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Geology, petrology and geodynamic evolution of the Paleoarchean Onverwacht Group, Barberton greenstone belt, South Africa

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The Barberton greenstone belt of South Africa consists of a low-grade, supracrustal sequence of volcano-sedimentary rocks (greenstones) surrounded by high-grade tonalitic-trondhjemitic-granodioritic (TTG) gneisses. Traditionally, the greenstone supracrustal sequence is referred to as the Barberton Supergroup and is subdivided into 3 groups: the predominantly mafic-ultramafic Onverwacht Group (ca. 3.530-3.334 Ga), the Fig Tree Group (ca. 3.258 – 3.226 Ga) and the Moodies Group (ca. 3.230 – 3.110 Ga). This study presents a multi-disciplinary geological and petrological investigation of surface and scientific drill core samples across selected formations of the Onverwacht Group to further our understanding of the regional stratigraphy, structure and geodynamic evolution.

Thermodynamic modelling on metabasaltc assemblages across the ca. 3472 Ma Hooggenoeg Formation in conjunction with mineral chemistry and oxygen stable isotope data will be presented. The petrological data is used to explore the nature and extent of seafloor versus burial metamorphism. Detrital zircon grains in clastic sedimentary rocks of the Noisy formation that unconformably overlies the Hooggenoeg Formation are investigated by laser ablation-ICP-MS to constrain their depositional age and provenance. A wide range in $^{207}Pb/^{206}Pb$ ages between ca. 3600 and 3430 Ma is reported, corresponding to surrounding TTG plutons and the ca. 3667–3223 Ma Ancient Gneiss Complex. The youngest detrital zircon grain identified has an age of 3432 ± 10 Ma [1]. Given the short time interval for major erosion along the unconformity between ca. 3472 Ma and ca. 3432 Ma, it is argued here, that the Noisy formation represents sediments deposited in the earliest tectonic basin in the BGB [1].

In the overlying ca. 3334 Ma Kromberg type-section, application of thermodynamic phase diagram modelling indicates a wide range in metamorphic conditions from sub-greenschist to the uppermost greenschist facies across the Kromberg type-section. A central mylonitic fuchsite-bearing zone, referred to as the Kromberg Section Mylonites (KSM), records at least two metamorphic events: a high-T, low-P (420 ± 30°C, < 3kbar) metamorphism, and a lower-T event (T = 240–350°C, P = 2.9 ± 0.15kbar) related to retrograde metamorphism [2]. An inverted metamorphic field gradient is documented beneath the KSM suggesting thrust repetition of the Kromberg and Mendon oceanic sequence over the clastic rocks of the Noisy formation around ca. 3227 Ma [2].

A SIMS multiple sulfur isotope dataset on sulfides from across the Onverwacht Group is used to test current models of mid-Archean biogeochemical sulfur cycling. In-situ $\delta^{34}S_{CDT}$ and $\Delta^{33}S$ values of volcanic, detrital, diagenetic and hydrothermal pyrite of the Kromberg, Noisy and Hooggenoeg formations are presented [3]. The Kromberg cherts and mafic-ultramafic hydrothermal vein pyrites exhibit $\Delta^{33}S$ of -0.20 to +2.50‰, and $\delta^{34}S_{CDT}$ from -6.00 to +1.50‰ recording mixing between atmospheric sulfur and hydrothermal magmatic fluids [3]. The Noisy formation sedimentary sequence contains detrital and diagenetic pyrites with a significant variation in $\Delta^{33}S$ of -0.62 to +1.4‰ and $\delta^{34}S_{CDT}$ between -7.00 and +12.6‰ in the upper turbidite unit, to more narrow isotopic ranges with magmatic-atmospheric values in the underlying polymictitic diamictite [3].

The new geological observations and petrological data are used to test competing stratigraphy and geodynamic models of the Onverwacht Group and to further our understanding of the Barberton greenstone belt evolution.

References:

[1] Grosch et al. (2011) Precambrian Research, 191, 85-99

[2] Grosch et al. (2012) J. Petrol. 53(3), 513-545

[3] Grosch and McLoughlin (2013) Earth Planet Sci. Lett. 377-378, 142 -154