Geophysical Research Abstracts
Vol. 12, EGU2010-1919-1, 2010
EGU General Assembly 2010

Mafic enclaves in Caucasian granitoids: generation of mantle-looking lamprophyre nodules by reaction with (meta)-sedimentary carbonates

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The occurrence of mafic enclaves in granitic plutons is a very common feature, particularly in the late- to post-collision granites. Origin of the enclaves is conventionally ascribed to the magma mingling processes, with the mafic component being derived from an "enriched" mantle source. Here we report geochemical and petrological data on the late-Miocene granitoid stocks and laccolites of the Caucasian Spring Waters region (CSW), which indicate principal involvement of contamination by (meta)-sedimentary carbonates in the origin of mafic nodules. The stocks and laccolites are composed of amphibole-bearing (Amph) granite, granosyenite, syenite and leucogranite varieties. Mafic nodules are rather abundant in granosyenite and syenite, and almost entirely absent in Amph- and leucogranite. All granitoids except for the leucogranites, which are believed to represent late differentiates of the Amph-granites not contaminated by the carbonates, are enriched in Ba and Sr (1227-1766 and 899-1143 ppm, correspondingly). 87Sr/86Sr ratio in the granitoids, recalculated to the intrusion age (8.3 Myr), falls in a narrow range from 0.7083-0.7086, while epsilon Nd(T) varies from -4.2 to -2.1. The epsilon Nd(T) values point to the crustal precursor for the granitoid melts, while the nearly constant 87Sr/86Sr ratio indicates derivation of all granitoid bodies from the same magma reservoir. Mafic nodules in granosyenite and syenite consist of fluorine-rich phlogopite (Phl, up to 5 wt.% F) + clinopyroxene (Cpx) + subordinate plagioclase (Pl, An14-16) + minor carbonate (Carb, 0.2-0.4 wt.% SrO) and apatite. Rare, up to 100 micron sized Sr-rich (up to 2 wt.% SrO) barite (Brt) grains have been identified in the nodules. Stable isotope composition of both Carb (delta 18O = +18.8 per mille, delta 13C = -13.4 per mille) and Brt (delta 34S = +13.5 per mille) indicate (meta)-sedimentary origin of the carbonate precursor rock. Jurassic dolomite-rich evaporates with the required Sr- and S-isotope signature are indeed present in the crustal section of the CSW. A schematic mafic nodule-producing reaction can be written as: Dolomite + Felsic Melt = Phl + Cpx + Carb + CO2 (1). The pressure (P) – temperature (T) parameters of the nodules' formation have been estimated based on the composition of coexisting Phl, Cpx and Pl using Berman and Aranovich (1996) systematic with the correction for the F-content in the biotite solid solution: P = 1.5 kbar; T = 800oC. Model melt calculations to reproduce early Pl phenocrysts (An14-16) showed that the reacting melt must have been water under-saturated at these P-T conditions (3.5 wt.% H2O). The amount of Dolomite required to produce granosyenite and syenite with the measured geochemical features, has been estimated with a mixing model of Dubinina and Lakshtanov (1997) at about 17 wt.% of the felsic melt. Mixing had occured within the mid-crustal magma chamber prior to intrusion to the present-day upper-crustal levels.
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