

156602: granophyric dolerite sill, No. 36 Well

Location and sampling

TUREE CREEK (SF 50-15), KENNETH RANGE (2350)
MGA Zone 50, 513704E 7365731N

Sampled on 9 September 2003

The sample was taken from a very coarse-grained, leucocratic (granophyric) segregation within a thick dolerite sill, about 25.3 km south of No. 36 Well.

Tectonic unit/relations

The unit sampled is a granophyric dolerite sill emplaced into the Backdoor Formation, which is the lowermost unit of the Collier Group in the Collier Basin (Martin and Thorne, 2002; Martin et al., 2005). The igneous crystallization age determined herein is in good agreement with those obtained from similar sills intruding the underlying Edmund Group (Nelson, 2001a, b; Wingate, 2002), indicating that all of these sills belong to the c. 1075 Ma Warakurna Large Igneous Province (Wingate et al., 2004).

Petrographic description

This sample is an altered, granophyric quartz dolerite that contains about 30% plagioclase, 30% quartz–feldspar granophyre, 5% residual clinopyroxene (augite), 15% hornblende, 18% clay and limonite (iddingsite and/or stilpnomelane?), and accessory apatite, zircon, and opaque oxide minerals. Plagioclase forms euhedral crystals up to 7 mm long. Residual augite forms prismatic grains up to 3 mm long that are partly rimmed by greenish brown hornblende, which in turn is partly intergrown with plagioclase or granophyre. Small crystals of clouded K-feldspar are common, as well as areas of quartz-rich granophyre, up to 2 mm in diameter, that are nucleated on euhedral crystals of plagioclase or K-feldspar. Discrete cores of greenish-brown hornblende, possibly of late magmatic origin, pass into rims of green amphibole of probable subsolidus (deuteric) origin. Skeletal oxide minerals appear to be mostly ilmenite. Disseminated skeletal and dendritic zircon is up to 0.7 mm long, and elongate crystals of apatite are up to 1.5 mm in length.

Sericite, prehnite, and rare epidote are common in smaller plagioclase crystals, and suggest low-temperature hydrothermal alteration. There are also abundant aggregates of clay, mostly smectite with and without goethite, possibly derived from olivine. Sparser aggregates rich in ferrostilpnomelane occur mostly within feldspar. Similar clay minerals have partly replaced clinopyroxene,

and occur along fractures in plagioclase and hornblende. It is likely that these reflect incipient weathering.

Zircon morphology

Zircons isolated from this sample are mainly euhedral, with some irregular faces, and range from clear and colourless to dark brown or opaque. They are up to 400 μm long, and elongate, with aspect ratios up to 7:1. Many crystals possess central channels, a form of skeletal habit indicating very rapid crystallization (Lofgren, 1980; Bossart et al., 1986). Concentric growth zoning is common, and some show sector zoning. A cathodoluminescence image of representative zircons is shown in Figure 1.

Analytical details

This sample was analysed on 15–16 August 2005, using SHRIMP-A. Fifteen analyses of the CZ3 standard were obtained, and indicated an external spot-to-spot (reproducibility) uncertainty of 1.16% (1σ) and a $^{238}\text{U}/^{206}\text{Pb}^*$ calibration uncertainty of 0.38% (1σ). Common-Pb corrections were applied to all analyses using common-Pb isotopic compositions determined by the method of Stacey and Kramers (1975).

Results

Twenty analyses were obtained from 20 zircons. Results are listed in Table 1, and shown in a concordia diagram (Fig. 2).

Interpretation

The analyses are concordant to moderately reversely discordant (Fig. 2), and their $^{238}\text{U}/^{206}\text{Pb}^*$ dates are positively correlated with uranium and thorium concentration (Fig. 3). Reverse discordance is common in ion microprobe analyses of zircons containing very high contents of uranium and thorium (e.g. Lanyon et al., 1993; Wingate et al., 1998), and may be caused by enhanced sputtering of Pb relative to U in radiation-damaged (metamict) material (McLaren et al., 1994). However, this phenomenon does not affect $^{207}\text{Pb}^*/^{206}\text{Pb}^*$ ratios, which are used to determine the age of the zircons. The analyses can be divided into two groups, based on their $^{207}\text{Pb}^*/^{206}\text{Pb}^*$ ratios.

Group 1 comprises 14 analyses of 14 zircons (Table 1), which yielded a weighted mean $^{207}\text{Pb}^*/^{206}\text{Pb}^*$ date of 1076 ± 4 Ma (MSWD = 1.42).

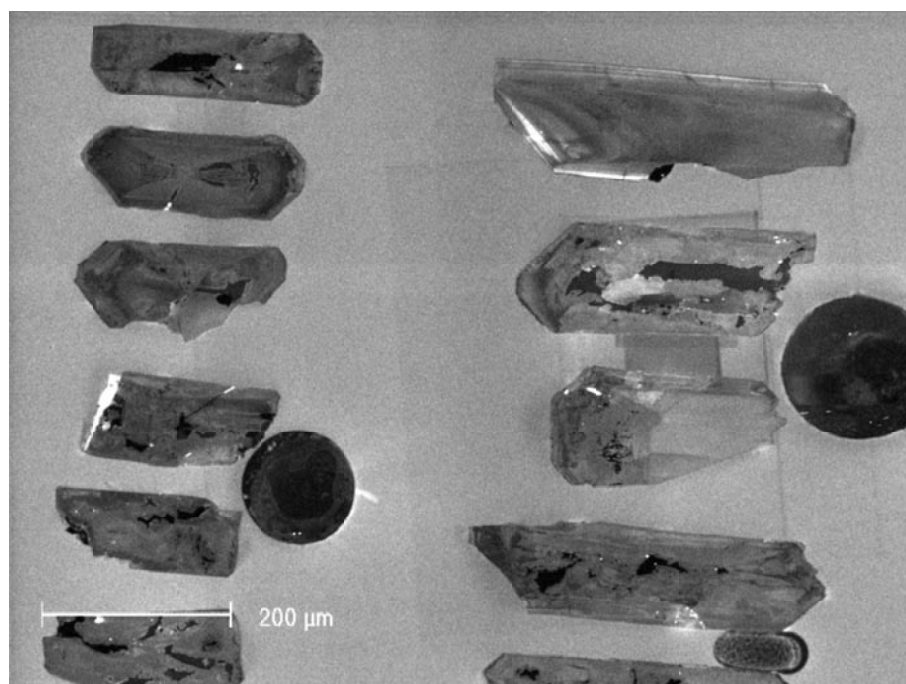


Figure 1. Cathodoluminescence image of representative zircons from sample 156602: granophyric dolerite sill, No. 36 Well

Group 2 comprises six analyses of six zircons (Table 1), which yielded $^{207}\text{Pb}^*/^{206}\text{Pb}^*$ dates of 1057–1017 Ma.

The date of 1076 ± 4 Ma for the 14 analyses in Group 1 is interpreted as the age of igneous crystallization of the dolerite sill. This interpretation is strongly supported by the uniformly euhedral to irregular morphologies of the zircons, the presence of central channels within many zircons, and their very high and variable U and Th concentrations and Th/U ratios (Table 1, Fig. 3). These observations are typical of primary, late-stage, interstitial zircons crystallized within the differentiated parts of mafic intrusions (Lanyon et al., 1993; Wingate et al., 1998).

The six analyses in Group 2 yield $^{207}\text{Pb}^*/^{206}\text{Pb}^*$ dates significantly younger than those in Group 1, and their distribution (Fig. 2) is interpreted to reflect the combined effects of reverse discordance (as described above), and minor ancient loss of radiogenic Pb.

References

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Table 1. Ion microprobe analytical results for zircons from sample 156602: granophyric dolerite sill, No. 36 Well

Grp no.	Spot no.	Grain .spot	^{238}U (ppm)	^{232}Th (ppm)	$^{232}\text{Th}/^{238}\text{U}$	f^{204} (%)	$^{238}\text{U}/^{206}\text{Pb}$ $\pm 1\sigma$	$^{207}\text{Pb}/^{206}\text{Pb}$ $\pm 1\sigma$	$^{238}\text{U}/^{206}\text{Pb}^*$ $\pm 1\sigma$	$^{207}\text{Pb}^*/^{206}\text{Pb}^*$ $\pm 1\sigma$	$^{238}\text{U}/^{206}\text{Pb}^*$ date (Ma) $\pm 1\sigma$	$^{207}\text{Pb}^*/^{206}\text{Pb}^*$ date (Ma) $\pm 1\sigma$	Disc (%)
1	19	19.1	682	3088	4.68	-0.037	5.475 \pm 0.068	0.07531 \pm 0.00045	5.472 \pm 0.068	0.07562 \pm 0.00048	1082 \pm 12	1085 \pm 13	0.3
1	1	1.1	3359	11666	3.59	0.001	5.274 \pm 0.065	0.07559 \pm 0.00016	5.274 \pm 0.065	0.07559 \pm 0.00017	1119 \pm 13	1084 \pm 4	-3.2
1	20	20.1	785	3190	4.20	-0.024	5.388 \pm 0.067	0.07534 \pm 0.00042	5.387 \pm 0.067	0.07555 \pm 0.00045	1098 \pm 12	1083 \pm 12	-1.3
1	9	9.1	6307	15560	2.55	0.022	4.814 \pm 0.057	0.07568 \pm 0.00014	4.815 \pm 0.057	0.07550 \pm 0.00015	1216 \pm 13	1082 \pm 4	-12.5
1	14	14.1	1652	5103	3.19	0.033	5.318 \pm 0.064	0.07577 \pm 0.00029	5.319 \pm 0.064	0.07549 \pm 0.00030	1111 \pm 12	1082 \pm 8	-2.7
1	5	5.1	5923	14328	2.50	0.030	5.213 \pm 0.066	0.07563 \pm 0.00011	5.215 \pm 0.066	0.07538 \pm 0.00012	1131 \pm 13	1079 \pm 3	-4.8
1	17	17.1	1299	5169	4.11	0.021	5.320 \pm 0.064	0.07552 \pm 0.00033	5.321 \pm 0.064	0.07534 \pm 0.00040	1110 \pm 12	1078 \pm 11	-3.0
1	8	8.1	2589	3230	1.29	0.008	5.463 \pm 0.065	0.07529 \pm 0.00023	5.464 \pm 0.065	0.07522 \pm 0.00024	1083 \pm 12	1074 \pm 6	-0.8
1	15	15.1	886	3470	4.05	0.210	5.436 \pm 0.071	0.07694 \pm 0.00047	5.447 \pm 0.071	0.07517 \pm 0.00066	1086 \pm 13	1073 \pm 18	-1.2
1	16	16.1	6644	29075	4.52	0.040	4.675 \pm 0.055	0.07547 \pm 0.00014	4.677 \pm 0.055	0.07514 \pm 0.00015	1249 \pm 13	1072 \pm 4	-16.5
1	11	11.1	5245	8607	1.70	0.005	5.048 \pm 0.060	0.07514 \pm 0.00015	5.048 \pm 0.060	0.07510 \pm 0.00016	1165 \pm 13	1071 \pm 4	-8.8
1	10	10.1	2547	7886	3.20	0.053	5.141 \pm 0.061	0.07541 \pm 0.00023	5.143 \pm 0.061	0.07497 \pm 0.00027	1145 \pm 13	1068 \pm 7	-7.3
1	18	18.1	4042	15396	3.94	0.039	5.070 \pm 0.060	0.07527 \pm 0.00018	5.072 \pm 0.060	0.07495 \pm 0.00019	1160 \pm 13	1067 \pm 5	-8.7
1	2	2.1	4903	6676	1.41	0.020	5.359 \pm 0.064	0.07482 \pm 0.00030	5.360 \pm 0.064	0.07465 \pm 0.00030	1103 \pm 12	1059 \pm 8	-4.1
2	13	13.1	5207	11568	2.30	0.026	5.318 \pm 0.062	0.07479 \pm 0.00016	5.319 \pm 0.062	0.07457 \pm 0.00017	1111 \pm 12	1057 \pm 5	-5.1
2	3	3.1	3548	10593	3.09	0.015	5.506 \pm 0.066	0.07459 \pm 0.00015	5.506 \pm 0.066	0.07446 \pm 0.00015	1076 \pm 12	1054 \pm 4	-2.1
2	4	4.1	4486	12254	2.82	0.093	5.433 \pm 0.065	0.07522 \pm 0.00013	5.438 \pm 0.065	0.07444 \pm 0.00018	1088 \pm 12	1053 \pm 5	-3.3
2	7	7.1	5093	20412	4.14	0.012	5.142 \pm 0.062	0.07415 \pm 0.00016	5.143 \pm 0.062	0.07405 \pm 0.00016	1145 \pm 13	1043 \pm 4	-9.8
2	6	6.1	4356	17143	4.07	0.068	5.406 \pm 0.064	0.07395 \pm 0.00022	5.409 \pm 0.064	0.07338 \pm 0.00025	1093 \pm 12	1025 \pm 7	-6.7
2	12	12.1	410	2358	5.95	0.900	5.541 \pm 0.078	0.08064 \pm 0.00061	5.592 \pm 0.079	0.07310 \pm 0.00160	1061 \pm 14	1017 \pm 44	-4.3

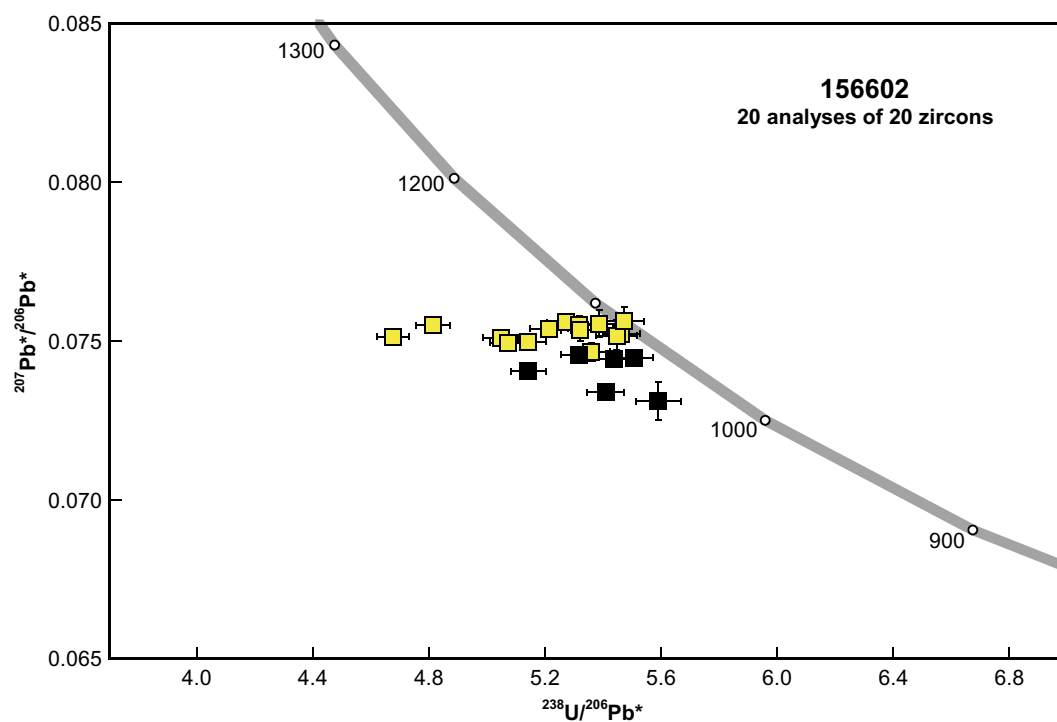


Figure 2. U–Pb analytical data for sample 156602: granophyric dolerite sill, No. 36 Well. Yellow squares indicate Group 1 (igneous crystallization); black squares indicate Group 2 (affected by minor loss of radiogenic Pb)

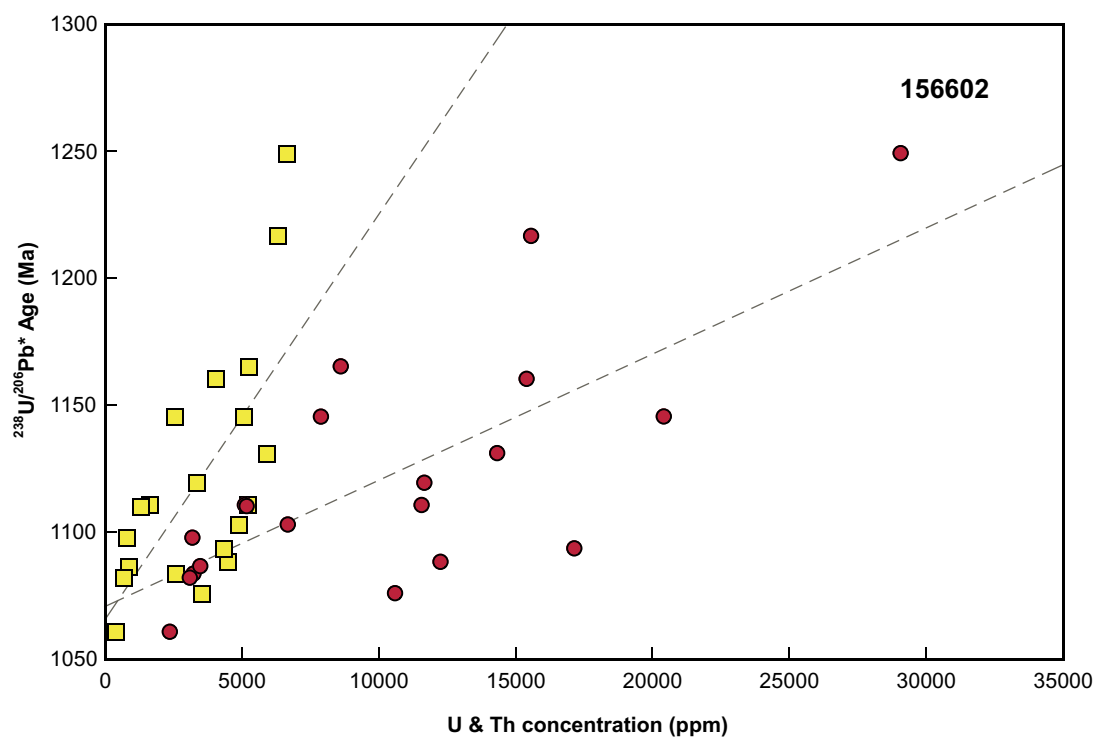


Figure 3. Variation of $^{238}\text{U}/^{206}\text{Pb}^*$ age with uranium (squares) and thorium (circles) concentrations for sample 156602: granophyric dolerite sill, No. 36 Well. Dashed lines indicate regressions through each data set

Recommended reference for this publication

WINGATE, M. T. D., and BODORKOS, S., 2007, 156602: granophyric dolerite sill, No. 36 Well; Geochronology dataset 695, *in* Compilation of geochronology data: Western Australia Geological Survey.

Data obtained: 16 August 2005

Data released: 30 June 2007