HIGH DENSITY PHASES AS AN ATTRIBUTE OF IMPACT STRUCTURES. CONDITIONS OF FORMATION AND PRESERVATION IN SHOCK PROCESSES.

V.I.Feldman [1], L.V.Sazonova [1], E.A.Kozlov [2]

[1]Department of Petrology, Moscow State University, Moscow, Russia, e-mail: feldman@geol.msu.ru ; saz@geol.msu.ru; Russian Federal Nuclear Center - Research Institute of Technical Physics, Snezhinsk, Chelyabinsk Region, Russia

High density phases are considered to be one of characteristic attributes of impact structures. Their presence or absence is usually included into a number of decisive reasons for "pro" or "contra" references of concrete structure to shock-explosive formation. However in astroblemes these minerals are formed in very small amounts, they are distributed in impactites extremely non-uniformly and arise at different times and under different conditions; they have different mechanisms of formation.

At present time *high-pressure polymorphic modification* of SiO_2 (coesite, stishovite), carbon (diamond, lonsdaleite), pyroxene (majorite) and olivine (ringwoodite) are found in impact craters [1-6]. Moreover these minerals have been discovered in meteorites and received in laboratory experiments. We may speak of the four ways of formation of the above listed minerals: 1) martensite phase transition; 2) recrystallization at solid state stages of shock metamorphism with migration of material; 3) crystallization from impact melt; 4) fluid-mineral interaction.

Martensite phase transition is observed in shock wave experiments with dense quartz (more than 1.55 g/cm^3) [7]. In this case quartz transforms into stishovite due to high shear strain with velocities of 10 orders higher than at static compression thus avoiding coesite formation. In nature such stishovite was found in impact crater Ries [8] and also in massive quartzites of crater Arizona [9]. The same mechanism is responsible for paramorphism of diamond after graphite in crater Popigai [2, 3, 6], crater Ries [10] and others.

Recrystallization on solid state stages of shock metamorphism with migration of material is described as well both in experiment and in nature. This also refers to coesite observed after low density quartz (less than 1.55 g/cm3) [7]. In nature such coesite is found in porous quartzites of crater Arizona [9]. The same mechanism is responsible for formation of diamonds (togorites) after coals of Kara crater [11, etc.]. Occurence of ringwoodite after biotite is observed in explosion experiments with loading of slates by converging spherical shock-isentropic waves [12,13].

Crystallization from melt is known for coesite in astroblemes El'gygytgyn [14], Popigai [6], Kamensk [15] and others. In this process the crystal coesite form (needle-like or lamellar habit) well corresponds to the data on measured water contents in melt – low in the first case [16] and high in the second one [17]. Crystallization of stishovite from impact melt is observed in Vredefort astrobleme [18] and in shock-metamorphosed chondrites [19]. The prevailing part of impact diamonds is also formed from melts [2, 3, 6]. And, at last, skeletal crystals of ringwoodite are found in melt glasses of El Gasco (Spain) impact pumices [5, 20].

The fourth mechanism *(fluid-mineral interaction*) is described for formation of *high-pressure* phases of silica in astrobleme Terny [21].

In all listed cases high density phases usually arise in rather short time (parts of second or seconds), which is defined by diminishing rate of shock pressure and temperature. Preservation of these minerals depends on dynamics of temperature changes – they undergo annealing at slow cooling of impactites and consequently more often "survive" in suevite and fall out deposits, while they are extremely rare in melt impactites inside a crater. Extreme heterogeneity of physical and chemical conditions in astroblemes determine non-uniformity of development of high density phases in total amount of mineral structure. All these factors taken together demand very cautious approach to conclusions about presence or absence of high pressure polymorphs in individual cases.

References:

1. Feldman V.I. (1990). Petrology of impactites. Moscow. MSU. 299p. (in Russian). 2. Val’ter A.A. et al. (1992). The shock-metamorphic minerals of carbon. Kiev. 172 p. (in Russian). 3.Vishnevsky et al. (1997). Transaction of United Inst. of Geol., Geoph. and Miner. RAS. Novosibirsk. V.835. 53p. 4. Badyukov (1985). LPS XVI. P.21-22. 5. Diaz-Martinez E. et al. (2001). Impact Marker in the Stratigraphic Record. Abstr. Book. Granada. Spain. P.21-22. 6. Diamond-bearing impactites of the Popigai astrobleme (V.L.Masaitis ed.). (1998). S.-Peterburg. VSEGEI-Press. 179 p. 7. Podurez M.A. et al. (1987). Physic. Of burming and explosion. _1. P.98-101. 8. Engelhardt W. et al. (1969). Contr. Min. and Petrol. V.20. _3. P.203-234. 9. Kieffer S.W. et al. (1980). Review Geoph. a. Space Physics. V.18._1. P.143-181. 10. Rost R. et al. (1978). Doklady AN USSR. V.241._3.P.695-698.(in Russian). 11. Ezersky V.A. (1986). Zapiski Vsesouznogo Mineral. Obstchestva.V.115. _1. P.26-33 (in Russian). 12. Kozlov E. et al (2002). Bayerisches Forschungsinstitut für Experimentelle Geochemie und Geophysik Universität Bayreuth. Annual Report (2002). P.100-102. 13. Kozlov E. et al (2003). Doklady Earth Sciences. P.571-574. V.390. _4. 14. Impactites (ed. A.A. Marakushev) (1981). MSU. 240 p. (in Russian). 15. Val’ter et al. (1982). Miner. Journ. _5. P.21-28. (in Rusian). 16. Kameyama T. et al. (1974). Journal Am. Ceram. Soc. V. 57. _11. P.499. 17. Naka S. et al. (1976). Mem. Fac. Eng. Nagoya Univ. V. 28. _2. P. 265-316. 18. Martini J.E.J. (1978). Nature. V. 272. _5655. P.715-717. 19. Beck F. et al. (2002). Goldschmidt Conf. Abstr. Davos. Switzerland. CDA59.pdf 20. Glazovskaya L.I. et al. (2002). VIII Workshop ESF-Impact Program. Progr. Abstr. A. Field Trip Book. Mora. P.23. 21. Masaitis V. L. et. Al. (1980). Doklady AN USSR. V.255. _3. P.709-713.