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OBSIDIAN DEPOSITS FROM NORTH-WESTERN IRAN AND FIRST ANALYTICAL RESULTS: IMPLICATIONS FOR PREHISTORIC PRODUCTION AND TRADE

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ABSTRACT

New studies on prehistoric obsidian artifacts and their provenance have been published by Iranian and international researchers during recent years, which showed, that some obsidian tools might have come from an unknown source located in Iran (perhaps Sahand or Sabalan Mountains). The aim of this paper is to discuss recently discovered obsidian sources in north-west Iran. After a brief introduction of recent obsidian studies in Iran the paper addresses some recent field work and the geochemical analyses of samples from these surveys (from Tajaraq near Miyaneh and Ghizilja near Bostabad in the Bozghoosh Mountains) by using portable ED-XRF analysis. The results suggest that three major obsidian groups can be distinguished, which are classified as group A and B of Tajaraq besides a single group of Ghizilja. The implications of the new results are discussed along with actual limitations and future research directions.

KEYWORDS: Obsidian Deposit, Tajaraq, Ghizilja, North-West IRAN, portable ED-XRF, Prehistoric Sites

1. INTRODUCTION

Obsidian is one of the most important raw materials for tool making that was used from the Paleolithic to the Iron Age in NW Iran (Abdi, 2004). The color of obsidian ranges generally from green and green-grey to black, brown, red and pink. It is translucent at the edges and in thin sections and also completely transparent, glass like, colorless obsidian tools are known. (Reedy, 2008: 9; Gourgaud, 1998). Although there is a variety of minerals, inclusions and products of re-crystallization and weathering, found in obsidian thin sections under the microscope, almost none of these could be used successfully for provenance studies. Therefore, the chemical analysis of obsidian is the standard method for provenance studies of archaeological artefacts (Reedy, 2008: 9; Gourgaud, 1998).

In general, obsidians are divided into three main groups, based on the chemical composition and mineralogy of the geological source magma within which they occur. These three groups are alkaline, calc-alkaline and per-alkaline. Besides the main components, there are trace elements that make it possible to identify different sources. Different magmas in the same volcanic area can have different geochemical fingerprints, so after the sampling of each of these sources the artefacts can be attributed to the studied obsidian outcrops. (Glascok et al., 1998).

Regarding the high number of the obsidian samples found in NW Iran and western Asia, at well-known sites during the last century, many questions about their origin have been raised. More precisely, it has to be asked, if the extremely large number of obsidian tools in most prehistoric sites of NW Iran has been imported or if were they were possibly made of local (up to now unknown) sources? The answers to these questions will be very influential on the interpretation of regional and trans-regional trade mechanisms in the light of so called obsidian exchange networks, connecting adjacent regions such as Anatolia and the Caucasus.

With a focus on these research questions, a field campaign with the intention to find local obsidian sources was carried out by some of the authors in September 2016. This survey, at its first step, led to the identification of an obsidian source around the village of Tajaraq, Miyaneh, located in the Bozqush Mountains, which, as the first identified source of obsidian in Iran, could play an important role the discussions mentioned above.

The geological background of NW-Iranian obsidian deposits can be described in the framework of regional structural zoning models. The studied area is located in western Alborz-Azerbaijan zone (Naba-

vi, 1976), with widespread and linear Tertiary magmatism in the Urmieh-Dokhtar magmatic belt, north of the Lut desert and central Iran, and the western Alborz-Azerbaijan structure. Most of the magmatism seems associated with the active subduction of the oceanic crust of the Neotethys below the Central Iran plateau (Berberian and King, 1981; Alavi, 1991; 1994-1996; Shahabpour, 2004). The acid magmatism is a synchronous phenomena and resulted in very similar chemical compositions of volcanic and plutonic rocks (calc-alkaline to high potassium calc-alkaline, alkaline and shoshonite series).

Based on another model proposed by Moayyed (Moayyed, 2001 and 2002), the Urmieh-Dokhtar Tertiary age magmatism, besides the northern block of the Lut and Central Iran, as well as the western Alborz of Azerbaijan, has no relation to the active subduction of the Neotethys oceanic crust but should be related to the post collisional arc magmatic processes.

2. HISTORY OF OBSIDIANS PROVENANCE STUDIES IN NORTHWEST IRAN

Renfrew and his colleagues have initiated obsidian studies in the Middle East and Iran. With the advent of obsidian studies in relation to trade and exchange in the Neolithic period in the whole Near East, some typical Iranian sites, such as Tepe Sarab and Goran in Kermanshah, Tepe Ali Kosh of Dehloran, etc. have been investigated and analyzed and provided the required background for the future studies on obsidian. These studies continued from the 1960s to the 1970s, but as in the other parts of the Near East, they suffered a long interruption from the 1980s to the early 21st Century. Again, from around 2000, after excavations in obsidian rich sites by Iranian archaeologists, a broad academic collaboration was established between Iranian scholars and researchers from out-side Iran, which led to a joint scientific research up till now. In the northwest of Iran, due to its proximity to the obsidian sources of East Anatolia and the Caucasus (and probably local sources too), the percentage of obsidian tools obtained is much higher than in other parts of Iran. So far, valuable studies have been carried out by various researchers in the area. Most of the studies that were carried out by Renfrew and his colleagues since the 1960s, have revealed the Anatolian (Lake Van Basin) and Armenia deposits (Lake Sevan Basin), as the source of obsidian tools from Iran. Considering the fact that during the sixth to the third millennium B.C. (Neolithic to Bronze Age period), there have been many cultural and trade connections with these regions, they have been trying to figure out how these communications were in detail (Renfrew, 1969; 1977; Renfrew and Dixon, 1976; Wright,

1969; Renfrew et al., 1966; Mahdavi and Bovington, 1972).

Burney was the first who mentioned the possible existence of local obsidian sources in NW-Iran, discussing the excavations carried out in the Neolithic layers of Yanik Tepe (Burney, 1964). But without any support from chemical analyses or the geological record of distinct obsidian outcrops, this was not much more than a reasonable assumption, considering the abundancy of obsidian tools at Yanik Tepe. Since the Sa-hand Mountain is very close to Yanik Tepe, Burney referred to it as a possible resource and origin of the obsidian from Yanik Tepe (Burney, 1964: 56-57).

The provenance of prehistoric artefacts is one of the main topics in archaeometry, since it provides the background for the investigation of trade routes, the way in which raw materials were provided for ancient societies, and how inter-regional communication networks evolved. In the case of the provenance of obsidians from the northwestern regions of the country, long-distance trade through different parts of West Asia and the Middle East can be reconstructed (Chataigner et al., 1998). Based on the results obtained at previous and recent studies (Renfrew et al., 1966, 1969, Dixon et al., 1968, Cann et al., 1968, 1969, Renfrew, 1969, 1970, Dixon, 1976; Renfrew and Dixon, 1976; Blackman, 1984; Williams-Thorpe, 1995; Chataigner et al., 1998; Liritzis, 2002; Frahm, 2010; Liritzis and Zacharias, 2011; Liritzis and Stevenson, 2012; Düring Bleda and Gratuze, 2013; Chataigner and Gratuze, 2014a-b;), the only obsidian sources discovered in the Middle and the Near East are at present located in the Anatolia and the Caucasian region and most of the laboratory investigations have revealed the origin of all obsidian artefacts from ancient sites originate from these two regions. But amongst some of the samples, in particular samples from Iranian sites, there are some artefacts whose original source cannot be defined as their chemistry differs distinctively from the well-known sources of Anatolia and the Caucasus. Iranian re-searchers have tried to define some candidates for local obsidian sources (Khademi et al., 2007; Ghorabi et al., 2009; Khademi et al., 2010), but in most cases, these samples did not belong to real geological outcrops but were surface finds. Also these findings have not been published yet in a detailed way, so they cannot be definitely confirmed or denied by referring to these documents alone. Amongst these, a study by Niknami and his colleagues on material from around Miyaneh and the mountains of Bozgush seemed the most promising (Niknami et al., 2010; Abedi, 2015). The identification of some real obsidian outcrops in the region of Tajaraq (Bozgush Mountains near Miyaneh), and at

Ghizilja (near Bostanabad), both in the East Azarbaijan province, presented in the following, can provide a sound base for a new focus in research on obsidian resources in Iran.

3. MATERIALS AND METHODS

3.1. GEOGRAPHICAL LOCATION OF TAJARAQ (BOZGUSH MOUNTAINS, MIYANEH)

The region of investigation (N 37° 73' 58" - E 47° 68' 38") is located c. 1.5 km south of the village of Tajaraq, Kandovan area (20 km aerial distance, northeastern part of the district), near the city of Miyaneh, in the province of East Azarbaijan, northwestern Iran (Figs. 1 and 2.1).

In terms of regional morphology, this area is located in one of the most violent areas of the Azarbaijan region. High mountains, deep valleys and meandering, massive landslides. Relatively plain water rivers such as Germe Chay and its sub branches have given this area a very disparate and disconnected visage. However, the region of investigation at this study has not too rough, mostly hill-like cliffs. The altitude of the site exceeds 2150 m above sea level. This region has a mountainous climate with moderate summers and very cold winters and the snowy summits are a spectacular characteristic of the area. The humidity level in the region is high and this, from the viewpoint of human geography, means plenty of water for agriculture and horticulture, resulting vast gardens and agricultural farms in the region, especially around the Tajaraq village. The small village of Tajaraq is located north of the obsidian outcrop.

3.2. GEOLOGY OF THE SITE (TAJARAQ)

The territory of Azarbaijan in northwestern Iran includes the provinces of Zanjan, Ardabil, plus East and West Azarbaijan. Due to the diversity of geological evolution and the complexity of the structural setting of different rocks, the lack of sufficient geological studies provokes often different and contradictory views about it. This zone is classified in the Alborz-Azarbaijan zone, the Gorgan-Rasht zone and the Khoy-Mahabad zone (Fig. 2.1). Iran's crustal thickness map (Dehghani and Makris, 1983) show the increasing of crustal thickness in eastern parts of Azarbaijan (west coast of the Caspian Sea towards the Talesh Mountains and Ardebil province) up to 45 Km based on geophysical (gravimetric) data. The maximum thickness of the crust is seen in Azarbaijan in its central part, near the mountains of Moro and Mishoo, which reaches 48 kilometers.

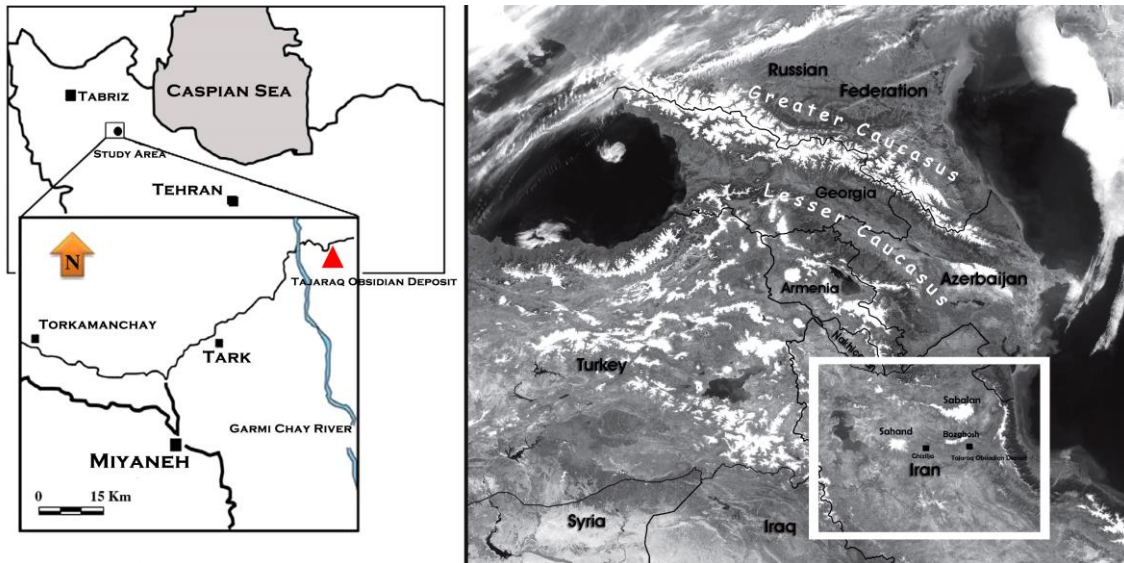


Figure 1. Geographical location of the study area and the Tajaraq deposit of obsidian in Miyaneh, and Ghizilja, East Azarbaijan province, NW IRAN

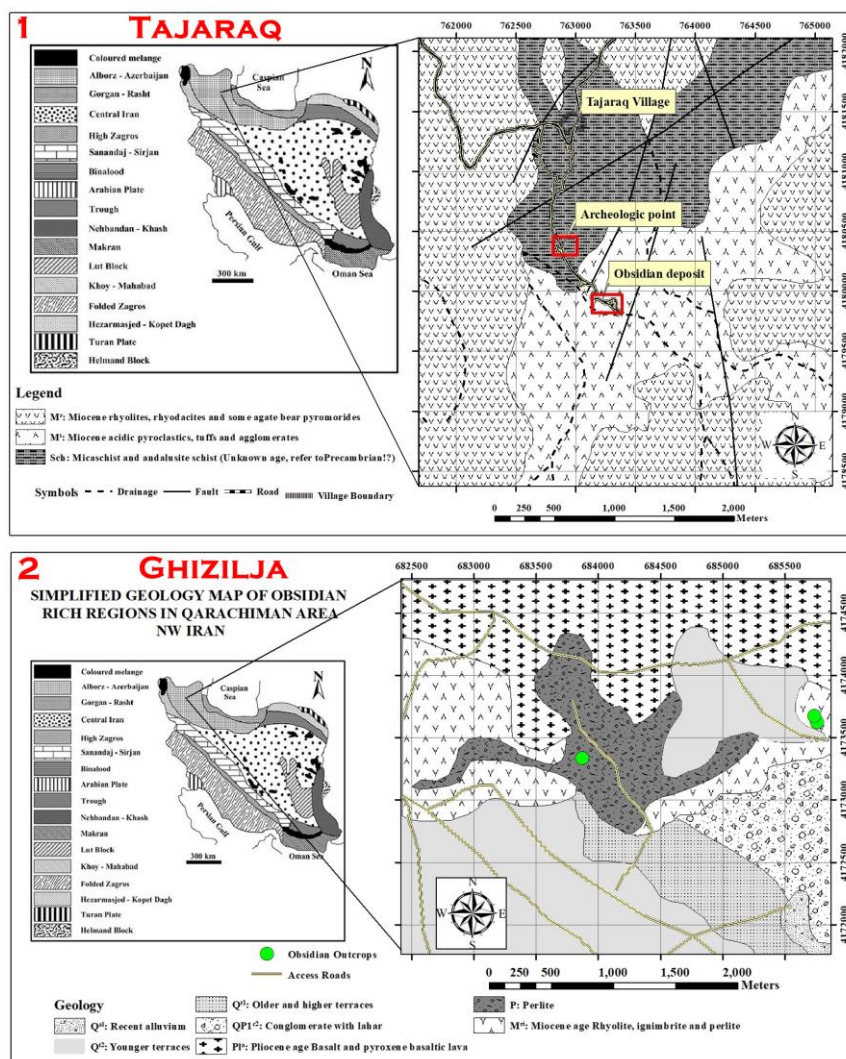


Figure 2. Simplified geological map of Tajaraq district (after Behrouzi and Amini, 1992) and its location on the Iranian tectonic zoning map (after Nabavi, 1976)

The oldest deposits in the territory of Azarbaijan and in the Miyaneh region belong to Precambrian and has been exposed in different parts often along faults and uplifts. In the east of the Bozgusuh Mountains and along the Germe Chay River, Ney Baghi and Sari Qomish villages, a relatively large outcrop of metamorphic rocks with andalusite, cordierite, amphibolite and forsterite schists besides wollastonite marble and metadiabase characteristics have been reported. On these units, different geological formations from the early Paleozoic to recent ages can be seen in the Middle, South, and Eastern parts of Bozgoush. The most important geological event in this region is magmatism, or more precisely, Alpine phase volcanism from Eocene to Quaternary, which causes the formation of the most important geological events in the region, the formation of Bozgoush Mountains in the Eocene and the Chehel Noor Mount in the Miocene (Aghanabati, 2004).

According to the 1: 100,000 scale Sarab geological map quadrangle (Behrouzi et al., 1992), the major units exposed in the visited area are (Fig. 2.1): Schist (old metamorphic attributed to Precambrian composed of mica schist, andalusite schist and marble). Miocene age pyroclastic (Mt) are deposited on the above mentioned metamorphics after a great unconformity as light colour acidic tuff, lapilli stone and agglomerates. This unit is the host of the obsidian reserves in Tajaraq region with NW-SE/SW bedding status. Finally, the violet-hepatic brown color rhyo-

lite-rhyodacite- devitrified pyromerides (Fig. 2.1) are observable in this region. The obsidian reserve is located in a pyroclastic unit as dispersed lenses in a horizon of variable-thickness (Fig. 3). The actual thickness of the obsidian rich pyroclastic horizon in this area is between 1 to 10 m and the boundary of the host rocks with the obsidian black lenses in this region is completely sharp (Fig. 4). It seems that the host rock is often crushed and reworked by tectonic stresses (Fig. 5). Obsidians in this region have a dark green to black colour, glassy luster and shelly fracture.

3.3. GEOGRAPHICAL LOCATION OF GHIZILJA (BOZGUSH MOUNTAINS, MIYANEH)

The Ghizilja area (N 37° 68' 85" - E 47° 08' 45") is located between Qara-Chaman and Tikmeh Dash towns in the East Azerbaijan province and 90 km east of Tabriz. The closest village to this area is the Imamiyeh village. To reach the obsidian rich perlite quarries in this area one has to move along the old road of Tabriz, after moving through Bostanabad and Tikmehdash, use the exit at the village of Qizilja on the north side of the road before the Qar-e Chaman reaches the Imamiyeh village. Then from c.5 km of Imamiyeh perlite quarry, after 6.5 km, we finally reach the Ghizilja perlite quarry. Both ranges are easily accessible by using rides (Fig.1, 2.2).

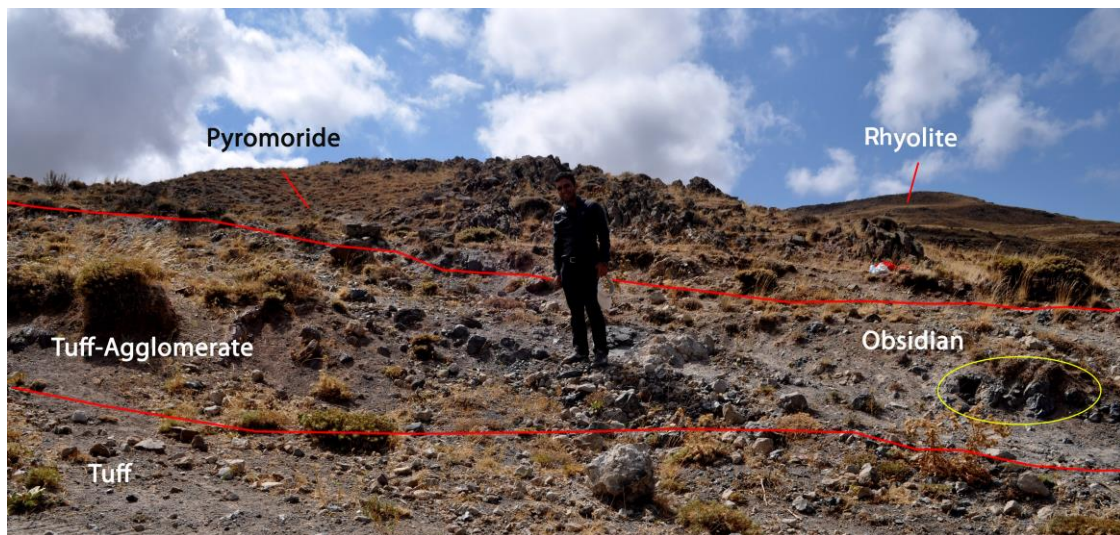


Figure 3. Obsidian formation outcrop and its foot and hang walls (view to South)



Figure 4. The location of Obsidian level into Tuff-Agglomerate member (view to South)



Figure 5. A mesoscopic view of the crushed Obsidian particles at Tajaraq (view to South)

3.4. GEOLOGY OF THE SITE (GHIZILJA)

Based on structural zoning of Iran, this region is located in western Alborz of Azerbaijan structural zone (Nabavi, 1976), and generally all of the rock outcrops and lithologies observed in it are of Pliocene age volcanic lavas and pyroclastic units. In visited zones, the perlite is in actual layers compatible with the layering of lava and pyroclastic units in the form of layers between 1 cm to 2 m thickness with grey, brown and black colours and the perlitic structure is common. In addition, the so called thunder eggs derived from devitrification, can be found. The quarries are currently semi-active (Fig. 2.2).

In the Imamiyeh quarry, with 670126, 4176104 to 683871, 4173333 coordinates (UTM-WGS-1984 / N38Zone system): obsidian rich perlite layer are observable as concordant intercalation with their porphyry texture volcanic and pyroclastic host rocks.

The same status are observable in obsidian rich perlite Ghizilja quarry in 685785, 4173624 coordi-

nates. In c. 100 m distance of the quarry (at 685735, 4173672 coordinates) a place with concentrations of ancient pottery is observable.

3.5. STUDIED SAMPLES AND ANALYTICAL METHODS

The samples of this study were gathered on a survey from surface obsidian outcrops. A total of 18 samples were selected from several sets of rocks and 10 samples were analyzed. Of these 10 samples, eight samples belong to the Tajaraq deposit near Miyaneh and two samples were selected from the Ghizilja deposit (Shahriyar Perlite quarry) near Bostanabad. (Fig. 6) Up to now only small homogeneous obsidian specimens have been collected, with a maximum diameter of c. 5 cm. Larger samples were fractured substantively tectonically or by perlitization. Therefore it is not clear at the moment, if large and homogeneous obsidian nodules of good quality occur in the area, which is essential if this raw material should have been used in Prehistory for tool making.



Figure 6: Selected samples from Tajaraq, Miyaneh, and Ghizilja, Bostanabad (MA-TJ- 001, MA-TJ- 002, MA-TJ- 003, MA-TJ- 004, MA-TJ- 007, MA-TJ- 008, MA-TJ- 012, MA-TJ- 014; Finding place of the samples, Tajaraq village, Miyaneh city, East Azerbaijan BS-GHZ-001 ·BS-GHZ-003; Finding place of the samples, Ghizilja/Shahryar perlite quarry, Bostanabad, East Azerbaijan)

For the measurements a portable ED-XRF device (Thermo Scientific Niton XL3t 950-HE GOLDD+ Serial nr. 89086 from the Eurasia Department of the German Archaeological Institute, Berlin) was used, equipped with an Ag anode at max. 50 kV, silicon drift detector. Technical parameters: TestAllGeo-mode with filter settings 90/90/60/125 seconds, total measuring time 360 seconds, aperture 8 mm. This setting gives best results for ceramics, stones, slags and other material with high silica content and not too bad results for light elements also. Sodium cannot be detected with this device, but most elements from magnesia onwards, which have higher atomic weights. Factory calibration was used and the oxides were normalized to 100 wt% (without Na₂O). To ensure reliable data, measurements of international

certified standard reference material (NIST2780, NIST2709a, Till4 and others) were used during the sessions. The standard deviation and the variability according to the standards is in a low and normal range, that ensures comparability with published datasets. Some of the most reliable element concentrations in obsidian that can be obtained using portable ED-XRF are Rb, Sr, Y, Zr and Nb, if the concentrations are above the detection limit (Darabi and Glascock, 2013). Sample thickness plays an important role and several elements are difficult to be detected in low quantities, when the samples or artefacts are too thin (as documented for the device used in this study by test measurements of the Eurasia Department; also for other difficulties using pXRF on obsidian and further references c.f.: Ferguson 2012).

Table I. pXRF results of elemental analysis of the samples from Tajaraq, Miyaneh, and Ghizilja Bostanabad (oxides normalized to 100 wt%, without Na₂O)

Samples No	Location	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	K ₂ O
MA TJ2016 - 001	NTV*	79,04	0,07	13,25	1,64	0,08	0,93	0,46	4,51
MA TJ2016 003	NTV	80,53	0,07	12,63	1,64	0,07	0,11	0,43	4,48
MA TJ2016 002	NTV	75,9	0,3	14,04	2,43	0,11	0	1,16	6,01
MA TJ2016 004	NTV	79,81	0,08	11,67	1,7	0,08	0,67	0,5	5,45
MA TJ2016 007	NTV	80,34	0,07	10,99	1,72	0,08	0,72	0,46	5,59
MA TJ2016 008	NTV	78,68	0,07	12,48	1,73	0,08	0,9	0,56	5,45
MA TJ2016 012	NTV	73,18	0,39	15,23	2,84	0,1	1,26	1,61	5,36
MA TJ2016 014	NTV	74,01	0,38	15,2	2,86	0,08	0,56	1,06	5,8
BS GHZ 2016 001	SPM**	82,7	0,13	10,88	0,77	0,06	0,65	0,01	3,72
BS GHZ 2016 003	SPM**	83,41	0,14	10,28	0,72	0,06	0,29	1,1	3,92

*NTV: NEAR TAJARAQ VILLAGE **SPM: SHAHRIAR PERLITE MINE

3.6. RESULTS

The chemical analysis clearly shows that the samples of the two sources have a peculiar composition that is different from other obsidian groups previously known (Tab. I-II and Fig. 7). These new groups are introduced and proposed as the new group of Tajaraq Obsidian (MA TJ - Miyaneh Tajaraq Obsidian Source) and are referred to as Tajaraq A and Tajaraq B, while from Ghizilja the analysed samples seem to form one homogenous group.

3.6.1. DISPERSION CHART ANALYSIS - ZIRCONIUM AND RUBIDIUM (ZR/RB)

The zirconium and rubidium relation (Fig. 8) shows that the above mentioned three groups are clearly distinguishable. Group Tajaraq A is very dense because the samples were comparably fresh and from a small scale geological horizon. Group Tajaraq B is more variable. The other two samples belong to the Ghizilja perlite quarry of Bostanabad (BS GHZ).

3.6.2. DISPERSION CHART ANALYSIS: RUBIDIUM AND STRONTIUM (RB/SR)

In the diagram of Rb/Sr the samples of the three sites plot again in three distinct areas (Fig. 9) and therefore they can be separated geochemically quite easy.

Table II. *pXRF* results of elemental analysis of the samples from Tajaraq, Miyaneh, and Ghizilja Bostanabad (trace elements in ppm)

Sample No	Loction	Zn	As	Rb	Sr	Y	Zr	Nb	Sn	Sb	Ba
MA TJ2016 001	NTV*	55	22	270	2	45	290	66	7	12	185
MA TJ2016 003	NTV	55	23	275	2	45	295	69	7	9	131
MA TJ2016 002	NTV	48	10	215	101	35	611	62	8	13	477
MA TJ2016 004	NTV	52	21	257	4	41	271	62	7	12	165
MA TJ2016 007	NTV	53	20	254	5	41	266	61	9	13	188
MA TJ2016 008	NTV	53	21	261	4	42	272	62	8	11	172
MA TJ2016 012	NTV	55	10	203	135	34	627	64	7	11	388
MA TJ2016 014	NTV	57	12	237	74	40	718	73	7	11	380
BS GHZ 2016 001	SPM**	24	9	92	121	9	77	12	13	26	1126
BS GHZ 2016 003	SPM**	26	8	124	126	10	77	13	11	22	1109

*NTV: NEAR TAJARAQ VILLAGE **SPM: SHAHRIAR PERLITE MINE

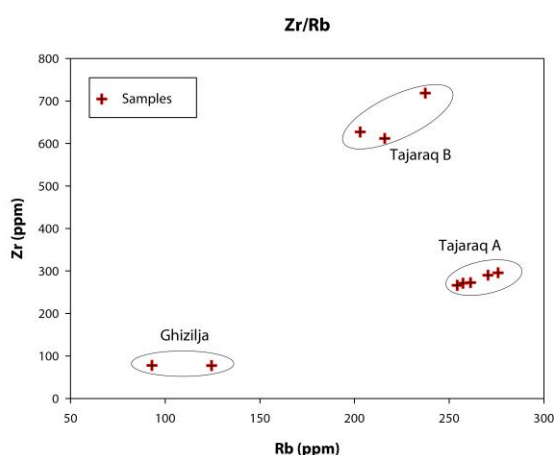


Figure 7. Scatterplot of Zr versus Rb for obsidian samples from Tajaraq and Ghizilja obsidian sources (*pXRF*).

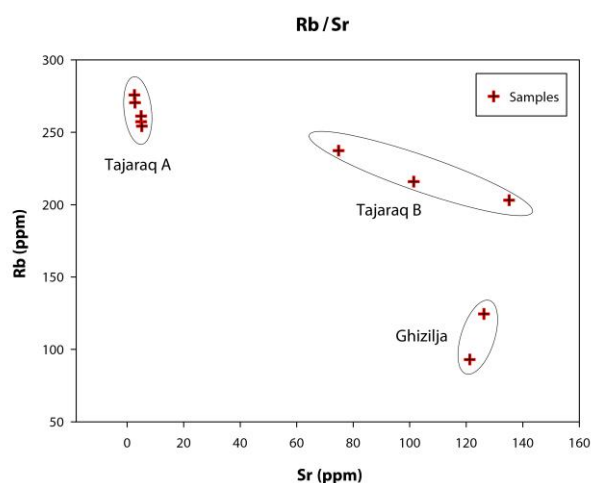


Figure 8. Scatterplot of Rb versus Sr for obsidian samples from Tajaraq and Ghizilja obsidian sources (*pXRF*).

4. DISCUSSION AND CONCLUSION

The present study introduces new obsidian sources in the northwest of Iran. The research has

been carried out with a focus on locating the origins and resources of obsidian procurement in the northwest of Iran, in order to rethink and reconstruct the regional and supra-regional trade and exchange

networks in future. The project clearly identified the three groups of geochemically different obsidians named Tajaraq A, Tajaraq B, and Ghizilja. Due to the fact that Tajaraq obsidian is of a higher quality than the Ghizilja ones, it seems likely that the samples of Tajaraq obsidians have had the ability to be used for tool-making in the past, while the samples of Ghizilja, Bostanabad are too fragile and perlitic in structure.

Hence, as the two groups of Tajaraq A and Tajaraq B have the ability to be used for ancient tools in all probability, they can be introduced as candidates for obsidian mining in prehistoric times in the northwest of Iran. The proposed hypothesis is actually still at a very early stage and future scientific studies and field research have to follow. Comparing the new results with prehistoric sites in the cultural areas of Miyaneh and Bostanabad, it becomes obvious that the Tajaraq B obsidian overlaps in some trace elements with published data Anatolian sources (Darabi and Glascock, 2013) (Fig. 10). If this overlap could be found also by comparing other elements and their combination and if it will be confirmed by other methods in future, it could lead to a

complete review of all previous obsidian analysis from Iran. Several samples that were up to now thought to be from Anatolia could come from source B of Tajaraq in reality. This is a serious and peculiar hypothesis, which means at first more data have to be collected at the geological outcrops and especially by analyzing archaeological finds from well stratified context.

Although the biplots Zr-Rb, Sr-Rb may be on a local scale discriminative they are not necessary condition for differentiation between peripheral sources e.g. Iranian with those from Anatolian or Aegean. For example, in the Aegean for Melos source $Sr \sim 120$, $Rb \sim 112$ ppm (Liritzis, 2007) which is similar to NW Iranian. This must be noted, in addition to Anatolian sources. Although it has been noted here for the Tajaraq B obsidian which overlaps in some trace elements with published data from Nemrut Dağ, and also with other Anatolian sources, it is too premature to pinpoint the question of provenance. Thus, in a future provenance project major and trace elements should be subjected to Cluster, PCA etc analysis. (Liritzis & Zacharias, 2013).

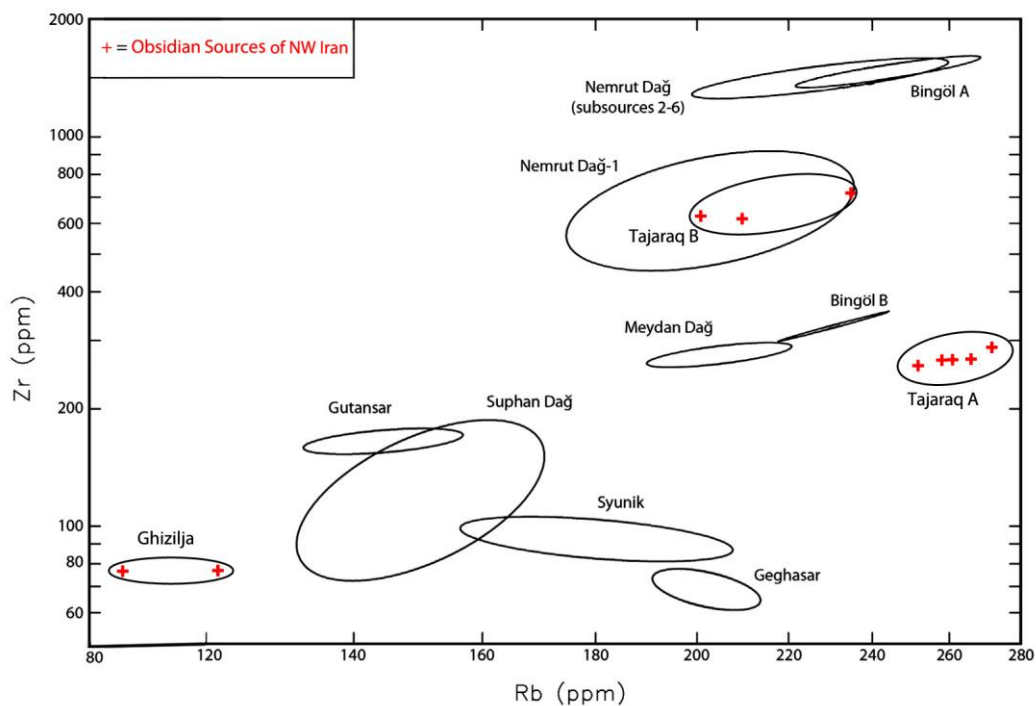


Figure 9. Log scatterplot of Rb versus Zr for obsidian sources of Turkey and Armenia (modified after Darabi and Glascock, 2013) and Tajaraq A, B and Ghizilja (NW Iran, pXRF).

SUGGESTIONS AND THE WAY FORWARD

The next important step is certainly the investigation of ancient sites from the Neolithic to the Iron Age, especially in the eastern part of Lake Urmia and close to the cities of Miyaneh and Bostanabad, so that it can be proven that the samples of Tajaraq ob-

sidian and other comparable sources in this region have been used for the manufacture of artefacts in Prehistory. As there have been many investigations and excavations in the areas of Miyaneh and Bostanabad in the recent years, the systematic and minute examination of the obsidian finds from these sites will be a huge part of the project. Then all these find-

ings of obsidian have to be analysed, first with pXRF and for detailed studies selections of the whole could be measured by laboratory methods. Another important part is the fieldwork and surveying around the obsidian outcrops themselves, for the identification of possible traces of ancient mining and processing, besides the first steps in the chaîne opératoire of obsidian manufacture. In a close circle

around the deposits, settlements can be expected, that were specialized in obsidian mining and the first steps of raw material treatment, before the valuable matter was exchanged and transported in the vicinity. This study opened a new horizon to research in NW-Iran around the Sahand, Sabalan and Bozghush Mountains and provided a sound base for future studies in the field of obsidian provenance.

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