Water-induced shear zone and fabric transition in the lithospheric mantle beneath the Siberian craton

Xiaotong Gu[1], Qin Wang[1], Vlad Shatsky[2]

[1]State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing 210023, China, qwang@nju.edu.cn

[2] Sobolev Institute of Geology and Mineralogy, Koptyuga 3, Novosibirsk 630090, Russia

Water can be incorporated into lattice defects of normally anhydrous minerals of the upper mantle as hydroxyl. Water can significantly affect physical and chemical properties of mantle minerals as well as deformation mechanisms and rheology of the upper mantle. The Udachnaya kimberlite in the Siberian craton erupted at ~360 Ma and brought up large amounts of fresh peridotite, eclogite and granulite. The eruption of the Siberian Traps occurred at ~250 Ma. Therefore, xenoliths from the Udachnaya pipe provide a window to investigate deformation and water distribution in the lithospheric mantle beneath the Siberian craton prior to the formation of the Siberian Traps.

In this study, Fourier transform infrared spectroscopy (FTIR) and electron backscattered diffraction (EBSD) were used to analyze water content and fabrics of garnet lherzolite xenoliths from the Udachnaya kimberlite pipe. The nine peridotite xenoliths can be divided into three groups: group 1 are peridotite mylonite, group 2 are peridotite protomylonite, and group 3 is coarse-grained peridotite with granoblastic texture. The Mg# in olivine, orthopyroxene and clinopyroxene ranges from 90.4-91.6, 91.6-92.6 and 89.9-93.0, respectively. The calculated equilibrium temperature of the peridotite xenoliths varies from 846 to 1276 ºC, and the calculated pressure ranges from 4.0 GPa to 5.2 GPa. The P-T condition of coarse-grained peridotite follows the geothermal profile with the surface heat flow of 35 mW/m^2, whereas the others show higher geothermal gradients. The water contents in olivine, orthopyroxene, clinopyroxene and garnet from the garnet lherzolite xenoliths are 34-166 ppm, 32-126 ppm, 83-166 ppm and 7-46 ppm, respectively. The trace elements of clinopyroxene reveal mantle metasomatism by both silicate melts and carbonatitic melts.

Nine peridotite xenoliths develop different fabrics. Recrystallized olivine in peridotite mylonites develops a [100](001) slip system, i.e., the E-type fabric. In contrast, olivine in most peridotite protomylonites and coarse-grained peridotite develops a [100](010) slip system, i.e., the A-type fabric. Combined with previous water content measurements, the lithospheric mantle of the Siberian craton at a depth of 130-200 km has been hydrated by mantle metasomatism at ~360 Ma, which caused strain localization and development of a mantle shear zone characterized by the E-type olivine fabric. Because water can significantly decrease the melting point of peridotite, when the mantle plume arrived at the lithosphere-asthenosphere boundary of the Siberian craton, the relatively hydrous lithospheric mantle should have been subjected to a high degree of partial melting and contributed to the formation of the Siberian Traps, the largest igneous province in the world.