Rutile petrochronology of Eoarchean metasediments from the southern Inukjuak domain, Québec (Canada) and Akila island (SW Greenland)

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Introduction: The world's oldest rocks of demonstrably volcano-sedimentary origin comprise the Archean "supracrustal belts" these occur as variably deformed enclaves within ancient metamorphosed granite-granitoid gneiss terranes. Two problematical examples are the Eoarchean metasediments of the Superior Province, Canada and Akilia island in SW Greenland. The aim of this study was to provide concise geochronologic and geothermometric constraints on the Neoarchean metamorphic evolution of these Eoarchean metasediments.

Inukjuak Domain

The Inukjuak Domain in northern Québec is part of the Archean Minto Block in the northwestern Superior Province of Canada.

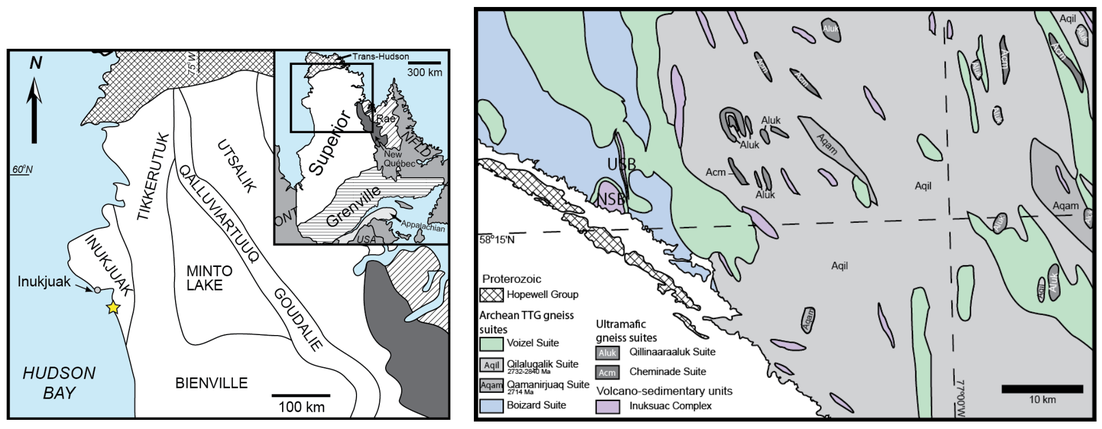

Fig. 1: Simplified geology of the Inukjuak domain showing the NSB and USB (Cates and Mojzsis, 2009).

Geology: Eoarchean (ca. 3800-3780 Ma) rocks of the Nuvvuagittuq supracrustal belt (NSB) and the Ukaliq supracrustal belt (USB) are the best known of numerous supracrustal enclaves within this domain (Fig. 1). Sample IN14032 represents a quartzite, interpreted as a quartz-pebble metaconglomerate from the USB. The main mineral assemblage is anthophyllite + muscovite + quartz + rutile + zircon (Greer et al., 2020).

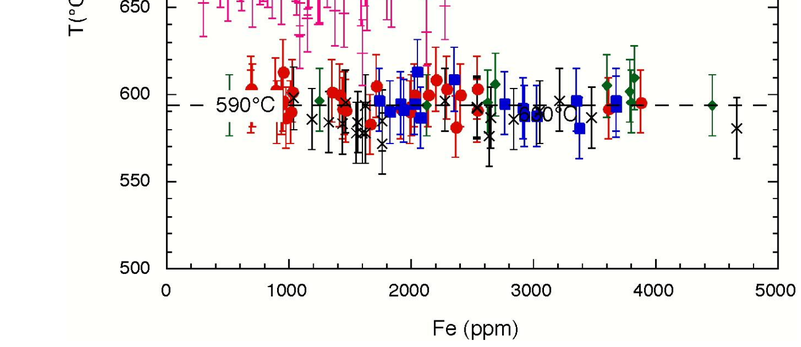

Fig. 2: U-Pb results of rutile dating of sample IN14032.

Geochronology: U-Pb dating of rutile from this sample using the ion microprobe at Heidelberg University following Schmitt & Zack (2012) yielded ages of 2500-2600 Ma (Fig. 2), which correlate well with the youngest zircon ages from this sample, consistent with the lower closure T for Zr diffusion in rutile (<600° C).

Fig. 3: Zr-in-rutile geothermometry of sample IN14032 (USB). For comparison are the Zr-in-rutile data of the NSB domain shown. The data show that rutiles from the USB clearly yield higher T of 670° C ± 40° C (2σ) while the NSB rutiles yielde only 590° C ± 40° C (2σ).

Geothermobarometry: Owing to the pervasive greenschist-facies retrogression of the sample it was not possible to constrain P-T conditions using phase equilibrium calculations; however, the Zr-in-rutile geothermometer provides a tight constraint on T (Fig. 3). A total of 41 rutile analyses were done by electron microprobe at the University of Innsbruck. Zr contents of rutile range from 407 ppm to 914 ppm and yielded T of 660-730° C at an assumed pressure of 0.6 GPa (compatible with the observed mineral assemblage) and the calculated mean T is 670° C ± 40° C (2σ). This possibly hints to either a higher degree of metamorphism in the USB compared to the NSB or a stronger degree of retrogression in the NSB.

Literature

Cates N.L. & Mojzsis S.J. (2009): Chemical Geology 261, 98-113.
Greer, J., Caro, G., Cates, N.L., Tropper, P., Bleeker, W., Kelly, N.M. & Mojzsis, S.J. (2020): Lithos, doi.org/10.1016/j-lithos.2020.105520
Manning C.E., Mojzsis S.J. & Harrison T.M. (2006): American Journal of Science, 306, 305-366.
Peine, J. (2020): Unpublished BSc. Thesis, University of Innsbruck, 53p.
Schmitt, A. K. & Zack, T. (2012): Chemical Geology, 332, 65-73.

Akilia Island

Complex supracrustal rocks from the Nuuk region of West Greenland preserve a record of surficial processes in the early Archean (>3800 Ma).

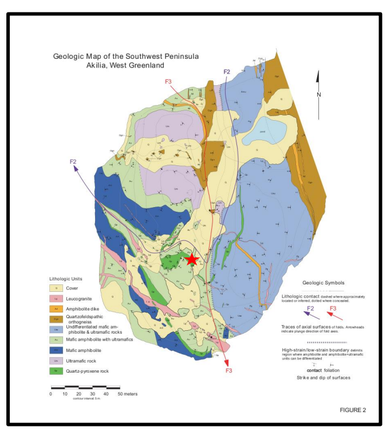

Fig. 4: Simplified geology of the SW peninsula of Akilia island (Manning et al., 2006).

Sample GR114 occurs within the amphibolites in the central part of the SW peninsula of Akilia island. Most of this part of the island consists of amphibolites (blue, green), ultramafic rocks (pink), quartz-pyroxene rocks (dark green) and the Itsaq gneiss (brown). The sample location of GR114 is indicated with the red star.

Geology: Within the lithologies of the enclave a minor anthophyllite-garnet rock (sample GR114) with chemical characteristics suggesting a sedimentary protolith was identified (Fig. 4). The main mineral assemblage of this sample is garnet + anthophyllite + hornblende + biotite + plagioclase + K-feldspar + quartz. Evidence for a later metamorphic overprint is given by the growth of a second generation of biotite and plagioclase as well as diffusive modification of the garnet composition along fractures.

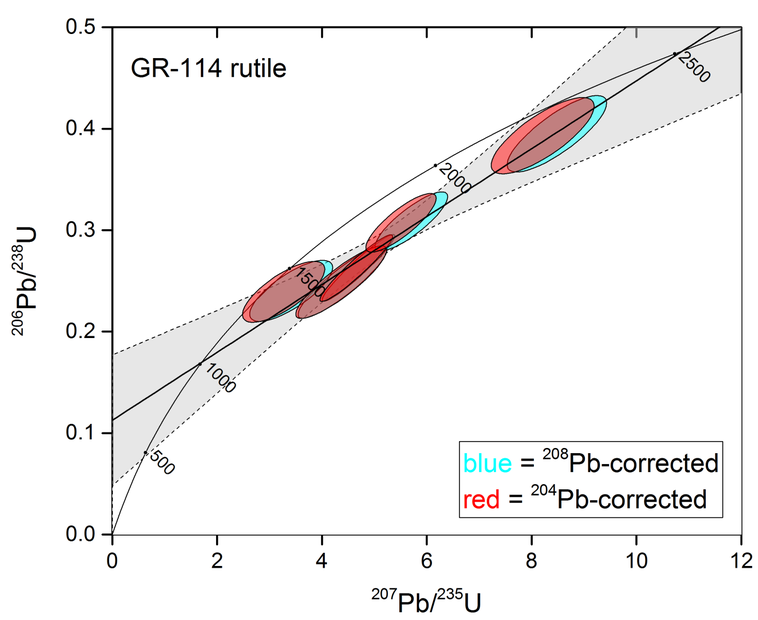

Fig. 5: U-Pb results of rutile dating of sample GR114.

Geochronology: U-Pb dating of rutile from this sample yielded discordant ages of 2400-1400 Ma (Fig. 5). The upper intercept yields an age of ca. 2500 Ma, which again correlates again well with previous Neo-Archaean U-Pb zircon ages around 2700 Ma whereas the lower intercept at ca. 1000 Ma is indicative of a Grenville-age overprint.

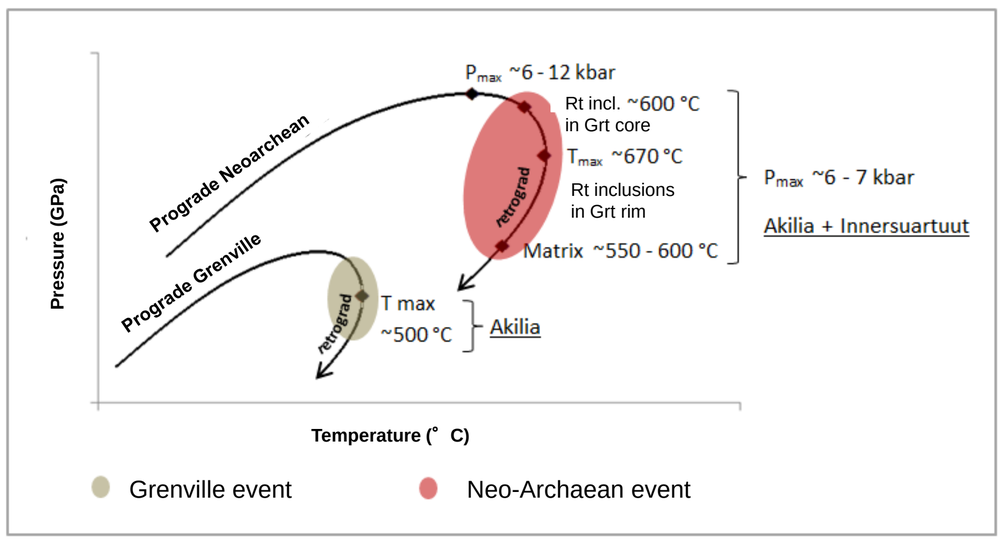

Fig. 6: P-T results of Akilia island. Phase equilibrium calculations of matrix minerals yielded amphibolite-facies conditions of 550-600° C. The peak of metamorphism was at ca. 670° C (rutile inclusions in garnet rim) and the pressure estimates are from the literature. The second generation of biotite yields Ti-in-Bt temperatures of ca. 500° C indicating a later metamorphic event (Peine, 2020).

Geothermobarometry: Phase equilibrium calculations of the main matrix assemblage yielded average P-T conditions of 580 ± 40° C and 0.6 ± 0.1 GPa (Fig. 6). Zr-in-rutile geothermometry of rutile inclusions in garnet yielded increasing T from 610 ± 30° C of rutile inclusions in the garnet core to 670 ± 30° C of rutile inclusions in the garnet rim.

Conclusions

The rutile U-Pb ages combined with Zr-in-rutile geothermometry show that Neoarchean metamorphism reached upper amphibolite-facies conditions (580-670° C) in both supracrustal localities in accordance with previous P-T estimates and U-Pb zircon ages. In addition, the sample from Akilia island yields hitherto unknown evidence of a later-stage Grenville metamorphic (high-greenschist-lower amphibolite-facies) overprint.

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