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Mixing of high-Ca arc-related melts in Lombok (Indonesia)

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Controversy exists whether ankaramitic magmas, with $CaO/Al_2O_3>1$, represent liquid compositions or reflect the presence of accumulated clinopyroxene in excess of its abundance on the liquidus. New data on mineral phases and melt inclusions in a volcanic sample from Lombok (Indonesia) confirms the existence of ankaramitic melts within an island arc setting, and shows evidence for mixing of different high-CaO melts with distinct CaO/Al_2O_3 ratios.

The sample studied has 11.3% MgO, 0.9% K_2O, $CaO/Al_2O_3=1.03$ and 2 wt% normative nepheline. Phenocrysts are olivine (~65 vol.%; with Cr-spinel inclusions), clinopyroxene (~35 vol.%) and rare plagioclase. Olivine Fo-contents vary from 67 to 91; at Fo=90, CaO ranges between 0.22 and 0.37 wt% and NiO 0.1-0.22 %. These variations at a given Fo-content suggest the presence of compositionally diverse melt fractions, although with similar Mg#. Clinopyroxene phenocrysts, with $100*Mg/(Mg+Fe_{tot})$ 72-92, appear to belong to a single population.

Melt inclusions in high-Fo olivine with CaO>0.3 have CaO/Al_2O_3 1.07-1.46; those in olivine with CaO<0.27 have CaO/Al_2O_3 0.85-1.02. Olivines with intermediate CaO contents have intermediate CaO/Al_2O_3 ratios, and there is a good correlation between CaO content of the olivine and CaO/Al_2O_3 of the melt. High CaO/Al_2O_3 inclusions have lower Na_2O contents (1.9-2.7%) than low CaO/Al_2O_3 inclusions (2.4-3.4%). Major elements other than calcium, sodium, and alumina do not show distinctions between the two groups of melt inclusions; both types are silica undersaturated and relatively dry. Distinctions in trace element patterns do not bear a clear relationship to the CaO/Al_2O_3 ratio of the inclusion.

Our results contrast with data from the Philippines [1], where melt inclusions show mixing between ne-normative high-Ca melts with 'normal' island arc magmas, whereas we find evidence for mixing between two types of ne-normative melts, which both classify as "high-Ca" melts (CaO>13%). The correlations between Ca, Al and Na suggest that modal abundances of clinopyroxene entering the melt control the behaviour of these elements.

References

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Tracing crust-mantle interaction during Karakoram-Kohistan accretion (NW Pakistan)

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Plutonic rocks in the Karakoram (KK) and Kohistan (KO) terranes in NW Pakistan serve as probes for the evolution of mantle and crustal sources involved during convergence-related magmatism, using U-Pb dating and the Hf isotope composition of zircon. Andean-type magmatism in the Karakoram active margin took place in a narrow age range, between 107 and 100 Ma, tapping sources yielding εHf values of -3 to +11. Analysed samples span 300 km along the KK-KO (North-Kohistan) suture from the Drosh to the Hunza valleys. Gabbroic and dioritic intrusions entrained in the suture clearly are of KK affinity. KO terrane magmatism lasted for 120 m.y. (oceanic granitoids at 150 Ma, subduction-related gabbros to granites at 110-90 Ma, intra-arc extensional norites at 85-70 Ma, and gabbro to granite batholith emplacement lasting till 30 Ma). The melts were tapping an increasingly enriched (metasomatized) mantle source evolving from εHf of +24 at 150 Ma to +10 at 30 Ma. Leucogranitic dykes, dated at 47, 39 and 30 Ma, represent either recycled arc basement (with εHf of +10 to +12), or partial melts of Indian crust with Paleozoic and Proterozoic inheritance.

The 150 Ma old Matum Das tonalite represents extremely depleted oceanic magmatic components in the Tethys crust.

The geochemical evolutionary trend of Hf isotopic compositions is interpreted as continuous additions of metasomatized mantle of Paleozoic age (KK continental lithosphere or metasomatized continental mantle predating the Tethys breakup?) to initially depleted (ultra-depleted?) oceanic mantle. Slab components cannot be used to explain the Hf isotope evolution since the geodynamic situation is not favourable for slab melting. Preliminary data for Pb isotopic composition are, however, characteristic of a DMII component in both KO and KK rocks. Leucogranites at 47 Ma (Beorai Gol, Drosh area) and 30 Ma (Indus confluence) likely mark the presence of Indian crust beneath the KK-KO suture and ascent of its partial melts into the overriding plate.