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ANALYTICAL INVESTIGATION OF OBSIDIAN TOOLS FROM KURDISTAN PROVINCE, IRAN: DETERMINATION OF EXCHANGE PATHS DURING THE CHALCOLITHIC PERIOD

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ABSTRACT

A collection of Chalcolithic period obsidian artefacts from the sites of Namashir, Ghazikhan and Galali in Kurdistan province, Iran, were studied by X-ray fluorescence and neutron activation analysis. All of the artefacts were found to have originated from sources in Anatolia and Armenia. The source of Early to Late Chalcolithic 1 artefacts recovered from the site of Namashir was Meydan Dağ. The source of Late Chalcolithic 1 artefacts from the site of Galali was Nemrut Dağ. During the Late Chalcolithic 2, the sites received obsidian from multiple sources and the number of importing paths also increased. Changes in the sources of cultural materials can reveal their paths as well.

KEYWORDS: Kurdistan Province, Western Iran, Chalcolithic Period, X-ray fluorescence, Neutron activation analysis, Provenance

1. INTRODUCTION

Studies of obsidian artefacts to identify their sources have proven to be a valuable tool for understanding communication and exchange between prehistoric people. In Iran, obsidian artefacts mostly date to the Neolithic (Abdi, 2006; Darabi and Glascock, 2013; Renfrew *et al*., 1969; Renfrew and Dixon, 1977) and Chalcolithic (Abdi *et al*., 2002, 61; Abedi *et al*., 2018a, 2018b; Barge *et al*., 2018; Binandeh *et al*., 2020; Mahdavi and Bovington, 1972; Maziar and Glascock, 2017; Renfrew *et al*., 1966) periods. They have been attributed to a variety of sources in Anatolia and Armenia. The identification of sources for obsidian artefacts found in Iran is an important subject especially because of the geographical extent, different prehistoric traditions and the diversity of sources utilized. This information can be useful when characterizing exchange paths between sources and destinations.

The Kurdistan province of Iran is located along the northern continuation of the Central Zagros. The western part of the province is adjacent to Iraq and near Mesopotamia. The northern part is adjacent to northwestern Iran which includes the provinces of East and West Azerbaijan that surround Lake Urmia (Fig. 1). The sites of Tepe Namashir and Tepe Ghazikhan discussed in this study are located near the city of Baneh and the site of Tepe Galali is located near the city of Qorveh. The sites are also near the border with Iraqi Kurdistan and northeast of Mesopotamia. Elucidation of the sources of cultural materials like obsidian in Kurdistan province is helping to understand interactions with the surrounding areas during the Chalcolithic period.

In the Chalcolithic period, we see an increase in the development of settlement sites in Kurdistan province with several sites having been identified throughout the province. Based on Late Chalcolithic studies, different pottery traditions are observed at the sites (Saed Mucheshi, 2011; Saed Mucheshi *et al*., 2017). However, knowledge of obsidian usage in Kurdistan province and the Central Zagros is much less than for the more northern regions.

In the Central Zagros, the Nemrut Dağ source in Anatolia is considered to be the main source of obsidian during both the Chalcolithic and Neolithic periods (Renfrew *et al*., 1986; Abdi, 2006: 150; Abdi *et al.* 2002, 61; Darabi and Glascock 2013; Wright 2005). This is in contrast to far northwestern Iran where the main sources from both Armenia (as a main resource) and then Anatolia were utilized (Khademi Nadooshan *et al*., 2013; Abedi et al., 2018a, 2018b; Barge *et al*., 2018; Mazair and Glascock, 2017; Renfrew *et al*., 1966; Renfrew and Dixon, 1977).

With respect to the Chalcolithic period, the excavated sites in northwestern Iran can be divided into three groups based on their use of non-local sources of obsidian. Other local lithic sources (Abedi *et al*., 2019; Ghorabi *et al*., 2010: 10; Niknami *et al*., 2010) are not considered in this classification. The first group of sites are located in the region immediately north and east of Lake Urmia where, due to their proximity, a majority of their obsidian came from Armenian sources. In this group, Anatolian obsidian was also used but the obsidian from Meydan Dağ was preferred instead of Nemrut Dağ. Among the sites in this group are Kul Tepe, Dava Göz and sites located along the Araxes (Aras) River separating Iran from the countries of Azerbaijan and Armenia (Abedi *et al*., 2018a, 2018b; Khademi Nadooshan *et al*., 2013; Maziar, 2010; Maziar and Glascock, 2017). The second group of sites are located on the southern and western sides of Lake Urmia. In this group, obsidian sources from Anatolia were mostly used with the Meydan Dağ source preferred instead of Nemrut Dağ. A small number of artefacts also came from Armenian sources (Mahdavi and Bovington, 1972; Renfrew *et al*., 1966; Renfrew and Dixon, 1977). The third group consists of two sites that were recently excavated and are located close to the southwestern edge of Lake Urmia, near the road connecting the city of Piranshahr to Iraq. At these two sites, obsidian from Nemrut Dağ was mainly used (Binandeh *et al*., 2020).

The location of Kurdistan province between northwestern Iran and the Central Zagros is interesting in terms of the obsidian sources utilized and the possible routes of entry. Considering that no previous studies have been made on obsidians in Kurdistan province, a study of obsidian artefacts from this area provides valuable new information about the origins of obsidian as well as exchanges and communication between regions in the Early to Late Chalcolithic periods.

By studying the obsidian artefacts from the sites of Namashir, Ghazikhan and Galali, we attempt to identify their origin and communication paths during different phases of the Chalcolithic period. This study is important because the obsidian artefacts being studied belong to all three phases of the Chalcolithic period and come from different locations in comparison to previous studies of obsidian in the surrounding region (Fig. 1).

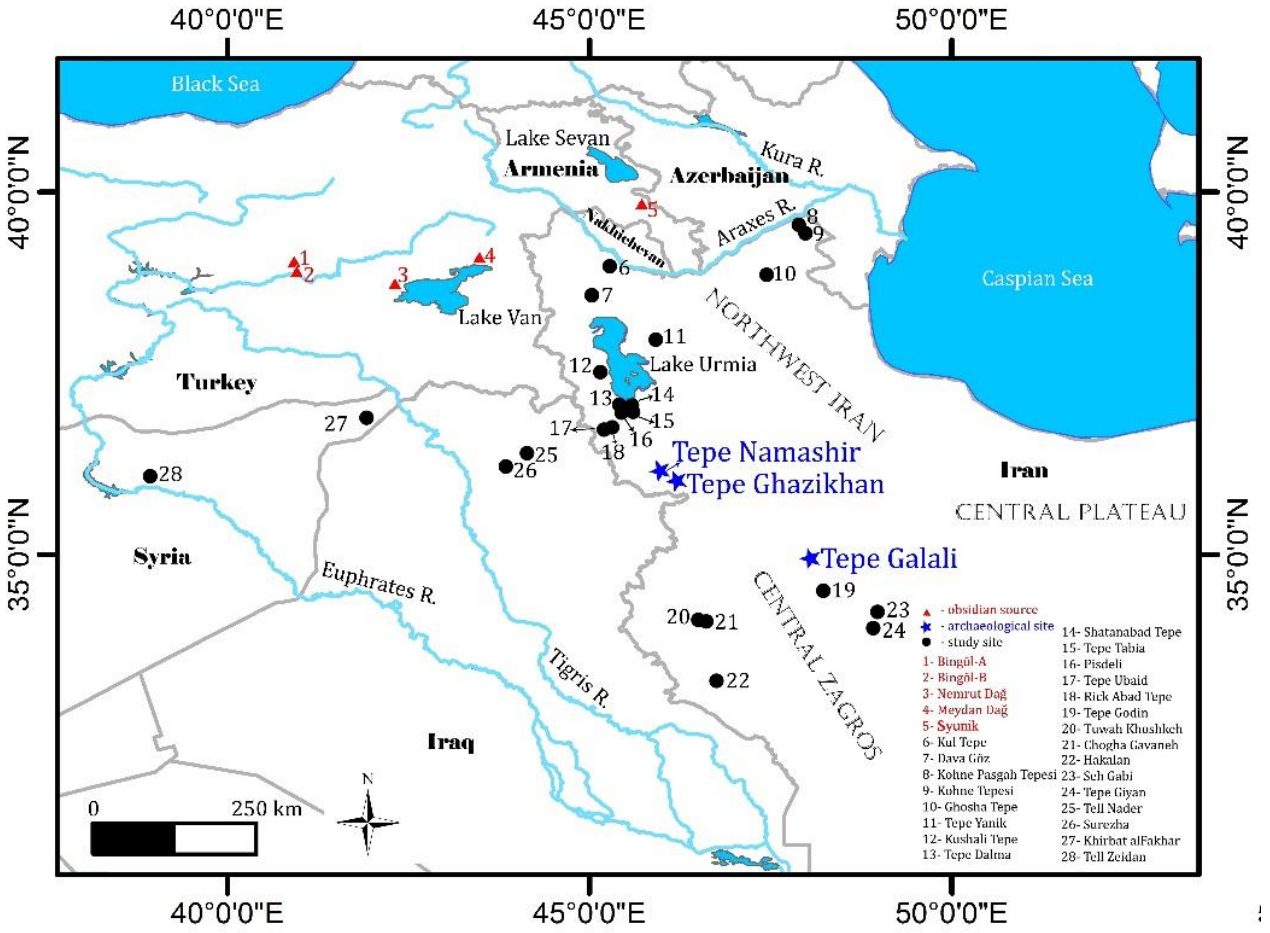

Figure 1. Map showing locations of Tepe Namashir, Tepe Ghazikhan and Tepe Galali in addition to the major obsidian sources located around Lake Van and Lake Sevan. Locations of other archeological sites mentioned in the text are also shown.

2. ARCHAEOLOGICAL SITES AND CORRESPONDING RESEARCH

2.1 Tepe Namashir

The site of Tepe Namashir is located at 36°07'56.00"N, 45°44'04.00"E about 33 km northwest of Baneh city in northwestern Kurdistan province (Fig. 1). At this site, six trenches were excavated. Two of the trenches were for the purpose of examining stratigraphy. Based on the excavations, five cultural layers were identified. Namashir V is an Early Chalcolithic (EC) layer from 5000-4500 BC; Namashir IV is a Late Chalcolithic 1 (LC1) layer from 4500-4200 BC; Namashir III is a Late Chalcolithic 2 (LC2) layer from 4200-3850 BC; Namashir II is a thin layer from the Iron Age; and the Namashir I layer is from the Islamic period. A total of 31 obsidian artefacts were recovered from the site of Tepe Namashir from which 16 artefacts, covering all three Chalcolithic phases (Saed Mucheshi *et al*., 2017) were selected for chemical analysis.

The Dalma culture, whose potteries are common throughout northwestern Iran, including the provinces of East and West Azerbaijan and Ardabil, is associated with the Namashir V period (Abedi *et al*., 2014, 2018a, 2018b; Hamlin, 1975; Solecki and Solecki, 1973), the Kurdistan Province (Saed Mucheshi, 2011) and the eastern half of the Central Zagros (Henrickson, 1985; Young and Levine, 1974). The Dalma potteries from Namashir V are divided into groups of plain, impressed and painted.

In the Namashir IV period, a tradition of plain buff and painted potteries appears which is both similar to and contemporaneous with pottery from the Pisdeli period around Lake Urmia and the LC1 in northern Mesopotamia (Saed Mucheshi *et al*., 2017). In the Namashir III period, a Chaff-Faced/Chaff-Tempered (CF/CT) pottery appears which is similar to pottery at Kul Tepe and in general, northwestern Iran, northern Mesopotamia, southern Caucasus and eastern Anatolia (Abedi *et al*., 2014: 37; Saed Mucheshi *et al*., 2017; Stein and Alizadeh, 2014: 134; Stein *et al*. 2013: 33-35).

2.2 Tepe Ghazikhan

Tepe Ghazikhan (35°59'34.64"N, 45°51'6.79"E) is the second site from which obsidian artefacts were recovered. The site is located 19 km south of Tepe Namashir, and the excavated trench revealed materials from the LC2 period (Fig. 1). The excavations showed that pottery from Ghazikhan is similar to pottery from the Namashir III layer. Among the trenches excavated, three obsidian pieces were discovered in Trench V all of which were selected for chemical analysis.

2.3 Tepe Galali

The third site is Tepe Galali. It is located in Qorveh city, southeast of Kurdistan province and in the northern vicinity of the Central Zagros (Fig. 1). Among 24 excavated trenches, a single obsidian fragment was discovered from a Seh Gabi period layer in Trench 8. The potteries excavated from this trench belong to the Seh Gabi phase in the eastern part of the Central Zagros and are contemporaneous with Namashir IV (Saed Mucheshi, 2018).

2.4 Lithic technological and typological analysis

A total of 288 lithic pieces were recovered from the sites of Namashir, Ghazikhan and Galali. The lithic assemblage from Namashir is composed of 266 artefacts of which 128 (48.1%) are debitage and 138 pieces (51.9%) are classified as tools. The other two sites yielded a small number of lithic tools and debitage. Lithic assemblages of the three sites are mostly made of chert and a small number of obsidians (Table 1), which represent various types (Table 2).

Table 1: Numbers and percentages of chipped stone samples

		Site	Period	Core	Debitage	Tools	Total (100%)
Namashir	LC 2	Chert	Obsidian	Chert	Chert	Obsidian	
		8 (4.5%)	2 (1.1%)	95 (54.2%)	50 (28.5%)	20 (11.4%)	175
	LC 1	14 (18.2%)	0	6 (7.7%)	50 (64.9%)	7 (9.1%)	77
	EC	2 (14.2%)	0	1(7.1%)	7 (50%)	4 (28.5%)	14
Ghazikhan	LC 2	2 (11.1%)	0	0	12 (66.7%)	4 (22.2%)	18
Galali	LC 1	0	0	0	3 (75%)	1 (25%)	4

Table 2. Obsidian artefacts selected for analysis detailing site, trench, type, period and source.

No	Site and Trench	Lithic type	Period	Source
1A	Namashir, Trench A	Scraper	LC1	Meydan Dağ
1B	Namashir, Trench A	Scraper	LC1	Meydan Dağ
2	Namashir, Trench A	Scraper	LC1	Meydan Dağ
4	Namashir, Trench A	Scraper	LC1	Meydan Dağ
5	Namashir, Trench A	Borer	EC	Meydan Dağ
6	Namashir, Trench A	Scraper	LC2	Meydan Dağ
7	Namashir, Trench A	Scraper	LC1	Meydan Dağ
8	Namashir, Trench A	Scraper	LC2	Nemrut Dağ
9	Namashir, Trench A	A part of object	LC2	Syunik
10	Namashir, Trench A	Borer	LC1	Meydan Dağ
11	Namashir, Trench A	Notched blade	EC	Meydan Dağ
12	Namashir, Trench B	core	LC2	Meydan Dağ
13	Namashir, Trench B	simple flake	EC	Meydan Dağ
14	Namashir, Trench B	Notched bladelet	LC2	Nemrut Dağ
15	Namashir, Trench B	Notched flake	LC1	Meydan Dağ
16	Namashir, Trench B	Scraper	EC	Meydan Dağ
17	Galali, Tr. 8	Scraper	LC1	Nemrut Dağ
18	Ghazikhan, Tr. V	core	LC2	Nemrut Dağ
19A	Ghazikhan , Tr. V	Scraper	LC2	Nemrut Dağ
19B	Ghazikhan, Tr. V	bladelet	LC2	Syunik

The Chalcolithic core technology in the early and LC1 phase is limited to flake cores that are sometimes partially cortical. In the LC2 phase, four main components are seen: flake cores, bidirectional bladelet cores, unidirectional bladelet cores and lateral bidirectional bladelet cores (including chert and obsidian). Moreover, high removal of the core surface suggests limited access to raw materials, especially obsidian. Typologically, the chipped stone industry of the sites shows a monotony which is mostly evident in scrapers, borers, retouched blades and bladelets. In the LC2 phase, various-sized regular sickle blades with abrupt and semi-abrupt retouching indicates products of regular conical cores. The presence of obsidian cores and flakes as well as use of obsidian cores indicate on-site knapping.

3. OBSIDIAN STUDIES IN NORTHWESTERN IRAN, CENTRAL ZAGROS AND MESOPOTAMIA

Previous studies of obsidian artefacts in northwestern, western and southwestern Iran have shown that the oldest are related to the Neolithic period (Barge *et al*., 2018: 306; Darabi and Glascock, 2013; Pullar *et al*., 1986; Renfrew *et al*., 1966; Renfrew *et al*., 1969; Renfrew and Dixon, 1977: Table 1; Zeidi and Conard, 2013). The end of the eighth millennium and the beginning of the seventh millennium BC is the period of time that has been suggested for the beginning of import of obsidian into Iran, and these obsidians arrived in raw form (Darabi and Glascock, 2013: 3806-7). The sources are mostly in the region of Eastern Anatolia, especially Nemrut Dağ, and Bingöl-A and Bingöl-B. Their main exchange path is through Mesopotamia and from there to the plateau of Iran (Barge *et al*., 2018; Darabi and Glascock, 2013: 3806; Renfrew *et al*., 1966; Renfrew *et al*., 1969). Another path suggested for the import of obsidian to the Neolithic sites is through northwestern Iran. By the latter path, obsidian was imported from the sources around Lake Van to the areas around Lake Urmia and then transferred to other parts of Iran (Barge *et al*., 2018: Figs. 5-7).

Multiple sites from the Chalcolithic period have been excavated in Iran, but few sites in Kurdistan province from which obsidian artefacts were recovered have been studied. Artefacts from this period have been studied in areas adjacent to Kurdistan province, including the Central Zagros, northwestern Iran and northern Mesopotamia (Table 3). In this area, the sites at Tepe Tabia, Tepe Shatanabad and Tepe Dalma in the south, Tepe Kushali in the west and Tepe Yanik in the east of Lake Urmia have been studied (Fig. 1). The artefacts from these sites have been attributed to Meydan Dağ, Nemrut Dağ and Syunik (Mahdavi and Bovington, 1972; Renfrew *et al*., 1966; Renfrew and Dixon, 1977). Syunik refers to a set of Armenian sources that include Sevkar, Satanakar and Bazenk (Chataigner and Gratuze, 2014).

Table 3. Summary of the literature data about the main sources and trading routes for obsidian artefacts recovered from sites around Lake Urmia, Mesopotamia and Central Zagros. The information represented in grey cells are similar to those observed for Tepe Namashir during EC and LC1; the yellow cells are similar to those observed for Tepe Galali during LC1; and the green cells are similar to those observed for Tepe Namashir and Ghazikhan during LC2. There are no data published data for unfilled cells.

		EC		LC1		LC2	
region		**main source (s)**	**trading route**	**main source (s)**	**trading route**	**main source (s)**	**trading route**
Lake Urmia	north and east	Armenian sources	Northwestern path of Iran	Armenian sources	Northwestern path of Iran	Armenian sources	Northwestern path of Iran
	South	Meydan Dağ	Northwestern path of Iran	Meydan Dağ	Northwestern path of Iran	Nemrut Dağ	Northwestern path of Iran + Mesopotamian path
	west			Meydan Dağ	Northwestern path of Iran		
	southwest	Nemrut Dağ	Mesopotamian path				
Mesopotamia		Sources around Lake Van + Bingöl	Mesopotamian path	Nemrut Dağ	Mesopotamian path	Nemrut Dağ	Mesopotamian path
Central Zagros		Nemrut Dağ	Mesopotamian path				

Completely different results have revealed that obsidian artefacts from the sites of Tepe Rick Abad and Tepe Ubaid located southwest of Lake Urmia are from Nemrut Dağ (Binandeh *et al*., 2020). The sites are

also a short distance from Mesopotamia and are characterized by a natural passage from Mesopotamia into Iran. Therefore, their obsidian sources are like those for Mesopotamian sites. In addition, other sites studied in recent years are Kul Tepe (Khademi Nadooshan *et al*., 2013; Abedi *et al*., 2018b), Ghosha Tepe (Ghorabi *et al*., 2010), Dava Göz (Abedi *et al*., 2018a), Kohne Pasgah Tepesi (Maziar, 2010) and Kohne Tepesi (Maziar and Glascock, 2017), all of which are located to the north and east of Lake Urmia. Due to their proximity to Armenia and eastern Anatolia, the number of obsidian tools is very high and the main sources are those around Lake Sevan in Armenia. Also, in using the sources of obsidian around Lake Van, the source of Meydan Dağ is preferred instead of Nemrut Dağ. For obsidian import into Iran, a north-south path has been proposed for the import of obsidian from Armenia and an east-west path for the import of obsidian from Anatolia into northwestern Iran (Barge *et al*., 2018).

Several sites in the Central Zagros related to the Chalcolithic period have been excavated and their obsidian artefacts have been studied (Fig. 1). The sites of Tuwah Khoshkeh (Abdi *et al*., 2002: 61), Seh Gabi (Abdi, 2006: 150) and Chogha Gavaneh (Abdi, 2006: 150; Wright, 2005) are in this category. Nemrut Dağ has been proposed as the primary source of obsidian for the area (Barge *et al*., 2018: Table 7).

In the Mesopotamian region, several sites with obsidian artefacts from the Chalcolithic period have been identified. As this region is located to the south of Anatolia, various sources were available. Sources around the Lake Van have been identified as the source of obsidian in areas located on the eastern side of the Tigris River with an emphasis on the Nemrut Dağ source (Khalidi *et al*., 2016). Examples include the sites of Surezha and Tell Nader (Fig. 1) for which the Bingöl-A and Nemrut Dağ sources were identified (Kopanias *et al*., 2013: 34; Stein and Alizadeh, 2014: 142). The proposed path for the import of obsidian from Anatolia into Mesopotamia is a north-south path (Barge et al., 2018).

4. OBSIDIAN SAMPLES

Twenty obsidian artefacts (sixteen samples from Namashir, three samples from Ghazikhan and one sample from Galali) were selected for chemical analysis by XRF (Fig. 2). Selected samples from the EC (Namashir V) period include four obsidians from the Namashir site. Among the eight artefacts belonging to the LC1 period (Namashir IV), one is from Galali and the remainder came from Namashir. Finally, eight artefacts belonging to LC2 period (Namashir III) were selected, three samples from Ghazikhan and five samples from Namashir (Table 4). Although the total number of samples studied is small, from a chronological perspective (4 EC, 8 LC1, and 8 LC2), the numbers are relatively even. Unlike the northwestern region of Iran, the number of artefacts from sites in Kurdistan province is very limited.

Figure 2. Photographs of analyzed obsidian artefacts from Tepe Namashir, Ghazikhan and Galali.

Table 4. Number of obsidian artefacts belonging to EC, LC 1 and LC 2 periods recovered from Namashir, Ghazikhan and Galali.

Site	Number of analyzed obsidian artifacts		
	EC	LC1	LC2
Namashir	4	7	5
Ghazikhan			3
Galali		1	

5. ANALYTICAL METHODS

The artefacts were analyzed by X-ray fluorescence (XRF) at the University of Missouri Research Reactor (MURR) to determine their elemental compositions. A Thermo Quantx ARL spectrometer operating at 35 kV was used. The samples were exposed to x-rays for 60 seconds each to measure the following elements: Mn, Fe, Zn, Rb, Sr, Y, Zr, Nb, and Th. The spectrometer was calibrated for obsidian studies by analyzing a suite of 40 geological obsidians previously analyzed by neutron activation analysis (NAA), XRF, and inductively coupled plasma-spectrometry (Glascock, 2020). All analyses were monitored for quality control by analyzing the international reference standard JR-1 Rhyolite from the Geological Survey of Japan.

The data for five of the artefacts were inconclusive because they have compositions by XRF similar to geologic data for both Bingöl-A and Nemrut Dağ. To identify the proper source, an abbreviated-NAA procedure was used by which the short-lived elements: Al, Cl, Dy, K, Mn, and Na are measured (Glascock et al., 1994). A previous NAA investigation of geologic samples from the Bingöl-A and Nemrut Dağ sources (Glascock, 2020: Table 2) found that the element Cl provided an effective means for differentiating between the Bingöl-A than Nemrut Dağ. Concentrations for geologic samples from all subsources at Nemrut Dağ ranged from 380 to 1045 ppm while geologic samples from Bingöl-A were found to have a mean and standard deviation of 1455±70 ppm.

6. RESULTS

The list of obsidian artefacts selected for chemical analysis by XRF, detailing the type of tools, their sources and corresponding periods are shown in Table 2. The results of chemical analysis by XRF and NAA are presented in Tables 5 and 6, respectively. The results show that the artefacts from three sites of Namashir, Ghazikhan and Galali were imported from the sources at Meydan Dağ, Nemrut Dağ and Syunik (Table 2; Fig. 3).

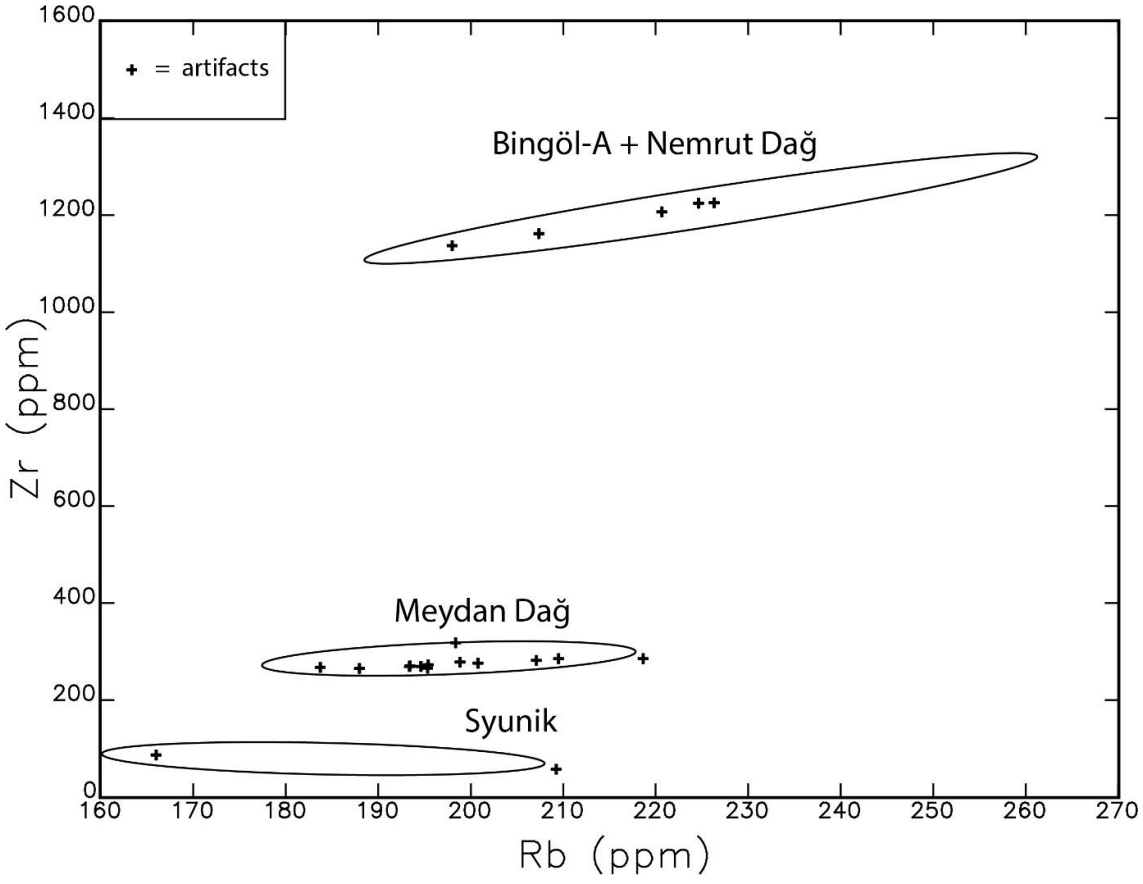

Figure 3. Scatterplot of Rb vs. Zr for obsidian artefacts in this study compared to 90% confidence ellipses for geologic samples. Due to overlapping compositions for Rb and Zr in Bingöl-A and Nemrut Dağ, a combined ellipse is shown.

Table 5. Element compositions (ppm) by XRF and source assignments for the obsidian artefacts listed in Table 2 and the results for JR-1 quality control.

ANID	Source name	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Th
ASM001A	Meydan Dağ	640	10536	83	209	20.1	54	285	30	25
ASM001B	Meydan Dağ	521	9563	76	201	15.2	54	276	31	25
ASM002	Meydan Dağ	539	9209	71	184	31.4	49	267	30	22
ASM004	Meydan Dağ	667	11358	88	219	16.1	57	285	32	26
ASM005	Meydan Dağ	518	8985	76	195	14.6	52	269	31	24
ASM006	Meydan Dağ	535	9187	75	195	14.8	52	272	31	22
ASM007	Meydan Dağ	518	9082	72	193	15.4	52	269	30	23
ASM008	Nemrut Dağ	474	21847	190	225	0.5	118	1225	62	27
ASM009	Syunik	444	4874	36	166	15.6	16	86	34	25
ASM010	Meydan Dağ	566	9391	78	199	19.4	53	278	31	22
ASM011	Meydan Dağ	535	9545	76	195	14.3	51	266	30	22
ASM012	Meydan Dağ	526	9156	77	193	14.2	52	270	30	23
ASM013	Meydan Dağ	618	9815	79	207	15.5	54	281	32	25
ASM014	Nemrut Dağ	440	21248	177	221	0.7	117	1207	61	27
ASM015	Meydan Dağ	511	9476	80	198	21.5	53	318	31	23
ASM016	Meydan Dağ	466	8463	68	188	13.0	51	265	31	22
ASM017	Nemrut Dağ	436	19750	167	207	0.5	112	1162	59	25
ASM018	Nemrut Dağ	363	19089	158	198	1.0	107	1137	59	23
ASM019A	Nemrut Dağ	537	22234	188	226	0.7	118	1225	62	26
ASM019B	Syunik	782	4195	39	209	10.3	30	57	51	27
JR-1	this work	790	6010	22	250	28.0	42	95	15	28
	certified value	770	6220	31	257	29.0	45	100	15	27

Table 6. Comparison of element compositions by NAA for obsidian artefacts to means and standard deviations for geologic samples from Bingöl-A and the range of concentrations for all subsources of Nemrut Dağ.

ANID	Source name	Al (%)	Cl (ppm)	Dy (ppm)	K (%)	Mn (ppm)	Na (%)
ASM008	Nemrut Dağ	6.02	846	20.5	3.52	462	3.71
ASM014	Nemrut Dağ	5.78	806	19.3	3.89	465	3.64
ASM017	Nemrut Dağ	5.72	868	19.2	3.78	461	3.63
ASM018	Nemrut Dağ	5.56	829	20.4	3.86	475	3.66
ASM019a	Nemrut Dağ	6.16	799	20.0	3.77	475	3.74
geologic samples							
Bingöl-A (n=11)	mean	5.78	1455	23.0	3.57	607	4.14
	± std. dev.	± 0.29	± 70	± 0.7	± 0.20	± 10	± 0.16
Nemrut Dağ (n=22)	minimum	4.69	380	16.2	3.07	352	3.62
	maximum	7.45	1045	26.5	4.17	1412	4.69

7. DISCUSSION

Due to the stratigraphic excavations at Tepe Namashir, the largest number of obsidian artefacts in this study were collected from this site. The goal of trench excavations at Ghazikhan and Galali was delimiting. Therefore, a smaller number of artefacts was collected from these sites. In the following, the results obtained from the chemical analysis of the samples of the three sites of Namashir, Ghazikhan and Galali relative to the early through late phases are discussed.

7.1 EC (Namashir V)

The only site in this study with artefacts from the EC period is Namashir. Four of the artefacts related to this phase are from the Meydan Dağ source (Table 4). Other sites that are characterized by the occurrence of obsidian artefacts belonging to the EC period have

been identified in areas located in the west, south and north of Kurdistan province. Therefore, it seems necessary to compare them with Tepe Namashir. The obsidian artefacts found in these areas can be divided into five categories by site: Mesopotamian sites, Central Zagros sites, sites southwest of Lake Urmia, sites north and east of Lake Urmia, and sites south of Lake Urmia (Table 3).

7.1.1 EC period sites in Mesopotamia

During the EC period, obsidian artefacts at sites in Mesopotamia were supplied from sources around Lake Van and Bingöl (Chataigner *et al*., 1998: 534; Khalidi *et al*., 2016). During this period, use of obsidian from Lake Van extended from the Tigris and Euphrates basins southward to the Persian Gulf (Blackman, 1984; Chataigner, 1998; Renfrew *et al*., 1966). This path has been proposed since the Neolithic period for the import of obsidian into western Iran (Chataigner *et al*., 1998: 517; Darabi and Glascock, 2013: 3807). It should be noted that during the Neolithic period almost no obsidian from the Meydan Dağ source was used (Khalidi *et al*., 2016: Table 2). Given this explanation, as well as the differences between the obsidian artefacts at Mesopotamian sites and the Namashir site, it is unlikely that the artefacts at Namashir originated from the Mesopotamian path.

7.1.2 EC period sites in the Central Zagros

During the EC period, the Mesopotamian path was used to import obsidian into the Central Zagros (Barge et al., 2018: Fig. 8) which contrasts to what is deduced from Namashir data. The main source of obsidian to the Central Zagros region during this period was Nemrut Dağ and then other sources from Nemrut/Bingöl-A (Ibid, 314). In addition, Nemrut Dağ was the main source of obsidian during the Early Neolithic period (Barge *et al*., 2018; Renfrew *et al*., 1966; Renfrew *et al*., 1969).

7.1.3 EC period sites southwest of Lake Urmia

The artefacts studied in this area belong to the Ubaid site southwest of Lake Urmia and near the city of Piranshahr. The main source of obsidian was Nemrut Dağ with obsidian from Meydan Dağ in the minority (Binandeh *et al*., 2020). Therefore, the source of obsidian supply in the southwestern regions of Lake Urmia is similar to the northern region of Mesopotamia and different from the Namashir site. This similarity is due to location of the Ubaid site. This site is located near the Tamarchin / Haji Omran path, providing connections from the northern Mesopotamia region. The presence of Dalma impressed and painted potteries in this area as well as the Mesopotamian regions (Henrickson and Vitali, 1987: 39; Oates, 1983: 258, 261; Stein, 2018: 21) also supports the probability of a connection between the Mesopotamian communities and the southwest of Lake Urmia. It has been suggested that these potteries, which date back to 5000 to 4500 BC, are the first signs of commodity and cultural connections between the Erbil plain (located in Mesopotamia) and northwestern Iran (Stein and Fisher, 2019: 130). Therefore, the connections of Mesopotamian communities with the southwestern parts of Lake Urmia can be seen in the sources of obsidian artefacts and also the potteries.

7.1.4 EC period sites north and east of Lake Urmia

The sites mentioned so far are all comparable to Mesopotamia and their obsidian artefacts are from the sources located around Lake Van. The situation is different for sites located north and east of Lake Urmia. Due to the short distance to the Armenian sources, the obsidian artefacts were largely from Armenia (Abedi *et al*., 2018a, 2018b; Khademi Nadooshan *et al*., 2013; Maziar and Glascock, 2017). Therefore, the sources of artefacts are different from those at Tepe Namashir. It should be noted that at sites around Lake Urmia, artefacts from Meydan Dağ are also observed, but the use of this source is in the minority (Abedi *et al*., 2018a, 2018b: Table 3; Khademi Nadooshan *et al*., 2013: Table 2; Maziar and Glascock, 2017: Table 2; Renfrew *et al*., 1966; Renfrew and Dixon, 1977).

7.1.5 EC period sites south of Lake Urmia

The main source of obsidian for sites (Tepe Tabia, Shatanabad Tepe, and Dalma Tepe) located south of Lake Urmia was Meydan Dağ (Renfrew and Dixon, 1977: Table 1). Therefore, according to the explanations provided so far in relation to the northwestern regions of Iran, Mesopotamia and the Central Zagros, the results obtained from Tepe Namashir V are consistent with those from sites south of Lake Urmia and are different from the Central Zagros and Mesopotamia. The path for import of obsidian to the Namashir site is the same as the path of Meydan Dağ into the northwest of Iran and then to the north of Kurdistan province. This path was proposed by Barge *et al*., (2018). It should be noted that near the end of the Early Neolithic period, the path of import of obsidian was suggested to be from northwest of Iran but in using this path, the obsidian of Nemrut Dağ was exchanged, not the obsidian from Meydan Dağ. The northwestern path of Iran was developed in later periods and from the Late Neolithic period, specifically the obsidian materials from Meydan Dağ were exchanged by this path (Renfrew and Dixon, 1977: Table 1). This path is different from the path in the Neolithic

as well as the EC periods in parts of the Central Zagros in that their obsidians were imported along the Mesopotamia path.

A comparison of obsidian and pottery at Namashir to other sites around Lake Urmia and with those around Lake Van and Mesopotamia shows two communication paths between these areas. One was the path that connected northwestern Iran to the Mesopotamian region (based on pottery and the obsidian from the Ubaid site) and the other is the north-south path that connected northwestern Iran to Lake Van (based on obsidian). According to Tonoike (2009: 160-162), local regional and inter-regional trade was an important factor in spreading Dalma culture in the region. In addition, according to studies on the Chalcolithic period of the Central Zagros, nomadic pastoralism became common in western Iran (Abdi, 2003; Abdi *et al*., 2002; Henrickson, 1985), also led to the transport of goods like obsidian.

7.2 LC1 (Namashir IV and Galali)

Seven samples from Namashir IV and one sample from Galali, all of which belong to LC1 were selected for chemical analysis (Table 4). During this period, we found different results for the sites as all the samples of Tepe Namashir are from the obsidian source at Meydan Dağ and the only sample of the Tepe Galali is from Nemrut Dağ.

The source of obsidian at Namashir IV during LC1 phase is similar to the previous period for this site (i.e. the EC). Nevertheless, the source of obsidian at Tepe Galali is similar to the source of obsidian at Mesopotamian sites. As the location of Tepe Galali is in the southeast of the Kurdistan province and next to the Central Zagros region, it is reasonable to propose the source and importing path of the obsidians to Tepe Galali is similar to Mesopotamian sites. In addition to the distance between the Namashir and Galali sites, their pottery traditions are different. In Namashir IV, the tradition of Ubaid-like pottery in northern Mesopotamia and the tradition of Pisdeli pottery in northwestern Iran are similar (Saed Mucheshi *et al*., 2017). However, at Tepe Galali, the tradition of Seh Gabi pottery of east of Central Zagros occurs chronologically after the Dalma period (Saed Mucheshi, 2018; Henrickson, 1985: 97; Levine and Young, 1987: 29). At Tepe Namashir and during the LC1 period, cultural material changes to the plain and painted buff wares similar to northern Mesopotamia and northwestern Iran appeared. This period is contemporaneous with the Pisdeli phase in Azerbaijan province of northwestern Iran.

The obsidian artefacts at sites south (Tepe Pisdeli) and west (Kushali Tepe) of Lake Urmia are related to the Pisdeli period (LC1) and similar to those from Namashir IV and are mainly attributed to the Meydan Dağ source (Renfrew *et al*., 1966; Renfrew and Dixon, 1977: Table 1). This suggests that during the LC1 period the path in northwestern Iran, especially to the west of Lake Urmia, was used to import obsidian from the Meydan Dağ source to the Iranian plateau.

During LC1, Nemrut Dağ is the main source and Meydan Dağ and Bingöl are minor sources of obsidian for the Mesopotamian sites. Examples are Tell Nader, Khirbat Al Fakhar, Tell Zeidan and Surezha sites (Khalidi *et al*., 2016: Tables 2, 4 and 5; Kopanias *et al*., 2013: 34). This contrasts with the artefacts observed north and east of Lake Urmia. Examples include artefacts from Kul Tepe (Abedi *et al*., 2018b), Dava Göz (Abedi *et al*., 2018a) and sites south of the Araxes River (Maziar and Glascock, 2017). Due to the short distance to these sites from the Syunik source, most obsidian is from this source (Abedi *et al*., 2018a: 763). Although a few artefacts from the Lake Van sources are present they are mostly from Meydan Dağ not Nemrut Dağ. In relation to the latter case, we refer to the Dava Göz site (Abedi *et al*., 2018b: Table 3).

In summary, importing obsidian from Meydan Dağ to the Namashir IV during the LC1 period is supported based on the following reasons: 1) the main source of obsidian at the sites is Meydan Dağ, 2) use of Meydan Dağ is favored over Nemrut Dağ, and 3) the shorter distance of the northwestern path compared to the Mesopotamian path. Use of this path was also common during the period of Namashir V, but in Tepe Galali, unlike Namashir, the source of obsidian is Nemrut Dağ. This result is similar to the older periods of the Central Zagros.

7.3 LC2 (Namashir III and Ghazi Khan)

The site at Ghazikhan represents a single period belonging to the LC2 and is geographically located near the Namashir site. Eight artefacts from the LC2 were analyzed (five samples from Namashir and three samples from Ghazikhan; Table 4). One artefact is a fragment from a disk-shaped specimen and the remainder are tools (Fig. 2, No. 9). Four of the artefacts came from Nemrut Dağ, two came from Syunik and two others came from Meydan Dağ. The sources represented by these artefacts are different from those in previous periods, especially with respect to the site of Tepe Namashir. In addition to the Meydan Dağ source, obsidian from the Nemrut Dağ and Syunik sources were also used at Tepe Namashir and Ghazikhan (Table 7). The path in the northwest of Iran can be suggested for the import of obsidian from the Meydan Dağ source, but a more detailed discussion is necessary to explain the paths of obsidian from other sources.

Table 7. Representative number of Late Chalcolithic 2 obsidian artifacts recovered from the Namashir and Ghazikhan sites and their corresponding sources.

Sites	Late Chalcolithic 2		
	Meydan Dağ	Nemrut Dağ	Syunik
Namashir	2	2	1
Ghazikhan		2	1

In addition to the obsidian artefacts at Namashir and Ghazikhan, there are more obsidian artefacts from the LC2 period located in other areas of northwest of Iran and Mesopotamia. The areas can be categorized into three groups: sites north and east of Lake Urmia, sites south of Lake Urmia, and sites north of Mesopotamia. In the following we will compare the obsidian artefacts found in these areas with those from the Namashir and Ghazikhan sites.

7.3.1 LC2 period sites north and east of Lake Urmia

At the sites of Kul Tepe, Kohneh Pasgah Tepesei, Yanik and other studied sites from this area, Syunik has been proposed as the most common source of obsidian. Meydan Dağ is the other source that is less common and Nemrut Dağ is so rare that no obsidian is reported in some areas like the Yanik site (Khademi Nadooshan *et al*., 2013: Table 2; Maziar and Glascock, 2017: Table 2; Renfrew *et al*., 1966; Renfrew and Dixon, 1977; Abedi *et al*., 2018a, 2018b). For all these sites, the northwestern path has been suggested for the import of obsidian (Maziar and Glascock, 2017; Abedi *et al*., 2018a, 2018b). Thus, imports of obsidian from Syunik to Namashir and Ghazikhan sites were probably by the northwestern path.

7.3.2 LC2 period sites south of Lake Urmia

In the area south of Lake Urmia, a number of obsidian artefacts from Balukchi (which date back to 4000 to 3000 years ago, but their phase has not been well identified) and Tepe Pisdeli sites were studied. Like some of the Namashir and Ghazikhan samples, the source was attributed to Nemrut Dağ (Mahdavi and Bovington, 1972: 151). At the Rick Abad Tepe site in Piranshahr city, which belongs to the LC/Early Bronze Period, two artefacts are from the Nemrut Dağ source. This site, like the Ubaid site to the southwest of Lake Urmia, is located next to the Tamarchin / Haji Omran natural path, which connects northwestern Iran to Mesopotamia. Therefore, it is possible that during the LC2 period, in addition to the northwestern path, obsidian was also imported along the Mesopotamian path. This path was used to import obsidian from the Nemrut Dağ source (Khalidi *et al*. 2016; Barge *et al*. 2018).

7.3.3 LC2 period sites north of Mesopotamia

Among the Mesopotamian sites and especially the sites belonging to LC2, the majority of their obsidian came from sources around Lake Van specifically Nemrut Dağ and Meydan Dağ in the minority (Khalidi *et al*., 2016: Tables 2, 6, 8). Therefore, the occurrence of a high number of artefacts from this period from Nemrut Dağ at Tepe Namashir and Ghazikhan is additional evidence supporting the Mesopotamian path for importing obsidian from the Nemrut Dağ source.

Based on the existence of similar pottery styles in Mesopotamia, Baneh, northwestern Iran and the Caucasus, extensive communications in these areas is suggested. In the LC2 period (Namashir III), the tradition of CF/CT pottery was common in this area including northwestern Iran, Nakhichevan, eastern Anatolia and northern Mesopotamia (Abedi *et al*., 2014; Kepinski, 2011: 65; Stein and Alizadeh, 2014: 134; Stein *et al*., 2013: 33-35). Potteries from Namashir III are also CF/CT. They are similar and coeval to potteries from Dava Göz III and Kul Tepe VI in northwestern Iran and Mesopotamia (Abedi *et al*., 2014: 41; Abedi *et al*., 2018a; Saed Mucheshi *et al*., 2017: 51). Such extensive communication supports importing obsidian from Nemrut Dağ to Baneh sites using the Mesopotamian path.

The western counties of the Kurdistan Province are characterized by CF/CT pottery tradition (similar to Mesopotamia) but other parts of this province are similar to Godin tradition (similar to the Central Zagros). In Baneh and Marivan counties, close to Mesopotamia, CF/CT pottery tradition is common (Saed Mucheshi *et al*., 2017; Zamani Dadaneh *et al*., 2019) while in other areas Godin pottery tradition (Godin VII and VI) is more common (Saed Mucheshi, 2011). Therefore, the high abundance of obsidian related to Nemrut Dağ at the Namashir and Ghazikhan sites may be due to extensive cultural connections with Mesopotamia.

During the LCI period (Godin VIII period in the Central Zagros region), the High Road trade route (later renamed Khorasan Road) which is north of the desert plain and faces east-west from Afghanistan to Mesopotamia was active. During the this time, various objects such as Lapis Lazuli, a semi-precious blue stone, were transported from northeastern Afghanistan to northern Mesopotamia. During the LC2, the trade route shifted to the Iranian plateau so that in the LC2-5 periods (Godin VII-VI: 1), traffic changes to north-south as the path changes from Central west Zagros to Susa, and from this new route, obsidian and other chipping stone and finished blades as well as metal ores were traded (Rothman and Badler, 2011: 77). It seems that the north-south route became more

active and this can be seen from the northwest of Iran to Kurdistan Province. Therefore, the presence of Syunik obsidian at the Namashir and Ghazikhan sites in the LC2 period is explained.

The existence of a portion of a polished obsidian object at the Namashir site (Fig. 2, No. 9) in the LC2 period is a rare example in Iran. Among Namashir obsidians, the only sample from Syunik is this polished object, which was probably produced outside this site due to the distance of Namashir from the sources of obsidian and the small number of obsidian tools compared to other lithic tools. Another possibility is the conversion of pieces of obsidian that are unsuitable for making tools into objects other than tools, which could have happened to this object as well. The existence of this object may indicate a luxury good and luxurious use of this stone in this period. Obsidian use increased during the LC2-3 period in northern Mesopotamia, indicating a growth of inequality during the LC2 period (McMahon, 2020: 302, 313). Sites such as Brak and the tombs of Tepe Gawra refer to obsidian objects such as vessels of obsidian, chalices, and neatly ground obsidian discs (Oates *et al.*, 2007: 590, 591, Fig. 5; Tobler, 1950: 82) which the disk-shaped specimens are similar to the polished Namashir specimen. In general, the obsidian artefacts at the sites of Namashir and Ghazikhan during the LC2 indicate the use of two different paths. The first path was through northwestern Iran. This path was used to import obsidian from the Meydan Dağ and Syunik sources. The second path was through Mesopotamia, where the obsidian of Nemrut Dağ was imported to the area via the north-south and then east-west path.

8. CONCLUSIONS

In this paper, we studied chemical analysis of obsidian artefacts collected from Namashir, Ghazikhan and Galali sites in Kurdistan province. We found that the obsidian belong to Early Chalcolithic (EC), Late Chalcolithic 1 and 2 (LC1 and LC2) phases and are originally from two known sources of Anatolia (including Nemrut Dağ and Meydan Dağ) and Armenia (Syunik), which were imported as raw material. Namashir is the only site with obsidian belonging to all three phases. At Namashir, the obsidian artefacts of the EC and LC1 are from the Meydan Dağ source, but in the LC2 period, artefacts from all three sources are observed. The only obsidian artefact recovered from Galali is related to the LC1 and came from the Nemrut Dağ source. Ghazikhan obsidian artefacts are related to LC2 and came from the Syunik and Nemrut Dağ sources.

In terms of the source of obsidian in the EC and LC1 periods, the Namashir site is similar to sites south and west of Lake Urmia. Probably, the path for importing obsidian was from Meydan Dağ to the east and then toward the southwest of Lake Urmia and from there to the Namashir site. In a similar period, the obsidian at Galali was imported via a path from Mesopotamia to the Central Zagros and then to the Galali site. Evidence of nomadism suggests that obsidian exchange may be attributed to nomads or middleman trading. Archaeological evidence reveals that during the EC and LC1 periods, people living in western and northwestern Iran were in contact with surrounding areas such as Armenia, Anatolia and Mesopotamia. Our investigation about the obsidian artefacts at the Namashir and Galali sites indicates the existence of a communication path between these areas respectively with the Meydan Dağ and Nemrut Dağ sources. The results obtained from the LC1 period at the Namashir and Galali sites show that in addition to different pottery traditions, the sources of obsidian in northern and southern Kurdistan province were different.

The obsidian artefacts at Namashir and Ghazikhan, which belong to the LC2 time, were imported from the sources at Nemrut Dağ, Meydan Dağ and Syunik. Therefore, for the first time, obsidian from the source of Syunik appeared in western Kurdistan province. The diversity of sources in addition to occurrence of an obsidian object can be related to extensive connections and communications with the northwestern regions of Iran as well as with Mesopotamia. Therefore, both paths introduced in this article were used for the import of obsidian. Also, other cultural materials and especially pottery exhibit many similarities that can be seen over a large area including northern Mesopotamia, eastern Anatolia, southern Caucasus and northwestern Iran.

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Author Contributions

Conceptualization, AS and ZK; methodology, AS; software, MDG; validation, MDG; formal analysis, MDG; investigation, AS; resources, MDG; data curation, MDG; writing—original draft preparation, AS; writing—review and editing, AE, MDG, AO; visualization, AS, MDG; supervision, AS.; project administration, AS; funding acquisition, AS and MDG. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors state no conflict of interest.

Data availability statement

The primary analytical data are listed in the tables. Other supplementary data are available on the MURR Archaeometry Lab website: https://archaeometry.missouri.edu/murr_database.html.

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