P-T modelling and geochronology of the Barberton Granite Greenstone Belt, South Africa: Rates of tectonic processes in the Archaean

CUTTS, K.A.[1]* , STEVENS G.[1], HOFFMANN J.E.[2], BUICK, I.S.[1], FREI, D.[1] AND MÜNKER, C.[2]

[1]Centre for Crustal Petrology, Department of Earth Sciences, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa, *(correspondence: cuttsk@sun.ac.za;)

[2]Universität zu Köln, Institut für Geologie und Mineralogie, Zülpicher Str. 49b, 50674 Köln, Germany

The Barberton Granite Greenstone Belt (BGGB) of South Africa is an exceptionally well preserved Meso-Paleoarchean metamorphic supracrustal belt, within which metamorphic studies have considerable potential to advance our understanding of tectonic processes in the Archean crust. In this study, metamorphic P-T analysis has been combined with garnet Lu-Hf and monazite U-Pb geochronology, to directly date the amphibolite facies metamorphism within the Stolzburg terrane of the BGGB and constrain the P-T path. A garnet-biotite-chlorite bearing sample yields a Lu-Hf garnet age of 3233 ± 17 Ma and a garnet-staurolite-kyanite bearing sample produces a U-Pb monazite age of 3191 ± 9 Ma. Phase diagrams and garnet compositional modeling indicate a clockwise P-T evolution reaching peak P-T conditions of 8.5 kbar and 640 °C. The duration of metamorphism is estimated to be 50 to 20 Ma based on differences in age between U-Pb and Lu-Hf systems and durations needed to fit models of diffusionally modified garnet chemical zoning. Based on similar shaped clockwise P-T paths over the entire Stolzburg terrane it is probable that the metamorphism occurred in response to crustal thickening due to an accretionary tectonic process.

The difference in the ages obtained from the Lu-Hf and U-Pb systems constrains the rate of burial to 0.5-2.5 mm/yr, while the time required for garnet diffusion provides estimates on rates of exhumation (0.25-0.5 mm/yr). These estimates are consistent with burial via crustal thickening in modern orogens, however the exhuamtion rates are an order of magnitude slower than what is expected for exhumation of continental crust in the modern plate tectonic regime (cm-mm/yr). Plausibly, higher volumes of mafic and ultramafic rocks in the meso-Archaean proto-continental crust reduce the bouyancy of the lower crust compared to modern orogens leading to slower rebound. Against this scenario of slower exhumation, the high-pressure amphibolite fcaies conditions documented imply a relatively cool Meso-Archean continental crust.

www.minersoc.org
DOI: 10.1180/minmag.2013.077.5.3