An early REE fractionated mantle?

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Nd whole-rock systematics on samples from SW Greenland indicate that an Early Enriched Reservoir (EER) with super-chondritic Sm/Nd may have been sampled by Paleo-Eoarchaean TTG gneisses [1]. This EER could have persisted for >350 Ma [2] but it was not global in extent [1]. The formation of the EER was likely concomitant with a complementary low Sm/Nd crust, which has since been destroyed. We have analysed titanites from such TTG samples for Sm-Nd, U-Pb and O isotopes using a variety of *in situ* and solution techniques. The U-Pb and O data, along with BSE imaging, indicate minimal isotopic disturbance of originally magmatic titanite. The O data are consistent with a mantle source for the magma, rather than interaction with evolved continental crust, or sediments. Epsilon ^{143}Nd data, appropriately age-corrected, are super-chondritic and agree with previous whole-rock and titanite data [1, 2]. This gives us confidence that the budget for Nd in these TTG's mainly resides in titanite, which are therefore largely mirrored by whole-rock analyses. However, Lu-Hf isotope systematics within zircons from these age rocks in SW Greenland are mostly chondritic, implying that the evolved crustal components sampled a reservoir with high Sm/Nd but chondritic Lu/Hf. The offset is marked and is not replicated elsewhere on Earth; younger samples display a strong correlation between εHf and εNd. In this case, an unusual set of circumstances are required to account for Sm/Lu fractionation, which apparently has not been detected elsewhere throughout Earth history. The role of differing ratios of Mg and Ca perovskite crystallising in the deep mantle could account for this fractionation and should be modelled in order to provide constraints on deep mantle petrogenesis in the early Earth. This may in turn provide further insight into the nature of the earliest crust formed.

[1] Bennet, Brandon & Nutman (2007) *Science* **318**, 1907–1910. [2] Amelin (2009) *Chemical Geology* **261**, 53–61.

Sequential pluton emplacement, garnet granulite metamorphism, and partial melting during construction and modification of magmatic arc crust, Fiordland, New Zealand

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New geochronologic data from Fiordland provide insights into the processes, timing, and duration of crustal formation and modification in continental magmatic arcs. Fiordland geology is dominated by high Sr/Y diorite plutons of the Western Fiordland Orthogneiss (WFO) [1, 2] that intruded Paleozoic metamorphic rocks during the Late Cretaceous. Lower crust is exposed on the east side of the Alpine Fault and the corresponding upper crust is exposed on the west, in Westland. Intrusion and subsequent metamorphism of the WFO plutons indicate rapid growth, modification, and stabilization of cratonic rocks.

U-Pb zircon ages indicate that intrusion of plutons and subsequent metamorphism occurred sequentially from north to south. Emplacement occurred at 0.6-1.1 GPa in the north to 1.0-1.2 GPa in the south [2]. In northern Fiordland [N of Milford Sound], intrusion of 135-128 Ma (Zrn) gabbroic magma was followed by 0.6-1.1 GPa two-pyroxene granulite metamorphism at 126-135 Ma, and then 1.2-1.4 GPa garnet granulite metamorphism and partial melting ca. 126-123 Ma (Grt). In southern Fiordland, WFO plutons have a similar history from north to south: the low pressure 125-120.1 Ma (Zrn) [2] Worsley was metamorphosed to garnet granulite at 1.2-1.4 GPa, ca. 115 Ma (Zrn) [3]; the low pressure ca. 120 Ma (Zrn) Misty was metamorphosed to garnet granulite at 1.2 GPa, ca. 115 Ma (Zrn); the high pressure 117.8-113.2 Ma (Zrn) Malaspina was metamorphosed to garnet granulite at 1.0-1.4 GPa, ca. 113 Ma (Grt) along Doubtful Sound and 111.9±1.6 Ma (Grt) to the south on Resolution Island.

About 30% of Fiordland (ca. 1,000 km^2) is underlain by WFO plutons that were emplaced, metamorphosed, and partially melted in <12 m.y. Partial melting of low (e.g. Pembroke Granulite) and intermediate silica rocks (e.g. WFO) produced secondary high Sr/Y trondhjemite magmas that likely fed upper crustal plutons and volcanic rocks similar to but not direct equivalents of those now exposed on the west side of the Alpine Fault.

[1] Tulloch & Kimbrough (2003) *Geol. Soc. Am.* **SP 374**, 275–295. [2] Allibone *et al.* (2009) *NZ J. Geo. Geophys*, **52**, 379–415. [3] Daczko & Halpin (2009) *J. Met. Geo.* **27**, 167–185.