

## ID-TIMS as a tool for terrane provenance studies in polyorogenic complexes: A case from the SW-Norwegian Caledonides

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The Caledonian mountain range along the western coast of Norway formed by the collision between Baltica and Laurentia in Silurian times. Several nappe sheets were thrust onto the Baltic basement and built up a mountain range which collapsed during following extensional tectonics and suffered severe erosion. Today the SW-Norwegian Caledonian nappe pile is fragmented into different tectonic units, overlying Baltic basement, without lateral connections.

In this work we look at the provenance of the Hardangervidda-Ryfylke Nappe Complex and its relations to the other nappes in the Caledonides. This nappe complex has been subdivided into three distinct nappe sheets, from bottom to top: the Dyrskard, Kvitnut and the Revsegg nappes. Previous dating with the Rb-Sr method had shown that the rocks formed in the Meso- to Neoproterozoic, but there was considerable uncertainty on the timing of metamorphic overprints and deformation. One specific question is whether the nappes have been emplaced together as one block, or as separate units, during the Caledonian orogeny.

We use ID-TIMS analyses, mainly on single grains of zircon, titanite and rutile from orthogneisses, metavolcanics, neosomes and pegmatites. Some of the main differences emerging at this stage concern the oldest units in the different nappes, which in the Kvitnut nappe point towards 1600 Ma whereas both the Revsegg and the Dyrskard nappes are around 1500 Ma. All three nappes have been affected by the Sveconorwegian orogeny. A most prominent effect is the emplacement of a large granitic body in the Kvitnut nappe at around 990 Ma, coeval with formation of local neosomes and the metamorphism of amphibolite and orthogneiss. The Caledonian overprint was also quite strong in all three nappe segments, disturbing the U-Pb systematics of zircon, forming new rutile, some titanite and local pegmatites. The latter have been affected by regional deformation and hence their age can be used to constrain the dynamics of the Caledonian processes in the region.

## Redox-freezing and -melting of carbonates in the deep mantle and the role of transient carbides

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The onset of deep melting in the Earth's mantle is likely to be related to small amounts of CO<sub>2</sub>/carbonate [1] buried to depths below the 660 km discontinuity as a component in subducted oceanic lithosphere. Thus, we investigate redox processes between oxidized carbonates and the reduced ambient mantle that potentially hosts an Fe, Ni metal phase [2–4]. We locate the carbon/carbonate redox equilibrium in terms of  $f_{O_2}$  and the solidus temperature of carbonated peridotite at P and T relevant for the transition zone and lower mantle. Experiments were performed on a fertile peridotite composition containing 5 wt.% CO<sub>2</sub> at ETH. At 10–23 GPa, solidi temperatures are in the range of a mantle geotherm implying that small degree carbonatite melting is generally possible through thermal relaxation of subducted lithosphere.  $f_{O_2}$  controlled experiments indicate that the carbon/carbonate equilibrium is situated  $\geq 2$  log units above IW at 10–23 GPa, i.e.  $\geq 2$  log units higher than likely  $f_{O_2}$  conditions of ambient mantle. Consequently, carbonatite melts infiltrating the mantle are unstable and will suffer redox freezing through reduction of CO<sub>2</sub> to diamond causing their immobilization. On a local scale, carbonatite melts will consume Fe, Ni metal to leave a mantle domain that contains all iron as Fe<sup>2+</sup> and Fe<sup>3+</sup> in silicates and ferropericlase and all carbon as diamond [5]. The inverse process, carbonatitic redox melting, consuming Fe<sup>3+</sup> and diamond would occur when such heterogeneities are entrained by upwelling mantle. Such melts cannot travel far within the metal bearing mantle matrix (as they would again reduce at depths > 250 km) and will only escape at less than ~120 km because the ambient  $f_{O_2}$  remains too low also in metal free mantle to about this depth [6]. We expect a zone of Fe, Ni carbides to form at the boundaries of such domains where the mass of carbonatite is insufficient to oxidize all metal present. Preliminary data indicate that such carbides melt surprisingly at a few 100 degrees below the mantle geotherm.

[1] Dasgupta & Hirschmann (2006) *Nature* **440**, 659–662.  
[2] Frost *et al.* (2004) *Nature* **428**, 409–412. [3] Rohrbach *et al.* (2007) *Nature* **449**, 456–458. [4] Rohrbach *et al.* (2011) *J. Petrol.* **52**, 717–731. [5] Rohrbach & Schmidt (2011) *Nature* **472**, 209–212. [6] Stagno & Frost (2010) *EPSL* **300**, 72–84.