

On the Origins of the Dome

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The earliest use of the dome is to be found mainly in funerary constructions, i.e. megalithic structures built from the V to the IV millennia in western and northern Europe. A few of these constructions can be considered as proto architectures; conceivably the use of the dome marked the birth of architecture. One possible source of inspiration is certainly the cavern and its natural structural organization; rudimental types of domical graves were in fact excavated in soft soil. The most widespread building technique is that of the corbelled domes, a type found everywhere, from prehistoric times to today, without any apparent shared influences between existing examples. Ribbed domes made with branches fixed in the soil and fastened at the top can be acknowledged as another fertile prototype that still survives.

The dome has often been used as a symbol of the underground world, the celestial vault, the sanctuary, the womb and others. The most important criterion for restoration of a dome is to preserve its structural configuration along with its shape.

KEYWORDS: *Dome, Funerary constructions, Corbelled domes, Ribbed domes, Pendentives, Structural configuration.*

Early employ of the dome

The hypothesis presented in this paper is that originally the dome was used mainly in funerary employ.

The first documented and most ancient uses of vaulted and domical structures are found in Megalithic constructions built for funeral purposes for single or group burial in prehistoric western Europe of the V and IV millennia. The earliest constructions of this kind built with a corbelling system are chiefly located in the territories now called Spain, France, Ireland (Portugal, Netherland, Denmark, and Germany as well). It is worth noting that some of these early constructions are worthy of being considered proto-architectures because of the presence of domical shapes, because of their structural conceptions utilizing apposite lay-out, and above all the rigorous congruence of all the cited characteristics (Tampone, 2002 and followings, cit.).

Therefore it is not an absurd notion to imagine that the birth of architecture was marked by the introduction of the construction of domes.

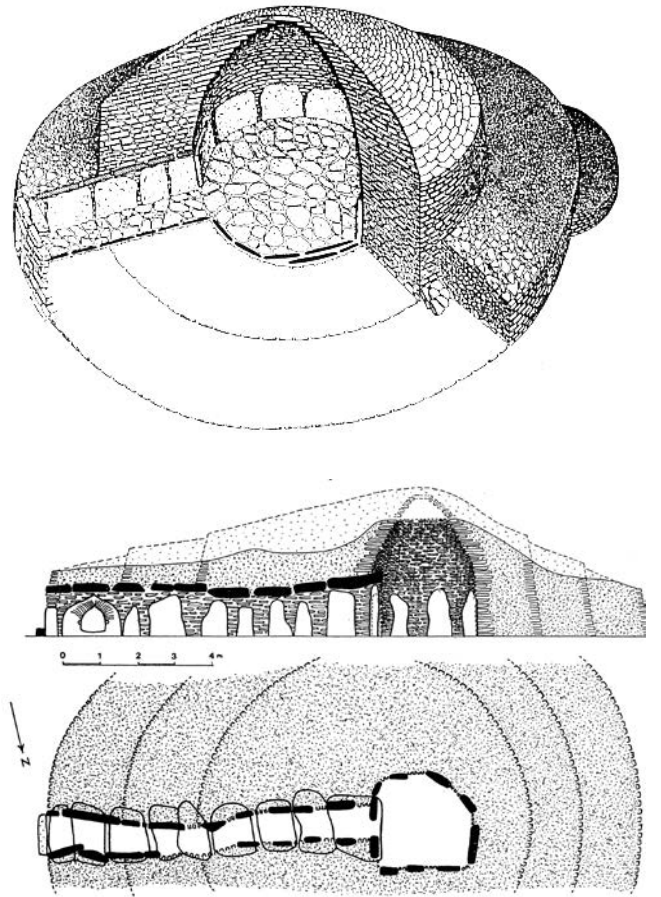
Consequently, it also seems possible to propose the assumption that architecture was conceived to satisfy funeral needs of a “spiritual” kind. Since architecture is a language, the dome was elected as the distinctive ele-

ment capable of making evident the function of certain rooms of a building, creating a specialized space that could inspire emotion. The related symbolism can be interpreted as allusion to the subterranean world.

Sources of inspiration

No doubt, as witnessed through the evidence in many archaeological remains, the first builders of structures made to shelter the dead took inspiration from nature — caverns, for instance, offered examples of suitable shape and structure. One can see from the first early artifacts, even though very rough, many examples of graves scraped out from the rocky earth, made by digging a kind of well that in a later phase could be enlarged to become an underground room.

The diggers soon learned that a concave ceiling could stand up if determinate conditions were present, foremost the compactness of the rock. Later they were able to differentiate the rooms excavated in soft rock, tuffs or similar terrain, organizing them into a group of compartments and an articulation of differently specialized spaces — in this way producing a layout suitable for funeral rites where no light was able to penetrate.



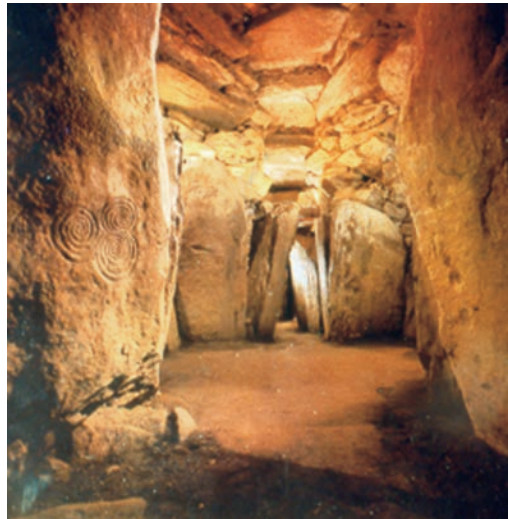
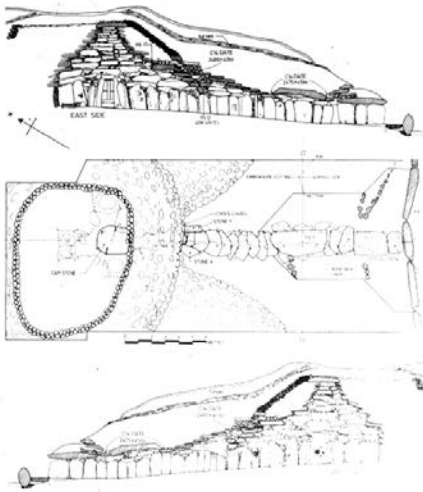
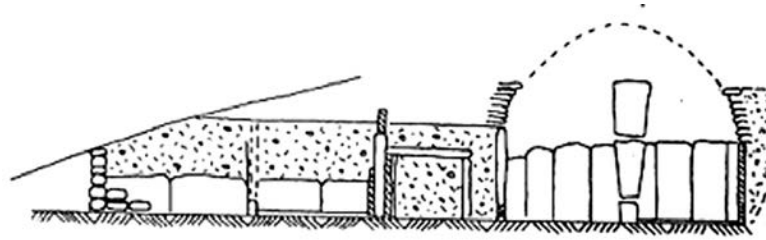
Omphalos, Delphi.

*The so called Dolmen of Basoges, France.
Dolmen de l'île longue, France.*

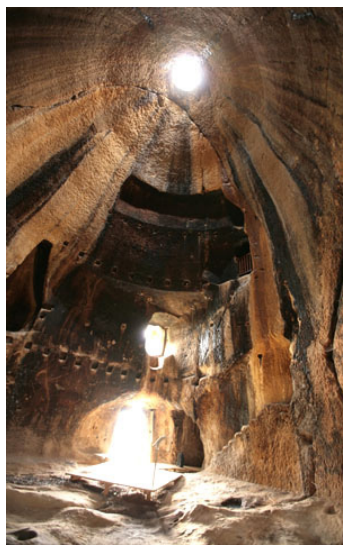


Tholos Tombs, Sudan.

Prehistoric settlement of Los Millares, Spain. One of the rooms of the prehistoric Hypogeum of Hal Saflieni, mid-III m B.C. Malta, Maltese Archipelago.



Megalithic Tomb of Newgrange, Ireland, 3200 B.C. circa. Plan and sections, view of the domed chamber and the dome (from O'Kelly, cit.)



The grotto of the Gurfu, Palermo.



Tomba della Montagnola, Sesto fiorentino, Firenze. VII c. B.C. interior of the tholos of the last chamber. (Photo Tampone).



Structure of a Yakuta tent, Republic of Sakha, Russia.

Construction of a domical shelter, Namibia.

Construction of a ribbed dome made with branches placed orthogonally (Songhai village, Mali).

Landscape of domes in the Peul village of Djaloube, Mali.

Sometimes they reproduced, in selected parts of a sepulcher, the most typical features of their contemporary dwellings.

Alternatively, in territories where the soil was loose or not adequate for this kind of structure, they built domical tombs (for instance the mausoleums built on the banks of the Nile river in Sudan), or burial constructions equipped with a domical chamber at the end of a passageway which included an entrance and preparatory rooms. Very often they covered the whole building, except the entrance, with an earthen tumulus as is the case with many funerary installations like those already cited in Ireland, Spain, France, and the tholos tombs of ancient Greece (Cycladic Islands, Peloponnesus, Attica, Messenia, Thessaly etc.) as well as the Etruscan funerary installations of northern Etruria, ranging from the X to the III-II c. B.C., the tombs of Thrace (in modern Bulgaria) from the V to the mid-III c. and others, of which the excellence is to be acknowledged in the so called Tombs of the Homeric Heroes (XV-XIII c B.C.) in Mycenae and surroundings, discovered in the XIX c. by H. Schliemann.

No openings were generally made except the entrance door.

The structural typology of the very oldest known domes belong to the domain of our continuous past.

The normal situation of the dead is to be buried and pass the afterlife in subterranean places. Builders had to mark the burial chamber as the final destination of the deceased and, at times, have it represent the most important phase of the passage from life to death, introducing a distinction between the rooms of the same tomb. Domes, intended as elaborate and sophisticated architectural elements, were a special device capable of marking this distinction. Where applicable, it seems more appropriate to speak of domed “chambers” instead of rooms.

As a result of these considerations it can be assumed that the concept of the dome has been adapted from underground to aboveground and not vice versa.

Construction

It is much more difficult to construct a dome in a building in the open air than excavating it in the soil where the reaction of the flanks of the rock contributes greatly to absorbing the thrusts generated by the void obtained by means of the excavation.

It is plausible to imagine some other mechanisms that could generate the form of domes. From a constructive point of view, it is possible to use the elementary system adopted for temporary shelters in the countryside consisting of building the warp of the skeleton of a dome by fixing in the soil, along a perimeter (square, circular, elliptical, polygonal), flexible branches and fastening together their free ends at the top, like meridians in a globe. The operation is completed by weaving and tying through them resistant vegetal rings, like parallels of warp and weft, to realize meshes of four curved sides. Straw, fabric, skins or later lead or copper foils were also used as covering material which contributed considerably to prevent deformations of a dome, supplying an additional tangential stiffness very favorable to its general stability.

Careful and intelligent observation of the cavities of caverns created by flowing water cutting into the layers of a foliated geologic structure could certainly have been a source of inspiration for the first dome builders, both for geometry and building technique, and for the creation of corbelling vaults and domes.

Corbelling domes, that can be built with small stones, huge blocks, earth or timber, do not need centres during construction, do not generate thrusts on the supports; therefore they have developed apparently spontaneously and have been used everywhere in any time period, becoming a universal architectural element. One can count among the variants of the corbelled domes examples made by constructing a series of small arches that need only local centres (the funeral chamber of the Emperor Diocletian's Mausoleum in Split for instance), the muqarnas domes or semi-domes of Islamic architecture, the very special dome of the Pantheon in Rome that is made of cast concrete elements projecting one above the other of the underlying horizontal course.

One can intuit that timber corbelled domes were largely in use in Antiquity and later disappeared; in the Caucasian regions there is a concentration of these building techniques. Interesting representations or a better likeness of these methods, excavated in rock but simulating timber structures, are found in some Etruscan hypogeal architectures of Vulci, Chiusi, Sovana, IV c., Perugia, III c. B.C. (Tampone, 2011, 2012, cit.).

Regarding the use of concrete, it is worth drawing attention to ancient Roman vaults and domes which were made by creating a foundation of bricks laid side by side supported over a temporary wooden framework; the brick layer was then consolidated with cast concrete. An outstanding achievement made with this technique is the lower dome of the already cited Diocletian's Mausoleum,



Volumni's Hipogeum, end of the III c. B.C. Perugia. Chamber with a simulated timber corbelled dome. (photo Tampone, 2010).

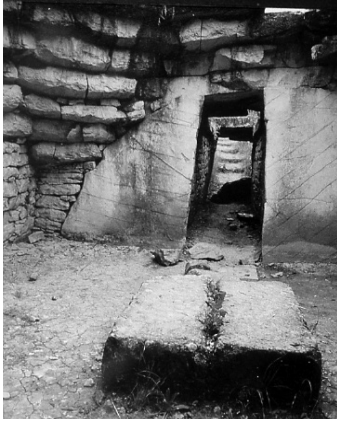


Tomba François, first decades following of the IV c B.C., Vulci. Chamber (left in the photo) with a simulated timber corbelled dome. (photo Tampone, 2011).

using a lime-based cement that was cast on a temporary timber framework.

The most significant given datum when designing a dome is the span, which represents the real challenge. As for the other parameters to grapple with and coordinate, the designer-builder has to select the most appropriate materials and the best building technique, as well as de-

termine the thickness — an element to define for either a simple or double shell — and a profile. Essential for the success of construction is the bond, a system for placing the single elements of the structure in order to join them in the most efficient way. These criteria constitute the field of research for efficacy and, along with the shape, the realm of invention.



Tomb of the Diavolino, VII c. B.C., Vetulonia.



Tomb of the Pissidi cilindriche, San Cerbone Necropolis, Populonia.



Detail of the inclined pendentive in the tomb of the photo at left.

Devices for joining a dome to its supports

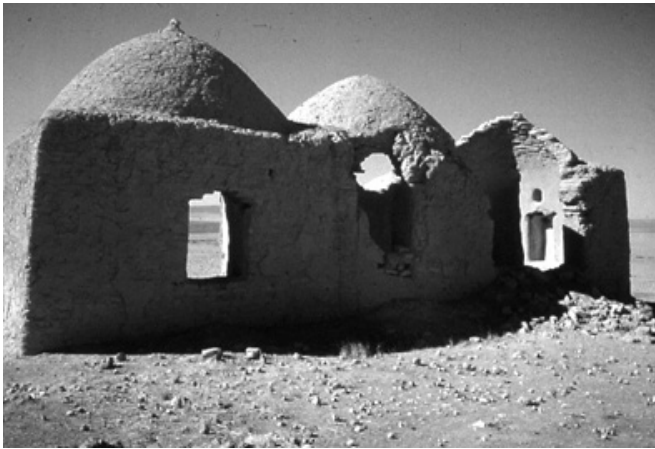
The various devices invented for the connection of a square or rectangular chamber with a rotational dome are very interesting. Some Etruscan settlements of Populonia and Vetulonia in Tuscany offer advanced examples of pendentives made with the corbelling technique to connect the square chamber to a tholos: the Tomba del Diavolino, built in the Orientalizing Period, VII c. B.C., is among the earliest and most notable, as is the Tomba delle Pissidi Cilindriche among several other similar tombs that deserve mention.

Squinches (trumpet arches) and conical vaults, that work as arched pendentives were very much in use in Iran, especially during the Seljuk period. This technique was widespread throughout the Islamic world.

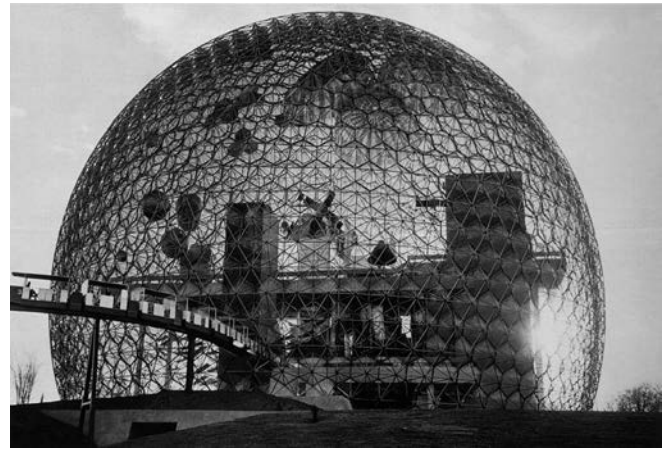
The dome as symbol

To a certain extent the funerary and the sacral are equivalent, since the dead are venerated or, in some cases, worshipped. Some time after its introduction, the dome of the funerary chamber, intended as the symbol and the representation of the underground world, also took on a sacral meaning, chiefly as the symbol of the celestial vault.

Other connotations were given later to these primeval meanings. The dome and the domed chamber became the symbol of the enclosed place, the destination of the course of life, knowledge, redemption, purification, the place closest to the sky because it is the most elevated part of a building. It is the sanctuary, the place suitable for prayer; furthermore, it can represent the reconnection to the divinity, the vertex of the terrestrial or celestial hierarchy. A dome draws attention, a symbol of a world unto itself, uniform in every direction thus undetermined, free of the tensions generated by differences, the meeting place of a civilian, religious or military community. A mathe-



Remains of domical contemporary dwellings in Syria. (Courtesy of the late Prof. P. E. Pecorella, photo circa 2000).



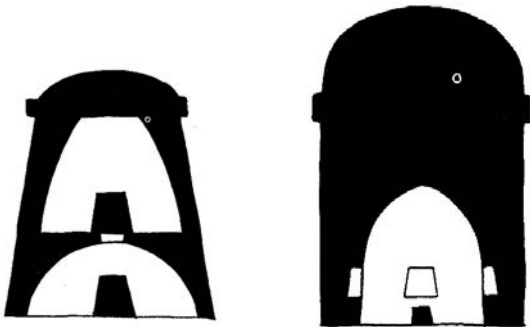
Contemporary dome, 1967, R. Buckminster Fuller Architect. USA pavilion, Universal Expo, Montreal.

mathematical formula, a theorem. The egg (the basic cell), the male element (the outside), the womb (the interior).

Very important to consider is that the dome is a product of particular, specialized abilities, and therefore a costly and complex “organism.”

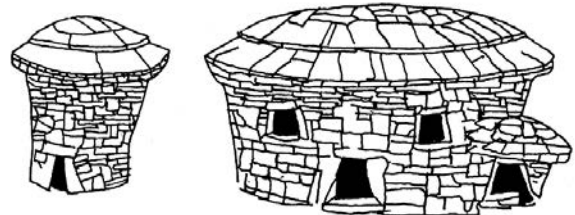
It is a visible sign in any territory where it is found, that is, an efficient means to indicate the power of dominant families. It is a kind of gigantic *omphalos*.

Today, domes are built in many ways using many materials, including traditional ones, but also using cables and sheets with prefabricated elements of steel, reinforced concrete, FRP (Fiber Reinforced Polymers), pultruded members, pneumatic structures, and more. But their capacity to symbolize ideal concepts, values, places or objects and, consequently, to arouse deep emotions, remains intact.



Section of a simple type of “Chullpa”, pre Incan civilization, Sillustani, Peru. (Drawing by Denise Berton)

Section of a “Chullpa” with superposed chambers, pre Incan civilization, Sillustani, Peru. (Drawing by Denise Berton)



Simple and large “kulpi”, pre Incan civilization, Peru. (Drawings by Denise Berton)

Set of simple chullpa, pre-Incan civilization, Sillustani, Titicaca, Peru.



No other constructive element but the dome is able to express and synthesize the building ability achieved by a civilization, to stir up deep spatial emotions, to confer characterizing connotations in a landscape, in this way achieving values that are universally understood.

Conservation and Reinforcement

The patrimony of corbelled domes, especially of those built until the present day, is enormous and can be found on four Continents. This heritage needs preservation.

To do so it is essential to save the original configuration that translates the structural concept and symbolism carried by the dome, from immaterial to material realization. The methodology for the structural conservation of a dome should follow, then, the same concept of the original constructive structural system, i.e. carrying out local repairs and the addition as needed of devices resistant to tension, in order to strengthen the areas of the structure subject to maximum deformability.

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