UHPHT COESITE-CONTAINING VEIN-TYPE MELT GLASSES IN SUEVITES OF THE GIANT KARA METEORITE CRATER (PAY-KHOY, RUSSIA). T. G. Shumilova[1], S.I.Isaenko[1], A.A.Zubov, [1]Institute of Geology FRC Komi SC UB RAS, Pervomayskaya st. 54., Syktyvkar, 167982, Russia; shumilova@geo.komisc.ru; s.i.isaenko@gmail.com; dixares@gmail.com.

Introduction: The disordered substances such as glasses belong to value type of materials. The latter formed under extremely high PT-conditions have especial interest in fundamental field and in perspective for high-tech technologies. But usually experimental technologies are provided at room temperature under pressures lower 1-2 GPa (exclusively rare up to 8 GPa). But, it is strongly previewed that high temperature can have very important role for glasses structure and properties [1]. However, by present the latter remain insufficiently clear, despite actively conducted studies in materials science.

At the same time natural impact glasses formed under ultrahigh pressure high temperature (UHPHT) is the least studied as a possible new type of high-pressure materials. Progressively the analysis of natural impact glasses can dive a fundamental information on the noncrystalline substances formation under extreme conditions, about their stability, and also to estimate them from the point of possible materials for hi-tech applications, in particular for different microelectronics and high-energy laser technologies.

Here we present our recent results on the found by us an unusual type of ultrahigh pressure high temperature vein glasses from the giant diamondiferous Kara meteoritic crater [2-5]. The UHPHT glasses have been found in 2015 within suevite complex at the edge of the Southern part of the Kara meteoritic crater on the right and left banks of the Kara river (Pay-Khoy, Russia). The glass bodies have subvertical stockwork-like complex of the veins with the thickness 0.5-10 cm [1]. The latter have cut position to the host suevites. The UHPHT nature of the vein glasses has been proven by presence of melt crystallized defect-free coesite within liquated structures of silica/aluminosilicate glasses [2].

Results: On the basis of X-ray diffraction studies it is established that the UHPHT vein glasses have the lowest crystallization degree in comparison to other condensed impact melts – bulk clast-free and clast-poor melt rocks and vitro-clasts in suevite. The bulk melt rocks are characterized by high degree of crystallinity – up to 90%; the clastic melt glass within suevite breccia has divided into two varieties – containing up to 10% of an amorphous component and its total absence. The vein glasses cutting suevite have the largest content of an amorphous component can get up to 95% according to X-ray diffraction measurements.

The especial specifics of the found UHPHT vein glasses is connected with presence of several levels of liquation, which partly has been described in [2].

The uniform sites of aluminosilicate impact glasses contain in local areas rather evenly the distributed clinopyroxene microcrystals with their possible higher concentration in inhomogeneous regions. The detailed studies by means of the high-resolution transmission electron microscopy showed that the coesite microcrystals are located in completely amorphous SiO_2 glass (Figure 1, 2). It is established that the vein ultrahigh-pressure impact glasses are characterized by high content of nonstructured molecular H_2O in comparison to massive clas-poor melt rock, vitro-clasts within suevite and the sedimentary rock target.

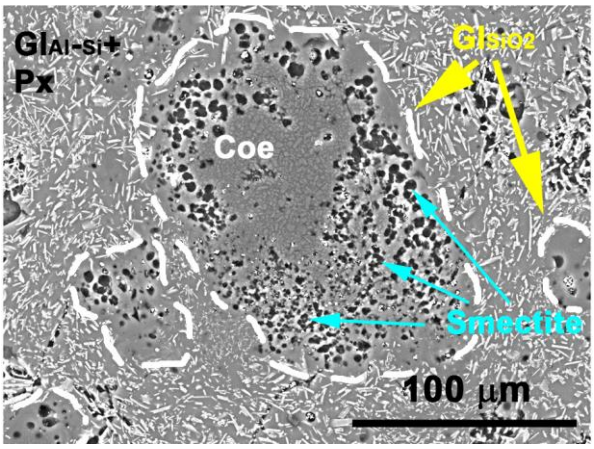

Figure 1. Scanning electron microscopy image of UHPHT glass with silica glass drops including melt crystallized coesite, Gl_{Al-Si} – aluminosilicate glass, Px – pyroxene, Gl_{SiO2} – silica glass, Coe-coesite; Smectite – smectite inclusions within silica glass, the silica glass "drop" boundaries are marked with perforated line.

The detailed analysis of UHPHT vein impact glasses structure with use of the high resolution transmission electron microscopy allowed to reveal presence of smectite crystallized directly from an impact melt [5].

Nanostructures of UHPHT vein impact glasses of the Kara astrobleme under comparing with low pressure low temperature glasses of natural and artificial origin showed a number of features. The comparative analysis of the impact glasses of in-crater impactites, outer crater emissions, volcanic and artificial glasses,

including Suprasil standard, showed that the low pressure fast quenched impact glasses have more uniform SiO_2 matrix with smaller amount of impurity in comparison to volcanic glasses and high pressure impact glasses of suevites. In the complex analysis of atomic force microscopy data and microprobe analyses the dependence of the extent of nanostructural heterogeneities of natural glasses from a saturation of their structure by cations modifiers (Al, Na, Ca, Mg) is revealed [4]. The especially strong influence is noticed in connection with Na impurity presence that, most likely, in many respects and defines nanostructural heterogeneity of natural silica-alumina glasses.

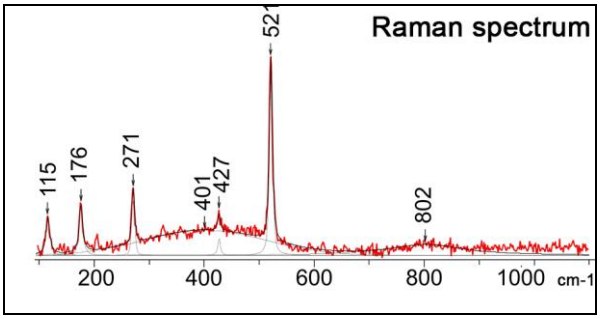

Figure 2. Raman spectrum of coesite crystal within silica glass.

Some physical properties of the impact glasses have been investigated. Absolute values of nanohardness has the strong dispersion – from 2000 HV to 10-100 HV. This circumstance, most likely, is defined by inhomogeneities in the studied impact glasses resulted by non-uniform distribution of impurities and, also possibly, caused by the non-regular content of non-structured water and crystallization degree level of an impact melt.

According to spectroscopic studies with ultraviolet Raman spectroscopy the very low degree of polymerization of the impact glasses is established. Besides, the experimental data about a possibility of existence of a certain specific state – carbon-containing silicate glass, which was revealed as separate particles among products of thermochemical extraction and in subsurface layers of impact diamonds, was obtained. And also it is revealed directly within a matrix of the vein glasses "in situ". This find will be studied in the future works in detail.

Conclusion: The complex analysis of geological, mineralogical-petrographic, petrochemical features and degree of crystallinity of melt impactites (clast-poor melt rocks, vein glasses and vitro-clastic formations from suevites) to establish that the structural and phase states of the melt impactites are defined, first of all, by the initial character of the melted sedimentary target and cooling velocity of an impact melt. The large volumes of an impact melt created massive clast-poor melt bodies have longer cooling underwent with the almost complete crystallization. The obtained data indicate the specific nature of melt glasses of vein type and prospects of their further study of the fundamental questions and application perspectives.

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References:

[1] Bolmatov D., Brazhkin V.V., Trachenko K. (2013) *Nat. Commun. 4,* 2331, https://doi.org/10.1038/ncomms3391.

[2] Shumilova T. G , Isaenko S. I., Makeev B. A , Zubov A. A., Shanina S. N., Tropnikov Ye. M., Askhabov A. M. (2018) *Dokl. Earth Sci., 480(1),* 595–598. DOI: 10.1134/S1028334X18050070

[3] Shumilova T. G., Lutoev V. P., Isaenko S. I., Kovalchuk N. S., Makeev B. A., Lysiuk A. Yu., Zubov A .A. (2018) *Sci. Rep., 8.* DOI:10.1038/s41598-018-25037-z.

[4] Golubev Ye. A., Shumilova T. G., Isaenko S. I., Makeev B. A., Utkin A. A., Suvorova E. I., Ernstson K. (2018) *Non-Crystalline Solids, 500,* 388–400.

[5] Shumilova, T.G. , Zubov, A.A., Isaenko, S.I., Karateev, I.A., Vasiliev, A.L. (2019) *Sci. Rep.*, submitted.