Geochronology of the Sikombe Granite, Transkei, Natal Metamorphic Province, South Africa

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ABSTRACT

A new U-Pb SHRIMP zircon date of 1181 ± 15 Ma has been obtained from a sample of the syntectonic, gneissose Sikombe Granite from northeastern Transkei (Eastern Cape Province). The outcrops form the most southerly exposures of the ~1.1 Ga Natal Metamorphic Province (NMP). Previously, these isolated outcrops have been regarded as possibly forming a separate southerly, amphibolite facies terrane of the NMP, as the lithological assemblage is somewhat different from those of the granulite grade Margate terrane to the north. The new data do not conclusively demonstrate this, but they do show that the accretion age of the southerly terrane of the NMP is not significantly younger than the more northerly terranes. Sm-Nd analyses of three samples of the Sikombe Granite give consistent, positive ϵ_{Nd} values (+4 at t = 1180 Ma) showing that, like the rest of the NMP, the granite was derived from juvenile Mesoproterozoic crust, with little or no involvement of older material in its genesis

Introduction and geological setting

The Sikombe Granite is the southernmost intrusive granitic body in the ~1.1 Ga Natal Metamorphic Province. It is exposed in a ~5km^2 coastal outcrop in the former Transkei (now Eastern Cape Province), some 15km south of the Mtamvuna River which forms the border with KwaZulu-Natal Province (Figure 1). The outcrop was first identified as "Red Hills granite" (named after the prominent Quaternary Berea Formation dunes of the coastal strip) on the geological map of Pondoland (Du Toit, 1920), and a further description is given in Du Toit (1946). The Sikombe Granite has a pervasive strong southerly-dipping gneissic foliation and appears to be a tabular body with an approximate thickness of about 2500m. Thus, in terms of nomenclature, the rocks could be described by a variety of terms such as "foliated granite", "augen gneiss", "granite-gneiss", "gneissic granite", "orthogneiss" etc. For the sake of brevity, we will refer to the body simply as the "Sikombe Granite", with the understanding that the other, longer, terms could equally apply. A detailed study, including geochemical analyses is presented in Thomas and Mawson (1989), who found the outcrops in the (then) northeastern Transkei to be more extensive than previously recognised. Thomas and Mawson (1989) described three granitoid types in this basement outlier, with the Sikombe Granite being the oldest. It is intruded by variably foliated garnet leucogneisses correlated by Thomas and Mawson (1989) with similar rocks of the Margate Suite further north in the Margate terrane of southernmost KwaZulu-Natal. The Sikombe Granite has no obvious correlates elsewhere in Natal, though Thomas *et al.* (1997) noted that it shared petrographic and geochemical similarities with the "G2" augen gneisses of the Cape Meredith Complex, which may have lain close to southern KwaZulu-Natal in Gondwana. Thus, Thomas and Mawson (1989) suggested that these isolated outcrops might be the exposed part of a separate southerly, amphibolite facies terrane of the NMP, occurring as a "outboard terrane" south of the granulite grade Margate terrane.

In terms of the age of the Transkei inlier, by comparison with the Margate terrane of the NMP to the north, the rocks are assumed to be of comparable age; *i.e.* Mesoproterozoic (~1100 Ma). The Port Edward pluton has been dated at 1025 ± 8 Ma (Eglington *et al*, 2003, in press), giving the date of the youngest enderbitic outcrops. The Margate Suite Granites have not yet been dated by the U-Pb zircon method, though Rb-Sr data suggests an age in excess of 1050 Ma (Thomas *et al.*, 1990). The Sikombe Granite has not been dated prior to this study. As the oldest granite in the inlier, the age of the granite is important firstly in confirming that it does indeed belong to the Natal Metamorphic Province and secondly in refining the regional Mesoproterozoic chronology. In this article we

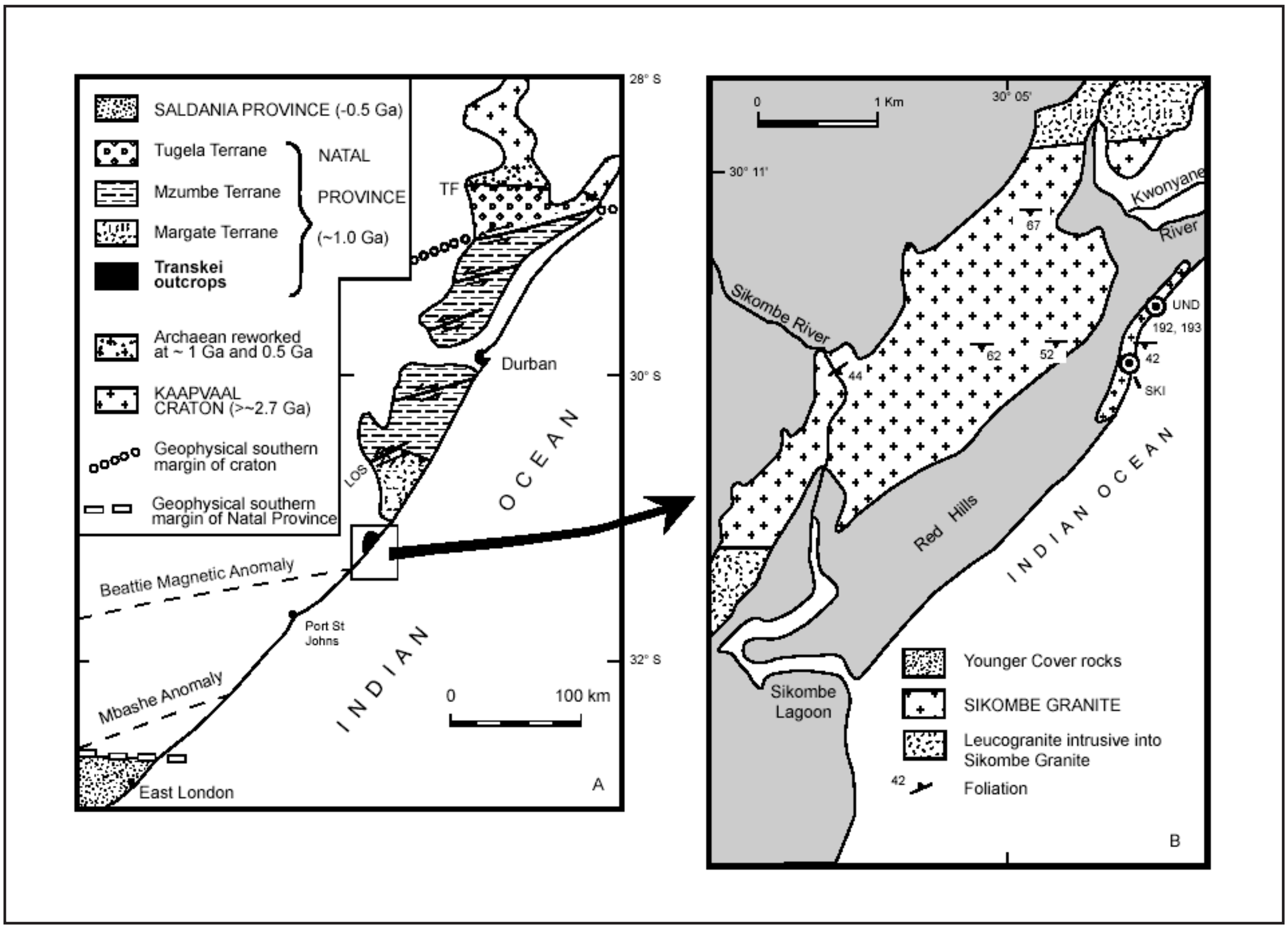

Figure 1. (**A**) Position of the Transkei outcrops at the southern part of the Natal metamorphic Province (after Thomas *et al.*, 1994). (**B**) Detailed Locality map of the Sikombe Granite (after Thomas, 1990) and sample sites of the present study.

present new U-Pb SHRIMP (Super High Resolution Ion Mass Spectrometer) data for a sample (SK1) of the Sikombe Granite. We also present Sm-Nd Whole-rock data on SK1 and two additional samples of the granite in order to establish the source-region characteristics of this southernmost granite of the NMP

Characteristics of the Sikombe Granite, samples and analytical techniques

A full field petrographic and geochemical description of the Sikombe Granite is given in Thomas and Mawson (1989) and Thomas (1990). In summary, the granite is coarse-grained (2 to 4mm groundmass, feldspar augen up to 25 x 10mm), grey (pink-weathering), strongly foliated feldspar-megacrystic biotite augen gneiss, with granite (*sensu stricto*) modal and normative composition. The uniformly strongly foliated texture of the granite, coupled with the moderate southerly dips of that fabric, suggests that it is pre- to syntectonic with respect to the earliest deformation phase in the area. Later coarse-grained segregations are locally developed and these are associated with small (~5mm) rosettes of graphite. Discoidal xenoliths of older country-rock biotite-hornblende gneiss and schist are common. The granite is composed of quartz (~30 volume %), K-feldspar (microcline microperthite ~35%), plagioclase (oligoclase ~25%) and biotite (~10%) with accessory myrmekite, zircon, opaque minerals and apatite ± rare garnet. Geochemically and mineralogically the granite was classified as S-type granite by Thomas and Mawson (1989).

A large (20kg) fresh sample of the Sikombe Granite (SK1) was collected with the aid of a Pionjar rock drill from the coastal section in northeastern Transkei, north of the Sikombe River mouth (Figure 1B). This sample was selected for zircon extraction and for Sm-Nd whole-rock analyses. The sample was crushed and zircon extraction carried out in the CSIR laboratory in Pretoria by Dr E.A Retief. An aliquot of the sample was powdered for Sm-Nd analysis. Two more samples for which powders were available (from the study of Eglington 1987) were used for additional Sm-Nd analysis.

All zircon isotopic analyses were carried out at the laboratories of the Australian National University (ANU) in Canberra on SHRIMP 1. The data were reduced following Compston *et al.* (1992) and Williams and Claesson (1987). For all analysed spots, the ion microprobe analyses consisted of six scans through the mass range. The observed coefficient of variation in the Pb/U ratios measured for the SL13 standard was 2.49% for the analytical session. The Pb/U ratios have

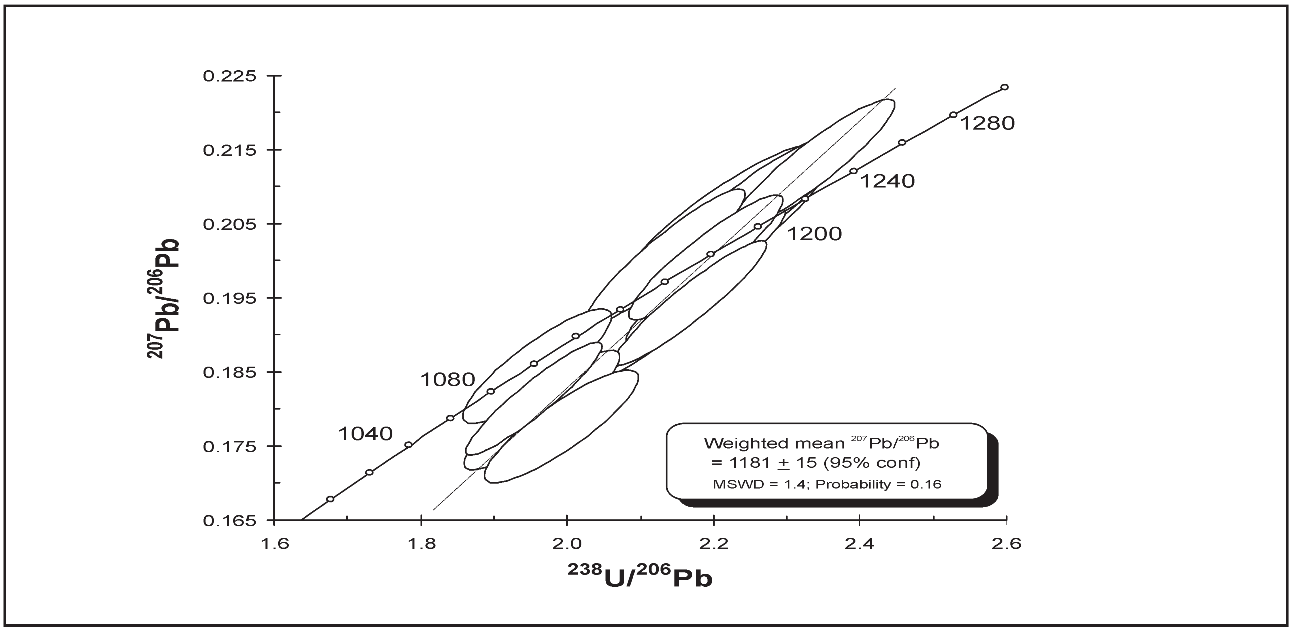

Figure 2. Concordia plot of zircons from SK1 of the Sikombe Granite.

been normalised to a value of 0.0928 for the $^{206}Pb/^{238}U$ ratio for standard SL13 (*i.e.* equivalent to an age of 572 Ma. Common lead corrections were made using the directly measured abundances of ^{204}Pb and the appropriate compositions according to the Cumming and Richards (1975) model. Uncertainties in the isotope ratios and ages in the data tables (and in the error boxes in the plotted data) are reported at the one sigma level, but all final weighted mean ages are reported with 95% confidence limits. SK1, along with two other samples from the coastal outcrops of the Sikombe Granite were analysed for Sm-Nd isotopes at the CGS laboratories in Pretoria according to standard techniques (*e.g.* Harmer *et al.*, 1998).

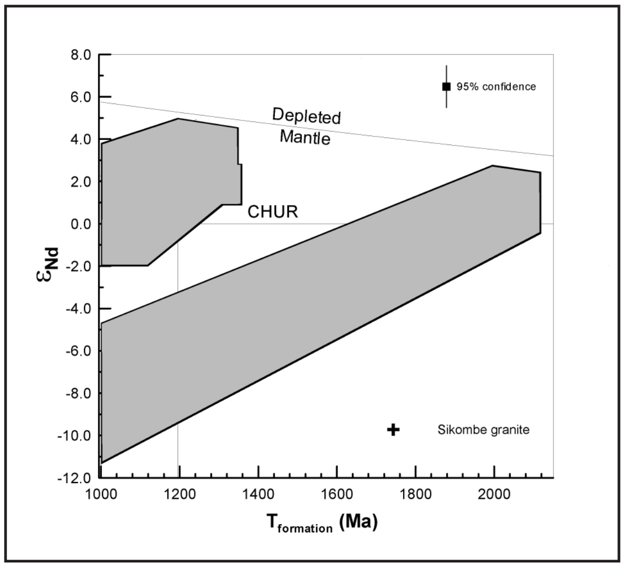

Figure 3. ϵ_{Nd} versus $T_{FORMATION}$ for the three Sikombe Granite samples.

Zircon morphology

The zircons from SK1 are highly variable in colour, shape and degree of preserved crystallinity, but almost all are highly fractured and contain numerous opaque and other unidentified inclusions. Most grains are subhedral with some degree of (metamorphic?) rounding, although primary magmatic zoning is visible in some instances. Microscopic examination in transmitted light suggests the presence of core-rim relationships, but these were not confirmed in cathodoluminescence images.

Isotopic data

U-Pb SHRIMP data

19 spots were analysed from 18 different zircon grains. The results are given in Table 1 and plotted on a conventional concordia plot in Figure 2. Although some of the data are discordant, the majority of the analyses plot in a group on, or near, concordia and yield a weighted mean $^{207}Pb/^{206}Pb$ age of 1181 ± 15 Ma (95% confidence limits; MSWD=1.4, probability = 0.16). Three analyses fall outside this group: 13.1 and 17.1 are apparently older and 10.1 apparently younger (see Figure 2). The apparently older age given by the first two anomalous analyses (of which spot 13.1 is a very imprecise analysis) could indicate an inherited component. As noted above no zircon cores were identified in CL images of the grains, so Sm-Nd analyses were carried out to throw light on the age of the source material from which the granite was derived (see below). The lower age recorded in analysis 10.1 could by the same token indicate a younger metamorphic component, but again CL imaging did not show any such metamorphic rim on any grains examined.

Table 1. U-Pb SHRIMP isotopic analyses of the analysed spots of zircons from the Sikombe Granite sample SK1.

Grain spot	U (ppm)	Th (ppm)	Th/U	Pb*	204/206	$\%f_{206}$	206/238	207/235	207/206	Ages in Ma 206/238	206/238	207/235	% CONC
1.1	237	123	0.52	46	0.000001	~	0.1799 ± 0.0053	1.969 ± 0.070	0.0794 ± 0.0013	1067	1105	1182	90
2.1	562	70	0.12	98	0.000001	~	0.1815 ± 0.0050	1.959 ± 0.061	0.0783 ± 0.0009	1075	1102	1154	93
3.1	243	54	0.22	43	0.000047	0.08	0.1777 ± 0.0050	1.996 ± 0.069	0.0815 ± 0.0014	1054	1114	1233	86
4.1	400	98	0.24	78	0.000001	~	0.1943 ± 0.0055	2.172 ± 0.068	0.0811 ± 0.0009	1145	1172	1223	94
5.1	228	38	0.17	43	0.000001	~	0.1938 ±0.0060	2.113 ± 0.074	0.0791 ± 0.0011	1142	1153	1174	97
6.1	209	50	0.24	42	0.000001	~	0.2005 ± 0.0060	2.138 ± 0.072	0.0774 ± 0.0010	1178	1161	1131	104
7.1	113	35	0.31	23	0.000001	~	0.2047 ± 0.0073	2.217 ± 0.099	0.0786 ± 0.0018	1200	1186	1161	103
8.1	205	77	0.37	41	0.000001	~	0.1946 ± 0.0063	2.139 ± 0.080	0.0797 ± 0.0012	1146	1161	1190	96
9.1	372	94	0.25	69	0.000012	0.02	0.1858 ± 0.0051	1.963 ± 0.067	0.0766 ± 0.0013	1099	1103	1111	99
10.1	572	97	0.17	99	0.000001	~	0.1783 ± 0.0048	1.870 ± 0.056	0.0761 ± 0.0008	1058	1071	1097	97
11.2	192	53	0.28	40	0.000026	0.04	0.2076 ± 0.0060	2.262 ± 0.078	0.0790 ± 0.0013	1216	1201	1173	104
12.1	178	62	0.35	37	0.00001	0.02	0.2031 ± 0.0067	2.198 ± 0.085	0.0785 ± 0.0013	1192	1181	1160	103
13.1	178	60	0.34	40	0.001378	2.33	0.2055 ± 0.0063	2.855 ± 0.138	0.1007 ± 0.0034	1205	1370	1638	74
14.1	177	45	0.26	34	0.000019	0.03	0.1921 ± 0.0057	2.124 ± 0.079	0.0802 ± 0.0013	1133	1157	1202	94
14.2	184	42	0.23	35	0.00001	0.02	0.1921 ± 0.0057	2.108 ± 0.077	0.0796 ± 0.0014	1133	1152	1187	95
15.1	440	39	0.09	89	0.000154	0.26	0.213 ± 0.0057	2.339 ± 0.073	0.0796 ± 0.0010	1245	1224	1188	105
16.1	251	75	0.3	51	0.000026	0.04	0.2004 ± 0.0055	2.192 ± 0.069	0.0793 ± 0.0010	1178	1178	1180	100
17.1	290	63	0.22	59	0.000018	0.03	0.2035 ± 0.0061	2.297 ± 0.078	0.0818 ± 0.0010	1194	1211	1242	96
18.1	281	67	0.24	55	0.00001	0.02	0.1979 ± 0.0059	2.193 ± 0.072	0.0804 ± 0.0008	1164	1179	1207	97

Uncertainties given at one sigma level

Table 2. Sm-Nd and Rb-Sr whole-rock isotopic analyses of the three analysed samples of the Sikombe Granite.

Sample #	Sm (ppm)	^{147}Sm (nm/g)	Nd (ppm)	^{144}Nd (nm/g)	^{147}Sm/^{144}Nd	^{143}Nd/^{144}Nd *	$\epsilon_{Nd}(t_0)$
UND 192	9.07	9.050	48.03	79.222	0.11423	0.512204 ± 21	-9.28
UND 193	11.72	11.687	62.35	102.8407	0.11364	0.512212 ± 19	-9.13
SK1	10.94	10.906	57.30	94.53	0.11538	0.512217 ± 11	-9.03

Notes: (1) *Measured, present-day ^{143}Nd/^{144}Nd ratios, normalised to ^{146}Nd/^{144}Nd = 0.7219

(2) $\epsilon_{Nd}(t_0)$ refers to the present-day, calculated relative to a BCR-1 value of 0.51268;

Sm-Nd and Rb-Sr whole-rock data

Sm-Nd whole-rock isotopic data were obtained for three samples of the Sikombe Granite and are presented in Table 2. These data give ϵ_{nd} values of + 4.1 ± 0.3 at 1181 Ma (MSWD = 0.05, probability = 0.96). The data are plotted on a $T_{FORMATION}$ versus ϵ_{Nd} diagram in Figure 3, following the depleted mantle model of De Paulo (1981). The diagram clearly shows that the Sikombe Granite was derived from the melting of an essentially "juvenile" source, and that no significant quantities of older (*e.g.* 2 or 3 Ga crust) can have been present in that source material. This is consistent with all previous findings from the NMP (*e.g.* Eglington *et al.*, 1989; Thomas and Eglington, 1990). It also supports the work of Eglington (1987) who obtained Rb-Sr isotope analyses on two of the samples (UND 192, 193) analysed for Sm-Nd in the present study. These samples have very low, albeit imprecise, initial Sr ratios of ~0.70 at 1180 Ma.

Discussion and Conclusions

New U-Pb SHRIMP zircon data show that the southernmost intrusion of the Natal Metamorphic Province, the Sikombe Granite of NE Transkei was intruded at ~1181 Ma. The granite is the oldest of three intrusive granites in the area and the date is significant in that it is the oldest date yet obtained from the NMP south of the Mzumbe terrane, which has a history going back to about 1250 Ma (Thomas *et al.*, 1999). The data do not show whether the Transkei rocks belong to a separate tectonic block from the Margate Terrane and this question remains unresolved. The date is also older than any yet obtained from the Margate terrane (*e.g.* Mendonidis *et al.*, 2002), and it is considerably older than that reported from zircons of the "G2" augen gneiss of the Cape Meredith Complex (1067 ± 14 Ma: Jacobs *et al.*, 1999), showing that this granite cannot be correlated with the Sikombe Granite. The Sikombe Granite is pre- to syntectonic with respect to the earliest (collision-related) metamorphic fabrics seen elsewhere within the belt. The date of 1181 ± 15 Ma thus gives a maximum age for that early deformation phase, which has been dated at ~1140 Ma in the central and northern parts of the belt (*e.g.* Jacobs *et al*, 1997). This suggests that there may be no significant "younging" of tectono-magmatic events within the belt (*c.f.* Mendonidis *et al.*, 2002), or that the Sikombe Granite belongs to a block that is older than the Margate terrane to its north.

Sm-Nd data on three samples of the granite give "juvenile" T_{dm} dates (no older than 1300 Ma) and positive End values (~+4) at t = 1181 Ma, the time of intrusion. This confirms previous isotopic data from all over the Natal Metamorphic Province that have consistently shown a juvenile character.

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