BRECCIA VEINS, PSEUDOTACHYLITES AND FLUIDIZITE DYKES IN ARCHEAN GNEISS FRAGMENTS FROM THE POPIGAI MEGABRECCIA. S. A. Vishnevsky¹, J. Raitala², N. A. Gibsher¹, N. A. Palchik¹, and T. Öhman², ¹Institute of Mineralogy & Petrology, Novosibirsk-90, 630090, Russia <nadezhda@uiggm.nsc.ru>; ²University of Oulu, Oulu, Finland, <jouko.raitala@oulu.fi>.

Introduction: Some Archean gneiss fragments from the Popigai megabreccia exhibit traces of shock metamorphism up to stage II after [1], whereas other gneiss lumps are only fractured and locally brecciated [2]. One of us (S.V.) observed fine-fragment breccia veins with “stream-like” masses of dark cryptograin matter in the lumps; one of the gneiss fragments contains several thin (3-10 cm) dykes filled with tuff-like glass-bearing material. Later it was found that the “stream-like” masses in some breccia veins are pseudotachylites (outcrop No. 479), and dykes with the tuff-like material are injections of impact fluidizes.

Description: Fine-fragment breccia of outcrop No. 479 forms linear or branching veins, from first cm to 70 cm thick, in the host biotite-hypersthene gneiss and is made up of psammite-like moderately lithified material. In thin sections, it is a mixture of angular fragments 0.05 mm to 3-5 mm in size, of feldspar, quartz, pyroxene and biotite derived from the parental gneiss, plunged into cryptograin matrix, which composes 15 to 30 % of the rock volume. The breccia contains also submicroscopic bands, of 1-2 mm width and up to 1 cm length, composed by the cryptograin matrix. These bands have no fluidal texture, but form a roughly ordered “stream-like” net in the breccia. Except for the bands, the cryptograin material forms the borders around some gneiss fragments and is present sometimes as clasts in the breccia. No traces of shock metamorphism are found in the gneiss fragments, i.e., shock pressures were <5 GPa at the origin of veins. The breccia is moderately altered and exhibits borders of opaque minerals around some clasts, and cryptograin aggregates of secondary minerals by places (X-ray data: smectite and traces of chlorite). Loose cryptograin bands did not studied in thin sections and contain smectite + traces of caolinite, chlorite and gypsum (X-ray data). Initially, this material was probably an ultramylonite. Material from the hard bands is fluidal and shows a clear “hump” of amorphous phase on the X-ray diffraction patterns in interval from 19° to 35° (29CuKα). That is why, we consider the material as a result of friction melting, i.e., as the pseudotachylite, following to [3]. Alteration of pseudotachylite is represented by calcite and non-maturated smectite; traces of gypsum are also detected (X-ray data).

Impact fluidizes, found in the lump of hypersthene gneiss (outcrop No. 601), are made up of small, from 1-3 mm to 20 mm, particles of the impact glass (from 50 to 70 % of the rock volume) plunged into crystalloclastic matrix represented by fragments, 0.05-3 mm, of the parental gneiss (quartz, feldspar, pyroxene and biotite) and strongly altered cryptograin material. In the most cases, glass particles have fluidal or stream-curved shape, and are “welded” with matrix, i.e., the glass was molten or plastic, when the dykes originated. Highly porous and pumice, strongly altered (X-ray data: smectite + traces of chlorite and dolomite) glasses dominate. Sometimes, the glass is massive and looks like relatively fresh. The glasses contain impurity of troilite-pyrrhotite spherules (1.5 to 40 µ in size); some of them are nickel-bearing or contain the minute inclusions of nickel sulphides (0.7-17.1 wt. % of Ni). Besides it, the spherules, 5 to 33 µ in size, of shock molten and partially decomposed zircon (in wt. %: ZrO₂-66.71; SiO₂-30.81; CaO-0.97; FeO-1.02; total: 99.51) are found in some glasses. Lechatelierite schlierens (97.6-98.8 wt. % of SiO₂) and fragments of diaplectic quartz glass (97.87 wt. % of SiO₂) are present in some glass particles. Gas+liquid fluid inclusions of various densities at 20°C (up to those with dominating of liquid phase, >80 % of the inclusion volume) are present in lechatelierite. Lechatelierite and fused zircon indicate high temperature of the injected...
impact melt (>1700°C and ~1800°C, respectively). A bulk geochemistry of the altered glass (72 microprobe analyses) is the next (in wt. %): SiO$_2$ 57.3-70.59; TiO$_2$ 0.31-0.88; Al$_2$O$_3$ 6.61-16.73; FeO 2.46-7.15; MgO 1.33-4.46; CaO 0.79-3.26; MnO <0.00-0.16; Na$_2$O 0.61-2.39; K$_2$O 1.69-3.09; P$_2$O$_5$ <0.00-0.14; totals 88.19-96.97. Of average, the glasses are similar to the Popigai tagamites but due to alteration shows the low totals, depletions in Si, Ca and Na, enrichment in Al, Fe, Mg and P; K and Ti are indifferent. A bulk geochemistry of the “fresh” glass (10 microprobe analyses) is the next (in wt. %): SiO$_2$ 59.23-64.16; TiO$_2$ 0.67-1.16; Al$_2$O$_3$ 14.42-15.96; FeO 5.28-7.94; MgO 3.30-4.80; CaO 2.38-2.85; MnO 0.02-0.18; Na$_2$O 0.41-1.97; K$_2$O 2.08-3.02; and totals 91.56-95.60. Of average, the glasses and the Popigai tagamites are very similar to each other.

Gneiss fragments in the rock bear no traces of shock metamorphism, i.e., the dykes originated at shock pressures ≤5 GPa. Except for the “parental” fragments, small (5-7 mm) rounded clasts of “strange” micro grain dolerite are rarely present in the dykes.

Pumice state of the glasses (in the closed volume of the dykes!), their intensive alteration (in contrast to a fresh state of the host gneiss), mineralogical thermometers (lechatelierite and zircon), and dense fluid inclusions as well show that the tuff-like dyke breccia is a result of dynamic injection of very mobile, hot and fluid-enriched tagamite melt. That is why, we consider the “tuffs” as the *impact fluidizites*. Except for the fluid, the injecting melt contained spherules of liquid iron sulphide. Although the injection of the melt did not provide a shock metamorphism of the host gneiss (lechatelierite, diaplectic quartz glass and spherules of the molten zircon were brought by the melt), nevertheless, the dense fluid inclusions in the lechatelierite indicate a high confining pressure of the melt. In case of the water fluid, following to [4], this pressure at ~1700°C could range from ~0.8-1.5 GPa (gas+liquid inclusions with density 0.5-0.7 g/cm$^3$) to ~1.9-3.3 GPa (gas+liquid inclusions with density 0.8-1 g/cm$^3$).

**Discussion:** Gneiss lumps of outcrop No. 479 with no traces of shock metamorphism were brought from the middle/margin zone of the crater outside the inner ring of Archean gneisses (shock pressures <5 GPa). Their fracturing occurred either at final stages of the shock wave propagation, or at the stage of excavation (colliding in dense turbulent centrifugal bottom flow). Breccia veins show that the gneiss deformation was accompanied by small-scale but fast sliding of the fragments in respect to each other. At this, a part of the material experienced milonitization (*fine-fragment breccia veins*) and friction melting (*breccia veins with pseudotachylites*). Milonite fragments show several stages of brecciation at the origin of the veins.

**Fluidizite dykes** in the outcrop No. 601 have a specific origin. As in the previous case, the host gneiss lump was brought from the low shock pressure (<5 GPa) zone by means of bottom centrifugal flow. However, at the excavation and transport, it had a dynamic contact with the hot (>1700-1800°C) very mobile and fluid-enriched tagamite melt, which was under the high excess pressure (~0.8-3 GPa in case of water fluid inclusions in lechatelierite). Such pressure could not be lithostatic. We have to conclude that the melt, after its travel from the birthplace to the point of contact with the gneiss lump (not less than 12-15 km), was still under the high residual shock pressure and had large injection ability. It is impossible in case of a fast rarefaction pressure release of the “dry” system. So, we suppose the slow unloading of the melt, as it was found for the “wet” system in shock experiments [5]. Since any moment, a behavior of compressed fluid controls the expansion of the system; “piston”-like expanding, the drops of the fluid work against the melt viscosity and act as the buffer, slowing down the pressure fall [4]. Being under the excess pressure, the fluid-rich melt could inject into the fractured gneiss to a distance not less than 5 to 7 m (a size of the host lump). “Boiling” of the melt took place after the pressure fall. The melt was quenched in “cold” host gneiss, but fused silica glass was still in molten state at the time of injection. Rare clasts of tagamite and silica glass show additional brecciation after the origin of dykes. Then the fluidizites were strongly altered.

Troilitte-pyrrohotite Ni-bearing spherules do not exclude contamination of the glass by projectile. We already noted [6], that outer klippen+megabreccia belt in large astroblemes can contain non-eroded portions of the projectile-contaminated impactites. Usually, the meteoritic matter is quickly eroded in large astroblemes, because it is either ejected out, or is deposited at the top of the impact formations inside the crater.