Obsidian provenance studies in the far eastern and north-eastern regions of Russia and exchange networks in the prehistory of Northeast Asia: a review

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ABSTRACT – *This overview is based on the results of 25+ years of provenance studies to identify the sources of high-quality volcanic glass (obsidian) in prehistoric cultural complexes of the far eastern and northeastern regions of Russia (Maritime Province, the Amur River basin, Sakhalin Island, the Kurile Islands, Kamchatka Peninsula, Chukotka region, the Kolyma River basin, and the High Arctic), as well as in adjacent parts of Northeast Asia (Hokkaido Island, the Korean Peninsula, and Manchuria). The extended networks of obsidian exchange in antiquity are reconstructed for the southern Russian Far East and Northeastern Siberia. A possible mechanism of long-distance obsidian exchange/ trade in Northeastern Siberia is suggested.*

KEY WORDS – *obsidian; provenance study; prehistoric exchange; far eastern Russia; Northeastern Siberia*

Študije provenience obsidiana na območju ruskega Daljnega Vzhoda in v severovzhodni Rusiji ter mreže menjav v prazgodovini v severovzhodni Aziji: pregled

IZVLEČEK – *Pričujoča presoja je osnovana na rezultatih več kot 25 let študij provenience pri iskanju izvorov visoko kakovostnega vulkanskega stekla (obsidiana) v prazgodovinskih kulturnih kompleksih na ruskem Daljnem Vzhodu in v regijah severovzhodne Rusije (obmorske province, območje reke Amur, otok Sahalin, Kurilsko otočje, polotok Kamčatka, območje Čukotka, območje reke Kolime in Arktično višavje) kot tudi v sosednjih delih severovzhodne Azije (otok Hokkaido, Korejski polotok in Mančurija). Za območji južnega dela ruskega Daljnega Vzhoda in severovzhodno Sibirijo smo že rekonstruirali razširjeno mrežo menjave obsidiana v preteklosti. Predlagamo pa možne mehanizme menjav/ trgovine z obsidianom na daljše razdalje na območju severovzhodne Sibirije.*

KLJUČNE BESEDE – *obsidian; provenienca; prazgodovinska menjava; ruski Daljni Vzhod; severovzhodna Sibirija*

Introduction

Research on the provenance of artefacts made of waterless volcanic glass (obsidian) began at the modern methodological level in the 1960s, first in the Mediterranean (*Cann, Renfrew 1964*) and afterwards in the Americas, Europe, East Africa, Oceania, and East and Southeast Asia (see bibliographies: *Skinner, Tremaine 1993; Pollmann 1999*). The success of obsidian source studies in the 1970s to 2010s, following the pioneering works of the 1960s, was due to the fact that almost every source of obsidian has a unique 'geochemical portrait (signature)' (*i.e.* the content of several chemical elements) which can be determined using analytical methods (*Williams-Thorpe 1995; Glascock* et al. *1998; Shackley 2005;*

 DOI: 10.4312/dp.46.18

Carter 2014). The establishment of primary sources for obsidian artefacts is very important for understanding the patterns of ancient migrations and contacts.

Obsidian is quite common in the far eastern and northeastern regions of Russia, in the prehistoric assemblages of Kamchatka Peninsula, Chukotka region, Primorye (Maritime) Province, Sakhalin Island, and Kurile Islands (*Kuzmin 2010; 2014; Grebennikov* et al. *2018*). In other parts of eastern Russia – the Amur River basin, northern coast of the Sea of Okhotsk, the basins of the Kolyma and Indigirka rivers, and the High Arctic (*Kuzmin 2014; Pitulko* et al. *2019*) – obsidian tools are also present but are not numerous. Actual studies of archaeological obsidian in these regions only began in the early 1990s (*Glascock* et al. *1996; Shackley* et al. *1996*), even though in eastern Russia the presence of such artefacts has been known since the end of the nineteenth century (*Kuzmin 2014.144*). In this overview, brief information on the current state-of-the-art in obsidian provenance research in eastern Russia is presented, based on the latest summaries (*Kuzmin 2010; 2011; 2012; 2014; 2017; 2019*).

Methodology of obsidian provenance research and the materials used

Since the 1960s (*Cann, Renfrew 1964; Parks, Tieh 1966; Griffin* et al. *1969*), the identification of obsidian sources for archaeological materials has been conducted by comparing the geochemical composition (mainly of trace elements – U, Th, Ta, Hf, Lu, Yb, Dy, Tb, Eu, Sm, Nd, and some others) of obsidian from primary sources and archaeological assemblages (see *Glascock* et al. *1998; Shackley 2005*). One of the most important conditions for the interpretation of geochemical data is the use of uniform analytical standards, although this is not always the case; therefore, data from different laboratories often cannot be compared (see review: *Suda* et al. *2018a*). In our case studies described here, all measurements for eastern Russia were performed in one laboratory, the Research Reactor Center of the University of Missouri (Columbia, MO, USA) (*Glascock* et al. *2007*), using the same methodology (*Glascock* et al. *1998*). This makes it possible to conduct a direct comparison of the results obtained for both primary ('geological') locales of obsidian and artefacts.

Two main analytical techniques for the geochemical analysis of obsidian in eastern Russia were used by our informal Russian-US group: (1) Neutron Activation Analysis (NAA); and (2) X-ray Fluorescence (XRF). Full descriptions of these methods were given previously (*Kuzmin, Glascock 2014; Kuzmin* et al. *2002a; 2008; Glascock* et al. *2011; Grebennikov* et al. *2018*), and here I refer to these publications for more details. As for the research strategy employed by our group since 1992, we initially identified, using XRF and NAA, the geochemical groups for a few dozen obsidian artefacts from Primorye Province and the Amur River basin. This made it possible to find out about the number of primary obsidian sources which were exploited (*Glascock* et al. *1996; Shackley* et al. *1996*). Afterwards, all major primary sources of obsidian in these regions were examined by NAA (*Kuzmin* et al. *2002a; Popov* et al. *2005; Glascock* et al. *2011; Kuzmin* et al. *2013*). First, the full version of NAA, which allows the determination of 28 elements with high precision (one part-per-million, or 10^{-4}%), was used. When the 'geochemical signatures' of the main sources were established, it was possible to use the abridged version of NAA (with measurement of the content of 7–12 elements) for the examination of artefacts only, due to the relatively high cost of the full NAA and its destructive nature (samples become radioactive and need to be utilised as low-level nuclear waste).

Other analytical methods used by different groups of South Korean, Australian and US scholars in eastern Russia and adjacent Northeast Asia were Proton-Induced X-ray Emission (PIXE) and Proton-Induced Gamma-ray Emission (PIGME) (*Kim* et al. *2007; Doelman* et al. *2008*); portable XRF and a laser ablation version of the Inductively Coupled Plasma – Mass Spectrometry (LA–ICP–MS) (*Phillips 2010*); and a Prompt Gamma Activation Analysis (PGAA) (*Jwa* et al. *2018*).

As a result of the comparison based on established statistical procedures (*Glascock* et al. *1998*), common geochemical groups for sources and archaeological samples were identified (*Kuzmin, Glascock 2014*). This made it possible to determine with a high degree of reliability from where the ancient people acquired obsidian. This information constitutes a solid basis for the reconstruction of the procurement and exchange of raw materials in the prehistoric cultural complexes of the entire Northeast Asia.

Various groups of scientists up to early 2019 have analysed about 3110 samples of obsidian from far eastern and northeastern Russia, as well as from adjacent parts of Northeast Asia – the Korean Peninsula, Northeast China (Manchuria), and Hokkaido Island (Tab. 1) (see *Kuzmin, Popov 2000; Popov* et al. *2005; Kim* et al. *2007; Doelman* et al. *2008; 2012; 2014; Phillips 2010; Jia* et al. *2010; 2013; Kuzmin 2014; Kuzmin, Glascock 2014; Kim 2014; Lee, Kim 2015; Lynch* et al. *2016, 2018; Kuzmin* et al. *2018; Grebennikov* et al. *2018; Chang, Kim 2018; Pitulko* et al. *2019*). Due to the plethora of information on obsidian geochemistry for the Honshu and Kyushu islands of Japan, available mostly in Japanese only (*Sugihara 2014*), these regions are excluded from this overview; some English summaries have recently been published and can serve as primary data (see *Tsutsumi 2010; Obata* et al. *2010; Ikeya 2014; 2015; Sato, Yakushige 2014; Shiba 2014; Shimada 2014; Shimada* et al. *2017; Suda* et al. *2018b*).

Results and discussion

Sources of obsidian in Primorye Province

In the southern part of Primorye Province, the main primary source of obsidian (more precisely, waterless volcanic glass) is the Shkotovo (Basaltic) Plateau (Tab. 1, Fig. 1). High quality volcanic glass is associated here with basic rocks (basalts and andesite-basalts), unlike the majority of sources in Northeast Asia which are part of acidic rocks (mainly rhyolites) in volcanic arc positions (*Kuzmin* et al. *2013; Wada* et al. *2014*). Although basaltic glasses have been known in Primorye for a long time (*Petrov, Zamurueva 1960*), their detailed study only began in the 1990s (*Kuzmin* et al. *2002a*). During the eruption of molten basalt, pillow lavas were formed at the contact of the hot basalt mass and cold water or solid surface. Due to rapid cooling of the lava, spherical ('pillow-shaped') bodies with a diameter of 1–5m were created (*Doelman* et al. *2012*). The surface layer of pillow lava consists of volcanic glass. Obsidian on the Shkotovo Plateau is present in the form of hyaloclastites, a material formed during the fragmentation of the glassy outer part of pillow lava blocks. Welded crusts with volcanic glass are also known in this region; they are relatively thin (up to 0.3–0.5m) horizons of non-crystallised glass at the contact of the lava flow and the underlying surface.

Another primary source of volcanic glass of acidic (rhyolite) composition is located in the basin of the Gladkaya River in the extreme southwestern part of Primorye (*Kuzmin* et al. *2002a*), but it was not widely exploited in prehistory (*Kuzmin 2014; Doelman* et al. *2014*).

Obsidian source on the Korean Peninsula

As far as we know today, the single primary obsidian source in Korea of alkaline composition is situated near the modern Paektusan Volcano (*Popov* et al. *in press*). It was originally recognised by Kuzmin *et al.* (*2002a*) and Vladimir K. Popov *et al.* (*2005*), but for a long time our knowledge was based exclusively on archaeological materials (*i.e.* obsidian artefacts). Only a handful of 'geological' samples with unknown exact location – somewhere within the northern part of Korea, called today the Democratic People's Republic of Korea, or North Korea – were analysed in the early-mid 2010s (*Kim 2014.169; Yi, Jwa, 2016; Jwa* et al. *2018; Popov* et al. *in press*).

Regions	Geological samples	Archaeological samples	Main obsidian sources*
Primorye (Maritime) Province	102	390	BP, PA
Amur River basin	12	39	OP, BP, SH-OK
Sakhalin Island	–	206	SH-OK, AK
Kamchatka Peninsula	63	444	KAM-01 – KAM-15
Kurile Islands	–	773	SH-OK, KAM-01, KAM-02, KAM-04, KAM-05, KAM-07
Chukotka	37	216	LK, KAM-01, KAM-03, KAM-08, VAK
Siberian Arctic (Zhokhov I.)	–	14	LK
Manchuria (Northeast China)	–	533	PA, BP
Korean Peninsula	14	211	PA, KO
Hokkaido Island	53	–	SH-OK, AK, TM
Number of samples	**281**	**2826**	**3107****

* BP Basaltic Plateau; PA Paektusan Volcano region; OP Obluchie Plateau; SH-OK Shirataki and Oketo; AK Akaigawa; KAM-01 – KAM-15 various Kamchatkan sources (see for details: *Grebennikov, Kuzmin 2017*); LK Lake Krasnoe; VAK Vakarevo type; KO Koshidake; TM Tokachi-Mitsumata.
** Total number of obsidian samples analysed for this overview (see text for references).

Tab. 1. Number of samples analysed for each region of Northeast Asia (1992–2019), and major obsidian sources used in prehistory.

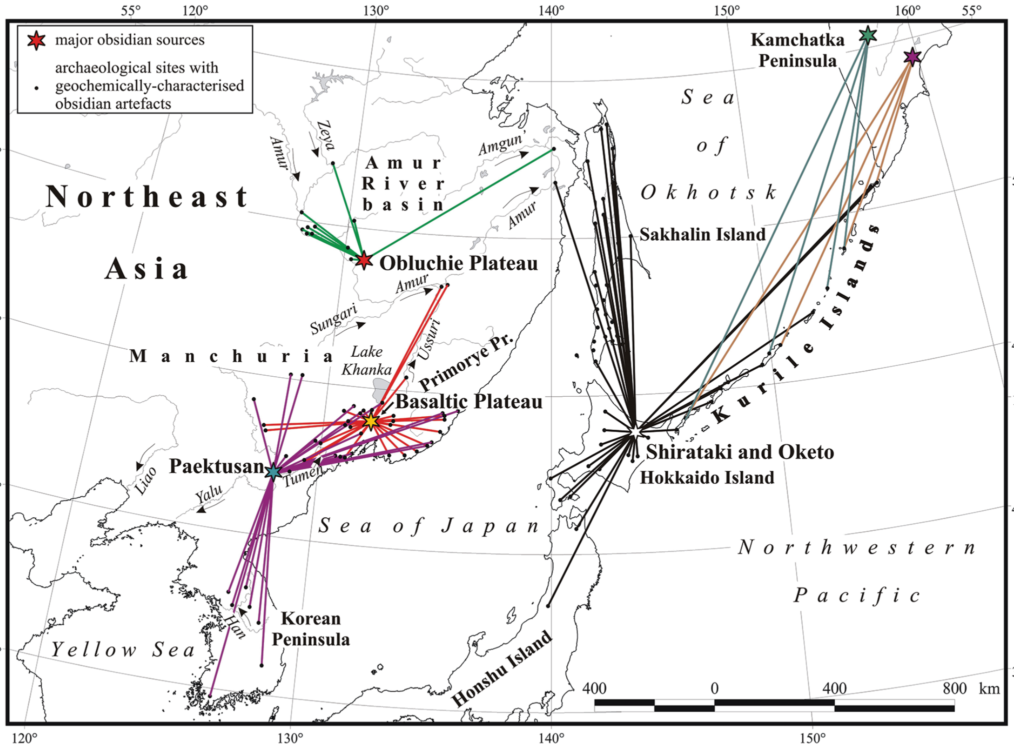

Fig. 1. Prehistoric obsidian exchange/trade networks in the southern Russian Far East and neighbouring Northeast Asia (after* Kuzmin 2017*, modified).

Nevertheless, all these data testify in favour of a single geochemical group which reflects the 'geochemical signature' of a primary source. Based on comprehensive analysis of all available evidence, it is concluded that the primary obsidian locale previously named 'Paektusan' or PNK1 is situated somewhere south of the Paektusan Volcano (Fig. 1). It is hoped that in the near future it will be possible to pinpoint the exact position of this important source in the logistically difficult region of North Korea.

Sources of obsidian in the Amur River basin

The major primary source of volcanic glass in the Amur River basin is known from the Obluchie Plateau, where it is confined to basaltic hyaloclastites (*Glascock* et al. *2011*) (Tab. 1; Fig. 1); its geological position is similar to the Shkotovo Plateau. There are also data about the existence of another kind of basaltic obsidian in this region, but the exact location of its source is still unknown. In the meantime, we called it 'Samarga' (*Kuzmin 2014.Fig. 6.1*), and suggest that it is situated in the Samarga River basin, the northern part of Primorye Province (*Kuzmin* et al. *2002a; Glascock* et al. *2011*).

Sources of obsidian on Hokkaido Island

Our informal Russian-US-Japanese group conducted NAA analyses of four major obsidian sources on Hokkaido Island – Shirataki (with two sub-sources), Oketo (with two sub-sources), Akaigawa, and Tokachi-Mitsumata (*Kuzmin* et al. *2002b; 2013; Kuzmin, Glascock 2007*). Other primary obsidian locales from Hokkaido (around 17 in number), consisting of *c.* 17–20 geochemical groups, were investigated by Keiji Wada *et al.* (*2014*) and Jeffrey R. Ferguson *et al.* (*2014*). All these sources are situated in a volcanic arc setting (*Wakita 2013; Wada* et al. *2014*).

Sources of obsidian on Kamchatka Peninsula

The Kamchatka Peninsula of eastern Russia is one of the few regions in the world with a high concentration of obsidian sources, along with the Japanese Islands (*Kannari* et al. *2014.Fig. 4.2*) and Mesoamerica (*Glascock* et al. *1998; 2010*). Today, at least 30 to 40 locales of acidic volcanic glass (associated with rhyolites and rhyodacites) are known in Kamchatka (*Grebennikov, Kuzmin 2017; Grebennikov* et al. *2010*). They are genetically related to the volcanism of the subduction zone of the Kurile-Kamchatkan arc (see *Khain 1994*). The major problem in the geological investigations of this region is its remoteness, and the logistical aspect of fieldwork is difficult and costly.

Currently, our Russian-US group has determined the geochemical composition of only 16 primary sources of Kamchatkan obsidian (*Grebennikov, Kuzmin 2017*). This is due to the difficulty of carrying out fieldwork in the Sredinny Range which is devoid of roads and settlements (*Grebennikov* et al. *2010. 90*). Sources are usually lava flows, extrusive (embedded in other rocks) bodies and pyroclastic flows. Of the 30 to 40 primary locales, 14 sources were actively used in prehistory.

Obsidian source in the Chukotka region (Northeastern Siberia)

It has been known for a long time that an obsidian source exists on Lake Krasnoe (with krasnoe meaning 'red') in the lower reaches of the Anadyr River (*Nasedkin 1983*) (Fig. 2), but more precise information about it was non-existent before our fieldwork in 2009. As a result of a survey and study of obsidian and other rocks on the shore and around Lake Krasnoe, we were able to obtain reliable data on the geology and geochemistry of this source (*Popov* et al. *2017; Grebennikov* et al. *2018*). Obsidian in Chukotka is part of the rhyolites of the West Koryak volcanic belt, and it can be found as pebbles and small boulders on the eastern shore of the lake; the primary source is perhaps currently under water (*Grebennikov* et al. *2018.609*).

Prehistoric obsidian exchange networks in the far eastern and northeastern regions of Russia

One of the main tasks of studying obsidian for archaeological purposes is to establish the patterns of its acquisition from primary sources, which allows reliable reconstructions of obsidian exchange networks, as well as human contacts and migrations in prehistory (*Williams-Thorpe 1995;* see also *Kuzmin 2012; 2015; 2017*). Currently, the existence of several large-scale exchange systems has been established (using obsidian as a commodity) for the southern part of the Russian Far East and adjacent regions, and for Northeastern Siberia (Figs. 1–2). Obsidian in these regions was most intensively exploited in the Stone Age – the Upper Palaeolithic (*c.* 25 000–12 000 years ago) and the Neolithic (*c.* 12 000–3000 years ago) (*Kuzmin 2011; 2015*). In the Bronze and Early Iron ages (*c.* 3000–1500 years ago), the value of obsidian as a raw material almost vanished, with the exception of Kamchatka and the Siberian Arctic, where the ancient populations continued to use it until the arrival of Russian settlers in the 17th–18th centuries AD, who introduced metals.

Three obsidian exchange networks have been reconstructed in the mainland Russian Far East (Fig. 1; Tab. 1), centred around the sources of the Shkotovo and Obluchie plateaus, and the Paektusan Volcano. While obsidian from the Shkotovo Plateau and the Paektusan sources is widely distributed in the region, including Primorye, the Korean Peninsula, Manchuria, and the Amur River basin, the Obluchie Plateau supplied only the Amur River basin. The distances from the sources to the utilisation sites in Primorye and the Amur River basin range from a few kilometres to 660–700km in a straight line, and for the Paektusan obsidian network it is even further, up to 800km (Fig. 1). The extensive exchange of obsidian centred around the Paektusan source was initially established by our group in the early 2000s (*Kuzmin* et al. *2002a*); subsequent studies confirmed this conclusion (*Doelman* et al. *2008; 2012*).

In insular Russian Far East – Sakhalin Island and the Kurile Islands – the main sources of obsidian were Shirataki and Oketo locales on Hokkaido Island (Fig. 1). Obsidian from the Shirataki source was also detected on the mainland (lower reaches of the Amur River), and it was brought there *c.* 8000 years ago (*Glascock* et al. *2011*). The distance from the Hokkaido sources to the utilisation sites in some cases exceeds 1000km in a straight line. For the Kurile Islands, the use of obsidian from several Kamchatkan sources has been established (Fig. 1), with distances of up to 1400–1500km as the crow flies. These obsidian exchange networks are an example of the super-long transport of raw materials, and their existence would be impossible without the use of watercraft from *c.* 10 000 years ago onwards (*Kuzmin 2016; 2017*).

Based on current knowledge on obsidian sourcing in insular Northeast Asia, one can confidently say that obsidian from sources in the Japanese Islands almost never reached the mainland part of the region, except the lower Amur River basin (*Kuzmin* et al. *2013*) and the southernmost part of the Korean Peninsula (*Kim 2014; Kim* et al. *2007; Lee, Kim 2015*). As for the latter, the main supplier of obsidian was the Koshidake source in northern Kyushu Island; it was also transported to the Ryukyu Archipelago in later prehistory (*Obata* et al. *2010; Kuzmin 2010.Fig. 8.8*). The use of watercraft for the creation of this network since the Upper Palaeolithic is evident, because even during the Last Glacial Maximum, *c.* 27 000–23 000 years ago, the Korea (Tsushima) Strait between the Korean Peninsula and Kyushu Island existed, with *c.* 20km width (*Kuzmin 2017.Fig. 4*).

Research conducted on the Kamchatka Peninsula by our group allowed us to reconstruct several obsidian exchange networks, with distances from sources to utilisation sites up to 600–650km in a straight line.

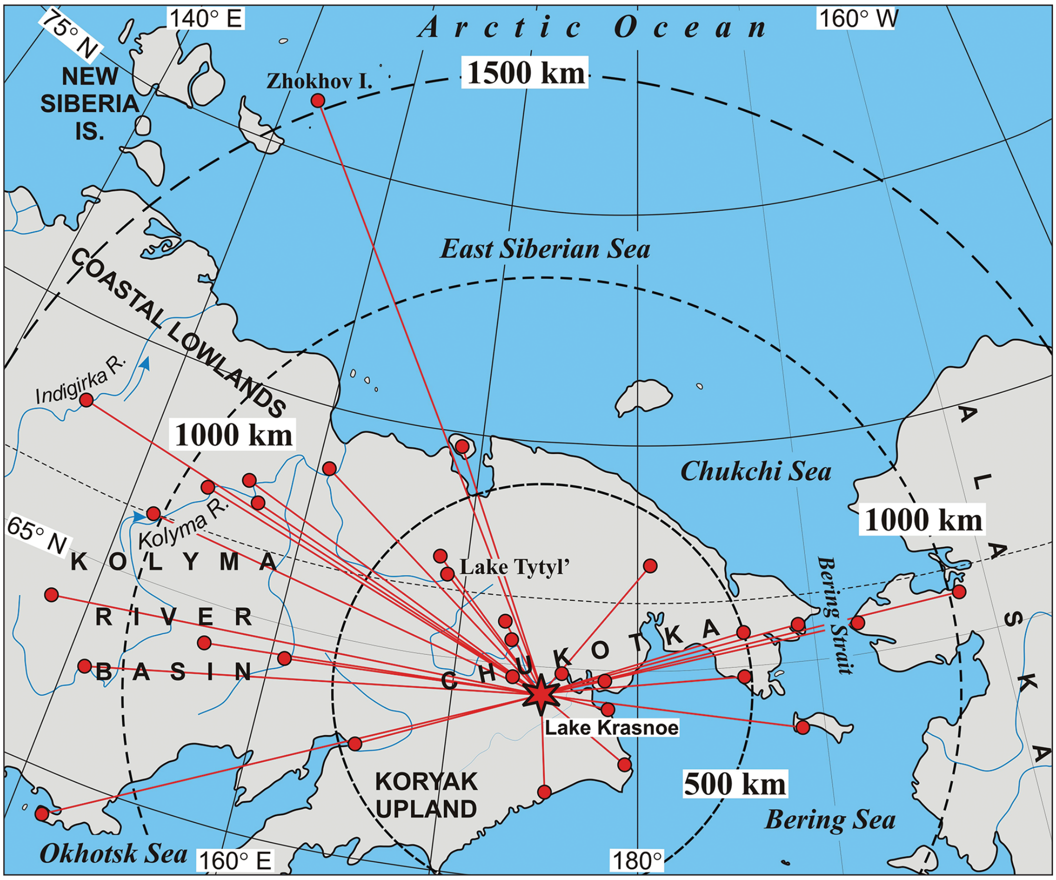

Fig. 2. Distribution of obsidian of the Lake Krasnoe source in Northeastern Siberia and Alaska (modified from* Kuzmin 2019 *and* Pitulko *et al.* 2019*). Red circles are sites with geochemically-characterised obsidian artefacts belonging to the Lake Krasnoe source.

The study of the obsidian sources in Kamchatka is still in its initial stage, primarily due to the high cost of fieldwork in the more remote parts of the peninsula where the majority of sources are located. Currently, on the basis of general geological and geochemical data, the most promising areas that require research have been identified (*Grebennikov, Kuzmin 2017*).

Northeastern Siberia (Chukotka and adjacent areas) is a relatively new territory for the study of obsidian sources at the modern methodological level. According to the results of geochemical analyses of *c.* 220 artefacts from the Chukotka region, a single source of obsidian was found, at Lake Krasnoe (*Grebennikov* et al. *2018*). The raw materials from this locale spread beyond Chukotka – to the Koryak Uplands, the basin of the Kolyma River, and Alaska (*Grebennikov* et al. *2018; Kuzmin* et al. *2018; Rasic 2016*) (Fig. 2). The distance from the source to the utilisation sites in some cases exceeds 1000km in a straight line.

The latest data from this region were obtained for the Zhokhov site in the High Arctic (76°N latitude). Here 79 obsidian artefacts were found in the Mesolithic cultural layer, dated to *c.* 8900–8600 years ago (*Pitulko, Pavlova 2016*). A provenance study of 14 artefacts showed that the raw material of all of them originated from the Lake Krasnoe source (*Pitulko* et al. *2019*). The straight distance between site and the source is *c.* 1500km; considering the coastline of the Arctic Ocean at the time of human occupation, it would be *c.* 2000km (Fig. 2; *Pitulko* et al. *2019. Fig. 7*). The obsidian from the Zhokhov site along with other archaeological localities in Northeastern Siberia (*Kuzmin* et al. *2018*) is evidence of the super-long-distance transport of raw material. It also shows that the size of the human interaction sphere in the Mesolithic of the Siberian Arctic was very large, up to *c.* 4 000 000km^2 (*Pitulko* et al. *2019*).

An important feature of obsidian exploitation by ancient humans in the eastern regions of Russia is the use of this raw material from several sources at a given site from the same cultural component; such cases have been repeatedly noted in Kamchatka, Primorye, Sakhalin Island and the Kurile Islands (*Kuzmin 2014*). The clearest example in this respect is the multilayered Ushki site cluster in Kamchatka (*Kuzmin* et al. *2008*). In the Late Pleistocene Layer 7 (dated to *c.* 12 600–17 400 years ago), seven sources of obsidian were identified. In the Final Pleistocene Layer 6 (dated to *c.* 11 900–12 900 years ago), the use of obsidian from four primary sources was detected. In the Holocene strata 5–1 (dated to *c.* 300–10 100 years ago), obsidian from one to six sources was determined. The distance from the site to the sources of obsidian is *c.* 140–260km in a straight line, and the sources are *c.* 250–500km apart. This complex strategy in the acquisition of valuable raw material in the harsh sub-Arctic environment, revealed after obsidian provenance research done by our group (see *Kuzmin* et al. *2008; Grebennikov, Kuzmin 2017; Grebennikov* et al. *2010*), represents a striking pattern of human adaptation to the natural environment in northeastern Russia in the late Upper Palaeolithic, Mesolithic and Neolithic.

One of the most important aspects in the study of the acquisition and use of archaeological obsidian is the mechanism for acquiring raw material from remote sources. In the southern Russian Far East, the travel distance of obsidian pebbles transported by rivers is up to 30–50km downstream from the source (*Pantukhina 2007*). Because today the presence of long-distance movement of obsidian, which greatly exceeds the range of obsidian transport by natural agents, is well-established (Figs. 1–2; Tab. 1), the issues related to exchange of this high-quality raw material are of great significance. Studies done in the Mediterranean and Near East in the 1960s (*Renfrew 1975*) allowed the creation of the 'down-the-line' concept of prehistoric trade/exchange. The main components of this concept are: (1) a *supply zone*, with a radius of up to 300km from the centre where the utilisation site is located, with the share of obsidian in the composition of the raw materials up to 80%; and (2) a *contact zone* beyond the supply zone, inhabitants of which could not easily visit the sources of obsidian due to the large distance to them, and they exchanged (traded) obsidian with people of the supply zone; the share of obsidian ranges from 30–40% to 0.1%.

In many cases established by our group for eastern Russia, the archaeological obsidians are separated from the primary sources by distances greater than *c.* 300km (Figs. 1–2), and this is evidence of well-developed exchange/trade networks, especially in Northeastern Siberia where the raw material from an obsidian source of Lake Krasnoe was spread in an enormously large area, with straight distances between end points up to *c.* 2000–2250km (Fig. 2). This kind of obsidian spread across an enormously large region can be called 'super-long-distance' exchange. It would be impossible to maintain the acquisition of obsidian from so remote a source without primitive trade and/or exchange, as is also evident in some other parts of Asia (*Campbell, Healey 2018*) and other continents (*Haines, Glascock 2013*).

The reconstruction of exchange/trade networks requires a detailed study of the petrographic composition of stone artefacts, and technical and technological investigation of obsidian products (tools, along with flakes and other sub-products), in order to understand the nature of raw materials brought to utilisation sites – in the form of either angular blocks, cores or finished products. Using the Zhokhov site (Mesolithic, *c.* 8900–8600 years ago) as a case study, one can conclude that obsidian was used for making microblades (*Pitulko* et al. *2019*). No obsidian cores were found, although it seems that microblade manufacture occurred at the site. Therefore, obsidian appeared at the Zhokhov site in a semi-ready form (cores and blades). Other rocks from the Zhokhov site, including local flint and sandstone, and 'exotic' chalcedony, were also used as raw materials for the manufacture of microblades by pressure flaking (*Pitulko* et al. *2012*). The technological analysis of the lithics concluded that the raw material was not in the form of blocks, but prepared cores and large blades were transported to the site. This is true in terms of both local and 'exotic' rocks (*Pitulko* et al. *2012. 240*).

Some information on the distribution of obsidian artefacts and their typological characteristics exists for other parts of Northeastern Siberia (Fig. 2). At archaeological sites in the lower Kolyma River course dated to the Neolithic (*c.* 7000–3000 years ago), the main obsidian artefacts are blades and their fragments, flakes, insets, and arrowheads, while a few obsidian prismatic cores were also recovered (*Kuzmin* et al. *2018*). It seems that obsidian was brought to the lower Kolyma River region from far away in the form of cores, and blade-making was performed locally. The high value of obsidian as an 'exotic' raw material forced prehistoric people to use cores to complete exhaustion. Several sites with obsidian were excavated at the Lake Tytyl' cluster in western Chukotka (*Kiryak 2010*), and they belong to the Mesolithic (*c.* 11 200 years ago) and Neolithic (*c.* 4800 years ago). Some of the artefacts (the exact number is unknown, but it is relatively small), especially points, are made of obsidian. It was suggested that this area may have served as a 'hub' for the exchange of obsidian between the source in eastern Chukotka and the Kolyma River basin and territories west of the Kolyma River (*Pitulko* et al. *2019*) (see Fig. 2). Because in the Kolyma River and Lake Tytyl' regions obsidian was traded as an 'exotic' raw material with populations near the source located at Lake Krasnoe (*Grebennikov* et al. *2018; Kuzmin* et al. *2018*) – at least *c.* 400–800 km away in a straight line – the exchange of it was carried out as prepared cores and tools rather than unworked pieces.

As far as I know, similar work has not yet been carried out in far eastern Russia. Some of the steps taken in this direction for the southern Russian Far East and Manchuria (see *Doelman* et al. *2008; 2012; 2014*) are still at a very preliminary stage.

Conclusions

Over the last 25+ years, significant progress has been achieved in obsidian provenance research in eastern Russia. The main networks of prehistoric exchange / trade of obsidian were reconstructed in the continental and insular parts of the southern Russian Far East; more work is underway in the northern part of the Russian Far East (Kamchatka Peninsula) and in Northeastern Siberia.

However, several issues still remain unresolved. The lack of standardisation for geochemical analyses conducted by different researchers has often made it impossible to compare the results obtained. To overcome this problem, a parallel analysis of obsidian source samples from Hokkaido Island was conducted in several laboratories, followed by interpretation of the results and determination of the optimal analytical strategy (*Suda* et al. *2018a*). The Kamchatka Peninsula remains the least studied region in eastern Russia in terms of the provenance of archaeological obsidian; the exact positions of seven sources used in prehistory are currently unknown (*Grebennikov, Kuzmin 2017*). The question of the mechanism of obsidian exchange between the populations near the sources and those who lived at a considerable distance from the primary obsidian locales requires in-depth study.

ACKNOWLEDGEMENTS

This study was conducted on the State Assignment of the Sobolev Institute of Geology and Mineralogy, Siberian Branch of the Russian Academy of Sciences, with funding provided by the Ministry of Science and Higher Education of the Russian Federation. I am grateful to several colleagues for long-term collaboration, especially to Dr. Vladimir K. Popov (deceased), Dr. Michael D. Glascock, Dr. Andrei V. Grebennikov, and Dr. Vladimir V. Pitulko; to Prof. Emeriti Akira Ono and Jong-Chan Kim; and to Prof. Clive Oppenheimer. I am grateful to Prof. Mihael Budja for the invitation to participate in this volume, and to an anonymous reviewer for useful comments. Dr. Susan Keates kindly corrected the grammar, although all possible mistakes belong to me.

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