Construction Systems of Neolithic Dolmen Walls on the Iberian Peninsula

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Abstract: Walls of corridors and chambers in the Neolithic dolmens of Portugal and Spain were constructed using megalithic slabs or masonry. When constructed with slabs, the slabs were arranged using two very different construction systems, based either on placement of an orthostat or on imbrication of the slabs. Although generally dolmens are described with orthostats, on the Iberian Peninsula are most often constructed using imbricated slabs. The walls of orthostatic and masonry dolmens are lintelled structures. The walls of imbricated slab dolmens, however, are unique structures without later representation. Temporally, the orthostatic dolmens represent the earliest construction system, followed by those of imbricated slabs and finally those of masonry. This evolution can be explained in terms of the capacities of the self-supporting walls and simplification of the construction processes.

Keywords: Imbricated slabs, masonry, megalithic architecture, orthostat, Portugal, Spain.

INTRODUCTION

Dolmens are Neolithic funerary monuments constructed between 4200 BC and 1800 BC; in some cases, they were used as pantheons for long periods of time. The numbers of individuals buried in dolmens can be of the order of several hundred. Substantial volumes of material were used in the construction of a dolmen, which required great effort in the transportation and placement of the materials. As cultural icons, dolmens imply a relatively high degree of social organization, reflected in its construction process.

The architectural elements of a dolmen are: a chamber and a corridor that contain an empty space, and an external tumulus covering the monument. Dolmens are usually classified according to the size and morphology of the inner space, as: dolmen cists, simple dolmens (i.e., without a corridor), and dolmens with a corridor or covered gallery. The geometry on the chamber floor is also a characteristic feature of dolmens; for example, square, hexagonal, circular. So, dolmen typology are usually refered exclusively to its internal morphology. Construction systems of dolmens are rarely commented upon, despite their being the oldest architectural structures preserved in Atlantic Europe.

The tumulus is the visible outer structure of a dolmen, whereas the chamber and corridor are the physical structures that constitute the inner cavity. From a structural perspective, the chamber and the corridor consist of internal spaces with covers or capstones, which are supported by bearing walls (supporting elements). The surface of the tumulus is generally cone-shaped, and the structure is defined by its dimensions, surface slope, and the morphometries and litholigies of constituent materials [1]. The tumulus is a non-structural element of the dolmen, although internal structures have been recognized in some tumuli [2].

The bearing walls of the chambers and corridors are classified according to the types and sizes of building materials used in the construction, and the arrangements of structural elements. Three types of bearing walls have been distinguished: orthostatic walls (which are assumed as the basis for the dolmen architectural style), walls of imbricated slabs (which, curiously, are the most common type), and walls of masonry.

SIZES OF CONSTRUCTION MATERIALS

Construction materials used in the chambers and corridors can be classified according to the sizes of slabs and masonry materials. Masonry consists of blocks that could have been manipulated by a single individual. Slabs, used synonymously with the term ‘megaliths’, are typically measured in units of meters, and several individuals were required for their manipulation and placement.

If we only consider the cover, the tholos and the dolmen *sensu lato* are classified separately. Tholos is a dolmen with masonry cover constructed in a false vault. It is characteristic of the southeastern Iberian Peninsula, more specifically, of the necropolis of Los Millares. The covers in dolmen *sensu lato* are constructed by slabs. In any case, in this work does not analyse the covers.

Materials used for the interior supporting walls are either masonry or rock slabs. In addition, in walls comprising slabs, the slabs were positioned either as orthostats or in imbricated arrangements.

TYPOLOGY OF WALLS

Walls of Orthostats

Walls constructed using orthostats are the basis for the common conception of dolmens: a vertical slab (orthostat) is

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the foundation and support for a horizontal slab (cover), reminiscent of a table. Many analyses and schematic representations of dolmens are in accordance with this simple schema, which is repeated in numerous dolmenic recreations. A dolmen of orthostats and lintels represents a system in which cover loads are transmitted to the ground through the orthostats, which function as jambs or columns (Fig. **1**). Stabilization of an orthostat requires some sort of foundation or structure to confine the stone; in other words, the walls of orthostats are not self-supporting, but rather require external structures to maintain their verticality. In any case, the structural loads of the cover are supported by the vertical orthostats.

Walls of Imbricated Slabs

Walls constructed of imbricated slabs represent a structural system unique in the history of architecture; such structures are specific to Neolithic megalithic monuments, and subsequently were not used in other constructions. Imbricated structures were first described in dolmens from Rioja Alavesa, where they helped explain how the dolmens survived one or more large earthquakes occurring at ca. 2700 BC, which partially destroyed some chambers [3]. Since then, the structural system of imbricated slabs has been analysed in detail [4].

Walls of imbricated slabs are readily understood in terms of the phases of wall construction (Fig. **2**). The process begins with the erection of a generating slab, which is the only vertical slab in the structure, and hence the only slab which can be referred to as an orthostat. This first slab (the generating slab) supports two other inclined slabs which point towards what will be the inside of the chamber. Another two symmetrical slabs are then supported by the first two inclined slabs, and then further slabs are placed upon those, until the closing the walls of the chamber have been established. The imbrication of slabs continues into the corridor. This arrangement of slabs transfers part of the load of a slab to the inferior slab, where it is supported tangentially; this configuration is different from that of the lintelled system, in which all loads are transmitted vertically to the ground.

The numbers of slabs and the sizes of chambers in imbricated-style dolmens are variable. A very simple imbricated structure, in which the chamber has just two inclined slabs and no generating slab, is found in the dolmen of Letranz (Fig. **3a**). Chambers with walls of three slabs are common in the Pyrenees (Fig. **3b**). The numbers of slabs in the chamber can be increased (Fig. **3c-g**), as in the nine slabs in the La Chabola de la Hechicera (Fig. **3h**). Regarding size, some dolmens are very small, and are locally described as dolmen cists [2], whereas others, such as those of Iberia, are large; for instance, slabs in the Anta Grande do Zambujeiro dolmen are 8 m high (Fig. **3g**).

Walls of imbricated slabs, once established, are self-supporting; that is, they are stable in and of themselves, and do not require the support of external structures [4]. However, during construction, the generating slab requires support to keep it erect until the two adjoining slabs (E1 and W1) have been placed (Fig. **2**). The system of imbricating slabs is unique in the history of architecture, and is specific to Neolithic megalithic monuments; the construction style was not used in later constructions.

Fig. (1). Dolmens with orthostat walls. (**a**) El Moreco: the chamber is 2 m high. (**b**) Magacela: the chamber is 2.5 m high. (**c**) Alberite: the corridor is 23 m long and 2 m high. (**d**) Los Llanos: the average height is 1.2 m.

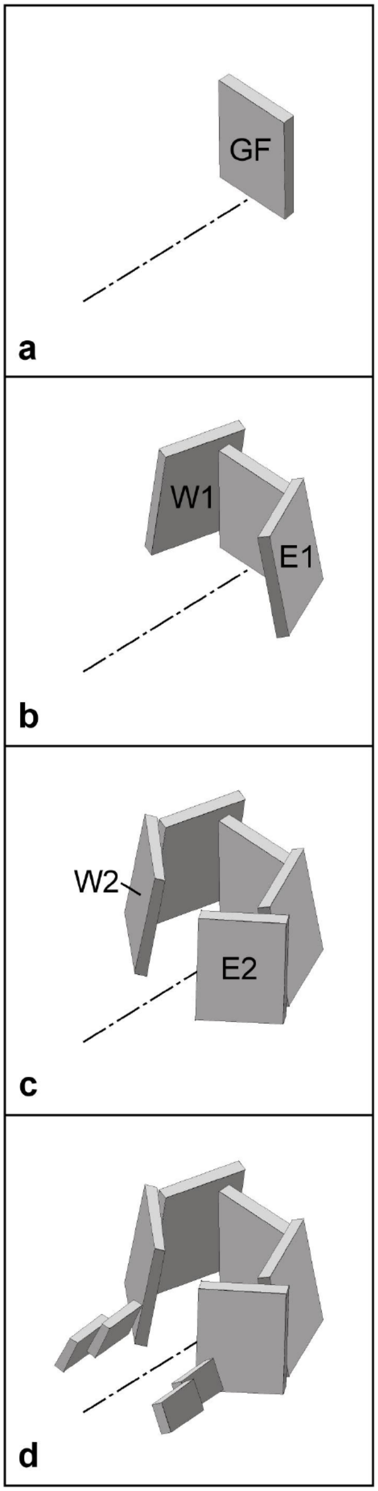

Fig. (2). Phases of construction of a megalithic dolmen based on walls of imbricated slabs. GF: generating flagstone. (**a**)–(**c**) Construction of the chamber walls. (**d**) Construction of the walls of the corridor. At a later stage, covers would be placed over the chamber and corridor.

Masonry Walls

Masonry construction techniques were used in the walls of some corridors, as for example in the tholos de El Romeral (Fig. **4a**) and some chambers, as for example the dolmen of Longar. In the latter, the chamber was constructed using a single slab resting on a wall of masonry (Fig. **4b**). Masonry walls were constructed dry, without bonding agents or mortars; they are stable and self-supporting, and do not require a foundation or auxiliary structures. In terms of Iberian megalithic architecture, the masonry wall typology is present in a minor portion of the dolmens.

Fig. (3). Dolmens with imbricated walls. Asterisks indicate the generating flagstone. (**a**) Letranz: the chamber (1 m high) consists of two inclined slabs, one resting upon the other. (**b**) Luperta: the chamber (1 m in height) consists of walls of three slabs. (**c**) Monte Areo XV: the chamber (1.5 m high) consists of five slabs. The slab on the right is positioned lower, although it is also imbricated and belongs to the corridor. (**d**) Sorginetxe: the chamber (2 m high) consists of 6 slabs. (**e**) Dombate: the chamber (3 m high) consists of seven slabs. (**f**) Creu d'en Corbetella: the chamber (3 m high) consists of seven slabs. (**g**) Anta Grande do Zambujeiro: the chamber (8 m high) consists of eight slabs. This is the largest dolmen on the Iberian Peninsula. (**h**) La Chabola de la Hechicera: the chamber (3 m high) consists of nine slabs.

GEOGRAPHIC DISTRIBUTION

Fig. (**5**) shows the distribution of the three types of dolmenic walls in Portugal and Spain. A total of 205 dolmens have been recognized, and attempts were made to visited the most representative of each megalithic region. Several

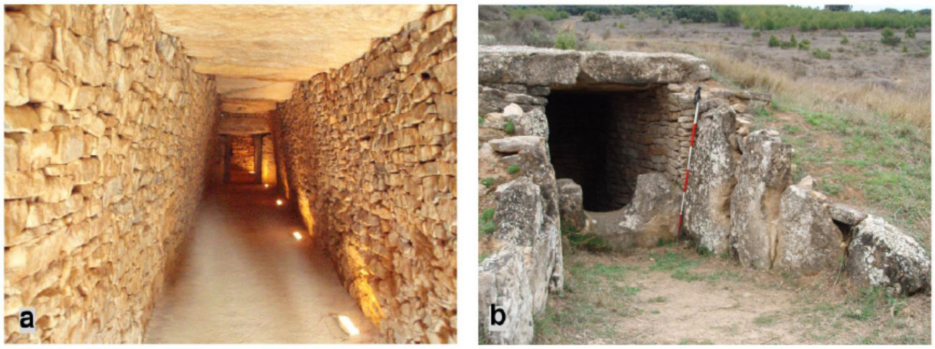

Fig. (4). Dolmens with masonry walls. (**a**) El Romeral: the corridor is 2 m high. (**b**) Longar: the chamber is 1.5 m high.

thousand dolmens have been catalogued in Iberia, and it is likely that the present sample is representative of the frequency of occurrence of the different typologies.

Dolmens with masonry are in the minority, and represent only 3% of the sample. Except for the dolmen of Longar, all of the masonry dolmens are located in the south of the Iberian Peninsula. The dolmens with orthostatic walls represent 30% of the sample, and are concentrated in the peninsula interior. The remaining 67% of the sample are dolmens with walls of imbricated slabs, which are found mainly in the periphery of the peninsula. The causes of the observed spatial distributions of the different types of dolmens are unknown.

Based on the sample of visited dolmens, the architectural model most extensive in Iberia is the dolmen constructed with walls of imbricated slabs, although this design is not represented in later architectural traditions. In addition, it was observed that the walls of orthostats, even though they are often considered as representative of dolmen typology, cannot be considered as a mainstay of dolmenic architecture. Finally, dolmens constructed of masonry walls are clearly in the minority.

CHRONOLOGY

An analysis of the chronology of the different architectural types, as well as their geographical distributions, would require more data than are currently available. However, references for dolmens in the north and south of the Iberian Peninsula provide a basis for a tentative assessment of the temporal sequence of megalithic construction techniques, which is discussed below.

The dolmen of Alberite is a cover gallery with an orthostatic wall (Fig. **1c**). Its recent discovery and excavation have allowed precise dating of the structure at 4150–3950 cal BC, which makes this dolmen one of the oldest megalithic structures on the peninsula [5]. The Anta Grande do Zambujeiro (Fig. **3g**) is the largest imbricated dolmen of Iberia, and one of the most southerly; it belongs to the megaliths of Evora region dated at 4000–3500 cal BC [6]. Dolmens with masonry, characterized by Los Millares, yield ages of 2700-1800 cal BC [7]. Thus, the dates of the dolmens in the southern peninsula suggest that dolmens were first constructed using orthostats, then imbricated slabs, and finally masonry.

On the northern peninsula, three different dated megalithic structures occur within a radius of only 10 km from the dolmen of La Chabola de la Hechicera (Fig. **3h**). The orthostatic dolmen of Los Llanos (Fig. **1d**) is dated at 4015 cal BC [8], the dolmen of imbricated slabs of La Chabola de la Hechicera (Fig. **3h**) is dated at 3890–3650 cal BC [9], and the masonry dolmen of Longar (Fig. **4b**) is dated at 3175 cal BC [10]. These data are consistent with the succession of construction techniques observed for dolmens in the southern peninsula. First, orthostatic dolmens were constructed, then dolmens of imbricated slabs, and finally dolmens of masonry (Fig. **5**). It should be noted, however, that chronological data are limited, and a conclusive chronology is currently not available; in addition, the dates refer to dates of occupation of the dolmens, and not to their dates of construction.

DISCUSSION

The lintel, or "architrave", rests on and transmits its load to two jambs or columns. In a dolmen with cover slabs, the lintelled system is represented by orthostats or masonry walls, as both vertically discharge the mass of the cover to the ground (Fig. **6**). A different structural system is the wall of imbricated slabs, a unique structure in that part of the vertical loads are horizontally transform by transmitting the load of a slab to the next one on which it supports [4]. The sub-horizontal loads, which are transmitted symmetrically to each of the flanks of the dolmen, converge at the generating slab (Fig. **2**). Therefore, although the covers behave as lintels, in the walls of imbricated slabs, a system of horizontal forces develops which are non-existent in the jambs or columns of lintelled structures.

Other differences between the three types of Neolithic walls relate to their self-supporting characteristics during and after construction (based on the definition of a self-supporting structure as one which is stable without the support of a foundation or auxiliary structures). Orthostatic walls are not self-supporting; the walls of imbricated slabs are self-supporting, once the slabs are in place, but not during their construction; and masonry walls are self-supporting both during and after construction (Fig. **6**).

For stability, megalithic stones must be set into a pit, in a process similar to that of the erection of monoliths [11]. In addition, during the backfilling of the pit, some sort of temporary structure is required to hold the erected stone. Therefore, the walls of orthostats are not self-supporting during or after their construction.

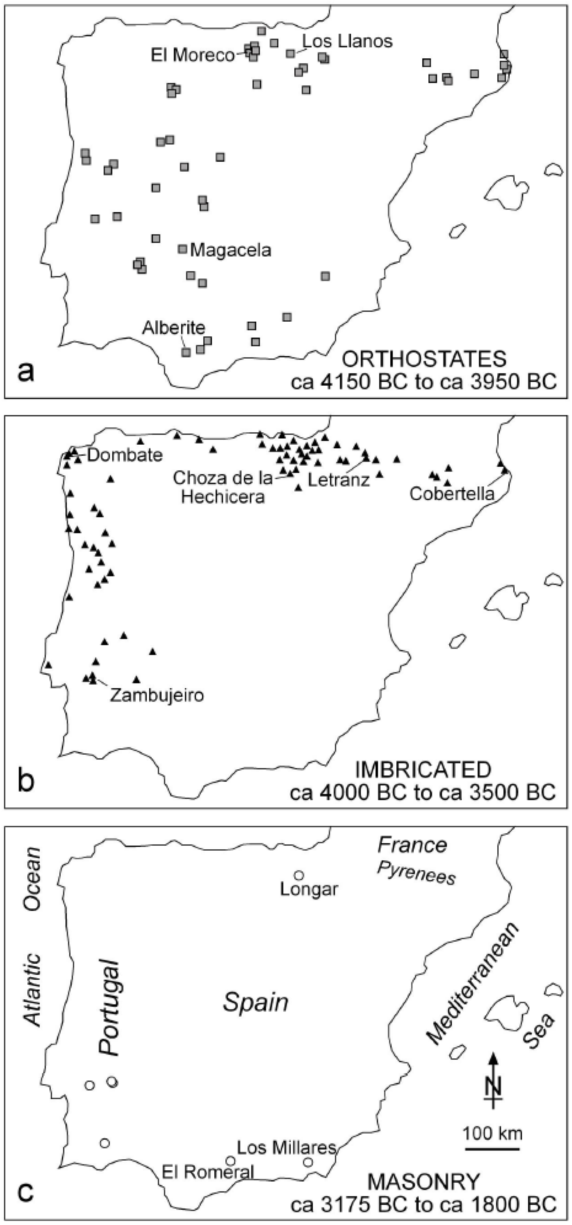

Fig. (5). Distribution of dolmens on the Iberian Peninsula with walls of (**a**) orthostats, (**b**) imbricated slabs, and (**c**) masonry. The dolmens mentioned in the text are marked, along with the estimated time intervals for each dolmen typology.

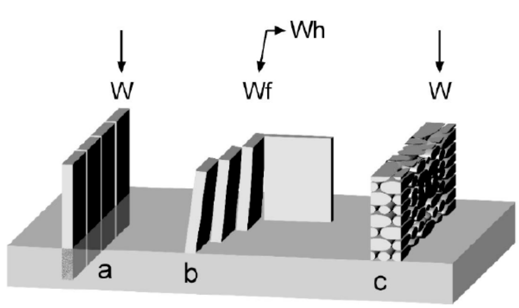

Fig. (6). Schematics of the three construction systems used in the walls of Neolithic dolmens on the Iberian Peninsula: (**a**) orthostatic walls, (**b**) walls of imbricated slabs, and (**c**) walls of masonry. See the text for a complete explanation.

The walls of imbricated slabs are self-supporting in and of themselves; they do not require basal pits or any other type of foundation for their support [4]. However, during the construction process, and more specifically during the placement of the generating slab (Fig. **2**), some sort of structure is required to maintain the upright position of the generating slab until it is able to withstand the loads of the adjacent slabs, at which point the structure is self-supporting.

Walls of masonry are self-supporting both during and after their construction. Such walls do not require a foundation or any sort of external support.

Therefore, if we consider the self-supporting capacities of different walls in terms of their construction qualities, orthostatic walls would represent the most basic structure, the walls of imbricated slabs would represent an intermediate stage, and the walls of masonry would represent the most evolved structure. This evolutionary trend might also be related to the evolution of the structures themselves, or to structural improvements.

The construction processes represented by each type of Neolithic wall are also likely to vary. The construction process of orthostatic walls is relatively complex, as it requires pits and backfilling in addition to lifting of the slabs, in a process comparable to the placement of monoliths [11]. In the construction of the walls of imbricated slabs, the slabs must also be lifted, but pits are not necessary. Finally, the walls of masonry, on account of the simple stacking process employed in their construction, require a minimum of effort.

Construction complexity is also related to the sizes of the construction materials, specifically as related to the collection and handling of materials. The removal of meter-sized slabs is more complex than the removal of locally produced masonry, as the latter can be obtained by the fragmentation of slabs. In addition, the manipulation of megalithic slabs requires the assistance of several operators. On the other hand, masonry materials can be obtained and placed by a single operator.

In summary, the walls of Neolithic Iberian dolmens present different construction systems, which involve differences in the self-supporting nature of the walls, details of construction processes, and complexity of operations. The differences in design seem to represent technical improvements. The evolution of the walls, as represented first by orthostatic walls, then of imbricated slabs, and, finally of masonry, corresponds to the chronological changes considered herein (Fig. **5**).

CONCLUSIONS

Three types of load-bearing walls (orthostatic, imbricated slab, and masonry) have been identified in the dolmens of Portugal and Spain. The orthostatic and masonry walls represent lintelled structural systems. The dolmens with walls of imbricated slabs are unique to the Neolithic megalithic structures of the Iberian Peninsula, and have not been repeated in the history of architecture. Imbricated wall structures are based on the tilting of slabs toward the interior of the monument, with successive slabs imbricated one upon the other. This structure transmits part of the load of the slab horizontally onto the contiguous preceding slab (Fig. **2**).

In Iberia, dolmens with walls of imbricated slabs, which are more common than those of orthostatic and masonry walls, show a peripheral distribution on the Atlantic coast and in the Pyrenees region. Dolmens with orthostatic walls tend to be located in the peninsular interior. Finally, masonry walls, which represent the least common mode of wall construction in dolmens, occur locally in the south of the peninsula (Fig. **5**).

Chronologically, as based on the available data, the first dolmens were of orthostatic construction; next, dolmens were constructed of imbricated slabs; finally, masonry construction was utilized during the latest period of dolmen construction. This structural evolution can be explained in terms of improvements in the capacities of self-supporting walls and details of the construction processes, as well as a simplification of construction techniques.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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