THE POPIGAI IMPACT FLUIDIZITES. S. A. Vishnevsky[1], J. Raitala[2], N. A. Gibsher[1], N. A. Palchik[1] and S. G. Simakin[3]. [1]Institute of Mineralogy & Petrography, 3 Koptug prospect, Novosibirsk-90, 630090, RUSSIA (svish@uiggm.nsc.ru); [2]University of Oulu, Oulu, P.O. Box 3000, FI-90014, FINLAND, <jouko.raitala@oulu.fi>; [3]Institute of Microelectronics & Informatics, Yaroslavl-7, 150007, RUSSIA, <simser@mail333.com>.

Introduction: Endogenic *tuffisites*, or *fluidizites*, are known for a long time and have a wide extent in the crust [1-3, et al.]. They originate as injections of hot volatile+melt mixtures under the surplus pressure and have both the academic and economic importance. Detailed investigation of the Popigai astrobleme revealed that the impact processes could produce the similar injections also [4-8]. We select them as impact fluidizites.

Description: Brief overview and new data on the Popigai impact fluidizites (PIFs) are presented below.

Geological setting. PIFs are found in Megabreccia formation, which broadly widespread in the marginal part of the astrobleme [9]. PIFs are as dykes or veins in the target gneiss lumps of the Megabreccia **(Fig. 1).** Macroscopically PIFs have the appearance of non-sorted tuff-like sandy-size clastic agglomerates.

Fig. 1. Popigai impact fluidizites: veins in the host gneiss lump from Megabreccia. Outcrop 601.

Petrography and Mineralogy. PIFs are made up of glass particles (10 to 90 vol. %), sandy-like fragments of host gneisses and of crypto grain "matrix". Dominating part of the glass is as porous fluidal schlieren "welded" with other rock components **(Fig. 2);** however, some glass particles are true fragments. Next types are found among the glasses: type I homogeneous glasses, which are equal to the source gneisses in terms of their bulk composition; type II heterogeneous glasses, which are made up of fine banding of "femic" (Fe+Mg-rich species), "salic" (Si-, K- and Na-rich species) and type I glasses. Besides it, pure "salic" species (type III glasses) are also present; part of them is of "feldspar" composition, whereas another part is made up of coesite-bearing **(Fig. 3)** fragments of diaplectic quartz glass and lechatelierite schlieren.

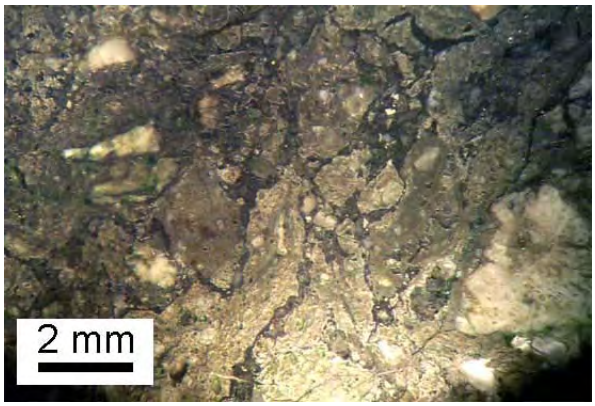

Fig. 2. General petrography of Popigai impact fluidizites. Glass particles (gray) are welded with crypto grain dark-gray matrix. Micro photo, oblique reflected light.

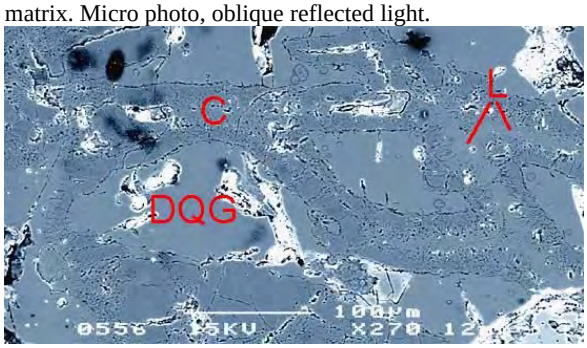

Fig. 3. Diaplectic quartz glass (DQG) with linear coesite aggregates (C) and axial zones of lechatelierite (L) within them. Backscattered electron SEM-image, after [8].

The glasses, mainly of types II and III, contain fluidal, rounded or fragment-like "shadows" of "femic" minerals derived from the parental sources and subjected to shock melting, decomposition and partial homogenization. Globules of magnetite, native Ni-bearing iron, zircon and grains of fused rutile are also present in the glasses [6]. Like lechatelierite schlieren (T~1700°C), they indicate high temperatures of the melts (>1590°C, >1530°C, ~1800°C and >1850°C, correspondingly) at the moment of their injection. Being of the target gneiss composition, PIF glasses contain, by places, globules of calcite and montmorillonite. They show that carbonate and high-hydrous silicate melts derived from sedimentary rocks, took place in the PIFs origin also. No traces of shock metamorphism are found in the host gneisses and their fragments within the PIFs.

Alteration and volatiles. Much of the PIF glasses we study are highly porous and strongly altered, being replaced by smectite. Simultaneously, the host gneisses

are weakly altered. Following to gas chromatography [7], the bulk volatile amount in fluidizites is 2.64 to 4.1 wt. %, including H_2O (1.99-3.77 wt. %). SEM- and microprobe data for the fresh PIF glasses show the low totals (in wt. %) [8]: ~88-97 for type I, ~76-95 for type II, ~75-88 for type III "salic" and ~93-98 for type III high-silica ones. Following to ion probe data, all the glasses analyzed are rich in H_2O [7] (in wt. %): type I – 1.76-6.41; type II – 5.22-8.97; type III high-silica ones – 1.11-3.32. Following the data, new totals for the glas-ses analyzed are rather improved (95.95 to 101.61).

Water fluid inclusions in lechatelierite. A great number of syngenetic water fluid inclusions of various densities (from essentially-gaseous to essentially-liquid and entirely liquid ones at 20°C) are common for the PIFs lechatelierite schlieren [6,10].

Discussion and Conclusion: High temperature and pressure minerals and glasses undoubtedly indicate the impact origin of the PIFs and their relation to the Popigai impact event. Bulk geochemistry of major part of the PIF glasses show that their melts were derived from the target gneisses. Heterogeneity of many of the PIF glasses points out that the source of the melts was localized on the outer limit of the Popigai impact melting zone (P~50-60 GPa). Based upon impact cratering theory, the radius of the zone in the target gneisses is estimated to be ~14-15 km.

Enrichment with H_2O show that the products originated were volatile+melt mixtures. High porosity of the PIF glasses and a strong alteration of the rocks as well are also in agreement with this conclusion. Compared to the host gneisses, the strong alteration of the PIFs looks like as a self-initiated process.

Following to high solidification point of SiO_2 melt, unique assemblages of water fluid inclusions in lechatelierite provide the information about the earliest stages of the PIF dykes' origin and are of particular concern. They show that the injection of the volatile+melt mixtures into the host gneisses took place at pressures as much as up to 3.3 GPa [10]. These high pressures could not be lithistatic.

The host gneiss lumps from Megabreccia bear no petrographic traces of shock metamorphism in quartz and feldspar (P<8-10 GPa). So, initially these target gneisses were localized within zone of a weak shock metamorphism. The radius of this zone for the Popigai impact event is estimated to be >25-30 km **(Fig. 4).** We have to conclude that while traveling to a distance ~12-15 km from the birthplace, the volatile+melt mixtures still kept the residual shock pressures.

Simplest general estimations (without density, strength and other target rock features), based upon attenuation rate of ejecta velocities V after [11]* and appropriate boundary conditions (minimal ejecta velocity on the crater rim was ~360 m/s after [12]**, and maximal ejecta velocity for melt is ~4 km/s) allow obtain the equation [11] for the Popigai in the next form [13]: $V_{(km/s)} \sim 21.52 \times R_{(km)}^{-1.046}$. Following to it, the ejection velocity of PIF-generating volatile+melt mixtures was ~1.2-1.3 km/s, and the time of travel to the point of dynamic contact with the host gneisses – ~10-12 s. At this time, the shock pressures attenuate from ~60 to ~3 GPa. We suppose that such a delay of shock pressure release was provided by the action of water buffer [10].

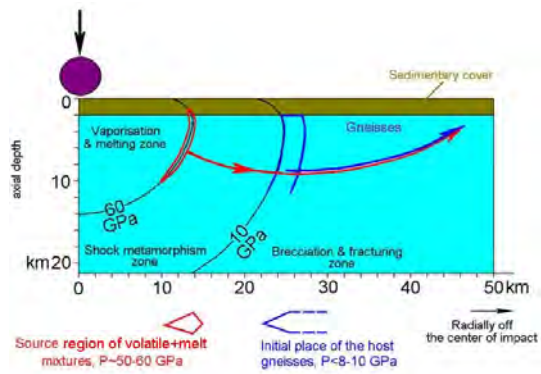

Fig. 4. Principal spatial sources of volatile+melt material giving rise to impact fluidizites, and of the host gneisses in the Popigai astrobleme

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References: [1] Cloos H. (1941) *Geologische Rundschau, 32,* 708-800. [2] Reinolds D. L. (1954) *Amer. J. of Sci., 252, 10,* 577-614. [3] Makhlaev L. V. and Golubeva I. I. (2001) *Priroda, 9,* 59-68 (in Russian). [4] Vishnevsky S. A. et al. (2003) *LPI Contr. #1167,* Abs. #4034. [5] Vishnevsky S. A. et al. (2004) *MAPS, 39,* Supplement, A109. [6] Vishnevsky S. A. et al. (2005) *LPSC XXXVI,* Abs. #1145. [7] Vishnevsky S. A. et al. (2005) *MAPS, 40,* Supplement, A162. [8] Vishnevsky S. A. et al. (2006) *Geologia i Geofizika* (Forthcoming, in Russian & English). [9] Vishnevsky S. A. and Montanari A. 1999. *Geological Society of America Special Paper 339,* 19-59. [10] Gibsher N. A. and Vishnevsky S. A. (2006) *LPSC XXXVII,* Abs. #1234. [11] Basilevsky A. et al. (1983) *Shock craters on the Moon and Planets.* Moscow, Nauka Press, 200 p. (in Russian). [12] Ivanov B. A. (1979) *Meteoritika, 38,* 68-85 (in Russian). [12] Vishnevsky S. A. (1992) *The suevites of the Popigai: some paradoxes…* . Novosibirsk, UIGGM Press, 53 p.p. (in Russian).

* - $V \sim A \times R^{-m}$, where *A* and *m* are some coefficients, depending on initial conditions;

** - $V_{min} \sim [4/15 \times g \times R]^{1/2}$, where R is the crater radius.