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PHOTO: VIEW OF THE HISTORIC SEB CASTLE IN SARAVAN COUNTY, SISTAN AND BALUCHESTAN PROVINCE, IRAN.

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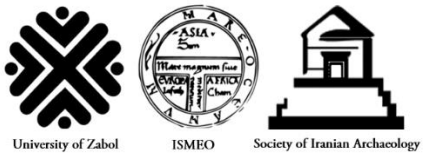

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ARCHAEOLOGY OF THE ANCIENT MINING AND SMELTING IN THE CENTRAL PART OF TABAS COUNTY, ON THE EDGE OF LUT DESERT

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Abstract: Tabas county in South Khorasan province is one of the regions that have high capacities in terms of mining and metallurgy studies, and compared with the other regions of Iran, this region is unknown. The abundance of smelting areas and accumulated slag and the presence of mineral cavities to extract minerals in the central part of Tabas are proof of extensive mining and metal production in this region, which plays an important role in the economy and ecological sustainability of the region along with other economic activities. Regarding the quantity and quality of the studies prepared so far on mining and metallurgy in this city, the cultural and historical capacities of this cultural area have not been introduced as they should be. During the archaeological studies conducted by experts hired by the Cultural Heritage Office of South Khorasan, working in the central part of Tabas county, a mining site and two slag sites have been identified and studied, which indicates the role and importance of the mining and metalworking in the social and economic life of the central cultural region. Citing the results of the field method, reviewing texts and written sources related to the central part, identifying evidence related to the metalworking industry, smelting technology and type of the ore deposit thoroughly, this study has been provided to understand better the process and cycle of ancient metalworking, which includes three stages of mining, extraction, and melting. By typological and comparative studies of discovered slag with adjacent metal centers, it seems that the composition of slag includes the main elements of iron, lead, and copper. The typological and comparative studies of slag discovered in neighboring metal centers indicate that the composition of slag includes the main elements of iron, lead, and copper. The archaeological field studies conducted on the mines and smelting verify the fact that metallurgists in this area used open and underground methods to extract the ore, and after transferring the mineral parts to the smelting workshops and furnaces, they used the roasting method.

Keywords: Tabas county, central part, archaeology, mining, smelting furnace.

چکیده: شهرستان طبس در استان خراسان جنوبی از جمله مناطقی است که از منظر مطالعات معدن‌کاوی و فلزگری دارای قابلیت‌های بالایی است و در قیاس با دیگر مناطق ایران منطقه‌ای ناشناخته است. در این میان بخش مرکزی طبس به جهت انبوه محوطه‌های ذوب و سرباره‌های انباشته از یک جهت و وجود حفره‌های مواد معدنی به‌منظور استخراج کانی فلز مورد استحصال شاهدی بر فعالیت گستردهٔ معدن کاری و استحصال فلز در این منطقه است که نقش مهمی در اقتصاد و پایداری زیست بوم منطقه در کنار سایر فعالیت‌های اقتصادی داشته است. با این وجود حجم و کیفیت مطالعاتی که تاکنون در مورد مطالعات معدن‌کاوی و فلزکاری در این شهرستان صورت گرفته درخور استعدادهای فرهنگی- تاریخی این پهنهٔ فرهنگی نبوده است و آن‌گونه که شایسته است معرفی نشده‌اند. طی بررسی‌های باستان‌شناسی انجام شده توسط کارشناسان اداره میراث فرهنگی خراسان جنوبی و بازنگری این بررسی‌ها توسط نویسندگان در بخش مرکزی شهرستان طبس یک معدن و دو محوطه سرباره مورد شناسایی و بررسی قرارگرفته است که بیانگر نقش و اهمیت معدن‌کاوی و فلزکاری در حیات اجتماعی و اقتصادی منطقه فرهنگی مرکزی است. این پژوهش سعی دارد به استناد نتایج بررسی روشمند میدانی باستان‌شناسی، متون و منابع نوشتاری در بخش مرکزی، شواهد مرتبط با صنعت فلزکاری، فنّاوری ذوب و نوع کانسار استحصال‌شده را باز شناساند تا امکان درک بهتر فرایند و چرخهٔ فلزکاری شامل سه مرحله معدن‌کاوی، استخراج و ذوب فلزات فراهم آید. با بررسی‌های انجام شده، گونه‌شناسی و مقایسه تطبیقی سرباره‌های مکشوفه با مراکز فلزی شناخته‌شده همجوار به نظر می‌رسد ترکیب سرباره‌ها شامل عناصر اصلی آهن، سرب و مس باشد مطالعات و بررسی‌های میدانی باستان‌شناسی انجام‌گرفته در معادن و محوطه‌های ذوب فلز شناسایی‌شده نشان می‌دهد، فلزگران این منطقه از روش‌های روباز و زیرزمینی برای استخراج کانی استفاده کردند و پس از انتقال قطعات کانی به کارگاه‌ها و کوره‌های ذوب به روش تشویه (برشته کردن) برای ذوب فلزات بهره برده‌اند.

کلمات کلیدی: شهرستان طبس، بخش مرکزی، باستان‌شناسی، معدن‌کاری، کوره ذوب.

I. Introduction

According to the studies conducted by researchers inside Iran and abroad, the land of Iran has been the birthplace, center, and cradle of various types of ancient technologies. One of the important technologies in studying the Iranian culture and history is mining and metalworking, which has a long history from ancient times. Agreeing with the numerous surviving evidences, we can assume that Iranians have been one of the effective pioneers in the mining and metallurgical industry, and it can be said that the history of metallurgy in Iran dates back to the 7th millennium BC (Thornton, 2009: 303).

The first metals used by humans were not obtained by mining or smelting ore but existed in pure forms in nature, the first blacksmiths shaped, and purified pure

metals by hammering (Chegini *et al*., 2000: 281).

The first known metals in the natural environment are gold, copper, silver and iron. The limited amounts of metals that were naturally available to humans and the urgent need for metal products were the first causes that made a great change in the art and industry of metalworking. The revolution occurred moving from identification to smelting the copper ore in Iran in the late fifth millennium BC (Talaei, 2002: 548, Vatandoust, 2000: 2, Oudbashi *et al*., 2012: 157, Nezafati *et al*., 2008: 3). The Iranian plateau naturally ensures a great mineral reservoir. All the geological and archaeological facts confirm that Iran is one of the oldest metalworking industries in the ancient world. It is obvious that our primate ancestry could only realize the usefulness of metal in a land where there are many metals and minerals (Farmani A. and Sadati, 2015: 1). The richness of Iran's mineral resources and the identification of the ancient industrial settlements in connection with metal smelting are present in various sites such as Tapeh Yahya, Tapeh Qabrestan, Shahdad, Tapeh Iblis, Tapeh Damghan, Arisman (Nikzad *et al*., 2018: 2).

The cycle of the metalworking industry, like other types of industries, includes chain stages that start from the mining stage and continue with the extraction of mineral ore, eventually, in the end, the melting stage, and then standing in the following production and distribution lines. These regular cycles over the centuries and millennia, present in each piece of the fragments of these stages, produce reliable archaeological evidence left for the researchers. By identifying and studying them, it is possible to corner the potential metalworking sites in the region and agree with the ability of its inhabitants to exploit the facilities and capacities of the environment, water resources, vegetation, and ore deposits (Haji A., Laleh 2013: 101).

In this regard, one should identify the remains and artifacts associated with each of these metallurgic activities in order to start the recycling and rebuilding process, representing the metalworking industry as in ancient times. The central part of Tabas in South Khorasan province is one of the areas which holds a large amount of smelting slag as well as many deposits extraction holes. However, the mining and metal smelting studies with rich instances and a high capacity have not received much attention. Tabas county is very important in terms of mining activities. Over recent years, various studies have been conducted by geologists to identify the new mines around the city. However, few archaeological research papers have been published studying the ancient mining sites of the region. During the archaeological excavations in the central part of Tabas county (Mahmoodi Nasab, 2018), evidence from two smelting sites and a mine related to the Middle, and Late Islamic Ages were examined and identified. By studying them, we can better understand the process of the metalworking industry, including mining, metal extraction and smelting, and finally, recognize the metalworking of the region and the socio-economic role and effects of the metalworking industry in the context of historical and cultural developments in Tabas. In line with the significance of the subject, three questions and hypotheses were considered initiating the present research: 1- Considering the importance of Tabas county from the point of mining studies, in which period did the oldest mining evidence in this region emerge? 2. The evidence of extraction of which metals from mines and furnaces was identified? 3- What was the first method of extracting the ores from the mine? Research hypotheses are: 1- The identified cultural materials indicate that this mine lingered for centuries (Seljuk to Timurid). 2- Considering the typology and comparison of the discovered slag with the known metal centers, it seems that the composition of the slag includes the main elements of iron, lead, and copper. Archaeological field studies demonstrate the identified mines and metal smelting sites. 3- Metalworkers of this region used open and underground methods to extract minerals, and after transferring mineral parts to the smelting workshops and furnaces, they used roasting methods.

II. Research method

The present study is based on the research objectives defined in the limits of the standard basic research, and focuses on the function and methodology, representing the type of historical research. The given data is collected based on the two pillars of library studies and archaeological field studies. Historical and geological books, articles, dissertations, and reports of the archaeological studies of the region have been used in library studies. Field studies and surveys, including topographic mapping of the area, photography, identification of sites and mines, and determining the area and the type of mines, identification of smelting furnaces and finally, sampling of the metal smelting sites performed randomly.

III. Research background of mining activities in Tabas

Research and surveys conducted in relation to the mining activities in Tabas county in South Khorasan Province, the documents of which are available in the research archives of the General Directorate of the Cultural Heritage, provide evidence of mining and metalworking activities. These mines and kilns were identified only in the archaeological study of Tabas county (Annani, 2015; Mahmoodi Nasab, 2015). These ancient mines show the role and importance of ancient mining and metallurgy in the social and economic life of this cultural region.

Most of the research is related to other cities in South Khorasan province. In addition, as mentioned in the historical texts, there are references to the existence of mines in this cultural region, including the comments noting the copper mines in Khorasan in the Islamic era (Ibn Huql, 1966: 169).

Moghaddasi also mentioned the existence of the mummification elements, and silver and gold mines in the Ghahestan region (Moghaddasi, 1982: 594). Some of the references to point are "Metalworking in the southeastern region of Iran" (Abbasnejad, 1997: 73-65). "Archaeological research of ancient mines in South Khorasan, a case study of new discoveries of ancient metal smelting centers of Shosaf Nehbandan" (Hashemi Zarjabad, 2013). "Archaeological study of Shosaf region of Nehbandan, the introduction of metal smelting centers" (Hashemi Zarjabad, 2012).

"An article entitled Archaeometallurgical and ancient mining research in South Khorasan based on the archaeological studies and petrographic analysis" (Beigi Herchgani *et al.*, 2015), "Archaeological Research of Metal Smelting in Eastern Iran: A Case Study of the Coppersmith Site of One of the Largest Metal Smelting plants in the South Khorasan" (Hashemi Zarjabad *et al.*, 2016), "Introduction of the ancient industrial smelting workshops based on the archaeological studies, the case study of Zirkuh region)" (Qasemnejad *et al.*, 2017), "Investigation of the ancient mining and metallurgy activities in Khosf county, South Khorasan province, Eastern edge of Lut Desert, Iran (Nikzad, 2015)", In this article, the metal smelting furnaces and yards of Dehuk district of Tabas county are examined for the first time. According to the cultural artifacts obtained from the surface of these yards, relative historiography was considered for this site.

IV. Geographical location

Tabas county is located west of South Khorasan province, with an area of 55,460 square kilometers divided into three parts and eight villages.

The three parts of the city are 1- Markazi, the central part, 2-the Dastgerdan part, and 3- the Dehuk part, located on the edge of the Lut desert (Fig. 1).

Figure 1. Divisions of Tabas county and its location on the edge of the Lut desert (Mahmoodi Nasab, 2018).

V. Traces and evidence of mining and smelting in the central part of Tabas

Today, from an economic point of view, due to the mining-related activities in the central part of Tabas county, it is considered one of the most important areas in the country.

In the past, mining and metalworking have played a major role in the economic and social structures of the region. The area under study, located in the central part of Tabas county, is an unknown area in terms of archaeological studies in comparison to the other regions of Iran. Archaeological studies conducted in the studied area provided evidence of an ancient mine and two slag sites, including the Talkhab mountain mine, the desert lead site, and the Talkhab smelting area (Mahmoodi Nasab, 2018) (Fig. 2).

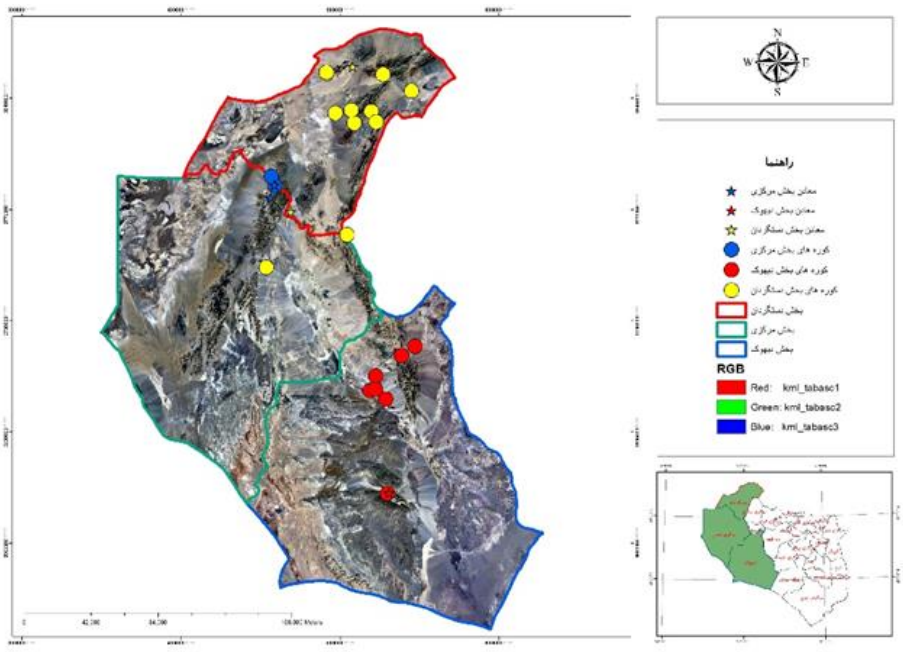

Figure 2. Location and distribution of mines and smelting sites in three parts of Dehuk, Markazi, and Dastgerdan in Tabas county (Authors, 2021).

VI. Desert metal smelting site:

The kiln site, located on the edge of the desert, is accessible to Ashgabat via a road crossing the northeast of Pir Hajat village (Fig. 3). Along this route, after 27 km begins, another route separated from the old unpaved road that, through a river, leads to the livestock neighborhood of Mr. Ahmad Rahimi, a resident of the province. From this place, after crossing the river and ending the mountainous route for three kilometers on the edge of the central desert and the added seven kilometers along the Talkhab Mountains, access to this furnace is possible.

Figure 3. Position of desert smelting furnace, (Google Earth).

This kiln is surrounded by a wide plain. The source of water nourishing the metal plant is the temporary presence of the seasonal rivers that pass through the north-south direction. The vegetation around this kiln is composed of hawthorn, bean caper, and turmeric trees.

This brook flows from the Talkhab and Gomorgh mountains towards the desert. The Desert lead kiln is located at the foot of the Talkhab Mountains, and on the edge of the central desert. This kiln is completely destroyed, and the only sign of the existed kiln is the slag and architectural remains in the residential space on the surface (Fig. 4, 5 and 6).

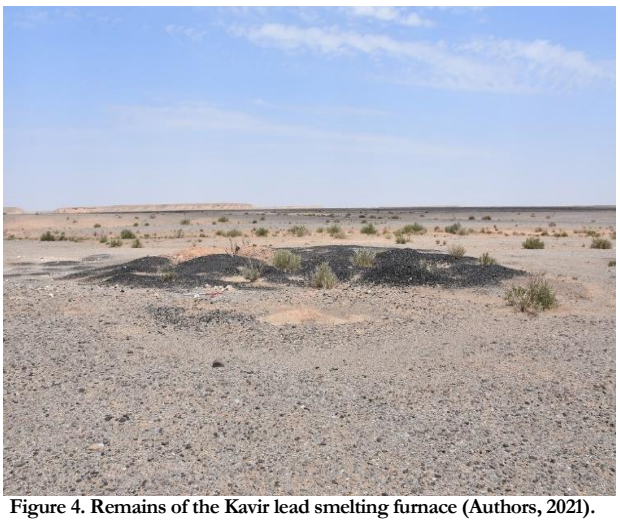

Figure 4. Remains of the Kavir lead smelting furnace (Authors, 2021).

The height of this furnace is half a meter above the ground. The lead ore used for smelting in this kiln was supplied from the Shahdad mines on the Talkhab Mountain, located six kilometers southeast on the heights of Talkhab Mountains.

The remains of the furnace architecture show that the perimeter of the furnace was circular and had dimensions of 2×2/5 meters. There are also quartz rocks around the kiln, which were probably used to better melt metals, and locally it is called auxiliary smelting. This furnace was probably a type of furnace that was usually lit with wood to generate heat. The stove-type Kiln probably had a dome cover.

Figure 5. Remains of the Kavir lead smelting furnace (Authors, 2021).

The smoke from the fire inside the stove was carried to the outside by the chimney on the roof. In addition to the chimney on the roof of the furnace some pipes were placed inside the furnace and on the body of the wall to transfer smoke. Only scattered slag was found in the area around the kiln site. On the southern side of the kiln, the architectural remains of two residential spaces are available with access to the ruined space from the south.

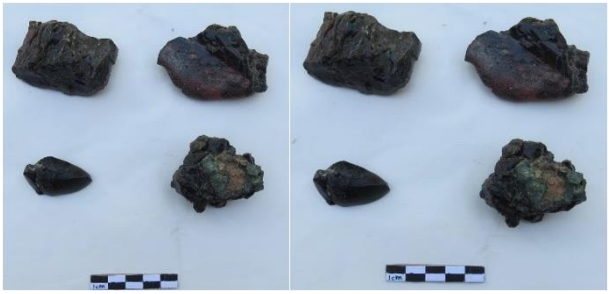

Figure 6. Desert smelting furnace slag (Authors, 2021).

VII. Telkhab metal smelting site

Telkhab metal smelting site, based on the UTM, is located at latitude and longitude 0458465/3785233 with an average altitude of 1170 above sea level. This area is located near the Talkhab mine 50 meters distance. Access to this area is through an unpaved road in the northeast of Pir Hajat village which leads to Ashgabat.

After 17 km, the route separates from the unpaved road and leads through a river to the livestock neighborhood of Mr. Ahmad Rahimi, a resident of the province.

From this livestock neighborhood on the northwest, after crossing the mountains and valleys 2.5 km, we reach this area and the nearby mine. The water source of this area is the seasonal rivers flowing in four sides. The only visible mark of the furnace on the surface is the remaining slag (Fig. 7 and 8).

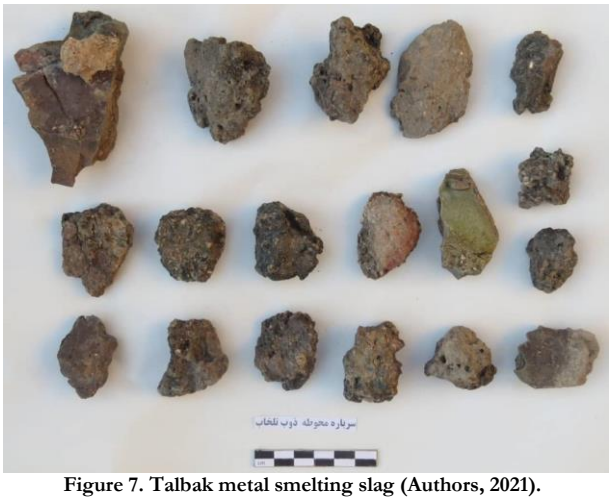

Figure 7. Talbak metal smelting slag (Authors, 2021).

At the surface of the site, as found in other similar areas, there is no trace of the architectural structure except for the remnants of the metal-smelting furnaces such as copper and lead. The vegetation around the area consists of Almond trees and Artemisia bushes.

Figure 8. Talkhab metal smelting site (Authors, 2021).

VIII. Talkhab Mountain Mine

The Talkhab mine is located in a mountainous area on a mountain known as Talkhab. One of the reasons for the designation of this mountain is the existence of a spring one-kilometer northwest, and at the foot of the mountain, which is known as Talkhab spring, which means the bitter water. The central desert of Iran is in the west of this bitter spring. Access to this mine is through an unpaved road in the northeast of Pir Hajat village, which leads to Ashgabat (Fig. 9). After 17 km, the route separates from the unpaved road and leads through a river to the livestock neighborhood of Mr. Ahmad Rahimi, who is a resident of the province. From this livestock neighborhood on the northwest, after crossing the mountains and valleys 2.5 km, we reach this area and the nearby mine. The water source of this area is the seasonal rivers flowing in four sides.

Figure 9. Location of the Talkhab mine, the satellite image (Google Earth).

The plants growing in this area consist of Almond trees and Artemisia bushes.

The mineral extraction from this mine has been done by digging horizontal and vertical tunnels (Fig. 10). The lead extraction was carried out in the Talkhab Mountain mine (Fig. 11). There are also rooms next to the mine for workers to rest. These chambers were usually dry-stack without roofs (Fig. 12).

Figure 10. Talkhab Mine and Ore Mining Tunnels (Authors, 2021).

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Figure 11. Lead grains of Talkhab mine (Mahmoodi Nasab 2018).

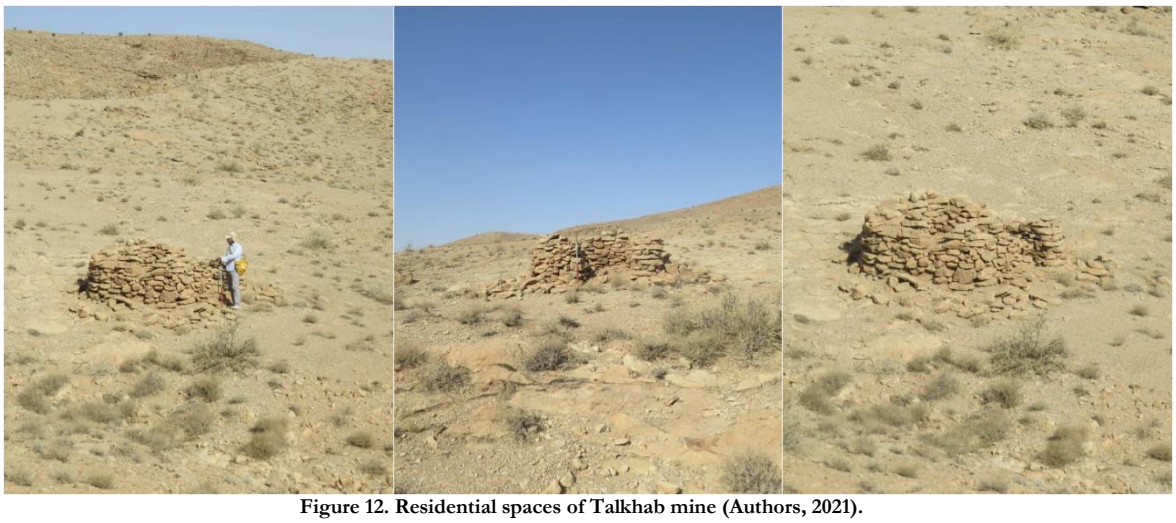

Figure 12. Residential spaces of Talkhab mine (Authors, 2021).

IV. Conclusion:

Lut Desert is important in terms of archaeology, metalworking, and mining. The most important archaeological sites on both sides of this desert are Shahdad, Tape Yahya, Tal Iblis, and Shahr-i Sokhta, containing the oldest metal works of ancient Iran. Therefore, the Lut Desert and its environs most likely played a major role in supplying the raw materials feeding these ancient metalworking plants. Today, more than ever, it has become clear that the Lut block and its surrounding areas are home to a variety of minerals such as copper, lead, zinc, etc. One of these areas is the central part of Tabas county on the edge of the Lut desert in South Khorasan province. In addition to the mining during the current period, the existence of ancient mines in this area reveals the geological importance of this area in the past. The most important areas to mention are the Kavir and Talkhab lead sites as well as the Talkhab Kal mountain mine. The obtained cultural materials spread throughout the area are regularly scattered slag. The sampling of metal smelting in slag sites was done randomly. In this sampling, an attempt was made to sample both the surface of the sites and the inside of the furnaces. The selected samples had a glossy and glassy shape in terms of form and appearance, as well as samples with porosity on their surface. The slag collected from the site, due to the high percentage of iron silicate compounds, tends to be blacker and darker gray. The surface of the samples is very shiny and glossy. The slag obtained from the copper smelting site is black to light brown color, which has red grooves in its texture due to the presence of copper oxides. The texture, powder color, and porosity are seen immediately in most slags. This porosity is either due to the exit of gas from cavities that were heated and escaped due to smelting operations and detached from the system, or in some samples, the presence of minor minerals causes porosity in the slag tissue. In some samples, the presence of a type of rare gas in the environment or deposit such as arsenic can be detected according to the amount of porosity and the geological location of the area. In highly porous slags, parts of combustible materials such as charcoal are sometimes seen. The structure, corrosion, and volumetric weight display different appearance characteristics due to the temperature of the furnace, which according to the physical evidence such as color, texture, and porosity in the slag, indicate the extraction of the lead and copper (Fig. 13).

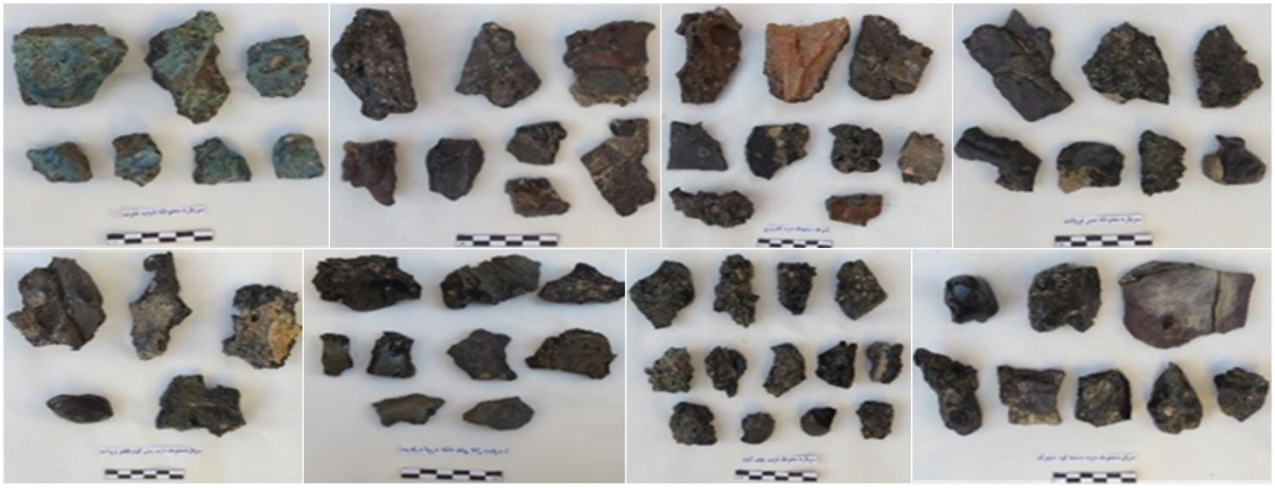

Figure 13. Sample of the slag in the central part (Authors).

In addition to the slag remains, the residential architecture related to the accommodation of workers and employers around the kiln is observable, in which approximately 25 rooms can be identified. The dimensions of the rooms are typically 2.5 x 4 meters and are made of dry-stack stone or mud bricks. Most of these rooms are covered with stone boards, wood, and artichoke bushes. The residential spaces accommodating the employers have larger dimensions and are made of raw clay, and the walls are plastered. In addition to the residential spaces along the way to the kilns, the remains of the road leading to the kilns are also visible, and in some parts, due to the slope of the ground, the stone walls were installed to facilitate access from the kilns to the mines. The extraction procedure in the old mines, similar to the new mines, is based on the two main types of underground and open space operations. The underground method was to dig a pit vertically and then move in the horizontal corridors until they reached the mineral grains. The method of digging vertical pits and horizontal tunnels was a familiar technique in the Islamic world that was used to build aqueducts. In contrast, most of the miners preferred to dig the horizontal corridors and follow the ridges instead of digging vertical pits on the slopes of a mountain. This method could only be used when the land was suitable and was easier and less expensive for the miner who worked individually. In open mines, the presence of minerals on the surface is clean, and there is no need for tunneling or tracking of the mineral veins in the form horizontal and vertical mineshafts. Due to the large volume of minerals in open mines, these minerals are extracted in the form of pits dug on the surface. This type of mineral extraction does not require much effort and time. Usually, the slope surface to the mineral extraction site is created by deepening the extraction hole to transfer and separate the mineral and transfer it to the smelting furnaces. In the central region, we see the underground extraction method (Fig. 10).

After transferring the mineral parts to the smelting workshops and furnaces, miners use the roasting method to melt down the extracted ores. In the land around the smelters to provide fuel for smelting minerals, almond trees and artichoke shrubs are abundant in the Mazkazi area. The main problem in studying such works is the chronological question. The small number of cultural materials, such as the distinguished pottery, is usually not possible to date these handcrafts easily and define the exact time they were used. Also, the location of the mentioned section in the Lut desert facing the regular movement of quick-sands causes the cultural evidence to be buried under the sand dunes. The exact location of many of these ancient evidences has not been identified. Therefore, we have less information about the mentioned area and its relationship to the mines in the neighboring areas. On the other hand, due to the length of its tunnels and the large volume of extraction, it must be said that the extraction from this mine must have been done over a long period of time.

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