NEW DATA ON THE EXPLOITATION OF OBSIDIAN IN THE SOUTHERN CAUCASUS (ARMENIA, GEORGIA) AND EASTERN TURKEY, PART 2: OBSIDIAN PROCUREMENT FROM THE UPPER PALAEOLITHIC TO THE LATE BRONZE AGE*

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Within the framework of the French archaeological mission ‘Caucasus’, in a previous paper we have presented new geochemical analyses on geological obsidians from the southern Caucasus (Armenia, Georgia) and eastern Turkey. We present here the second part of this research, which deals with provenance studies of archaeological obsidians from Armenia. These new data enhance our knowledge of obsidian exploitation over a period of more than 14 000 years, from the Upper Palaeolithic to the Late Bronze Age. The proposed methodology shows that source attribution can be easily made by plotting element contents and element ratios on three simple binary diagrams. The same diagrams were used for source discrimination. As the southern Caucasus is a mountainous region for which the factor of distance as the crow flies cannot be applied, we have explored the capacity of the Geographic Information System to evaluate the nature and patterns of travel costs between the sources of obsidian and the archaeological sites. The role of the secondary obsidian deposits, which enabled the populations to acquire raw material at a considerable distance from the outcrops, is also considered.

KEYWORDS: OBSIDIAN PROCUREMENT, LESSER CAUCASUS, ARMENIA, GEORGIA, EASTERN TURKEY, UPPER PALAEOLITHIC, MESOLITHIC, NEOLITHIC, BRONZE AGE, LA–ICP–MS ANALYSES, GEOGRAPHIC INFORMATION SYSTEM (GIS)

INTRODUCTION

In Armenia, obsidian represents more than 90% of the material used by prehistoric populations for their tools and weapons. Indeed, obsidian deposits are plentiful in Armenia as well as beyond the periphery of its territory, in neighbouring regions such as southern Georgia, western Azerbaijan and eastern Turkey (Fig. 1).

Analysis of the chemical composition of these sources (Keller et al. 1996; Blackman et al. 1998; Poidevin 1998) and of artefacts coming from approximately 70 Transcaucasian archaeological sites dating from the sixth to the first millennia bc (Badalyan et al. 2004) have enabled the establishment of an initial cartography of the movements of obsidian between the Neolithic and the Iron Age, and confirmation of the great variability in their distribution in the region. The
villagers obtained their supplies either from a single source or from several sources, and the nearest deposits were not necessarily the most favoured.

In order to explain these phenomena, complementary studies have been carried out. A series of chemical characterizations has enriched the database and provided new information on the exploitation of the material. A model of the supply routes between the archaeological sites and the sources of obsidian has been made using a Geographic Information System (GIS) in order to assess the real ‘cost’ that the direct acquisition of the material represented for the prehistoric populations and to better understand how it circulated.

**DATA**

**Archaeological sites**

The archaeological samples studied come from sites situated in different regions of Armenia and relate to periods extending from the final Upper Palaeolithic to the Late Bronze Age/Early Iron...
Age, from 15 000 to 1 000 cal BC (Table 1). This study enables presentation of the diversity of the sources of supply and the methods of acquisition through time and space.

The samples come from sites (Kalavan-1, Kmlo, Aratashen, Aknashen and Godedzor) excavated conjointly by the Institute of Archaeology and Ethnography of Yerevan and the French ‘Caucasus’ mission, as well as from earlier excavations (samples provided by R. Badalyan, Institute of Archaeology and Ethnography of Yerevan).

These different sites will be described in the presentation of the results.

METHODS

On the archaeological sites of Transcaucasia, there are thousands of artefacts in obsidian (more than 20 000 at Aratashen; Badalyan et al. 2007); but for each site only a small number could be submitted for chemical analyses, for administrative restrictions (export authorization). The sample is therefore not representative: the analytical results give only a very partial picture of the diversity of the supply, as only the major sources are identified.

Visual discrimination

Analysis based on visual examination is commonly considered a low-cost, non-destructive technique to ‘source’ large numbers of obsidian artefacts on site. However, the major question is how efficient this method of sourcing is for Anatolian and Transcaucasian obsidian (Frahm 2010).

This method can provide interesting results when the number of obsidian sources exploited is small, and when their physical and chemical characteristics are clearly differentiated. Unfortunately, this is not the case for Anatolia and Transcaucasia, where the sources of obsidian are numerous and the same varieties (texture and colour) can be found in different deposits. Indeed, texture and colour are related to the process of dehydration of the material during the eruption (Morizumi et al. 2009; Seaman et al. 2009) and not to its geochemical signature.

Therefore, a single flow can produce obsidian of different macroscopic types (the complex at Gutansar produces black, grey, transparent, brown, red and black obsidian, etc.) and the same varieties can exist on different volcanoes (the red mottled with black variety can be found at Geghasar near Lake Sevan, at Kamakar in the Tsaghkunyats range, and also at Chikiani, in southern Georgia).
A visual discrimination test, enabling the suggestion of provenance, has recently been carried out on an obsidian collection from the Aegean and Turkey (Carter and Kilikoglou 2007). This collection was then subjected to geochemical analysis; the result of the experiment is undeniable: ‘The trace-elemental analyses have shown our visually discriminated source assignations to be deeply flawed . . . ’ In particular, among the 42 samples attributed visually to a non-Aegean origin, only five (i.e., only 12%) were consistent with this criterion, the remaining 37 clearly coming from the Aegean (Melos).

For this reason, analytical methods remain necessary for certain identification of the origin of the obsidian—and it is the perfecting of these analytical methods, to provide the possibility of dealing rapidly with a large number of samples, that will enable a more objective picture of how and where the obsidian was obtained. Recent studies (Forster and Grave 2012; Williams et al. 2012) have shown that fairly reliable results can be obtained by using portable XRF instrumentation. As pointed out by these authors, there must be a dual approach, combining both field measurements with portable instrument carried out on a large population of artefacts and laboratory analyses of a selected number of samples. Field measurements done on a large number of objects will allow a first grouping and a first attempt at source attribution, while more complete laboratory analysis will enable the separation of overlapping groups and the proposal of more secure source attribution.

**LA–ICP–MS analysis**

Analyses of obsidian objects conducted at the Centre Ernest-Babelon of the IRAMAT (Orléans) were carried out according to the analytical protocol described in Part 1 of this paper (Chataigner and Gratuze 2013).

**GIS modelling**

The southern Caucasus is a mountainous region and the factor of distance as the crow flies cannot be applied. We have thus explored the capacity of the Geographic Information System (GIS) to integrate spatial data (relief, hydrography etc.) to analyse more realistically the movement of persons and materials across this territory (Chataigner and Barge 2008).

The first stage of our analysis was to evaluate the nature and patterns of travel costs between the sources of obsidian and the archaeological sites, in order to understand what was actually involved for the prehistoric peoples who sought this material (climatic factors, vegetation, rivers to cross, distance covered, slopes climbed, weight of material transported, ‘political’ boundaries etc.). The topographical element, with elevations often higher than 3000 m and deep valleys, appeared to be the main constraint on travelling.

Transportation in the prehistoric periods would mainly have been either on human backs or, from the Late Neolithic onwards, on the backs of oxen; equids were domesticated locally only in the Early Bronze Age. From different experiments (Scott and Christie 2004), we inferred that a reasonably trained walker could accomplish an average speed on the flat of 5 km h⁻¹, for a load between 25 and 30 kg and a walking time of 7–8 hours per day. According to ethnographic studies, the pack oxen can carry loads from 50 to 90 kg, with an average speed on the flat of 4 km h⁻¹; the walking time is reduced to about 5 hours per day for draft animals, as they need to stop to graze.

The second stage was to calculate, using the ‘Spatial Analysis’ functions of ESRI’s ArcGIS®, the time needed to journey between the sources of obsidian and the different archaeological sites...
and to recreate the most efficient travel pathways through the region. The main travel cost being the topography, the ‘cost surface’ of the GIS has been defined by the time needed for a walker, according to the slope and the distance (Eastman 1999). Then the ‘cost-weighted’ and ‘least-cost path’ analysis functions enabled calculation of the time needed to go from one point to another on the map (equal to the time between sources and villages), as well as to memorize the pathways requiring the least effort and the least time in relation to the distance to be travelled and the slope (that is, the best route to take).

RESULTS AND DISCUSSION

Chemical results from archaeological obsidian

The 136 artefacts studied were analysed using the old (Gratuze 1999) or the recent (as described in Part 1 of that paper) analytical protocols. The obtained data were plotted on the same diagrams as used to discriminate the geological sources (Figs 2 and 3). Among these artefacts, 130 could be related to the various chemical groups defined for the geological samples, while six of them could not be related to any of the geological groups defined above (Table 2). Twenty-eight artefacts come from the Arteni complex [Arteni 1 (one), Arteni 2 (five) and Arteni 3 (22)], 23 from Gutansar, 22 from Syunik [Syunik 2 (seven) and Syunik 3 (15)], 19 from Tsaghkunyats [Tsaghkunyats 1 (17) and Tsaghkunyats 2 (two)], 18 from the surroundings of Sarikamis

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![Figure 2](image-url)  
*Figure 2  The binary diagram for the Zr–Ba contents of the studied artefacts and related outcrops.*
[Sarikamis North 11 (Hamamli six/Handere five); Sarikamis South seven (Sarikamis South 1 one/Sarikamis South 2 six)], 12 from the Hatis Mountain [Hatis 1 (one) and Hatis 2 (11)] and eight from the Gegham Mountains. In order to simplify the graphical representation, only the seven volcanic complexes involved in obsidian distribution will be represented on the diagrams that follow.

The six unattributed artefacts form two groups containing two and four artefacts, respectively. They are both characterized by high concentrations of barium (407 and 506 ppm, respectively) and low zirconium contents (57 and 86 ppm). The composition of these artefacts has been compared with the composition of the obsidian from central and eastern Turkey, which contains similar barium, zirconium and strontium concentrations (Figs 4 and 5): Erzincan, west Erzurum 1, Digor/Yaglica (Chataigner et al. 2013), Nenezi Dag, Bingöl B, Acigöl and Göllü Dag 1 and 2.

Two of the unattributed artefacts, however, show several similarities with the obsidian from the Arteni 3 group (Figs 4 and 5). The main difference lies in their barium content, which is higher in the artefacts while the other element contents are similar (Table 3). We could thus consider that these two artefacts may either come from unsampled obsidian outcrops of the Arteni mountains or belong to the obsidian with the variability of Arteni 3, which perhaps shows a continuous variation in barium concentration, as observed at Chikiani. This group will be referred to as Arteni 3b. As mentioned above, it demonstrates that a new systematic sampling and a new set of analyses of the Arteni outcrops is necessary.
Table 2: Repartition of the studied artefacts among the different obsidian sources

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*nb, Number of artefacts related to volcanic complexes and obsidian sources.
The four other unattributed artefacts form a homogeneous group characterized by higher zirconium and lower Nb/Zr and Y/Zr ratios. They have compositions close to those of several sources (Acigöl, Nenezi Dag, Göllü Dag 2 and Yaglica South) with regard to their barium, zirconium, strontium, yttrium and niobium contents (Poidevin 1998). However, these sources can be distinguished by using other elements such as caesium and tantalum (Fig. 5). It then appears that the only source that matches the composition of the four artefacts very closely is one of the outcrops of the Digor area, referred to as Yaglica South (Chataigner et al. 2013). We shall, however, note that for Yaglica, on the six different obsidian blocks analysed, the Yaglica South subgroup was defined by only two samples (Table 3). It is therefore difficult to circumscribe the whole variability of that chemical subgroup. At that time, the relationships established between these four artefacts and Yaglica South have to be considered as the most probable hypothesis, but this has to be confirmed by new systematic sampling and a new set of analyses of these outcrops.

Archaeological sites

The archaeological samples studied come from sites in different regions of Armenia, concerning periods extending from the final Upper Palaeolithic to the Late Bronze Age/Early Iron Age; that is, from 15 000 to 1 000 cal BC. This study provides evidence of the diversity of the sources of supply and the methods of acquisition over time in different environmental and socio-economic contexts.
At the last glacial maximum (20 000–18 000 BP), most of the Lesser Caucasus range was covered by glaciers and therefore deserted. During the warming at the end of the Pleistocene, human populations came to progressively reoccupy the Lesser Caucasus, as indicated by the site of Kalavan-1, recently discovered in the mountains overlooking the northern edge of Lake Sevan and dated by 14C to the 15th millennium cal BC (Liagre et al. 2009; Montoya et al. 2013). The lithic industry of Kalavan-1 is linked to the Epigravettian tradition and has parallels in western Georgia (Ortvale Klde, Dzudzuana and Sabelisopeli), in

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At the last glacial maximum (20 000–18 000 BP), most of the Lesser Caucasus range was covered by glaciers and therefore deserted. During the warming at the end of the Pleistocene, human populations came to progressively reoccupy the Lesser Caucasus, as indicated by the site of Kalavan-1, recently discovered in the mountains overlooking the northern edge of Lake Sevan and dated by 14C to the 15th millennium cal BC (Liagre et al. 2009; Montoya et al. 2013). The lithic industry of Kalavan-1 is linked to the Epigravettian tradition and has parallels in western Georgia (Ortvale Klde, Dzudzuana and Sabelisopeli), in

contexts of the 17th to the 12th millennia BC (Nioradze and Otte 2000; Nioradze 2001; Meshveliani et al. 2007).

At this site, it is striking that most of the tools are in obsidian (about 66%), although it is an exogenous rock, while the local siliceous rocks transported abundantly by the Barepat River played a secondary role. The quantity and the variety of the obsidian found at Kalavan-1 (translucent, smoky grey, sparkling black, very dull black, red, mottled brown etc.) suggest a diversity of sources. The cultural links (Epigravettian community) between Kalavan-1 and the Georgian sites of Ortvale Klde or Dzudzuana could also be reflected in the obsidian procurement,
the populations of Georgia mainly exploiting the deposits of Chikiani, in the south of the country (Le Bourdonnec et al. 2012). But the analyses of the origin of the artefacts of Kalavan-1 have revealed a completely different system of supply.

The 18 artefacts that were analysed by LA–ICP–MS are flakes and not retouched pieces. The results of the analyses (Table 2) show that most of the supply came from deposits situated to the west of Lake Sevan (Hatis, Gutansar and Geghasar), while only one sample comes from south-east of Lake Sevan (Sevkar) (Fig. 6). Modelling of the time taken to cover the distance between the Kalavan site and the obsidian sources, depending on the relief, shows that between 20 and 30 hours would have been required to reach the three main deposits (Gutansar, Geghasar and Hatis), or 3–4 days of walking. It thus appears probable that the hunters of Kalavan first sought a supply of obsidian as they moved through the mountains around Lake Sevan, in order to prepare adequate weaponry for hunting caprins (mouflons), the bones of which were found in abundance on the site. At the Upper Palaeolithic site of Ortvale Klide in Georgia, hunting activities were structured according to the migratory behaviour of the Cauca- casian tur (Capra caucasica), which made them locally abundant on a seasonal basis (Adler et al. 2006). Likewise, Kalavan-1 could have been a key site for the ambush of mouflon herds during their seasonal movements between the mountains overlooking Lake Sevan and the low- lands of the Aghstev Valley.

Mesolithic/Early Neolithic: Kmlo-2 The Mesolithic and Early Neolithic are very poorly known phases in Armenia. New data have been provided by the Franco-Armenian excavations at Kmlo-2, a small cave situated in the canyon of the Kasakh River, on the eastern flank of the

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Figure 5 The binary diagram for the Cs–Ta contents of the unattributed artefacts and obsidian outcrops with similar Ba and Zr contents.
Aragats massif (Arimura et al. 2010). The 14C dates suggest a succession of several occupations, which form levels IV (end of the 10th and first half of the ninth millennia BC) and III (second half of the ninth and beginning of the eighth millennia BC).

The lithic industry of Kmlo-2 is almost exclusively in obsidian. Made on the site, as shown by the numerous debitage products, this material includes a high proportion of microliths (~30%), as well as artefacts characterized by abrupt, parallel and regular retouch, clearly carried out by pressure. These ‘Kmlo tools’, which appear at the transition between levels IV and III, are reminiscent, from a techno-typological point of view, of other artefacts in obsidian, present in the cultures of neighbouring regions:

- the ‘Çayönü tools’, spread over the northern Near East, in the eighth and seventh millennia BC (Pre-Pottery Neolithic B and Early Pottery Neolithic); and
- the ‘hook-shaped tools’ of the Pre-Pottery Neolithic culture of Paluri-Nagutny, which developed on the south-western slopes of the Greater Caucasus, and then in southern Georgia—the only 14C date known for this culture belongs to the mid-eighth millennium cal BC (Kotias Klde, Neolithic layer; Z. Matskievich, pers. comm.).

The obsidian found at Kmlo belongs to different varieties: opaque black, opaque grey, red, red–mottled black, marbled red and black, transparent, translucent. The analysis of 20 ‘Kmlo tools’ showed that these artefacts were knapped in various types of obsidian, all local (Armenia and north-eastern Turkey) (Fig. 7).

The source used the most was Gutansar (50% of the samples). In second place was the Tsaghkunyats range (20% of the samples), the two subgroups Damlik-Ttvakar and Kamakar-Aïkasar being represented. The Kasakh River flows alongside the chain of Tsaghkunyats in its

Figure 6 Isochrones of 7 hours between Kalavan-1 and the obsidian sources.
upper course and transports numerous blocks of obsidian. Several artefacts from Kmlo have retained the cortex of the pebbles rolled down by the river; these were then collected in the Kasakh, which flows at the foot of the Kmlo cave.

The complex of Arteni represents 15% of the samples. The three other sources each represented by a sample, are the Hatis volcano, near the complex of Gutansar, the Geghasar deposit to the south-west of Lake Sevan, and the deposits of Sarikamis South (Mescitli, Sehitemin).

Modelling of the routes between Kmlo and these different sources of obsidian shows that they were divided into three main directions: (a) towards the north and the Tsaghkunyats range, 1 day’s walk (about 7 h) following the Kasakh Valley, but the river itself clearly played the role of secondary source; (b) towards the east, with the Gutansar complex situated also at a day’s walk from Kmlo, then the Hatis volcano (close to Gutansar) and, further to the south-east, the Geghasar highlands at 3 days’ walk; and (c) towards the west with the deposits of Arteni at 2 days’ walk (~15 h), and then, by crossing the Kars plateau, the obsidian deposits of Sarikamis South, at 5 days’ walk.

The deposits of Sarikamis South are far from Kmlo and the shortest route crosses the obsidian outcrops of the Yaglica Dag volcano, which was not identified among the sources exploited by the Kmlo human group. A study on obsidian procurement in California (Eerkens et al. 2008) showed that hunter-gatherers had a high degree of mobility and often ignored smaller intermediary sources where the glass was of poorer quality. In the upper part of the Yaglica Dag, the obsidian is full of inclusions and not very suitable for knapping; but on the southern flank of this volcano,
the obsidian is homogeneous and of a high quality (Chataigner et al. 2013). Nevertheless, besides direct procurement, other hypotheses can be considered: the existence of secondary deposits in the Araxes Valley (a deposit should exist near the village of Gaziler, according to Poidevin 1998) or an exchange with populations of the Kars region.

Mobility, exchange and social interaction were integral components of Mesolithic hunter–gatherer lifeways (Lovis et al. 2006). The use of lithics at 100 km or more from their sources is commonly attributed to long-distance logistical movements that required either negotiation with groups local to the source areas or transactions during seasonal aggregation ceremonies (Sulgostowska 2006). It must be added that near the confluence of the Akhurian and the Araxes, at Tuzluca (Gokhp or Koulpi, for the Armenians) is a mountain of gem salt, which played a very important part in the Middle Ages and in recent centuries in supplying Armenia, Georgia and eastern Turkey (Ouoskherdjan 1828; Karajan 1920). Beds of tertiary (Miocene) rock salt are widespread in eastern Anatolia, in particular in the Araxes Valley, between Kagizman and Tuzluca (Yilmaz 2007). Such salt deposits may have been known in the early Holocene and served as places of exchange, in this way enabling the redistribution of obsidians from neighbouring outcrops.

The study of the supply of obsidian by the human group living at Kmlo therefore suggests a fairly vast territory of routes, but with no link either with the region of Lake Van, where the northern Mesopotamian cultures possessing Çayönü tools obtained their supply, or with the great deposit of Chikiani, in southern Georgia, near to which are located the Paluri-Nagutny sites with ‘hook-shaped tools’ similar to those of Kmlo.

**Late Neolithic: Arataşen** At the very beginning of the sixth millennium BC, populations that already possessed an advanced mastery of the domestication of plants and animals appeared in the Kura basin (in Georgia and Azerbaijan) and the Araxes basin (in Armenia). These were the cultures of Shulaveri-Shomutepe in the Kura basin (Kiguradze and Menadbe 2004) and of Arataşen in the Araxes basin (Badalyan et al. 2007). Agriculture (wheat, barley, lentils) and herding (sheep especially, and goats and cattle) were from then on the bases of the economy.

The two levels of the tell of Arataşen (Badalyan et al. 2004, 2007) belong to the Neolithic period (sixth millennium BC) and have produced an abundance of lithic tools in obsidian (more than 20,000 artefacts), flint being extremely rare (fewer than 10 artefacts). The techno-typological analysis having shown the existence of several methods of debitage (indirect percussion, light pressure and pressure with levering), it was interesting to test whether a correlation existed at Arataşen between the debitage techniques and the sources of obsidian. Thirty tools from levels I and II were therefore analysed. Debitage by indirect percussion shows a predominance of Arteni (60%), then of Sarikamis South (27%) and finally of Gutansar (13%). However, debitage using light pressure (with a crutch) shows a great variety of sources: 28% from Arteni, 21% from Gutansar, 21% from the sources of Sarikamis South and North, 15% from Hatis and 15% from Geghasar. Thus there would seem to be no obvious link between the origin of the material and the debitage technique used.

An interesting element is the fact that the most exploited sources (Arteni, Sarikamis South and Sarikamis North, which represent in all 77% of the material analysed) are situated to the west of the Ararat plain (Fig. 8). Arteni (50%), which is visible from the site of Arataşen itself, lies about 11 hours’ walk (1.5 days) away. In the region of Kars, the deposits of Sarikamis South (17%) and Sarikamis North (10%) are at a great distance from Arataşen (about 5 days’ walk). However, these villagers were able to obtain their supply of Sarikamis obsidian in two other ways:
Blocks from the sources of Sarikamis North are transported in large quantities by the Kars River up to its confluence with the Akhurian River and further on. Deposits of obsidian pebbles, forming a layer of more than 1 m thick, are still visible today in the cliffs of the Akhurian canyon, especially in the region of Haykadzor, south of the dam lake.

The important role played by husbandry at Aratashen perhaps obliged the inhabitants of this village to gather salt often enough at places such as Tuzluca, which is about 1.5 days’ walk away, across the Ararat plain, and where they could meet inhabitants of the Sarikamis region.

Clearly, the territory of circulation of the inhabitants of Aratashen was oriented towards the west. And this tendency, which existed for 66% of the material in level IIb, increases to 90% in level IIa. The only artefact from level I that has been analysed also comes from Sarikamis South. The presence of the salt mountain of Tuzluca, which may have served as a place for meeting and trade, can be an element of explanation.

**Chalcolithic: Godedzor**  
The village of Godedzor, established at an altitude of about 1800 m in the mountains of the south-eastern Lesser Caucasus (Fig. 9), was probably the summer encampment of transhumant populations. Indeed, the region of Godedzor is covered by a thick layer of snow from October to March, which makes the survival of animal herds very difficult during the winter, as the ethnographic data show (Mkrtumyan 1974). Light architecture (numerous post holes) confirms temporary occupation in this place. Moreover, the presence of painted pottery,
characteristic of the basin of Lake Urmiah in the Late Chalcolithic, is evidence of relations with this region (Chataigner et al. 2010).

On the high plateaus that dominate Godedzor are several large deposits of obsidian (Satanakar, Sevkar and Bazenk). The torrents flowing across these deposits carry many blocks towards the Vorotan River, which passes through a canyon below the village of Godedzor. The 21 artefacts analysed come all from the deposits of these high plateaus, predominantly from the sources of Sevkar (71%), and the rest from the deposit of Mets Satanakar.

The fact that a certain number of artefacts bear strips of neo-cortex (surface ground down by movement in the river), and the reduced size of most of them, shows that the pebbles found in the Vorotan were actually exploited by the inhabitants of Godedzor, who also went on to the high

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Figure 9  *The main routes of communication between the region of Godedzor and the northern Near East.*
plateaus or traded with the local populations, since large cores were found together in a cache on the site.

The inhabitants of Godedzor, who used their cattle for transporting heavy loads, as is shown by the pathological deformations observed on the vertebrae and phalanxes of several animals (Chataigner et al. 2010), probably brought blocks and obsidian artefacts down to their winter encampment in the basin of Lake Urmia. Indeed, the analyses carried out on the Chalcolithic sites established around Lake Urmia (Pisdeli Tepe, Yanik Tepe etc.) show a predominance of ‘group 3C’ obsidian, coming from Syunik (Sevkar, Satanakar and Bazenk) (Renfrew and Dixon 1976; Voigt 1983; Keller et al. 1996; Niknami et al. 2010).

Early Bronze: Gegharot, Karmrakar and Lusaghbyur  From 3500 cal BC, the culture of the Kuro-Araxes (Early Bronze Age) developed in Armenia and experienced great expansion during the third millennium. The bicoloured pottery (black outside, red or light brown inside) that is characteristic of this culture spread westwards as far as the Mediterranean Sea and eastwards to the Caspian Sea. The sites of Gegharot, Karmrakar and Lusaghbyur, which belong to the late phase of this culture (2600–2400 cal BC), are situated to the north of the Aragats massif.

Gegharot is located on a hill, on the southern flank of the Pambak range, on the north-eastern edge of the Tsaghkahovit plain. The Early Bronze Age settlement occupies the summit and the western flank of the hill: a tomb discovered at the western foot of the hill contained a rough obsidian block weighing 8.860 kg (Badalyan and Avetisyan 2007). The analysis of this block shows that it probably came from Arteni, nearly 14 hours’ or 2 days’ walk away by skirting the Aragats massif to the west (Fig. 10). A source so far away for a block as heavy as this suggests the use of pack-animals (cattle), but such a load could also have been transported by a walker, for a special purpose. Moreover, most of the supplies at Gegharot come from the deposits of Damlik-Ttvakar (Tsaghkunyats 1), situated less than 6 hours’ walk from the village. One sample comes from the Gutansar complex, to the east of the massif, at about 12 hours’ walk.

Karmrakar and Lusaghbyur are located on the southern flank of the Shirak range, on the northern edge of the Pambak Valley. The Karmrakar settlement sits on a triangular spur and the Lusaghbyur settlement occupies a hill bordered by ravines. At Lusaghbyur, the only sample analysed is from Arteni (about 2 days’ walk). As for the inhabitants of Karmrakar, most of their supply (60%) came from the deposits of Sarikamis North, of which the blocks, transported by the Kars River, had accumulated in the secondary deposits at the confluence of the Kars and Akhurian Rivers, 1 day’s walk away (Fig. 10). From there, the inhabitants could cross the Akhurian and go towards Yaglica Dag (30% of their supply) at 1 day’s walk, and then the deposits of Sarikamis South (10%) at 2 days’ walk further on. The three sources identified at Karmrakar are therefore situated in the province of Kars, in north-eastern Turkey.

The settlements of Gegharot and Karmrakar, both situated in north-western Armenia and both belonging to the late phase of the Kuro-Araxes culture, therefore clearly exploited different sources. The inhabitants of Gegharot exploited the deposits from around the Aragats massif, while those of Karmrakar were oriented towards the province of Kars. This division reflects different territories of routes and trade networks. It reveals profound local differences, masked by the apparent uniformity of the Kuro-Araxes culture.

Late Bronze Age: Gegharot, Hnaberd, Keti and Getashen  After the Early Bronze Age, in the first half of the second millennium, a period followed (the Middle Bronze Age) that is characterized by the development of transhumant pastoralism (the general abandonment of
agro-pastoral settlements) and a clear hierarchization of society (the inhumation of a fraction of the population in kurgans with rich funerary furniture). Then, towards 1600 BC, a rapid transition occurs towards the Late Bronze Age, seen in the reappearance of numerous permanent settlements in the form of stone-built fortresses of differing size built atop hills (Smith 2005). The social inequalities visible in the kurgans of the Middle Bronze Age appear to have been formalized into a tightly integrated socio-political apparatus where critical controls over resources—economic, social and sacred—were concentrated within the Cyclopean stone masonry walls of powerful new centres; in addition, vast cemeteries appear coincident with the emergence of Late Bronze Age polities (Smith 2005). Fortresses and cemeteries are present at the sites of Gegharot, Hnaberd and Keti, in north-western Armenia, and date to between the 15th and the 13th/12th centuries BC (Badalyan and Avetisyan 2007).

At Gegharot, the analysis of eight obsidian samples from the fortress has determined that six samples come from the Damlik-Ttvakar deposits in the Tsaghkunyats range (Tsaghkunyats 1), and the other two from the Aragats flow of the Arteni complex (Arteni 1) (Fig. 11). The territory of provisionment for this site had thus hardly changed since the Early Bronze Age. The neighbouring sources of Tsaghkunyats are logically in the majority and the existence of a route west of the Aragats towards Arteni is confirmed.

The fortress of Hnaberd, which is situated on the southern slope of the Tsaghkahovit plain less than 10 km from Gegharot, shows evidence of a different provisionment. The deposits of the...
Gutansar complex are clearly more predominant (50%) than those of Tsaghkunyats, Arteni and Geghasar (Fig. 11).

At Keti, further north, Arteni is the main source of obsidian, and the deposits of Sarikamis North, via the secondary deposits carried by the Kars River as far as Akhurian, as well as those of neighbouring Yaglica Dag, played a secondary role (Fig. 11).

Thus the territories of supply for the populations of the Late Bronze Age established to the north of the Aragats massif were appreciably the same as those of their predecessors of the Early Bronze Age. They provide evidence of the same diversity, which can be linked in this period to the well-attested breaking-up of the territory into small political entities (Smith 2005).

The tombs of Nor Getashen, on the south-western bank of Lake Sevan, have produced two obsidian artefacts, one of which comes from the Gegham mountains, very close by, and the other from Gutansar, situated on the other side of these mountains.

CONCLUSION

Our study confirms that, whatever the period and the geographical location of the settlements, the prehistoric populations of Armenia supplied themselves with several sources of obsidian. Clearly, the distance to the source was not the essential parameter in the choice of the deposit. Other factors were involved in the choice of sources: the role of the secondary deposits of obsidian, the importance of contacts and exchange between the prehistoric groups, and the existence of territories of circulation.
The role of the secondary deposits in the river valleys has often been underrated, and yet they enabled the populations to acquire raw material at a considerable distance from the outcrops. This is the case, in particular, for the sources of Sarikamis North, whose material is available in abundance in the valley of the Kars River, as well as in that of the Akhurian. This is also the case for the Tsagkhunyats obsidian blocks, brought down by the Kasakh River to Kmlo, and for the Sevkar obsidian pebbles carried by the Vorotan River as far south as Godedzor.

In the Upper Palaeolithic and the Mesolithic, the hunter–gatherers had a high degree of mobility, but exchange and social interaction were also integral components of their lifeways. At an inter-regional level, exchanges occurred between adjacent regions that were geographically distinct and therefore capable of producing specific items (including obsidians), which became objects of exchange for practical reasons or for their social value (Kind 2006). From the Late Neolithic onwards, domestication is in evidence in Armenia and another form of mobility is attested as early as the sixth millennium BC: the practice of semi-transhumance (Badalyan et al. 2010). This custom, which reached its peak in the Bronze Age, is an absolute necessity, because of the high temperatures and drought conditions that descend upon the lowlands in summer. Consequently, the obsidian from the deposits at high altitude (Syunik and Gegham) was largely diffused as a result of the transhumant movements (Chataigner and Barge 2008).

In different periods, the primacy given to remote sources of obsidian in a specific direction suggests the existence of territories of circulation. In the Late Neolithic, the human group living at Aratashen obtained its obsidian supply mainly in deposits located in the western part of the Ararat plain and in the Kars region. The Tuzluca salt mountain, located near the confluence of the Akhurian and the Araxes, could be an element in the explanation of this movement towards the west. In the Late Bronze Age, striking differences, observed in the provisionment of obsidian for sites located near each other, such as Gegharot and Hnaberd, enable the perception of territorial division into small entities and into distinct trade networks.

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