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Characterising the continental crust factory: new insights into the roots of an island arc from Hf isotopes in rutile (Kohistan complex, Pakistan)

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Island arcs are one of the primary sites of generation of new continental crust. As such, a question of fundamental importance to models of continental growth is to what extent island arc magmas are strictly juvenile melts derived directly from the mantle, versus potentially incorporating a significant recycled continental component, for example from subducted sediment. The Kohistan complex (northeastern Pakistan) preserves a remarkably complete ∼50 km thick cross-section through an exhumed Jurassic–Cretaceous island arc. It affords a rare opportunity to study the evolution of island arc magmatism from subduction initiation, through intra-oceanic subduction, to arc–continent collision. In this study, we investigate the ultramafic–mafic Jijal Complex, which preserves part of the plutonic roots of the Kohistan complex formed over ∼20 Ma of intra-oceanic subduction.

The Jijal Complex is volumetrically dominated by ultramafic rocks and garnet-bearing gabbros whose petrogenesis is controversial. Garnet formation has variously been attributed a prograde metamorphic origin[1], a magmatic origin recording crystallisation at high pressures[2,3], or a restitic origin following partial melting[4]. We have characterised the source of the Jijal Complex using *in situ* LA-MC-ICPMS determination of the Hf isotope composition of rutile from garnet gabbros, which are zircon-free. This work exploits the superior sensitivity of the Neptune Plus, coupled with an improved analytical protocol, to improve precision of this novel technique and permit *in situ* analysis of rutile with only ∼10–30 ppm Hf.

Rutile occurs included in early-formed minerals such as clinopyroxene and garnet, indicating crystallisation at high pressures and temperatures. Rutile from all samples, collected across ∼3 km of former crustal depth, has indistinguishable Hf isotope compositions close to depleted mantle values. Integrating the new Hf isotope data for rutile with previously published whole rock Nd–Sr isotope data[5], we show that the Jijal Complex gabbros have an enriched Indian Ocean type mantle source. The Hf isotope data permit only a very limited contribution from subducted sediments to this source. This is in contrast to the previous interpretation of derivation of the Jijal gabbros from typical depleted MORB type mantle, which would require a significant sedimentary contribution to explain the Nd–Sr isotope systematics[5]. The distinction between these two scenarios, which is permitted by the new Hf isotope data, is of fundamental importance in understanding the relative proportions of juvenile mantle versus recycled crustal material in the source of the early stages of island arc magmatism.

[1]Yamamoto & Yoshino (1998), Lithos 43: 219–234. [2]Ringuette et al. (1999), Geology 27: 139–142. [3]Jagoutz et al. (2011), EPSL 303: 25–36. [4]Garrido et al. (2006), JPET 47: 1873–1914. [5]Dhuime et al. (2009), JPET 50: 531-569