H_2O+MELT JETS IN THE POPIGAI LECHATELIERITES: PRODUCTS OF SHOCK-INDUCED FLUID +MELT SELECTIVE SEPARATION DERIVED FROM THE TARGET GNEISS.

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Introduction: Water plays an important role at all stages of impact cratering. However, the fluid regime of impactites is still poorly known, although its study is of interest for both the terrestrial and extraterrestrial impact research. The Popigai astrobleme is a unique testing site for various investigations of so kind owing to Its size, age, diversity of target rocks and impact formations, their preservation and exposure. Earlier we discussed the role of H_2O for the Popigai impact anatexis [1], origin of suevite-tagamite mega-mixtures [2], impact fluidizites [3,4] and buffer action of H_2O in delay of shock pressure release [5]. The fluid+melt jets in lechatelierite from the Popigai suevites are of similar interest and described below.

Glass Petrography: Some of the lechatelierite (LH) particles have a complex fabric and contain the blocks of diaplectic quartz glass (DQG) + three types of the glasses injected into the samples from outside as a highly-mobile material **(Fig. 1).** Earlier jets are made up of type I and type II glasses; they are colorless or pale-yellowish, saturated with vesicles (up to the pumice state) and exhibit the traces of partial homogenization between each other and with the host LH. Type III glasses are yellow-brownish, show no traces of homogenization and form either the dynamically-injected strips **(Fig. 2)** or crack-filling veins in the host LH. Together with the dominating of the amorphous phase, traces of crystobalite and coesite (<10 wt. %) are X-ray detected in the samples.

Glass Chemistry: LHs and DQGs are highly-silica (all the data here and below are of average, in wt. %): SiO_2 98.83; summary of main petrogenic oxides, MPOs, is 0.27; totals of analyses, TA, 99.10. Both types I and II glasses are highly-silica. Type I glasses have SiO_2 96.04; ΣMPOs 1.99 (including Na_2O+K_2O 0.72; Al_2O_3 0.73); TA 98.03. Once the feldspars were the main K-Na bearing phases of the target gneiss, the glasses show a deficit in Al (1.47 times lower to create the corresponding amounts of "albite"+"orthoclase" minals). Type II glasses have SiO_2 91.51; ΣMPOs 5.59 (TiO_2 0.13; Al_2O_3 2.50; FeO 0.67; MgO 0.45; MnO 0.02; CaO 0.37; Na_2O 0.47; K_2O 0.94; P_2O_5 0.04); TA 97.10. There is no Al deficit in respect to "albite" + "orthoclase" minals only, but in some cases it is also present in the glasses when the "anorthite" minal is taken into account. Type III glasses are completely equal to the Popigai impact melt rocks derived from the target gneisses in terms of the bulk geochemistry: SiO_2 63.58; TiO_2 0.61; Al_2O_3 15.65; FeO 6.84; MgO 3.71; MnO 0.09; CaO 2.92; Na_2O 1.75; K_2O 2.56; P_2O_5 not detected; TA 97.71.

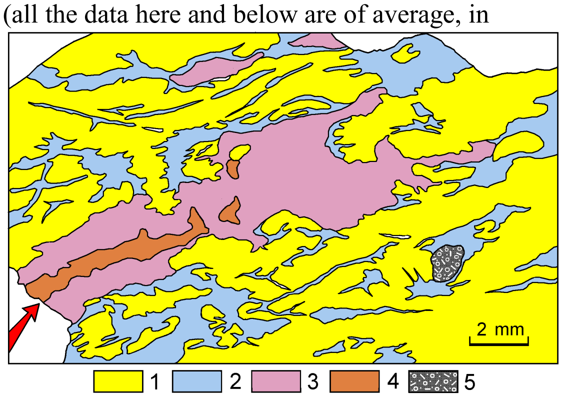

Fig. 1. One of the LH particles: scheme of double-polished thin section. Popigai suevite, sample #1308. Arrow indicates the direction of jetting. *Legend:* 1 – DQG; 2 – LH; 3 – type I+II glasses shown together; 4 – type III glass; 5 – inclusion of suevite matrix.

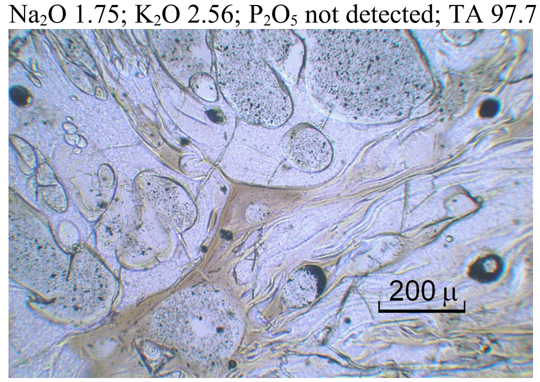

Fig. 2. Dynamic interfingering between types II (colorless) and III (brownish strips in the center) glasses. Popigai suevite, LH sample #1308, micro photo.

Volatiles: Next water amounts (ion probe analyses, in wt. %) were found in the glasses described: LHs 0.63; type I glasses 0.92÷2.86; type II glasses 4.12.

Fluid Inclusions: LHs, type I and type II glasses contain a great number of co-genetic fluid inclusions of spherical to elliptical shape and of various densities (at 20°C): entirely-liquid ones, gas+liquid ones with various proportions between the gas and liquid phases, and up to completely gaseous ones; the latter are the most widespread. All types of the inclusions co-exist within the glasses in the scale of several hundred microns **(Fig. 3).** This feature is very common for the Popigai LHs and high-silica glasses in many cases. Type III glasses contain gaseous vesicles only.

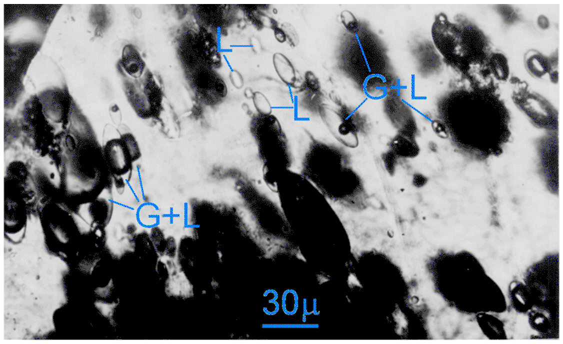

Fig. 3. Co-genetic liquid (L) & gas+liquid (G+L) H_2O inclusions in pumice type II glass. Popigai suevite, sample #1308, micro photo, at 20ºC.

Discussion:

Petrography and Petrochemistry. Complex fabric of the LH particles shows their multistage origin and dynamic interaction of strongly-shocked quartz with highly-mobile products from outside. At least, 3 stages of the jetting took place here: 2 earlier ones (type I and II glasses) and a late one (type III glasses). Fluidal contacts of the glasses indicate their high, up to 1700ºC, temperature. A partial homogenization took place between the host silica and types I+II jetting products whereas the type III jetting products exhibited immiscibility with other melts. Close interfingering between type III and other glasses indicates the unstable micro flow gradients and the residual shock pressures at the jetting. A lot of fluid inclusions in types I+II glasses show the participation of H_2O in the jetting.

Following to the bulk geochemistry of types I+II glasses, their origin was rather more complex than a simple total melting of the source gneiss. It was accompanied by a selective separation of some MPOs. Type I glasses have a large excess of SiO_2, relatively high amount of K+Na and a clear deficit of Al. Type II glasses also have a large excess of SiO_2, and sometimes show a deficit of Al also. So, the origin of the glasses was a kind of selective impact anatexis and was controlled by a high mobility of Si, activity of Na, K (type I glasses) and Na, K, Ca, Fe, Mg (type II glasses sometimes) vs. low mobility of Al. Principal possibility of shock-induced separation of some MPOs at the impact melting is confirmed in experiments [6] and was observed for the impact anatexis of Popigai gneisses [1].

Water in glasses. Types I+II glasses are "wet" (up to 2.86 wt. % and 4.12 wt. % H_2O, respectively), and the measured amounts of H_2O cover the deficit of TAs in much of the probe analyses. However, the H_2O amounts characterize only the glasses themselves. A lot of water fluid inclusions in the glasses **(Fig. 3)** show that while jetting the material was a kind of water-rich fluid+melt mixture. Simplest volume estimations show that the initial H_2O content in the mixtures could be up to several tens of wt. %. When cooling, these hydrous impact melts, HIMs (or supercritical water+silicate fluids, SWSFs), become "unmixed" to form a melt of I or II type with a lot of water fluid inclusions. So, water was also a very mobile component during the selective impact anatexis of gneisses and origin of types I and II jets. Traces of HIMs (or SWSFs) are found in LHs of Barringer crater [7], in shocked Popigai gneisses [1], in Ries suevites [8] and in the Popigai fluidizite dykes [9]. Shock-induced origin of HIMs or SWSFs is confirmed in experiments by [10, 11].

Water fluid inclusions. Dence, ~0.5 to 1 g/cm^3, H_2O inclusions in types I and II glasses indicate their high, ~0.8 to 3.3 GPa, conservation pressures (data by [5] after phase diagram of water by [12]). Such high pressures on the Earth's surface are explained by the action of water buffer which delays the shock pressure release for the "wet" compressed lithologies (up to 10-12 s for the Popigai case [5,13]).

Conclusion: Quenched in suevites, a multi-stage origin of some LH particles is observed. Three stages of dynamic jetting of very hot and very mobile material from outside are documented in the particles. Origin of the types I and II material was provided by early impact anatexis of shocked gneisses and was accompanied by selective mobilization of some MPOs (very mobile Si; active Na, K and some others vs. low mobile in many cases Al). Participation of H_2O led to the origin of HIMs or SWSFs. Diaphthorites or brecciated water-saturated gneisses were the target source rocks. The examples of the impact anatexsis may be of interest in understanding the impact-induced early evolution and differentiation of planetary bodies.

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References: [1] Vishnevsky S., Pospelova L. (1986) in *Meteoritic Matter and Earth*, *Novosibirsk,* p. 117-131 (in Russian). [2] Vishnevsky S. (2003) *LPI Contr. #1167,* Abstract #4024. [3] Vishnevsky S. et al. (2006) *LPSXXXVII,* Abstract #1268. [4] Vishnevsky S., Raitala J. (2007) *Bridging the Gap II*, Abstract # 8014. [5] Vishnevsky S., Gibsher N. (2008) *LPSXXXIX,* Abstract #1043. [6] Kozlov E.A. et al. (2002) *LPSXXXIII,* Abstract #1050. [7] Kieffer S. et al. (1976) *Contr. Mineral. Petrol., 59,* 41-93. [8] Osinski G.R. (2003) *MAPS, 38,* 1641-1667. [9] Vishnevsky S. (2007) *Astroblemes Novosibirsk,* 288 p. (in Russian). [10] Kieffer S. & Simmonds C. (1980) *Rev. of Gephys. & Space Physics, 18,* 134-181. [11] Bureau H. & Keppler H. (1999) *EPSL, 165,* 187-196. [12] Juza J. et al. (1986) *Proc. 10th Internat. Conf. on the Properties of Steam, Moscow,* 106-116. [13] Vishnevsky S. et al. (2006) *LPSXXXVII,* Abstr. #1268.