SILICATE MELT INCLUSIONS IN PHENOCRYSTS FROM GLASSY BASANITES OF THE TERGESH PIPE (NORTH MINUSA DEPRESSION, KHAKASIA, RUSSIA)

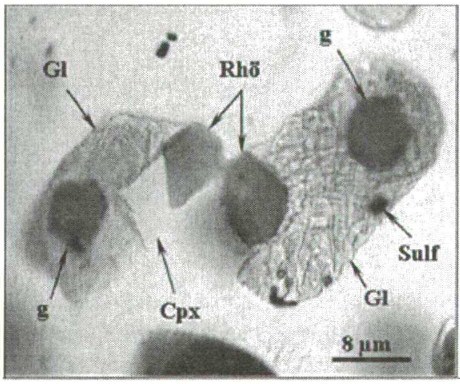
TIMINA, T. Ju.[1], SHARYGIN, V. V.[2], GOLOVIN, A. V.[2], PETŐ, M.[3]
[1] Department of Geology and Geophysics, Novosibirsk State University, Pirogova st. 2, 630090 Novosibirsk, Russia.
[2] Institute of Mineralogy and Petrography, Koptyuga pr. 3, 630090 Novosibirsk, Russia.
[3] Lithosphere Research Group, Department of Petrology and Geochemistry, Eötvös University, Pázmány Péter sétány 1/C, H-1117 Budapest, Hungary.
E-mail: sharygin@uiggm.nsc.ru

Introduction

The Tergesh pipe contains the deepest mantle garnet-spinel xenoliths among all pipes of the North Minusa depression. The eruptive breccias are predominant over basanites in the Tergesh pipe (Kryukov, 1964). The recent Ar/Ar dating of the Tergesh pipe shows age 77±1.9 Ma (Bragin et al., 1999). The glassy basanites of this pipe were selected for the study of silicate melt inclusions. Olivine (Fo_{81-69}) and rare clinopyroxene are phenocrysts (about 10 vol. %). The groundmass consists of clinopyroxene, plagioclase (An_{68-51}), Ti-magnetite, F-apatite and glass.

Petrography of inclusions

Primary silicate melt inclusions were observed only in phenocrystal olivine and clinopyroxenes. Their sizes vary from 5 to 50 μm. In olivine they occasionally decorate the growth zones of the host and are associated with single Cr-spinel crystals and CO_2 fluid inclusions. Phase composition of the melt inclusions in olivine is glass + fluid ± daughter/trapped crystals ± Fe-Ni-Cu-sulfide globule. In some inclusions glass is finely devitrified. Rhönite and clinopyroxene are the main daughter phases. Apatite, ilmenite and Ti-magnetite occur rarely. It should be noted that rhönite-bearing inclusions are generally confined to the core of the host olivine while rhönite-free ones are situated in the outer parts. The relationships of minerals within olivine-hosted inclusions show that rhönite is the earliest daughter phase (Fig.1). The clinopyroxenes-hosted inclusions contain glass, low-density fluid and sometimes Ti-magnetite.



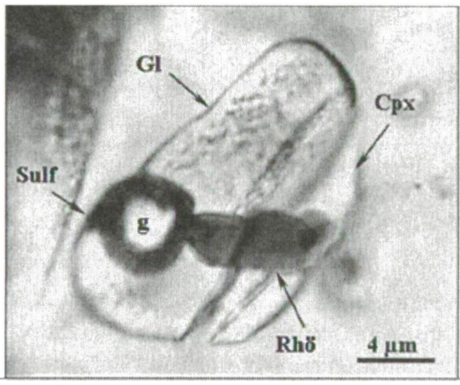


Figure 1. Primary melt inclusions from the core of olivine phenocrysts.

Gl – glass; **Rhö** – rhönite; **Cpx** – Ti-augite; **Sulf** –sulfide bleb; **g** – gas bubble.

Thermometry

The heating experiments with olivine-hosted inclusions were performed using two methods: (1) the Vernadsky heating stage with visual observations to get homogenization temperatures; (2) heating experiments (T>1250°C) with single grains in the stage design by Petrushin et al. (2003) to get homogenous inclusions "in blind" for further microprobe study. The quenched inclusions heated up to temperatures more than 1270°C have the following phase composition: glass + gas ± sulfide globule. This indicates that sulfide melt was possibly separated immicibly from basanitic liquid at high temperatures (>>1250°C).

According to thermometric studies olivine-hosted melt inclusions are homogenized at 1270-1310°C, while clinopyroxene ones – at 1100°C. The moderate density of the CO_2 inclusions (homogenization of vapor into liquid at +25°C), which associated with melt inclusions in olivine, suggest that their trapping pressure was more than 3 kb.

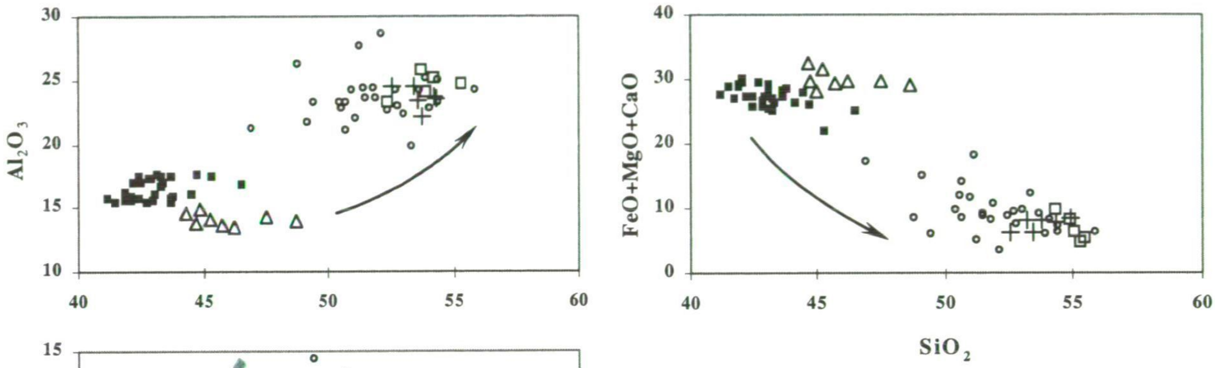
Chemistry of inclusion glasses

Glasses of heated and unheated of olivine- and clinopyroxene-hosted inclusions as well as daughter phases of unheated inclusions in olivine were analyzed by microprobe at UIGGM, Novosibirsk.

Glasses of inclusions heated in the 1280-1320°C temperature interval are characterized by high contents of FeO (9-15), MgO (4-10), CaO (6-11.5), TiO_2 (1.9-3.3), P_2O_5 (0.2-1.2) and relatively low abundances of SiO_2 (41.2-48.4), Al_2O_3 (14.7-17.8), Na_2O+K_2O (2.1-8.8 wt. %). These compositions are very similar to host basanites (Fig. 2). Residual glasses of unheated inclusions in olivine and clinopyroxene strongly vary in major elements depending on the amount of daughter crystals within inclusion. In general, they are more acidic than heated inclusions (in wt. %): SiO_2 - 47-57.3, TiO_2 – 0.9-3.5, Al_2O_3 - 21-28.5, FeO - 1.3-6, MgO - 0.3-3.2, CaO - 1.3-11.5, Na_2O - 3-9.6, K_2O - 1.8-8.6, P_2O_5 - 0.5-1.9, Cl - 0.1-0.3. Silica-rich glasses (SiO_2 >52 wt. %) in olivine correspond in composition to glasses from clinopyroxene-hosted inclusions and from the basanite groundmass, excepting alkalis concentrations.

Chemistry of daughter phases

Clinopyroxene of olivine-hosted inclusions drastically differ from phenocrystal and groundmass clinopyroxenes in SiO_2, Al_2O_3 и TiO_2. It belongs to Ti-rich augite (TiO_2 – 2.5-6.1 wt. %) with high Al_2O_3 и P_2O_5 (9-11.9 и 0.1-1.3 wt. %, respectively). It should be noted that the presence of P_2O_5 in clinopyroxene is characteristic of apatite-free inclusions containing small amount of daughter phases. The composition of daughter rhönite also strongly varies (in wt. %): SiO_2 – 24.7-31, TiO_2 – 8.7-10.7, Cr_2O_3 – 0.1-1.4, Al_2O_3 – 15.4-18.9, FeO – 16.8-19.9, MgO – 11.2-13.8, CaO – 10.2-13, Na_2O – 1.1-1.8. Magnetite from olivine- and clinopyroxene inclusions is rich in TiO_2 (up to 23 wt. %) and is similar to groundmass magnetite.



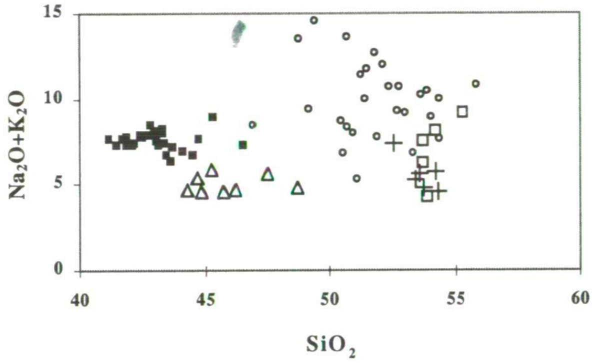


Figure 2. Compositional variations for silicate melt inclusions in the Tergesh basanites.
Solid square – glass of heated inclusions in olivine; **open circle** – glass of unheated inclusions in olivine; **cross** – glass of unheated inclusions in clinopyroxenes; **open square** – glass of basanite groundmass; **open triangle** – basanites (Sobolev et al., 1988; author's data).

Discussion

The diagrams (Fig. 2) show compositional variations for inclusion glasses (heated and unheated) in comparison with bulk basanite of the Tergesh pipe (as probable initial magma) and their groundmass glass (as derivate of initial magma). The data obtained allow us assume that basanitic melt of the Tergesh pipe during crystallization evolved towards increasing of SiO_2, Al_2O_3, alkalis, Cl and depleting of mafic components. The absence of water-bearing phases in silicate melt inclusions is evidence that initial basanitic magma and its derivates contained low H_2O abundances. Previously the similar evolutionary character was established for the Bele pipe of the North Minusa depression (Golovin et al., 2000) as well as for some alkaline basalts of the world.

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