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EXPERIMENTAL ARCHAEOLOGY AND INDIGENOUS KNOWLEDGE OF IRAN: A CASE STUDY OF THE SISTAN BASIN

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Abstract: Archaeology, as a scientific discipline, investigates the interactions between humans and their environment in the past by applying various scientific methods to analyze and interpret findings. This study critically examines experimental archaeology research conducted specifically in the Sistan Basin, focusing on how such methods can simulate the technological and cultural behaviors of past societies. Using a case study approach, the paper analyzes two key experimental archaeology projects carried out in the region. Methodologically, the evaluation involves comparative analysis of field experiments and reconstruction techniques to assess the reliability and scientific rigor of these studies. The findings highlight both the strengths-such as accurate data collection and the potential for reconstructing pottery production-and the challenges, including methodological limitations and the need for strict adherence to scientific principles to avoid bias. This paper contributes to a deeper understanding of experimental archaeology's role in reconstructing past behaviors and suggests ways to enhance its application in the context of Iranian archaeology. By focusing on the Sistan Basin, this research not only sheds light on a specific regional case but also discusses broader implications for employing experimental methods in archaeology.

Keywords: Sistan Basin, Bronze Age, Indigenous Knowledge, Experimental Archaeology, Simulation.

چکیده: باستان‌شناسی به‌عنوان یک رشته علمی، تعاملات میان انسان و محیط زیست در گذشته را با بهره‌گیری از روش‌های علمی مختلف مورد بررسی و تحلیل قرار می‌دهد. این مطالعه به‌صورت انتقادی به بررسی پژوهش‌های باستان‌شناسی تجربی انجام‌شده در حوضه سیستان می‌پردازد و تمرکز آن بر چگونگی بازسازی رفتارهای فناورانه و فرهنگی جوامع گذشته از طریق روش‌های تجربی است. این مقاله با رویکرد مطالعه موردی، دو پروژه کلیدی باستان‌شناسی تجربی در این منطقه را تحلیل می‌کند. از نظر روش‌شناسی، ارزیابی از طریق تحلیل تطبیقی آزمایش‌های میدانی و فنون بازسازی صورت گرفته تا میزان اعتبار و دقت علمی این مطالعات بررسی شود. یافته‌ها نشان می‌دهد که این مطالعات در کنار نقاط قوتی چون جمع‌آوری دقیق داده‌ها و امکان بازسازی فرآیند تولید سفال، با چالش‌هایی نظیر محدودیت‌های روش‌شناسی و لزوم رعایت اصول علمی سخت‌گیرانه برای جلوگیری از سوگیری نیز روبه‌رو هستند. این مقاله با ارائه بینشی ژرف‌تر نسبت به نقش باستان‌شناسی تجربی در بازسازی رفتارهای گذشته، راهکارهایی برای ارتقای کاربرد آن در زمینه باستان‌شناسی ایران پیشنهاد می‌کند. تمرکز بر حوضه سیستان در این پژوهش، علاوه بر روشن‌سازی یک مورد منطقه‌ای خاص، به بررسی پیامدهای گسترده‌تر کاربرد روش‌های تجربی در باستان‌شناسی نیز می‌پردازد.

کلیدواژه‌ها: حوضه سیستان، عصر مفرغ، دانش بومی، باستان‌شناسی تجربی، شبیه‌سازی.

I. Introduction

In archaeological studies, hypotheses concerning the production methods and function of objects can be examined, tested, and experienced. Consequently, the reconstruction of manufacturing and construction technologies falls under one of the most significant areas of archaeological study, namely experimental archaeology (Fazel & Razani, 2023: 5). Experimental archaeology, while well-established internationally, is still a relatively new research field within Iranian archaeology. It assists archaeologists in simulating the technologies employed in the production of tools and other material data recovered from archaeological sites. Since archaeologists only observe accumulated material data and do not witness the production and consumption processes of these materials, the application of this method (experimental archaeology), along with caution in simulating the past, appears necessary.

Therefore, researchers must ensure that no distortion occurs in the process of simulating past behaviors. Although the final product in experimental archaeology likely bears a close resemblance to the ancient artefact, it cannot definitively assure the archaeologist that the produced final product followed the same production path as that of its original creator. For instance, the toolmaking industry, particularly the creation of stone tools, is very common in experimental

archaeology today and compels archaeologists to use this method. In these types of studies, although the output resembles the ancient specimen, the ancient and simulated specimens have very likely undergone different production processes. The reason for this can be stated as follows: archaeologists at an archaeological site only encounter the material remains left behind and base the simulation process on informed hypotheses about the probable ancient production methods. These hypotheses are developed to reconstruct and replicate products similar to those found at the site. This definition aims to highlight the experimental nature of archaeological reconstruction, though it is a simplified description and does not cover the full complexity of archaeological activities. Thus, despite the similarity of the final product simulated through experimental archaeology, the difference in the production or simulation process is a clear and evident characteristic of this type of method because archaeologists undertake simulation without precise knowledge of the production process that existed in the past. In accordance with these explanations, the authors in the present study adopt a critical approach to the common methods in experimental archaeology and will outline the strengths and weaknesses of this method accordingly.

II. Aims and Importance of the Research

Experimental archaeology and ethnoarchaeology, which are among the four key strategies of behavioral archaeology (alongside systemic and archaeological context studies), play a central role in reconstructing past human behaviors (Reid et al., 1975; Schiffer, 1976: 6).It involves constructing artificial systems through which specific processes can be studied by controlling relevant variables (Ascher, 1961; Tunnicliffe, 1978). Typically, the experimental archaeologist "produces materials, behaviors, or both in order to observe one or more processes involved in the production, use, discard, destruction, or recovery of material culture" (Skibo, 1992: 18). The roots of experimental archaeology trace back to the antiquarian era, with early experiments using original or replica tools. For instance, Pitt-Rivers (1876) conducted experiments at Cissbury using antler picks to dig ditches similar to those found at the site (Pitt-Rivers, 1876: 382). As a distinct methodological approach, experimental archaeology gained recognition during the 1960s with the emergence of the New Archaeology and the scientific work of Lewis Binford, who emphasized hypothesis-driven research (Binford, 1968: 11). The approach came under critique in the 1980s with the rise of Post-processual archaeology, which questioned the limits of scientific methods in cultural interpretation (Trigger, 2008: 450–457). However, with the introduction of advanced scientific techniques in the 1990s-such as residue analysis and AMS dating-scientific approaches regained prominence (Trigger, 2008: 540). Today, experimental archaeology integrates elements of both scientific rigor and interpretive flexibility, reflecting a more balanced methodological perspective.

Experimental archaeology, as a branch of archaeological science, has received relatively little attention from archaeologists in Iran. Therefore, the authors of the present study-while first outlining the conceptual framework of this scientific method-aim to critically assess it and explore the techniques of pottery production in the past. This is followed by efforts toward reconstructing, standardizing, and ultimately modernizing pottery production in the Sistan Basin. This work is significant, as indigenous knowledge and its application are vital for societal development, and studying traditional production processes plays an essential role in preserving and enhancing this knowledge (Shirani & Izadi Jiran, 2019: 116).

Indigenous or traditional knowledge (IK), which is considered a branch of anthropology, holds a special place in studies of sustainable development infrastructure. By recognizing, reviving, and adapting indigenous knowledge to the contemporary needs of human societies, modern methods of production control and the latent energies within nature can be best utilized by humans (Haji Ali Mohammadi, 2006: 97-98). Therefore, indigenous knowledge is a collection and philosophical system of knowledge arising from centuries of reason and experience; a collection that constantly grows and changes over time with new information, and to utilize this philosophy, the indigenous people themselves must first be employed as the main actors (Jomehpour, 2014: 75). Thus, while using the experimental archaeology method, archaeologists should face the existing obstacles in the research path with an open perspective. Furthermore, it should be clearly understood that indigenous knowledge can be beneficial to the production of Sistan Basin pottery, similar to the pottery of Kalporgan in Baluchestan and Lalejin in Hamedan, through the use of experimental archaeology (standardization and indigenization) and the branding of this forgotten art industry.

III. Research Framework and Methodology

As Farhadi (2014: 25 - 26) discussed in his article on

the importance of understanding indigenous knowledge and technologies, knowledge and technologies in traditional societies, especially in production, seem amazing but are largely unknown, and awareness of such knowledge and technologies is very rare. Therefore, the authors of this research aim to critique the application of experimental archaeology in scientific activities related to archaeology. Based on the subject of the present research, the main question arises: What are the strengths and weaknesses of implementing the experimental archaeology method as a scientific approach at archaeological sites? To answer this question, the authors will explain two experimental archaeology studies conducted in the Sistan Basin and ultimately highlight the general strengths and weaknesses of the experimental archaeology method as well as those of the two studies carried out in this region.

This research, adopting a critical approach toward the method of experimental archaeology, has utilized two study methods: library studies and field studies. In the field studies, the authors conducted their own experimental archaeology research in the Sistan Basin, the results of which have also been published (Moradgholi et al., 2019; Moradgholi and Mortazavi, 2021). Additionally, they participated alongside other researchers involved in experimental archaeology activities (Gorgi et al., 2021), supervised by Mehdi Mortazavi, closely observing the implementation process. Consequently, the authors have also evaluated and analyzed his other studies.

IV. Background of the Research

This section refers to some related studies. The research "A Look at Experimental Archaeology and the Importance of Paying Attention to it in Archaeological Studies" discusses the significance, attractiveness, and application of experimental archaeology in archaeological studies, stating that this applied branch, in addition to conducting archaeological experiments empirically, can be effective in attracting domestic and foreign tourists and consequently introducing archaeology, the history and culture of the country, and attracting investment (Samiei & Ghamari Fatideh, 2017). In the study "An Essay on the Experimental Deficiencies of Archaeological Knowledge," the author examines the limits of experience and the experimental limitations of archaeological knowledge from an epistemological perspective and attempts to address the obstacles that archaeological evidence poses experimentally (Molasalehi, 2007). The research "Investigation and Reconstruction of Grey Ware Pottery Firing Techniques during the Third to First Millennium BC in the Eastern Regions of Central Zagros" investigates and reconstructs the firing techniques of two types of Yanik Grey Ware pottery related to the Early Bronze Age (third millennium BC) and Iron Age Grey Ware (second and first millennia BC) (Karimi Mansoub & Mohammadi-Far, 2019). In the study "One, Two, Three: How to Count Stone Artifacts? A Study of Counting Methods for Broken Stone Artifacts Using Experimental Reconstruction of Fracture Patterns," the authors, using experimental studies, examined seven assemblages of stone artifacts subjected to fracturing by applying different counting methods for their broken pieces to identify the appropriate method and the accuracy of these methods in counting the fractured stone artifact assemblage and estimating the number of artifacts before they were fractured (Jayez & Vahdati Nasab, 2015).

As mentioned earlier, the use of experimental archaeology studies has been limited in archaeological research in Iran. This also holds true in the field of archaeological studies of the Sistan Basin. Accordingly, the authors of the present study have strived, while maintaining a critical perspective on the experimental archaeology studies conducted in the Sistan Basin, which were themselves the result of two separate theses, to take steps towards expanding the use of this method and, by writing this research, to encourage researchers to utilize experimental archaeology in their research experiences.

V. The Science of Archaeology: Beyond Material Remains

Archaeology, as a branch of knowledge, deals with the study of material remains left by past human societies, with the ultimate goal of recognizing their cultures and various dimensions (Askarpour, 2018: 35). This science has two fundamental realms: 1. The Core**:** This realm has a relatively fixed structure and includes fieldwork, data recording, laboratory studies, and the utilization of achievements from other sciences. In this section, reasoning, logical inferences, and data analysis are based on scientific methods and principles. 2. Milieu Approaches: This realm is dynamic and susceptible to deviation, encompassing various archaeological and pseudo-archaeological tendencies. Therefore, archaeology can be defined as a science that, while focusing on material remains (raw data) obtained from the past, seeks to gain deeper information from this data and analyze it (Renfrew & Bahn, 2012: 184; Preucel,

1991; Yadollahi & Yelveh-i, 2011: 193). In archaeology, data and evidence serve as documents that sometimes describe past events and sometimes depict phenomena. Therefore, archaeological evidence is a broad concept that includes an infinite source of evidence (documented and unobservable) (Fazeli Nashli & Abedi, 2009: 120-121). It is clear that ancient artifacts at a site do not only encompass material quantities; rather, non-material qualities also exist, the understanding of which requires the use of appropriate cognitive tools. From this perspective, an archaeological site is "a place, landscape, and archaeological layer at any scale and belonging to a period unique to its type of site, place, landscape, and layer, the opportunity for repeated excavation of which is unrepeatable" (Molasalehi, 2009: 14-15). In other words, during the excavation of a site, archaeologists are able to excavate ancient data but cannot directly extract the social system, rituals, and symbols of past societies (Mosapour Negari & Mortazavi, 2015: 11).

For about half a century, the science of archaeology has increasingly utilized various scientific measures and the achievements of other sciences to produce models, construct hypotheses, formulate theories, and provide accurate inferences accordingly (Fazeli Nashli & Abedi, 2009: 119). In fact, the scientific methods used in archaeological research clarify the fundamental link between this discipline and science, as science is capable of producing accurate and detailed information for the purpose of archaeological interpretations. In other words, utilizing evidence and being aware of scientific methods significantly contributes to enhancing the design and implementation of archaeological research (Green, 2004: 297). Theoretical discussions are an integral part of archaeology, encompassing all necessary aspects of this science, from survey and excavation to library and laboratory studies, reasoning, interpretations, and theorizing. The significant advancements in archaeology are largely indebted to the emergence of New Archaeology and Processualism, as New Archaeology emphasizes theoretical archaeology, various theoretical schools, and the continuous refinement of theories (Mosapour Negari & Mortazavi, 2015: 8). Among the prominent features of New Archaeology for the science of archaeology is the transformation in interpretations, conceptual adaptations, and the systematic reasoning from empirical sciences in archaeological research (Mosadeghi Amini, 2021: 308). The crucial role of the New Archaeology approach lies in the fact that although tangible data obtained from fieldwork are not inherently self-explanatory, with the development of theoretical approaches, archaeologists can move beyond the silent appearance of data and understand their contextual structure (Alizadeh, 2007: 89). Since archaeological data are static, in order to simulate the artifacts and characteristics of the complex of activities that took place in the past, in addition to using static data, obtaining more information related to dynamic processes will be necessary for archaeologists; this possibility is provided through experimental research. Therefore, experimental results bring static data to life, and their testing leads to the understanding of dynamic processes. Archaeologists should seek research laboratories where the impact of dynamic processes on archaeological cultural materials can be investigated; this is considered one of the fundamental principles of experimental archaeology (Yvonne, 2005: 19, 20).

Given this description, archaeology can perhaps be defined as a science in which archaeologists examine the output of the reciprocal relationship between humans and their environment. This output, which is material data, may have formed in a natural, cultural, social, or economic environment. The differences we attribute to different cultures stem from these very environmental differences; arguably, the most important environment is the natural environment, which has different characteristics in various regions (Mortazavi, 2024).

VI. Experimental Archaeology: A Bridge to Understanding Past Processes

For a deeper understanding of experimental archaeology, the study of the works of pioneering experimental archaeologists such as John Coles and Peter Reynolds is recommended (Paardekooper, 2009: 65). These individuals introduced the key form of Experimental Archaeology to the field in the 1960s and 1970s and ultimately established and formulated the principles and discussions related to it (Marshall, 2011: 1). Although about 30 years ago, experimental archaeology was introduced to the archaeological community as a modern research method that disregarded some fundamental research principles, today many of its operational limitations have been overcome, positioning it as a useful and efficient branch within the science of archaeology (Reynolds, 1994: 1). This means that experimental archaeologists, by simulating past behaviors, strive to protect the heritage of a culture and can contribute effectively to the preservation of a region's cultural heritage alongside activities such as excavation, analysis, and interpretation (Paardekooper, 2009: 67). The fundamental axis of this research method is the simulation of past artifacts or

material achievements for use in the cultural preservation of what has been forgotten or diminished in the modern world (Reeves Flores, 2012: 3). Therefore, archaeologists can take steps towards standardizing and modernizing the methods of utilizing ancient phenomena with the aim of generating wealth in the contemporary world.

However, in utilizing experimental archaeology, adherence to certain principles and rules is essential, including:

1. Sourcing of Raw Materials: The materials used in simulating the process intended by the archaeologist must be of the same type of raw materials that were used by predecessors in the same location.

2. Compatibility and Consistency of Examination Methods with their Application in the Society under Study (Fagan, 2006: 556).

3. The Importance of the Time Period of Data Production in the Past: Data produced in the prehistoric period cannot be simulated based on the principles of the production process of the same data in the Islamic period. In other words, an experimental archaeologist, after completing the simulation process in their research, faces three types of interpretation:

1. Interpretation Based on Intuition: The researcher describes their intuitions and uses phrases such as "it seems logical that," without revealing any certainty in their statements.

2. Interpretation Based on Experimental Data: The basis of the researcher's interpretations in each experiment is the data obtained from experiments conducted in line with their research objectives.

3. Interpretation Based on Scientific Experimental Results: According to archaeological information, a hypothesis is formulated, and a tested design is developed. Therefore, archaeologists must pay attention to all factors that are likely to affect the experimental results, ensuring that the influence of these factors does not determine the final outcome or bias the experimental results in a particular direction (Yvonne, 2005: 21).

VII. Analyzing Experimental Archaeology within the Framework of Processual Archaeology: A Step Towards Explaining Past Behaviour

In the process of utilizing experimental archaeology, fundamental questions arise: What activities encompass experimental archaeology? Are these activities organized into distinct levels? What is meant by the temporal scale of an experiment? Why is the value of some materials variable, while that of others remains constant? Researchers can find answers to these questions through the repetition of experiments or even the replication of experimental results (Bell et al., 2009: 3). Indeed, five main stages can be identified in experimental archaeology: (1) hypothesis construction, (2) experimental process and performance, (3) the use of modern technologies, (4) simulation, and (5) conclusion.

VII.1. Hypothesis Construction

A hypothesis is defined as a purposeful question aimed at achieving laws, new relationships, or offering novel experimental suggestions for a pre-selected real phenomenon. In other words, a hypothesis is the researcher's educated guess, based on their prior knowledge, which is subjected to empirical testing and evaluation. A hypothesis is a powerful tool and an inseparable element of research for explanation, guiding the researcher in selecting relevant facts and the types of observations that need to be made. In this process (hypothesis formation), the researcher must consider several stages:

1. Preparing presuppositions (originating from thought, logic, and direct observations).

2. Examining presuppositions (including review, rearrangement, strengthening, or sometimes rejection).

3. Testing (determining the criteria for rejecting or accepting the hypothesis).

Accordingly, in formulating a hypothesis, the following criteria should be considered by the experimental archaeologist:

1. The power of the hypothesis to explain facts.

2. The testability of the hypothesis.

3. The expression of the correlation between two variables by the hypothesis.

4. The hypothesis's connection to a suitable and relevant theory.

5. The hypothesis should be clear and unambiguous.

6. The hypothesis should be precise and specific.

7. The principle of value neutrality (the researcher's values should not interfere with the research).

8. The hypothesis's compatibility with existing technology.

9. The absence of contradictory, self-evident, and synonymous features in the hypothesis (Niazi &

Mortazavi, 2015: 3-8). Typically, the initiation of this stage (hypothesis construction) occurs when the archaeologist is present at the archaeological site and encounters data and evidence. In all sciences, understanding the core meaning of a set of data and evidence without constructing a hypothesis is not possible; archaeology is no exception to this important principle, as archaeologists must have a complete understanding of what they are looking for, which allows them to temporarily set aside indirect and secondary aspects from their goal; otherwise, they will be faced with a plethora of data, both relevant and irrelevant to their objective (Alizadeh, 2007: 88-89). In other words, archaeologists must be aware that the presence of various ideas in a scientific study only leads to distrust and the establishment of skepticism, and to address this issue, archaeologists should strive to present a simple combination of data through experimental archaeology (Grzegorz, 2006: 3). If the aim of testing a hypothesis is to determine whether it can be falsified after conducting the experiment, a new alternative hypothesis should be proposed and the experiment repeated. If the hypothesis is supported by the experiment, it can be considered a valid hypothesis. The concept of "valid" does not mean "correct" but only identifies the potential areas for falsification (Outram, 2008: 3). Therefore, every hypothesis proposed by an archaeologist is based on their interpretations of archaeological data and evidence, and to provide a correct interpretation, archaeologists need to be aware of various methods within the science of archaeology; experimental archaeology is one such method, as its perspective is to discover the "truth and reality of the matter" (Norway, 2012: 40). In other words, in archaeology, reasoning, inference, and conclusion are possible through hypothesis construction, which subsequently leads to the development of a model to explain prevalent past cultures and the testing of this model's data. Indeed, the scientific question in archaeology is "how do we know what we know?"Archaeologists must learn to discover, not discover to learn (Mosapour Negari & Mortazavi, 2015: 18).

VII.2. Experimental Process and Performance

This stage specifies what the goal of conducting the experiment will be (Outram, 2008: 3). The points that an experimental archaeologist should pay attention to when implementing the simulation process include:

1. Avoiding experiments where the final output merely reiterates the research questions.

2. Stability of experimental results: Variability in results makes understanding any pattern impossible; therefore, experimental archaeologists must pay attention to the principle of result stability to be able to rely on the experimental outcome as scientific work.

3. The production of a large or small amount of data is effective in the researcher's decision-making, as it leads to minor and potentially random results, hindering the individual's ability to analyze the data.

One of the basic needs in experimental archaeology is "work scheduling," which leads to the duration of the experiment, analysis, and modification of experimental results (Bell et al., 2009: 5-6). In fact, time-related issues seem complex for two reasons:

1. If the duration of a research project exceeds the initial investment period, its completion will be difficult.

2. Experiences; recording time in the process of experimental archaeology reflects a completed experience, and if time is not recorded correctly, the concept of time will no longer have a place in the archaeological community (Renfrew & Bahn, 2012: 184).

VII.3. Use of Modern Technologies

This involves applying appropriate innovation and technology during the execution of the activity (Outram, 2008: 3). The presence of knowledge and technology together will be helpful in achieving a common goal in a scientific study, meaning that technology is not a process belonging to a specific realm; rather, technology is the ultimate product of the interaction of many scientific fields (Azadi Ahmadi Abadi, 2016: 47 & 50). In fact, valuable results in archaeology originate from insights into the tools and methods of past peoples' interaction with their surrounding environment; therefore, experimental archaeology cannot be limited solely to difficult experiments and a multitude of questions, as other potential factors such as technology also play an important role (Woolford & Dunn, 2012: 1). Perhaps this can be stated as follows: in experimental archaeology, while utilizing the expertise of scientific methods, the proposed hypotheses will also be tested (Busuttil, 2008-2009: 61). For this reason, an archaeologist, aiming to simulate ritual behaviors or common production methods in an ancient society that the passage of time has obscured in the darkness of oblivion, seeks to answer the questions raised by using various methods within their subfield, and alongside describing the material data obtained from that

archaeological site, utilizes the modern achievements of other scientific methods to reduce existing limitations (Mosapour Negari & Mortazavi, 2015: 18).

In the science of archaeology, archaeologists use various technologies to carry out activities; these technologies are divided into four categories:

1. Database: This section is the main platform for carrying out activities with the help of technology and includes recording information from excavations, storing information for the analysis of excavations, and providing information from different geographical areas.

2. Software: This stage plays a significant role in the analysis of archaeological data and information, and is divided into three levels:

2.1. Specialized software in archaeology, such as Harris Matrix software during excavation.

2.2. Interdisciplinary software such as AutoCAD and GIS, etc.

2.3. Software such as museum guides designed to convey concepts in simple language to the general public.

3. Digital Documentation: Various methods of documentation, in two or three dimensions, to prepare images and reveal hidden information on the surface of objects and other data, helping archaeologists to discover the reality of the data and access information.

4. Research towards the physical and chemical analysis of data: A method used to analyze ancient data; this method will also be suitable for data re-sharing, as the reuse of data from excavations is a major challenge for archaeology (Mirsafdari & Mohammadi Far, 2020: 187 & 188).

VII.4. Simulation

Simulation is defined in the field of interdisciplinary sciences in three ways:

1. A method that, while explaining the relationship between propositions taken from a scientific field, leads to the production of knowledge.

2. An intellectual method that uses the coherent and purposeful output of other knowledge to answer a problem.

3. A method that, through a logical process, presents an organized, transparent, and dynamic combination of the results of other related knowledge to produce knowledge (Noghrehkar et al., 2010: 131).

In this stage, to simulate a process rooted in the past, uniformity and consistency in the method of process execution "in the past and present" and attention to the preservation process of data and the environment in which the data is located (taphonomy) should be considered by the archaeologist (Outram, 2008: 3).

VII.5. Conclusion

In this section, because archaeologists have a great interest in experience and experimentation, as a result of which they can examine human conditions in the past, in line with this interest, archaeologists should choose a topic for research in which discussion and conclusion are among the main goals; attention to this matter specifies the appropriate intellectual framework for the archaeologist (Outram, 2005: 109). As stated, if the process of implementing experimental archaeology is organized and systematic, the results obtained from it will be evaluable in archaeological analyses; in line with this evaluation, the proven propositions in the process of experimentation and implementation of experimental archaeology display the correct combination of results (Norway, 2012: 41). Therefore, scientists' use of the experimental archaeology method to answer experimental questions requires appropriate order in the results of these methods. In fact, order in the results places the simulation process at a higher level than traditional archaeology and also serves as a clear document for understanding the difference between experimental archaeology and other activities, including the construction of archaeological models with new tools; therefore, it can be said that the goal in experimental archaeology is not only to be informed of a personal test but also to provide services to the science of archaeology (Grzegorz, 2006: 6).

VIII. Re-evaluating Experimental Archaeology Studies of the Bronze Age in the Sistan Basin: Achievements and Challenges

Archaeologists seek to gain information about the human societies that inhabited ancient sites in the past through survey and excavation. To facilitate this, the science of archaeology has developed methods that enable archaeologists to gather information from non-dynamic and extinct societies (Alizadeh, 2007: 55). Consequently, experimental archaeology has been widely used by archaeologists, and experimental studies are employed to link the results of tests with archaeological evidence. Experimental archaeology models and designs archaeological problems,

experiments, and tests, and the results of new experiments are compared with archaeological data to generate knowledge about the behavior of useful variables for data interpretation. Therefore, the distinctive feature of experimental studies is the precise control of the variables under investigation (Ghorbani, 2021: 254). However, experimental archaeology studies are not well-known in Iran, and it is difficult to find documented research related to this scientific method. This section examines two research activities conducted in southeastern Iran, particularly the Sistan Basin (Fig. 1).

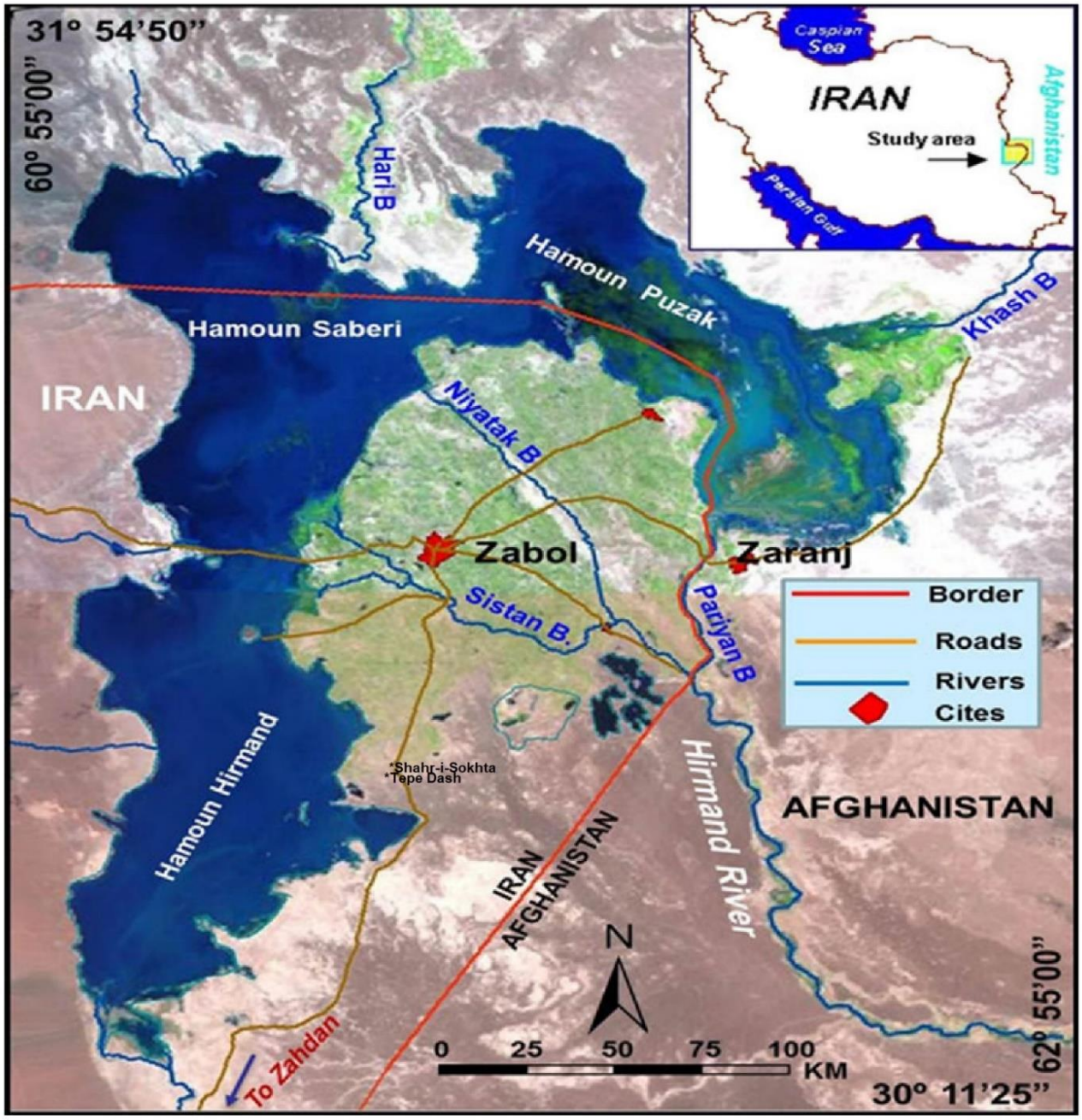

Figure 1: Map of the study area within the Sistan Basin, showing the locations of Shahr-i-Sokhta, Tepe Dash, and other relevant features (After: Mortazavi et al., 2015: 45 and modified by the Authors).

Before delving into the two research activities, it is helpful to first examine the case study that forms the basis of these investigations. In this site, where six excavation seasons have so far been conducted under the supervision of Mehdi Mortazavi, highly valuable findings related to the industrial production of pottery have been uncovered (Fig. 2). The discovery of a large volume of pottery from Periods II, III, and IV of Shahr-i-Sokhta in a location called Tepe Dash situated three kilometers from Shahr-i-Sokhta and identified as a pottery production center is not surprising. Various types of storage jars (Fig. 3), bowls (Fig. 4), and pear-shaped vessels (Fig. 5) are among the most common items. Additionally, the discovery of clay cow figurines (Fig. 6) in the Sistan region is not unrelated to industrial activities, especially considering that cow dung was used as fuel in pottery kilns-a subject also explored in this study. Alongside these final products, several key pieces of evidence related to the production process have been found in Tepe Dash, including pottery kilns (Fig. 7), clay sources adjacent to the kilns (Fig. 8), kiln clinkers (Fig. 9), and discarded or deformed vessels (Fig. 10), all of which serve as crucial indicators of pottery manufacturing at the site. One of the most important pieces of evidence for pottery production at Tepe Dash is the fingerprints of the potters found on irregular clay lumps (Fig. 11). These clay lumps are likely the excess pieces that the potter trimmed off while shaping the pottery and discarded. Approximately 500 such clay pieces were recovered over six excavation seasons, and they can provide valuable information not only about the production process but also about the age and gender of the potters.

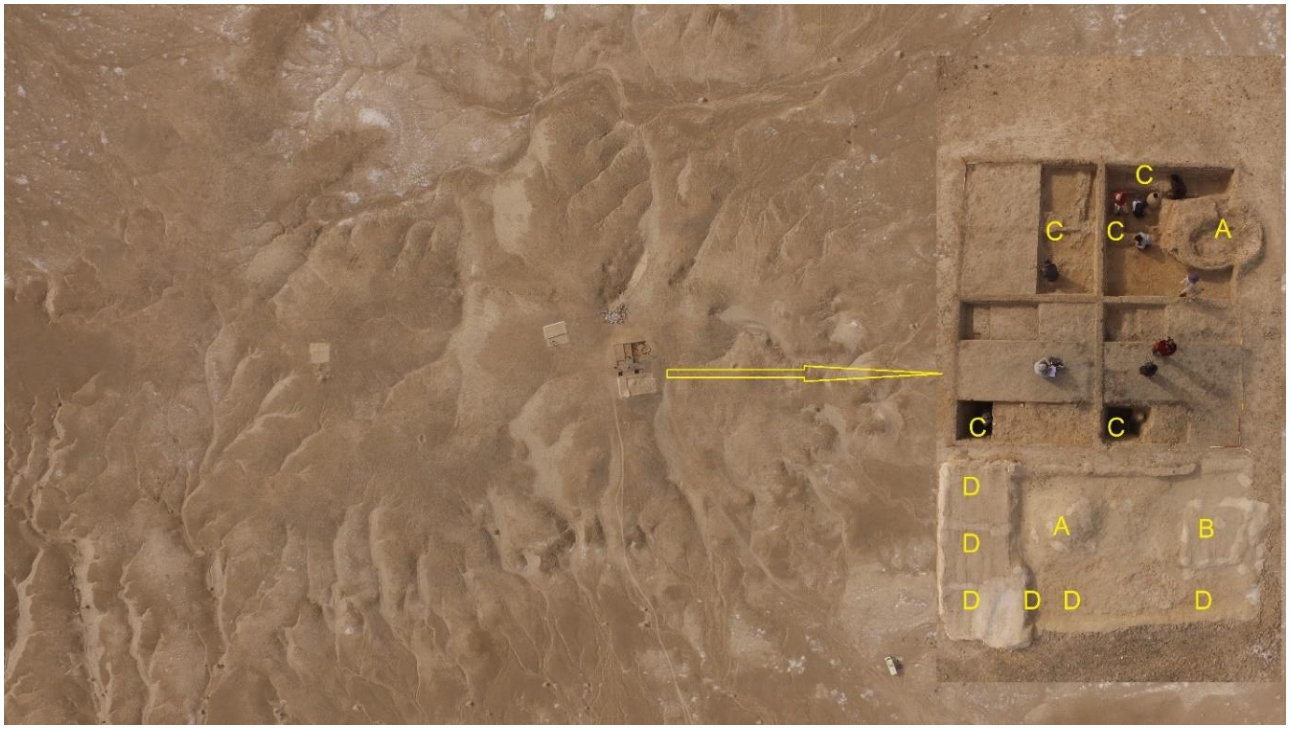

Figure 2: View of the excavation workshop during the third season (2015). In this image, several key features can be identified: A – Two pottery kilns located in the trenches from the 2014 and 2015 excavation seasons at the site, B – A clay deposit area used as the raw material source, C – Several large storage jars visible in the workshop season 2015, D – Location where clay figurines of Sistani Cows and fingerprints on clay objects were discovered (After: Mortazavi, 2017).

Figure 3: Various types of storage jars discovered from different excavation seasons at Tepe Dash (After: Mortazavi, 2017; Mortazavi et al., 2014).

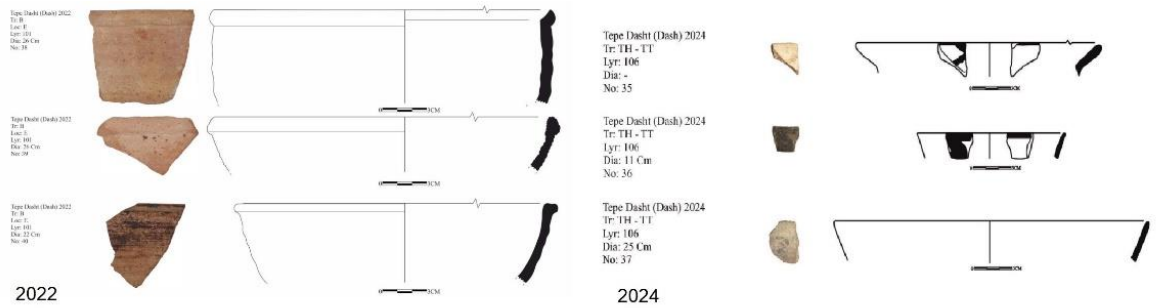

Figure 4: Various types of bowls discovered during different excavation seasons at Tepe Dash, reflecting the diversity in form and function within the site's pottery production (After: Mortazavi, 2022; Mortazavi et al., 2024).

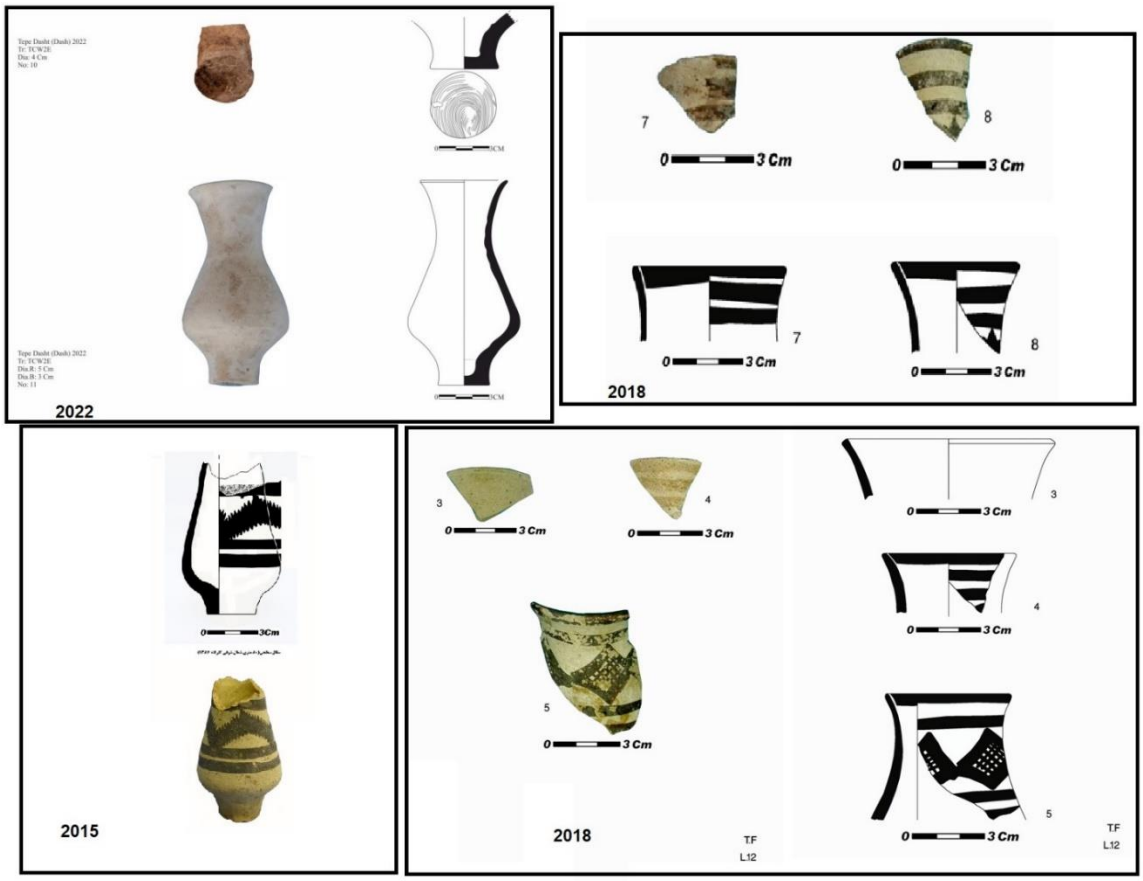

Figure 5: Pear-shaped vessels most common pottery form at Tepe Dash, discovered across multiple excavation seasons, highlighting a consistent production style at the site (After: Mortazavi, 2017 & 2022; Mortazavi et al., 2019).

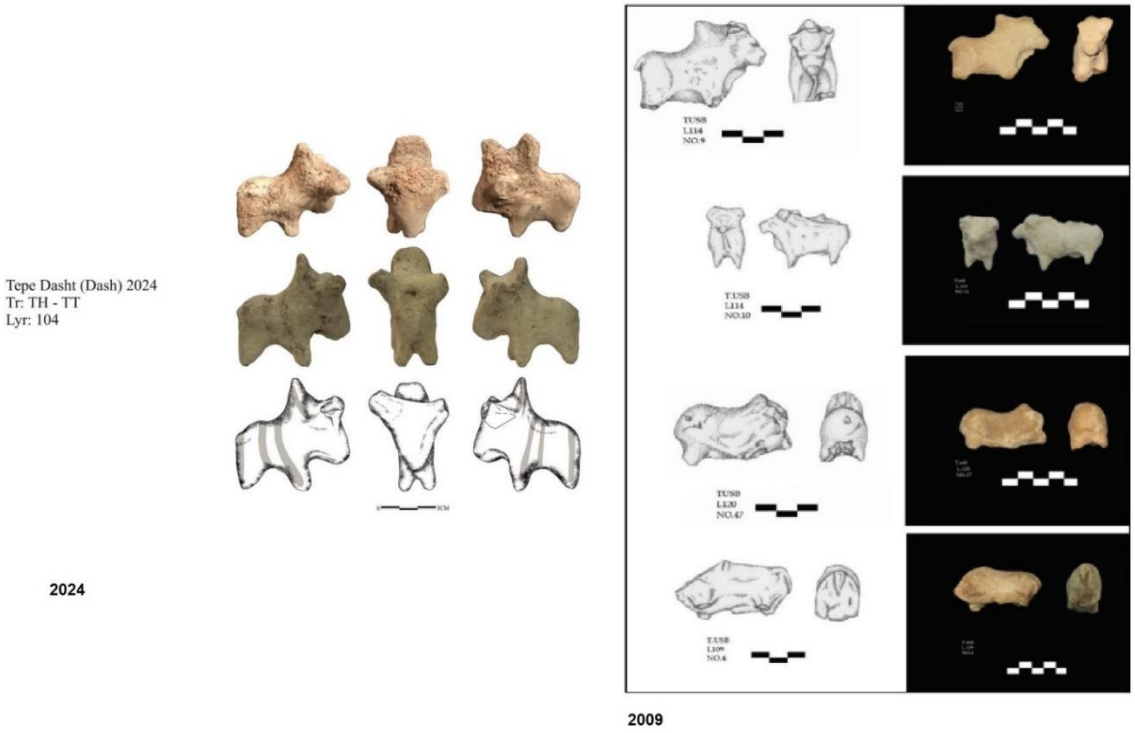

Figure 6: The discovery of clay cow figurines in the Sistan Basin is not unrelated to industrial activities, especially considering that cow dung was used as fuel in pottery kilns-a topic also examined in this study (After: Mortazavi, 2010; Mortazavi et al., 2024).

Figure 7: Pottery kilns discovered at Tepe Dash, representing direct evidence of on-site ceramic production activities (After: Mortazavi, 2009; 2017; 2022; Mortazavi et al., 2019).

Figure 8: Clay sources found adjacent to the kilns at Tepe Dash, indicating proximity and accessibility of raw materials for pottery manufacturing (After: Mortazavi, 2017).

Figure 9: Kiln clinkers unearthed at the site hardened remnants from the firing process, offering insights into kiln operation techniques (After: Mortazavi, 2009).

Figure 10: Discarded or deformed vessels discovered at Tepe Dash, reflecting production waste and quality control aspects in the ceramic-making process (After: Mortazavi, 2017).

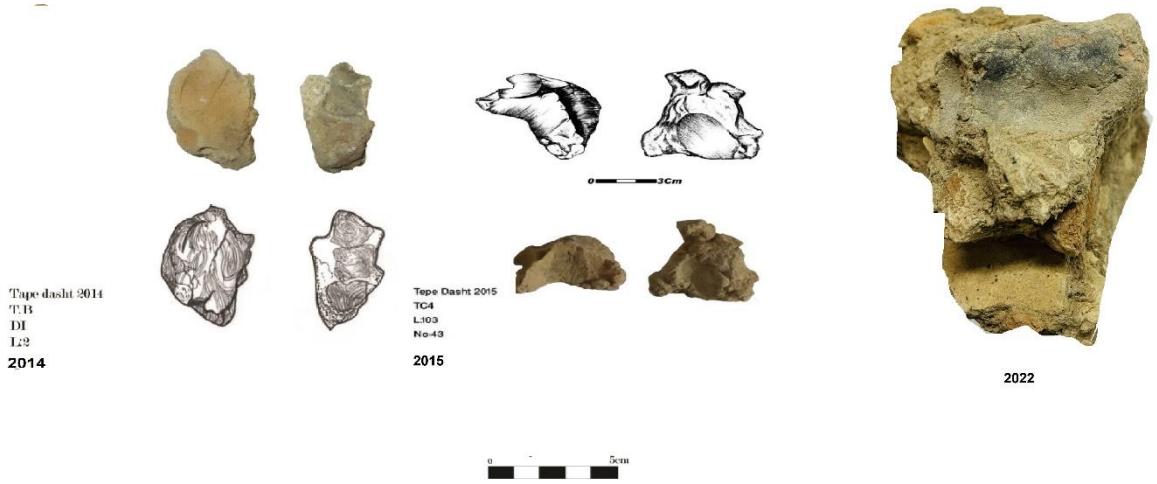

Figure 11: A selection of Potters' fingerprints on irregular clay lumps from Tepe Dash indicate industrial pottery activities and serve as key evidence of the manufacturing process at the site (After: Mortazavi, 2017 & 2022; Mortazavi et al., 2014).

As previously mentioned, two specific research activities have been conducted in southeastern Iran, particularly in the Sistan Basin, aimed at exploring aspects of experimental archaeology within the cultural and industrial context of this area. The findings from the Tepe Dash site recognized as one of the most significant pottery production centers near Shahr-i-Sokhta have not only provided a solid foundation for these studies but have also inspired the design of experiments intended to reconstruct ancient pottery production processes. In the following section, we will introduce and analyze these two research projects, each of which attempts to scientifically reconstruct and document elements of ancient industrial knowledge.

1) The research of Morteza Gorgi entitled "Characterization of Gray Ware Pottery from the Bronze Age Sites of Shahr-i Sokhta and Tepe Bampur to Better Understand Potential Exchange Patterns and Technical Processes"**:** This research was conducted as a Master's thesis under the supervision of Mehdi Mortazavi in 2015. In line with their research objectives, Gorgi and colleagues, in a part of their thesis process, used the experimental archaeology method and utilized soil from the two regions of the Sistan Basin and Tepe Bampur to produce pottery in order to record the apparent and structural changes in the gray ware pottery soil of these regions. For this purpose, Gorgi and colleagues simulated two pottery kilns with a circular plan, similar to the kiln plans of the pottery production satellite site of Shahr-i Sokhta, with the aim of creating two reducing and oxidizing environments in Tepe Dash (Fig. 12) (Gorgi et al., 2015: 65-112).

2) The research of Nahid Moradgholi entitled "Experimental Archaeological Studies on Animal Dung in the Sistan Basin, Case Study: Tepe Dash": This research was conducted as a Master's thesis under the supervision of Mehdi Mortazavi. Based on their research objectives, Moradgholi and colleagues simulated the process of collecting animal dung according to the contemporary traditional societies of the region under study (Moradgholi & Mortazavi, 2021: 370-372), and with the aim of providing fuel for the Bronze Age kilns of the region and determining the appropriate pottery firing temperature using this type of fuel (Moradgholi et al., 2019: 92-99), through the experimental archaeology method.

Any researcher embarking on fieldwork must have a structured plan for their research activities. The experimental archaeology studies conducted in the Sistan Basin were no exception. At the beginning of their research, Moradgholi and colleagues (2016) simulated kilns (Figs. 13 to 16) to replicate pottery firing conditions in their experiments. In one stage, due to the lack of natural wind, the researchers used a blower to create artificial air circulation inside the kiln to raise the temperature to a suitable level for firing pottery. Within the first ten minutes, the temperature reached 142 degrees Celsius. Temperature was measured by a thermocouple inserted through small holes in the kiln. To stabilize the thermocouple in place, some clay was applied around it, but due to the cooling effect of the clay's moisture, the temperature dropped to 79 degrees Celsius. At this stage, a generator was used to supply electricity to the measuring device, but temperature recording was stopped due to the depletion of the generator's fuel (Fig. 14).

Figure: 12: Location shahr-i-sokhta and Tepe Dasht. also main utilizations of the settlement space: 1. Limit of the Plio-Pleistocene terrace; 2. maximum surface extension of southern workshops; 3. Western workshops; 4. Graveyard; 5. Presumed residential areas; 6. Factory at Tepe Dash (After: Mortazavi et al., 2011: 62).

Figure 13: Kiln No. 1, with a medium-sized windward entrance and three holes in the roof for oxygen supply and a pit fuel reservoir (After: Mortazavi, 2015).

Figure 14: Kiln No. 2, constructed with a domed roof and a deep in-ground reservoir. Electric Blower was created using a blower to increase temperature for pottery firing. A thermocouple was installed to measure the temperature, but measurement was ultimately halted due to generator fuel depletion (After: Mortazavi, 2015).

Figure 15: Kiln No. 3, designed as a single unit with one entrance to create an oxidizing environment, and similar in appearance to the Bronze Age kilns found at the satellite sites of the region under the researchers' study (After: Mortazavi, 2015).

Figure 16: Kiln No. 4, with a height of 82 cm, width of 66 cm, wall thickness of 7 cm, fuel reservoir depth of 30 cm, entrance height of 16 cm, four 7 cm holes, and a circumference of 210 cm. In this simulation stage, due to the increase in temperature (higher than the defined temperature for the thermocouple), the thermocouple's heat-sensitive rod malfunctioned, and the temperature measurement process was stopped (After: Moradgholi et al., 2016: 37-64).

The simulations carried out through the application of the experimental archaeology method in these studies were accompanied by strengths and weaknesses, which the authors of the present study will examine in the following section.

IX. Evaluating the Strengths and Weaknesses of Employing Experimental Archaeology in Research

This section will examine the general strengths and weaknesses of experimental archaeology research. Furthermore, it will analyze these points (where relevant) in the context of the two experimental archaeology studies conducted in the Sistan Basin, which were detailed in the previous section.

IX.1. Strengths

1) Data Collection**:** Experimental archaeology, by monitoring conditions, aims to simulate past events (Dark, 2008: 66) and, in its broadest sense, encompasses all experiences used to explain an archaeological issue. In other words, this branch of archaeology answers questions posed in the science of archaeology through experimentation (Renfrew & Bahn, 2012: 182). In New Archaeology, the archaeologist's effort is focused on finding answers to their questions through data collection, not a mass of data lacking logical connections and only causing ambiguity and confusion (Mosapour Negari & Mortazavi, 2015: 18). Indeed, this stage (data collection) is considered one of the most important parts of scientific research; the alignment of collected information with research objectives directly impacts the accuracy of the results. The methods of data collection and data analysis, two complementary approaches, are both selected based on the goals and hypotheses of the scientific research (Mostakhdemin Hosseini, 2015: 61). In the two experimental archaeology studies mentioned, the researchers collected data relevant to their research objectives by being present in the study areas. In the research by Gorgi and colleagues, local materials and tools were used to gather data (local soil for pottery and kiln construction, the Sistani "*kaj-bil*" and brick-making molds in Sistan; local soil, "*tituk*" stone for pottery color, and local tools for decorative motifs on pottery in Baluchestan). In the research by Moradgholi and colleagues (2019), an ethnoarchaeological approach was used to gather evidence of animal dung use as fuel in contemporary traditional societies.

2) Obtaining Superior Inferences: Reasoning, in a general sense, involves discovering unknown judgments through known judgments and is a complex mental action for the advancement of civilization and culture, the discovery of geometric theorems, algebraic and physical equations and formulas (Mosapour Negari & Mortazavi, 2015: 17). The archaeologists' inclination towards positivist philosophy—logical deduction, a

characteristic of New Archaeology (empiricism)—led to the formation of experimental archaeology, and Binford, by emphasizing the importance of interpretation and the testability of hypotheses, played a significant role in the advancement of this branch. In the processual archaeology approach, it is believed that experimental archaeology can be used alongside anthropological evidence, historical sources, behavioral archaeology, and ethnoarchaeology to answer archaeological questions (Fazeli Nashli, 2005: 43-44). Thus, experimental archaeology helps the archaeologist obtain the best inferences because the goal in Middle Range Theory (an important approach in New Archaeology) is to create a logical link between material data and their interpretations, which is what behavioral archaeology, ethnoarchaeology, experimental archaeology, and the behavioral chain seek to understand the problem of global connections between the static and dynamic aspects of cultural and environmental factors (Alizadeh, 2007: 95). An example of this can be seen in both mentioned studies; the researchers, based on the objectives set in their research, used the results of Marzieh Kordan's Master's thesis entitled "Chemical Analysis of Tepe Dash Pottery" (2011) regarding the use of animal dung as fuel in the Bronze Age kilns of the Sistan Basin, and utilized this type of fuel in their simulated kilns based on their research goals.

3)Accuracy in Observations: Observation is a method of data collection, and the criterion for accurate observation is the recording of all aspects. During careful observation, archaeologists should pay attention to the relevance of observations to research objectives, pre-planning the course of action after observation, accurate and systematic recording of observations, and the evaluability of the validity of observations. In careful observation, awareness of the subject and the ability to identify it in any form are important. Accurate observation is a crucial principle in most scientific research (Mostakhdemin Hosseini, 2015: 64). The key point to consider when answering a question for an experimental archaeologist is accurate observation. Some researchers believe that experimental archaeology is beneficial to the science of archaeology in that it considers the data, evidence, and the archaeologist's concerns regarding ambiguities and questions, and through careful observation, undertakes experimentation and the simulation of a process, thereby placing the experimental variables, measurements, and overall conditions under the archaeologist's control (Albero Santacreu, 2014: 118-119). The researchers of both mentioned experimental archaeology studies also used this important keyword based on their research process by: a. Using a plan similar to Bronze Age kilns for kiln construction. b. Using local materials for the construction of simulated kilns. c. Simulating kilns in an ancient environment.

IX.2. Weaknesses

1) Research Method: Experimental archaeology utilizes the "archaeology of past material culture" method to gain more information and employs the feature of "comparison" to simulate archaeological data. The methods and their types are important in experimental archaeology because the difference in the method of experiments helps in providing scientific reasoning (Yvonne, 2005: 19-20).

2) Data Validity: The approach of the New Archaeology school emphasizes testing hypotheses and not allowing personal opinions or judgments to interfere, as hypothesis testing is a crucial principle in processual archaeology. The acceptance or rejection of individuals' opinions is not related to their power or status; rather, the criterion for determining the validity of theories is their consistency with evidence and documentation (Mosapour Negari & Mortazavi, 2015: 18). Therefore, an experiment conducted in an open environment may appear to be the most realistic, but controlling and replicating conditions in this setting is difficult (Renfrew & Bahn, 2012: 183). Regarding the difficulty of controlling conditions in the simulation process in the experimental archaeology studies mentioned earlier, this issue can be observed in the lack of temperature control and its sudden increase in the simulated kilns in both studies. In the research by Gorgi and colleagues, the disintegration of some of the pottery made by the researchers due to high temperature or poor pottery construction quality in the simulated kilns occurred; also, due to the blockage of air inlets and the effect of fuel materials inside the kiln, the pottery inside the simulated kilns became smoked. In the research by Moradgholi and colleagues, the lack of temperature control and the sudden increase in temperature damaged the temperature measuring device (thermocouple) and deactivated its heat-sensitive rod.

3) Having an Accurate Database**:** As we know, archaeology deals with evidence left from the past, and any negligence in this regard (especially a lack of information related to the archaeological site under study) complicates the implementation process of experimental archaeology (Lobisser, 2006: 6). Although the two studies mentioned in this article are among the few studies related to experimental archaeology in the

Sistan region, it can be said that the information obtained from the implementation of these two studies can be stored in the database of archaeological research in the Sistan region and used as an information base for future research in the region by other researchers.

4) The Scarcity of Relevant Research Evidence in Contemporary Traditional Societies: The questions that experimental archaeology seeks to answer originate from raw data of the past, and archaeologists should seek to supplement their information by searching in the dynamic traditional societies around the archaeological site under study. However, there is scarce evidence of traditional methods and data found in archaeological sites in contemporary traditional societies. This is an issue that archaeologists should try to resolve using other sub-branches of New Archaeology. The researchers of the second study (Moradgholi and colleagues) faced this issue; they used an ethnoarchaeological approach to find evidence of the use of animal dung as fuel in contemporary traditional societies of their study area, but collecting this evidence was difficult due to successive droughts in the region, which led to a decrease in livestock keeping in contemporary traditional societies, ultimately reducing the use of animal dung as fuel.

5) Sole Reliance on Experimentation: The main focus in archaeology is excavation, site analysis, and research on material culture, meaning that experimentation does not yet have a strong foothold in archaeological research, while the foundation of experimental archaeology is based on trial and error (Paardekooper, 2009: 67). This can be observed in the research by Gorgi and colleagues, where despite recording a temperature of 750 degrees Celsius in the simulated kilns by the researchers, the paste of some pottery lacked sufficient cohesion.

6) Borderline Differentiation: Sometimes there is no clear boundary between experimental archaeology (research tool), experiences, and the simulation process, and the implementation process of experimental archaeology tends towards a point where doubts arise about labelling it a scientific activity (Outram, 2008: 3).

7) Funding Provision, Time Constraints, and Resources: These three points are major concerns for the implementation of experimental archaeology (Paardekooper, 2009: 67). Both experimental archaeology studies mentioned in this research also faced these issues, which the researchers tried to overcome with patience.

X. Conclusion

In this study, experimental archaeology was examined as an effective method for reconstructing past technologies and understanding the implicit knowledge embedded in archaeological data. The results showed that using local materials and tools, along with repeated experimentation, allows for more accurate inferences. However, limitations such as difficulties in fully controlling experimental conditions, scarcity of data from contemporary traditional societies, and constraints of time and funding present challenges in implementing this approach. Despite these challenges, applying experimental archaeology in the Sistan case studies has provided valuable opportunities to enrich regional archaeological knowledge.

Given the pivotal role of reconstructing technological traditions in understanding the production process and the implicit knowledge within archaeological data in experimental archaeology, and the reproducibility of this method in achieving the best results and presenting superior ideas and hypotheses to archaeologists, acting as a powerful arm for archaeology, based on the characteristics discussed in the section on examining experimental archaeology within the framework of processual archaeology, this branch of archaeology relies on experimentation and the possibility of repeated trial and error of hypotheses. It utilizes the achievements of other sciences or, in other words, interdisciplinary methods that are close to the archaeologist's research objectives. However, for the implementation of experimental archaeology based on the subject of this research, the following considerations are important:

1) Necessity of Uniform Environmental Conditions: The uniformity of natural environmental conditions during the experiment with the past environmental conditions of the archaeological site is essential for achieving more accurate answers. Providing this condition is difficult for the archaeologist. In the experimental archaeology research by Moradgholi and colleagues, a weakness in this area was evident; wind flow and fuel supply were important factors in the simulation of the Bronze Age kilns of the site under the researchers' study, which were not fully achieved.

2) Unfamiliarity with Ancient Knowledge: The experimental archaeologist selects the process of answering their question based on a hypothesis formed from ancient data and evidence present at the archaeological site, while being unaware of the (ancient) knowledge of how to implement the subject being simulated through experimental archaeology. The

attempt to understand the expertise hidden in silent data through trial and error is always accompanied by the possibility of success and failure.

3) Impact of Modern Technology on Simulation: The implementation method of experimental archaeology in simulation involves utilizing new and advanced modern facilities, to which the advanced ideas and thought and trained expertise of experimental archaeology can also be added. Thus, simulating a behavior rooted in the past and shaped by the tools and resources of that era becomes a kind of dictation of present-day resources and thought onto the knowledge, resources, and thought of the past, suggesting a kind of evolution and superiority in the implementation of the simulation process. This means potentially achieving a similar product without using the same technology as the past in its production.

4) Resource Limitations: Lack of facilities, budget, and time are constant challenges in scientific research. In the implementation of experimental archaeology, deficiencies in any of these three aspects can lead to errors in the simulation process. The researchers of both mentioned studies also faced these limitations, which slowed down the progress of the research.

5) Necessity of Maintaining Scientific Neutrality: Sometimes the conditions of implementing a subject under the agenda of experimental archaeology proceed in such a way that the results of the process are consciously or unconsciously manipulated. The experimental archaeologist must be careful and prioritize scientific integrity, and also consider that the results of the experiment do not necessarily have to confirm their hypotheses. The non-confirmation of hypotheses in the process of experimental archaeology should not be considered a failure, and one should not resort to changing results to confirm their hypotheses; because every experiment in experimental archaeology is not absolutely bound to confirm or reject hypotheses, and may even lead to results outside the archaeologist's hypotheses, which in itself may be the prelude to new scientific research.

6) Importance of Visual Documentation: The implementation process of experimental archaeology and its presentation to scientific communities largely relies on visual documentation. If the experimental archaeologist neglects to record a stage of the work, they compromise their research, because visual documents are the eloquent language of a process rooted in the past and currently being simulated.

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