

# 148970: quartz sandstone, Carnoby Well

## Location and sampling

EDMUND (SF 50-14), EDMUND (2150)  
MGA Zone 50, 400408E 7383044N

Sampled on 26 September 2004

The sample was taken from a thick, steeply north-dipping bed of medium-grained quartz sandstone with well-developed trough cross-stratification, 1.8 km north-northwest of Carnoby Well. The rock is moderately fresh; although feldspars are altered to clay minerals, scattered heavy minerals are preserved.

## Tectonic unit/relations

This quartz sandstone occurs within the upper part of the Gooragoora Formation of the lower Edmund Group, Edmund Basin. The Gooragoora Formation conformably overlies the Irregularly Formation, and is conformably overlain by the Blue Billy Formation (Martin and Thorne, 2002; Martin et al., 2005). A minimum age for the Gooragoora Formation is provided by the c. 1465 Ma dolerite sills that intrude the Edmund Group (Wingate, 2002), and a maximum age is provided by 1680–1620 Ma granites of the Durlacher Supersuite in the underlying Gascoyne Complex (Martin et al., 2005; Sheppard et al., 2005).

## Petrographic description

This rock is a quartz-rich sandstone that contains irregular lenses rich in limonite or hematite. It is dominated (80–85%) by deformed single-crystal quartz grains up to 0.8 mm in diameter, as well as 5–10% interstitial, fine-grained quartz that has been recrystallised. Minor constituents include colloform-banded kaolinite (10%) in limonite-free areas, colloform-banded limonite or sparse limonite-rimmed voids (5%), and kaolinite in limonite-rich areas (5%). The clay patches are mostly about 1 mm in diameter, and the limonite patches are up to 2 mm long. The single-crystal quartz grains have undulose extinction and sutured grain boundaries. No heavy minerals were observed, and the limonite may have replaced carbonate minerals. The kaolinite may represent former feldspar grains although there is no obvious textural preservation.

## Zircon morphology

The zircons isolated from this sample are anhedral to subhedral, variably rounded, and range from clear and

colourless to dark brown or opaque. They are up to 300  $\mu\text{m}$  long, with aspect ratios up to 4:1. Concentric growth zoning is common, and typically is truncated at (abraded) grain boundaries. Several zircons exhibit disrupted internal structures indicative of alteration. A cathodoluminescence image of representative zircons is shown in Figure 1.

## Analytical details

This sample was analysed on 4–6 April 2005, using the SHRIMP-II ion microprobe at the Research School of Earth Sciences, Australian National University. Twenty-two analyses of the CZ3 standard were obtained, and following deletion of one analysis as an outlier, the remaining 21 analyses indicated an external spot-to-spot (reproducibility) uncertainty of 2.65% ( $1\sigma$ ) and a  $^{238}\text{U}/^{206}\text{Pb}^*$  calibration uncertainty of 0.60% ( $1\sigma$ ). Common-Pb corrections were applied to all analyses using common-Pb isotopic compositions determined by the method of Stacey and Kramers (1975).

## Results

Sixty-one analyses were obtained from 60 zircons, with one grain (32) analysed twice. Results are listed in Table 1, and shown in a concordia diagram (Fig. 2) and a probability density diagram (Fig. 3).

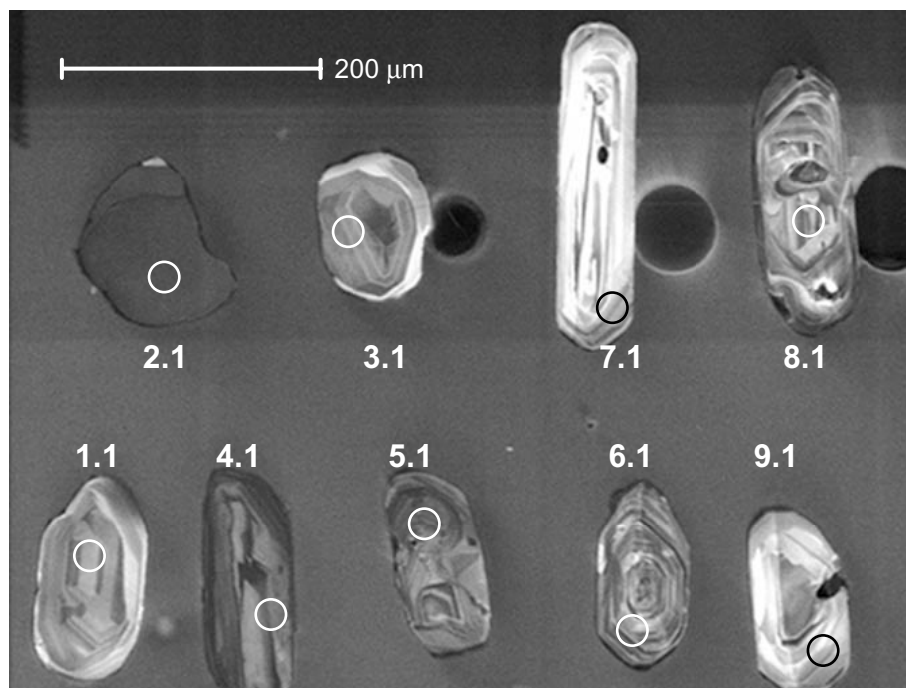
## Interpretation

The analyses are mostly concordant (Fig. 2), with seven analyses characterised by moderate to strong discordance ( $>5\%$ ). The dates obtained from these seven analyses (Group D; Table 1) are imprecise or unreliable, and are not considered geologically significant. The remaining 54 analyses can be divided into two groups, based on their  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  ratios.

Group 1 comprises 19 analyses of 19 zircons (Table 1), which yielded a weighted mean  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  date of  $1749 \pm 9$  Ma (MSWD = 1.55).

Group 2 comprises 35 analyses of 35 zircons (Table 1), which yielded  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  dates of 2634–1773 Ma.

It is possible that all of the analyses are of unmodified detrital zircons, in which case the  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  date of  $1664 \pm 71$  Ma ( $1\sigma$ ) for analysis 24.1 represents the maximum age for deposition of the sandstone. However, the date of  $1749 \pm 9$  Ma yielded by the 19 analyses in Group 1 represents a more robust estimate of the maximum



**Figure 1. Cathodoluminescence image of representative zircons from sample 148970: quartz sandstone, Carnoby Well. Numbered circles indicate approximate positions of analysis sites**

depositional age. Using a maximum-likelihood mixture-modelling approach (Sambridge and Compston, 1994), Martin et al. (2007) determined a maximum depositional age of  $1733 \pm 12$  Ma from the same data.

The 35 analyses in Group 2 indicate  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  dates that define significant age components (based on three or more analyses) at c. 1780 and c. 1970 Ma, and several minor components spanning the range 2634–1773 Ma (Fig. 3). These are interpreted as the ages of zircon-bearing rocks in the source region of the sandstone.

## References

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## Recommended reference for this publication

WINGATE, M. T. D., BODORKOS, S., and SIRCOMBE, K. N., 2007, 148970: quartz sandstone, Carnoby Well; Geochronology dataset 687, in Compilation of geochronology data: Western Australia Geological Survey.

Date analysed: 6 April 2005

Date released: 30 June 2007

Table 1. Ion microprobe analytical results for zircons from sample 148970: quartz sandstone, Carnaby Well

Grp no.	Spot no.	Grain .spot	<sup>238</sup> U (ppm)	<sup>232</sup> Th (ppm)	<sup>232</sup> Th/ <sup>238</sup> U	f <sub>204</sub> (%)	<sup>238</sup> U/ <sup>206</sup> Pb ±1σ	<sup>207</sup> Pb/ <sup>206</sup> Pb ±1σ	<sup>238</sup> U/ <sup>206</sup> Pb* ±1σ	<sup>207</sup> Pb*/ <sup>206</sup> Pb* ±1σ	<sup>238</sup> U/ <sup>206</sup> Pb* date (Ma) ±1σ	<sup>207</sup> Pb*/ <sup>206</sup> Pb* date (Ma) ±1σ	Disc (%)
1	24	24.1	25	23	0.96	0.756	3.457 ± 0.112	0.10871 ± 0.00199	3.483 ± 0.114	0.10215 ± 0.00393	1627 ± 47	1664 ± 71	2.2
1	3	3.1	128	191	1.55	0.556	3.236 ± 0.089	0.11024 ± 0.00084	3.254 ± 0.090	0.10541 ± 0.00174	1727 ± 42	1722 ± 30	-0.3
1	10	10.1	76	83	1.14	0.278	3.288 ± 0.095	0.10789 ± 0.00107	3.298 ± 0.095	0.10547 ± 0.00205	1707 ± 43	1723 ± 36	0.9
1	11	11.1	73	107	1.52	0.318	3.201 ± 0.093	0.10829 ± 0.00111	3.211 ± 0.094	0.10553 ± 0.00140	1748 ± 45	1724 ± 24	-1.4
1	13	13.1	614	764	1.29	0.241	3.380 ± 0.095	0.10765 ± 0.00042	3.388 ± 0.095	0.10555 ± 0.00062	1667 ± 41	1724 ± 11	3.3
1	4	4.1	348	245	0.73	0.087	3.180 ± 0.086	0.10640 ± 0.00049	3.183 ± 0.086	0.10564 ± 0.00056	1761 ± 42	1726 ± 10	-2.1
1	9	9.1	71	90	1.31	0.339	3.232 ± 0.099	0.10901 ± 0.00112	3.243 ± 0.099	0.10606 ± 0.00152	1733 ± 47	1733 ± 26	0.0
1	33	32.2	369	136	0.38	0.030	3.275 ± 0.088	0.10672 ± 0.00051	3.276 ± 0.088	0.10646 ± 0.00054	1717 ± 41	1740 ± 9	1.3
1	28	28.1	85	89	1.08	0.173	3.176 ± 0.091	0.10840 ± 0.00106	3.182 ± 0.092	0.10690 ± 0.00149	1762 ± 44	1747 ± 25	-0.8
1	29	29.1	106	76	0.74	0.176	3.146 ± 0.088	0.10859 ± 0.00095	3.152 ± 0.088	0.10706 ± 0.00098	1776 ± 44	1750 ± 17	-1.5
1	18	18.1	153	156	1.05	0.165	3.223 ± 0.090	0.10870 ± 0.00077	3.229 ± 0.090	0.10726 ± 0.00098	1739 ± 42	1753 ± 17	0.8
1	45	44.1	231	270	1.21	0.237	3.370 ± 0.092	0.10951 ± 0.00061	3.378 ± 0.092	0.10745 ± 0.00098	1671 ± 40	1757 ± 17	4.8
1	49	48.1	62	47	0.78	0.412	3.107 ± 0.089	0.11111 ± 0.00118	3.120 ± 0.090	0.10752 ± 0.00181	1792 ± 45	1758 ± 31	-2.0
1	19	19.1	90	64	0.74	0.064	3.207 ± 0.096	0.10824 ± 0.00101	3.209 ± 0.096	0.10769 ± 0.00109	1749 ± 46	1761 ± 18	0.7
1	7	7.1	88	95	1.11	0.168	3.278 ± 0.092	0.10926 ± 0.00100	3.283 ± 0.092	0.10780 ± 0.00108	1714 ± 42	1763 ± 18	2.8
1	51	50.1	153	119	0.80	0.101	3.157 ± 0.087	0.10885 ± 0.00075	3.160 ± 0.087	0.10797 ± 0.00090	1773 ± 43	1765 ± 15	-0.4
1	16	16.1	374	385	1.06	0.093	3.177 ± 0.086	0.10891 ± 0.00050	3.180 ± 0.086	0.10810 ± 0.00057	1763 ± 42	1768 ± 10	0.3
1	2	2.1	292	515	1.82	0.158	3.222 ± 0.090	0.10950 ± 0.00055	3.227 ± 0.090	0.10813 ± 0.00060	1740 ± 43	1768 ± 10	1.6
1	40	39.1	135	217	1.66	0.165	3.304 ± 0.091	0.10958 ± 0.00083	3.309 ± 0.092	0.10814 ± 0.00092	1702 ± 41	1768 ± 16	3.7
2	17	17.1	319	619	2.01	0.037	3.168 ± 0.086	0.10875 ± 0.00054	3.170 ± 0.086	0.10843 ± 0.00055	1768 ± 42	1773 ± 9	0.3
2	6	6.1	140	101	0.74	0.092	3.295 ± 0.092	0.10934 ± 0.00079	3.298 ± 0.092	0.10855 ± 0.00081	1707 ± 42	1775 ± 14	3.8
2	15	15.1	536	366	0.71	0.061	3.060 ± 0.082	0.10928 ± 0.00043	3.062 ± 0.082	0.10875 ± 0.00050	1822 ± 43	1779 ± 8	-2.4
2	27	27.1	157	152	1.00	0.195	3.151 ± 0.087	0.11046 ± 0.00086	3.157 ± 0.087	0.10876 ± 0.00107	1774 ± 43	1779 ± 18	0.3
2	25	25.1	205	288	1.45	0.064	3.168 ± 0.086	0.10942 ± 0.00068	3.170 ± 0.086	0.10886 ± 0.00073	1768 ± 42	1780 ± 12	0.7
2	34	33.1	154	168	1.13	0.166	3.051 ± 0.084	0.11032 ± 0.00082	3.056 ± 0.085	0.10887 ± 0.00094	1825 ± 44	1781 ± 16	-2.5
2	8	8.1	182	272	1.54	0.069	3.303 ± 0.090	0.10997 ± 0.00089	3.305 ± 0.090	0.10937 ± 0.00090	1704 ± 41	1789 ± 15	4.8
2	41	40.1	60	59	1.01	0.219	3.257 ± 0.095	0.11129 ± 0.00126	3.264 ± 0.095	0.10937 ± 0.00175	1723 ± 44	1789 ± 29	3.7
2	5	5.1	243	205	0.87	0.069	3.149 ± 0.085	0.11002 ± 0.00061	3.151 ± 0.086	0.10942 ± 0.00068	1777 ± 42	1790 ± 11	0.7
2	57	56.1	262	461	1.82	0.143	3.105 ± 0.087	0.11068 ± 0.00063	3.109 ± 0.087	0.10943 ± 0.00076	1798 ± 44	1790 ± 13	-0.4
2	60	59.1	167	108	0.67	0.101	3.088 ± 0.088	0.11040 ± 0.00079	3.091 ± 0.088	0.10952 ± 0.00089	1807 ± 45	1791 ± 15	-0.8
2	55	54.1	104	81	0.81	0.394	3.083 ± 0.087	0.11296 ± 0.00101	3.096 ± 0.087	0.10953 ± 0.00145	1805 ± 44	1792 ± 24	-0.7
2	39	38.1	290	114	0.40	0.026	3.106 ± 0.084	0.10987 ± 0.00057	3.107 ± 0.084	0.10965 ± 0.00058	1799 ± 42	1794 ± 10	-0.3
2	44	43.1	119	104	0.90	0.028	3.156 ± 0.089	0.10995 ± 0.00092	3.157 ± 0.089	0.10970 ± 0.00109	1774 ± 44	1794 ± 18	1.2
2	21	21.1	235	170	0.75	0.058	3.186 ± 0.087	0.11023 ± 0.00064	3.188 ± 0.087	0.10972 ± 0.00066	1759 ± 42	1795 ± 11	2.0
2	56	55.1	119	115	0.99	0.157	2.962 ± 0.084	0.11110 ± 0.00093	2.967 ± 0.084	0.10974 ± 0.00101	1872 ± 46	1795 ± 17	-4.3
2	38	37.1	135	59	0.45	0.222	3.103 ± 0.086	0.11169 ± 0.00086	3.109 ± 0.086	0.10976 ± 0.00117	1798 ± 44	1795 ± 19	-0.1
2	46	45.1	122	85	0.72	0.172	3.121 ± 0.086	0.11129 ± 0.00084	3.126 ± 0.087	0.10978 ± 0.00110	1789 ± 43	1796 ± 18	0.4
2	35	34.1	149	179	1.24	0.000	3.222 ± 0.089	0.11004 ± 0.00083	3.222 ± 0.089	0.11004 ± 0.00091	1743 ± 42	1800 ± 15	3.2
2	14	14.1	124	142	1.19	0.051	3.251 ± 0.090	0.11058 ± 0.00083	3.253 ± 0.090	0.11014 ± 0.00088	1728 ± 42	1802 ± 15	4.1
2	50	49.1	81	121	1.54	-0.068	3.237 ± 0.091	0.10982 ± 0.00105	3.234 ± 0.091	0.11041 ± 0.00110	1737 ± 43	1806 ± 18	3.9
2	22	22.1	205	128	0.64	0.160	3.213 ± 0.088	0.11201 ± 0.00069	3.218 ± 0.088	0.11062 ± 0.00085	1744 ± 42	1810 ± 14	3.6
2	53	52.1	228	208	0.94	0.066	3.100 ± 0.084	0.11183 ± 0.00061	3.102 ± 0.084	0.11126 ± 0.00064	1801 ± 43	1820 ± 10	1.0

Table 1. (continued)

Grp no.	Spot no.	Grain .spot	$^{238}\text{U}$ (ppm)	$^{232}\text{Th}$ (ppm)	$^{232}\text{Th}/^{238}\text{U}$	$f^{204}$ (%)	$^{238}\text{U}/^{206}\text{Pb}$ $\pm 1\sigma$	$^{207}\text{Pb}/^{206}\text{Pb}$ $\pm 1\sigma$	$^{238}\text{U}/^{206}\text{Pb}^*$ $\pm 1\sigma$	$^{207}\text{Pb}^*/^{206}\text{Pb}^*$ $\pm 1\sigma$	$^{238}\text{U}/^{206}\text{Pb}^*$ date (Ma) $\pm 1\sigma$	$^{207}\text{Pb}^*/^{206}\text{Pb}^*$ date (Ma) $\pm 1\sigma$	Disc (%)
2	1	1.1	116	186	1.66	-0.073	3.167 $\pm$ 0.089	0.11085 $\pm$ 0.00088	3.164 $\pm$ 0.089	0.11149 $\pm$ 0.00097	1770 $\pm$ 43	1824 $\pm$ 16	2.9
2	54	53.1	337	327	1.00	0.023	3.043 $\pm$ 0.082	0.11179 $\pm$ 0.00051	3.044 $\pm$ 0.082	0.11159 $\pm$ 0.00052	1831 $\pm$ 43	1825 $\pm$ 9	-0.3
2	26	26.1	360	294	0.84	0.074	2.783 $\pm$ 0.075	0.12106 $\pm$ 0.00054	2.785 $\pm$ 0.075	0.12041 $\pm$ 0.00060	1978 $\pm$ 46	1962 $\pm$ 9	-0.8
2	42	41.1	221	97	0.45	0.074	2.826 $\pm$ 0.077	0.12189 $\pm$ 0.00065	2.828 $\pm$ 0.077	0.12124 $\pm$ 0.00069	1952 $\pm$ 46	1975 $\pm$ 10	1.2
2	47	46.1	309	212	0.71	0.049	2.810 $\pm$ 0.076	0.12270 $\pm$ 0.00066	2.812 $\pm$ 0.076	0.12227 $\pm$ 0.00072	1962 $\pm$ 46	1990 $\pm$ 10	1.4
2	30	30.1	65	22	0.35	0.155	2.745 $\pm$ 0.080	0.12525 $\pm$ 0.00175	2.749 $\pm$ 0.080	0.12389 $\pm$ 0.00177	2000 $\pm$ 50	2013 $\pm$ 25	0.6
2	58	57.1	383	846	2.28	0.147	2.486 $\pm$ 0.067	0.14343 $\pm$ 0.00055	2.489 $\pm$ 0.067	0.14213 $\pm$ 0.00064	2177 $\pm$ 50	2253 $\pm$ 8	3.4
2	12	12.1	154	65	0.44	0.002	2.151 $\pm$ 0.059	0.16201 $\pm$ 0.00080	2.152 $\pm$ 0.059	0.16200 $\pm$ 0.00082	2461 $\pm$ 56	2477 $\pm$ 8	0.6
2	31	31.1	250	190	0.78	0.107	2.203 $\pm$ 0.060	0.16507 $\pm$ 0.00065	2.206 $\pm$ 0.060	0.16411 $\pm$ 0.00072	2410 $\pm$ 55	2498 $\pm$ 7	3.5
2	20	20.1	134	117	0.91	0.087	2.112 $\pm$ 0.058	0.17081 $\pm$ 0.00088	2.114 $\pm$ 0.058	0.17003 $\pm$ 0.00089	2497 $\pm$ 57	2558 $\pm$ 9	2.4
2	52	51.1	128	83	0.67	0.026	1.976 $\pm$ 0.054	0.17735 $\pm$ 0.00086	1.976 $\pm$ 0.054	0.17712 $\pm$ 0.00095	2640 $\pm$ 60	2626 $\pm$ 9	-0.5
2	36	35.1	124	54	0.45	0.105	1.986 $\pm$ 0.055	0.17891 $\pm$ 0.00093	1.988 $\pm$ 0.055	0.17798 $\pm$ 0.00101	2627 $\pm$ 60	2634 $\pm$ 9	0.3
D	61	60.1	540	729	1.40	0.129	2.054 $\pm$ 0.055	0.18721 $\pm$ 0.00050	2.057 $\pm$ 0.055	0.18605 $\pm$ 0.00056	2554 $\pm$ 57	2708 $\pm$ 5	5.7
D	32	32.1	203	118	0.60	0.068	3.437 $\pm$ 0.094	0.10763 $\pm$ 0.00067	3.439 $\pm$ 0.094	0.10704 $\pm$ 0.00071	1645 $\pm$ 40	1750 $\pm$ 12	6.0
D	23	23.1	202	107	0.54	-0.008	3.469 $\pm$ 0.095	0.10694 $\pm$ 0.00067	3.468 $\pm$ 0.095	0.10701 $\pm$ 0.00067	1633 $\pm$ 40	1749 $\pm$ 11	6.6
D	48	47.1	653	1106	1.75	0.144	3.507 $\pm$ 0.094	0.11017 $\pm$ 0.00038	3.512 $\pm$ 0.094	0.10892 $\pm$ 0.00050	1615 $\pm$ 38	1781 $\pm$ 8	9.3
D	43	42.1	71	285	4.17	0.559	3.856 $\pm$ 0.110	0.11160 $\pm$ 0.00123	3.877 $\pm$ 0.111	0.10675 $\pm$ 0.00201	1479 $\pm$ 38	1745 $\pm$ 34	15.2
D	59	58.1	805	2888	3.71	0.296	2.799 $\pm$ 0.075	0.16262 $\pm$ 0.00110	2.808 $\pm$ 0.075	0.15998 $\pm$ 0.00116	1964 $\pm$ 45	2455 $\pm$ 12	20.0
D	37	36.1	648	3528	5.62	0.557	4.042 $\pm$ 0.108	0.11625 $\pm$ 0.00044	4.065 $\pm$ 0.109	0.11139 $\pm$ 0.00073	1418 $\pm$ 34	1822 $\pm$ 12	22.2

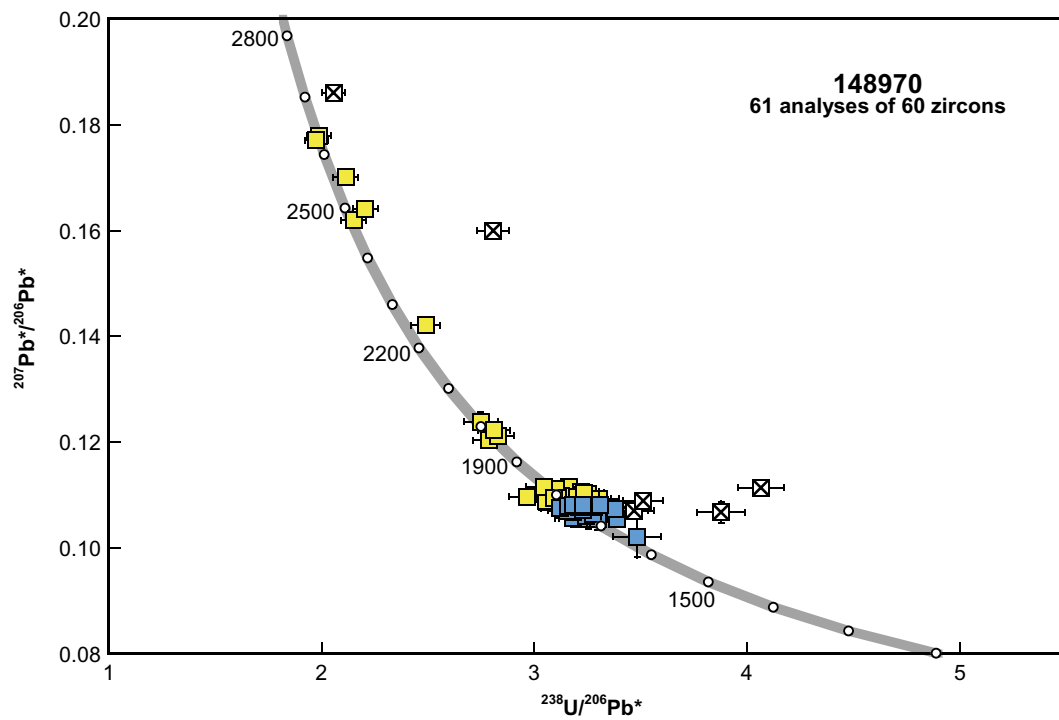


Figure 2. U–Pb analytical data for sample 148970: quartz sandstone, Carnoby Well. Blue squares indicate Group 1 (youngest detrital zircons); yellow squares indicate Group 2 (older detrital zircons); crossed white squares indicate ungrouped analyses (discordance >5%)

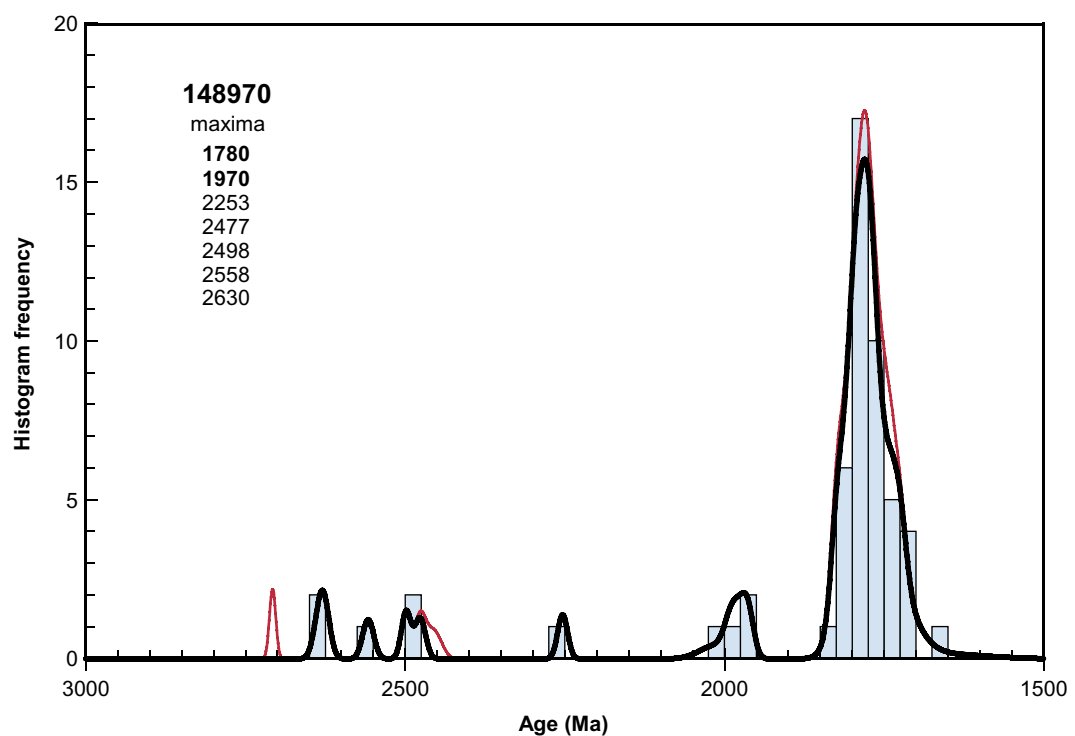


Figure 3. Probability density diagram and histogram for sample 148970: quartz sandstone, Carnoby Well. Heavy curve, maxima values, and frequency histogram (bin width 25 Ma) include only data with discordance <5% (54 analyses of 54 zircons). Lighter curve includes all data (61 analyses of 60 zircons)