180057: tonalitic orthogneiss, Big Junction Well

(Warrawagine Granitic Complex, East Pilbara Terrane, Pilbara Craton)

Location and sampling

YARRIE (SF 51-1), WARRAWAGINE (3056)
MGA Zone 51, 249510E 7710284N

Sampled on 2 September 2005

The sample was obtained from an area of low, rounded granite outcrops, about 1.1 km west of Big Junction Well (abandoned).

Tectonic unit/relations

The unit sampled is a retrogressed, blue–grey, banded, migmatitic tonalitic orthogneiss intruded by homogeneous medium-grained granite of the Warrawagine Granitic Complex (Williams, 2001). The geochronology of several previous samples from the Warrawagine Granitic Complex on WARRAWAGINE are discussed in Nelson (1999) and Williams (2001, Table 2).

Petrographic description

The sample is a well-banded gneiss with biotite-rich and quartzofeldspathic bands on a mm- to cm-scale, mostly 1 to 5 mm wide. In thin section, the sample contains about 60% plagioclase and/or sericite, 25% quartz, 8% biotite and/or chlorite, 3% epidote, 1–2% hornblende, <1% each of opaque oxide minerals, titanite, apatite, pyrite, allanite, and sparsely disseminated, rounded zircon grains from 0.05 to 0.15 mm long. Biotite-rich lamellae have a moderate layer-parallel foliation although much of the biotite and hornblende in the more quartzofeldspathic bands is aligned at a high angle to the layering, suggesting a spaced or crenulation cleavage or a type of S–C fabric. Some lenses of quartz are also aligned at a high angle to the layering, whereas others are parallel to the layering and to the main foliation. Much of the biotite is 0.5 to 1.5 mm in grainsize, associated with lenses of epidote up to 3 mm long, which locally enclose allanite. Quartz and plagioclase vary from 0.2 to 3 mm in size and are anhedral, and minor epidote and irregularly disseminated sericite occurs within the plagioclase. Weak chlorite alteration has affected some biotite, although most or all hornblende is fresh. Some opaque oxide minerals have rims of fine-grained secondary titanite in addition to primary disseminated titanite. The prograde assemblage was apparently quartz–plagioclase–biotite–hornblende–titanite–magnetite–apatite–zircon with rare allanite, possibly representing low-amphibolite facies tonalite gneiss or metamorphosed migmatite. Sericite, epidote, and chlorite formed during greenschist-facies retrogression.

Zircon morphology

Zircons from this sample are mainly subhedral, variably rounded, and colourless to dark brown. The crystals are up to 600 μm long, and equant to elongate, with aspect ratios up to 6:1. Euhedral growth zoning is common, and some zircons show disrupted internal structures, consistent with alteration. Many crystals consist of older cores surrounded by rims that have radial fractures and low uranium contents. A cathodoluminescence image of representative zircons is shown in Figure 1.

Analytical details

This sample was analysed on 9–10 November 2006, using SHRIMP-B. Eighteen analyses of the CZ3 standard were obtained during the session, and following rejection of two outlying analyses, the remaining 16 analyses indicated an external spot-to-spot (reproducibility) uncertainty of 1.97% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.54% (1σ). Common-Pb corrections were applied using contemporaneous common-Pb isotopic compositions determined according to the model of Stacey and Kramers (1975).

Results

Forty-three analyses were obtained from 42 zircons. Results are listed in Table 1 and shown in a concordia diagram (Fig. 2).

Interpretation

Most analyses are concordant to slightly discordant (Fig. 2). A single analysis is characterized by strong discordance (>40%), and three analyses represent mixtures of core and rim material. The dates obtained from these four analyses (Group D; Table 1) are unreliable, and are not considered geologically significant. The remaining 39 analyses can be divided into four groups, based on $^{207}Pb^*/^{206}Pb^*$ ratios and analytical positions within the crystals.

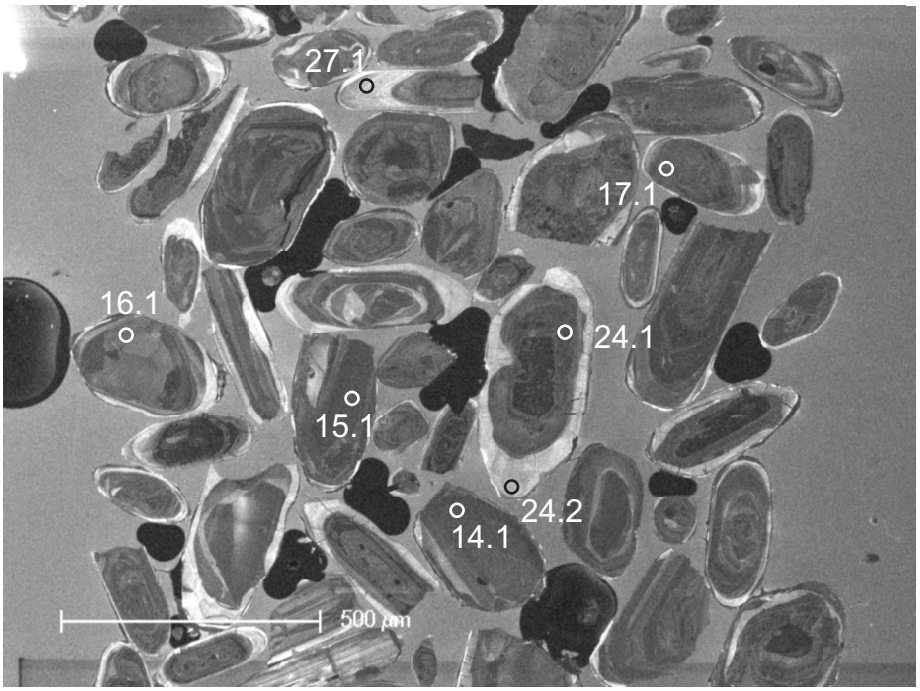

Figure 1. Cathodoluminescence image of representative zircons from sample 180057: tonalitic orthogneiss, Big Junction Well. Numbered circles indicate approximate positions of analysis sites.

Group M2 comprises a single analysis of a zircon rim (32.1, Table 1), which yields a Th/U ratio of 0.04, and a $^{207}Pb^*/^{206}Pb^*$ date of 3356 ± 9 Ma (1σ).

Group M comprises five analyses of five zircon rims (Table 1), which yield a weighted mean $^{207}Pb^*/^{206}Pb^*$ date of 3388 ± 11 Ma (MSWD = 1.49).

Group I comprises 13 analyses of 13 zircons (Table 1), which yield a weighted mean $^{207}Pb^*/^{206}Pb^*$ date of 3423 ± 3 Ma (MSWD = 1.20).

Group X (Table 1) comprises 20 analyses of 20 zircons (mainly cores), which yield $^{207}Pb^*/^{206}Pb^*$ dates between 3583 and 3415 Ma.

The date of 3423 ± 3 Ma for 13 analyses in Group I is interpreted as the age of igneous crystallization of the tonalitic precursor to the gneiss. The date of 3388 ± 11 Ma for the five analyses in Group M is interpreted to reflect a metamorphic event that affected this rock. The date of 3356 ± 9 Ma (1σ) for the single analysis (32.1) in Group M2 is interpreted as the time of a slightly younger metamorphic episode. The dates of 3583 to 3415 Ma for the 20 analyses in Group X are interpreted to represent the ages of precursor components within the banded gneiss.

References

Nelson, DR 1999, Compilation of geochronology data, 1998: Geological Survey of Western Australia, Record 1999/2, 222p.

Stacey, JS and Kramers, JD 1975, Approximation of terrestrial lead isotope evolution by a two-stage model: Earth and Planetary Science Letters, v. 26, p. 207–221.

Williams, IR 2001, Geology of the Warrawagine 1:100 000 sheet: Geological Survey of Western Australia, 1:100 000 Geological Series Explanatory Notes, 33p.

Recommended reference for this publication

Wingate, MTD, Bodorkos, S and Van Kranendonk, MJ 2009, 180057: tonalitic orthogneiss, Big Junction Well; Geochronology Record 809: Geological Survey of Western Australia, 4p.

Data obtained: 10 November 2006
Data released: 30 June 2009

Table 1. Ion microprobe analytical results for zircons from sample 180057: tonalitic orthogneiss, Big Junction Well

Group ID	Spot no.	Grain. spot	^{238}U (ppm)	^{232}Th (ppm)	$^{232}Th/^{238}U$	f204 (%)	$^{238}U/^{206}Pb$ ± 1 σ		$^{207}Pb/^{206}Pb$ ± 1 σ		$^{238}U/^{206}Pb^*$ ± 1 σ		$^{207}Pb^*/^{206}Pb^*$ ± 1 σ		$^{238}U/^{206}Pb^*$ date (Ma) ± 1 σ		$^{207}Pb^*/^{206}Pb^*$ date (Ma) ± 1 σ		Disc. (%)
I	28	27.1	49	31	0.67	0.018	1.486	0.035	0.29309	0.00147	1.486	0.035	0.29293	0.00147	3317	60	3433	8	3.4
I	15	15.1	259	46	0.18	0.027	1.471	0.029	0.29234	0.00072	1.472	0.029	0.29211	0.00072	3343	52	3429	4	2.5
I	42	41.1	150	52	0.36	0.134	1.406	0.028	0.29317	0.00083	1.408	0.029	0.29202	0.00089	3460	54	3428	5	-0.9
I	1	1.1	91	45	0.51	0.105	1.382	0.028	0.29253	0.00111	1.383	0.028	0.29163	0.00116	3508	55	3426	6	-2.4
I	27	26.1	200	158	0.82	0.016	1.475	0.029	0.29171	0.00075	1.476	0.029	0.29157	0.00076	3335	52	3426	4	2.6
I	31	30.1	167	73	0.45	0.028	1.394	0.028	0.29175	0.00075	1.395	0.028	0.29151	0.00076	3485	54	3426	4	-1.7
I	6	6.1	115	78	0.70	0.034	1.421	0.029	0.29122	0.00103	1.422	0.029	0.29093	0.00103	3434	54	3423	5	-0.3
I	32	31.1	172	47	0.28	0.040	1.456	0.029	0.29095	0.00079	1.457	0.029	0.29061	0.00082	3369	52	3421	4	1.5
I	10	10.1	67	99	1.52	0.062	1.396	0.029	0.29093	0.00175	1.396	0.029	0.29040	0.00176	3482	56	3420	9	-1.8
I	5	5.1	63	97	1.59	0.205	1.446	0.030	0.29210	0.00145	1.449	0.030	0.29033	0.00154	3383	55	3419	8	1.1
I	36	35.1	72	44	0.64	0.148	1.454	0.031	0.29143	0.00124	1.456	0.031	0.29016	0.00129	3370	56	3418	7	1.4
I	30	29.1	147	74	0.52	0.040	1.453	0.029	0.28980	0.00082	1.453	0.029	0.28946	0.00084	3376	53	3415	5	1.1
I	41	40.1	151	38	0.26	0.058	1.449	0.029	0.28993	0.00082	1.450	0.029	0.28944	0.00084	3381	53	3415	5	1.0
X	14	14.1	330	299	0.94	0.046	1.388	0.029	0.32323	0.00065	1.388	0.029	0.32285	0.00066	3497	55	3583	3	2.4
X	29	28.1	73	52	0.74	0.205	1.362	0.028	0.32360	0.00124	1.365	0.028	0.32188	0.00130	3543	56	3579	6	1.0
X	26	25.1	296	182	0.64	0.051	1.375	0.027	0.32215	0.00060	1.375	0.027	0.32172	0.00061	3523	54	3578	3	1.5
X	23	23.1	56	28	0.51	-0.045	1.345	0.028	0.32080	0.00135	1.344	0.028	0.32118	0.00140	3586	57	3575	7	-0.3
X	18	18.1	95	48	0.52	0.073	1.419	0.031	0.32169	0.00122	1.420	0.031	0.32108	0.00124	3436	59	3575	6	3.9
X	11	11.1	97	56	0.60	0.023	1.414	0.030	0.31829	0.00123	1.414	0.030	0.31809	0.00137	3448	56	3561	7	3.2
X	20	20.1	266	172	0.67	-0.010	1.390	0.028	0.31703	0.00062	1.390	0.028	0.31712	0.00063	3494	54	3556	3	1.7
X	4	4.1	110	43	0.41	0.042	1.363	0.028	0.31684	0.00107	1.363	0.028	0.31649	0.00108	3546	55	3553	5	0.2
X	19	19.1	558	66	0.12	0.015	1.532	0.030	0.31581	0.00051	1.532	0.030	0.31568	0.00051	3239	50	3549	2	8.7
X	37	36.1	104	73	0.72	0.042	1.401	0.028	0.31445	0.00104	1.402	0.028	0.31410	0.00158	3472	54	3541	8	2.0
X	8	8.1	173	76	0.45	0.051	1.384	0.028	0.31383	0.00088	1.385	0.028	0.31340	0.00088	3505	54	3538	4	0.9
X	3	3.1	118	21	0.18	0.053	1.370	0.030	0.30632	0.00102	1.371	0.030	0.30587	0.00103	3531	59	3500	5	-0.9
X	38	37.1	227	58	0.26	0.058	1.459	0.029	0.30383	0.00073	1.460	0.029	0.30334	0.00075	3363	52	3487	4	3.6
X	7	7.1	197	29	0.15	0.020	1.427	0.029	0.30022	0.00086	1.427	0.029	0.30005	0.00087	3423	53	3470	5	1.4
X	43	42.1	174	12	0.07	0.018	1.408	0.028	0.29662	0.00077	1.408	0.028	0.29646	0.00079	3459	54	3452	4	-0.2
X	35	34.1	253	181	0.74	0.043	1.453	0.029	0.29674	0.00065	1.454	0.029	0.29637	0.00067	3375	53	3451	3	2.2
X	17	17.1	171	32	0.19	0.092	1.457	0.029	0.29588	0.00089	1.458	0.029	0.29509	0.00096	3367	53	3445	5	2.3
X	24	24.1	361	79	0.23	0.042	1.462	0.029	0.29456	0.00051	1.462	0.029	0.29420	0.00052	3359	52	3440	3	2.4
X	9	9.1	98	16	0.17	-0.058	1.417	0.029	0.29356	0.00116	1.416	0.029	0.29406	0.00117	3445	55	3439	6	-0.2
X	22	22.1	281	90	0.33	0.041	1.419	0.028	0.29335	0.00058	1.419	0.028	0.29300	0.00059	3438	53	3434	3	-0.1
M	2	2.1	28	16	0.58	0.424	1.403	0.031	0.29202	0.00200	1.408	0.031	0.28838	0.00247	3458	59	3409	13	-1.5
M	25	24.2	44	22	0.52	0.144	1.421	0.030	0.28837	0.00154	1.423	0.030	0.28713	0.00176	3432	56	3402	10	-0.9
M	34	33.1	99	15	0.16	0.013	1.498	0.033	0.28420	0.00099	1.499	0.033	0.28409	0.00102	3295	57	3386	6	2.7
M	39	38.1	108	44	0.42	0.044	1.416	0.029	0.28407	0.00092	1.417	0.029	0.28370	0.00106	3443	54	3383	6	-1.7
M	12	12.1	70	18	0.26	0.152	1.438	0.030	0.28489	0.00123	1.440	0.030	0.28358	0.00133	3399	54	3383	7	-0.5
M2	33	32.1	48	2	0.04	0.220	1.432	0.030	0.28061	0.00140	1.435	0.030	0.27871	0.00153	3409	55	3356	9	-1.6
D	21	21.1	60	23	0.40	0.039	1.398	0.029	0.28891	0.00122	1.399	0.029	0.28857	0.00124	3477	55	3410	7	-2.0
D	40	39.1	36	20	0.56	0.399	1.427	0.030	0.29239	0.00176	1.433	0.030	0.28896	0.00198	3413	56	3412	11	0.0
D	13	13.1	190	50	0.27	0.243	1.509	0.030	0.29120	0.00079	1.513	0.030	0.28911	0.00086	3271	51	3413	5	4.2
D	16	16.1	399	48	0.12	0.033	2.801	0.056	0.27013	0.00073	2.801	0.056	0.26985	0.00078	1968	34	3305	5	40.5

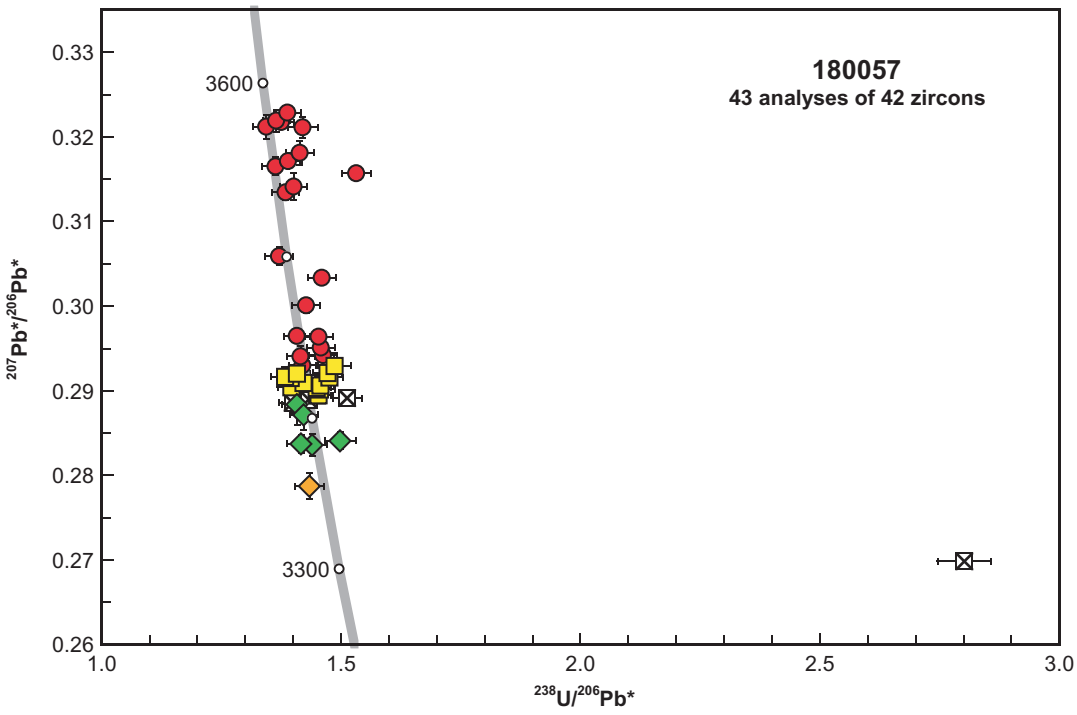

Figure 2. **U–Pb analytical data for sample 180057: tonalitic orthogneiss, Big Junction Well. Yellow squares indicate Group I (magmatic zircons); green diamonds indicate Group M (metamorphic rims); brown diamond indicates Group M2 (younger metamorphic rim); red circles indicate Group X (xenocrystic zircons); crossed squares indicate Group D (discordance >40% or core–rim mixture).**