243061: siliciclastic schist, Radiator prospect

(Aileron Province, North Australian Craton)

Location and sampling

Webb (SF 52-10), Dwarf Well (4553)
MGA Zone 52, 420098E 7534602N

Sampled on 15 July 2019

This sample was collected from the 243.0 – 244.3 m depth interval of diamond drillcore RDD01, drilled in 2010 by Meteoric Resources NL at their Radiator prospect (Reddy, 2012), with support from the Western Australian Government's Exploration Incentive Scheme (EIS). The drillhole is located west of Lake Mackay in the Great Sandy Desert, about 75 km northeast of Kiwirrkurra community, 72 km north of Mount Webb, and 61 km south-southeast of Carnegie Bluff.

Geological context

The unit sampled is a siliciclastic schist within crystalline basement in the northern Aileron Province of the North Australian Craton (Kelsey et al., 2021). Drillhole RDD01 targeted a coincident gravity and magnetic anomaly, and intersected mainly quartz–biotite– muscovite–garnet–magnetite–apatite±sillimaniteschists, interpreted as regionally metamorphosed sedimentary rocks with variable magnetite–hematite–sulfide alteration (Reddy, 2012). The present sample was collected to determine the maximum depositional age and detrital provenance of the sedimentary protolith. Detrital zircons from a quartzite about 8.8 km to the north yielded a conservative maximum depositional age of 1775 ± 7 Ma (GSWA 184341, Kirkland et al., 2009a). About 13.5 km to the west-southwest, a metagranodiorite of the Dwarf Well Granite, assigned to the 1779–1767 Ma Carrington Suite (Scrimgeour, 2013; Spaggiari and Kelsey, 2022), yielded an igneous crystallization age of 1773 ± 6 Ma (GSWA 184367, Kirkland et al., 2009b).

Petrographic description

The sample is a strongly foliated, medium-grained biotite–muscovite–sillimanite–garnet schist, consisting of about 25–30% quartz, 20–35% biotite, 10–20% plagioclase, 5–20% muscovite, 5–10% sillimanite, <5% garnet, 2–4% magnetite, and trace tourmaline, apatite and zircon. Quartz is anhedral, equant to slightly elongate, up to 2.5 mm long, has a polygonal texture with plagioclase, is mildly to moderately strained, and exhibits minor subgraining. Green-brown biotite forms subhedral laths up to 5 mm long that are strongly aligned in subparallel folia that define the schistosity. Plagioclase is anhedral, slightly sericite- or clay-altered, and up to 2 mm in size; some grains contain minor quartz inclusions. Muscovite forms anhedral to subhedral laths up to 8 mm long, which are slightly to moderately oblique to the foliation. Some muscovite has clearly grown across the fabric and contains numerous inclusions of quartz, plagioclase, biotite, magnetite and fibrous sillimanite. Fibrolitic sillimanite forms irregular masses up to 6 mm long, 0.25 mm wide, associated with and parallel to biotite in the foliation. Garnet forms pale pink, anhedral, fractured grains up to 1.2 mm in diameter. Magnetite is subhedral to euhedral, equant to elongate, up to 1.5 mm in size, is disseminated and also in discontinuous linear trails. Tourmaline is pale to deep blue and rarely pink, and forms equant and elongate subhedral grains up to 2 mm long. The schist had a sedimentary protolith, and the trails of magnetite and biotite and sillimanite folia possibly reflect an original compositional layering. Peak metamorphic grade reached upper amphibolite facies.

Zircon morphology

Zircons isolated from this sample are colourless to dark brown, anhedral to subhedral, and variably rounded. The crystals are up to 200 µm long, and equant to elongate, with aspect ratios up to 5:1. In cathodoluminescence (CL) images, most zircons are observed to consist of rounded to angular, concentrically zoned cores, overgrown by high-U zircon rims. Some zircon cores exhibit concentric zoning truncated at grain boundaries, and some show pitted outer surfaces, features consistent with sedimentary transport. A CL image of representative zircons is shown in Figure 2.

Analytical details

This sample was analysed on 10–12 and 17–18 September 2020, using SHRIMP-B. Analyses 1.1 to 48.1 (spot numbers 1–52) were obtained during the first session, together with 25 analyses of the M257 standard, of which 24 analyses indicated an external spot-to-spot (reproducibility) uncertainty of 0.58% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.19% (1σ). Isotopic mass fractionation of $^{207}Pb/^{206}Pb$ ratios during the first session was corrected by reference to the OGC1 standard; measured ratios were increased by 0.23%. Analyses 49.1 to 62.2 (spot numbers 53–76) were obtained during the second session, together with 15 analyses of the M257 standard, of which 13 analyses indicated an external spot-to-spot (reproducibility) uncertainty of 0.75% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.34% (1σ). Isotopic mass fractionation of $^{207}Pb/^{206}Pb$ ratios during the first session was corrected by reference to the OGC1 standard; measured ratios were increased by 0.62%. Calibration uncertainties are included in the errors of $^{238}U/^{206}Pb^*$ ratios and dates listed in Table 1.

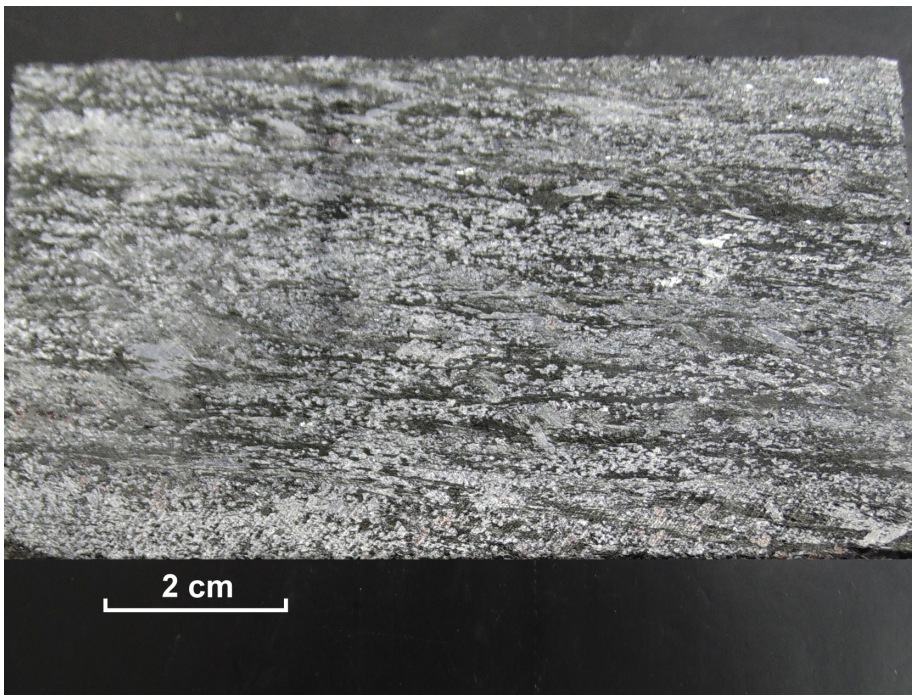

Figure 1. **Drillcore image for sample 243061: siliciclastic schist, Radiator prospect**

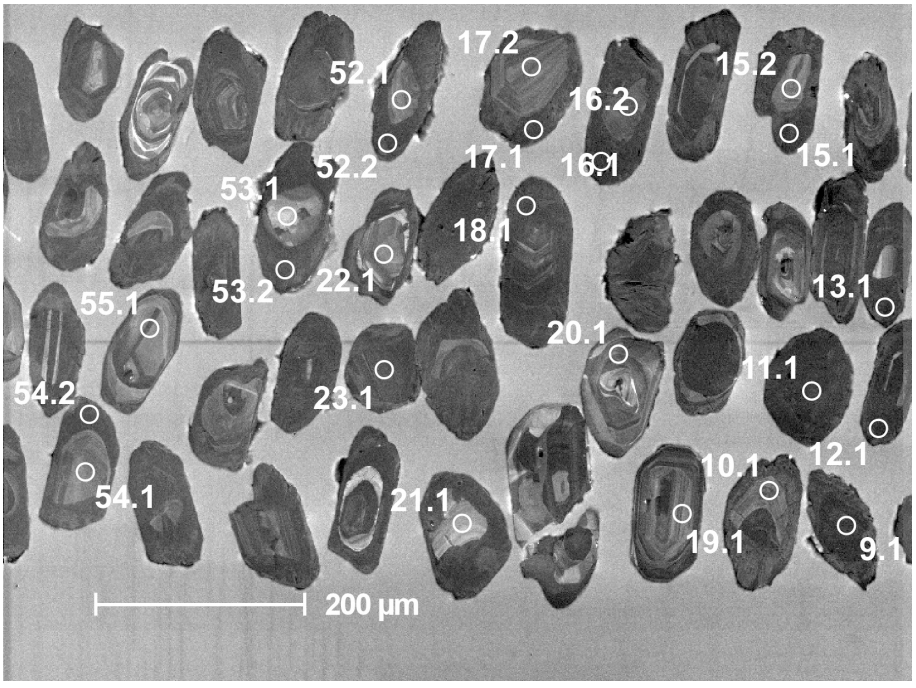

Figure 2. **Cathodoluminescence image of representative zircons from sample 243061: siliciclastic schist, Radiator prospect. Numbered circles indicate the approximate locations of analysis sites**

Table 1. Ion microprobe analytical results for zircons from sample 243061: siliciclastic schist, Radiator prospect

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. (%)
Y	11	10.1	340	78	0.23	0.028	3.175	0.030	0.10824	0.00087	3.176	0.030	0.10800	0.00089	1765	15	1766	15	0.1
S	3	2.2	171	65	0.38	0.027	3.122	0.036	0.10878	0.00110	3.123	0.036	0.10855	0.00113	1791	18	1775	19	-0.9
S	35	31.1	134	61	0.46	0.114	3.203	0.041	0.10973	0.00124	3.206	0.041	0.10873	0.00137	1750	20	1778	23	1.6
S	23	19.1	220	61	0.28	0.045	3.170	0.034	0.10933	0.00103	3.172	0.034	0.10893	0.00107	1767	17	1782	18	0.8
S	15	14.1	273	78	0.29	0.033	3.027	0.030	0.10970	0.00092	3.028	0.030	0.10942	0.00094	1840	16	1790	16	-2.8
S	5	4.1	290	59	0.20	0.066	3.221	0.032	0.11001	0.00092	3.223	0.032	0.10944	0.00097	1742	15	1790	16	2.7
S	33	29.1	145	62	0.43	0.032	3.120	0.038	0.10973	0.00118	3.121	0.038	0.10944	0.00121	1792	19	1790	20	-0.1
S	24	20.1	389	81	0.21	0.012	3.174	0.029	0.10957	0.00083	3.175	0.029	0.10946	0.00084	1765	14	1790	14	1.4
S	36	32.1	107	56	0.53	0.000	3.091	0.074	0.10950	0.00132	3.091	0.074	0.10950	0.00132	1807	38	1791	22	-0.9
S	17	15.2	211	55	0.26	0.020	3.258	0.034	0.10974	0.00098	3.258	0.034	0.10957	0.00099	1726	16	1792	16	3.7
S	44	40.1	202	51	0.25	0.128	3.133	0.034	0.11070	0.00109	3.137	0.034	0.10959	0.00118	1784	17	1793	20	0.5
S	49	45.1	397	62	0.16	0.000	3.184	0.029	0.10988	0.00084	3.184	0.029	0.10988	0.00084	1761	14	1797	14	2.0
S	30	26.1	370	94	0.26	-0.036	3.175	0.045	0.10957	0.00084	3.174	0.045	0.10989	0.00085	1765	22	1798	14	1.8
S	58	54.1	225	86	0.38	-0.118	3.084	0.040	0.10896	0.00128	3.080	0.040	0.10999	0.00138	1813	21	1799	23	-0.7
S	7	6.1	219	48	0.22	0.043	3.126	0.034	0.11049	0.00102	3.127	0.034	0.11012	0.00105	1789	17	1801	17	0.7
S	31	27.1	303	72	0.24	0.060	3.111	0.030	0.11078	0.00090	3.113	0.030	0.11026	0.00094	1796	15	1804	15	0.4
S	56	52.1	177	49	0.28	-0.038	3.188	0.044	0.11012	0.00139	3.186	0.044	0.11046	0.00143	1760	21	1807	24	2.6
S	19	16.2	317	46	0.15	0.014	3.162	0.030	0.11067	0.00089	3.163	0.030	0.11054	0.00090	1771	15	1808	15	2.1
S	6	5.1	170	53	0.31	0.054	3.141	0.036	0.11108	0.00111	3.143	0.036	0.11061	0.00116	1781	18	1809	19	1.6
S	21	17.2	284	65	0.23	0.000	3.151	0.031	0.11073	0.00091	3.151	0.031	0.11073	0.00091	1777	15	1811	15	1.9
S	51	47.1	352	91	0.26	0.014	3.208	0.030	0.11099	0.00088	3.208	0.030	0.11087	0.00089	1749	14	1814	15	3.6
S	25	21.1	114	40	0.35	0.168	3.176	0.043	0.11237	0.00133	3.181	0.043	0.11090	0.00152	1762	21	1814	25	2.9
S	60	56.1	202	55	0.28	0.096	3.199	0.042	0.11215	0.00133	3.202	0.042	0.11131	0.00141	1752	20	1821	23	3.8
S	28	24.1	310	82	0.26	0.015	3.145	0.030	0.11177	0.00090	3.145	0.030	0.11164	0.00090	1780	15	1826	15	2.6
S	41	37.1	423	167	0.39	-0.029	3.181	0.028	0.11187	0.00080	3.180	0.028	0.11213	0.00081	1763	14	1834	13	3.9
S	50	46.1	195	54	0.28	0.134	3.147	0.035	0.11350	0.00104	3.151	0.035	0.11232	0.00114	1777	17	1837	18	3.3
S	27	23.1	485	270	0.56	0.062	3.031	0.026	0.11324	0.00078	3.033	0.026	0.11270	0.00081	1837	14	1843	13	0.3
S	57	53.1	101	21	0.21	0.060	3.129	0.051	0.11333	0.00167	3.131	0.052	0.11280	0.00175	1787	26	1845	28	3.1
S	34	30.1	288	109	0.38	-0.016	3.031	0.030	0.11278	0.00092	3.030	0.030	0.11291	0.00093	1839	16	1847	15	0.5
S	45	41.1	372	51	0.14	0.013	3.088	0.029	0.11392	0.00087	3.089	0.029	0.11380	0.00088	1808	15	1861	14	2.8
S	29	25.1	460	309	0.67	0.009	3.095	0.027	0.11437	0.00080	3.095	0.027	0.11429	0.00080	1805	14	1869	13	3.4
S	4	3.1	803	333	0.41	0.005	2.994	0.024	0.11475	0.00070	2.995	0.024	0.11470	0.00070	1858	13	1875	11	0.9
S	40	36.1	485	55	0.11	-0.058	3.100	0.027	0.11531	0.00078	3.098	0.027	0.11582	0.00080	1804	14	1893	12	4.7
S	39	35.1	242	115	0.48	-0.076	3.010	0.031	0.11641	0.00100	3.007	0.031	0.11708	0.00105	1851	17	1912	16	3.2
S	52	48.1	373	328	0.88	0.022	2.982	0.027	0.11776	0.00084	2.983	0.027	0.11757	0.00085	1864	15	1920	13	2.9
S	37	33.1	720	65	0.09	0.012	2.926	0.024	0.12036	0.00102	2.927	0.024	0.12025	0.00102	1895	13	1960	15	3.3
S	10	9.1	712	197	0.28	0.000	2.848	0.023	0.12133	0.00073	2.848	0.023	0.12133	0.00073	1940	14	1976	11	1.8
S	12	11.1	675	508	0.75	0.016	2.812	0.023	0.12343	0.00072	2.812	0.023	0.12329	0.00072	1961	14	2004	10	2.1

Table 1. continued

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. (%)
S	32	28.1	1256	223	0.18	0.018	2.712	0.020	0.12714	0.00066	2.713	0.020	0.12697	0.00066	2023	13	2056	9	1.6
S	55	51.1	135	78	0.57	0.324	2.698	0.040	0.13016	0.00155	2.707	0.040	0.12728	0.00186	2027	26	2061	26	1.7
S	8	7.1	178	109	0.61	0.046	2.529	0.030	0.12891	0.00113	2.530	0.030	0.12850	0.00117	2147	22	2078	16	-3.4
S	68	64.1	208	124	0.60	-0.053	2.595	0.034	0.12957	0.00135	2.594	0.034	0.13005	0.00139	2102	24	2099	19	-0.2
S	53	49.1	186	149	0.80	0.000	2.491	0.034	0.13670	0.00137	2.491	0.034	0.13670	0.00137	2176	25	2186	17	0.5
S	62	58.1	75	94	1.25	0.395	2.112	0.039	0.16137	0.00201	2.121	0.039	0.15783	0.00242	2491	38	2433	26	-2.4
S	1	1.1	329	209	0.63	0.029	2.229	0.022	0.15875	0.00094	2.230	0.022	0.15849	0.00096	2389	19	2440	10	2.1
S	64	60.1	98	58	0.60	-0.282	2.245	0.038	0.15814	0.00184	2.239	0.037	0.16068	0.00210	2381	34	2463	22	3.3
S	43	39.1	121	105	0.87	0.095	2.176	0.028	0.16676	0.00135	2.178	0.028	0.16591	0.00142	2436	27	2517	14	3.2
S	42	38.1	118	29	0.25	-0.025	2.141	0.030	0.16698	0.00138	2.140	0.030	0.16720	0.00139	2472	29	2530	14	2.3
S	26	22.1	199	110	0.55	0.029	2.146	0.024	0.16749	0.00111	2.146	0.024	0.16723	0.00112	2466	23	2530	11	2.5
S	66	62.1	166	167	1.01	-0.047	2.115	0.029	0.16767	0.00148	2.114	0.029	0.16809	0.00151	2497	29	2539	15	1.6
S	63	59.1	279	194	0.69	0.088	1.982	0.024	0.17190	0.00128	1.984	0.024	0.17110	0.00132	2632	27	2568	13	-2.5
S	54	50.1	117	42	0.36	0.266	1.962	0.031	0.17776	0.00174	1.967	0.031	0.17537	0.00194	2650	35	2610	18	-1.5
S	59	55.1	278	122	0.44	0.058	1.695	0.041	0.22299	0.00211	1.696	0.041	0.22247	0.00212	2988	58	2999	15	0.4
M	71	54.2	547	3	0.01	-0.013	3.631	0.038	0.09534	0.00223	3.631	0.038	0.09546	0.00224	1568	15	1537	44	-2.0
M	76	62.2	541	3	0.01	0.039	3.737	0.057	0.09762	0.00102	3.738	0.057	0.09728	0.00104	1528	21	1573	20	2.8
M	20	17.1	554	3	0.01	0.039	3.611	0.031	0.09768	0.00076	3.613	0.031	0.09734	0.00078	1575	12	1574	15	-0.1
M	16	15.1	524	3	0.01	0.080	3.673	0.031	0.09810	0.00076	3.676	0.031	0.09740	0.00080	1551	12	1575	15	1.5
M	47	43.1	716	4	0.01	0.043	3.695	0.043	0.09784	0.00074	3.697	0.043	0.09747	0.00076	1543	16	1576	15	2.1
M	2	2.1	573	3	0.00	0.037	3.662	0.031	0.09814	0.00075	3.663	0.031	0.09782	0.00077	1556	12	1583	15	1.7
M	13	12.1	579	4	0.01	-0.019	3.678	0.031	0.09776	0.00075	3.677	0.031	0.09793	0.00076	1551	12	1585	15	2.2
M	14	13.1	638	3	0.00	0.024	3.639	0.041	0.09817	0.00073	3.639	0.041	0.09796	0.00074	1565	16	1586	14	1.3
M	18	16.1	588	3	0.00	-0.010	3.634	0.031	0.09805	0.00076	3.633	0.031	0.09813	0.00076	1567	12	1589	15	1.4
M	22	18.1	807	25	0.03	0.053	3.550	0.029	0.09873	0.00072	3.552	0.029	0.09827	0.00074	1599	12	1592	14	-0.5
M	69	52.2	619	3	0.00	-0.011	3.594	0.036	0.09832	0.00099	3.594	0.036	0.09841	0.00100	1583	14	1594	19	0.7
M	48	44.1	623	12	0.02	-0.009	3.454	0.029	0.09844	0.00074	3.454	0.029	0.09852	0.00074	1639	12	1596	14	-2.7
M	9	8.1	588	3	0.01	-0.030	3.660	0.031	0.09836	0.00076	3.659	0.031	0.09861	0.00078	1558	12	1598	15	2.5
M	75	60.2	691	9	0.01	0.020	3.586	0.048	0.09928	0.00129	3.587	0.048	0.09911	0.00130	1585	19	1607	24	1.4
D	73	57.2	707	6	0.01	0.047	4.478	1.064	0.08358	0.01427	4.480	1.065	0.08318	0.01428	1299	280	1273	335	-2.0
D	72	58.2	700	7	0.01	0.038	3.999	0.042	0.10092	0.00106	4.001	0.042	0.10058	0.00107	1438	14	1635	20	12.0
D	74	59.2	690	9	0.01	-0.030	3.551	0.036	0.10132	0.00098	3.550	0.036	0.10158	0.00100	1600	14	1653	18	3.2
D	70	53.2	687	4	0.01	-0.031	3.885	0.351	0.10327	0.00666	3.884	0.351	0.10354	0.00666	1477	119	1689	119	12.5
D	67	63.1	586	133	0.23	-0.013	3.673	0.785	0.10888	0.01362	3.673	0.785	0.10899	0.01362	1552	295	1783	228	12.9
D	38	34.1	245	53	0.22	-0.077	3.241	0.033	0.11189	0.00098	3.238	0.033	0.11256	0.00104	1735	16	1841	17	5.8
D	46	42.1	558	191	0.34	0.046	3.031	0.025	0.11988	0.00077	3.032	0.025	0.11947	0.00079	1837	14	1948	12	5.7
D	61	57.1	316	101	0.32	0.294	2.737	0.056	0.13752	0.00121	2.745	0.057	0.13492	0.00136	2003	36	2163	18	7.4
D	65	61.1	168	28	0.16	0.376	2.451	0.033	0.15165	0.00151	2.461	0.033	0.14829	0.00177	2199	26	2326	21	5.5

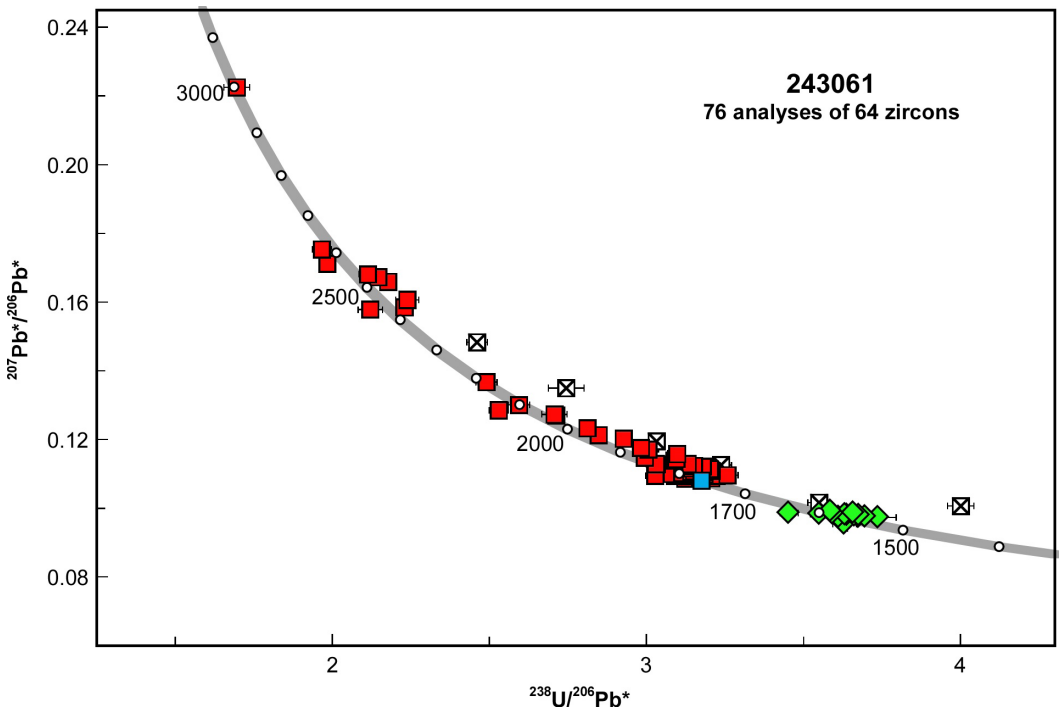

Figure 3. U–Pb analytical data for zircons from sample 243061: siliciclastic schist, Radiator prospect. Blue square indicates Group Y (youngest detrital zircon core); red squares indicate Group S (older detrital zircon cores); green diamonds indicate Group M (metamorphic zircon rims); crossed squares indicate Group D (discordance >5%, core–rim mixture, or high within-run variation). Three highly imprecise analyses in Group D are not shown

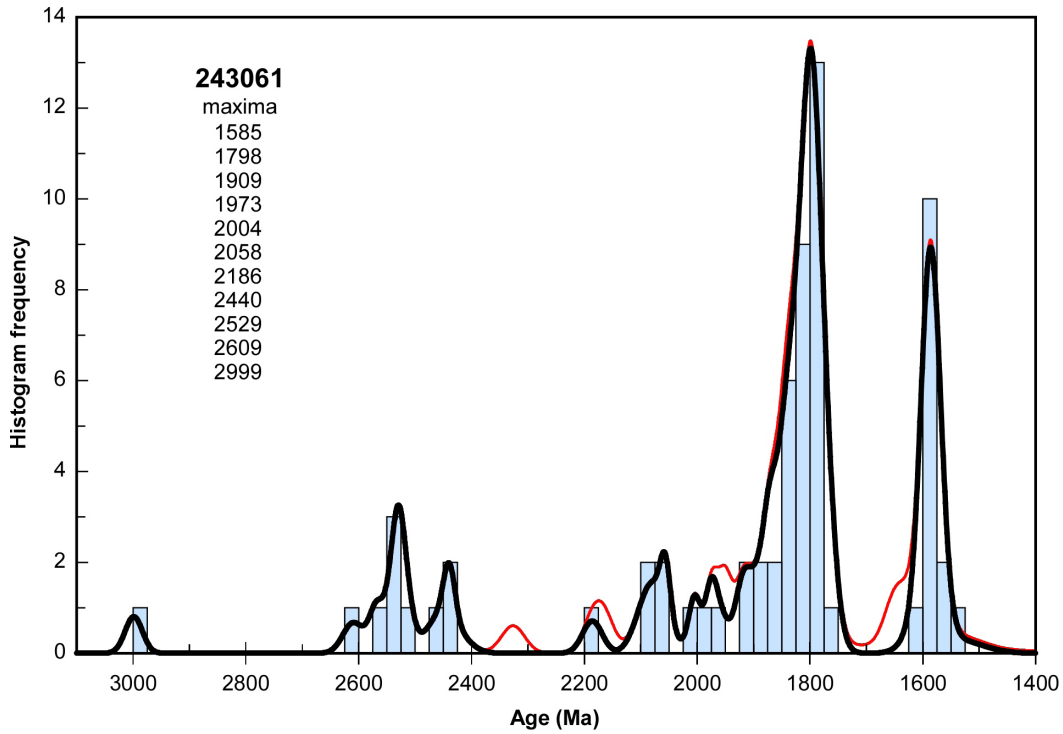

Figure 4. Probability density diagram and histogram for sample 243061: siliciclastic schist, Radiator prospect. Thick curve, maxima values, and frequency histogram (bin width 25 Ma) include only data in Groups Y, S and M (67 analyses of 58 zircons). Thin curve includes all data (76 analyses of 64 zircons)

Common-Pb corrections were applied to all analyses using contemporaneous isotopic compositions determined according to the model of Stacey and Kramers (1975).

Results

Seventy-six analyses were obtained from 64 zircons. Results are listed in Table 1, and shown in a concordia diagram (Fig. 3) and a probability density plot (Fig. 4).

Interpretation

The analyses are concordant to moderately discordant (Fig. 3). Eight analyses are >5% discordant and/or indicate high within-run variation of isotope ratios, and one analysis is interpreted to represent a mixture of core and rim material. The dates obtained from these nine analyses (Group D; Table 1) are unreliable, and are considered not to be geologically significant. The remaining 67 analyses can be divided into three groups, based on their $^{207}Pb^*/^{206}Pb^*$ and Th/U ratios, their U concentrations, and their positions within the crystals.

Group Y comprises one analysis of a zircon core (Table 1), which yields a $^{207}Pb^*/^{206}Pb^*$ date of 1766 ± 15 Ma (1σ). This analysis indicates a U concentration of 340 ppm, and a Th/U ratio of 0.23.

Group S comprises 52 analyses of 52 zircon cores (Table 1), which yield $^{207}Pb^*/^{206}Pb^*$ dates of 2999–1775 Ma. These analyses indicate U concentrations of 75–1256 ppm, with a median of 233 ppm, and Th/U ratios of 0.09 – 1.25, with a median of 0.35.

Group M comprises 14 analyses of 14 zircon rims (Table 1), which yield a weighted mean $^{207}Pb^*/^{206}Pb^*$ date of 1586 ± 8 Ma (MSWD = 0.44). These analyses indicate U concentrations of 524–807 ppm, with a median of 588 ppm, and Th/U ratios of 0.005 – 0.032, with a median of 0.005.

It is possible that all of the analyses in Groups Y and S are of unmodified detrital zircons, in which case the date of 1766 ± 15 Ma (1σ) for the single analysis in Group Y represents a maximum depositional age. A more conservative estimate of the maximum depositional age can be based on the weighted mean $^{207}Pb^*/^{206}Pb^*$ date of 1802 ± 7 Ma (MSWD = 1.1) for the youngest 26 analyses in Groups Y and S.

The data for combined Groups Y and S indicate significant age components at c. 2529, 2440, 2058, 1909, and 1798 Ma, based on contributions from approximately 4, 3, 3, 3, and 24 analyses, respectively (Fig. 4). 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 1586 ± 8 Ma for the 14 analyses in Group M is interpreted as the age of high-grade metamorphism.

References

Kirkland, CL, Wingate, MTD, Spaggiari CV and Tyler, IM 2009a, 184341: quartzite, Lake Mackay; Geochronology Record 818: Geological Survey of Western Australia, 5p.

Kirkland, CL, Wingate, MTD, Tyler, IM and Spaggiari, CV 2009b, 184367: metagranodiorite, Dwarf Well; Geochronology Record 846: Geological Survey of Western Australia, 4p.

Reddy, D 2012, Surrender Report, Webb Project E80/3820 East Pilbara Shire, Western Australia, Reporting period 30 January 2008 to 12 June 2012: Geological Survey of Western Australia, Mineral Exploration Report A94934 (unpublished), 22p.

Scrimgeour, IR 2013, Aileron Province: Chapter 12 in Ahmad M and Munson TJ (compilers). Geology and mineral resources of the Northern Territory. Northern Territory Geological Survey, Special Publication 5, p. 12:1 – 12:74.

Spaggiari, CV and Kelsey, DE (partial report), Dwarf Well Granite (P_-CNdw-mgm): Geological Survey of Western Australia, WA Geology Online, Explanatory Notes extract, viewed 25 March 2022, <www.dmp.wa.gov.au/ens>.

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.

Recommended reference for this publication

Wingate, MTD, Lu, Y, Fielding, IOH, Kelsey, DE and Spaggiari, CV 2022, 243061: siliciclastic schist, Radiator prospect; Geochronology Record 1389: Geological Survey of Western Australia, 6p.

Data obtained: 18 September 2020

Data released: 20 May 2022