THE POPIGAI FLUIDIZITES: DENSE WATER INCLUSIONS IN LECHATELIERITE; EVIDENCE FOR SHOCK-GENERATED CARBONATE AND HYDROS SILICATE MELTS. S. A. Vishnevsky[1], N. A. Gibsher[1], J. Raitala[2], T. Öhman[3] and N. A. Palchik[1], [1]Institute of Mineralogy & Petrology, 3 Koptug prospect, Novosibirsk-90, 630090, RUSSIA, <nadezhda@uiggm.nsc.ru>; [2]University of Oulu, Oulu, P.O. Box 3000, FI-90014, FINLAND, <jouko.raitala@oulu.fi>; [3]the same, <teemu.ohman@oulu.fi>.

Introduction: Earlier, the Popigai impact fluidizites, which are the first occurrence of so kind in the terrestrial impact structures, were preliminary described in [1-3]. The fluidizites form dykes in the target gneisses and are tuff-like agglomerates made up of glass (10-90 vol. %), host gneiss fragments and cryptograin matrix. Commonly, the particles of the glass are fluidal porous (up to pumice state) schlieren "welded" with the matrix and strongly replaced with smectite. There are three types of the glass particles among the "fresh" ones: I) homogeneous glass derived from the target gneisses; II) fine-banded heterogeneous glass, with alternating of "femic", homogeneous (type I) and "salic" species; III) "salic" glasses, including those ones derived from quartz (diaplectic quartz glass and lechatelierite, both coesite-bearing). "Shadows" of "femic" and some other minerals of target rocks, as well as high-temperature indicators (together with lechatelierite, with its melting point >1700°C, there are globules of magnetite, native iron, zircon and ruthile, with the melting/decomposing points >1590°C, >1530 °C, ~1800°C and >1850°C, correspondingly), are present within the glasses. Low totals suppose that all the glasses are enriched with volatiles (glass type/wt. % of volatiles): I/4-12; II/5-24; III/2-7 for silica glasses and III/12-25 for other type III glasses. No petrographic evidences of shock metamorphism are found either in the host gneisses or their fragments within the dykes. In general, hyaline components of the fluidizites were volatile+melt mixtures derived from the target gneisses within the margin part of shock melting zone, P~50-60 GPa, ~14-15 km far from the center of the explosion. Host gneisses were placed initially within the zone of weak shock metamorphism (P<8-10 GPa, >25-30 km far from the center of the explosion).

Observations: Water inclusions in lechatelierite, as well as evidences for carbonate (calcite globules) and hydrous silicate (montmorillonite globules) melt within the fluidizite glasses are described below.

Water inclusions in lechatelierite. There is a great number of syngenetic fluid inclusions of various density (gaseous, gas-liquid with various proportions between the components, and even entirely liquid ones at 20°C) is present in lechatelierite schlieren (Fig. 1). These inclusions are of particular concern, because they present information about the pressure-temperature parameters of the origin of the fluidizite dykes at the earliest stages of the process.

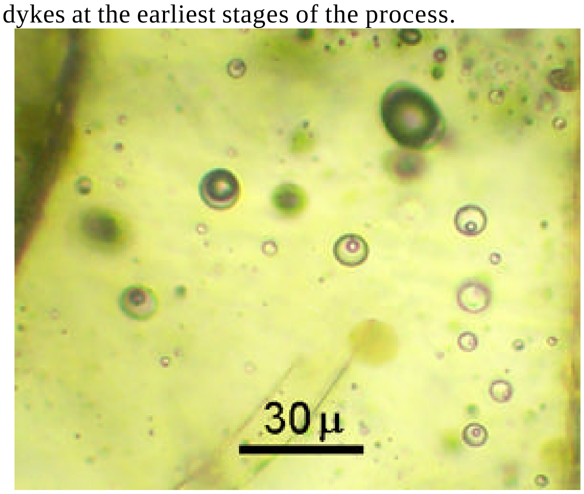

Fig. 1. Syngenetic water fluid inclusions of various densities in lechatelierite from the impact fluidizites. Microphotograph in plane polarized light.

Cryometric investigations show that the liquid phase of the inclusions is made up of water with low salinity, ranging from 0.5 to 8 wt. % in NaCl-equivalent. At this, in common, the salinity of water is <2 wt. % (Fig. 2).

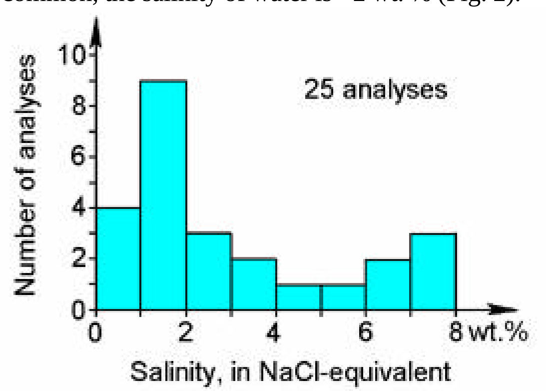

Fig. 2. Histogram of water salinity in fluid inclusions.

Following to phase diagram of water by [4], the dense, ~0.5-1 g/cm^3, water inclusions in lechatelierite show that the pressure at the solidification point for SiO_2-melt (~1700°C) was ~0.8-3.3 GPa, correspondingly.

Evidence for carbonate melt. Calcite globules (CGs) and schlieren are found in some fluidizite glasses, mainly within the type I of them. CGs exhibit textural evidence of liquid immiscibility between the carbonate and enclosing silicate melts (Fig. 3). Following to SEM data, CGs composition is (in wt. %): CaO 43.16-50.39; MgO 0.37-0.98; FeO <0.01-3.25; MnO 1.43-4.6; SO_3 <0.01-1.05; and totals 47.5-54.82. Thin, not more than several μ in width, rims of clay (?) mineral border some of the globules.

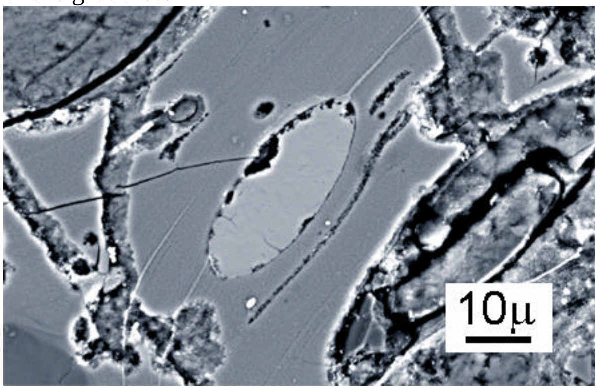

Fig. 3. Calcite globule (centered) in partially altered glass II. SEM-image, backscattering electron regime.

Evidence for hydrous silicate melt. Globules of montmorillonite (MGs) are present in some glasses, mainly of the type I. Within the "fresh" glasses, MGs are bordered by alteration film (Fig.4). Owing to their uniform texture and shape-bordering crack (of shrinkage?), MGs distinguish clearly from the products of complete alteration of the glass. Calcite crystals are present in some MGs (Fig. 4). Based upon the SEM data, MGs have the next composition (in wt. %): SiO_2 43.19-52.37; TiO_2 <0.01-0.45; Al_2O_3 14.17-16.92; FeO 6.32-11.44; MgO 4.52-7.07; CaO 1.22-2.46; Na_2O <0.01; K_2O <0.01-0.71; totals 75.35-84.75.

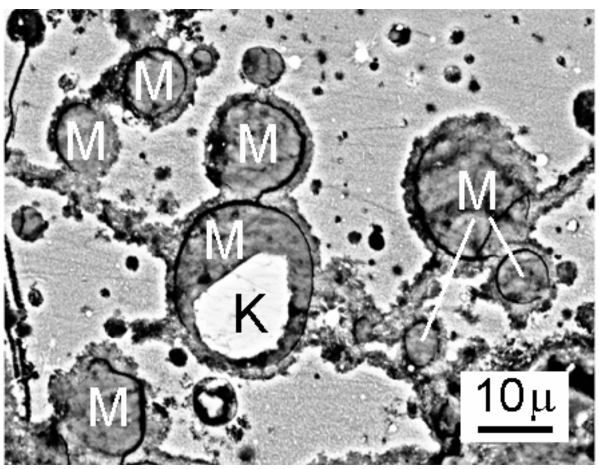

Fig. 4. Montmorillonite globules (M) with calcite crystal (K) in one of them, within the partially altered glass I. SEM-image, backscattering electron regime.

Discussion and conclusion: Dense water inclusions in lechatelierite show that, while being injected into the host gneisses, volatile+melt mixtures (VMMs) were under the pressures not less than 0.8-3.3 GPa. These pressures could not be the lithostatic ones. So, it is evident that while being transported during the excavation at the distance not less than 12-15 km from the birthplace, VMMs were still under the high residual shock pressure. We suppose the delayed shock pressure release could be result of the action of water buffer. Importance of water in behavior of shocked "wet" lithologies was reported by [6]. CGs with textural evidence for immiscibility between carbonate and silicate melts are first reported for Popigai impactites. Earlier, CGs were found in Chicxulub [7], Ries [8] and Hafton [9] craters. Cambrian carbonate target lithologies were the potential source for the Popigai CGs. CGs in impact structures show that shock melting of carbonates is a real process. MGs, similar to the Popigai ones, were found earlier in the Ries [5]. After [5], MGs are the re-crystallized products of quenched highly hydrous silicate melt (HHSM). We follow to the model [5], as it explains the observable textural features of the MGs (including their distinction from products of complete glass alteration). So, Popigai MGs are former HHSM "drops", immiscible with the host melt. After quenching, at the devitrification stage, the "drops" were transformed into MGs. The process was accompanied by MGs shrinkage. Surplus water took part in alteration of the host glass. Maturated, depleted with Na, and water-saturated sandy-clay target lithologies could be the potential source for the Popigai HHSMs. CGs and MGs in fluidizite glasses indicate a complex dynamic interaction of impact melts derived from spatially-different target lithologies during excavation of the Popigai crater.

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References: [1] Vishnevsky S. A. et al. (2003) LPI Contr. #1167 (abs. #4034). [2] Vishnevsky S. A. et al. (2004) MAPS, 39, Supplement, A109. [3] Vishnevsky S. A. et al. (2005) Geologia i Geofizika (in press, in Russian). [4] Juza J. et al. (1986) Proc. 10-th Int. Conf. On Properties Of Steam, Moscow, Mir Publish., 106-116 (in English). [5] Osinski G. R. (2003) MAPS, 38 (11), 1641-1667. [6] Kieffer S. W. and Simmonds C. H. (1980) Rev. in Geophysics and Space Physics, 18 (1), 143-181. [7] Jones A. P. et al. (1998) MAPS, 33 (Supplement), A79. [8] Graup G. (1999) MAPS, 34, 425-438. [9] Osinski G. R. and Spray J. G. (2001) EPSL, 194, 17-29.