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Pre-Mesozoic intraplate and subduction-related metasomatism in the Scottish lithospheric mantle

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Mantle xenoliths entrained in late Carboniferous to mid-Permian silica-poor basic magmas from northern Scotland were investigated using major and trace elements of minerals and isotopic compositions of whole-rock and clinopyroxenes. The work concerns peridotites from two localities in the ENE and WSW of the Scottish Northern Highlands Terrane, namely; 1) Rinibar (South Ronaldsay, Orkney) and 2) Streap Com'laidh, (near Glenfinnan). Two groups of clinopyroxenes can be distinguished both at Streap Com'laidh (Type-S1 and Type-S2) and Rinibar (Type-R1 and Type-R2) based on different trace element contents and isotopic ratios. Type-R1 is characterised by the lowest concentrations of Ba, Rb, Sr, LREE, and U-Th, associated with remarkable high levels of Ti and Zr. These clinopyroxenes have measured 87Sr/86Sr ratios ranging from 0.70330 to 0.70383, 144Nd/143Nd ratios from 0.512643 to 0.512761 and 176Hf/177Hf from 0.282730 to 0.282873. On the contrary, Type-R2 shows the highest concentrations of Ba, Rb, Sr, LREE, and U-Th and pronounced Ti and Zr negative anomalies. They have measured 87Sr/86Sr isotopic ratios similar to Type-R1, but lower 144Nd/143Nd (0.512431-0.512524) and higher 176Hf/177Hf (0.282946-0.283039). Calculated melt in equilibrium with Type-R1 is very similar to inferred primary kimberlitic magmas and the clinopyroxene trace element profiles may have resulted from an efficient chemical exchange between a percolating melt and the peridotite host rock. On the other hand the calculated Type-R2 melt overlap the field of Proterozoic carbonatites. Significantly, at the age of 550 (+50) Ma, the two groups have almost identical Sr-Nd compositions, similar to average DMM at 550 Ma. This

age is crucial for Scotland and for global tectonics. It corresponds to the opening of Iapetus Ocean following the break-up of Rodinia supercontinent. At about the same time the Canadian and Finnish Shields were also affected by kimberlitic and carbonatitic magmatism. Late Proterozoic-Early Phanerozoic carbonatite magmatism is also recognized within Scotland (Loch Borralan, Northern Highland Terrane; Young et al., 1994). Moreover, the megacrysts in the Carbo-Permian basanites & melanephelinites appear to represent a coherent suite, across Scotland from the Hebridean Terrane (Loch Roag) to the Southern Uplands (Burn-Between-the-Laws). Their genesis, involving high LREE and Nb, arguably involved carbonatitic melt fractions (Long et al., 1994: Upton et al., 1999).

At 500 Ma the tectonic regime changed from divergent to convergent as Iapetus began to close and the Baltica continent start approaching Laurentia. It may have been during this convergent stage ($\sim$400Ma) that the metasomatism affecting the sub-Streap lithospheric mantle occurred. Clinopyroxenes from Streap show in fact trace element and isotopic features that can be explained by metasomatic fluids coming off a subducted slab. Type-S1 is characterized by an almost flat profile from MREE to HREE accompanied by an overall LREE enrichment. It shows the highest Th and U, coupled with low Sr, Zr and TiO2 contents. Type-S2 exhibits humped LREE-enriched patterns and a steep decrease from Nd to Yb. They present the lowest Th and U, coupled with the highest Sr, TiO2 and Zr contents. Both groups of clinopyroxenes present analogous isotopic features. They have measured 87Sr/86Sr values from 0.70652 to 0.70826; 144Nd/143Nd from 0.512093 to 0.512687 and 176Hf/177Hf from 0.282712 to 0.283065. A substantial amount of sediments (ca. 10%) are also necessary in order to explain the isotopic features of these samples. The various terranes that now constitute Scotland came into conjunction at the end of Caledonian Orogeny, and were certainly contiguous by 415 Ma. The Rinibar clinopyroxenes record no subduction-related imprinting. This could imply that i) the north easternmost portion of the Highland Terrain lithospheric mantle was unaffected by the subduction or, alternatively, ii) the subduction-related metasomatism recorded in the Streap mantle may be older, when the two lithospheric blocks were far apart.

These data indicate a complex metasomatic history of the Scottish lithospheric mantle, which underwent to different geological events, most probably prior the juxtaposition of the several tectonic blocks which nowadays constitute the Northern Highland Terrains.