UHPHT Glasses in Bottom Suevite Facies (Ust´-Kara, Arctic Ocean, Russia)

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Abstract. Amorphous substances, including glasses, are very important kind of value materials for numerous applications. Among the glasses the impact matter has especially high fundamental interest and use potential, being formed under extremely high PT conditions – up to hundreds GPa and thousands degrees Celsius. In this direction the detail studies of new natural occurrences with UHPHT impact glasses and their features are very actual fundamentally and probably potential useful for new ideas for technologies. Our analytical studies of the UHPHT ribbon-like impact glasses of the Ust´-Kara area at the Baydarat Bay (Kara Sea, Arctic Ocean) revealed the presence a number of special features such as multilevel differentiation of impact melt and coesite abundance. The specifics of the Ust´-Kara UHPHT glasses rather point to bottom facies of the suevitic breccia. The observed impactites characteristics allow to see new geological importance of the studied Ust´-Kara suevites, allow to correct geological model of the impact structure.

1. Introduction
Numerous amorphous substances belong to very valuable types of materials, where glasses have especially important for different applications. The high top interest in the field is connected with the state of matter under extreme conditions [1-5]. In the nature the formation conditions of the glasses arise from magmatic melts (for example volcanic glasses and buchite); under impact (shock) processes (including melt impactites and tektites), and also, by quite rare fulgurite occurrences formed under lightning discharges, additionally in the nature some matter can be formed under nuclear weapon explosions [5]. Analyzing a variety natural glasses it is follow that they are quite widely spread on the Earth, Moon and Venus. In general, the substances have very wide range of chemical composition, structure and properties. Among the listed glasses the impact matter is especially potentially interesting [5]. According to the technical possibilities of the modern facilities for lab modelling of high pressure high temperature (HPHT) materials only tiny-sized particles can be produced with sizes no more than counting hundreds of micrometers under pressure usually up to 100 GPa and usually at room temperature [1-4]. The mentioned impact glasses are formed under extremely high conditions - up to n×100 GPa and n×1000 °C. The impact glasses recently attract active attention after our discovery of unusual natural UHPHT impact glasses forming vein bodies within the Kara astrobleme (Pay-Khoy, Russia) in 2015. The Kara glasses have been described in our publications in 2018-2020 [5-8]. Thus, the new impact objects with the UHPHT glasses are actual to be find and have a focus of our present interest. Here we describe our find of the HPHT impact glasses on the Ust´-Kara Area being set close
to the Kara astrobleme and in some works assigned to an independent meteorite twin crater of the single Kara impact event.

2. Materials and methods
The material was sampled in 2019 at the Baydarata Bay sub-seashore area (Kara Sea, Arctic Ocean, Russia) (Figure 1). The suevites with UHPHT impact melt glasses have described in natural outcrops. The detailed investigation of the impactites have been provided by a complex of mineralogical, petrological and geochemical methods in the Center of collective use of the Institute of Geology of Komi Scientific Center UB RAS (IG FRC Komi SC UB RAS, Syktyvkar, Russia). The methods included optical microscopy, Raman spectroscopy (RS), scanning electron microscopy (SEM) and electron microprobe analysis (EMPA).

Figure 1. Geographic position of the Kara region (red square) on the Google map (a) and geological position of the Kara Meteorite Crater and the Ust’-Kara Area (b) on the part of the State Geological Map of the Russian Federation, R-41, Anderma, scale 1:1000000 [9], the work region is marked by a red square.

The preliminary optical study has been performed using POLAM R-312 polarization microscope (LOMO, Russia). For the detail information about spatial relations of the liquation and crystallization differentiates of the UHPHT impact glasses we used a scanning electron microscope TESCAN VEGA3 (Czech Republic) equipped by energy dispersive device (Oxford instruments X-Max). For the SEM and
microprobe study of suevites with UHPHT impact glasses we used thin polished sections of the large square – 3×4 cm which were covered with a conductive thin carbon layer. The large square allowed to watch better the varying matter through the suevitic inhomogeneous structure. For the phase state diagnostics and phases relations within the suevite components and glasses a high-resolution Raman spectrometer LabRam HR 800 (Horiba Jobin Yvon) has been used for point analysis with locality about 1 µm and phase mapping. The Raman spectra have been recorded at room temperature with Ar+ laser (514 nm) excitation.

3. Results and discussion
During the expedition 2019 we have observed the suevites extended along the Baydarata Bay of the Kara Sea, Ust'-Kara Area (UKA), where the outcrops chain gets about 20 km till the Tolstik Cape to the west from the presented point (Figure 2). Among the analyzed suevites following to their structural-textural features we have divided 8 varieties differently presented on the ocean shore. The suevites form long chain with tooth-like ledges interrupted sometimes with large fragments of disintegrated giga-breccia blocks of black shales. The latter are intensively destroyed and form niches. Sometimes within suevites grottos can be observed which formed after fully or partly destroyed large fragments of the target black shales. The observed from the surface wideness of the suevitic zone lasts on the distance of about 1 km from the ocean line into the continent land.

Figure 2. Suevite continuing outcrop along the seashore of the Baydarata Bay of the Kara Sea, Ust’-Kara Area. The image orientation corresponds to South-East in the left-right hand direction. The suevitic outcrops line goes up to the horizon (several kilometres in extention), the suevite visible thickness at the nearest point view is about 8 m.
Figure 3. Natural outcrop of two types of suevites – bottom flow and air-fall varieties. The Baydarata Bay of the Kara Sea, the Ust’-Kara Area. North direction – from left to right.

Figure 4. The violet glasses (Gl) within the proposed “bottom flow” suevite in the natural outcrop. The Baydarata Bay of the Kara Sea, the Ust’-Kara Area.
Sometimes the suevites relate with impact melt rocks being in a tight position with not well observed contacting line between the impactites, with continuous pass from the melt rock to suevite. The melt rocks have thickness up to 2-3 meters and form lens-like bodies usually covered by suevitic masses with abounding glasses. In spite on the wide variety of the suevitic breccia at the Ust’-Kara Area, we would to take attention to the bottom and top parts of the suevitic sequence.

Analyzing UKA suevites, first of all, we took attention to the presence of violet glasses abounding within the suevite variety at the bottom of the outcrops. Following to the field observations we describe them as rather stream-like (belt-like) strongly twisting thin bodies penetrating the host suevite (suevite II by field descriptions). The UKA suevite II has tight massive structure with preferably small size of target fragments (about 1 cm) in the general matrix. At the same time going to the top large melt bombs are widely spread (Figures 3, 4) often having zoned structure with the core either by heated black shales or violet (figure 4) and rose glass with abundant coesite microcrystals (Figure 5).

As impact glasses are in the center of our special interest being a potentially value material for the extremely solid matter [5] we had spend the more detail study with the focus to the observed violet glasses which look on the glance view similar to the UHPHT vein glasses of the Kara astrobleme studied by us in detail [5-8]. In this paper we describe just the slight view to the specific impact glasses, pointing just to their general characteristics.

Following to preliminary studies by SEM, microprobe and Raman spectroscopy we see that the violet impact glasses are presented with aluminosilicate general mass which is preferably tiny crystallized with pyroxene (augite) microcrystals. At the same time within the general aluminosilicate impact glass there are silica glass drops with smectite “smaller drops” and abounded coesite microcrystals mainly in the centers of the SiO2 drops (Figure 5).

![Figure 5. SEM images of the phase components of the violet glasses – SiO2 glass drops (a) with coesite microcrystals within the silica glass (b). The SEM images correspond to the violet glass on the figure 4.](image-url)
This feature of the UKA violet glasses look to be very similar to the Kara vein glasses. The general difference is the shape and morphology of the UKA glasses – strongly twisting thin bodies penetrating the host suevite while the Kara UHPHT glasses have better recognized vein or vein-like morphology within the more friable host suevite [5-7]. Also, at this stage of the study it is rather look that the UKA bottom suevites are more rich in coesite presence but in some cases with related quartz and less level if the impact melt differentiation. Thus, the UKA glasses can be attributed to the UHPHT variety but probably with some lower pressure level.

4. Conclusions

By the provided field study followed by instrumental mineral matter analysis we have found for the first time the unusual features of the UKA suevites. First of all, it would be important to underline that at the Ust’-Kara Area suevites have several varieties with different structural-textural features differ in impact glass abundance and its origin, fragments sizes, rock density and color. The melt rocks are present at the Baydarata Bay but in several lens bodies in tight relation with suevites. Among the divided suevitic breccia we point to the bottom variety differ from the others by dense small-size clast character with abundance of violet glasses with coesite. Thus, on the basis of our studies we propose that the UHPHT impact glasses are quite widely spread at the UKA region. Following to the bottom position of the described suevites we propose their possible belonging to the “bottom flow” variety. As the “bottom” impactites facies by the moment are not clear in detail, the UKA impactites can be a nice object to recognize and describe the facies at the fundamental level as the impactites have nicely observed relations between suevite breccia varieties and have widely spread natural outcrops. The future facies analysis would allow to correct the real diameter and structure of the Kara-UKA impact object.

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