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Investigating traces of early life in the oldest tectono-sedimentary basin of the 3.5 – 3.1 Ga Barberton greenstone belt, South Africa

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The ca. 3.5 - 3.1 Ga Barberton greenstone belt (BGB) in the Kaapvaal Craton of South Africa, contains some of the world's best preserved sequences of volcano-sedimentary and mafic-ultramafic rocks representative of the Paleoarchean. These rocks provide a unique opportunity to investigate dynamic environments and possible evidence for life on the young Earth. Evidence for early microbial life has been argued to be preserved in silicified marine sediments (cherts) and subseafloor pillow lavas of the upper Onverwacht Group of the BGB. This study will focus on the ca. 3.472 – 3.334 Ga Hooggenoeg, Noisy and Kromberg Formations argued to contain textural, geochemical and isotopic evidence for the oldest traces of subseafloor life on Earth. These include filamentous titanite microtextures as candidate 'ichnofossils', X-ray maps of carbon linings associated with these microtextures and negative carbon stable isotope ratios in Archean pillow lava rims (Furnes et al., 2004, 2008; Banerjee et al., 2006). Based on previously reported similarity between these titanite microtextures and partially mineralized microtubes found in altered in-situ oceanic crust, a complex 'bioalteration' model has been proposed, involving microbial-mediated alteration of basaltic glass.

Despite numerous claims for the exceptional preservation of early subseafloor alteration in the proposed 'Biomarker' type-section, constraints on the nature and timing of low-temperature alteration are not available for the Hooggenoeg Formation. In this talk, new field and petrological data from the mafic-ultramafic Kromberg, volcano-sedimentary Noisy, and dominantly mafic Hooggenoeg Formations in the southeastern part of the Onverwacht Group anticline are presented. Thermodynamic modelling provides the first metamorphic constraints on low-temperature alteration conditions preserved in the Hooggenoeg pillow metabasites. This includes a new quantitative microscale mapping approach that characterizes metamorphic temperature and redox conditions surrounding the candidate titanite biotextures. New carbon stable isotope data from pillow cores and rims are presented. U-Pb dating of the alteration in the pillow metabasites determined by laser-ablation ICP-MS, places new constraints on the timing of alteration locally in parts of the pillow lava sequence.

A U-Pb detrital zircon provenance study of clastic sediments in the Noisy formation that unconformably overlies the Hooggenoeg pillow lavas, provides evidence for the earliest tectono-sedimentary basin in the BGB at ca. 3.432 Ga (Grosch et al., 2011). Petrological characterization of altered and deformed mafic-ultramafic rocks of the structurally overlying Kromberg type-section indicates a mid-Archean convergent margin setting at 3.23 Ga, similar to modern-day ophiolite terrains. On the basis of SIMS sulfur isotope data, it is proposed that sulfur-metabolizing bacteria and possibly methanogenic microbes may have thrived in the shallow-marine subsurface of this tectono-sedimentary basin as early as ca. 3.432 Ga (Grosch & Mcloughlin, 2013).

Collectively, the new field mapping and petrological data allows for a better understanding of the early geologic evolution of the Barberton greenstone belt and the potential habitats that may once have been available for early life. The candidate titanite biotextures are thus placed in better metamorphic and geological context. As such their syngenicity and biogenicity are evaluated particularly in light of an early 'bioalteration' subseafloor model.