Geophysical Research Abstracts, Vol. 7, 09837, 2005
SRef-ID: 1607-7962/gra/EGU05-A-09837

"Adakites" formed by Garnet Fractionation at the Base of the Crust – An alternative Scenario supported by Field and Experimental Data

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A series of differentiated intermediate to acidic arc-type calc-alkaline magmas occurring at convergent plate margins are characterized by unusually steep REE patterns reflected by very high La_N/Yb_N ratios as well as high Sr/Y ratios. In conjunction with additional geochemical parameters such characteristics unequivocally point to a prominent role of garnet and only minor influence of plagioclase during generation of 'adakitic' magmas. A popular and widely accepted scenario to explain generation and occurrence of such magmas is the concept of 'slab-melting', i.e. the generation of intermediate to acidic magma as primary liquids from, subducted oceanic basaltic crust under eclogite-facies conditions. This requires temperatures above the fluid-saturated solidus of metasediments and/or metabasalts in the subducted lithosphere. Although recent thermal models incorporating temperature-dependent viscosity (van Keken et al. 2002, Kelemen et al. 2004) predict temperatures at the slab – wedge interface that approach the fluid-saturated solidus for old oceanic lithosphere subducting at high convergence rates, it is physically very difficult to emplace magmas generated by 'slab melting' at convergent plate boundaries.

In this contribution, we report results from several high-pressure experimental studies targeted to understand equilibrium and fractional crystallization of primary mantle derived and differentiated picrobasaltic to andesitic liquids at the base of growing 'island arc crust'. Water-undersaturated melting experiments were performed in the pressure range 0.8 – 1.5 GPa, corresponding to 25-50 km depth. They clearly reveal that at pressure $\geq$ 0.8 GPa garnet starts playing an important role as a fractionating mineral phase at temperatures $\leq$ 1100˚C, whereas plagioclase was absent in all experiments

under hydrous conditions at pressures $\geq$ 1.0 GPa. Alonso-Perez et al. (2004, EOS Trans. AGU, 85(47), Fall Meet. Suppl., Abstract V13B-1473) determined trace element partitioning between garnet, cpx, hbl and andesitic to dacitic liquid at 0.8 – 1.2 GPa; they found extremely high partitioning coefficients for HREE and Y and very low coefficients for Sr for garnet in equilibrium with these liquids. Fractionation of moderate amounts of garnets at the base of the crust can easily account for the trace and major element compositions of many Adakite-type magmas observed at convergent plate margins.

The experimental results are supported by the occurrence of garnet-bearing ultramafic to gabbroic cumulate rocks at the base of the Kohistan Island Arc (Northern Pakistan) exposed in the Jijal section. The lower crustal cumulates are composed of a series of ultramafic rocks ranging from dunites to (garnet-bearing) pyroxenites, garnet-hornblendites and garnetites overlain by garnet-bearing gabbroic rocks. Crystallization sequence and mineral compositions closely match experimental data and emphasize the potential role of garnet fractionation from mantle-derived parental magmas at the base of the growing island arc crust for the formation and composition of some intermediate to acidic calc-alkaline differentiates, including ‘adakites’.