Lu-Hf age and isotope systematics of the Dora Maira nappe, western Alps

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Lu-Hf garnet-whole rock geochronology applied to metamorphic rocks that contain old and unequilibrated zircon can effect both the isochron age and calculated initial Hf isotope composition. In order to better constrain the magnitude of these effects, we have performed Lu-Hf isotope analyses of the Dora Maira nappe because it contains zircons that are ~230 Ma older than the age of metamorphism.

The sample locality within the Dora Maira contains pyrope megacrysts within a matrix of mostly quartz and white mica. Evenly distributed throughout the major phases are zircon grains that contain ~275 Ma cores and ~35 Ma rims; locally, the 35 Ma zircons are unzoned (Gebauer *et al*., 1997; Lithos, 41:5-24). Preservation of old U-Pb zircon ages suggests that Hf within the zircons may have only partially equilibrated with the UHP metamorphic assemblage, producing two reservoirs of Hf: one in old zircon and another in UHP-equilibrated phases that crystallized at ~35 Ma. We have conducted Lu-Hf isotope analyses of garnet and matrix phases such that the entire sample was digested, including unequilibrated zircon. This approach contrasts with the digestion methods used by Duchêne *et al*. (1997; Nature, 387:586-589), which were designed to avoid dissolution of zircon. The Lu-Hf age and initial $^{176}Hf/^{177}Hf$ ratio determined using the complete dissolution method is 35.74±0.71 Ma (2σ) and 0.282580±7, respectively; this compares with 34.1±1.2 Ma and 0.282661±16 obtained by Duchêne *et al*.

The difference in age and initial Hf isotope compositions between our isochron and that of Duchêne *et al*. reflects a rotation of the isochron due to inherited zircon. The atypically high 'whole rock' $^{176}Lu/^{177}Hf$ ratio of 0.263 (Duchêne *et al*., 1997) is much higher than what would be expected for any reasonable protolith and highlights the strong leverage that zircon has on the effective Lu/Hf ratio and Hf evolution of the zircon-free matrix reservoir between the time of protolith crystallization and Alpine meta-morphism. Based on the present data, we calculate that roughly 30-40% of the protolith zircon (by volume) equilibrated during metamorphism. This partial equilibration preserves significant differences in Hf isotope compositions between the two reservoirs and is coupled with a systematic, but subtle difference in the measured Lu-Hf ages which are within error of one another. Because some zircon will be dissolved during sample digestion regardless of technique employed, any liberated Hf that did not isotopically equili-brate during metamorphism will result in the rotation of an isochron. In order to obtain accurate Lu-Hf ages of rocks such as the Dora Maira, the difference in age between protolith zircon and metamorphism must be less than a few 10s of Ma or nearly all of the zircon must have equilibrated with its co-existing phases during metamorphism.

Geochemical characteristics of eclogites from the Eastern part of the Kokchetav complex (N. Kazakhstan)

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Amphibolised eclogites were studied in the eastern part of the Kokchetav complex (Borovoe region). They consist mainly of garnet, omphacite, quartz, and rutile. During the retrogression, eclogites assemblages became unstable: omphacite was substituted by clinopyroxene-plagioclase symplectites. Garnet grains were surrounded by two coronas: an inner (adjoining to garnet) made of plagioclase (sometimes - of symplectites of Pl and Cpx), an outer – of hornblende. Rutile is surrounded by ilmenite, and by titanite rims. Borovoe eclogites show a P-T peak conditions (at T=670-690 C, P=16-19 kbar) of the metamorphism, its decompression stage with Cpx-Pl symplectite development at 9-12 kbar, and final transformation to garnet amphibolites. Host quartz-phengite schists show similar P-T parametres (up to 20 kbar).

Major and trace element study of the Borovoe eclogites provides an insight into their magmatic petrology, and also to the later metamorphic transformations: dehydration processes during the subduction of the basalts, and to the amphibolisation of the eclogites at the exhumation stage.

Geochemistry of the eclogites shows that their protolith composition probably corresponds to the MORB and/or island-arc basalts. Depletion in the light REE, that is observed in some samples, might be related to these elements loss during dehydration of the subducted oceanic crust.

Strong enrichment in large-ion-lithophile-elements (LILE) and U may be due to the amphibolisation of the eclogites during their exhumation stage. Moreover trace elements consentrations probably vary slightly depending on the extent of the retrograde changes of the eclogites.

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