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Alteration of Mid-Archean oceanic lithosphere, Barberton greenstone belt (South Africa): Insights into fluid-rock interaction processes from metamorphic and geochemical constraints

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The Paleoarchean Barberton greenstone belt (BGB) of South Africa/Swaziland hosts some of the world's best preserved sequences of Mid-Archean (ca. 3.5 - 3.2 Ga) mafic-ultramafic oceanic crustal rocks. However, metamorphic and geochemical constraints on the hydrothermal alteration of these exceptionally well preserved rocks are sparse. As such these rocks may provide key information on a number of unresolved questions concerning crustal and geothermal conditions, as well as and sub-seafloor hydrothermal life-sustaining environments on the early Earth.

This study provides new *PT*-estimates and descriptions of the petrological characteristics of altered mafic-ultramafic rocks across the ca. 3334 Ma Kromberg type-section and parts of the ca. 3472 - 3432 Ma Hooggenoeg Formation of the Onverwacht Group, from both surface samples and fresh drill core collected during the Barberton Scientific Drilling Project (Grosch et al., 2009). Metamorphic *PT*-constraints are derived using a chlorite-quartz-H_2O thermodynamic modelling approach, a chlorite-mica-quartz-H_2O multi-equilibrium calculation, a geothermobarometer that considers hydration in white mica and pseudosection modelling using THERMOCALC v 3.31. In the ca. 3334 Ma Kromberg type-section, a central fuchsite-carbonate-quartz-bearing (listvenitic) zone containing strong mylonitic fabrics, referred to as the Kromberg Section Mylonites (KSM), records at least two metamorphic events: a high-T, low-P (420 $\pm$ 30^{o}C, $<$ 3 kbar) metamorphism, and a lower-T event (T= 240 -350^{o}C, P= 2.9 $\pm$ 0.15 kbar) related to retrograde metamorphism associated with extensional carbonate-quartz veins. The carbonate veins record carbon stable isotope values of 0 $\pm$ 1.5‰ (Archean seawater composition), but highly radiogenic (continental crust) initial $^{87}Sr/^{86}Sr$ isotopic ratios between 0.71048 to 0.71621. Lower in the Kromberg section, metamorphic conditions vary from 215-321^{o}C (at P = 2.9 kbar) to very low-grade conditions of 140-209^{o}C in the lowermost Kromberg. This preserved inverted metamorphic field gradient, suggests that the KSM may represent an early Paleoarchean thrust zone in an obducted thrust nappe pile (see Grosch et al., 2012).

In the basal part of the older ca. 3472 Ma Hooggenoeg Formation, pseudosection modelling in THERMOCALC v.3.31 using an equilibrium greenschist assemblage in a low-grade pillow metabasite records low *PT*-conditions of P = 0.5 – 1.3 kbar and T = 240 -270^{o}C. These preliminary results indicate the preservation of low-pressure/low-temperature Archean seafloor alteration in these ancient Hooggenoeg pillow metabasites consistent with the preservation of delicate igneous textures in these rocks. This questions previous geodynamic models for simple regional burial metamorphism argued to have affected the entire greenstone sequence. Significant variation in modelled XFe^{3+} content using chlorite and epidote compositions of Hooggenoeg pillow metabasites suggests the possibility of moderately variable hydrothermal redox conditions in the Archean subseafloor.

The metamorphic and geochemical results presented here illustrates that a wealth of petrological information is preserved in the low- to medium-grade oceanic mafic-ultramafic sequences of the Barberton greenstone belt. Deriving such petrological constraints helps to further our understanding of Archean geodynamic processes and the nature of oceanic hydrothermal alteration processes on the early Earth. This in turn, provides for further comparison with modern *in-situ* oceanic crust alteration processes.