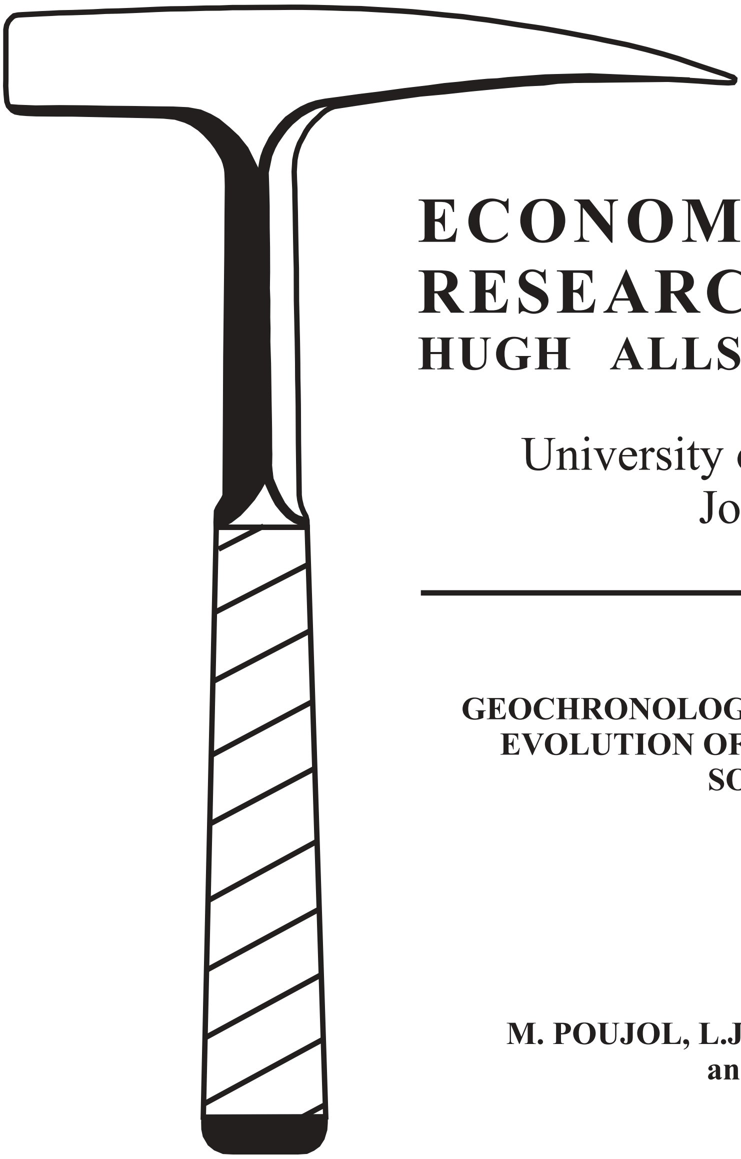

ECONOMIC GEOLOGY RESEARCH INSTITUTE
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Johannesburg

GEOCHRONOLOGICAL CONSTRAINTS ON THE EVOLUTION OF THE KAAPVAAL CRATON, SOUTH AFRICA

M. POUJOL, L.J. ROBB, C.R. ANHAEUSSER and B. GERICKE

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GEOCHRONOLOGICAL CONSTRAINTS ON THE EVOLUTION OF THE KAAPVAAL CRATON, SOUTH AFRICA

by

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ABSTRACT

All the published U-Pb geochronological data from zircon, titanite, sphene and monazite, and Pb-Pb evaporation data applicable to the Palaeoarchaean-to-Neoarchaean geology of the Kaapvaal Craton are employed to reconstruct the history and crustal architecture of the *c*. 3600 to 2500 Ma cratonic basement in South Africa. Only data interpreted as representative of the age of crystallization, or the $^{207}Pb/^{206}Pb$ ages from zircon xenocrysts, have been considered in constructing graphs of cumulative probability versus age of rock formation. In this manner it has been possible to identify the main magmatic events occurring within each of several discrete domains that have contributed to the assembly of the craton. For convenience of data handling the Kaapvaal Craton has been subdivided into Eastern, Central, Northern and Western terranes. Each of these terranes has its own geological and chronological character, although consanguinity of events is also evident. The oldest rocks so far recognised are located in the Swaziland-Barberton areas of the Eastern Terrane where ages > 3600 Ma have been recorded. The early stages of shield development are best exposed in the Barberton Mountain Land where it is now apparent that continent formation took place by magmatic accretion and tectonic amalgamation of small protocontinental blocks. At Barberton, several diachronous blocks, formed between 3600 and 3200 Ma, have been identified, each of which represents a cycle of arc-related magmatism and sedimentation. This phase of crustal development was followed by a period of Mesoarchaean cratonic magmatism, particularly prevalent between approximately 3100-3000 Ma, and marked by the development of a major, crescent-shaped, juvenile arc that was accreted onto the northern and western margins of the evolving Kaapvaal shield. Cratonization was accomplished by the emplacement of major granitoid batholiths, which thickened and stabilized the continental crust during the early stages of this cycle. Subsequent evolution of the craton, between 3000 and 2700 Ma, was associated with continent-arc collision, during which time the Witwatersrand basin and its correlatives were deposited as foreland sequences, followed by episodic extension and rifting, when the Gaborone-Kanye and Ventersdorp sequences were laid down. The high- precision geochronological data that has been obtained over the past decade has enabled this initial attempt at modeling and constraining the geological events that occurred on what is one of the oldest and best-preserved Palaeoarchaean-to-Palaeoproterozoic cratons available for study.

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GEOCHRONOLOGICAL CONSTRAINTS ON THE EVOLUTION OF THE KAAPVAAL CRATON, SOUTH AFRICA

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GEOCHRONOLOGICAL CONSTRAINTS ON THE EVOLUTION OF THE KAAPVAAL CRATON, SOUTH AFRICA

INTRODUCTION

The Kaapvaal Craton is one of the oldest and best-preserved Archaean continental fragments on Earth. Its assembly during the Archaean eon is attributed to a complex combination of processes analogous to modern-day plate tectonics. Such processes took place episodically over a 1000 million year period (3500 to 2500 Ma) and involved magmatic arc formation and accretion as well as tectonic amalgamation of numerous, discrete terranes or blocks (de Wit et al., 1992; Lowe, 1994; Poujol and Robb, 1999). Delineation of these domains, and constraining the timing and duration of the principal magmatic events within them, is best achieved by the craton-wide application of accurate and precise U-Pb zircon dating (e.g., Armstrong et al., 1990; Robb et al., 1992; Kamo and Davis, 1994; Poujol et al., 1996, 2000; Poujol and Anhaeusser, 2001). This paper summarizes some of the recent age data that identify the main magmatic events occurring within each of several discrete domains that have contributed to the assembly of the craton.

For the purposes of description, the Kaapvaal Craton has been subdivided into four sectors termed the Eastern, Central, Northern and Western Terranes. The Eastern Terrane comprises the Barberton Mountain Land (BML), which in turn consists of the Barberton greenstone belt (BGB) as well as all granitoids extending northwards to Hazyview and southwards into Swaziland. The Central Terrane includes the Johannesburg Dome, the Rand Anticline and the Vredefort Structure. The Northern Terrane comprises the Murchison (MGB), Giyani (GBG) and Pietersburg (PGB) greenstone belts. Lastly, the Western Terrane is made up of the Kraaipan (KGB), Amalia (AGB), and Madibe (MaGB) greenstone belts, and their southerly extensions, as well as the Gaborone Granite Complex to the north, which intrudes the Archaean granite-greenstone basement in southeastern Botswana (Fig.1).

Much of the Kaapvaal Craton is covered by Neoarchaean-to-Palaeoproterozoic volcano-sedimentary sequences and good exposures exist in only a few areas. Of these the BML is a region of superb three-dimensional exposure and represents the type area for Archaean crustal evolution on the craton. The majority of all studies and age dating has also been carried out in the Barberton region and, accordingly, crust-forming processes are best described from this portion of the craton. Increasingly, however, it has become apparent that the sequence of crust-forming events evident at Barberton cannot simply be applied to other portions of the craton.

With the recent recognition that the MGB, for example, records an entirely different sequence of crust-forming events, that are not present at Barberton (Poujol et al., 1996), it has become necessary to revisit the concept of terranes on the craton and to consider their delineation and tectono-magmatic histories. In this paper we synthesize the geological evolution and accurate geochronological data applicable to the BML well as three other sectors of the craton where a useful body of data has now been generated. These include the central portions of the Kaapvaal Craton as well as its northern and western margins. We subsequently use this information in an attempt to provide a revised model for the formation and amalgamation of the Kaapvaal Craton.

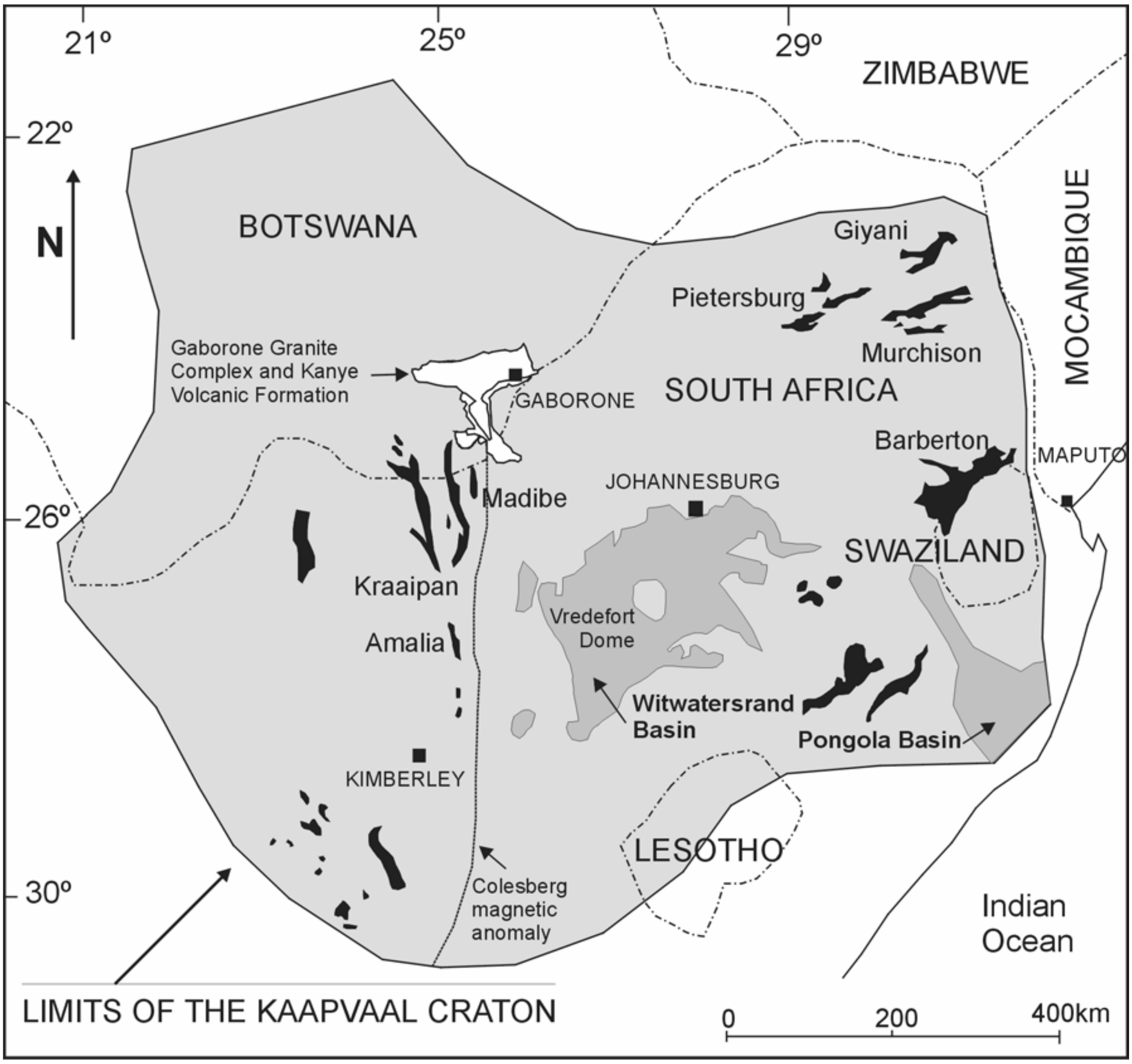


Figure 1: *Simplified diagram showing the outline of the Kaapvaal Craton and the main geological components referred to in the paper.*

GEOLOGICAL EVOLUTION OF THE KAAPVAAL CRATON – A SYNOPSIS

Eastern Terrane (Barberton Mountain Land)

The pioneering work that led to the unraveling of Archaean crustal evolutionary processes in South Africa was largely carried out during the 60s and 70s in the BML. One of the contentious issues that was raised by this early work relates to whether modern plate-tectonic processes, largely studied in and applicable to the Phanerozoic Eon, can be extended to the Archaean. More recent work, mainly in the form of mapping and high-precision geochronology in the area (see Appendix 1), has succeeded reasonably well in establishing that the basic uniformitarian precepts of global plate tectonics can be applied to Archaean crustal evolution at Barberton, although certain conditions (such as heat flow, magmatic production rates, extent of continental re-cycling, ocean water depth, etc.) must have been significantly different.

De Wit et al. (1992) were the first to suggest that the BGB comprises two terranes that were juxtaposed (to form a single “belt”) during a period of major crustal shortening at c. 3228 Ma, and that this belt was also amalgamated with an older, largely sialic block, the Ancient Gneiss Complex (AGC), at this time. Lowe (1994) refined this model and suggested that the BGB is actually an amalgamation of no less than four discrete blocks. These blocks young towards the north and define two major periods of magmatic activity, the older at *c*. 3550 to 3440 Ma and the younger at 3230 ± 50 Ma. Each block comprises an early sequence of extension-related mafic/komatiitic volcanism representing oceanic plateaux or back-arc spreading centres, followed by a period of quiescence, chemical sedimentation and subsidence. This is followed, in turn, by subduction-related felsic volcanism and TTG plutonism that both over-plated and intruded the pre-existing mafic/ultramafic crust. Amalgamation of these blocks to form a larger continental domain is considered to have been achieved mainly by magmatic accretion, where younger blocks developed at the rifted and subducted margins of older blocks. Tectonic accretion is also considered to have occurred when geographically separate blocks, or amalgamations of blocks, were brought together during a period of severe crustal shortening (such as at *c.* 3228 Ma when the northern and southern sectors of the Barberton granite-greenstone terranes were amalgamated). The development of the BGB was terminated at *c.* 3200 Ma with the deposition of the orogenic, clastic Moodies Group sedimentation marking the final stages of block amalgamation. The *c.* 350 million year evolutionary history of the belt is now considered to "…reflect an early Archean plate tectonic cycle that characterized a world with few or no large, stabilized blocks of sialic crust." (Lowe, 1994).

The development of the BGB between *c.* 3550 and 3200 Ma represents, in fact, only a portion of the entire period of crustal evolution in this region. Magmatic activity actually continued episodically for close on 1000 Ma and these events are best represented by the spectrum of ages currently available from the huge variety of granitoids in the region. Because they generally contain zircon and monazite, granitoids are much more amenable to high-precision U-Pb dating than are mafic rocks and it is the former, therefore, that more fully record the entire magmatic history of the early crust.

The preservation of Palaeoarchaean (>3600 Ma) magmatic events is extremely rare around the world and, with the exception of southwest Greenland, there are few cohesive terranes where rocks of this age occur. The oldest rock yet dated on the Kaapvaal Craton – and probably on the entire African continent – is a sample of banded tonalite gneiss from part of the AGC in the Piggs Peak area of northwest Swaziland. This sample provided a population of zircons, which yielded an U-Pb isotope age of 3644 ± 4 Ma (Compston and Kröner, 1988). Crystallization and recrystallization of other zircons in the same sample indicate that this rock was affected by subsequent events, the most notable of which were at 3504 ± 6 Ma and 3433 ± 8 Ma. Although rare and sparsely preserved, this sample indicates that felsic plutonic material has been preserved at the core of the craton prior to the development of even the oldest crustal block in the southern portion of the BGB. The tonalitic protoliths of this material themselves contain mafic remnants, which might be similar to or older than this age.

In the Barberton region Mesoarchaean magmatism is reflected mainly in the emplacement (at *c*. 3105 Ma - Kamo and Davis, 1994), of voluminous, sheet-like, granodioritic-adamellitic, composite batholiths. This event thickened and consolidated the barely stabilized protocontinent that had formed by block amalgamation by about 3200 Ma. The batholiths outcrop over large areas both to the north and south of the BGB and have been well studied in the Nelspruit, Mpuluzi and Heerenveen bodies (Anhaeusser and Robb, 1983; Robb et al., 1983). Smaller plutons, such as the Boesmanskop syeno-granite complex (Anhaeusser et al., 1983) and the Salisbury Kop body (Robb, 1983), were also emplaced at exactly the same time as the batholiths. The tectonic scenario responsible for the emplacement of the huge potassic batholiths in the Barberton region at *c.* 3105 Ma is still enigmatic, although it has been suggested that the event coincides with a transition from largely convergent (at *c.* 3228 Ma) to a transtensional tectonic regime at around 3080 Ma (de Ronde and de Wit, 1994). Also present in the Barberton region, as a Mesoarchaean magmatic event, is a linear belt of at least four low-Ca (possibly S-type or ilmenite series; Meyer et al., 1994; Ishihara et al., 2001) granite plutons. Of these four plutons, at least one, the Sinceni pluton, appears to be as old as *c.* 3074 Ma, whereas the others (Mooihoek, Mhlosheni and Godlwayo plutons) range in age between *c.* 2863 and 2822 Ma (Maphalala and Kröner, 1993). The tectonic setting for these intrusions is also unknown at this stage.

In the Neoarchaean Era the Kaapvaal continent had stabilized and consolidated and granitic magmatism was restricted to the development of numerous, but small, discrete, post-tectonic granite intrusions, emplaced mainly between *c.* 2780 and 2690 Ma. In the Barberton region a number of high-Ca (possibly I-type) granite plutons occur along a north - south linear array that parallels the trend occupied by the Mesoarchaean S-type granites. Four of these plutons occur, namely the Mpageni, Mbabane, Ngwempisi and Sicunusa bodies, all of which are highly differentiated alkali granites (Meyer et al., 1994). These granites post-date the deposition of the Witwatersrand and Pongola Supergroups and coincide with a period when the central and western portions of the Kaapvaal Craton existed under tensional tectonic conditions. It was at this time that the Gaborone-Kanye Complex (*c.* 2785 Ma; Moore et al., 1993) was developed as well as the voluminous outpourings of the Ventersdorp volcanics (2714 to 2709 Ma; Armstrong et al., 1991).

Central Terrane

The central regions of the Kaapvaal Craton are largely covered by Mesoarchaean-to-Palaeoproterozoic volcano-sedimentary formations and it is only in a few areas that older basement rocks are exposed. These inliers, coupled with borehole information obtained from extensive Witwatersrand gold exploration, have revealed Palaeo-to Meso-archaean granite-greenstone floor rocks ranging in age from *c.* 3480 to 2727 Ma. The best-exposed inlier is the Johannesburg Dome, located in the central part of the Kaapvaal Craton (Anhaeusser, 1973). The Vredefort Dome, located approximately 100km to the south, also reveals ancient basement granitoid rocks, as well as greenstone remnants, but good exposures are limited to the northern and northwestern parts of the dome (Gibson and Reimold, 2001- and references therein).

The oldest granitoid phase recognised so far in the central cratonic region is a Palaeoarchaean trondhjemite gneiss from the northwestern part of the Johannesburg Dome that yielded an age of 3340 ± 3 Ma (Poujol and Anhaeusser, 2001). Still older xenocrystic zircon ages have, however, been reported from a *c*. 3107 Ma paragneiss sampled on the Vredefort Dome (3430 ± 3 Ma zircon xenocryst age - Hart et al., 1999) and from the *c*. 2700 Ma Neoarchaean Makwassie Quartz Porphyry of the Ventersdorp Supergroup (zircon xenocryst age *c.* 3480 Ma; Armstrong et al., 1991). These older xenocrystic zircon ages suggest that some old crustal material may lie beneath the cover formations on the central portion of the craton. This early crustal material may have developed penecontemporaneously with crust that formed in the Barberton region between *c.* 3550 and 3440 Ma.

Evidence from the Johannesburg Dome shows that a number of magmatic events were responsible for the development of the crust in this region. These events included the emplacement of: (1) mafic and ultramafic volcanic rocks ("greenstones") comprising komatiites, komatiitic basalts, high-magnesian basalts and tholeiites, as well as their plutonic equivalents, which now consist of serpentinized dunites, harzburgites, pyroxenites and gabbros; and (2) a suite of tonalite-trondhjemite-granodiorite (TTG) granitoid rocks that intruded the greenstones causing their fragmentation, metamorphism, assimilation and migmatization. Trace element and REE geochemical studies undertaken on the various granitoid rocks on the Johannesburg Dome led Anhaeusser (1999) to conclude that these rocks probably developed in a tectono-magmatic setting analogous to that found in Phanerozoic volcanic arcs.

The Palaeoarchaean granitoid gneisses on the Johannesburg Dome are of two types. The oldest variety (3340 ± 3 Ma; Poujol and Anhaeusser, 2001) consists of leuco-biotite trondhjemitic gneisses and associated migmatites developed on the northern half of the dome. The younger variety, on the southern edge of the dome, consists of hornblende-biotite tonalitic gneisses that yielded a multiple zircon age of 3170 ± 34 Ma (Anhaeusser and Burger, 1982), and a more recent single zircon emplacement age of 3201± 5 Ma (Poujol and Anhaeusser, 2001).

Following the trondhjemite-tonalite gneiss emplacement a further period of magmatism took place on the Johannesburg Dome, which resulted in the intrusion of mafic dykes that are manifest as hornblende amphibolites. The age of these dykes has yet to be determined, but they fall within the time constraints imposed by the age of the trondhjemite-tonalite gneisses and later cross-cutting potassic granitoids. These rocks, consisting of Mesoarchaean granodiorites, occupy an area of batholithic dimensions extending across most of the southern portion of the dome. Two granodiorite phases have been distinguished, the one in the southern and southeastern part of the dome consisting mainly of medium-grained, homogeneous, grey granodiorites and a second variety, found mainly in the southwestern part of the dome, consisting of porphyritic granodiorites (Anhaeusser, 1973). Zircons extracted from the two granodiorite types yielded ages of 3121± 5 Ma for the homogeneous variety and 3114 ± 2.3 Ma for the porphyritic variety (Poujol and Anhaeusser, 2001). Numerous pegmatite dykes and veins crosscutting the granodiorites are younger than 3114 Ma and may represent the final stages of magmatism associated with the batholith emplacement at about 3000 Ma. In the central part of the Kaapvaal Craton this final stage of crustal development formed the basement upon which the Pongola, Witwatersrand and Ventersdorp Supergroups were deposited in Mesoarchaean-to-Neoarchaean times. The Johannesburg Dome granodiorites are very similar petrologically, geochemically, and in field relationships to the potassic batholiths previously described in the BML. They also appear to be penecontemparaneous or overlapping in age with the *c.* 3105 Ma Barberton-Swaziland batholiths described earlier.

Granitic rocks (essentially massive, porphyritic, adamellitic-to-granitic rocks, but with some tonalitic gneisses and migmatites in places), fitting the description of those on the Johannesburg Dome, have also been encountered in borehole intersections to the west and northwest of Welkom, some 250 km southwest of the Johannesburg Dome (Drennan, 1988), as well as in surface and borehole intersections along the Rand Anticline extending southwest of Johannesburg (Robb and Meyer, 1987). Little detailed information exists on the age of these granitoid rocks, but Armstrong et al. (1991) reported an age of 3120 ± 5 Ma from the basement predating the 3074 ± 6 Ma upper lava sequence of the Dominion Group, which, in turn, underlies Witwatersrand Supergroup successions southwest of Klerksdorp (located approximately 150 km southwest of the Johannesburg Dome). A slightly younger age of 3031 +11/-10 Ma (Robb et al., 1992) was also obtained from granodiorites exposed near Coligny on the western edge of the Central Terrane. The youngest (Neoarchaean) granitoid rock found in the central Kaapvaal Craton region was encountered in a borehole drilled approximately 80 km northwest of the Welkom Goldfield. This granite, which gave an age of 2727 +6/-5 Ma (Robb et al., 1992), is only slightly older than the lowermost volcanic rocks of the Ventersdorp Supergroup (*c.* 2714 Ma; Armstrong et al., 1991) and must have been emplaced very late, during, or after, Witwatersrand deposition.

The Vredefort Dome, located in the centre of the Witwatersrand basin, also displays a wide variety of granitic, gneissic and migmatitic rocks of mid-Palaeoarchaean to mid-Mesoarchaean age. Greenstone remnants ranging from granulite to greenschist metamorphic grade also occur on the Vredefort Dome (Stepto, 1990; Minnitt et al., 1994), and reflect the complex history this region has undergone, including being impacted by a meteorite approximately 2000 Ma ago. Most of the ages listed in Appendix 2 display the effects of the metamorphic overprinting, the spread of ages ranging from 3425 to 2564 Ma being derived from zircons considered to be xenocrystic in character. The older Vredefort ages are indicative of the presence of granitoid crust approximating the ages of mid-Palaeoarchaean crust found in the southern parts of the BML. Most Vredefort xenocryst ages span the period 3172 to 3016 Ma suggesting a major metamorphic event at approximately this time. These ages again overlap with ages reported for potassic granitoid batholithic bodies from widespread areas, including Barberton and the Johanneburg Dome (see Appendix 1) and from the areas west and northwest of the Vredefort Dome (Robb et al., 1992). Coincident with this period of crustal heating and extension on the central Kaapvaal Craton was the onset of Dominion Group volcanism, the latter dated at 3074 ± 6 Ma (Armstrong et al., 1991).

Northern Terrane

Because of lithological similarities, and prior to the advent of precise temporal constraints, the geology and evolution of the granite-greenstone terrane in the northern sector of the Kaapvaal Craton was broadly likened to that of the BML (Viljoen et al., 1978; Anhaeusser, 1981). The various greenstone belts, including the Giyani (formerly Sutherland), Pietersburg, Rhenosterkoppies and Murchison belts, and the surrounding granitoid terranes have, for the most part, now been well documented and new single zircon ages indicate that the rocks in the Northern Terrane are considerably younger than equivalent rocks found approximately 200km further south in the Barberton area.

Available ages from the Northern Terrane range from early Mesoarchaean to mid-Neoarchaean (3364 - 2674 Ma, see Appendix 3). The oldest ages recorded in this sector of the Kaapvaal Craton include those of xenocrystic zircons (3364 ± 18 Ma) from the Mac Kop conglomeratic sedimentary unit in the MGB (Poujol et al., 1996) and a Pb-Pb evaporation age of 3333 ± 5 Ma reported by Brandl and Kröner (1993) from migmatitic tonalitic gneisses occurring north of the PGB.

The area best documented in the Northern Terrane is that of the MGB (Fig.1), which is orientated along a major northeast-trending crustal lineament and is bounded to the north and south by a variety of granitic gneisses, migmatites and pegmatites. The felsic rocks of the MGB, which have been interpreted as a volcanic arc by Vearncombe et al. (1992), appear to have formed over a few tens of millions of years, being deposited between *c.* 3090 to 2970 Ma (Brandl et al., 1996; Poujol et al., 1996). Granitic magmatism, closely associated with the felsic-to-mafic volcanism of the Weigel Formation, occurred at about 3090 Ma, but there is evidence for an older *c.* 3230 Ma trondhjemite-tonalite gneiss basement juxtaposed with the southern edge of the Murchison belt (Poujol et al., 1996; Poujol and Robb, 1999). These TTG gneisses are similar in age to those defining the younger cycle of granitic magmatic activity described earlier on the northern flank of the BGB. Thus, the approximately 200km tract of dominantly granitic basement rocks exposed between Barberton and Murchison may represent a *c.* 3230 Ma old protocontinental block along the northern edge of which formed the Murchison volcanic arc. At approximately the same time, the southern edge may have been involved in tectonic amalgamation with the older (*c.* 3550 to 3440 Ma) Barberton block.

The region to the north and west-northwest of the Murchison belt is made up of the Giyani and Pietersburg-Rhenosterkoppies granite-greenstone terranes. These greenstone belts are, like the Murchison belt, aligned in a northeasterly direction. They extend along the Southern Marginal Zone of the Limpopo Belt and are separated from each other by an intensely migmatised zone, approximately 60 km in extent, and well exposed in the escarpment area near Mooketsi between Tzaneen and Soekmekaar. This migmatitic terrane was considered by Anhaeusser (1992) to represent the tectono-thermally reworked equivalents of the Pietersburg and Giyani greenstone belts and their associated tonalitic and trondhjemitic intrusive granitoids. Kröner et al. (2000), by contrast, regarded the Giyani and Pietersburg belts as defining two separate crustal entities, originally close together, but later displaced by strike-slip movement.

Meta-andesites from the GGB were dated at 3203.3 ± 0.2 Ma by Kröner et al. (2000). In addition, these authors also reported polydeformed pre-3200 Ma gneisses, similar in age to those reported in the Murchison area by Poujol et al. (1996) and Poujol and Robb (1999), which they felt may have constituted a basement to the Giyani greenstone sequence. This suggests that an extensive area in the Northern Terrane appears to be made up of a variety of *c.* 3200 Ma basement granitoids. As yet there are no ages, equivalent to the Giyani meta-andesites, reported from the mafic successions of either the Murchison or Pietersburg belts. Kröner et al. (2000) have, however, provided evidence suggesting that felsic volcanism in the PGB (*c.* 2949 Ma) and granitoid rocks intruding and deformed with the greenstones at 2910 ± 2 Ma, show felsic volcanism in this belt to have been broadly coeval with the *c*. 2971 Ma felsic volcanism in the Murchison belt. They also reported a younger, cross-cutting feldspar porphyry in the GGB with an emplacement age of 2874.1 ± 0.2 Ma. The suggestion is, therefore, that the greenstone belts in the Northern Terrane may have formed approximately penecontemporaneously over a time span ranging from about 3200 to 2874 Ma.

The Northern Terrane also experienced granitoid magmatic activity during early Neoarchaean times, including the emplacement of largely post-tectonic granitoids in the Pietersburg and Murchison areas. The Melkboomfontein granite in the vicinity of the PGB represents the youngest, strongly foliated granitoid dated at *c.* 2853 Ma (Kröner et al., 2000). Pegmatites, and the undeformed porphyritic Willie granite, south of the Murchison belt yielded ages of 2848 ± 58 Ma and 2820 ± 38 Ma, respectively (Poujol and Robb, 1999; Poujol, 2001), while still younger ages of between 2777 and 2674 Ma have been recorded from the Turfloop batholith south of the PGB (Henderson et al., 2000; Kröner et al., 2000). Hornblende-tonalite rocks at the top of the Rooiwater layered mafic complex north of the Murchison belt gave an age of 2740 ± 4 Ma and the peraluminous Mashishimala granite body south of the MGB gave an age of 2698 ± 21 Ma (Poujol et al., 1996; Poujol, 2001).

From the above it is evident that the ages of all the components described from the Northern Terrane are markedly younger than those recorded in the Eastern Terrane of the BML and Swaziland, thereby supporting the overall view that the Northern Terrane accreted onto, or was tectonically amalgamated with, the evolving Kaapvaal Craton. We interpret the formation of the Northern Terrane to have taken place as an initial 3200 to 2874 Ma period of sustained volcanic-arc formation, followed by episodes of intracratonic granitoid emplacement that ended at around 2674 Ma.

Western Terrane

The Western Terrane is situated to the west of the Colesberg magnetic anomaly, the latter considered by Corner et al. (1990) to represents a mid-crustal layer upwarped along the western edge of the Kaapvaal Craton. The region also incorporates 3 of the 12 subdomains demarcated by de Wit et al. (1992) in their evolutionary model of the Kaapvaal Craton and includes the Colesberg, Amalia and Kraaipan subdomains. Metamorphosed Archaean mafic volcanic rocks and interlayed ferruginous and siliceous metasediments, together with a variety of granitoid rocks, including tonalitic and trondhjemitic gneisses, granodiorites and adamellites occur in these regions (Drenann et al., 1990; Anhaeusser and Walraven, 1999). The regional trend of greenstone belt formations in this part of the craton is generally north-south (Fig. 1), which is strikingly different to the northeasterly trends displayed by greenstone belts in the Northern and Eastern Terranes. Information on these western belts and surrounding granitoids is limited due to their poor exposures beneath Neoarchaean- to late-Palaeozoic Ventersdorp-Karoo cover sequences and Cenozoic Kalahari sands. In addition, this terrane is further obscured by exposures of the Gaborone Granite Complex, consisting of volcanic, granophyric and granitic rocks which occur to the north of Mafikeng and in southeast Botswana (Sibiya, 1988; Grobler, 1993),

The oldest basement rocks so far dated in the Western Terrane occur in mine exposures and borehole intersections in the Kimberley region (Fig. 1), and consist mainly of gneissic-to-migmatitic, heterogeneous, tonalitic-to-granodioritic rocks, which have been dated at *c*. 3250 Ma (Drennan, 1988; Drennan et al., 1990). Several hundred kilometres north of Kimberley, but still part of the Western Terrane as defined in this paper, are the Amalia and Kraaipan granite-greenstone terranes, which extend northwards to the Botswana border and beyond.

The northernmost Kraaipan terrane can be subdivided into three north-to northwest-trending belts, spaced at 30-40 km intervals, namely the western, eastern and Madibe belts. The age of the KGB is not yet well constrained due to the paucity of material suitable for dating. An U-Pb single zircon date, reported from the eastern belt, provided a provisional age of *c.* 3080 Ma (Robb et al., 1991). Attempts made to date the western belt have yielded an age of 3191.1 ± 7.9 Ma (Gericke, 2001) for a volcanoclastic unit, but it is not yet clear whether this date represents the age of formation or a xenocryst age.

The MaGB represents the easternmost belt in the Kraaipan terrane. The lithologies strike in a north-south direction and represent an assemblage of metamorphosed and strongly deformed volcanic and minor sedimentary rocks, now represented by phyllites, quartz-sericite and quartz-chlorite schists, amphibolites, talc-carbonate schists and banded iron formation. The succession, which is poorly exposed, has been interpreted as a mid-Mesoarchaean volcanic island arc that was welded onto the western margin of the Kaapvaal Craton. SHRIMP dating of two metavolcanic samples from the Madibe area yielded ages of 3097.4 ± 8.8 Ma and 3082.5 ± 5.9 Ma , respectively (Hirner et al., 2001).

The Amalia granite-greenstone terrane further to the south is dominated by a narrow, north-northwest-trending linear belt consisting mainly of mafic metavolcanic rocks, banded iron formation and various mafic schists (Van Eeden et al., 1963; Anhaeusser, 1991). An accretionary lapilli tuff unit, described by Jones and Anhaeusser (1993), has been dated at 2754 ± 5 Ma, while a quartz-chlorite-sericite schist in the same vicinity was dated at 2740 ± 13 Ma (Poujol et al., 2001b).

The granitoid rocks in the Amalia-Kraaipan region present ages at *c*. 3000 Ma, 2940-2920 Ma, and 2880-2850 Ma with the intrusion of a younger adamellite (Mosita pluton) at 2791 ± 8 Ma (McCourt et al., 2000; Poujol and Anhaeusser, 2001). The youngest granitoid recorded in the Western Terrane consists of a biotite-muscovite granite (Skalkseput pluton) in the Marydale granitoid-greenstone terrane on the extreme southwestern flank of the Kaapvaal Craton (Fig. 1), which was dated at 2718 ± 8 Ma (McCourt, 2000). In the northern part of the Western Terrane the Gaborone Granite Complex has been dated at *c.* 2785 Ma (Moore et al., 1993; Grobler and Walraven, 1993).

In concert with the findings in the Northern Terrane it is evident that the granite-greenstones of the Western Terrane are of markedly younger age than their counterparts in the eastern and central sectors of the Kaapvaal Craton. This, once again, re-affirms the view that the northern and western parts of the craton were accreted onto an earlier, essentially Palaeoarchaean, protocontinental nucleus as a consequence of volcanic arc activity that took place essentially during Mesoarchaean times. However, in the Western Terrane, Neoarchaean volcanic activity has been recognized for the very first time in the Amalia greenstone belt.

GEOCHRONOLOGICAL FRAMEWORK FOR THE KAAPVAAL CRATON

Data treatment

The data employed in this palaeo-geochronological reconstruction of events that took place early in the development of the crustal architecture of the Kaapvaal Craton are listed in Appendices 1-4. It was decided to focus only on the U-Pb (zircon, titanite, sphene and monazite) and Pb-Pb evaporation data, as these are adjudged the most suitable for providing an indication of the emplacement ages of the different Palaeoarchaean-to-Neoarchaean volcano-sedimentary formations and associated granitoid rocks found on the craton. It was also decided to incorporate concordant to sub-concordant (i.e., less than 10% discordant) $^{207}Pb/^{206}Pb$ xenocryst zircon ages, as they are often the only proof of the existence of older rocks in some parts of the craton. It is further acknowledged that the interpretations that follow are dependant on the number of analyses available for each part of the craton. Consequently, this type of summation might impose a data bias as some parts of the craton still lack adequate U-Pb ages. All the data are reflected in Figure 2 (graphs A-D), which shows the cumulative probability distribution obtained by summing the probability distributions of the data with normally-distributed errors (Ludwig, 2000). Only the data interpreted as representative of the age of crystallization, or the $^{207}Pb/^{206}Pb$ ages from zircon xenocrysts, have been considered in these graphs. It should be emphasized that these graphs do not provide any quantitative information on each event, as some formations/granitoids have been dated more often than others. It can be argued, however, that each major peak reflected in these graphs is representative of a geological event.

Events in the Eastern Terrane

Data shown in Appendix 1 comprises 182 dates extracted from 28 different publications. They include the BGB, the Ancient Gneiss Complex in Swaziland and terranes south of Swaziland, as well as some formations from the Pongola Supergroup. The oldest dates identified so far in the region occur at *c.* 3702 Ma and *c.*3685 Ma and were obtained on zircon xenocrysts extracted from the Vlakplaats granodiorite and the Ngwane gneiss, respectively, in Swaziland (Kröner et al., 1996; Kröner and Tegtmeyer, 1994). The oldest rock age is represented by a tonalitic gneiss from the Ancient Gneiss Complex dated at 3644 ± 4 Ma (Compston and Kröner, 1988). The general trend in Figure 2 (A) defines three main events at *c.* 3545-3445 Ma, 3255-3225 Ma and 3105-3070 Ma. They are accompanied by minor discrete events at around 3350-3310 Ma, 2985 Ma and 2725 Ma, respectively. The Kaapvaal Craton in the vicinity of the BGB consists of a compound crustal block made up of amalgamated protocontinental blocks formed over a timespan of 500 Ma between 3700 Ma and 3200 Ma. This was followed by the intrusion of several intra-continental plutons or batholiths at *c.* 3105-3100 Ma. Volcanism associated with the Pongola Supergroup occurred at around 3090 and 2985 Ma and may also be linked to the emplacement of granitoid rocks (mainly granodiorite) at this time. Lastly, the first granite (*sensu stricto*) emplacements occurred at around 2725 Ma.

Events in the Central Terrane

Appendix 2 summarizes 50 dates published in 11 different publications from the Johannesburg and Vredefort Domes, the Witwatersrand Supergroup and basement granitoids encountered in the central part of the Kaapvaal Craton. The oldest dates, at *c.* 3480 and 3425 Ma, are from zircon xenocrysts in the Makwassie Quartz Porphyry and a paragneiss from the Vredefort Dome (Armstrong et al., 1991; Hart et al., 1999). The oldest rock so far dated in the central Kaapvaal Craton is a 3340 ± 3.3 Ma trondhjemitic gneiss from the Johannesburg Dome (Poujol and Anhaeusser, 2001). Displayed in Figure 2 (B), the data define three main peaks at 3200-3175 Ma, 3120-3075 Ma, and 2730-2705 Ma, respectively. Consequently, the central part of the craton is younger than its eastern equivalent as most of the granitoid emplacements took place between 3340 and 3120 Ma.

Events in the Northern Terrane

Data summarized in Appendix 3 represent 49 dates from 8 different publications relating to the Murchison, Pietersburg and Giyani greenstone belts and their surrounding granitoids. Once again the oldest date at *c.* 3364 Ma derives from a zircon xenocryst found in the Mac Kop conglomerate in the Murchison belt (Poujol et al., 1996). The oldest rock, a migmatitic tonalitic gneiss sampled north of the Pietersburg belt has been dated at 3333 ± 5 Ma (Brandl and Kröner, 1993), while the oldest rock south of the Murchison belt is a trondhjemitic-tonalitic gneiss dated at 3228 ± 12 Ma (Poujol et al., 1996). The geochronological trends displayed in Figure 2 (C) for this part of the craton are more complex, and can be attributed to the few dates available for the region as a whole. The most prominent peak is clustered around 2970-2955 Ma with other peaks at *c.* 3285 Ma, 3170 Ma, 3090-3075 Ma, 2885 Ma and 2690 Ma. The Northern Terrane records similar granitoid emplacement ages to those of the Central Terrane for the timespan between 3330 and 3120 Ma. The volcanic activity in the GGB is dated at around 3200 Ma, but appears to be younger elsewhere, with ages of 3090-2950 Ma recorded in the Murchison and Pietersburg greenstone belts. Late magmatic activity in the region is identified at *c.* 2885 Ma and 2690 Ma.

Events in the Western Terrane

Fifty-four dates from 15 different publications are reported in Appendix 4. They concern the Amalia, Kraaipan and Madibe greenstone belts, the Gaborone Complex and the granitoid terrane in the Kimberley region. The oldest date derives from a *c.* 3428 Ma zircon xenocryst extracted from a felsic schist in the Madibe belt (Hirner et al., 2001). The oldest cores of some zircons from the Bultfontein Mine gneiss near Kimberley have been dated at around

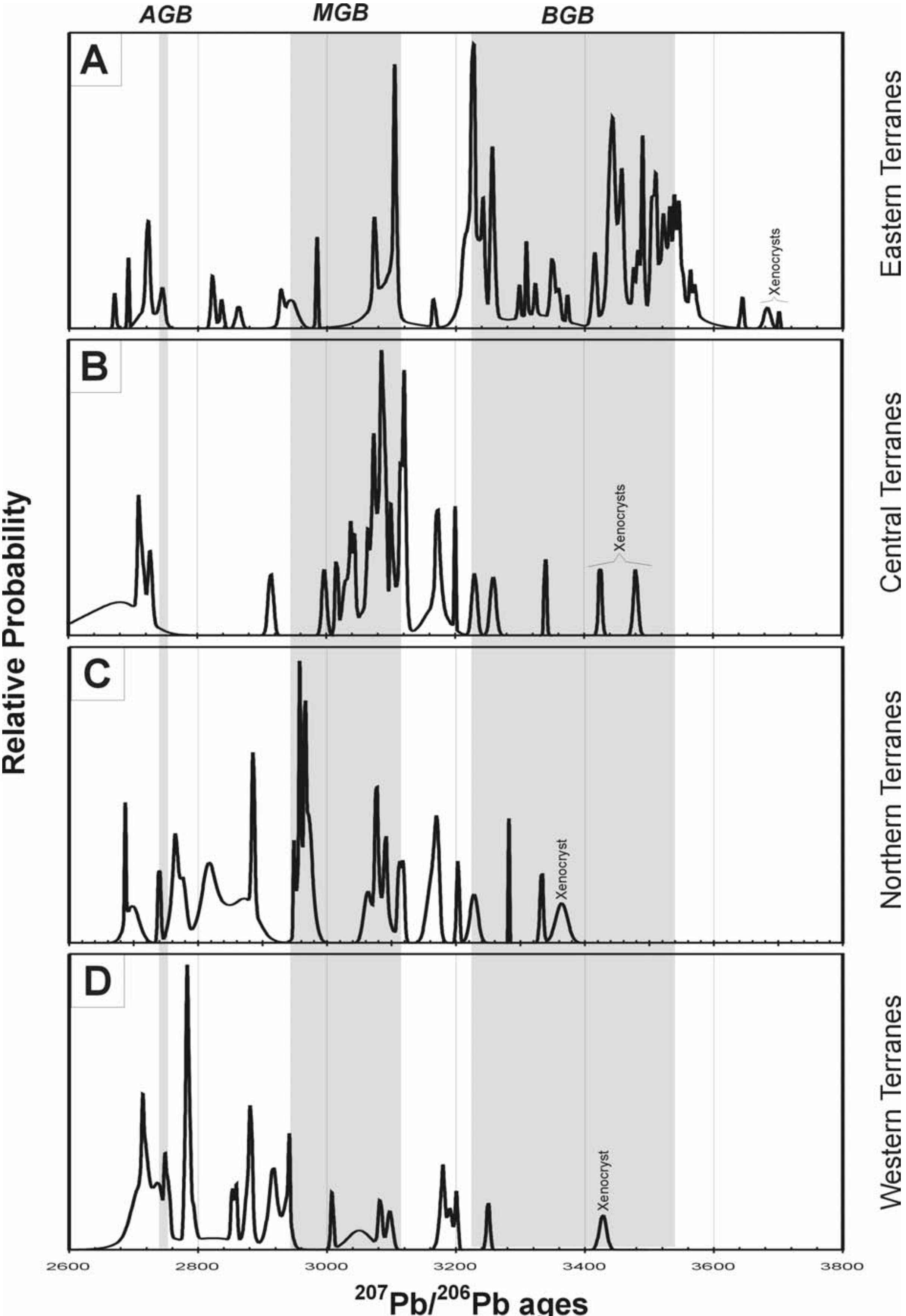


Figure 2: *$^{207}Pb/^{206}Pb$ cumulative probability distribution ages for the four terranes described in the paper. The grey background tones represent the times of emplacement of the Barberton (BGB), Murchison (MGB) and Amalia (AGB) greenstone belts.*

3250 Ma (Drennan et al., 1990). The most prominent peak in Figure 2 (D) clusters around 2785 Ma with some smaller peaks at 3200-3180 Ma, 3100-3080 Ma, 2940-2915 Ma, 2880 Ma and 2750-2715 Ma. Although 3428 Ma zircon xenocrysts have been identified in the northern part of the Western Terrane, the oldest basement rock identified in this part of the craton is only 3250 Ma old (Drennan et al., 1990). Volcanic activity at around 3090 Ma is identified within the Madibe belt, whereas granitoid emplacement took place at around 2940 Ma, 2880 Ma, 2785 Ma and 2750-2715 Ma. The interesting point in this part of the craton is the unusually young age (i.e., for the Kaapvaal Craton) of the Amalia greenstone belt, which is bracketed between 2755 Ma and 2740 Ma (Poujol et al., 2001).

Summary of the main events on the Kaapvaal Craton

The oldest rocks so far recognized are located in the Ancient Gneiss Complex in the eastern part of the Kaapvaal Craton. As demonstrated in Figure 2, the eastern terranes recorded intense plutonic and volcanic activity between 3550-3250 Ma, while the rest of the craton had probably not yet formed. In the central terranes the oldest xenocrysts give ages at around 3480-3425 Ma. In the northern terranes, the oldest xenocryst is dated at *c.* 3364 Ma, while in the western terranes the oldest is at *c.* 3428. It is only toward the end of the BGB formation that activity is recorded in the other terranes. As an example, the oldest rock recognized in the MGB vicinity, a *c.* 3228 Ma tonalitic gneiss, presents the same age as the youngest emplacement in the BGB (viz., the Kaap Valley pluton at 3226 Ma). A phase of granitoid (mainly trondhjemite and tonalite) emplacement took place between 3200 and 3170 Ma in the north, central and western part of the craton, while little or no activity was recorded in the east. During this period the PGB and possibly also the western KGB were formed at around 3200 Ma. A major phase of igneous activity is then recorded thoroughout the entire craton between 3100 and 2970 Ma. This corresponds to the intrusion of younger plutons in the BGB vicinity at around 3100 Ma while volcanic activity started in the MaGB and the MGB. At about the same time the central part of the craton experienced the emplacement of the Dominion Group. This volcanic activity was accompanied by emplacement of granite plutons in the MGB and the PGB, as well as in the central part of the craton. This period of igneous activity was followed by a second event at around 2980-2970 Ma, at least for the MGB in the north as well as for the Pongola Supergroup in the east. The eastern and central part of the craton subsequently recorded almost no magmatic activity until 2800 Ma. By contrast, the northern and western parts of the craton were magmatically active at this time with the emplacement of numerous plutons at around 2880-2820 Ma. This period corresponds to the deposition of the Central Rand Group in the Witwatersrand basin. Magmatic activity is present to the north of the craton at around 2780-2770 Ma while both volcanic and magmatic activity are very prominent to the west. Once again both the eastern and central parts of the craton do not seem to have recorded any magmatic activity at that time. Finally, another period of activity is identified throughout the craton at around 2750-2700 Ma, with the emplacement of the AGB to the west, several granitic plutons in the east, granitoid bodies to the north and in the central part of the craton, and deposition of the Ventersdorp Supergroup over most of the west-central parts of the craton.

DISCUSSION AND CONCLUSIONS

Magmatic accretion and the development of Palaeoarchaean- to-Mesoarchaean granite-greenstone terranes

Lowe's (1994) model for the formation of early Archaean crust in the BGB envisages the existence of small, discrete blocks which grew progressively by a combination of magmatic accretion and tectonic amalgamation. Each tectono-stratigraphic block is considered to have formed by four distinct stages: early extrusion of mafic and komatiitic lavas on top of or adjacent to the margins of pre-existing blocks to form back-arc basins or oceanic plateaux, followed by a period of subsidence and chemical sedimentation. This is followed in turn by subduction-like calc-alkaline magmatism, which thickened and stabilized the newly forming block.

What has been envisaged for the geological evolution and development of the tectono-stratigraphic blocks in the BGB is believed to have widespread applicability for the formation of the Kaapvaal Shield during its early stages of protocontinental block formation between *c.* 3600 and 3200 Ma years ago. Figure 3 (A) attempts to display conceptually the nature and diachronous style of assembly of the shield-forming blocks at the earliest recognisable stage of crust formation in southern Africa. Each block, in effect a separately evolved arc or greenstone belt, may attach itself to an earlier-formed, yet similar greenstone belt, either by magmatic accretion or by tectonic amalgamation, the latter resulting from the destruction or consumption of oceanic crust in areas of subduction or shrinkage. Magmatic accretion might be seen as a succession of on- or over-lapping magmatic arcs as described by Lowe (1994, 1999) for the southern parts of the BGB, whereas in the north the welding together of a younger block (*c.* 3230 Ma) with the older blocks (*c.* 3644 Ma in Swaziland, combined with the *c.* 3550-3440 Ma successions in the Komati valley region) may have been accomplished by tectonic accretion or collisional suturing. The Archaean shield that had formed by 3200 Ma is the core of the Kaapvaal Craton and is considered to represent the amalgamation of several smaller protocontinental blocks, the definitions of which, with the exception of the Barberton Mountain Land, remain unclear.

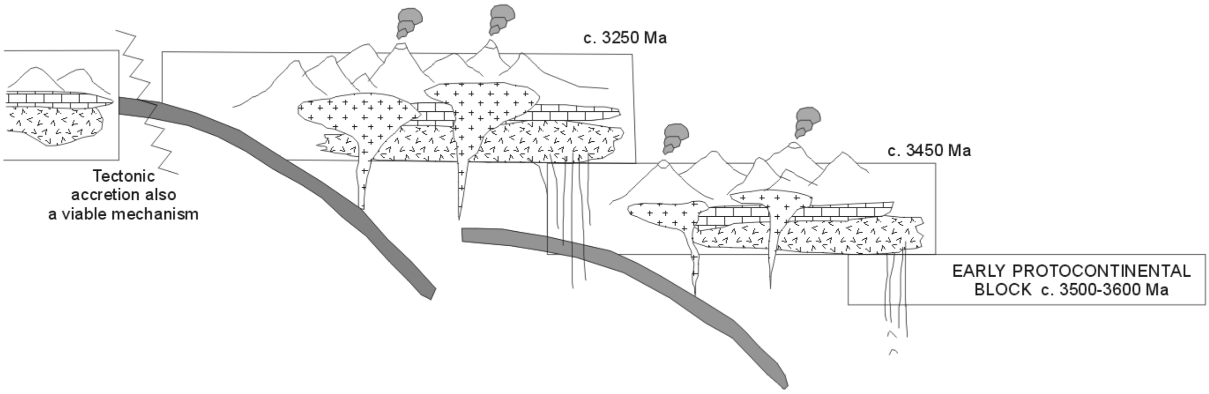
Intracratonic magmatism related to continental margin orogenesis

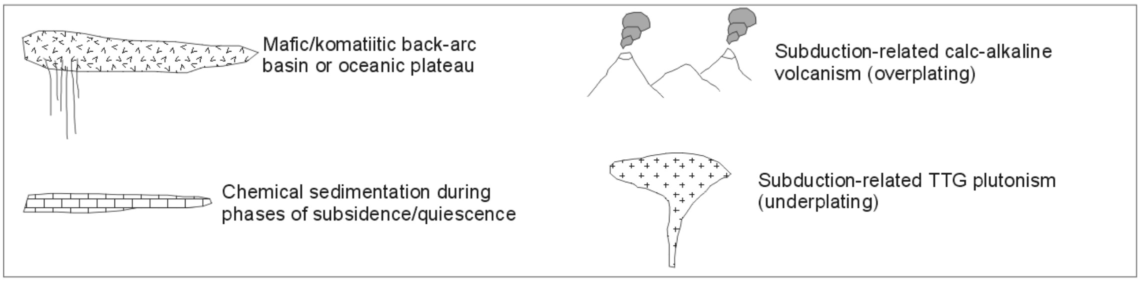
Following the assembly of the components making up the Kaapvaal Shield, which at *c.* 3200 Ma were geotectonically relatively unstable, there followed a period of Mesoarchaean magmatism that commenced at around 3100 Ma and was manifest in the emplacement of voluminous, arealy extensive, sheet-like, potassic granoitoid batholiths. These granitoids, found in all four of the terranes described in this paper, were responsible for thickening and stabilizing the crust and for consolidating the shield components into a single entity now identified as the Kaapvaal Craton.

From the evidence presented it has been demonstrated that first the Eastern and then the Central terranes formed a nucleus onto which annealed the younger segments of the craton, both in a northerly and westerly direction. Growth in this manner is envisaged to have been facilitated by the development, at *c.* 3100-3000 Ma, of a major, crescent-shaped, juvenile arc extending around the northern and western margins of the craton from the Murchison-Giyani-Pietersburg area westwards towards Gaborone (Fig.1) and then southwards through the Kraaipan-Amalia region to Kimberley and beyond. The arc probably extended further into the Marydale region on the southwestern craton margin. Figure 3 (B) depicts, schematically, the nature of the Kaapvaal Craton at this stage in its development with younger greenstone belts (*c.* 3100-3000 Ma) forming in the area of influence of the juvenile arc. As oceanic crust was consumed between "drifting" cratons (possibly, but not unequivocally, the Zimbabwe Craton in the north and the Kheis craton/domain (?) in the west) compression occurred which initiated the events now reflected in the areas influenced by the orogenic zones seen around the craton margins.

A. Magmatic accretion of small protocontinental blocks - c. 3600-3200 Ma

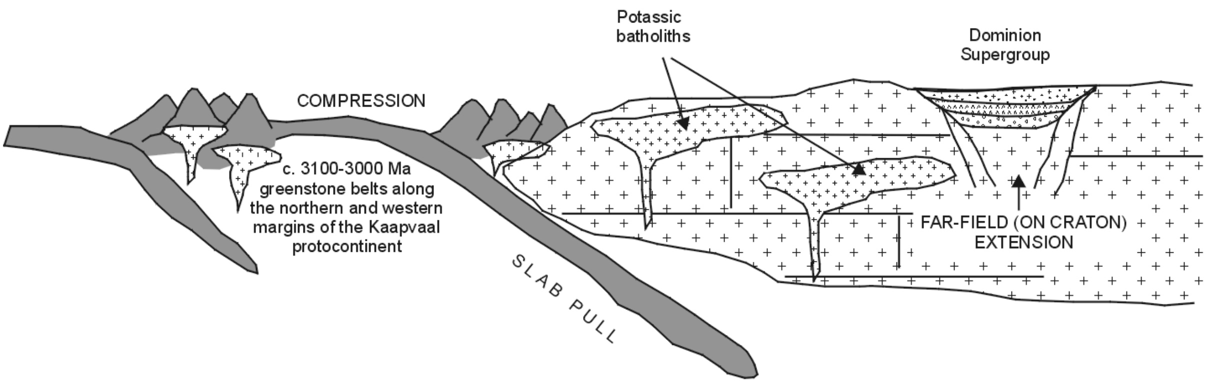
KAAPVAAL SHIELD FORMATION (after Lowe, 1994;1999; de Ronde and de Wit, 1994)

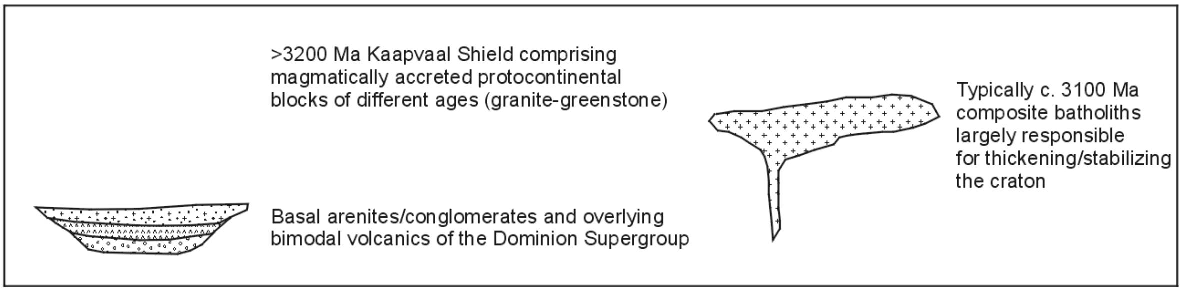


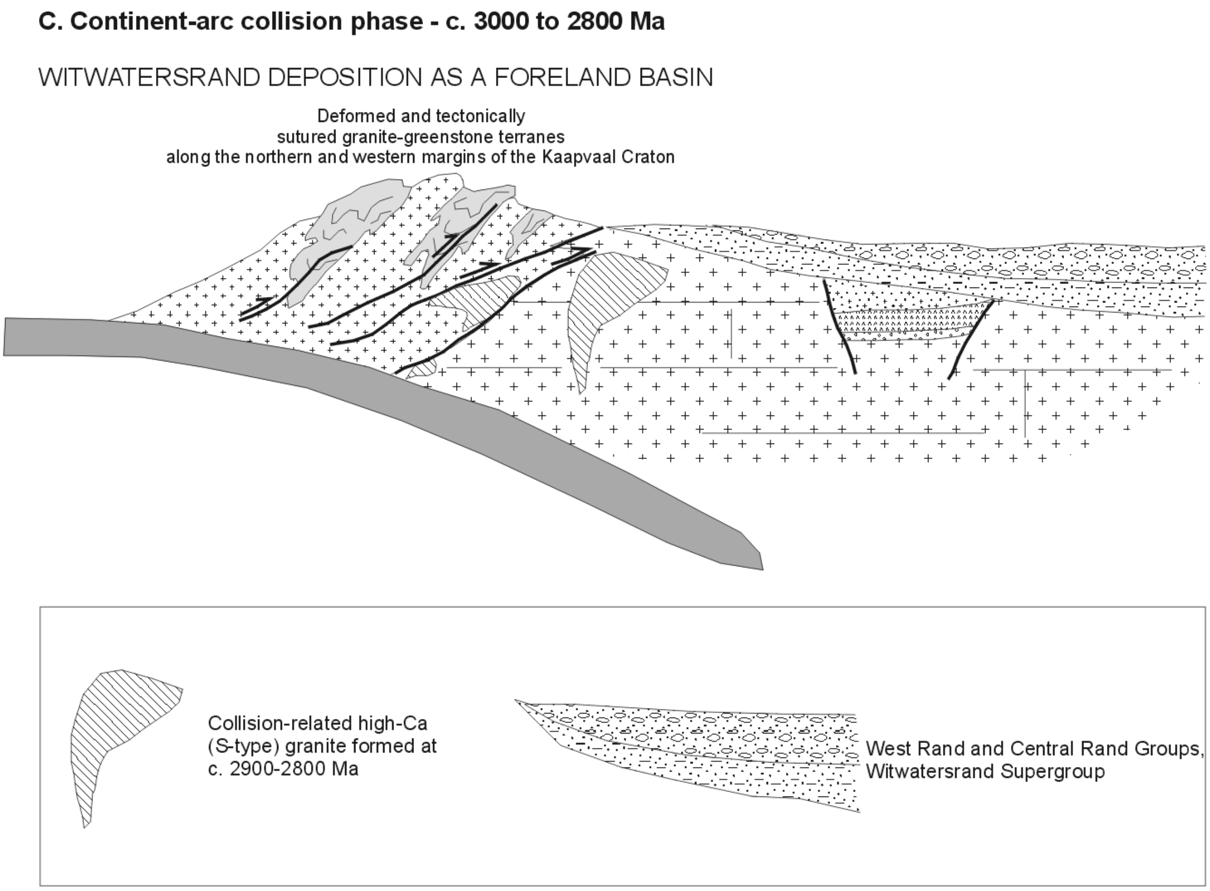


B. Juvenile arc formation on margins of >3200 Ma Kaapvaal Shield - c. 3100-3000 Ma

KAAPVAAL CRATON FORMATION/CONSOLIDATION







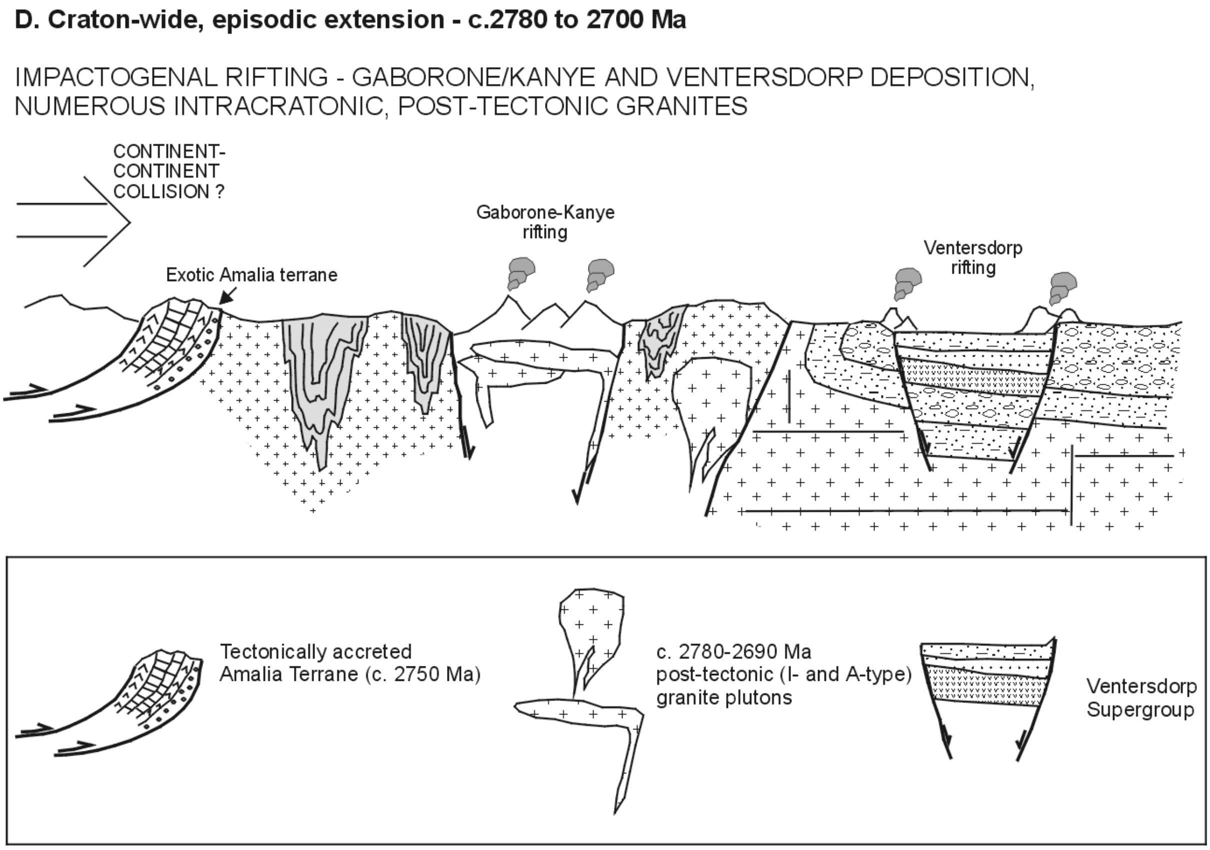


Figure 3: *Conceptual models (A-D) showing the development of the Kaapvaal Craton between 3600 Ma and 2700 Ma.*

Slab pull beneath the Kaapvaal Craton may have been responsible for "far-field " crustal extension on the craton itself. This could explain the rift-related intracratonic bi-modal volcanism encountered in the Dominion volcano-sedimentary successions developed as a protobasinal stage of Witwatersrand deposition (Fig. 3b).

Continent-arc collision and foreland basin development

Following the stages of juvenile arc development around the northern and western margins of the Kaapvaal Craton, the events that followed led to episodes of continent-arc collision at *c*. 3000-2800 Ma and the establishment of conditions ideal for the development of foreland basins south and east of the orogenic regions mentioned above (Fig. 4C). One such area of foreland sedimentation resulted in the deposition of the Meso- to Neo-archaean Witwatersrand basin approximately 3000 to 2800 Ma ago.

Apart from the tectonic and metamorphic complexity imposed on the rocks in the orogenic regions around the craton margins during the collisional phases, a further manifestation of events associated with this deformation can be found in the emplacement, locally, of what are regarded as collision-related granitoid plutons. These intrusive bodies, which are dominantly low-Ca (S-type) granitoids, formed as either syn- or post-tectonic plutons and are mainly developed in or adjacent to orogenic areas, within or close to the craton margins (Fig. 3C).

Post-tectonic intracratonic magmatism, episodic extension and impactogenal rifting

On the Kaapvaal Craton numerous post-tectonic granites (*c*. 2780-2690 Ma) are to be found mainly in areas adjacent to the craton margins, but away from the northern and western zones of collisional orogenesis to which reference has previously been made. These bodies, of limited volumetric and areal extent, are almost exclusively restricted to the Swaziland-Barberton area (Eastern Terrane), the Murchison-Pietersburg area (Northern Terrane), and the Kraaipan greenstone belt (Western Terrane). Only a single Neoarchaean granitoid body, the extent of which is unknown, but which yielded an age of *c*. 2727 Ma, has been recorded in the Central Terrane. This occurrence was intersected in a Witwatersrand exploration borehole drilled southwest of the Vredefort Dome (Fig.1).

At approximately the same time as the intracratonic plutons described above were being emplaced, impactogenal rifting occurred elsewhere on the Kaapvaal Craton, particularly in the central and western parts. Figure 3 (D) conceptually illustrates the nature of the events that took place during this period of craton-wide, episodic extension at c. 2780-2700 Ma. In the west a late stage of continent-continent collision is believed to have been responsible for the tectonic accretion of the *c*. 2750 Ma old Amalia greenstone terrane onto the older *c*. 3250-3080 Ma Kraaipan greenstone terrane. Given that this small, preserved, remnant of granite-greenstone crust is temporally unlike anything else documented on the craton, and yet has an age which globally is associated with the voluminous formation of arc-related greenstone belts (e.g., Zimbabwe, Yilgarn, Abitibi, etc.), we suggest at this stage that the Amalia belt may be an exotic fragment derived from a now remote continental fragment. To the north, in southeast Botswana and adjacent areas of the North West Province of South Africa, rifting of the craton appears to have been responsible for the development of an extensive felsic igneous and volcanic episode involving the emplacement of the *c*. 2785 Ma Gaborone Granite Complex and Kanye Volcanic Formation, both of which may represent the oldest and largest rapakivi-anorthosite-rhyolite suite yet described (Moore et al., 1993). Nearer the central part of the craton, rift-related volcanism was responsible for the extensive *c*. 2714 -2709 Ma Ventersdorp volcanism and associated rift-style sedimentation.

In conclusion, the availability of an already extensive U-Pb and Pb-Pb geochronological database for the Kaapvaal Craton (Appendices 1-4) has made possible this first attempt to constrain the evolutionary history of the Kaapvaal Craton. However, much additional dating remains to be done in order to sharpen the focus and to provide a statistically more acceptable interpretation of events leading to the construction of one of the oldest and best-preserved Palaeoarchaean-to- Palaeoproterozoic cratons available for study.

REFERENCES

Anhaeusser, C. R., 1973. The geology and geochemistry of the Archaean granites and gneisses of the Johannesburg-Pretoria Dome. Spec. Publ. Geol. Soc. S. Afr., 3, 361-385.

Anhaeusser, C. R., 1981. The granitic-gneiss greenstone shield - South Africa, 424-453. In: Hunter, D. R. (Ed.), Precambrian of the Southern Hemisphere. Developments in Precambrian Geology 2, Elsevier, Amsterdam, p. 882.

Anhaeusser, C. R., 1991. The Archaean Kraaipan Group volcano-sedimentary rocks and associated granites and gneisses of the southwestern Transvaal, northwestern Cape Province and Bophuthatswana. Excursion Guidebook, Inform. Circ. Econ. Geol. Res. Unit, Univ. Witwatersrand, Johannesburg , 252, p.44.

Anhaeusser, C. R., 1999. Archaean crustal evolution of the central Kaapvaal Craton, South Africa: evidence from the Johannesburg Dome. S. Afr. J. Geol., 102 (4), 303-322.

Anhaeusser, C.R. and Burger, A.J., 1982. An interpretation of U-Pb zircon ages for Archaean tonalitic gneisses from the Johannesburg-Pretoria granite dome. Trans. Geol. Soc. S. Afr., 85, 111-116.

Anhaeusser, C.R. and Walraven, F., 1999. Episodic granitoid emplacement in the western Kaapvaal Craton: evidence from the Archaean Kraaipan granite-greenstone terrane, South Africa. J. Afr. Earth Sci., 28(2), 289-309.

Anhaeusser, C. R., Robb, L.J. and Barton, J.M. Jr., 1983. Mineralogy, petrology and origin of the Boesmanskop syeno-granite complex, Barberton Mountain Land, South Africa. Spec. Publ. Geol. Soc. S. Afr., 9, 169-183.

Armstrong, R.A., Compston, W., de Wit, M.J. and Williams, I.S., 1990. The stratigraphy of the 3.5-3.2 Ga Barberton greenstone belt revisited : a single zircon ion microprobe study. Earth Planet. Sci. Lett., 101, 90-106.

Armstrong, R.A., Compston, W., Retief, E.A., Williams, I.S. and Welke, H.J., 1991. Zircon ion microprobe studies bearing on the age and evolution of the Witwatersrand triad. Precambrian Res., 53, 243-266.

Barton, J.M., Barton, E.S. and Kröner, A., 1999. Age and isotopic evidence for the origin of the Archaean granitoid intrusives of the Johannesburg Dome, South Africa. J. Afr. Earth Sci., 28 (3), 693-702.

Brandl, G., Jaeckel, P. and Kröner, A., 1996. Single zircon age for the felsic Rubbervale Formation, Murchison Greenstone Belt, South Africa. S. Afr. J. Geol., 99 (3), 229-234.

Brandl, G. and Kröner, A., 1993. Preliminary results of single zircon studies from various Archaean rocks of the Northeastern Transvaal. Ext. Abstr. 16th International Colloquium of African Geology, Mbabane, Swaziland, p. 54-56.

Burger, A.J. and Coertze, F.J., 1973. Radiometric age determinations on rocks from southern Africa up to the end of 1971. Bull. Geol. Surv. S. Afr., 58, 1-46.

Burger, A.J. and Coertze, F.J., 1975. Age determinations - April 1972 to March 1974. Ann. Geol. Surv. S. Afr., 10, 135-141.

Burger, A.J. and Walraven, F., 1979. Summary of age determinations carried out during the period April 1977 to March 1978. Ann. Geol. Surv. S. Afr., 12, 209-218.

Byerly, G.R., Kröner, A., Lowe, D. R., Todt, W. and Walsh, M. M., 1996. Prolonged magmatism and time constraints for sediment deposition in the early Archaean Barberton greenstone belt: evidence from the Upper Onverwacht and Fig Tree Groups. Precambrian Res., 78, 125-138.

Compston, W. and Kröner, A., 1988. Multiple zircon growth within early Archean tonalitic gneiss from the Ancient Gneiss Complex, Swaziland. Earth Planet. Sci. Lett., 87, 13-28.

Corner, B., Durrheim, R. J. and Nicolaysen, L.O., 1990. Relationships between the Vredefort structure and the Witwatersrand Basin within the tectonic framework of the Kaapvaal Craton as interpreted from regional gravity and aeromagnetic data. Tectonophysics, 171, 49-61.

de Ronde, C.E.J., Kamo, S., Davis, D.W., de Wit, M. J. and Spooner, E.T.C., 1991. Field, geochemical and U-Pb isotopic contraints from hypabyssal felsic intrusions within the Barberton greenstone belt, South Africa : implications for tectonics and the timing of gold mineralization. Precambrian Res., 49, 261-280.

de Ronde, C.E.J. and Kamo, S. L., 2000. An Archaean arc-arc collisional event: a short-lived (ca 3 Myr) episode, Weltevreden area, Barberton greenstone belt, South Africa. J. Afr. Earth Sci., 30 (2), 219-248.

de Wit, M.J., Armstrong, R.A., Kamo, S. L. and Erlank, A.J., 1993. Gold-bearing sediments in the Pietersburg greenstone belt : age equivalents of the Witwatersrand Supergroup sediments, South Africa. Econ. Geol., 88, 1242-1252.

Drennan, G.R., 1988. The nature of the Archaean basement in the hinterland to the Welkom Goldfield. M.Sc thesis (unpubl.), Univ. Witwatersrand, Johannesburg, p.187.

Drennan, G.R., Robb, L.J., Meyer, F. M., Armstrong, R.A. and de Bruiyn, H., 1990. The nature of the Archaean basement in the hinterland of the Witwatersrand Basin: II. a crustal profile west of the Welkom Goldfield and comparisons with the Vredefort crustal profile. S. Afr. J. Geol., 93, 41-53.

Dziggel, A., Stevens, G., Poujol, M., Anhaeusser, C.R. and Armstrong, R.A., 2001. Metamorphism of the granite-greenstone terrane south of the Barberton greenstone belt, South Africa: an insight into the tectono-thermal evolution of the 'lower' portions of the Onverwacht Group. Precambrian Res. (in press).

Gericke, B., 2001. New single zircon U-Pb age constraints on the Kraaipan and Amalia granite-greenstone terrane, South Africa: implications for the evolution of the western Kaapvaal Craton. B.Sc (Hons.) dissertation (unpubl.), Univ. Witwatersrand, Johannesburg, p. 91.

Grobler, D.F. and Walraven, F., 1993. Geochronology of Gaborone Granite Complex extensions in the area north of Mafikeng, South Africa. Chem. Geol., 105, 319-337.

Gutzmer, J., Nhleko, N., Beukes, N. J., Pickard, A. and Barley, M.E., 1999. Geochemistry and ion microprobe (SHRIMP) age of a quartz porphyry sill in the Mozaan Group of the Pongola Supergoup: implications for the Pongola and Witwatersrand Supergroups. S. Afr. J. Geol., 102 (2), 139-146.

Hart, R., Moser, D. and Andreoli, M., 1999. Archaean age for the granulite facies metamorphism near the centre of the Vredefort structure, South Africa. Geology, 27 (12), 1091-1094.

Hart, R. J., Welke, H.J. and Nocolaysen, L.O., 1981. Geochronology of the deep profile through Archaean basement at Vredefort, with implications for early crustal evolution. J. Geophys. Res., 86 (B11), 10663-10680.

Hegner, E., Kröner, A. and Hofmann, A.W., 1984. Age and isotope chemistry of the Archaean Pongola and Usushwana suites in the Swaziland , southern Africa: a case for crustal contamination of mantle-derived magma. Earth Planet. Sci. Lett., 70, 267-279.

Hegner, E., Kröner, A. and Hofmann, A.W., 1993. Trace element and isotopic constraints on the origin of the Archaean Pongola and Usushwana suites in Swaziland. In: Ext. Abstr. 16th International Colloquium of African Geology, Mbabane, Swaziland, p. 147-149.

Hegner, E., Kröner, A. and Hunt, P., 1994. A precise U-Pb zircon age for the Archaean Pongola Supergroup volcanics in Swaziland. J. Afr. Earth Sci., 18 (4), 339-341.

Henderson, D. R., Long, L.E. and Barton, J.M., 2000. Isotopic ages and chemical and isotopic compositions of the Archaean Turfloop batholith, Pietersburg granite-greenstone terrane, Kaapvaal Craton, South Africa. S. Afr. J. Geol., 103 (1), 38-46.

Hirner, A., Poujol, M. and Armstrong, R.A., 2001. New petrological, geochemical and geochronological data for the Madibe greenstone belt, Kaapvaal Craton, South Africa: implications for the crustal growth on the western margin of the Kaapvaal Craton. S. Afr. J. Geol., (submitted).

Kamo, S. L. and Davis, D.W., 1994. Reassessment of Archaean crustal development in the Barberton Moutain Land, South Africa, based on U-Pb dating. Tectonics, 13 (1), 167-192.

Kamo, S. L., Reimold, W.U., Krogh, T.E. and Colliston, W. P., 1996. A 2.023 Ga age for the Vredefort impact event and a first report of shock metamorphosed zircons in pseudotachylitic breccias and granophyre. Earth Planet. Sci. Lett., 144, 369-387.

Kohler, E.A., Anhaeusser, C.R. and Isachsen, C., 1993. The Bien Venue Formation: a proposed new unit in the northeastern sector of the Barberton greenstone belt. Ext. Abstr. 16th International Colloquium on African Geology, Mbabane, Swaziland, p. 186-188.

Kröner, A., Byerly, G.R. and Lowe, D. R., 1991. Chronology of early Archean granite-greenstone evolution in the Barberton Moutain Land, South Africa, based on precise dating by single grain zircon evaporation. Earth Planet. Sci. Lett., 103, 41-54.

Kröner, A. and Compston, W., 1988. Ion microprobe ages of zircons from early Archaean granite pebbles and greywacke, Barberton greenstone belt, southern Africa. Precambrian Res., 38, 367-380.

Kröner, A., Compston, W. and Williams, I.S., 1989. Growth of early Archaean crust in the Ancient Gneiss Complex of Swaziland as revealed by single zircon dating. Tectonophysics, 161, 271-298.

Kröner, A., Hegner, E., Byerly, G.R. and Lowe, D. R., 1992. Possible terrane identification in the early Archaean Barberton greenstone belt, South Africa, using single zircon geochronology. EOS Trans. AGU, Fall Meeting Suppl.,73 (43), 616.

Kröner, A., Hegner, E., Wendt, J.I. and Byerly, G.R., 1996. The oldest part of the Barberton granitoid-greenstone terrain, South Africa: evidence for crust formation at 3.5 and 3.7 Ga. Precambrian Res., 78, 105-124.

Kröner, A., Jaeckel, P. and Brandl, G., 2000. Single zircon ages for felsic to intermediate rocks from the Pietersburg and Giyani greenstone belts and bordering granitoid orthogneisses, northern Kaapvaal Craton, South Africa. J. Afr. Earth Sci., 30 (4), 773-793.

Kröner, A. and Tegtmeyer, A., 1994. Gneiss-greenstone relationships in the Ancient Gneiss Complex of southwestern Swaziland, southern Africa, and implications for early crustal evolution. Precambrian Res., 67 (1/2), 109-139.

Layer, P.W., Kröner, A., McWilliams, M. and York, D., 1989. Elements of Archaean thermal history and apparent polar wander of eastern Kaapvaal Craton, Swaziland from single grain dating and paleomagnetism. Earth Planet. Sci. Lett., 93, 23-34.

Layer, P.W., Kröner, A. and York, D., 1992. Pre-3000 Ma thermal history of the Archean Kaap Valley pluton, South Africa. Geology, 20,717-720.

Maphalala, R.M. and Kröner, A., 1993. Pb-Pb single zircon ages for the younger Archaean granitoids of Swaziland, southern Africa. Ext. Abstr. 16th International Colloquium on African Geology, Mbabane, Swaziland, p. 201-206.

McCourt, S., Hilliard, P. and Armstrong, R.A., 2000. SHRIMP U-Pb zircon geochronology of granitoids from the western margin of the Kaapvaal Craton: implications for crustal evolution in the Neoarchaean. In: A.F.M. Kisters and R.J. Thomas (Eds.), 27th Geocongress, Geol. Soc. S. Afr., Stellenbosch. J. Afr. Earth Sci., 31, 1A, p. 48.

Meyer, F.M., Robb, L.J., Reimold, W. U. and de Bruiyn, H., 1994. Contrasting low- and high-Ca granites in the Archaean Barberton Mountain Land, southern Africa. Lithos, 32, 63-76.

Moore, M., Davis, D.W., Robb, L.J., Jackson, M.C. and Grobler, D.F., 1993. Archaean rapikivi granite-anorthosite-rhyolite complex in the Witwatersrand basin hinterland, southern Africa. Geology, 21, 1031-1034.

Poujol, 1997. Etude U-Pb et Pb-Pb de la Murchison greenstone belt et du bassin aurifère d'Evander, Afrique du Sud: implications pour l'évolution du Kaapvaal Craton. Ph.D. thesis (unpubl.), Univ. Montpellier II, France, 247 pp.

Poujol, M., 2001. U-Pb isotopic evidence for episodic granitoid emplacement in the Murchison greenstone belt, South Africa. J. Afr. Earth Sci., 33 (1), 155-163.

Poujol, M. and Anhaeusser, C.R., 2001. The Johannesburg Dome, South Africa: new single zircon U-Pb isotopic evidence for early Archaean granite-greenstone development within the central Kaapvaal Craton. Precambrian Res., 108, 139-157.

Poujol, M. and Robb, L.J., 1999. New U-Pb zircon ages on gneisses and pegmatite from south of the Murchison greenstone belt, South Africa. S. Afr. J. Geol., 102 (2), 93-97.

Poujol, M., Robb, L.J., Respaut, J.P. and Anhaeusser, C.R., 1996. 3.07-2.97 Ga greenstone belt formation in the northeastern Kaapvaal Craton : implications for the origin of the Witwatersrand basin. Econ. Geol., 91 (8), 1455-1461.

Poujol, M., Anhaeusser, C.R. and Armstrong, R.A., 2001a. Episodic granitoid emplacement in the Archaean Amalia-Kraaipan terrane, South Africa: confirmation from single zircon U-Pb geochronology. J. Afr. Earth Sci., 33 (2), 435-449.

Poujol, M., Kiefer, R., Robb, L. J., Anhaeusser, C.R. and Armstrong, R.A., 2001b. Amalia - the first Neoarchaean (2.75 Ga) greenstone sequence on the Kaapvaal Craton, South Africa. J. Geol. Soc. Lond., (submitted).

Reimold, W.U., Meyer, F. M., Walraven, F. and Matthews, P. E., 1993. Geochemistry and chronology of the pre- and post-Pongola granitoids for northeastern Transvaal. Ext. Abstr. 16th International Colloquium of African Geology, Mbabane, Swaziland, p. 294-296.

Robb, L. J. (1991). U-Pb determinations-felsic volcanics, Kraaipan Group. In: Anhaeusser, C.R., 1991, The Archaean Kraaipan Group of volcano-sedimentary rocks and associated granites and gneisses of the south-western Transvaal, north-western Cape Province and Bophuthatswana, Excursion Guidebook, Inform. Circ. Econ. Geol. Res., Unit, Univ. Witwatersrand, Johannesburg, 244, 28-30.

Robb, L.J., Davis, D.W., Kamo, S. L. and Meyer, F. M., 1992. Ages of altered granites adjoining the Witwatersrand basin with implications for the origin of gold and uranium. Nature, 357, 677-680.

Robb, L.J., Meyer, F. M., Kröner, A., Trumbull, R. B., Reimold, W. U., de Bruiyn, H., Walraven, F. and Toulkeridis, T., 1993. Late-stage granite plutons in the Barberton region and Swaziland: an update. Ext. Abstr. 16th International Colloquium of African Geology, Mbabane, Swaziland, 299-301.

Sibiya, V. B., 1988. The Gaborone Granite Complex, Botswana, southern Africa: an atypical rapakivi granite-massif anorthosite association. Free University Press, Amsterdam, p.449.

Tegtmeyer, A. R. and Kröner, A., 1987. U-Pb zircon ages bearing on the nature of early Archean greenstone belt evolution, Barberton Moutain Land, southern Africa. Precambrian Res., 36, 1-20.

Van Eeden, O. R., de Wet, N. P. and Strauss, C. A., 1963. The geology of the area around Schweizer-Reneke. Expln. Sheets 2724 B (Pudimoe) and 2725A (Schweizer-Reneke), Geol. Surv. S. Afr., p.76

Van Niekerk, C. B. and Burger, A.J., 1978. A new age for the Ventersdorp acidic lavas. Trans. Geol. Soc. S. Afr., 81, 155-163.

Viljoen, M. J., Van Vuuren, C.J.J., Pearton, T., Minnitt, R. C. A., Muff, R. and Cilliers, P., 1978. The regional geological setting of mineralization in the Murchison Range with particular reference to antimony. Spec. Publ. Geol. Soc. S. Afr., 4, 55-76.

Walraven, F., Grobler, D.F. and Key, R.M., 1996. Age equivalence of the Plantation Porphyry and the Kanye Volcanic Formation, southeastern Botswana. S. Afr. J. Geol., 99 (1), 23-31.

Walraven, F. and Martini, J., 1995. Zircon Pb-evaporation age determinations of the Oak Tree Formation, Chuniespoort Group, Transvaal Sequence: implications for Transvaal-Griqualand West basin correlations. S. Afr. J. Geol., 98 (1), 58-67.

Walraven, F., Retief, E.A. and Allsopp, H.L., 1987. Summary of age determinations carried out during the period April 1983 to March 1984. Ann. Geol. Surv. S. Afr., 21, 107-113.

Walraven, F., Smith, C. B. and Kruger, F.J., 1991. Age determinations of the Zoetlief Group - a Ventersdorp Supergroup correlative. S. Afr. J. Geol., 94, 220-227.

Wendt, J.I., Toulkeridis, T., A., K. and Heubeck, C., 1993. Single zircon geochronology of Archaean granitoids in South Africa and Swaziland. Ext. Abstr. 16th International Colloquium of African Geology, Mbabane, Swaziland, p. 378-379.

York, D., Layer, P.W., Lopez Martinez, M. and Kröner, A., 1989. Thermal histories from the Barberton greenstone belt, southern Africa. International Geological Congress, Washington D.C., p. 413.

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Appendix 1: Summary of U-Pb and Pb-Pb zircon evaporation data for the Eastern Terrane

Locality	Sample nature and number	Age	Error	Method	Interpretation	Ref.
BGB Vlakplaats Granodiorite	Weakly foliated porphyritic granodiorite BA 47	3702	1	Pb-Pb zircon evaporation	Xenocrysts	1
Ngwane Gneiss	Tonalitic gneiss AGC 55	3683	10	SHRIMP	Xenocryst	2
AGC	Tonalitic Gneiss AGC 150	3644	4	SHRIMP	Age of crystallization	3
BGB	Moodies Clast MD 6 (Granitoid Gneiss)	3570	6	SHRIMP	Age of crystallization	4
Dwalile greenstone belt	Metapelite AGC 40	3563	63	SHRIMP	Age of the source of the metapelite	2
AGC Central and SW Swaziland	Well foliated tonalitic gneiss AGC 200	3563	3	SHRIMP	Age of crystallization	5
BGB Hooggenoeg Formation	Tuff SA 351-3	3559	27	SHRIMP	Xenocryst	6
BGB Steynsdorp Pluton	Trondhjemitic Gneiss BA 48	3553	4	Pb-Pb zircon evaporation	Xenocryst	1
BGB Theespruit Formation	Felsic Metavolcanics SA 414-2	3548	1.3	Pb-Pb zircon evaporation	Age of crystallization of the felsic tuff	1
BGB Theespruit Formation	Strongly foliated felsic schist BA 50	3548	3	Pb-Pb zircon evaporation	Age of crystallization of the felsic tuff	1
BGB Theespruit Formation	Felsic Metavolcanics BA 39	3547	2	Pb-Pb zircon evaporation	Age of crystallization of the felsic tuff	1
BGB Theespruit Formation	Felsic Metavolcanics BA 40	3547	2	Pb-Pb zircon evaporation	Age of crystallization of the felsic tuff	1
BGB Theespruit Formation	Felsic Metavolcanics BA 39	3544	3	ID-TIMS	Age of crystallization of the felsic tuff	1
Dwalile greenstone belt	Fine-grained siliceous greywacke AGC 46a and AGC 31	3544	6	SHRIMP	Age of the source of the greywacke	2
BGB Vlakplaats Granodiorite	Weakly foliated porphyritic granodiorite BA 46	3540	3	Pb-Pb zircon evaporation	Age of crystallization	1
BGB Steynsdorp Pluton	Trondhjemitic Gneiss BA 48	3538	9	SHRIMP	Xenocryst	1
BGB Theespruit Formatiom	Tonalite gneiss A	3538	+4/-2	ID-TIMS	Age of crystallization	7
BGB Theespruit Formation	Tonalite gneiss BB 03/86	3538	6	SHRIMP	Age of crystallization	8
BGB	Moodies Clast MD 251 (Granitoid Gneiss)	3531	4	SHRIMP	Age of crystallization	4
BGB Steynsdorp Pluton	Strongly foliated trondhemitic gneiss BA 26	3531	3	Pb-Pb zircon evaporation	Xenocryst	9
BGB Theespruit Formation	Fine-grained volcanoclastic unit BBC 04/87	3531	10	SHRIMP	Age of the underlaying tonalite gneiss	8
BGB Komati Formation	Mettagabbro B-Gab 08/86	3523	6	SHRIMP	Xenocryst	8
BGB Fig Tree Group	Grewacke SWAZ-53	3523	13	ID-TIMS	Age of source region for detrital zircons	10
BGB Fig Tree Group	Dacitic breccia SA 224-1	3522	4	Pb-Pb zircon evaporation	Xenocryst	9
BGB Onverwacht Group	Arkose Be 5	3521	5.6	SHRIMP and ID-TIMS	Maximum age estimate for deposition	11
Ngwane Gneiss	Tonalitic gneiss AGC 55	3521	23	SHRIMP	Age of crystallization	2
BGB	Clast C 48 (Granite boulder)	3518	11	SHRIMP	Age of crystallization	4
BGB Steynsdorp Pluton	Trondhjemitic Gneiss BA 48	3510	4	Pb-Pb zircon evaporation	Trondhjemite emplacement	1
BGB Theespruit Formation	Strongly foliated felsic schist BA 49	3510	3	Pb-Pb zircon evaporation	Grain growth related to intrusion of the Steynsdorp pluton	1
BGB Steynsdorp Pluton	Trondhjemitic Gneiss BA 48	3509	4	SHRIMP	Trondhjemite emplacement	1
BGB Steynsdorp Pluton	Highly strained trondhjemite gneiss B	3509	+8/-7	ID-TIMS	Age of crystallization	7
BGB Steynsdorp Pluton	BA 26	3505	5	SHRIMP	Age of crystallization	1

Appendix 1 (Cont.)

Locality	Sample nature and number	Age	Error	Method	Interpretation	Ref.
AGC NE Swaziland	Trondhjemitic gneiss AGC 185	3505	24	SHRIMP	Age of crystallization	5
BGB Onverwacht Group	Dacitic tuff SA 351-2	3504	4	Pb-Pb zircon evaporation	Xenocryst	9
AGC	Tonalitic Gneiss AGC 150	3504	6	SHRIMP	Recrystallization	3
BGB Steynsdorp Pluton	Granodioritic phase BA 41	3502	2	Pb-Pb zircon evaporation	Age of crystallization	1
BGB Steynsdorp Pluton	Strongly foliated trondhemitic gneiss BA 27	3496	3	Pb-Pb zircon evaporation	Mixture of different isotopic compositions	9
BGB Steynsdorp Pluton	Strongly foliated trondhemitic gneiss BA 27	3490	4	Pb-Pb zircon evaporation	Age of crystallization	9
BGB Steynsdorp Pluton	Strongly foliated trondhemitic gneiss BA 26	3490	3	Pb-Pb zircon evaporation	Age of crystallization	9
BGB Steynsdorp Pluton	Tonalite	3490	3	Pb-Pb zircon evaporation	Age of crystallization	12
BGB Steynsdorp Pluton	Tonalite	3490	4	Pb-Pb zircon evaporation	Age of crystallization	12
Ngwane Gneiss	Tonalitic gneiss AGC 55	3490	3	Pb-Pb zircon evaporation	Age of crystallization	2
BGB Fig Tree Group	Dacitic tuff LH 844	3484	4	Pb-Pb zircon evaporation	Xenocryst	9
BGB Komati Formation	Mettagabbro B-Gab 08/86	3482	5	SHRIMP	Age of emplacement of the gabbro	8
Dwalile greenstone belt	Siliceous greywacke AGC 46	3480	20	SHRIMP	Age of the source of the greywacke	2
BGB Fig Tree Group	Dacitic tuff LH 843	3476	3	Pb-Pb zircon evaporation	Xenocryst	9
BGB	Moodies Pebble (Md-6)	3474	+35/-31	ID-TIMS	Minimum age for granite emplacement for the pebble rock source	10
BGB Middle Marker	Sedimentary unit separating the Komati and Hooggenoeg Formations	3472	5	SHRIMP		8
BGB Komati Formation	Quartz-feldspar porphyry dyke C	3470	+39/-9	ID-TIMS	Age of crystallization	7
BGB Stolzburg Pluton	Medium-grained foliated trondhjemite D	3460	+5/-4	ID-TIMS	Age of crystallization	7
BGB Komati Formation	Quartz-feldspar porphyry dyke C	3458	1.6	ID-TIMS - Titanite		7
AGC Central and SW Swaziland	Tonalitic gneiss AGC 58	3458	3	Pb-Pb zircon evaporation	Age of crystallization	5
BGB Komati Formation	Undeformed intrusive felsic sill V	3457	3	ID-TIMS	Xenocryst	7
BGB Onverwacht Group	Metaquartzite AGC 208 and AGC 225	3457	15	Pb-Pb zircon evaporation	Underlaying lower Onverwacht Group metavolcanics	13
Tsawela Gneiss	Foliated hornblende-biotite tonalite AGC 75	3455	3	Pb-Pb zircon evaporation	Age of crystallization	2
AGC Central and SW Swaziland	Garnetiferous gneiss AGC 201	3455	11	SHRIMP	Age of crystallization if this gneiss is igneous in origin	5
BGB Komati Formation	Quartz-feldspar porphyry dyke C	3454	9.6	ID-TIMS - Titanite		7
BGB	Fig Tree Group Greywacke SWA 53	3453	9	SHRIMP	Age of crystallization of the parent rock	4
BGB Theespruit Formation	Fine-grained volcanoclastic unit BBC 04/86	3453	6	SHRIMP	Maximum age estimate for deposition	8
BGB Hooggenoeg Formation	Dacitic tuff SA 351-2	3452	3	SHRIMP	Tuff formation	6
BGB Doornhoek Pluton	Undeformed trondhjemite E	3448	4	ID-TIMS zircon+monazite	Age of crystallization	7
BGB Onverwacht Group	Dacitic tuff SA 351-2	3445	3	Pb-Pb zircon evaporation	Age of crystallization	9
BGB Stolzburg Pluton	Tonalitic to trondhjemitic gneiss BA 28	3445	3	Pb-Pb zircon evaporation	Age of crystallization	9

Appendix 1 (Cont.)

Locality	Sample nature and number	Age	Error	Method	Interpretation	Ref.
BGB Hooggenoeg Formation	Dacitic to dacite-andesitic rock BSV 30/86	3445	12	SHRIMP	Age of the hypabyssal intrusion	8
BGB Stolzburg Pluton	Trondhjemite	3445	3	Pb-Pb zircon evaporation	Age of crystallization	12
BGB upper Hooggenoeg Fm	Dacitic tuff	3445	3	Pb-Pb zircon evaporation	Maximum age of felsic volcanism	12
BGB Theespruit Pluton	Massive trondhjemite F	3443	+4/-3	ID-TIMS zircon+titanite	Age of crystallization	7
Tsawela Gneiss	Foliated hornblende-biotite tonalite AGC 97	3443	6	Pb-Pb zircon evaporation	Age of crystallization	2
BGB Fig Tree Group	Dacitic breccia SA 224-1	3441	4	Pb-Pb zircon evaporation	Xenocryst	9
BGB Theespruit Pluton	Foliated and banded tonalitic gneiss AGCE	3440	5	Pb-Pb zircon evaporation	Age of crystallization	9
BGB Theespruit Pluton	Granitoid	3440	5	Pb-Pb zircon evaporation	Age of crystallization	12
BGB Hooggenoeg Formation	Felsic Flow BA 10 and BA 11	3438	6	Pb-Pb zircon evaporation	Age os acid volcanism in the Hooggenoeg Formation	13
BGB Theespruit Pluton	Trondhjemite BG 04/86	3437	6	SHRIMP	Age of crystallization	8
Tsawela Gneiss	Foliated hornblende-biotite tonalite AGC 107	3436	6	Pb-Pb zircon evaporation	Age of crystallization	2
AGC	Tonalitic Gneiss AGC 150	3433	8	SHRIMP	Recrystallization	3
BGB Stolzburg Pluton	Trondhjemitic Gneiss Marc 2	3431	11	ID-TIMS	Age of crystallization	11
BGB Hooggenoeg Formation	Dacitic tuffaceous sanstone MW 64	3416	5	Pb-Pb zircon evaporation	Age of crystallization	9
BGB Fig Tree Group	Dacitic tuff SA 326	3416	6	Pb-Pb zircon evaporation	Xenocryst	9
BGB Fig Tree Group	Dacitic breccia SA 224-1	3413	8	Pb-Pb zircon evaporation	Xenocryst	9
BGB Fig Tree Group	Tuffaceous sandstone SA201-3	3374	2	Pb-Pb zircon evaporation	Xenocryst	6
Usuthu Suite (S-central Swaziland)	Granodiorite	3360	4	Pb-Pb zircon evaporation	Age of crystallization	14
BGB Komati Formation	Pegmatitic and medium-grained gabbro G	3352	+6/-5	ID-TIMS	Age of crystallization	7
BGB Komati Formation	Mettagabbro B-Gab 08/86	3351	6	SHRIMP	Age of metamorphism	8
BGB Komati Formation	Pegmatitic and medium-grained gabbro G	3347	3	ID-TIMS baddeleyite	Age of crystallization	7
BGB Stentor Pluton	Coarse-grained granodiorite AGC-27	3347	+67/-60	ID-TIMS	Age of crystallization of the older part of the Craton	10
BGB Kromberd Formation	Footbridge Chert MW19-5	3334	3	Pb-Pb zircon evaporation		6
BGB Fig Tree Group	Dacitic breccia SA 224-1	3323	4	Pb-Pb zircon evaporation	Xenocrysts	9
BGB Mendon Formation	Tuffaceous layer SA 168	3310	2	Pb-Pb zircon evaporation	Xenocryst	6
BGB Fig Tree Group	Tuffaceous sandstone SA201-2	3310	3	Pb-Pb zircon evaporation	Xenocrysts	6
BGB	Moodies Pebble (Md-1)	3306	+65/-57	ID-TIMS	Granite emplacement for the pebble rock source	10
BGB Nelspruit Batholith	Gneissic tonalite xenolith P	3304	6	ID-TIMS	Proof of crustal contamination in the batholith	7
BGB Mendon Formation	Tuffaceous layer SA 167	3298	3	Pb-Pb zircon evaporation	Tuff formation	6
BGB Fig Tree Group	Dacitic tuff SA 259	3259	5	Pb-Pb zircon evaporation	Age of crystallization	9
BGB upper Fig Tree Group	Dacitic tuff	3259	5	Pb-Pb zircon evaporation	early stage felsic volcanism	12

Appendix 1 (Cont.)

Locality	Sample nature and number	Age	Error	Method	Interpretation	Ref.
BGB Fig Tree Group	Thick tuff bed SA310-1	3258	3	SHRIMP		6
BGB Fig Tree Group	Dacitic breccia SA 224-1	3256	4	Pb-Pb zircon evaporation	Breccia deposition	9
BGB bellow Stolzburg Moodies	Felsic volcanic-volcanoclastic rock BSV 02/87	3256	8	SHRIMP - zircon cores	Xenocryst	8
BGB Fig Tree Group	Dacitic Breccia	3256	4	Pb-Pb zircon evaporation	Age of breccia deposition	12
BGB upper Fig Tree Group	Silicic metavolcanics	3256	1	ID-TIMS	Overlies argilaceous assemblages of Fig Tree Gp	15
BGB Stolzburg Pluton	Medium-grained foliated trondhjemite N	3255		ID-TIMS		7
BGB Fig Tree Group	Tuffaceous sandstone SA201-1	3253	3	Pb-Pb zircon evaporation	Tuff formation	6
BGB Stentor Pluton	Medium-grained granodiorite AGC-26	3250	30	ID-TIMS	Age of crystallization of the younger part of the Craton	10
BGB Fig Tree Group	Dacitic tuff SA 326	3243	4	Pb-Pb zircon evaporation	Age of crystallization	9
BGB basal Fig Tree Group	Dacitic tuff	3243	4	Pb-Pb zircon evaporation	Age of volcanism	12
BGB Fig Tree Group	Dacite dyke SA 57-1	3241	6	Pb-Pb zircon evaporation	Age of crystallization	9
BGB Fig Tree Group	Dacitic feeder dyke	3241	6	Pb-Pb zircon evaporation	Age of crystallization	12
BGB Fig Tree Group	Dacitic intrusive SA413-1	3237	3	Pb-Pb zircon evaporation	Age of crystallization	6
BGB Stolzburg Pluton	Medium-grained foliated trondhjemite N	3237		ID-TIMS		7
BGB Nelshoogte Pluton	Strongly foliated Trondhjemite B-90-16	3236	1	ID-TIMS	Age of crystallization	16
Usuthu Suite (N-central Swaziland)	Granodiorite	3231	4	Pb-Pb zircon evaporation	Age of crystallization	14
BGB Kromberg Formation	Deformed Quartz-porphyry L	3229	+4/-3	ID-TIMS	Maximum age estimate for emplacement	7
BGB Kaap Valley Pluton	Tonalite AGFA	3229	5	ID-TIMS	Age of crystallization	10
BGB Weltevreden area	B-90-5 meso-tonlite intrusion	3229	1	ID-TIMS	Age of crystallization	16
BGB Weltevreden area	B-90-6 Meso-tonalite intrusion	3229	1	ID-TIMS	Age of crystallization	16
BGB Weltevreden area	B-92-7 Tonalite dyke	3228	2	ID-TIMS	Age of crystallization	16
BGB Fig Tree Group	Dacitic tuff LH 842	3227	4	Pb-Pb zircon evaporation	Tuff emplacement	9
BGB Kaap Valley Pluton	Hornblende-rich tonalite H	3227	1	ID-TIMS zircon+titanite	Age of crystallization	7
BGB Kaap Valley Pluton	Hornblende-biotite-rich tonalite I	3227	1	ID-TIMS zircon+titanite	Age of crystallization	7
BGB upper Fig Tree Group	Dacitic tuff	3227	4	Pb-Pb zircon evaporation	Age of crystallization	12
BGB intrudes Fig Tree Group	Feldspar-quartz porphyry	3227	3	ID-TIMS	Maximum age of porphyry; minimum age of Fig Tree Group sediments	17
AGC NW Swaziland	K-feldspar-rich granitic gneisses AGC 142 and 144	3227	21	SHRIMP	Age of crystallization	5
BGB	Ignimbrite cross-bedded ash flow J	3226	1	ID-TIMS	Age of crystallization	7
BGB Kaap Valley Pluton	Homogeneous foliated hornblende tonalite Z262	3226	14	SHRIMP	Age of crystallization	8
BGB Kaap Valley Pluton	Hornblende tonalite	3226	5	Pb-Pb zircon evaporation	Age of crystallization of the margin of the pluton	18
BGB Fig Tree Group	Dacitic conglomerate SA 353-1	3225	3	Pb-Pb zircon evaporation	Age of crystallization	9

Appendix 1 (Cont.)

Locality	Sample nature and number	Age	Error	Method	Interpretation	Ref.
BGB upper Fig Tree Group	Dacitic agglomerate	3225	3	Pb-Pb zircon evaporation	Age of crystallization	12
BGB	Moodies Pebble (Md-9)	3224	6	ID-TIMS	Granite emplacement for the pebble rock source	10
BGB Kaap Valley Pluton	Hornblende-biotite tonalite	3223	4	Pb-Pb zircon evaporation	Age of crystallization of the interior of the pluton	18
BGB Stolzburg Syncline	Porphyry intrusion K	3222	+10/-4	ID-TIMS	Age of crystallization	7
BGB Dalmein Pluton	Massive K-feldspar monzonite M	3216	+2/-4	ID-TIMS zircon+titanite	Age of crystallization	7
BGB Fairview Mine	Feldspar-quartz porphyry	3216	21	ID-TIMS	Maximum age of porphyry; maximum age for gold mineralization	17
AGC NW Swaziland	Granodiorite AGC 140	3216	3	Pb-Pb zircon evaporation	Minimun age of intrusion	5
BGB Doornhoek Pluton	Undeformed trondhjemite E	3215		ID-TIMS titanite		7
BGB Dalmein Pluton	Massive K-feldspar monzonite M	3215	2	ID-TIMS titanite	Minimum estimate age for emplacement	7
AGC NE Swaziland	Tonalitic gneiss AGC 136	3214	20	SHRIMP	Age of crystallization	5
Dwalile greenstone belt	Unfoliated granodiorite AGC 53 intusive into the belt	3213	10	Pb-Pb zircon evaporation	Age of crystallization	2
BGB Nelshoogte Pluton	Granitoid	3212	2	Pb-Pb zircon evaporation	Age of crystallization	19
Natal Spa	Granite (sensus stricto) NA-75 and NA-76	3210	25	Pb-Pb zircon evaporation	Age of crystallization	20
BGB Stolzburg Pluton	Medium-grained foliated trondhjemite N	3201	1.6	ID-TIMS titanite	Minimum estimate age for emplacement	7
BGB Steynsdorp Pluton	Highly strained trondhjemite gneiss B	3190	1.6	ID-TIMS - Rutile		7
AGC NE Swaziland	Leucogranite veins in AGC 185	3166	4	SHRIMP	Age of crystallization	5
BGB bellow Moodies Group	Felsic volcanic-volcanoclastic rock BSV 01/86	3164	12	SHRIMP	Maximum age estimate for deposition	8
BGB bellow Moodies Group	Felsic volcanic-volcanoclastic rock BSV 02/86	3164	12	SHRIMP	Maximum age estimate for deposition	8
BGB Stentor Pluton	Heterogeneous granodiorite R	3107	5	ID-TIMS	Age of crystallization	7
BGB Boesmanskop Pluton	T	3107	+4/-2	ID-TIMS zircon+titanite	Age of crystallization	7
BGB Nelspruit Batholith	Porphyrytic O	3106	+4/-3	ID-TIMS zircon+titanite	Best estimate age of crystallization	7
BGB Nelspruit Batholith	Porphyrytic O	3105	2	ID-TIMS titanite	Best estimate age of crystallization	7
BGB Mpuluzi Pluton	Equigranular granodirite S	3105	3	ID-TIMS zircon+titanite	Age of crystallization	7
BGB Salisbury Kop Pluton	Granodiorite U	3105	+10/-8	ID-TIMS	Age of crystallization	7
Mliba pluton	Granodiorite	3105	5	Pb-Pb zircon evaporation	Age of crystallization	14
BGB Hebron Pluton	Medium-to fine-grained granodiorite Q	3104	+3/-2	ID-TIMS zircon+titanite	Age of crystallization	7
BGB Mliba Pluton	Granodiorite	3100	11	ID-TIMS	Age of crystallization	21
Mozaan Group (Pongola Supergroup)	Quartz-porphyry sill MOS-POR	3093	18	SHRIMP	Xenocryst	22
Nsuze Group (Pongola Supergroup)	Volcanic lavas	3090	90	ID-TIMS	Age of crystallization	23
BGB Fairview Mine	Gold mineralization	3084	18	ID-TIMS rutile	Minimum age for Fairview Mine gold mineralization	17
Mozaan Group (Pongola Supergroup)	Quartz-porphyry sill MOS-POR	3083	24	SHRIMP	Xenocryst	22

Appendix 1 (Cont.)

Locality	Sample nature and number	Age	Error	Method	Interpretation	Ref.
BGB Stentor Pluton	Heterogeneous granodiorite R	3082	3	ID-TIMS rutile	Minimum age of metamorphism/alteration	7
BGB Komati Formation	Undeformed intrusive felsic sill V	3080	3	ID-TIMS	Older limit for emplacement of the sill	7
BGB Salisbury Kop Pluton	Undeformed homogeneous granodiorite	3079	39	ID-TIMS	Age of crystallization and minimum age for deposition of the Moodies Group	21
Sinceni Pluton	Granodiorite	3074	4	Pb-Pb zircon evaporation	Age of crystallization	21
Sinceni Pluton	Granodiorite	3074	4	Pb-Pb zircon evaporation	Age of crystallization	14
Lochiel batholith/Mpuluzi	Granodiorite, adamellite	3074	6	Pb-Pb zircon evaporation	Age of crystallization	14
AGC NW Swaziland	Trondhjemitic gneiss AGC 204	3005	6	Pb-Pb zircon evaporation	New zircon growth	5
Pongola Supergroup	Rhyodacite Po 84	2985	1	ID-TIMS	Age of crystallization	24
Pongola Supergroup	Rhyolite Po 84	2984	2.6	ID-TIMS	Age of crystallization	25
Mozaan Group (Pongola Supergroup)	Quartz-porphyry sill MOS-POR	2946	18	SHRIMP	Xenocryst	22
Pongola Supergroup	Nsuze Rhyolite 87	2940	22	ID-TIMS	Age of crystallization	26
Nhlangano Gneiss	Foliated gneiss	2929	5	Pb-Pb zircon evaporation	Age of crystallization	14
Godlwayo Pluton	Granite (sensus stricto) NA-13	2863	8	ID-TIMS	Age of crystallization	27
Mozaan Group (Pongola Supergroup)	Quartz-porphyry sill MOS-POR	2837	5	SHRIMP	Age of emplacement and minimum age for deposition of the Mozaan Group	22
Mooihoek Pluton	Granite (sensus stricto)	2824	6	Pb-Pb zircon evaporation	Age of crystallization	14
Mhlosheni Pluton	Granite (sensus stricto)	2822	5	Pb-Pb zircon evaporation	Age of crystallization	14
AGC Central and SW Swaziland	Biotite-rich quartzofeldspathic gneiss AGC 126	2745	6	SHRIMP	Age of crystallization or recrystallization of the zircons	5
BGB Mpageni Pluton	Granite (sensus stricto) W	2740	15	ID-TIMS	Age of crystallization	7
Sicunusa Pluton	Granite (sensus stricto)	2723	7	Pb-Pb zircon evaporation	Age of crystallization	14
Kwetta Pluton	Granite (sensus stricto)	2722	6	Pb-Pb zircon evaporation	Age of crystallization	14
Ngwempisi Pluton	Granite (sensus stricto)	2722	4	Pb-Pb zircon evaporation	Age of crystallization	14
Hlatikulu batholith	Granite (sensus stricto)	2722	7	Pb-Pb zircon evaporation	Age of crystallization	14
Spekboom Granite	Granite (sensus stricto) NA-18	2714	19	Pb-Pb zircon evaporation	Age of crystallization	20
BGB Mbabane Pluton	MBE	2691	2	Pb-Pb zircon evaporation	Age of crystallization	28
BGB Mbabane Pluton	MBC	2691	2	Pb-Pb zircon evaporation	Age of crystallization	28
Kwetta Pluton	Granite (sensus stricto) NA-62	2671	3.3	Pb-Pb zircon evaporation	Age of crystallization	20

1.Kröner et al., 1996; 2. Kröner and Tegtmeyer, 1994; 3. Compston and Kröner, 1988; 4. Kröner and Compston, 1988; 5. Kröner et al., 1989; 6. Byerly et al., 1996; 7. Kamo and Davis, 1994; 8. Armstrong et al., 1990; 9. Kröner et al., 1991; 10. Tegtmeyer and Kröner, 1987; 11. Dziggel et al., 2001; 12. Kröner et al., 1992, 13. Kröner and Todt, 1988; 14. Maphalala and Kröner, 1993; 15. Kohler et al., 1993; 16. De Ronde and Kamo, 2000; 17. De Ronde et al., 1991; 18. Layer et al., 1992; 19 York et al., 1989; 20. Reimold et al., 1993; 21. Wendt et al., 1993; 22. Gutzmer et al., 1999; 23. Burger and Coertze, 1973; 24. Hegner et al., 1994; 25. Hegner et al., 1993; 26. Hegner et al., 1984; 27. Robb et al., 1993 and 28. Layer et al., 1989.

Appendix 2: Summary of U-Pb, Pb and Pb-Pb zircon evaporation data for the Central Terrane

Locality	Sample nature and number	Age	Error	Method	Interpretation	Reference
Ventersdorp Supergroup (Platberg Group)	Makwassie Quartz Porphyry FW83Va	3480	7	SHRIMP	Xenocryst	1
Vredefort Dome	Paragneiss V55	3425		ID-TIMS	Xenocryst	2
Johannesburg Dome	Trondhjemitic gneiss JHBD 98-9	3340	3.3	ID-TIMS	Age of crystallization	3
Vredefort Dome	Lesutaskraal pseudotachylitic breccia LES	3310		ID-TIMS	Xenocryst minimum age of crystallization	4
Witwatersrand Supergroup (Crown lava)	Highly amigdaloid volcanic horizon R-1	3259	9	SHRIMP	Xenocryst	1
Witwatersrand Supergroup (Crown lava)	Highly amigdaloid volcanic horizon CR-1/89	3230	8	SHRIMP	Xenocryst	1
Johannesburg Dome	Tonalitic Gneiss JHBD 98-1	3199.9	2	ID-TIMS	Age of crystallization	3
Hartbeesfontein Dome	Peraluminous granodiorite-adamellite DHF9	3174	+9/-7	ID-TIMS	Age of crystallization	5
Vredefort Dome	Lesutaskraal pseudotachylitic breccia LES	3172	2	ID-TIMS	Xenocryst	4
Johannesburg Dome	Tonalitic Gneiss AN1, AN2, AN3, AN4, AN5, PV2, RK3, RP	3170	34	ID-TIMS	Age of crystallization	6
Johannesburg Dome	Medium-grained granodiorite JHBD 98-3	3121.2	5	ID-TIMS	Age of crystallization	3
Witwatersrand Supergroup (Crown lava)	Highly amigdaloid volcanic horizon CR-1/89	3121	6	SHRIMP	Xenocryst	1
Basement granitoid	Granitoid DRL-7	3120	5	SHRIMP	Age of crystallization	1
Johannesburg Dome	Mafic Dyke JHBD 98-11	3117	12	ID-TIMS	Age of crystallization of the granodioritic phase	3
Johannesburg Dome	Porphyritic granodiorite JHBD 98-5	3114.2	2.4	ID-TIMS	Age of crystallization	3
Vredefort Dome	Paragneiss V55	3107	9	ID-TIMS monazite	Age of the high-metamorphism	2
Vredefort Dome	Mafic granulite V54	3107	9	ID-TIMS	Age of the high-metamorphism	2
Witwatersrand Supergroup (Crown lava)	Highly amigdaloid volcanic horizon R-1	3103	9	SHRIMP	Xenocryst	1
South of the Vredefort Dome	Low-Ca granite GH1	3101	2	ID-TIMS monazite	Age of crystallization	5
Johannesburg Dome	Granite B-81-21A	3093	3.2	Pb-Pb zircon evaporation	Age of crystallization	7
Vredefort Dome	Coarse-grained gneiss OGG	3090		ID-TIMS	Age of crystallization	8
Witwatersrand Supergroup (Crown lava)	Highly amigdaloid volcanic horizon CR-1/89	3087	5	SHRIMP	Xenocryst	1
Westerdam Dome	Low-Ca granite SF8/RAT1	3086	3	ID-TIMS monazite	Age of crystallization	5
Witwatersrand Supergroup (Crown lava)	Highly amigdaloid volcanic horizon R-1	3083	8	SHRIMP	Xenocryst	1
Witwatersrand Supergroup (Crown lava)	Highly amigdaloid volcanic horizon CR-1/89	3083	13	SHRIMP	Xenocryst	1
Vredefort Dome	Charnockitic gneiss Ch	3083	8	ID-TIMS	Xenocryst minimum age of crystallization or metamorphism	4
Dominion Group	Fine-grained quartz-feldspar porphyry DRL-13/B	3074	6	SHRIMP	Age of crystallization	1
Vredefort Dome	Lesutaskraal pseudotachylitic breccia LES	3073	4	ID-TIMS	Xenocryst	4
Ventersdorp Supergroup (Platberg Group)	Makwassie Quartz Porphyry FW83Va	3068	39	SHRIMP	Xenocryst	1
Vredefort Dome	Lesutaskraal pseudotachylitic breccia LES	3065		ID-TIMS	Xenocryst	4
Vredefort Dome	Charnockitic gneiss Ch	3060	12	ID-TIMS	Xenocryst minimum age of crystallization or metamorphism	4
Vredefort Dome	Granophyre Gr	3055	2	ID-TIMS	Xenocryst minimum age of crystallization or metamorphism	4

Appendix 2 (Cont.)

Locality	Sample nature and number	Age	Error	Method	Interpretation	Reference
Vredefort Dome	Lesutaskraal pseudotachylitic breccia LES	3045	2	ID-TIMS	Xenocryst	4
Vredefort Dome	Lesutaskraal pseudotachylitic breccia LES	3040	2	ID-TIMS	Xenocryst	4
Vredefort Dome	Lesutaskraal pseudotachylitic breccia LES	3037	2	ID-TIMS	Xenocryst	4
Ottosdal-Coligny Dome	Low-Ca leucogranite Coligny	3031	+11/-10	ID-TIMS	Age of crystallization	5
Vredefort Dome	Lesutaskraal pseudotachylitic breccia LES	3016	4	ID-TIMS	Xenocrysts	4
Johannesburg Dome	Trondhjemitic gneiss JHBD 98-8&98-10	2997	7	ID-TIMS	Age of emplacement of pegmatitic dykes ?	3
Johannesburg Dome	Homogeneous granodiorite JHBD 98-2	2947	57	ID-TIMS	Minimum age of crystallization	3
Vredefort Dome	Granophyre Gr	2924	4	ID-TIMS	Xenocryst minimum age of crystallization or metamorphism	4
Witwatersrand Supergroup (Crown lava)	Combined R-1 and CR-1/89	2914	8	SHRIMP	Crystallization event ?	1
Vredefort Dome	Granophyre Gr	2800	19	ID-TIMS	Xenocryst minimum age of crystallization or metamorphism	4
West of Welkom goldfield	Granodiorite-adamellite 1633	2727	+6/-5	ID-TIMS	Age of crystallization	5
Ventersdorp Supergroup (Klipriviersberg Group)	Fine-grained amygdaloidal basalt EK-4/5 Z320	2714	8	SHRIMP	Age of extrusion of the Klipriviersberg magma	1
Ventersdorp Supergroup (Platberg Group)	Makwassie Quartz Porphyry FW83Va	2709	4	SHRIMP	Age of crystallization	1
Ventersdorp Supergroup (Platberg Group)	Makwassie Quartz Porphyry	2693	+60/-59	ID-TIMS	Age of crystallization	9
Ventersdorp Supergroup (Platberg Group)	Makwassie Quartz Porphyry	2643	80	ID-TIMS	Age of crystallization	10
Vredefort Dome	Dolerite Dyke VT97-5	2584	10	ID-TIMS	Age of crystallization	2
Vredefort Dome	Dolerite Dyke VT97-5	2564	16	ID-TIMS	Age of crystallization	2
Transvaal Sequence	Tuff from the Oak Tree Formation, Chuniespoort Group	2550	5	Pb-Pb zircon evaporation	Age of crystallization	11

Mineral analyzed is zircon (unless otherwise stated); All errors are at 2σ.

1. Armstrong et al., 1991; 2. Hart et al., 1999; 3. Poujol and Anhaeusser, 2001; 4. Kamo et al., 1996; 5. Robb et al., 1992; 6. Anhaeusser and Burger, 1982; 7. Barton et al., 1999; 8. Hart et al., 1981; 9. Walraven et al., 1987; 10. Van Niekerk and Burger, 1978 and 11. Walraven and Martini., 1995.

Appendix 3: Summary of U-Pb and Pb-Pb zircon evaporation data for the Northern Terrane

Locality	Sample nature and number	Age	Error	Method	Interpretation	Reference
MGB Mac Kop conglomerate	Conglomerate MURCH 94-9	3364	18	ID-TIMS	Xenocryst	1
North of PGB	Migmatitic tonalitic gneiss T 3	3333	5	Pb-Pb zircon evaporation	Age of crystallization	2
Northwest of GGB	Well-foliated tonalitic gneiss TR 66	3282.6	0.4	Pb-Pb zircon evaporation	Age of emplacement	3
Northwest of GGB	Well-foliated tonalitic gneiss TR 66	3274	+56/-45	ID-TIMS	Minimum age for the emplacement	3
MGB French Bob's Mine Granite	Trondhjemitic and Tonalitic gneiss MURCH 94-5	3228	12	ID-TIMS	Age of crystallization	1
GGB	Meta-andesite T 10	3203.3	0.2	Pb-Pb zircon evaporation	Age of andesite extrusion	3
GGB	Felsic metavolcanic T 10	3203	4	Pb-Pb zircon evaporation	Age of crystallization	2
Groot-Letaba Gneiss (N of MGB, S of Giyani)	T9	3171	6	Pb-Pb zircon evaporation	Age of crystallization	2
South of GGB	Well-foliated migmatitic granodiorite T 9	3170.5	0.3	Pb-Pb zircon evaporation	Age of emplacement	3
MGB Mac Kop conglomerate	Conglomerate MURCH 94-9	3168	11	ID-TIMS	Age of one of the source for the conglomerate	1
PGB	Pre-or syntectonic pluton 88-13	3160	14	ID-TIMS	Xenocryst	4
MGB Makhutswi gneiss	T7	3118	5	Pb-Pb zircon evaporation	Age of crystallization	2
MGB Makhutswi gneiss	T6	3112	5	Pb-Pb zircon evaporation	Age of crystallization	2
MGB Harmony Granite	Trondhjemitic gneiss MURCH 94-7	3091	5	ID-TIMS	Age of crystallization	5
MGB Weigel Formation	Felsic volcanic MURCH 95-16	3087	21	ID-TIMS	Best estimate for the emplacement age of the Weigel Formation	1
MGB Makhutswi gneiss	T8	3078	6	Pb-Pb zircon evaporation	Age of crystallization	2
MGB Mac Kop conglomerate	Conglomerate MURCH 94-9	3076	4	ID-TIMS	Maximum age for the deposition of the Mac Kop conglomerate	1
MGB Makhutswi gneiss	Tonalitic gneiss MURCH 95-21	3063	12	ID-TIMS	Age of crystallization	5
MGB Baderoukwe Gneiss	Trondhjemitic gneiss MURCH 94-10	3018	15	ID-TIMS	Minimum age of crystallization	6
MGB Rubbervale Formation	Rhyolite MURCH 94-3	2971	10	ID-TIMS	Age of crystallization	1
MGB	Malati Pump Mine granodiorite MURCH 94-11	2970	15	ID-TIMS	Age of crystallization	9
MGB Rubbervale Formation	Dacite MURCH 95-18	2969	20	ID-TIMS	Age of crystallization	6
MGB Discovery Granite	Granite MURCH 94-13	2969	17	ID-TIMS	Age of crystallization	6
MGB Rubbervale Formation	Rhyolite TR 61	2967.5	1.3	Pb-Pb zircon evaporation	Age of crystallization	7
MGB Rubbervale Formation	Rhyolite TR 61	2965.2	1.4	ID-TIMS	Age of crystallization	7
PGB	Pre-or syntectonic pluton 88-13	2958	2	ID-TIMS	Age of emplacement	4
PGB (Uitkyk sediments)	Conglomerate 88-24	2957	+8/-7	ID-TIMS	Age of un unidentified granitoid source of the detrital zircons	4
PGB (Uitkyk sediments)	Conglomerate 88-23	2957	1	ID-TIMS	Age of un unidentified granitoid source of the detrital zircons	4
East of GGB (Groot Letaba Gneiss)	Homogeneous biotite-bearing monzogranitic gneiss TR 67	2953	+68/-61	ID-TIMS	Minimum age for the emplacement	3
PGB (Ysterberg Formation)	Metaquartz porphyry TR 109	2949	2	Pb-Pb zircon evaporation	Age of emplacement	3
PGB (Ysterberg Formation)	Metaquartz porphyry TR 109	2939	26	ID-TIMS	Minimum age of crystallization	3

Appendix 3 (Cont.)

Locality	Sample nature and number	Age	Error	Method	Interpretation	Reference
MGB Maranda Granite	Granite MURCH 94-12	2901	12	ID-TIMS	Minimum age for the emplacement of the granite	1
PGB (Uitkyk sediments)	Conglomerate 88-23	2901	2	ID-TIMS	Maximum age for the deposition of the Uitkyk Formation	4
North of PGB	Banded tonalitic gneiss T1	2886	4	Pb-Pb zircon evaporation	Age of crystallization	2
North of PGB	Discordant leucosome band T 2	2885	4	Pb-Pb zircon evaporation	Age of crystallization	2
South of PGB (Turfloop Batholith)	Monzogranite TR 53	2883.6	0.2	Pb-Pb zircon evaporation	Inherited component	3
GGB	Slightly foliated feldpar porphyry TR 63	2877	+33/-30	ID-TIMS	Age of porphyry intrusion during deformation of the GGB	3
GGB	Slightly foliated feldpar porphyry TR 63	2874.1	0.2	Pb-Pb zircon evaporation	Age of porphyry intrusion during deformation of the GGB	3
PGB Melkboomfontein Granite	Strongly foliated muscovite-bearing Granite	2853	+19/-18	ID-TIMS	Minimum age for the emplacement	3
MGB (south)	Pegmatite MURCH 95-20	2848	58	ID-TIMS	Age of crystallization	5
MGB Willie Granite	Undeformed biotite-bearing porphyritic granite MURCH 94-14	2820	38	ID-TIMS	Age of crystallization	6
South of Soutpansberg	Homogeneous biotite-bearing granodioritic gneiss TR 68	2816	17	ID-TIMS	Age of emplacement	3
South of Soutpansberg	Homogeneous biotite-bearing granodioritic gneiss TR 68	2810.6	0.4	Pb-Pb zircon evaporation	Age of emplacement	3
South of PGB (Turfloop Batholith)	Porphyritic granodiorite T3	2777	10	ID-TIMS	Age of crystallization	8
South of PGB (Turfloop Batholith)	Monzogranite TR 53	2765	7	ID-TIMS abraded	Age of emplacement in agreement with Henderson et al., 2000	3
South of PGB (Turfloop Batholith)	Porphyritic granodiorite T3	2763	15	ID-TIMS titanite	Age of crystallization	8
MGB Rooiwater Complex	Hornblende Tonalite MURCH 94-6	2740	4	ID-TIMS	Age of crystallization	1
MGB Mashishimala Granite	Peralumineous granite	2698	21	ID-TIMS	Age of crystallization	6
PGB (intrusive into Uitkyk sediments)	Post-D2 Granite PGB-1	2687	2	ID-TIMS	Age of intrusion and minimum age for the Uitkyk sediments	4
South of PGB (Turfloop Batholith)	Monzogranite TR 53	2674	16	ID-TIMS	Minimum age for the emplacement	3

Mineral analyzed is zircon (unless otherwise stated); All errors are at 2σ. MGB = Murchison greenstone belt; GGB = Giyani greenstone belt; PGB = Pietersburg greenstone belt.

1. Poujol et al., 1996; 2. Brandl and Kröner, 1993; 3. Kröner et al., 2000; 4. de Wit et al., 1993; 5. Poujol and Robb, 1999; 6. Poujol, 2001; 7. Brandl et al., 1996; 8. Henderson et al., 2000 and 9. Poujol, 1997.

Appendix 4: Summary of U-Pb and Pb-Pb zircon evaporation data for the Western Terrane

Locality	Sample nature and number	Age	Error	Method	Interpretation	Reference
Madibe greenstone belt	Felsic Schist (Madibe 2) Western Succession	3428	11	SHRIMP	Xenocryst	1
Bultfontein Mine	Gneiss	3250		SHRIMP	Oldest cores	2
Madibe greenstone belt	Felsic Schist (Madibe 1) Eastern Succession	3201	4	SHRIMP	Xenocryst	1
Kraaipan greenstone belt (West)	Volcanoclastic unit MOS 1	3191.1	7.9	ID-TIMS	Age of crystallization ?	3
Madibe greenstone belt	Felsic Schist (Madibe 2) Western Succession	3180		SHRIMP	Xenocrysts	1
Amalia terrane	Fine-grained leuco-trondhjemitic gneiss AL3	3178	10	SHRIMP	Xenocryst	4
Kraaipan terrane	Stlagole borehole DKT FW92-103	3162	8	Pb-Pb zircon evaporation	Maximum age of crystallization	5
Kraaipan terrane	Felsic schist from the Kraaipan Group	3157		ID-TIMS	Xenocryst	15
Marydale granitoid-greenstone terrane	Draghoender granite	3125		SHRIMP	Minimum age of the basement material	6
Madibe greenstone belt	Felsic Schist (Madibe 2) Western Succession	3097.4	8.8	SHRIMP	Age of crystallization	1
Kraaipan Terrane	Felsic schist from the Kraaipan Group	3083	+40/-14	ID-TIMS	Age of emplacement ?	15
Madibe greenstone belt	Felsic Schist (Madibe 1) Eastern Succession	3082.5	5.9	SHRIMP	Age of crystallization	1
Kraaipan terrane	Stlagole borehole DKT FW92-104	3070	7	Pb-Pb zircon evaporation	Maximum age of crystallization	5
Amalia terrane	Coarse-grained biotite-trondhjemite gneiss Al1	3050	35	ID-TIMS	Xenocryst	4
Gaborone granite suite	Granite Derdepoort	3010		U-Pb zircon		7
Amalia terrane	Coarse-grained biotite-trondhjemite gneiss Al1	3008	4	ID-TIMS	Age of crystallization	4
Kraaipan terrane	Granodiorite EKRAP 98-9	2941	2	ID-TIMS	Age of crystallization	3
Bultfontein Mine	Gneiss	2940		SHRIMP	Metamorphic overgrowth	2
Amalia terrane	Fine-grained leuco-trondhjemitic gneiss AL3	2939	9.6	SHRIMP	Age of crystallization	4
Marydale granitoid-greenstone terrane	Skalkseput leucocratic biotite-muscovite granite	2938	5	SHRIMP	Unclear	6
Marydale granitoid-greenstone terrane	Skalkseput leucocratic biotite-muscovite granite	2930	9	SHRIMP	Unclear	6
West of Amalia	Tonalitic gneiss TA2	2927	+23/-6	ID-TIMS	Age of migmatization ?	8
Kraaipan terrane	Meium-grained homogeneous granodiorite MAD1	2917	9	SHRIMP	Age of crystallization	4
Kraaipan terrane	Homogeneous fine-to-medium grained granodiorite KP5	2913	15	SHRIMP	Age of crystallization	4
West of Amalia	Hydrothermal vein cutting sample TA2	2884	2	ID-TIMS rutiles	Exogeneous hydrothermal manifestation of the Schweizer-Reneke Dome	8
Schweizer-Reneke Dome	Peraluminous adamellite-granite	2880	2	ID-TIMS monazite	Age of crystallization	8
Kraaipan terrane	Fine-grained homogeneous granodiorite DG6	2879	9	SHRIMP	Age of crystallization	4
Kraaipan terrane	Brecciated and hydrothermally altered granodiorite KHUN 1	2879	11	SHRIMP	Age of crystallization	4
Kraaipan terrane	Stlagole borehole DKT FW92-103	2866	25	Pb-Pb zircon evaporation	Minimum age of crystallization	5
Amalia terrane	Coarse-grained biotite-trondhjemite gneiss Al1	2859	4	ID-TIMS	Metamorphic event ?	4
Marydale granitoid-greenstone terrane	Draghoender granite	2853	4	SHRIMP	Age of crystallization	6
Kraaipan terrane	Granodiorite	2846	22	Pb-Pb zircon evaporation	Minimum age of crystallization	5
Gaborone granite suite	Majwana granites (Kubung area)	2830	10	U-Pb zircon	Minimum age of crystallization	9
Gaborone granite suite	Granite Derdepoort	2825	100	U-Pb zircon	Age of crystallization	7

Appendix 4 (Cont.)

Locality	Sample nature and number	Age	Error	Method	Interpretation	Reference
Kraaipan terrane	Stlagole borehole DKT FW92-104	2816	16	Pb-Pb zircon evaporation	Minimum age of crystallization	5
Kraaipan terrane	Mosita adamellite MOS2	2791	8	SHRIMP	Age of crystallization	4
Kanye Formation	Volcanic KV16-1	2787.7	1.7	ID-TIMS	Age of crystallization	10
Gaborone granite suite	Granophyre 91313-3	2784.9	1.9	ID-TIMS	Age of crystallization	10
Kanye Formation	Volcanic KV16-2	2784.8	1.8	ID-TIMS	Age of crystallization	10
Kanye Formation	Rhyolite KV 16.2	2783.8	1.1	Pb-Pb zircon evaporation	Age of crystallization	11
Gaborone granite suite	Granite phase (Kgale granite) DG91313-7	2783.2	1.8	Pb-Pb zircon evaporation	Age of crystallization	11
Gaborone granite suite	Leucocratic granite 91331-7	2783.1	2	ID-TIMS	Age of crystallization	10
Gaborone granite suite	Granophyric granite (Kgale granite) DG91313-6	2782	5	Pb-Pb zircon evaporation	Age of crystallization	11
Lobatse Volcanic Group	Plantation porphyry	2781.7	1.9	Pb-Pb zircon evaporation	Age of crystallization	12
Gaborone granite suite	Spherulitic microgranophyre (Kgale granite) DG91313-3	2779.1	2.8	Pb-Pb zircon evaporation	Age of crystallization	11
Amalia greenstone belt	Lapilli tuff (Amalia greenstone belt) BOT 1	2754	5	SHRIMP	Age of crystallization	16
Kraaipan terrane	Mosita adamellite FW92-105)	2749	3	Pb-Pb zircon evaporation	Age of crystallization	5
Amalia greenstone belt	Quartz-chlorite-sericite volcanic schist BOT 2	2740	13	SHRIMP	Age of crystallization	16
Amalia greenstone belt	Quartz-chlorite-sericite volcanic schist BOT 3	2728	25	ID-TIMS	Age of crystallization	3
Marydale granitoid-greenstone terrane	Skalkseput leucocratic biotite-muscovite granite	2718	8	SHRIMP	Age of crystallization	6
Kraaipan terrane	Mosita adamellite MCH	2718	65	ID-TIMS	Age of crystallization	13
Zoetlief Group	Volcanic	2714	3	Pb-Pb zircon evaporation	Age of crystallization	14
Ventersdorp Supergroup (Platberg Group)	Makwassie Quartz Porphyry PUD1	2714	+28/-30	ID-TIMS	Age of crystallization	3
Ventersdorp Supergroup (Platberg Group)	Makwassie Quartz Porphyry PUD6	2706	22	ID-TIMS	Age of crystallization	3

Mineral analyzed is zircon (unless otherwise stated); All errors are at 2σ.

1. Hirner et al., 2001; 2. Drennan et al., 1990; 3. Gericke, 2001; 4. Poujol et al., 2001a; 5. Anhaeusser and Walraven, 1999; 6. McCourt et al., 2000; 7. Burger and Coertze, 1975; 8. Robb et al., 1992; 9. Sibiya, 1988; 10. Moore et al., 1993; 11. Grobler and Walraven, 1993; 12. Walraven et al., 1996; 13. Burger and Walraven, 1979;14. Walraven et al., 1991; Robb, 1991 and 16. Poujol et al., 2001b.