Archaeometric studies on Neolithic bullet-shaped cores from East Chia Sabz, Seymareh, Luristan

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The East Chia Sabz site is located on the bank of the Seymareh River in the middle of the Zagros Mountain chain. The site is among the few examples of the acramic Neolithic sites of the 8th millennium B.C. of Zagros which was archaeologically investigated during the rescue archaeological studies of the Seymareh dam. Numerous bullet-shaped cores were unearthed during the archaeological excavation of the site, from which twenty were investigated using XRD and XRF analyses. According to the results, most of the lithic artifacts demonstrate a similar mineralogy and geochemistry and are mainly composed of a cherty material with some impurities of calcite, chlorite, hematite and clay minerals. The presence of these impurities has lowered the cutting quality of these lithic materials. It seems that the cores had been provided from a local source. In this regard, the chert cobbles of the Amiran Formation that are also available from the river beds of the area could have been a significant source.

Keywords: *Zagros, mineralogy, geochemistry, XRD, XRF, Amiran Formation, lithic industry*

Introduction

Lithic technology has been widely used by human being in the ancient times, especially from Paleolithic to Neolithic periods. This makes lithic tools and their associated technology a useful material for the study of ancient cultural andtechnological developments. In this regard, the middle Zagros Mountain chain and western Iran (Pullar 1977; Zeder 2000) are outstanding places for the study of such tools and their associated technology, especially for the Neolithic period. Typological, cultural, behavioral, and provenance studies on such lithic artifacts will broaden our knowledge over the Neolithic societies. In this study an archaeometric research was performed on some bullet-shaped cores from East Chia Sabz in Luristan area, western Iran, an ancient settlement occupied from the early 9th to the early 7th millennium B.C. (Darabi *et al*. 2011; Hessari *et al.* 2015). The East Chia Sabz is one hektar large and located 9km NW of the arch of Seymareh dam in the Luristan Province. This site is situated at the bank of the Seymareh River on a natural rock of Gachsaran Formation in the catchment of the Seymareh dam andoverlooks the Seymareh River and has a good access to several sweet water springs (Figures 1a and 1b). The East Chia Sabzwas first discovered in the course of an archaeological salvage survey within the catchment area of the Seymareh dam (Seyedein Boroujeni 2007). Consequently, two series of rescue archaeological investigation were carried out by Iranian teams under the supervision of Hojjat Darabi (first season, 2009) and Morteza Hessari (second season, 2010, Darabi and Glascock 2013; Hessari *et al*. 2015). A significant amount of lithic artifacts were unearthed from the site, which were mostly composed of a cherty material but also a few obsidian pieces from later periods (Darabi *et al*. 2013; MirBolouki *et al*. 2015).

During the second season of excavation (supervised by M. Hessari), six workshops were excavated among which the workshop No. 3 with 14 stratigraphic (settlement) levels and diverse cultural materials including architectural and burial structures as well as bone pieces, lithic materials, and zoological and botanical remainings was the most important workshop. Such findingsintroduce East Chia Sabz as a rare Neolithic aceramic site from the Late eighth millennium B.C. of Zagros (Hessari *et al*. 2015). 126 lithic artifacts were unearthed from

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the workshop No. 3 which mostly include different forms of cores consisting of complete bullet core, bladelet core, mixed core (flake and bladelet), semi bullet core, cone bullet core, flake core, broken bullet core, tongue-shaped core, semi tongue-shaped core, mega coreand polygonal cores. Figure 2 shows a few types of the aforementioned forms.

A radiocarbon dating performed by Hessari and Nishiaki (2016) on cultural fining from the 11th architectural phase of workshop No. 3corresponds to 9005 ± 34 B.P. This confirms the archaeological dating of Late eighth millenium B.C. for this workshop.

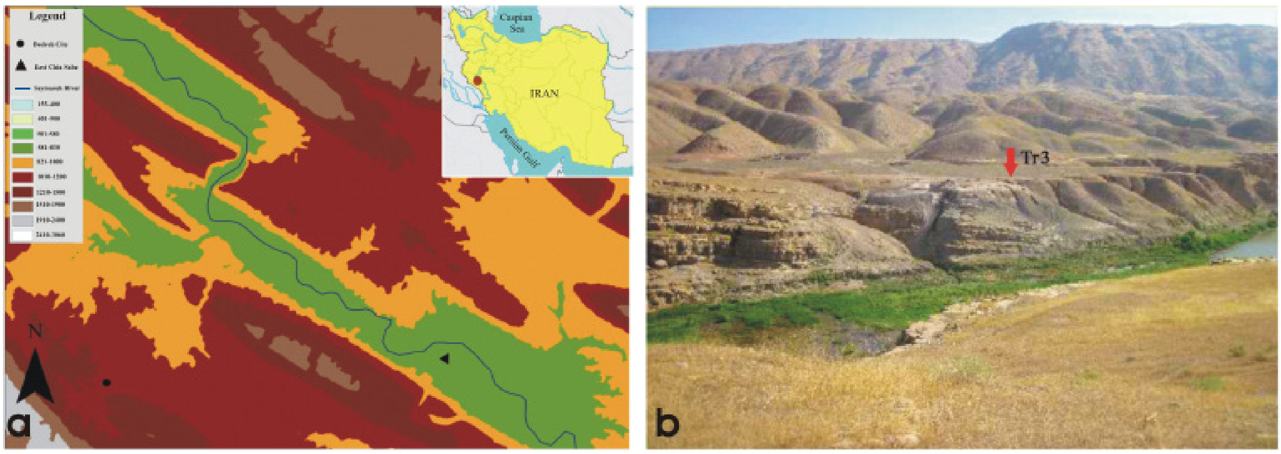

Fig 1: *a) Location of the East Chia Sabz and part of the Seymareh River, b) an overview of the East Chia Sabz at the Seymareh River, looking to the south (pictures modified after MirBolouki et al. 2015).*

This study lead to better understanding of the quality of the materials utilized and also the possible sources used for their production which as a whole partly clarified the living conditions of the ancient people of East Chia Sabz.

Materials and Methods

In this research twenty representative bullet-shaped cores were selected for archaeometric analysis (Figure 2). The samples were investigated using X-ray fluorescence (XRF) and X-ray Diffraction (XRD) methods in order to better understand the geochemical and mineralogical composition of the cores. This, consequently featured the cutting quality as well as the provenance of the materials used. The analyses were performed at the Zarazma Mineral company, Tehran. In order to find the possible source of the lithic artifacts, the results were compared with the previously published information over the geology and mineralogy of the area.

Resluts

According to the analysis results (Table 1), 18 out of 20 samples are made up of a cherty material and indicate a rather homogeneous geochemical and mineralogical composition. In these samples, more than 85% of the composition is of SiO2, while the subordinate amounts of other oxides including Al, Ca, Fe, and Mg have appeared as fine-grained calcite, dolomite, hematite, chlorite, and clay minerals (montmorillonite, illite, and kaolinite). The hand specimen examination of these samples shows that they are also similar from the viewpoint of color and are mainly light in color including white, light cream, light brown, and light gray. The presence of traces of hematite has given some of the lithics a reddish shade. Conchoidal fracture is a common characteristic among all the samples which in fact gives the cutting property to such a material and makes it a suitable cutting tool. Presence of non-silica impurities in the samples (from 4 to 14%) lowers their cutting quality and introduces them as medium-quality cutting materials. Two samples (out of 20), due to their high contents of clacium (and magnesium) oxides, are geochemically and

Fig 2: *The samples that were investigated during this study (the scale size = 2cm), the sample numbers are written below the pictures.*

mineralogically different from the others. The sample No. 3638 contains about 49% CaO, 3.3% MgO and only 3.96% SiO2, and therefore is a carbonate rock (with a calcite-dolomite composition) which has been silicified to some extent. Interestingly, also the color and the fracture type of this rock is different from the other samples. The lithic blades made of such core have had a low quality of cutting. The sample No. 3407 with 70.99% SiO2 and 13.95% CaO is a siliceous-carbonate rock with conchoidal fractures. Also such a material has probably been used for production of a low quality cutting tool.

A review of the geological units of the surrounding area of Chia Sabz on the geologic map and also in the field (Figure 3) indicatess that the study area is composed of a series of mountain chains with a general NW-SE trend. A sequence of anticlines (ridges) and synclines (troughs) is a frequent landmark of the area, where the anticlines are mainly made up of erosion-resistant limestone while the synclines are mainly composed of erosionaly weak rocks including marl and gypsum. The highest peak of the area (with 2700 m.a.s.l height) is on the large anticline of Kabirkuh, while

***Table 1:** Mineralogical and compositional measurement of the East Chia Sabz bullet-shaped cores using XRD and XRF analyses. Elemental concentrations are given in %. Elements below detection limit are indicated by <.*

Sample No.	XRD		XRF (%)								
	Major phase	Minor phase	SiO_2	Al_2O_3	CaO	Fe_t	MgO	K_2O	Na_2O	MnO	LOI
3064	Quartz		95.26	1.24	0.11	1.02	0.18	0.27	0.37	<	0.98
3090	Quartz	Montmorillonite	94.63	1.54	0.14	0.93	0.12	0.44	0.51	0.01	1.18
3150	Quartz	Montmorillonite+Kaolinite	93.84	0.27	0.19	3.26	0.05	0.23	0.64	0.02	-0.06
3207	Quartz		95	0.3	0.22	0.94	0.03	0.26	0.67	0.94	1.11
3228	Quartz	Hematite+Montmorillonite	93.23	1.6	0.19	1.55	0.24	0.54	0.81	0.01	1.02
3393	Quartz	Calcite+Dolomite	85.5	0.7	4.82	0.89	0.37	0.33	0.92	0.01	5.89
3398	Quartz	Chlorite	86.24	3.35	0.15	3.53	1.32	0.43	0.86	0.07	2.29
3407	Quartz+Calcite	Illite	70.99	0.74	13.95	0.48	0.14	0.39	0.82	0.15	12.06
3434	Quartz	Calcite+Dolomite	88.22	0.61	4.01	0.55	0.11	0.31	0.77	>	4.93
3500	Quartz		96.13	0.44	0.08	1.01	0.01	0.29	0.72	0.01	0.83
3574	Quartz	Hematite	95.64	0.91	0.08	0.58	0.06	0.36	0.75	>	1.24
3598.1	Quartz	Calcite+Montmorillonite	92.12	0.18	2.9	0.54	0.04	0.27	0.64	0.01	3.04
3605	Quartz		93.65	1.76	0.11	0.73	0.38	0.49	0.67	0.01	1.78
3623	Quartz	Montmorillonite	95.97	0.91	0.2	0.46	0.11	0.34	0.58	0.01	1.1
3624	Quartz	Montmorillonite+Hematite	91.96	2.51	0.15	1.11	0.49	0.72	0.63	0.01	1.79
3638	Calcite+Dolomite	Quartz+Hematite+Hornblende	3.96	0.46	48.82	0.26	3.3	0.37	0.55	0.03	41.98
3643.1	Quartz	Chlorite+Montmorillonite	89.48	3	0.31	1.88	0.8	0.46	0.56	0.05	2.35
3656	Quartz	Montmorillonite	94.28	1.54	0.25	0.85	0.17	0.45	0.45	0.04	1.35
3660	Quartz	Montmorillonite	95.2	1.1	0.12	0.94	0.3	0.33	0.41	>	1.04
3PH10.1	Quartz	Calcite	91.71	0.07	3.24	1.06	0.03	0.18	0.29	0.02	2.91

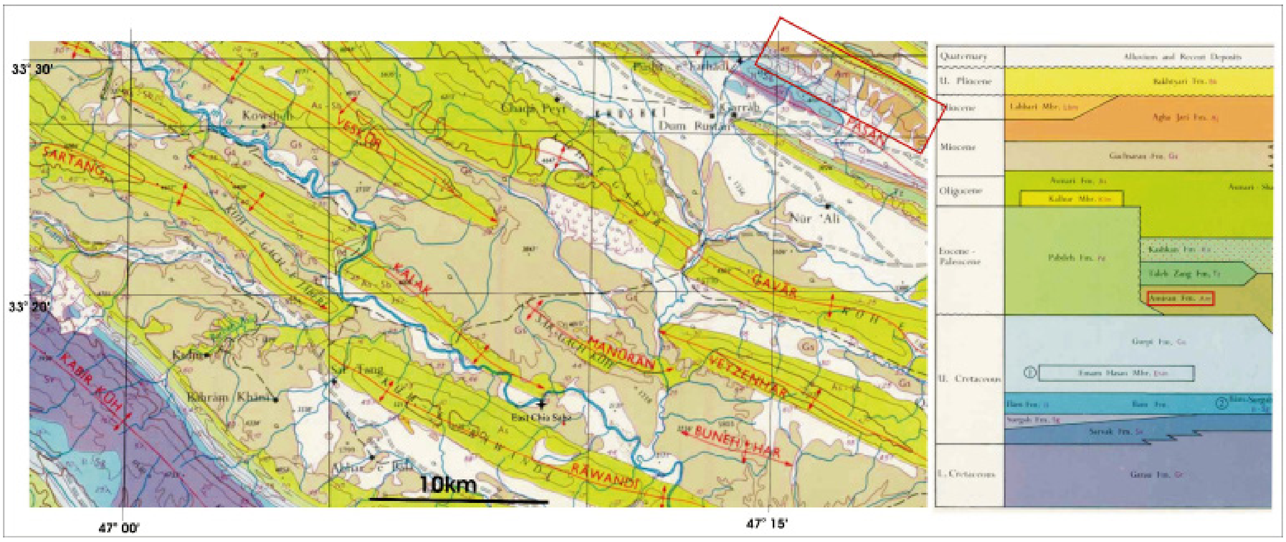

***Fig 3:** The geologic map of the study area (part of the Ilam-Kuhdasht 1:250,000 geologic map, Llewellyn 1974), the Amiran Formation has been highlighted by a frame.*

the river bed of Seymareh with about 600 m.a.s.l composes the lowest level of the area. The East Chia Sabz itself is located on the Gachsaran Formation which is mainly composed of evaporate sediments and lacks the material appropriate for production of the cores. Nevertheless, the siliceous material from the Amiran Formation is widely scattered in the surroundings, especially in the riverbed and the streams.According to the Ilam-Kuhdasht geologic map, the closest geological units to the site include Gachsaran and Asmari-Shahbazan which are mainly composed of carbonates and evaporates as well as some non-siliceous detrital rocks and rareley contain silicic fragments (Stöcklin and Setoudehnia 1971; Llewellyn 1974). On the other hand, the only possible unit with chert and silicic fragments in the vicinity of the site is the Amiran formation. The East Chia Sabz is almost located in the middle of the Zagros Mountain Chain, where there is a considerable amount of outcrops of the Amiran Formation. This formation,withMaastrichtian-Paleocene age, is one of the siliciclastic formations of Zagros which has formed after the Laramide Orogeny in the Luristan area (Aghanabati 2006; Nasiri *et al*. 2013). After the collision of the Arabian and Central Iranian plates, a major rising, folding, and thrusting has occurred which was followed by erosion of high Zagros as well as radiolarite-ophiolite units of Zagros. Due to the rise of the oceanic crust at the central and northeastern areas, the detrital materials originated fromerosion, were transported to the southwestern and southeastern areas (Alavi 2004). During Upper Cretaceous to Paleocene, the erosional material from this collision has formed the Amiran Formation in the foreland basin of the Zagros fold belt (Casciello *et al*. 2009). The Amiran Formation is mainly composed of clastic sediments locally mixed with carbonate sediments. In the Luristan area, this formation is mainly composed of brown sandstone, green shale, and limestoneunits. Formation of carbonate siliciclastic mixtures occurs in diverse mechanisms including lateral admixture of facies, changes in the sea level as well as the change in the discharge of sediments to the basin (Budd and Harris 1990; Nasiri *et al*. 2013). In this regard, the Amiran Formation is, as a whole, composed of a carbonate siliciclastic mixture whose siliciclastic units are composed of shale, siltstone, calclithite, lithic greywacke, chert arenite, and orthoconglomerate (Nasiri *et al*. 2013; Piriaii 1996). Especially in Luristan, the conglomerate memebr of this formation contains chert pebbles and cobbles as a major constituent (Amiri Bakhtiar and NouraiiNezhad 2014).

According to the mineralogical investigation performed by Nasiri *et al*. (2014) on some clastic samples from Amiran Formation, quartz and clacite are the major constituents of the rocks of this formation, while albite, anorthite, muscovite, paragonite, chlorite, illite, and montmorillonite form the minor constituents. Presence of plagioclase, albite, anorthite and muscovite indicate an igneous origin for the sediments of this formation.Therefore, the source rock could have been a basic igneous rock (gabbro or basalt) constituting the ophiolites of the subduction zone of Zagros. This can also be true for the origin of the conglomerate member of the Amiran Formation whose chert cobbles could have originated from the radiolarian part of the ophiolites.A comparison of the mineralogical results by Nasiri *et al*. (2014) with the analyzed samples of current research indicates a close similarity of the results.

Conclusions

Based on the mineralogical and geochemical composition of the samples and the aforementioned information,18 (out of 20) samples demonstrate a similar chemistry and mineralogy and are mainly composed of a cherty material with some impurities of calcite, chlorite, hematite and clay minerals. The presence of these impurities has lowered the cutting quality of the lithic materials. It seems that the ancient people of Chia Sabz were content with the local medium to low quality material of their surroundings for the production of their lithic cutting tools and except for a few pieces of obsidian rarely imported a better quality material from farther places. Interestingly, the geology of the surroundings boosts such an assumption.

From the abovementioned information and the field and analytical investigations on the rocks of the study area, it can be concluded that the siliciclastic fragments of the Amiran Formation could have well been the origin of the bullet-shaped cores used in the East Chia Sabz site. The closest outcrops of this

formation to the site are located about 10 to 15km north-northeast of the site (Figure 3). It should be taken into consideration that it was not necessary for the ancient people of Chia Sabz to extract the in situ siliciclastic fragments from the rock, but could simply collect the already (by erosion) freed pieces in the surrounding field and riverbeds. The natural erosional factors not only extracted the siliciclastic boulders from the rock, but also brought them to an appropriate workable size (fist-size).
It seems that the ancient people of Chia Sabz were well aware of the raw materials available on their surroundings and made use of the siliceous boulders and cobbles scattered in the surrounding riverbeds and streams, although they sometimes used low quality carbonate materials too.

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References

Aghanabati, A.
2006 *Geology of Iran. Geological Survey and Mineral Exploration of Iran*, 586p (in Persian).

Alavi, M.
2004 Regional stratigraphy of the Zagrosfold-thrust belt of Iran and its proforeland evolution. *American Journal of Science*, 304:1-20.

Amiri Bakhtiar, H. & K. A. NouraiiNezhad
2014 Stratigraphic Reconsideration of Zagros; The Amiran Formation, *Oil and Gas Exploration and Production Monthly Journal*, National Iranian Oil Company (in Persian), 118: 37-39.

Budd, D. A. & P. M. Harris
1990 Carbonate siliciclasticmixtures. SEPM Reprint Series, 26, Tulsa: *Society for Economic Paleontologists and Mineralogists*, 185–204.

Casciello, E; J. Vergés; E. Saura; G. Casini; N. Fernández; E. Blanc; S. Homke & D.W. Hunt
2009 Foldpatterns and multilayer rheology of the Lurestan Province,Zagros Simply Folded Belt, Iran. *Journal of the GeologicalSociety*,166:947-959.

Darabi, H.; R. Naseri; R. Young & H. Fazeli
2011 Absolute chronology of East Chia Sabz: a Pre-Pottery Neolithic Site in Western Iran. *Documenta Praehistorica* 38:255-265.

Darabi, H., and Glascock, M. D.
2013 The source of obsidian artefacts found at East Chia Sabz, Western Iran, *Journal of Archaeological Science* 40:3804-3809.

Darabi, H.
2014 The Chipped Stone Industry of East Chia Sabz, Seymareh Dam: Technological Changes from Transitional Neolithic to Aceramic Neolithic Time in Western Iran, *Pazhuhesh-ha-ye Bastanshenasi Iran* (Archaeological Researches of Iran),

Hessari, M.; M. Amiri & S. M. Mirbolouki
2015 East Chia Sabz, the aceramic neolithic village of Seymareh, Zagros cultural distric, In Leili Niakan (ed.) *Archaeological researches on the catchment area of the Seymareh dam*, Iranian Cultural Heritage Research Institute Press, 25-33 (in Persian with ana English abstract).

Hessari, M. & Y. Nishiaki
2016 *Radiocarbon dating of some samples from different sites of Iran*, unpublished report, Art University of Isfahan.

Llewellyn, P. G.
1974 *1:250,000 geologic map of Ilam-Kuhdasht,* Oil Service Company of Iran, Geological and Exploration Devision, Tehran.

S. M. MirBolouki; M. Hessari & K. A. Niknami
2015 *The Evolution of the bullet-shaped cores of the workshop No. 3 of the East Chia Sabz site, Seymareh of Luristan, Iran*, In: Morteza Hessari (ed.) A Festschrift in honor of Dr. Sadegh Malek Shahmirzadi (2015), Iranian Cultural Heritage Organization, Tehran, Iran (in Persian).

Nasiri, Y.; A. Mahboubi; S. R. Mousavi Harami; A. R. Khazaii & B. Yousefi Yeganeh
2013 Reconstruction of the sedimentary environment of the terigenous siliceous-carbonates of Amiran Formation (Upper Cretaceous-Paleocene) in southwest of Luristan, *Quarterly journal of Geology of Iran*, Vol. 7, No. 27, 55-74 (in Persian with an English abstract).

Nasiri, Y.; S. R. Mousavi Harami; A. Mahboubi & B. Yousefi Yeganeh
2014 *Identification of the constituent minerals of the shales of Amiran Formation and their origin using XRD method*, Proceedings of the 32nd geoscience conference, Geological Survey and Mineral Exploration of Iran (in Persian with an English abstract).

Piriaii, A.
1996 *Microfacies, petrography, and sedimentary environment of the Amiran Formation,* Unpublished MSc thesis, Tarbiat Moalem University, Terhan (in Persian).

Pullar, J.
1977 Early cultivation in the Zagros. *IRAN* 15: 15-37.

Seyedein Boroujeni, S. R.
2007 *Archaeological Survey in the catchment area of the Seymareh Dam.* Iranian Center for Archaeological Research, Tehran, Unpublished internal report (in Persian).

Stöcklin, J. & A. Setudehnia
1971 Stratigraphic lexicon of Iran. *Geological Survey of Iran*, Report No. 18, 376 p.

Zeder, M. A.
2000 The Initial Domestication of Goats (Capra hircus) in the Zagros Mountains 10,000 Years Ago. *Science* 5461:2254-2257.