194725: metagranite, Uraryie Rock

(Biranup Zone, Albany–Fraser Orogen)

Location and sampling

ZANTHUS (SH 51-15), COONANA (3535)
MGA Zone 51, 540851E 6541647N

Sampled on 4 July 2008

This sample was collected from an area of scattered outcrop approximately 8.3 km south of Uraryie Rock, 10.2 km west of the edge of Harris Lake, and 19.2 km southeast of Fly Dam.

Tectonic unit/relations

The unit sampled is a metagranite within the Biranup Zone, a belt of mid-crustal rocks that girdles the southern and southeastern margins of the Yilgarn Craton (Myers, 1990; Spaggiari et al., 2009; Kirkland et al., in press). The Biranup Zone is dominated by intensely deformed orthogneiss, paragneiss, and metagabbro, with ages of c. 1710 to 1620 Ma. Based on the presence of Archean granitic rocks, and on Sm–Nd and Lu–Hf isotopic signatures, the Biranup Zone is interpreted to have formed along the Yilgarn Craton margin (Kirkland et al., in press). The Biranup Zone was deformed and metamorphosed during the Zanthus Event at c. 1680 Ma, and was then 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., in press).

The metagranite at this locality is garnet-rich, and has a strong, gneissic, northeasterly trending foliation, and a well-developed mineral lineation plunging moderately to the northeast.

Petrographic description

The sample is a foliated metagranite, with a visually estimated mineralogy comprising 51% quartz, 18% plagioclase or plagioclase–K-feldspar intergrowths, 14% garnet, 9% biotite, 6% microcline, 1% titanite, and accessory opaque oxide minerals, hornblende, limonitized sulfide, altered allanite, apatite, and zircon. The rock is heterogeneous, and contains grains and aggregates of garnet from 0.5 to 12 mm long, containing inclusions of quartz, microcline, biotite, titanite, and zircon. The foliation is defined by biotite grains up to 2 mm, which are locally accompanied by titanite and/or hornblende and rare zircon. Some biotite also defines a decussate texture. Quartz is coarse-grained and anhedral, whereas microcline and plagioclase grains are fine-grained and commonly intergrown with K-feldspar. The feldspar intergrowths are too rich in K-feldspar to represent exsolution, and are likely a product of replacement. About one third of the plagioclase grains lack K-feldspar. Minor myrmekite is also present.

Zircon morphology

Zircons isolated from this sample are colourless to brown, euhedral, up to 400 μm long, and elongate, with aspect ratios up to 6:1. In cathodoluminescence (CL) images, the zircons display oscillatory zoned cores overgrown by homogeneous, low-uranium rims. A CL image of representative zircons is shown in Figure 1.

Analytical details

This sample was analysed over three sessions on 20–21 August 2009, using SHRIMP-A. Analyses 1.1 to 15.1 (spot numbers 1–17) were obtained during the first session, together with 12 analyses of the BR266 standard, of which six indicated an external spot-to-spot (reproducibility) uncertainty of 1.12% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.47% (1σ). Analyses 18.1 to 19.1 (spot numbers 18–20) were obtained during the second session, together with four analyses of the BR266 standard, of which four indicated an external spot-to-spot (reproducibility) uncertainty of 0.50% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.38% (1σ). Analyses 14.2 to 36.1 (spot numbers 21–43) were obtained during the third session, together with nine analyses of the BR266 standard, of which seven indicated an external spot-to-spot (reproducibility) uncertainty of 2.76% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 1.03% (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

Forty-five analyses were obtained from 36 zircons. Results are listed in Table 1, and shown in concordia diagrams (Figs 2 and 4) and an X–Y correlation plot (Fig. 3).

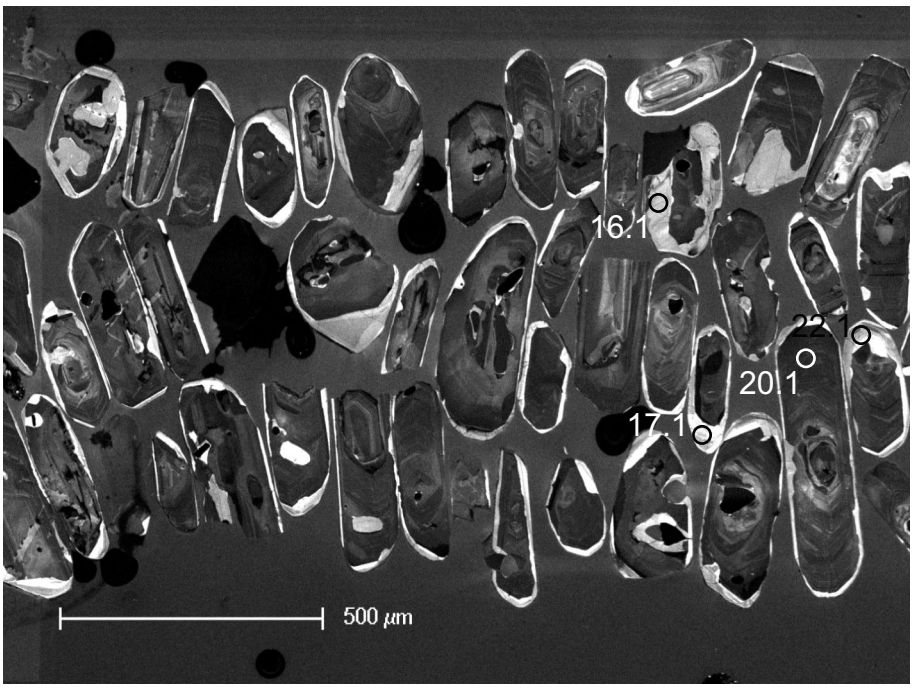

Figure 1. Cathodoluminescence image of representative zircons from sample 194725: metagranite, Uraryie Rock. Numbered circles indicate the approximate positions of analysis sites.

Interpretation

The analyses are concordant to strongly discordant (Fig. 2). Seventeen analyses are >5% discordant. Of these, seven (Group D; Table 1) are imprecise or unreliable, and are not considered geologically significant. The remaining ten are considered in Group M. The $^{207}Pb^*/^{206}Pb^*$ dates in Group M correlate with their common-Pb contents (*f*204, Fig. 3), indicating that common-Pb corrections using ^{204}Pb are inaccurate for some or all of these analyses. The date for Group M is therefore determined from the intersection with the concordia curve (Fig. 4) of a regression through uncorrected data, anchored at contemporaneous initial Pb ($^{207}Pb/^{206}Pb$ = 0.9257 at 1200 Ma; Stacey and Kramers, 1975). Those analyses not in Group D define three groups, based on their $^{207}Pb^*/^{206}Pb^*$ ratios, and their analytical positions within the crystals.

Group I comprises 16 analyses of 16 zircons (Table 1), which yield a weighted mean $^{207}Pb^*/^{206}Pb^*$ date of 1677 ± 5 Ma (MSWD = 0.58). These analyses indicate moderate Th/U ratios (0.23 – 0.45).

Group P comprises three analyses of three zircons (Table 1), which yield $^{207}Pb^*/^{206}Pb^*$ dates of 1651–1635 Ma. These analyses indicate moderate Th/U ratios (0.31 – 0.42).

Group M comprises 19 analyses of 19 zircon rims (Table 1), for which the regression intersects the concordia curve at 1206 ± 14 Ma (MSWD = 1.4). These analyses indicate very low Th/U ratios (0.001 – 0.110).

The date of 1677 ± 5 Ma for the 16 analyses in Group I is interpreted as the magmatic crystallization age of the granite. The dates of 1651–1635 Ma for the three analyses in Group P are interpreted to reflect minor ancient radiogenic-Pb loss. The date of 1206 ± 14 Ma for the 19 analyses in Group M is interpreted as the age of metamorphism.

References

Clark, DJ, Hensen, BJ and Kinny, PD 2000, Geochronological constraints for a two-stage history of the Albany–Fraser Orogen, Western Australia: Precambrian Research, v. 102, p. 155–183.

Kirkland, CL, Spaggiari, CV, Pawley, MJ, Wingate, MTD, Smithies, RH, Howard, HM, Tyler, IM, Belousova, EA and Poujol, M in press, On the edge: U–Pb, Lu–Hf, and Sm–Nd data suggests reworking of the Yilgarn Craton margin during formation of the Albany–Fraser Orogen: Precambrian Research.

Myers, JS 1990, Albany–Fraser Orogen, *in* Geology and mineral resources of Western Australia: Geological Survey of Western Australia, Memoir 3, p. 255–263.

Spaggiari, CV, Bodorkos, S, Barquero-Molina, M, Tyler, IM and Wingate, MTD 2009, Interpreted bedrock geology of the south Yilgarn and central Albany–Fraser Orogen, Western Australia: Geological Survey of Western Australia, Record 2009/10, 84p.

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

Kirkland, CL, Wingate, MTD and Spaggiari, CV 2011, 194725: metagranite, Uraryie Rock; Geochronology Record 994: Geological Survey of Western Australia, 6p.

Data obtained: 21 August 2010
Data released: 30 June 2011

Table 1. Ion microprobe analytical results for zircons from sample 194725: metagranite, Uraryie Rock

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	11	11.1	187	78	0.43	0.088	3.397	0.049	0.10251	0.00071	3.400	0.049	0.10175	0.00079	1662	22	1656	14	-0.4
I	9	9.1	241	92	0.39	-0.011	3.336	0.046	0.10238	0.00057	3.336	0.046	0.10248	0.00058	1690	21	1669	10	-1.2
I	15	13.2	271	111	0.42	-0.028	3.400	0.047	0.10225	0.00053	3.400	0.047	0.10249	0.00055	1662	20	1670	10	0.4
I	31	27.2	250	97	0.40	0.030	3.240	0.098	0.10277	0.00055	3.241	0.098	0.10251	0.00057	1734	47	1670	10	-3.8
I	38	32.1	336	143	0.44	0.008	3.277	0.099	0.10261	0.00049	3.277	0.099	0.10254	0.00050	1717	47	1671	9	-2.8
I	10	10.1	111	45	0.42	0.025	3.293	0.051	0.10292	0.00086	3.293	0.051	0.10270	0.00089	1709	24	1673	16	-2.1
I	34	29.1	227	94	0.43	0.011	3.459	0.105	0.10284	0.00058	3.459	0.105	0.10274	0.00058	1637	45	1674	11	2.2
I	4	4.1	302	119	0.41	-0.009	3.389	0.046	0.10269	0.00052	3.388	0.046	0.10277	0.00052	1667	20	1675	9	0.5
I	2	2.1	277	113	0.42	0.030	3.400	0.047	0.10310	0.00055	3.401	0.047	0.10284	0.00057	1662	20	1676	10	0.9
I	6	6.1	262	111	0.44	0.075	3.369	0.046	0.10363	0.00057	3.372	0.046	0.10298	0.00062	1674	21	1679	11	0.3
I	20	19.1	252	56	0.23	0.059	3.414	0.032	0.10357	0.00059	3.416	0.032	0.10306	0.00064	1655	14	1680	11	1.5
I	3	3.1	270	110	0.42	0.019	3.448	0.047	0.10333	0.00053	3.448	0.047	0.10316	0.00055	1641	20	1682	10	2.4
I	19	18.2	291	102	0.36	0.063	3.525	0.033	0.10393	0.00060	3.527	0.033	0.10338	0.00064	1609	13	1686	11	4.5
I	5	5.1	199	88	0.45	0.000	3.461	0.049	0.10345	0.00063	3.461	0.049	0.10345	0.00063	1636	21	1687	11	3.0
I	7	7.1	281	118	0.43	0.000	3.386	0.046	0.10358	0.00052	3.386	0.046	0.10358	0.00052	1668	20	1689	9	1.3
I	37	31.2	94	37	0.41	0.000	3.296	0.103	0.10375	0.00090	3.296	0.103	0.10375	0.00090	1708	48	1692	16	-1.0
P	8	8.1	153	46	0.31	0.053	3.396	0.050	0.10104	0.00071	3.398	0.050	0.10058	0.00076	1663	22	1635	14	-1.7
P	23	21.1	382	154	0.42	0.038	3.281	0.098	0.10154	0.00047	3.282	0.098	0.10121	0.00050	1714	46	1646	9	-4.1
P	12	12.1	394	144	0.38	0.007	3.534	0.047	0.10154	0.00046	3.534	0.047	0.10148	0.00046	1606	19	1651	8	2.7
M	32	27.3	65	0	0.00	0.061	4.759	0.313	0.07724	0.00109	4.762	0.313	0.07673	0.00121	1229	78	1114	31	-10.3
M	42	35.1	63	3	0.05	0.705	5.391	0.220	0.08277	0.00232	5.430	0.223	0.07684	0.00417	1090	43	1117	108	2.4
M	29	26.1	80	0	0.00	0.237	4.805	0.151	0.07945	0.00098	4.817	0.152	0.07745	0.00133	1216	36	1133	34	-7.3
M	25	23.1	60	0	0.00	0.160	4.770	0.155	0.07884	0.00129	4.778	0.155	0.07749	0.00160	1225	37	1134	41	-8.0
M	26	24.1	58	2	0.04	0.751	4.839	0.156	0.08406	0.00129	4.875	0.157	0.07773	0.00240	1203	37	1140	61	-5.5
M	41	34.1	52	0	0.00	0.242	4.694	0.154	0.07995	0.00130	4.705	0.154	0.07791	0.00175	1242	38	1145	45	-8.5
M	40	12.3	39	0	0.00	0.097	4.589	0.154	0.07891	0.00139	4.593	0.155	0.07809	0.00162	1270	40	1149	41	-10.5
M	43	36.1	72	0	0.00	0.250	4.538	0.143	0.08066	0.00102	4.550	0.144	0.07855	0.00140	1281	38	1161	35	-10.3
M	21	14.2	85	0	0.00	0.047	4.717	0.148	0.07958	0.00098	4.719	0.148	0.07918	0.00105	1239	36	1177	26	-5.3
M	36	31.1	39	0	0.00	0.103	4.656	0.157	0.08023	0.00146	4.660	0.157	0.07936	0.00170	1253	40	1181	42	-6.1
M	30	27.1	72	8	0.11	0.130	5.154	0.164	0.08112	0.00117	5.161	0.164	0.08002	0.00141	1142	34	1197	35	4.6
M	1	16.1	63	0	0.00	0.170	4.905	0.064	0.08172	0.00109	4.914	0.065	0.08029	0.00138	1194	15	1204	34	0.8
M	2	17.1	71	0	0.01	-0.052	4.802	0.231	0.08000	0.00103	4.799	0.231	0.08044	0.00112	1220	56	1208	27	-1.0
M	16	14.1	79	0	0.00	0.098	4.909	0.081	0.08143	0.00101	4.914	0.081	0.08061	0.00117	1194	18	1212	29	1.5
M	13	6.2	79	0	0.00	-0.095	4.887	0.252	0.07989	0.00100	4.882	0.252	0.08070	0.00115	1201	59	1214	28	1.1
M	39	33.1	104	0	0.00	-0.035	4.813	0.150	0.08100	0.00085	4.812	0.150	0.08129	0.00090	1217	36	1229	22	0.9
M	17	15.1	52	0	0.00	-0.147	5.005	0.091	0.08013	0.00126	4.997	0.091	0.08138	0.00154	1176	20	1231	37	4.4
M	24	22.1	103	0	0.00	0.047	4.841	0.151	0.08186	0.00101	4.843	0.151	0.08146	0.00108	1210	35	1233	26	1.8
M	33	28.1	49	0	0.00	-0.080	4.840	0.159	0.08508	0.00135	4.836	0.159	0.08576	0.00152	1212	37	1333	34	9.1
D	28	25.1	135	13	0.10	0.372	14.578	0.929	0.08017	0.00139	14.633	0.933	0.07704	0.00210	426	28	1122	54	62.0
D	14	13.1	132	8	0.06	0.165	7.257	0.109	0.08134	0.00094	7.269	0.109	0.07994	0.00118	831	12	1196	29	30.5
D	35	30.1	68	1	0.02	0.000	5.903	0.194	0.08065	0.00160	5.903	0.194	0.08065	0.00160	1009	32	1213	39	16.8

Table 1. (continued)

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. (%)
D	1	1.1	106	72	0.70	0.000	4.423	0.094	0.10059	0.00242	4.423	0.094	0.10059	0.00242	1314	26	1635	45	19.6
D	27	24.2	312	116	0.38	-0.008	3.211	0.097	0.10141	0.00052	3.211	0.097	0.10149	0.00052	1748	47	1651	10	-5.8
D	22	20.1	255	104	0.42	0.031	3.225	0.097	0.10201	0.00056	3.226	0.097	0.10173	0.00058	1740	47	1656	11	-5.1
D	18	18.1	280	106	0.39	0.121	3.595	0.030	0.10374	0.00050	3.600	0.030	0.10270	0.00057	1580	12	1673	10	5.6

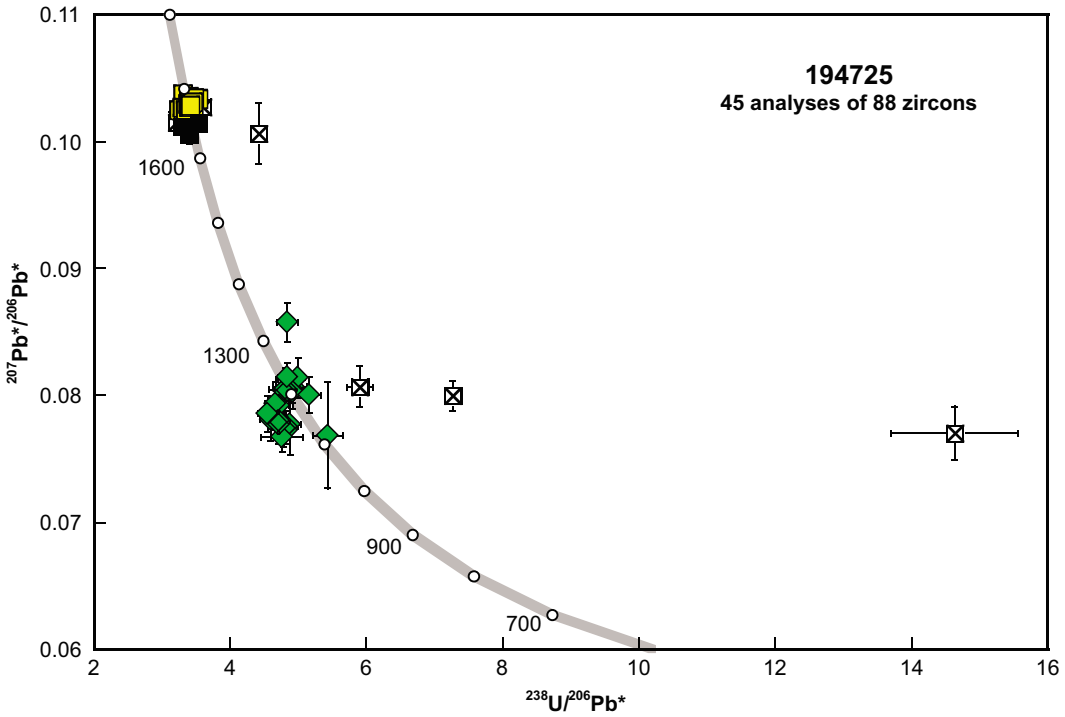

Figure 2. U–Pb analytical data for zircons from sample 194725: metagranite, Uraryie Rock. Yellow squares indicate Group I (magmatic zircons); black squares indicate Group P (radiogenic-Pb loss); green diamonds indicate Group M (metamorphic zircon); crossed squares indicate Group D (discordance >5%).

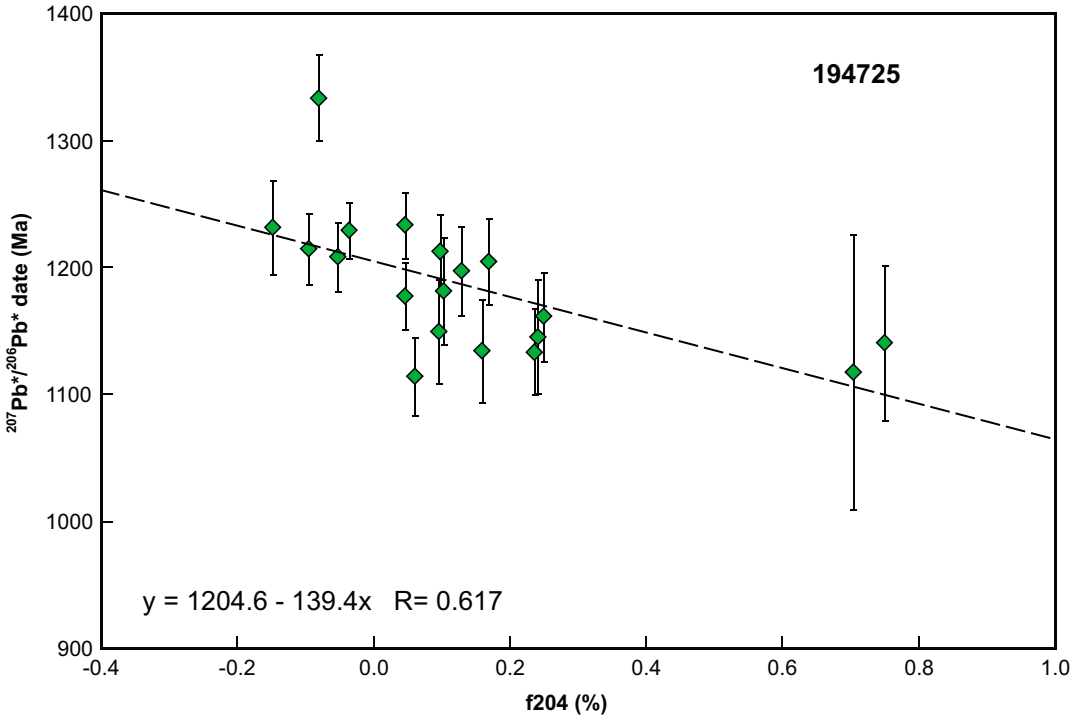

Figure 3. Correlation between $^{207}Pb^*/^{206}Pb^*$ age (corrected for common Pb using measured ^{204}Pb) and *f*204 for Group M zircon analyses in sample 194725: metagranite, Uraryie Rock. The dashed line indicates a regression through data in Group M; the equation of the best-fit line is shown. R is Pearson's correlation coefficient. Symbols as in Figure 2.

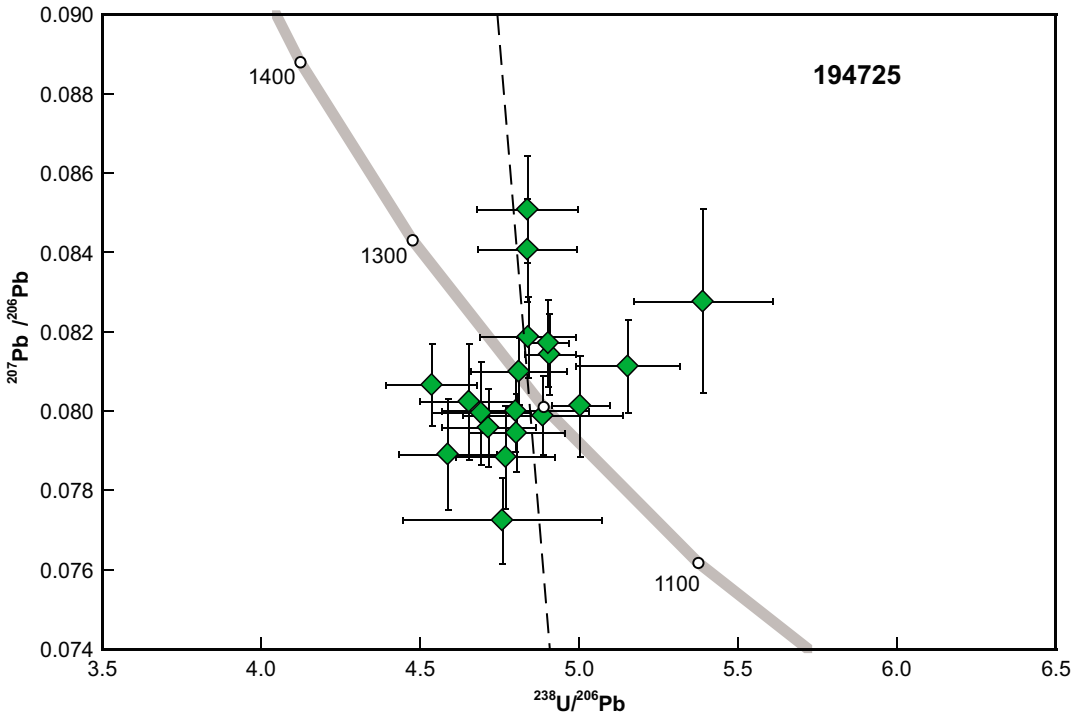

Figure 4. **U–Pb analytical data, not corrected for common Pb, for Group M zircons from sample 194725: metagranite, Uraryie Rock. The dashed line indicates a regression from initial Pb. Symbols as in Figure 2.**