194726: granodioritic gneiss, Uraryie Rock

(Biranup Zone, Albany–Fraser Orogen)

Location and sampling

ZANTHUS (SH 51-15), COONANA (3535)
MGA Zone 51, 540239E 6549701N

Sampled on 4 July 2008

This sample was collected from platform exposures adjacent to a large hill of exposed rock named Urayie Rock, approximately 600 m east of Udarra Bore, and 12.5 km southeast of Fly Dam.

Tectonic unit/relations

The unit sampled is a granodioritic gneiss assigned to the Biranup Zone, a belt of mid-crustal rocks that lie along the southern and eastern margins of the Yilgarn Craton (Myers, 1990; Spaggiari et al., 2009; Kirkland et al., 2011). The Biranup Zone is dominated by intensely deformed orthogneiss, paragneiss, and metagabbro, with ages ranging from c. 1760 to 1620 Ma. Based on Sm–Nd and Lu–Hf isotopic signatures, and on the presence of Archean granitic rocks, the Biranup Zone is interpreted to have formed autochthonously along the Yilgarn Craton margin (Kirkland et al., 2011). The Biranup Zone was deformed and metamorphosed during the Zanthus Event at c. 1680 Ma, and was later intruded by granitic rocks, and deformed and metamorphosed again, during Stages I and II of the Mesoproterozoic Albany–Fraser Orogeny (Clark et al., 2000; Kirkland et al., 2011; Spaggiari et al., 2011).

This granodioritic gneiss, from west of the Fraser Fault, is part of the c. 1665 Ma Eddy Suite. Rocks of this suite range from megacrystic metamonzogranite and equigranular metasyenogranitic gneiss, to rapakivi-textured metagranodiorite and metagabbronoritic rocks (Kirkland et al., 2011; Spaggiari et al., 2011). The granodioritic gneiss sampled has a strong gneissic foliation and mineral lineation; abundant leucosomes are mostly parallel to the foliation, forming layers and lenses, but locally coalesce into patches. The granodioritic gneiss is interpreted to be intruded by metasyenogranite, which was sampled 150 m to the north of the present site, and which yielded a magmatic crystallization age of 1670 ± 7 Ma (GSWA 194727, Kirkland et al., 2012).

Petrographic description

The sample is a granodioritic gneiss, with a visually estimated mineralogy comprising 40% quartz, 32% antiperthitic plagioclase, 9% biotite, 8% garnet, 7% K-feldspar, 3% hornblende, and accessory titanite, apatite, and zircon. Minor myrmekite is also present. The foliation is defined by mafic aggregates. Garnet aggregates are up to 5 mm long, and contain inclusions of quartz, biotite, hornblende, and titanite. Hornblende is up to 3 mm in grain size, and is associated with garnet, whereas biotite is evenly disseminated throughout the rock. The very dark maximum absorption colour of biotite suggests a high content of iron and/or titanium. Plagioclase grains are up to 4 mm long and have minor K-feldspar inclusions, possibly exsolved from plagioclase. Minor, discrete K-feldspar grains are mostly untwinned, and may be orthoclase. Titanite, up to 1 mm long, occurs mostly in mafic lenses.

Zircon morphology

Zircons isolated from this sample are subhedral to euhedral, and colourless to yellow. The crystals are up to 200 μm long, with aspect ratios up to 5:1. In cathodoluminescence (CL) images, the zircons display oscillatory zoning, and many are overgrown by low-uranium rims. A CL image of representative zircons is shown in Figure 1.

Analytical details

This sample was analysed on 13–14 August 2009, using SHRIMP-B. Twelve analyses of the BR266 standard were obtained during the session, and indicated an external spot-to-spot (reproducibility) uncertainty of 1.76% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.53% (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).

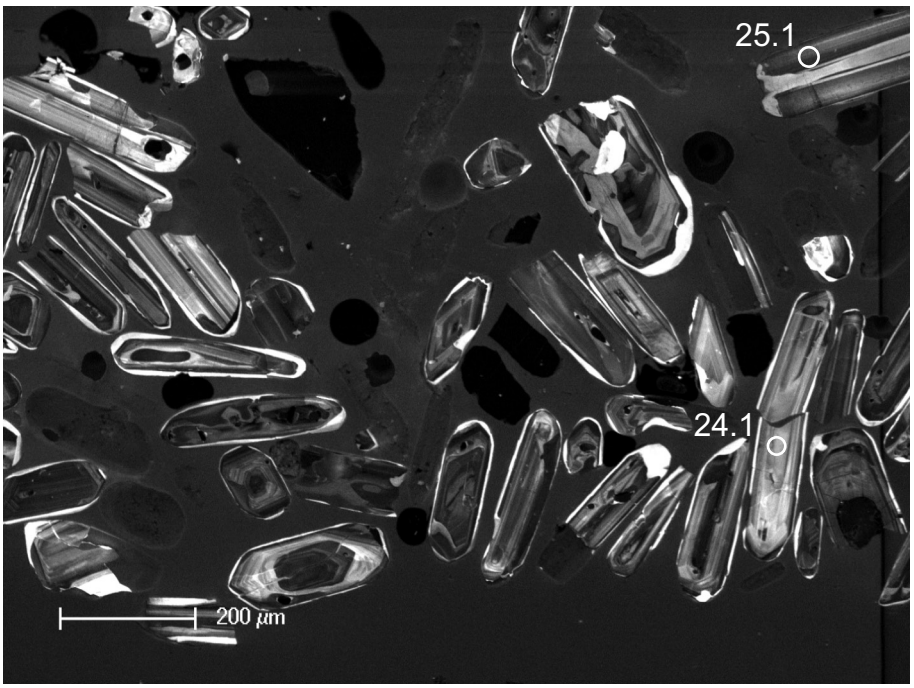

Figure 1. Cathodoluminescence image of representative zircons from sample 194726: granodioritic gneiss, Uraryie Rock. Numbered circles indicate the approximate positions of analysis sites.

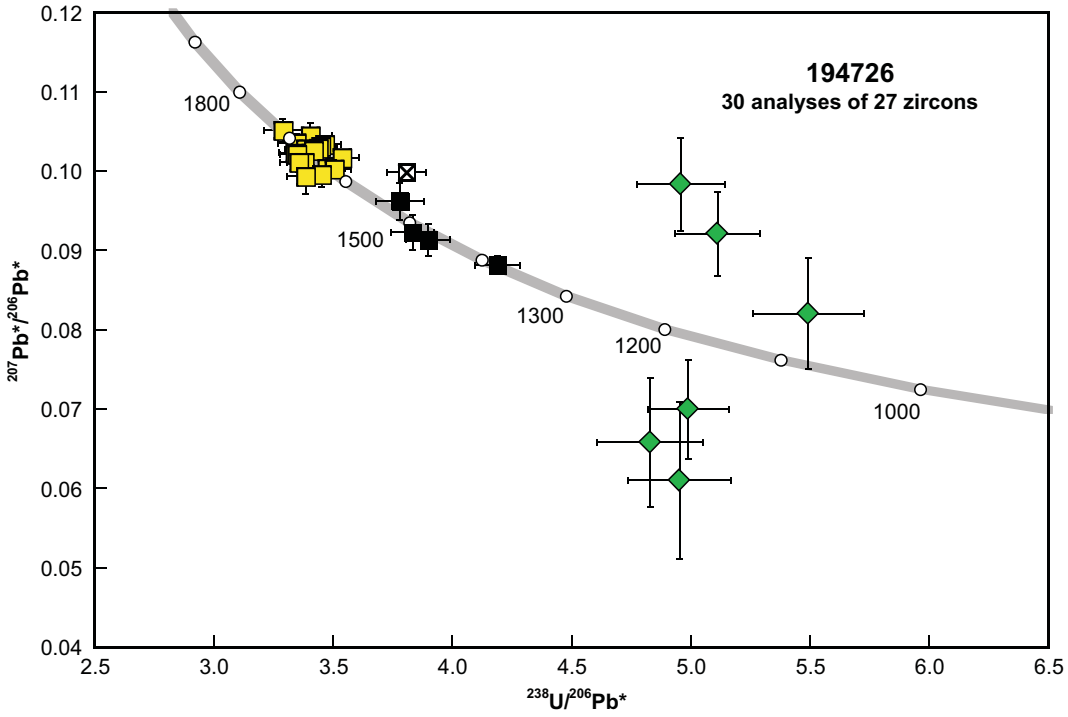

Figure 2. U–Pb analytical data for sample 194726: granodioritic gneiss, Uraryie Rock. Yellow squares indicate Group I (magmatic zircons); black squares indicate Group P (radiogenic-Pb loss); green diamonds indicate Group M (metamorphic zircon rims); crossed squares indicate Group D (discordance >5%).

Table 1. Ion microprobe analytical results for zircons from sample 194726: granodioritic gneiss, Uraryie Rock

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. (%)
I	3	3.1	64	35	0.56	0.228	3.378	0.078	0.10130	0.00212	3.385	0.080	0.09933	0.00230	1668	45	1612	43	3.5
I	9	9.1	52	33	0.66	0.300	3.441	0.082	0.10220	0.00121	3.452	0.084	0.09961	0.00161	1640	45	1617	30	1.4
I	30	27.1	148	110	0.77	0.116	3.499	0.071	0.10132	0.00075	3.503	0.073	0.10032	0.00085	1619	38	1630	16	0.7
I	5	5.1	71	38	0.55	0.234	3.464	0.078	0.10236	0.00107	3.472	0.080	0.10034	0.00135	1632	43	1630	25	0.1
I	25	22.1	137	80	0.60	10.000	3.377	0.069	0.10112	0.00079	3.377	0.071	0.10112	0.00079	1672	40	1645	15	1.7
I	22	19.1	74	47	0.66	0.162	3.350	0.075	0.10251	0.00109	3.355	0.078	0.10111	0.00130	1682	44	1645	24	2.2
I	4	4.1	268	79	0.30	0.063	3.535	0.068	0.10223	0.00060	3.538	0.070	0.10168	0.00065	1605	36	1655	12	3.0
I	24	21.1	121	87	0.74	0.046	3.350	0.069	0.10175	0.00081	3.348	0.071	0.10214	0.00085	1685	41	1663	15	1.3
I	6	6.1	239	166	0.72	0.105	3.335	0.064	0.10322	0.00062	3.339	0.067	0.10231	0.00070	1689	39	1667	13	1.3
I	7	7.1	38	26	0.69	0.248	3.409	0.090	0.10481	0.00157	3.417	0.093	0.10266	0.00201	1655	51	1673	36	1.1
I	23	20.1	150	93	0.64	0.100	3.394	0.068	0.10368	0.00077	3.397	0.071	0.10281	0.00086	1663	39	1675	15	0.7
I	1	1.1	44	25	0.59	10.000	3.385	0.086	0.10278	0.00140	3.385	0.088	0.10278	0.00140	1669	49	1675	25	0.4
I	11	11.1	222	100	0.46	0.042	3.436	0.067	0.10327	0.00064	3.437	0.069	0.10291	0.00067	1646	38	1677	12	1.9
I	21	18.1	187	103	0.57	0.088	3.444	0.068	0.10392	0.00072	3.447	0.071	0.10315	0.00080	1642	38	1682	14	2.3
I	12	12.1	361	289	0.83	0.016	3.465	0.065	0.10352	0.00050	3.465	0.067	0.10338	0.00051	1634	36	1686	9	3.0
I	26	23.1	69	28	0.42	0.041	3.344	0.076	0.10390	0.00111	3.345	0.078	0.10354	0.00116	1686	45	1688	21	0.1
I	2	2.1	36	24	0.70	9.000	3.402	0.091	0.10450	0.00155	3.402	0.093	0.10450	0.00155	1661	51	1706	27	2.6
I	10	10.1	55	24	0.45	0.108	3.294	0.079	0.10420	0.00127	3.290	0.081	0.10514	0.00144	1711	48	1717	25	0.3
P	18	17.1	86	32	0.39	0.047	4.186	0.092	0.08857	0.00105	4.188	0.095	0.08816	0.00112	1380	35	1386	24	0.4
P	29	26.1	64	37	0.61	0.591	3.875	0.090	0.09640	0.00125	3.898	0.093	0.09133	0.00205	1472	39	1453	43	1.3
P	8	8.1	64	20	0.33	0.320	3.820	0.089	0.09504	0.00189	3.832	0.091	0.09230	0.00220	1495	40	1473	45	1.4
P	27	24.1	42	17	0.41	0.503	3.759	0.097	0.10059	0.00154	3.778	0.100	0.09625	0.00236	1514	45	1553	46	2.5
M	17	4.2	11	0	0.01	2.477	4.829	0.202	0.08130	0.00317	4.951	0.216	0.06101	0.00986	1186	57	640	348	85.4
M	20	17.2	8	0	0.00	1.523	4.755	0.212	0.07837	0.00325	4.828	0.221	0.06578	0.00809	1213	61	799	258	51.8
M	13	13.1	26	0	0.01	1.500	4.915	0.162	0.08252	0.00255	4.989	0.170	0.07003	0.00624	1178	44	929	183	26.7
M	19	4.3	12	5	0.47	0.993	5.438	0.224	0.09045	0.00350	5.493	0.231	0.08204	0.00697	1078	49	1246	166	13.5
M	16	16.1	18	4	0.22	1.102	5.168	0.175	0.08263	0.00248	5.111	0.178	0.09208	0.00528	1152	44	1469	109	21.6
M	14	14.1	20	0	0.01	1.206	5.017	0.180	0.08791	0.00277	4.957	0.183	0.09831	0.00583	1185	48	1592	111	25.6
D	15	15.1	24	5	0.22	1.217	8.396	1.225	0.08558	0.00307	8.499	1.243	0.07537	0.00673	717	110	1078	179	33.5
D	28	25.1	105	77	0.75	10.000	3.807	0.079	0.09989	0.00089	3.807	0.082	0.09989	0.00089	1503	36	1622	17	7.3

Results

Thirty analyses were obtained from 27 zircons. Results are listed in Table 1, and shown in a concordia diagram (Fig. 2).

Interpretation

The analyses are concordant to strongly discordant (Fig. 2). One analysis >1600 Ma is >5% discordant, and one other analysis indicates high within-run variation. The dates obtained from these two analyses (Group D; Table 1) are imprecise or unreliable, and are considered not geologically significant. The remaining 28 analyses define three groups, based on their uranium contents, and $^{207}Pb^*/^{206}Pb^*$ and Th/U ratios.

Group I comprises 18 analyses of 18 zircons (Table 1), which yield a weighted mean $^{207}Pb^*/^{206}Pb^*$ date of 1668 ± 11 Ma (MSWD = 1.7). These analyses indicate low to moderate Th/U ratios (0.30 – 0.83), and low to moderate uranium contents (36–361 ppm).

Group P comprises four analyses of four zircons (Table 1), which yield $^{207}Pb^*/^{206}Pb^*$ dates of 1553–1386 Ma.

Group M comprises six analyses of six zircon rims (Table 1), which yield a weighted mean $^{238}U/^{206}Pb^*$ date of 1162 ± 39 Ma (MSWD = 0.84). These analyses indicate low Th/U ratios (0.005 – 0.465) and very low uranium contents (8–26 ppm).

The date of 1668 ± 11 Ma for the 18 analyses in Group I is interpreted as the magmatic crystallization age of the granodiorite. The dates of 1553–1386 Ma for the four analyses in Group P are interpreted to reflect minor ancient radiogenic-Pb loss. The date of 1162 ± 39 Ma (MSWD = 0.84) for the six analyses in Group M is interpreted as the age of metamorphism. The low precision of results in Group M reflects the low uranium content of the zircon rims.

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