In situ U-Pb analysis of detrital titanite: A new provenance technique applied to enigmatic metasedimentary cover sequences in SW Scotland

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Provenance studies, which provide crucial insight into crustal evolution and palaeogeography, are particularly important in deformed and metamorphosed cover sequences that may be displaced during orogeny thereby obscuring the link with their original basement. Of the various sedimentary provenance techniques available (e.g. whole-rock major and trace element analyses and single grain U-Pb zircon dating), none can be described as the definitive tool and as such integrated, multi-method approaches are necessary.

This contribution presents the first *in situ* ion microprobe U-Pb study of detrital titanite, applied in conjunction with petrography, whole-rock Sm-Nd and U-Pb detrital zircon data. These techniques were used to investigate the provenance of two enigmatic, probable Neoproterozoic, metasedimentary cover sequences in the Inner Hebrides, SW Scotland – the Colonsay Group, which unconformably overlies the Palaeoproterozoic Rhinns Complex on Islay and the Iona Group, unconformably overlying Archaean Lewisian gneisses on Iona. U-Pb detrital zircon data point to the Rhinns Complex (*c*. 1780 Ma) as the major source of both successions and are consistent with whole-rock Sm-Nd data. Detrital titanite data, for the most part, support predominant derivation from the Rhinns Complex, but yield younger maximum depositional ages of *c*. 942 Ma and *c*. 1482 Ma for the Colonsay and Iona groups, respectively. One sample (from the Dun Gallain Grit Formation of the Colonsay Group) exhibits a markedly different titanite age distribution to that of the zircon, with a pronounced peak at *c*. 1.0 Ga. This difference could reflect additional source contributions, lacking in zircon but containing titanite. Alternatively the titanite may be recording metamorphic events in the source(s). As detrital titanites from this sample are found overgrowing ilmenite (implying a metamorphic origin) the latter explanation seems more plausible. The pronounced peak at *c*. 1.0 Ga suggests that these titanites are recording Grenville events in the source(s).

Petrogenesis of pyrochlore from the Motzfeldt Centre, SW Greenland

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The Mid-Proterozoic Gardar province of South Greenland represents the products of rift-related magmatism. The Motzfeldt complex is one of the earliest Gardar centres, comprising plutons and minor intrusives of peralkaline syenites, nepheline syenites, syenogabbros that range in composition from quartz- to nepheline-normative and displaying complex magmatic and sub-solidus histories.

This study examines highly altered nepheline syenites to the NE of the Motzfeldt centre, known to contain economically interesting amounts of Th, U, Nb, Ta, Zr and LREE. The rocks lie in the roof zone of a major (120 km^2) magma chamber abutting granite-gneiss of the Julianehåb batholith on its margins and sequences of lavas, pyroclastics and arenites at the roof, together known as the Eriksfjord formation. Luminescence petrography and microchemical analysis of altered units have shown that post-magmatic fluid-rock interaction remobilised and redistributed elements within the system. HFSE, notably Nb and Zr, were mobile in the fluid via element complexing, probably with F ± CO_3. Differing amounts and/or mechanisms of complexation for each HFSE element mean that HFSE ratios, usually constant in rocks of similar petrogenesis, are extremely variable in these lithologies. Pyrochlore and zircon populations and whole-rock samples from altered syenite were examined using MC-ICP-MS for U-Pb, Lu-Hf and Pb-Pb isotopes. LA-ICP-MS zircon populations define a well-constrained concordia age of 1273.1 ± 8.1 Ma for the centre. Lu-Hf data on zircon separates suggest mixing of material derived from both mantle and crustal sources, with $^{176}Hf/^{177}Hf$ values ranging from 0.281856 to 0.282344. Pyrochlores can be divided into two populations depending on internal growth textures. “Primary” pyrochlores have $^{208}Pb/^{204}Pb$ between 54 - 441 compared to a more restricted range of 38 – 68 in altered grains. The higher values are considered characteristic of magmatic, unaltered pyrochlore. The enrichment of HFSE that characterises this area resulted from: a) formation of primary HFSE-rich magma via fractional crystallisation, b) emplacement of this magma against an arenite roof zone, c) metasomatism by F- and CO_3-rich late-stage hydrothermal activity remobilising and enriching HFSE elements.