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Afalleh: A Parthian Iron Foundry Site on Northern Slopes of Central Alborz

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Abstract

The archaeological site of Afalleh is located in the north of Khachak village, in the intermountain plain of Kojour, in southern end of Nowshahr District, Mazandaran Province. Drawing on the available evidence, the site is dated to the Parthian period. Afalleh is clearly an archaeo- metallurgical center in the area, and by virtue of its relatively large size (more than 5 ha) might be one of the most significant and/or important archaeo- metallurgical sites of the Parthian period in the entire region. Large and dense scatters of slag and kiln wasters, especially in southern and western quadrants, hint at extensive and/or long-termed archaeo- metallurgical activities at the site. The surface slag could be divided into two groups of sponge and dense with a dark color near to black. Most slags are seen on southern part of the site. A stone building is partially exposed in western side of the site, where a dirt road has cut a part of the archaeological deposits. Macroscopic and microscopic analyses indicate that the slags are rich of fayalite and wustite, ferrous silicate and iron oxide minerals, respectively. Inside one of these slags a thick prill of iron is observed that has been largely replaced with secondary iron oxides. This observation indicates an indirect reduction of iron from its ore-producing carbonized iron (steel and cast iron)-and refers to its separation from silicate melt more probably outside of furnace. In this paper we describe the site and data has produced concerning the probable extent of the smelting activities, this is a comparative study and is a discussion on possible provenance of ore deposits.

Keywords: Afalleh; Archaeo- Metallurgy; Iron Metallurgy; Parthian Period; Kojur

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Introduction

Iron is the main metal in the earth's crust, and it ranks fourth amongst the constituent elements of the crust (Pigott 2004). The history of the Iranians iron acquaintance goes back to very far past so that some scholars regard Iran as the center of metallurgy extension in Southwest Asia given its rich metal quarries (Pigott 2004; Nezafati et al. 2008; Mortazavi et al. 2011: 49). The earliest evidence of iron in southwestern Asia dates to the third millennium. At that time, the metal objects were generally made of bronze. Iron use was extended gradually since late second millennium B.C. in southwestern Asia, and it began to play a central role in the economy of the local societies (Pigott, 1982: 22; 1984: 67).

However, the evidence for widespread use of iron comes from the post-Achaemenian period, i.e. the Parthian era during which saw more extensive interactions prevailed between Iran and Transoxiana (Pigott, 1984: 628). In effect, The Parthian, Sassanian and early Islamic periods can be regarded as the period of extension of iron metallurgy using local sources in Iran (Stöllner 2004 et al.: 57).

There is little information on the archaeology of northern Iran and in particular its metalworking industry. Archaeological investigations have so far documented evident metalworking activities in several Iranian regions, including Qazvin, Firuzkuh, Damavand, Damghan, Semnan, Shahrud, Kashan, Gilan and Mazandaran (Abbasnejad 2009: 2).

While the wider region of the northern Iran, here defined as the northern slopes of the Alborz mountain range, is itself relatively unknown due to the lack of adequate archaeological field missions, the situation is even gloomier in the central part of the northern slopes of Alborz, which is the under the focus of the present study (Fig. 1). The French archaeologist J. deMorgan was the first who reported some evidence of iron production in Gilan (probably Masouleh), Mazandaran and western Urmia basin (Abbasnejad , 2009: 2) but his data is rather incomplete and limited in scope. The more recent years have seen a growth in the archaeological endeavors in the northern Iran, in particular in Kojur County, Nowshahr, which is the subject of the present study. The reconnaissance survey program of the Nowshahr County (Mousavi Kouhpar, 2008), the research design of Reconnaissance Survey of

Ancient Mines and Metalworking Centers in the Northern Slopes of the Alborz Mountain Range: Western Mazandaran as the First Priority (Mousavi Kouhpar, 2009), trial excavation at the site of “Kharabeh Shahr” at Kojur village (Mousavi Mirkala, 2010) and finally the sounding program at Tepe Afalleh at the Khachak village (Ghamari Fatideh, 2012) are some examples of the more recent efforts.

Fig.1. Map of Iran Showing the Location of Mazandaran and Kojur

Geographical setting and Mineralogy of Area

The archaeological site of Afalleh lies on the north of the new Khachak village, at the center of the intermountain plain of Kojur that is in turn situated on the southern fringe of the county (Fig. 2).

Fig.2. General View of Tepe Afalleh, View From Southeast

The site was first identified during the research project of Reconnaissance Survey of Ancient Mines and Metalworking Centers on the Northern Slopes of the Alborz Mountain Range: Western Mazandaran as the First Priority (Mousavi Kouhpar, 2009). During this project other slag sites were also recorded that, similar to Afalleh, contained iron foundry slags. Identified in western Mazandaran Province, these sites extend up from Kojur in the east to Ramsar in the west. They include Jir Maryam on southern uplands of Ramsar County, Lakterashan on southern uplands of Tonekabon County next to the new village of Lakterashan, and Kokh Neshin, Ahan Parreh and Tepe Kelar in Kelardasht on southern highlands of Chalus, and Baharbon on southern highlands of Nowshahr County (Fig. 3).

An interesting fact is that ancient quarries are located in these regions, namely Duna quarry on southern highlands of Chalus County on the Chalus-Karaj road with tin, silver and barite deposits, and Naser Abad quarries in Kojur region near Naser Abad village, with clear evidence of tin mining. As said before, unfortunately none of these quarries have produced remains of iron foundry, the evidence of slag sites of which is abundant in the region.

Fig.3. Distribution of Ancient Archaeo-Metallurgical Sites and Mines in the West Mazandaran

Excavation at Tepe Afalleh

The excavation at Tepe Afalleh was carried out in the summer of 2011, and the field strategy involved opening several test trenches around the site. The site with its typical Parthian ceramics was as an obvious iron foundry and given its vast area (over 5 ha) could have acted as one of the major regional ironworks during this period.

The intermountain plain is characterized by the lofty surrounding mountains that provide major portions of the valley with a relatively permanent shadow. This, along with the resultant coldness, gives rise to all-year-round southward winds in the northern part of the valley, where Tepe Afalleh and the Khachak village are located. The winds blow almost incessantly though with varying speed. It is our contention that this setting, in which the local people would have taken the advantage of the natural winds to enhance the function of their iron smelting furnaces, might have played a role in location of this archaeological workshop (Figs. 2 & 4).

Fig.4. Tepe Afalleh, View From Southwest

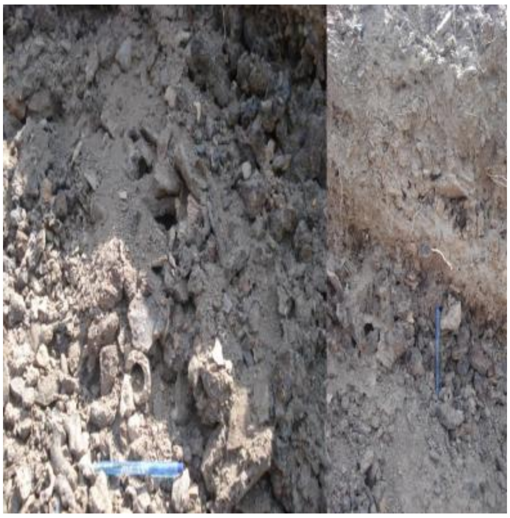

Fig.5. Slags and Bellows in Southern Section of the Mound

Large numbers of slags were recorded at Tepe Afalleh in particular in its southern and western quadrants, a fact that hints at possible extensive metallurgic activities at the site. The recorded material falls into two categories of compacted and spongy slags, and are dark, blackish in color. These industrial wasters show a higher concentration in the southern quadrant (Fig. 5). Some stone structures had also been exposed as a result of recent road construction activities.

The site was excavated through opening bondages along its entire edge with the aim of defining the extent of the cultural remains. On the whole, fourteen 2x2 meter test trenches were laid out at different points (Fig. 6). The total area of the archaeological site was estimated based on these trenches to be almost 5 ha.

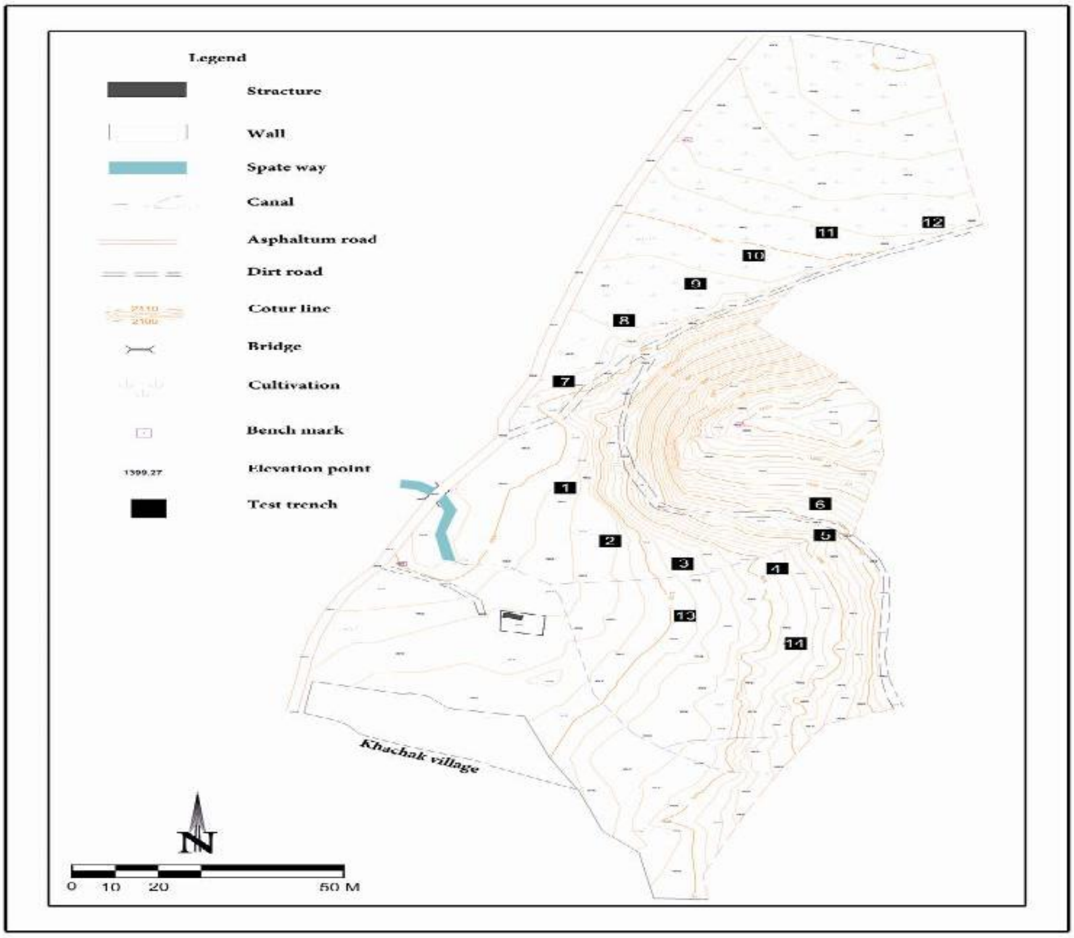

Fig.6. Topographical Map of Afalleh and Location of Test Trenches

Finds

The major finds from the site date back to the Parthian period (Fig. 7). To get a picture of the nature of the metal smelting activities carried out at the site, samples of pottery and slags were selected for X-Ray Diffraction (XRD), Petrographic (thin polish, thin section) and Thermo luminescence analyses (Figs 7-10).

Ceramics from the mid-Islamic period are also represented in the assemblage, which were mainly found during excavations in the northern quadrant.

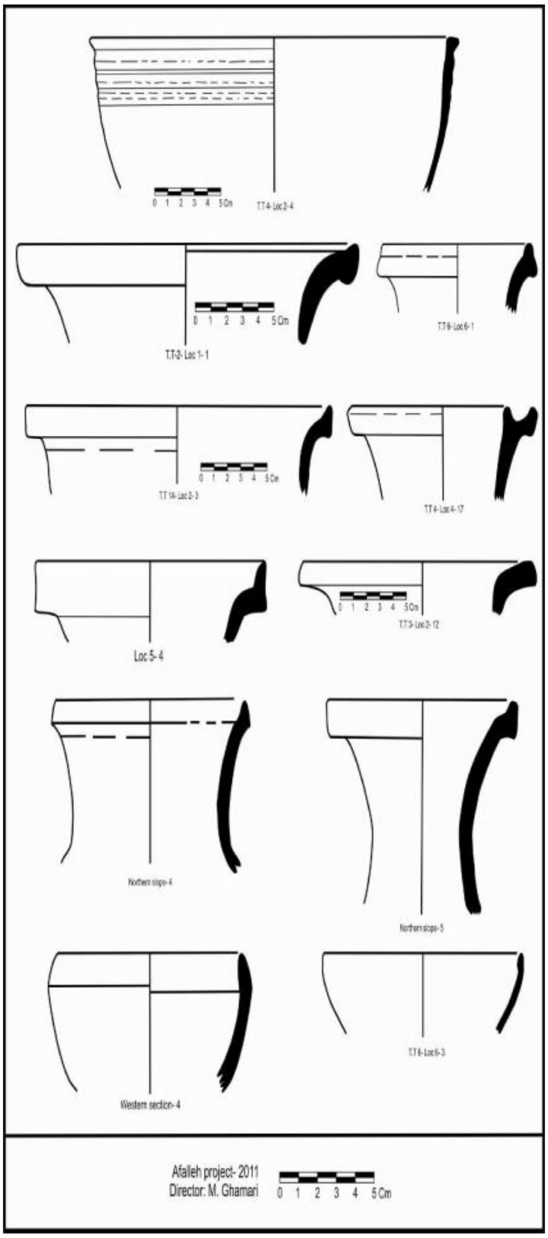

Fig7. Some of the Historical Pottery Forms From Tepe Afalleh

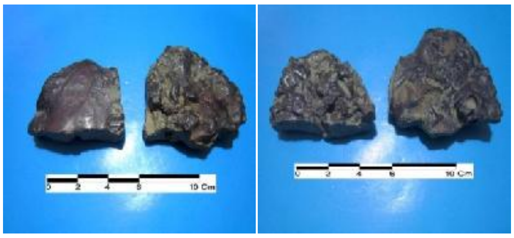

Fig8. *Right*: Upper Surface of the Flat Slags with Flow Wrinkles; *Left*: Lower Surface of the Specimen with Flat Morphology at the Left in Contrast to Irregular Morphology of Upper Surface at the Right.

Fig9. *Right*: Upper Surface of the Branching Slag with Semi-Cylindrical Section; *Left*: Lower Surface of the Specimen with Irregular Morphology as a Function of the Irregularity of the Ground Surface. The Shape of the Slag Probably Followed the Shape of the Channel that Directed the Smelt From the Furnace into the Separation Pit Wherein Iron Was Separated From Silicate Melt.

Fig10. *Right*: Upper Surface of the Specimen with Bulging, Reform Morphology that Reflects Plastic Deformations of the Melt during its Freezing Process; *Left*: Lower Surface of the Specimen Characterized by Relatively Irregular Morphology, Concentration of Secondary White Minerals Around

the Pores and the Traces of Plant Fuels (Yellow Arrow).

Experiments and analytical technique

For the purposes of the present study, several laboratory experiments were designed. The first step was to determine the chronology of the excavated objects. Typologically, the pottery assemblage resembled diagnostic Parthian (fig. 7) and mid-Islamic forms, but given the archaeologically unknown state of the regional sites and stratigraphic sequence and in order to obtain a reliable chronology, a sample of ceramics collected during the Reconnaissance Survey of Ancient Mines and Metalworking Centers in Northern Alborz Mountain Range were chosen for Thermo luminescence analysis. The analyzed samples included both sherds and tuyeres. The analysis provided an estimated date ranging from 200 to 1550 AD. In particular, the sherds mainly fall into two ranges that cluster around 200-400 AD and 1500-1600 AD, respectively. Thus, the analysis verified the earlier attribution of the sherds to the Parthian and Safavid periods in terms of the typological criteria. However, the dates from the tuyeres specimens that were sent for analysis in order to assure the chronology of the furnaces all indicated the range 200-400 AD (Mousavi Kouhpar 2009).

The next essential step involved determining the type of the metal and the ways in which it was smelted in the workshop.

To this end, several slags with different morphologies were submitted to Kansaran of Binalud Co. for technical analysis.

Accordingly, XRD and petrography techniques were employed to analyze the slags. The XRD results revealed that slags were rich in fayalite and wustite minerals, the first of which is ferrous orthosilicate and the second is iron oxide (fig 11).

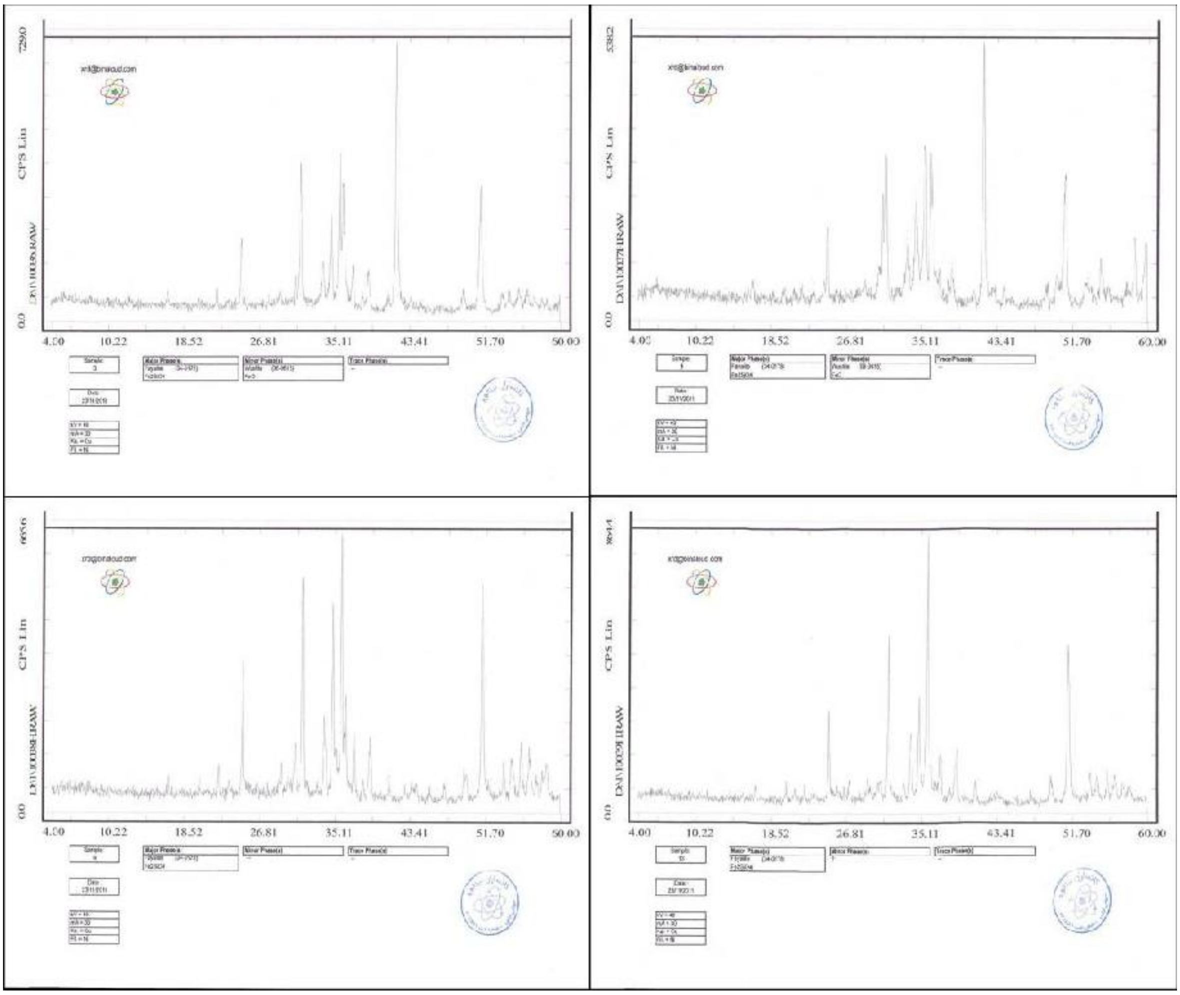

Fig.11. XRD Figs of Four Samples of Slags of Afalleh that in All of Them Wustite and Fayalite Are Basic Ingredients

Petrographic experiment and microscopic observation are generally used to assess and analyze the type of metal in ancient metallurgical workshops and the way in which the metal was smelted. This approach rests on preparing a thin-section from the slag and its close analysis. Through close observation of the thin-section one can determine the smelting process and remains of the main metal (Pigott 1989: 76).

The petrographic analysis also corroborated the fact that the workshop was involved in activities related with iron smelting. The parallel arrangement of the fayalite crystals in many of the specimens indicated that they had been formed outside of the furnace as melt flows (Fig. 12). Among these slags there was also a relatively large iron prill, most parts of which were replaced by secondary iron oxides (Fig. 13). This observation demonstrates that iron was smelted from ore using the indirect method–production of carbon iron (steel and/or cast iron)–and probably was separated from the silicate melt outside of the furnace.

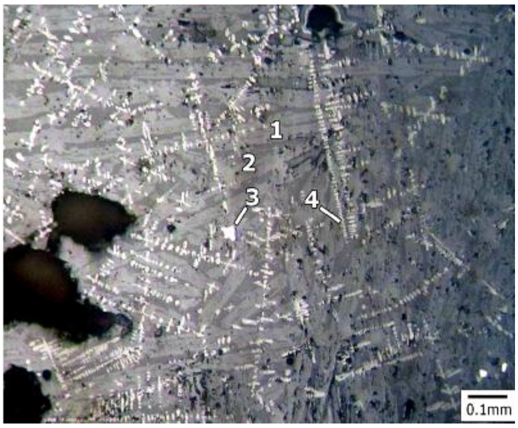

Fig.12. Microscopic View of the Slag in Fig.8—Dendrites of the Original Iron Oxide (4) Cutting the Elongated Fayalite Crystals (1) and Dark Glassy Background. Note the Almost Parallel Arrangement of the Iron Silicate Crystals along the Direction of the Primary Melt Flow

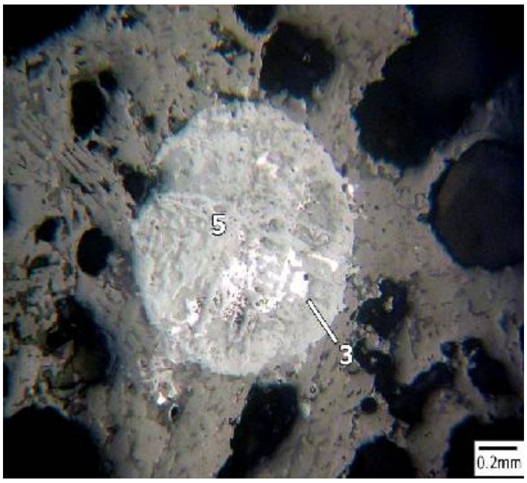

Fig.13. Microscopic View of the Slag in Fig.9—a Relatively Large Iron Prill (3) Most Parts of which Were Replaced by Secondary Iron Oxides (5).

Conclusions

Morphological study and macroscopic observation as well as microscopic analysis of the slag specimens proved the fact that the excavated workshop had presumably served as an ironworks. This metallurgic practice appears to have been restricted to the Parthian settlement, and due to some uncertain reasons did not continue into the later periods. Remains from succeeding periods up to the middle Islamic centuries were totally absent from the sequence, and based on the available data the periods following the Parthian era had not witnessed any activities related to metal smelting. The iron smelted in Tepe Afalleh might have been exported, probably as ingots, to other areas where it would be used as raw material for the manufacture of iron objects since the test trenches and the surface survey did not yield any iron objects or casting molds. The iron smelting installations used in the ironworks excavated at Tepe Afalleh probably resembled the early furnaces: ore was fired within the furnace and resultant melt was directed out of the furnace. The morphology of the slags also corroborates the claim. Vegetal remains on many of the slags suggest that, given the local abundance of vegetal resources, the metalworkers of Tepe Afalleh would have powered their furnaces with the local plants and woods from the surrounding forests.

But with respect to the importance of this mound and its metallurgic activities, an overview of metallurgy during the Parthian period will be helpful. As already stated, Parthian period marks the beginning of widespread metallurgical activities. We are fairly well familiar with the metallurgy and iron foundry of the Parthians. For instance, we know that in the battle of Carrhae (53 B.C.) the Iranian army under their young commander Surena was able to defeat the Roman army led by Crassus. In this battle the Iranian warriors are said to have worn glossy iron armors, with their horses also covered by iron and copper armors, a fact that seems to have played a central role in the Iranians' triumph (Litvinsky 2006: 602).

As far as the available information reveals, the highest concentration of iron quarries in Iran is seen in its central east, northeast and southeast quarters (Momenzadeh, 2004: 18). In northeastern Iran, e.g. in Marv, numerous evidence of iron metallurgy is available from this period. An interesting fact is that no iron quarries are known from Marv, and the iron could have imported from other regions as raw material. Also, several areas have yielded iron ingots ranging in weight from 0.5 to 2 km, among them Marv and Nesa (Litvinsky, 2006: 602). Nesa has produced remains of iron armors (Litvinsky, 2006: 603). The results of technical analyses of Afalleh finds suggest that similar ingots were probably produced at the site.

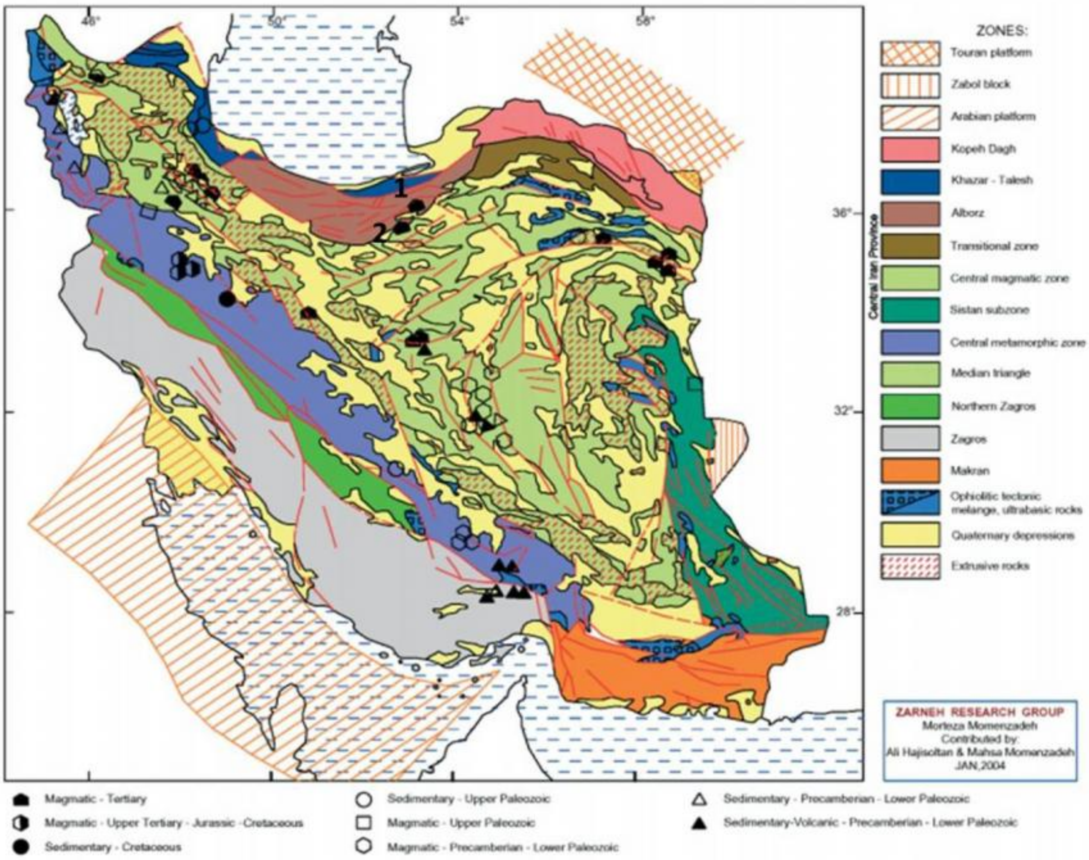

Fig.14. Distribution of Iron Deposits and Occurrences in Iran (Momenzadeh, 2004: Fig8)

This multitude of iron metallurgy sites in Iran, in particular in northeastern regions and northern Alborz, is surprisingly enough attested in regions with no iron quarries so far been located in their purlieus. In particular, Fig. 14 clearly shows that the nearest iron quarry to the northeastern (Fig 14: 1&2) and northern Alborz sites and the region under discussion is a center in southeast Alborz while this high volume of iron metallurgical activities must have been supported by a nearer source. This and identification of the quarries exploited by these metallurgical sites require further systematic research into these sites, better understanding the relations between them and determining the exact type and content of minerals in slags.

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آفله: سایت ذوب فلز دوره اشکانیان واقع بر دامنه های شمالی البرز مرکزی

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محوطه آفله در نزدیکی ضلع شمالی روستای خاچک، در درۀ میان کوهی کجور در جنوبی‌ترین بخش شهرستان نوشهر واقع شده است. این محوطه با توجه به شواهد به دست آمده مربوط به دوران اشکانی است. این محوطه مشخصاً کارگاهی مربوط به ذوب فلز است که به سبب وسعت زیاد ـــ اندکی بیشتر از ۵ هکتار ـــ می‌تواند یکی از اصلی‌ترین و یا مهم‌ترین محوطه‌های ذوب فلز در منطقه از دوران اشکانی باشد.

حجم بالایی از سرباره‌ها و دورریزهای صنعتی در این محوطه به خصوص در ضلع جنوبی و غربی به چشم می‌خورد. بر این اساس می‌توان به حجم بالای تولید محصولات متالوژی در این محوطه پی برد. سرباره‌های موجود در این محوطه به دو دسته متراکم و اسنفجی تقسیم می‌شود که رنگی تیره و مایل به سیاه دارند. حجم بیشتر این دورریزهای صنعتی بیشتر در بخش جنوبی تپه است. بر اثر برش جاده بخش-هایی از بناهایی سنگی نیز در ضلع غربی محوطه به چشم می‌خورد.

با انجام مطالعات ماکروسکوپی و میکروسکوپی سرباره‌های به دست آمده از محوطه مشخص شد که سرباره‌ها غنی از کانی‌های فایالیت و ووستیت هستند که اولی سیلیکات غنی از آهن و دومی اکسید آهن است. در بین این سرباره‌ها یک قطره فلزی (**prill**) نسبتاً درشت از فلز آهن نیز دیده شده که بخش زیادی از آن توسط اکسیدهای آهن ثانویه جایگزین شده است. این مشاهده نشان می‌دهد که احیای فلز آهن از کانسنگ آن، به روش غیرمستقیم ـــ تولید آهن کربن‌دار (فولاد و یا چدن) ـــ بوده و جدایش آن از مذاب سیلیکاتی به احتمال زیاد در بیرون از کوره گداخت (**furnace**) صورت می‌گرفته است.

واژگان کلیدی: آفله، متالوژی باستانی، ذوب آهن، دوره اشکانی، کجور.

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