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Ultrahigh temperature granulites and magnesian charnockites: Evidence for Neoarchean accretion along the northern margin of the Kaapvaal Craton

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ABSTRACT

SHRIMP U–Pb analysis of zircon grains from an ultrahigh temperature Mg–Al granulite from the northern margin of the Kaapvaal Craton (Southern Marginal Zone) shows ages of ~2.72 Ga for the peak metamorphism. Geochemical characteristics of syn-tectonic charnockites in the area are similar to magnesian charnockites, typically formed in subduction settings. In contrast to the prevailing models on peak metamorphism in the context of Neoarchean continent collision between Archean Zimbabwe and Kaapvaal cratons resulting in the formation of the Limpopo Complex, we relate the Neoarchean events to the accretion of this marginal block to the rest of the Kaapvaal Craton. In this model, the subduction event is marked by the formation of magnesian charnockites, and the ultrahigh temperature metamorphism dates the collision event.

1. Introduction

Records of extreme temperatures (≥900 °C) of crustal metamorphism [ultrahigh temperature (UHT) metamorphism; Harley, 2004; Kelsey, 2008], and orthopyroxene-bearing granitoids (charnockites; Frost and Frost, 2008; Rajesh and Santosh, 2012) from the Archean record are useful indicators to evaluate plate tectonic processes in the early Earth. The Neoarchean ultrahigh temperature metamorphism and magnesian charnockites occurring along the northern margin of the Archean Kaapvaal Craton offer important insights into subduction-collision history in the early Earth. We report SHRIMP U–Pb zircon ages from Mg–Al granulites on which UHT metamorphic conditions were reported by Belyanin et al. (2012). Together with the geochemical characteristics of charnockites, we evaluate the role of UHT metamorphism and charnockites as evidence for Neoarchean accretion of this marginal block to the rest of the Kaapvaal Craton. With the northern margin of the Kaapvaal Craton forming the Southern Marginal Zone of the Limpopo Complex, a high grade metamorphic province between the Archean Zimbabwe and Kaapvaal cratons, the ensuing discussion also considers the scenario of the two cratons not being in proximity to each other in the Neoarchean.

2. Geologic setting

The Southern Marginal Zone, exposed within South Africa along the northern margin of the Kaapvaal craton, is dominantly composed of migmatitic tonalitic-trondhjemitic gneisses (the Baviaanskloof Gneiss) intercalated with metavolcanic and metasedimentary supracrustal rocks of mafic, ultramafic and pelitic composition and rare magnetite quartzite (the Bandelierkop Formation), together with syn- (~2.69 Ga) to post-tectonic (~2.46 Ga) granitoid intrusions (Fig. 1a) (see review in Van Reenen et al., 2011). All the rocks of the Southern Marginal Zone have been metamorphosed to granulite grade, but were retrogressed to amphibolite grade within a narrow zone to the south of the N'Tabalala Shear Zone (Fig. 1a). The kinematic indicators in the Southern Marginal Zone rocks are interpreted to indicate southwest thrusting of the high-grade rocks over the low-grade granite-greenstone terrain (Pietersburg block) of the Kaapvaal Craton along the E-W trending and NE-dipping Hout River Shear Zone (Smit et al., 1992). Passeraub et al. (1999) dated shallow NE-verging thrust faults in the Rhenosterkoppies greenstone belt of the Pietersburg block at 2729 ± 19 Ma on the basis of syn-tectonic growth of titanite in sheared mafic

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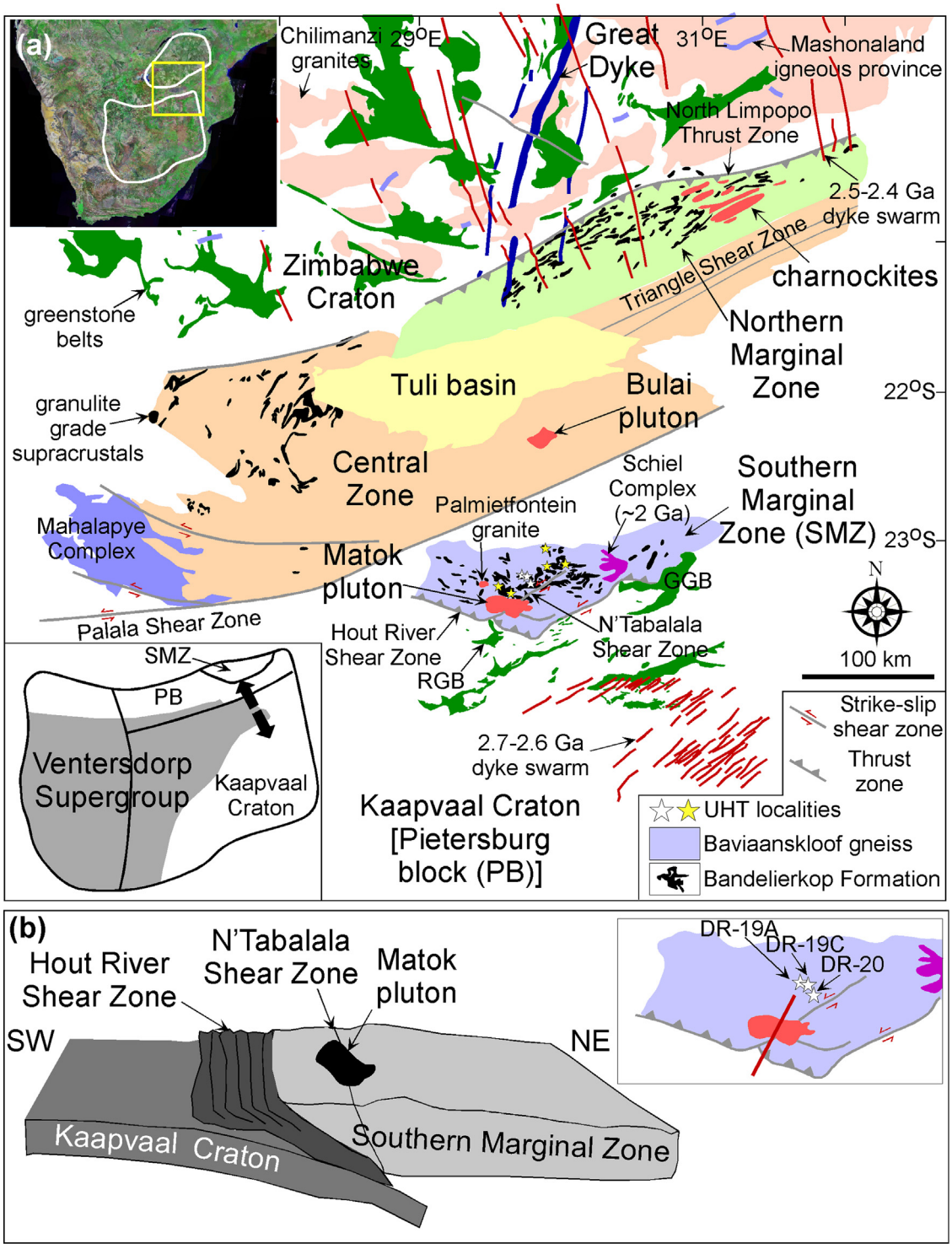

Fig. 1. (a) Generalized geologic map of the Pietersburg block of Kaapvaal Craton, Southern Marginal Zone, Central Zone, Northern Marginal Zone and the adjacent Zimbabwe Craton. The yellow box in the top inset indicates the approximate extent of the area covered. The bottom inset shows the approximate extent of the ~2.73–2.71 Ga Ventersdorp Supergroup and associated intracratonic extension in the Kaapvaal Craton. RGB – Rhenosterkoppies greenstone belt; GGB – Giyani greenstone belt. Only individual charnockite bodies that have been mapped in detail are shown from the Northern Marginal Zone. White stars indicate UHT localities from which samples were collected for geochronologic study. Yellow stars indicate other known UHT localities from the Southern Marginal Zone. (b) The model for Southern Marginal Zone presented in this study. The red line in the inset represents the approximate direction and extent of the traverse in the model.

rocks. The steeply SW-verging Hout River Shear Zone terminates these shallow NE-verging structures within the Rhenosterkoppies greenstone belt. Kreissig et al. (2001) dated the time of shear deformation associated with the Hout River Shear Zone at ~2.71–2.67 Ga on staurolite (2712 ± 37 Ma), garnet (2691 ± 20 Ma) and kyanite (2672 ± 51 Ma) from sheared mica schists in the Giyani greenstone belt.

Previous geochronologic studies have shown that the Southern Marginal Zone was affected by a single Neoarchean high-grade metamorphic event (see review in Van Reenen et al., 2011).