198669: pelitic gneiss, Mount Narryer

(Narryer Terrane, Yilgarn Craton)

Location and sampling

Byro (SG 50-10), Chulyawarra (2144)
MGA Zone 50, 440332E 7068444N

Sampled on 2 November 2010

This sample was collected from a boulder in a stream bed on the east flank of the Mount Narryer Range on Boolardy Station, about 7.9 km northeast of Lanes Well, 5.5 km north of Elizabeth Springs Well, and 3.0 km northeast of Mount Narryer. The sample was collected as part of a Yilgarn-wide metamorphism study undertaken by Dr Ben Goscombe for the Geological Survey of Western Australia.

Tectonic unit/relations

The unit sampled is a pelitic gneiss of the Narryer Terrane in the northwest Yilgarn Craton (Myers, 1990; Wilde and Spaggiari, 2007). The Narryer Terrane includes rocks with U–Pb zircon ages ranging up to c. 3750 Ma (Kinny et al., 1988; AIS Kemp, 2014, written comm.), the oldest known rocks in Australia, and detrital zircons up to c. 4404 Ma, the oldest terrestrial material on Earth (Wilde et al., 2001). The Narryer Terrane consists of granite and granitic gneiss interleaved with sedimentary, mafic–ultramafic intrusive rocks, and banded iron-formation, metamorphosed at greenschist to granulite facies (Myers and Williams, 1985). A pelitic gneiss, sampled about 2.7 km to the southwest, yielded a maximum depositional age of 3297 ± 5 Ma (GSWA 198644; Lu et al., 2015a), and a quartzite, sampled about 2 km to the west-northwest, yielded a maximum depositional age of 3340 ± 20 Ma (GSWA 198654; Lu et al., 2015b).

Petrographic description

This sample is a fine- to medium-grained pelitic gneiss, consisting of about 30% quartz, 25% plagioclase, 25% biotite, 15% K-feldspar, 3% garnet, and accessory apatite and zircon. The overall texture is granoblastic and the rock is foliated. Quartz is intergranular and 0.5 – 1.0 mm in diameter. Plagioclase (labradorite, An_{68}) is about 0.5 – 2 mm across, strongly altered to muscovite and sericite, and veined by chlorite and sericite. Biotite is red-brown and up to 1 mm long, and K-feldspar (microcline and perthite) is up to 1 mm across. Garnet porphyroblasts are mainly subhedral and up to 1 mm across.

Zircon morphology

Zircons isolated from this sample are colourless to dark brown, mainly anhedral to subhedral, and variably rounded. The crystals are up to 250 µm long, and equant to elongate, with aspect ratios up to 4:1. In cathodoluminescence (CL) images, most zircons exhibit concentric zoning, and some appear to contain older cores. A CL image of representative zircons is shown in Figure 1.

Analytical details

This sample was analysed on 21–22 September 2012, using SHRIMP-A. Fifteen analyses of the BR266 standard were obtained during the session. Significant drift of standard $^{238}U/^{206}Pb^*$ dates during the session was addressed by fitting a LOWESS curve (Cleveland, 1979) with a smoothing window of five analyses, implemented using the program Isoplot 2.50 (Ludwig, 2009; Wingate and Kirkland, 2015). During the session, 14 standard analyses indicated an external spot-to-spot (reproducibility) uncertainty of 0.52% (1σ). Calibration uncertainties are included in the errors of $^{238}U/^{206}Pb^*$ ratios and dates listed in Table 1. Common-Pb corrections were applied to all analyses using contemporaneous isotopic compositions determined according to the model of Stacey and Kramers (1975).

Results

Sixty-one analyses were obtained from 60 zircons. Results are listed in Table 1, and shown in a concordia diagram (Fig. 2), and a probability density diagram (Fig. 3).

Interpretation

The analyses are concordant to strongly discordant (Fig. 2). Twenty-six analyses are >5% discordant. The dates obtained from these 26 analyses (Group D; Table 1) are unreliable, and are considered not to be geologically significant. The remaining 35 analyses can be divided into three groups, based on their $^{207}Pb^*/^{206}Pb^*$ ratios.

Group Y comprises one analysis (Table 1), which yields a $^{207}Pb^*/^{206}Pb^*$ date of 3311 ± 37 Ma (1σ).

Group S comprises 33 analyses of 33 zircons (Table 1), which yield $^{207}Pb^*/^{206}Pb^*$ dates of 3751–3336 Ma.

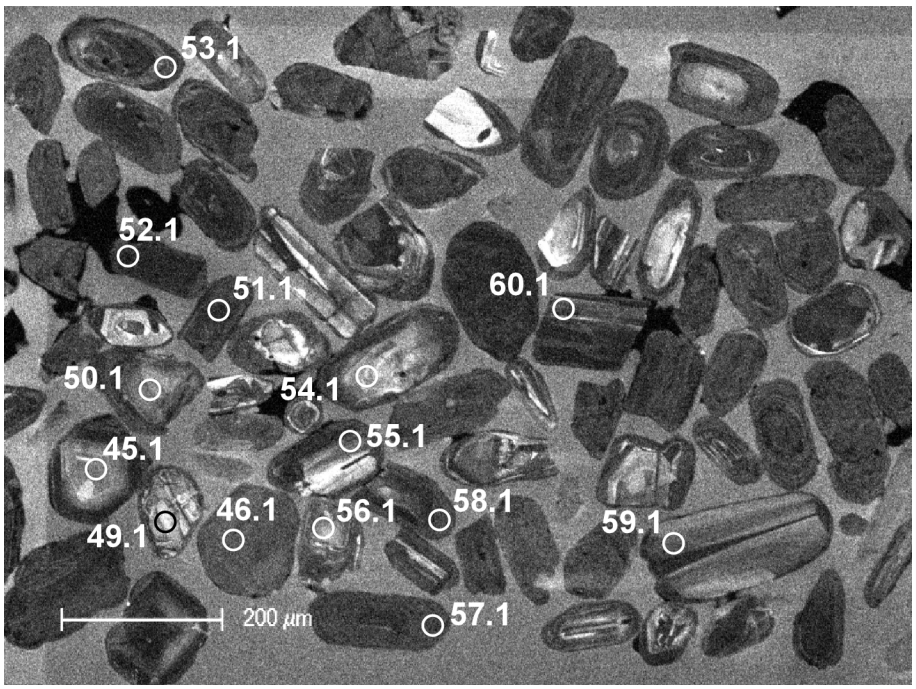

Figure 1. Cathodoluminescence image of representative zircons from sample 198669: pelitic gneiss, Mount Narryer. Numbered circles indicate the approximate locations of analysis sites.

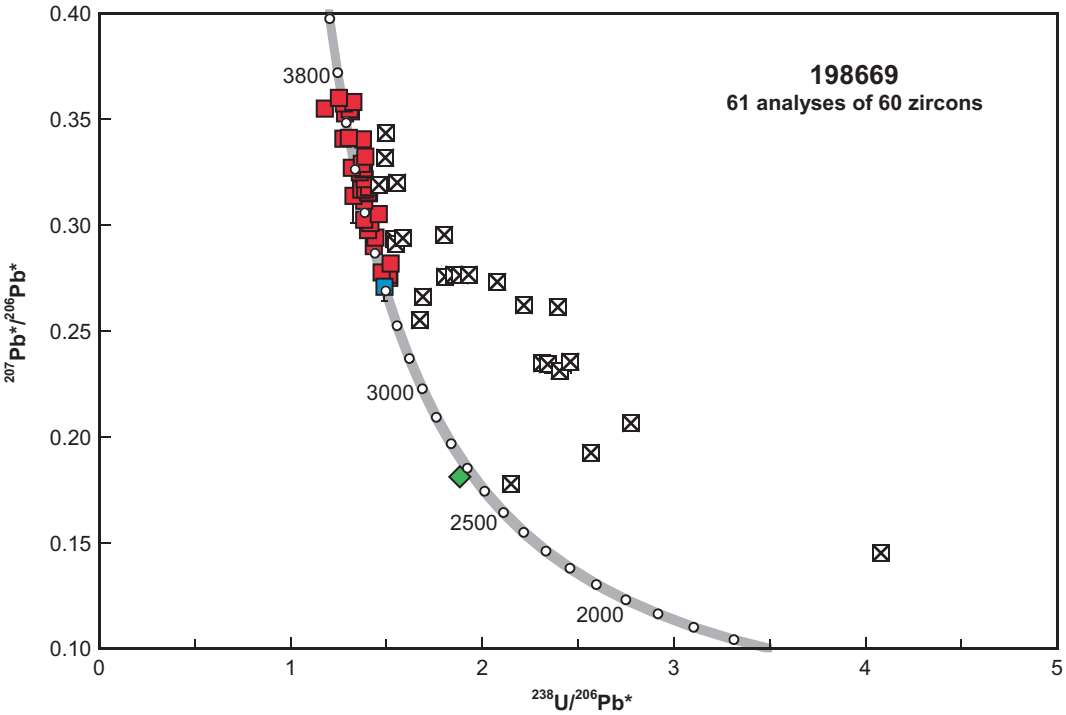

Figure 2. U–Pb analytical data for zircons from sample 198669: pelitic gneiss, Mount Narryer. Blue square indicates Group Y (youngest detrital zircon); red squares indicate Group S (older detrital zircons); green diamond indicates Group M (metamorphic zircon); crossed squares indicate Group D (discordance >5%).

Table 1. Ion microprobe analytical results for zircons from sample 198669: pelitic gneiss, Mount Narryer

Group ID	Spot no.	Grain. spot	^{238}U (ppm)	^{232}Th (ppm)	$\frac{^{232}Th}{^{238}U}$	f204 (%)	$^{238}U/^{206}Pb$ ± 1σ		$^{207}Pb/^{206}Pb$ ± 1σ		$^{238}U/^{206}Pb^*$ ± 1σ		$^{207}Pb^*/^{206}Pb^*$ ± 1σ		$^{238}U/^{206}Pb^*$ date (Ma) ±1σ		$^{207}Pb^*/^{206}Pb^*$ date (Ma) ±1σ		Disc. (%)
Y	53	52.1	479	36	0.08	0.009	1.489	0.011	0.27098	0.00647	1.489	0.011	0.27090	0.00647	3313	19	3311	37	0.0
S	29	28.1	538	323	0.62	0.005	1.515	0.011	0.27526	0.00052	1.515	0.011	0.27521	0.00052	3267	18	3336	3	2.1
S	36	35.1	552	111	0.21	0.000	1.511	0.011	0.27664	0.00054	1.511	0.011	0.27664	0.00054	3275	19	3344	3	2.1
S	52	51.1	485	135	0.29	0.033	1.475	0.011	0.27792	0.00058	1.475	0.011	0.27763	0.00059	3336	20	3350	3	0.4
S	26	25.1	136	33	0.25	0.019	1.520	0.016	0.28204	0.00100	1.521	0.016	0.28187	0.00100	3258	27	3373	6	3.4
S	44	43.1	68	42	0.64	0.044	1.433	0.020	0.29049	0.00154	1.434	0.020	0.29011	0.00156	3410	38	3418	8	0.2
S	45	44.1	99	67	0.70	0.056	1.440	0.017	0.29471	0.00125	1.441	0.017	0.29422	0.00127	3397	32	3440	7	1.2
S	60	59.1	240	83	0.36	0.000	1.404	0.013	0.29767	0.00084	1.404	0.013	0.29767	0.00084	3467	24	3458	4	-0.3
S	41	40.1	243	91	0.39	0.041	1.415	0.012	0.30143	0.00523	1.416	0.012	0.30108	0.00523	3445	24	3476	27	0.9
S	1	1.1	126	125	1.03	0.000	1.383	0.014	0.30267	0.00098	1.383	0.014	0.30267	0.00098	3507	27	3484	5	-0.7
S	20	19.1	800	390	0.50	0.017	1.459	0.010	0.30538	0.00042	1.459	0.010	0.30524	0.00042	3365	18	3497	2	3.8
S	38	37.1	448	211	0.49	0.006	1.383	0.010	0.31161	0.00074	1.383	0.010	0.31156	0.00074	3508	21	3529	4	0.6
S	30	29.1	49	52	1.10	-0.018	1.328	0.022	0.31368	0.01294	1.328	0.022	0.31383	0.01294	3619	45	3540	64	-2.2
S	21	20.1	262	178	0.70	0.029	1.409	0.012	0.31539	0.00075	1.409	0.012	0.31515	0.00075	3457	23	3546	4	2.5
S	7	6.1	166	108	0.67	0.000	1.403	0.013	0.31555	0.00084	1.403	0.013	0.31555	0.00084	3468	24	3548	4	2.3
S	37	36.1	1045	51	0.05	0.002	1.368	0.010	0.31693	0.00501	1.368	0.010	0.31691	0.00501	3538	21	3555	24	0.5
S	8	7.1	1302	732	0.58	0.000	1.388	0.008	0.31697	0.00031	1.388	0.008	0.31697	0.00031	3498	16	3555	2	1.6
S	57	56.1	119	68	0.59	0.031	1.408	0.016	0.31827	0.00124	1.408	0.016	0.31801	0.00125	3459	30	3560	6	2.8
S	48	47.1	150	159	1.09	0.059	1.386	0.014	0.32229	0.00108	1.386	0.014	0.32180	0.00109	3501	28	3578	5	2.2
S	61	60.1	234	206	0.91	0.014	1.361	0.012	0.32514	0.00549	1.361	0.012	0.32502	0.00549	3552	24	3594	26	1.2
S	6	5.1	82	66	0.83	0.105	1.376	0.017	0.32727	0.00135	1.378	0.017	0.32640	0.00137	3518	33	3600	6	2.3
S	56	55.1	144	123	0.88	0.122	1.381	0.015	0.32793	0.00115	1.382	0.015	0.32692	0.00118	3509	29	3603	6	2.6
S	35	34.1	90	97	1.10	-0.011	1.320	0.017	0.32706	0.00148	1.319	0.017	0.32715	0.00148	3637	37	3604	7	-0.9
S	43	42.1	474	286	0.62	0.000	1.370	0.010	0.32905	0.00061	1.370	0.010	0.32905	0.00061	3533	20	3613	3	2.2
S	9	8.1	139	59	0.44	-0.013	1.389	0.013	0.33237	0.00115	1.389	0.013	0.33248	0.00116	3497	26	3629	5	3.6
S	24	23.1	322	112	0.36	0.002	1.377	0.011	0.34059	0.00074	1.377	0.011	0.34057	0.00074	3519	22	3665	3	4.0
S	50	49.1	92	145	1.62	0.010	1.274	0.016	0.34099	0.00145	1.274	0.016	0.34091	0.00145	3735	36	3667	7	-1.9
S	46	45.1	131	64	0.51	0.000	1.304	0.014	0.34122	0.00118	1.304	0.014	0.34122	0.00118	3670	31	3668	5	-0.1
S	5	4.1	585	658	1.16	0.025	1.283	0.009	0.35308	0.00048	1.283	0.009	0.35288	0.00049	3715	19	3719	2	0.1
S	27	26.1	794	887	1.15	0.000	1.314	0.009	0.35386	0.00048	1.314	0.009	0.35386	0.00048	3648	19	3724	2	2.0
S	17	16.1	125	66	0.54	0.169	1.307	0.014	0.35621	0.00120	1.309	0.014	0.35484	0.00123	3658	30	3728	5	1.9
S	55	54.1	81	41	0.52	0.073	1.276	0.017	0.35810	0.00161	1.277	0.017	0.35752	0.00162	3728	38	3739	7	0.3
S	22	21.1	421	221	0.54	0.002	1.326	0.010	0.35829	0.00076	1.326	0.010	0.35828	0.00076	3622	21	3743	3	3.2
S	51	50.1	112	62	0.57	0.007	1.252	0.015	0.36028	0.00167	1.252	0.015	0.36023	0.00167	3785	33	3751	7	-0.9
M	47	46.1	960	12	0.01	0.003	1.888	0.013	0.18069	0.00034	1.888	0.013	0.18067	0.00034	2739	15	2659	3	-3.0

Table 1. continued

Group ID	Spot no.	Grain. spot	^{238}U (ppm)	^{232}Th (ppm)	$\frac{^{232}Th}{^{238}U}$	ƒ204 (%)	$^{238}U/^{206}Pb$ ± 1σ		$^{207}Pb/^{206}Pb$ ± 1σ		$^{238}U/^{206}Pb^*$ ± 1σ		$^{207}Pb^*/^{206}Pb^*$ ± 1σ		$^{238}U/^{206}Pb^*$ date (Ma) ±1σ		$^{207}Pb^*/^{206}Pb^*$ date (Ma) ±1σ		Disc. (%)
D	11	10.1	1466	893	0.63	0.030	4.080	0.026	0.14535	0.00032	4.081	0.026	0.14509	0.00033	1413	8	2289	4	38.3
D	34	33.1	769	10	0.01	0.019	2.150	0.014	0.17792	0.00037	2.150	0.014	0.17775	0.00037	2462	14	2632	3	6.5
D	28	27.1	1614	54	0.03	0.005	2.568	0.016	0.19245	0.00034	2.568	0.016	0.19241	0.00034	2120	11	2763	3	23.3
D	32	31.1	728	42	0.06	0.017	2.775	0.019	0.20654	0.00049	2.776	0.019	0.20639	0.00049	1983	12	2877	4	31.1
D	33	32.1	1467	342	0.24	0.010	2.404	0.061	0.23121	0.00035	2.404	0.061	0.23112	0.00035	2242	49	3060	2	26.7
D	54	53.1	472	122	0.27	0.014	2.342	0.018	0.23440	0.00394	2.342	0.018	0.23428	0.00394	2292	15	3082	27	25.6
D	12	11.1	1074	117	0.11	0.035	2.313	0.015	0.23503	0.00166	2.313	0.015	0.23472	0.00167	2316	13	3085	11	24.9
D	15	14.1	1172	50	0.04	0.023	2.461	0.016	0.23573	0.00041	2.461	0.016	0.23553	0.00042	2198	12	3090	3	28.9
D	13	12.1	1026	18	0.02	0.004	1.675	0.011	0.25515	0.00039	1.675	0.011	0.25511	0.00039	3018	16	3217	2	6.2
D	16	15.1	1107	324	0.30	0.070	2.393	0.015	0.26191	0.00052	2.395	0.015	0.26130	0.00053	2249	12	3255	3	30.9
D	25	24.1	1091	202	0.19	0.026	2.217	0.014	0.26243	0.00189	2.218	0.014	0.26220	0.00190	2399	13	3260	11	26.4
D	39	38.1	941	37	0.04	0.007	1.690	0.011	0.26633	0.00043	1.690	0.011	0.26627	0.00043	2996	16	3284	3	8.8
D	42	41.1	1183	55	0.05	0.011	2.079	0.013	0.27329	0.00042	2.079	0.013	0.27319	0.00042	2532	13	3324	2	23.8
D	2	1.2	736	83	0.12	0.011	1.805	0.012	0.27585	0.00043	1.806	0.012	0.27576	0.00043	2841	15	3339	2	14.9
D	59	58.1	835	16	0.02	0.052	1.882	0.013	0.27673	0.00049	1.883	0.013	0.27628	0.00050	2746	15	3342	3	17.8
D	58	57.1	992	67	0.07	0.015	1.854	0.012	0.27673	0.00046	1.854	0.012	0.27660	0.00046	2781	15	3344	3	16.8
D	49	48.1	899	306	0.35	0.024	1.929	0.013	0.27682	0.00047	1.929	0.013	0.27661	0.00047	2692	15	3344	3	19.5
D	23	22.1	679	965	1.47	0.022	1.551	0.010	0.29146	0.00045	1.551	0.010	0.29127	0.00045	3208	17	3424	2	6.3
D	4	3.1	315	109	0.36	0.031	1.540	0.012	0.29368	0.00064	1.540	0.012	0.29341	0.00065	3225	20	3436	3	6.1
D	18	17.1	753	165	0.23	0.028	1.586	0.011	0.29410	0.00048	1.586	0.011	0.29387	0.00048	3151	17	3438	3	8.3
D	3	2.1	1745	75	0.04	0.016	1.802	0.011	0.29562	0.00031	1.802	0.011	0.29548	0.00031	2846	14	3447	2	17.4
D	19	18.1	545	349	0.66	-0.003	1.461	0.010	0.31904	0.00054	1.461	0.010	0.31906	0.00054	3362	19	3565	3	5.7
D	31	30.1	610	175	0.30	0.022	1.557	0.011	0.32020	0.00054	1.557	0.011	0.32002	0.00054	3198	17	3570	3	10.4
D	14	13.1	754	52	0.07	0.002	1.493	0.010	0.33192	0.00218	1.493	0.010	0.33190	0.00218	3306	18	3626	10	8.8
D	10	9.1	462	197	0.44	0.011	1.496	0.011	0.34356	0.00057	1.496	0.011	0.34347	0.00057	3299	18	3678	3	10.3
D	40	39.1	551	378	0.71	0.011	1.178	0.010	0.35521	0.00094	1.178	0.010	0.35512	0.00094	3962	26	3729	4	-6.3

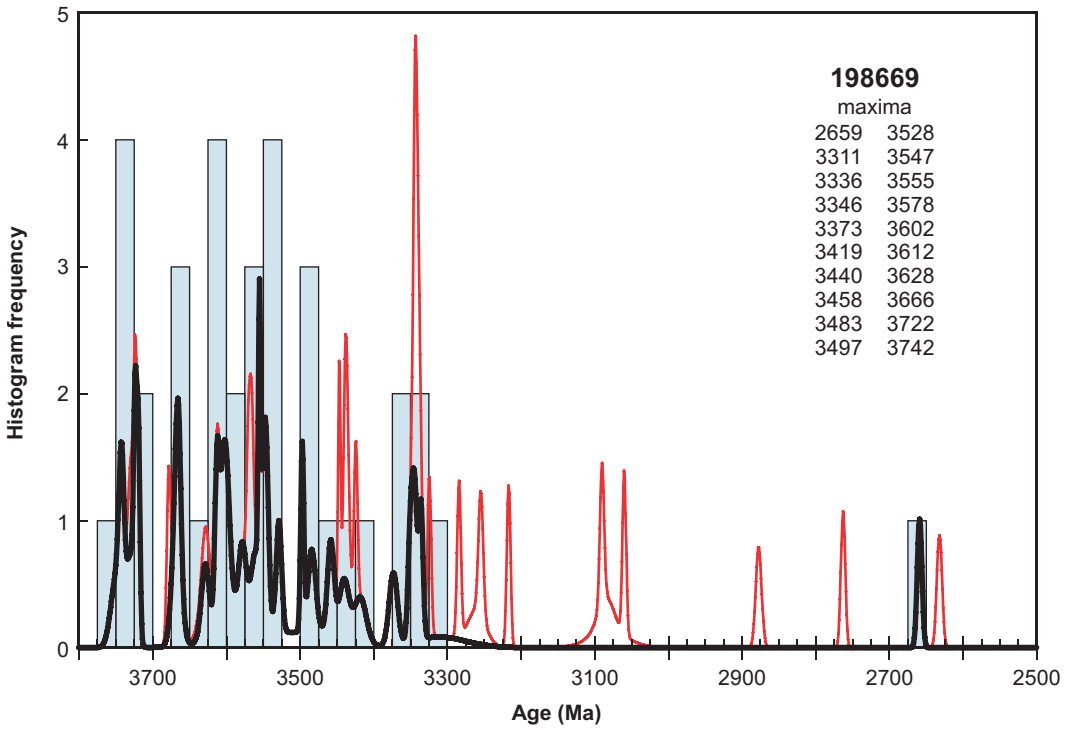

Figure 3. Probability density diagram and histogram for sample 198669: pelitic gneiss, Mount Narryer. Thick curve, maxima values, and frequency histogram (bin width 25 Ma) only include data with discordance <5% (36 analyses of 36 zircons). Thin curve includes all data (61 analyses of 60 zircons).

Group M comprises one analysis (Table 1), which yields a $^{207}Pb^*/^{206}Pb^*$ date of 2659 ± 3 Ma (1σ).

It is possible that all of the analyses in Groups Y and S are of unmodified detrital zircons, in which case the date of 3311 ± 37 Ma (1σ) for the single analysis in Group Y represents a maximum depositional age for the sedimentary precursor. A more conservative estimate of the maximum depositional age can be based on the weighted mean date of 3343 ± 17 Ma (MSWD = 4.9) for the three youngest analyses in Group S.

The data for Groups Y and S indicate significant age components at c. 3750–3720, 3666, 3620–3520, 3500–3480, and 3375–3325 Ma (Fig. 3). These are interpreted as the ages of zircon-crystallizing rocks in the detrital source region(s), or as the ages of detrital components within sediments that have been reworked into this rock.

The date of 2659 ± 3 Ma (1σ) for the single analysis in Group M is interpreted as the age of high-grade metamorphism.

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