TRANSMISSION ELECTRON MICROSCOPY OF IMPACT CARBON PRODUCTS FROM THE GIANT KARA ASTROBLEME. V. V. Ulyashev[1], T.G. Shumilova[1], B. A. Kulnitskiy[2], I. A. Perezhogin[2], V. D. Blank[2], [1]Institute of Geology FRC Komi SC UB RAS, Pervomayskaya st. 54., Syktyvkar, 167982, Russia; vas-kom77@mail.ru, shumilova@geo.komisc.ru; [2]Technological institute of superhard and new carbon materials, 7a Tsentralnaya street, Troitsk, Moscow, Russia, 108840, info@tisnum.ru.

Introduction: Under natural impact processes not only graphite, but also other varieties of carbonaceous substance can be treated including the organic matter of sedimentary rocks in targets. By present only two non-graphitic objects with after-coal diamonds had been found and described for the first time about 30 years ago at the giant Kara (65 km in diameter) and Ust`-Kara (25 in diameter) astroblemes (Pay-Khoy, Russia) [1]. The deep studies of the after-coal diamonds was provided 3 decades ago and were no any novel information on the modern level had been provided. Thus, the detail structure, composition and formation mechanism of the impact diamonds are still not clear. In this work we have provided high resolution transmission electron microscopy (HRTEM) studies of after-coal diamonds, diamond fossils and co-following carbons. Thus, the vision on the carbon varieties at the Kara astrobleme has been essentially corrected and developed.

Material and methods: The carbon particles have been enriched from the impactites of the Kara impact crater by thermochemical dissolution of the host rock, the method had been described in [2]. For the studies we have used powder specimens set on perforated carbon TEM foils. For preliminary studies we used Tesla BS 500 operated at 60 kV and for high resolution investigations JEM-2010 was used with the voltage 200 kV.

Results: As a result of TEM and HRTEM studies we have found out that within the high pressure products of the Kara impactites multiphase nanostructured aggregates occur. The proven phases are presented with ultrananocrystalline diamond, glass-like carbon (Figure 2), holey onion-like carbon (Figure 3), graphite.

It was established that the proposed earlier "togorite" described by Yeserskii as an independent new hard dense carbon mineral (natural dense carbon polymer) was rather presented with tight aggregate of nanocrystalline diamond core covered with glass-like carbon [2].

The spatial relationship between glass-like carbon and nanodiamond diamond on a nanolevel was analyzed for the first time, the borders are clear, without gradual transitions and violations of structure. The all studied carbon phases are without signs of mechanical deformations. The nanostructural features of the glass-like carbon allow suppose that the carbons formation temperature was at least 2600 °C for the studied particles [3].

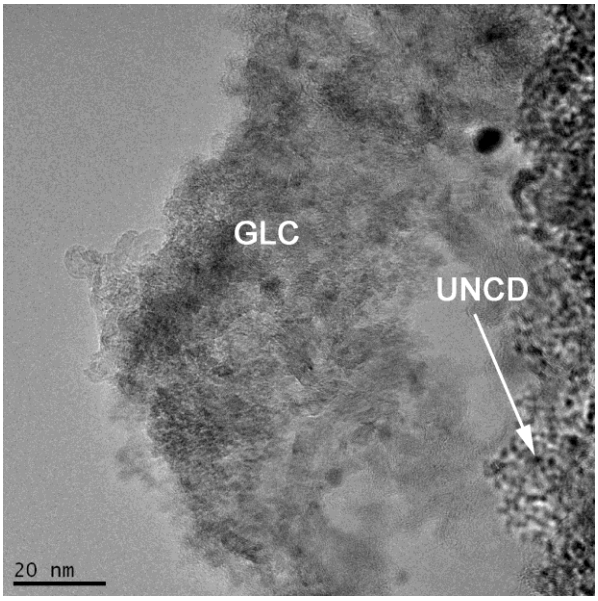

Figure 1. Bright field TEM image of polyphase carbon aggregate: glass-like carbon (GLC) and ultrananocrystalline diamond (UNCD).

Additionally to impact Kara diamond the especially interesting is find of onion-like holey carbon (or multiple concentric fullerene-like carbon shells) [4-6], which never was found earlier within the impact natural objects. It is experimentally known that the onion-like carbons are formed by various ways: 1) transformation of graphite under high pressure, 2) annealing of nanodiamonds, 3) vacuum sedimentation, 4) soot annealing, 5) arc process, 6) radiation treatment on soot by electron beam, 7) ions implantation [5]. From the listed ways for carbon bulbous structures in impactites we see more similarity only with annealing of nanodiamonds with residual high temperatures with transformation to onions.

However, the relic sedimentary origin of onion-like carbons cannot be excluded, as the low ordered carboniferous matter presents within the initial sedimentary rocks of the Kara target, such as shungit-like/coal matter [2]. Usually the experimentally produced onion-like carbons are produced with hole sizes 3-5 nm. The bulbs size increasing is connected with pressure growth

[5, 6]. For example at 55 GPa the bulbs have sizes of 25 nanometers. This size is similar to our case for holey onion-like carbons found in Kara impactites.

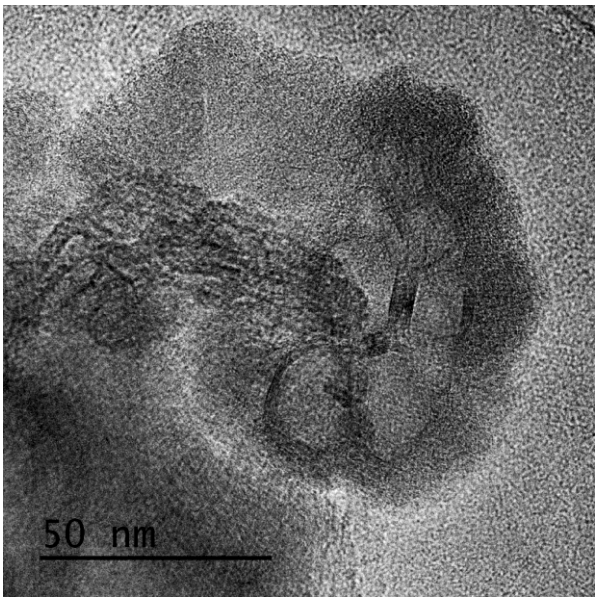

Figure 2. Holey onion-like carbon from the polyphase carbon aggregate, HRTEM image.

Conclusion: The studied carbon polyphase aggregates were formed no less than 55 GPa with the probable temperature about 2600 °C. The simultaneous presence and tight spatial relations of the carbon phases allow propose very nonequilibrium P-T conditions of carbons formation within the very local volume. The future detail studies will allow to get more information on carbon polymorphism under impact processes with possible finds of new carbon phases.

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