Archaeological Research in Asia 32 (2022) 100397

Contents lists available at ScienceDirect

Archaeological Research in Asia

journal homepage: www.elsevier.com/locate/ara

Full length article

New data on different patterns of obsidian procurement in Georgia (Southern Caucasus) during the Chalcolithic, Bronze and Iron Age Periods

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ARTICLE INFO

Keywords:
Obsidian procurement patterns
LA-ICP-MS analysis
Southern Caucasus (Georgia
Shida Kartli
Kakheti)
Chalcolithic
Bronze Age
Early Iron Age

ABSTRACT

The analysis of 107 obsidian samples collected in the course of the archaeological investigations carried out from 2009 to 2019 by the Georgian-Italian expeditions in Eastern Georgia in the provinces of Shida Kartli (Natsargora, Aradetis Orgora and Okherakhevi) and Kakheti (Tsiteli Gorebi 5) allowed us to confirm the existence of two contrasting obsidian procurement patterns in the region. Virtually all the samples (56 out of 57) from the province of Shida Kartli, west of the present capital Tbilisi, regardless of their site of origin and of their date, which varies from the late 4th to the early 1st millennium BC, originate from a single general source (i.e., the outcrops of the Chikiani volcano near lake Paravani in southern Georgia). On the other hand, the samples from the early 5th millennium site of Tsiteli Gorebi 5 in the province of Kakheti, close to the present border of Azerbaijan, originate from seven different volcanoes located in Armenia (Gegham, Syunik, Gutansar and Tsaghkunyats), in southern Georgia (Chikiani), and in eastern Turkey (Sarıkamış region and Yağlıca Dağ). They thus outline for Kakheti a more complex multisource procurement pattern, already familiar from other sites of the same region, as well as of the neighbouring area beyond the Georgian/Azerbaijani and Georgian/Armenian borders, which deserves being further investigated in the future.

1. Introduction

The Southern Caucasus is a highly volcanic region, very rich in obsidian deposits. These have been extensively exploited by the local population since most ancient times: indeed, with frequencies which not rarely exceed 90% of the total, obsidian represents by far the most common raw material of the local chipped lithic assemblages. Over the last 30 years, the database of analysed artefacts from archaeological sites in the region dramatically increased, and the characterisation of the different local sources has greatly improved (Chataigner and Gratuze, 2014a; Chataigner et al., 2014; Biagi and Gratuze, 2016; Biagi et al., 2017; Frahm et al., 2017; Cherry et al., 2010). It has thus not only been possible to establish that obsidian from South Caucasian sources circulated (albeit in limited amounts) beyond the region, in particular toward Northern Mesopotamia and Northwestern Iran (e.g. Frahm et al., 2016; Frahm, 2019; Barge et al., 2018; Maziar and Glasgock, 2017), but also to analyse in increasing detail the patterns of its intra-regional circulation and, in some cases, to diversify them from a spatial as well as from a chronological point of view (Badalyan et al., 2004; Badalyan, 2010; Chataigner and Barge, 2010; Le Bourdonnec et al., 2012; Chataigner and Gratuze, 2014b; Nishiaki et al., 2019; Chataigner et al., 2020; Orange et al., 2021).

Based on a limited set of data, Badalyan, 2010 already observed the existence of two contrasting obsidian procurement models in Eastern Georgia: one which utilised a single source of obsidian, the Chikiani volcano – this was attested, among others, at the two sampled Early Bronze Age (EBA) sites of the Shida Kartli province (Berikldeebi and Tsikhiagora) as well as at several sites of the southern province of Kvemo Kartli – and a multisource one, which made use of two to six different sources, although in some cases with the domination of a single one. The Neolithic site of Khramis Didi Gora in Kvemo Kartli and the Chalcolithic site of Tsiteli Gorebi in Kakheti followed the latter model, whereas the Early Iron Age (EIA) site of Naomari Gora in the same province exhibited almost 90% of obsidian from the Chikiani source. Interestingly, the Chikiani source was not recorded at Tsiteli Gorebi. This could suggest that the Alazani valley, where Tsiteli Gorebi is located, belonged to a separate procurement network; however at the Late Chalcolithic site of Padar in Azerbaijan, located further east in the same river basin, Chikiani obsidian was prevalent (more than 60%), although in the framework of a multisource scenario.

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https://doi.org/10.1016/j.ara.2022.100397
Received 10 August 2021; Received in revised form 29 July 2022; Accepted 8 August 2022
Available online 19 August 2022

Clearly, data from a larger number of sites of different periods are needed for a well-founded evaluation of the local and diachronic variability between these two contrasting models of obsidian procurement patterns in Eastern Georgia. These should then be evaluated against the background of the procurement patterns attested in the neighbouring regions of northern Armenia and western Azerbaijan (Chataigner and Gratuze, 2014b; Nishiaki et al., 2019; Chataigner et al., 2020). Additionally, further research is needed in order to achieve a reliable picture not only of obsidian circulation but also of human mobility in the region, of the interregional communication routes crossing this, and of other aspects of economy and material culture of the local groups. Accordingly, the main aim of this article is to present new data derived from the analysis of 107 additional obsidian samples from Eastern Georgia collected in the course of the archaeological investigations carried out from 2009 to 2019 by the Georgian-Italian expeditions in the provinces of Shida Kartli (Natsargora, Aradetis Orgora and Okherakhevi) and Kakheti (Tsiteli Gorebi 5).

2. The archaeological sites and their obsidian assemblages

2.1. Shida Kartli province

The three Shida Kartli sites are located in the basin of the Kura, the main river of the region and one of the major communication corridors of the Southern Caucasus (Fig. 1), in a hilly area bounded by the northern slopes of the Lesser Caucasus and the southernmost fringe of the Greater Caucasus, at an altitude between 500 and 800 m a.s.l. Their environmental conditions can be considered as roughly comparable; the climate is moderate humid, with moderately cold winters and long warm summers.

Natsargora (Khashuri district, 42°04′13" N, 43°42′54″ E) lies, at ca 760 m a.s.l., on a secondary route leading from the Kura valley to the mountains. The area is occupied by smooth hills and valleys mostly developing in EW direction. The distance from the Kura amounts to 7 km; direct connection is provided by the Pleula stream, a small tributary of the Western Prone, which in its turn flows into the Kura (Puturidze and Rova, 2012, 3–7). The site is a small multi-period mound, ca. 90 m long and 50 m wide, joined by a flat settled area and by a neighbouring cemetery. It was excavated between 1984 and 1992 by a team of the Georgian National Museum lead by Alexander Ramishvili (Ramishvili, 2013) and, subsequently, by the joint "Georgian-Italian Shida Kartli Archaeological Project" (GISKAP) directed by Elena Rova, Marina Puturidze, and Zurab Makharadze (Puturidze and Rova, 2012; Rova et al., 2017; Puturidze and Rova, n.d.; Georgian-Italian Shida Kartli Archaeological Project, 2022). According to the re-evaluation of the site's stratigraphy by the new excavators, its first occupation dates back to the EBA, when it was the seat of a Kura-Araxes village of rather short duration, which was ^{14}C-dated around the 31-30th centuries BC (Rova, 2014, p. 66). There followed a period of virtual abandonment – corresponding to the Late Kura-Araxes/Martqopi phases – and an ephemeral re-occupation, mostly consisting of pits, during the Bedeni phase (Early Kurgan period, second half of the 3rd millennium BC).[1] After a longer period of abandonment, the site was re-occupied (around the mid-2nd millennium BC) by a Late Bronze/Early Iron Age (LBA/EIA) village. The remains of these later periods had for the most part been excavated by Ramishvili, but LBA/EIA pits and foundations had considerably disturbed both the intermediate accumulation layer, and the underlying Kura-Araxes level. Obsidian, both worked and unworked, was found in large quantities both in Ramishvili's excavations and in those of the Georgian-Italian expedition, mainly in the form of flakes, which sometimes showed traces of retouch and/or use. These were accompanied by a small number of formal tools (arrowheads, lamellae, end- and side-scrapers, cutters, etc.), and by a few small cores.[2] It was also occasionally used for ornaments, as proved by five beads discovered in one of the graves of the Kura-Araxes cemetery (Puturidze and Rova, 2012, p. 55, Fig. 7: 8; pl. 30, 5). In the Bedeni period, it was also used as an inlay material for the eyes of cultic reliefs of terracotta depicting anthropomorphic figures (Rova, 2016, Fig. 11). In the same period, it was occasionally used, after being carefully crushed, as a tempering material for fine-ware ceramics (Babetto et al., 2021).

Aradetis Orgora (Kareli district, 42°02′47" N, 43°51′37″ E) is a large archaeological complex close to the confluence of the Western Prone with the Kura, occupied from the end of the 4th millennium BC to the 6th century AD. It develops on three different mounds and an adjacent cemetery at the edge of the gently sloping plain. The Main Mound (Dedoplis Gora) occupies an easily defendable position dominating the river valley, at approximately 680 m a.s.l. It shows a 14 m-thick anthropic accumulation topped by a large Hellenistic fortified building. The underlying levels, spanning the EBA to the MIA (Middle Iron Age), corresponding to ca 3000–700 BC, were investigated, between 2013 and 2016, by the GISKAP project under the joint direction of Elena Rova and Iulon Gagoshidze in two different areas on the opposite sides of the mound (Gagoshidze and Rova, 2015, 2018; Georgian-Italian Shida Kartli Archaeological Project, 2022). The main phases of occupation are the Kura-Araxes period, with a 4 m-thick sequence of domestic occupation, and the LBA to IA (Iron Age), with an up to 5 m-thick sequence, which yielded a succession of open spaces equipped with installations for food preparation and refuse disposal areas. The intervening phases – late EBA (Martqopi and Bedeni, second half of the 3rd millennium BC) and MBA (Middle Bronze Age, first half of the 2nd millennium BC) –, though attested, are characterised by less intensive occupation. Obsidian made up 84% of the total chipped lithic corpus recovered from the site (a total of 3304 items). The obsidian assemblage consisted of nine cores, 57 tools and 2703 debitage elements (Amato, 2019, 2020). The evaluation of possible diachronic changes in the percentages of obsidian versus flint at the site is made difficult by the different surface of the areas excavated for each period, but it does not seem to show any important variation. The same difficulty concerns the absolute frequency of obsidian in the different levels, although it was observed that obsidian was especially common in the layers dating from the MBA to the Transitional MBA/LBA period, although these were excavated only on a very small surface (Amato, 2020, p. 107 f.). As these levels seem characterised by a rather ephemeral/intermittent occupation, it was tentatively supposed that their mobile way of life may have had granted to the local groups better access to the obsidian sources. The presence of obsidian in the burial goods of the Kura-Araxes cemetery (the only ones which have been analysed in detail so far), is on the contrary, merely episodic (only one arrow-head) (Amato, 2020).

Okherakhevi (Kaspi district, 41°52′12″, 44.31′24" N) is a field of small kurgans (burial mounds) located on a flat area on the lower terrace of the Kura River, ca 15 m above the present course of the latter. Two of them were excavated in 2010 by the GISKAP project under the joint direction of E. Rova, M. Puturidze, and Z. Makharadze (Rova et al., 2010; Rova, 2016; Georgian-Italian Shida Kartli Archaeological Project, 2022). The first (no. 1) belonged to the later part of the EBA (Bedeni culture); the second (no. 2) most probably dates back to the LBA. Numerous flakes of unworked obsidian were recovered from among the

[1] The attribution of the so-called Early Kurgan period (Martqopi and Bedeni cultures, second half of the 3rd millennium BC) to the EBA or to the MBA represents a still open question within South Caucasian archaeology. Here the former option is adopted and the period is considered to correspond to the late EBA. For a thorough discussion of the question, the reader is referred to Sagona, 2018, 298–305; Rova and Tonussi, 2017, 4–5; Rova, 2020.

[2] Preliminary information provided by Tamar Meladze, mainly on the basis of the preliminary analysis of the material from the 2011 and 2012 excavations by the GISKAP project. No formal tool was recognised among the items from Ramishvili's EBA settlement excavation (Meladze in Puturidze, Rova, in preparation).

Fig. 1. Map of Georgia with modern administrative divisions (Shida Kartli and Kakheti provinces highlighted) and approximative location of the four archaeological sites.

pebbles which constituted the mound of both kurgans, especially of the first one. Here, some were also found in the underlying filling of the burial chamber, where they had clearly been intentionally scattered, following a funerary ritual which is rather common in the Bronze Age cultures of the Southern Caucasus.

2.2. Kakheti province

The site representing the Kakheti region is located nearly 150 km to the east of Okherakhevi as the crow flies, at the eastern limit of Georgia, close to the border of Azerbaijan. Its environmental conditions are peculiar, and need to be briefly introduced. It lies in the valley of the Alazani River, one of the main tributaries of the Kura. The Alazani valley is famous for its uniquely moderate humid and mild climate, with moderately cold winters and moderately hot summers. The territory of Lagodekhi district, where the site is located, is however characterised by an extreme environmental variability. As one moves southwards, the forested lower ranges and foothills of the Greater Caucasus give way, quite quickly, to the very gently sloping, and heavily cultivated, Alazani plain. Close to the river course, the altitude is about 200 m. a.s.l., the climate is warmer, temperate/subtropical. Along the left bank, there extends a ca 4–6 km wide belt of dense lowland forest interspersed with swampy areas.

Tsiteli Gorebi 5 (Lagodekhi district, 41°40′19" N, 46°11′13″ E) is one of a cluster of several Chalcolithic sites situated in the just described low-lying plain ca 4 km to the north of the present course of the Alazani, at an altitude slightly over 200 m a.s.l. Two of these sites were investigated by V. Varazashvili in the late 1970/early 1980s (Varazashvili, 1992): the obsidian samples analysed in Badalyan, 2010 came from these excavations. Tsiteli Gorebi 5 is a new site of the same group, excavated since 2018 by the "Georgian-Italian Lagodekhi Archaeological Project" (GILAP) directed by Elena Rova and David Kvavadze (Rova et al., 2022; Rova and Kvavadze, 2022; Georgian-Italian Lagodekhi Archaeological Project, 2022). It is a single-period settlement with a mounded area of less than two hectares, ^{14}C-dated to the Early Chalcolithic (ECh) period (first two centuries of the 5th millennium BC), with evidence of rectilinear architecture and ditches, heavily damaged by 20th century A.D. mechanised agriculture, which yielded a coherent assemblage of contemporary artefacts (ceramics, lithics and worked bone material). While the presence of substantial architecture may suggest sedentary occupation, the role of cereal agriculture does not appear to have been very significant at the site. Preliminary study of the faunal remains confirms that domestic animals played a significant role in the site's subsistence economy and, if anything, suggests a pastoral society based on sheep and cattle breeding, although bone analysis did not reveal any explicit hint at seasonality which might indicate a mobile style of life (Rova et al., 2022; Rova and Kvavadze, 2022).

The chipped lithic assemblage (2002 items in total from the first two seasons) was composed almost exclusively (98%) by obsidian: it included 54 cores – which attest to on-site working – and 188 tools, while the rest consists of debitage. Flint is extremely rare, and attested almost exclusively in the shape of finished tools, mainly blades, for some of which preliminarily trace analysis suggest a use as sickle elements used to reap cereals (Rova et al., 2022; Amato, 2022). Small fragments of obsidian were also sometimes used at the site as tempering material for pottery (Rova et al., 2022).

2.3. Distance of the sites from the nearest obsidian sources

Though with slightly different features, obsidian represents by far

the most common raw material for chipped lithics at all the four sites and in all the periods under consideration. Clearly, it was easily available to all of them regardless of their geographical position. If one considers the location of the four sites compared to the main known sources of obsidian, the nearest possible source for the three Shida Kartli sites is undoubtedly the Chikiani volcano (Fig. 2). Natsargora and Aradetis Orgora lie, at a distance of about 12 km from each other, at approximately 65 km from Chikiani as the crow flies. The distance from Okherakhevi to Chikiani, ca 70 km as the crow flies, is only slightly greater. Undoubtedly, absolute distance is only a very rough indicator of accessibility in a diverse highland environment, such as that of the Southern Caucasus, and travel costs-weighed models such as proposed by Chataigner and Barge, 2008, 2010 (or, for another region, by Barge et al., 2018 and, more in general, by Wilkinson, 2014) may represent a much more reliable indicator. In the absence of specific studies, we may suppose that Chikiani would be accessed from the two western sites through a route following the valley of the Kura, as in the present highway (the distance might in this case amount to up to 150 km), while a more eastern route may have been possibly used from Okherakhavi. The distance from Okherakhevi to Chikiani following the present highway connecting Tbilisi with Paravani lake following the valley of the Khrami river, for instance, amounts to ca 135 km. Be that as it may, any other source would clearly be less profitable, in terms of accessibility, for the three Shida Kartli sites, as all the nearest Armenian sources lie well over 100 km from them as the crow flies.

The situation of Tsiteli Gorebi 5 is more complex. In fact, the site lies at a considerable distance (between 185 and 195 km as the crow flies), from all the main known sources of obsidian. Its distance from the nearest Armenian sources, Tsaghkunyats (ca 185 km), Gegham and Gutansar/Hatis (ca 190 km) is approximately equivalent to its distance from Chikiani. Least-cost path models taking into account natural obstacles and other factors might certainly be helpful, in the future, for evaluating the most easily accessible source; one might however suppose that the choice between alternative sources may have been more open than in the previous case, and at least partially influenced by other, more unpredictable considerations (such as changing relations with the neighbouring groups, etc.).

3. Materials and methods

3.1. Obsidian specimens for provenance analysis: origin and date

The assemblage of 107 obsidian samples submitted to analysis (Fig. 3) is constituted by 22 from Nastargora, 8 from Okherakhevi, 27 from Aradetis Orgora, and 50 from Tsiteli Gorebi 5. Sample selection was made by the archaeologists in the expedition house at the end of the field season, after visual inspection of the whole assemblage (occasionally under the supervision of a geologist). In all cases, only debitage fragments were selected for analysis. Although outer appearance (colour, transparency, etc.) is, as known, not a good indicator to trace obsidian provenance, care was taken to try to include the whole range of observed variability into the sample from each site. As far as this was possible, stratigraphic reliability and chronological representativeness were additional choice criteria.

Samples Natsargora 2010, nos 1–10 were collected in 2010 under the supervision of Alberto Stinghen (at that time MA candidate in Geology at Padua University) from the boxes containing artefacts from Ramishvili's settlement excavation stored at the Khashuri Museum that had been attributed by the excavators to the EBA level. Although subsequent restudy of the settlement's pottery and stratigraphy and the renewed Georgian-Italian excavations in 2011–2012 clarified that the EBA layers were considerably disturbed (Rova et al., 2017), it appears that all samples derive from rather deep in the settlement's stratigraphical sequence, and have therefore a good probability to belong to undisturbed EBA contexts. In fact seven of the 10 sampled contexts contained either only Kura-Araxes, or Kura-Araxes and Bedeni pottery. Although the presence of a few Late Bronze sherds in the contexts of samples nos 6, 7 and 10 does not allow to completely exclude a later origin for the latter, it seems reasonable to assume that all the sampled obsidian derives from Kura-Araxes occupational layers or from Bedeni pits cutting them.[3]

Samples Natsargora 2011, nos 1–12 were selected from the new Georgian-Italian excavations at the site. Nos. 1 and 2 come from a well stratified Kura-Araxes layer; nos. 8–12 come from a Kura-Araxes level located near the present surface of the mound, and nos 3–7 from the filling of a LBA pit, which contained almost exclusively Kura-Araxes material. On the whole, although a presence of later material cannot be totally excluded, the assemblage can be considered representative of the Kura-Araxes phase. At visual inspection, the obsidian from Natsargora is mostly black to grey in colour (with different degrees of transparency), although a few brownish and banded black and red items are attested as well.

All the eight samples from Okherahevi come from Kurgan no. 1, which belongs to the Bedeni culture of the later part of the EBA (Rova et al., 2010). They do not differ significantly, at visual inspection, from those from Natsargora. Numerous flakes of unworked obsidian were recovered on top of (sample 2010/1), among (samples 2010/2–6) and around the kurgan's stones (sample 2010/7), as well as in the filling of the underlying burial chamber (sample 2010/8), where they had clearly been intentionally scattered. No other traces of human activity were detected in the area, except for a small pit of unknown date, located a few meters from the kurgan.

The 27 samples from Aradetis Orgora were collected from both excavation areas (Field A and Field B) during the 2013 (10 samples) and 2015 seasons (17 samples). As the outer appearance of the obsidian assemblage from the site was very similar to that of Natsargora and Okherakhevi, the main aim of the sampling was to exploit the stratigraphical sequence of the site to increase the chronological representativity of the samples from the Shida Kartli region. Accordingly, only one sample belongs to the EBA (Kura-Araxes period); 10 to the MBA-MBA/LBA Transition (first half of the 2nd mill. BC), and 16 to the LBA and IA (second half of the 2nd-first half of the first mill. BC).

Finally, the 50 samples from Tsiteli Gorebi 5 were collected during the 2018 (30 items) and 2019 (20 items) excavations at the site. All of them can be confidently assigned to the Early Chalcolithic period (5000–4800 BC) although strictly speaking only one of them (0437-M-2) comes from a well stratified closed context: the filling of a Chalcolithic pit cut into the virgin soil. In fact, although virtually no in situ material was recovered from the site, the uni-period nature of the latter and the short duration of its occupation allow us to consider all the recovered material as broadly speaking contemporary. At first sight, obsidian from Tsiteli Gorebi 5 appears more diversified in comparison with that from the Shida Kartli sites: visual inspection led to the distinction of nine main types (Rova et al., 2022), including grey, black, and orange/red mottled ones, and varying from completely transparent to completely opaque, which suggested a wider sampling strategy.

To sum up, the samples from Natsargora presumably date to the Kura-Araxes or Bedeni periods (2010 samples), or to the Kura-Araxes period (2011 samples), i.e. to the EBA, although a few of them might derive from LBA disturbances; those from Aradetis Orgora, except for one which is of Kura-Araxes date, belong to the MBA, LBA and IA; all the samples from Okherakhevi date to the Bedeni culture (late EBA) and all of those from Tsiteli Gorebi 5 to the Early Chalcolithic period.

3.2. Methods of chemical analysis: LA-ICP-MS

The analyses of the 107 obsidian objects conducted at the Ernest-Babelon Centre of the IRAMAT (Orléans) were carried out with an

[3] A more detailed description of the samples from Natsargora will be provided in Puturidze, Rova, in preparation.

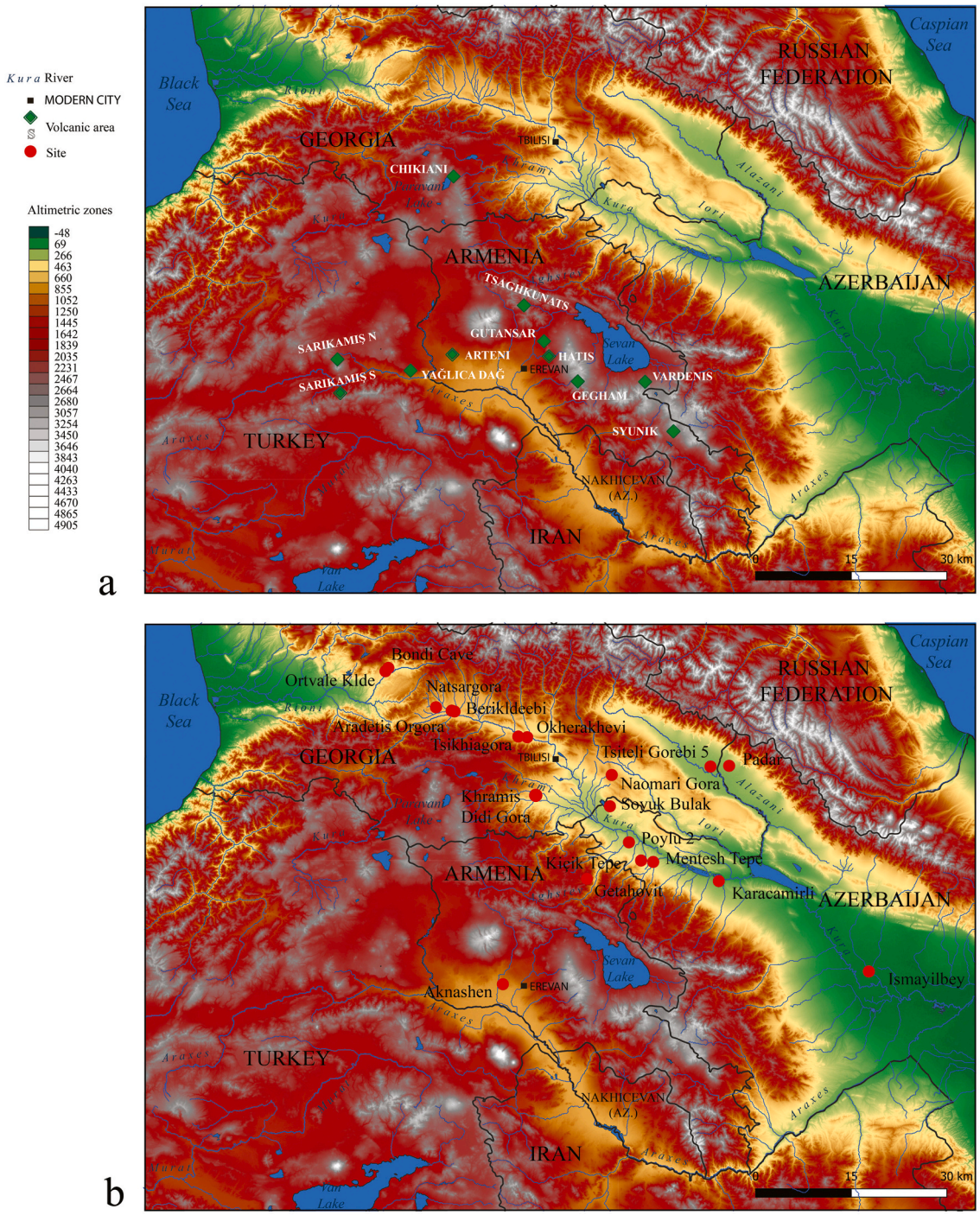

Fig. 2. Maps showing the approximate location of the main sources of obsidian (volcanic areas) in the Southern Caucasus (a) and of the sites mentioned in the text (b).

Element XR mass spectrometer from Thermofisher Instruments (Gratuze, 1999; Chataigner and Gratuze, 2014a). This system offers the advantage of being equipped with a three-stage detector: a dual mode (pulse-counting and analog modes) secondary electron multiplier (SEM) with a linear dynamic range of over nine orders of magnitude, associated with a single Faraday collector, which allows an increase of the linear dynamic range by an additional three orders of magnitude. This feature is particularly important for laser ablation analysis of lithic samples, as it is possible to analyse major, minor, and trace elements in a single run, regardless of their concentrations and isotopic abundance.

The measurements were carried out in peak jump acquisition mode, taking four points per peak in the case of pulse-counting and analog detection modes, and ten points per peak when using Faraday detection. Automatic detection mode was used for most of the elements; only sodium, silicon, aluminium and potassium were systematically measured with the Faraday detector. Silicon was measured with its isotope ^{28}Si, and was used as an internal standard. A total of 38 elements were recorded (Li, B, Na, Mg, Al, Si, K, Ca, Sc, Ti, Mn, Fe, Zn, Rb, Sr, Y, Zr, Nb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, Th and U). With our analytical parameters, the scanning time needed to measure the selected isotopes was about 2 s. As most of the isobaric interferences encountered could be dealt with by working on non-

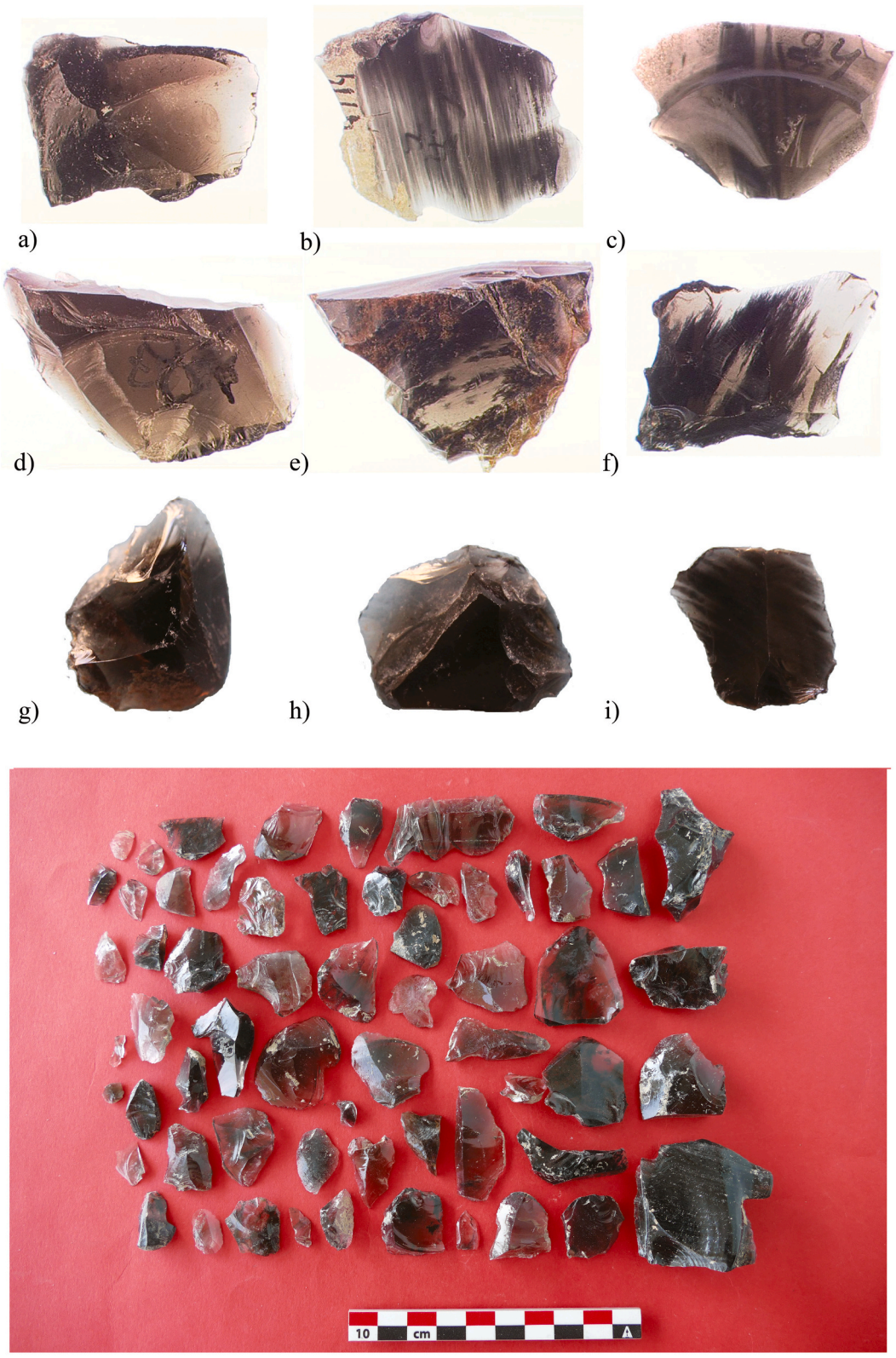

Fig. 3. Above: examples of analysed obsidian samples (not to scale): a) Natsargora 2010/06 Box 149; b) Natsargora 2010/10 Box 474 4114; c) Natsargora 2010/04 Box 941 608; d; Natsargora 2010/01 Box 18; e) Okherakhevi 2010/7 005-M-2; f) Okherakhevi 2010/8 013-M1; g) Aradetis Orgora 2139-M-1; h) Aradetis Orgora 1893-M-3 C; i) Aradetis Orgora 1863-M-1 B. Below: example of obsidian assemblage from Tsiteli Gorebi 5 (0118-M-4).

interfered isotopes, all the measurements were carried out in low resolution mode.

Two series of analysis were carried out. For the first one (Natsargora and Okherakhevi, 30 artefacts), we used a VG UV-laser, generated by a Nd YAG pulsed beam and operating at 266 nm wavelength, 3-4 mJ power and 7 Hz repetition rate. An argon stream (1.15–1.35 l/min) carried the ablated material to the plasma torch. For the second series (Tsiteli Gorebi 5 and Aradetis Orgora, 77 artefacts), a Resonetics RESOlution M50e ablation device was used. This is an excimer laser produced by argon fluoride at 193 nm wavelength, and operated at 4 mJ and 10hz. A dual gas system with helium (0.65 l/min) released at the base of the chamber, and argon at the head of the chamber (1.1 l/min) carried the ablated material to the plasma torch. For both series of analyses, ablation time was set to 70 s: 20s for pre-ablation, so that potential surface contaminations could be removed, and 50s for collection time. Spot sizes were set to 100 µm. Blanks were run every 10 samples.

Calibration was done by using 3 reference-standard glass materials: NIST610, Corning glass B and D, which were run periodically for correction in case of instrumental drift. ^{28}Si was used as internal standard to normalise the measured signal for each element, and the final percentage composition was calculated from the response coefficient (k) defined from the reference material (Gratuze, 1999). Standard glass materials NIST612 was analysed independently of calibration, to provide comparative data and check for accuracy and precision. For the major elements, the analysed values were within 5% relative to all elements. Most trace elements were within 10%. Coefficients of variation for all major elements were < 5%. For the minor and trace elements, most were < 5% and all <10%.

4. Results

At a first step, if we analyse the results obtained independently of their archaeological provenance and periodisation, the barium/strontium and barium/zirconium ratios lead to a distribution of the obsidian artefacts into seven main compositional groups subdivided into fourteen sub-groups (Fig. 4 and Tables 1 and 2). Recent published studies concerning the sources of obsidian or their distribution for the Southern Caucasus and north-eastern Turkey (Poidevin, 1998; Chataigner and Gratuze, 2014a, 2014b; Chataigner et al., 2014; Biagi et al., 2017; Chataigner et al., 2020; Palumbi et al., 2021; Astruc et al., 2022; Gratuze et al., 2022; Biagi et al., 2022), show that these groups and sub-groups correspond to the obsidian sources of the following volcanoes: Chikiani (59 artefacts divided into 5 sub-groups), Gegham/Geghasar (33 artefacts), Gutansar (4 artefacts), Tsaghkunyats (4 artefacts divided into 3 sub-groups), Sarıkamış (3 artefacts divided into 2 sub-groups), Syunik 3 (3 artefacts), and Yağlıca Dağ (1 artefact). All these attributions result from direct or indirect comparisons between the measured compositions of the tools with those from geological samples collected during geological surveys in the various volcanic zones of Turkey, Armenia and Georgia and analysed by the same methods (Chataigner and Gratuze, 2014a; Chataigner et al., 2014; Biagi and Gratuze, 2016; Biagi et al., 2017). The results obtained allow also, in some cases (Chikiani, Tsaghkunyats and Sarıkamış), a more precise attribution to particular outcrops or sub-sources of these volcanoes (Tables 1 and 2).

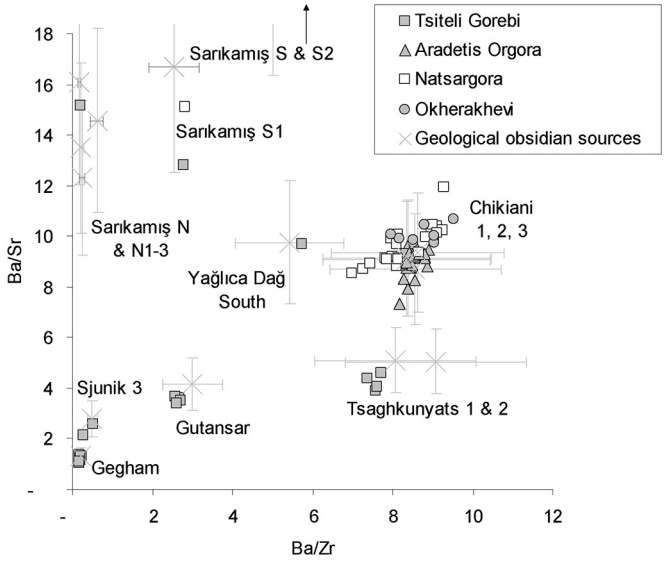

Fig. 4. Binary diagram of Ba/Zr-Ba/Sr ratios for the studied artefacts and the identified sources. For geological sources the crosses correspond to average values plus or minus 3 standard deviation.

If we now analyse the distribution of the artefacts by taking into account their archaeological provenance, two main types of distribution are observed. At Aradetis Orgora (27 artefacts), Okherakhevi (8 artefacts) and Natsargora (22 artefacts), all the artefacts except for one from Natsargora are related to only one volcano: 56 among the 57 artefacts come from the different Chikiani outcrops. On the other hand, the obsidian supply at Tsiteli Gorebi 5 (50 artefacts) is more diversified. The obsidian from that site originates from seven different volcanoes located in Armenia, to the south, the west and the north of lake Sevan (Gegham, Syunik, Gutansar and Tsaghkunyats), in Georgia (Chikiani) and in eastern Turkey (Kars region: surroundings of Sarıkamış and Yağlıca Dağ). However, the distribution is uneven, as 33 artefacts among 50 come from the Gegham/Geghasar outcrops, and if we consider all the volcanoes located around the lake Sevan, it reaches 44 artefacts among 50. The six remaining artefacts come evenly from Turkey (3 artefacts from the surrounding of Sarıkamış and Yağlıca Dağ) and Georgia (3 artefacts from Chikiani).

If we consider more finely the distribution among the different Chikiani oucrops, the distribution is again uneven. Most of the artefacts come from sub-group Chikiani 2 (43 artefacts among 59 divided evenly between 2a and 2b), a fourth of the artefacts come from sub-group Chikiani 3 (15 artefacts, 12 from 3a and 3 from 3b) and only one artefact is related to the sub-group Chikiani 1. This distribution is however more difficult to comment on, as it has been shown that the different types of obsidian could originate from the same places in the surrounding of Chikiani and were distributed at archaeological sites regardless of the period of the latter (Biagi and Gratuze, 2016; Biagi et al., 2017; Biagi et al., 2022).

5. Discussion

The results of the analyses carried out on the samples from Natsargora, Aradetis Orgora and Okherakhevi confirm the almost exclusive use of the Chikiani volcano as a source of obsidian by the EBA populations of the Shida Kartli province of Georgia hypothesised by previous researchers (Badalyan, 2010, p. 33). 30 among the 31 studied artefacts (all of the 8 samples from Okherakhevi, the only one from Aradetis Orgora dated to this period, and all but one of the 22 ones from Natsargora) come from the Chikiani volcano, while the last one originates from the south of the Sarıkamış area. However, this does not mean that the original obsidian block come from the primary outcrops located around Sarıkamış: large deposits of obsidian blocks, transported by the Araxes River, exist along the Araxes valley. It is thus possible that these item came from one of these secondary deposits. It could also have been exchanged by the Georgian population with southern population groups.

On the other hand, the 27 samples from Aradetis Orgora, all of which come from Chikiani regardless of their date, confirm that this single-source pattern of obsidian procurement remains characteristic of Shida Kartli throughout the Bronze Age and probably during the Iron Age as well. It is clear that, even in changing historical and political situations, the geographic proximity and relatively easy access to the Paravani plateau did not leave much space for any alternative source for

Table 1
Distribution of the studied artefacts according to their main volcanic area or, when possible, to more precise obsidian outcrops or chemical groups (sub-sources).

Geographic region	Lake Sevan, Armenia							Eastern Turkey			Georgia				
Volcanic area		Gegham	Syunik	Gutansar	Tsaghkunyats			Sarıkamış		Yağlıca Dağ	Chikiani				
Outcrops and/or chemical groups		Geghasar	3 Pokr Sevkar / Mets Sevkar	Dzhraber / Fontan / Alapars / Gjumush / Aivazan	1 Damlik	1 Ttvakar	2 Kamakar / Aïkasar	North N 1	South S 1A	South	1	2a	2b	3a	3b
Tsiteli Gorebi 5 (Early Chalcolithic)	50	33	3	4	2	1	1	1	1	1			3		
Aradetis Orgora (all)	27											5	9	10	3
Aradetis Orgora EBA	1														1
Aradetis Orgora Trans MBA/LBA	10											2	3	3	2
Aradetis Orgora LBA	11											2	4	5	
Aradetis Orgora Trans LBA/EIA-EIA	5											1	2	2	
Natsargora (EBA)	22								1			12	7	2	
Okherakhevi (EBA)	8										1	5	2		

the sites located in this region. All the analysed Shida Kartli sites used the different Chikiani chemical groups, which are often mixed together on the volcano (Biagi et al., 2022) and do not originate from differentiated outcrops contrary to what is sometimes observed for other volcanic complexes.

The 50 samples from the Early Chalcolithic Kakhetian site of Tsiteli Gorebi 5 highlighted a very diversified obsidian provenance pattern, which includes 7 different sources located in Armenia, mainly to the west and south of lake Sevan (Gegham, Gutansar, Tsaghkunyats, Syunik), in Eastern Turkey (Sarıkamış and Yağlıca Dağ) and in Georgia (Chikiani). There is no doubt that this wider variety, although it may be influenced by the larger size of the sample from this site, reflects the reality of a multi-source procurement pattern which, however, shows a clear prevalence of Armenian sources, in particular of the Gegham group. The few samples from the contemporary sites of the Tsiteli Gorebi cluster which had been analysed in the past (Badalyan, 2010) exhibit a comparable variety, with three samples attributed to Geghasar (Gegham group), two from Damlik (Tsaghkunyat group) and two from then unknown sources (TKUNK-1 and 2) supposedly located on the Kars plateau (Sarıkamış?).

The resulting picture is rather similar to that recently obtained from level III in the Getahovit-2 cave in the Tavush region of Armenia, for which ^{14}C analyses suggest a date between 4700 and 4000 BC (Chataigner et al., 2020), that is some centuries later than Tsiteli Gorebi 5. Obsidian from the 61 analysed samples from this site came, in order of decreasing frequency, from the following sources: Tsaghkunyats, Gutansar, Gegham, Chikiani, Arteni and Sarıkamış. Among the Armenian sources, a chronological development was observed, in that Tsaghkunyats and Gegham increase their frequency in the course of time to the detriment of the other sources, and non-Armenian sources are present only in the later sub-phase. The site, a cave-sheepfold intermittently used by pastoralists to shelter caprine herds during the cold season (autumn-winter), is located in a forested zone at mid-altitude (ca 960 m a.s.l.) in the valley of the Aghstev river, a tributary of the Kura, in the mountainous region overlooking the Azerbaijani part of the middle valley of the Kura.

There are, in spite of the clear chronological and functional differences between the two sites (Tsiteli Gorebi 5 is a lowland settlement with evidence of stable architecture, although its economy appears to be especially focused on animal husbandry), some remarkable similarities in the material culture (in particular in pottery) between Tsiteli Gorebi 5 and Getahovit-2 (Chataigner et al., 2020; Rova et al., 2022), which suggest that they belong, in broad terms, to the same cultural tradition.

The excavators of Getahovit-2 observed that according to the "least-cost path" analysis the cave is almost equidistant (between 30 and 35 hours of travelling) from the obsidian deposits of Armenia and the valley of the Alazani in Georgia (Chataigner et al., 2020; Chataigner and Barge, 2008). They suggested that the cave may have been frequented, among others, by long-distance transhumants, who acquired obsidian during their seasonal wanderings through the high-plateau summer pasture areas of Armenia or through exchanges with local groups practicing short-distance transhumance, and brought it to the Kura valley, where they transferred their herds in winter, if climatic conditions became too hard, after crossing the Lesser Caucasus through the valley of the Aghstev (see map in Chataigner et al., 2020, Fig. 15). From the Kura plain, the raw material may have then reached the Tsiteli Gorebi area via the Alazani valley. Be that as it may, in the first centuries of the 5th millennium BC the connections of the Tsiteli Gorebi sites of the Alazani valley highlighted by obsidian procurement appear to be prevailingly oriented in a south-western direction; a view which is not contradicted by other elements of the material culture (especially ceramics, see Rova et al., 2022).

The presence at Tsiteli Gorebi 5 of some obsidian from Syunik, on the other hand, may suggest that the site's network of connections extended in a more eastern direction as well, most probably via the Kura valley corridor. Obsidian from Syunik is in fact well represented at sites in the Azerbaijani section of the middle Kura valley. Indeed, pottery from Tsiteli Gorebi 5 shows some similarities with materials from level II at Mentesh Tepe in the Tovuz district of Azerbaijan, which is ^{14}C-dated to the second quarter of the 5th millennium BC (Lyonnet et al., 2017; cf. Rova et al., 2022). Further east in the same valley, some recently published Chalcolithic pits at Karacamirli Tepe 5 (Kaniuth, 2020) may belong to the same general chronological horizon, whose pottery

Table 2
Compositions of the obsidian artefacts. Data are expressed in wt% of oxides for the main oxides (Na_2O to Fe_2O_3) and in parts per million for trace elements (Li to U), 1 ppm = 0,0001, %. Averages values and associated standard deviation are also given for the identified sources when available.

Tsiteli Gorebi 5 (ECh)		Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	Fe_2O_3	Li	B	Sc	Zn	Rb	Sr	Y	Zr	Nb	Cs	Ba
Gegham	0201-M-1	4.06	0.044	14.2	76	4.29	0.63	0.058	0.079	0.53	42.4	44.8	10.4	28.7	198	9.13	20	58	46.4	7.13	10.1
Gegham	0105-M-1	4.06	0.043	14	76.3	4.31	0.61	0.058	0.078	0.45	47.9	44.8	10.4	26.2	201	9.04	19.8	57.9	46.3	7.1	10.2
Gegham	0105-M-1	4.11	0.046	14.3	75.9	4.31	0.64	0.058	0.079	0.51	63.4	45.1	10.4	27.8	200	9.85	20.4	59.2	46.2	7.19	10.5
Gegham	0002-M-2	4.14	0.045	14.3	75.7	4.34	0.64	0.058	0.079	0.53	62.8	45.3	10.6	27.3	202	9.41	20.1	59.3	45.3	7.08	10.7
Gegham	0123-M-2	4.15	0.044	14.3	75.8	4.37	0.64	0.058	0.08	0.53	63.9	45.3	10.6	27.9	204	9.23	20	57.9	45.9	7.26	10.2
Gegham	0123-M-1	4.17	0.043	14.2	75.8	4.37	0.62	0.058	0.078	0.54	62	44.9	10	27.1	206	9.14	20.2	58.2	46.1	7.23	10.2
Gegham	0214-M-2	4.09	0.044	14.2	75.9	4.36	0.63	0.058	0.079	0.52	60.4	44.3	10.1	27.5	200	9.39	20.1	59.4	45.7	7.12	11
Gegham	0214-M-2	2.96	0.044	14.2	75.4	6.16	0.63	0.058	0.079	0.46	16.6	44.5	9.89	26.4	203	9.35	20	58.2	45.9	7.18	10.3
Gegham	0214-M-2	4.18	0.044	14.2	75.8	4.36	0.64	0.058	0.079	0.47	61.5	45.4	10.3	27.6	204	9.3	20.3	59	46.3	7.21	10.3
Gegham	0118-M-4	4.16	0.044	14.1	76.1	4.38	0.62	0.058	0.077	0.32	61	45.2	10.2	26.6	205	9.08	19.7	57.7	46	7.18	10.2
Gegham	0118-M-4	4.15	0.043	14.1	76	4.34	0.62	0.058	0.078	0.5	59.8	44.3	9.69	27.1	204	9.11	20.2	59	46.1	7.2	10
Gegham	0118-M-4	4.2	0.042	14.1	76.3	4.34	0.54	0.058	0.075	0.31	58.7	44.8	9.61	23	206	7.63	19.9	57.6	46	7.28	10.3
Gegham	0012 -M-1	4.12	0.045	14	75.9	4.35	0.6	0.058	0.082	0.76	59.4	44.5	9.71	33.2	204	8.92	19.8	57.8	45.7	7.14	9.93
Gegham	0102-M-1	3.82	0.04	14.1	76	4.86	0.61	0.058	0.074	0.4	23.4	45.1	9.83	24.6	201	9.24	20.3	58.7	46	7.24	10.4
Gegham	0102-M-1	4.14	0.045	14.2	76	4.28	0.64	0.059	0.078	0.47	64.6	44.3	9.65	27.2	200	10	19.9	58.6	45.5	7.15	11.8
Gegham	0102-M-1	4.18	0.044	14.2	75.7	4.39	0.65	0.058	0.08	0.53	59	46.1	10.2	28.7	203	9.75	20.3	59.3	45.8	7.24	11.5
Gegham	0001-M-1	4.15	0.048	14.1	75.9	4.37	0.61	0.058	0.085	0.66	59.5	44.9	10.1	35.6	203	9.03	19.5	56.6	45.6	7.14	10.2
Gegham	0001-M-1	4.08	0.045	14.2	76.1	4.38	0.64	0.061	0.073	0.41	59.9	43.3	9.6	26.6	195	11.1	18.7	59.5	43.1	6.66	14.4
Gegham	0001-M-1	4.16	0.045	14.2	75.9	4.31	0.63	0.057	0.079	0.52	60.8	46.1	9.88	27.4	202	9.16	19.6	56.8	45.5	7.26	10.3
Gegham	0001-M-1	4.16	0.044	14.2	75.8	4.4	0.63	0.058	0.079	0.52	59.3	44.3	9.99	27.5	205	9.2	20.3	58.5	46	7.22	10.3
Gegham	0118-M-5	4.12	0.045	14.1	76.1	4.28	0.62	0.058	0.078	0.49	61.4	46	9.58	27.8	202	9.16	19.8	57.5	46	7.27	10.4
Gegham	0107-M-1	4.18	0.045	14.1	76	4.34	0.62	0.058	0.079	0.54	58.9	45.4	9.47	27.4	202	9.21	19.3	56.5	45.2	7.2	10.6
Gegham	0229-M-1	4.49	0.045	13.4	77	3.78	0.54	0.059	0.08	0.52	47.9	47.9	6.6	27.8	219	8.82	19.5	56.5	44	7.32	9.81
Gegham	0260-M-7 A	4.33	0.041	13.2	76.8	4.43	0.55	0.056	0.074	0.38	68.6	50.3	6.5	27.4	215	8.56	18.1	52.2	42.6	7.37	9.16
Gegham	0260-M-7 C	4.14	0.044	13.8	76.4	4.31	0.57	0.057	0.082	0.53	67.7	48.1	6.74	28.4	214	8.87	19.3	54.8	42.9	7.31	9.16
Gegham	0314-M-1 A	4.12	0.045	13.4	76.7	4.28	0.58	0.058	0.08	0.56	66.9	47.6	6.39	30.9	214	8.99	19.6	54.9	43.2	7.37	9.5
Gegham	0314-M-1 B	4.21	0.044	13.7	76.3	4.43	0.59	0.058	0.078	0.44	68.4	48.6	6.36	28.8	219	8.99	19.6	55.8	43.7	7.44	9.33
Gegham	0349-M-1	4.3	0.044	13.1	77	4.41	0.53	0.057	0.078	0.41	69.9	49.4	5.92	29.9	221	8.27	18.4	52.8	43.3	8.17	9.75
Gegham	0406-M-1 C	4.15	0.044	13.7	76.5	4.31	0.57	0.057	0.079	0.53	68.4	47.8	6.3	27.8	214	8.89	19.5	54.8	43.2	7.51	10.1
Gegham	0437-M-2	4.06	0.044	14	76.2	4.37	0.59	0.058	0.079	0.51	56.7	48.3	6.08	28.1	212	9.17	20	57.1	44	7.4	10.3
Gegham	0503-M-2 A	4.15	0.044	13.5	76.8	4.24	0.57	0.057	0.077	0.52	67.9	46.3	6.07	28.9	213	8.95	19.3	55.4	43.3	7.32	9.61
Gegham	0708-M-3 B	4.23	0.043	12.8	77	4.58	0.56	0.059	0.075	0.55	67.7	48.5	5.96	33.9	212	9.41	17.8	54.3	42.1	7.05	12.1
Gegham	0714-M-6 A	2.73	0.044	13.5	75.9	6.5	0.57	0.058	0.08	0.54	16.2	47.4	5.81	28.8	211	9.16	19.4	55.8	43.3	7.23	9.83
Sarıkamış North N 1	0118-M-5	4.55	0.022	13.6	76.1	4.29	0.34	0.065	0.068	0.88	49.2	29	10.1	57.9	147	2.09	40.7	162	26	4.51	31.6
Sarıkamış South S 1A	0239-M-3 B	4.75	0.11	14.9	73.6	4.16	0.66	0.1	0.084	1.46	34.1	23.8	6.9	63.9	128	38.3	34.9	176	18.6	3.99	491
Sjunik 3	0009-M-1	4.03	0.053	13.6	76.2	4.59	0.55	0.089	0.053	0.71	44.1	16	8.6	29.3	170	17.8	9.03	87.6	30.3	4.06	45.6
Sjunik 3	0708-M-3 A	4.04	0.052	13.4	76.6	4.51	0.49	0.086	0.058	0.7	47.6	15.2	4.68	33.5	158	12.1	8.89	88.6	29.4	3.71	25.6
Sjunik 3	0406-M-1 A	3.99	0.052	13.5	76.5	4.51	0.48	0.086	0.058	0.73	46.7	15.7	4.91	33.6	157	12	8.87	88.9	29.3	3.73	25.9
Gutansar	0118-M-4	4.26	0.22	14.9	74.1	4.05	1.09	0.16	0.077	1.03	48.9	27.8	9.77	35.2	142	110	18.7	149	33.9	4.76	398
Gutansar	0012-M-1	4.28	0.23	14.9	73.7	4.1	1.1	0.16	0.081	1.34	46.7	27.8	9.67	39.5	143	109	19.7	154	33.7	4.81	398
Gutansar	0239-M-3 A	4.22	0.2	14.5	74.4	4.06	1.07	0.16	0.075	1.19	53.8	29.2	6.49	39.1	146	113	18.8	145	31.8	4.89	394
Gutansar	0260-M-7 B	4.18	0.22	14.9	73.9	3.99	1.12	0.16	0.075	1.37	52.5	29.1	6.64	41.5	146	119	19	153	31.2	4.87	400
Tsaghkunyats 1 Damlik	0002-M-6	4.1	0.093	14.8	74.7	4.12	1.12	0.091	0.047	0.8	32.6	21.7	9.36	27.5	106	160	9.52	81.6	18.7	3.39	619
Tsaghkunyats 1 Damlik	0123-M-2	4.03	0.12	14.5	75.1	4.4	1.02	0.092	0.054	0.59	34.8	22.1	9.49	26.4	113	133	9.09	79	18.7	3.54	610
Tsaghkunyats 1 Ttvakar	0714-M-6 B	4.1	0.13	14.2	75.2	4.29	0.92	0.095	0.053	0.9	38.7	24.3	4.79	28	95	169	7.47	90.4	19.7	2.78	687
Tsaghkunyats 2	0009-M-1	4.21	0.15	15	73.8	4.28	1.12	0.12	0.046	1.06	26.5	21.6	8.3	29.2	89.3	216	7.17	129	17.3	2.74	949
Yağlıca Dağ South	0102-M-1	4.21	0.14	14.5	74.9	4.08	0.89	0.13	0.052	1.01	33.4	34.1	8.44	32.8	123	65.1	14.4	110	15.9	3.71	631
Chikiani 2b	0406-M-1 B	3.81	0.12	14.3	75.3	4.57	0.76	0.1	0.055	0.83	35.1	24	5.33	39.3	130	79	11.8	83	16.3	4.31	720
Chikiani 2b	0239-M-3 C	3.21	0.12	14.2	75.1	5.35	0.82	0.1	0.053	0.87	8.4	22.5	5.59	40.2	126	86.8	11.8	91.2	15.9	4.07	786
Chikiani 2b	0503-M-2 B	3.76	0.13	14	75.5	4.54	0.8	0.11	0.053	0.89	34.3	22.4	5.11	39.4	126	84.9	11.6	94.8	15.3	4.06	791

Aradetis Orgora		Na_2O	MgO	Al_2O_3	SiO_2	K2O	CaO	TiO_2	MnO	Fe_2O_3	Li	B	Sc	Zn	Rb	Sr	Y	Zr	Nb	Cs	Ba
Chikiani 2a	1880-M-2 C* LBA	3.84	0.099	14.3	75.4	4.57	0.78	0.09	0.056	0.77	27.7	24	8.41	38.2	130	71.4	12	74.2	17.8	4.34	626
Chikiani 2a	1893-M-3 A MBA/LBA	3.86	0.1	14.5	75.1	4.62	0.81	0.092	0.055	0.77	31.4	23.9	8.59	37.6	130	75.6	12.1	75.2	17.7	4.38	666
Chikiani 2a	1893-M-3 C* MBA/LBA	3.85	0.1	14.5	75.1	4.58	0.79	0.093	0.055	0.77	28.9	23.5	8.61	37.5	129	73.3	12.2	76.3	17.7	4.35	643
Chikiani 2a	2129-M-3 LBA/EIA	3.85	0.1	14.3	75.3	4.61	0.78	0.094	0.055	0.77	22.7	23.2	8.22	38.5	129	73.1	11.9	76	17.4	4.34	644
Chikiani 2a	2139-M-1 LBA	3.87	0.1	14.2	75.4	4.57	0.78	0.094	0.055	0.77	21.9	23.2	8.3	37.8	128	73.2	11.9	76.8	17.5	4.32	648
Chikiani 2b	1362-M-3 EIA	3.81	0.11	14.3	75.2	4.57	0.82	0.1	0.053	0.82	20.6	22.2	8.49	36.9	125	81.8	11.8	88.1	16.8	4.15	738
Chikiani 2b	1376-M-1 LB/EIA	3.98	0.1	14.2	75.4	4.31	0.84	0.1	0.052	0.83	20.1	22.2	8.32	36.5	121	88.1	11.8	83.2	17.2	4.09	699
Chikiani 2b	1863-M-1 C LBA	3.8	0.11	14.4	75.3	4.52	0.82	0.1	0.053	0.75	22.2	23.2	8.8	34.6	124	81	11.7	85.1	16.9	4.10	710
Chikiani 2b	1893-M-1 A* MBA/LBA	3.85	0.11	14.5	75	4.57	0.83	0.1	0.053	0.82	25.4	23.1	8.53	36.3	124	83.4	11.9	87	17	4.10	739
Chikiani 2b	1893-M-1 C* MBA/LBA	3.82	0.11	14.6	75	4.51	0.82	0.1	0.055	0.81	35.2	22.9	8.73	38.5	126	79	12.4	85.6	17.3	4.20	699
Chikiani 2b	1893-M-1 D* MBA/LBA	3.81	0.11	14.3	75.3	4.51	0.81	0.1	0.054	0.82	24.4	22.9	8.49	35.4	126	78.3	11.6	85.2	17	4.13	700
Chikiani 2b	2137-M-8 LBA	3.75	0.11	14.3	75.2	4.59	0.77	0.1	0.056	0.96	23.3	22.9	8.44	39.7	126	74.4	11.9	86.1	16.9	4.19	726
Chikiani 2b	2205-M-8 LBA	3.85	0.11	14.3	75.2	4.59	0.82	0.1	0.053	0.82	20.3	22.5	8.44	37.5	125	81.2	11.8	87.1	16.9	4.15	729
Chikiani 2b	2211-M-1 LBA	3.75	0.11	14.3	75.2	4.67	0.81	0.1	0.053	0.79	22.7	22.6	8.28	37.6	125	80.5	11.8	84.8	16.9	4.08	736
Chikiani 3a	1381-M-2 MBA/EIA	3.78	0.14	14.3	75.1	4.55	0.9	0.12	0.049	0.91	20.8	20.7	8.34	36.6	117	98.7	11.4	103	15.7	3.71	905
Chikiani 3a	1385-M-3 MBA/EIA	3.8	0.12	14.3	75.1	4.6	0.86	0.12	0.05	0.87	19.5	20.8	8.31	37.1	121	91.1	11.7	100	16.2	3.91	855
Chikiani 3a	1863-M-1 A LBA	3.96	0.1	14.4	75.3	4.24	0.95	0.11	0.048	0.71	21.1	22.5	8.68	34.9	118	104	11.5	93.3	16.2	3.80	763
Chikiani 3a	1863-M-1 B LBA	3.8	0.14	14.3	75	4.63	0.89	0.12	0.05	0.93	22.2	21.7	8.59	36.6	120	96.2	11.2	102	15.6	3.80	912
Chikiani 3a	1863-M-1 D LBA	3.84	0.13	14.5	74.9	4.53	0.88	0.11	0.051	0.9	19.9	21.9	8.79	36.7	121	94.4	11.6	98.2	16.1	3.92	862
Chikiani 3a	1880-M-2 A* LBA	3.86	0.12	14.4	75	4.57	0.88	0.11	0.051	0.87	26.6	22.1	8.66	37.6	122	93.4	11.5	98.3	16.2	3.95	866
Chikiani 3a	1880-M-2 B* LBA	3.85	0.12	14.3	75.2	4.53	0.84	0.11	0.052	0.87	26	22.5	8.62	36.9	124	83.6	11.4	93.1	16.3	3,.98	782
Chikiani 3a	1893-M-1 B* MBA/LBA	3.83	0.12	14.4	75.1	4.52	0.86	0.11	0.051	0.88	26.1	22	8.46	37.3	122	89.3	11.7	95.6	16.1	3.94	819
Chikiani 3a	1893-M-1 E MBA/LBA	3.81	0.13	14.4	74.9	4.57	0.86	0.12	0.051	0.96	31.9	22	8.66	37.9	122	90.1	11.6	100	16	3.92	862
Chikiani 3a	1893-M-3 E* MBA/LBA	3.82	0.12	14.4	74.9	4.59	0.88	0.12	0.05	0.87	26	21.6	8.68	48.4	121	91.5	11.5	99.1	16.2	3.89	844
Chikiani 3b	1893-M-3 B* MBA/LBA	3.77	0.22	14.8	74.2	4.29	1.11	0.15	0.049	1.2	20.7	18.8	8.74	39.7	105	134	11.3	134	14.5	3.20	1111
Chikiani 3b	1893-M-3 D* MBA/LBA	3.8	0.18	14.5	74.5	4.46	1.06	0.15	0.046	1.09	26.4	20	8.66	36.6	111	131	11.1	126	14.6	3.40	1083
Chikiani 3b	2239-M-1 EBA	3.75	0.16	14.2	74.5	4.46	0.92	0.13	0.052	1.66	16.8	19.6	8.34	46.8	114	107	11.2	115	15.1	3.52	994

Natsargora (EBA)		Na_2O	MgO	Al_2O_3	SiO_2	K2O	CaO	TiO_2	MnO	Fe_2O_3	Li	B	Sc	Zn	Rb	Sr	Y	Zr	Nb	Cs	Ba
Chikiani 2a	2010/02 Box 79	3.85	0.098	13.5	76.6	4.24	0.65	0.098	0.052	0.78	97.8	21.3	6.37	35.1	108	56.5	8.73	62.3	19.2	3.86	564
Chikiani 2a	2010/03 Box 891 359	3.84	0.1	13.6	76.3	4.42	0.64	0.099	0.05	0.77	98.3	22.3	6.96	36	109	51.1	8.34	58.4	18.9	3.86	532
Chikiani 2a	2010/06 Box 149	3.85	0.11	13.6	76.1	4.44	0.69	0.11	0.048	0.87	96.4	21.4	7.25	36.9	105	59.1	8.31	68.1	18	3.64	612
Chikiani 2a	2010/09 Box 186 4009	3.87	0.1	13.4	76.7	4.19	0.67	0.1	0.051	0.82	97.9	20.9	6.67	35.7	108	60.8	8.93	67.2	18.9	3.80	621
Chikiani 2a	2010/10 Box 47 4114	3.82	0.1	13.6	76.6	4.14	0.68	0.1	0.05	0.71	97.1	20.6	6.53	33.4	105	64.2	9.24	72.3	18.8	3.66	638
Chikiani 2a	2011/04 0442-M-1	3.66	0.099	14.3	75.9	4.29	0.71	0.11	0.059	0.76	38.7	25.8	4.02	40.7	111	68.3	13	83.7	21.4	3.82	585
Chikiani 2a	2011/05 0442-M-1	3.94	0.1	13.2	76.6	4.51	0.65	0.11	0.062	0.78	39.2	27.3	3.57	46.2	117	58.7	10.2	68.2	20.2	3.84	535
Chikiani 2a	2011/07 0442-M-1	3.78	0.098	13.4	76.5	4.48	0.69	0.11	0.056	0.69	39.5	25.3	4.02	42	114	68.5	11.2	78.6	20.7	3.78	628
Chikiani 2a	2011/08 0004-M-1	3.85	0.11	13.2	76.5	4.49	0.7	0.12	0.057	0.81	37	25.1	4.08	44.6	112	68.5	10.7	79.1	19.8	3.79	622
Chikiani 2a	2011/09 0004-M-1	3.62	0.1	13.3	76.7	4.48	0.71	0.11	0.057	0.78	37.7	24.8	4.23	39.8	113	69	11.3	82.5	20.3	3.84	600
Chikiani 2a	2011/10 0004-M-1	3.96	0.1	12.6	77	4.59	0.64	0.11	0.057	0.76	36.3	26.4	3.81	45.5	117	61.3	9.57	68.7	19.8	3.90	559
Chikiani 2a	2011/11 0004-M-1	4.01	0.11	13.6	75.8	4.7	0.65	0.1	0.062	0.85	39.7	25.4	3.67	51.	119	61	9.78	66.3	19.9	3.97	538
Chikiani 2b	2010/01 Box 18	3.9	0.12	13.2	76.7	4.15	0.69	0.12	0.048	0.88	95.8	19.3	6.57	35.4	104	68.3	8.61	79	17.7	3.49	713
Chikiani 2b	2010/04 Box 94 1608	3.59	0.12	14.6	75.8	4.07	0.74	0.12	0.045	0.81	87.6	19.9	6.64	29.1	96.7	72.1	10.2	89	18.4	3.34	726
Chikiani 2b	2010/05 Box 145 2660	3.67	0.12	13.7	76.6	4	0.75	0.11	0.048	0.81	60	20.4	6.34	38.7	103	70.4	10.7	87.4	19.7	3.59	695
Chikiani 2b	2010/08 Box 175 3937	3.89	0.11	12.9	76.9	4.46	0.64	0.12	0.048	0.83	96.4	20.1	6.33	35.7	110	60.7	8.66	77.8	17.7	3.66	724
Chikiani 2b	2011/01 0092-M1	3.85	0.12	13.7	75.7	4.58	0.74	0.12	0.059	0.91	35.4	25.8	4.26	44.8	112	76.1	10.3	84.9	18.5	3.65	691
Chikiani 2b	2011/02 0353-M-1	3.98	0.13	13.2	76	4.7	0.72	0.13	0.058	0.92	35.6	25.8	3.46	46.6	111	76	9.52	82.1	18.4	3.71	712
Chikiani 2b	2011/12 0004-M-1	3.4	0.12	13.2	76.4	5.03	0.72	0.12	0.056	0.85	23.1	25.8	4.05	44.3	114	71.7	10.7	85.9	19.5	3.59	639
Chikiani 3a	2010/07 Box 151 2961	3.81	0.14	13.8	75.9	4.08	0.81	0.14	0.045	1.06	91.4	18.5	6.79	35.5	98.9	90.2	9.39	100	17.5	3.22	913
Chikiani 3a	2011/03 0442-M-1	3.75	0.14	13.3	76.4	4.33	0.87	0.13	0.055	0.93	36.2	25.4	4.15	43.5	109	80	10.1	95.5	18.6	3.51	775
Sarıkamış South S 1A	2011/06 0442-M-1	4.88	0.099	14.2	74.2	4.2	0.62	0.11	0.089	1.44	45.6	24.6	5.32	72.5	115	29.6	30.6	159	22.3	3.45	447

Okherakhevi (EBA)		Na_2O	MgO	Al_2O_3	SiO_2	K2O	CaO	TiO_2	MnO	Fe_2O_3	Li	B	Sc	Zn	Rb	Sr	Y	Zr	Nb	Cs	Ba
Chikiani 1	2010/2 002-M1a	4.01	0.089	13.2	76.6	4.51	0.62	0.088	0.053	0.78	93.8	23.4	7.03	42.9	116	46.2	8.05	49.5	19.8	4.26	448
Chikiani 2a	2010/1 001-M1	3.85	0.092	13.7	76.4	4.31	0.64	0.094	0.051	0.72	105	22.2	6.91	36	110	51.2	8.84	58.4	19.7	3.99	498
Chikiani 2a	2010/4 002-M2	3.66	0.1	14.1	76.2	4.16	0.67	0.1	0.048	0.77	97.8	20.8	6.7	32.1	104	58.7	9.74	70.8	19.5	3.66	579
Chikiani 2a	2010/6 002-M6	4.08	0.1	14.5	75.2	4.34	0.69	0.1	0.053	0.79	103	22.4	6.66	34.1	123	56.4	9.41	62.5	20.5	4,.15	565
Chikiani 2a	2010/7 005-M2	3.72	0.11	14.2	76	4.18	0.67	0.1	0.048	0.8	87.3	20.7	6.8	32.6	105	59.2	10.1	75.1	19.7	3.69	597
Chikiani 2a	2010/8 013-M1	3.76	0.1	14	76.1	4.23	0.67	0.1	0.047	0.82	97.5	20.1	6.87	33.3	104	59	9.17	68.4	18.7	3.64	582
Chikiani 2b	2010/3 002-M1b	3.77	0.12	13.9	76	4.27	0.72	0.12	0.046	0.9	93.7	19.7	7.18	33.8	102	67.3	8.54	79.8	17.5	3.43	703
Chikiani 2b	2010/5 002-M5	3.86	0.13	13.5	76.2	4.32	0.71	0.12	0.046	0.95	92.8	19.5	6.7	34.7	100	68.8	7.75	77	17.1	3.36	735

Geological Sources sources or chemical groups		Na_2O	MgO	Al_2O_3	SiO_2	K2O	CaO	TiO_2	MnO	Fe_2O_3	Li	B	Sc	Zn	Rb	Sr	Y	Zr	Nb	Cs	Ba
Chikiani 1	Av.	3.83	0.088	13.6	76.4	4.55	0.71	0.087	0.057	0.66	37	23.8	5.37	36.9	129	61.1	11.8	66.8	18.7	4.35	559
	St.Dev.	0.11	0.004	0.4	0.6	0.1	0.05	0.005	0.001	0.06	2.9	1.4	1.45	4	6	4.3	0.4	3.6	0.7	0.23	22
Chikiani 2	Av.	3.83	0.11	13.9	75.7	4.57	0.76	0.1	0.054	0.8	35.6	22.3	5.58	40.3	126	76.6	11.9	83.6	17.3	4.17	697
	St.Dev.	0.09	0.01	0.4	0.5	0.11	0.05	0.01	0.002	0.1	2	0.9	0.98	3	5	7.1	0.6	7.3	0.8	0.19	55
Chikiani 3a	Av.	3.77	0.14	13.9	75.6	4.48	0.86	0.12	0.049	0.9	32.9	20.5	5.88	37.2	117	96.7	11.4	105	16	3.69	906
	St.Dev.	0.13	0.02	0.4	0.6	0.14	0.05	0.01	0.003	0.11	2.5	0.9	1.08	3.4	5	11	0.6	8.5	0.8	0.21	64
Chikiani 3b	Av.	3.81	0.19	14.1	75	4.42	1.02	0.15	0.046	1.09	30	18.9	5.82	38.9	109	129	11.1	131	14.7	3.29	1121
	St.Dev.	0.1	0.03	0.4	0.4	0.12	0.05	0.01	0.003	0.13	2.2	0.7	0.89	10.7	4	8.7	0.6	8	0.6	0.16	41
Gegham	Av.	4.27	0.051	13.5	76	4.22	0.59	0.062	0.078	0.5	80.3	44.6	5.6	31.2	191	6.6	15.4	42.4	47.2	7.2	8.7
	St.Dev.	0.1	0.006	0.4	0.9	0.07	0.07	0.003	0.009	0.05	8.6	5.2	0.5	4.2	13	0.9	1.9	5.3	3.5	0.8	0.9
Gutansar	Av.	4.34	0.22	14.6	74.7	3.8	0.94	0.17	0.073	1.15	63.6	30.9	4.4	40.9	137	87.3	15.3	121	33.5	5	363
	St.Dev.	0.2	0.02	0.7	0.5	0.09	0.1	0.01	0.007	0.13	8	5.5	1.4	5.9	9	12.2	1.8	13	2.2	0.6	25
Sjunik 3	Av.	4.08	0.052	13.3	76.1	4.2	0.54	0.087	0.05	0.61	56.6	25.3		31.4	167	11.3	6.5	63.6	30	4.3	31.6
Mets Sevkar/Pork Sevkar	St.Dev.	0.08	0.002	0.2	1.1	0.05	0.06	0.007	0.003	0.04	5.1	4.1		7.5	8	0.9	0.7	3.9	1.9	0.5	4
Tsaghkunyats 1	Av.	4.28	0.12	13.4	75.8	4.2	0.86	0.1	0.056	0.8	45.4	26.3	5.4	32.4	103	115.9	6.1	64.6	20.5	3.5	586
Damlik & Ttvakar	St.Dev.	0.12	0.01	0.3	0.6	0.09	0.05	0.01	0.004	0.13	3.9	3.9		1.4	9	18.5	1	10.7	2	0.4	76
Tsaghkunyats 2	Av.	4.22	0.18	14.3	74.9	4.12	0.88	0.14	0.049	1.09	34	22.4	2.9	33.5	84	175.1	6.2	111	18.5	2.8	895
Aïkasar & Kamakar	St.Dev.	0.23	0.01	0.6	0.5	0.09	0.09	0.01	0.005	0.06	5	3.5	1.4	3.1	6	18.3	0.6	9	0.4	0.4	38
Sarıkamış north	Av.	4.4	0.033	12.8	77.3	4.11	0.29	0.075	0.078	1.05	48	26.8		71.5	132	2.5	35.5	152	27.3	4.2	33.8
	St.Dev.	0.14	0.005	0.2	0.2	0.11	0.02	0.008	0.001	0.05	2.2	1.5		5	4	0.88	1.3	19	1	0.26	7.2
Sarıkamış N1	Av.	4.5	0.029	13.1	76.5	4.18	0.36	0.077	0.08	1.1	55.5	26.7	9.52	73.6	134	1.75	37.5	169	28.5	4.13	28
	St.Dev.	0.21	0.004	0.5	0.5	0.19	0.06	0.007	0.008	0.13	8.3	2.3	4.99	10.3	10	0.18	2.6	24	1.4	0.38	2
Sarıkamış N2	Av.	4.54	0.039	13.3	76.1	4.23	0.36	0.09	0.08	1.13	52.6	26	9.77	72.4	132	3.89	38	188	28.4	3.95	47.6
	St.Dev.	0.19	0.005	0.6	0.6	0.22	0.05	0.005	0.007	0.07	6.4	3.2	4.31	9.5	8	0.4	2.6	12	1.4	0.32	3.6
Sarıkamış N3 A/B	Av.	4.57	0.048	13.1	76.3	4.3	0.39	0.098	0.079	0.98	53.5	27.6	9.64	66.3	135	6.53	36.1	158	29.6	4.09	94.5
	St.Dev.	0.33	0.007	0.6	0.8	0.24	0.04	0.008	0.007	0.16	6.7	4.7	4.06	9.5	12	0.78	2.8	27	2	0.42	7.9
Sarıkamış south	Av.	3.68	0.058	12.8	78.3	4.09	0.41	0.083	0.042	0.74	35.8	22.5		33	119	17.5	17	76.3	12.5	4	381
	St.Dev.	0.17	0.005	0.4	0.5	0.06	0.04	0.006	0.002	0.11	2.6	1.3		5	5	1.7	0.8	11	0.6	0.24	51
Sarıkamış S1 A/B/C	Av.	4.48	0.095	14.4	74.4	4.19	0.65	0.12	0.078	1.54	49.4	23.1	9.83	63.3	118	23.1	28.4	150	19.8	3.62	382
	St.Dev.	0.39	0.03	0.7	1.2	0.26	0.1	0.02	0.025	0.27	5.9	4.3	3.21	18.9	14	6.1	5	23	2.2	0.66	89
Sarıkamış S2 A/B	Av.	3.77	0.066	13	77.2	4.26	0.49	0.097	0.044	0.9	40	21.2	6.74	32.1	119	16.9	17.4	82.7	12.9	3.79	419
	St.Dev.	0.13	0.023	0.5	0.6	0.13	0.07	0.011	0.002	0.17	5.9	0.8	2.09	7.6	10	1.9	0.8	10.1	0.8	0.43	58
Yağlıca south	Av.	4.11	0.14	14.1	75.4	4.16	0.82	0.15	0.055	1	36.5	35.5		37	121	54.5	12.5	98	18.5	3.85	532
	St.Dev.	0.12	0	0.1	0.1	0.11	0	0	0	0.01	2.1	0.7		1.4	6	3.5	0.7	7.1	0.7	0.21	21

Tsiteli Gorebi 5 (ECh)		La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Gegham	0201-M-1	15.9	31.1	3.14	10.8	2.72	0.18	2.47	0.48	3.12	0.67	1.91	0.31	2.17	0.33	2.67	3.82	26.5	14.3
Gegham	0105-M-1	15.8	30.9	3.14	10.8	2.66	0.19	2.46	0.47	3.07	0.65	1.92	0.29	2.29	0.33	2.63	3.78	26	14.3
Gegham	0105-M-1	16.2	31.2	3.13	10.9	2.77	0.2	2.61	0.5	3.26	0.66	1.91	0.31	2.27	0.34	2.68	3.82	26.7	14.3
Gegham	0002-M-2	15.9	30.7	3.17	11	2.62	0.2	2.53	0.48	3.16	0.66	1.89	0.29	2.25	0.35	2.66	3.8	26	14
Gegham	0123-M-2	15.9	30.6	3.1	10.8	2.68	0.19	2.59	0.49	3.16	0.66	1.93	0.3	2.24	0.33	2.71	3.78	25.9	14.1
Gegham	0123-M-1	16	31.3	3.13	10.9	2.71	0.17	2.46	0.49	3.17	0.64	1.91	0.3	2.27	0.33	2.64	3.85	26.7	14.5

(*continued on next page*)

Table 2 (*continued*)

Tsiteli Gorebi 5 (ECh)		La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Gegham	0214-M-2	16.3	31.5	3.17	11.1	2.69	0.18	2.49	0.49	3.14	0.66	1.92	0.31	2.24	0.33	2.71	3.79	26.6	14.3
Gegham	0214-M-2	16	31.2	3.13	10.9	2.63	0.19	2.54	0.49	3.13	0.65	1.93	0.3	2.27	0.33	2.69	3.8	26.4	14.4
Gegham	0214-M-2	16	31.2	3.15	11.2	2.66	0.2	2.55	0.5	3.23	0.67	1.95	0.3	2.36	0.33	2.7	3.82	26.7	14.4
Gegham	0118-M-4	15.6	30.8	3.09	10.9	2.63	0.19	2.45	0.49	3.13	0.64	1.9	0.29	2.23	0.32	2.59	3.79	25.9	14.3
Gegham	0118-M-4	16.3	31.4	3.14	10.9	2.74	0.19	2.51	0.5	3.1	0.67	1.89	0.3	2.23	0.32	2.66	3.8	26.8	14.3
Gegham	0118-M-4	16.2	31.4	3.09	10.8	2.59	0.16	2.43	0.48	3.08	0.65	1.88	0.29	2.23	0.32	2.69	3.8	26.5	14.4
Gegham	0012 -M-1	16.1	31.3	3.14	10.9	2.59	0.18	2.44	0.48	3.14	0.66	1.87	0.3	2.17	0.32	2.67	3.81	26.5	14.5
Gegham	0102-M-1	16.3	31.3	3.18	11	2.7	0.19	2.47	0.5	3.11	0.65	1.91	0.3	2.27	0.33	2.71	3.81	26.9	14.5
Gegham	0102-M-1	16.4	31.7	3.2	11.3	2.63	0.21	2.55	0.49	3.16	0.66	1.9	0.29	2.21	0.33	2.69	3.7	26.2	14.2
Gegham	0102-M-1	16.3	31.4	3.22	11.2	2.88	0.19	2.6	0.5	3.18	0.66	1.99	0.3	2.27	0.34	2.72	3.81	26.6	14.2
Gegham	0001-M-1	15.5	30.8	3.07	10.7	2.61	0.18	2.41	0.48	3.03	0.62	1.82	0.3	2.25	0.32	2.64	3.77	25.6	14.4
Gegham	0001-M-1	17.1	33	3.3	11.4	2.66	0.21	2.5	0.45	2.91	0.6	1.82	0.29	2.12	0.3	2.63	3.44	25	13.5
Gegham	0001-M-1	15.6	30.2	3.04	10.8	2.65	0.19	2.5	0.48	3.08	0.66	1.84	0.3	2.17	0.32	2.53	3.74	25.2	14
Gegham	0001-M-1	16.1	31	3.14	11.1	2.7	0.19	2.54	0.5	3.15	0.67	1.93	0.3	2.3	0.32	2.69	3.79	26.5	14.4
Gegham	0118-M-5	15.9	31	3.08	10.9	2.62	0.19	2.46	0.49	3.05	0.67	1.88	0.3	2.22	0.32	2.67	3.81	25.9	14.2
Gegham	0107-M-1	15.6	30.9	3.09	10.7	2.57	0.2	2.45	0.47	3	0.63	1.85	0.28	2.16	0.32	2.54	3.66	25	14
Gegham	0229-M-1	15.6	30.1	2.99	10.6	2.59	0.14	2.38	0.46	2.94	0.65	1.78	0.27	2.23	0.31	2.58	3.47	25.9	14
Gegham	0260-M-7 A	14.6	28.3	2.87	9.95	2.36	0.14	2.25	0.44	2.7	0.61	1.72	0.28	2.07	0.29	2.42	3.43	23.5	14.1
Gegham	0260-M-7 C	15.1	29.3	3.02	10.6	2.8	0.16	2.3	0.46	3.13	0.66	1.86	0.29	2.18	0.3	2.62	3.59	25.4	14.2
Gegham	0314-M-1 A	15.4	29.7	3.01	10.5	2.58	0.16	2.31	0.46	2.95	0.63	1.82	0.27	2.11	0.3	2.63	3.48	24.9	14.1
Gegham	0314-M-1 B	15.5	30	3.05	10.3	2.6	0.16	2.26	0.47	3.01	0.63	1.83	0.3	2.15	0.31	2.55	3.47	25.5	14.4
Gegham	0349-M-1	14.7	29.5	2.88	10.3	2.53	0.17	2.21	0.45	2.83	0.58	1.71	0.26	2.04	0.29	2.45	3.39	24	14.9
Gegham	0406-M-1 C	15.4	30	3.05	10.7	2.56	0.19	2.29	0.48	3.09	0.62	1.85	0.3	2.12	0.29	2.68	3.53	25.7	14.2
Gegham	0437-M-2	15.8	30.4	3.09	10.9	2.61	0.18	2.36	0.48	3.04	0.65	1.86	0.3	2.24	0.32	2.66	3.55	25.9	14.2
Gegham	0503-M-2 A	15.4	29.4	2.94	10.4	2.56	0.19	2.34	0.45	2.87	0.63	1.83	0.28	2.17	0.29	2.52	3.4	24.8	13.7
Gegham	0708-M-3 B	15.4	30.9	3.04	10.6	2.51	0.17	2.2	0.43	2.71	0.58	1.67	0.26	2.08	0.3	2.44	3.31	23.9	13.9
Gegham	0714-M-6 A	15.5	30	3.04	10.8	2.69	0.15	2.31	0.46	2.89	0.63	1.77	0.27	2.13	0.3	2.59	3.47	24.9	13.9
Sarıkamış North N 1	0118-M-5	31.1	61.9	6.41	23.7	5.54	0.24	5.31	1.01	6.55	1.45	4.16	0.63	4.69	0.7	5.34	1.54	18.3	6.59
Sarıkamış South S 1A	0239-M-3 B	38.5	71	7.28	27.4	5.58	0.75	5.08	0.91	5.63	1.22	3.61	0.55	4.13	0.61	5.12	1.15	16.3	5.81
Sjunik 3	0009-M-1	34.7	55.3	4.42	12.2	1.54	0.16	1.52	0.19	1.18	0.27	0.9	0.15	1.28	0.2	3.17	1.79	31.2	9.45
Sjunik 3	0708-M-3 A	37.6	56	4.34	11.5	1.62	0.14	1.09	0.18	1.13	0.27	0.86	0.16	1.18	0.18	3.2	1.64	27.4	8.35
Sjunik 3	0406-M-1 A	36.5	56.1	4.39	11.4	1.51	0.16	1.08	0.18	1.18	0.27	0.88	0.16	1.22	0.19	3.31	1.67	27.4	8.25
Gutansar	0118-M-4	30.9	53.3	4.86	15.7	2.86	0.53	2.64	0.47	2.94	0.63	1.81	0.29	2.29	0.34	4.21	2.46	16.7	8.88
Gutansar	0012-M-1	31.8	54.1	4.99	16.3	2.94	0.51	2.73	0.48	3.04	0.65	1.9	0.3	2.35	0.35	4.3	2.47	17.3	8.96
Gutansar	0239-M-3 A	30.1	51.5	4.7	14.9	2.89	0.5	2.41	0.45	2.82	0.62	1.8	0.28	2.19	0.33	4.12	2.31	16.1	8.37
Gutansar	0260-M-7 B	31	51.8	4.9	15.5	2.96	0.47	2.54	0.48	2.96	0.64	1.83	0.3	2.21	0.33	4.18	2.27	16.5	8.55
Tsaghkunyats 1 Damlik	0002-M-6	35.1	54.4	4.69	14.7	2.22	0.42	2.08	0.28	1.53	0.3	0.89	0.14	1.02	0.16	2.55	1.33	21.9	7.88
Tsaghkunyats 1 Damlik	0123-M-2	33.6	52.9	4.54	14.1	2.24	0.42	2.04	0.27	1.46	0.3	0.87	0.13	1.01	0.15	2.41	1.3	21.1	7.84
Tsaghkunyats 1 Ttvakar	0714-M-6 B	39.3	57.6	4.82	14.1	2	0.33	1.48	0.21	1.22	0.26	0.68	0.11	0.82	0.13	2.66	1.32	28.7	9.62
Tsaghkunyats 2	0009-M-1	50.9	74.1	6.06	17.9	2.21	0.34	2.14	0.21	1.15	0.24	0.75	0.12	0.92	0.15	3.1	1.1	26	7.83
Yağlıca Dağ South	0102-M-1	32.9	51.5	4.51	14.5	2.4	0.43	2.33	0.37	2.28	0.49	1.47	0.22	1.81	0.27	3.06	1.1	18.7	6.66
Chikiani 2b	0406-M-1 B	25.8	45.9	4.36	14.8	2.77	0.56	2.13	0.36	2.01	0.41	1.12	0.17	1.26	0.19	2.82	1.12	14.1	4.97
Chikiani 2b	0239-M-3 C	27.7	48.8	4.68	15.7	2.87	0.58	2.12	0.36	2.04	0.4	1.15	0.18	1.31	0.18	3.06	1.06	14.5	4.92
Chikiani 2b	0503-M-2 B	29.3	51.1	4.86	15.8	2.74	0.55	2.11	0.33	1.93	0.41	1.12	0.16	1.24	0.19	2.89	1.02	14.6	4.64

Aradetis Orgora		La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Chikiani 2a	1880-M-2 C* LBA	22.4	42	4	13.4	2.66	0.52	2.3	0.36	2	0.4	1.14	0.18	1.28	0.19	2.55	1.17	13.7	5.23
Chikiani 2a	1893-M-3 A MBA/LBA	22.5	41.4	4.06	13.4	2.64	0.54	2.29	0.35	2.03	0.41	1.13	0.17	1.34	0.19	2.57	1.19	13.7	5.14
Chikiani 2a	1893-M-3 C* MBA/LBA	22.9	42	4.08	13.6	2.57	0.55	2.32	0.35	2.07	0.42	1.17	0.18	1.34	0.19	2.64	1.19	13.7	5.13
Chikiani 2a	2129-M-3 LBA/EIA	23.2	42.7	4.04	13.5	2.57	0.53	2.23	0.35	1.97	0.4	1.16	0.17	1.29	0.19	2.62	1.17	13.9	5.13
Chikiani 2a	2139-M-1 LBA	23.5	43.2	4.11	13.8	2.63	0.54	2.28	0.34	1.97	0.41	1.15	0.18	1.27	0.19	2.58	1.18	14	5.18
Chikiani 2b	1362-M-3 EIA	27.1	48.5	4.59	15.1	2.79	0.56	2.35	0.35	2.01	0.42	1.12	0.18	1.28	0.2	2.86	1.12	14.6	4.92
Chikiani 2b	1376-M-1 LBA/EIA	25.6	46.7	4.42	14.6	2.61	0.52	2.28	0.35	1.97	0.41	1.16	0.17	1.25	0.19	2.77	1.14	14.2	5.07

(*continued on next page*)

Table 2 (*continued*)

Aradetis Orgora		La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Chikiani 2b	1863-M-1 C LBA	25.9	46.7	4.41	14.8	2.79	0.54	2.43	0.35	2	0.41	1.16	0.17	1.28	0.19	2.71	1.13	14.1	4.93
Chikiani 2b	1893-M-1 A* MBA/LBA	26.5	47.4	4.49	15.1	2.7	0.56	2.4	0.36	1.94	0.4	1.14	0.17	1.27	0.2	2.72	1.12	14.4	4.98
Chikiani 2b	1893-M-1 C* MBA/LBA	25.7	46	4.38	14.8	2.81	0.56	2.43	0.37	2.07	0.44	1.22	0.18	1.38	0.2	2.82	1.18	14.6	5.07
Chikiani 2b	1893-M-1 D* MBA/LBA	26.1	47.8	4.5	14.8	2.58	0.57	2.35	0.34	1.96	0.4	1.12	0.17	1.26	0.19	2.71	1.13	14	4.94
Chikiani 2b	2137-M-8 LBA	26.5	47.3	4.47	14.8	2.8	0.55	2.27	0.34	2.01	0.42	1.18	0.18	1.3	0.18	2.73	1.12	14.4	4.95
Chikiani 2b	2205-M-8 LBA	26.9	48.2	4.5	14.9	2.62	0.58	2.37	0.34	1.98	0.41	1.2	0.18	1.36	0.19	2.79	1.14	14.5	5.02
Chikiani 2b	2211-M-1 LBA	26.2	47	4.39	14.6	2.67	0.56	2.3	0.36	1.95	0.41	1.13	0.18	1.28	0.2	2.79	1.12	14.3	4.93
Chikiani 3a	1381-M-2 MBA/EIA	31.3	54.9	5.03	16.6	2.85	0.61	2.4	0.33	1.87	0.38	1.09	0.16	1.3	0.19	2.97	1.02	14.5	4.54
Chikiani 3a	1385-M-3 MBA/EIA	31	54.5	5.01	16.6	2.92	0.6	2.35	0.34	2.02	0.41	1.14	0.18	1.31	0.18	3	1.1	15.2	4.79
Chikiani 3a	1863-M-1 A LBA	28.5	50.6	4.74	15.8	2.7	0.62	2.45	0.34	1.93	0.4	1.12	0.17	1.32	0.18	2.93	1.1	14.4	4.78
Chikiani 3a	1863-M-1 B LBA	31	54.8	5.03	16.7	2.94	0.62	2.45	0.34	1.94	0.37	1.12	0.18	1.3	0.19	3.05	1.03	14.4	4.62
Chikiani 3a	1863-M-1 D LBA	29.4	52.4	4.88	16.3	2.89	0.61	2.55	0.36	1.98	0.4	1.12	0.17	1.24	0.2	2.95	1.08	14.5	4.71
Chikiani 3a	1880-M-2 A* LBA	30.2	54.2	4.96	16.6	2.86	0.62	2.48	0.35	1.94	0.41	1.13	0.17	1.27	0.2	2.92	1.06	14.7	4.76
Chikiani 3a	1880-M-2 B* LBA	28.6	51.3	4.81	15.9	2.83	0.59	2.41	0.34	1.92	0.38	1.16	0.17	1.25	0.18	2.9	1.08	14.2	4.77
Chikiani 3a	1893-M-1 B* MBA/LBA	29.4	52	4.86	16.1	2.78	0.59	2.47	0.34	2	0.41	1.15	0.17	1.26	0.19	2.89	1.07	14.6	4.76
Chikiani 3a	1893-M-1 E MBA/LBA	30.7	54.2	5.04	16.7	2.88	0.61	2.55	0.34	1.98	0.4	1.13	0.17	1.27	0.19	3.04	1.07	14.7	4.66
Chikiani 3a	1893-M-3 E* MBA/LBA	30.2	53.2	4.98	16.5	2.87	0.62	2.48	0.34	1.91	0.4	1.12	0.17	1.25	0.2	3.02	1.09	14.6	4.69
Chikiani 3b	1893-M-3 B* MBA/LBA	38.2	64.1	5.89	19.5	3.07	0.72	2.62	0.35	1.92	0.39	1.14	0.17	1.33	0.2	3.63	0.97	15.5	4.18
Chikiani 3b	1893-M-3 D* MBA/LBA	36.5	62	5.68	18.8	2.99	0.69	2.54	0.35	1.87	0.38	1.1	0.17	1.28	0.2	3.51	0.94	14.8	4.2
Chikiani 3b	2239-M-1 EBA	34.6	59.5	5.43	17.8	3.07	0.64	2.49	0.34	1.93	0.38	1.09	0.17	1.24	0.19	3.25	0.99	15.1	4.4

Natsargora (EBA)		La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Chikiani 2a	2010/02 Box 79	18.2	39.2	3.42	11.5	2.02	0.43	1.64	0.28	1.64	0.33	0.91	0.15	1.11	0.15	2.2	1.3	12.1	5.55
Chikiani 2a	2010/03 Box 89 1359	17.2	37.9	3.28	10.9	2.02	0.43	1.57	0.27	1.57	0.33	0.89	0.14	1.04	0.15	2.19	1.3	11.9	5.63
Chikiani 2a	2010/06 Box 149	19.9	42.4	3.61	11.9	2.13	0.41	1.51	0.25	1.53	0.29	0.9	0.12	1.05	0.14	2.33	1.21	12.2	5.29
Chikiani 2a	2010/09 Box 186 4009	19.6	41.3	3.64	12.1	2.21	0.44	1.62	0.28	1.69	0.35	0.98	0.15	1.12	0.17	2.39	1.32	12.6	5.44
Chikiani 2a	2010/10 Box 474 4114	20.8	43.2	3.82	12.7	2.25	0.47	1.66	0.28	1.68	0.34	0.99	0.14	1.09	0.17	2.52	1.33	13.1	5.34
Chikiani 2a	2011/04 0442-M-1	24	41.1	4.03	13.5	2.75	0.57	2.72	0.37	2.21	0.44	1.36	0.19	1.43	0.21	2.76	1.36	15.6	5.17
Chikiani 2a	2011/05 0442-M-1	20.7	39.8	3.53	11.8	2.39	0.45	1.91	0.31	1.75	0.34	1.06	0.16	1.02	0.16	2.43	1.2	13	5.46
Chikiani 2a	2011/07 0442-M-1	23.4	43.8	4	13.3	2.64	0.49	2.33	0.35	1.92	0.41	1.1	0.16	1.22	0.18	2.8	1.37	14.6	5.31
Chikiani 2a	2011/08 0004-M-1	24.5	45.4	3.95	13.4	2.28	0.5	2.17	0.31	1.82	0.35	1.04	0.15	1.12	0.16	2.72	1.27	13.8	5.42
Chikiani 2a	2011/09 0004-M-1	25.3	45.8	4.06	14.2	2.44	0.58	2.19	0.34	1.99	0.39	1.18	0.2	1.07	0.16	2.73	1.28	14.5	5.24
Chikiani 2a	2011/10 0004-M-1	21.6	42.4	3.65	11.8	2.2	0.45	1.77	0.28	1.77	0.32	0.95	0.13	1.02	0.16	2.31	1.25	12.8	5.66
Chikiani 2a	2011/11 0004-M-1	19	38	3.44	11.4	2.11	0.44	1.8	0.28	1.54	0.32	0.9	0.14	1.1	0.15	2.19	1.19	11.7	5.2
Chikiani 2b	2010/01 Box 18	22.7	46.6	4.06	13.3	2.29	0.49	1.64	0.27	1.67	0.32	0.94	0.15	1.12	0.17	2.58	1.23	13	5.06
Chikiani 2b	2010/04 Box 94 1608	25.2	46.9	4.25	14.6	2.63	0.53	1.97	0.32	1.9	0.39	1.09	0.17	1.31	0.19	3.23	1.43	15.5	5.04
Chikiani 2b	2010/05 Box 145 2660	24.6	45.5	4.35	14.7	2.65	0.52	1.95	0.35	2.06	0.42	1.13	0.18	1.31	0.2	3.21	1.47	15.5	5.08
Chikiani 2b	2010/08 Box 175 3937	22.6	46.9	4	13.2	2.2	0.46	1.6	0.26	1.6	0.32	0.92	0.14	1.08	0.15	2.54	1.22	12.8	5.12
Chikiani 2b	2011/01 0092-M1	24.6	45.2	4.05	13.6	2.51	0.48	2.66	0.32	1.68	0.31	1.02	0.12	1.09	0.12	2.59	1.05	12.8	4.79
Chikiani 2b	2011/02 0353-M-1	24.2	45.3	3.99	13.4	2.24	0.49	2.2	0.28	1.54	0.3	0.96	0.1	1.02	0.13	2.61	1.11	12.4	4.87
Chikiani 2b	2011/12 0004-M-1	26.1	47.9	4.19	14.7	2.6	0.49	2.36	0.31	1.89	0.38	1.12	0.17	1.17	0.18	2.64	1.22	14.7	5.15
Chikiani 3a	2010/07 Box 151 2961	27.4	52.6	4.68	15.6	2.56	0.58	1.88	0.29	1.81	0.34	1.05	0.16	1.22	0.17	3.12	1.24	14.2	4.79
Chikiani 3a	2011/03 0442-M-1	29.1	52.1	4.44	15.2	2.73	0.69	2.35	0.32	1.79	0.34	1.11	0.15	1.09	0.16	2.8	1.14	14.3	4.78
Sarıkamış South S 1A	2011/06 0442-M-1	35.2	66.7	6.58	24.5	5.25	0.74	4.71	0.86	5.36	1.03	3.5	0.5	3.76	0.53	4.96	1.27	15.6	6.28

Okherakhevi (EBA)		La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Chikiani 1	2010/2 002-M1a	14.4	33.7	2.91	9.6	1.86	0.37	1.49	0.24	1.51	0.3	0.86	0.13	0.99	0.14	1.87	1.31	10.7	5.89
Chikiani 2a	2010/1 001-M1	16.9	36.8	3.21	10.5	1.97	0.46	1.49	0.28	1.87	0.34	0.98	0.15	1.12	0.16	2.31	1.37	12.2	5.71
Chikiani 2a	2010/4 002-M2	20.2	40.8	3.64	12.4	2.24	0.44	1.77	0.3	1.84	0.37	1.07	0.16	1.24	0.17	2.58	1.43	13.8	5.41
Chikiani 2a	2010/6 002-M6	18.1	38.6	3.4	11.3	2.17	0.4	1.7	0.29	1.69	0.35	0.95	0.15	1.11	0.15	2.32	1.35	12.9	5.63
Chikiani 2a	2010/7 005-M2	21.3	41.4	3.81	12.8	2.37	0.43	1.9	0.32	1.9	0.39	1.09	0.16	1.27	0.19	2.79	1.45	14.4	5.37

(*continued on next page*)

Table 2 (*continued*)

Okherakhevi (EBA)		La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Chikiani 2a	2010/8 013-M1	19.8	40.5	3.55	12	2.15	0.45	1.68	0.28	1.68	0.36	0.99	0.15	1.12	0.17	2.48	1.32	13	5.26
Chikiani 2b	2010/3 002-M1b	23.2	47.8	4.13	13.7	2.28	0.46	1.76	0.27	1.63	0.33	0.96	0.15	1.1	0.16	2.6	1.24	13.3	5.16
Chikiani 2b	2010/5 002-M5	22.5	48.2	3.96	13	2.19	0.48	1.56	0.25	1.45	0.3	0.86	0.13	0.98	0.15	2.52	1.17	12.4	5.17

Geological Sources or chemical groups		La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Chikiani 1	Av.	21	40.7	3.77	12.4	2.46	0.44	1.72	0.3	1.96	0.4	1.08	0.16	1.21	0.18	2.44	1.21	13.8	5.46
	St.Dev.	0.9	1.6	0.13	0.5	0.09	0.08	0.3	0.03	0.09	0.02	0.07	0.01	0.06	0.01	0.1	0.05	0.5	0.18
Chikiani 2	Av.	25.7	46.9	4.38	14.6	2.7	0.55	2.3	0.34	1.97	0.41	1.14	0.17	1.27	0.19	2.74	1.14	14.3	5.05
	St.Dev.	2.3	3.7	0.29	1	0.14	0.04	0.3	0.02	0.11	0.02	0.07	0.01	0.08	0.01	0.19	0.06	0.8	0.21
Chikiani 3a	Av.	32.4	57	5.18	16.9	2.88	0.62	2.38	0.34	1.9	0.39	1.11	0.17	1.24	0.19	3.08	1.04	15	4.66
	St.Dev.	2.7	4.3	0.3	0.8	0.11	0.06	0.28	0.02	0.1	0.02	0.06	0.01	0.07	0.01	0.19	0.05	0.9	0.19
Chikiani 3b	Av.	38	65.1	5.83	19.1	3.06	0.7	2.49	0.34	1.86	0.38	1.1	0.17	1.25	0.19	3.49	0.93	15	4.18
	St.Dev.	2.3	3.9	0.25	0.8	0.12	0.07	0.22	0.02	0.1	0.02	0.06	0.01	0.08	0.01	0.18	0.05	0.8	0.16
Gegham	Av.	12.4	28.2	2.4	8.7	2.2	0.16	2	0.4	2.7	0.56	1.7	0.26	2	0.28	2.1	3.9	19.5	15.5
	St.Dev.	0.9	1.5	0.2	0.7	0.1	0.01	0.1	0.03	0.2	0.05	0.2	0.01	0.2	0.03	0.4	0.4	3.6	2.3
Gutansar	Av.	24.9	50.3	4.2	14.3	2.7	0.48	2.3	0.43	2.9	0.59	1.8	0.29	2.3	0.33	3.9	2.5	14.3	10.4
	St.Dev.	2.7	3.5	0.5	1.2	0.2	0.04	0.2	0.03	0.3	0.05	0.2	0.03	0.2	0.03	0.5	0.2	1.9	1
Sjunik 3	Av.	24.3	46.7	3.1	8.7											2.7	1.6	23.8	10.9
Mets Sevkar/Pork Sevkar	St.Dev.	1.6	2.6	0.2	1.1											0.5	0.2	1.9	1.4
Tsaghkunyats 1	Av.	28.3	53.7	4.2	12.7	1.8	0.25	1.2	0.22	1.1	0.26	0.6	0.15	0.9	0.14	2.5	1.5	21.8	11.3
Damlik & Ttvakar	St.Dev.	4.4	5.2	0.5	1.4											0.4	0.1	5.3	1.8
Tsaghkunyats 2	Av.	43.9	74	5.6	16.3	2	0.43	1.2	0.19	1.1	0.22	0.7	0.11	0.9	0.14	3.1	1.2	24.5	9
Aïkasar & Kamakar	St.Dev.	2.7	3.8	0.4	1.3	0.1	0.04	0.1	0.02	0.1	0.02	0	0.01	0.1	0.02	0.3	0.1	2.6	0.3
Sarıkamış north	Av.	29	59.3	5.73	21.8	4.68	0.2	4.53	0.89	5.9	1.2	3.65	0.54	4.23	0.65	5.2	1.55	16.5	6.65
	St.Dev.	4.1	5.5	0.43	1.7	0.21	0.03	0.31	0.03	0.16	0	0.13	0.02	0.32	0.07	0.42	0.06	0.6	0.37
Sarıkamış N1	Av.	30.6	61.7	6.05	22.9	5.27	0.23	5.01	1	6.33	1.34	4.04	0.6	4.45	0.65	5.63	1.6	18	6.59
	St.Dev.	3.8	6.7	0.61	2.1	0.36	0.05	0.52	0.11	0.43	0.11	0.29	0.05	0.29	0.05	0.56	0.12	1.3	0.52
Sarıkamış N2	Av.	35.5	70.1	6.74	25	5.45	0.27	5.12	1	6.41	1.35	4.07	0.6	4.45	0.65	5.92	1.55	17.8	6.48
	St.Dev.	3	5.6	0.58	1.8	0.36	0.06	0.53	0.12	0.37	0.12	0.29	0.06	0.27	0.07	0.42	0.09	1.3	0.49
Sarıkamış N3 A/B	Av.	32.5	64.8	6.23	22.8	5.11	0.3	4.65	0.93	6.04	1.26	3.83	0.56	4.13	0.61	5.24	1.6	17.4	6.68
	St.Dev.	5.8	10.8	0.98	3	0.48	0.08	0.7	0.11	0.5	0.12	0.38	0.06	0.41	0.07	0.63	0.17	1.5	0.61
Sarıkamış south	Av.	22.5	40.3	3.65	13.3	2.38	0.34	2.35	0.41	2.65	0.59	1.68	0.25	2.05	0.32	2.75	0.95	14.3	6.1
	St.Dev.	3.5	5	0.48	1.5	0.33	0.02	0.25	0.01	0.26	0.04	0.15	0.01	0.26	0.03	0.33	0.06	1.5	0.34
Sarıkamış S1 A/B/C	Av.	31.9	60.8	5.73	22.7	4.6	0.58	4.57	0.75	4.86	0.99	3.12	0.45	3.49	0.5	4.61	1.18	15.6	6.08
	St.Dev.	3.7	5.6	0.78	3.9	0.97	0.18	0.95	0.15	0.91	0.17	0.54	0.07	0.47	0.08	0.71	0.11	2.8	1.07
Sarıkamış S2 A/B	Av.	23.4	41.9	3.84	13.8	2.71	0.31	2.64	0.44	2.81	0.59	1.85	0.28	2.16	0.32	2.98	0.94	15.2	5.83
	St.Dev.	3.2	4.9	0.42	1.6	0.21	0.04	0.45	0.03	0.15	0.03	0.09	0.02	0.12	0.02	0.24	0.07	1	0.62
Yaglica south	Av.	29	48.5	4	12.5	2.2	0.44	2.5	0.35	2	0.44	1.35	0.21	1.6	0.25	2.85	1.15	18	7.45
	St.Dev.	1.4	0.7	0.14	0.7	0.14	0.04	0.28	0.03	0.14	0.04	0.07	0.01	0.14	0.01	0.21	0.07	1.4	0.21

appears to be characterised by a mixture of mineral and vegetal tempers. Obsidian from the pits at Karacamirli mainly comes from Gegham/Geghasar (36 items out of 48), with a minor component from Syunik (11 items) and 1 occurrence from Chikiani (Kaniuth, 2020, pp. 282–289, table 37). Analysed obsidian from Mentesh Tepe which comes from Chalcolithic layers (269 items out of 695, Astruc et al., 2022) shows a more diversified picture, with nine different sources attested: Gegham (172 items out of 269), Sarıkamış (33 items), Tsaghkunyats (19 items), Chikiani (17 items), Gutansar (13 items), Syunik (9 items), Arteni (4 items), Hatis (1 item) and one obsidian pebble from Khorapor. A tenth source, Yağlıca Dağ, is attested in Neolithic (1 item out of 165) and undetermined (2 items out of 261) levels.

As already observed by Chataigner et al., 2020, pp. 16–17, in the course of the Chalcolithic period the interregional exchange network within the Southern Caucasus progressively included a wider geographical area, whereby the valleys of the main rivers, the Kura and the Araxes, possibly increased their role as main communication corridors. This may explain the remarkable difference in obsidian procurement observed by Badalyan, 2010 between the Tsiteli Gorebi sites (now firmly dated to the first half of the 5th millennium) and the neighbouring site of Padar (which belongs to the 4th millennium Chaff-Faced Ware Leilatepe culture), located just beyond the Georgian/Azerbaijani border in the same valley of the Alazani, where 11 out of 16 samples came from Chikiani and the rest from miscellaneous east-Armenian sources. In fact, Chikiani obsidian is well represented at sites of the later part of the Chalcolithic period in the Azerbaijani section of the Middle Kura valley, as for instance at the kurgans of Soyuk Bulak (Lyonnet et al., 2008, p. 40, note 24) and at the Poylu 2 settlement (Taylor and Maynard, 2018).

6. Conclusions

The results of the analyses carried out on the 57 new samples from Natsargora, Aradetis Orgora and Okherakhevi confirm the almost exclusive use of the Chikiani volcano as a source of obsidian, in all chronological periods, by the ancient populations of the Shida Kartli province of Georgia already hypothesised by previous scholars. The considerable distance between Shida Kartli and all the other South Caucasian sources of obsidian clearly made the latter less profitable, in terms of accessibility, for the sites of this province, and led these to a monosource procurement pattern.

On the other hand, the location of the Alazani valley and, more in general, of the Kakheti region relative to the different obsidian outcrops does not constrain the sites of this region to a single source, but allows them to receive the raw material from several of them at the same time, exploiting their connections with different regions and human groups. This gives rise to a very complex pattern of obsidian procurement, which is not only open to some degree of individual site variability, but, probably, to diachronic evolution connected to cultural developments as well.

The 50 new samples from the Early Chalcolithic Kakhetian site of Tsiteli Gorebi 5 highlighted a very diversified obsidian provenance pattern, which includes 7 different sources located in Armenia, mainly in the mountainous area to the west and south of lake Sevan (Gegham, Gutansar, Tsaghkunyats, Syunik), in Eastern Turkey (Sarıkamış and Yağlıca Dağ) and in Georgia (Chikiani). Combined with those of previous analysis on other neighbouring sites, these results may support a shift from the still poorly known Early Chalcolithic phase, with attests a multi-source procurement pattern focusing on sources located in the mountainous area around Lake Sevan, to a phase characterised by an increasing role of the Chikiani obsidian, which circulated along the Kura valley.

Sites from which obsidian provenance analyses are available are still too few and, above all, too patchy in location and/or in date to allow the validation of these emerging patterns. In addition to densifying the network of analyses, a help in progressing with their interpretation may come from a more systematic correlation of obsidian provenance data with the evaluation of the sites' cultural orientation as inferred from similarities in pottery and other artefacts, or with other, less traditional indicators of human mobility, such as, for example, with the results of stable isotope analyses of human and animal bones.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. It was carried out within the activities of the Georgian-Italian Shida Kartli and Lagodekhi Archaeological projects, which, in the course of the years, benefitted from multiple funding sources.

The publication of the material from the Georgian excavations at Natsargora was supported by a special grant of the Shelby White-Leon Levy Program for Archaeological Publications. The following institutions contributed to funding the 2009–2019 field seasons in Georgia and connected research: Ca' Foscari University of Venice (Fondo Ateneo Scavi Archeologici, SPIN-2 2018 project, Dipartimento di Studi Umanistici), Ministero degli Affari Esteri e della Cooperazione Internazionale (Contributi missioni archeologiche, antropologiche e etnologiche italiane all'estero), Ministero dell'Istruzione, dell'Università e della Ricerca (PRIN 2009) and a private sponsor (Metamondo Tour Operator).

Author statement

The proposed categories (CRediT authorship contribution statement) are not really applicable: Elena Rova provided the samples to be analysed, the information about their context of recovery and general historical interpretation, and acted as corresponding author; Bernard Gratuze analysed the samples and interpreted the results of the analysis; each of the two authors wrote and revised the relevant paragraphs (see supplementary material, Paragrah authorship) and prepared their illustrations; introduction and conclusions are the joint effort of both. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. It was carried out within the activities of the Georgian-Italian Shida Kartli and Lagodekhi Archaeological projects (responsible E. Rova), which, in the course of the years, benefitted from multiple funding sources.

CRediT authorship contribution statement

Bernard Gratuze: Methodology, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Visualization. **Elena Rova:** Conceptualization, Investigation, Resources, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

Declaration of Competing Interest

None.

Acknowledgements

The authors would like to thank the Georgian National Museum in the persons of prof. David Lorkipanidze (General Director) and dr. Zurab Makharadze (Director of the Archaeological Centre), the National Agency for Cultural Heritage Preservation of Georgia, the Lagodekhi Regional Department of the Ministry of Culture, Sport and Youth and the Lagodekhi Municipality for the permission to undertake archaeological investigations and collect, export and analyse obsidian samples from the sites of Natsargora, Okherakhevi, Aradetis Orgora and Tsiteli Gorebi 5, as well as the Georgian co-directors of the joint archaeological expeditions: dr. Zurab Makharadze and prof. Marina Puturidze (Natsargora, Okherakhevi), prof. Iulon Gagshidze (Aradetis Orgora) and Mr. Davit Kvavadze (Tsiteli Gorebi 5).

Alberto Stinghen and Flavia Amato helped in the selection of the

samples from Natsargora and Tsiteli Gorebi 5. Thanks are also due to dr. Chistine Chataigner, who first established the contact between the authors, to prof. Marilyn Kelly-Buccellati, who kindly revised the English text of the article, and to Francesco Bianchi, who prepared some of the illustrations.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ara.2022.100397.

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