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The procurement of obsidian: factors influencing the choice of deposits

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Abstract

More than 20 sources of obsidian are scattered across Armenia and the determination of provenance of about 400 artefacts from archaeological sites permits analysis, on a methodological level, of factors which could have influenced the choice of deposit by prehistoric people. The study of the distribution of obsidian shows that there is no simple model: the villages were supplied sometimes from one source, sometimes from several, and in the latter case the nearest deposit was not necessarily the one preferred. The factor of distance as the crow flies, which is often considered a determinant in the choice of sources, is thus often irrelevant. Thanks to a Geographic Information System, we have been able to create a model of 'time–distance' between the deposits and the villages and to establish maps of accessibility to the sources of obsidian from each of the archaeological sites. When several sources are available, a threshold appears which corresponds to the maximum time accepted by the populations for direct procurement; beyond this threshold, the quantity of obsidian is reduced and appears to be related to gradual redistribution or to a transhumance process.

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1. Introduction

More than 20 sources of obsidian which were extensively exploited in prehistory are scattered across Armenia. A preliminary study of obsidian circulation in this area was carried out as part of an INTAS programme [1]: the systematic characterization of all Armenian obsidian sources was achieved through geochemical analyses and fission-track dating; these geological data served as a base for determining the origins of an important collection of artefacts from sites dating to between the 4th and the 1st millennia BC (Fig. 1).

The large number of available obsidian sources throughout the country and the distribution of the archaeological sites enable analysis, on a methodological level, of factors which could have influenced the choice of deposit by prehistoric people. The models used in archaeology in studies of regional exchange generally maintain that the distance to the source is the essential parameter for explaining the quantity of obsidian recovered on the sites. Thus, according to the 'opportunistic model' [2], in the 'supply zone' containing sites where consumers obtain their own supplies, the

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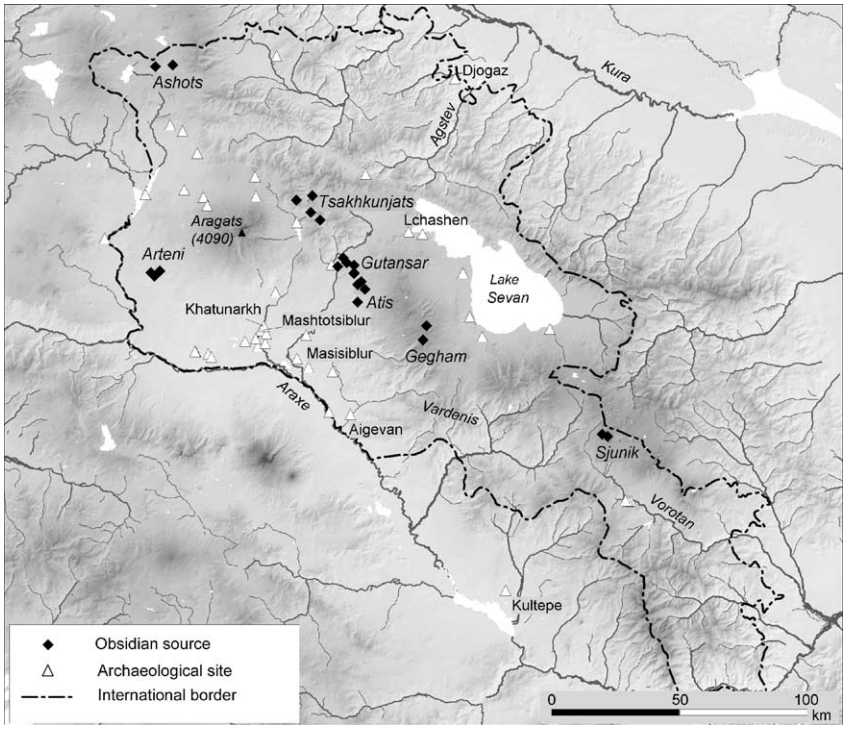

Fig. 1. Map of Armenia. The obsidian sources and the main archaeological sites.

quantity of obsidian decreases progressively as a function of distance from the source ('law of monotonic decrement') up to a certain threshold (about 300 km); beyond this threshold, this quantity falls quickly, the sites of the 'contact zone' receiving their obsidian through exchange with neighbours located nearer the source ('down-the-line exchange').

Several modifications have been proposed for this model in order to account for situations which do not fit the rule [3]: (a) the boundary between the supply and contact zones is determined by the availability of alternative goods; (b) the sites distant from the source which receive an important quantity of obsidian play the role of 'central places' of exchange (markets) or redistribution (centralising power)...

These modifications concern the means of distribution, but not those of acquisition. Procurement from the nearest source appears to be a fact. But the study carried out in Armenia indicates that this theory is often refutable, and that the villages were sometimes supplied from one source, sometimes from several, the nearest deposit not necessarily being the one preferred.

2. Experimental procedure

In order to better understand the factors that have influenced the exploitation of obsidian in Armenia, we have conducted work in two directions: an in-the-field analysis of the environmental parameters characterising the different obsidian deposits, and the creation of a model of the circulation of obsidian, thanks to a Geographic Information System (a computer-assisted system for the display and analysis of geographic data) [4].

2.1. Environmental parameters of the deposits

Armenia occupies the central part of the Little Caucasus chain, which rises to more than 4000 m (Aragats) and is bordered on the north by the Kura basin and to the south by the valley of the Arax.

A systematic survey of all the known obsidian sources in Armenia has enabled definition of the characteristics of each deposit: (a) the quality of the obsidian – its serviceability for fashioning artifacts; (b) the quantity of the obsidian – the size of the deposit; (c) its spatial accessibility – the altitude of the deposit and its geomorphological context; the existence of secondary deposits (blocks washed down by rivers), (d) its temporal accessibility – the number of months of snow cover; the presence of permanent habitations in the vicinity and/or transhumants during the summer; and (e) the location of the primary or secondary deposits in relation to the routes of communication.

This study shows that obsidian deposits in Armenia, all of which produce a material of good quality for knapping, can be classed into three groups:

- the Arteni, Gutansar and Atis volcanic complexes: situated in contact with the plain, accessible almost all the year, near a permanent habitat and main communication routes;
- the Tsakhkunjats (Damlik, Kamakar...) and Ashots ranges: moderate accessibility, due to higher altitude and more snow cover; permanent habitations are found nearby and in summer shepherds move to pastures on the slopes of the volcanos; but these two volcanic complexes are not near the main communication routes, and Ashots has a low number of outcrops;
- the Gegham mountains (Geghasar, Spitaksar) and Syunik range (Sevkar, Satanakar...): deposits situated on the high plateaus at more than 2500 m, snow-covered for most of the year and visited only by transhumant shepherds during the summer.

2.2. Modelling based on the Geographic Information System

The Geographic Information System enabled analysis of the diffusion of obsidian by merging data in raster mode (or image mode) and data in vector mode (or object mode) [4,5]. The precise location of the archaeological sites and the obsidian deposits, as well as information concerning the geological provenance of the analysed artefacts, has enabled the study of the distribution of obsidian from each source. A modelisation in three dimensions of the relief (a Digital Elevation Model) was made and a map of the inclines in degrees taken from this model. Joining the climatic information to the relief information, the map of the periods of snow cover enabled a description to be made of the environment of the obsidian deposits.

Moreover, a model of 'time–distance' between the villages and the obsidian sources was developed by calculating the time of access to the sources as a function of the inclines map, relief being considered the essential constraint factor for movement. This analysis was conducted in raster mode in three stages:

(a) An area of constraint (c), function of the incline in degrees (p), was calculated according to the equation:

$$c = 0.031p^2 - 0.025p + 1 \quad [4]. \tag{1}$$

(b) An analysis of distance/cost (d) was then conducted: the distance of each cell in relation to a source is calculated in cell units, counterbalanced by the value of constraint (c). Thus, moving over 1 km (10 cells) on flat terrain (constraint (1)) results in a distance/cost of 10, equivalent to that necessary for moving 500 m (5 cells) over terrain for which the constraint value is 2.

(c) The distance/cost values are then converted into time, by simply multiplying the values by the time necessary to move over one cells (here, 100 m at 5 km/h, 0.02 h).

The time of access to each source from each archaeological site can thus be obtained. From the location of the sources, isochrones of 2 h and one day distant were also produced (Figs. 2 and 3).

Finally, from the area of the defined constraint, the most rapid path was calculated for each archaeological site/obsidian deposit relationship. These paths can be drawn on the map of Armenia as a theoretical network (Fig. 4).

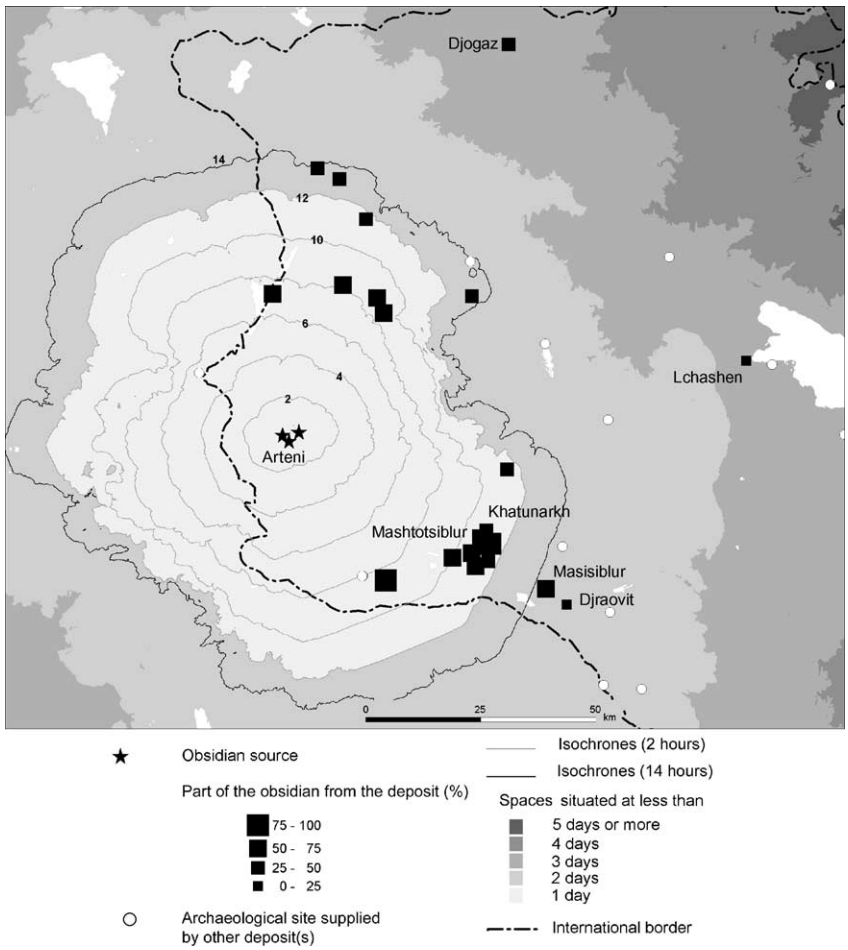

Fig. 2. Map of isochrones for Arteni. The Arteni deposit, situated in the plain of Ararat, is exploited by the villages situated between 6 and 15 h away by foot; beyond this, obsidian is intermittenly present in villages located more than 25 h by foot and situated along axes of communication (Lchashen, Djogaz).

3. Results and discussion

This presentation demonstrates that several natural factors affect the choice of sources, but that other elements should also be looked for.

3.1. Diversity of supply sources

Relatively few sites have a single source of supply (only 25%), while the others depend upon at least three deposits. The exclusive choice of one source is explained by a geographically enclosing location, as for the villagers of the basin of Lake Sevan who look for their obsidian on the high plateaus of Gegham dominating the southwest bank of the lake (Fig. 3), or for the inhabitants of the valley of Vorotan who are supplied exclusively by the deposits of Syunik, 9 h away by foot, the second available source (Geghasar) lying 35 h away by foot.

When there are several supply sources, two cases are distinguishable (Fig. 2): (a) one of the sources clearly supplies the majority of the material (Arteni represents 72% of the obsidian analysed at Masisiblur in the eastern part of the Ararat plain); (b) the proportions of different sources are relatively balanced, none being truly dominant (Arteni, Gutansar, Atis, Geghasar ... are exploited

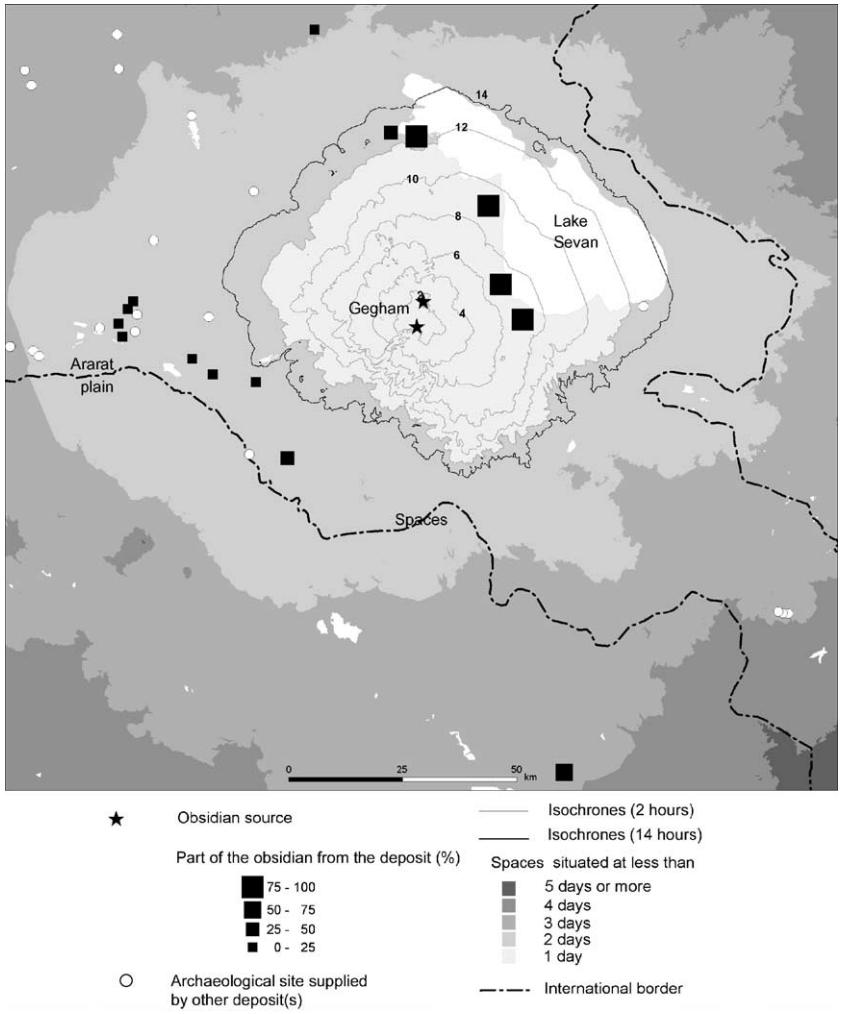

Fig. 3. Map of isochrones for Gegham. The Gegham deposits, situated between 2500 and 3000 m altitude, are mainly exploited by the villagers of the western bank of Lake Sevan; the villages installed at the foot of the massif, between 15 and 25 h by foot, are supplied with a small quantity of obsidian, brought in by the transhumants.

equally by the villagers of Djaravit, situated not far from Masisiblur).

The availability of sources being the same in the two cases, it seems that cultural factors are at the origin of the difference between the two sites: Masisiblur was occupied in the Chalcolithic, a period when the villagers of the plain of Ararat were mainly supplied from the Arteni complex; Djraovit is a settlement of the Bronze Age, a period marked by population movements throughout Armenia, which favoured diversification of supply sources.

3.2. The distance factor as relative

Calculation of the time separating the villages from the obsidian sources shows that only 40% of the sites are mainly supplied by the nearest source; 42% exploit the nearest source less than other ones, and 18% do not exploit it at all.

The 'opportunist' model has been tested: it defines the zones around the sources by allocating each deposit a 'client' zone in which all points are nearer that source than any others. This model has been largely refuted, as only 32% of the sites

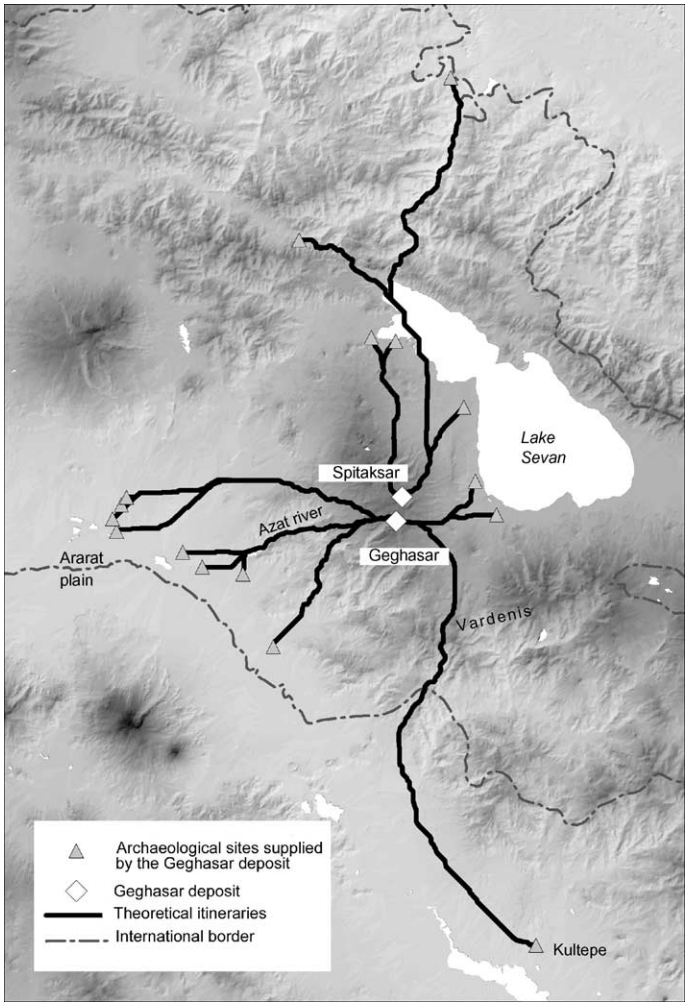

Fig. 4. Model of routes for Geghasar and Spitaksar (Gegham mountains), according to the lines of least constraint; most of them follow the roads taken in the recent past by transhumants leading their herds to summer pasture on the high plateaus.

which are supplied by a volcano are situated in the client zone. This proportion is however 80% for those sites supplied by a single source. Based on time periods, the results are hardly any different with proportions of 34% and 60% respectively.

3.3. Accessibility maps

Accessibility maps show that there are two modes of exploitation related to the type of deposit.

The deposits situated in plains (Arteni, Gutansar, Atis) are exploited by the villages situated between 6 and 15 h away by foot. The proportion of obsidian is variable (between 80% and 10%) and does not show a progressive decrease as a function of time–distance (as the 'law of monotonic decrement' dictates): thus obsidian from Arteni (Fig. 2) is present at 30% and 70% respectively in the material of two neighbouring sites in the Ararat plain, Khatunarkh and Mashtotsiblur, both Chalcolithic sites situated 10.9 h away by foot; this proportion reaches 72%

in a settlement of the same period, Masisiblur, situated at 14.5 h by foot from the source. Beyond this, direct supply stops and obsidian is intermittently present in villages located more than 25 h by foot. These villages are situated along axes of communication, such as Kultepe of Nakhichevan, established near the road which runs west–east along the Arax valley, Lchashen on the northwest bank of Lake Sevan, and Djogaz in the valley of the Agstev, both on an important route leading to the Kura basin...

The deposits at altitude (Gegham, Sevkar, Tsakhkunjats...) are exploited by two distinct categories of the population (Fig. 3):

- the villagers of the interior basins, at a time–distance of between 6 and 14 h by foot, exploit these deposits almost exclusively (90–100%);
- other villages, installed at the foot of volcanic massifs, at a distance of between 15 and 25 h, are supplied from these sources at only 10–40%. It appears that these are settlements from which transhumants spent the summer with their herds on the high plateaus, descending in the autumn with the obsidian which they had collected or worked.

3.4. Modelling lines of movement

The routes modelled according to the lines of least constraint (Fig. 4) consist of itineraries which can be validated by ethnographic data. Some follow the roads taken in the recent past by transhumants leading their herds to summer pasture on the high plateaus; this is the case for the road following the plain of Ararat to Geghasar by ascending the valley of the Azat, whose source is at the foot of obsidian flows.

In other cases, when several possible routes exist, this model reveals the route which is least difficult and potentially the most used. This is so for the route which could have been followed by the inhabitants of Kultepe of Nakhichevan, to seek obsidian at Geghasar (represented by 50% of the samples analysed from this site) by ascending the valley of the Araxe, then crossing the Vardenis range through a pass at 2400 m.

4. Conclusion

Whatever the model studied, the time–distance of 14 h seems to correspond to a threshold for prehistoric populations seeking supplies; this threshold corresponds to the maximum time accepted by the populations for direct procurement. Beyond this threshold, the quantity of obsidian is reduced and appears to be related either to gradual redistribution or to acquisition related to transhumance (in the case of source at altitude).

Several factors are involved in the choice of sources, and although time–distance (for mountainous regions, this measure is more pertinent than the distance as the crow flies) remains an important criterion, it must be tempered by other considerations:

- the geographic context of the settlements: in an enclosed situation (valley of the Vorotan, basin of Lake Sevan), the sources situated on the heights, which surround the interior basin where the populations are established, are exploited almost exclusively; in all other cases, procurement is diversified;
- the quality of the material: when several sources are available, the closest deposit is not necessarily exploited, and in this case the quality of the material seems to be an important criterion; thus, the deposits of Atis were often neglected in favour of the neighbouring complex of Gutansar;
- the transhumance routes: when a deposit is located on a high plateau frequented by transhumants, the obsidian is found in reduced quantity in many villages, disseminated long distances from the source;
- the axes of communication: Kultepe of Nakhichevan, situated in the eastern part of the valley of the Araxe, is more than 25 h from the first source of obsidian; however the material is abundantly represented on the site and its sources are diverse: Sevkar, Geghasar, Guransar, Arteni and a source in eastern Turkey. This abundance and diversity can be explained by the location of Kultepe on an important route along the left bank of the Araxe, leading from

eastern Turkey (region of Erzurum) to the northwest of Iran (basin of Lake Urmia);

- the exchange of raw materials: the integration of a communication network enabled the exchange of various materials for obsidian; Kultepe is situated near a place where salt was mined in Antiquity, and rich copper minerals are found in the mountains of the Kafan region not far from the site;
- the cultural context: if environmental factors seem to play a major role in the choice of sources, this choice can evolve over time; thus in the Chalcolithic, only the Ararat plain was inhabited and the obsidian of Arteni was preferentially exploited; in the Bronze Age, population movements affected all the regions of Transcaucasia and new sources were used (Atis, Tsakhkunjats...).

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