Mobility of isotopes in deformed and undeformed rocks

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Understanding the mechanisms that govern the mobility of elements in rocks and minerals is critical to unravelling the tectonothermal evolution of orogenic belts. The redistribution by diffusion of elements in a system is considered to be extremely sluggish under dry, static conditions, such that reequilibration will not take place even though temperatures far exceed commonly assumed closure temperatures over long periods of time. Here we consider the general question of what physicochemical factors (such as dry vs wet and deformed vs undeformed) control mobility of isotopes in a system (i.e., rock-scale, mineral-scale).

In the Musgrave Block, central Australia the Nulchara charnockite outcrops as a low angle sheet over the Michell Nob Granite. Mutally intrusive relationships and indistinguishable U/Pb ages on zircon of ~1070 Ma in both rock-types indicates that the two magmas crystallized at the same time. Consequently, both rock types have experienced exactly the same thermal and deformational events. The region was subsequently deformed at upper-greenschist to amphibolite facies conditions during the Petermann Orogeny (~550 Ma). The Michell Nob granite is foliated and shows recrystallization/neocrystallization/mylonitic textures. The charnockite does not have a foliation, but exhibits recrystallization/neocrystallization textures that may have formed during cooling.

In the Michell Nob granite, zircon and titanite did not respond to deformation and metamorphism, and the U/Pb analyses yield the emplacement age. $^{147}Sm/^{143}Nd$ ratios on metamorphic garnet and whole rock suggest that this isotopic system did not equilibrate under these conditions. The apparent $^{40}Ar/^{39}Ar$ ages of hornblende and biotite are older than the emplacement age, suggesting the presence of excess Ar. This excess Ar is attributed to a relatively high partial pressure of Ar owing to release of radiogenic Ar during recrystallisation of K-feldspar. The Rb/Sr system is partially equilibrated, with the outcome on the age dependent on the biotite. In the charnockite, magmatic amphibole gives a $^{40}Ar/^{39}Ar$ age that is similar to the U/Pb zircon age and records the age of crystallization. Biotite and K-feldspar give ages that are considerably younger but older than the age of the Petermann Orogeny.

The isotopic results suggest that high-strain deformation at upper-greenschist to amphibolite facies conditions will not necessarily equilibrate the different isotopic systems to give a consistent age. In addition, we show that Ar is mobile in rocks that are relatively dry and undeformed, which has implications for diffusion rates and for determining the duration of thermal events.

Lu-Hf isotope study of mafic and ultra mafic plutonic rocks, Grenville province

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Proterozoic anorthosite suites are common features occurring along the Grenville Province. Still debated, the genesis of these suites is commonly assumed to be linked to lithospheric delamination [1] during or post to collisional and contractional orogenies. A new possible origin that has been proposed is the recycling of juvenile crust [2] in the long-lasting Laurentian convergent margin during the Mesoproterozoic. This crust could be buried into the mantle and/or lower crust, due to subduction processes and later recycled into partial melts that generates AMCG magmatism.

In order to test these hypotheses and to study the magma sources, we determined Lu-Hf, Sm-Nd isotopic ratios, coupled with trace element contents from six sites of anorthosites suites and mafic-ultramafic plutons from the Grenville Province of Québec that range from 1.45 to 1.069 Ga. We also look at plutonic mafic to ultra mafic rocks as possible candidates to represent juvenile crust.

Following the method described by Blichert-Toft [3] we obtained Hf and Lu concentrations using isotope dilution on MC-ICP-MS and TIMS; they range from 0.037 to 14.56 ppm and from 0.003 to 0.989 ppm respectively. We also measured $^{176}Hf/^{177}Hf$ ratios ranging from 0.282123 to 0.282936, displaying various trends from apparently mantle derived material, to possible crustal contamination with less radiogenic materials. Anorthosite $^{176}Hf/^{177}Hf$ ratios range from 0.282373 to 0.282490. For these samples, $\varepsilon Hf(t)$ values are between +9.77 and +1.48, what shows possible crustal contamination for anorthosite genesis. Plutonic mafic and ultramafic rocks $^{176}Hf/^{177}Hf$ ratios range from 0.282123 to 0.282942 and present $\varepsilon Hf(t)$ values between +10.21 and +2.76. They display different trends for each sites, from mantle derived material to possible mixing with crustal-like source. Model ages were calculated for each samples. Except for one case, anorthosites model ages tend to be older than known crystallisation ages by nearly four hundred million years. For plutonic mafic to ultramafic rocks, some samples present juvenile crust characteristic with calculated model ages close to crystallisation age by nearly one or two hundred million years. These results could be explained by incorporation of a less radiogenic component such as melting of the inferior crust by hot asthenosphere in the case of lithospheric delamination, or burying of juvenile crust in a subduction-like environment.

[1] McLelland, Daly & McLelland (1996) *Tectonophysics* **265**, 1-28. [2] Chiarenzelli *et al.* (2010) *Geology* **38**, 151-154. [3] Blichert-Toft (2001) *Geostandards Newsletter* **25**, 41-56.