the diameters of the blocks are centimetric and remember soil levels. These tumuli are always located on *cayuelas*, marl limestones, or marls of the Upper Cretaceous. The *cayuelas* usually contains a small fraction of swelling clay that changes in volume with humidity, resulting in rapid weathering [7]. If *cayuelas* from the Upper Cretaceous was used in the tumuli of these dolmens, it is likely that the present soil-like appearance corresponds to the weathering of the original rock.

6.3. Angularity

If a boulder is hit and broken into two fragments, the fracture surface shows a sharp edge, unlike the original outer surface, which is rounded. Based on this observation, the angularity of the blocks of the tumuli is considered an important parameter. The angular blocks were produced by intentional mechanical fracturing, which implies an extraction quarry, whereas the eroded rounded blocks were collected from the ground surface.

In the La Chabola de la Hechicera dolmen (Fig. **2c**), the strong angularity of the Miocene sandstone blocks has been interpreted as reflecting an origin by quarrying [19]. In the neighbouring dolmen of Alto de la Huesera, tumulus blocks with the same lithology are highly rounded (Fig. **5b**), inducing to suppose that they have been collected from the surface. Among the fifty-two dolmens visited, two-thirds of the tumulus blocks were collected from the surface and one-third was obtained mechanically by manual fracturation. It is assumed that for a given lithology, the blocks will be collected on the surface or by fracturing according to the principle of minimum effort.

Fig. (6). Dolmen of Layaza. Retouched top of a chamber slab, with unknown age and genesis. Slab width, 1.5 m.

DISCUSSION

Local natural stones were used in most Alavesian dolmens, usually from the megalithic station itself. In the two dolmens located in an area lacking available building materials, the rocks were transported to the site. In these cases, the chosen location took precedence over the availability of building materials. The criteria used in choosing these sites are unknown.

In terms of the types of rocks chosen for the slabs, the only anomaly is observed in the Eguilaz dolmen [20, 21]. It contains a slab of Albian sandstone, moved at least 5 km, whereas the remaining Paleocene limestone slabs were moved from the nearest source, 3 km away. Why that slab of sandstone was selected, despite involving more arduous transport, is unknown.

The blocks of the tumuli were also often locally sourced, except in five dolmens in Rioja Alavesa, which were constructed with limestone blocks transported from 1 to 4.5 km away. Very little allochthonous limestone was used, except in the tomb of Alto de la Huesera, where it accounts for 30% of the building material. This high percentage of white limestone produces a strong colour contrast with the surroundings, which could justify its transport for 3 km. The presence of allochthonous rocks is difficult to explain, and their use may be motivated by factors not understood today.

The morphology of the Neolithic building materials also provides information about the selection of the rocks and their handling. In general, erosion tends to smooth the shapes of rocks. This can obscure the origins of some fracture planes, and neither their function nor age can be determined. In general, it is assumed that the slabs of chambers and corridors were not carved. However, the angularity of tumulus blocks means that rocks generated by mechanical fragmentation can be distinguished from those collected from the surface.

The choice of rocks used in Alavesian historical buildings is governed by the principle of minimal effort [8], although in other areas has not been verified [24 - 26]. This principle has been confirmed for the Alavesian Neolithic dolmens, except for the singular choice of a slab in the Eguilaz dolmen and the allochthonous blocks used in the dolmens of Rioja Alavesa. In these cases, the criteria used in their selection, as in the choice of sites, are not yet understood.

Dolmens are the oldest architectural structures thanks to the used construction materials. The analysis of Neolithic building materials provides information on building processes, from the collection or manufacture of the material to its placement on the monument. Our knowledge of the morphology and origin of the rocks used in Neolithic times has also been applied to reconstruct the dolmens of La Chabola de la Hechicera [19] and Alto de la Huesera [14]. Understanding the building materials also adds valorisation to the monuments, promoting their knowledge.

CONCLUSION

This study analysed the building materials of fifty-two Neolithic dolmens in Alava. These were differentiated according to their functions as either the slabs of chambers and corridors or the blocks of tumuli. Slabs delimit the interior volumes and blocks fill the external structures of the dolmens. The slabs were large and their manipulation required the cooperation of several operators, whereas the blocks were transportable by a single person.

The dolmens were distributed according to megalithic stations that correspond to litho-morphological units. These units were related, in turn, to the lithotectos already recognized in historical buildings [7, 8]. In general, all the constructions were built with the lithotype that was characteristic of the megalithic station, confirming that the acquisition of the material followed the principle of minimal effort. If no building material was available on site, it was transported from nearby locations. The few exceptions, in which allochthonous rocks that required an additional transport were selected, cannot be explained.

The analysis of Neolithic building materials allows reconstructing the processes used in the past, and in addition, it facilitates the restoration and conservation of these structures as well as their knowledge.

CONFLICT OF INTREST

The author confirms that this article content has no conflict of interest.

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Declare none.

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