

## **Supporting information for:**

# **An anticlockwise metamorphic P-T path and nappe stacking in the Reisa Nappe Complex in the Scandinavian Caledonides, northern Norway: evidence for weakening of lower continental crust before and during continental collision**

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## **Appendix S1 – Analytical methods**

Bulk rock X-ray fluorescence analyses were performed with a Panalytical Axios XRF spectrometer at the University of Cape Town, South Africa. Analyses for eleven major elements (Fe, Mn, Ti, Ca, K, S, P, Si, Al, Mg, and Na) were performed on fused disks prepared with a lithium borate flux. Loss on ignition (LOI) was determined from weight loss of the samples after 1.5 h ignition at 1050 °C (Table S1). Compositions of garnet (Table S2), biotite, feldspar, and white mica (Table S3) were measured using three instruments. The above minerals in samples AR25b, AR26, AR71 and AR153 were measured using a JEOL JXA-8100 electron microprobe at the University of Cape Town. Analyses were carried out using a 15 kV accelerating voltage, 20 nA probe current and 2-3 µm spot size. Counting times were 5 seconds for both background and 10 seconds for peaks on all elements. Data were processed using ZAF matrix corrections and reduced with the PAP procedure.

The composition of minerals in sample UL248 were analyzed using a JEOL JXA-8900R electron microprobe at the Christian-Albrechts University in Kiel, Germany. Analyses were carried out using an accelerating voltage of 15 kV and beam current of 15 nA. Counting times for background was 7 seconds and for peaks was 15 seconds. Garnet, biotite and muscovite were measured with a fully focused beam of 1 µm diameter and feldspar was measured with a 5 µm beam. Matrix corrections were carried out according to the CITZAF procedure version 3.5 in the JEOL software. The garnet map for sample UL248 was produced by dividing the mapped area into a grid of measuring points on which counting rates were generated to obtain relative element concentrations. Garnet compositions in samples AR25b and AR26 were determined on a Zeiss Merlin VP SEM housed at the University of Tromsø by semi-quantitative Energy Dispersive Spectroscopy (Oxford X-mag 80 detector) running Aztec 3.3 software. The EDS system is consistently calibrated using a cobalt standard. Consistency of

the EDS analyses with microprobe analyses was checked by analyzing a common sample (AR71; table S2), and results do not differ.

Zircon and titanite were separated from crushed samples by standard mineral enrichment techniques and hand picked under a binocular microscope. Zircon was mounted in epoxy and polished to reveal grain cores. CL images of grains guided SIMS U-Th-Pb zircon geochronology. Analyses were carried out in two separate sessions on three zircon separates on the Cameca IMS 1270 large-geometry ion microprobe at the Nordsim facility at the Swedish Museum of Natural History (methodology of Whitehouse and Kamber, 2005 and references therein). An  $O_2^-$  primary beam with 23 kV incident energy (-13kV primary, +10 kV secondary) was used to sputter zircon, with the primary beam operated in aperture illumination (Köhler) mode yielding a  $\sim 15\text{-}20\text{ }\mu\text{m}$  spot which was presputtered using a  $25\text{ }\mu\text{m}$  raster for 90 s to remove gold and minimise surface contamination. For zircon, centring of the secondary ion beam in the  $4000\text{ }\mu\text{m}$  field aperture (FA), mass calibration optimisation, and optimisation of the secondary beam energy distribution in the 45eV energy window were performed automatically for each run using the  $^{90}\text{Zr}_2^{16}\text{O}^+$  species at nominal mass 196. Mass calibration of all peaks in the mono-collection sequence was performed at the start of each analytical session; while within run mass calibration optimisation scanned only  $^{90}\text{Zr}_2^{16}\text{O}^+$  to adjust the mass calibration slope to account for small drift. A mass resolution ( $M/\Delta M$ ) of  $\sim 5400$  was used to ensure adequate separation of Pb isotope peaks from nearby HfSi $^+$  species. Ion signals were detected using the axial ion-counting electron multiplier. All analyses were run in fully automated chain sequences. Zircon data reduction assumes a power law relationship between  $\text{Pb}^+/\text{U}^+$  and  $\text{UO}_2^+/\text{U}^+$  ratios with an empirically derived slope in order to calculate actual Pb/U ratios based on those in the 91500 reference zircon. The U concentration and Th/U ratio are also referenced to the Geostandards 91500 zircon, which has a  $^{207}\text{Pb}/^{206}\text{Pb}$  age of 1065 Ma (Wiedenbeck *et al.*, 1995).

Titanites were analysed by U-Pb thermal ionization mass spectrometry (TIMS) at the University of Oslo, Norway. Titanite grains were washed in dilute  $\text{HNO}_3$ , ionized water and acetone and an ultrasonic bath was used in order to remove any contamination. Each sample was weighed on a microbalance and spiked with a  $^{202}\text{Pb} - ^{205}\text{Pb} - ^{235}\text{U}$  tracer. The samples were dissolved in HF and a drop of  $\text{HNO}_3$  in Teflon bombs in an oven at  $\sim 195^\circ$  overnight. The solutions were chemically separated using micro-columns and anion exchange resin to remove cations that may inhibit ionization (Krogh, 1973). The U-Pb solutions were dried down and loaded on degassed single Re filaments with silica gel and measured on a Finnigan MAT 262 mass spectrometer. Details are given in Appendix A of Augland *et al.*, (2010). The analytical error and corrections were incorporated and propagated using an in-house programme (ROMAGE 6.3). ISOPLLOT 3.75 (Ludwig, 2012) was used for results from both zircon and titanite analyses.

## References

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