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Himalayan eclogites and their protolith: effect of crustal component and metasomatic fluids

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Major and trace element geochemistry of bulk-rock from the Himalayan high- and ultrahigh-pressure (UHP) eclogites in Kaghan valley of Pakistan has been determined in order to (1) geochemically characterize their protolith formation in the Permian, and (2) the effect of metamorphic or metasomatic fluids on these rocks in the Eocene when the Indian plate collided with the Asian plate and subducted beneath it.
Texturally these eclogites are classified into two groups. Group I eclogites are fine to medium-grained (< 200 micron in size), have mostly retrogressed omphacite, garnet, and phengite with no coesite phase silica. The abundance of quartz-albite-augite and biotite symplectites records dry eclogite facies overprinted by texturally late stage amphibolite facies assemblage. Group II eclogites are medium to coarse-grained (> 500 micron in size), and have fresh garnet, omphacite, and phengite. They preserve UHP grade metamorphic equilibrium conditions (coesite pseudomorph in omphacite) indicating a minimum depth of 90 km for their metamorphism. Mineralogically, both groups of eclogites are composed of almandine-rich garnet, Na-clinopyroxene, epidote/zoisite, and phengite with accessory rutile, ilmenite and zircon. They experienced peak metamorphic pressure temperature conditions at 2.7 ? 3.2 GPa and 727 ? 786 oC.
Major element compositions of Group I and II eclogites show basaltic compositions (42?50 wt. % SiO2). Group I eclogites have high Fe-Ti contents compared with Group II eclogites whereas the Mg# is low for Group I (37 to 44) and high for Group II (43 to 51). Trace elements analyses show enriched large-ion lithophile and rare earth elements (REE) with large variations in high field strength elements (HFSE). Chondrite-normalized REE patterns are flat with slight fractionation of heavy from light REE for both groups however, higher values in case of Group I eclogites. The HFSE abundances also show two distinct groups as highly enriched (Group I with Zr/Hf ratio of 4 8 to 52) and less enriched (Group II with Zr/Hf ratio of 34 to 40). Similarly, the LREE/MREE fractionation (La/Sm)N =2.6 of Group II slightly differs from those of Group I eclogites, which have (La/Sm)N ratios of 2.3.
On the basis of major and trace element geochemistry it is interpreted that these eclogites were derived from tholeiitic to within-plate-basalts equivalent of the Permian Panjal Trap volcanics. Group I eclogites are products of lava flows whereas Group II eclogites are the products of feeder dykes. The large variation in major and trace element composition in Group I and II eclogites in general, and in each individual eclogitic sample in particular, indicates that (1) the protolith of these eclogites may have been contaminated by crustal component during magmatic activity in the Permian, and/or (2) these eclogites may have been affected by fluid infiltration during metamorphic or metasomatic process in the Eocene when the Indian plate lithosphere was subducted beneath the Asian plate.

Keywords: Himalaya, eclogites, geochemistry, protolith, subduction, metamorphism