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**PREHISTORIC SCIENTIFIC MODELS:
THE STONE CIRCLE AS WELL AS THE COW STONE
AND BEDROCK SCULPTURES OF NABTA PLAYA**

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Abstract

Although the history of science traces the roots of scientific and technological activity back to ancient Egypt and Mesopotamia after 3.200 BC, impressive findings during the last 50 years testify that prehistoric, probably nomads of the Nubian desert, had obtained significantly advanced knowledge regarding astronomy, being implemented in various structures, such as the stone circle and the cow stone and bedrock sculptures of Nabta Playa. The stone circle of Nabta Playa (approx. <4.800 BC) has been characterized as a star map or an astronomical observatory and represents parts of the constellation of Orion and Ursa Major. The knowledge of the

constellations, the positions of the stars, the distance between them, and their velocity are necessary for an accurate representation through this monument, which requires meticulous and systematic research of the celestial bodies. The stone circle, the cow stone, and bedrock sculptures, which were argued to have been used for the observation, the description of inaccessible systems, and the prediction of climate phenomena, are prehistoric technological achievements. An important question is whether these monuments are proof of the existence of scientific thought and technological activity during this period. A second question is whether the stone circle can be considered a scientific model, and into what category of models it could fall. Finally, what does the invention and construction of these monuments imply for the prehistoric civilizations that created them, and what for our knowledge about them?

Starting from describing these monuments and examining the scientific model concept, we develop our argument that these monuments constitute prehistoric analogue models and, more specifically, scale models. They are, in other words, physical setups that were constructed to be similar to other physical setups, which people could not observe directly due to distance, and represent them in order to describe and study these inaccessible systems, towards the prediction of crucial phenomena (e.g., summer monsoons). Their religious dimension does not affect their role as representations of natural systems, and on this basis as scientific scale models. Therefore, the stone circle, cow stone, and bedrock sculptures of Nabta Playa, as early scientific models, constitute evidence for the existence of scientific and technological activity, centuries before the generally accepted beginnings of these two kinds of intellectual activity. In addition to answering the above questions, the ultimate purpose of this study is to encourage pondering on the truth and validity of the assumption that the beginning of science is traced in Ancient Egypt and Mesopotamia but also to trigger questions regarding the civilization of these prehistoric populations.

Introduction

Several historians support that the roots of science and the development of various scientific techniques are traced back to ancient Egypt between 3.200 and 1.200 BC. (Lindberg, 1997; Speiser, 1942). Others argued that the intellectual activity of ancient Egyptians corresponds more to technology than to science as they used to adopt empirical rules to understand and control nature and ensure better living conditions than to acquire knowledge of the natural world per se (Grigoriadou, 2023). The application of empirical rules does not imply the perception and conceptualization or the development of theories, laws, or principles beyond them. If we follow this aspect, the ancient Egyptians developed specific techniques to control nature, but they did not aim at the definition of the general principles beyond these techniques or at the formulation of theories. The first attempts to gain knowledge about the natural world were systematized in the ancient Greek world (Andrew, 2007(a), 2007(b); Farrington, 1989; Grigoriadou et al., 2021; Lindberg, 1997; Moss, 2020).

On this basis, it seems that the ancient Egyptians achieved know-how techniques that corresponded to technology while ancient Greeks engaged in know-why research that corresponded to science. Therefore, the transition from technology to science can be traced from ancient Egypt to the ancient Greek world (Farrington, 1989). However, a reasonable question arises here: Wasn't there any scientific thought or technological activity before ancient Egypt? The discovery and research of the stone circle, the cow stone, and the bedrock sculptures of Nabta Playa in the Nubia desert raise questions regarding the validity of these general assumptions. But why do historians insist on placing the beginnings of science in the Bronze Age in ancient Egypt? One explanation can be based on the absence of written evidence regarding the intellectual activity of prehistoric people since writing had not yet been discovered at that time. Can we reject the existence of scientific and technological activity before the Egypt of 3.200 BC just because there are no texts proving it?

During this period, the only linguistic communication was oral speech, and the only repository of knowledge was the personal memories of the

members of the community. Therefore, the transmission of ideas and beliefs in such a culture could occur only through meetings between the community members and oral tradition. This is obviously a core problem of the fluidity of oral tradition as a significant account of observations could not be collected and transmitted in oral form (Lindberg, 1997). Moreover, the issue of credibility in the dissemination of information arises.

In this context, seeking to support the existence of the study of the natural world without having some written evidence is a difficult and possibly presumptuous undertaking. However, we strongly believe that the absence of written evidence is not sufficient to convince us about the absence of scientific and technological activity before the discovery of writing. On the contrary, scientific, and technological knowledge can be codified and transferred to the next ages through monuments, as demonstrated by the stone circle of Nabta Playa. In this case, the decoding of this knowledge requires a significant effort and even more systematic and meticulous research by scientists from different fields, such as the research effort of the archeologist Fred Wendorf, who discovered the monument, and the astrophysicist, Thomas Brophy, who meticulously examined it and proposed a theory concerning the significant astronomical knowledge codified into the stone circle.

Throughout the present study, describing these prehistoric monuments and examining the concept of a scientific model, we will conclude that the stone circle and the cow stone and bedrock sculptures constitute a kind of prehistoric analogue model, an observation that enhances the belief that there was “science before science.”

1. The discovery of the monuments by Fred Wendorf and the theory of Thomas Brophy

In 1973 the American archaeologist Fred Wendorf and his research team discovered the stone circle, cow stone, and bedrock (or Complex Structure A or Table rock) sculptures, in the Nubian desert about 800 kilometers from Cairo, west of the Nile (Figure 1). The stone circle has been moved to the Nubian Museum in Aswan (Brophy, 2002; Malville,

2015; Malville, n.d.; Malville et al., 1998). These findings dated back to (approx.) 4,800 BC, about 1,600 years earlier than the generally accepted beginnings of what we today call “science.” The monument was discovered in the region of Nabta Playa which is one of the earliest and the most significant archeological sites of the Egyptian Neolithic period, providing us with important information about the culture, habits, religious practices, and knowledge of this civilization (Wendorf & Schild, 1998). Although nowadays this region is drainage, in prehistory there were rainy periods during which there were lakes, large springs, and seasonal streams (Brophy, 2002; Malville, 2015; Wendorf & Schild, 1998). Perhaps for this reason, the Nabta playa became a ceremonial and cultural center as specific findings such as a cow's and human's skeleton prove that sacrifices were taking place there. Megalithic alignments, stone circles, and cattle burials have been discovered in this region (Brophy, 2002; Malville, 2015; Wendorf & Schild, 1998).

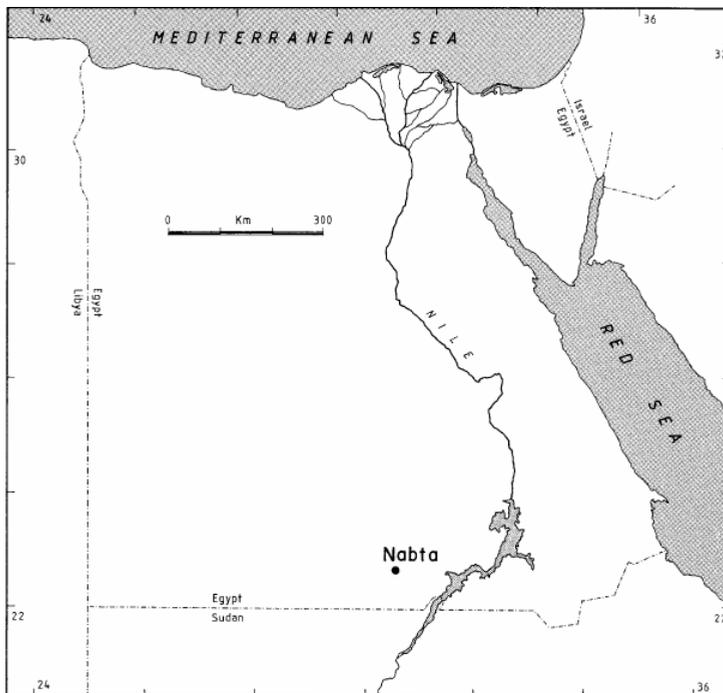


Figure 1: Map of Egypt showing the location of Nabta Playa.
(Wendorf & Schild, 1998).

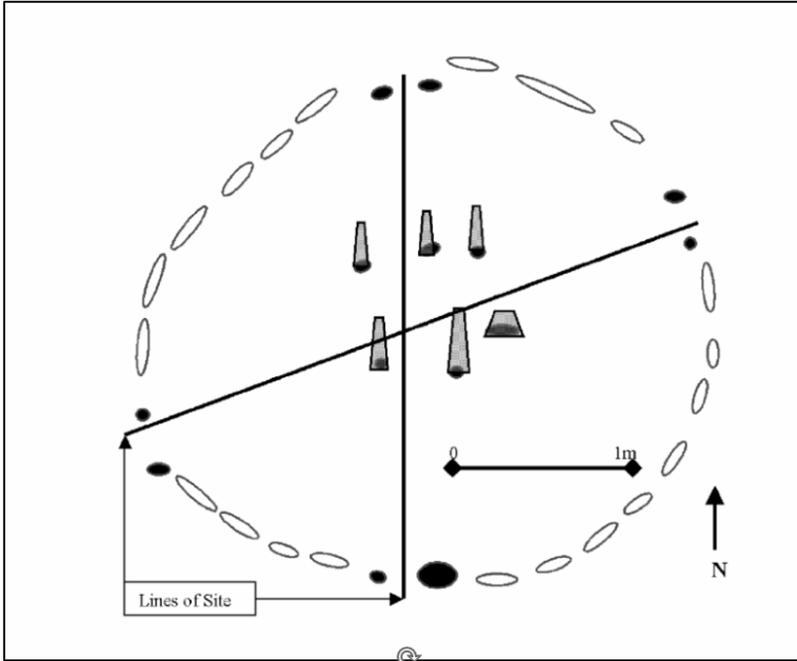


Figure 2: Stone circle of Nabta Playa
(Brophy, 2002).

However, the real enigma is related to the stone circle, a complex construction whose discovery triggered several questions concerning mainly the level of astronomical knowledge of these prehistoric people. The stone circle (Figures 2, 3, 4) is a circular arrangement consisting of 29 large stones, buried at a great depth. The perimeter of the circle is about 4 meters. Inside the circle, six other stones are located forming two imaginary corridors, one from north to south and one from north to east (Bauval & Brophy, 1989). The stone structures are aligned with specific constellations including Ursa Major, the constellation of Orion, and Sirius (AE LEARNING, 2019). In other words, the stones represented the constellations of Orion, Ursa Major, and the solstices. On this basis, several archaeologists and historians supported that the stone circle was an astronomical

observatory, the oldest planetarium, a map, or a calendar circle. Specifically, the stone circle is considered a prehistoric calendar, a star map that accurately marked the summer solstice, the summer season, and the beginning of the summer monsoons (AE LEARNING, 2019). It was a tool that allowed the prehistoric nomadic people to watch the sky, the stars, and the celestial phenomena. Another enigma was underground where two megalithic sculptures known as cow stone and bedrock, weighing about three tons, were found (Ancient Architects, 2017).

In 1998 the astrophysicist Thomas Brophy was convinced that something more complex but also significant was hidden behind the megalithic structure of Nabta Playa. He visited the area, examined the prehistoric monument carefully, and drew important inferences based on calculations and mathematics. He supported that the findings of Nabta Playa correspond to a prehistoric megalithic astrophysical map and that the cow stone is a sculpture representing the universe (Brophy, 2002).

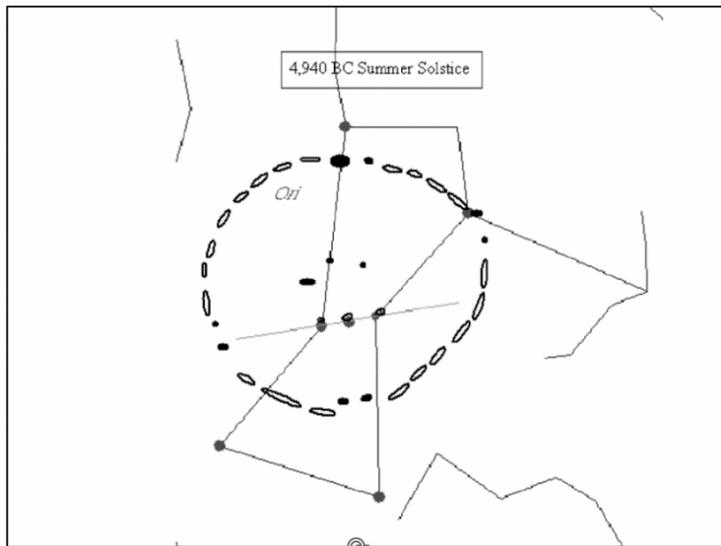


Figure 3: The representation of the three stars of Orion's Belt in the stone circle (Brophy, 2002).

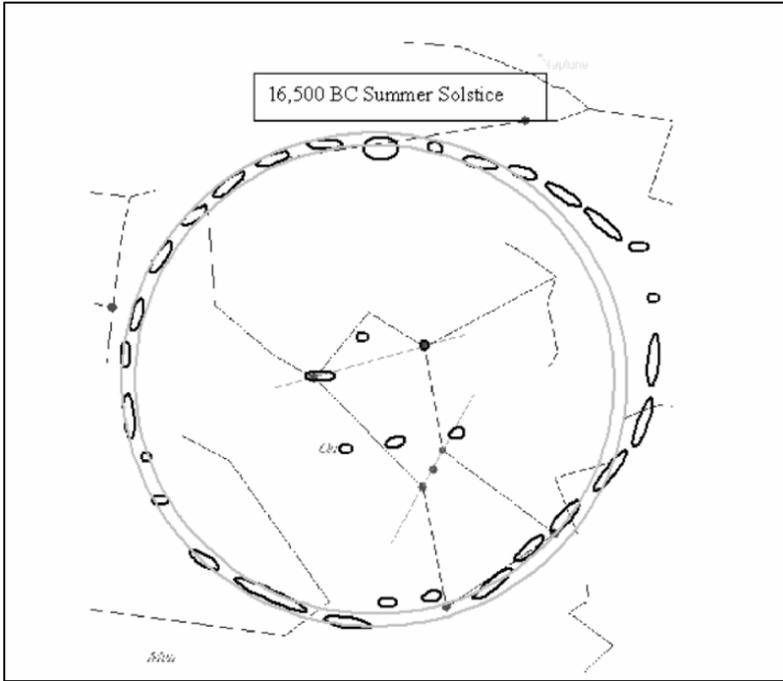


Figure 4: The representation of the three stars of Orion's shoulders and head in the stone circle (Brophy, 2002).

According to Brothy, these prehistoric people had three levels of knowledge regarding the celestial bodies and the galaxy, as evidenced by the Nabta Playa monument (Brophy, 2002). The first level of knowledge is confirmed by the stone circle's function as a map representing celestial bodies, alignments, and events that can be observed in the sky with the naked eye. The Nabta Playa stone circle and inner stones form a stargazing chart. The southern line of the three stones in the circle represents the three stars of the Orion's Belt (Alnitak, Alnilam, Minitaka-between 1.340 and 1.200 light years away from Earth) (Figures 2, 3, 4). The other three stones represent the stars of Orion's shoulders and head exactly as they appear in the sky (Figures 2, 3, 4) (Brophy, 2002). An important question is: how did the star observatory work? According to Brothy, when the ob-

server stood at the north end of the imaginary corridor between the central stones he could first look down at the diagram and see a representation of the stars of Orion's belt exactly as they appeared when he looked up into the sky (Brophy, 2002). These two representations correspond to two specific periods of time; thus, the two series of inner stones represent how the sky moves in the long run. The constellation of Orion's belt, as it appears in the circle of stones, corresponds to the position they had between 6.400 and 4.900 before the summer solstice, while the constellation of Orion's shoulders and head could, according to Brophy, have been observed in this position around 16.500 BC. This hypothesis triggers many questions regarding the year of construction or reconstruction of the monument (Brophy, 2002).

The second level of knowledge regarding the celestial bodies and the galaxy, as evidenced by the Nabta Playa monument, corresponds to signs that indicate celestial phenomena and events that cannot be observed directly by the naked eye. As Brophy argued the information that seems to come from the Nabta Playa monument is not limited to visible phenomena. Brophy noted that one of the stones in the circle represents the center of the galaxy in the year 17.000 BC which also corresponds to the orientation of the galactic center in the carved rock that was under the cow stone (Figure 6). He argues that similar information is provided by the monuments of the Giza plateau, which represent the center of the galaxy at the time it was at its highest point in the southern meridian, around 10.909 BC (Brophy, 2002). In this context, Brophy argues that the circle of stones was made and used at a much later date than the positions and movements of the stars it represents (it represents the positions of the stars and an imaginary movement of them in a complete rotation). On this basis, he concluded that this specific knowledge existed a long time before its representation through the stone circle (Brophy, 2002).



Figure 5: Cow stone with Fred Wendorf (Malville, n.d.).

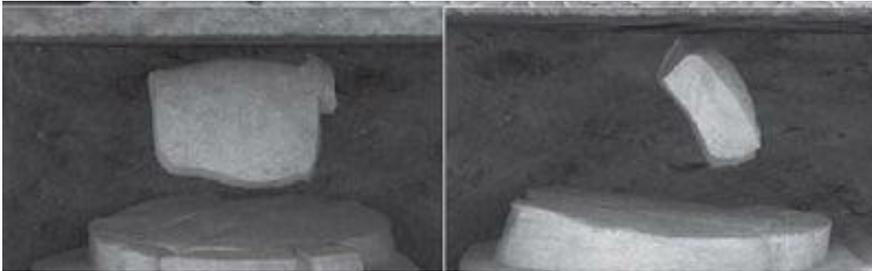


Figure 6: Depiction of cow stone and bedrock sculptures as it was before excavation.

(Bauval & Brophy, 2011)

The third level of knowledge corresponds to detailed astronomical and cosmological information, such as the distances between stars, the speed of their movement, the structure of our galaxy, as well as information about the origin of the universe, which we have either discovered recently or have not discovered yet. Brothy studied the cow stone, a large cow-shaped stone beneath which was another sculpture the bedrock sculpture

(Figures 5, 6), which he believed was a scale model of our galaxy from the edge of the north galactic pole around 17,700 BC, and probably corresponds to the date of its creation. This model represents the position and orientation of our sun (Brophy, 2002).

Science before science: Three prehistoric scientific models

The concept of the scientific model is related to the concept of image or representation combined with the concept of construction and, according to Maxwell the function of the model as a “consistent representation” (Christodoulidis, 1979; Grigoriadou, 2023). The scientific model is often defined either as the representation of a physical object, phenomenon, or system or as the interpretation of theories (Rogers, 2012; Frigg and Hartmann, 2020) while in the past it was also attributed as structural isomorphism, as an equivalence of structural relations (Christodoulidis, 1979; Grigoriadou, 2023, 2024). Different kinds of scientific models are developed and utilized in modern science. A widely applied kind of model is the analogue, material, or physical model. Marry Hesse called this kind of model “analogue machines” whose function is based on material analogy and allows us to make predictions about the target systems. In her theory, the material analogy can be defined as the identification of common properties between two objects or systems such as the common properties between the earth and the moon (e.g. spherical, opaque, solid celestial bodies), as similar properties such as the similar properties between the sound and the light, or as the analogy that is used in a classification scheme, such as the analogy that Aristotle used in order to classify more than 500 animal species in his treatises “Animal Stories” (Hesse, 1967). Analogue models are specific parts of the real world, physical set-ups that represent other selected parts of the real world (Sterrett, 2003, 2017) which are usually called target systems, based on a specific similar feature or relation between them. Analogue models are powerful experimental tools applied in various scientific fields to contribute to the examination of a system, a phenomenon, or an object that cannot be directly observed due to limitations such as their size, space, time distance of it, or various other reasons,

even ethical (Sterrett, 2003, 2017; Grigoriadou, 2023, 2024). More generally we can define analogue models as powerful tools that through their representational function, which is based on the identification and verification of a specific similarity between the model and the target system, contribute to the acquisition of scientific knowledge, being integral parts of the scientific experimentation process.

One widely utilized subcategory of analogue models is scale models (Frigg & Hartmann, 2020; Sterrett, 2003) which are physical objects, systems, or devices used to examine a specific feature or behavior of a target system with different dimensions. Scale models are larger or smaller than the system under study, maintaining the relative proportions of the physical size of it. However, according to the philosopher Susan Sterrett, scale models are used to investigate, test, or predict the behavior of a machine or system based on a specific analogy that governs the features of interest between the two physical systems (Sterrett, 2003). Therefore, the similarity that is involved during the application of a scale model is not only geometric similarity but also physical similarity, which is the similarity of specific relations of specific quantities between two different systems or phenomena (Sterrett, 2003, 2017). Although scale models are core tools applied in various fields of engineering, they are also used in other scientific fields such as astronomy and cosmology.

Coming back to the prehistoric constructions of Nabta Playa we will identify the features of the stone circle and of the two sculptures that can lead to the inference that they are precursors of scale models. First, the stone circle as it emerges from the investigation and the dissertation of Thomas Brophy, represents not only specific constellations providing important information concerning for example the distances between the stars with great accuracy but also about their movement. The stone circle represents specific stars, the distances between them, and celestial events. Furthermore, according to Brophy, the bedrock sculpture (Complex Structure A-CSA) was a scale model of our galaxy from the edge of the north galactic pole around 17.700 BC, which corresponds to the date of its creation. This model correctly represents the position and orientation of our sun and the cowstone represents the universe (Brophy, 2002).

Thus, information emerged from the utilization of these monuments, and mainly of the stone circle, contributes to the description and explanation of specific inaccessible celestial systems. We could say that the prehistoric people of the Nubia desert codified their knowledge concerning these specific systems and phenomena into these constructions, which can be perceived as technological and scientific achievements, and through their use they enhanced their knowledge about them. Therefore, the stone circle, the cow stone, and the bedrock sculptures can be perceived as tools achieved to represent specific inaccessible systems and phenomena, constructed based on specific similarities.

But what types of similarities can we discern in the case of the stone circle? On the one hand, there is geometrical similarity. The stone circle is a physical setup smaller than the system it represents. Moreover, if we accept the theory of Brophy according to which this construction represents the movement of these constellations and more generally the movement of the sky in the long run, another kind of similarity seems to be involved in the construction and utilization of the circle; the similarity that Sterrett called physical similarity and more specifically similarity related to the movement, or the velocity of the movement of these stars. A reasonable question that arises is how these people succeed in verifying accurately a specific similarity between the model and the target system. Unfortunately, we don't have an answer to this question yet. This proves that the stone circle still holds important "secrets." Therefore, it must be further and more meticulously investigated.

Furthermore, it seems that the prehistoric Egyptians did not use this first astronomical system simply to observe the stars, describe the constellations, or even perform religious ceremonies, but also to predict specific phenomena such as the summer solstice, the arrival of the summer monsoons to prepare their movements or to collect information related to agriculture (Brophy, 2002; Malville, 2015; Malville, n.d.; Malville et al., 1998; Wendorf & Schild, 1998). Therefore, this tool except for the possibility to describe systems, and objects, or explain celestial phenomena, seems to have provided the possibility to make predictions about crucial phenomena for these prehistoric civilizations' survival. As we have mentioned al-

ready, scientific analogue or scale models contribute to describing and explaining difficult-to-access systems or making predictions about them. Thus, the function of analogue models and the function of these three prehistoric tools seem to be extremely similar.

In this respect, we can conclude that the stone circle and the cow stone and bedrock sculptures are scientific models. They are models that represent the constellations of Orion, Ursa Major, and Sirius and respectively our galaxy. In other words, they are natural arrangements that were constructed based on specific similarities to other natural arrangements, which could not be observed directly due to distance from them, their size, and other reasons and were used to describe, to explain the inaccessible systems but also to predict phenomena decisive for the survival of these prehistoric peoples. Their use as places for performing religious ceremonies does not affect their role as representations of natural systems, as scientific scale models as we call them today. Finally, if we consider that the year of their construction is approx. 4.800 BC and there haven't been discovered other similar monuments before this date until today, we strongly believe that these prehistoric constructions are the first scale models discovered to date, that were built and used not only before the discovery of writing but also before the generally accepted beginnings of science. This is the evidence for the existence of "science before science."

Conclusions

The discovery and research of the stone circle, the cow stone, and the bedrock sculptures of Nabta Playa, trigger questions regarding the truth and validity of the assumption that the beginning of science and technology is traced back to the Bronze Age while revealing how fragmentary our knowledge is concerning the level of scientific and technological activity of prehistoric civilizations living in Nubia Dessert around 4.800 BC.

The absence of written evidence is obviously a barrier in the endeavor of uncodified knowledge that these civilizations left throughout their monuments. However, the absence of texts doesn't mean the absence of scientific thought and scientific and technological activity during these

times. We must not reject the existence of scientific knowledge before Bronze Age just because there is no written evidence, which explicitly confirms its existence. On the contrary, the first results of the investigation of these constructions convince us that there was advanced scientific knowledge and technological activity 6.800 ago. However, issues related to the lever of astronomical knowledge, the development of technology, cultural innovation but also environmental and climate changes in this region must be more systematically investigated by researchers of different scientific fields to enhance our knowledge concerning these prehistoric civilizations.

Through the analysis of the concept of analogue and scale models based on approaches coming from the field of philosophy of science along with the description of the stone circle, the cow stone, and bedrock sculptures and their function as it arises from Brophy's research, it seems that they are the first scale models discovered to date. In this respect, this is a shred of strong evidence for the existence of scientific and technological activity about 1.600 – 1.700 years earlier than it is generally accepted today.

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