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Zirconology of charnockitised gneisses from Söndrum, SW Sweden

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High grade metamorphic rocks occurring in the Eastern Segment of the Sveconorwegian orogen, SW Sweden are dominated by migmatised granitic gneisses locally recrystallised into charnockite. At the Söndrum quarry charnockite forms distinct ca. 2 m wide symmetrical margins to a ca. 0.5 m wide pegmatitic dyke. The transition from charnockite to migmatised gneiss is gradual on a decimetre scale. In some parts of the charnockites a weak migmatitic structure is preserved, clearly indicating that charnockitisation overprints migmatitic fabric. Therefore the Söndrum locality is a perfectly exposed classical example of metamorphic charnockite formation. In this study we focus on changes in zircon chemistry and microtextures induced by migmatisation and charnockitisation using SIMS and cathodoluminescence (CL) imagining.

On the basis of CL imaging and SIMS U-Pb zircon geochronology we identify three generations of zircon growth present in all lithologies: (1) 1.67 Ga - protolith zircons with or without oscillatory zoning patterns (OZPs); (2) recrystallised sectors within protolith grains with blurred primary OZPs but mainly featureless. These sectors altered the protolith zircons chemistry to variable degrees. The $^{207}Pb/^{206}Pb$ ages on these sectors have a continuous spread from 1.67 Ga to 1.56 Ga with the youngest concordant ages being concentrated at 1.56 Ga; (3) 1.40 Ga - featureless rims (all lithologies) or newly formed zircon (pegmatitic dyke only).

Normalised REE patterns show smooth trends with positive Ce and negative Eu anomalies. The HREE show similar steeply increasing trends towards Lu for protolith and recrystallised domains of the zircons. Only minor enrichment of the LREE in protolith zircons compare to recrystallised domains was observed. The combined imaging, geochronological and REE data suggest that the first metamorphic event (migmatisation) at 1.56 Ga caused a recrystallisation of protolith zircons, partial to complete resetting of the isotopic system and expulsion of large ionic radius LREE from recrystallised domains. The 1.40 Ga newly formed zircons and rims directly date intrusion of the dyke and charnockitisation. They have steep LREE and HREE trends, which indicates that dehydration recrystallisation released Zr and REE to form new zircons but there were no HREE competing minerals (i.e. garnet) formed during the event. Presence of 1.40 Ga rims outside the visible extend of the charnockitisation (i.e. fluid front) indicates that this metamorphic event affected country rock in larger scale.

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Intracrystalline mobility of Pb in zircon in a high-temperature aureole

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Pelitic and mafic gneisses in northern Labrador formed at 1.86 Ga during regional (M1) metamorphism and were reheated at 1.32 Ga (M2) during contact metamorphism in the high-*T* (700-900ºC) aureole around the Makhavinekh Lake Pluton (MLP). An ideal site to examine a wide range of T-t phenomena, we report here one facet of our study that employs conventional thermal-ionization mass spectrometry (TIMS) and sensitive high-resolution ion microprobe (SHRIMP) techniques to evaluate mobility of Pb in zircon at high temperature.

Inherited magmatic and M1 zircons in samples in lower-temperature portions of the aureole (i.e. <800°C) are concordant at 1860 Ma and were, thus, virtually unaffected by M2 contact metamorphism. In contrast to this well-established baseline, sector-zoned, low-CL M1 zircons in samples that experienced temperatures >800ºC have large analytical errors (reflecting nanometer scale decoupling of U and Pb), scatter along an M1 and M2 mixing line (indicating Pb loss given the lack of 1.32 Ga overgrowths), are locally reversely discordant and, most surprisingly, commonly return younger apparent ages for lower-U cores than higher-U rims.

These data collectively require widespread intracrystalline Pb redistribution on scales of at least 10's of nanometers during M2 metamorphism at temperatures above 800°C for a period less than ca. 1.5 m.y. However, Pb mobility cannot be adequately accounted for by the most commonly cited mechanisms, namely, hydrothermal alteration (given the lack of evidence for alteration fronts, similarity of Pb mobility in cores and rims and dry M2 conditions), thermally-activated recrystallization of highly-metamict domains (given the calculated highly-crystalline state of these zircons at 1.32 Ga) or volume diffusion (given that Pb moved against Pb concentration gradients).

Instead, it appears that: 1) thermally-activated solid-state "recovery" of strained impurity-rich (eg. LREE) domains and/or 2) unit cell shrinking related to dehydration of hydroxylated zircon provided the driving force(s) behind the well-established expulsion/movement of incompatible Pb in these zircons.