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Critical relationship of fluid-bearing mantle: interaction of hypercritical fluid-melts with peridotite

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Introduction. Processes of mantle magma formation proceed with the assistance of fluids. Fluids make effective influence on phase relationship and mantle melting. Depending on P-T silicate fluidbearing systems can be in undercritical and hypercritical conditions. Existence of critical relations related with high solubility of fluids in silicate melts and silicates in a fluid with increase P and T. At critical P and T is observed absolute miscibility between fluid and silicate melt, and in the second critical end point – between phases of liquidus silicate, melt and a fluid (fig. 1).

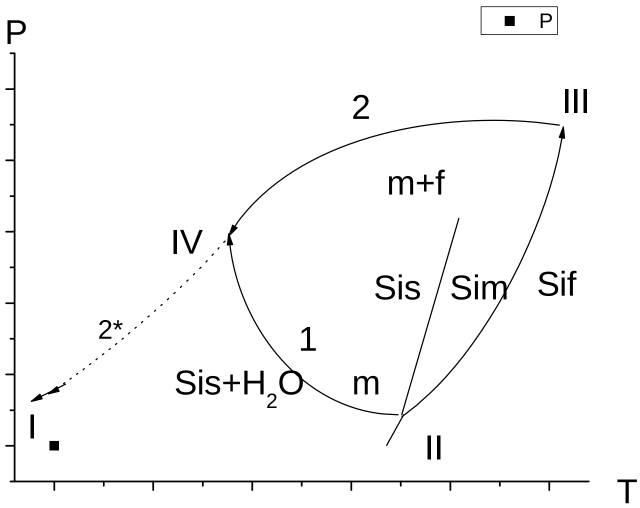

Fig. 1. Schematic T-P diagram silicate Si-H_2O. 1-water saturated solidus of silicate, 2-critical line – P-T-X trend of the critical points, which stable part comes to an end with the second critical end point IV on crossing water saturated solidus. s – hard, m – melt, , f – fluid.

For the purpose of studying of features of phase structure fluidbearing mantle at melting in undercritical and hypercritical P-T the system a peridotite-basalt-fluid at 1000-1450°C, 1.5-4 GPa has been studied. As the test of transition of system in an undercritical and hypercritical conditions features of phase relationship and a structure of quenching experimental samples served.

Equipment and technique. Experiments were carried out using of apparatus high pressure (piston cilinder and anvil with hole) by a quenching technique. The technique of direct melting of initial peridotite in the Pt ampoules saturated with iron and two ampoules technique with Pt and peridotitic ampoules was used. The peculiarity of structure, phase relationship and composition of experimental samples as test of transition system in hypercritical condition were used.

Results. Essential distinctions of phase relations and structure of experimental samples depending on P and fluid composition are revealed. For the first time results of interaction hypercritical fluidomelt with a peridotite are resulted.

Normal, undercritical P-T conditions. At partial melting of a peridotite quenching samples are characterized by the massive structure caused by that silicate glass - quenching silicate melt, cements silicate and oxide liquidus minerals. In experiments with peridotitic ampoule glass fills internal volume of an ampoule. Formation of quenching phases, immiscibilities melts (sulphidic,carbonatic) don't change massive structure of the sample. The phase composition is presented by equilibrium association of restite (peridotite) +melt or nonequilibrium quenching phases – Cpx+Glass (fig. 2 а-в).

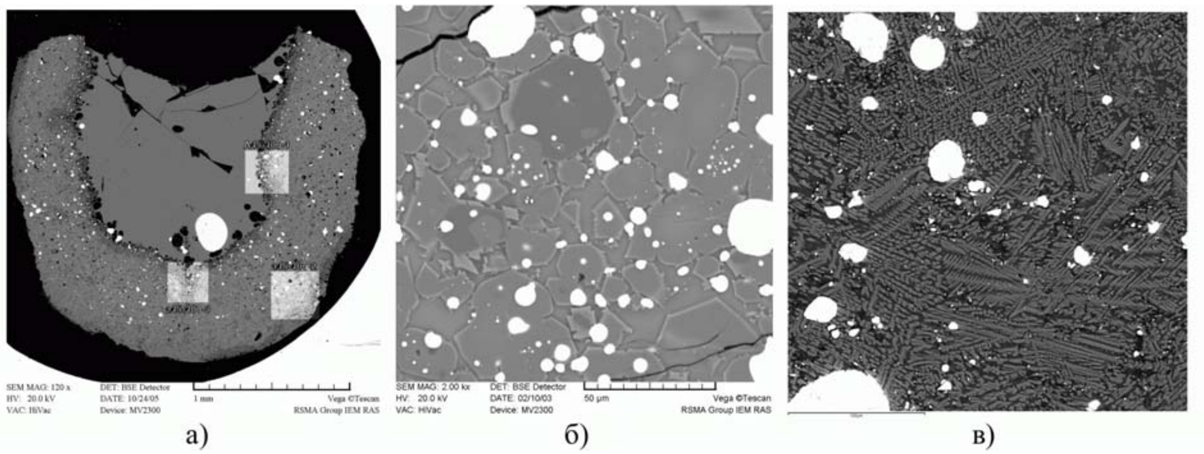

Fig. 2. A microphoto polished thin section of experimental samples in secondary electrones. System a peridotite-basalt-H_2O+CO_2, undercritical T-P conditions: a – method peridotitic ampoules; б – partial melting of peridotite. T=1400ºC, P=4 GPa; в – alkali-olivine basalt (eclogite)-H_2O+CO_2. T=1400ºC, P=4 GPa.

Hypercritical T-P conditions. *A method of peridotitic ampoules.* It is observed full, at P-T the second critical end point, (fig. 3 б) or partial (fig. 4 а-в) decomposition of experimental samples. The phase composition is presented by the nonequilibrium association consisting of a mix of microlits of silicate minerals, oxides and their joints needle, dendrite forms, with globules Al-Si glasses, sulfides (fig. 3, 4).

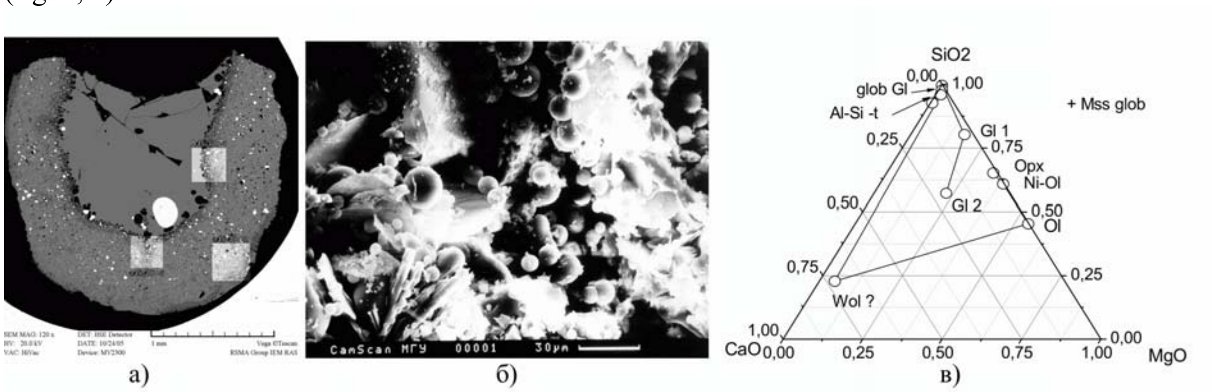

Fig. 3. A microphoto polished thin section of experimental samples in secondary electrones. System a peridotite-basalt-fluid. T=1400ºC, P=4 GPa: a – with H_2O+CO_2, normal, undercritical P-T conditions, the initial structure of the sample remains; б - the same system with H_2O fluid, hypercritical conditions. Full decomposition and peridotite and basalt of the initial sample after the experience, testifying to achievement of the second critical end point is observed at 1400ºC, 4 GPa [*Gorbachev*, 2000]; в – phase composition.

At partial melting fluidbearing peridotite at P-T-X conditions, answering to critical line, critical relationship can be reached only between partial melt and fluid. Thus hypercritical fluid-melt interact with a peridotite. Interaction hypercritical fluid-melt with a peridotite was observed in system a peridotite-basalt-sulfide-alcali-hydrous-carbonate fluid at 1400ºC, 4 GPa (fig. 4 а-д). The internal part of peridotitic ampoules is filled by products of quenching basaltic fluid-melt. The quenching material is presented by a friable mix of microlits of silicates, carbonates, sulphidic and alumo-silicate microglobules (fig. 4). Absence intergrain melt leads destruction external peridotitic ampoules. Reactionary relations between restite Ol-Opx-CaCpx composition, and KCpx, carbonate, presence of quenching phases - phlogopite, Al-Si globules are caused by interaction hypercritical fluid-melt with minerals of restite (fig. 4 c-e).

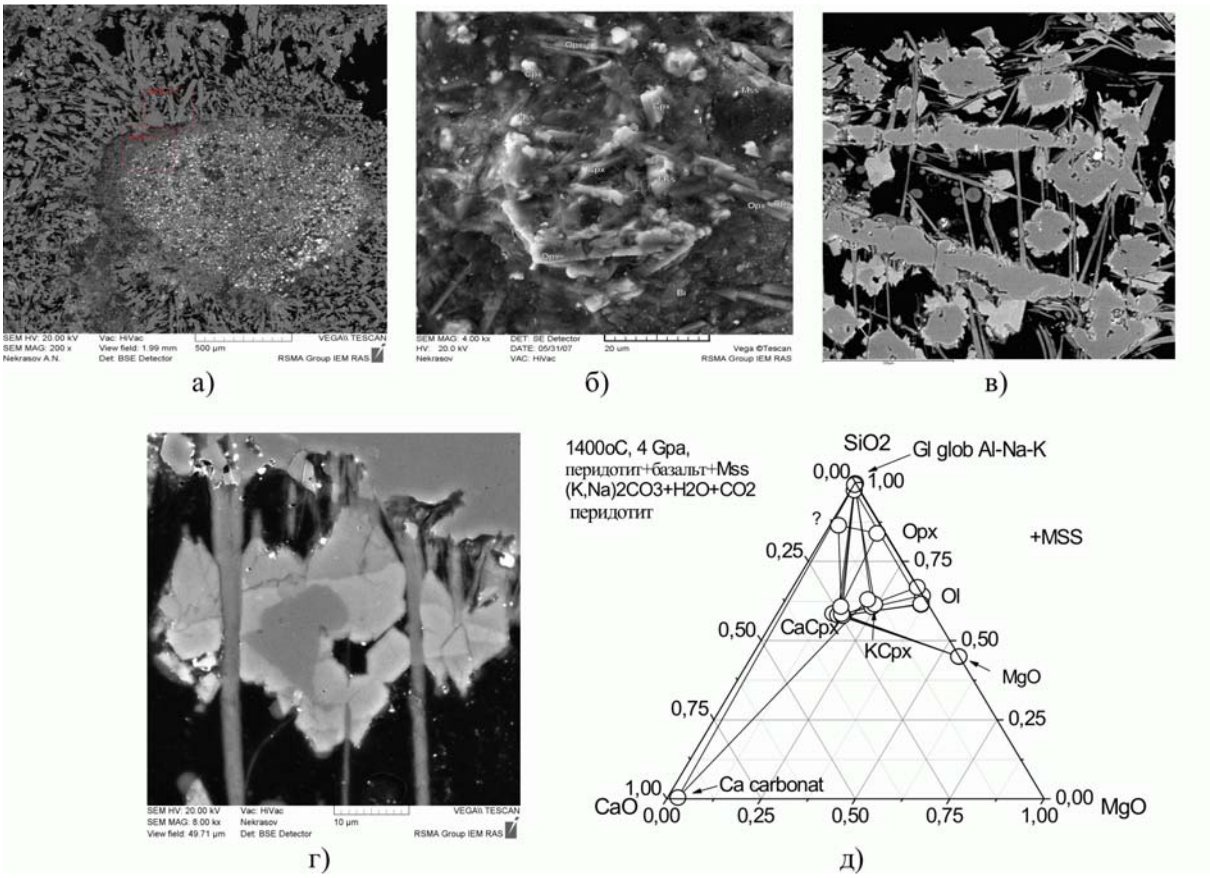

Fig. 4. A microphoto polished thin section experimental samples in secondary electrones: a - peridotitic ampoule; б – its internal part filled with products of quenching basaltic fluid-melt; в, г – peridotitic ampoule. Full decomposition of a peridotitic ampoule is observed; д – phase composition.

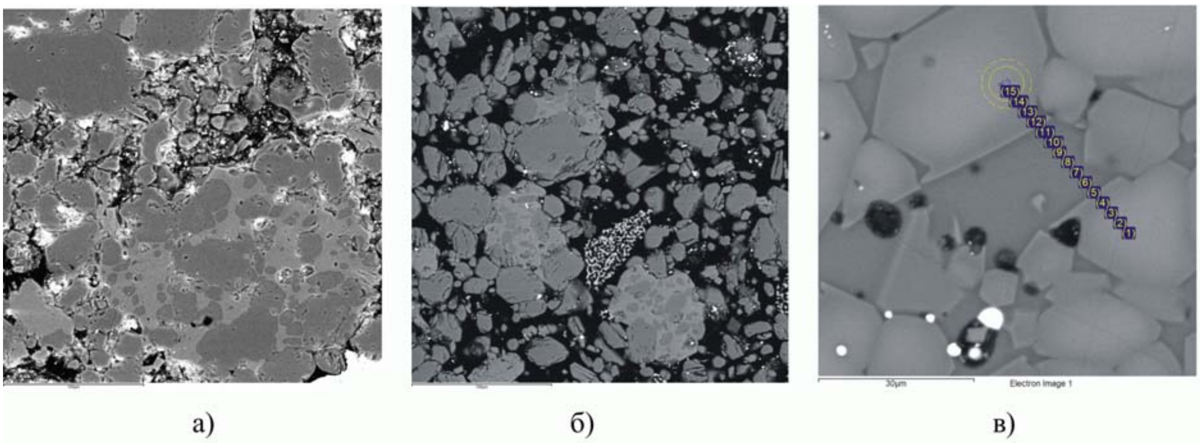

Fig. 5. A microphoto polished thin section experimental samples in secondary electrones. System peridotite-H_2O. Interaction hypercritical fluid-melt with peridotite: a - 1100°C; б - 1000°C; P=4 GPa. Destruction of peridotite, "gravel-stone" structure. For comparison: в – view of the sample at partial melting peridotite with H_2O+CO_2 fluid at undercritical P-T conditions. 1400°C, 4 GPa.

System peridotite-H_2O. Interaction hypercritical fluid-melt with a peridotite. In system a peridotite-H_2O at 1100-1200°C, 4.0 Gpa at small degrees of melting peridotite critical relationship are reached between anear-liquduse alkali-silicate melts and water fluid. Interaction hypercritical hydrous fluid-melt with peridotite leads to formation quenching «blue ground» with characteristic "gravel-stone" structure. Samples consist from isolated rolled relicts minerals of peridotite Ol, Opx, Cpx composition with neogenic cement of garnet Grt-Cpx composition (fig. 5 a, б).

Absence of signs of partial melting of peridotite, abnormal the phase composition and structure of samples, dissolution of relic minerals of a peridotite, formation reactionary margins, quenching phases testify to peridotite melting in hypercritical conditions, and reactionary relationship - about high reactionary ability hypercritical phases.

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