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Decorative Volcanic Glasses from Hyaloclastites of the Shkotovo Basaltic Plateau (Primorye, Russia)

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俄羅斯 Primorye之水生凝灰岩中產出具裝飾性的火山性玻璃，熔岩厚度達250米。其中Shkotovo之玄武岩高原產出兩類火山性玻璃。第一類是與枕狀熔岩及水生凝灰岩有關，第二類形成地殼之簿層熔岩。兩類玻璃的顏色、形成條件、物理特性及分佈均有不同。

Among the decorative volcanic glasses a special place belongs to the glasses associated with the eruption of basalt lavas. In Primorye these decorative volcanic glasses occur in hyaloclastites, pillow lavas, and thin lava tongues, widely distributed within the Shkotovo basaltic plateau, covering an area of about 4500 km^2. In the north-eastern margin of the Shkotovo plateau, there are hyaloclastite outcrops in a strip of the north-west strike the length of which is about 70 km and the width 5-7 km (Fig. 1).

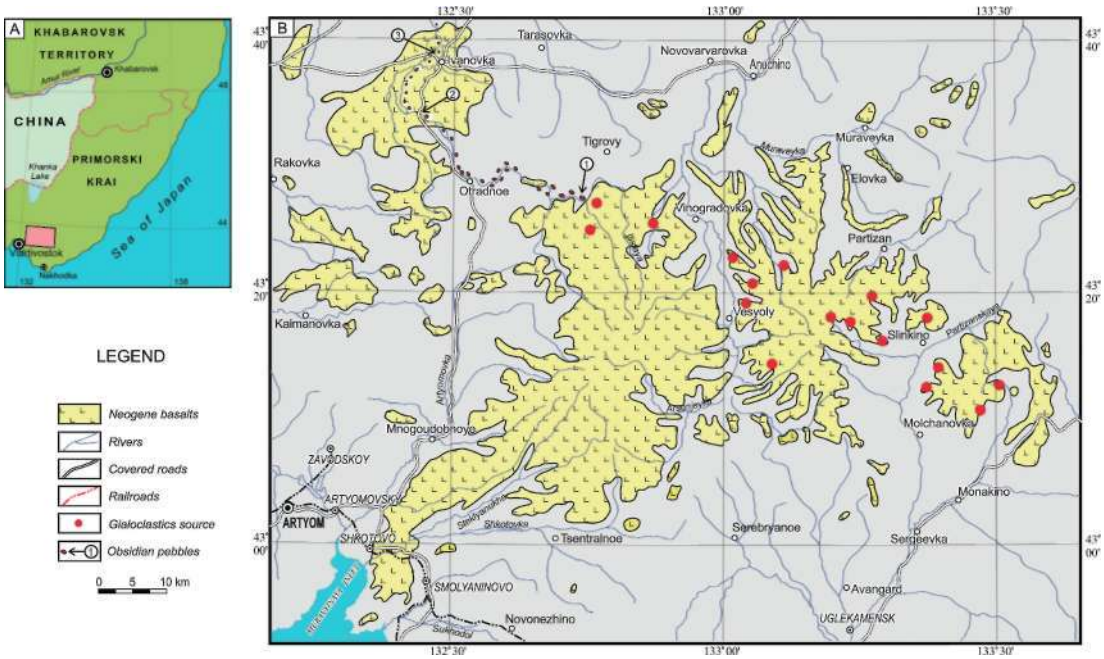

Fig. 1 Distribution of hyaloclastite occurrences in basalts of Shkotovo plateau.

The outcrops of hyaloclastites are confned to the lower parts of the basalt plateau section. Hyaloclastites and pillow lavas are associated with the underlying layers and overlapping them are massive and porous lava flows of andesite-basalts of different thicknesses (from 1 to 7 m). Towards the upper layer of the section, andesite-basalts are overlapped by lavas of olivine and high-alumina (often, megaplagiophyric) basalts. The lavas of subalkali- and alkali-basalts complete the plateau section. The total thickness of the section of the lava complex of rocks is about 250 m. Data of the absolute ages of volcanic glasses suggests that they were formed in the Late Miocene (Table 1). In the present paper, the results of studying these "uncommon" volcanic glasses in the sources of the Ilistaya River basin are presented.

Two genetic types of volcanic glass sources are identifed in basalt-andesitic lavas from the Shkotovo basaltic plateau. The first type is associated with pillow lavas and hyaloclastites. The second genetic type forms lava tongues and quenching crusts of thin lava flows. Volcanic glasses from these sources differ in colour, and in the conditions of formation, in their physical properties, and distribution.

The quenching crusts of volcanic glass of pillow lavas are a source of lavaclastic material in various genetic types of hyaloclastites. These glasses vary in thickness from 1 to 15 cm. Individual large fragments are represented by massive glass and exhibit no cracks. In general, the quenching crusts formed in pillow lavas are composed of glass and are dissected by numerous cooling cracks (Fig. 2). Black volcanic glass forms large fragments (up to 10-15 cm in diameter) in hyaloclastites or, in the central parts of the individual pillows, they are broken by cooling cracks into separate massive fragments. This type of volcanic glass is formed when a lava flow interacts with water [1].

Fig. 2 Volcanic glass constituting the central part of pillow lava.

Rarely, volcanic glasses coloured dark blue and gray occur in pillow-lavas and hyaloclastites. They form quenching crusts on the individual pillows where a gradual colour transition from black (on the surface of a pillow) to dark blue (on the inside of the intermediate zone) and gray (in the internal zone of the quenching crust) are observed. Gray glass changes its texture to a glassy-microgranular (aphyric) in the central part of pillows. Dark blue volcanic glass is more viscous than the black glass and it is more diffcult to process. The gray volcanic glass contains voids, sometimes comprising a significant number of crystal grains, which considerably reduce its technological qualities. Colour zoning is observed from black to dark blue and further to gray in a direction running from the external quenching crust to its internal parts.

Thin lava flows and lava tongues represent another genetic type of volcanic glass different from glass from pillow-lavas and hyaloclystites. Volcanic glass forms quenching crusts on lava flows and lava tongues. The volcanic glasses show variable dark blue and gray colouring with tincture varying from dark blue to light gray (Fig. 3). These crusts range in thickness from 2 to 10 cm.

Fig. 3 The internal structure of a lava tongue composed of volcanic glass coloured dark blue (an external zone) and gray (an internal zone).

Many pebbles of basaltic glass are to be found in the banks of the Ilistaya River (Fig. 4). Basaltic glass artifacts and tools are common and have been found at many sites dating from the Late Pleistocene – the Early Holocene in the Primorye region [2,3,4].

Fig. 4 Gravel fragments of volcanic glass from the banks of the Ilistaya River.

In comparison to the black volcanic glasses from pillow-lavas and hyaloclystites, quenching glasses of lava flows are characterised by an inhomogeneous internal texture that considerably reduces their quality. Studying such volcanic glasses of various colours under an optical microscope and a Scanning Electron Microscope established an homogeneous structure of black volcanic glass and an intermediate structure of a volcanic glass dark blue in colour. The most heterogeneous structure of gray volcanic glass is caused by the presence of numerous crystallites (Fig. 5).

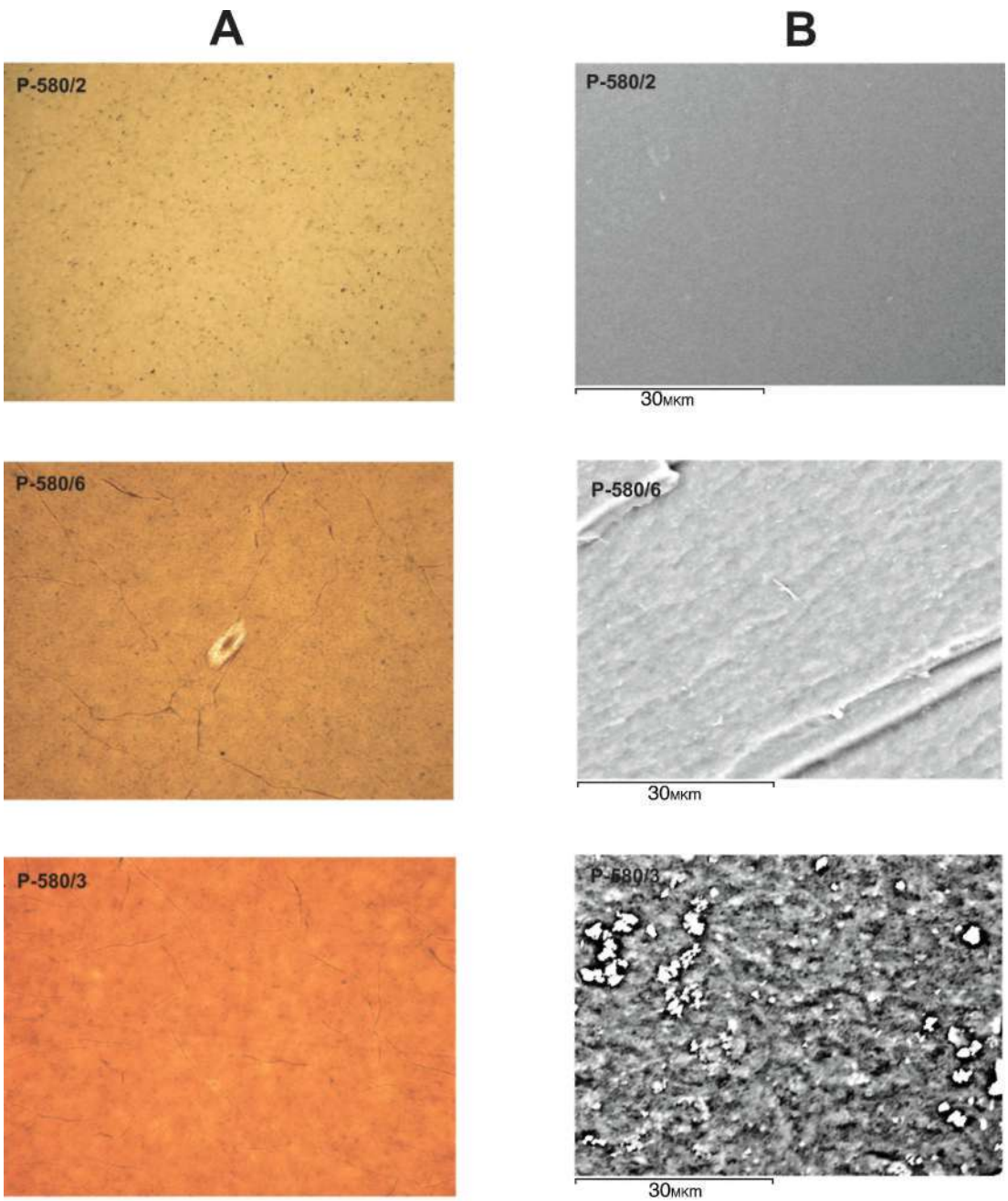

Fig. 5 The optical (A) and scanning (B) electron microscopy pictures of the different inner structures of the volcanic glasses (P-580/2 (black), P-580/6 (dark-blue), P-580/3 (gray) from the Shkotovo basaltic Plateau.

Two differently coloured volcanic glass cabochons (Fig. 6) were examined with common gemmological equipment.

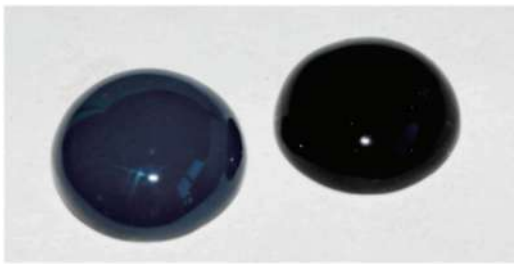

Fig. 6 Cabochons of blue (No.1 - 25,426 ct) and black (No.2 - 18,731 ct) volcanic glasses.

The gemmological features of the samples studied (No.1 and No.2) are (according to the GIA System) as follows:

Sample No.1

Colour: B, tincture *gb*, saturation *slgr*

Refractive index: 1.52

Thermal conductivity test - glass, isotropic, in UV rays (356 and 254 nm) inert.

Sample No.2

Colour: black

Refractive index: 1.59

Thermal conductivity test - glass, isotropic, in UV rays (356 and 254 nm) inert.

A group of sources revealed in the A group of samples from the Miocene basalts of the Shkotovo plateau proved to be the most unusual. The chemical composition (Table 2) of volcanic glasses of this group is fundamentally different from the rhyolitic obsidian that is "common" to the archaeological sites of many regions of the world. These "uncommon" glasses form the quenching crusts of basaltic lavas and, as for their chemical composition, they fall into the group of basalt glasses often called tachylytes or hyalomelanes [5]. What use was made of such basalt glasses in antiquity is only known in a few regions of the world. However, in the Shkotovo plateau the history of its volcanic glasses *is* known. They were used widely by the ancient people in stone tool production, and continue to be used today - although now this is as decorative ornaments.

Table 1. K-Ar: Ages of the volcanic glasses from the Shkotovo basaltic plateau

Sample	Volcanic Glass Colour	Potassium, % ± *a*	$^{40}Ar_{rad}$ (ng/g) ± *a*	Age, Ma ± 2cr
P-567	Black	0,410±0,012	0,362±0,003	**12,7±0,8**
P-571	Dark-blue	0,432±0,012	0,410±0,003	**13,6±0,8**
P-572/2	Black	0,398±0,012	0,378±0,003	**13,6±0,8**

Table 2. Representative major (wt %) elements of volcanic glasses from the Shkotovo basaltic plateau

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3*	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total
P-567	55,54	1,36	15,30	10,49	0,14	5,89	7,41	3,36	0,47	0,17	100,13
P-571	55,27	1,36	15,44	10,61	0,14	5,80	7,54	3,26	0,50	0,17	100,09
P-572/2	55,79	1,37	15,38	10,32	0,14	5,73	7,36	3,27	0,47	0,17	100,53

* Total iron Fe_2O_3

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References:

1. Batiza, R., With J.D.L. (2000) *Submarine Lavas and Hyaloclastite.* In H. Sigurdsson (Ed.), Encyclopedia of Volcanoes. San-Diego: Academic Press. pp. 361-381.

2. Kuzmin Y.V., Popov V.K., Glascock M.D. and Shakley M.S. (2002) *Sources of Archaeological Volcanic Glass in the Primorye (Maritime) Province, Russian Far East.* Archaeometry. 2002. Vol. 44. No 4. pp. 505-515.

3. Kluev N.A., Septsov I.Y. (2007) *Late Pleistocene and Early Holocene Uses of Basaltic Glass in Primorye, Far East Russia: a New Perspective Based on Sites Near the Sources.* Bulletin of the Indo-Pacific Prehistory Association. Canberra: Australian National University. Vol. 27. pp. 129-134.

4. Doelman, T., Torrence, R., Popov, V. , Ionescu, M., Kluyev, N., Sleptsov, I., Pantyukhina, I., White, P. and Clements, M. (2008) *Source Selectivity: An Assessment of Volcanic Glass Sources in the Southern Primorye Region, Far East Russia.* Geoarchaeology. Vol. 2. No 2. pp. 243-273.

5. Tomkeieff S.I. (1986) *Petrological English-Russian Explanatory Dictionary.* M., Mir. Vol. 1, p. 285. Vol. 2, p. 284.