143784: sandstone, Dovers Hills

(Paterson Formation, Canning Basin)

Location and sampling

Macdonald (SF 52-14), Macdonald (4651)
MGA Zone 52, 478651E 7443330N

Sampled on 1 June 2009

This sample was collected from the edge of a low range of quartzite and sandstone (Fig. 1), about 11.8 km west-northwest of Mount Tietkens, 11.5 km east of the summit of Dovers Hills, and 1.7 km north of the Kiwirrkurra – Kintore Road.

Tectonic unit/relations

The sample was collected from near the base of a unit originally mapped as Buck Formation (Wells et al., 1964), but now assigned to the Permo-Carboniferous Paterson Formation and considered an outlier of Canning Basin unconformably overlying the Amadeus Basin. The Paterson Formation comprises sandstone, conglomerate, diamictite and mudstone with evidence of glacial influence including faceted and striated clasts. At the sample locality, the Paterson Formation unconformably overlies the Neoproterozoic Heavitree Quartzite (Fig. 1) and a striated pavement with chatter marks on the unconformity surface nearby indicates ice movement to the west (Haines et al., 2010). A sample from the same stratigraphic unit in the Pollock Hills (GSWA 143747, Wingate et al., 2013) yielded a maximum depositional age of 565 ± 8 Ma (1σ).

Petrographic description

The sample is a medium-grained, porous, quartz-rich sandstone, containing millimetre-scale intraclasts. Excluding intraclasts, the rock consists of about 70–75% detrital quartz, 10–15% clay minerals, and 10–15% pore spaces. A hand specimen exhibits irregular pink and cream patches, representing hematite-stained and hematite-free material. Detrital quartz occurs as poorly sorted, rounded to subangular grains up to 1 mm in diameter (coarse sand size). Clouded or limonite–hematite-stained clay and patches of porosity up to 1 mm or more in diameter are interstitial to quartz. Polycrystalline quartz grains are very minor and include quartz-rich siltstones and quartz-sericite schist. The intraclasts measure up to 4 x 10 mm and are rich in clay, probably kaolinite, together with very fine quartz, with or without very fine to medium sand-sized single-crystal quartz grains. Some intraclasts appear to have been compressed and contain quartz grains introduced from the surrounding sandstone.

Zircon morphology

Zircons isolated from this sample are colourless to dark brown, and range from anhedral and strongly rounded to subhedral. The crystals are up to 300 µm long, and equant to slightly elongate, with aspect ratios up to 5:1. Some crystals have pitted outer surfaces and, in cathodoluminescence (CL) images, many exhibit concentric zoning truncated at grain edges, features consistent with abrasion during sedimentary transport. A CL image of representative zircons is shown in Figure 2.

Analytical details

This sample was analysed on 17–18 February 2011, using SHRIMP-B, and 21–23 February 2011, using SHRIMP-A. Analyses 1.1 to 55.1 (spot numbers 1–56) were obtained during the first session, together with 14 analyses of the BR266 standard, of which 11 analyses indicated an external spot-to-spot (reproducibility) uncertainty of 1.68% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.52% (1σ). Analyses 56.1 to 73.1 (spot numbers 57–81) were obtained during the second session, together with 23 analyses of the BR266 standard, of which 20 analyses indicated an external spot-to-spot (reproducibility) uncertainty of 0.96% (1σ) and a $^{238}U/^{206}Pb^*$ calibration uncertainty of 0.24% (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). Dates from analyses for which 204-corrected $^{238}U/^{206}Pb^*$ ratios indicate ages <1300 Ma are based on 207-corrected $^{238}U/^{206}Pb^*$ ratios; those >1300 Ma are based on 204-corrected $^{207}Pb^*/^{206}Pb^*$ ratios.

Results

Eighty-one analyses were obtained from 73 zircons. Results are listed in Table 1, and shown in a concordia diagram (Fig. 3), and a probability density diagram (Fig. 4).

Figure 1. Outcrop photograph for sample 143784: sandstone, Dovers Hills. The photograph shows dark rubbly Paterson Formation (sampled) unconformably overlying Neoproterozoic Heavitree Quartzite exposed as the pavement in the foreground.

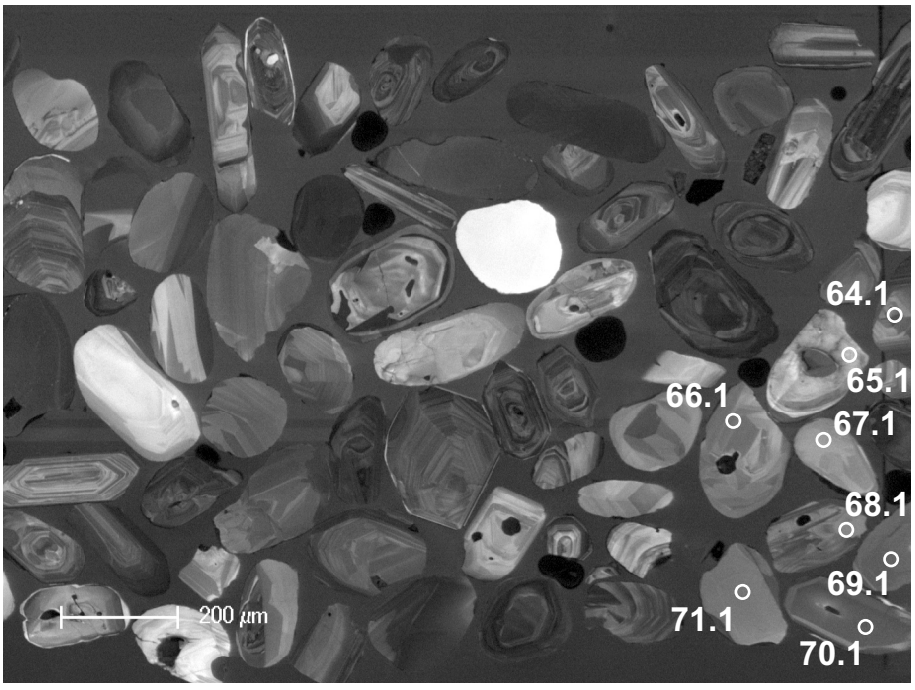

Figure 2. Cathodoluminescence image of representative zircons from sample 143784: sandstone, Dovers Hills. Numbered circles indicate the approximate locations of analysis sites.

Table 1. Ion microprobe analytical results for zircons from sample 143784: sandstone, Dovers Hills

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. (%)
Y	38	784-37.1	79	86	1.13	-0.492	13.344	0.304	0.05682	0.00149	13.278	0.305	0.06086	0.00275	468	11	634	97	26.2
Y	63	784-37.2	72	66	0.95	2.184	12.682	0.230	0.05809	0.00189	12.965	0.256	0.04073	0.00657	479	9	-304	413	257.4
S	53	784-52.1	347	99	0.30	0.283	12.887	0.240	0.05771	0.00069	12.924	0.241	0.05542	0.00106	480	9	429	43	-11.9
S	43	784-42.1	131	136	1.07	0.550	12.315	0.788	0.06068	0.00114	12.383	0.793	0.05622	0.00216	501	33	461	85	-8.6
S	64	784-42.2	135	146	1.11	0.629	12.136	0.179	0.05950	0.00133	12.213	0.183	0.05442	0.00265	507	7	388	109	-30.6
S	60	784-59.1	174	81	0.48	0.845	12.028	0.162	0.06328	0.00119	12.130	0.167	0.05642	0.00260	511	7	469	102	-8.9
S	40	784-39.1	174	83	0.49	0.541	11.959	0.257	0.06030	0.00097	12.024	0.259	0.05592	0.00184	515	11	449	73	-14.7
S	20	784-20.1	146	129	0.91	0.286	11.448	0.240	0.06256	0.00106	11.481	0.241	0.06022	0.00158	538	11	611	57	12.0
S	48	784-47.1	158	60	0.39	1.100	11.375	0.225	0.05934	0.00100	11.502	0.230	0.05055	0.00251	537	10	220	115	-143.9
S	16	784-16.1	918	414	0.47	0.041	11.340	0.211	0.05877	0.00052	11.345	0.211	0.05843	0.00056	545	10	546	21	0.3
S	31	784-30.1	169	112	0.69	0.429	11.292	0.239	0.05985	0.00093	11.341	0.241	0.05637	0.00162	545	11	467	64	-16.7
S	27	784-26.1	39	54	1.45	0.746	11.142	0.275	0.06439	0.00197	11.226	0.281	0.05831	0.00406	550	14	542	152	-1.6
S	73	784-65.1	111	42	0.39	0.918	11.126	0.176	0.06314	0.00153	11.229	0.182	0.05570	0.00343	550	9	441	137	-24.8
S	47	784-46.1	690	174	0.26	-0.031	11.052	0.202	0.05909	0.00047	11.048	0.202	0.05935	0.00050	559	10	580	18	3.7
S	52	784-51.1	98	66	0.70	-0.240	10.989	0.233	0.06106	0.00136	10.963	0.233	0.06304	0.00195	563	12	710	66	20.7
S	14	784-14.1	300	145	0.50	0.213	11.011	0.208	0.05901	0.00077	11.035	0.208	0.05727	0.00109	559	10	502	42	-11.4
S	24	784-23.1	163	115	0.73	0.223	10.917	0.216	0.05951	0.00102	10.941	0.217	0.05770	0.00146	564	11	518	56	-8.8
S	61	784-60.1	188	103	0.56	0.299	10.844	0.145	0.06236	0.00105	10.877	0.146	0.05992	0.00162	567	7	601	58	5.6
S	36	784-35.1	69	40	0.59	1.955	10.799	0.238	0.06369	0.00149	11.014	0.251	0.04816	0.00465	560	12	107	228	-422.9
S	7	784-7.1	124	159	1.32	0.574	10.884	0.224	0.05729	0.00113	10.946	0.227	0.05268	0.00221	564	11	315	95	-79.0
S	32	784-31.1	140	96	0.71	0.229	10.828	1.639	0.06064	0.00106	10.853	1.643	0.05878	0.00151	568	96	559	56	-1.7
S	26	784-25.1	143	67	0.48	0.239	10.809	0.217	0.05935	0.00106	10.835	0.218	0.05741	0.00155	569	11	507	59	-12.2
S	21	784-20.2	103	70	0.70	0.350	10.776	0.763	0.05771	0.00737	10.814	0.766	0.05488	0.00757	570	41	407	309	-39.9
S	54	784-53.1	390	154	0.41	0.134	10.580	0.207	0.06011	0.00074	10.594	0.207	0.05902	0.00089	581	11	568	33	-2.4
S	72	784-64.1	109	59	0.56	0.526	10.331	0.162	0.06329	0.00141	10.386	0.165	0.05900	0.00258	593	9	567	95	-4.5
S	79	784-71.1	63	63	1.03	0.233	10.134	0.190	0.06698	0.00195	10.158	0.191	0.06505	0.00275	605	11	776	89	22.0
S	11	784-11.1	90	134	1.54	1.156	10.165	0.217	0.06367	0.00131	10.284	0.223	0.05434	0.00327	598	13	385	135	-55.4
S	18	784-18.1	59	46	0.81	1.475	9.990	0.227	0.05816	0.00155	10.140	0.237	0.04650	0.00447	606	14	23	231	-2484.0
S	58	784-57.1	91	131	1.49	1.847	9.874	0.165	0.06328	0.00155	10.060	0.177	0.04860	0.00478	611	10	128	232	-376.0
S	77	784-69.1	138	46	0.35	0.922	9.661	0.158	0.06345	0.00123	9.751	0.162	0.05597	0.00281	629	10	451	111	-39.4
S	81	784-73.1	309	123	0.41	0.312	9.297	0.115	0.06223	0.00362	9.326	0.116	0.05967	0.00374	657	8	592	136	-11.0
S	33	784-32.1	88	56	0.66	0.554	9.231	0.220	0.06430	0.00145	9.282	0.222	0.05977	0.00236	660	15	595	86	-10.8
S	13	784-13.1	139	85	0.63	0.491	9.150	0.184	0.06393	0.00103	9.195	0.186	0.05992	0.00184	665	13	601	67	-10.8
S	56	784-55.1	158	86	0.56	0.411	6.911	0.136	0.06921	0.00084	6.939	0.137	0.06582	0.00137	868	16	801	44	-8.4
S	30	784-29.1	177	79	0.46	0.189	6.784	0.134	0.07245	0.00078	6.797	0.134	0.07088	0.00102	885	17	954	29	7.2
S	4	784-4.1	162	71	0.45	0.141	6.767	0.136	0.06976	0.00090	6.776	0.136	0.06859	0.00113	887	17	886	34	-0.1
S	34	784-33.1	106	55	0.54	0.117	6.552	0.135	0.07183	0.00105	6.560	0.135	0.07086	0.00126	915	18	953	36	4.1
S	46	784-45.1	120	99	0.85	0.332	6.443	0.131	0.07374	0.00094	6.465	0.131	0.07098	0.00141	927	18	957	41	3.1
S	9	784-9.1	229	56	0.25	0.164	6.340	0.123	0.07154	0.00392	6.350	0.123	0.07017	0.00396	943	17	933	116	-1.0
S	10	784-10.1	49	18	0.39	0.931	6.213	0.162	0.07435	0.00147	6.271	0.165	0.06664	0.00313	954	24	826	98	-15.4

Table 1. continued

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. (%)
S	41	784-40.1	361	163	0.46	0.083	5.700	0.107	0.07545	0.00058	5.704	0.107	0.07475	0.00066	1041	18	1062	18	1.9
S	23	784-22.1	56	55	1.01	0.563	5.674	0.131	0.07412	0.00132	5.706	0.133	0.06943	0.00234	1041	23	912	69	-14.2
S	44	784-43.1	53	48	0.94	0.513	5.627	0.132	0.07485	0.00139	5.656	0.133	0.07057	0.00238	1049	23	945	69	-11.0
S	28	784-27.1	202	138	0.71	0.099	5.403	0.104	0.07956	0.00310	5.408	0.104	0.07873	0.00313	1094	20	1165	79	6.1
S	29	784-28.1	34	39	1.20	0.666	5.292	0.630	0.07106	0.00209	5.328	0.634	0.06556	0.00348	1109	136	792	111	-40.0
S	39	784-38.1	13	18	1.37	-1.261	5.241	0.189	0.07764	0.00308	5.176	0.190	0.08841	0.00686	1139	40	1391	149	18.2
S	68	784-34.2	170	14	0.08	0.203	5.164	0.072	0.08077	0.00093	5.174	0.072	0.07905	0.00121	1139	15	1174	30	2.9
S	15	784-15.1	182	105	0.60	0.048	5.170	0.101	0.07935	0.00072	5.173	0.101	0.07894	0.00077	1139	21	1171	19	2.7
S	55	784-54.1	36	179	5.21	1.240	5.172	0.133	0.07825	0.00168	5.237	0.136	0.06796	0.00387	1127	28	867	118	-29.9
S	42	784-41.1	48	83	1.77	-0.093	5.119	0.121	0.08122	0.00145	5.114	0.121	0.08201	0.00165	1151	26	1246	39	7.6
S	65	784-62.1	87	69	0.83	0.392	5.041	0.084	0.08160	0.00129	5.061	0.085	0.07829	0.00197	1162	18	1154	50	-0.7
S	19	784-19.1	24	27	1.14	0.175	5.037	0.143	0.08067	0.00195	5.046	0.143	0.07919	0.00245	1165	31	1177	61	1.0
S	3	784-3.1	166	86	0.54	0.344	5.037	0.105	0.08024	0.00081	5.054	0.106	0.07734	0.00120	1164	23	1130	31	-3.0
S	71	784-63.1	25	33	1.36	1.692	5.009	0.137	0.08047	0.00244	5.096	0.144	0.06646	0.00633	1155	31	821	199	-40.7
S	74	784-66.1	119	119	1.03	0.167	5.003	0.077	0.08126	0.00109	5.012	0.077	0.07985	0.00137	1173	17	1193	34	1.7
S	45	784-44.1	174	213	1.27	0.027	4.988	0.098	0.08066	0.00076	4.990	0.098	0.08043	0.00079	1178	21	1208	19	2.5
S	5	784-5.1	176	66	0.39	0.153	4.960	0.237	0.07983	0.00080	4.967	0.238	0.07854	0.00099	1182	54	1161	25	-1.9
S	35	784-34.1	31	5	0.17	0.305	4.964	0.137	0.07578	0.00173	4.979	0.137	0.07323	0.00251	1180	31	1020	69	-15.6
S	1	784-1.1	55	75	1.40	0.259	4.813	0.120	0.07953	0.00128	4.826	0.121	0.07735	0.00180	1214	28	1130	46	-7.4
S	78	784-70.1	111	136	1.27	-0.282	4.732	0.077	0.08241	0.00112	4.719	0.077	0.08481	0.00154	1239	19	1311	35	5.5
S	2	784-2.1	156	141	0.93	0.478	4.729	0.097	0.08024	0.00089	4.751	0.098	0.07622	0.00144	1231	24	1101	38	-11.9
S	80	784-72.1	42	32	0.79	0.393	3.469	0.075	0.10647	0.00179	3.482	0.075	0.10306	0.00248	1627	32	1680	44	3.1
S	51	784-50.1	226	150	0.69	0.085	3.428	0.066	0.10520	0.00066	3.431	0.066	0.10447	0.00073	1649	29	1705	13	3.3
S	8	784-8.1	334	76	0.23	0.124	3.270	0.061	0.10659	0.00053	3.274	0.062	0.10551	0.00061	1718	29	1723	11	0.3
S	67	784-49.2	470	148	0.33	0.045	3.075	0.037	0.10793	0.00066	3.076	0.037	0.10754	0.00069	1814	19	1758	12	-3.2
S	37	784-36.1	99	105	1.10	0.000	2.908	0.061	0.11501	0.00118	2.908	0.061	0.11501	0.00118	1905	35	1880	19	-1.3
S	22	784-21.1	52	70	1.39	0.041	2.315	0.056	0.14280	0.00142	2.316	0.056	0.14244	0.00147	2313	48	2257	18	-2.5
S	76	784-68.1	106	46	0.44	-0.022	1.787	0.037	0.19728	0.00137	1.787	0.037	0.19748	0.00138	2865	49	2806	11	-2.1
S	75	784-67.1	45	74	1.68	0.198	1.866	0.040	0.19991	0.00249	1.870	0.040	0.19814	0.00265	2762	49	2811	22	1.7
S	66	784-48.2	58	26	0.46	0.000	1.570	0.030	0.26201	0.00195	1.570	0.030	0.26201	0.00195	3177	49	3259	12	2.5
S	70	784-24.2	137	66	0.50	0.065	1.488	0.022	0.30362	0.00139	1.489	0.022	0.30307	0.00141	3312	39	3486	7	5.0
D	6	784-6.1	13	30	2.38	8.213	10.705	0.404	0.07436	0.00414	11.663	0.562	0.00624	0.02520	530	26	0	0	0.0
D	57	784-56.1	12	66	5.59	8.041	5.601	0.211	0.10774	0.00401	6.091	0.270	0.04409	0.01904	980	42	-106	1063	1026.1
D	12	784-12.1	145	383	2.73	0.127	5.296	0.365	0.11408	0.01004	5.303	0.365	0.11297	0.01007	1114	75	1848	161	39.7
D	59	784-58.1	15	25	1.71	3.760	4.966	0.163	0.10028	0.00343	5.160	0.183	0.06903	0.01141	1142	38	899	341	-27.0
D	62	784-61.1	320	273	0.88	0.225	3.868	0.048	0.09914	0.00065	3.877	0.048	0.09721	0.00082	1479	16	1571	16	5.9
D	50	784-49.1	459	86	0.19	0.033	3.366	0.244	0.10910	0.00906	3.367	0.244	0.10881	0.00906	1676	114	1780	152	5.8
D	17	784-17.1	82	84	1.07	0.113	1.797	0.218	0.16017	0.01891	1.799	0.218	0.15916	0.01893	2850	311	2447	201	-16.5
D	69	784-17.2	69	75	1.12	0.175	1.865	0.141	0.17052	0.00167	1.868	0.142	0.16895	0.00179	2764	182	2547	18	-8.5
D	49	784-48.1	93	53	0.59	0.013	1.708	0.036	0.26338	0.00133	1.708	0.036	0.26327	0.00134	2971	51	3266	8	9.0
D	25	784-24.1	198	125	0.65	-0.017	1.680	0.033	0.29246	0.00097	1.680	0.033	0.29260	0.00098	3010	47	3431	5	12.3

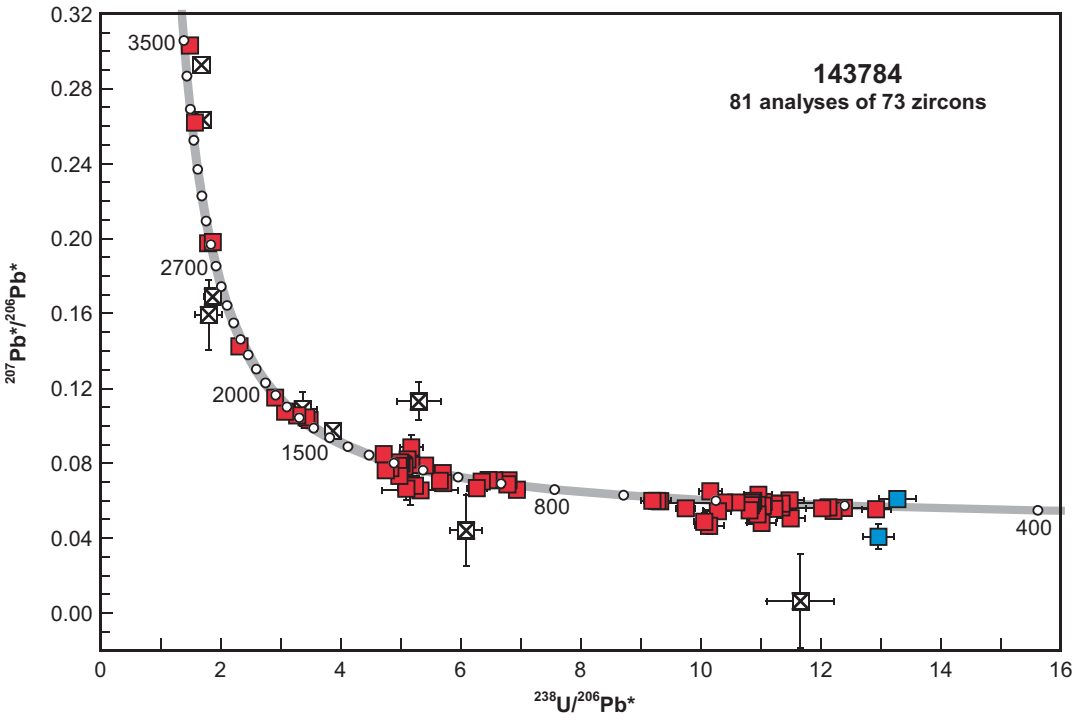

Figure 3. U–Pb analytical data for zircons from sample 143784: sandstone, Dovers Hills. Data are corrected for common Pb using measured $^{204}Pb/^{206}Pb$. Blue squares indicate Group Y (youngest detrital zircon); red squares indicate Group S (older detrital zircons); crossed squares indicate Group D (U/Pb date >1300 Ma and discordance >5% or U/Pb date <1300 Ma and $f207$ >1%).

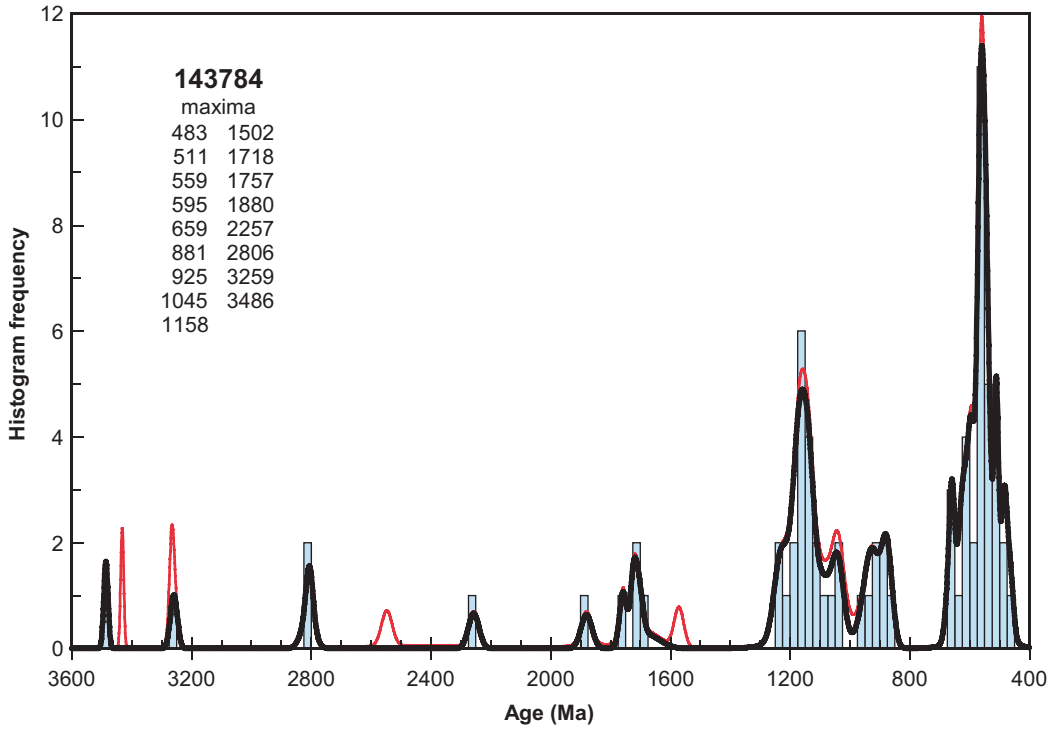

Figure 4. Probability density diagram and histogram for sample 143784: sandstone, Dovers Hills. Dates <1300 Ma are based on 207-corrected $^{238}U/^{206}Pb^*$ ratios. Thick curve, maxima values, and frequency histogram (bin width 25 Ma) include only accepted data (71 analyses of 67 zircons). Thin curve includes all data (81 analyses of 73 zircons).

Interpretation

Most analyses are concordant to slightly discordant (Fig. 3). Six analyses >1300 Ma are >5% discordant, and four analyses <1300 Ma indicate high common-Pb corrections (f207 >2%). The dates obtained from these 10 analyses (Group D; Table 1) are imprecise or unreliable, and are considered not to be geologically significant. The remaining 58 analyses can be divided into two groups, based on their $^{207}Pb^*/^{206}Pb^*$ and $^{238}U/^{206}Pb^*$ ratios.

Group Y comprises two analyses of one zircon (Table 1), which yield a weighted mean 207-corrected $^{238}U/^{206}Pb^*$ date of 478 ± 13 Ma (2σ).

Group S comprises 69 analyses of 66 zircons (Table 1), which yield $^{207}Pb^*/^{206}Pb^*$ or $^{238}U/^{206}Pb^*$ dates of 3486–481 Ma.

It is possible that all of the analyses are of unmodified detrital zircons, in which case the date of 478 ± 13 Ma (2σ) for the two analyses in Group Y represents a maximum depositional age for the sandstone. A more conservative estimate of the maximum depositional age can be based on the weighted mean 207-corrected $^{238}U/^{206}Pb^*$ date (2σ) of 498 ± 11 Ma (MSWD = 3.0) for the three youngest analyses in Group S.

The data for Group S indicate significant age components at c. 1158, 1045, 925, 881, 659, 595, 559, 511, and 483 Ma (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.

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