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DIGITAL ANALYSIS OF PETROGLYPHS AT THE KAHTOOYE SITE, IRAN

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Abstract: Over the past few decades, interest in rock art studies in Iran has increased significantly, and numerous sites have been identified from different parts of the country. During archaeological surveys in Bavanat County, several sites with petroglyphs were identified. The mountainous landscape of this region and the presence of suitable rock surfaces have provided a favorable environment for the creation of petroglyphs in various historical and prehistoric periods. One of the most important of these sites is the Kahtooye Site in the south of Bavanat City, where numerous petroglyphs are visible on its rock surfaces. Given the importance of rock art in reconstructing aspects of the thought, symbolism, and lifestyle of past societies, the present study was conducted to examine the rock art at this site. This study also emphasizes the importance of utilizing modern technologies and digital documentation of cultural heritage, as well as more accurate artifact analysis. In this regard, DStretch Software was used to digitally process images, which enhanced the clarity of some faded and heavily weathered motifs and revealed more of their details. The results of the study show that the motifs of this site were executed through various techniques, including deep engraving, deep pecking, and shallow pecking. Also, the degree of weathering, patina development, and surface deposition on the rocks indicates that these motifs belong to different chronological phases and were probably created in several stages. The use of digital methods in this research showed that modern technologies can significantly contribute to the documentation, preservation, and analysis of rock art, and pave the way for a more detailed analysis of this valuable cultural heritage.

Keywords: Iran, Rock Art, Petroglyphs, Digital Documentation, DStretch.

چکیده: در دهه‌های اخیر، مطالعات هنر صخره‌ای در ایران با رشد چشمگیری همراه بوده و محوطه‌های متعددی از نقاط مختلف کشور شناسایی و معرفی شده‌اند. در جریان بررسی‌های باستان‌شناختی شهرستان بوانات نیز چندین محوطه دارای نگاره‌های صخره‌ای شناسایی شد. چشم‌انداز کوهستانی این منطقه و وجود سطوح سنگی مناسب، بستر مطلوبی را برای خلق نقوش صخره‌ای در دوره‌های مختلف فراهم کرده است. یکی از مهم‌ترین این محوطه‌ها، محوطه کهتویه در جنوب شهر بوانات است که شمار قابل توجهی از نگاره‌های صخره‌ای بر روی سطوح سنگی آن مشاهده می‌شود. با توجه به اهمیت هنر صخره‌ای در بازسازی جنبه‌هایی از اندیشه، نمادپردازی، باورها و شیوه زندگی جوامع گذشته، پژوهش حاضر با هدف مطالعه و تحلیل نگاره‌های این محوطه انجام شده است. افزون بر این، پژوهش بر نقش و اهمیت بهره‌گیری از فناوری‌های نوین در مستندسازی دیجیتال میراث فرهنگی و دستیابی به تحلیل‌های دقیق‌تر از آثار باستانی تأکید دارد. در این راستا، از نرم‌افزار *DStretch* برای پردازش دیجیتالی تصاویر استفاده شد؛ روشی که موجب افزایش وضوح برخی نقوش محو و به‌شدت فرسوده گردید و جزئیات بیشتری از آنها را آشکار ساخت. نتایج این پژوهش نشان می‌دهد که نقوش این محوطه با بهره‌گیری از شیوه‌های فنی گوناگونی از جمله کنده، کوبش عمیق و کوبش سطحی اجرا شده‌اند. همچنین میزان فرسایش، شکل‌گیری پتینه و رسوبات سطحی بر روی سنگ‌ها نشان می‌دهد که این نقوش به دوره‌های زمانی متفاوت تعلق دارند و احتمالاً در چند مرحله و طی بازه‌های زمانی مختلف ایجاد شده‌اند. کاربرد روش‌های دیجیتال در این پژوهش نشان داد که فناوری‌های نوین می‌توانند نقشی مؤثر و تعیین‌کننده در مستندسازی، حفاظت و تحلیل هنر صخره‌ای ایفا کنند و زمینه را برای شناختی دقیق‌تر و همه‌جانبه‌تر از این میراث فرهنگی ارزشمند فراهم سازند.

کلیدواژه: ایران، هنر صخره‌ای، سنگ‌نگاره‌ها، مستندسازی دیجیتالی، DStretch.

I. Introduction

Rock art is one of the most important manifestations of symbolic and visual expression in human societies, and since it is a reflection of the thoughts, beliefs, rituals, and lifestyles of past people, it has special importance in archaeology, anthropology, history, and social science studies. In many prehistoric and historical societies, due to the lack of written texts or the limited archaeological findings, rock art is the only direct source for understanding the cognitive world and symbolic systems of past humans. This art was created extensively in different regions of the world, and its evidence can be seen from various time periods, from prehistoric times to historical and even contemporary periods.

In general, rock art can be classified into three main groups: petroglyphs, pictographs, and geoglyphs (Clottes, 2008; Deacon & Agnew, 2012). In the first type, motifs are created by engraving, deep pecking, and shallow pecking on the surface of the rock, while in pictographs, motifs are drawn on the rock surface using pigments. Although both methods have been observed in different parts of the world, petroglyphs are more

abundant in many arid and mountainous regions, including Iran. This is probably due to their ease of creation and their greater resistance to natural weathering processes. To create pictographs, pigment preparation and prior planning were necessary, while petroglyphs were created only using simple stone or metal tools and by striking the surface of the rock. In addition, pictographs are more vulnerable to natural erosion than petroglyphs and have not survived in many areas. Iran, due to its mountainous landscape and the widespread presence of rock outcrops, is considered one of the regions prone to the formation of rock art, and over the past few decades, numerous sites have been identified from different parts of the country (e.g., Moradi et al., 2013; Karimi, 2014; Karimi et al., 2016; Mohammadi Sefidkhani & Sarhaddi-Dadian, 2022; Khanipour, 2024a-b; Salimi & Azizi Kharanaghi, 2025). For a long time, rock art in Iran was considered of little importance, and even some researchers considered many of these motifs to be modern productions and devoid of archaeological value. As a result, research has been largely limited to the general introduction and description of sites. However, in the last two decades, the importance of rock art in reconstructing aspects of the culture, ideology, subsistence, and social interactions of past societies has received increasing attention (e.g., Sarhaddi-Dadian et al., 2015; Sarkhosh et al., 2015).

Along with this development, the use of digital technologies in the documentation and study of rock art has also expanded. Nowadays, methods such as digital imaging, photogrammetry, image processing (Trinks et al., 2005; Domingo et al., 2013; Plisson & Zotkina, 2015; Horn et al., 2022; Karimi, 2024) and laboratory analyses play an important role in recording, preserving, and analyzing these works more accurately (Chalmin et al., 2003; Aubert et al., 2007; Beck et al., 2012; Bonneau et al., 2017). One of the most widely used software in this field is DStretch, which allows the detection and enhancement of faded and worn motifs through digital image processing (Quellec et al., 2015; Quesada & Harman, 2019). This technology is particularly effective in studying motifs that are difficult to see due to erosion, sedimentation, or discoloration of the rock surface, and can help to record and document data more accurately. During the archaeological surveys conducted by the first author in Bavanat city in 2015, several rock art sites were identified, indicating that this area has a high potential for studies related to rock art. One of the most important of these sites is the Kahtooye Site in the south of Bavanat city, where numerous motifs can be seen on its rocks. Given the importance of these findings, the present study aims to introduce this site, investigate the techniques for making the motifs, classify the motifs, and present their relative chronology. This study also attempts to provide better recording, documentation, and interpretation of the motifs by utilizing digital methods and the DStretch software.

Accordingly, the main research questions are: What techniques were used to create petroglyphs at the Kahtooye site? How can the iconographic patterns and combinations of rock art motifs at this site be classified? And to what extent can digital technologies and image processing software be effective in recording, revealing, and more accurately analyzing the rock art at this site? In order to answer these questions, data from archaeological surveys of the Kahtooye site will be analyzed, and the types of motifs along with their execution techniques will be introduced and examined.

II. Archaeology of the Bavanat River Basin

The Bavanat River Basin is located in the northeast of Fars Province and consists of a relatively narrow valley with a length of approximately 60 km. The Bavanat River originates from the surrounding highlands and mountains and flows through this valley, eventually draining into the plains and the drier regions of eastern Fars, extending toward the Marvast Desert. This natural structure, namely the combination of a longitudinal valley, stable water resources, and a network of seasonal and permanent springs, has created a distinct environmental setting in the region.

The presence of permanent water and diverse natural resources in the Bavanat River Basin has made this region a suitable habitat for the settlement of human societies since Prehistory, particularly since the Neolithic period (Khanipour & Abe, 2025). Access to water, agricultural lands, natural pastures, and the valley's geographical location have provided the basis for the formation of permanent and sometimes seasonal settlements, making this region one of the important centers of human-environment interaction in southern Iran. The first archaeological studies in this basin were conducted by Stein (1936), during which limited surveys were conducted on some prehistoric sites, including Shahabad and Chir. Subsequently, in 2015, targeted and systematic archaeological surveys were conducted by the first author in this region, which led to the identification of about 200 archaeological sites (Khanipour et al. 2025). These sites were assigned relative dates from the Neolithic to the late Islamic periods based on surface assemblages, including pottery and stone tools. The results of this study showed that the Bavanat Basin has a long and continuous sequence of human settlement and has played an important role in the settlement patterns and population movements in different historical periods.

Culturally, in the prehistoric period, this area was strongly influenced by the Fars cultural area, and its material characteristics are comparable to the cultural traditions of southern Iran. In the historical and Islamic

periods, this area was always considered part of the cultural and administrative territory of Fars and played a role in the interaction networks between the mountainous areas and the adjacent plains (Khanipour, 2025).

During these field studies, in addition to the settlement sites, several examples of rock art were also identified, all in the form of petroglyphs. These petroglyphs have been observed in various parts of the valley and on natural rock outcrops, and include thematic categories such as zoomorphs, anthropomorphs, and unknown shapes. The presence of this rock art alongside numerous settlements indicates a deep connection between the natural environment, human subsistence patterns, and symbolic expressions throughout the long history of habitation in the Bavanat River Basin.

III. The Kahtooye Rock Art Site

The Kahtooye Rock Art Site is located about 200 meters south of the city of Bavanat, in the southern part of the Bavanat River (Fig. 1). This part of the southern Bavanat basin has several natural mounds and outcrops that are located along the Khataban Mountain Range. Within these mounds and also in the lower part of a mountain called "Khatun", on the surfaces of these outcrops, a variety of petroglyphs have been identified. One of the most important of these outcrops is a mound known as "Kahtooye or Kahtun", on whose smooth horizontal and vertical surfaces, more than 50 rock art motifs have been identified (Fig. 2).

These petroglyphs are found in two forms: some are created singly on a rock surface, and others are grouped as a series of several motifs. In some of these series, newer motifs are carved on top of older motifs, which may indicate repeated use of the site at different times. Such overlap in rock art is often interpreted as an indication of human occupation continuity, changes in iconographic traditions, or changes in the function and meaning of the motifs over time.

III.1. Motif Types at Kahtooye Site

The petroglyphs identified at Kahtooye Site include zoomorphic, anthropomorphic, and unknown shapes. Among this collection, anthropomorphic motifs are few in number, with only three examples identifiable. The first anthropomorphic motif occurs as a single isolated figure, and the body parts are depicted in a simple, schematic manner. The figure's arms are fully extended to the sides, and the left leg is slightly raised and bent. In this petroglyph, the palms and fingers are exaggeratedly larger (Fig. 3, No. 2).

The second anthropomorphic appears to be more complete and relatively accurate in terms of execution. In this example, the body, arms, and legs are more clearly formed, but the head is only represented by a few pecking strokes, and the facial details are not fully discernible. The legs are slightly apart, and the hands are shown open. On the left side of this petroglyph is also a zoomorphic motif that suggests a possible symbolic or narrative relationship between humans and animals (Fig. 3, No. 3). The third anthropomorphic motif probably depicts a horse-riding scene. In this motif, the animal's body is clearly recognizable, and in its upper part, a motif that seems to represent a human head and torso can be seen. The person is holding an object (Fig. 3, No. 1).

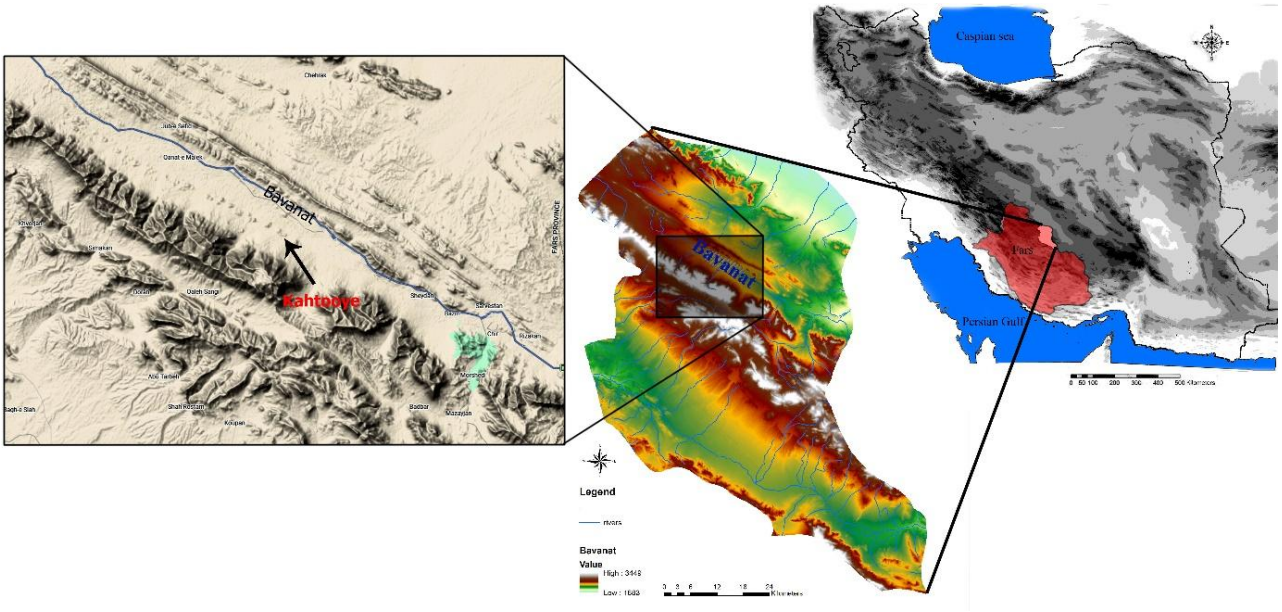

Figure 1: Geographic setting of the Kahtooye site.

Figure 2: Overview of the Kahtooye site.

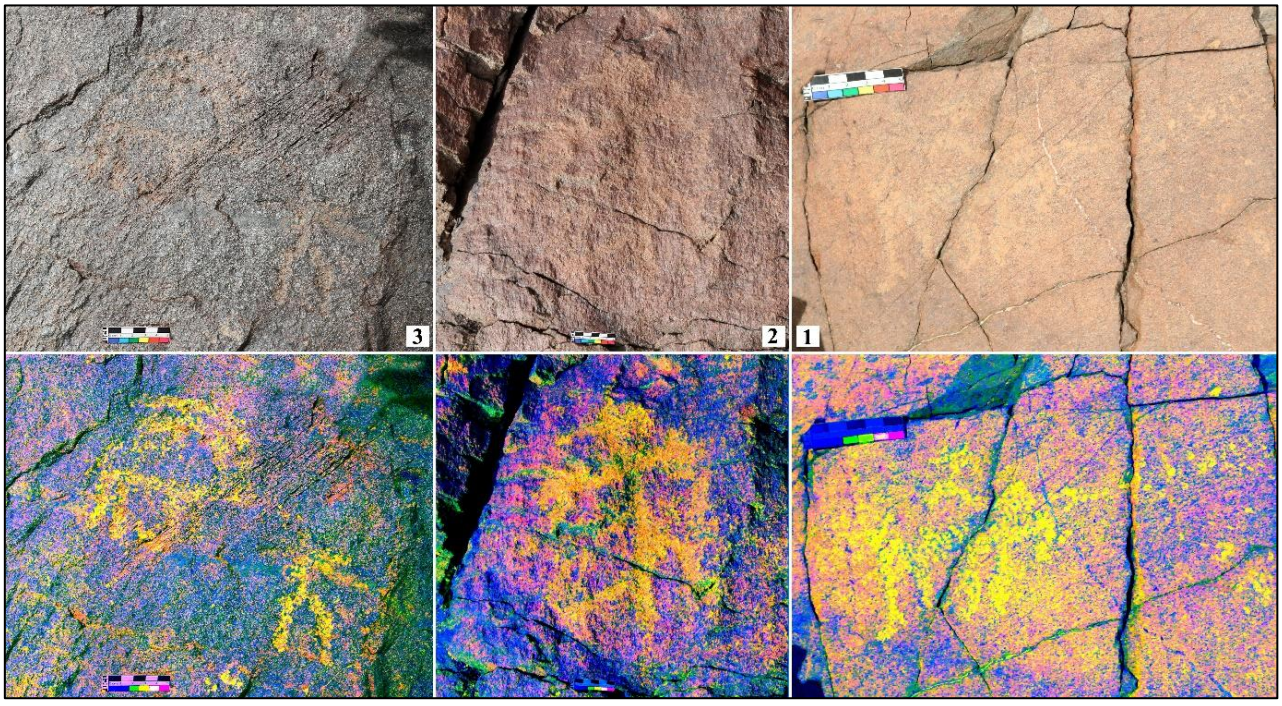

Figure 3: anthropomorphic motifs documented using digital photography and enhanced through DStretch processing (YBK mode).

The most frequent category identified at Kahtooye is zoomorphic motifs (Fig. 4). The widespread presence of animal motifs is one of the characteristic features of Iranian rock art (Karimi et al., 2020), and in many petroglyph sites, zoomorphics are the most common pictorial subject. This importance is also observed in other artistic manifestations of prehistoric Iran; For example, during the Bakun Period in Fars, potters painted a variety of zoomorphic motifs on pottery (Langsdorff & McCown, 1942; Alizadeh, 2006).

Animals, especially caprines, held a significant place in the subsistence, beliefs, and worldviews of past societies.

At Kahtooye Site, all identified animal motifs belong to caprines, and unlike some other sites, the diversity of animal species is not seen in this collection. This could indicate the economic or symbolic significance of caprines for the inhabitants of the region. The predominance of caprine motifs may suggest a close association with pastoral lifeways whose lives and subsistence strategies were directly related to livestock and caprine farming. The animal motifs of Kahtooye Site are executed in two stylistic modes: schematized and stylized. These motifs mainly consist of curved, horizontal, and vertical lines that form parts such as the horns, body, and legs of the animal. The most important difference between these motifs is observed in the way the horns are represented; Three main motifs can be distinguished: oblique horns, slightly curved horns, and wavy or curved horns (Fig. 5).

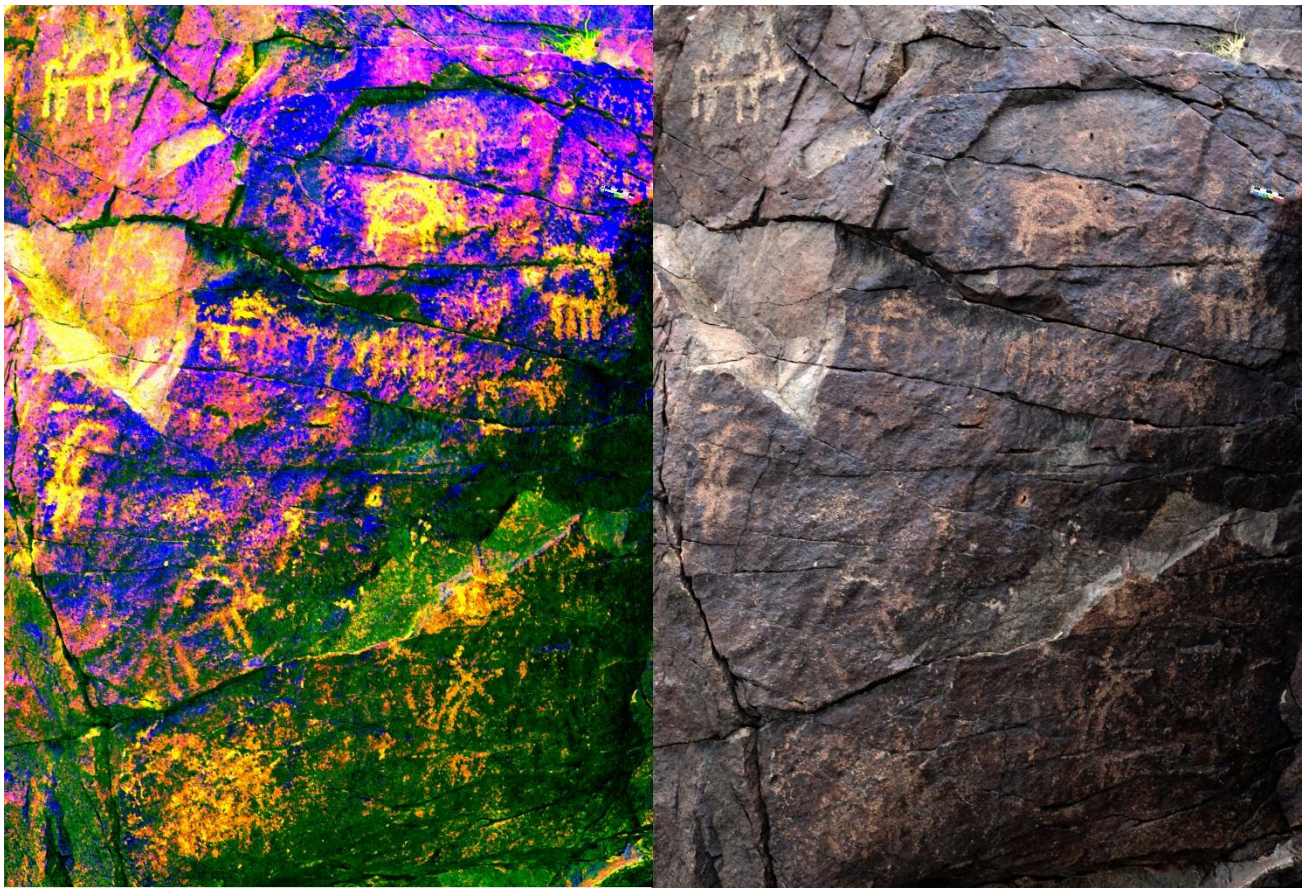

Figure 4: Zoomorphic motifs documented using digital photography and enhanced through DStretch processing (YBK mode).

These differences may be due to stylistic variations, time differences, or even references to different species of caprine. The animals are often depicted standing, but in some cases, they can also be seen moving or grazing (Fig. 6). The dynamism of some of these motifs shows that the artist was not only interested in the symbolic representation of the animal but also tried to represent its natural behavior. Further, in the Kahtooye Site petroglyphs, several motifs are observed that lack a specific, identifiable form and cannot be definitively placed in the categories of zoomorphic, anthropomorphic, or geometric motifs; therefore, this category is classified in the present study as "Unknown shape." These motifs often consist of scattered lines and irregular strokes that do not suggest a specific, meaningful pattern (Fig. 7). Several possibilities can be put forward regarding the nature of these motifs. The creator may have originally intended to create a specific motif, but for reasons such as the incomplete execution process, the stone surface cracking, or a change of idea, the motif was left unfinished. It is also possible that some of these works were not created with the aim of creating a specific image and are more the result of experimental strokes, engraving practice, or an action without a specific visual purpose. In some rock art studies, such patterns are interpreted as part of the process of experimenting with the stone surface or testing engraving tools. Therefore, although these motifs lack obvious visual meaning, they can provide researchers with important information about the production techniques, behavioral practices, and human interaction with the rock surface.

Figure 5: Zoomorphic (Caprine) motifs with varying horn shapes

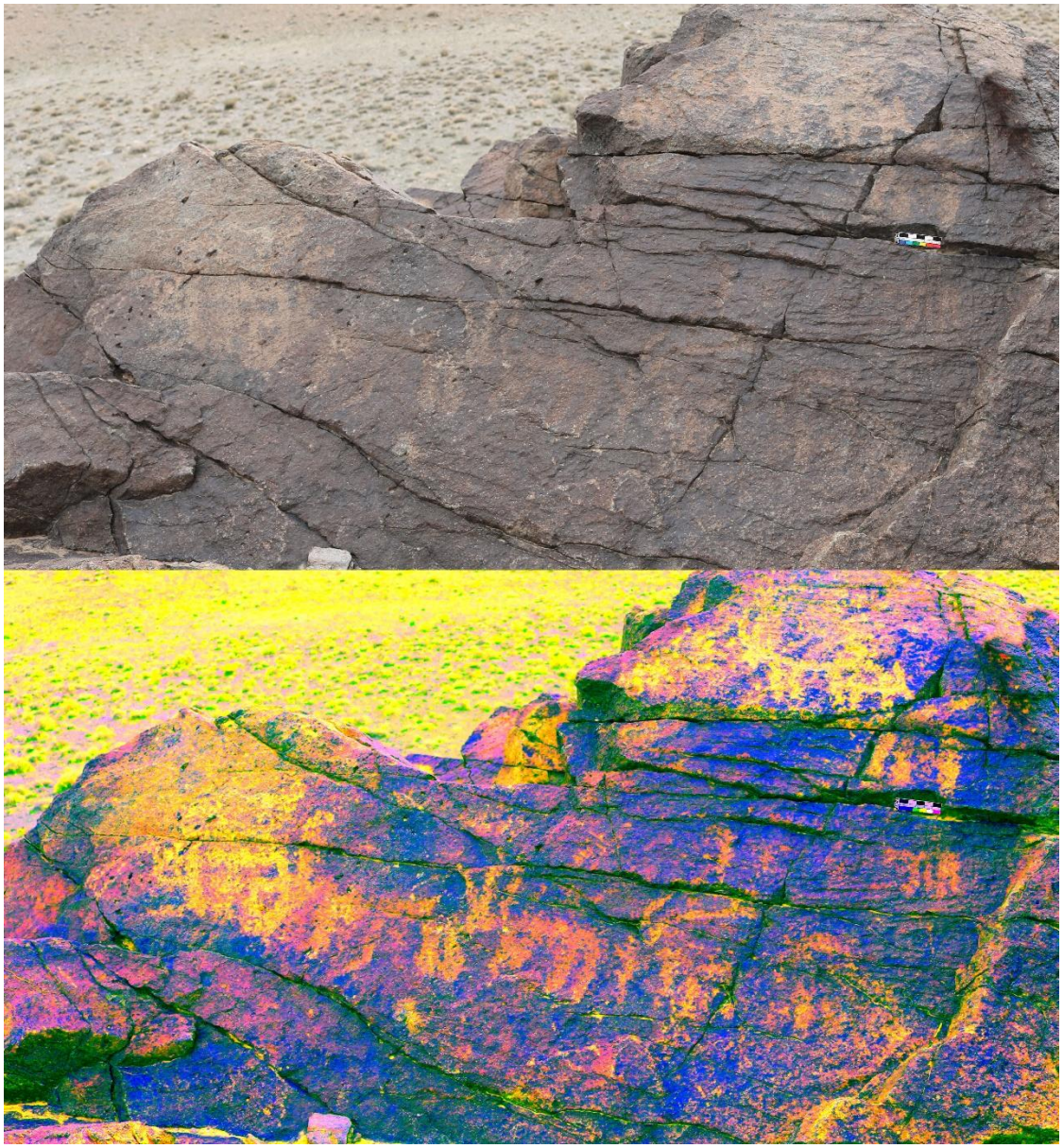

Figure 6: Zoomorphic motifs documented using digital photography and enhanced through DStretch processing (YBK mode).

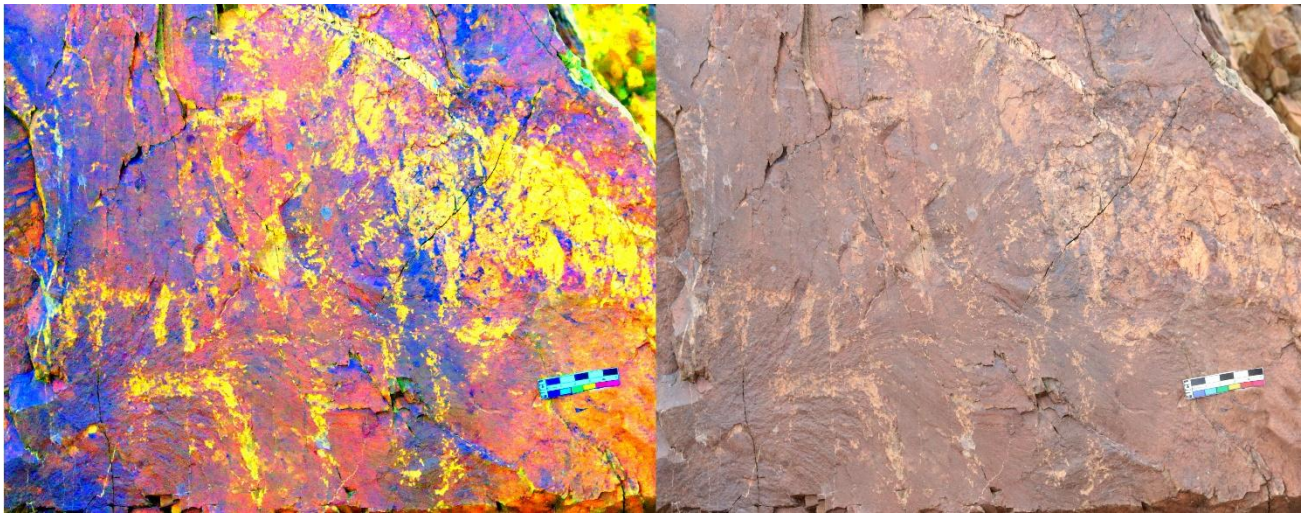

Figure 7: Unknown shape and zoomorphic motifs documented from the rock art assemblage.

IV. Techniques of Petroglyph Production

As mentioned, during the Archaeological Survey of the Kahtooye Site, more than 50 petroglyphs were identified, which can be classified into three technological categories in terms of production technique. The technological diversity of these motifs, in addition to showing the technical skill and technical expertise of the creators, can indicate chronological differences, functional variations, and even cultural variability between different periods of petroglyph creation.

IV.1. Deep Engraving

The first method involves creating motifs with a depth of at least 2 millimeters. The main feature of the motifs of this group is that the motifs were created by direct incision into the rock surface, in such a way that the border lines of the motifs are carved first and then the interior of the motif is further shaped by removing additional portions of the rock surface. In the end, a noticeable difference in surface level is observed between the motif and the background rock, which makes the motif more prominent. This method requires more time, precision, and technical skill than other methods and was probably done using hard stone tools or metal implements.

In many studies of rock art, the deep engraving technique is known as one of the earliest petroglyph production techniques. Over time, natural factors such as wind, rain, temperature changes, and sedimentation cause gradual erosion of the surface of the rock. Therefore, the degree of erosion and the formation of a thicker patina on the motifs of this group in the Kahtooye can be an indication of their relative antiquity. In addition, the greater depth of the grooves has increased the preservation potential of these motifs against natural weathering, allowing them to remain identifiable.

IV.2. Deep Pecking

The second method involves creating motifs through repeated pecking of the rock surface. In this method, the motif is produced by a series of successive blows delivered to the rock surface with a hammer stone or a similar tool, creating a rough and uneven texture composed of numerous small impact marks. Unlike deep engraving, the individual peck marks remain clearly visible on the surface of the motif. Also, the depth of this technique is usually less than that of deep engraving.

Most of the motifs found in Kahtooye were produced using this technique. This method is known in rock art studies as one of the most common methods of creating petroglyphs in mountainous regions because it was faster to perform than full engraving, and at the same time allowed for the creation of larger motifs. The presence of repetitive pecking marks on the surface of the motifs of this group can provide valuable information about the type of tool, the hand movements, and even the skill level of the artist. Also, since part of the stone surface is destroyed and roughened in this method, the rate of sediment accumulation and patina formation is different from that of engraved motifs. For this reason, a comparative study of the rate of erosion and sedimentation in this group can be effective in determining the relative chronology of the creation of motifs.

IV.3 Shallow Pecking

The third method involves shallow pecking of the rock surface. In this method, the motif is created through light and repeated blows that remove only the outer patinated surface of the rock without producing a significant depression in the bedrock. As a result, the impact marks are still visible, but the motif is defined mainly by the contrast between the lighter exposed rock surface and the darker surrounding patina. As a result, the petroglyphs have very shallow and relatively fine lines, and there is no noticeable surface relief between the motif and the background. This technique is simpler and faster to execute compared to the other two methods. Since this method does not create a deep depression in the surface of the stone, the resulting motifs are more susceptible to

being covered by patina, natural sediments, and environmental erosion. For this reason, these motifs are more difficult to recognize in many petroglyph sites. However, in the Kahtooye site, the lower amount of patina on these motifs compared to other techniques may indicate their more recent age.

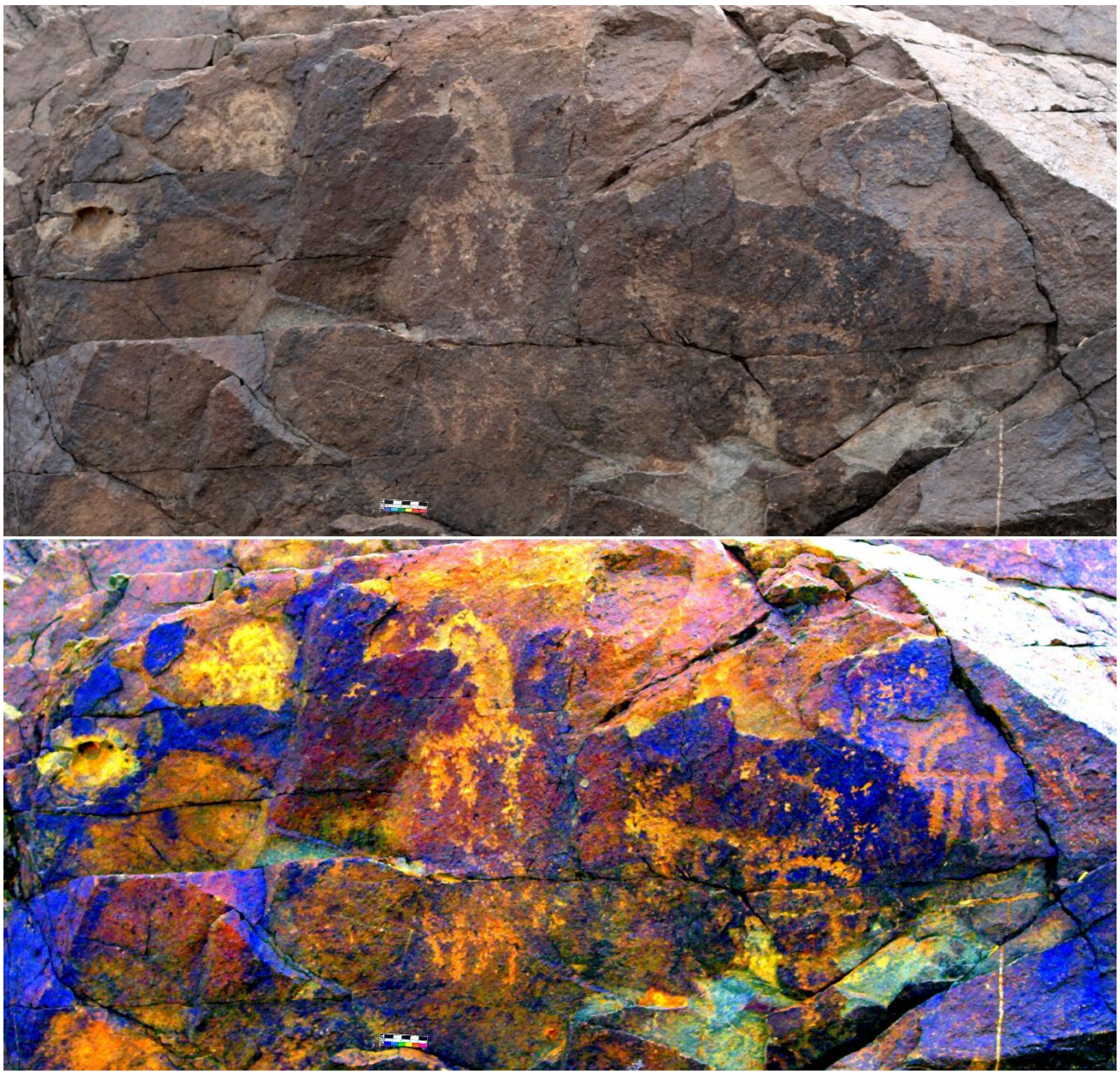

Figure 8: Anthropomorphic motifs created using deep pecking and shallow pecking techniques.

V. Chronology of the Kahtooye Petroglyphs

Rock art dating has always been one of the most important and at the same time most complex topics in rock art studies. Unlike many forms of archaeological evidence, including pottery assemblages, whose decorative and morphological features usually belong to specific cultural periods and facilitate comparative dating, no such consistent chronological framework exists in rock art studies. In many regions, human groups have used similar motifs and styles in different periods; Therefore, the stylistic similarity does not necessarily indicate their synchronicity. For this reason, comparative dating in the study of petroglyphs has many limitations, and it is not possible to determine the precise date of the motifs based on stylistic similarities alone. As mentioned, most motifs at Kahtooye are zoomorphic in type, that is, caprines with long horns. Among the archaeological findings of Fars in the Bakun Period, such motifs were commonly depicted on pottery; although there are formal similarities between these motifs, their direct comparison between the two may be misleading. On the other hand, directly associating rock art sites with nearby settlements is often problematic. The presence of a settlement site near the petroglyphs does not necessarily mean that the motifs belong to the same society or period, as nearby settlements may belong to periods before or after the creation of the motifs. This is also true

for the Kahtooye Site. Archaeological surveys show that evidence of human occupation exists around this site from the Chalcolithic period to the late Islamic period and even the contemporary period. Therefore, the precise age of the motifs cannot be determined based on settlement data alone. However, some technical and environmental evidence allows for a relative chronology for the Kahtooye motifs. Differences in the degree of patination, the degree of erosion, the depth of the lines, and the production techniques indicate that these petroglyphs were probably created in different time periods. The motifs produced using the engraving technique are probably older due to greater erosion and heavier patination (Fig. 5, Nos. 5 & 8). In contrast, some of the shallow pecking motifs, due to less patina and clearer line visibility, are probably from later periods (Fig. 5, No. 1). In addition, the gradual cracking of the rock surfaces on which the motifs were created indicates that these motifs have been exposed to natural factors for a long period and cannot be regarded as recent creations. Technological and stylistic analyses also suggest that the site was used over multiple periods and that the rock art tradition continued there over time. Variations in techniques, execution quality, and the degree of erosion may reflect the presence of different human groups or changes in the function and meaning of the motifs over time. According to archaeological data from the Bavanat region, no site older than the Neolithic Period has been identified in this region. Accordingly, the available evidence suggests that the Kahtooye motifs are unlikely to predate the Neolithic period. Although it is not possible to determine the exact date of these motifs in the absence of absolute dating, the available technical, environmental, and archaeological evidence indicates that the Kahtooye petroglyphs were produced through repeated human activities over a long period and across multiple cultural periods.

VI. Digital Analysis and Documentation of Petroglyphs Using DStretch

The use of modern technologies in archaeological data recording and analysis plays a very important role in improving the accuracy of documentation and interpretation of cultural heritage, and this is especially important in rock art studies. In recent years, archaeologists have used advanced digital imaging techniques to improve the readability of rock art, one of the most important of which is DStretch Software (Quellec et al., 2015; Quesada & Harman, 2019). This tool is specifically designed for the analysis and enhancement of rock art images in the field of rock art. Enhancing and separating color spectra, it allows for the visualization of hidden details on the surface of the rock. Although DStretch is primarily used for identifying and analyzing pictographs, it has been shown in many cases that it can also be effective in improving the visibility and interpretation of petroglyphs. In the present study, the use of this software also played an important role in improving the visibility and documentation of the motifs, so that some motifs that were difficult to distinguish under normal visual conditions appeared much more clearly in the processed images. In fact, this software highlights the boundaries of motifs by creating color contrast between the natural rock surface and anthropogenic markings, allowing for better separation of motif elements.

The processing results showed that the use of color enhancement modes, particularly YDT (Figs. 9 & 10) and YBK (Figs. 3, 4 & 5), is more effective in revealing petroglyphs, especially motifs produced through engraving and pecking techniques. In these modes, the color difference between the background surface and the one produced by human activity is well enhanced, and the overall structure of the motif is more clearly visible. In contrast, some color combinations, such as YRE and YRD, may cause reduced visibility and even blurring of some details in the case of shallow pecked motifs, thus reducing the visibility of the motif.

In limited cases, it was also observed that modes such as YWE can be effective in better revealing deep pecking motifs, especially in cases where the depth of percussion marks and the differences in the texture of the stone surface are less clear. Therefore, the results of this study show that no single mode can be used for all types of motifs, and the selection of appropriate settings should be based on the production technique, weathering condition, and rock surface characteristics. Using tools such as DStretch not only increases the accuracy of field data recording and analysis but also allows for the enhanced visualization of parts of rock art that are difficult to identify under normal visual conditions. This shows that combining traditional archaeological methods with digital technologies can play an important role in advancing rock art studies and improving the quality of archaeological documentation and analysis.

VII. Discussion

The study of the petroglyphs at the Kahtooye Site shows that this site allows for multi-layered analysis not only in terms of technological variability and iconographic diversity, but also in terms of documentation and analytical methods. The results of field observations and digital processing indicate that the site was used during multiple chronological phases and that the petroglyph production tradition continued over time. Differences in execution techniques, including deep engraving, deep pecking, and shallow pecking techniques, the degree of patina development, and the degree of weathering intensity all together reinforce the assumption that the motifs were not produced contemporaneously but were formed in the context of a long-term cultural sequence. From a theoretical perspective, this diversity can be interpreted within the framework of Agency Theory, where the production of each motif is understood as the result of

deliberate human action within a specific social and cultural context. Differences in execution quality and technique selection may reflect differences in the social status of agents, skill level, or even different functions of the motifs. In this context, some deep and detailed motifs may have been associated with social memory or identity construction, while simpler and more superficial motifs may have been the result of individual, rapid, or informal actions. Further, the existence of unknown or incomplete motifs can be considered as part of the human creative process that has not necessarily led to the production of a final coherent image.

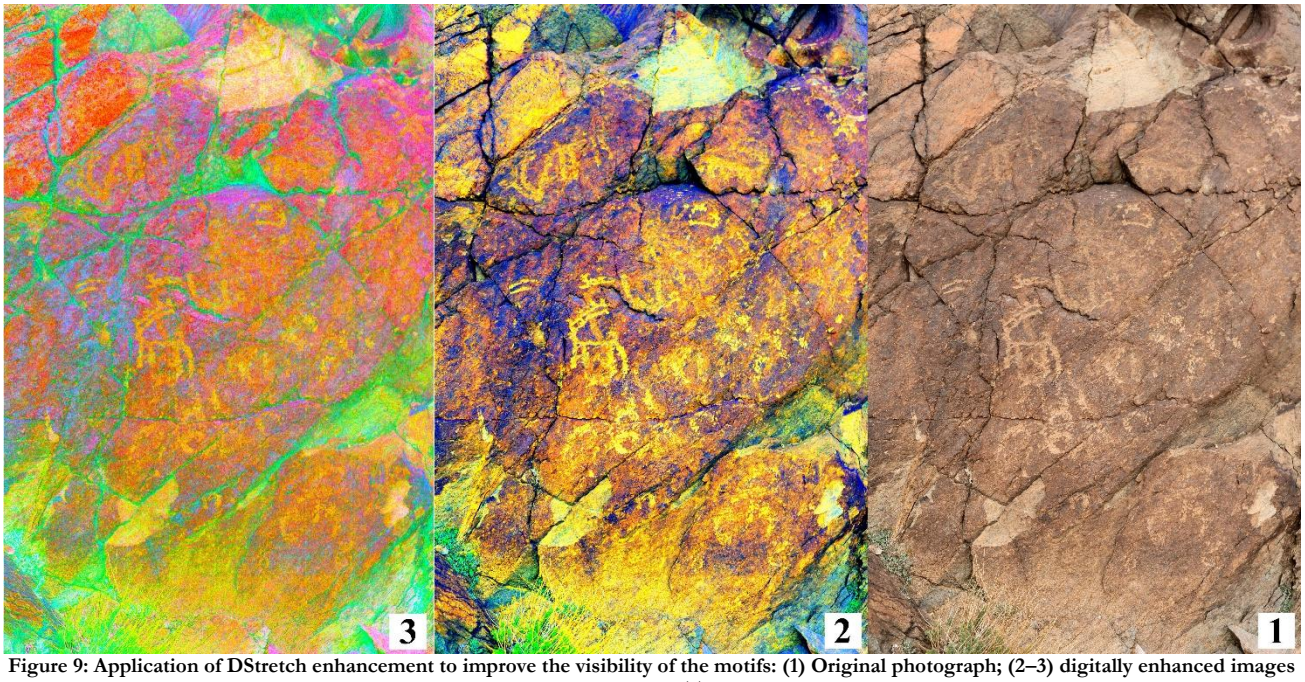

Figure 9: Application of DStretch enhancement to improve the visibility of the motifs: (1) Original photograph; (2–3) digitally enhanced images produced using DStretch in YDT (2), CRGB (3) modes.

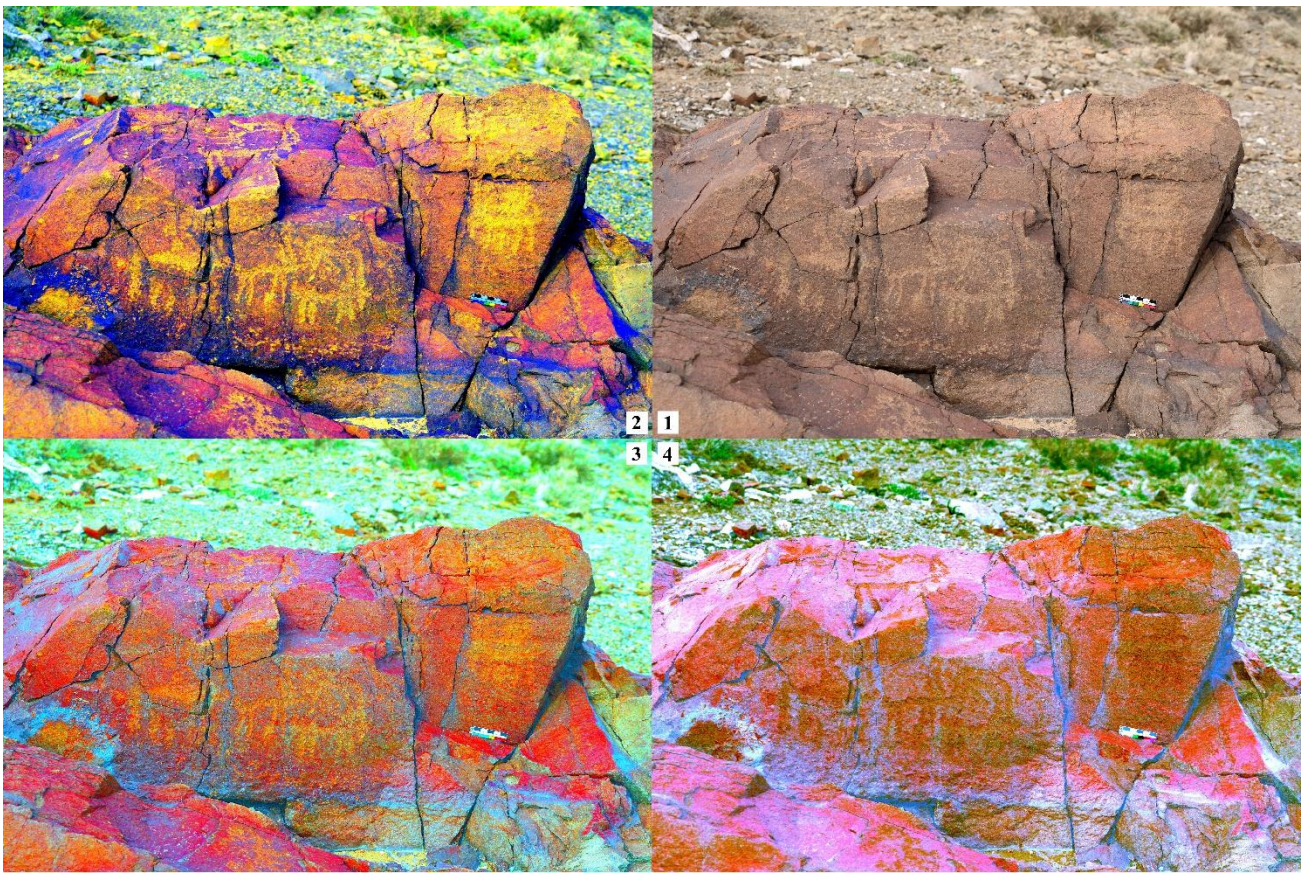

Figure 10: Application of DStretch enhancement to improve the visibility of the motifs: (1) Original photograph; (2–4) digitally enhanced images produced using DStretch in YDT (2), YRD (3), and YYE (4) modes.

In addition to these theoretical and technical analyses, the use of advanced imaging technologies, especially DStretch Software, has played an important role in improving data readability. This tool has enabled more accurate identification of faint or weathered motifs by enhancing the color contrast between the natural rock surface and anthropogenic modifications. The results showed that the YDT and YBK enhancement modes have the highest efficiency in revealing motifs, especially motifs produced through engraving and pecking techniques, while some modes, such as YRE and YRD, may reduce clarity and cause loss of detail in some cases. This emphasizes that the use of digital archaeological tools requires informed selection based on the type of technique and the condition of the stone surface. The combination of theoretical approaches, field observations, and digital processing in this study shows that rock art research is not simply a descriptive study, but rather an analytical and multidimensional process in which technical, behavioral, and technological data are brought together. As a result, the Kahtooye Petroglyphs can be considered not only as visual representations but also as reflections of human agency, cultural transformations, and continuous interactions between humans and their environment through time.

VIII. Conclusion

Archaeological research conducted in the Bavanat River Basin demonstrates the significant archaeological potential of this region, especially for petroglyph studies in Iran. Favorable environmental conditions, including the presence of sustainable water resources, the Bavanat valley, and environmental diversity, made this region attractive to agricultural and pastoral communities in various historical and prehistoric periods, resulting in the development of a diverse petroglyph assemblage. Among these sites, the Kahtooye Site, as one of the most important rock art centers in the region, has a special place in understanding the cultural and behavioral patterns of past societies.

The use of DStretch software played an effective role in increasing the visibility and interpretability of the motifs and enabled the identification of over 50 motifs with greater accuracy. These motifs include anthropomorphic, zoomorphic, and unknown shapes created on the rock surface using various techniques. Among them, caprine motifs are recognized as the most dominant petroglyphs, indicating the subsistence, symbolic, and cultural importance of this animal among the communities living in Bavanat across different periods; a motif that is also observed in many Iranian rock art sites. Although establishing an absolute chronology for these motifs is not possible, evidence such as motif superimposition, differences in erosion rates, and variations in patina levels indicates that this assemblage represents the result of a long-term, multi-phase process and cannot be attributed to a single chronological phase.

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