177908: quartzite, Noondeening Hill

(Jimperding Metamorphic Belt, South West Terrane, Yilgarn Craton)

Location and sampling

PERTH (SH 50-14), NORTHAM (2234)
MGA Zone 50, 457624E 6500083N

Sampled on 29 January 2004

The sample was obtained from a 0.4 m diameter boulder on a low rocky outcrop on the eastern slope of a prominent knoll, within the abandoned shooting range on Baillie Farm, 1.5 km southeast of the Noondeening Hill survey marker.

Tectonic unit/relations

The unit sampled is a grey-white, coarse-grained, recrystallized quartzite that occurs within a succession of metamorphosed supracrustal rocks on the eastern slope of Noondeening Hill. This succession is part of the Jimperding Metamorphic Belt, within the South West Terrane of the Yilgarn Craton (Wilde, 2001; Cassidy et al., 2006). Pelites interbedded with the metamorphosed quartz sandstone contain cordierite, prismatic sillimanite, and garnet-bearing leucosomes. Intercalated metamorphosed mafic rocks are dominated by coarse-grained hornblende and plagioclase, indicating metamorphism under uppermost amphibolite facies conditions (Rennie, 1998).

The quartzite was sampled to constrain the maximum age for deposition of the precursor quartz sandstone, and the timing of high-grade metamorphism in this part of the Jimperding Metamorphic Belt. Previous data for this sample were reported by Bodorkos et al. (2006), and data for three additional samples (GSWA 177901, 177904, 177907) from this succession are reported by Wingate et al. (2008a–c).

Petrographic description

This sample is dominated (>99%) by quartz, with accessory opaque oxide minerals, muscovite, biotite, zircon, and pyrite. Quartz forms as inequigranular, polygonal to lobate grains (some at least 30 mm in diameter) with well-developed undulose extinction and subgrains. Different grain boundary forms (planar or ragged) are found within different regions of the thin section. Small grains of opaque oxide minerals (0.1 – 0.4 mm diameter), weakly schistose muscovite and biotite (up to 1.5 mm long), zircon (<0.1 mm long), and pyrite (<0.5 mm diameter) are randomly distributed.

In the absence of diagnostic mineral assemblages, the exaggerated quartz grain growth probably indicates deformation and metamorphism under amphibolite facies conditions. Biotite and pyrite are both altered to limonite and clay minerals, reflecting incipient weathering.

Zircon morphology

Zircons from this sample are mainly clear and colourless to pale brown, and range from subhedral and variably rounded to euhedral and well-faceted. The zircons are up to 200 µm long and equant to elongate (aspect ratios up to 3:1). Most grains consist of a subhedral to subspherical core that exhibits concentric growth zoning in cathodoluminescence (CL) images, surrounded by a subhedral to euhedral rim with weak concentric zoning and very low CL response. A CL image of representative zircons is shown in Figure 1.

Analytical details

This sample was analysed on 18 October 2004, 24–25 March 2006, and 5–6 September 2006, using SHRIMP-A. Analyses 1.1 to 37.1 (spot numbers 1–47 inclusive) were obtained during the first session, together with 13 analyses of the CZ3 standard. Following deletion of one standard analysis as an outlier, the remaining 12 analyses indicated an external spot-to-spot (reproducibility) uncertainty of 1.62% (1σ), and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.52% (1σ). Analyses 38.1 to 65.1 (spot numbers 48–98 inclusive) were obtained during the second session, together with 12 analyses of the CZ3 standard. Following deletion of one standard analysis as an outlier, the remaining 11 analyses indicated an external spot-to-spot (reproducibility) uncertainty of 0.0% (1σ), and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.21% (1σ). Analyses 66.1 to 92.1 (spot numbers 99–126 inclusive) were obtained during the third session, together with 17 analyses of the CZ3 standard, which indicated an external spot-to-spot (reproducibility) uncertainty of 0.78% (1σ), and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.23% (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 common-Pb isotopic compositions determined according to the model of Stacey and Kramers (1975).

Results

A total of 126 analyses were obtained from 91 zircons. Results are listed in Table 1, and shown in a concordia

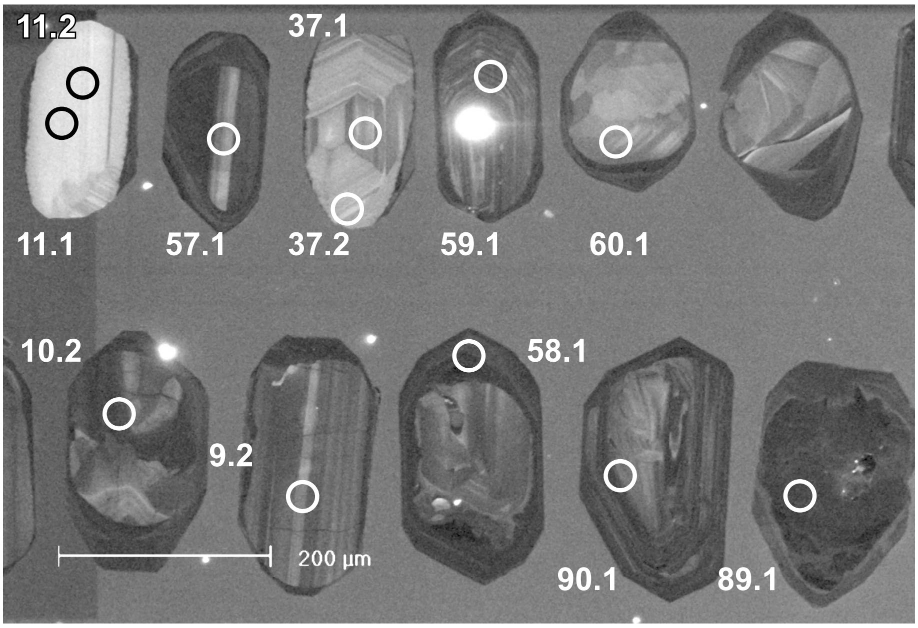

Figure 1. Cathodoluminescence image of representative zircons from sample 177908: quartzite, Noondeening Hill. Numbered circles indicate approximate locations of analysis sites

diagram (Fig. 2) and a probability density diagram (Fig. 3).

Interpretation

Most analyses are concordant to slightly discordant, and their distribution is consistent with episodes of ancient, and probably some recent, loss of radiogenic Pb. Seventeen analyses are characterized by slight to moderate discordance (>5%) or high common Pb (>1%). The dates obtained from these 17 analyses (Group D; Table 1) are unreliable, and are not considered geologically significant. The remaining 109 analyses can be divided into four groups, based on their $^{207}Pb^*/^{206}Pb^*$ ratios and Th/U ratios.

Group 1 comprises 14 analyses of 13 zircon rims and one zircon core (Table 1), which indicate low Th/U ratios of 0.11–0.32, and yield a weighted mean $^{207}Pb^*/^{206}Pb^*$ date of 2657 ± 3 Ma (MSWD = 1.12).

Group 2 comprises a single analysis (2.1; Table 1) of a zircon rim which indicates a Th/U ratio of 0.34 and yields a $^{207}Pb^*/^{206}Pb^*$ date of 2609 ± 10 Ma (1σ).

Group 3 comprises seven analyses of seven zircons (Table 1), which indicate Th/U ratios of 0.12–0.95, and yield $^{207}Pb^*/^{206}Pb^*$ dates of 3022–2755 Ma.

Group 4 comprises five analyses of five zircon cores (Table 1), which indicate Th/U ratios of 0.26–0.70, and yield a weighted mean $^{207}Pb^*/^{206}Pb^*$ date of 3069 ± 6 Ma (MSWD = 0.79).

Group 5 comprises 82 analyses of 68 zircon cores (Table 1), which indicate Th/U ratios of 0.07–2.16, and yield $^{207}Pb^*/^{206}Pb^*$ dates of 3593–3096 Ma.

The date of 2657 ± 3 Ma for the 14 analyses of low Th/U zircons in Group 1 is interpreted as the age of the upper amphibolite facies metamorphic episode that affected this region. This result is in good agreement with previous estimates of the age of this event (Rennie, 1998; Wilde, 2001; Bodorkos et al., 2006).

The date of 2609 ± 10 Ma (1σ) for the single analysis in Group 2 is interpreted to reflect minor ancient loss of radiogenic Pb from a metamorphic zircon rim.

The significance of the dates of 3022–2755 Ma for the seven analyses in Group 3 is difficult to interpret. Two analyses (43.2, 53.1) yielded dates significantly younger than those obtained by additional analyses of similar zoned material in the same crystals, implying that the younger dates reflect loss of radiogenic Pb. The craters produced during analyses 19.1 and 55.1 overlap both rim and core domains resulting in an inadvertent mixture of material of different ages. There are no additional results to which the remaining three analyses (67.1, 72.1, 75.1) can be compared. The preferred interpretation is that all seven analyses in Group 2 reflect either loss of radiogenic Pb or mixtures of core and rim material, and that the resulting dates probably have no geological significance.

It is possible that the five analyses in Group 4 are of unmodified detrital zircon cores, in which case the date of 3063 ± 8 Ma (1σ) for analysis 65.1 represents a maximum depositional age for the protolith of this metasedimentary rock. Alternatively, a more conservative estimate of the maximum depositional age is 3069 ± 6 Ma, based on the weighted mean $^{207}Pb^*/^{206}Pb^*$ date of the five zircon cores in Group 3.

The 82 analyses in Group 5 define major age components (based on three or more data points) at c. 3162, 3184,

Table 1. Ion microprobe analytical results for zircons from sample 177908: quartzite, Noondeening Hill

Grp no.	*Spot no.*	*Grain .spot*	^{238}U *(ppm)*	^{232}Th *(ppm)*	$^{232}Th/^{238}U$	*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 (%)*
1	19	15.1	377	87	0.24	0.111	1.932 ± 0.034	0.17989 ± 0.00073	1.935 ± 0.034	0.17890 ± 0.00079	2686 ± 39	2643 ± 7	–1.6
1	122	88.2	572	63	0.11	0.092	2.006 ± 0.019	0.18011 ± 0.00058	2.008 ± 0.019	0.17929 ± 0.00060	2605 ± 20	2646 ± 6	1.6
1	17	13.1	484	140	0.30	0.071	1.989 ± 0.035	0.18029 ± 0.00066	1.991 ± 0.035	0.17966 ± 0.00069	2624 ± 38	2650 ± 6	1.0
1	22	17.1	381	117	0.32	0.043	1.978 ± 0.035	0.18034 ± 0.00067	1.979 ± 0.035	0.17995 ± 0.00069	2637 ± 38	2652 ± 6	0.6
1	14	10.1	417	116	0.29	0.014	2.004 ± 0.036	0.18019 ± 0.00069	2.004 ± 0.036	0.18006 ± 0.00071	2609 ± 38	2653 ± 7	1.7
1	2	1.2	600	174	0.30	0.029	2.035 ± 0.036	0.18063 ± 0.00077	2.036 ± 0.036	0.18037 ± 0.00078	2576 ± 37	2656 ± 7	3.0
1	46	36.1	406	98	0.25	–0.013	1.981 ± 0.035	0.18044 ± 0.00072	1.981 ± 0.035	0.18055 ± 0.00072	2635 ± 39	2658 ± 7	0.9
1	62	47.2	477	88	0.19	0.011	2.037 ± 0.013	0.18074 ± 0.00081	2.037 ± 0.013	0.18065 ± 0.00081	2574 ± 14	2659 ± 7	3.2
1	6	4.2	355	94	0.27	0.043	2.013 ± 0.036	0.18126 ± 0.00075	2.014 ± 0.036	0.18087 ± 0.00076	2599 ± 38	2661 ± 7	2.3
1	8	5.2	505	107	0.22	0.095	1.984 ± 0.035	0.18177 ± 0.00064	1.986 ± 0.035	0.18092 ± 0.00068	2629 ± 38	2661 ± 6	1.2
1	44	34.1	698	90	0.13	0.009	1.965 ± 0.034	0.18103 ± 0.00053	1.965 ± 0.034	0.18095 ± 0.00053	2652 ± 38	2662 ± 5	0.4
1	12	8.1	406	110	0.28	0.059	2.048 ± 0.036	0.18160 ± 0.00072	2.049 ± 0.036	0.18108 ± 0.00076	2562 ± 37	2663 ± 7	3.8
1	91	58.1	347	102	0.30	0.051	1.948 ± 0.013	0.18171 ± 0.00084	1.949 ± 0.013	0.18126 ± 0.00086	2670 ± 14	2664 ± 8	–0.2
1	48	38.1	406	118	0.30	–0.013	2.049 ± 0.014	0.18137 ± 0.00082	2.049 ± 0.014	0.18149 ± 0.00083	2563 ± 14	2666 ± 8	3.9
2	3	2.1	557	186	0.34	0.092	2.102 ± 0.037	0.17608 ± 0.00104	2.104 ± 0.037	0.17526 ± 0.00108	2507 ± 37	2609 ± 10	3.9
3	79	55.1	627	90	0.15	0.011	1.880 ± 0.011	0.19162 ± 0.00072	1.880 ± 0.011	0.19152 ± 0.00072	2749 ± 13	2755 ± 6	0.2
3	24	19.1	195	68	0.36	–0.026	1.859 ± 0.034	0.20511 ± 0.00134	1.858 ± 0.034	0.20534 ± 0.00134	2775 ± 41	2869 ± 11	3.3
3	54	43.2	553	188	0.35	0.022	1.813 ± 0.012	0.20648 ± 0.00082	1.813 ± 0.012	0.20629 ± 0.00083	2831 ± 15	2877 ± 7	1.6
3	108	75.1	847	237	0.29	0.034	1.795 ± 0.016	0.21608 ± 0.00050	1.795 ± 0.016	0.21577 ± 0.00051	2854 ± 20	2949 ± 4	3.2
3	100	67.1	225	61	0.28	0.027	1.769 ± 0.018	0.21939 ± 0.00100	1.770 ± 0.018	0.21915 ± 0.00102	2888 ± 24	2974 ± 7	2.9
3	105	72.1	749	88	0.12	0.004	1.778 ± 0.016	0.22045 ± 0.00359	1.778 ± 0.016	0.22041 ± 0.00359	2876 ± 21	2984 ± 26	3.6
3	74	53.1	257	237	0.95	0.063	1.749 ± 0.014	0.22631 ± 0.00108	1.750 ± 0.014	0.22575 ± 0.00112	2914 ± 19	3022 ± 8	3.6
4	98	65.1	210	127	0.62	0.000	1.641 ± 0.014	0.23151 ± 0.00119	1.641 ± 0.014	0.23151 ± 0.00119	3068 ± 21	3063 ± 8	–0.2
4	36	28.1	255	173	0.70	0.039	1.657 ± 0.030	0.23208 ± 0.00094	1.657 ± 0.030	0.23174 ± 0.00096	3043 ± 44	3064 ± 7	0.7
4	68	50.1	296	191	0.67	0.021	1.665 ± 0.012	0.23226 ± 0.00102	1.665 ± 0.012	0.23207 ± 0.00102	3032 ± 18	3066 ± 7	1.1
4	25	20.1	271	176	0.67	–0.010	1.640 ± 0.030	0.23293 ± 0.00089	1.639 ± 0.030	0.23302 ± 0.00089	3070 ± 44	3073 ± 6	0.1
4	27	21.2	399	100	0.26	–0.012	1.702 ± 0.030	0.23367 ± 0.00110	1.702 ± 0.030	0.23377 ± 0.00111	2980 ± 42	3078 ± 8	3.2
5	126	92.1	206	172	0.86	0.142	1.678 ± 0.018	0.23771 ± 0.00107	1.681 ± 0.018	0.23646 ± 0.00115	3010 ± 26	3096 ± 8	2.8
5	109	76.1	285	257	0.93	0.090	1.670 ± 0.016	0.23881 ± 0.00088	1.672 ± 0.016	0.23802 ± 0.00091	3022 ± 23	3107 ± 6	2.7
5	92	59.1	226	237	1.08	0.000	1.599 ± 0.013	0.23835 ± 0.00116	1.599 ± 0.013	0.23835 ± 0.00116	3131 ± 21	3109 ± 8	–0.7
5	75	53.2	369	207	0.58	0.021	1.619 ± 0.011	0.24192 ± 0.00094	1.619 ± 0.011	0.24174 ± 0.00094	3100 ± 17	3131 ± 6	1.0
5	70	52.1	435	247	0.59	0.005	1.662 ± 0.010	0.24393 ± 0.00086	1.662 ± 0.010	0.24389 ± 0.00086	3037 ± 15	3146 ± 6	3.5
5	80	55.2	226	140	0.64	0.010	1.592 ± 0.014	0.24439 ± 0.00119	1.592 ± 0.014	0.24431 ± 0.00120	3143 ± 21	3148 ± 8	0.2
5	81	55.3	249	134	0.55	0.040	1.594 ± 0.013	0.24547 ± 0.00114	1.595 ± 0.013	0.24512 ± 0.00116	3138 ± 20	3154 ± 8	0.5
5	104	71.1	416	207	0.51	0.098	1.646 ± 0.015	0.24694 ± 0.00137	1.647 ± 0.015	0.24608 ± 0.00139	3058 ± 22	3160 ± 9	3.2
5	84	56.1	186	128	0.71	–0.018	1.609 ± 0.015	0.24608 ± 0.00132	1.609 ± 0.015	0.24624 ± 0.00133	3116 ± 23	3161 ± 9	1.4
5	99	66.1	293	253	0.89	0.024	1.584 ± 0.016	0.24652 ± 0.00087	1.584 ± 0.016	0.24631 ± 0.00088	3155 ± 25	3161 ± 6	0.2
5	112	79.1	446	306	0.71	0.039	1.614 ± 0.016	0.24695 ± 0.00070	1.614 ± 0.016	0.24661 ± 0.00071	3108 ± 25	3163 ± 5	1.7
5	124	90.1	748	357	0.49	0.040	1.618 ± 0.014	0.24814 ± 0.00057	1.619 ± 0.014	0.24778 ± 0.00059	3101 ± 22	3171 ± 4	2.2
5	43	33.1	313	295	0.97	–0.026	1.545 ± 0.027	0.24941 ± 0.00088	1.544 ± 0.027	0.24964 ± 0.00088	3218 ± 45	3182 ± 6	–1.1
5	117	84.1	352	212	0.62	0.002	1.589 ± 0.015	0.24974 ± 0.00080	1.589 ± 0.015	0.24973 ± 0.00080	3147 ± 23	3183 ± 5	1.1
5	102	69.1	336	210	0.65	0.011	1.598 ± 0.015	0.24986 ± 0.00080	1.599 ± 0.015	0.24976 ± 0.00080	3132 ± 23	3183 ± 5	1.6
5	67	49.2	512	122	0.25	0.317	1.610 ± 0.009	0.25296 ± 0.00081	1.615 ± 0.009	0.25017 ± 0.00090	3107 ± 14	3186 ± 6	2.5

Table 1. (continued)

Grp no.	*Spot no.*	*Grain .spot*	^{238}U *(ppm)*	^{232}Th *(ppm)*	$^{232}Th/^{238}U$	*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 (%)*
5	110	77.1	662	470	0.73	0.014	1.573 ± 0.014	0.25143 ± 0.00062	1.574 ± 0.014	0.25131 ± 0.00062	3171 ± 22	3193 ± 4	0.7
5	94	61.1	215	162	0.78	0.000	1.554 ± 0.014	0.25269 ± 0.00123	1.554 ± 0.014	0.25269 ± 0.00123	3203 ± 22	3202 ± 8	0.0
5	73	13.2	202	101	0.52	0.019	1.608 ± 0.014	0.25286 ± 0.00127	1.609 ± 0.014	0.25270 ± 0.00127	3116 ± 22	3202 ± 8	2.7
5	120	87.1	156	76	0.50	–0.022	1.592 ± 0.017	0.25352 ± 0.00121	1.591 ± 0.017	0.25370 ± 0.00122	3143 ± 26	3208 ± 8	2.0
5	72	52.3	307	194	0.65	0.017	1.563 ± 0.012	0.25687 ± 0.00108	1.563 ± 0.012	0.25673 ± 0.00109	3187 ± 19	3227 ± 7	1.2
5	52	42.1	254	204	0.83	0.072	1.532 ± 0.012	0.25985 ± 0.00115	1.534 ± 0.012	0.25922 ± 0.00118	3236 ± 20	3242 ± 7	0.2
5	31	24.1	72	45	0.64	–0.114	1.593 ± 0.032	0.25905 ± 0.00416	1.591 ± 0.032	0.26005 ± 0.00418	3144 ± 50	3247 ± 25	3.2
5	9	6.1	347	430	1.28	–0.005	1.545 ± 0.027	0.26011 ± 0.00084	1.545 ± 0.027	0.26016 ± 0.00084	3218 ± 45	3248 ± 5	0.9
5	35	27.2	142	78	0.57	0.049	1.523 ± 0.028	0.26115 ± 0.00128	1.523 ± 0.028	0.26072 ± 0.00129	3253 ± 47	3251 ± 8	–0.1
5	7	5.1	222	142	0.66	0.071	1.570 ± 0.031	0.26134 ± 0.00104	1.571 ± 0.031	0.26072 ± 0.00105	3175 ± 50	3251 ± 6	2.3
5	45	35.1	361	294	0.84	0.016	1.461 ± 0.029	0.26104 ± 0.00084	1.461 ± 0.029	0.26090 ± 0.00085	3361 ± 51	3252 ± 5	–3.3
5	41	31.1	76	21	0.29	–0.016	1.577 ± 0.032	0.26163 ± 0.00192	1.577 ± 0.032	0.26177 ± 0.00192	3166 ± 51	3257 ± 12	2.8
5	32	25.1	122	94	0.79	–0.060	1.511 ± 0.028	0.26138 ± 0.00136	1.510 ± 0.028	0.26191 ± 0.00139	3276 ± 48	3258 ± 8	–0.5
5	33	26.1	359	144	0.41	–0.026	1.520 ± 0.027	0.26178 ± 0.00081	1.520 ± 0.027	0.26201 ± 0.00082	3260 ± 45	3259 ± 5	0.0
5	116	83.1	150	66	0.45	0.022	1.512 ± 0.016	0.26254 ± 0.00123	1.513 ± 0.016	0.26235 ± 0.00123	3272 ± 27	3261 ± 7	–0.3
5	66	49.1	248	85	0.35	0.077	1.546 ± 0.013	0.26311 ± 0.00119	1.547 ± 0.013	0.26243 ± 0.00121	3213 ± 21	3261 ± 7	1.5
5	34	27.1	78	51	0.68	–0.015	1.540 ± 0.030	0.26232 ± 0.00174	1.540 ± 0.030	0.26245 ± 0.00174	3226 ± 50	3261 ± 10	1.1
5	111	78.1	202	145	0.74	0.004	1.533 ± 0.015	0.26361 ± 0.00106	1.533 ± 0.015	0.26357 ± 0.00106	3238 ± 26	3268 ± 6	0.9
5	28	22.1	103	42	0.42	–0.022	1.539 ± 0.029	0.26349 ± 0.00154	1.539 ± 0.029	0.26368 ± 0.00155	3228 ± 48	3269 ± 9	1.3
5	106	73.1	87	71	0.84	0.106	1.519 ± 0.018	0.26474 ± 0.00208	1.521 ± 0.018	0.26381 ± 0.00225	3257 ± 31	3270 ± 13	0.4
5	59	46.1	173	108	0.64	0.000	1.546 ± 0.015	0.26402 ± 0.00141	1.546 ± 0.015	0.26402 ± 0.00141	3217 ± 24	3271 ± 8	1.7
5	57	44.1	274	317	1.20	0.000	1.566 ± 0.012	0.26439 ± 0.00106	1.566 ± 0.012	0.26439 ± 0.00106	3183 ± 19	3273 ± 6	2.7
5	26	21.1	340	149	0.45	0.083	1.539 ± 0.027	0.26519 ± 0.00083	1.540 ± 0.027	0.26447 ± 0.00085	3225 ± 45	3274 ± 5	1.5
5	29	22.2	190	263	1.43	–0.014	1.497 ± 0.027	0.26438 ± 0.00118	1.496 ± 0.027	0.26451 ± 0.00119	3299 ± 47	3274 ± 7	–0.8
5	15	11.1	30	25	0.85	0.466	1.463 ± 0.037	0.26868 ± 0.00301	1.470 ± 0.037	0.26462 ± 0.00341	3345 ± 66	3274 ± 20	–2.2
5	85	10.2	214	121	0.59	–0.010	1.542 ± 0.013	0.26454 ± 0.00126	1.541 ± 0.013	0.26462 ± 0.00126	3223 ± 22	3274 ± 7	1.6
5	56	40.2	78	46	0.60	0.000	1.520 ± 0.021	0.26495 ± 0.00208	1.520 ± 0.021	0.26495 ± 0.00208	3258 ± 35	3276 ± 12	0.5
5	30	23.1	311	205	0.68	0.003	1.519 ± 0.028	0.26506 ± 0.00090	1.519 ± 0.028	0.26503 ± 0.00090	3261 ± 48	3277 ± 5	0.5
5	60	46.2	56	81	1.49	0.126	1.563 ± 0.024	0.26677 ± 0.00229	1.565 ± 0.024	0.26568 ± 0.00236	3185 ± 38	3281 ± 14	2.9
5	69	51.1	205	89	0.45	0.029	1.519 ± 0.015	0.26612 ± 0.00127	1.519 ± 0.015	0.26587 ± 0.00127	3260 ± 25	3282 ± 8	0.7
5	50	17.2	92	41	0.46	0.098	1.508 ± 0.019	0.26678 ± 0.00189	1.510 ± 0.019	0.26592 ± 0.00189	3276 ± 32	3282 ± 11	0.2
5	58	45.1	108	124	1.18	0.030	1.519 ± 0.018	0.26623 ± 0.00173	1.519 ± 0.018	0.26597 ± 0.00174	3260 ± 30	3282 ± 10	0.7
5	97	64.1	271	88	0.33	0.017	1.601 ± 0.015	0.26638 ± 0.00164	1.602 ± 0.015	0.26623 ± 0.00164	3127 ± 23	3284 ± 10	4.8
5	93	60.1	100	86	0.89	0.001	1.550 ± 0.019	0.26636 ± 0.00186	1.550 ± 0.019	0.26635 ± 0.00188	3210 ± 31	3285 ± 11	2.3
5	21	16.1	128	8	0.07	–0.056	1.509 ± 0.029	0.26680 ± 0.00134	1.508 ± 0.029	0.26729 ± 0.00136	3279 ± 49	3290 ± 8	0.3
5	42	32.1	157	60	0.40	–0.025	1.481 ± 0.027	0.26750 ± 0.00126	1.481 ± 0.027	0.26771 ± 0.00128	3326 ± 48	3293 ± 7	–1.0
5	95	62.1	217	262	1.25	0.142	1.519 ± 0.016	0.27002 ± 0.00295	1.521 ± 0.016	0.26879 ± 0.00299	3257 ± 27	3299 ± 17	1.3
5	119	86.1	226	144	0.66	0.025	1.502 ± 0.015	0.26946 ± 0.00104	1.503 ± 0.015	0.26924 ± 0.00105	3289 ± 26	3302 ± 6	0.4
5	18	14.1	65	44	0.70	0.093	1.489 ± 0.030	0.27029 ± 0.00198	1.491 ± 0.030	0.26948 ± 0.00208	3309 ± 53	3303 ± 12	–0.2
5	40	30.3	131	45	0.35	–0.060	1.476 ± 0.028	0.26918 ± 0.00134	1.476 ± 0.028	0.26970 ± 0.00136	3336 ± 49	3304 ± 8	–0.9
5	103	70.1	217	112	0.54	0.113	1.526 ± 0.015	0.27128 ± 0.00101	1.528 ± 0.015	0.27030 ± 0.00109	3246 ± 25	3308 ± 6	1.9
5	16	12.1	80	131	1.69	0.041	1.487 ± 0.029	0.27080 ± 0.00179	1.488 ± 0.030	0.27045 ± 0.00200	3314 ± 51	3309 ± 12	–0.2
5	114	81.1	68	42	0.65	–0.022	1.552 ± 0.034	0.27103 ± 0.00193	1.552 ± 0.034	0.27123 ± 0.00193	3206 ± 56	3313 ± 11	3.2
5	37	29.1	116	83	0.73	0.031	1.482 ± 0.028	0.27162 ± 0.00145	1.482 ± 0.028	0.27135 ± 0.00146	3324 ± 49	3314 ± 8	–0.3
5	11	7.1	181	378	2.16	0.061	1.524 ± 0.028	0.27243 ± 0.00121	1.525 ± 0.028	0.27190 ± 0.00123	3251 ± 46	3317 ± 7	2.0
5	61	47.1	264	77	0.30	0.012	1.480 ± 0.011	0.27207 ± 0.00110	1.480 ± 0.011	0.27196 ± 0.00110	3328 ± 20	3317 ± 6	–0.3
5	86	11.2	27	23	0.86	–0.144	1.487 ± 0.036	0.27211 ± 0.00380	1.485 ± 0.036	0.27336 ± 0.00388	3320 ± 62	3325 ± 22	0.2

Table 1. (continued)

Grp no.	Spot no.	Grain .spot	^{238}U (ppm)	^{232}Th (ppm)	$^{232}Th/^{238}U$	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 (%)
5	83	15.4	79	38	0.51	–0.050	1.474 ± 0.021	0.27365 ± 0.00209	1.473 ± 0.021	0.27408 ± 0.00209	3340 ± 37	3329 ± 12	–0.3
5	63	47.3	126	81	0.66	0.004	1.539 ± 0.016	0.27480 ± 0.00161	1.539 ± 0.016	0.27477 ± 0.00162	3227 ± 27	3333 ± 9	3.2
5	5	4.1	91	42	0.48	–0.003	1.516 ± 0.030	0.27578 ± 0.00228	1.516 ± 0.030	0.27581 ± 0.00228	3265 ± 50	3339 ± 13	2.2
5	13	9.1	189	169	0.92	0.023	1.531 ± 0.028	0.27690 ± 0.00118	1.531 ± 0.028	0.27670 ± 0.00125	3241 ± 47	3344 ± 7	3.1
5	90	9.2	131	91	0.72	0.015	1.523 ± 0.017	0.27725 ± 0.00166	1.523 ± 0.017	0.27711 ± 0.00166	3254 ± 28	3347 ± 9	2.8
5	4	3.1	68	59	0.89	0.269	1.494 ± 0.031	0.28058 ± 0.00223	1.498 ± 0.031	0.27825 ± 0.00240	3296 ± 54	3353 ± 13	1.7
5	38	30.1	36	68	1.95	–0.409	1.470 ± 0.035	0.27540 ± 0.00258	1.464 ± 0.035	0.27893 ± 0.00286	3356 ± 62	3357 ± 16	0.0
5	65	48.2	93	99	1.10	0.000	1.485 ± 0.022	0.28166 ± 0.00206	1.485 ± 0.022	0.28166 ± 0.00206	3319 ± 39	3372 ± 11	1.6
5	64	48.1	95	88	0.96	–0.014	1.453 ± 0.017	0.28411 ± 0.00177	1.452 ± 0.017	0.28423 ± 0.00178	3377 ± 31	3386 ± 10	0.3
5	20	15.2	176	139	0.82	–0.010	1.456 ± 0.026	0.28953 ± 0.00118	1.456 ± 0.026	0.28962 ± 0.00119	3371 ± 48	3416 ± 6	1.3
5	1	1.1	64	41	0.65	–0.047	1.475 ± 0.031	0.29074 ± 0.00210	1.474 ± 0.031	0.29114 ± 0.00213	3338 ± 54	3424 ± 11	2.5
5	23	18.1	95	102	1.11	–0.004	1.448 ± 0.028	0.29322 ± 0.00157	1.448 ± 0.028	0.29326 ± 0.00157	3385 ± 51	3435 ± 8	1.5
5	101	68.1	299	254	0.88	0.038	1.385 ± 0.013	0.30225 ± 0.00092	1.386 ± 0.013	0.30193 ± 0.00093	3502 ± 26	3480 ± 5	–0.6
5	47	37.1	65	49	0.77	0.134	1.415 ± 0.029	0.30332 ± 0.00212	1.417 ± 0.029	0.30218 ± 0.00218	3443 ± 54	3481 ± 11	1.1
5	88	37.2	77	78	1.06	–0.049	1.379 ± 0.020	0.30460 ± 0.00228	1.378 ± 0.020	0.30502 ± 0.00227	3518 ± 39	3496 ± 12	–0.6
5	89	37.3	54	41	0.78	0.051	1.401 ± 0.024	0.30616 ± 0.00270	1.402 ± 0.024	0.30572 ± 0.00277	3471 ± 46	3499 ± 14	0.8
5	115	82.1	200	86	0.44	0.030	1.408 ± 0.014	0.30776 ± 0.00119	1.408 ± 0.014	0.30750 ± 0.00119	3459 ± 27	3508 ± 6	1.4
5	49	39.1	202	118	0.60	0.042	1.401 ± 0.012	0.31124 ± 0.00157	1.402 ± 0.012	0.31089 ± 0.00158	3471 ± 24	3525 ± 8	1.5
5	76	54.1	209	117	0.58	–0.006	1.361 ± 0.012	0.32484 ± 0.00135	1.361 ± 0.012	0.32490 ± 0.00135	3551 ± 24	3593 ± 6	1.2
D	121	88.1	89	135	1.56	0.324	1.598 ± 0.021	0.27008 ± 0.00168	1.603 ± 0.021	0.26726 ± 0.00182	3124 ± 32	3290 ± 11	5.0
D	123	89.1	854	144	0.17	0.121	1.734 ± 0.015	0.23811 ± 0.00059	1.736 ± 0.015	0.23705 ± 0.00062	2932 ± 21	3100 ± 4	5.4
D	53	43.1	436	288	0.68	0.211	1.755 ± 0.011	0.23460 ± 0.00086	1.759 ± 0.011	0.23274 ± 0.00093	2902 ± 15	3071 ± 6	5.5
D	107	74.1	314	293	0.96	0.126	1.699 ± 0.017	0.24699 ± 0.00086	1.702 ± 0.017	0.24588 ± 0.00091	2980 ± 24	3158 ± 6	5.6
D	125	91.1	159	106	0.69	0.049	1.624 ± 0.018	0.26688 ± 0.00173	1.625 ± 0.018	0.26646 ± 0.00174	3091 ± 27	3285 ± 10	5.9
D	87	57.1	493	1760	3.69	0.807	1.624 ± 0.010	0.27061 ± 0.00086	1.638 ± 0.010	0.26357 ± 0.00117	3073 ± 15	3268 ± 7	6.0
D	55	40.1	227	280	1.27	0.035	1.697 ± 0.014	0.25078 ± 0.00122	1.698 ± 0.014	0.25048 ± 0.00124	2985 ± 20	3188 ± 8	6.4
D	82	15.3	118	24	0.21	0.061	1.722 ± 0.020	0.24549 ± 0.00173	1.723 ± 0.020	0.24495 ± 0.00174	2950 ± 28	3152 ± 11	6.4
D	113	80.1	402	191	0.49	0.103	2.125 ± 0.019	0.18134 ± 0.00068	2.127 ± 0.019	0.18042 ± 0.00072	2484 ± 19	2657 ± 7	6.5
D	39	30.2	29	33	1.16	–0.109	1.648 ± 0.039	0.26780 ± 0.00303	1.646 ± 0.039	0.26875 ± 0.00314	3060 ± 57	3299 ± 18	7.2
D	10	6.2	560	116	0.21	0.105	2.149 ± 0.038	0.18103 ± 0.00062	2.151 ± 0.038	0.18010 ± 0.00067	2461 ± 36	2654 ± 6	7.3
D	78	54.3	586	327	0.58	0.888	1.840 ± 0.010	0.23284 ± 0.00075	1.856 ± 0.010	0.22497 ± 0.00112	2778 ± 13	3017 ± 8	7.9
D	96	63.1	130	79	0.63	0.022	1.735 ± 0.019	0.25036 ± 0.00163	1.735 ± 0.019	0.25016 ± 0.00163	2933 ± 26	3186 ± 10	7.9
D	77	54.2	388	285	0.76	0.131	1.506 ± 0.011	0.32168 ± 0.00106	1.508 ± 0.011	0.32059 ± 0.00109	3280 ± 19	3573 ± 5	8.2
D	71	52.2	456	527	1.19	0.061	1.812 ± 0.011	0.26440 ± 0.00093	1.813 ± 0.011	0.26387 ± 0.00095	2831 ± 14	3270 ± 6	13.4
D	51	25.2	91	63	0.72	0.119	1.946 ± 0.026	0.25398 ± 0.00241	1.948 ± 0.026	0.25294 ± 0.00243	2671 ± 29	3203 ± 15	16.6
D	118	85.1	953	983	1.07	3.910	2.456 ± 0.021	0.21283 ± 0.00060	2.556 ± 0.024	0.17796 ± 0.00293	2129 ± 17	2634 ± 27	19.2

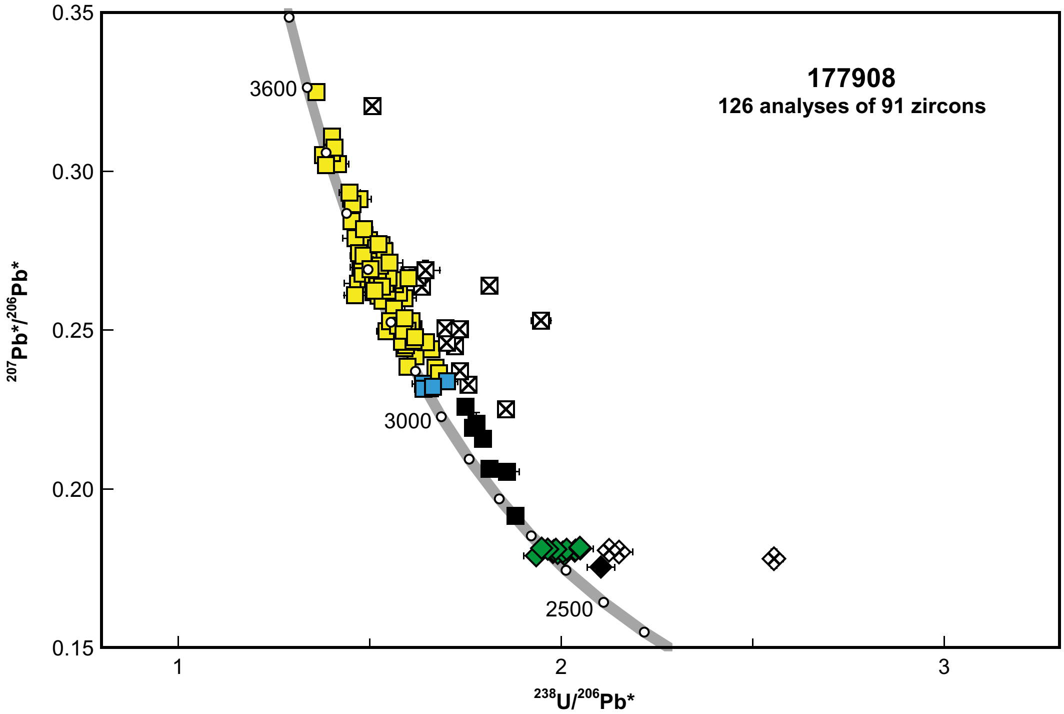

Figure 2. U–Pb analytical data for zircons from sample 177908: quartzite, Noondeening Hill. Green diamonds indicate Group 1 (metamorphic zircon rims); black diamond indicates Group 2 (minor radiogenic Pb loss from metamorphic rim); black squares indicate Group 3 (probable radiogenic Pb loss or core-rim mixture); blue squares indicate Group 4 (youngest detrital zircons); yellow squares denote Group 5 (older detrital zircons); crossed diamonds and squares denote ungrouped analyses of rims and cores, respectively (discordance >5% or ƒ204 >1%)

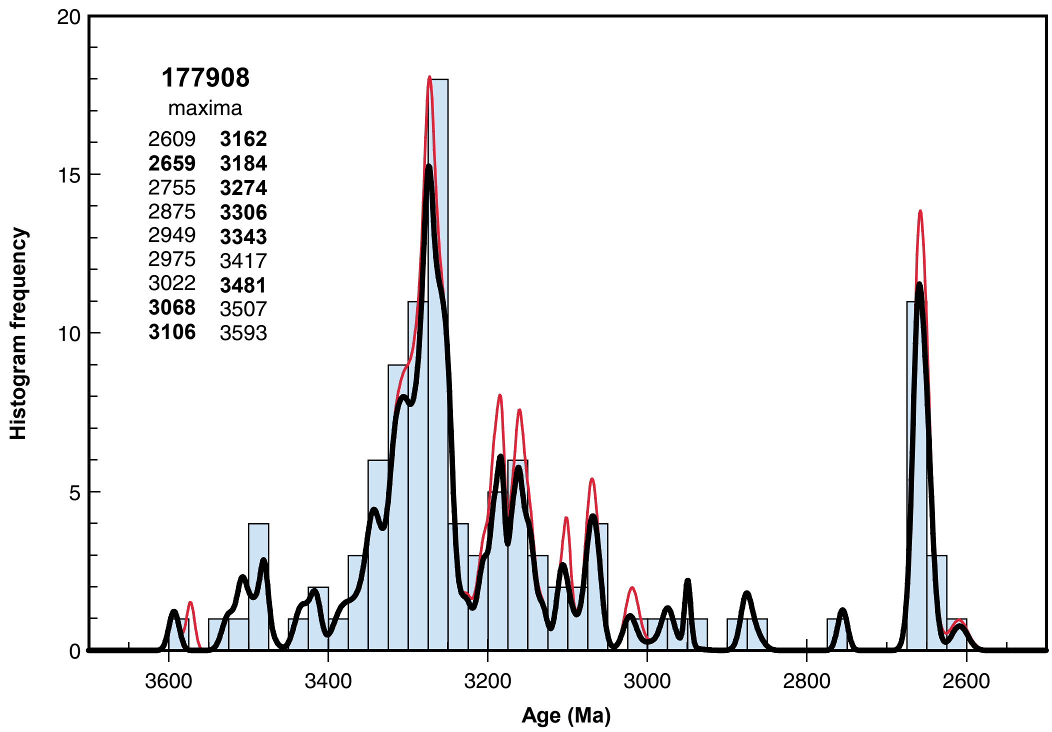

Figure 3. Probability density diagram and histogram for sample 177908: quartzite, Noondeening Hill. Heavy curve, maxima values, and frequency histogram (bin width 25 Ma) includes only concordant data (109 analyses of 81 zircons). Light curve includes all data (126 analyses of 91 zircons)

3274, 3306, 3343, and 3481 Ma (Fig. 3), and several minor components spanning the range 3593–3096 Ma. These are interpreted as the ages of zircon-crystallizing rocks in the detrital source region(s), or the ages of detrital components within sediments which have been reworked.

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Recommended reference for this publication

Wingate, MTD, Bodorkos, S, and Kirkland, CL, 2008, 177908: quartzite, Noondeening Hill; Geochronology dataset 742, *in* Compilation of geochronology data: Geological Survey of Western Australia.

Data obtained: 6 September 2006
Data released: 31 July 2008