

Evolution of the northeastern Kaapvaal craton and the central Limpopo belt, South Africa, based on single-zircon ages (extended abstract)

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The northeastern Kaapvaal craton is predominantly composed of 2.7 to 3.3-Ga-old granitoid gneisses with a few interspersed NE-trending greenstone belts (Brandl & Kröner 1993) which are, from south to north, the Murchison belt, the Pietersburg belt and the Giyani belt (Figure 1). Its southern boundary is the 3.20 to 3.55-Ga-old Barberton greenstone belt (De Wit 1991; Kröner et al. 1991, 1996; Ward 1995) that probably marks a major crustal discontinuity (suture?) separating an early Archaean terrane in the south from a middle to late Archaean terrane in the north (see also De Wit, this issue). These rocks can be followed, in part, into the southern Marginal Zone of the Limpopo belt where high-grade metamorphism has occurred in the late Archaean, some 2.6 to 2.7 Ga ago (Barton & Van Reenen 1992). The Central Zone of the Limpopo belt is separated from the Southern Marginal Zone by a major shear zone and is composed of granitoid gneisses and supracrustal rocks ranging in age from > 3.3 to about 2.5 Ga (Kröner et al. 1998a). The main tectonic evolution of the Central Zone appears to have occurred between 2.5 and 2 Ga ago, and the peak of granulite metamorphism was reached about 2 Ga ago, followed by fast cooling and uplift (Layer et al. 1996; Jaeckel et al. 1997). We summarize new single-zircon ages obtained by conventional U-Pb analysis, Pb-evaporation and SHRIMP-dating¹ on rocks from the cratonic realm and the Central Zone of the Limpopo belt and speculate on possible tectonic scenarios.

The large terrain between the Barberton and the Murchison greenstone belts (light grey area north of Barberton belt in Figure 1) is predominantly composed of variously deformed granitic gneisses with a surprisingly narrow range in ages between 3.1 and 3.2 Ga (Brandl & Kröner 1993). This includes gran-

itoid gneisses and migmatites in the southern Kruger National Park (zircon ages between 3163 ± 4 and 3183 ± 1 Ma) that fall into the same age range as migmatitic orthogneisses of the Nelspruit Batholith farther west (Kamo & Davis 1991).

A felsic volcanic rock from the Murchison greenstone belt yielded a precise zircon age of 2967 ± 2 Ma (Brandl et al. 1996), while a quartz-porphyry from the upper part of the Pietersburg greenstone succession has a zircon age of 2950 ± 2 Ma (Kröner et al. 1998b). The close temporal association of the felsic rocks of the Pietersburg belt with the surrounding granitoids suggests that the former might represent high-level, comagmatic equivalents of the latter. Also, these zircon ages signify that the Murchison and Pietersburg greenstone belts are virtually coeval but significantly younger than the Barberton greenstone belt with which they were previously equated (e.g. De Wit 1991; De Wit et al. 1992 a, b).

In contrast, zircons from an andesitic volcanic rock of the Giyani greenstone belt are considerably older and were dated at 3203 ± 4 Ma (Brandl & Kröner 1993; Kröner et al. 1998c). This difference in age makes it unlikely that the Pietersburg-Giyani 'line' defines a simple terrane boundary in the northeastern Transvaal, but the differences in age and rock type on both sides of this shear-zone-demarcated line still justify the assumption of a major crustal break (De Wit et al. 1992 a, b; Brandl & Kröner 1993).

The terrain north of Pietersburg is made up of a tonalite-trondhjemite-granodiorite (TTG) suite and granitic gneisses ranging in age between 2.88 and 3.3 Ga (Brandl & Kröner 1993). No ages > 3.3 Ga have so far been found north of the Barberton belt, supporting the view that the northeastern Kaapvaal craton is a crustal entity distinct from, and younger than, the

¹ SHRIMP: Sensitive high-resolution ion microprobe.

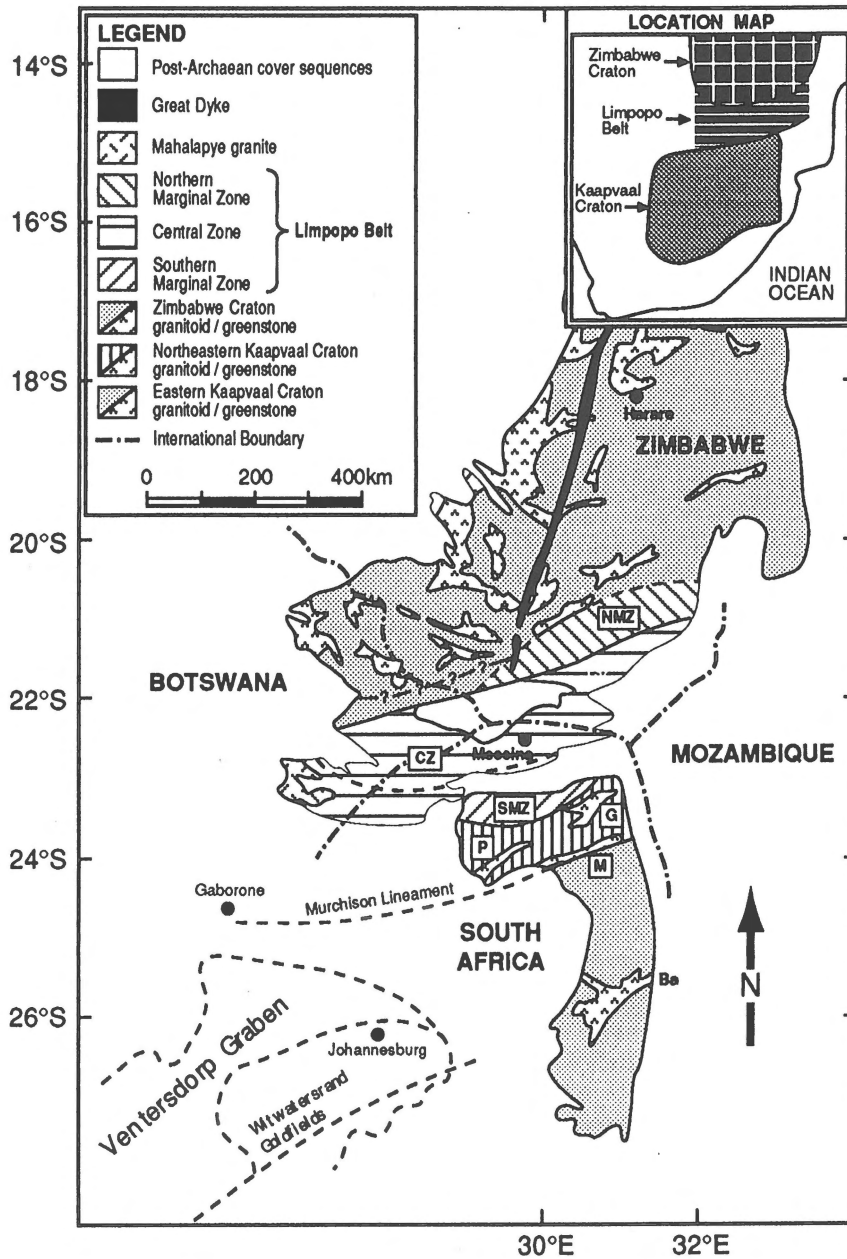


Figure 1. Simplified map of southeastern Africa showing Zimbabwe craton in the north and Kaapvaal craton in the south, separated by the Limpopo belt. Ba = Barberton greenstone belt; M = Murchison greenstone belt; P = Pietersburg greenstone belt; G = Giyani (Sutherland) greenstone belt. SMZ = Southern Marginal Zone; CZ = Central Zone; NMZ = Northern Marginal Zone.

southeastern part of the craton. There appears to be no systematic pattern in the age distribution of granitoid rocks in the northeastern Kaapvaal craton, and simple models of terrane amalgamation, from south to north, are not supported by our zircon ages.

The northernmost granite-greenstone terrain of the Kaapvaal craton is separated from the adjoining amphibolite- to granulite-facies terrain of the Southern Marginal Zone of the Limpopo belt by a major north-dipping ductile shear zone, suggesting that the latter was thrust southwards onto the former (Van Reenen

et al. 1992). The Southern Marginal Zone comprises the high-grade metamorphic equivalents of the northern Kaapvaal granite-gneiss-greenstone terrain (Van Reenen et al. 1992), while the Central Zone, to the north of the Southern Marginal Zone, is lithologically markedly different and contains abundant granodioritic to granitic gneisses with subordinate tonalites and trondjemites, which are tectonically interlayered with clastic and chemical metasediments, suggesting stable depositional environments, and minor mafic metavolcanics (for summaries and older literature see Jaeckel et al. 1997; Kröner et al. 1998b).

The Limpopo belt has long been regarded as one of the oldest orogenic belts in the world with a long-lasting, polyphase tectono-metamorphic evolution extending for over 1000 Ma from about 3700 to about 2600 Ma and with very slow cooling thereafter (e.g. Watkeys et al. 1983). It has also been interpreted as the site where the Archaean Kaapvaal and Zimbabwe cratons apparently collided some 2.65 to 2.70 Ga ago (Barton & Van Reenen 1992; Rollinson 1993).

The Central Zone of the Limpopo belt has previously been interpreted as a segment of early to late Archaean crust which experienced its main deformation and metamorphism around 2.7 Ga ago. Our zircon ages for granitoid gneisses, supracrustal rocks and anatexically derived granitic melt patches do not substantiate this view. The oldest rocks are supracrustal gneisses of the Beit Bridge Complex that contain detrital components as old as 3.7 Ga and are intruded by well-layered TTG and granitic gneisses collectively referred to as Sand River Gneiss and dated between 3.18 and 3.3 Ga (Kröner et al. 1998a). Rocks similar in field appearance to the Sand River Gneiss and locally infolded with it (Verbaard Gneiss, Alldays Gneiss, Zanzibar Gneiss) have predominant ages in the range 2637 to 2734 Ma, but some are as young as 2517 Ma (Kröner et al. 1998b).

The Singelele gneiss, a heterogeneous granodioritic to quartz-monzonitic rock, has protolith ages between 2.55 and 2.58 Ga, while granitoid gneisses interlayered with supracrustal rocks of the Beit Bridge Complex range in age between 2.7 and 2.5 Ga. Since all the above gneisses experienced polyphase high-strain ductile deformation, much of this must have occurred later than 2.5 Ga ago (Kröner et al. 19978).

Granulite-facies pelitic gneisses of the Beit Bridge Complex contain abundant spherical, multifaceted zircons which reflect new zircon growth near or at the peak of metamorphism. These zircons provided ages with a mean at 2026.5 ± 6.3 Ma (Jaeckel et al., 1997),

which we interpret as reflecting a high-PT event (> 10 kbar, 825 ± 25 °C). Granitic melt patches in the metapelites as well as in the Sand River Gneiss and anatexic granites are probably related to rapid near-isothermal decompression to below 3 to 5 kbar and 600 to 750 °C. These rocks contain new magmatic zircons which yielded a mean age of 2005.6 ± 4.4 Ma and probably reflect a crustal melting event resulting from rehydration of the granulitic assemblage (Jaeckel et al. 1997). Fast but heterogeneous cooling thereafter is indicated by Ar-Ar mineral ages between 2025 and c. 1950 Ma (Layer et al. 1996).

Our zircon ages suggest that the most severe metamorphic imprint in the Central Zone was the granulite facies event at c. 2027 Ma that has obliterated most evidence for earlier metamorphism, although there are increasing signs that an older event has occurred around 2570 Ma ago (Holzer et al. 1998; Kröner et al. 1998a, b). Since much of the deformation seen in the gneisses of the Central Zone must have occurred later than 2.5 Ga ago, it is likely that the 'Limpopo Orogeny', at least in the Central Zone, is not an Archaean, but an early Proterozoic event. Thus, simple accretion and collision models for the Limpopo belt are not supported by our data.

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