178012: biotite tonalite gneiss, Quartz Hill

Location and sampling

NULLAGINE (SF 51-5), NULLAGINE (2954) MGA Zone 51, 212190E 7567170N

Sampled on 27 May 2002

The sample was taken from a 1 m-diameter lens within a low rocky, rubbly area 50 m west of the access track, 3 km west-southwest of Quartz Hill.

Tectonic unit/relations

The sample is from a pale grey, fine- and even-grained, foliated homogeneous tonalite gneiss consisting of aligned biotite, and quartz and feldspar, of the Golden Eagle Orthogneiss, Kurrana Granitoid Complex, Kurrana Terrane. The sample was dated to constrain the age of deformation in the overlying Mosquito Creek Formation (Bagas, in prep.).

Petrographic description

The principal minerals in this sample are plagioclase (andesine–oligoclase; 60 vol.%), quartz (25–30 vol.%), K-feldspar (5 vol.%), and mafic minerals, mostly biotite and magnetite (3 vol.%), with accessory apatite (trace), magnetite (trace), allanite (trace), zircon (trace), sericite (trace), chlorite (trace), epidote (trace), and stilpnomelane (trace). This fine-grained foliated granitoid rock has only very minor fine-grained K-feldspar, and is a biotite tonalite or trondhjemite gneiss. The plagioclase occurs largely as anhedral, commonly rounded grains or augen to 2.5 mm in diameter, with patches of sericite, clinozoisite, and epidote. Rarely, there are irregular inclusions of microcline in the plagioclase. Smaller, possibly recrystallized grains of plagioclase are also common, and are about 0.5 mm in diameter, with similar-sized grains of microcline and myrmekite. The quartz occurs as grains to 2 mm long and as smaller, possibly recrystallized grains, commonly in lamellae parallel to the foliation. Fine-grained biotite defines a wavy foliation in the rock. Much of the biotite has been altered to chlorite or epidote, with granular epidote also adjacent to altered biotite flakes, rarely with cores of altered allanite. Small bundles of ferri-stilpnomelane flakes occur in and adjacent to altered biotite or in plagioclase. Minor opaque oxide, probably magnetite, forms grains from 0.2 to 1.5 mm in length, usually parallel to the foliation. Some magnetite is coated with chloritized biotite. Traces of apatite are present but zircon, as slender prisms, is rare. This sample is an amphibolite-facies tonalite or trondhjemite gneiss with later alteration involving chlorite, sericite, epidote, and stilpnomelane, suggesting low-temperature oxidation.

Zircon morphology

The zircons isolated from this sample are typically colourless, pale yellowish-brown or dark brown, elongate, euhedral, and between 60 × 140 μm and 160 × 280 μm in size. Many grains have faint internal zonation, whereas a minority are structureless and unzoned but contain abundant fluid and mineral inclusions. Cathodoluminescence images of representative zircons are given in Figure 1.

Analytical details

This sample was analysed on 3 October 2002. The counter deadtime during the analysis session was 24 ns. Nine analyses of the CZ3 standard obtained during the analysis session indicated a Pb*/U calibration uncertainty of 3.42% (1σ). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 5.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-one analyses were obtained from 21 zircons. Results are given in Table 1 and shown on a concordia plot in Figure 2.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a single ancient episode of radiogenic-Pb loss. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses can be assigned to one of two groups. Fourteen concordant and slightly discordant analyses of 14 zircons, assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3178 ± 3 Ma (chi-squared = 1.10). Concordant and slightly discordant analyses 1.1, 2.1, 4.1, and 9.1, assigned to Group 2, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3150 ± 9 Ma (chi-squared = 0.52). The remaining analyses (10.1, 12.1, 15.1) are discordant and cannot be grouped.

There are no obvious morphological differences between the grains from which analyses belonging to Groups 1 and 2 were derived. There are two plausible interpretations of these results. The date of 3150 ± 9 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the four concordant and slightly discordant analyses 1.1, 2.1, 4.1, and 9.1, assigned to Group 2, can be interpreted as the age of igneous crystallization of the tonalitic precursor to the gneiss, with the older date indicated by the analyses of Group 1 attributed to the presence of xenocryst zircons. Alternatively, the date of 3178 ± 3 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 14 concordant and slightly discordant analyses of Group 1 can be interpreted as the age of igneous crystallization of the tonalite, with

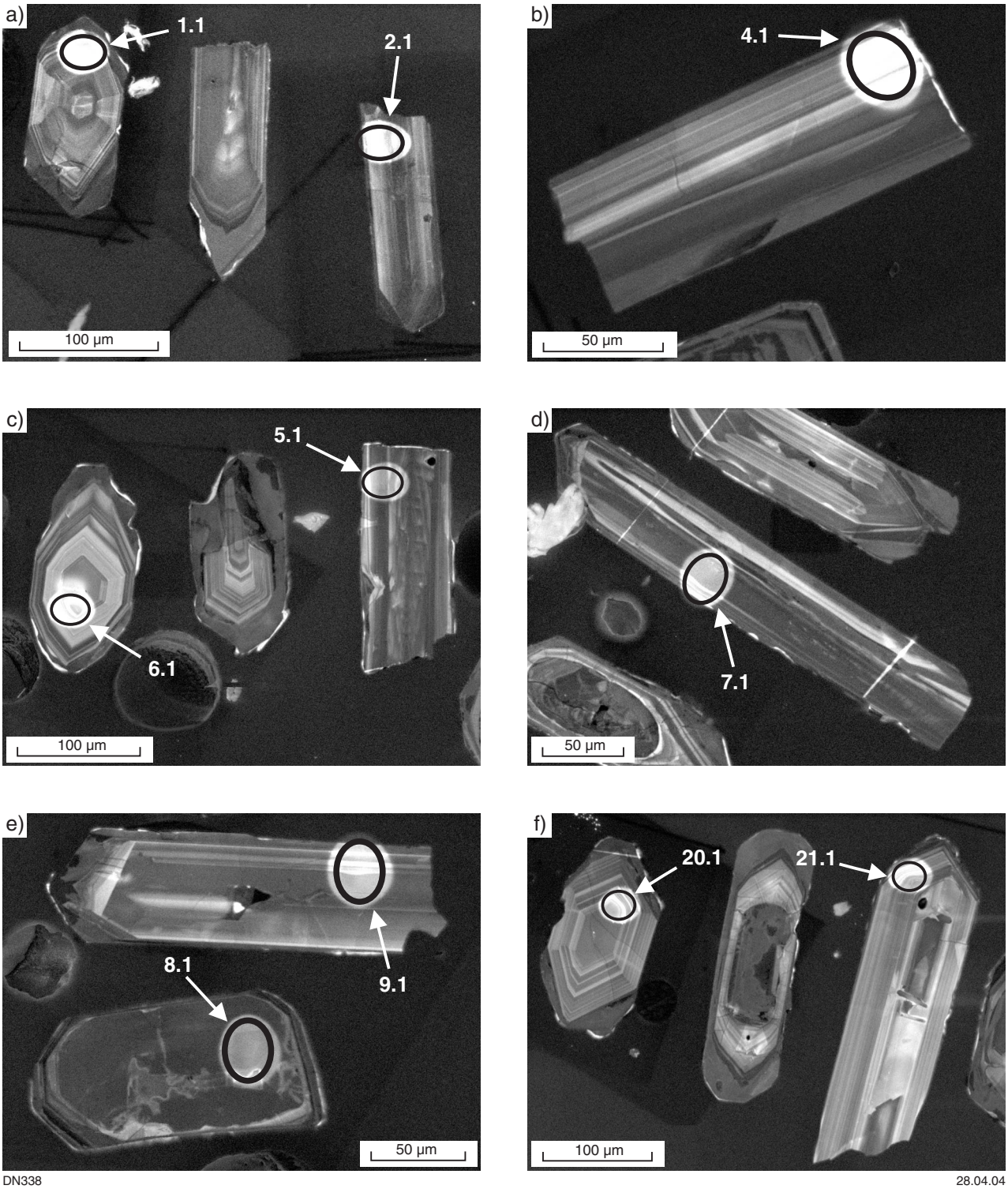

Figure 1. Cathodoluminescence images of representative zircons from sample 178012: biotite tonalite gneiss, Quartz Hill

the younger date indicated by the analyses of Group 2 due to ancient radiogenic-Pb loss during a disturbance event (?metamorphism) at or near this time. As the analyses of Group 2 generally indicate high U concentrations at these analysis sites, the latter interpretation is preferred. The slightly younger $^{207}Pb/^{206}Pb$ dates indicated by the remaining highly discordant analyses are interpreted to be of analysis sites that have lost radiogenic Pb during an ancient disturbance event.

Recommended reference for this publication:

NELSON, D. R., 2004, 178012: biotite tonalite gneiss, Quartz Hill; Geochronology dataset 96; in Compilation of geochronology data, June 2006 update: Western Australia Geological Survey.

Data obtained: 03/10/2002; Data released: 06/12/2004

Table 1. Ion microprobe analytical results for sample 178012: biotite tonalite gneiss, Quartz Hill

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1σ*	$^{208}Pb/^{206}Pb$	*±1σ*	$^{206}Pb/^{238}U$	*±1σ*	$^{207}Pb/^{235}U$	*±1σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *Age*	*±1σ*
1.1	190	73	142	0.343	0.24500	0.00084	0.11747	0.00113	0.6302	0.0216	21.287	0.743	100	3 153	5
2.1	202	108	152	0.343	0.24543	0.00084	0.15104	0.00118	0.6208	0.0213	21.008	0.733	99	3 156	5
3.1	175	108	145	0.505	0.24855	0.00087	0.17516	0.00134	0.6663	0.0229	22.836	0.798	104	3 176	6
4.1	83	33	63	0.479	0.24417	0.00132	0.11103	0.00193	0.6400	0.0221	21.544	0.766	101	3 147	9
5.1	251	190	210	0.582	0.25025	0.00074	0.22216	0.00121	0.6458	0.0221	22.282	0.775	101	3 186	5
6.1	95	48	73	0.157	0.24837	0.00107	0.13809	0.00131	0.6402	0.0220	21.923	0.772	100	3 174	7
7.1	401	352	334	0.154	0.24829	0.00051	0.24813	0.00075	0.6423	0.0220	21.990	0.760	101	3 174	3
8.1	448	226	352	0.096	0.24894	0.00047	0.13173	0.00051	0.6596	0.0226	22.640	0.782	103	3 178	3
9.1	260	165	189	0.248	0.24403	0.00066	0.19909	0.00096	0.5799	0.0199	19.512	0.678	94	3 146	4
10.1	743	314	425	0.116	0.22838	0.00040	0.13792	0.00049	0.4847	0.0166	15.262	0.527	84	3 041	3
11.1	147	88	111	0.141	0.24723	0.00086	0.16248	0.00110	0.6195	0.0213	21.118	0.738	98	3 167	6
12.1	654	271	323	0.080	0.21510	0.00042	0.13059	0.00050	0.4247	0.0145	12.595	0.435	77	2 944	3
13.1	194	117	155	0.072	0.24883	0.00066	0.16177	0.00078	0.6565	0.0225	22.523	0.783	102	3 177	4
14.1	67	27	51	0.318	0.24778	0.00140	0.10377	0.00185	0.6514	0.0225	22.256	0.795	102	3 171	9
15.1	398	236	261	0.239	0.23498	0.00058	0.18758	0.00085	0.5322	0.0182	17.243	0.598	89	3 086	4
16.1	77	42	65	0.305	0.24768	0.00128	0.14777	0.00178	0.6976	0.0241	23.823	0.847	108	3 170	8
17.1	104	44	83	0.149	0.24936	0.00100	0.11336	0.00115	0.6735	0.0232	23.156	0.813	104	3 181	6
18.1	198	110	157	0.060	0.24893	0.00070	0.15009	0.00076	0.6579	0.0226	22.582	0.785	103	3 178	4
19.1	119	51	89	0.066	0.25065	0.00088	0.11714	0.00096	0.6321	0.0217	21.844	0.764	99	3 189	6
20.1	109	46	84	0.097	0.24952	0.00093	0.11338	0.00103	0.6574	0.0226	22.618	0.793	102	3 182	6
21.1	100	41	78	0.169	0.24920	0.00103	0.10649	0.00129	0.6668	0.0229	22.911	0.805	104	3 180	7

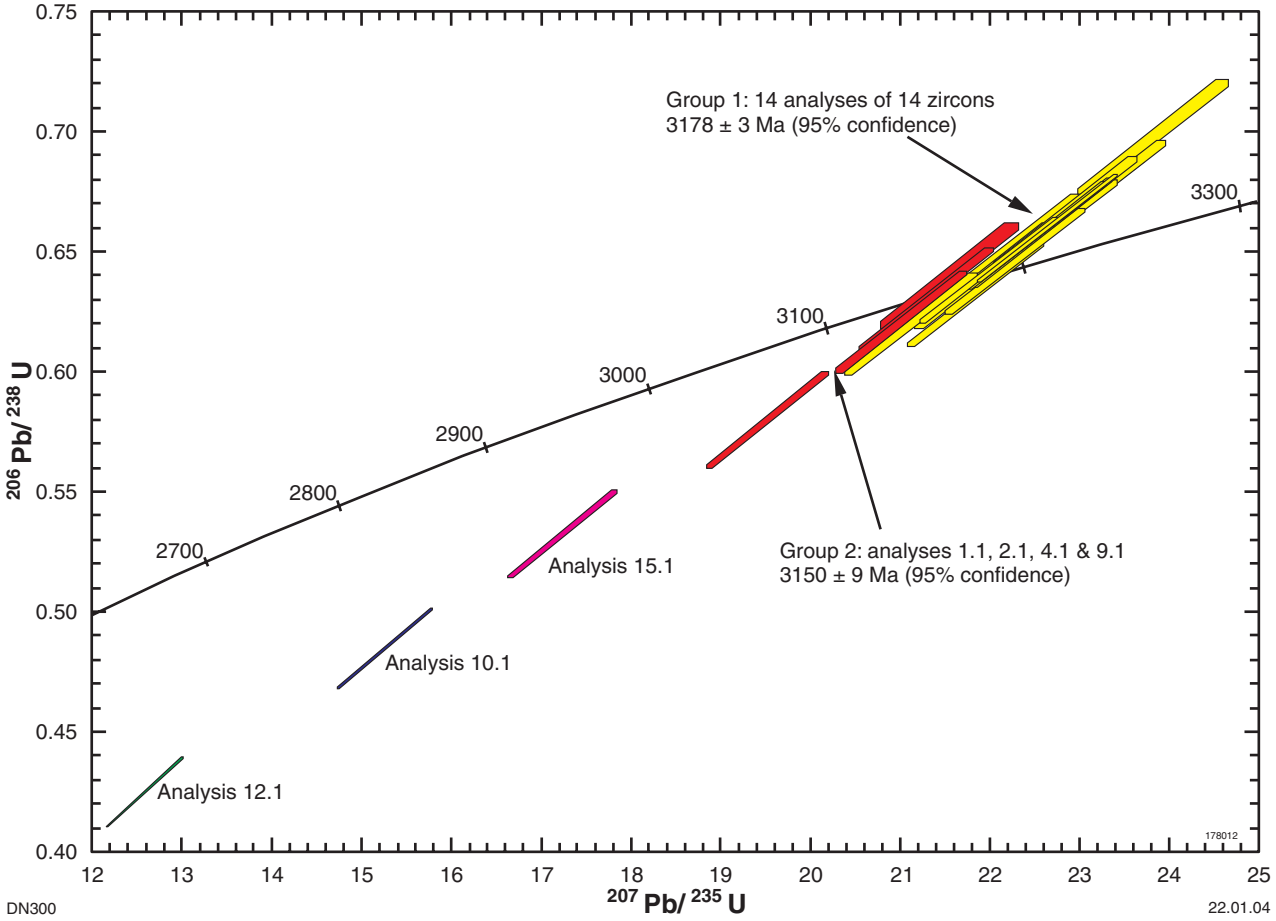

Figure 2. Concordia plot for sample 178012: biotite tonalite gneiss, Quartz Hill