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Evaluating the Motifs and Pigments of the Charta Pictographs in Kuhdasht, Lorestan

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Abstract

Rock arts, especially pictographs, feature peculiar characteristics in the history of Iranian art. Most scholars regard them as a form of visual art. Given the long history of representation in rock art spanning the Paleolithic period up to the present, they have been considered from various archeological, anthropological, artistic, symbolic, and historical and decorative arts perspectives to pin down their themes, meanings, and date. The present work examines a series of pictographs from the Kuhdasht region of Lorestan using a combination of field, laboratorial, and library research approaches. Notably, this is the very first study in Iran addressing the pigments of pictographs at a rock art site. A popular local tradition holds that the ancient artists used a mixture of blood, oak syrup, and soot to prepare the paint used at the site. Hence, the motifs, rock types, and pigments of the Charta region were analyzed to characterize their chemical composition and the elements constituting the pigments. To this end, a Dino Light digital loop microscope was used, and point tests and petrography were then carried out using scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS). The elemental analyses revealed the nature of the red pigment. The motifs at Charta include representations of tools, geometric motifs, and human figures, portraying fighting or pre-fighting scenes. The chemical composition of the red pigment consisted of a high iron (Fe) content as well as smaller percentages of Ca, Mg, Al, and Si. The abundance of iron element detected in the elemental analysis of the specimen's surface and the intensity of the peaks related to the composition of iron oxide in the FT-IR spectra might more strongly indicate the presence of these compounds in the pigment.

Therefore, the pigments were mainly made of iron oxides, such as red ocher or hematite, magnetite, and magnesium. Thus, the artists invariably used highly durable and resilient mineral pigments, which based on the micrographs of the paint layer cross-sections were directly applied to the rock and, thus the absence of any sort of primer. No organic element was detected in the pigment composition.

Keywords: Charta Pictographs, Kuhdasht, Motifs, Petrography, SEM-EDS, FT-IR.

Article Type: Research Article

Introduction

Human groups have traditionally made used of paint in ceremonial rituals, artworks, and everyday life. Paints used at the caves of Chauvet and Lascaux in France, the Altamira cave in Spain, the Argentinian cave of the Hands, and Gale Las in Somalia, all typifying application of pigments in rock art, are considered the earliest uses of pigments by human (Sedghi *et al*, 2020: 71). In addition, important attestation of rock art have been found in Iran, in the northeast (Bash Mahalleh in Farouj, North Khorasan (Afshari, 2015), and Nargeslu and Teke in Bojnourd (Vahdati, 2010), the central plateau (Tang Tadvan and Tang Tihui in Jahrom Fars (Fazel, 2012), Abdouz in Firouzabad Fars (Ghasimi *et al*, 2014), and the Donbeh Mountain in Isfahan (Sadeghi *et al*, 2023b & Karimi, 2014), the west (Sohrab Spring in Kermanshah (Afshari, 2015), Mirmalas and Chalge Shaleh (Izadpanah, 1971), Sang-e Mehrdad and Qaleh Sorkhe (Sadeghi *et al,*

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2023a), the northwest (Aghdash in Mahneshan, Zanjan (Ali, 2013), the south and southeast (Bastak in Hormozgan (Bahador, 2001), Lar ashakurguyeh in Meymand, Kerman (Afshari, 2019), and Pirguran in Saravan, Sistan and Baluchistan (Sarhaddi, 2013). A most conspicuous rock art site, especially in terms of pictographs, occurs in the Central Zagros in Lorestan. This study evaluates the pigments of the pictographs recovered in the Charta region, Kushdasht, Lorestan. As a major factor contributing to an even increased value of the site, these pigments are likewise exposed to damaging factors. Hence, characterization of historical pigments and the processes involved in their formation has always been of great interest to scholars. Each pigment is characterized by a specific elemental composition and ratio of mineral phases. Most of the time, the main phases (i.e., the parts of rare pigment elements) allow for properly identifying the geographical origins (resources) (Bersani & Lottici, 2016: 521). In this respect, mineralogy directly relates with their origination and natural origin, and helps study the techniques and materials used in historical paintings (Hradil *et al,* 2003: 228). Notwithstanding their significance as a particular category of cultural data, experimental analysis of these pictographs has been neglected by archeologists.

Rock art representations in the form of human figures, tools, and symbols using a combination of carving and painting methods have been addressed by scholars from different descriptive, historical, and comparative perspectives. Diverse methods and devices that are today available for examining different categories of historical works offer fantastic opportunities to archaeometric and archaeological studies. A series of motifs were depicted in red paint on the smooth walls of the mountains of Lorestan. Chemical characterization of their paint and pigments is important not only from an archeological point of view but also from such perspectives of art history, historical understanding of artworks, understanding degradation processes, and even developing preservation methods, dating problems, and authorship attribution.

Sadly, pictographs have mostly fallen victim to natural destructive factors, and the few surviving instances are in a rather poor state of preservation. The present study addresses the as yet untackled issue of the identification of the techniques and materials used in the creation of pictographs in Iran. It is notable that the focus here is solely on pigment characterization, and therefore a thematic analysis of pictographs from archeological, a morphological investigation from art historical and visual arts, and comparative evaluation from chronological perspectives are not considered in this research. This study provides information on rock arts in the Central Zagros, and takes the first step towards the archaeometry of pictographs through chemical and microscopic analyses, attempting to lay the foundations for further experimental enquiries.

Research Question

Considering the wide use of pigments and colorant agents and development of pigments in different periods, the main question here is: What are the compositions of the bedrock and the pigments used in the pictographs at Charta?

History of Research

Many studies have covered rock art in Iran, especially pictographs of Lorestan, including those dealing with introducing the representations, comparative-historical analysis, symbology, and artistic aspects and proposing a morphology of the pertinent representations based on field and library research. Notable works include Izadpanah, 1969; Garajian *et al*, 2001; Otte *et al*, 2003; Afshari & Bashtani, 2020; Ahari-Mustafavi & Asadi, 2021; and Sadeghi *et al*, 2023b. Those inquiries addressing historical, morphological, and artistic aspects reveal that pictographs were probably inspired by Lorestan bronzes and the Kassites. Thematically, pictographs display narrative scenes of animal hunting or grazing wherein human figures are frequently seen mounted on horse, riding camel, or doing archery, or in battle settings wielding swords and spears. Composition and proportions and perspectives of the depictions suggest that, inspired from local environment, ancient artists intentionally and for religious or non-religious purposes created these rock art pieces using motifs that were either revered as totems or admired for their beauty, power or natural benefits (Sadeghi *et al*, 2023a). The known works published on an annual basis rarely deal with laboratorial investigations of pigments used for pictographs not only from Lorestan but from Iran in general. The only publication with a passing reference to the nature of related pigments dates to several years ago (Izadpanah in 1969–71), in which the author merely claimed that the pigments were made of iron oxide, an assertion not backed by any laboratory work. Previous scholarship on pigments mainly relate to wall paintings of the historical and Islamic periods. No published research has to date covered the pictographs of Kuhdasht through laboratorial techniques (petrography, FT-IT, SED-EDS), and this lacuna justifies studies like the present work.

Study Area

The pictograph site of Charta lies in the Sarsakhon mountain range in the Homian valley of Kushdasht, Lorestan (Figure. 1). Stretching from east to west, the mountain range is formed of cream limestone. The southern flank of these mountains hosts the pictographs of Mirmalas depicted on the walls of a rocky shelter. Ranking among the most fertile regions in Iran, the Homian valley is located at N: 33.65993 and E: 47.56414. The Charta region lies at an elevation of 1668 m above sea level. The fairly flat valley stretching below the Charta pictographs is covered with oak trees. A series of transhumant groups spend spring in the valley and return to Kuhdasht in summer. While the mountainous terrain makes farming rather difficult, the abundantly available water has given rise to rich pastures, making the region an ideal herding landscape. Thanks to its desirable climate, lavish pastures and seasonal meadows, high mountains, and such rivers as Seymareh, Keshkan, and Madian with copious water discharge, Kuhdasht used to serve as a destination for seasonal migrations of regional nomads. Concomitantly, Homian offers both a summer and a winter quarter, so that the northern Homian represents a winter resort, *qeshlaq*, and its southern districts serve as a summer quarter, *yeylaq*. The majority of the nomadic populations inhabiting the valley are currently practicing a sedentary life in their permanent small villages, while others either travel between their fixed seasonal settlements or have still retained their ancestral nomadic mode of life (Figure. 2). Historical sources suggest that in the Seljuk period, the people of Lorestan and Kuhdasht led a nomadic life with unfixed summer and winter quarters, and the local rulers (the Atabakans) had permanent residents in both regions (Safinejad ,1996: 439–447). In 1971, Clare Goff participated in the seasonal migration of the nomads of the Rumeshgan district of Kuhdasht to the Noorabad summer quarter. Along their travel route through the Sarsarkhan and Homian Mountains, she recorded and examined settlement and cemetery sites spanning in date the Neolithic to the Islamic period, demonstrating that the area offered a desirable habitat for semi-sedentary, sedentary, and nomadic communities from the remote past. She published her observations during this travel along with a map. Having passed the sites of Sorkh Dom-e Laki, Chagha Zargaran, and Chagha Gandam, at the entrance of the Diyala valley she reached a fork in the route, where in one direction lay the Seymareh River and the Hulian plain, while the other led to Homian and northern Kuhdasht through Sarsakhon Mountain and finally to Delfan and southern Noorabad, where lay the summer quarters of Noorali and Mirbeig tribes. Goff states that, “it is said that an abundance of bronze artifacts dating to the second millennium BCE derives from the Humian mountain” (Goff, 1971: 131–152). The pictograph site of Homian is on the northern flank of the Sarsakhon Mountain. The representations combine carving and painting techniques.

Description of Pictographs

Charta contains a total of 10 pictographs, which are carved into an extended, east-west orienting limestone formation in creamy color. These rock cut representations face north and show natural damages such as cracking. Most of them were further painted using a red ocher pigment in a stylized manner. Thus, they exhibit a combination of pictography and petroglyph, with the motifs first carved into the rock and then filled with a red paint, giving the impression of a 3D artwork. The pictographs were probably made with tools such as brushes, reed grass, or a sharp-edged brush-shaped object, as is suggested a number of delicate pictographs across the region. The area housing the pictographs measures approximately 70 x 50 cm, and includes a total of 10 depictions. Human figures, symbols, and tools are all depicted in a schematic manner. Human figures are invariably in the front view (Figure. 3), with a weapon akin to dagger or sword affixed at their waist. These invariably standing figures have their hands resting on the waist in most cases. Only in two instances, one hand hangs down along the side of the body and the other wields a sword in a fighting setting. There are four symbolic cross-shaped motifs that occur above or beside the figures’ head. In general, the depictions give the impression of battle scenes or martial scenes (in a garrison) related with a

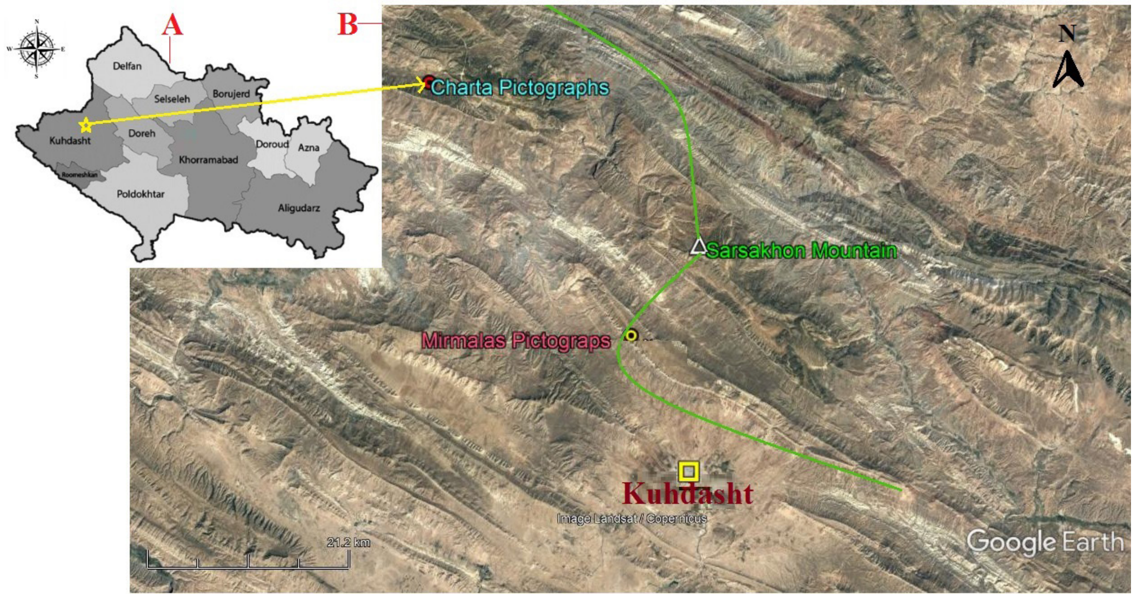


Figure. 1: *A. Provincial map showing the location of Charta pictograph site in Kuhdasht (After: Sepahvand et al, 2019: 89), B: satellite map of the pictographic sites of Charta, Mirmalas, and Sarsakhon Mountain in Kuhdasht (After: Google Earth, 2023/03/04).*

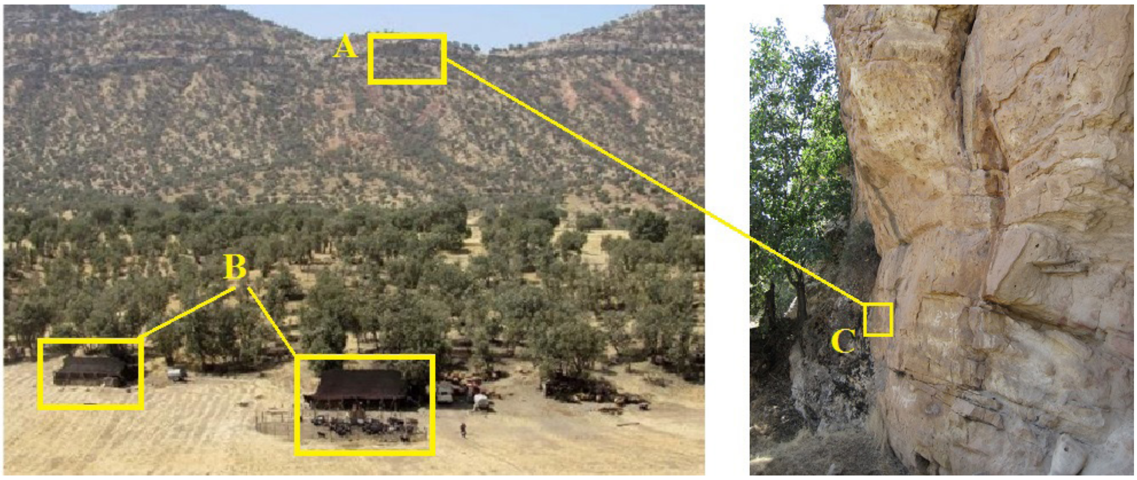


Figure. 2: *A nomadic camp in the Humian valley, at the base of the Charta pictograph site, Kuhdasht, Lorestan*

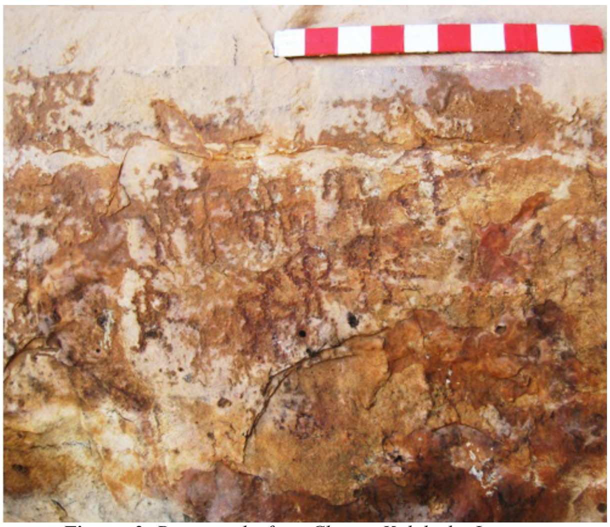


Figure. 3: *Pictographs from Charta, Kuhdasht, Lorestan*

particular ceremony or preparation for a battle. In terms of morphology and weapon type (stabbing dagger), the human figures are reminiscent of those on the Lorestan bronzes (Figure. 4). The drawings of the Charta pictographs are given in (Figure. 5). The depicted swords resemble those typically used by the Kassites, examples of which are kept in the National Museum of Iran (Figure. 6). As the main focus here is on the pigments of the representations, a detailed comparison and semiology of the motifs will require an independent study.

Figure. 4: *A metal statue with a dagger (dashneh) of Lorestan bronzes (After: Ghirshman, 1992: 58).*

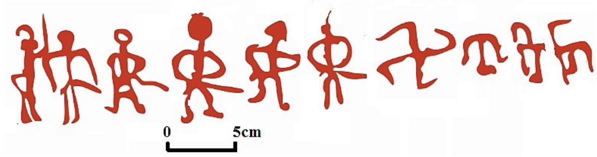


Figure. 5: *Linear drawings of the pictographs from Charta, Kuhdasht, Lorestan*

Figure. 6: *Kassite swords from Lorestan (After: National Museum of Iran).*

Methodology

For the past several decades, the use of various scientific fields, especially experimental sciences, has been popularized for the analysis of archaeological data.

Microscopic and chemical analyses pave the way for other empirical studies on pigments used in ancient remains. Specific pigments might be used in the paintings as a measure. A particular composition, mineral phase ratio, and various elements characterize each pigment. In most cases, the main phases, rare element composition, and special gradation (particle morphology) allow for precise determination of the geographical origin (source) of the pigments. One of these methods that can be used to analyze minerals is the petrography method, which has been used for more than a century in cultural heritage studies (Razani *et al*., 2015). Furthermore, SEM and FT-IR methods were used to identify pigments and their compositions in the Charta pictographs.

Sampling

The first-hand evidence used in this study was a powder sample taken from the Charta region of Kuhdash, Lorestan. Taking samples from stone layers is an important and delicate work because sampling from multiple layers is not easily feasible. Therefore, it is important to get an exact amount of the bedrock. In addition to the detached layers, the injured parts (i.e., big fractures) were sampled (mostly the end of the paintings). To this end, the samples were taken in very small amounts using pence and scalpel razors. All of the steps were taken without the direct use of hands and by wearing gloves to prevent contamination of the sample and improper identifications as much as possible. Generally, best effort was made to lower the destruction and gain the least samples. Samples were then coded using Latin letters. At Charta, the use of paint is not restricted to certain cases, and all the motifs and scenes are painted. To ascertain the pigments the Charta artists used to attain this red paint, specimens were sampled only from the damaged ends of the pictographs given the sampling limitations (Figure. 7). The specimens were then prepared for SEM-EDS analysis. All specimens were subjected to point tests to ensure more accurate results. Four points (A, B, C, and D) were selected for the tests (Figures. 7 & 8). Micrographs revealed that the paint layer was directly applied to the rock without any substrate preparation. The analysis of red paint specimens and their elemental percentages are reported below.

Equipment and Devices

The carved pictographs at Charta were further highlighted using a red paint. Several instrumental methods were used to characterize the nature of

Figure. 7: *Sampling location for experiment at Charta pictograh site, Kuhdasht, Lorestan*

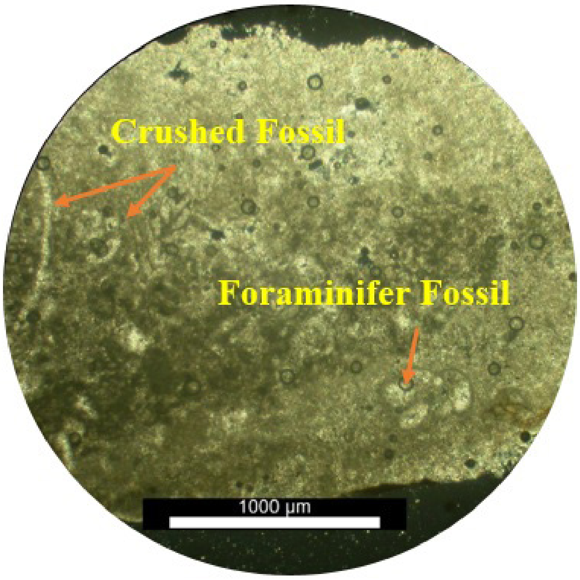


Figure. 8: *Micrograph of Specimen A-3, XPL light, 4X magnification, foraminiferal fossil and fossil remains in the matrix (After:Research Institute of Cultural Heritage & Tourism, Research Center for Conservation, Laboratory of Petrography, Tehran).*

the applied pigment. First, the thin-section method was employed to study the rock samples using a James Swift Co. polarized light microscopy (PLM) at a magnification of 4x. The thin-sections were prepared through simple cutting and abrasion to the standard thickness of 25–30 µm based on ASTM (2009). The main objective of the petrography was to identify two major components of the texture, including the matrix and the pigment type. Scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS) was used for point elemental analysis, which requires a very small sample, and the sample preparation process needs no particular chemical or physical methods. The SEM-EDS was a VEGA3 TESCAN made in the Czech Republic equipped with a Sirius SD elemental analysis device made in England. The analyses was conducted at the Central Laboratory of Tehran.

Furthermore, Fourier transform infrared (FT-IR) spectroscopic analysis was used to examine the main pigments and to supplement the previous tests. FT-IR is a laboratory technique that examines samples qualitatively (Hadian-Dehkordi, 2007). The spectroscopic test was performed with a NICOLET 510P FT-IR device made in the USA, with waves in the MIR range at the Tehran based Research Center for the Protection and Restoration of Historical and Cultural Artifacts.

Petrography

The sample was a cream limestone containing different foraminifera and crushed fossils (about 5% of the sample volume). The matrix consisted of a fine micrite calcite with limited microsparite. The voids were rare, and the texture was homogenous. A paint layer containing iron compounds is visible at the sample's margin (Figures. 8 & 9).

Following Folk's (1962) classification, the analyzed rocks can be described as a micrite limestone with fossil fragments and a fossil-containing microsparite.

As part of a structural study of the paint, samples were sent to the laboratory as a powder with traces and evidence of red pigment. In light of the microscopic evidence of pigments in the samples, the composition of iron oxide (hematite-ocher), which is the main mineral of the studied samples, is calcium carbonate (calcite). The studied rock samples proved to have a fine to granular texture, with their composition ranging from micrite (mudstone) to microsparite and sparite limestone. The samples are fossilized micrite rocks and variable biomicrite. The powder samples also have a carbonate composition, and micrite limestone is in evidence in them.

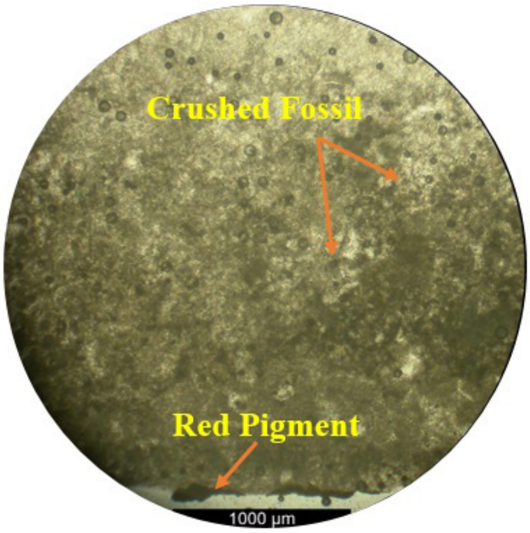


Figure. 9: *Micrograph of Specimen A-3, PPL light, 4X magnification, another view of the specimen, fossil fragments and paint layer at the specimen's edge (After:Research Institute of Cultural Heritage & Tourism, Research Center for Conservation, Laboratory of Petrography, Tehran)*

The sedimentary sequence and stratigraphy of Kuhdasht region includes various formations. Gorpi is the earliest formation in the region and other sedimentary sequences include Amiran, Telezang, Kashkan, Asmari-Shahbazan, Gachsaran, Imam Hassan, and Quaternary sediments. These formations are mostly composed of limestone shales, sandstones and conglomerates containing chert, which belong to the Cretaceous, Paleocene and Quaternary periods (Homke *et al*, 2010: 671). The area studied in this article is located in the folded Zagros region. This region, like other parts of Zagros, is stretched in a northwest-southeast direction and is between 150 and 250 km wide. The folded part is stretched parallel to High Zagros, which is separated from Central Iran by the Sanandaj-Sirjan belt metamorphic section (Maghsoudi, 2020: 78). Investigating this region from a geomorphological perspective is very important in the research, in order to check the compatibility of petrographic data with the chemical structure of the regional soil.

Geologists believe that most of the deposits are known and active mines today. Such minerals were known to and used by ancient communities as well. This is especially true for countries like Iran. The Keshkan Formation belongs to the Paleocene period. Taking its name from the Keshkan river in Lorestan province, its sample section is located in northwestern Poldokhtar, next to the Andimshek-Khorramabad road, and its thickness reaches 370 m in the type section (Games & Wynd, 1965: 2237). The largest spread of this formation is in the Lorestan region and it has conglomerate, sandstone and siltstone facies. This formation is located between the two geological formations of Asmari-Shahbazan at the top and Tele Zang at the bottom, and where there is no Tele Zang formation, it sits on top of the Amiran Formation. In the sandstone facies of this formation, an abundance of iron, silicon, and aluminum oxides, calcium, magnesium, uranium, and strontium is attested (Zareisahamiyeh *et al*, 2011: 55).

SEM-EDS

Table 1 presents the results of the elemental analysis of the red pigment for Specimen A3 from Charta. The main elements in this specimen, *viz*. Ca and Mg, belong to the rock layer. Al, Si, and K are elements that generally occur with the soils. The distribution map shows that the elements are more concentrated in the outer layer (Table. 1). Although Fe content was higher at Point A of the deeper layer (Figure. 10), the distribution map shows that the concentration is relatively homogenous across in all points (Figures. 11 & 12), suggesting that the Fe compound is related both to the red pigment and the impurities in the limestone. The spectrum resulting from the SEM-EDS elemental analysis of the red pigment used in the pictographs from Lorestan suggests that given the high iron content of this paint specimen, the iron oxide, *viz*. red ochre was used to create the red paint employed at the site (Figure. 13).

Table. 1: *Elemental analysis of Specimen A-3 (After: Central Laboratory of Iran Scientific and Industrial Research Organization, FE-SEM section)*

Elt	W%			
	1-6-A	1-6-B	1-6-C	1-6-D
O	35.60	53.63	49.83	48.58
Na	2.62	2.73	2.65	2.32
Mg	12.76	15.74	14.94	14.14
Al	5.37	2.31	4.71	3.07
Si	16.90	3.59	9.18	4.90
Cl	1.12	1.04	1.12	0.75
K	1.53	0.39	0.99	0.61
Ca	23.43	20.57	16.19	25.41
Fe	0.67	0.00	0.39	0.22

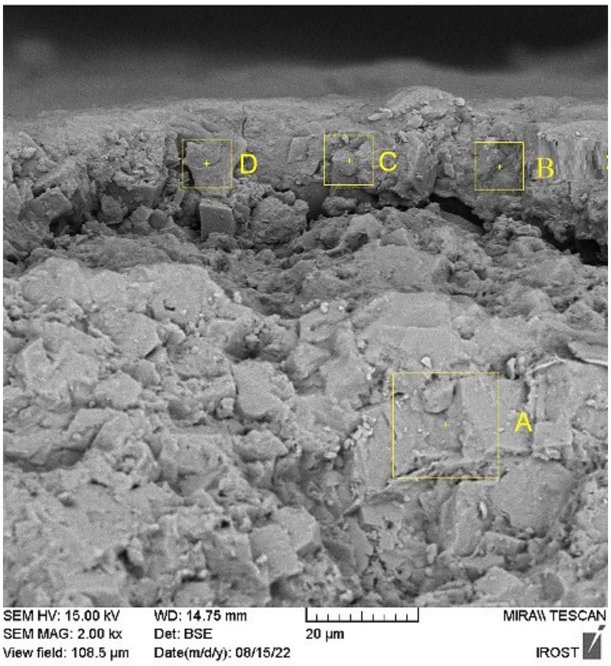


Figure. 10: *SEM-EDS photomicrograph of the red paint specimen, Charta pictograph site, Kuhdasht, Lorestan (After:Central Laboratory of Iran Scientific and Industrial Research Organization, FE-SEM section).*

Iron and manganese oxides are the most common materials used as pigments. These pigments are naturally found across the world in different shapes and forms. In the past, iron and manganese oxides have been most used as pigments. These pigments are obtained naturally and in different forms in all different regions of the earth. The range of iron oxide pigments is from dark yellow to red, crimson and brown. Its color elements depend on the degree of hydration of the mineral substance and also on the grain size of the particles, its shape and composition with other minerals. Also, the anhydration of iron oxides such as Fe_2O_3 causes the color of this substance to turn purple-red to dark red. Also, the hydration of iron oxides (such as: $Fe_2O_3.nH_2O$) causes its color to become yellow. Iron oxides are highly stable compounds against acidic, alkaline (weak to moderate) substances and also light radiation (Sedghi *et al*, 2020: 68). In the preparation of pigments used in color paintings, iron oxides are generally used in the form of red ocher or hematite, yellow ocher or limonite, and black color

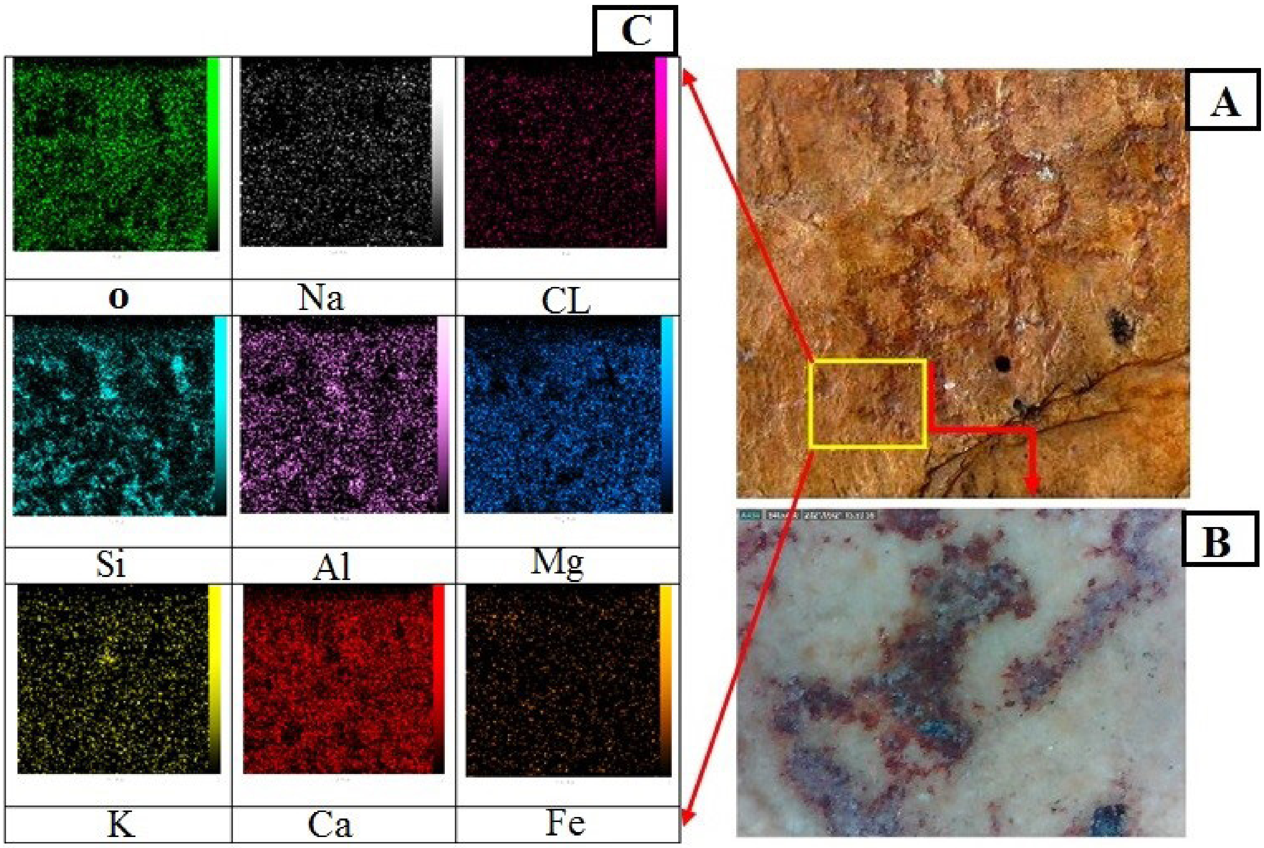
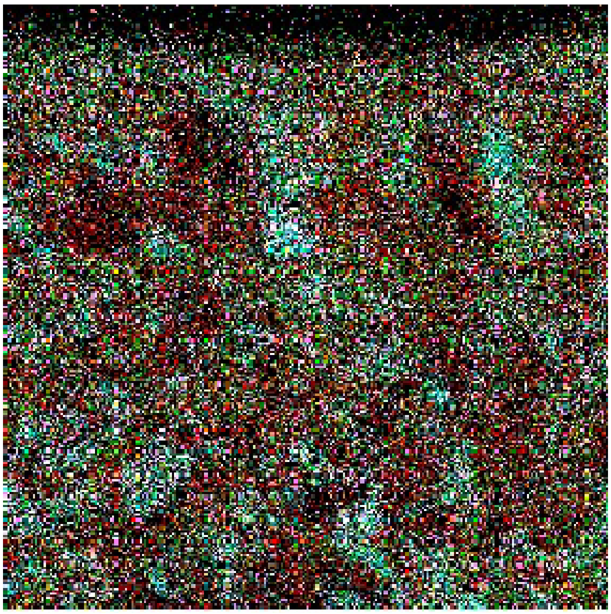


Figure. 11: *Distribution map of elements in the red paint sample, Charta pictograph site, Kuhdasht, Lorestan (After:Central Laboratory of Iran Scientific and Industrial Research Organization, FE-SEM section)*

of magnetite. These substances have been identified in many recent studies (Goodall *et al*, 2009: 99).

Evidence has shown that many prehistoric societies used iron oxide pigments in ceramic decoration. In addition, manganese oxides are also very important compounds in the group of mineral pigments, which range from yellowish brown to black (Rapp, 2009: 78). Also, these pigments have been used to decorate many prehistoric works. Therefore, according to the reddish color of the patterns of Lorestan province, and also by identifying and measuring the amounts of its elements, iron oxide is the main element followed by magnesium. Thus, one may safely posit that the base compound of the pigments used in these pictographs is iron oxide.



Coat

Figure. 12: *General distribution map of the elements in the red paint sample, Charta pictograph site, Kuhdasht, Lorestan (After:Central Laboratory of Iran Scientific and Industrial Research Organization, FE-SEM section)*

FT-IR Spectroscopy

Transparent pellets were prepared from the specimens using KBr at load of 10 ton. Spectra were obtained from the target specimen with a Nicolet 510P FT-IR device, in a range of 450 to 4000 cm-1 over 32 scans at a resolution of 4, which furnished the final spectra.

The abundant iron content seen in the results of elemental analysis on the surface of the sample and the intensity of the peaks related to the composition of iron oxide in the FT-IR spectra can indicate the presence of these compounds in the pigment. A carbonate (CO_3)-based compound is attestable in all the samples. In addition to its almost certainly belonging to calcium carbonate ($CaC0_3$), given the significant peaks at 712, 876, 1422, 1800 and 2517 the following probabilities can also be considered:

From the SEM-SDX report and petrography results, which confirm the presence of magnesium element and dumolite composition ($CaMg(CO_3)2$) in the sampled regional rocks, one may conjecture

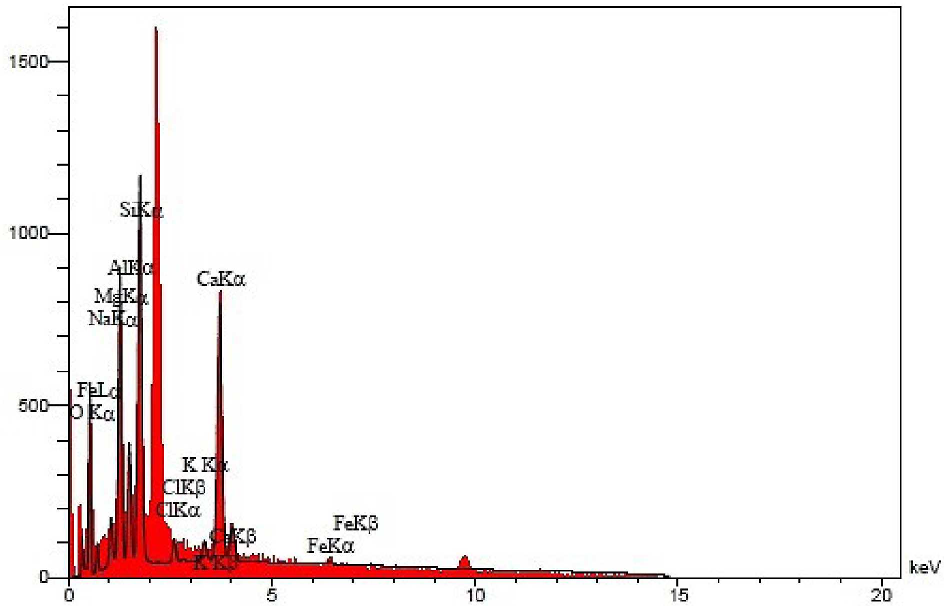


Figure. 13: *Elemental analysis spectrum of the red paint specimen sample, Charta pictograph site, Kuhdasht, Lorestan province by SEM-EDS method (After:Central Laboratory of Iran Scientific and Industrial Research Organization, FE-SEM section).*

that the peaks at 728, 882 and 1438 are related to this element.

Nonetheless, the presence of magnesium carbonate ($MgCO_3$) is also another possibility, which shows itself by the appearance of peaks related to this material at 714, 744, 800–886, 1484–1422, and 3648.

Based on the FTIR spectrum, and the absence of a peak at 711 as well as petrographic studies, the existing calcium carbonate can be considered of a non-crystalline type and biological origin.

As regards the silicate compounds, the presence of peaks at around 1100 and 790 might indicate their presence in the composition. If the peak at 790 appears as a bifurcation, our composition can be crystalline and quartz, otherwise it will be amorphous. This compound appears to be present in an amorphous form in the examined specimens. This composition type is visible in the FT-IR spectrum of the red paint specimen A3 (Figure. 14). Red paint has been in use since remote antiquity, and it is among the earliest artificially produced pigments (Mcbride, 2002: 235). It is noteworthy that at some Parthian sites, such as Qaleh-i Yazdigird, the red ocher was used for coloring. For example, Bollati identified the pigment on the terracotta sculptures recovered at the Parthian site of Nisa (Bollati 2008: 118). Also, the experiments at the British Museum showed that artists of Uruk used the same pigments for coloring plasterwork at this Parthian site (Simpson *et al*, 2010: 213). It seems that the same pigment was used in the coeval Kuh-e Khwaja pictographs (Batter, 2010).

Spectral bands at 1618 and 1321 belong to common frequencies of calcium oxalates, which naturally exist in limestone crust in the two forms of whewellite ($CaC_2O_4.H_2O$) and weddellite ($CaC_2O_4.{}_2H_2O$). Oxalates, often regarded as products of biological weathering, are attributed to the oxalic

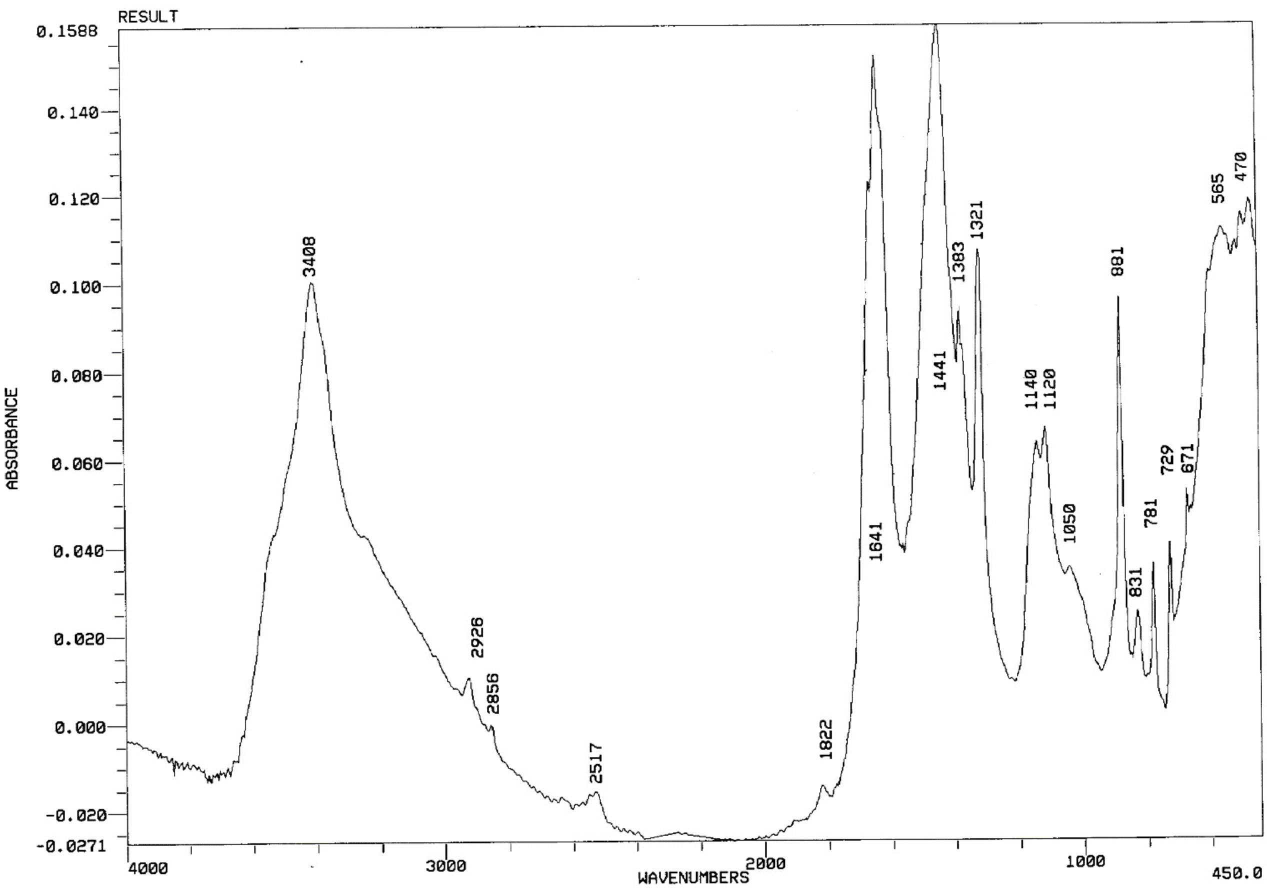


Figure. 14: *FT-IR spectrum in Sample A-3 with red pigment*

(After:Research Institute of Cultural Heritage & Tourism, Research Center for Conservation, Laboratory of FT-IR, Tehran).

acid produced by lichens or fungi on carbonate substrates. Calcium carbonate is precipitated as calcium oxalate. Hydrocarbons from industrial activities can also be reportedly converted to oxalic acid. The very weak intensity of the spectrum related to this material in the spectrum of the bedrock can corroborate this observation (Table . 2).

both the red pigment and the natural impurities of the limestone. Na and Cl can be attributed to the dissolved salt or table salt found all around the world. The compound penetrates the rock structure as nitrate.

From the related results of the SEM-EDX elemental analysis, which again confirm this assertion, one may conclude that hematite is (probably) also present in the bedrock structure. The abundance of iron content in the results of elemental analysis on the surface of the sample and the intensity of the peaks related to the composition of iron oxide in the FT-IR spectra might be better indications of the presence of these compounds in the pigment. Carbonate based compound (CO_3) is present in all specimens. Therefore, compounds of carbonate, silica, sulfate, iron oxide and calcium oxalate are detectable in the FT-IR spectra of most of the specimens.

Table. 2:*The detected elements within the sampled red pigment from Charta in the FT-IR analysis (After: Research Institute of Cultural Heritage & Tourism, Research Center for Conservation, Laboratory of FT-IR, Tehran).*

No. Sample	Feature Absorption Band in FT-IR/(cm^{-1})	Identified Compounds
A 3	1034,565,470	From Iron Oxide Pigments (Probably Ochre)
	---------	--------
	2517, 1822, 1441, 881, 729	Carbonate Compounds
	---------	----
	3408, 1641, 1383, 1140	Sulfate Compounds (Probably Bansanite)
	----------	--------
	1034, 781	Silica Compounds (Probaly Amorphous Silica)
	--------	---------
	2926, 2856	The possibility of organic binder
	---------	--------
	1321	Calcium Oxalate (infinitesimal)

Discussion

In this paper, several methods, such as petrography and SEM-EDS, were used to evaluate the pigments and the rock material. The results of petrography indicate that the studied sample consisted of a cream limestone with evidence of red pigments. On the basis of the microscopic evidence, the pigments include iron oxide compounds (hematite-ocher), which are the main constituent of carbonate calcium (calcite). The studied specimens were fine-grained microsparite and fossil-containing micrite calcite.

The SEM-EDS results show that the entire pictographs were created using highly durable and resilient mineral pigments. The paint was directly applied to the rock, and there were thus no indications of substrate preparation. For the samples with red pigments, the main elements are Ca and Mg that belonged to the rock layer. Also present are Al, Si, and K, which are usually found in the soil. The distribution map of the elements shows that the elements are more concentrated in the outer layer. Despite of a higher Fe content at point A of the deeper layer, the concentration is relatively the same across the specimen according to the distribution map. This means that the Fe compound represents

Therefore, the pigments used in the pictograph site of Charta are of mineral iron compound ($Ca(Fe, Mg)Si_2O_6$), where natural red pigments of the soil can give orange color tones to shades of red and black, depending on iron oxide chromophores and the presence of other minerals. This can be attributed to the content of iron oxide. Therefore, it is safe to assume that the mineral nature of the pigments has been among the major reasons for the survival of the pictographs, as mineral pigments are more resistant to natural damaging factors.

Conclusions

Identifying pigments and materials used in rock paintings is important in terms of historic-artistic studies and protection acts. The pictographs at Charta depict four categories of motifs that were carved and painted in a red paint, including animals, human figures, tools, and symbols. The human figures, which predominate in number, were drawn in the stylized manner in the front view. Depicted tools consist of swords worn at the waist of the human figures. The symbolic motifs are represented by three cross patterns between the human figures. The representations tend to display battle scenes. The colors used here contain red ocher. Despite the long time passed since their creation and exposure to the cold weather in fall and winter, their paints are still existent and enduring. Petrographic experiments, SEM-EDS and FT-IR used in this study indicated that in the red paint used to color the carved motifs in Kuhdasht of Lorestan, the main pigments are mineral and organic pigments are totally absent. In terms of bedrock in the petrographic method and according to the geology of the Kuhdasht area, it is inferred that rows of layers of limestone and dolomite from brown to gray thickness can be found such that some layers of clay-limestone also can be seen. In terms of pigments pedology and mineralogy, the entire paints were found to be identical in preparation process and composition, i.e. iron oxide compounds (i.e., hematite-ocher), an observation also confirmed by microscopic analyses. The compound formed a thin layer on the surface of the sample. The red pigment in the paint surface means that the iron element has a red color combination, and it is also due to a lack of purification in limestone rocks. Finally, because the color combination is within the range of mineral ones, this structure provides evidence for their permanence. Hence, colors with mineral structures can resist harmful environmental conditions, and those conditions cannot affect them considerably. Furthermore, drawing on the geological studies of the regional soil, all the samples were made from local resources as is evidenced from the iron oxide.

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