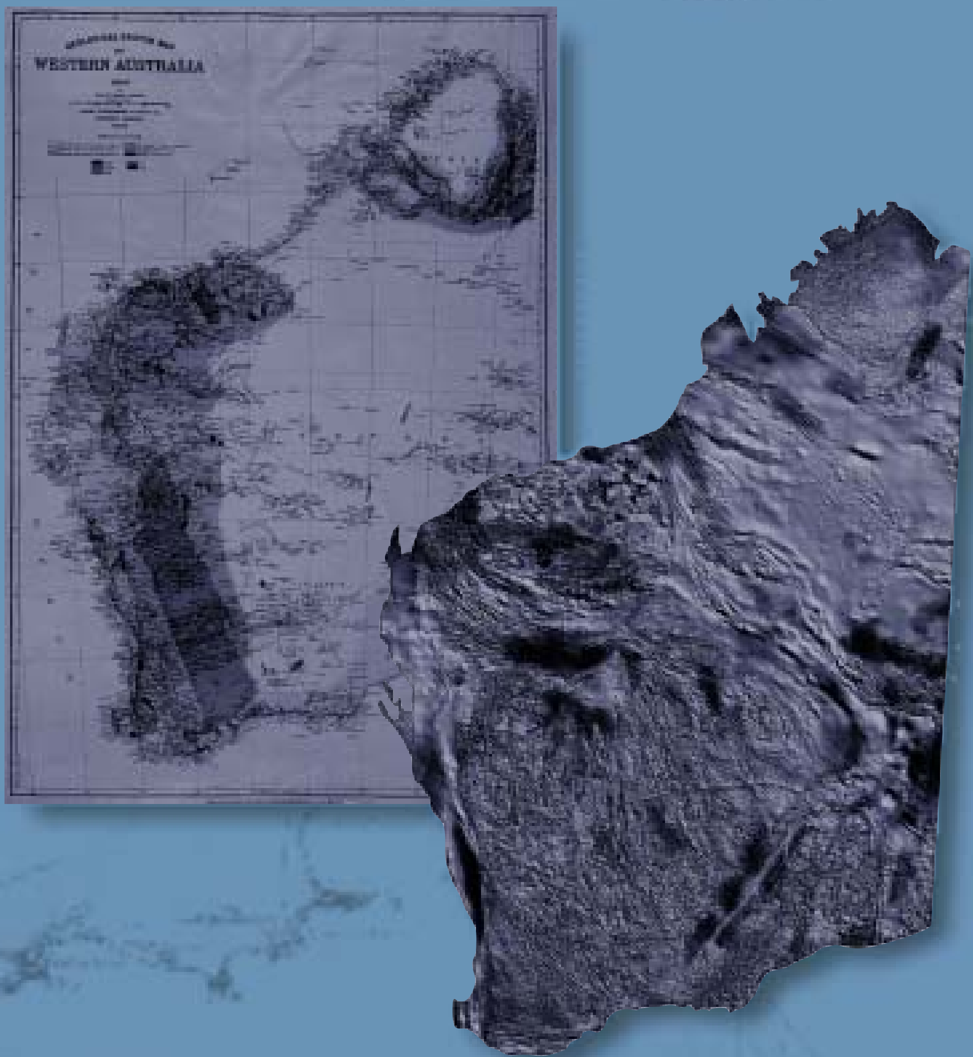
Department of
Mineral and Petroleum Resources

RECORD
2002/2

COMPILATION OF GEOCHRONOLOGY DATA, 2001

by D. R. Nelson



Geological Survey of Western Australia

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

Record 2002/2

COMPILATION OF GEOCHRONOLOGY DATA 2001

by

D. R. Nelson

Perth 2002

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by

D. R. Nelson

Introduction

This Record is the eighth in a series of publications that make high-precision geochronology data on rocks from Western Australia available within 12 months of their acquisition. All results reported herein, on samples taken from the East Pilbara Granite–Greenstone Terrane, the Narryer Terrane and Southern Cross Granite–Greenstone Terrane, the Malmac Dome, the Gascoyne and Leeuwin Complexes, and the Collier, Edmund, Gunbarrel, Hamersley, Mallina, Mosquito Creek, Officer, Yeneena and Yerrida Basins, were obtained during 2001. Approximate positions of sampling localities are shown in Figure 1.

This Record describes the samples analysed and the analytical results obtained, and contains some limited discussion of their interpretation. The broader geological implications of the data presented here will be published elsewhere. Discussion of recently published geochronology results is given in Bagas and Nelson (2001), Bagas et al. (2002), Chen and Wyche (2001a), Eriksson et al. (2001), Greenfield et al. (2001), Hickman et al. (2001), Myers and Nelson (2001), Nelson (2001a), Occhipinti et al. (2001), Smithies et al. (2001a), Van Kranendonk et al. (2001), and Wilde and Nelson (2001a).

Analytical procedures

Routine procedures applied at the Carlisle laboratories and the SHRIMP (Sensitive high-resolution ion microprobe) facility at the Department of Applied Physics, Curtin University of Technology, for the dating of rock samples by the U–Pb zircon technique, have been described elsewhere (Nelson 1997, 1999). A summary of some pertinent aspects of the procedures is given below.

Common-Pb corrections have been applied using the ^{204}Pb correction method (Compston et al., 1984) and assuming the isotopic composition of Broken Hill common Pb when the ^{204}Pb counts (for monazite analyses, corrected for excess ^{204}Pb counts) on unknowns are less than six times the average ^{204}Pb counts measured on the CZ3 or MAD standards (also corrected for excess ^{204}Pb counts where appropriate) during the analysis session. Where the (corrected) ^{204}Pb counts on unknowns exceeds six times the (corrected) average ^{204}Pb counts measured on the standards, common-Pb compositions have been determined using the method of Cumming and Richards (1975).

Errors given on individual analyses are based on counting statistics and include uncertainties in the corrections for the presence of common Pb. Uncertainties in Pb*/U ratios for individual analyses include those associated with the determination of the Pb/U calibration curve based on the reproducibility of the CZ3 zircon and MAD

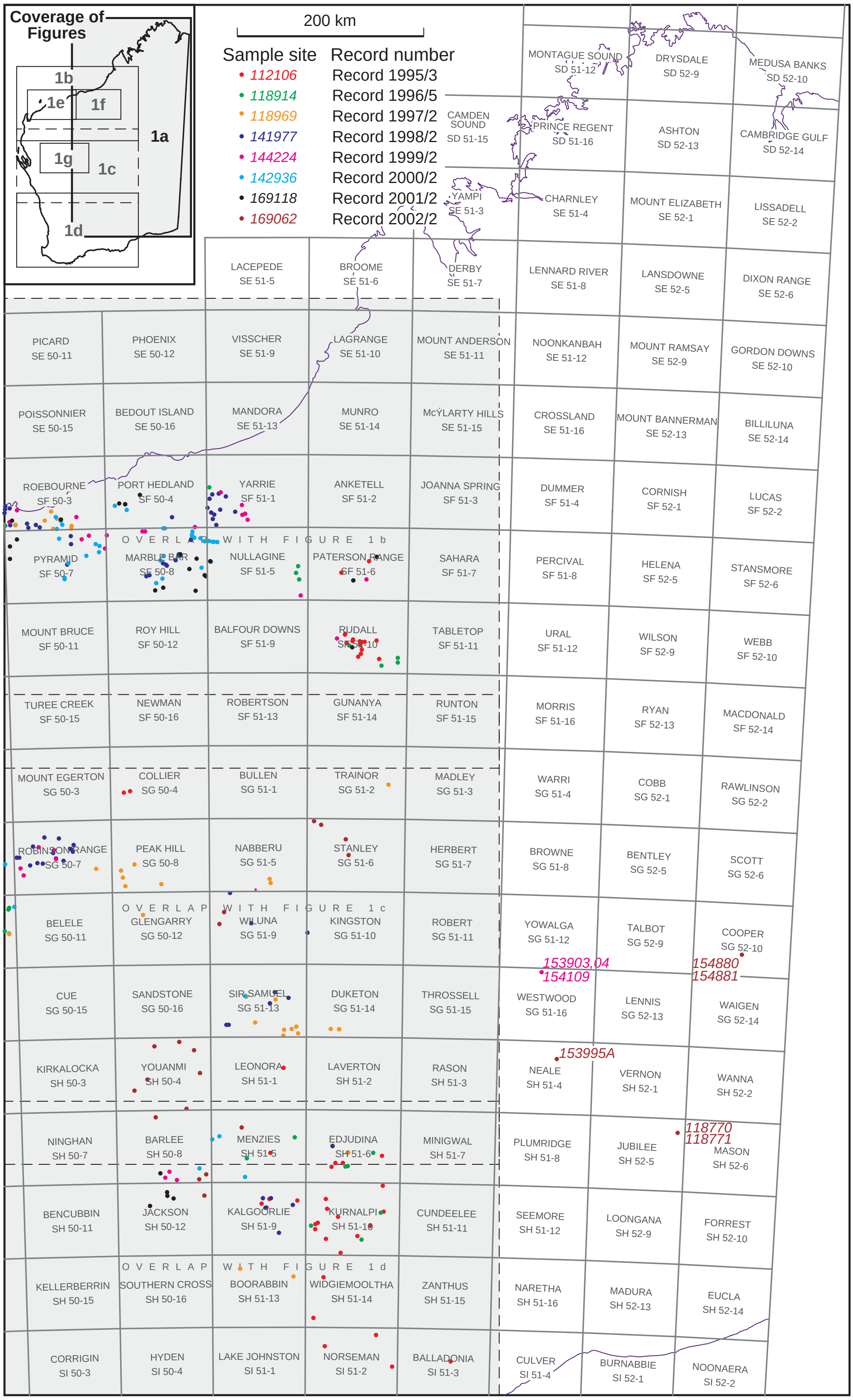

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Figure 1a. Approximate locations of samples for which geochronology data are given in this report. Positions of samples described in previous GSWA compilations of SHRIMP U–Pb zircon geochronology data (Nelson, 1995, 1996, 1997, 1998, 1999, 2000, 2001b) are also given

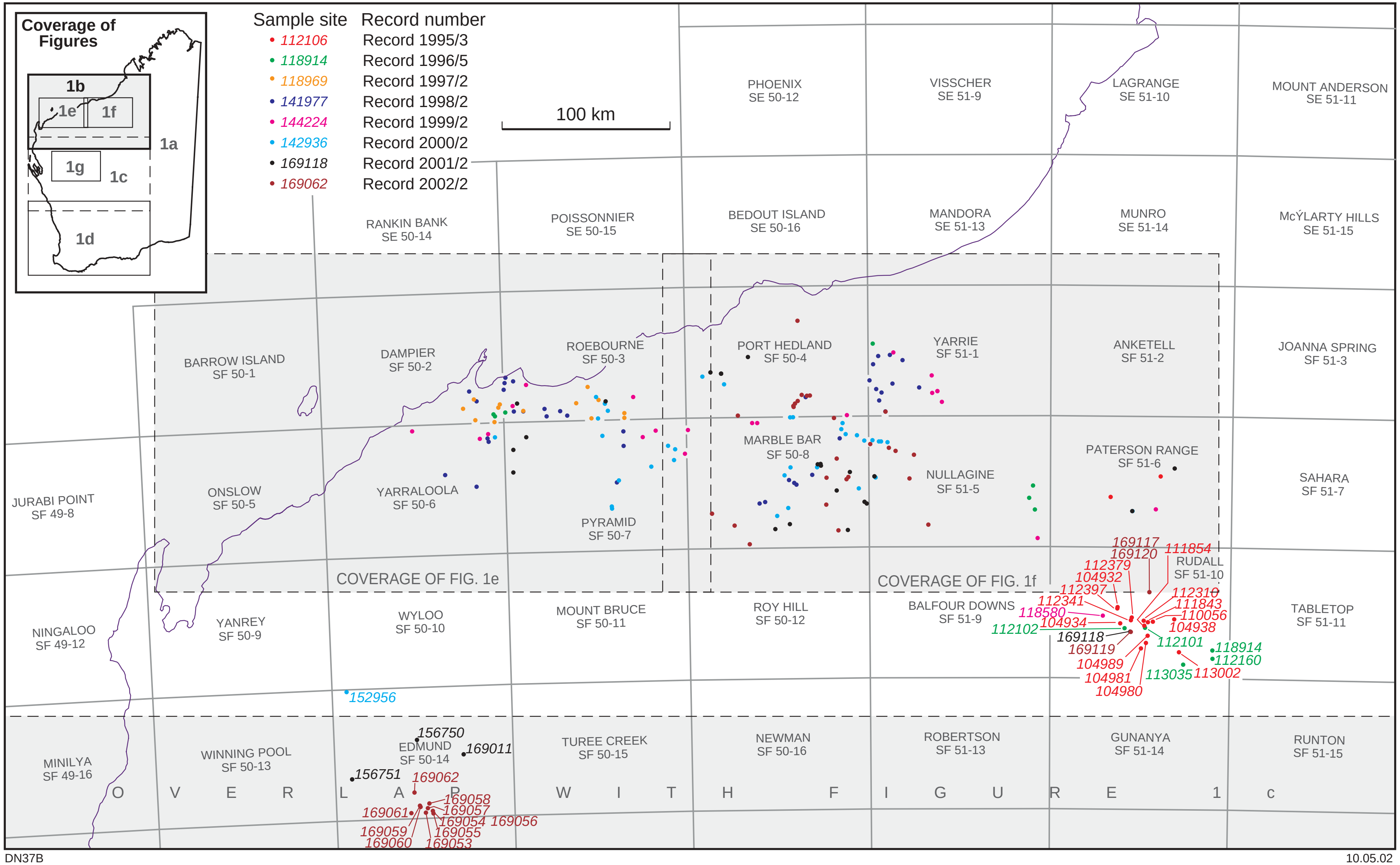

Figure 1b. (continued)

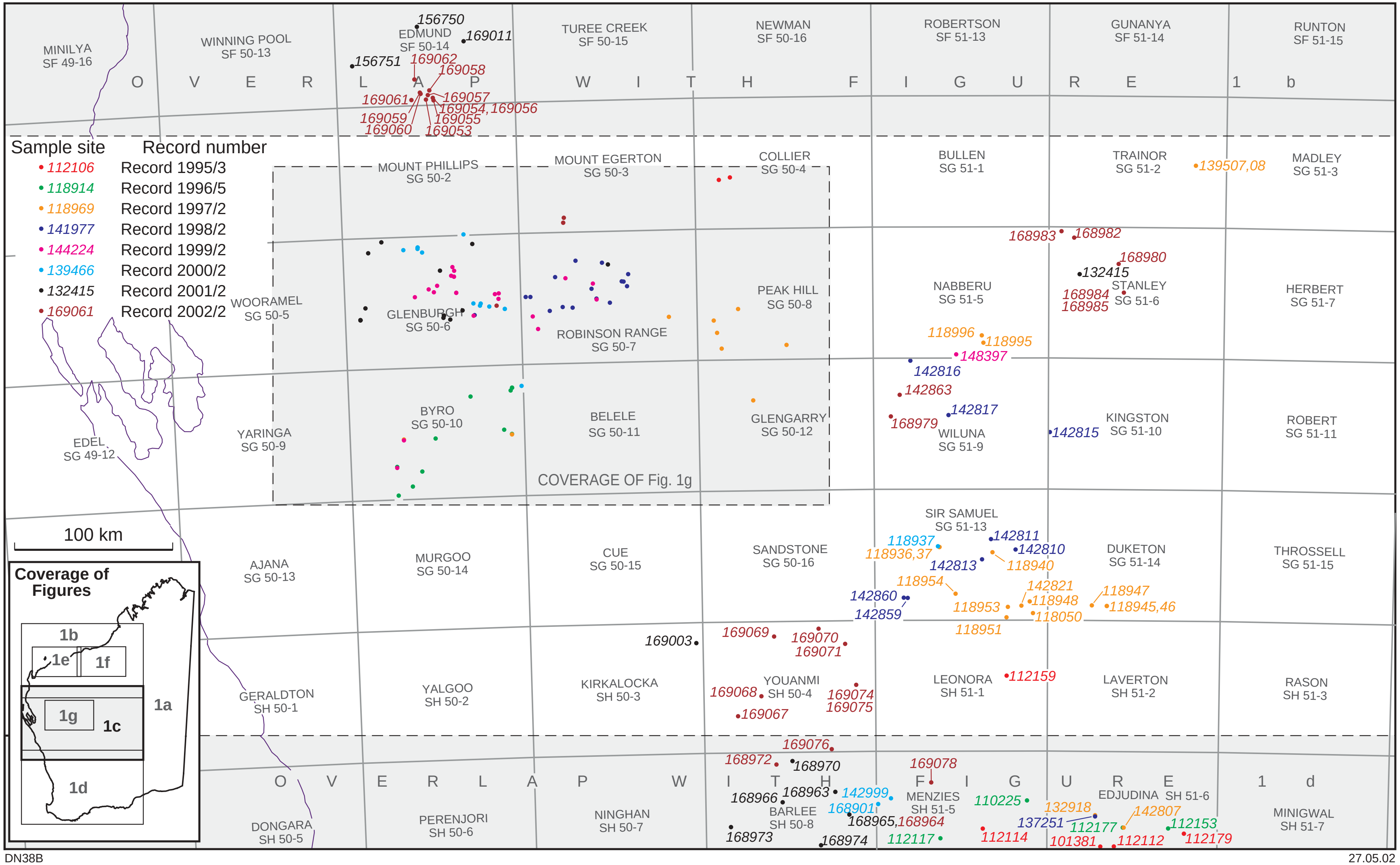

Figure 1c. (continued)

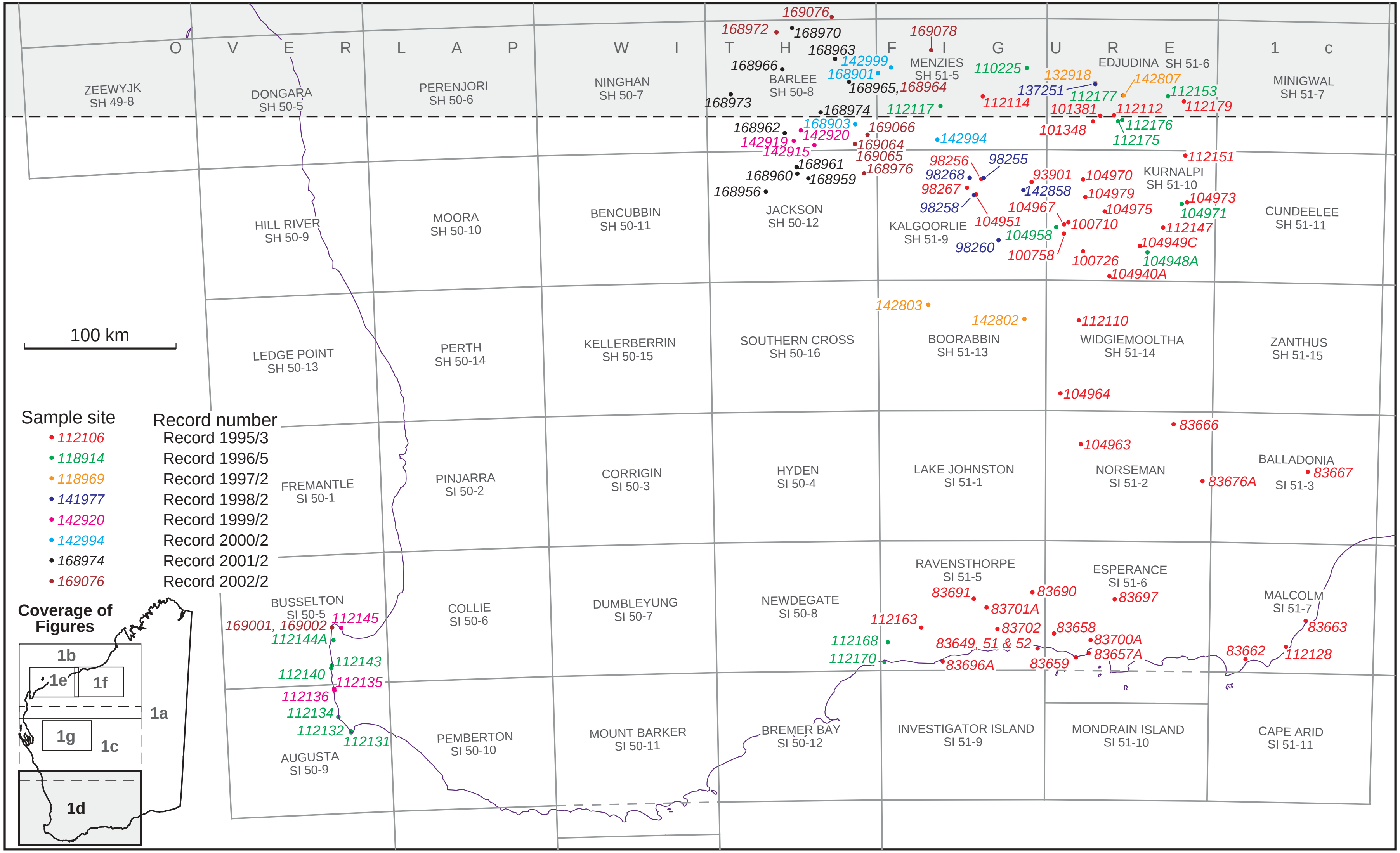

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Figure 1d. (continued)

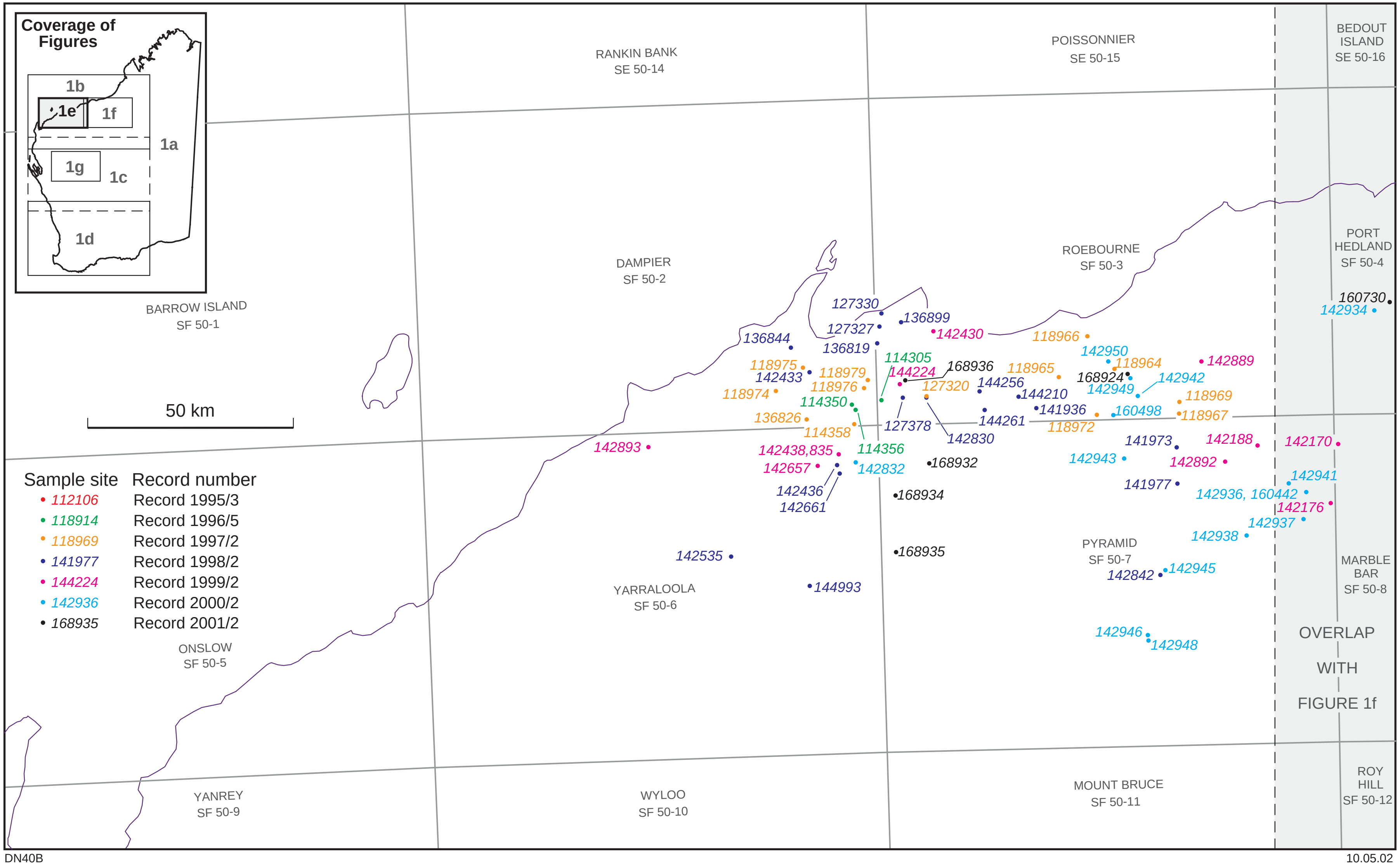

Figure 1e. (continued)

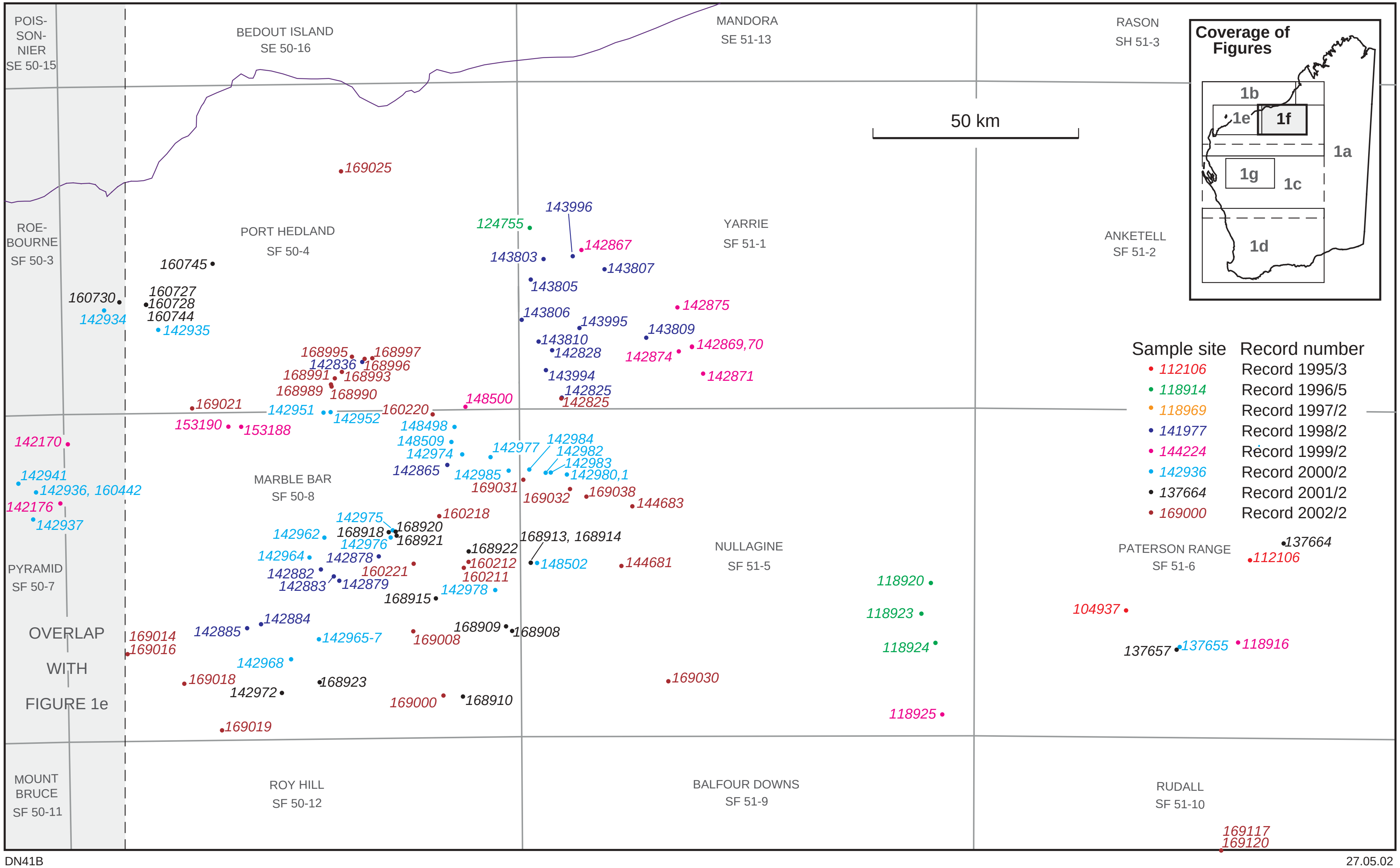

Figure 1f. (continued)

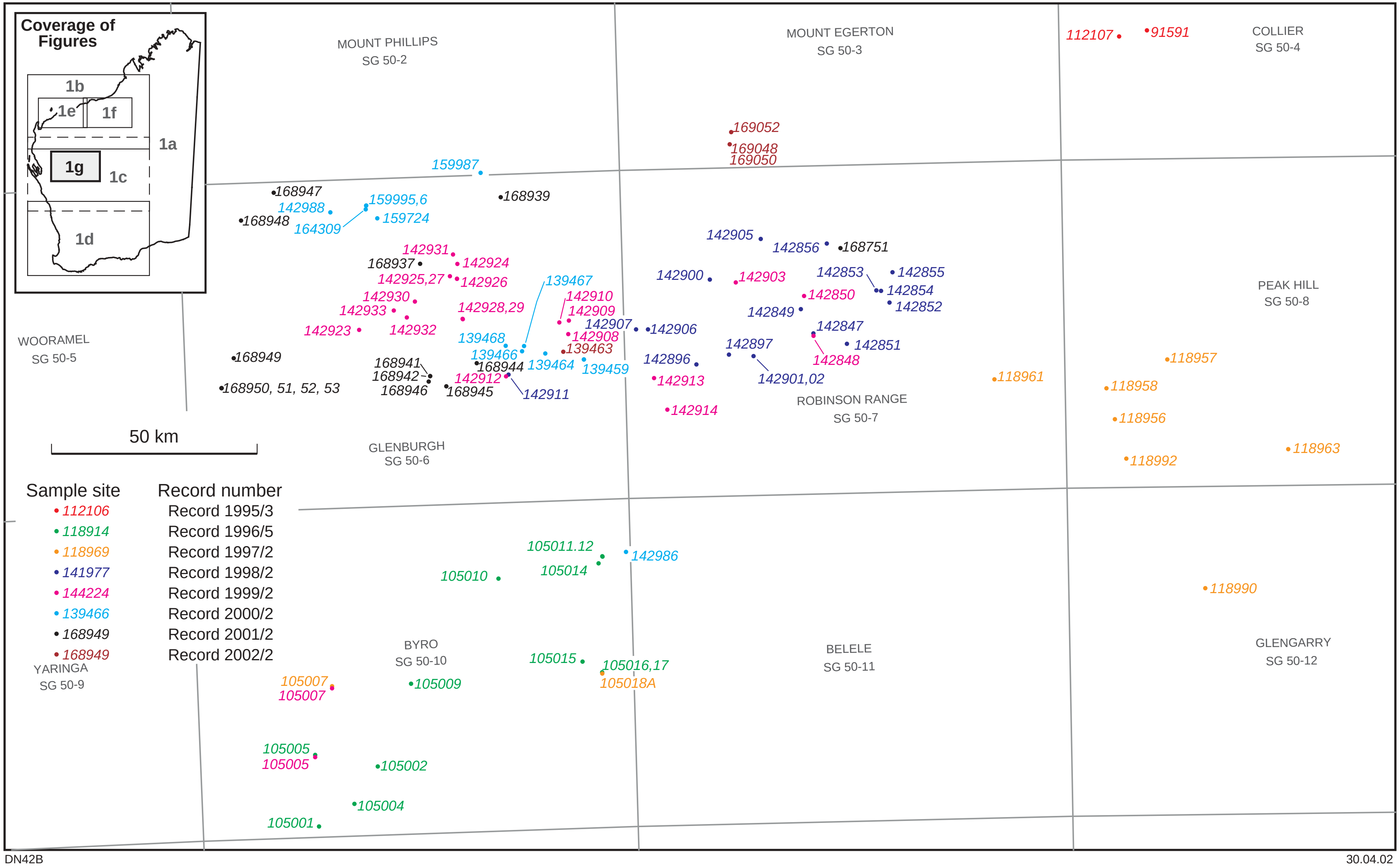

Figure 1g. (continued)

monazite standard Pb^*/U measurements, counting statistics-based errors, and error in the common-Pb correction, summed in quadrature. Uncertainties in Pb^*/U ratios for pooled analyses also include uncertainty in the Pb^*/U calibration based on the reproducibility of the Pb^*/U ratios of standard measurements, summed in quadrature with the other sources of error. Uncertainties in $^{208}Pb^*/^{232}Th$ ratios for individual monazite analyses do not include uncertainty associated with the determination of the Pb^*/Th calibration line, but pooled $^{208}Pb/^{232}Th$ dates include an uncertainty estimate based on the reproducibility of the standard $^{208}Pb/^{232}Th$ measurements during the analysis session. A minimum error in Pb^*/U and Pb^*/Th ratios of 1.0 (1σ%) is assumed.

A chi-square test is applied to grouped analyses in order to assess the relative effects of analytical sources of error, such as counting statistics, and geological sources of error, such as that arising from the inclusion of analyses of slightly older xenocrysts or of analyses that may have lost small amounts of radiogenic Pb. Chi-square values for grouped analyses of less than or equal to unity indicate that scatter about the weighted mean value determined for the grouped analyses can be accounted for by analytical sources of error alone. A chi-square value significantly greater than unity indicates that analyses are not normally distributed about the weighted mean value and that other (geological) sources of error are present within the grouped population. In these cases, the 95% confidence error is based on the observed, rather than the expected, scatter about the weighted mean $^{207}Pb/^{206}Pb$ (or Pb^*/U) ratio of pooled analyses. As uncertainties in $^{208}Pb^*/^{232}Th$ ratios for individual monazite analyses do not include uncertainty associated with the determination of the Pb^*/Th calibration line, errors cited for monazite $^{208}Pb/^{232}Th$ dates are based on the observed scatter about the weighted mean $^{208}Pb^*/^{232}Th$ ratio of pooled analyses.

Analyses obtained for each sample have been assigned to age groups using a computer algorithm and based on the following procedure. Radiogenic $^{207}Pb/^{206}Pb$ (or Pb^*/U) ratios were weighted according to the inverse square of the individual analytical error, to determine a weighted mean $^{207}Pb/^{206}Pb$ (or Pb^*/U) ratio for all pooled analyses obtained for the sample. Analyses were then rejected from the group using two criteria. A chi-square value was calculated for the grouped analyses. If the chi-square value was greater than a specified threshold value (typically, threshold value = 1.75 was used), geological sources of error were assumed to be present within the group and the analysis whose $^{207}Pb/^{206}Pb$ (or Pb^*/U) ratio with assigned error was most different from the group weighted mean value was excluded from the group. In addition, any analysis whose $^{207}Pb/^{206}Pb$ (or Pb^*/U) ratio with error was more than ±2.5σ from the group weighted mean value was also deleted from the group. The weighted mean value of the remaining analyses was then recalculated. This process was repeated until all remaining analyses were within ±2.5σ of the weighted mean value and the calculated chi-square value was below the threshold value. Analyses that belonged with a valid group were then excluded from the pool and process repeated until all remaining analyses had been grouped.

This grouping method is statistically conservative, in that only the minimum number of clearly resolvable dates based on the error limits assigned to each individual analysis will be identified. Analyses with assigned errors overlapping more than one age group were assigned to the larger group, as larger groups were identified earlier during the grouping procedure.

In addition to presentation on Wetherill concordia plots (Wetherill, 1956), data obtained on detrital zircon populations from sedimentary rock samples are displayed herein on a Gaussian-summation histogram plot. This plot presents a probability density curve for concordant analyses (i.e. those analyses for which the $^{206}Pb/^{238}U$ date is within error of $^{207}Pb/^{206}Pb$ date at the ±2σ error level) only. Where two or more analyses indicating analytically indistinguishable dates (at the ±1σ error level) have been obtained on a single zircon, a single weighted mean $^{207}Pb/^{206}Pb$ date and error has been substituted in generating the probability density curve.

Analyses are listed in the tables in the order in which they were obtained. All Pb/U and $^{207}Pb/^{206}Pb$ ratios given in the tables and discussed in the text are based on the calculated radiogenic Pb abundances and have been corrected for common Pb. Sample numbers given are GSWA sample numbers. Locality coordinates for the majority of samples were obtained using a hand-held Global Positioning System and the world Geodetic Datum 1984, are accurate to ±100 m. Mineral dimensions, cited as width × length in microns, were determined on the surfaces of polished mineral mounts. Errors given in the tables are at the $\pm 1\sigma$ level. Those given on pooled analyses in the text are at $\pm t\sigma$ (where t is Fisher's t) or 95% confidence unless otherwise indicated.

For the K–Ar Analyses undertaken within the CSIRO K–Ar laboratory at Curtin University of Technology, potassium content was determined by atomic absorption using a Varian AA 20 instrument and cesium at 1000 ppm concentration for ion suppression. The samples were dissolved with hydrofluoric acid and nitric acid following the method of Heinrichs and Herrmann (1990). The solution was then diluted to 0.3 to 1.5 ppm K for atomic absorption analysis. The pooled uncertainty for duplicate K determinations is less than or equal to ± 3%. Ar isotopic determinations were performed using a procedure similar to that described by Bonhomme et al. (1975). Samples were preheated under vacuum at 80°C for several hours to reduce the amount of atmospheric Ar adsorbed onto the mineral surfaces during sample handling. Argon was extracted by fusing samples within a vacuum line serviced by an on-line ^{38}Ar spike pipette. The isotopic composition of the spiked Ar was measured with a high sensitivity on-line VG3600 mass spectrometer. The ^{38}Ar spike was calibrated against standard biotite GA1550 (McDougall and Roksandic, 1974). After fusion of the sample in a low blank Heine resistance furnace, the released gases were subjected to a two-stage purification procedure with a Cu_2O getter for the first step and two TiO_2 getters for the second step. Blanks for the extraction line and mass spectrometer were systematically determined and the mass discrimination factor was determined periodically by airshots. Typically, about 2 mg of sample material was used for Ar isotopic analyses. The uncertainty for Argon analyses is ≤1.0% and the $^{40}Ar/^{36}Ar$ value for airshots averaged 292.94 ± 0.10 (2σ error). The age uncertainty includes uncertainties in sample weighing and $^{38}Ar/^{36}Ar$, $^{40}Ar/^{38}Ar$ and K concentration analyses.

Constants used

$\lambda_{U238} = 1.55125 \times 10^{-10} y^{-1}$
$\lambda_{U235} = 9.8485 \times 10^{-10} y^{-1}$
$\lambda_{Th232} = 4.9475 \times 10^{-11} y^{-1}$
$\lambda_{b} = 4.962 \times 10^{-10} y^{-1}$
$\lambda_{e} = 0.581 \times 10^{-10} y^{-1}$
^{40}K = 0.01167 atom%
Broken Hill common-Pb $^{204}Pb/^{206}Pb$ = 0.0625
Broken Hill common-Pb $^{207}Pb/^{206}Pb$ = 0.9618
Broken Hill common-Pb $^{208}Pb/^{206}Pb$ = 2.2285
CZ3 zircon standard $^{207}Pb/^{206}Pb$ = 0.05892
CZ3 zircon standard Pb^*/U = 0.0914
CZ3 zircon standard concentration = 551 ppm
MAD monazite standard $^{207}Pb/^{206}Pb$ = 0.05767
MAD monazite standard Pb^*/U = 0.083
MAD monazite standard $^{208}Pb^*/^{232}Th$ = 0.02576

Abbreviations used

(a) Pb^*/U = (radiogenic ^{206}Pb)/ ^{238}U
(b) $^{208}Pb^*/^{232}Th$ = (radiogenic ^{208}Pb)/^{232}Th
(c) f206% = 100 × (common ^{206}Pb/total ^{206}Pb)
(d) % concordance = 100 × ($^{206}Pb/^{238}U$ age)/($^{207}Pb/^{206}Pb$ age)
(e) $^{40}Ar^*$ = radiogenic ^{40}Ar
(f) vol.% = volume percent

168985: biotite pegmatite, Mount Sir James

Location and sampling

STANLEY* (SG 51-6), LEE STEERE (3346) MGA Zone 51, 413550E 7179530N

Sampled on 27 June 2000.

The sample was taken from the northwestern edge of a 20 m^2 area of low granite pavement located 6 km north of a telecommunications tower and 8 km north-northeast of Mount Sir James of the Lee Steere Range. The sampling site is 30 m west of the site of sample 168984.

Tectonic unit/relations

This sample is a light grey, coarse-grained pegmatite, with feldspar and quartz grains to 10 cm long, from the Malmac Dome, Yilgarn Craton (Hocking and Pirajno, in prep.). The pegmatite has intruded a fine- to medium-grained biotite monzogranite, of which sample 168984 is representative. The collected sample was free of any obvious veins.

Petrographic description

The principal minerals present in this sample are microcline (35 vol.%), quartz (30–35 vol.%), and plagioclase (30–35 vol.%), with accessory muscovite (<1 vol.%), opaque oxide (<1 vol.%), titanite (<1 vol.%), and monazite (trace). This is a coarse-grained leucogranite or a fine pegmatite. The largest crystals in the thin section are composed of microcline, 10 to 15 mm long, with finer-grained quartz and plagioclase, randomly intergranular to the microcline and as smaller inclusions in the microcline. The microcline is commonly poikilitic, with numerous inclusions of quartz and lesser plagioclase. The intergranular plagioclase and quartz are more compact, and less than 5 mm in grain size. The plagioclase is either albitic or albitized, and is dusted with sericite, and the quartz has weak undulose extinction. Accessory small grains, altered to quartz, sericite and limonite occur within leucoxene after opaque oxide and/or titanite. Rare small crystals of muscovite are scattered.

Monazite morphology

The monazites isolated from this sample are typically colourless, pale yellowish-grey or gold in colour, cubic, rod-shaped or subrounded, between 50 × 60 µm and 60 × 200 µm and are mottled or have irregular-shaped patches of dark-yellow discolouration. The polished surfaces of many grains have abundant (typically ≤2 µm) black spots and rarer irregular dark patches.

Analytical details

This sample was analysed on 30 May 2001. The counter deadtime during the analysis session was 32 ns. Six analyses of the MAD monazite standard obtained during the analysis session indicated a Pb^*/U calibration error of 0.856 (1σ%) and a $^{208}Pb^*/Th$ calibration error of 1.59 (1σ%). A Pb^*/U calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the analysis session. A correction of -0.85 counts/sec × (^{232}Th counts)$_{unknown}$/(^{232}Th counts)$_{std}$, based on the average value of the excess ^{204}Pb counts determined for the seven analyses of the MAD standard measured during the

* Capitalized names refer to standard 1:250 000-scale and 1:100 000-scale map sheets respectively.

Table 1. Ion microprobe analytical results for monazites from sample 168985: biotite pegmatite, Mount Sir James

Grain .spot	*f206%*	$^{207}Pb/^{206}Pb$	$\pm 1\sigma$	$^{208}Pb/^{206}Pb$	$\pm 1\sigma$	$^{206}Pb/^{238}U$	$\pm 1\sigma$	$^{207}Pb/^{235}U$	$\pm 1\sigma$	$^{208}Pb/^{232}Th$	$\pm 1\sigma$	*% concordance*	$^{206}Pb/^{238}U$ *age*	$\pm 1\sigma$	$^{207}Pb/^{235}U$ *age*	$\pm 1\sigma$	$^{207}Pb/^{206}Pb$ *age*	$\pm 1\sigma$	$^{208}Pb/^{232}Th$ *age*	$\pm 1\sigma$
1.1	0.078	0.17354	0.00022	10.684	0.008	0.504	0.005	12.06	0.13	0.1650	0.0018	102	2 631	23	2 609	10	2 592	2	3 087	30
2.1	0.122	0.17271	0.00023	11.226	0.009	0.512	0.005	12.19	0.13	0.1680	0.0018	103	2 665	23	2 619	10	2 584	2	3 139	31
3.1	0.038	0.17650	0.00016	8.686	0.005	0.559	0.006	13.59	0.14	0.2075	0.0021	109	2 861	24	2 722	10	2 620	2	3 812	36
4.1	1.326	0.16914	0.00038	11.368	0.010	0.494	0.005	11.53	0.13	0.1610	0.0017	102	2 589	22	2 567	10	2 549	4	3 017	30
5.1	1.520	0.17560	0.00034	10.236	0.008	0.513	0.005	12.41	0.13	0.1723	0.0018	102	2 668	23	2 636	10	2 612	3	3 213	31
6.1	0.123	0.17746	0.00024	10.651	0.008	0.518	0.005	12.68	0.14	0.1678	0.0018	102	2 692	23	2 656	10	2 629	2	3 136	31
7.1	0.399	0.17173	0.00028	12.049	0.010	0.508	0.005	12.03	0.13	0.1676	0.0018	103	2 648	23	2 606	10	2 575	3	3 133	31
8.1	0.040	0.17887	0.00024	11.994	0.010	0.537	0.006	13.25	0.14	0.1742	0.0019	105	2 771	24	2 697	10	2 642	2	3 246	32
9.1	0.180	0.16922	0.00017	5.933	0.004	0.508	0.005	11.85	0.12	0.1877	0.0019	104	2 648	22	2 593	10	2 550	2	3 477	33
10.1	2.115	0.17424	0.00044	12.972	0.012	0.515	0.005	12.36	0.14	0.1697	0.0018	103	2 676	23	2 632	10	2 599	4	3 168	31
11.1	2.022	0.17144	0.00043	10.961	0.010	0.512	0.005	12.09	0.14	0.1557	0.0017	104	2 663	23	2 612	11	2 572	4	2 925	29
3.2	0.045	0.17565	0.00017	9.001	0.005	0.532	0.005	12.87	0.13	0.2051	0.0021	105	2 748	23	2 670	10	2 612	2	3 771	36
12.1	0.178	0.17514	0.00027	12.167	0.010	0.513	0.005	12.38	0.14	0.1661	0.0018	102	2 669	23	2 634	10	2 607	3	3 105	31

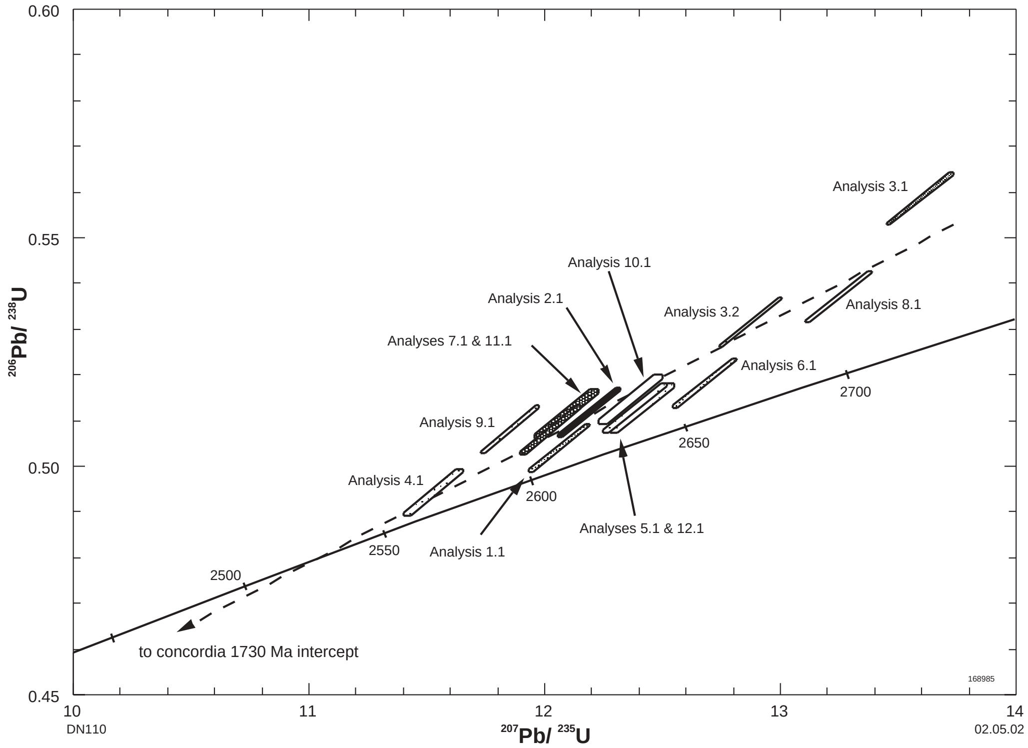

Figure 2. Concordia plot for monazites from sample 168985: biotite pegmatite, Mount Sir James

analysis of this sample, was made to measured ^{204}Pb counts of unknown analyses. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 4.1, 5.1, 7.1, 9.1, 10.1 and 11.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Thirteen analyses were obtained from 12 monazites. Results are given in Table 1 and shown on a concordia plot in Figure 2.

Interpretation

The analyses are slightly to highly reversely discordant and indicate a range of ^{207}Pb/^{206}Pb dates of from c. 2550 to 2640 Ma. The distribution of analyses along a reverse discordance trend is consistent with the gain of radiogenic Pb at the analysis sites during a poorly defined Middle Proterozoic disturbance episode, possibly combined with recent radiogenic-Pb redistribution. ^{208}Pb/^{232}Th dates range from c. 2925 to 3810 Ma and are anomalously old, consistent with either gain of ^{208}Pb or loss of ^{232}Th from the analysis sites. Three reversely discordant analyses of three monazites (3.2, 5.1 and 12.1) have ^{207}Pb/^{206}Pb ratios defining a single population and indicating a weighted mean ^{207}Pb/^{206}Pb date of 2611 ± 6 Ma (chi-squared = 0.98). The remaining analyses cannot be confidently grouped.

Although several interpretations of these results are possible, the preferred interpretation is that the monazites initially crystallized at a poorly defined Late Archaean time indicated by the upper intercept of the discordance trend with the concordia curve (i.e. between c. 2500 and 2600 Ma). Accumulated radiogenic Pb was subsequently redistributed, preferentially from high-U sites within these grains, during a poorly defined Middle Proterozoic disturbance episode, the time of which is indicated by the lower intercept of the discordance trend with the concordia curve. The results obtained on the monazites from this sample are consistent with a disturbance event at c. 1720 Ma, as indicated by the zircon results obtained from sample 168984 (see p. 186).

168983: metasandstone, Weld Spring

Location and sampling

STANLEY (SG 51-6), MUDAN (3247) MGA Zone 51, 359410E 7230570N

Sampled on 27 June 2000.

The sample was taken from a 0.5 m-diameter buried boulder located 5 m north of the access track and 2.8 km east of Weld Spring.

Tectonic unit/relations

This sample is a yellowish white, fine- to medium-grained and silicified sandstone, with scattered orange-yellow discolouration, from the Coonabildie Formation (Salvation Group), a probable part of the Bangemall Supergroup, Collier Basin.

Petrographic description

This sample consists principally of quartz (85–90 vol.%), kaolin, illite and/or limonite (10 vol.%), and chert (2–3 vol.%), with accessory zircon (trace). This is a weakly bedded, homogeneous, medium-grained quartzite derived from a poorly sorted, fine to coarse-grained sandstone. It contains minor evenly dispersed interstitial clays and limonite, a weak layering and a very weak foliation, with a minor porosity due to leached out grains. In thin section, it consists of a compact, weakly bedded aggregate of elongate subrounded single-crystal quartz grains, from 0.1 to 0.8 mm long (fine to coarse sand). Most grains have an average size of about 0.4 mm. Accessory small grains of chert are scattered. Intergranular grains and/or voids of apparent kaolin and/or illite, stained by limonite, form about 10 vol.% of the aggregate. There are only sparse combinations of cores with optically continuous overgrowths, and the larger quartz grains may have stylolitic grain boundaries. The overall texture is a low grade metamorphic mosaic derived from a mostly medium to coarse quartz sandstone.

Zircon morphology

The zircons isolated from this sample are generally between 30 × 50 µm and 200 × 250 µm in size, colourless or pale pinkish brown, internally structureless or with patchy brown discolouration, and are equant and rounded in shape. Fluid and mineral inclusions are common. The surfaces of most grains are pitted, consistent with detrital transport.

Analytical details

This sample was analysed on 2 February 2001. The counter deadtime during the analysis session was 32 ns. Ten analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 3.30 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Thirty-four analyses were obtained from 31 zircons. Results are given in Table 2 and shown on concordia and Gaussian-summation probability density plots in Figures 3 and 4.

Table 2. Ion microprobe analytical results for sample 168983: metasandstone, Weld Spring

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	68	74	27	0.595	0.11036	0.00236	0.32582	0.00564	0.3154	0.0106	4.799	0.201	98	1 805	39
2.1	60	69	24	0.736	0.10658	0.00266	0.33042	0.00639	0.3198	0.0108	4.700	0.208	103	1 742	46
3.1	49	49	19	0.600	0.10956	0.00254	0.29387	0.00594	0.3193	0.0108	4.823	0.209	100	1 792	42
4.1	225	372	69	0.341	0.08630	0.00120	0.48805	0.00358	0.2232	0.0074	2.656	0.100	97	1 345	27
5.1	60	63	23	0.827	0.10940	0.00356	0.30007	0.00832	0.3108	0.0105	4.688	0.233	97	1 789	59
6.1	157	69	95	0.196	0.19289	0.00111	0.12215	0.00164	0.5305	0.0177	14.109	0.487	99	2 767	9
7.1	187	122	68	0.304	0.10844	0.00118	0.18888	0.00250	0.3235	0.0107	4.836	0.175	102	1 773	20
8.1	264	119	92	0.385	0.10822	0.00097	0.12902	0.00188	0.3219	0.0107	4.803	0.170	102	1 770	16
9.1	189	220	75	0.163	0.10828	0.00098	0.34441	0.00249	0.3155	0.0105	4.711	0.167	100	1 771	17
10.1	105	89	39	0.738	0.11134	0.00188	0.24031	0.00422	0.3147	0.0105	4.831	0.190	97	1 821	31
11.1	221	49	74	0.318	0.10853	0.00099	0.06742	0.00171	0.3250	0.0108	4.864	0.173	102	1 775	17
12.1	213	92	70	0.398	0.10876	0.00093	0.11854	0.00180	0.3082	0.0102	4.621	0.163	97	1 779	16
13.1	113	55	38	0.409	0.10838	0.00149	0.14374	0.00304	0.3114	0.0104	4.654	0.175	99	1 772	25
14.1	205	61	69	0.440	0.10757	0.00114	0.08285	0.00218	0.3207	0.0107	4.756	0.172	102	1 759	19
15.1	264	116	84	0.455	0.10761	0.00104	0.11889	0.00207	0.2957	0.0098	4.387	0.156	95	1 759	18
16.1	203	145	75	0.166	0.11078	0.00097	0.21331	0.00205	0.3232	0.0107	4.936	0.175	100	1 812	16
17.1	338	84	107	0.161	0.10889	0.00070	0.07471	0.00113	0.3104	0.0103	4.661	0.161	98	1 781	12
18.1	120	92	42	0.342	0.10598	0.00156	0.22602	0.00347	0.3012	0.0100	4.401	0.168	98	1 731	27
19.1	106	40	37	0.581	0.10758	0.00181	0.11061	0.00372	0.3232	0.0108	4.795	0.188	103	1 759	31
20.1	279	91	89	0.358	0.10650	0.00093	0.07744	0.00171	0.3076	0.0102	4.517	0.160	99	1 740	16
21.1	371	200	129	0.139	0.10979	0.00067	0.15693	0.00127	0.3182	0.0105	4.817	0.166	99	1 796	11
22.1	152	158	55	0.524	0.10291	0.00137	0.30859	0.00330	0.2945	0.0098	4.178	0.156	99	1 677	25
23.1	39	30	14	1.675	0.10356	0.00487	0.21506	0.01110	0.2984	0.0102	4.261	0.262	100	1 689	87
24.1	88	99	34	0.493	0.10881	0.00205	0.34915	0.00500	0.3033	0.0101	4.549	0.184	96	1 780	34
25.1	314	392	163	0.385	0.17620	0.00083	0.21061	0.00153	0.4283	0.0142	10.405	0.354	88	2 617	8
26.1	58	87	25	0.567	0.10918	0.00281	0.44413	0.00716	0.3209	0.0108	4.831	0.217	100	1 786	47
27.1	110	57	38	0.409	0.10780	0.00147	0.15065	0.00298	0.3166	0.0106	4.706	0.177	101	1 763	25
28.1	159	63	54	0.367	0.10917	0.00117	0.11769	0.00220	0.3174	0.0106	4.777	0.173	100	1 786	20
29.1	119	131	42	0.216	0.10311	0.00143	0.31816	0.00351	0.2865	0.0095	4.073	0.153	97	1 681	26
30.1	153	233	64	0.456	0.10823	0.00131	0.44783	0.00353	0.3093	0.0103	4.615	0.170	98	1 770	22
31.1	116	136	49	0.530	0.10851	0.00163	0.33620	0.00396	0.3306	0.0110	4.946	0.189	104	1 775	27
4.2	196	395	61	0.405	0.08526	0.00099	0.59412	0.00317	0.2124	0.0070	2.497	0.091	94	1 321	22
4.3	153	293	43	1.164	0.08113	0.00160	0.52467	0.00444	0.1992	0.0066	2.228	0.090	96	1 225	39
4.4	133	203	39	0.492	0.08542	0.00175	0.45741	0.00479	0.2171	0.0072	2.557	0.105	96	1 325	40

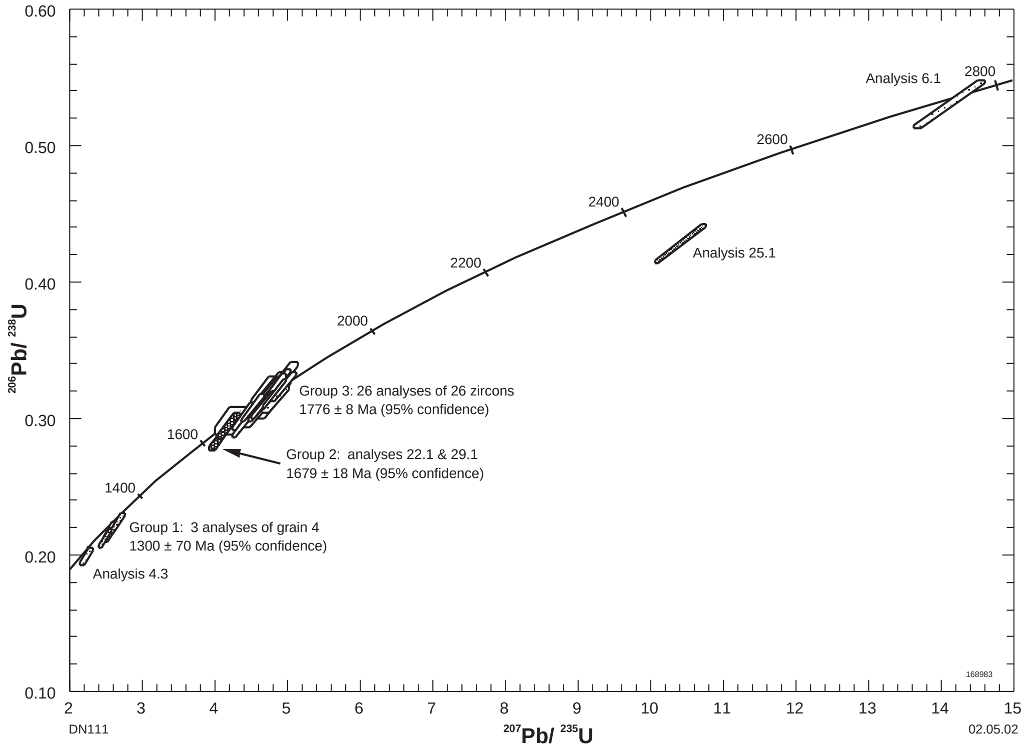

Figure 3. Concordia plot for sample 168983: metasandstone, Weld Spring

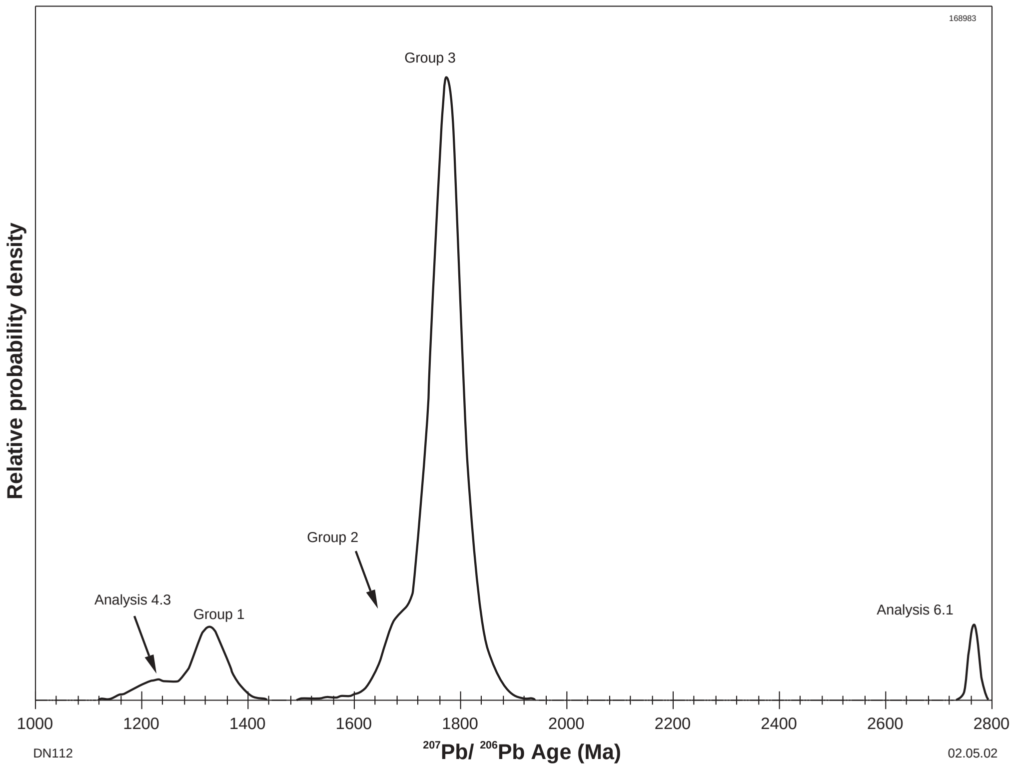

Figure 4. Gaussian-summation probability density plot for sample 168983: metasandstone, Weld Spring

Interpretation

The analyses are concordant to highly discordant and indicate a wide range of $^{207}Pb/^{206}Pb$ dates, from c. 1225 to 2767 Ma. Three concordant or near-concordant analyses of grain 4 (4.1, 4.2 and 4.4), 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 1330 ± 70 Ma (chi-squared = 0.17). Analysis 4.3 is discordant and indicates a younger $^{207}Pb/^{206}Pb$ date of 1225 ± 39 Ma (1σ error). Analyses 22.1 and 29.1, 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 1679 ± 18 Ma. Twenty-six concordant analyses of 26 zircons, assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1776 ± 8 Ma (chi-squared = 0.91). Discordant analysis 25.1 and concordant analysis 6.1 indicated Archaean $^{207}Pb/^{206}Pb$ dates.

Grain 4 is a 80 × 120 µm, colourless, structureless but fractured, euhedral and slightly elongate grain. Although the terminations of this grain are not abraded, this grain is inferred to be of detrital origin. Consequently, the weighted mean $^{207}Pb/^{206}Pb$ date of 1330 ± 70 Ma indicated by the three analyses of Group 1 obtained on grain 4 is interpreted as a maximum age for deposition of the sandstone precursor to the quartzite. The younger $^{207}Pb/^{206}Pb$ date indicated by analysis 4.3 is interpreted to be of an analysis site that has undergone ancient loss of radiogenic Pb.

Source rocks within the western part of Australia having ages similar to those of the zircons within this sample include the Rudall (Nelson, 1995, 1996), Arunta (Williams et al., 1996 and references cited therein), Gascoyne (Nelson, 1997, 1998, 1999, 2000, 2001b, this volume), and Musgrave (White et al., 1999 and references cited therein) complexes and the Albany–Fraser Orogen (Nelson et al., 1995). Grains 6.1 and 25.1 may have been derived from either of the Yilgarn or Pilbara Cratons (Nelson, 1995, 1996, 1997, 1998, 1999, 2000, 2001b, this volume).

169061: lithic quartz sandstone, Yangibana Yard

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 411120E 7350230N

Sampled on 15 October 2000.

The sample was taken from a prominent rocky outcrop situated on the eastern side of the Lyons River – Gifford Creek road crossing and 1.5 km southwest of Yangibana Yard.

Tectonic unit/relations

This sample is a dark grey, medium- and even-grained, recrystallized sandstone from an outcrop of massive, thickly bedded homogenous sandstone of the Kiangi Creek Formation (Edmund Group) of the Bangemall Supergroup, Edmund Basin.

Petrographic description

This is a medium-grained, lithic quartz sandstone with possibly authigenic K-feldspar, chlorite, carbonate and possible ferrostilpnomelane and rare zircon on a stylolite-like vein. This dark grey siliceous rock has a subconchoidal fracture. The thin section shows abundant rounded single crystal quartz grains to 0.6 mm in diameter (coarse sand) with sutured grain boundaries and rare polycrystalline, mostly cherty, clasts. Possible authigenic K-feldspar to 0.5 mm in grain size is disseminated and is heavily clouded by opaque microlites. Thin opaque plates also occur in or between the quartz grains. Minor chlorite and carbonate are present, as well as a pale-green micaceous mineral that may either be ferrostilpnomelane, magnesian biotite, or phlogopite. Oxide-rich stylolite-like veins locally contain zircon.

Zircon morphology

The zircons isolated from this sample are colourless, pale greenish brown, dark brown or black, generally between 40 × 80 µm and 100 × 280 µm in size, and are commonly subrounded or irregular fragments, or are subhedral and elongate in shape. Many grains have faint internal zonation and mineral inclusions are common. Many have irregular zones of dark alteration and many are metamict. Surface pitting, consistent with detrital transport, is apparent on the surfaces of most grains.

Analytical details

This sample was analysed on 26 May 2001. The counter deadtime was 32 ns. Fifteen analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.83 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Thirty-three analyses were obtained from 33 zircons. Results are given in Table 3 and shown on concordia and Gaussian-summation probability density plots in Figures 5 and 6.

Table 3. Ion microprobe analytical results for sample 169061: lithic quartz sandstone, Yangibana Yard

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	118	122	47	0.584	0.10997	0.00164	0.30249	0.00388	0.3201	0.0062	4.853	0.125	100	1 799	27
2.1	139	142	55	0.838	0.11024	0.00159	0.29123	0.00371	0.3169	0.0061	4.816	0.122	98	1 803	26
3.1	114	113	44	1.176	0.10703	0.00220	0.27146	0.00510	0.3098	0.0060	4.572	0.137	99	1 749	38
4.1	113	158	47	0.861	0.11072	0.00181	0.39636	0.00460	0.3133	0.0061	4.784	0.129	97	1 811	30
5.1	73	59	29	2.122	0.10505	0.00316	0.22204	0.00718	0.3260	0.0066	4.722	0.181	106	1 715	55
6.1	172	381	77	0.689	0.10873	0.00148	0.58905	0.00443	0.3003	0.0057	4.502	0.111	95	1 778	25
7.1	142	108	52	0.952	0.11242	0.00176	0.22246	0.00389	0.3081	0.0059	4.776	0.125	94	1 839	28
8.1	108	136	43	0.722	0.10985	0.00209	0.36012	0.00510	0.3099	0.0060	4.693	0.135	97	1 797	35
9.1	54	90	25	2.509	0.10402	0.00418	0.46621	0.01045	0.3193	0.0066	4.580	0.217	105	1 697	74
10.1	128	149	51	0.798	0.11062	0.00174	0.33304	0.00421	0.3122	0.0060	4.762	0.126	97	1 810	29
11.1	112	129	44	0.774	0.10899	0.00188	0.32630	0.00453	0.3088	0.0060	4.640	0.128	97	1 783	31
12.1	102	270	52	0.597	0.10965	0.00187	0.75198	0.00621	0.3095	0.0060	4.680	0.129	97	1 794	31
13.1	102	60	41	0.640	0.12311	0.00165	0.16502	0.00325	0.3567	0.0070	6.054	0.151	98	2 002	24
14.1	141	120	52	0.569	0.10853	0.00163	0.24246	0.00366	0.3137	0.0060	4.694	0.121	99	1 775	27
15.1	159	201	63	0.124	0.11066	0.00114	0.35509	0.00293	0.3151	0.0060	4.808	0.110	98	1 810	19
16.1	127	130	48	0.606	0.10863	0.00160	0.29222	0.00375	0.3090	0.0059	4.628	0.118	98	1 777	27
17.1	142	214	58	0.662	0.10829	0.00146	0.43459	0.00392	0.3028	0.0058	4.521	0.112	96	1 771	25
18.1	103	121	69	0.413	0.18464	0.00160	0.32161	0.00326	0.5105	0.0100	12.996	0.291	99	2 695	14
19.1	160	155	61	0.349	0.11232	0.00122	0.28192	0.00281	0.3148	0.0060	4.875	0.112	96	1 837	20
20.1	143	75	50	0.443	0.11221	0.00136	0.15421	0.00269	0.3175	0.0061	4.912	0.117	97	1 835	22
21.1	40	60	18	1.643	0.10819	0.00448	0.42257	0.01106	0.3233	0.0069	4.822	0.236	102	1 769	76
22.1	127	148	51	0.834	0.10717	0.00175	0.33418	0.00424	0.3184	0.0061	4.705	0.126	102	1 752	30
23.1	78	93	31	1.371	0.10940	0.00270	0.33706	0.00645	0.3063	0.0061	4.620	0.155	96	1 789	45
24.1	219	297	91	0.112	0.14010	0.00094	0.15182	0.00157	0.3723	0.0070	7.192	0.149	92	2 228	12
25.1	47	40	18	0.477	0.11754	0.00263	0.24829	0.00581	0.3127	0.0064	5.067	0.163	91	1 919	40
26.1	66	94	38	1.068	0.14508	0.00249	0.40795	0.00592	0.4178	0.0085	8.357	0.236	98	2 289	30
27.1	75	74	30	1.641	0.10859	0.00284	0.28693	0.00662	0.3173	0.0063	4.750	0.166	100	1 776	48
28.1	171	226	68	0.376	0.10777	0.00115	0.36182	0.00296	0.3119	0.0059	4.635	0.106	99	1 762	20
29.1	239	212	89	0.567	0.11076	0.00110	0.25581	0.00248	0.3101	0.0058	4.737	0.106	96	1 812	18
30.1	164	652	102	0.509	0.11226	0.00127	1.13075	0.00578	0.3192	0.0061	4.940	0.115	97	1 836	20
31.1	43	31	19	1.601	0.12533	0.00344	0.20926	0.00750	0.3628	0.0077	6.269	0.230	98	2 033	49
32.1	118	33	70	0.395	0.21137	0.00148	0.08393	0.00206	0.5252	0.0103	15.306	0.330	93	2 916	11
33.1	113	78	55	0.495	0.14350	0.00143	0.19171	0.00274	0.4201	0.0081	8.311	0.190	100	2 270	17

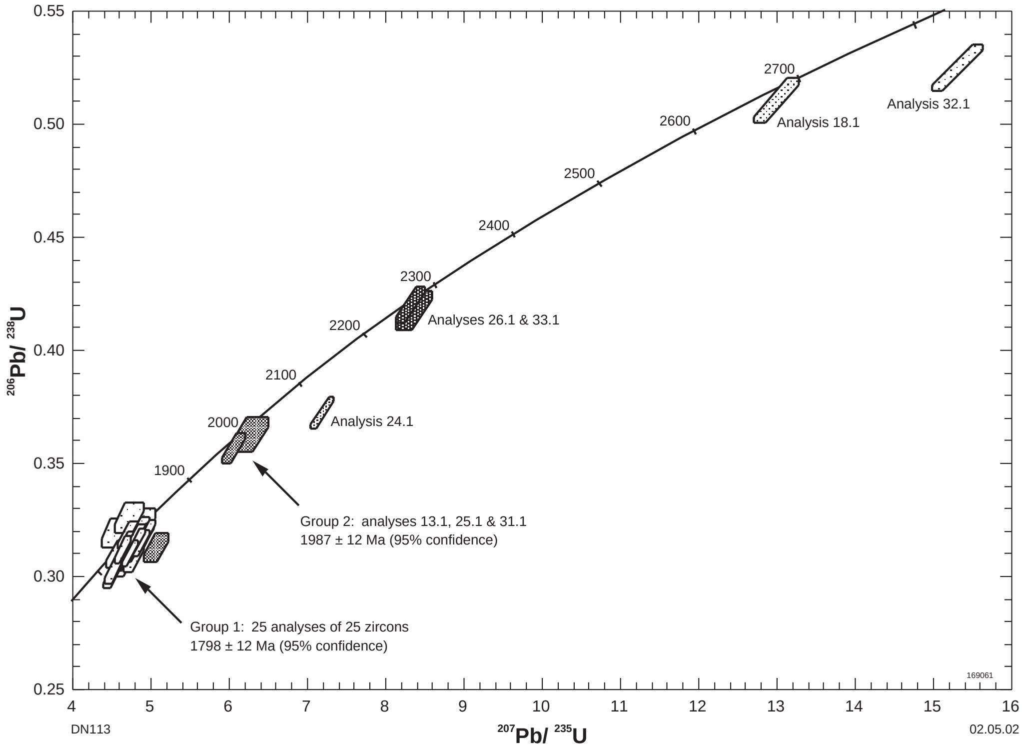

Figure 5. Concordia plot for sample 169061: lithic quartz sandstone, Yangibana Yard

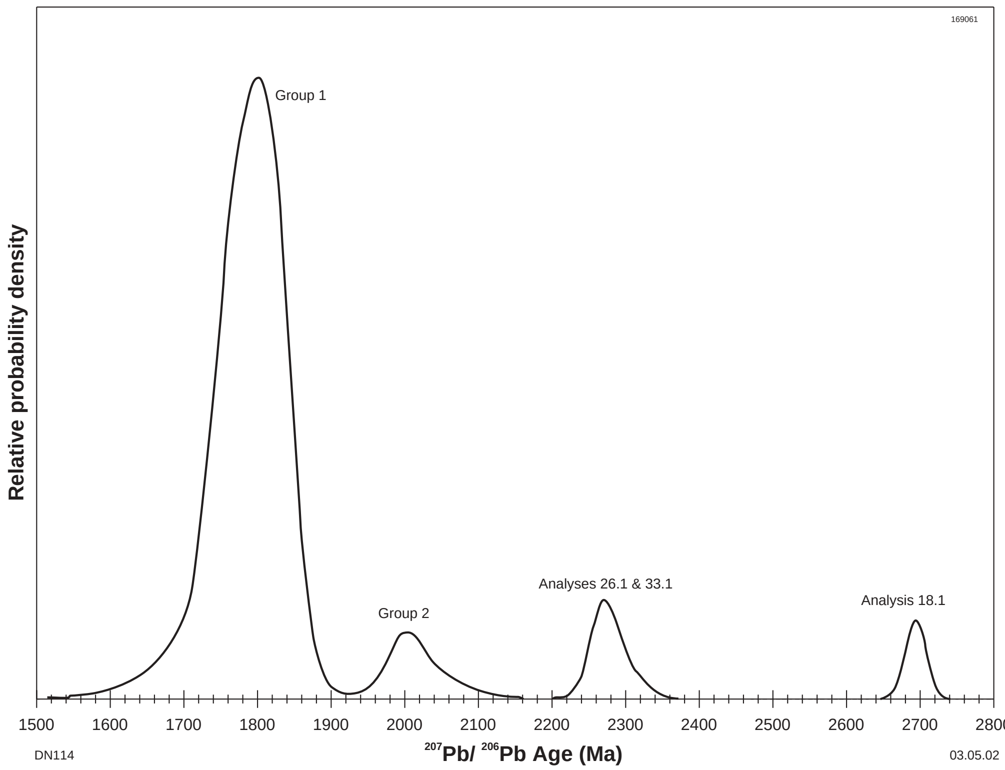

Figure 6. Gaussian-summation probability density plot for sample 169061: lithic quartz sandstone, Yangibana Yard

Interpretation

Most analyses are concordant to slightly discordant with the discordance patterns consistent with at least one recent episode of radiogenic-Pb redistribution. A range of $^{207}Pb/^{206}Pb$ dates of from c. 1800 to 2920 Ma is indicated. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of two groups. Twenty-five concordant to slightly discordant analyses of 25 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 1798 ± 12 Ma (chi-squared = 1.17). Concordant analyses 13.1 and 31.1 and discordant analysis 25.1, 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 1987 ± 12 Ma (chi-squared = 1.71). The remaining analyses (18.1, 24.1, 26.1, 32.1 and 33.1) cannot be confidently grouped.

Many of the grains from which Group 1 analyses were obtained are rounded, have rounded terminations, and/or have pitted surfaces, consistent with detrital transport. The weighted mean $^{207}Pb/^{206}Pb$ date of 1798 ± 12 Ma indicated by the 25 analyses of Group 1 is therefore interpreted as a maximum age for deposition of the sandstone. The remaining analyses are also interpreted to be of detrital zircons.

169048: leucocratic gneiss, Mount Remarkable Bore

Location and sampling

MOUNT EGERTON (SG 50-3), CANDOLLE (2348) MGA Zone 50, 538150E 7242920N

Sampled on 12 October 2000.

The sample was taken from a protruding edge of an uneven, steep pavement within a small rocky creek bed on the west face of Mount Remarkable, 5 m downslope of the site of sample 169050 and 2.5 km northeast of Mount Remarkable Bore.

Tectonic unit/relations

This sample is from a white, layered coarse-grained leucocratic gneiss that contains dark green-grey flattened chlorite- and epidote-rich lenses, of the Gascoyne Complex. The gneiss phase has a vertically dipping, east-striking foliation and contains strongly deformed veins of milky white quartz. The sampling site is located 15 m below an unconformity of the Tringadee Formation (Edmund Group), Bangemall Supergroup.

Petrographic description

The principal minerals present in this sample are plagioclase (35–65 vol.%, averaging 45 vol.%), quartz (25–35 vol.%), K-feldspar (10–35 vol.%, averaging 20–25 vol.%), and chlorite and epidote (5 vol.%), with accessory limonite (trace), rare monazite (trace), and zircon (trace). This is a leucocratic granodiorite to monzogranite gneiss with chlorite and epidote alteration and narrow veins. There is a strong fabric in this leucocratic gneiss, with rods of quartz and mafic minerals in a weakly layered arrangement in a feldspathic host. The thin section shows elongate grains and aggregates of quartz, from 1 to 4 mm long, mostly subparallel, and defining a foliation. Patches of chlorite are disseminated and represent deformed and recrystallized, altered biotite in patches 0.4 mm in diameter, commonly in poorly defined lenses connected by limonite-lined fractures. Minor epidote accompanies the chlorite in some areas. Fine-grained, partly recrystallized feldspar is abundant, with plagioclase usually more abundant than microcline. The feldspars are distributed irregularly, with lenses rich in plagioclase with little or no microcline as well as microcline-rich areas. Some of the microcline is in graphic intergrowths with quartz, and there are areas of sericite flooding in the plagioclase. The largest feldspar grains are about 1.5 mm long. Rare residual grains of antiperthitic plagioclase suggest an earlier high-grade metamorphism followed by low temperature alteration and recrystallization. Very rare zircon occurs and is about 50 µm in grain size. There are narrow veinlets containing quartz, epidote, minor chlorite and limonite after pyrite. Alteration envelopes rich in K-feldspar occur adjacent to these veins.

Zircon morphology

The zircons isolated from this sample are yellowish brown, dark brown and black, generally between 20 × 40 µm and 80 × 120 µm in size, and are rounded or elongate with rounded terminations. Most grains are fractured and structureless, but a minority have faint internal zonation. Some grains have thick unstructured rims and small rounded and unstructured cores. Many grains have sculpted surfaces and intensively pitted surface terminations, consistent with detrital transport. A minority of grains are metamict.

Table 4. Ion microprobe analytical results for sample 169048: leucocratic gneiss, Mount Remarkable Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	269	421	246	0.202	0.24777	0.00073	0.42238	0.00138	0.6310	0.0107	21.556	0.380	99	3 171	5
2.1	807	143	383	0.187	0.17855	0.00040	0.05139	0.00048	0.4463	0.0075	10.987	0.188	90	2 639	4
3.1	1 030	150	471	0.244	0.14524	0.00033	0.04140	0.00046	0.4445	0.0074	8.900	0.152	103	2 291	4
4.1	759	64	318	0.123	0.14405	0.00037	0.02316	0.00041	0.4149	0.0069	8.241	0.142	98	2 276	4
5.1	2 498	1 207	1 095	0.055	0.14130	0.00020	0.14210	0.00029	0.3960	0.0066	7.716	0.130	96	2 243	2
6.1	300	241	175	0.495	0.18486	0.00087	0.22012	0.00158	0.4760	0.0081	12.132	0.221	93	2 697	8
7.1	270	29	117	0.194	0.14839	0.00068	0.03087	0.00088	0.4246	0.0072	8.687	0.157	98	2 327	8
9.1	228	377	163	0.725	0.18345	0.00097	0.46659	0.00225	0.4937	0.0084	12.488	0.230	96	2 684	9
8.1	315	284	178	0.486	0.16620	0.00077	0.25543	0.00152	0.4556	0.0077	10.441	0.189	96	2 520	8
10.1	556	86	270	0.271	0.15756	0.00051	0.04237	0.00071	0.4660	0.0078	10.125	0.177	102	2 430	5
11.1	534	178	388	0.093	0.23442	0.00048	0.09005	0.00047	0.6361	0.0107	20.560	0.353	103	3 082	3
12.1	474	35	193	0.703	0.14030	0.00069	0.02104	0.00121	0.3979	0.0067	7.698	0.139	97	2 231	9
13.1	123	93	76	0.462	0.18152	0.00120	0.20563	0.00220	0.5099	0.0089	12.762	0.247	100	2 667	11
14.1	672	64	263	0.208	0.13519	0.00046	0.02751	0.00063	0.3887	0.0065	7.245	0.127	98	2 166	6
15.1	1 556	11	522	0.194	0.11820	0.00029	0.00240	0.00038	0.3460	0.0058	5.638	0.097	99	1 929	4
16.1	186	103	109	0.315	0.18611	0.00095	0.15395	0.00153	0.5022	0.0086	12.887	0.238	97	2 708	8
17.1	170	161	100	1.486	0.17744	0.00148	0.28104	0.00315	0.4489	0.0077	10.983	0.220	91	2 629	14
18.1	226	69	103	3.101	0.15349	0.00149	0.08729	0.00334	0.3885	0.0066	8.221	0.169	89	2 385	17
15.2	2 269	33	710	0.117	0.11756	0.00023	0.00519	0.00027	0.3227	0.0060	5.231	0.099	94	1 919	4
15.3	2 093	25	691	0.234	0.12285	0.00027	0.00710	0.00037	0.3370	0.0063	5.708	0.109	94	1 998	4

Analytical details

This sample was analysed on 24 and 29 November 2001. The counter deadtime during both analysis sessions was 32 ns. Seven analyses of the CZ3 standard obtained during the first analysis session indicated a Pb^*/U calibration error of 1.66 (1σ%). Analyses 1.1 to 18.1 were obtained during the first analysis session. During the second analysis session, three analyses of the CZ3 standard were obtained. Following deletion of one standard analysis as an outlier, the remaining two standard analyses indicated a Pb^*/U calibration error of 1.86 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 15.2, 15.3 and 18.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty analyses were obtained from 18 zircons. Results are given in Table 4 and shown on a concordia plot in Figure 7.

Interpretation

The analyses are concordant to slightly discordant and have $^{207}Pb/^{206}Pb$ dates ranging from c. 1920 to 3170 Ma. Discordant analyses 6.1, 9.1 and 16.1 have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2697 ± 29 Ma (chi-squared = 1.47). The remaining analyses cannot be confidently grouped.

The sculpted surfaces and intensively pitted surface terminations of many grains and the wide range of $^{207}Pb/^{206}Pb$ dates indicated by the analyses suggests that a

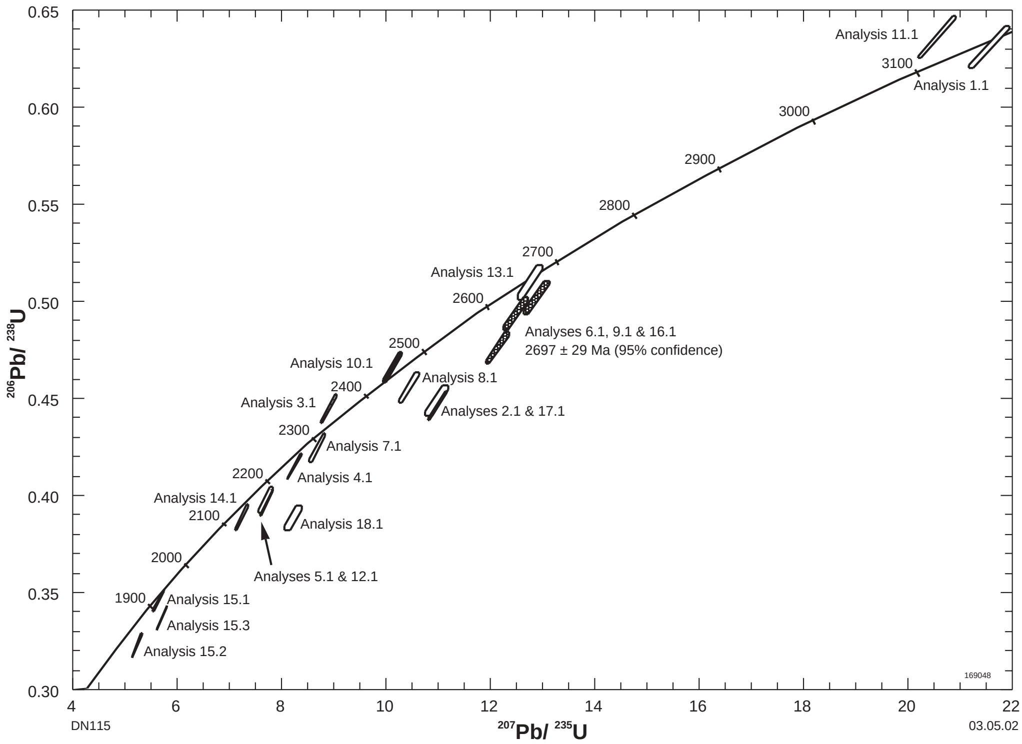

Figure 7. Concordia plot for sample 169048: leucocratic gneiss, Mount Remarkable Bore

sedimentary component may be present within this sample. The youngest concordant $^{207}Pb/^{206}Pb$ date of 1929 ± 4 Ma (1σ error), indicated by analysis 15.1, was obtained on an irregular shaped grain fragment with an intensively pitted surface, consistent with detrital transport. If grain 15 was derived from a sedimentary component present within this sample, the youngest concordant $^{207}Pb/^{206}Pb$ date of 1929 ± 4 Ma (1σ error) indicated by analysis 15.1 provides a maximum age for deposition of this sedimentary component.

169050: tonalite gneiss, Mount Remarkable Bore

Location and sampling

MOUNT EGERTON (SG 50-3), CANDOLLE (2348) MGA Zone 50, 538150E 7242920N

Sampled on 12 October 2000.

The sample was taken from a protruding edge of an uneven, steep pavement within a small rocky creek bed on the west face of Mount Remarkable, 5 m upslope of the site of sample 169048 and 2.5 km northeast of Mount Remarkable Bore.

Tectonic unit/relations

This sample is from a pink and white, coarse-grained, leucocratic tonalite that occurs as a small dyke in a dark greenish grey mafic gneiss phase, Gascoyne Complex. At the outcrop-scale, the mafic gneiss is interleaved with leucocratic gneiss (represented by sample 169048). The mafic gneiss phase has a vertically dipping, east-striking foliation and contains strongly deformed veins of milky white quartz. Both the leucocratic and mafic gneiss components were present in the sample taken. The sampling site is located 10 m below an unconformity of the Tringadee Formation (Edmund Group), Bangemall Supergroup.

Petrographic description

The principal minerals present in this sample are plagioclase (45–50 vol.%), quartz (40 vol.%), microcline (5 vol.%), chlorite and leucoxene after biotite (5 vol.%), and actinolite–chlorite (2 vol.%), with accessory epidote (trace), titanite (trace), and zircon (trace). The sample contains large, deformed feldspar grains, to 10 mm in diameter. Lenses, possibly composed of chlorite, define a weak fabric. The thin section shows abundant sericite- and clinozoisite-clouded, coarse-grained plagioclase to 10 mm long, that are weakly aligned in a foliation. Zones rich in clouded clinozoisite occur, separating rare patches of fresh plagioclase from zones that are clouded with sericite and clinozoisite. Irregular grains of microcline occur, to 4 mm long, possibly partly replacing plagioclase. Quartz is abundant as grains to 4 mm long in irregular lenses between the feldspar aggregates. Foliated biotite, to 2 mm in grain size, has been replaced by chlorite and leucoxene, with aggregates of fibrous actinolite with or without chlorite. The actinolite-rich aggregates locally have cores of chlorite and rims of actinolite in a radial arrangement and may represent former pyroxene or amphibole grains. Epidote and titanite occur in these aggregates, with rare separate titanite grains. This is an altered tonalite gneiss, with low temperature alteration under greenschist facies conditions. Quartz, albite, clinozoisite and sericite have been deposited in narrow fractures cutting the sample.

Zircon morphology

The zircons isolated from this sample are pink-brown, dark reddish brown, dark brown, and black, generally between 80 × 200 µm and 150 × 280 µm in size, and are variable in shape. Irregular, elongate, subrounded and euhedral shaped grains are present. Most grains are fractured and structureless, but a minority have weak internal zonation and a few elongate grains are striated. Some grains have radially fractured, metamict rims and small dark cores. Dark inclusions are common. Many grains have textured and pitted surfaces, and many are metamict.

Table 5. Ion microprobe analytical results for sample 169050: tonalite gneiss, Mount Remarkable Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	488	379	183	0.018	0.11041	0.00042	0.22340	0.00087	0.3262	0.0052	4.967	0.084	101	1 806	7
2.1	385	301	143	0.027	0.10978	0.00047	0.22518	0.00096	0.3222	0.0052	4.877	0.083	100	1 796	8
3.1	269	139	93	0.097	0.11074	0.00060	0.14918	0.00110	0.3169	0.0051	4.839	0.085	98	1 812	10
4.1	572	376	203	0.059	0.11008	0.00038	0.18922	0.00072	0.3167	0.0051	4.807	0.080	98	1 801	6
5.1	307	176	108	0.054	0.10995	0.00055	0.16515	0.00102	0.3210	0.0052	4.866	0.085	100	1 799	9
6.1	428	313	155	0.088	0.11064	0.00047	0.20922	0.00096	0.3173	0.0051	4.841	0.083	98	1 810	8
7.1	313	156	107	0.105	0.11013	0.00056	0.14285	0.00101	0.3170	0.0051	4.813	0.084	99	1 802	9
14.1	322	165	112	0.154	0.11096	0.00058	0.14866	0.00110	0.3197	0.0051	4.892	0.086	99	1 815	10
8.1	379	197	131	0.078	0.11121	0.00050	0.14787	0.00089	0.3175	0.0051	4.868	0.084	98	1 819	8
9.1	394	296	143	0.043	0.11059	0.00048	0.21756	0.00097	0.3170	0.0051	4.833	0.083	98	1 809	8
10.1	388	214	134	0.134	0.11105	0.00052	0.16012	0.00098	0.3152	0.0051	4.827	0.083	97	1 817	9
11.1	290	154	101	0.140	0.11065	0.00060	0.15320	0.00110	0.3192	0.0051	4.870	0.086	99	1 810	10
12.1	384	231	136	0.116	0.11019	0.00050	0.17326	0.00095	0.3194	0.0051	4.853	0.083	99	1 803	8
13.1	415	245	147	0.115	0.11006	0.00050	0.17078	0.00094	0.3189	0.0051	4.839	0.083	99	1 800	8

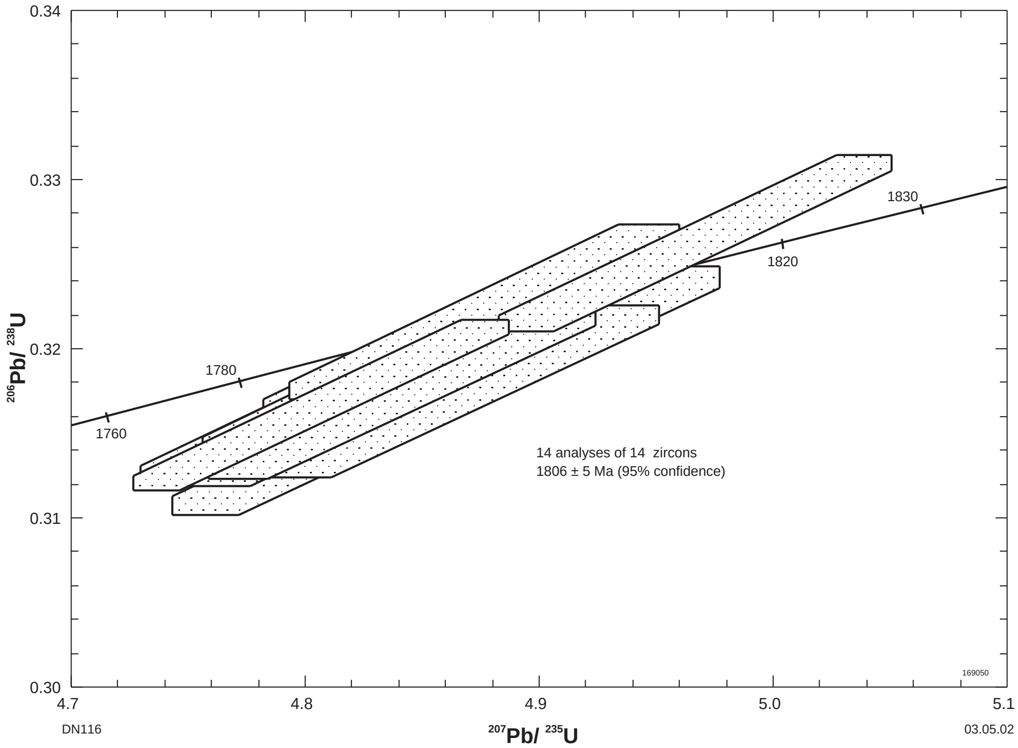

Figure 8. Concordia plot for sample 169050: tonalite gneiss, Mount Remarkable Bore

Analytical details

This sample was analysed on 13 May 2001. The counter deadtime during the analysis session was 32 ns. Ten analyses of the CZ3 standard were obtained during the analysis session. Following deletion of one standard analysis as an outlier, the remaining nine analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.59 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Fourteen analyses were obtained from 14 zircons. Results are given in Table 5 and shown on a concordia plot in Figure 8.

Interpretation

All 14 analyses are concordant and have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1806 ± 5 Ma (chi-squared = 0.72).

The date of 1806 ± 5 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of all 14 analyses is interpreted as the age of crystallization of the tonalite precursor to the gneiss.

169052: biotite–muscovite monzogranite, Tringadee Bore

Location and sampling

MOUNT EGERTON (SG 50-3), CANDOLLE (2348) MGA Zone 50, 538770E 7247050N

Sampled on 12 October 2000.

The sample was taken from a 0.5 m-diameter block within an area of undulating pavements and rocky rubble located within 150 m, and on the western side, of a prominent north-trending ridge, and 8 km northwest of Tringadee Bore.

Tectonic unit/relations

This sample is from a strongly jointed, undeformed to weakly deformed, medium- to coarse-grained leucocratic monzogranite, Gascoyne Complex. The monzogranite occurs within the hinge of an antiform. At the sampling site, the granite has been locally cataclastically deformed and contains abundant quartz veins. The sample taken was free of all obvious veins. The sampling site is located within 50 m of an unconformity with the overlying Tringadee Formation, Bangemall Supergroup.

Petrographic description

The principal minerals present in this sample are quartz (35–40 vol.%), microcline (30–35 vol.%), plagioclase (20 vol.%), biotite (5 vol.%), muscovite and sericite (5 vol.%), with accessory titanite (trace), opaque oxide (trace), carbonate (trace), and zircon (trace). This is a relatively fine-grained biotite–muscovite monzogranite, consisting of abundant augen of microcline and highly altered plagioclase, in a recrystallized quartz-rich host. The plagioclase grains are mostly anhedral and have intense sericite alteration, locally with fine-grained muscovite, and are up to 5 mm long. In contrast, the microcline, to 4 mm in grain size, is fresh and subhedral to anhedral. Lenses of fine-grained recrystallized dark, iron-rich biotite and muscovite are largely parallel to an anastomosing foliation. The biotite is only very rarely altered to chlorite. There are scattered larger quartz grains, to 2 mm in diameter, but most of the quartz forms a micromosaic of recrystallized grains, with minor microcline and rare recrystallized plagioclase. Fine-grained titanite and carbonate accompany the biotite in some areas, with rare zircon showing fine-scale zoning. Some of the titanite occurs as rims on opaque oxide grains.

Zircon morphology

The zircons isolated from this sample are colourless to pale pinkish brown, dark brown and black, generally between 40 × 80 µm and 150 × 280 µm in size, and are mostly sharply euhedral in shape. A small minority of grains (for example, grains 8, 13 and 17) are subrounded or rounded and have textured surfaces. Most grains have faint internal zonation and mineral inclusions are common. Many grains have irregular zones of dark alteration and many are metamict. A small minority (such as grain 11) have thick rims surrounding small cores.

Analytical details

This sample was analysed on 13 May 2001. The counter deadtime during the analysis session was 32 ns. Ten analyses of the CZ3 standard were obtained during the analysis

Table 6. Ion microprobe analytical results for sample 169052: biotite–muscovite monzogranite, Tringadee Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	168	163	70	4.337	0.11797	0.00211	0.32506	0.00522	0.2973	0.0049	4.836	0.124	87	1 926	32
2.1	387	193	130	0.327	0.10838	0.00060	0.14337	0.00118	0.3095	0.0050	4.626	0.081	98	1 772	10
3.1	197	65	65	0.183	0.11170	0.00076	0.09891	0.00134	0.3148	0.0051	4.848	0.089	97	1 827	12
4.1	556	290	189	0.155	0.10815	0.00043	0.15083	0.00080	0.3122	0.0050	4.655	0.079	99	1 768	7
5.1	164	95	37	0.410	0.08140	0.00116	0.16946	0.00258	0.2036	0.0033	2.285	0.052	97	1 231	28
6.1	615	209	201	0.058	0.11100	0.00037	0.09668	0.00055	0.3142	0.0050	4.809	0.080	97	1 816	6
7.1	413	129	133	0.115	0.11049	0.00049	0.09044	0.00077	0.3112	0.0050	4.741	0.081	97	1 807	8
8.1	639	387	217	0.572	0.10972	0.00052	0.16394	0.00113	0.3045	0.0049	4.607	0.079	95	1 795	9
9.1	641	308	216	0.669	0.11174	0.00052	0.14642	0.00111	0.3052	0.0049	4.702	0.081	94	1 828	8
10.1	583	191	269	0.111	0.11068	0.00039	0.53968	0.00127	0.3231	0.0052	4.931	0.083	100	1 811	6
11.1	181	158	69	0.424	0.11445	0.00094	0.24923	0.00209	0.3186	0.0052	5.028	0.096	95	1 871	15
12.1	246	168	89	0.103	0.10873	0.00061	0.19880	0.00123	0.3203	0.0052	4.802	0.085	101	1 778	10
13.1	502	171	53	0.091	0.06304	0.00061	0.10454	0.00123	0.1050	0.0017	0.913	0.018	91	710	20
14.1	177	77	59	0.087	0.11164	0.00075	0.12515	0.00134	0.3116	0.0050	4.796	0.088	96	1 826	12
15.1	340	104	108	0.100	0.11087	0.00053	0.08801	0.00085	0.3070	0.0049	4.693	0.081	95	1 814	9
16.1	244	143	86	0.069	0.11150	0.00062	0.17033	0.00116	0.3197	0.0051	4.916	0.087	98	1 824	10
17.1	225	275	92	0.146	0.10998	0.00065	0.34857	0.00167	0.3238	0.0052	4.910	0.088	101	1 799	11
18.1	201	155	73	0.079	0.11088	0.00073	0.22539	0.00156	0.3162	0.0051	4.834	0.088	98	1 814	12
19.1	202	186	82	0.298	0.11212	0.00086	0.26954	0.00196	0.3362	0.0054	5.197	0.097	102	1 834	14
20.1	474	279	165	0.135	0.10986	0.00046	0.16950	0.00086	0.3145	0.0050	4.764	0.081	98	1 797	8
21.1	651	374	240	1.394	0.12008	0.00069	0.18312	0.00159	0.3149	0.0050	5.214	0.092	90	1 957	10
22.1	428	174	125	1.558	0.11629	0.00118	0.13103	0.00268	0.2595	0.0042	4.160	0.083	78	1 900	18

session. Following deletion of one standard analysis as an outlier, the remaining nine analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.59 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 1.1, 8.1, 9.1, 21.1 and 22.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-two analyses were obtained from 22 zircons. Results are given in Table 6 and shown on a concordia plot in Figure 9.

Interpretation

The analyses are concordant to highly discordant, with discordance pattern consistent with several episodes of radiogenic Pb loss. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to two groups. Thirteen concordant and slightly discordant analyses of 13 zircons (3.1, 6.1, 7.1, 8.1, 9.1, 10.1, 14.1, 15.1, 16.1, 17.1, 18.1, 19.1 and 20.1), 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 1812 ± 7 Ma (chi-squared = 1.59). Concordant and slightly discordant analyses 2.1, 4.1 and 12.1, 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 1772 ± 22 Ma (chi-squared = 0.23). Concordant analysis 5.1 and discordant analysis 13.1 indicated significantly younger $^{207}Pb/^{206}Pb$ dates, whereas discordant analyses 1.1, 11.1, 21.1 and 22.1 indicated significantly older $^{207}Pb/^{206}Pb$ dates than those of Groups 1 and 2.

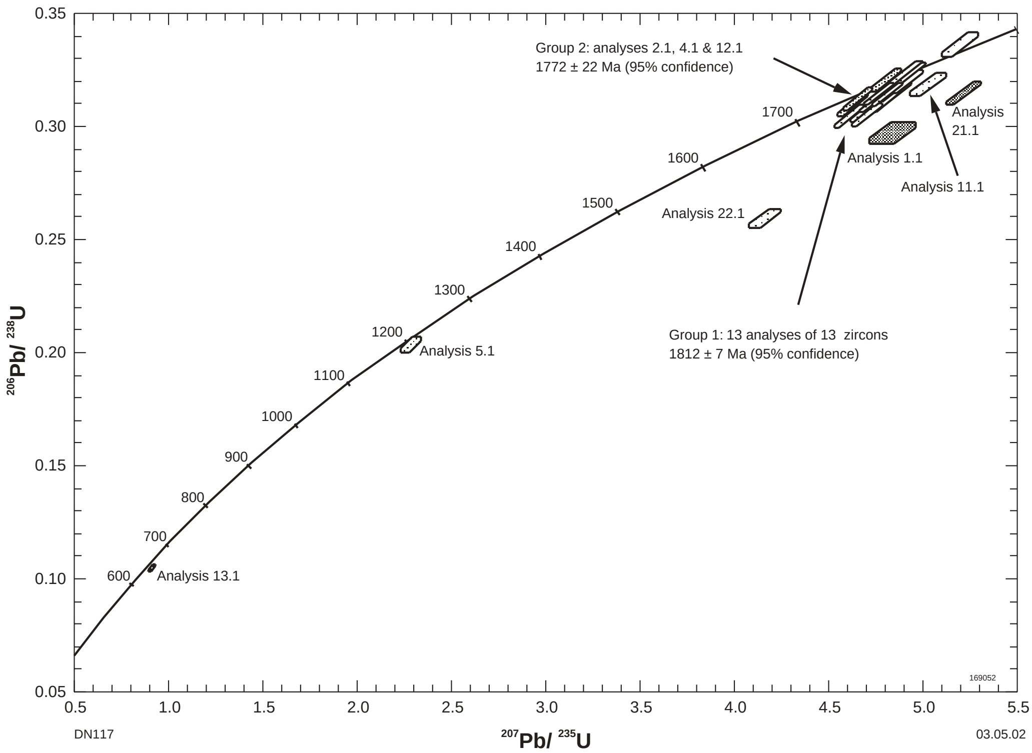

Figure 9. Concordia plot for sample 169052: biotite–muscovite monzogranite, Tringadee Bore

Analyses 2.1, 4.1 and 12.1 of Group 2 were obtained on grains that are not morphologically different than those from which the analyses of Group 1 were obtained. Analysis 5.1 was obtained on a irregular-shaped, structureless grain, whereas analysis 13.1 was obtained on a rounded, structureless grain fragment that was morphologically different from all other grains isolated from this sample.

Although several interpretations of these results are possible, the preferred interpretation is that the date of 1812 ± 7 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 13 analyses of Group 1 corresponds to the time of igneous crystallization of the monzogranite. Analyses 1.1, 11.1, 21.1 and 22.1, which indicated significantly older $^{207}Pb/^{206}Pb$ ages than those of Group 1, are interpreted to be of xenocryst zircons. The significance of the younger $^{207}Pb/^{206}Pb$ dates indicated by analyses 2.1, 4.1, 5.1, 12.1 and 13.1 is unclear. They are tentatively interpreted to be possibly due to several episodes of ancient loss of radiogenic Pb from these analysis sites.

169053: biotite–muscovite monzogranite, Fraser Well

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 423630E 7350160N

Sampled on 13 October 2000.

The sample was taken from a steep whaleback situated on the south side of Fraser Creek, 120 m west of the site where the track crosses the bed of Fraser Creek, and 2 km southwest of Fraser Well.

Tectonic unit/relations

This sample is from a dark grey, even- and medium-grained, biotite–muscovite monzogranite of the Gascoyne Complex. The monzogranite contains abundant 10 cm-long × 5 cm-wide, black, fine-grained biotite-rich metasedimentary inclusions. The outcrop from which the sample was taken shows features consistent with derivation of the monzogranite by the in situ partial melting of a sedimentary rock (Martin et al., 2002). The sample taken was free of any obvious veins.

Petrographic description

The principal minerals present in this sample are quartz (35–40 vol.%), albite (30–35 vol.%), sericite and muscovite (20 vol.%), biotite (5 vol.%), and chlorite (3 vol.%), with accessory apatite (trace), opaque oxide (trace), epidote (trace), carbonate (trace), and zircon (trace). This is an albite-, sericite-, biotite-, muscovite- and quartz-altered, greisenized monzogranite. Poikilitic mica flakes to 10 mm in diameter are present, and there is a greasy, greenish, possibly sericite-rich aggregate. The thin section shows abundant quartz as poikilitic grains to 10 mm in diameter, but only rare large flakes of muscovite up to 5 mm in diameter. There are large grains of plagioclase, to 7 × 4 mm, with albite- and sericite-altered areas commonly containing biotite with or without muscovite. Other grains are altered to sericite. Possible K-feldspar has been altered to albite with disseminated muscovite, biotite, rare carbonate, and ragged patches of secondary quartz that are optically continuous with adjacent primary quartz grains. Aggregates of biotite are disseminated. In some areas, chlorite occurs as well as, or instead of biotite, and the chlorite may be partly after biotite. Irregular grains of opaque oxide, to 1 mm long, are partly altered to leucoxene and there is accessory apatite to 0.5 mm in grain size. Rare epidote is disseminated and rare zircon grains are present.

Zircon morphology

The zircons isolated from this sample are colourless to pale greenish brown, dark brown and black, generally between 40 × 80 µm and 100 × 280 µm in size. Many are multifaceted and sharply euhedral or subhedral in shape. Rounded cores and euhedral, facetted rims can be distinguished in many grains. Many have faint internal zonation and mineral inclusions are common. Many have irregular zones of dark alteration and many are metamict.

Analytical details

This sample was analysed on 28 May and 11 July 2001. The counter deadtime during both analysis sessions was 32 ns. Twelve analyses of the CZ3 standard obtained during

Table 7. Ion microprobe analytical results for sample 169053: biotite–muscovite monzogranite, Fraser Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	207	310	79	0.227	0.09970	0.00093	0.41138	0.00257	0.2907	0.0044	3.996	0.074	102	1 618	17
2.1	625	741	184	0.334	0.10579	0.00054	0.06611	0.00093	0.2892	0.0043	4.219	0.068	95	1 728	9
3.1C	331	105	148	0.097	0.13958	0.00060	0.08239	0.00082	0.4239	0.0063	8.158	0.131	103	2 222	7
4.1	147	104	60	0.442	0.11880	0.00112	0.18629	0.00229	0.3560	0.0054	5.831	0.110	101	1 938	17
5.1	317	214	130	0.122	0.11891	0.00060	0.17847	0.00112	0.3667	0.0055	6.012	0.098	104	1 940	9
6.1R	527	91	156	0.137	0.10452	0.00048	0.04917	0.00072	0.2970	0.0044	4.280	0.068	98	1 706	9
7.1	954	147	297	0.154	0.10945	0.00036	0.03207	0.00050	0.3148	0.0046	4.750	0.073	99	1 790	6
8.1	186	88	81	0.227	0.13125	0.00088	0.13071	0.00154	0.3962	0.0060	7.169	0.124	102	2 115	12
9.1R	459	7	132	0.115	0.10318	0.00051	0.00485	0.00061	0.3001	0.0044	4.269	0.069	101	1 682	9
10.1C	275	345	106	1.167	0.10902	0.00180	0.34023	0.00434	0.2996	0.0046	4.503	0.108	95	1 783	30
11.1C	89	95	41	0.171	0.12638	0.00139	0.30486	0.00317	0.3734	0.0058	6.507	0.131	100	2 048	19
12.1C	760	151	247	0.077	0.11008	0.00039	0.05317	0.00053	0.3241	0.0048	4.919	0.076	101	1 801	6
13.1	518	15	150	0.110	0.10491	0.00049	0.00795	0.00060	0.3023	0.0045	4.373	0.070	99	1 713	9
14.1	488	289	177	0.128	0.11150	0.00053	0.17445	0.00100	0.3275	0.0048	5.035	0.081	100	1 824	9
15.1C	403	252	173	0.123	0.12621	0.00053	0.17475	0.00095	0.3813	0.0057	6.635	0.106	102	2 046	7
16.1R	1081	385	209	1.199	0.10826	0.00062	0.04889	0.00132	0.1863	0.0027	2.781	0.046	62	1 770	10
17.1	453	97	146	0.103	0.10984	0.00053	0.06470	0.00075	0.3178	0.0047	4.814	0.078	99	1 797	9
18.1R	652	9	187	0.170	0.10298	0.00052	0.00243	0.00072	0.3005	0.0036	4.267	0.058	101	1 679	9
19.1R	746	23	214	0.222	0.10236	0.00049	0.00253	0.00069	0.2999	0.0036	4.232	0.057	101	1 667	9
20.1R	677	12	192	0.180	0.10286	0.00049	0.00314	0.00064	0.2962	0.0036	4.201	0.057	100	1 676	9
21.1R	812	21	230	0.095	0.10318	0.00042	0.00324	0.00048	0.2973	0.0036	4.230	0.056	100	1 682	8
15.2R	792	40	220	0.142	0.10321	0.00047	0.00478	0.00059	0.2896	0.0035	4.121	0.055	97	1 683	8
22.1R	729	61	203	0.134	0.10304	0.00050	0.00599	0.00070	0.2905	0.0035	4.127	0.056	98	1 680	9
23.1R	661	21	185	0.116	0.10247	0.00047	0.00447	0.00055	0.2937	0.0035	4.150	0.056	99	1 669	8
24.1R	620	11	176	0.139	0.09983	0.00050	0.00416	0.00066	0.2973	0.0036	4.093	0.056	104	1 621	9
25.1R	709	13	206	0.084	0.10032	0.00046	0.00434	0.00055	0.3046	0.0037	4.213	0.057	105	1 630	9
26.1R	721	13	206	0.100	0.10113	0.00045	0.00469	0.00056	0.2996	0.0036	4.178	0.056	103	1 645	8
27.1R	711	16	204	0.093	0.10112	0.00045	0.00466	0.00054	0.3008	0.0036	4.194	0.056	103	1 645	8
26.2C	197	138	72	0.340	0.11114	0.00100	0.19802	0.00209	0.3218	0.0040	4.931	0.080	99	1 818	16
28.1C	191	224	114	0.284	0.15237	0.00093	0.31854	0.00199	0.4653	0.0059	9.775	0.144	104	2 373	10
28.2R	614	14	179	0.779	0.10265	0.00070	0.00431	0.00137	0.2974	0.0036	4.210	0.061	100	1 673	13
20.2C	203	112	92	0.106	0.13787	0.00086	0.15725	0.00145	0.4047	0.0051	7.693	0.113	100	2 201	11
23.2C	339	75	158	0.163	0.15413	0.00066	0.04175	0.00082	0.4505	0.0055	9.574	0.129	100	2 392	7

NOTE: C denotes analysis obtained on zircon core; R denotes analysis obtained on zircon rim

the first analysis session indicated a Pb*/U calibration error of 1.46 (1σ%). Analyses 1.1 to 17.1 were obtained during the first analysis session. During the second analysis session, five analyses of the CZ3 standard indicated a Pb*/U calibration error of 1.19 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 16.1 and 28.2, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Thirty-three analyses were obtained from 28 zircons. Results are given in Table 7 and shown on a concordia plot in Figure 10.

Interpretation

Most analyses are concordant to slightly discordant, with the discordance patterns consistent with at least one recent episode of radiogenic-Pb redistribution. A range of $^{207}Pb/^{206}Pb$ dates between c. 1620 to 2400 Ma is indicated. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to four groups. Five concordant analyses of five zircons (1.1, 24.1, 25.1, 26.1 and 27.1), assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean date of 1635 ± 15 Ma (chi-squared = 1.33). Nine concordant to slightly discordant analyses of nine zircons (9.1, 15.2, 18.1, 19.1, 20.1, 21.1, 22.1, 23.1 and 28.2), assigned to Group 2, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean date of 1677 ± 7 Ma (chi-squared = 0.39). Analyses 2.1, 6.1 and 13.1, assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean date of 1715 ± 14 Ma (chi-squared = 1.20). Six concordant to highly discordant

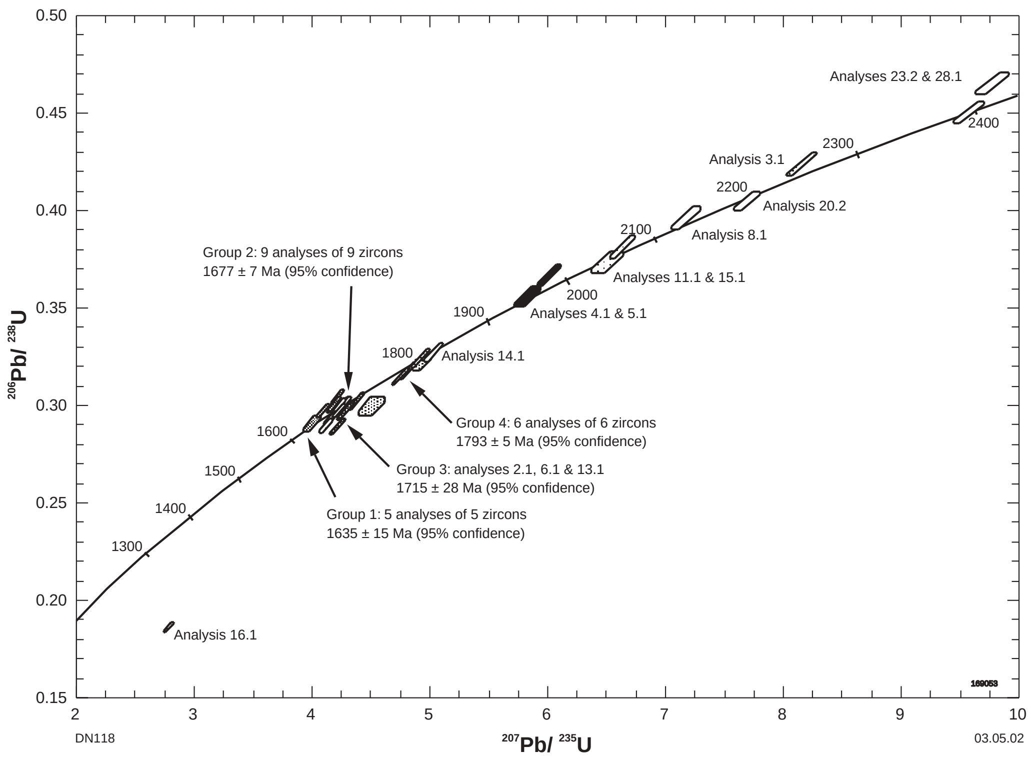

Figure 10. Concordia plot for sample 169053: biotite–muscovite monzogranite, Fraser Well

analyses of six zircons (7.1, 10.1, 12.1, 16.1 17.1 and 26.2), assigned to Group 4, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean date of 1793 ± 5 Ma (chi-squared = 1.60). The remaining analyses cannot be confidently grouped.

The complex distribution of analyses along the concordia is interpreted to indicate the presence of abundant xenocryst zircons within this granite. Analyses obtained on morphological cores and rim zones, in all cases where these can be confidently distinguished, have been identified in Table 7. Four of the five analyses of Group 1 (24.1, 25.1, 26.1 and 27.1) were obtained on rim zones; analysis 1.1 was obtained on a rectangular, colourless and structureless fragment. All nine analyses of Group 2 were obtained from rim zones. Apart from analysis 1.1, which indicated a generally high Th content, the analyses of Groups 1 and 2 have generally low Th contents (from 7 to 61 ppm) and low Th/U (0.017 to 0.083) compared to the remaining analyses, for which Th and Th/U average 195 ppm and 0.56 respectively (n = 19).

The dates of 1635 ± 15 Ma and 1677 ± 7 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratios of analyses of Groups 1 and 2 and mainly obtained on low-Th rim zones are interpreted to indicate the time of zircon rim growth. The low Th contents are consistent with rim growth within an environment rich in hydrous metasomatic fluids, rather than within a granitic melt. The date of 1635 ± 15 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the analyses of Group 1 is also interpreted to provide a maximum age for igneous crystallization of the monzogranite. The remaining analyses, including those obtained on cores, are interpreted to be of xenocryst zircons.

169054: quartz–plagioclase–biotite–orthoclase–muscovite schist, Fraser prospect

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 429490E 7351520N

Sampled on 13 October 2000.

The sample was taken from a 2 m-diameter boulder located on the top of a low hill and 500 m northwest of Fraser rare earth element prospect. The sampling site is located 10 m east of a low rocky outcrop, from which sample 169056 was taken.

Tectonic unit/relations

This sample is from a dark grey, fine- to medium- and even-grained, variably schistose biotite–feldspar–quartz rock that occurs in close association with a porphyritic granite of the Pimbyana Granite (Pearson et al., 1996; Martin et al., 2002), Gascoyne Complex. The biotite–feldspar–quartz rock contains irregular biotite-rich zones and may be comprised of two components; a medium- and even-grained tonalitic phase containing very rare, scattered less than 3 cm-long tabular feldspar grains, and a second, more biotite-rich phase. The associated porphyritic granite locally contains tabular feldspar phenocrysts.

Petrographic description

The principal minerals present in this sample are plagioclase (45–50 vol.%), quartz (40 vol.%), biotite (7–8 vol.%), microcline (5 vol.%), muscovite (4 vol.%), and epidote (1 vol.%), with accessory apatite (trace), opaque oxide (trace), and zircon (trace). This fine-grained grey schistose rock is an altered quartz–plagioclase–biotite–orthoclase–muscovite schist with opaque oxide, apatite and rare zircon. In thin section, a lenticular millimetre- to centimetre- scale compositional layering, with biotite-rich and biotite-poor lenses and an altered quartzofeldspathic component, is evident. Quartz is locally abundant as grains from 0.2 to 0.8 mm in diameter, weakly elongate parallel to the layering, with fresh and albite- to sericite-altered plagioclase with or without clinozoisite, mostly less than 1 mm in grain size but locally as much as 1.5 mm. The abundance of quartz in some layers (>50 vol.%), as well as the even grain size and layered distribution of the quartz, indicates a sandstone protolith. Minor microcline occurs and there are layers rich in microcline as well as quartz, with little or no plagioclase. Much of the biotite is seen as basal sections, suggesting a schistosity at a high angle to the compositional layering. Minor muscovite occurs as poikilitic plates to 1 mm or more in length, and minor granular epidote is present. Apatite and opaque oxide occur as accessory minerals, with rare zircon. Biotite has sagenitic webs of rutile, suggesting retrograde adjustment of its titanium content from a higher metamorphic grade to greenschist facies conditions.

Zircon morphology

The zircons isolated from this sample are pale brown and dark brown, generally between 20 × 30 µm and 35 × 100 µm in size, and are rounded in shape or are irregular fragments. Most grains lack any internal zonation and mineral inclusions are common. Rounded cores and thin rounded rims can be distinguished in a minority of grains. Surface pitting and abrasion is evident on the surfaces of some grains, particularly on the grain terminations, and is consistent with detrital transport.

Table 8. Ion microprobe analytical results for sample 169054: quartz–plagioclase–biotite–orthoclase–muscovite schist, Frasers prospect

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	916	22	292	0.068	0.11579	0.00035	0.00935	0.00036	0.3283	0.0038	5.241	0.064	97	1 892	5
2.1	272	175	96	0.099	0.10903	0.00074	0.17716	0.00147	0.3183	0.0038	4.784	0.069	100	1 783	12
3.1	152	81	53	0.041	0.11099	0.00103	0.16494	0.00200	0.3164	0.0038	4.842	0.078	98	1 816	17
4.1	582	386	191	0.050	0.10324	0.00043	0.20066	0.00087	0.2912	0.0034	4.145	0.053	98	1 683	8
5.1	316	77	99	0.041	0.10961	0.00058	0.07071	0.00073	0.3089	0.0036	4.668	0.063	97	1 793	10
6.1	552	35	155	0.062	0.10264	0.00045	0.01849	0.00050	0.2910	0.0034	4.118	0.053	98	1 672	8
7.1	633	759	234	0.039	0.10295	0.00043	0.36030	0.00117	0.2926	0.0034	4.154	0.053	99	1 678	8
8.1	538	68	155	0.074	0.10283	0.00048	0.03790	0.00064	0.2932	0.0034	4.157	0.054	99	1 676	9
9.1	225	361	88	0.041	0.10241	0.00073	0.45098	0.00220	0.2920	0.0035	4.124	0.060	99	1 668	13
10.1	399	209	127	0.119	0.10177	0.00057	0.15999	0.00108	0.2927	0.0034	4.107	0.056	100	1 657	10
11.1	680	21	194	0.087	0.10282	0.00043	0.00750	0.00053	0.2980	0.0034	4.225	0.054	100	1 676	8
12.1	523	26	152	0.104	0.10250	0.00051	0.00949	0.00058	0.3020	0.0035	4.269	0.056	102	1 670	9
13.1	568	35	164	0.025	0.10137	0.00044	0.01365	0.00050	0.3006	0.0035	4.202	0.054	103	1 649	8
14.1	128	92	47	0.053	0.10849	0.00115	0.20749	0.00245	0.3234	0.0040	4.838	0.083	102	1 774	19
15.1	331	212	150	0.071	0.14055	0.00059	0.18867	0.00101	0.3950	0.0047	7.654	0.099	96	2 234	7
16.1	255	130	87	0.109	0.10873	0.00068	0.14348	0.00121	0.3169	0.0038	4.751	0.067	100	1 778	11
17.1	155	264	64	0.078	0.10146	0.00103	0.49376	0.00318	0.2989	0.0036	4.181	0.070	102	1 651	19
18.1	597	229	187	0.049	0.10526	0.00042	0.09949	0.00065	0.3016	0.0035	4.378	0.056	99	1 719	7
19.1	577	79	168	0.031	0.10290	0.00044	0.03626	0.00050	0.2976	0.0034	4.222	0.054	100	1 677	8

Analytical details

This sample was analysed on 20 August 2001. The counter deadtime during the analysis session was 32 ns. Five analyses of the CZ3 standard obtained during the analysis session indicated a Pb*/U calibration error of 0.841 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Nineteen analyses were obtained from 19 zircons. Results are given in Table 8 and shown on concordia and Gaussian-summation probability density plots in Figures 11 and 12.

Interpretation

Most analyses are concordant to slightly discordant, with the discordance patterns consistent with at least one recent radiogenic-Pb redistribution episode. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of two groups. Ten concordant to slightly discordant analyses of ten zircons (4.1, 6.1, 7.1, 8.1, 9.1, 10.1, 11.1, 12.1, 17.1 and 19.1), assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean date of 1674 ± 6 Ma (chi-squared = 0.70). Five concordant analyses of five zircons (2.1, 3.1, 5.1, 14.1 and 16.1), assigned to Group 2, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean date of 1788 ± 6 Ma (chi-squared = 0.94). The remaining analyses (1.1, 9.1, 13.1 and 15.1) cannot be confidently grouped.

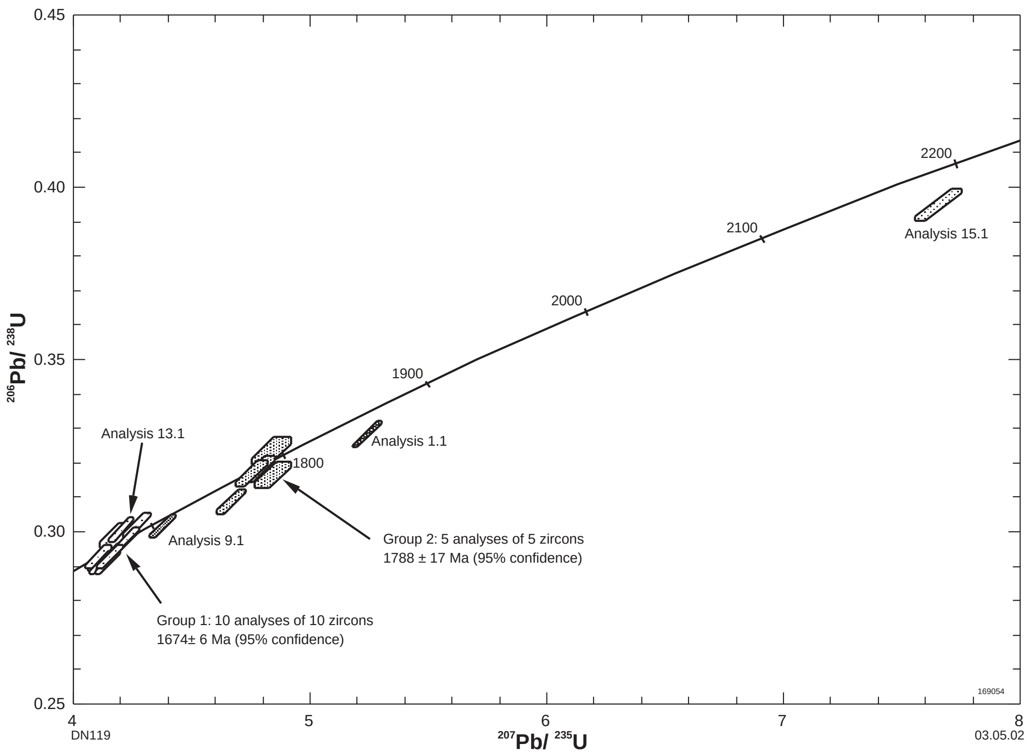

Figure 11. Concordia plot for sample 169054: quartz–plagioclase–biotite–orthoclase–muscovite schist, Fraser prospect

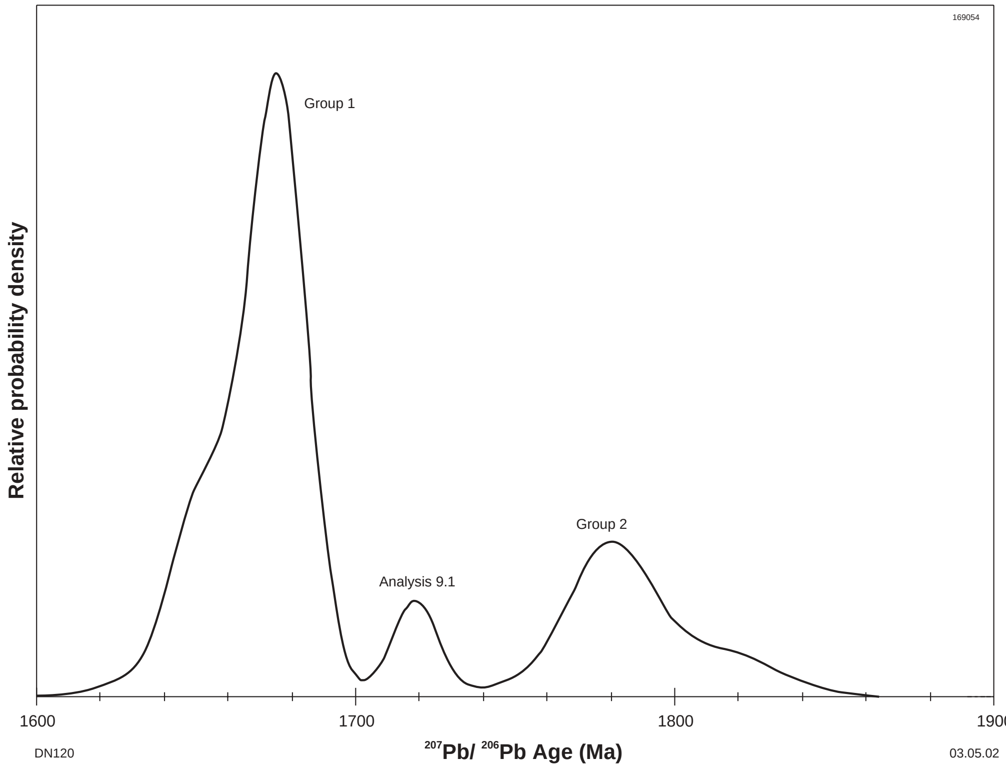

Figure 12. Gaussian-summation probability density plot for sample 169054: quartz–plagioclase–biotite–orthoclase–muscovite schist, Fraser prospect

The analyses of Group 1 were obtained on small elongate (typically 20 × 45 µm), pale straw-yellow, structureless, irregular and euhedral fragments. Th/U ratios of the analyses of Group 1 are highly variable and are consistent with at least a proportion of the zircons of Group 1 having crystallized within an igneous melt rather than from hydrous (metamorphic) fluids. The weighted mean $^{207}Pb/^{206}Pb$ date of 1674 ± 6 Ma indicated by the ten concordant to slightly discordant analyses of Group 1 is interpreted as the age of crystallization of an igneous phase present within the biotite–feldspar–quartz rock. The slightly younger $^{207}Pb/^{206}Pb$ date indicated by reversely discordant analysis 13.1 may indicate that this grain crystallized during the same event, but that some later redistribution of radiogenic Pb occurred within this analysis site. Alternatively, the younger $^{207}Pb/^{206}Pb$ date indicated by this analysis may correspond to a second zircon growth event (as was indicated by the results obtained for sample 169053). Analyses of Group 2 were obtained on brown equant to slightly elongate rounded grains. The older $^{207}Pb/^{206}Pb$ dates indicated by analyses 1.1, 9.1 and 15.1, and by the five concordant to slightly discordant analyses of Group 2, may have been obtained on zircons of detrital origin.

169055: biotite–muscovite monzogranite, Fraser Well

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 430040E 7349370N

Sampled on 14 October 2000.

The sample was taken from the edge of a 2 m-high whaleback situated within an area of pavements and rocky whalebacks, 4 km southeast of Fraser Well.

Tectonic unit/relations

This sample is from a light grey, even- and fine-grained, biotite–muscovite granite phase of the Yangibana Granite (Martin et al., 2002), Gascoyne Complex. The granite contains scattered muscovite plates, less than 0.5 cm long and has locally abundant metasedimentary inclusions. The sample taken was free of any obvious veins and inclusions.

Petrographic description

The principal minerals present in this sample are microcline (40 vol.%), quartz (25–30 vol.%), plagioclase (20 vol.%), muscovite (7–8 vol.%), and biotite (5 vol.%), with accessory apatite (trace), chlorite (trace), sericite (trace), carbonate (trace), and zircon (trace). This is an altered muscovite–biotite monzogranite to syenogranite, with rare apatite and zircon. There are large flakes of muscovite as well as aggregates of biotite to 7 mm in diameter in this sample. In thin section, there is abundant quartz as interstitial, partly poikilitic grains to 6 mm long and more abundant microcline with a variety of habits. Some of the orthoclase is poikilitic, to 5 mm in grain size, with rounded inclusions of quartz and plagioclase, some of which occurs as elongate subhedral laths mostly free of inclusions, and some of which has rounded or graphic inclusions of quartz. Plagioclase is less abundant, granular or elongate with grains to 2 mm long and clouded by sericite, with or without muscovite. Large plates of mostly elongate muscovite, to 5 mm long, occur at a high angle to their cleavage planes. Small radioactive grains are enclosed in the muscovite and have formed pleochroic haloes. Mostly ragged biotite flakes, to 1 mm long, have abundant pleochroic haloes. Alteration to chlorite is rare, and rare metamict zircon is present. Granular apatite, locally over 1 mm in grain size, has fluid inclusions and inclusions. There is also rare secondary carbonate.

Zircon morphology

The zircons isolated from this sample are colourless to pale yellowish brown, dark brown and black, generally between 40 × 80 µm and 100 × 280 µm in size, and are irregular fragments, subrounded, subhedral or euhedral in shape. Many grains have faint internal zonation, and mineral inclusions are common. Many have irregular zones of dark alteration, and many are metamict. Surface pitting, consistent with detrital transport, is apparent on the surfaces of some grains.

Analytical details

This sample was analysed on 15 June 2001. The counter deadtime was 32 ns. Ten analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U

Table 9. Ion microprobe analytical results for sample 169055: biotite–muscovite monzogranite, Fraser Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	210	233	82	4.578	0.09966	0.00273	0.32843	0.00686	0.2814	0.0032	3.867	0.120	99	1 618	51
2.1	320	88	128	0.188	0.17608	0.00085	0.07025	0.00110	0.3701	0.0039	8.986	0.110	78	2 616	8
3.1	199	194	69	0.221	0.10225	0.00109	0.28012	0.00258	0.2891	0.0032	4.076	0.066	98	1 665	20
4.1	224	45	65	0.441	0.10296	0.00118	0.05802	0.00221	0.2874	0.0031	4.080	0.068	97	1 678	21
5.1	149	139	58	0.529	0.11279	0.00155	0.27093	0.00354	0.3200	0.0036	4.976	0.094	97	1 845	25
6.1	203	254	74	0.786	0.09986	0.00147	0.35379	0.00365	0.2866	0.0032	3.946	0.077	100	1 621	27
7.1	126	118	43	0.166	0.10250	0.00118	0.26575	0.00275	0.2878	0.0032	4.068	0.069	98	1 670	21
8.1	233	184	77	0.414	0.10179	0.00084	0.22535	0.00187	0.2851	0.0030	4.000	0.057	98	1 657	15
9.1	340	141	105	0.317	0.10139	0.00067	0.11811	0.00128	0.2908	0.0030	4.065	0.053	100	1 650	12
10.1	213	126	67	0.444	0.10236	0.00098	0.16645	0.00205	0.2850	0.0030	4.023	0.061	97	1 667	18
11.1	284	45	82	0.181	0.10291	0.00072	0.04463	0.00119	0.2899	0.0030	4.113	0.054	98	1 677	13
12.1	127	138	45	0.369	0.10073	0.00119	0.30604	0.00289	0.2895	0.0032	4.021	0.069	100	1 638	22
13.1	159	154	55	0.342	0.10246	0.00102	0.27607	0.00240	0.2872	0.0031	4.057	0.063	98	1 669	18
14.1	93	64	55	0.284	0.18329	0.00126	0.18165	0.00213	0.4927	0.0056	12.450	0.175	96	2 683	11
15.1	282	949	234	0.294	0.10254	0.00076	2.18572	0.00597	0.2907	0.0030	4.109	0.056	98	1 671	14
16.1	303	367	110	0.460	0.10205	0.00079	0.33802	0.00198	0.2881	0.0030	4.054	0.056	98	1 662	14
17.1	229	500	81	2.444	0.10267	0.00160	0.27106	0.00393	0.2789	0.0030	3.948	0.079	95	1 673	29
18.1	454	77	213	0.191	0.15727	0.00052	0.04775	0.00069	0.4499	0.0046	9.755	0.109	99	2 427	6
19.1	259	340	93	0.459	0.09995	0.00080	0.32518	0.00199	0.2903	0.0030	4.001	0.056	101	1 623	15

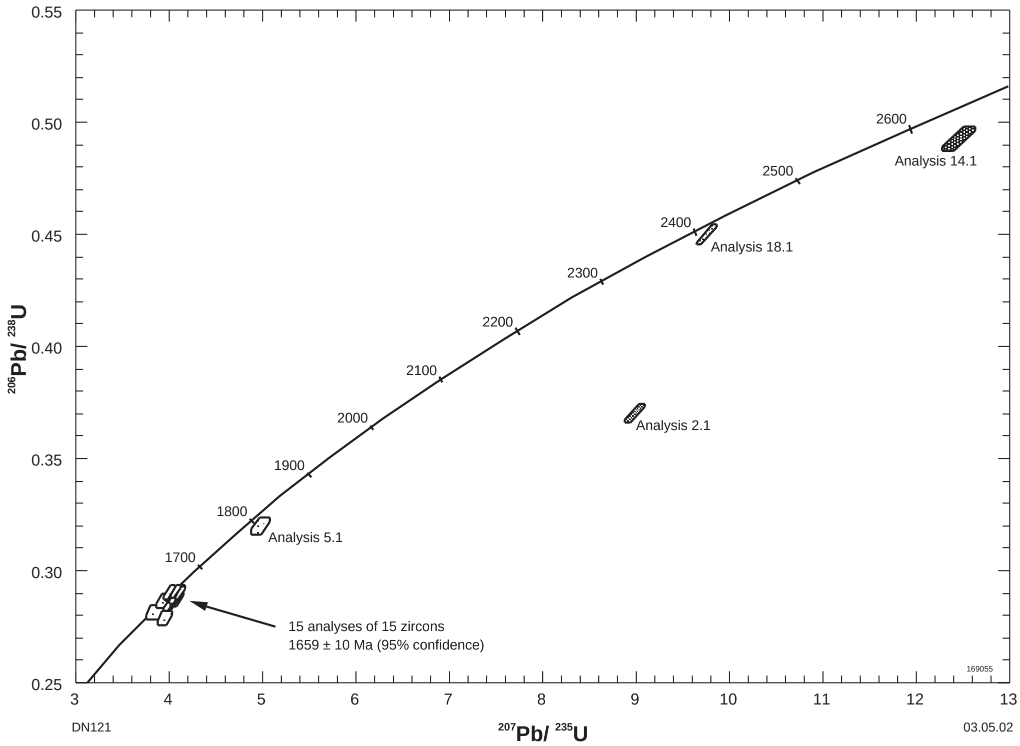

Figure 13. Concordia plot for sample 169055: biotite–muscovite monzogranite, Fraser Well

calibration error of 0.956 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 1.1 and 19.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Nineteen analyses were obtained from 19 zircons. Results are given in Table 9 and shown on a concordia plot in Figure 13.

Interpretation

Most analyses are concordant to highly discordant with the discordance patterns consistent with at least one recent radiogenic-Pb redistribution episode. Fifteen concordant to slightly discordant analyses of 15 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1659 ± 10 Ma (chi-squared = 0.98). The remaining analyses (2.1, 5.1, 14.1, and 18.1) indicate older $^{207}Pb/^{206}Pb$ dates and cannot be grouped.

The weighted mean $^{207}Pb/^{206}Pb$ date of 1659 ± 10 Ma indicated by 15 concordant to slightly discordant analyses of 15 zircons is interpreted as the age of igneous crystallization of the monzogranite. The remaining analyses are interpreted to be of xenocryst zircons.

169056: quartz–muscovite–biotite–plagioclase–epidote schist, Fraser prospect

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 429490E 7351520N

Sampled on 14 October 2000.

The sample was taken from a low rocky outcrop situated 10 m west of a low rocky hill (from which sample 169054 was taken) and 500 m northwest of Fraser rare earth element prospect.

Tectonic unit/relations

This sample is from an irregular, 10 m^2 dark grey to black, fine-grained, mica-rich metasedimentary inclusion within porphyritic granite of the Pimbyana Granite (Pearson et al., 1996), Gascoyne Complex. The inclusion has irregular veins of porphyritic granite less than 5 cm thick, but the sample taken was free of any obvious veins.

Petrographic description

The principal minerals present in this sample are quartz (65 vol.%), altered plagioclase (25 vol.%), biotite (7–8 vol.%), and muscovite (2–3 vol.%), with accessory apatite (trace), opaque oxide (trace), epidote (trace), and zircon (trace). This is a quartz-, muscovite-, biotite-, plagioclase- and epidote-bearing schist derived from a quartzofeldspathic medium-grained sandstone. This fine-grained, dark grey micaceous schist is rich in well-sorted single crystal quartz grains that are mostly less than 0.5 mm in diameter, together with definite to possible plagioclase grains altered variously to albite, sericite, granular to prismatic epidote, and minor biotite. The sericite is schistose and is parallel to the biotite schistosity. Clearly defined biotite flakes occur, to 0.5 mm long, passing into more shredded and altered flakes with sericite parallel to the cleavage planes. Separate flakes of muscovite are not abundant. Rounded zircon grains, apatite, and partly to completely leucoxenized opaque oxide are also present.

Zircon morphology

The zircons isolated from this sample have a wide range of morphologies. Many are colourless, pale greenish brown, dark brown or black, generally between 40 × 80 µm and 100 × 280 µm in size, and are irregular fragments, or are subhedral or euhedral in shape. Many grains have faint internal zonation and mineral inclusions are common. Many have irregular zones of dark alteration, and many are metamict. Surface pitting, consistent with detrital transport, is apparent on the surfaces of some grains.

Analytical details

This sample was analysed on 26 May 2001. The counter deadtime was 32 ns. Fifteen analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.83 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 10. Ion microprobe analytical results for sample 169056: quartz–muscovite–biotite–plagioclase–epidote schist, Fraser prospect

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	1269	353	683	0.068	0.18375	0.00036	0.08517	0.00037	0.4921	0.0091	12.468	0.234	96	2 687	3
2.1	374	56	178	0.170	0.15830	0.00066	0.04163	0.00077	0.4594	0.0086	10.026	0.197	100	2 438	7
3.1	671	221	276	0.222	0.13477	0.00053	0.08986	0.00080	0.3870	0.0072	7.192	0.139	98	2 161	7
4.1	434	68	171	0.160	0.13192	0.00072	0.04326	0.00094	0.3867	0.0072	7.034	0.141	99	2 124	10
5.1	274	115	92	0.405	0.10913	0.00096	0.11954	0.00180	0.3126	0.0059	4.704	0.102	98	1 785	16
6.1	347	163	169	0.229	0.15988	0.00078	0.10657	0.00114	0.4432	0.0083	9.771	0.194	96	2 454	8
7.1	431	178	195	0.110	0.14612	0.00063	0.11013	0.00093	0.4166	0.0078	8.394	0.165	98	2 301	7
8.1	672	161	215	0.134	0.11029	0.00050	0.06812	0.00074	0.3147	0.0058	4.786	0.094	98	1 804	8
9.1	472	160	159	0.299	0.11158	0.00070	0.09345	0.00123	0.3220	0.0060	4.955	0.101	99	1 825	11
10.1	341	46	159	0.216	0.15817	0.00075	0.03673	0.00094	0.4488	0.0084	9.788	0.194	98	2 436	8
11.1	248	37	120	0.214	0.15702	0.00085	0.04036	0.00106	0.4640	0.0087	10.045	0.203	101	2 424	9
12.1	614	73	255	0.133	0.14507	0.00054	0.03321	0.00061	0.4075	0.0075	8.152	0.158	96	2 289	6
13.1	174	39	71	0.397	0.13421	0.00115	0.05707	0.00190	0.3938	0.0075	7.287	0.159	99	2 154	15
14.1	723	157	228	0.175	0.11107	0.00049	0.06274	0.00071	0.3097	0.0057	4.743	0.093	96	1 817	8
15.1	252	73	111	0.258	0.14422	0.00084	0.08100	0.00119	0.4144	0.0078	8.241	0.168	98	2 278	10
16.1	246	116	86	0.299	0.10999	0.00094	0.13391	0.00177	0.3219	0.0060	4.882	0.105	100	1 799	16
17.1	734	76	332	0.185	0.15744	0.00048	0.02888	0.00056	0.4406	0.0081	9.565	0.183	97	2 428	5
18.1	197	67	83	0.198	0.13880	0.00097	0.09529	0.00146	0.3952	0.0075	7.563	0.158	97	2 212	12
19.1	886	166	370	0.186	0.14321	0.00044	0.05275	0.00058	0.4039	0.0075	7.974	0.152	96	2 266	5
20.1	625	46	294	0.078	0.15779	0.00050	0.01955	0.00047	0.4640	0.0086	10.096	0.194	101	2 432	5
21.1	161	64	73	0.544	0.14516	0.00122	0.11351	0.00216	0.4107	0.0078	8.220	0.179	97	2 290	14
22.1	199	107	92	0.159	0.13928	0.00092	0.14973	0.00148	0.4126	0.0078	7.923	0.165	100	2 218	11
23.1	246	241	96	0.466	0.10963	0.00103	0.28158	0.00240	0.3219	0.0060	4.866	0.107	100	1 793	17
24.1	400	122	203	0.172	0.16375	0.00066	0.08257	0.00087	0.4709	0.0088	10.632	0.208	100	2 495	7
25.1	579	646	227	0.501	0.11019	0.00068	0.30142	0.00161	0.3174	0.0059	4.822	0.098	99	1 803	11

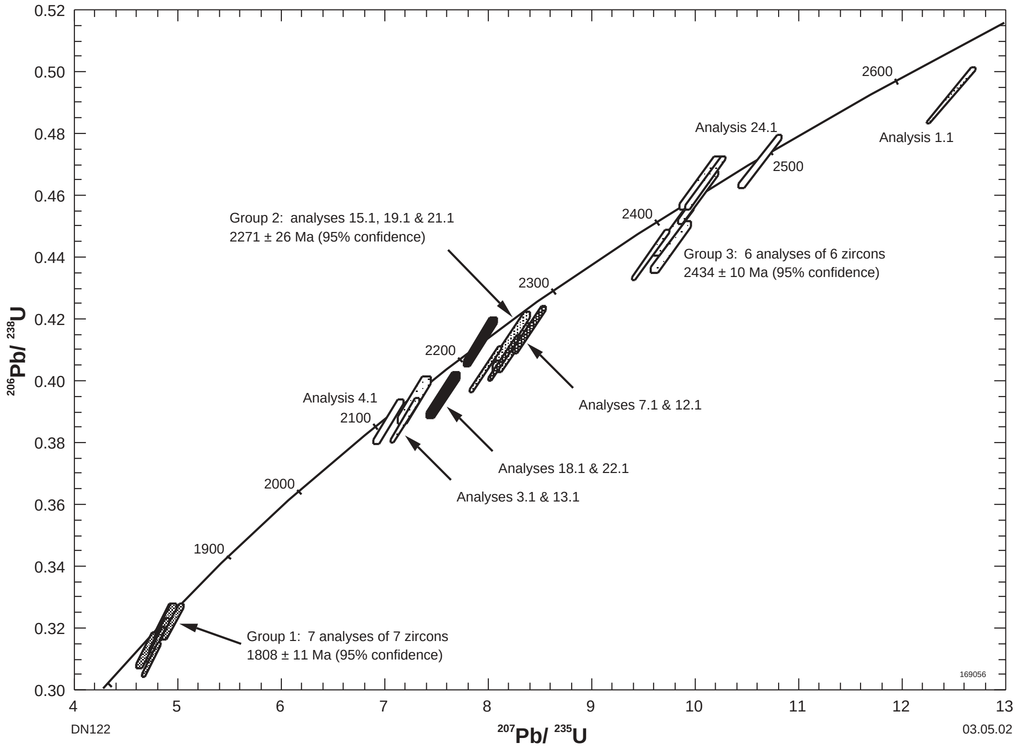

Figure 14. Concordia plot for sample 169056: quartz–muscovite–biotite–plagioclase–epidote schist, Fraser prospect

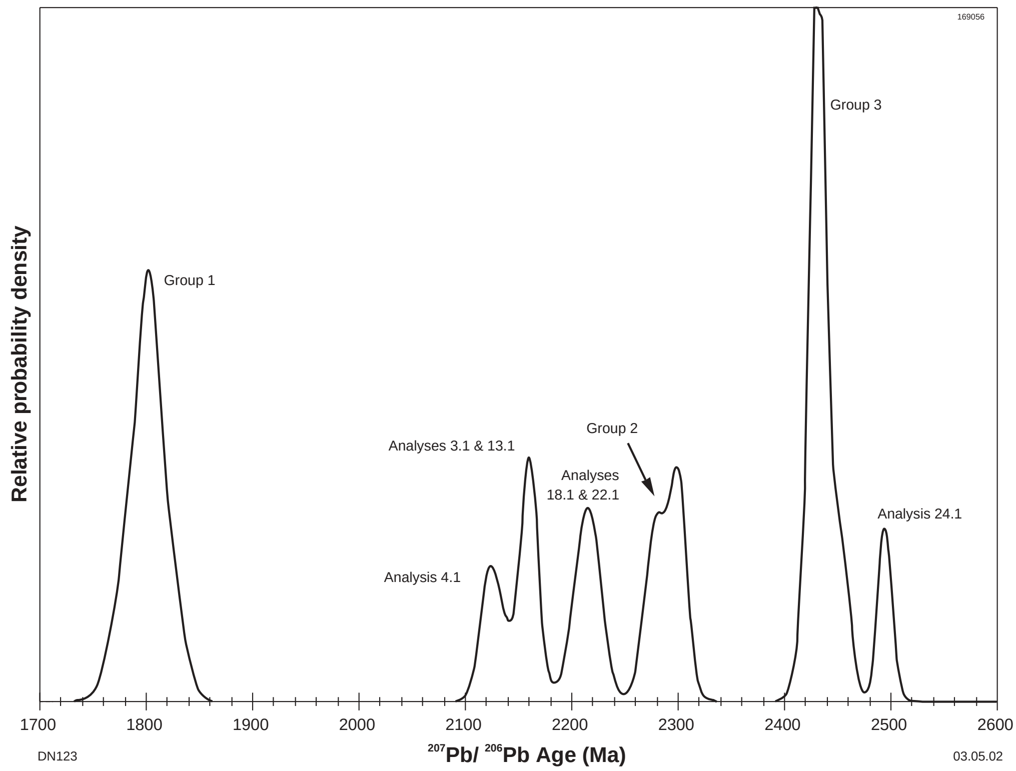

Figure 15. Gaussian-summation probability density plot for sample 169056: quartz–muscovite–biotite–plagioclase–epidote schist, Fraser prospect

Results

Twenty-five analyses were obtained from 25 zircons. Results are given in Table 10 and shown on concordia and Gaussian-summation probability density plots in Figures 14 and 15.

Interpretation

Most analyses are concordant to slightly discordant with the discordance patterns consistent with at least one recent radiogenic-Pb redistribution episode. A range of $^{207}Pb/^{206}Pb$ dates of from c. 1810 to 2690 Ma is indicated. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of three groups. Seven concordant to slightly discordant analyses of seven zircons (5.1, 8.1, 9.1, 14.1, 16.1, 23.1 and 25.1), 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 1808 ± 11 Ma (chi-squared = 1.06). Slightly discordant analyses 15.1, 19.1 and 21.1, 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 2271 ± 26 Ma (chi-squared = 1.22). Six concordant to slightly discordant analyses of six zircons (2.1, 6.1, 10.1, 11.1, 17.1 and 20.1), assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean date of 2434 ± 10 Ma (chi-squared = 1.59). The remaining analyses cannot be confidently grouped.

Many of the grains from which Group 1 analyses were obtained are rounded (for example, analysis 8.1), have rounded terminations (analyses 9.1, 14.1, 23.1), and/or have pitted surfaces (analyses 9.1, 16.1, 23.1), consistent with detrital transport. The weighted mean $^{207}Pb/^{206}Pb$ date of 1808 ± 11 Ma indicated by the analyses of Group 1 is therefore interpreted as providing a maximum age for deposition of the sedimentary precursor to the schist. The remaining analyses are interpreted to be of detrital zircons.

169058: augen orthogneiss, Kanes Gossan prospect

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 426780E 7357910N

Sampled on 14 October 2000.

The sample was taken from a 1 m-diameter boulder in an area of rocky weathered pavements and boulders, 2.5 km east-southeast of the Kanes Gossan rare earth element prospect.

Tectonic unit/relations

This sample is a dark grey and white, strongly deformed augen gneiss derived from a porphyritic granite, with feldspar augen less than 2 cm in diameter and dark biotite-rich layers, of the Gooche Gneiss (Martin et al., 2002), Gascoyne Complex. At the sampling site, the gneissic layering has been folded into tight mesoscale folds.

Petrographic description

This sample consists principally of altered plagioclase (40 vol.%), quartz (35 vol.%), orthoclase (10 vol.%), biotite (10 vol.%), and epidote (5 vol.%), with accessory sericite (trace), leucoxene (trace), chlorite (trace), clinozoisite (trace), and zircon (trace). This is a sheared quartzofeldspathic gneiss breccia with biotite and granular to prismatic epidote between possible fragments. Anastomosing foliae of biotite and/or chlorite with feldspathic or quartzofeldspathic areas occur in this sample. The thin section shows millimetre- to centimetre- scale domains rich in quartz, sericite with or without clinozoisite-flooded plagioclase, or perthitic orthoclase in various proportions. The quartz-rich areas have irregular, highly strained larger grains to 7 mm long and small fine-grained newly recrystallized areas. Perthitic orthoclase occurs as less deformed grains to 4 mm in diameter, in the quartz-rich areas and separately. Ragged plagioclase grains, which are mostly less than 4 mm in diameter, are flooded by sericite and veined by clouded clinozoisite. The biotite is mostly decussate but there are foliae of schistose sericite, some of which contain schistose biotite partly altered to chlorite or, more commonly, to sericite and leucoxene. The biotite occurs with epidote crystals to 1.5 mm long and some foliae are dominated by granular epidote. This sample has the character of a breccia, possibly with sheared and metasomatized material between poorly defined fragments, rather than of augen with a gneissic matrix.

Zircon morphology

The zircons isolated from this sample are colourless, pale yellowish brown, dark brown or black, generally between 40 × 120 µm and 100 × 280 µm in size, and are commonly subhedral and elongate in shape. Many grains are structureless, whereas others have faint internal zonation. Mineral and fluid inclusions are common. Many have irregular zones of dark alteration and many are metamict.

Analytical details

This sample was analysed on 15 June 2001. The counter deadtime was 32 ns. Ten analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 0.956 (1s%). A calibration error of 1.0 (1σ%) was applied to

Table 11. Ion microprobe analytical results for sample 169058: augen orthogneiss, Kanes Gossan prospect

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	301	116	99	0.133	0.10885	0.00061	0.10200	0.00102	0.3159	0.0033	4.742	0.059	99	1 780	10
2.1	230	167	81	0.196	0.10890	0.00077	0.19236	0.00160	0.3139	0.0033	4.713	0.063	99	1 781	13
3.1	298	212	105	0.066	0.10828	0.00061	0.18869	0.00123	0.3154	0.0033	4.709	0.059	100	1 771	10
4.1	113	86	40	0.267	0.10867	0.00119	0.18687	0.00249	0.3175	0.0035	4.758	0.079	100	1 777	20
5.1	148	69	49	0.306	0.10887	0.00101	0.13091	0.00194	0.3043	0.0033	4.567	0.069	96	1 781	17
6.1	232	105	77	1.636	0.10830	0.00125	0.10638	0.00282	0.3009	0.0032	4.493	0.074	96	1 771	21
7.1	277	125	90	0.224	0.10643	0.00068	0.10887	0.00124	0.3073	0.0032	4.509	0.058	99	1 739	12
8.1	157	86	55	0.092	0.11097	0.00082	0.15499	0.00148	0.3207	0.0035	4.906	0.068	99	1 815	13
9.1	199	112	68	0.174	0.10905	0.00078	0.15081	0.00151	0.3143	0.0033	4.725	0.064	99	1 784	13
10.1	127	96	45	0.322	0.10656	0.00111	0.19036	0.00235	0.3171	0.0035	4.659	0.075	102	1 741	19
11.1	273	146	95	0.090	0.10799	0.00066	0.13922	0.00122	0.3229	0.0034	4.808	0.061	102	1 766	11
12.1	385	215	134	0.073	0.10754	0.00051	0.14737	0.00091	0.3223	0.0033	4.779	0.057	102	1 758	9
13.1	246	160	87	0.061	0.11013	0.00064	0.18602	0.00125	0.3155	0.0033	4.791	0.060	98	1 802	11
14.1	368	119	121	0.145	0.10971	0.00056	0.09070	0.00094	0.3168	0.0033	4.792	0.058	99	1 795	9
15.1	253	99	82	0.158	0.10740	0.00066	0.09959	0.00113	0.3102	0.0032	4.594	0.059	99	1 756	11
16.1	187	117	66	0.195	0.10889	0.00080	0.17093	0.00158	0.3161	0.0034	4.746	0.065	99	1 781	13
17.1	347	82	112	0.274	0.10871	0.00062	0.06413	0.00103	0.3179	0.0033	4.766	0.059	100	1 778	10
18.1	260	153	90	0.129	0.10754	0.00063	0.15760	0.00119	0.3172	0.0033	4.703	0.059	101	1 758	11
19.1	230	176	84	0.079	0.10961	0.00065	0.20702	0.00130	0.3227	0.0034	4.876	0.062	101	1 793	11

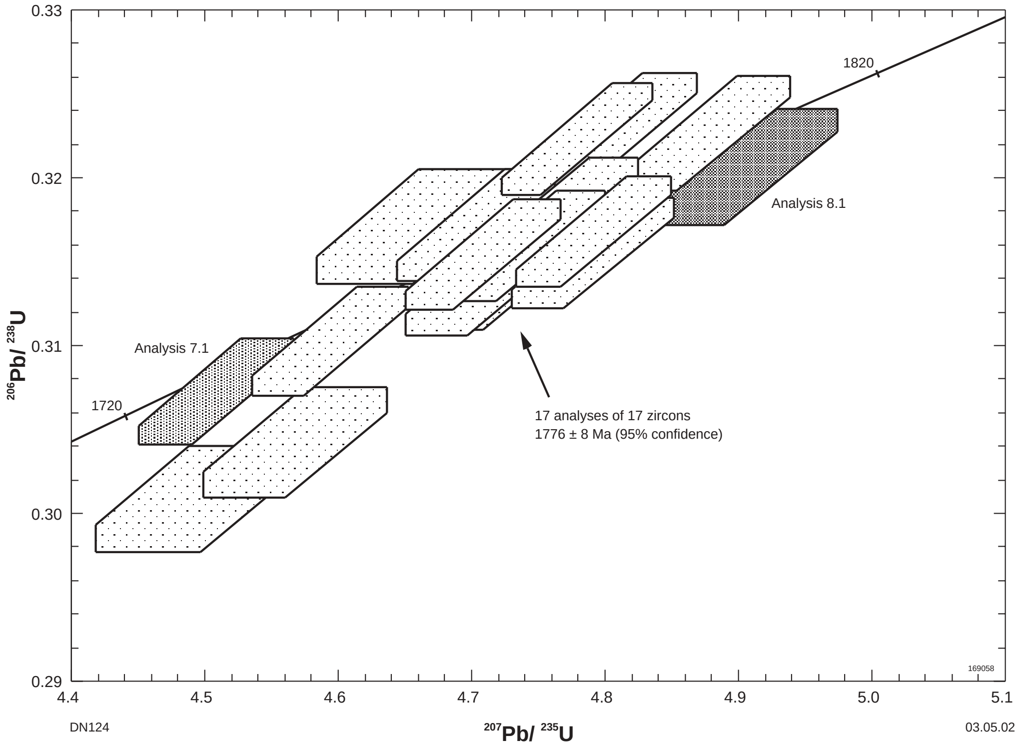

Figure 16. Concordia plot for sample 169058: augen orthogneiss, Kanes Gossan prospect

analyses of unknowns obtained during the analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 6.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Nineteen analyses were obtained from 19 zircons. Results are given in Table 11 and shown on a concordia plot in Figure 16.

Interpretation

Most analyses are concordant to slightly discordant, with the discordance pattern consistent with at least one recent episode of radiogenic-Pb redistribution. Seventeen concordant to slightly discordant analyses of 17 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1776 ± 8 Ma (chi-squared = 1.63). Concordant analysis 8.1 indicates a slightly older $^{207}Pb/^{206}Pb$ date whereas the $^{207}Pb/^{206}Pb$ date indicated by concordant analysis 7.1 is slightly younger than the main population.

The weighted mean $^{207}Pb/^{206}Pb$ date of 1776 ± 8 Ma indicated by 17 concordant to slightly discordant analyses is interpreted as corresponding to the age of igneous crystallization of the porphyritic granite precursor to the gneiss. Concordant analysis 8.1 is interpreted to be of a xenocryst zircon, whereas concordant analysis 7.1 is interpreted to be of a site that has lost some radiogenic Pb.

169059: muscovite–biotite monzogranite, Yangibana Bore

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 418690E 7356200N

Sampled on 15 October 2000.

The sample was taken from a 2 m-diameter boulder located in an area of rocky, weathered pavements and boulders, and 4 km southeast of Yangibana Bore.

Tectonic unit/relations

This sample is a light grey, fine- to medium-grained biotite–muscovite monzogranite of the Yangibana Granite (Martin et al., 2002), Gascoyne Complex. The monzogranite contains scattered muscovite plates less than 2 mm in diameter, and biotite clots also less than 2 mm in diameter, possibly after tourmaline.

Petrographic description

This sample consists principally of plagioclase (35 vol.%), microcline (30 vol.%), quartz (25 vol.%), muscovite (6 vol.%), and biotite (3 vol.%), with accessory apatite (trace), fluorite (trace), and zircon (trace). This is a partly fine-grained, granular, foliated, muscovite–biotite monzogranite with sericite-clouded plagioclase, quartz and microcline to 1.5 mm in grain size, coarse muscovite, and unusually abundant apatite. Large, slightly bent flakes of muscovite are visible in hand specimen. In thin section there are poikilitic muscovite flakes to 6 mm long, commonly elongate at a high angle to their cleavage planes. These may be bent or kinked and some have lamellae of chlorite parallel to the cleavage. There are irregular foliae of fine-grained biotite with or without muscovite, giving a gneissic character to the host rock, as well as larger, less well-oriented flakes of dark brown (iron-rich) biotite about 0.5 mm long. Apatite is common and as large as 1 mm in grain size. There are microcrystalline radioactive minerals with pleochroic haloes in the muscovite and biotite. The larger muscovite flakes may be post-tectonic, relative to the foliated micas. Rare fluorite is disseminated and some of the muscovite has inclusions that may be fibrolitic sillimanite.

Zircon morphology

The zircons isolated from this sample are colourless, pale greenish brown, dark brown or black, generally between 40 × 80 µm and 100 × 280 µm in size, and are commonly subrounded or irregular fragments, or are subhedral and elongate in shape. Many grains have faint internal zonation, and mineral inclusions are common. Many have irregular zones of dark alteration and many are metamict. The surfaces of many grains are pitted, consistent with detrital transport.

Analytical details

This sample was analysed on 3 June 2001. The counter deadtime was 32 ns. Thirteen analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.82 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 6.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Table 12. Ion microprobe analytical results for sample 169059: muscovite–biotite monzogranite, Yangibana Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	115	77	38	0.688	0.10148	0.00164	0.19384	0.00363	0.2911	0.0055	4.073	0.107	100	1 651	30
2.1	134	190	59	3.083	0.10926	0.00245	0.45378	0.00602	0.3015	0.0057	4.541	0.141	95	1 787	41
3.1	152	311	64	1.250	0.10167	0.00164	0.62291	0.00470	0.2765	0.0051	3.876	0.101	95	1 655	30
4.1	285	379	105	1.098	0.10241	0.00116	0.36001	0.00287	0.2846	0.0052	4.018	0.092	97	1 668	21
5.1	511	58	165	0.199	0.11141	0.00053	0.03214	0.00077	0.3267	0.0060	5.018	0.098	100	1 823	9
6.1	326	626	118	2.178	0.10097	0.00122	0.33403	0.00308	0.2761	0.0051	3.843	0.089	96	1 642	22
7.1	185	110	59	0.788	0.10141	0.00124	0.16891	0.00269	0.2829	0.0052	3.955	0.093	97	1 650	23
8.1	692	29	195	0.377	0.10229	0.00053	0.01255	0.00088	0.2893	0.0053	4.080	0.080	98	1 666	10
9.1	139	155	49	0.667	0.10091	0.00138	0.29106	0.00328	0.2901	0.0054	4.036	0.099	100	1 641	25
10.1	123	103	44	0.677	0.10645	0.00142	0.23888	0.00322	0.3056	0.0057	4.485	0.109	99	1 739	25
11.1	112	122	42	1.524	0.11239	0.00191	0.24048	0.00433	0.3081	0.0058	4.775	0.128	94	1 838	31
12.1	106	110	39	0.769	0.10186	0.00152	0.30446	0.00364	0.2922	0.0055	4.104	0.104	100	1 658	28
13.1	513	471	176	0.219	0.10141	0.00050	0.26057	0.00115	0.2897	0.0053	4.051	0.079	99	1 650	9
14.1	280	167	91	0.240	0.10320	0.00072	0.17349	0.00149	0.2938	0.0054	4.181	0.086	99	1 682	13
15.1	332	311	115	0.370	0.10193	0.00070	0.26335	0.00163	0.2916	0.0054	4.098	0.084	99	1 660	13
16.1	308	282	116	0.074	0.11185	0.00055	0.26009	0.00122	0.3177	0.0058	4.900	0.096	97	1 830	9
17.1	346	348	133	0.234	0.10764	0.00061	0.27814	0.00142	0.3191	0.0059	4.737	0.094	101	1 760	10
18.1	243	432	99	0.754	0.09966	0.00099	0.54105	0.00283	0.2829	0.0052	3.888	0.085	99	1 618	18
19.1	310	147	143	0.265	0.14973	0.00063	0.12730	0.00105	0.4176	0.0077	8.621	0.167	96	2 343	7
20.1	202	93	67	0.140	0.10850	0.00085	0.13779	0.00163	0.3103	0.0057	4.642	0.097	98	1 774	14
21.1	327	127	113	0.367	0.10610	0.00065	0.10528	0.00122	0.3289	0.0060	4.811	0.096	106	1 734	11
22.1	146	221	58	0.443	0.10188	0.00107	0.43446	0.00293	0.2947	0.0055	4.140	0.093	100	1 659	19
23.1	187	39	61	0.827	0.10832	0.00111	0.06030	0.00217	0.3135	0.0058	4.682	0.104	99	1 771	19
24.1	357	183	143	0.425	0.12624	0.00066	0.15015	0.00126	0.3602	0.0066	6.270	0.123	97	2 046	9
25.1	248	643	109	0.737	0.10302	0.00099	0.61855	0.00299	0.2917	0.0054	4.143	0.090	98	1 679	18
26.1	148	469	74	0.547	0.10055	0.00117	0.90712	0.00450	0.2865	0.0053	3.972	0.092	99	1 634	22
27.1	372	122	113	0.327	0.10313	0.00062	0.09253	0.00114	0.2914	0.0053	4.144	0.083	98	1 681	11

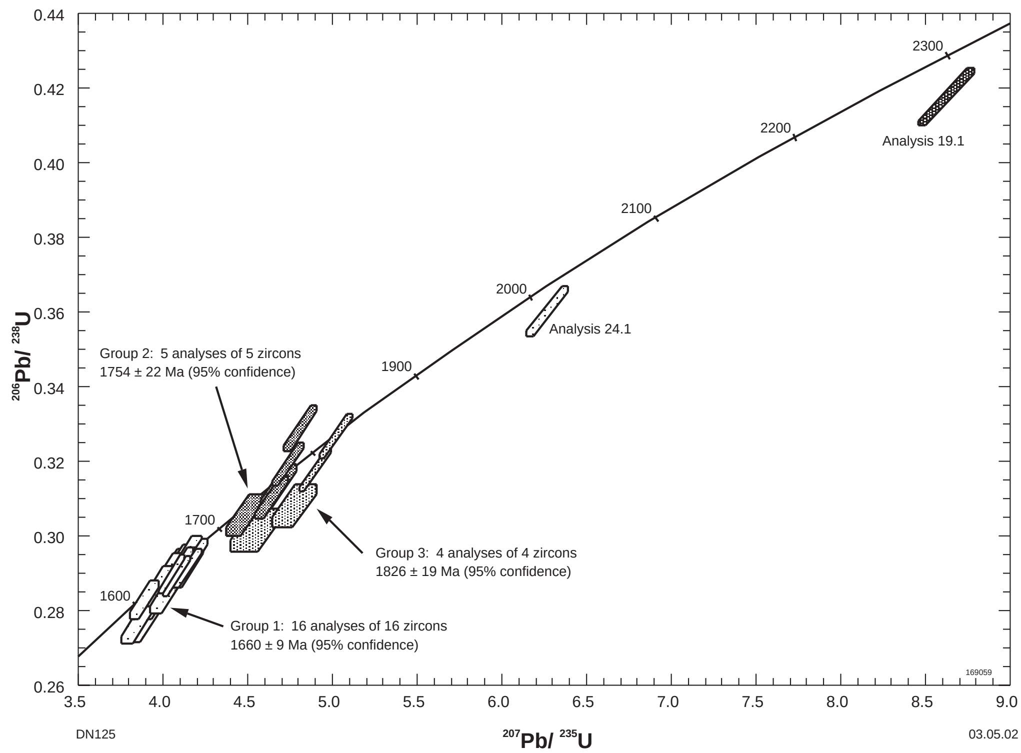

Figure 17. Concordia plot for sample 169059: muscovite–biotite monzogranite, Yangibana Bore

Results

Twenty-seven analyses were obtained from 27 zircons. Results are given in Table 12 and shown on a concordia plot in Figure 17.

Interpretation

Most analyses are concordant to slightly discordant with the discordance patterns consistent with at least one recent episode of radiogenic-Pb redistribution. A range of ^{207}Pb/^{206}Pb dates of from c. 1660 to 2340 Ma is indicated. On the basis of their ^{207}Pb/^{206}Pb ratios, many analyses may be assigned to one of three groups. Sixteen concordant to slightly discordant analyses of 16 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 1660 ± 9 Ma (chi-squared = 1.11). Concordant analyses 10.1, 17.1, 20.1 and 23.1 and reversely discordant analysis 1.1, 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 1754 ± 22 Ma (chi-squared = 1.41). Concordant analysis 5.1 and discordant analyses 2.1, 11.1 and 16.1, assigned to Group 3, have ^{207}Pb/^{206}Pb ratios defining a single population and indicating a weighted mean ^{207}Pb/^{206}Pb date of 1826 ± 19 Ma (chi-squared = 0.43). The remaining analyses (19.1 and 24.1) cannot be confidently grouped.

The weighted mean ^{207}Pb/^{206}Pb date of 1660 ± 9 Ma indicated by the 16 concordant to slightly discordant analyses of Group 1 is interpreted as corresponding to the age of igneous crystallization of the monzogranite. The remaining analyses are interpreted to be of xenocryst zircons.

169060: porphyritic syenogranite, Yangibana Bore

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 419130E 7355190N

Sampled on 15 October 2000.

The sample was taken from the edge of an undulating pavement located 5 km southeast of Yangibana Bore.

Tectonic unit/relations

This sample is a light to medium grey, undeformed seriate porphyritic syenogranite of the Pimbyana Granite (Pearson et al., 1996; Martin et al., 2002), Gascoyne Complex. The syenogranite contains scattered tabular, feldspar phenocrysts up to 5 cm long, within a dark, fine-grained groundmass. Feldspar phenocrysts are aligned and range from very abundant to sparse over distances of several metres.

Petrographic description

This sample consists principally of microcline and orthoclase (60–65 vol.%), quartz (20 vol.%), plagioclase (10 vol.%), biotite (4 vol.%), and muscovite (3 vol.%), with accessory apatite (trace) opaque oxide (trace), possible monazite (trace), and zircon (trace). This is a porphyritic syenogranite with partly altered biotite and muscovite, very minor opaque oxide and zircon, and possible monazite. Feldspar phenocrysts to 30 mm long are visible in hand specimen. In thin section these are perthitic K-feldspar, varying from orthoclase to microcline, with inclusions of quartz, altered plagioclase, fresh to altered biotite, and muscovite. The largest grain within the area of the thin section is only about 10 mm long, but larger crystals are more widely dispersed. Separate plagioclase grains are up to 4 mm long, with irregular flooding by sericite. Quartz occurs as lensoidal to rounded grains to 7 mm long, deformed with undulose extinction and subgrains. Biotite occurs as flakes to 3 mm long and is partly altered to chlorite or clay, with or without epidote. Muscovite is also common, passing into aggregates of fibrous muscovite and sericite of secondary origin. Inclusions of plagioclase and quartz in K-feldspar are locally rimmed by muscovite, some of which have myrmekite-like quartz inclusions, suggesting a subsolidus origin for the muscovite. Granular apatite occurs, to 0.5 mm in grain size, with rare possible monazite 0.2 mm in diameter. Very minor fine-grained opaque oxide is also present.

Zircon morphology

The zircons isolated from this sample are colourless, pale pinkish brown, dark brown or black, generally between 40 × 80 µm and 100 × 230 µm in size, and are commonly irregular fragments, or subhedral and elongate in shape. Many grains have faint internal zonation, and mineral inclusions are common. Many have irregular zones of dark alteration, and many are metamict.

Analytical details

This sample was analysed on 3 June 2001. The counter deadtime was 32 ns. Thirteen analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.82 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis

Table 13. Ion microprobe analytical results for sample 169060: porphyritic syenogranite, Yangibana Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	212	188	75	0.513	0.10119	0.00093	0.24561	0.00212	0.2978	0.0055	4.155	0.090	102	1 646	17
2.1	179	74	71	0.349	0.12132	0.00089	0.11644	0.00162	0.3663	0.0068	6.128	0.127	102	1 976	13
3.1	167	165	73	0.438	0.11950	0.00098	0.27375	0.00221	0.3581	0.0066	5.900	0.125	101	1 949	15
4.1	273	297	109	0.240	0.10870	0.00064	0.31393	0.00155	0.3237	0.0059	4.851	0.097	102	1 778	11
5.1	213	188	81	0.459	0.10970	0.00089	0.25369	0.00201	0.3213	0.0059	4.860	0.102	100	1 794	15
6.1	276	145	92	1.467	0.10299	0.00116	0.15783	0.00254	0.2921	0.0054	4.148	0.094	98	1 679	21
7.1	77	47	28	0.517	0.10996	0.00159	0.17725	0.00338	0.3180	0.0060	4.822	0.122	99	1 799	26
8.1	163	97	59	0.324	0.11002	0.00098	0.17801	0.00203	0.3202	0.0059	4.858	0.105	100	1 800	16
9.1	231	214	145	0.188	0.18080	0.00066	0.25629	0.00118	0.5060	0.0093	12.615	0.243	99	2 660	6
10.1	234	152	78	0.375	0.10132	0.00079	0.18213	0.00167	0.2984	0.0055	4.168	0.087	102	1 648	14
11.1	535	242	171	0.543	0.10237	0.00056	0.12674	0.00113	0.2962	0.0054	4.181	0.082	100	1 668	10
12.1	52	49	34	0.703	0.18115	0.00180	0.25961	0.00359	0.5165	0.0100	12.901	0.295	101	2 663	16
13.1	175	212	65	0.315	0.10311	0.00090	0.35255	0.00229	0.2920	0.0054	4.151	0.089	98	1 681	16
14.1	790	20	224	0.088	0.10313	0.00033	0.00752	0.00037	0.2955	0.0054	4.202	0.079	99	1 681	6
15.1	153	117	57	1.819	0.12313	0.00154	0.20276	0.00340	0.3063	0.0057	5.200	0.123	86	2 002	22
16.1	168	75	59	0.353	0.10888	0.00091	0.12463	0.00174	0.3266	0.0060	4.903	0.104	102	1 781	15
17.1	150	45	53	4.888	0.11292	0.00251	0.10302	0.00594	0.2871	0.0054	4.471	0.138	88	1 847	40
18.1	84	67	37	1.595	0.11854	0.00205	0.22012	0.00458	0.3634	0.0069	5.940	0.161	103	1 934	31
19.1	30	9	19	0.985	0.19317	0.00268	0.07693	0.00491	0.5699	0.0117	15.179	0.396	105	2 769	23

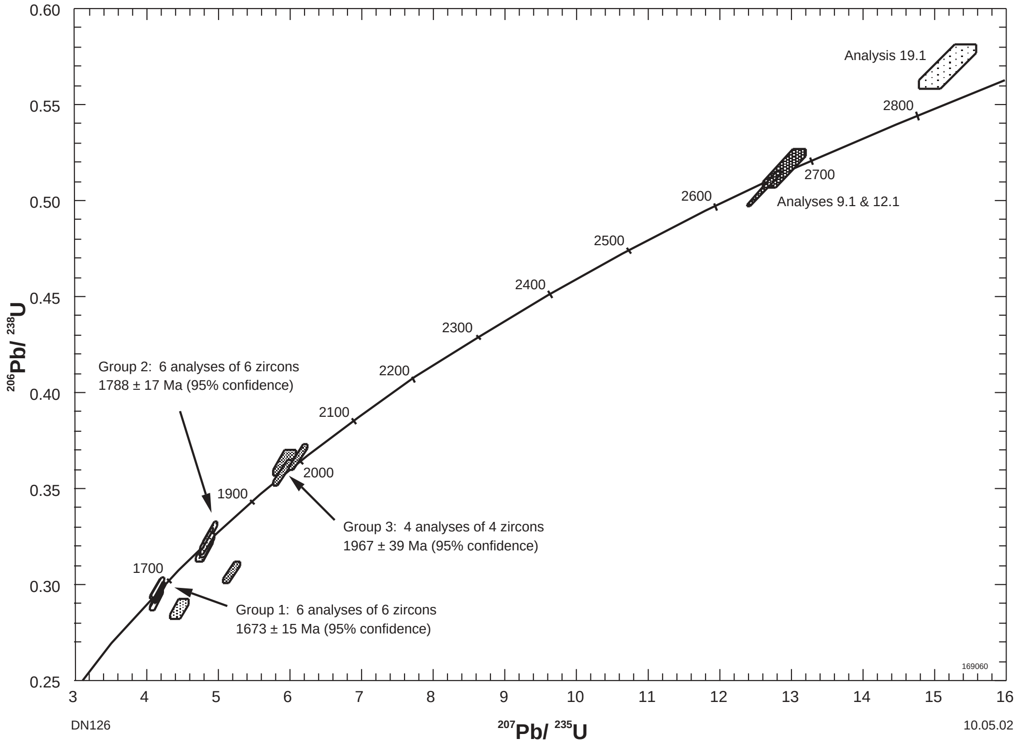

Figure 18. Concordia plot for sample 169060: porphyritic syenogranite, Yangibana Bore

17.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Nineteen analyses were obtained from 19 zircons. Results are given in Table 13 and shown on a concordia plot in Figure 18.

Interpretation

Most analyses are concordant to slightly discordant with the discordance patterns consistent with at least one recent episode of radiogenic-Pb redistribution. A range of $^{207}Pb/^{206}Pb$ dates of from c. 1670 to 2770 Ma is indicated. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of three groups. Six concordant analyses of six zircons (1.1, 6.1, 10.1, 11.1, 13.1 and 14.1), 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 1673 ± 15 Ma (chi-squared = 1.38). Six concordant analyses of six zircons (4.1, 5.1, 7.1, 8.1, 16.1 and 17.1), 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 1788 ± 17 Ma (chi-squared = 0.73). Concordant analyses 2.1, 3.1, 15.1 and 18.1, assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1967 ± 39 Ma (chi-squared = 1.55). The remaining analyses (9.1, 12.1 and 19.1) cannot be confidently grouped.

The weighted mean $^{207}Pb/^{206}Pb$ date of 1673 ± 15 Ma indicated by the six analyses of Group 1 is interpreted as corresponding to the age of igneous crystallization of the syenogranite. The remaining analyses interpreted to be of xenocryst zircons.

169062: porphyritic syenogranite, Contessis Bore

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 414280E 7367460N

Sampled on 15 October 2000.

The sample was taken from a 3 m-high whaleback on the western side of a prominent hill of rocky pavements, whalebacks and tors, located 3 km south-southwest of Contessis Bore.

Tectonic unit/relations

This sample is a medium to dark grey, medium-grained, porphyritic syenogranite of the Dingo Creek Granite (Pearson et al., 1996; Martin et al., 2002), Gascoyne Complex. The granite contains abundant cubic and tabular feldspar phenocrysts up to 10 mm long that define a flow foliation, and contains inclusions of medium-grained leucocratic, tourmaline-bearing granite and porphyritic biotite granite. At the sampling site, the granite has been intruded by irregular, leucocratic tourmaline-bearing pegmatite dykes up to 20 cm in thickness. The sample taken was free of any obvious dykes and veins.

Petrographic description

This sample consists principally of K-feldspar (40 vol.%), quartz (30 vol.%), plagioclase (15–20 vol.%), muscovite (7–8 vol.%), biotite (5 vol.%), and apatite (≤1 vol.%), with accessory opaque oxide (trace), fluorite (trace), and zircon (trace). This is a porphyritic, muscovite- and biotite-bearing microgranite or syenogranite. The thin section has phenocrysts of K-feldspar (orthoclase and/or microcline) to 5 mm long as well as ragged but clearly bipyramidal quartz phenocrysts to 4 mm in diameter. Ragged aggregates of coarse-grained quartz, to 7 mm in diameter, may partly represent recrystallized phenocrysts, but lack any obvious bipyramidal outline. Relatively rare plagioclase phenocrysts occur, to 4 mm long, with irregular alteration to sericite and fine-grained muscovite. There are scattered larger flakes of muscovite and biotite, to 3 mm long, with some of the muscovite elongate at a high angle to its cleavage. Much of the host rock is fine-grained, 0.2 to 1 mm in grain size, with microcline and quartz dominant over plagioclase, biotite, and muscovite. Granular apatite and opaque oxide are disseminated, but are mostly about 0.1 mm in grain size, with traces of fine-grained fluorite and rare zircon crystals. Microcrystalline radioactive grains, enclosed in biotite and muscovite, have pleochroic haloes, and microcrystalline titanite indicates retrograde modification of the biotite, although chloritization is rare.

Zircon morphology

The zircons isolated from this sample are light brown, dark brown or black, generally between 40 × 80 µm and 100 × 230 µm in size, and are commonly irregular fragments or subrounded and equant to slightly elongate in shape. Many grains are internally structureless or have faint internal zonation. Thin rims could be distinguished on a small minority of grains. Mineral inclusions are common. Many grains have irregular zones of dark alteration, and many are metamict.

Table 14. Ion microprobe analytical results for sample 169062: porphyritic syenogranite, Contessis Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	134	199	60	1.358	0.11536	0.00212	0.47607	0.00541	0.3143	0.0035	4.999	0.113	93	1 886	33
2.1	304	136	96	0.236	0.10196	0.00092	0.12641	0.00180	0.2961	0.0031	4.163	0.061	101	1 660	17
3.1	125	201	50	0.571	0.10042	0.00164	0.46005	0.00454	0.2925	0.0033	4.050	0.085	101	1 632	30
4.1	1 120	252	338	0.081	0.10345	0.00039	0.06580	0.00055	0.2988	0.0030	4.262	0.048	100	1 687	7
5.1	298	60	118	0.630	0.14595	0.00102	0.07475	0.00183	0.3700	0.0039	7.446	0.100	88	2 299	12
6.1	81	202	38	1.174	0.09258	0.00274	0.71022	0.00818	0.2962	0.0036	3.781	0.126	113	1 479	56
7.1	230	37	72	0.150	0.10836	0.00096	0.04667	0.00149	0.3114	0.0033	4.653	0.068	99	1 772	16
8.1	308	386	118	0.293	0.10183	0.00086	0.36722	0.00228	0.2993	0.0032	4.203	0.060	102	1 658	16
9.1	211	25	62	0.804	0.09920	0.00153	0.03059	0.00299	0.2914	0.0054	3.986	0.102	102	1 609	29
10.1	78	174	35	2.101	0.10029	0.00368	0.61995	0.00995	0.2838	0.0057	3.925	0.172	99	1 630	68
11.1	221	67	73	0.619	0.10880	0.00133	0.08310	0.00254	0.3171	0.0059	4.757	0.112	100	1 779	22
12.1	1 061	237	354	0.349	0.10996	0.00051	0.06733	0.00089	0.3252	0.0059	4.931	0.095	101	1 799	8
13.1	186	176	64	0.570	0.10808	0.00142	0.15914	0.00294	0.3096	0.0058	4.613	0.111	98	1 767	24
14.1	622	135	187	0.208	0.10378	0.00063	0.06191	0.00104	0.2966	0.0054	4.245	0.084	99	1 693	11
15.1	53	57	20	5.504	0.09174	0.00804	0.26387	0.01873	0.2802	0.0062	3.545	0.330	109	1 462	167
16.1	135	239	54	1.116	0.10195	0.00229	0.49992	0.00620	0.2842	0.0054	3.995	0.125	97	1 660	42
15.1	599	399	194	0.373	0.10188	0.00075	0.17435	0.00157	0.2909	0.0053	4.087	0.084	99	1 659	14
17.1	333	198	117	0.634	0.10901	0.00116	0.16589	0.00243	0.3131	0.0058	4.706	0.105	98	1 783	19
18.1	584	903	226	0.641	0.10308	0.00061	0.45119	0.00172	0.2848	0.0036	4.047	0.059	96	1 680	11
19.1	386	349	128	0.321	0.10243	0.00064	0.19990	0.00138	0.2934	0.0037	4.143	0.061	99	1 669	12
20.1	372	476	139	0.217	0.10138	0.00058	0.35695	0.00154	0.2961	0.0038	4.140	0.060	101	1 650	11
21.1	121	200	50	0.523	0.10173	0.00130	0.47687	0.00370	0.2992	0.0040	4.196	0.082	102	1 656	24
22.1	199	452	90	0.153	0.10341	0.00077	0.65855	0.00289	0.2954	0.0038	4.211	0.066	99	1 686	14
23.1	122	204	49	0.445	0.10342	0.00124	0.48264	0.00357	0.2912	0.0039	4.153	0.079	98	1 686	22
24.1	130	386	65	0.473	0.10034	0.00117	0.83722	0.00452	0.2940	0.0039	4.067	0.076	102	1 630	22
25.1	1 113	170	327	0.061	0.10301	0.00030	0.04359	0.00034	0.2974	0.0037	4.224	0.056	100	1 679	5
26.1	552	628	205	0.099	0.10299	0.00044	0.32925	0.00115	0.3002	0.0038	4.263	0.059	101	1 679	8
27.1	176	107	61	0.342	0.10887	0.00095	0.17079	0.00190	0.3110	0.0040	4.669	0.077	98	1 781	16

Analytical details

This sample was analysed on 29 July, and 6 and 15 August 2001. The counter deadtime during all three analysis sessions was 32 ns. During the first analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of 0.204 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the first analysis session. Analyses 1.1 to 8.1 were obtained during the first analysis session. During the second analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.79 (1σ%). Analyses 9.1 to 17.1 were obtained during the second analysis session. During the third analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.24 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 18.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-seven analyses were obtained from 27 zircons. Results are given in Table 14 and shown on a concordia plot in Figure 19.

Interpretation

Most analyses are concordant to slightly discordant with the discordance patterns consistent with one dominant recent episode of radiogenic-Pb redistribution. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of two groups. Nineteen concordant to slightly discordant analyses of 19 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 1674 ± 8 Ma (chi-squared = 1.70). Six concordant analyses of six

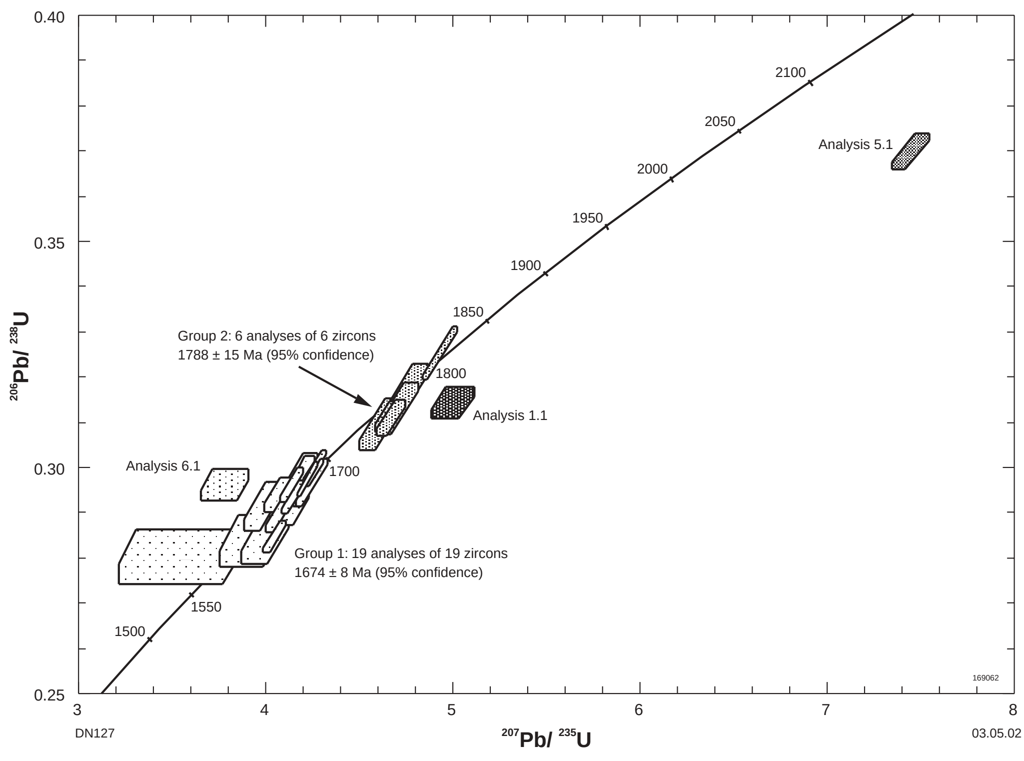

Figure 19. Concordia plot for sample 169062: porphyritic syenogranite, Contessis Bore

zircons (7.1, 11.1, 12.1, 13.1, 17.1 and 27.1), 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 1788 ± 15 Ma (chi-squared = 0.61). Discordant analyses 1.1 and 5.1 indicate substantially older $^{207}Pb/^{206}Pb$ dates, whereas analysis 6.1 is slightly reversely discordant and indicates a slightly younger $^{207}Pb/^{206}Pb$ date than the analyses of Group 1.

The weighted mean $^{207}Pb/^{206}Pb$ date of 1674 ± 8 Ma indicated by the 19 concordant to slightly discordant analyses of Group 1 is interpreted as the age of igneous crystallization of the syenogranite. The reverse discordance of analysis 6.1 may be due either to gain of radiogenic Pb at this analysis site, incorrect common-Pb composition for this analysis, or to incorrect centring on mass peak ^{206}Pb during acquisition of this analysis, with consequent undercounting at the ^{207}Pb mass station. The remaining analyses are interpreted to be of xenocryst zircons.

168979: metasandstone, North Pool

Location and sampling

WILUNA (SG 51-9), CUNYU (2495) MGA Zone 51, 215500E 7071880N

Sampled on 24 June 2000.

The sample was taken from a massive, fractured outcrop located 15 m north of the access track to North Pool, and 200 m west of North Pool.

Tectonic unit/relations

This sample is a light yellow-grey, coarse-grained and silicified arenite, with scattered reddish voids, from the Juderina Formation at the base of the Yerrida Group, Yerrida Basin (Pirajno et al., 1996; Pirajno and Adamides, 2000).

Petrographic description

This sample consists principally of quartz (95 vol.%) and limonite (2 vol.%), with rare small grains of microcrystalline cherty quartz (3 vol.%). It is a massive, medium to coarse-grained quartz sandstone, with intergranular, optically continuous overgrowths of quartz. Limonite rims occur on many detrital grains and there are rare, small leached areas. The thin section is dominated by a compact assemblage of rounded to subrounded single crystal quartz grains, mostly with an average size of about 0.5 mm but with a small proportion less than 0.25 mm and greater than 1 mm in diameter. The quartz grains are cemented by intergranular, optically continuous authigenic quartz overgrowths, with fine films of limonite also forming rims on the rounded quartz grains. A poorly defined quartz stringer less than 1 mm wide consists of quartz similar to, and passing into the optically continuous overgrowths. There are rare leached interstitial areas that may have contained carbonate, and rare leached small euhedral crystals that may have been pyrite.

Zircon morphology

The zircons isolated from this sample are generally between 30 × 50 µm and 200 × 250 µm in size, internally structureless and colourless or with patchy brown discolouration, and are equant and rounded in shape. Fluid and mineral inclusions are common. The surfaces of most grains are pitted, consistent with detrital transport.

Analytical details

This sample was analysed on 8 February 2001. The counter deadtime during the analysis session was 32 ns. Eleven analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.48 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 8.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Thirty-two analyses were obtained from 29 zircons. Results are given in Table 15 and shown on concordia and Gaussian-summation probability density plots in Figures 20 and 21.

Table 15. Ion microprobe analytical results for sample 168979: metasandstone, North Pool

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	73	58	42	0.579	0.17418	0.00212	0.21131	0.00412	0.4719	0.0111	11.334	0.315	96	2 598	20
2.1	102	51	59	0.517	0.19012	0.00177	0.13360	0.00310	0.5012	0.0115	13.139	0.339	95	2 743	15
3.1	60	57	38	0.430	0.18322	0.00224	0.26154	0.00444	0.5081	0.0120	12.835	0.357	99	2 682	20
4.1	73	35	44	0.353	0.18547	0.00187	0.13058	0.00307	0.5233	0.0122	13.381	0.355	100	2 702	17
5.1	178	117	102	0.194	0.17158	0.00111	0.18625	0.00189	0.4904	0.0110	11.602	0.281	100	2 573	11
6.1	538	406	128	0.040	0.08448	0.00074	0.22257	0.00173	0.2118	0.0047	2.467	0.061	95	1 304	17
7.1	101	79	61	0.373	0.19286	0.00166	0.18190	0.00281	0.5062	0.0116	13.461	0.343	95	2 767	14
8.1	179	610	72	5.403	0.17063	0.00363	0.21020	0.00847	0.2911	0.0066	6.849	0.226	64	2 564	36
9.1	100	81	64	0.311	0.17346	0.00168	0.21739	0.00312	0.5297	0.0122	12.669	0.330	106	2 591	16
10.1	171	80	67	0.091	0.12690	0.00105	0.13381	0.00169	0.3618	0.0081	6.331	0.158	97	2 055	15
11.1	124	91	59	0.249	0.13560	0.00136	0.19887	0.00265	0.4083	0.0093	7.635	0.198	102	2 172	18
12.1	109	91	51	0.288	0.13503	0.00156	0.24232	0.00325	0.3938	0.0090	7.332	0.197	99	2 164	20
13.1	130	109	78	0.641	0.18174	0.00157	0.20289	0.00295	0.4931	0.0112	12.356	0.312	97	2 669	14
14.1	57	23	34	0.476	0.19010	0.00215	0.11088	0.00337	0.5234	0.0124	13.718	0.377	99	2 743	19
15.1	83	88	56	0.245	0.18547	0.00183	0.28845	0.00366	0.5286	0.0122	13.518	0.354	101	2 702	16
16.1	118	113	54	0.273	0.13465	0.00142	0.26737	0.00301	0.3769	0.0086	6.998	0.183	95	2 160	18
17.1	179	96	104	0.167	0.18894	0.00113	0.14539	0.00171	0.5045	0.0114	13.142	0.316	96	2 733	10
18.1	152	172	75	0.118	0.13652	0.00137	0.32766	0.00311	0.3891	0.0088	7.324	0.189	97	2 184	17
19.1	111	160	79	0.159	0.18495	0.00170	0.40034	0.00374	0.5179	0.0119	13.207	0.340	100	2 698	15
20.1	197	128	111	0.135	0.17391	0.00102	0.17850	0.00162	0.4819	0.0108	11.555	0.277	98	2 596	10
21.1	159	59	114	0.254	0.23939	0.00127	0.10123	0.00163	0.6177	0.0140	20.389	0.487	100	3 116	8
22.1	107	56	57	0.189	0.18593	0.00165	0.11265	0.00271	0.4794	0.0110	12.289	0.314	93	2 706	15
23.1	87	91	43	0.187	0.13705	0.00175	0.29313	0.00383	0.3953	0.0091	7.469	0.207	98	2 190	22
24.1	26	32	13	1.838	0.12935	0.00509	0.33360	0.01182	0.3771	0.0097	6.726	0.333	99	2 089	69
25.1	142	89	64	0.290	0.13439	0.00144	0.17242	0.00283	0.3975	0.0090	7.365	0.193	100	2 156	19
26.1	66	23	38	0.461	0.18822	0.00210	0.09533	0.00349	0.5041	0.0118	13.083	0.355	97	2 727	18
27.1	130	112	73	0.178	0.19834	0.00135	0.12706	0.00192	0.4866	0.0111	13.307	0.326	91	2 813	11
28.1	219	168	126	0.098	0.18646	0.00099	0.19986	0.00161	0.4786	0.0107	12.303	0.291	93	2 711	9
29.1	100	122	71	0.257	0.18794	0.00163	0.33111	0.00329	0.5354	0.0123	13.873	0.354	101	2 724	14
6.2	884	565	156	0.027	0.07495	0.00047	0.13647	0.00097	0.1697	0.0037	1.753	0.041	95	1 067	13
6.3	635	659	149	0.059	0.08421	0.00050	0.24860	0.00122	0.2047	0.0045	2.376	0.056	93	1 297	12
6.4	776	582	190	0.075	0.08417	0.00042	0.22119	0.00097	0.2174	0.0048	2.522	0.058	98	1 296	10

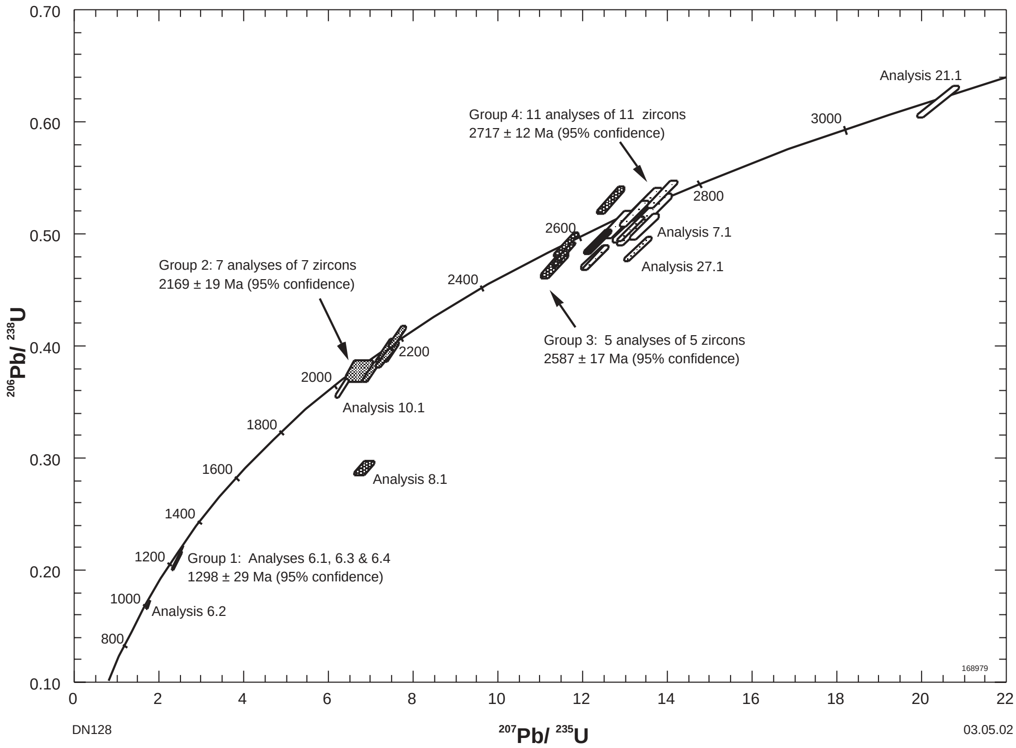

Figure 20. Concordia plot for sample 168979: metasandstone, North Pool

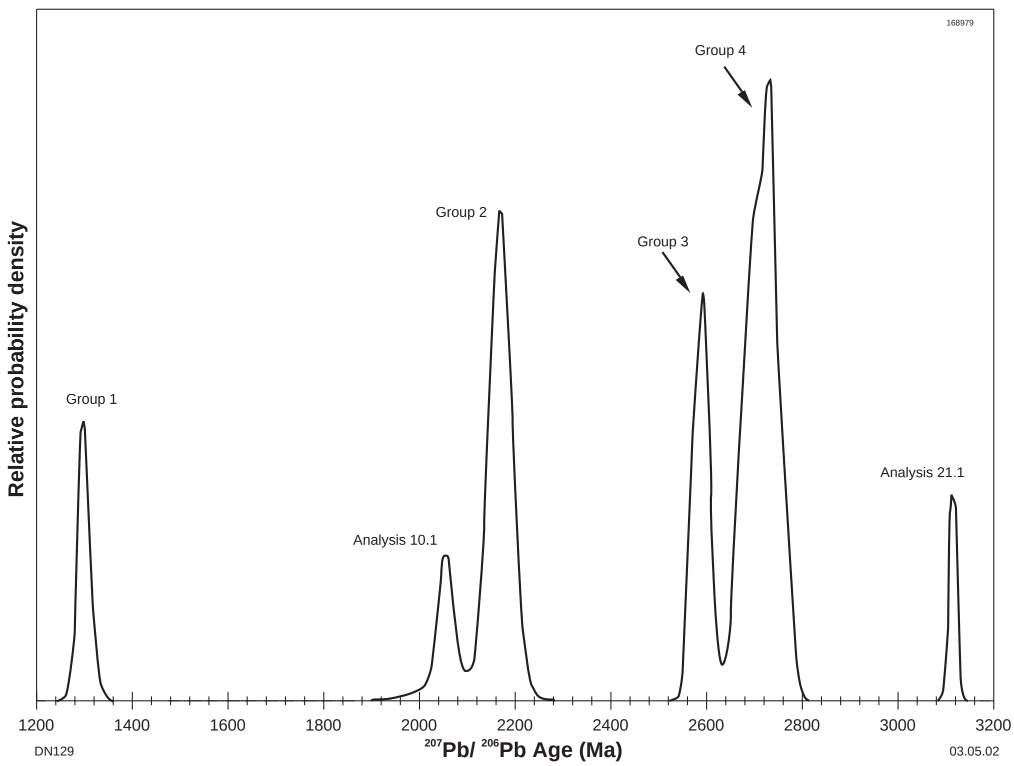

Figure 21. Gaussian-summation probability density plot for sample 168979: metasandstone, North Pool

Interpretation

The analyses are concordant to highly discordant and indicate a wide range of $^{207}Pb/^{206}Pb$ dates, from c. 1070 to 3120 Ma. Three analyses of grain 6 (6.1, 6.3 and 6.4), assigned to Group 1, are concordant or near-concordant and have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1298 ± 29 Ma (chi-squared = 0.06). Analysis 6.2 of this grain was discordant and indicated a younger $^{207}Pb/^{206}Pb$ date of 1067 ± 13 Ma (1σ error). Seven concordant analyses of seven zircons (11.1, 12.1, 16.1, 18.1, 23.1, 24.1 and 25.1), 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 2169 ± 19 Ma (chi-squared = 0.58). Five analyses of five zircons (1.1, 5.1, 8.1, 9.1 and 20.1), assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2587 ± 17 Ma (chi-squared = 0.64). The remaining analyses cannot be confidently grouped.

Grain 6 is a colourless, structureless elongate fragment with rounded terminations, consistent with detrital transport. The weighted mean $^{207}Pb/^{206}Pb$ date of 1298 ± 29 Ma indicated by the three analyses of Group 1 obtained on grain 6 is interpreted as a maximum age for deposition of the sandstone precursor to the quartzite. The younger $^{207}Pb/^{206}Pb$ date indicated by analysis 6.2 is interpreted to be of an analysis site that has undergone ancient loss of radiogenic Pb.

Source rocks within the western part of Australia having ages similar to those of the zircons within this sample include the Rudall (Nelson, 1995, 1996), Arunta (Williams et al., 1996 and references cited therein), Gascoyne (Nelson, 1997, 1998, 1999, 2000, 2001b, this volume) and Musgrave (White et al., 1999 and references cited therein) complexes and the Albany–Fraser Orogen (Nelson et al., 1995). Grains which yielded $^{207}Pb/^{206}Pb$ dates older than c. 2550 Ma (including grain 21.1) may have been derived from either of the Yilgarn or Pilbara cratons (Nelson, 1995, 1996, 1997, 1998, 1999, 2000, 2001b, this volume).

154880: sandstone, Pirrilyungka Outstation

Location and sampling

COOPER (SG 52-10), VINES (4544) MGA Zone 52, 42563E 7046420N

Sampled on 13 November 2000.

The sample was taken from GSWA stratigraphic drillhole Vines 1 (Apak et al., 2002), depth interval 1711.3 – 1713.0 m, located adjacent to the Great South Road, 26 km southwest of Pirrilyungka Outstation and 30 km southeast of the Lupton Hills.

Tectonic unit/relations

This sample is a light-grey, quartz-rich, coarse-grained, poorly sorted but grain-supported sandstone with lithic clasts and fragment of carbonate in a quartz–carbonate cement, from the Vines Formation of the Officer Basin.

Petrographic description

The principal minerals present in this sample are quartz (80 vol.%) and microcline (3 vol.%), with carbonate and quartz cement (15 vol.%), and lithic grains (2 vol.%). This is a coarse-grained sandstone with poorly sorted but well-rounded and grain-supported quartz clasts to 1 mm in diameter. Small microcline grains are disseminated and there are fragments of fine-grained carbonate and rare clasts of fine-grained quartzite with minor schistose muscovite. Clasts altered to clays and spherulitic quartz are present but are not abundant. Interstitial fine-grained carbonate and quartz comprise the cement in this sample.

Zircon morphology

The zircons isolated from this sample are colourless to pale pink and dark pinkish brown, generally between 60 × 80 µm and 200 × 250 µm in size and are subhedral and rounded, oval and elongate in shape. A minority of grains are black and metamict. Most grains are internally structureless but a minority show traces of internal growth zoning and many are fractured. Fluid and mineral inclusions are common. Surface pitting, particularly around the grain terminations, is evident for many grains, consistent with detrital transport.

Analytical details

This sample was analysed on 21 May 2001. The counter deadtime during the analysis session was 32 ns. Sixteen analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.31 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty-seven analyses were obtained from 27 zircons. Results are given in Table 16 and shown on concordia and Gaussian-summation probability density plots in Figures 22 and 23.

Table 16. Ion microprobe analytical results for sample 154880: sandstone, Pirrilyungka Outstation

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	±1 σ	$^{208}Pb/^{206}Pb$	±1 σ	$^{206}Pb/^{238}U$	±1 σ	$^{207}Pb/^{235}U$	±1 σ	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	±1 σ
1.1	496	340	70	1.006	0.07122	0.00182	0.05528	0.00385	0.1394	0.0019	1.369	0.042	87	964	52
2.1	379	143	140	0.389	0.13320	0.00123	0.04632	0.00205	0.3589	0.0050	6.592	0.116	92	2 141	16
3.1	173	78	30	2.521	0.07181	0.00441	0.12336	0.01002	0.1525	0.0023	1.510	0.098	93	980	125
4.1	786	24	135	0.440	0.07522	0.00096	0.00878	0.00177	0.1816	0.0024	1.883	0.037	100	1 074	26
5.1	138	135	29	1.770	0.07119	0.00426	0.26235	0.01017	0.1762	0.0026	1.730	0.110	109	963	122
6.1	92	169	60	1.569	0.16363	0.00305	0.50260	0.00745	0.4349	0.0072	9.813	0.260	93	2 493	31
7.1	290	232	58	0.944	0.07263	0.00209	0.20639	0.00491	0.1757	0.0024	1.759	0.059	104	1 004	59
8.1	351	139	155	0.439	0.14222	0.00112	0.11055	0.00191	0.4023	0.0056	7.889	0.133	97	2 254	14
9.1	108	86	22	3.600	0.06871	0.00625	0.22555	0.01465	0.1627	0.0026	1.541	0.145	109	890	189
10.1	224	88	38	1.551	0.06884	0.00319	0.11570	0.00717	0.1579	0.0022	1.498	0.075	106	894	96
11.1	41	21	9	6.561	0.07504	0.01317	0.17344	0.03037	0.1620	0.0035	1.676	0.301	91	1 069	359
12.1	442	293	78	0.639	0.07081	0.00157	0.17125	0.00360	0.1622	0.0022	1.583	0.043	102	952	45
13.1	282	249	73	0.726	0.08346	0.00188	0.25319	0.00449	0.2211	0.0031	2.544	0.071	101	1 280	44
14.1	160	46	65	0.809	0.13152	0.00210	0.07839	0.00398	0.3809	0.0058	6.907	0.161	98	2 118	28
15.1	368	108	68	0.471	0.07481	0.00158	0.07454	0.00325	0.1826	0.0025	1.883	0.050	102	1 063	43
16.1	508	166	84	0.976	0.07509	0.00164	0.03053	0.00339	0.1671	0.0023	1.730	0.047	93	1 071	44
17.1	333	91	60	0.737	0.07305	0.00191	0.08511	0.00406	0.1766	0.0025	1.778	0.055	103	1 015	53
18.1	669	345	302	0.202	0.15989	0.00075	0.08838	0.00101	0.4175	0.0057	9.203	0.137	92	2 454	8
19.1	362	115	71	0.845	0.08380	0.00175	0.05303	0.00356	0.1937	0.0027	2.238	0.059	89	1 288	41
20.1	277	193	56	0.757	0.07794	0.00194	0.21235	0.00453	0.1772	0.0025	1.904	0.057	92	1 145	49
21.1	271	174	53	0.950	0.07367	0.00216	0.19197	0.00502	0.1732	0.0024	1.760	0.060	100	1 032	59
22.1	154	61	55	0.643	0.11402	0.00215	0.11248	0.00434	0.3304	0.0049	5.195	0.132	99	1 865	34
23.1	176	110	60	0.647	0.10946	0.00197	0.19052	0.00421	0.2967	0.0043	4.478	0.110	94	1 790	33
24.1	108	88	24	2.279	0.07385	0.00510	0.23912	0.01201	0.1807	0.0028	1.840	0.134	103	1 037	140
25.1	182	64	33	1.767	0.07430	0.00343	0.11156	0.00765	0.1653	0.0024	1.693	0.085	94	1 050	93
26.1	190	120	39	1.426	0.07851	0.00316	0.20281	0.00733	0.1771	0.0026	1.917	0.085	91	1 160	80
27.1	158	102	55	1.529	0.10094	0.00269	0.17104	0.00596	0.3048	0.0046	4.243	0.136	104	1 641	50

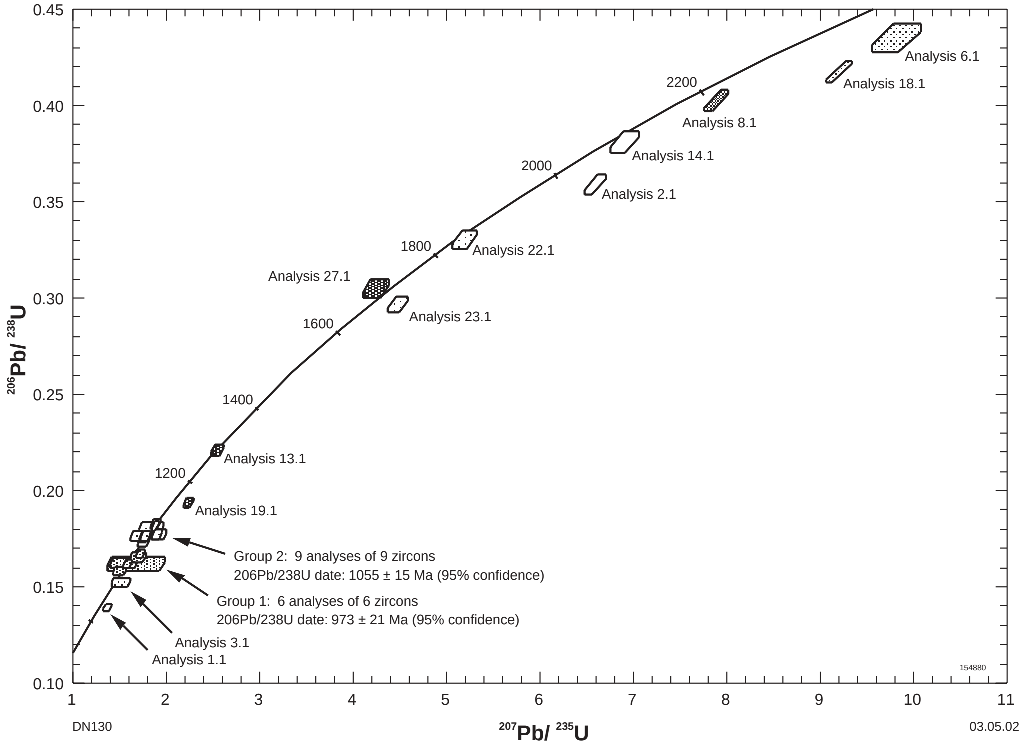

Figure 22. Concordia plot for sample 154880: sandstone, Pirrilyungka Outstation

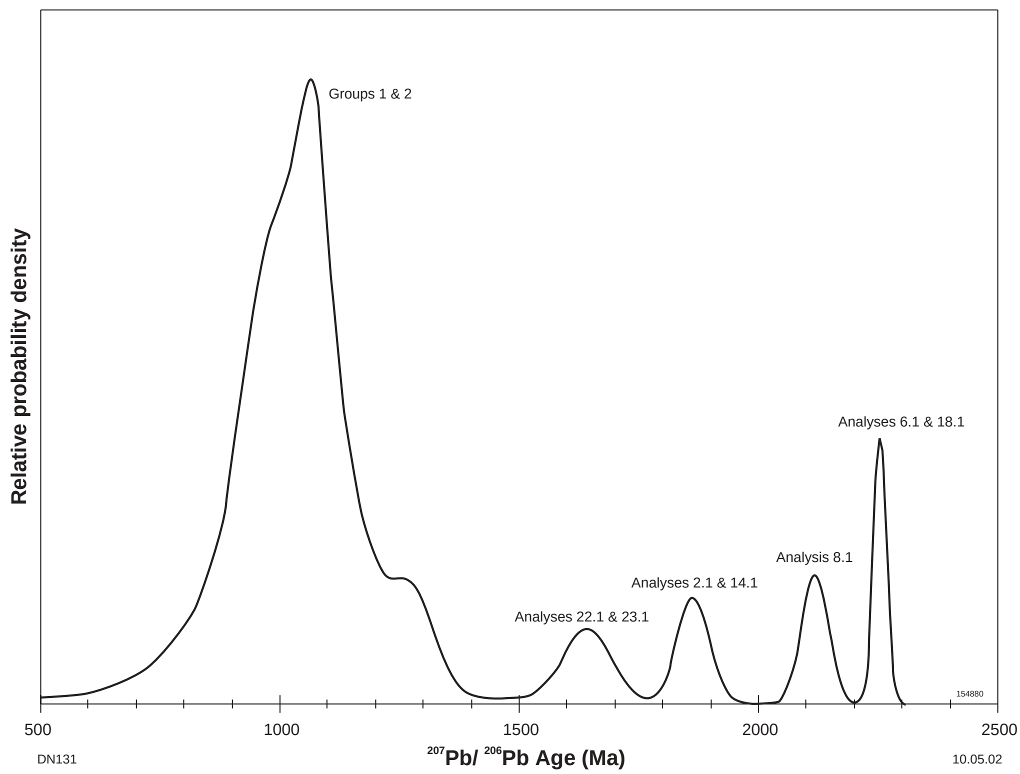

Figure 23. Gaussian-summation probability density plot for sample 154880: sandstone, Pirrilyungka Outstation

Interpretation

Most analyses are concordant or only slightly discordant and indicate a range of $^{207}Pb/^{206}Pb$ dates of from c. 950 to 2500 Ma. Six analyses of six zircons (9.1, 10.1, 11.1, 12.1, 16.1 and 25.1), 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 1000 ± 80 Ma (chi-squared = 0.90). The $^{206}Pb/^{238}U$ ratios of these analyses define a single population indicating a weighted mean $^{206}Pb/^{238}U$ date of 973 ± 21 Ma (chi-squared = 1.62). Nine analyses of nine zircons (4.1, 5.1, 7.1, 15.1, 17.1, 20.1, 21.1, 24.1 and 26.1), 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 1065 ± 38 Ma (chi-squared = 0.83). The $^{206}Pb/^{238}U$ ratios of these analyses define a single population indicating a weighted mean $^{206}Pb/^{238}U$ date of 1055 ± 15 Ma (chi-squared = 1.36). The remaining analyses cannot be confidently grouped. Discordant analysis 1.1 and concordant analysis 3.1 indicated younger $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ dates than those of Group 1, whereas the remaining analyses indicated a range of older dates. Concordant analysis 3.1 indicated a $^{206}Pb/^{238}U$ date of 915 ± 13 Ma (1s error).

The weighted mean $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ dates of 973 ± 21 Ma and 1000 ± 80 Ma respectively, indicated by the analyses of Group 1, are interpreted as maximum ages for deposition of the sandstone. Grain 3 is a rounded and elongate, structureless grain with pitted and abraded terminations. The $^{206}Pb/^{238}U$ date of 915 ± 13 Ma (1σ error) obtained for this grain provides a tentative younger maximum age for host sediment deposition. Source rocks within the western part of Australia having ages silimar to many of those obtained for the zircons within this sample include the Musgrave Complex (White et al., 1999 and references cited therein) and the Albany–Fraser Orogen (Nelson et al., 1995).

154881: sandstone, Pirrilyungka Outstation

Location and sampling

COOPER (SG 52-10), VINES (4544) MGA Zone 52, 425613E 7046420N

Sampled on 13 November 2000.

The sample was taken from GSWA stratigraphic drill hole Vines 1 (Apak et al., 2002), depth interval 307.8 – 309.3 m, located adjacent to the Great South Road, 26 km southwest of Pirrilyungka Outstation and 30 km southeast of the Lupton Hills.

Tectonic unit/relations

This sample is a red-brown and light grey-green, partly leached gritty sandstone or granule conglomerate, incorporating fragments of quartz, basalt, acid volcanic and sedimentary rock, with areas of carbonate cement, from the Vines Formation of the Officer Basin.

Petrographic description

This is a gritty sandstone or granule conglomerate with poorly defined bedding. In thin section, the sample has an abundant component of quartz-rich coarse-grained sandstone dominated by rounded, single, crystal quartz grains to 1 mm in diameter, which make up about 60 vol.% of the rock. Minor microcline and plagioclase accompany the quartz as well as small lithic clasts. Lithic clasts make up about 20 vol.% of the rock, with 2–3 vol.% each of plagioclase and microcline. In some areas, there are poikilitic grains of carbonate cementing the detritus, but other areas have an secondary porosity, possibly formed by leaching carbonate. Cement comprised 15 vol.% in the original sandstone. Larger lithic clasts up to 4 mm in diameter are also abundant, the largest being a quartz-rich siltstone with minor carbonate and sericite. The other fragments are altered variously to albite, hematite, leucoxene, chlorite, quartz and/or sericite, and represent basaltic and acid volcanic rocks. The basalt fragments have albitized plagioclase laths as well as opaque oxide and/or leucoxene, with generally good textural preservation. The acid volcanic fragments are more variable, but are generally reddish with hematite staining. Some possibly have spherulitic textures, whereas others are microcrystalline, or are rich in reddened K-feldspar as elongate crystals to 0.5 mm long. Phenocrysts are rare, but one clast has albitized, weakly reddened plagioclase phenocrysts. Clays and chlorite are minor to abundant components in some of these clasts. One clast of uncertain origin consists mostly of chlorite, with minor quartz and disseminated opaque oxide. Rare clasts exhibit granophyric textures and reddened K-feldspar, and clasts with abundant granular quartz as well as clay and hematite stained feldspar are also present.

Zircon morphology

The zircons isolated from this sample are colourless to pale pink and yellow-brown, generally between 80 × 100 µm and 250 × 350 µm in size and are subhedral and rounded or oval and elongate in shape. A minority of grains are black and metamict. Most grains are internally structureless, but a minority show traces of internal growth zoning, and many are fractured. Fluid and mineral inclusions are common. Surface pitting, particularly around the grain terminations, is evident in many grains, consistent with detrital transport.

Table 17. Ion microprobe analytical results for sample 154881: sandstone, Pirrilyungka Outstation

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	90	39	17	3.962	0.07506	0.00723	0.13357	0.01650	0.1533	0.0025	1.587	0.158	86	1 070	195
2.1	86	98	23	2.998	0.08343	0.00602	0.34392	0.01453	0.2003	0.0033	2.304	0.175	92	1 279	141
3.1	21	42	7	16.791	0.02979	0.03154	0.49588	0.07645	0.1679	0.0065	0.690	0.734	–	–	326
4.1	56	48	18	3.832	0.08963	0.00703	0.25168	0.01637	0.2444	0.0045	3.020	0.250	99	1 418	150
5.1	119	144	32	2.598	0.07580	0.00462	0.34018	0.01127	0.2029	0.0031	2.121	0.137	109	1 090	122
6.1	92	47	22	2.870	0.07597	0.00587	0.14488	0.01339	0.2023	0.0033	2.119	0.171	109	1 094	155
7.1	202	120	58	1.141	0.09137	0.00222	0.16169	0.00490	0.2544	0.0037	3.205	0.095	100	1 454	46
8.1	175	136	23	2.650	0.06052	0.00560	0.22885	0.01324	0.1073	0.0016	0.895	0.086	106	622	201
9.1	292	249	68	1.048	0.07684	0.00204	0.24911	0.00487	0.1972	0.0028	2.089	0.066	104	1 117	53
10.1	146	156	50	0.703	0.10493	0.00248	0.30540	0.00591	0.2767	0.0041	4.003	0.118	92	1 713	44
11.1	116	123	29	1.881	0.07945	0.00428	0.30741	0.01033	0.1978	0.0031	2.167	0.125	98	1 183	107
12.1	243	220	56	0.821	0.08110	0.00197	0.25892	0.00475	0.1935	0.0027	2.164	0.064	93	1 224	48
13.1	137	108	33	1.421	0.08123	0.00354	0.22761	0.00828	0.2038	0.0030	2.282	0.109	97	1 227	86
14.1	243	104	67	0.710	0.09954	0.00182	0.12545	0.00380	0.2547	0.0036	3.496	0.086	91	1 616	34
15.1	93	150	26	2.319	0.07958	0.00501	0.46204	0.01287	0.2000	0.0032	2.194	0.147	99	1 186	125
16.1	71	85	18	2.553	0.07835	0.00592	0.35943	0.01454	0.1925	0.0032	2.080	0.165	98	1 156	150
17.1	44	37	12	3.194	0.08728	0.00839	0.26826	0.01968	0.2053	0.0039	2.470	0.248	88	1 367	186
18.1	37	39	10	3.836	0.09430	0.01110	0.32027	0.02623	0.1959	0.0042	2.547	0.311	76	1 514	224
19.1	155	152	39	1.621	0.07836	0.00347	0.27172	0.00828	0.2061	0.0031	2.227	0.108	105	1 156	88
20.1	203	222	48	1.801	0.08092	0.00326	0.31322	0.00789	0.1856	0.0027	2.070	0.092	90	1 220	79
21.1	95	126	26	2.114	0.08108	0.00476	0.38235	0.01184	0.2036	0.0033	2.276	0.143	98	1 223	116
22.1	103	80	24	2.895	0.07578	0.00530	0.20925	0.01231	0.1922	0.0031	2.008	0.148	104	1 089	140
23.1	76	119	12	5.291	0.04932	0.01293	0.45898	0.03178	0.1078	0.0021	0.733	0.194	404	163	341
24.1	121	117	29	2.049	0.07400	0.00475	0.28043	0.01135	0.1944	0.0030	1.984	0.135	110	1 041	130
25.1	123	103	20	1.096	0.06861	0.00416	0.25585	0.01005	0.1354	0.0020	1.281	0.082	92	887	126
26.1	50	52	13	5.945	0.06793	0.01122	0.27139	0.02644	0.1893	0.0038	1.773	0.300	129	867	348
27.1	144	178	37	2.153	0.08063	0.00410	0.35942	0.01006	0.1938	0.0029	2.155	0.118	94	1 213	100
28.1	95	123	24	1.512	0.08506	0.00500	0.38497	0.01237	0.1914	0.0031	2.244	0.141	86	1 317	114
29.1	17	25	6	15.555	0.06342	0.03392	0.42993	0.08113	0.1726	0.0071	1.509	0.817	142	722	787
30.1	112	125	28	1.846	0.08377	0.00423	0.33553	0.01036	0.1918	0.0030	2.215	0.121	88	1 287	98

Analytical details

This sample was analysed on 21 May 2001. The counter deadtime during the analysis session was 32 ns. Sixteen analyses of the CZ3 standard obtained during the analysis session indicated a Pb*/U calibration error of 1.31 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Thirty analyses were obtained from 30 zircons. Results are given in Table 17 and shown on concordia and Gaussian-summation probability density plots in Figures 24 and 25.

Interpretation

Most analyses are concordant or only slightly discordant and indicate a range of $^{207}Pb/^{206}Pb$ dates of from c. 650 to 1700 Ma. Concordant analyses 8.1 and 23.1, assigned to Group 1, have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of 658 ± 8 Ma. Fifteen analyses of 15 zircons (2.1, 5.1, 6.1, 9.1, 11.1, 12.1, 15.1, 16.1, 18.1, 22.1, 24.1, 26.1, 27.1, 28.1 and 30.1), assigned to Group 2, have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of 1152 ± 14 Ma (chi-squared = 1.60). The $^{207}Pb/^{206}Pb$ ratios of these analyses define a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1178 ± 54 Ma (chi-squared = 0.72). Analyses 13.1, 17.1, 19.1 and 21.1, assigned to Group 3, have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of 1200 ± 30 Ma (chi-squared = 0.12). The $^{207}Pb/^{206}Pb$ ratios of these analyses define a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1210 ± 170 Ma (chi-squared = 0.31). The remaining analyses cannot be confidently grouped.

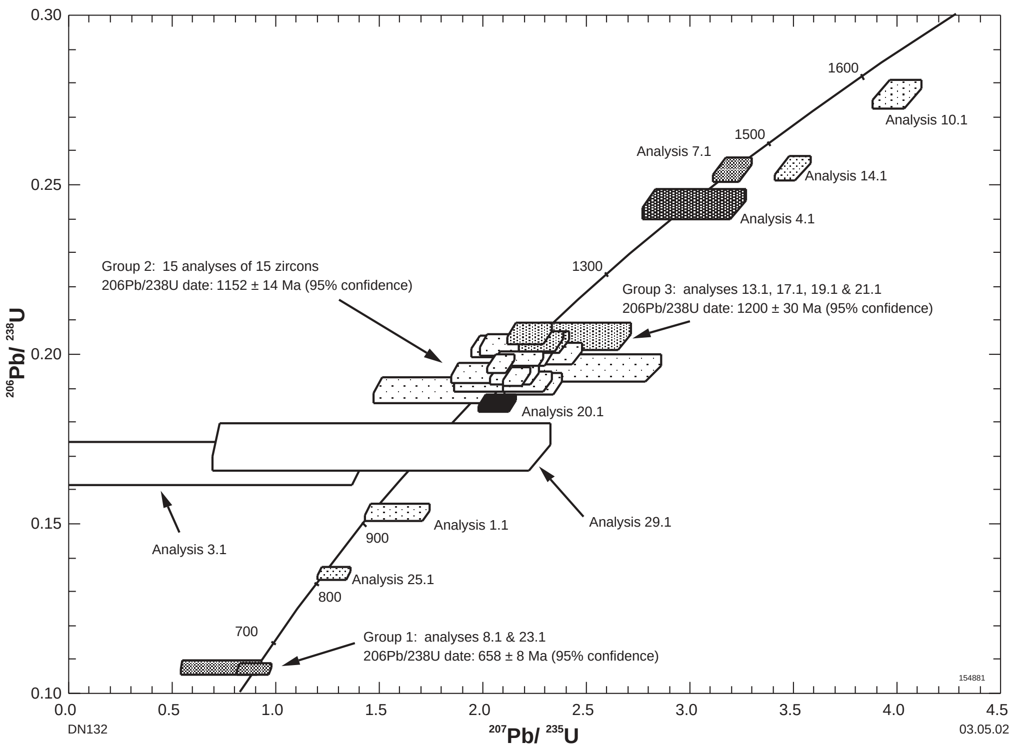

Figure 24. Concordia plot for sample 154881: sandstone, Pirrilyungka Outstation

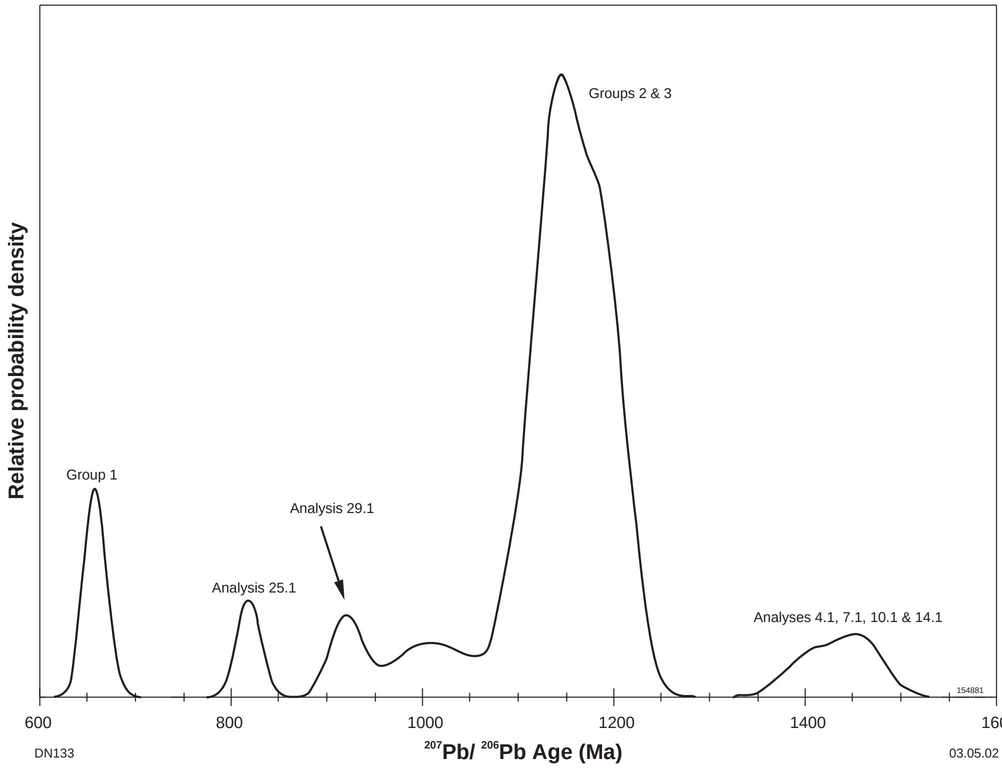

Figure 25. Gaussian-summation probability density plot for sample 154881: sandstone, Pirrilyungka Outstation

Grain 8 is an irregular, structureless fragment. Part of the surface of this fragment is rounded and pitted. Grain 23 is a clear, structureless, and euhedral grain with abundant fluid inclusions. The weighted mean $^{206}Pb/^{238}U$ date of 658 ± 8 Ma indicated by the analyses from grains 8 and 23 of Group 1 are interpreted as a maximum age for deposition of the sandstone. Source rocks within the western part of Australia having ages matching those of many of the zircons within this sample include the Musgrave Complex (White et al., 1999 and references cited therein) and the Albany–Fraser Orogen (Nelson et al., 1995).

169117: metasandstone, Desert Queens Bath

Location and sampling

RUDALL (SF 51-10), BROADHURST (3353)   MGA Zone 51, 430420E 7528930N

Sampled on 3 May 2000.

The sample was taken from drill hole SCD002, depth interval 476–477 m, located at the Sunday Creek prospect, about 16 km northeast of the Desert Queens Bath waterhole and 16 km south of Maroochydore prospect.

Tectonic unit/relations

This sample is a dark grey, massive and recrystallized quartz sandstone from the Coolbro Sandstone of the Throssell Group, Yeneena Basin (Hickman and Clarke, 1994; Bagas et al., 2000).

Petrographic description

The principal minerals present in this sample are quartz (90 vol.%), microcline (3–4 vol.%), sericite (3–4 vol.%), and biotite (3–4 vol.%), with accessory opaque oxide (trace), possible monazite (trace), and zircon (trace). This is a metamorphosed, medium- to very coarse-grained, weakly bimodal sandstone containing minor detrital microcline, and with sericite in the matrix micromosaic. Local laminae of schistose biotite contain most of the (rare) heavy minerals (zircon and/or monazite and opaque oxide). Macroscopically, this massive fine-grained, grey quartzite shows several parallel microfractures or foliae of dark biotite and/or limonite. The thin section shows abundant, reasonably well sorted, rounded, single-crystal quartz grains and minor grains of K-feldspar, mostly microcline, comprising about 50 vol.% of the rock. These grains have an average size of about 1 mm, with some grains up to 2 mm. These occur as a loosely packed (bedded) aggregate through a micromosaic (30 vol.%) of about 0.3 mm in grain size, again composed of detrital grains of quartz and minor K-feldspar within even finer recrystallized quartz (<0.1 mm in grain size) and/or sericite. Lenses of sericite occur locally, reaching 2 mm in length, and define a weak schistosity. Locally the sericite is bent into a second schistosity. Also locally, there are foliae/laminae of fine schistose biotite that parallel the second schistosity, and rare biotite elsewhere in the thin section is also mostly parallel to the second schistosity. Rare zircon (and/or monazite) is largely restricted to the biotite-rich lamellae, with rare opaque oxide in the same laminae. The metamorphism is of uncertain grade, but the sericite may indicate greenschist-facies retrogression. There is a reasonably consistent distinction between coarser subrounded quartz (and minor microcline) grains about 1 mm and finer detrital grains about 0.3 mm within the otherwise recrystallized matrix.

Zircon morphology

The zircons isolated from this sample are colourless to pale pink and dark pinkish brown, generally between 60 × 80 µm and 200 × 250 µm in size and are subhedral, oval or irregular in shape. A minority are black and metamict. Most grains are internally structureless and many are fractured, but a minority show traces of internal growth zoning. Fluid and mineral inclusions are common. Surface pitting, particularly around the grain terminations, is evident for many grains, consistent with detrital transport.

Table 18. Ion microprobe analytical results for sample 169117: metasandstone, Desert Queens Bath

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	190	104	52	0.733	0.08852	0.00137	0.16408	0.00300	0.2454	0.0085	2.995	0.118	102	1 394	30
2.1	268	102	44	0.584	0.06727	0.00133	0.11248	0.00292	0.1564	0.0054	1.451	0.061	111	846	41
3.1	72	97	47	0.568	0.17651	0.00179	0.40575	0.00400	0.4648	0.0162	11.312	0.425	94	2 620	17
4.1	277	78	50	0.367	0.07647	0.00107	0.09037	0.00213	0.1783	0.0061	1.880	0.073	96	1 107	28
5.1	149	117	39	0.841	0.08608	0.00167	0.25122	0.00397	0.2188	0.0075	2.597	0.108	95	1 340	38
6.1	78	42	22	1.692	0.09332	0.00295	0.16028	0.00660	0.2514	0.0087	3.235	0.161	97	1 494	60
7.1	120	73	41	0.794	0.09834	0.00163	0.18486	0.00358	0.3030	0.0105	4.109	0.165	107	1 593	31
8.1	113	65	23	1.681	0.07213	0.00293	0.17682	0.00676	0.1781	0.0062	1.771	0.100	107	990	83
9.1	128	72	25	0.911	0.07409	0.00224	0.16258	0.00509	0.1781	0.0062	1.819	0.089	101	1 044	61
10.1	51	51	12	2.183	0.07608	0.00554	0.31843	0.01334	0.1810	0.0064	1.899	0.161	98	1 097	146
11.1	72	44	20	1.000	0.09099	0.00274	0.17559	0.00612	0.2478	0.0086	3.108	0.152	99	1 446	57
12.1	152	70	43	0.434	0.09524	0.00132	0.15124	0.00277	0.2625	0.0091	3.447	0.134	98	1 533	26
13.1	16	15	6	3.306	0.11133	0.00996	0.30086	0.02317	0.2805	0.0105	4.306	0.436	88	1 821	163
14.1	186	136	64	0.328	0.09931	0.00116	0.21762	0.00259	0.2974	0.0103	4.073	0.154	104	1 611	22
15.1	35	79	22	3.098	0.12527	0.00597	0.82998	0.01689	0.3530	0.0128	6.097	0.387	96	2 033	84
16.1	246	62	50	0.419	0.07772	0.00177	0.08560	0.00363	0.2015	0.0070	2.160	0.094	104	1 140	45
17.1	135	57	24	3.026	0.05954	0.00426	0.11806	0.00977	0.1550	0.0054	1.273	0.106	158	587	156
18.1	611	98	137	0.392	0.08183	0.00080	0.04633	0.00145	0.2275	0.0078	2.567	0.095	106	1 242	19
19.1	252	229	61	1.061	0.07766	0.00204	0.27476	0.00496	0.2012	0.0070	2.154	0.099	104	1 138	52
20.1	171	174	49	0.819	0.08058	0.00185	0.30418	0.00465	0.2368	0.0082	2.632	0.116	113	1 211	45
21.1	179	126	43	1.210	0.08404	0.00260	0.20826	0.00600	0.2071	0.0023	2.400	0.082	94	1 293	60
22.1	324	163	88	0.699	0.08953	0.00155	0.14603	0.00335	0.2507	0.0027	3.094	0.067	102	1 415	33
23.1	83	30	33	1.664	0.12259	0.00317	0.10274	0.00654	0.3592	0.0048	6.071	0.186	99	1 994	46
24.1	118	129	33	1.387	0.08768	0.00308	0.33618	0.00763	0.2211	0.0027	2.673	0.103	94	1 375	68
25.1	58	34	12	5.019	0.06480	0.00959	0.16843	0.02219	0.1587	0.0025	1.418	0.214	124	768	316
26.1	234	211	51	1.341	0.07217	0.00236	0.26537	0.00572	0.1828	0.0020	1.819	0.065	109	991	67
27.1	110	153	56	1.477	0.12389	0.00297	0.36940	0.00709	0.3800	0.0048	6.491	0.184	103	2 013	43
28.1	60	42	12	3.676	0.06513	0.00853	0.19720	0.01989	0.1578	0.0023	1.417	0.189	121	779	278
29.1	357	68	72	0.388	0.08138	0.00125	0.05882	0.00235	0.2040	0.0022	2.289	0.045	97	1 231	30
30.1	277	156	46	0.594	0.07101	0.00186	0.16578	0.00425	0.1530	0.0016	1.498	0.044	96	958	54
31.1	377	75	71	0.331	0.07563	0.00139	0.06044	0.00272	0.1915	0.0020	1.997	0.044	104	1 085	37
32.1	74	41	13	1.345	0.07974	0.00482	0.19086	0.01108	0.1506	0.0019	1.656	0.105	76	1 191	120
33.1	234	95	42	0.591	0.07245	0.00193	0.12631	0.00420	0.1715	0.0019	1.713	0.051	102	999	54
34.1	94	39	19	0.977	0.08311	0.00417	0.13994	0.00929	0.1906	0.0024	2.184	0.116	88	1 272	98
35.1	381	9	95	0.239	0.10115	0.00108	0.00830	0.00172	0.2599	0.0028	3.625	0.058	91	1 645	20
36.1	187	159	49	0.589	0.08472	0.00182	0.25455	0.00437	0.2229	0.0025	2.603	0.066	99	1 309	42
30.2	147	55	24	0.691	0.07097	0.00238	0.11752	0.00529	0.1587	0.0017	1.553	0.057	99	957	69
30.3	71	30	12	2.269	0.06704	0.00499	0.11642	0.01136	0.1482	0.0018	1.370	0.105	106	839	155
30.4	171	71	26	0.358	0.07111	0.00169	0.12839	0.00374	0.1439	0.0015	1.411	0.038	90	960	49
30.5	113	48	18	1.005	0.07116	0.00285	0.12910	0.00643	0.1503	0.0016	1.475	0.063	94	962	82
36.1	56	63	11	3.526	0.06088	0.01114	0.24616	0.02624	0.1522	0.0025	1.278	0.237	144	635	402

Analytical details

This sample was analysed on 5 and 12 February 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, seven analyses of the CZ3 standard indicated a Pb*/U calibration error of 3.43 (1σ%). Analyses 1.1 to 20.1 were obtained during the first analysis session. During the second analysis session, six analyses of the CZ3 standard indicated a Pb*/U calibration error of 0.747 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the second analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Forty-one analyses were obtained from 36 zircons. Results are given in Table 18 and shown on concordia and Gaussian-summation probability density plots in Figures 26, 27 and 28.

Interpretation

Most analyses are concordant or only slightly discordant and indicate a range of $^{207}Pb/^{206}Pb$ dates of from c. 600 to 2620 Ma. Eleven analyses indicate $^{206}Pb/^{238}U$ ratios corresponding to dates younger than 1000 Ma. Eight analyses of six zircons (2.1, 17.1, 28.1, 30.1, 30.3, 30.5, 32.1 and 36.1), assigned to Group 1, have $^{206}Pb/^{238}U$ ratios within error of a single value corresponding to a weighted mean $^{206}Pb/^{238}U$ date of 911 ± 23 Ma (chi-squared = 1.72). The weighted mean $^{207}Pb/^{206}Pb$ date for this group is 889 ± 107 Ma (chi-squared = 1.84). Analyses 25.1 and 30.2 have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of

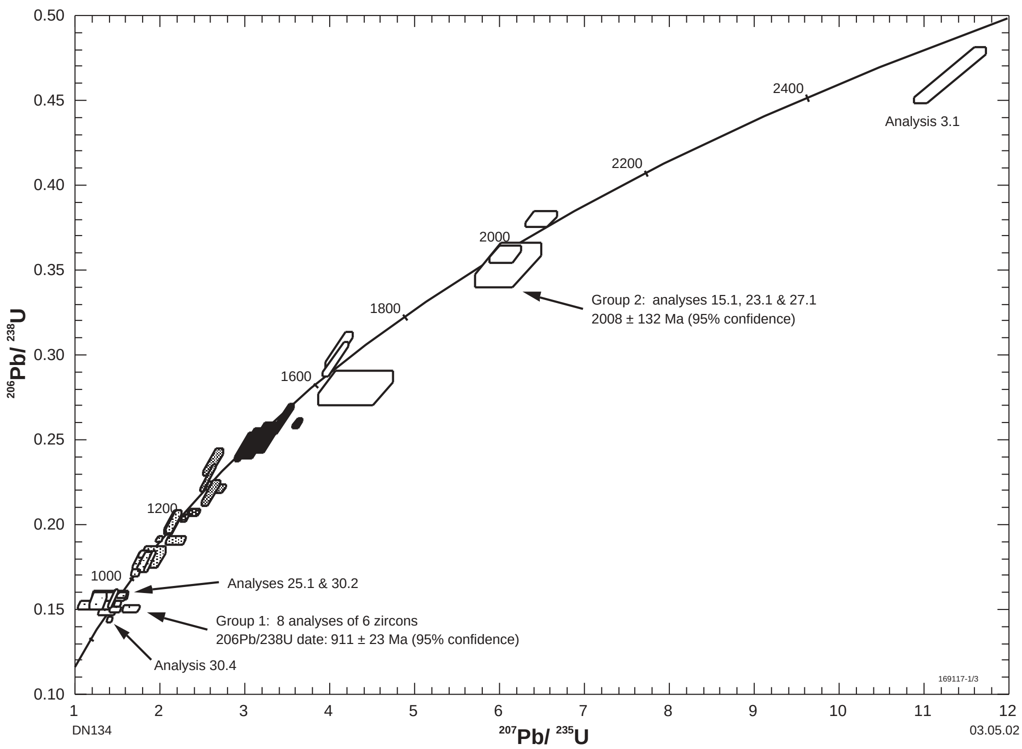

Figure 26. Concordia plot for sample 169117: metasandstone, Desert Queens Bath

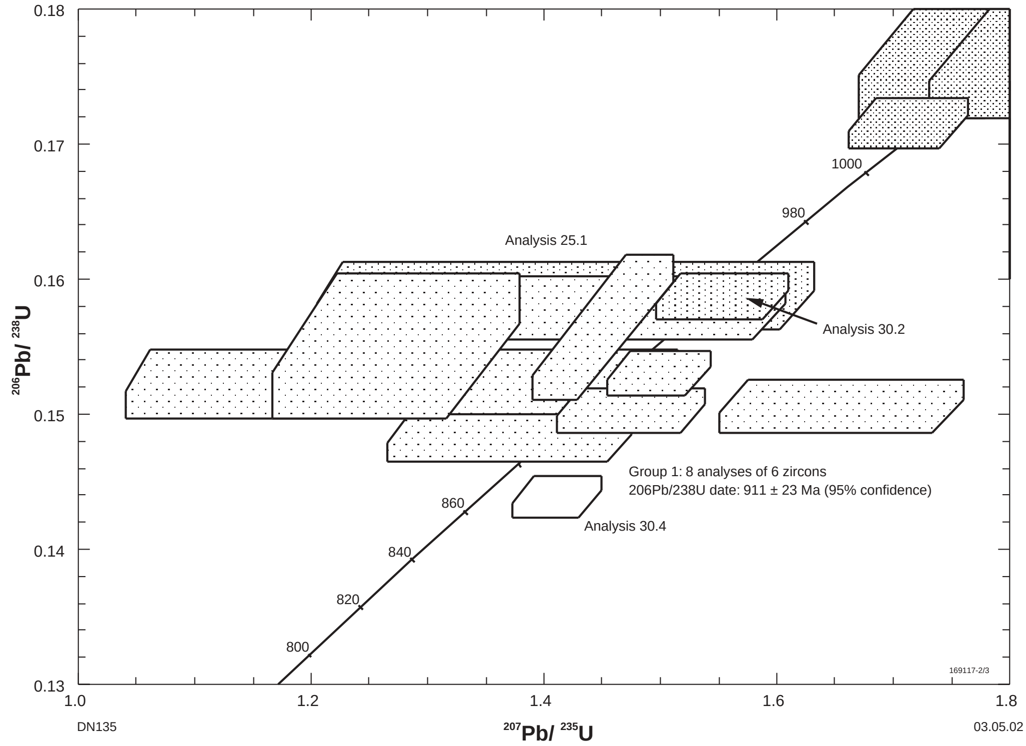

Figure 27. Concordia plot enlargement for sample 169117: metasandstone, Desert Queens Bath

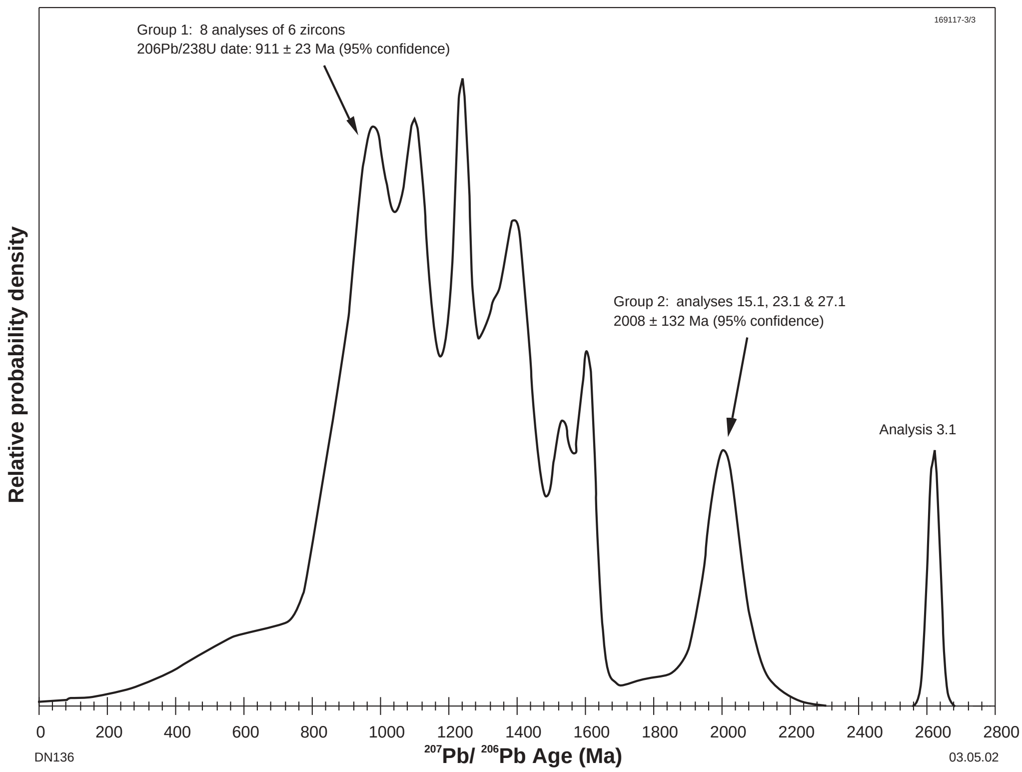

Figure 28. Gaussian-summation probability density plot for sample 169117: metasandstone, Desert Queens Bath

950 ± 12 Ma, with a weighted mean $^{207}Pb/^{206}Pb$ date of 946 ± 69 Ma. Analysis 30.4 indicated a slightly younger $^{206}Pb/^{238}U$ date of 867 ± 16 Ma, but the $^{207}Pb/^{206}Pb$ date of 960 ± 49 Ma suggests that this analysis site may have lost some of its accumulated radiogenic Pb. Analyses 15.1, 23.1 and 27.1 have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2008 ± 132 Ma (chi-squared = 0.07). Analysis 3.1 indicates an Archaean $^{207}Pb/^{206}Pb$ date of 2620 ± 17 Ma (1σ error), whereas the remaining analyses indicate $^{207}Pb/^{206}Pb$ dates between c. 900 and 1620 Ma.

The weighted mean $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ dates of 911 ± 23 Ma and 889 ± 107 Ma respectively, indicated by the analyses of Group 1 are interpreted as maximum ages for deposition of the sandstone precursor to the quartzite. Source rocks within the western part of Australia having ages similar to those of the zircons within this sample include the Rudall (Nelson, 1995, 1996), Arunta (Williams et al., 1996 and references cited therein), Gascoyne (Nelson, 1997, 1998, 1999, 2000, 2001b, this volume) and Musgrave (White et al., 1999 and references cited therein) complexes and the Albany–Fraser Orogen (Nelson et al., 1995). Grains 15, 23 and 27 may have been derived from either of the Rudall (Nelson, 1995, 1996) or the Gascoyne (Nelson, 1997, 1998, 1999, 2000, 2001b, this volume) Complexes, and grain 3 from the Yilgarn Craton (Nelson, 1995, 1996, 1997, 1998, 1999, 2000, 2001b, this volume).

169119: metasandstone, Fandango prospect

Location and sampling

RUDALL (SF 51-10), RUDALL (3352) MGA Zone 51, 414920E 7495290N

Sampled on 3 May 2000.

The sample was taken from drillhole FAD001, depth interval 195–196 m, located about 0.5 km west-southwest of the Fandango prospect.

Tectonic unit/relations

This sample is a dark purple-grey, massive and recrystallized quartz sandstone from the Coolbro Sandstone of the Throssell Group, Yeneena Basin (Hickman and Clarke, 1994; Bagas et al., 2000).

Petrographic description

The principal minerals present in this sample are quartz (70 vol.%), sericite (20 vol.%), and microcline (10 vol.%), with accessory zircon (trace), leucoxene (trace), and tourmaline (trace). This is predominantly a schistose, microcline-bearing, inequigranular but medium- to coarse-grained quartzite, with an extensive matrix of microcrystalline quartz–sericite schist. A thin band or bed within the rock consists of fine quartz–sericite schist, hosting fine to very coarse sand (quartz > microcline vol%), with heavy mineral laminations containing fine leucoxene, tourmaline and zircon. The hand specimen shows an apparently strong schistosity, with planes that are rich in schistose sericite. There is a gradational contact between a homogeneous inequigranular quartzite, with an extremely fine schistose quartz–sericite matrix forming about 90 vol.% of the rock and a band about 10 mm thick of very fine quartz–sericite schist, that hosts minor sand-sized detritus. The quartzite has abundant inequigranular detrital quartz grains from 0.25 to rarely 2 mm long, with minor microcline grains, rare detrital muscovite, scattered polycrystalline quartz grains and cherty lithic grains. These grains form a loosely packed aggregate within a microcrystalline quartz micromosaic, incorporating fine schistose sericite, which commonly occurs as rims on the detrital grains and amalgamate to form a matrix. A sericite-rich layer has minor detrital quartz and microcline grains, to 2 mm, apparently resorbed by the extensive fine quartz–sericite schist matrix. Poorly defined heavy-mineral laminations with more abundant leucoxene and tourmaline are also locally rich in scattered crystals and fragments of zircon. This narrow schist layer has 70 vol.% sericite, 25–30 vol.% quartz and 2–3 vol.% microcline, with zircon in diffuse heavy mineral laminations. Metamorphism is of uncertain grade but the sericite may represent greenschist facies retrogression.

Zircon morphology

The zircons isolated from this sample are colourless to pale pink and dark pinkish brown, generally between 60 × 80 µm and 200 × 250 µm in size, and are subhedral, oval or irregular in shape. Most grains are internally structureless but a minority show traces of internal growth zoning and many are fractured. Fluid and mineral inclusions are common. Surface pitting, particularly around the grain terminations, is evident for many grains, consistent with detrital transport.

Table 19. Ion microprobe analytical results for sample 169119: metasandstone, Fandango prospect

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	163	500	90	0.472	0.10861	0.00124	0.87151	0.00461	0.3214	0.0036	4.813	0.081	101	1 776	21
2.1	398	315	113	0.328	0.09637	0.00075	0.22221	0.00168	0.2467	0.0026	3.278	0.045	91	1 555	15
3.1	320	145	68	0.290	0.07873	0.00086	0.13600	0.00177	0.2009	0.0047	2.181	0.059	101	1 165	22
4.1	341	139	80	0.483	0.08363	0.00098	0.12717	0.00205	0.2221	0.0052	2.561	0.070	101	1 284	23
5.1	311	330	154	0.067	0.09394	0.00077	0.34590	0.00222	0.3992	0.0094	5.171	0.134	144	1 507	16
6.1	1 103	265	172	0.249	0.07234	0.00050	0.07273	0.00097	0.1571	0.0037	1.567	0.039	95	996	14
7.1	656	317	117	0.456	0.09147	0.00073	0.14505	0.00152	0.1649	0.0039	2.080	0.053	68	1 456	15
8.1	233	152	58	0.403	0.08565	0.00105	0.19581	0.00235	0.2219	0.0052	2.621	0.073	97	1 330	24
9.1	386	183	108	0.306	0.09076	0.00081	0.14250	0.00164	0.2607	0.0061	3.263	0.085	104	1 442	17
10.1	446	312	122	0.208	0.09458	0.00074	0.12164	0.00143	0.2588	0.0061	3.374	0.087	98	1 520	15
11.1	490	208	123	0.048	0.09170	0.00054	0.12470	0.00093	0.2404	0.0056	3.040	0.076	95	1 461	11
12.1	238	163	42	0.357	0.07778	0.00132	0.20150	0.00307	0.1601	0.0038	1.717	0.053	84	1 141	34
13.1	421	371	105	0.275	0.09004	0.00088	0.14718	0.00180	0.2316	0.0054	2.875	0.076	94	1 426	19
14.1	1 034	125	181	0.177	0.07565	0.00046	0.03495	0.00074	0.1818	0.0042	1.896	0.047	99	1 086	12
14.1	559	579	140	0.340	0.08354	0.00065	0.30379	0.00169	0.2082	0.0049	2.399	0.061	95	1 282	15
16.1	235	150	74	0.450	0.09476	0.00105	0.18510	0.00228	0.2814	0.0066	3.676	0.100	105	1 523	21
17.1	298	450	122	0.163	0.10938	0.00073	0.44684	0.00214	0.3044	0.0072	4.591	0.116	96	1 789	12
18.1	462	213	114	0.169	0.08895	0.00067	0.14714	0.00133	0.2306	0.0054	2.828	0.072	95	1 403	14
19.1	148	85	39	0.752	0.09076	0.00179	0.16054	0.00394	0.2405	0.0057	3.010	0.099	96	1 442	38
20.1	698	465	205	0.219	0.10875	0.00055	0.18899	0.00112	0.2604	0.0061	3.904	0.096	84	1 779	9
21.1	247	135	81	0.286	0.10582	0.00092	0.15781	0.00182	0.3004	0.0071	4.383	0.115	98	1 729	16
22.1	340	227	69	0.429	0.07676	0.00107	0.20109	0.00249	0.1821	0.0043	1.928	0.055	97	1 115	28
23.1	518	609	109	0.359	0.07585	0.00077	0.33705	0.00212	0.1705	0.0040	1.783	0.048	93	1 091	20
24.1	460	187	114	0.263	0.09081	0.00069	0.11758	0.00134	0.2371	0.0056	2.969	0.076	95	1 443	15
25.1	498	104	79	0.598	0.07902	0.00094	0.06730	0.00188	0.1583	0.0037	1.724	0.047	81	1 173	23
26.1	497	108	117	0.191	0.09158	0.00064	0.06787	0.00108	0.2344	0.0055	2.960	0.075	93	1 459	13
27.1	403	101	125	0.346	0.10829	0.00075	0.06539	0.00124	0.3032	0.0071	4.527	0.115	96	1 771	13
28.1	583	111	101	0.218	0.07843	0.00066	0.02582	0.00108	0.1802	0.0042	1.949	0.050	92	1 158	17
29.1	206	121	55	0.588	0.08992	0.00136	0.16593	0.00296	0.2417	0.0057	2.996	0.089	98	1 424	29
30.1	645	109	111	0.154	0.07664	0.00057	0.04624	0.00092	0.1771	0.0041	1.871	0.048	95	1 112	15
31.1	350	148	94	0.227	0.09132	0.00080	0.12080	0.00154	0.2568	0.0060	3.233	0.084	101	1 453	17
32.1	397	254	83	0.239	0.07927	0.00086	0.18636	0.00194	0.1914	0.0045	2.091	0.057	96	1 179	21
33.1	331	193	77	0.319	0.08399	0.00088	0.16774	0.00187	0.2136	0.0050	2.474	0.067	97	1 292	20
6.2	760	128	143	0.298	0.07580	0.00058	0.04518	0.00107	0.1936	0.0045	2.023	0.052	105	1 090	15
6.3	257	63	79	0.236	0.10320	0.00073	0.07110	0.00127	0.3009	0.0071	4.281	0.109	101	1 682	13

Analytical details

This sample was analysed on 30 April and 1 May 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, only one analysis of the CZ3 standard could be obtained, and a calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during this analysis session. Analyses 1.1 and 2.1 were obtained during the first analysis session. During the second analysis session, eleven analyses of the CZ3 standard indicated a Pb^*/U calibration error of 2.33 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Thirty-five analyses were obtained from 33 zircons. Results are given in Table 19 and shown on concordia and Gaussian-summation probability density plots in Figures 29 and 30.

Interpretation

Most analyses (with the exception of analyses 5.1, 7.1, and 20.1) are concordant to slightly discordant, with the discordance pattern consistent mostly with the recent loss of radiogenic Pb. Analysis 5.1 was highly reversely discordant, which was attributed to instability in the primary beam intensity during this analysis. The analyses indicate a range of $^{207}Pb/^{206}Pb$ dates of c. 1000 to 1820 Ma. Six analyses of six zircons (6.2, 12.1, 14.1, 22.1, 23.1 and 30.1), 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 1097 ± 18 Ma (chi-squared = 0.73). Discordant analysis 6.1 indicates a slightly younger $^{207}Pb/^{206}Pb$

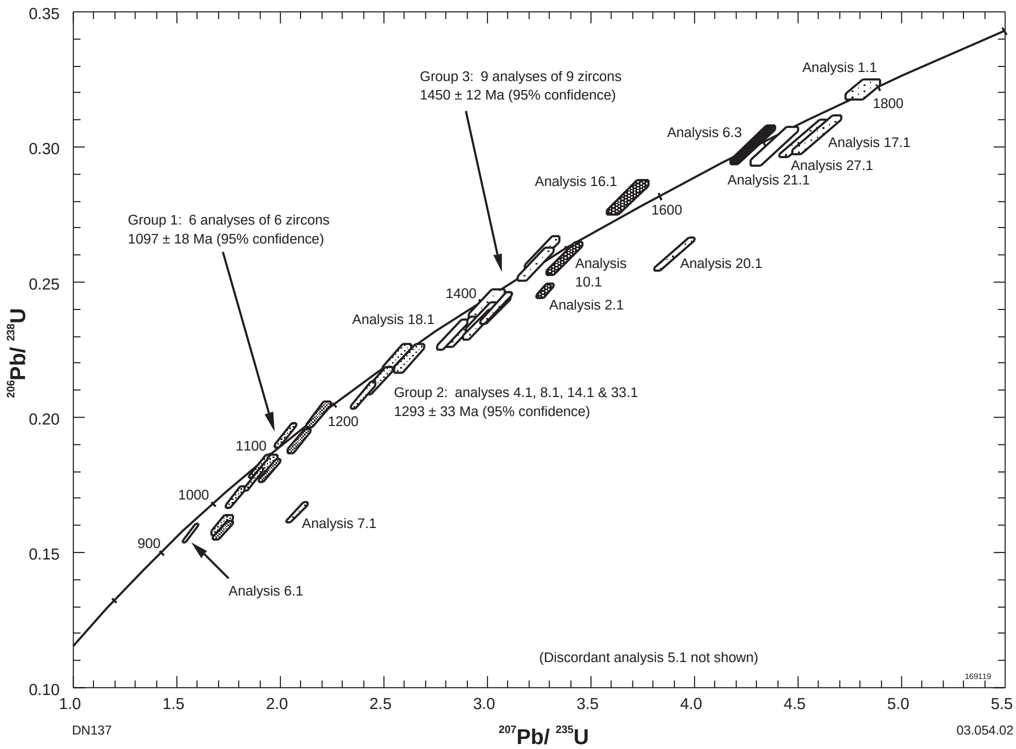

Figure 29. Concordia plot for sample 169119: metasandstone, Fandango prospect

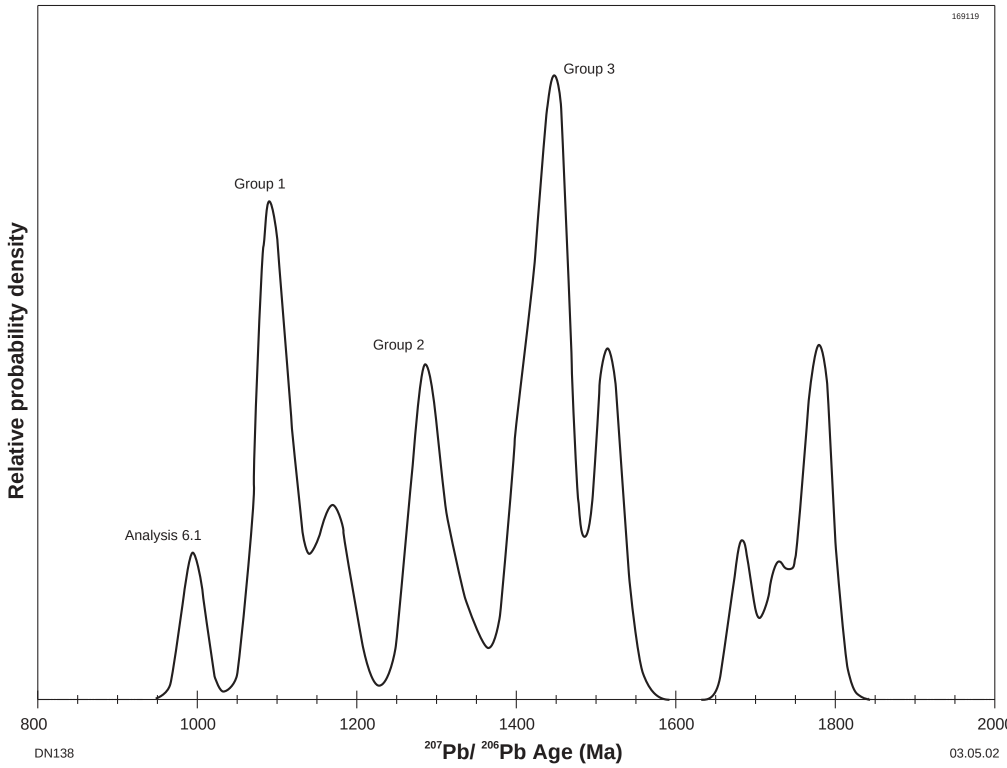

Figure 30. Gaussian-summation probability density plot for sample 169119: metasandstone, Fandango prospect

date of 996 ± 14 Ma (1σ error). However, analysis 6.2 (from the same grain) belongs with Group 1, suggesting that the younger $^{207}Pb/^{206}Pb$ date indicated by analysis 6.1 may be due to ancient radiogenic-Pb loss. Analyses 4.1, 8.1, 14.1 and 33.1, 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 1293 ± 33 Ma (chi-squared = 0.87). Nine analyses of nine zircons (7.1, 9.1, 11.1, 13.1, 19.1, 24.1, 26.1, 29.1 and 31.1), assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1450 ± 12 Ma (chi-squared = 0.52). The remaining analyses indicated $^{207}Pb/^{206}Pb$ dates between c. 1100 and 1820 Ma but cannot be confidently assigned to discrete groups.

The weighted mean $^{207}Pb/^{206}Pb$ date of 1097 ± 18 Ma indicated by the six analyses of Group 1 is interpreted as a maximum age for deposition of the sandstone precursor to the quartzite. Source rocks within the western part of Australia having ages similar to those of the zircons within this sample include the Rudall (Nelson, 1995, 1996), Arunta (Williams et al., 1996 and references cited therein), Gascoyne (Nelson, 1997, 1998, 1999, 2000, 2001b, this volume) and Musgrave (White et al., 1999 and references cited therein) complexes and the Albany–Fraser Orogen (Nelson et al., 1995).

169120: metasandstone, Desert Queens Bath

Location and sampling

RUDALL (SF 51-10), BROADHURST (3353) MGA Zone 51, 430420E 7528930N

Sampled on 3 May 2000.

The sample was taken from drillhole SCD002, depth interval 115–116 m, located at the Sunday Creek prospect, about 16 km northeast of the Desert Queens Bath waterhole and 16 km south of Maroochydore prospect.

Tectonic unit/relations

This sample is a dark purple-red, massive and recrystallized quartz sandstone from the Coolbro Sandstone of the Throssell Group, Yeneena Basin (Hickman and Clarke, 1994; Bagas et al., 2000).

Petrographic description

The principal minerals present in this sample are quartz (90 vol.%) and microcline (10 vol.%), with accessory sericite (trace), limonite (trace), biotite (trace), chlorite (trace), tourmaline (trace), and zircon (trace). This is a massive, siliceous quartzite derived from a well-sorted, medium-grained sandstone, with minor detrital microcline. The matrix consists of a recrystallized quartz micromosaic with minor sericite, rare biotite and detrital tourmaline. A brownish colour is due to very fine patchy limonite, commonly rimming microcline or quartz grains. Original detrital grains of subrounded quartz and lesser microcline are well sorted and form about 50 vol.% of the sample, with an average grain size of about 0.4 mm but with rare grains to 0.8 mm. An ubiquitous micromosaic of quartz, with grain size about 0.1 mm, forms about 50 vol.% of the sample. Minor patches of sericite, rare, small flakes of biotite, rare chlorite, and tourmaline occur within the matrix. The limonite patches are up to 1 mm long and some may have replaced sulfide or carbonate. There are no minerals or texture specifically indicative of metamorphic grade.

Zircon morphology

The zircons isolated from this sample are colourless to pale pink and dark pinkish brown, generally between 60 × 80 µm and 200 × 250 µm in size and are subhedral, oval or irregular in shape. A minority are black and metamict. Most grains are internally structureless but a minority show traces of internal growth zoning, and many are fractured. Fluid and mineral inclusions are common. Surface pitting, particularly around the grain terminations, is evident for many grains, consistent with detrital transport.

Analytical details

This sample was analysed on 30 April 2001. The counter deadtime during the analysis session was 32 ns. Nine analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 2.24 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 20. Ion microprobe analytical results for sample 169120: metasandstone, Desert Queens Bath

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	$\pm 1\sigma$	$^{208}Pb/^{206}Pb$	$\pm 1\sigma$	$^{206}Pb/^{238}U$	$\pm 1\sigma$	$^{207}Pb/^{235}U$	$\pm 1\sigma$	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	$\pm 1\sigma$
1.1	257	56	46	0.389	0.07666	0.00119	0.06803	0.00233	0.1784	0.0041	1.886	0.055	95	1 112	31
2.1	86	58	24	1.283	0.08619	0.00294	0.19174	0.00672	0.2406	0.0057	2.859	0.125	104	1 342	66
3.1	544	355	117	0.245	0.07853	0.00070	0.18632	0.00159	0.1957	0.0044	2.119	0.054	99	1 160	18
4.1	100	44	48	0.647	0.16119	0.00175	0.08031	0.00308	0.4371	0.0103	9.714	0.264	95	2 468	18
5.1	352	261	100	0.325	0.09200	0.00086	0.20704	0.00191	0.2521	0.0057	3.198	0.082	99	1 467	18
6.1	86	93	30	1.373	0.09534	0.00261	0.30576	0.00626	0.2750	0.0065	3.615	0.139	102	1 535	52
7.1	195	85	40	0.423	0.07712	0.00170	0.12514	0.00371	0.1933	0.0044	2.055	0.069	101	1 124	44
8.1	170	243	40	1.115	0.07413	0.00202	0.41468	0.00538	0.1799	0.0041	1.839	0.069	102	1 045	55
9.1	292	206	60	0.159	0.07841	0.00087	0.21218	0.00206	0.1829	0.0041	1.978	0.052	94	1 157	22
10.1	137	4	30	1.000	0.08341	0.00197	0.00393	0.00399	0.2273	0.0053	2.615	0.092	103	1 279	46
11.1	200	159	163	0.335	0.25774	0.00108	0.19764	0.00157	0.6447	0.0149	22.910	0.548	99	3 233	7
12.1	130	147	36	0.667	0.09167	0.00180	0.34032	0.00459	0.2227	0.0051	2.814	0.091	89	1 461	37
13.1	789	295	176	0.151	0.08387	0.00050	0.10507	0.00091	0.2167	0.0049	2.506	0.060	98	1 290	12
14.1	228	114	63	0.241	0.09233	0.00097	0.13963	0.00192	0.2581	0.0059	3.285	0.086	100	1 474	20
15.1	470	102	86	0.300	0.07636	0.00084	0.06300	0.00160	0.1851	0.0042	1.949	0.051	99	1 105	22
16.1	312	160	172	0.177	0.16891	0.00074	0.13945	0.00111	0.4886	0.0111	11.380	0.270	101	2 547	7
17.1	809	500	194	0.124	0.08480	0.00049	0.17377	0.00103	0.2204	0.0050	2.576	0.062	98	1 311	11
18.1	108	127	31	1.428	0.08104	0.00277	0.34673	0.00690	0.2223	0.0052	2.483	0.109	106	1 222	67
19.1	69	46	16	2.011	0.08162	0.00396	0.20320	0.00915	0.1954	0.0047	2.199	0.125	93	1 236	95
20.1	280	193	69	0.296	0.08507	0.00099	0.20054	0.00223	0.2206	0.0050	2.588	0.069	98	1 317	23
21.1	84	57	31	0.500	0.10781	0.00178	0.18895	0.00376	0.3283	0.0078	4.880	0.149	104	1 763	30
22.1	69	74	28	0.591	0.11218	0.00222	0.29463	0.00517	0.3297	0.0079	5.100	0.167	100	1 835	36
23.1	246	203	62	0.348	0.08524	0.00111	0.24125	0.00265	0.2179	0.0050	2.561	0.071	96	1 321	25
24.1	624	218	119	0.236	0.07624	0.00065	0.10821	0.00130	0.1862	0.0042	1.957	0.049	100	1 101	17
25.1	201	83	70	0.346	0.10995	0.00106	0.11261	0.00197	0.3281	0.0075	4.973	0.129	102	1 799	18
26.1	741	585	141	0.307	0.07554	0.00063	0.16229	0.00140	0.1770	0.0040	1.844	0.046	97	1 083	17
27.1	575	77	102	0.463	0.07367	0.00082	0.02629	0.00156	0.1839	0.0041	1.868	0.049	105	1 033	22
28.1	502	288	127	0.273	0.08607	0.00068	0.16339	0.00144	0.2336	0.0053	2.773	0.069	101	1 340	15
29.1	120	141	30	1.486	0.08298	0.00259	0.33949	0.00643	0.1920	0.0045	2.197	0.090	89	1 269	61
8.2	407	97	75	0.101	0.07626	0.00056	0.07050	0.00099	0.1849	0.0042	1.944	0.048	99	1 102	15
27.2	673	93	112	0.229	0.07638	0.00049	0.03210	0.00085	0.1735	0.0039	1.827	0.044	93	1 105	13

Results

Thirty-one analyses were obtained from 29 zircons. Results are given in Table 20 and shown on concordia and Gaussian-summation probability density plots in Figures 31, 32 and 33.

Interpretation

Most analyses are concordant to slightly discordant and indicate a range of $^{207}Pb/^{206}Pb$ dates of c. 1100 to 3230 Ma. Eleven analyses of ten zircons (1.1, 7.1, 8.1, 8.2, 9.1, 15.1, 18.1, 19.1, 24.1, 26.1 and 27.2), 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 1106 ± 18 Ma (chi-squared = 1.26). Of these, nine analyses (1.1, 7.1, 8.1, 8.2, 9.1, 15.1, 19.1, 24.1 and 26.1) have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of 1089 ± 29 Ma (chi-squared = 1.58). Eight analyses of eight zircons (2.1, 10.1, 13.1, 15.1, 17.1, 20.1, 23.1, 28.1 and 29.1), 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 1309 ± 17 Ma (chi-squared = 1.01). Analyses 5.1, 6.1, 12.1 and 14.1, assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1473 ± 39 Ma (chi-squared = 0.50). Analyses 21.1, 22.1 and 25.1, assigned to Group 4, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1796 ± 75 Ma (chi-squared = 1.02). The remaining analyses cannot be confidently grouped.

The weighted mean $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ dates of 1089 ± 29 Ma and 1106 ± 18 Ma respectively, indicated by grouping of the analyses of Group 1, are

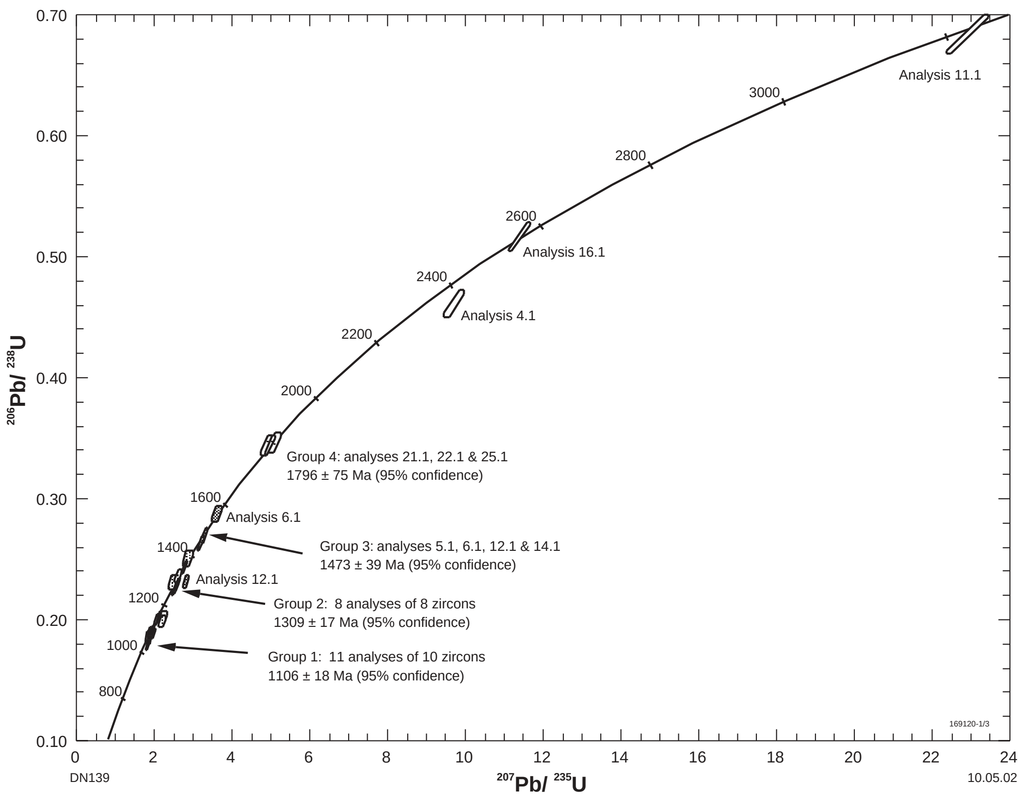

Figure 31. Concordia plot for sample 169120: metasandstone, Desert Queens Bath

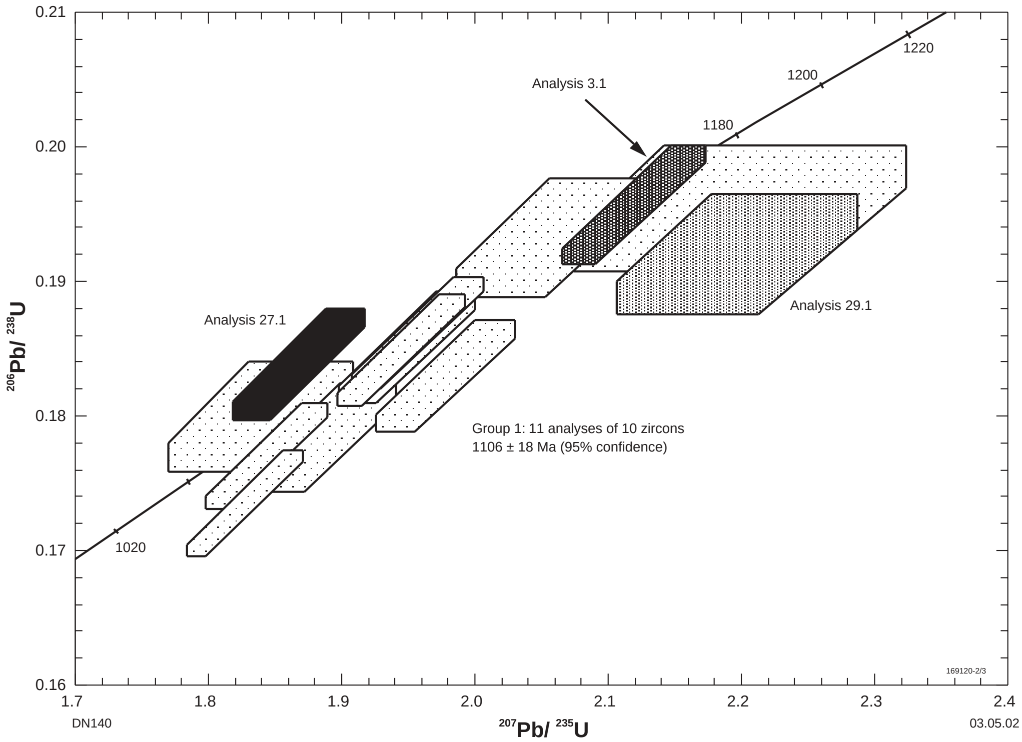

Figure 32. Concordia plot enlargement for sample 169120: metasandstone, Desert Queens Bath

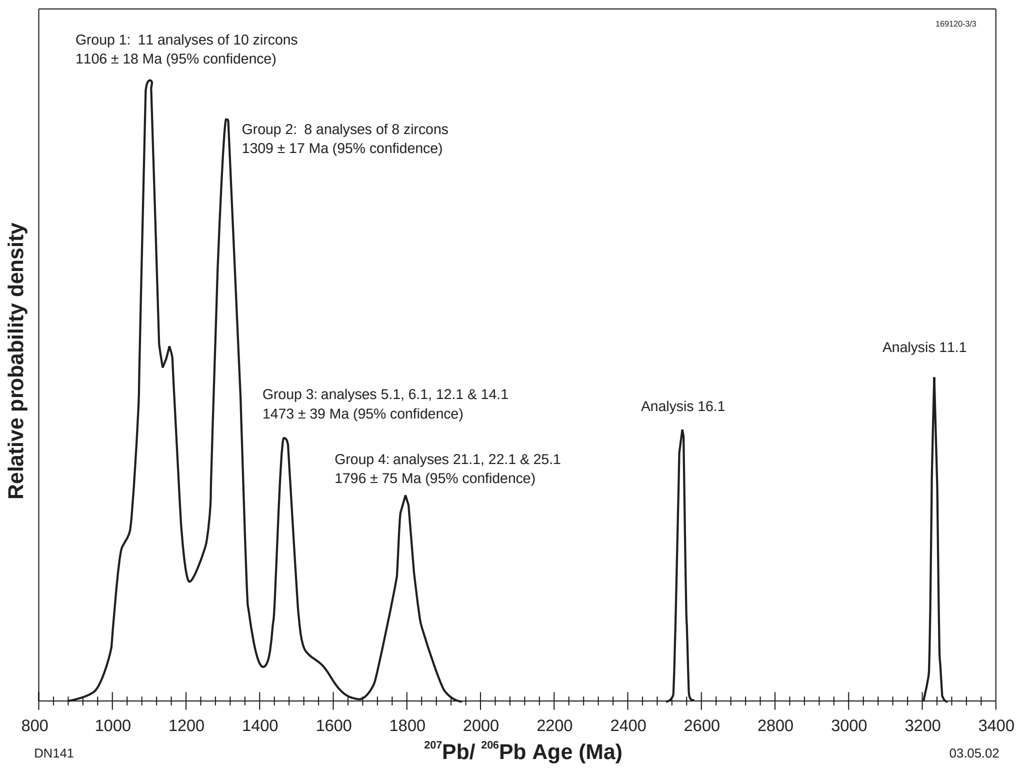

Figure 33. Gaussian-summation probability density plot for sample 169120: metasandstone, Desert Queens Bath

interpreted as maximum ages for deposition of the sandstone precursor to the quartzite. Source rocks within the western part of Australia having ages similar to those of the zircons within this sample include the Rudall (Nelson, 1995, 1996), Arunta (Williams et al., 1996 and references cited therein), Gascoyne (Nelson, 1997, 1998, 1999, 2000, 2001b, this volume) and Musgrave (White et al., 1999 and references cited therein) complexes and the Albany–Fraser Orogen (Nelson et al., 1995). Grain 11.1 may have been derived from either the Yilgarn or Pilbara cratons (Nelson, 1995, 1996, 1997, 1998, 1999, 2000, 2001b, this volume).

144681: agglomeratic rhyolite, Baroona Hill

Location and sampling

NULLAGINE (SF 51-5), MOUNT EDGAR (2955) MGA Zone 51, 223681E 7622218N

Sampled on 19 September 2000.

The sample was taken from the western side of a creek bed, 30 m upstream from a large rockhole, 5 km bearing 075° from Wallabirdee Ridge and 17.2 km west of Baroona Hill.

Tectonic unit/relations

This sample is from a medium grey agglomeratic rhyolite, consisting of fragments of coarse-grained rhyolite within a fine-grained rhyolitic matrix of the Wyman Formation, Warrawoona Group, East Pilbara Granite–Greenstone Terrane (Williams and Bagas, in prep.). The sampling site is located 125 m stratigraphically below the unconformity with the Mount Roe Basalt. Sparse quartz veinlets up to 1 mm thick are present.

Petrographic description

This sample consists of altered feldspar phenocrysts set within heterogeneous, inequigranular but fine-grained groundmass of quartz, sericite and K-feldspar. This is a porphyritic, felsic intrusive or volcanic rock with potassic and phyllic alteration. It has been cut by stylolites and veins with sericite, leucoxene and quartz in various proportions. In thin section, abundant feldspar phenocrysts are present to 3 mm long, now composed of low-temperature K-feldspar, possibly adularia, and sericite in various proportions. Possible hand specimen phenocrysts, to 1.5 mm long, have been replaced by sericite, quartz and minor leucoxene. Mineral cross-sections with crystal faces at 120°, typical of amphibole crystals, are visible. Disseminated opaque oxide to 0.4 mm in grain size has been altered to leucoxene. The groundmass is a heterogeneous, inequigranular but fine-grained aggregate of quartz, sericite and K-feldspar with diffuse lenticular veins, to 1 mm wide, of quartz and minor sericite. Planar quartz–sericite veins occur, as well as convoluted stylolites rich in sericite and leucoxene. Late planar quartz veins and planar sericite veins occur, both with enechelon offsets.

Zircon morphology

The zircons isolated from this sample are typically pale yellowish brown or dark brown, equant to slightly elongate with subrounded terminations and between 20 × 35 µm and 80 × 280 µm in size. Most grains are internally structureless, although fluid and mineral inclusions are common.

Analytical details

This sample was analysed on 28 September and 7 October 2001. The counter deadtime during both analysis session was 32 ns. Nine analyses of the CZ3 standard obtained during the first analysis session indicated a Pb^*/U calibration error of 2.14 (1σ%). Analyses 1.1 to 9.1 were obtained during the first analysis session. During the second analysis session, seven analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.11 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 21. Ion microprobe analytical results for sample 144681: agglomeratic rhyolite, Baroona Hill

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	146	72	117	0.258	0.27152	0.00088	0.12715	0.00108	0.6568	0.0143	24.587	0.553	98	3 315	5
2.1	150	81	120	0.613	0.27081	0.00096	0.13700	0.00142	0.6467	0.0141	24.149	0.544	97	3 311	6
3.1	71	34	56	0.363	0.26763	0.00129	0.12230	0.00168	0.6514	0.0145	24.038	0.561	98	3 292	8
4.1	84	44	66	0.693	0.26888	0.00131	0.12932	0.00201	0.6369	0.0141	23.611	0.549	96	3 300	8
5.1	99	52	78	0.288	0.27244	0.00107	0.13395	0.00138	0.6495	0.0143	24.399	0.556	97	3 320	6
6.1	96	49	76	0.339	0.27145	0.00109	0.13622	0.00145	0.6460	0.0142	24.177	0.552	97	3 314	6
7.1	152	94	122	0.528	0.27160	0.00092	0.16343	0.00134	0.6413	0.0140	24.014	0.539	96	3 315	5
8.1	96	45	74	0.199	0.27265	0.00106	0.12508	0.00125	0.6405	0.0141	24.077	0.548	96	3 321	6
9.1	169	95	132	0.352	0.27139	0.00083	0.14574	0.00110	0.6318	0.0137	23.640	0.528	95	3 314	5
10.1	94	48	75	0.298	0.27208	0.00112	0.13761	0.00152	0.6537	0.0144	24.524	0.563	98	3 318	6
11.1	67	32	54	0.778	0.27188	0.00182	0.12362	0.00282	0.6624	0.0083	24.833	0.372	99	3 317	11
12.1	92	42	73	0.622	0.27235	0.00147	0.11473	0.00212	0.6553	0.0080	24.608	0.342	98	3 320	8
13.1	106	54	85	0.200	0.27273	0.00120	0.13422	0.00140	0.6603	0.0079	24.831	0.330	98	3 322	7
14.1	88	45	72	0.592	0.27315	0.00149	0.13170	0.00217	0.6648	0.0081	25.037	0.350	99	3 324	9
15.1	115	75	94	1.087	0.27047	0.00149	0.17016	0.00254	0.6412	0.0077	23.911	0.329	97	3 309	9
16.1	110	60	89	0.287	0.27028	0.00122	0.14570	0.00159	0.6632	0.0080	24.713	0.330	99	3 308	7
17.1	106	59	86	0.208	0.27410	0.00121	0.14795	0.00147	0.6592	0.0079	24.913	0.332	98	3 330	7
18.1	49	22	39	0.665	0.27312	0.00211	0.11309	0.00326	0.6591	0.0086	24.820	0.397	98	3 324	12
19.1	84	57	62	1.092	0.26733	0.00183	0.14936	0.00310	0.5879	0.0072	21.671	0.321	91	3 290	11
20.1	69	31	55	0.643	0.27006	0.00170	0.11566	0.00252	0.6512	0.0082	24.249	0.357	98	3 306	10
21.1	90	41	72	0.504	0.26939	0.00147	0.11728	0.00216	0.6635	0.0081	24.643	0.344	99	3 302	9
22.1	109	53	87	0.380	0.27046	0.00127	0.12967	0.00171	0.6551	0.0078	24.431	0.327	98	3 309	7
23.1	124	68	103	0.296	0.27142	0.00113	0.14389	0.00146	0.6713	0.0080	25.121	0.329	100	3 314	7

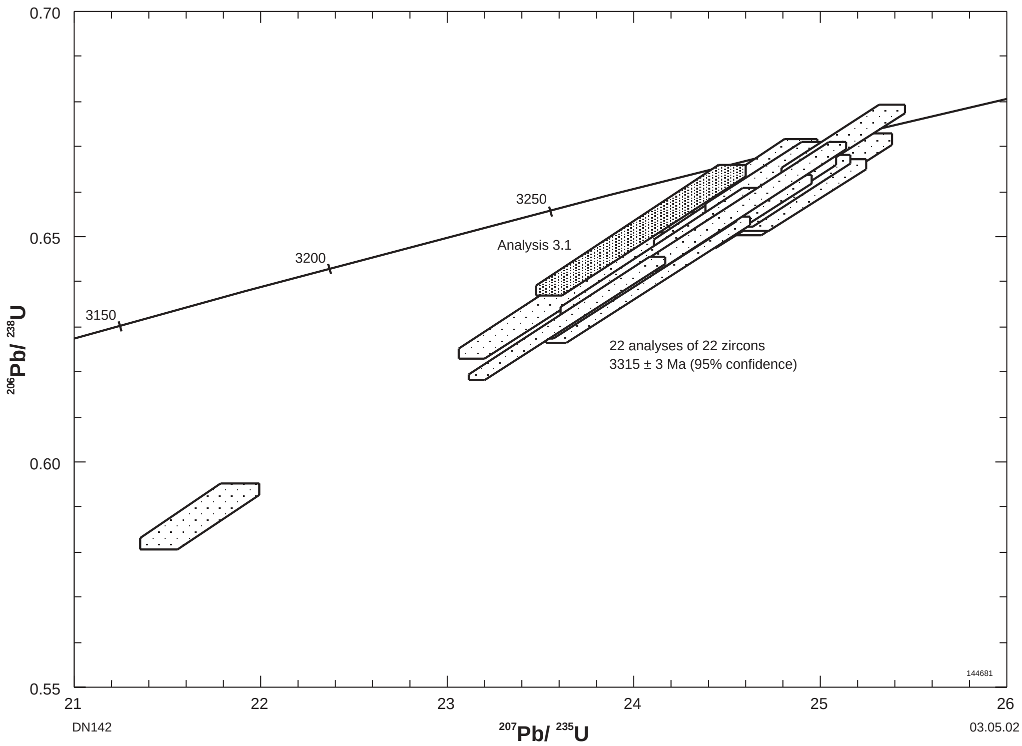

Figure 34. Concordia plot for sample 144681: agglomeratic rhyolite, Baroona Hill

Results

Twenty-three analyses were obtained from 23 zircons. Results are given in Table 21 and shown on a concordia plot in Figure 34.

Interpretation

The analyses are concordant to slightly discordant, with the discordance pattern consistent with one ancient episode and one recent episode of radiogenic-Pb loss. Twenty-two discordant analyses of 22 zircons have ^{207}Pb/^{206}Pb ratios defining a single population and indicating a weighted mean ^{207}Pb/^{206}Pb date of 3315 ± 3 Ma (chi-squared = 1.14). Concordant analysis 3.1 indicated a slightly lower ^{207}Pb/^{206}Pb ratio than the main population.

The date of 3315 ± 3 Ma indicated by the weighted mean ^{207}Pb/^{206}Pb ratio of 22 concordant analyses of 22 zircons is interpreted as the age of igneous crystallization of the rhyolite. The slightly lower ^{207}Pb/^{206}Pb ratio indicated by concordant analysis 3.1 is interpreted to be due to ancient loss of radiogenic Pb.

160211: altered biotite tonalite, Corunna Downs Homestead

Location and sampling

MARBLE BAR (SF 50-8), MARBLE BAR (2855) MGA Zone 50, 791620E 7621830N

Sampled on 24 September 2000.

The sample was taken from a pavement in the bed of Emu Creek, 70 m west of the site where a track crosses the creek and 3.6 km at a bearing of 236° from the Corunna Downs Homestead.

Tectonic unit/relations

This sample of the Nandingarra Granodiorite is a light grey, coarse-grained, altered biotite tonalite of the Corunna Downs Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Bagas et al., in prep.). At the sampling site, the complex has been intruded by dykes of seriate monzogranite.

Petrographic description

This principal minerals present in this sample are plagioclase (55 vol.%), quartz (35 vol.%), biotite (4 vol.%), microcline (4 vol.%), and epidote (1 vol.%), with accessory opaque oxide (trace), apatite (trace), and zircon (trace). This is an altered biotite tonalite, with altered biotite, plagioclase and rare microcline. Fine-grained biotite is disseminated uniformly through the rock, and has been altered to chlorite and epidote. In thin section, there is abundant plagioclase as subhedral grains from 1 to 8 mm long and up to 4 mm wide, extensively altered to an assemblage of sericite, epidote and muscovite, with irregular patches clouded by sericite and clinozoisite. Coarse-grained muscovite and epidote occur in some of the plagioclase grains, commonly with a poikilitic habit. There is also very minor microcline, to 1 mm in grain size. Disseminated biotite varies from fresh to chloritized, and occurs in aggregates with granular epidote to 1.5 mm in grain size, usually with poikilitic zones. Amoeboid grains of an altered mineral, possibly allanite, occur to 1 mm in diameter, rimmed by epidote. The biotite is unoriented and there is no obvious foliation in this sample. Rare apatite, zircon and opaque oxide are present.

Zircon morphology

The zircons isolated from this sample are typically dark brown or black, between 60 × 140 µm and 80 × 250 µm in size and are elongate, and subhedral or euhedral in shape. Many have mottled interiors and abundant small black spots and zones on their polished surfaces. These features are attributed to extensive radiation damage and recrystallization of parts of the crystal microstructure. Most grains have remnant internal zonation, and many are metamict.

Analytical details

This sample was analysed on 18 and 20 August 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.87 (1σ%). Analyses 1.1 to 16.1 were obtained during the first analysis session. During the second analysis session,

Table 22. Ion microprobe analytical results for sample 160211: altered biotite tonalite, Corunna Downs Homestead

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	763	78	192	0.088	0.20583	0.00058	0.03159	0.00050	0.2354	0.0044	6.681	0.129	47	2 873	5
2.1	311	98	230	0.156	0.28866	0.00075	0.08680	0.00073	0.6215	0.0118	24.735	0.482	91	3 410	4
3.1	1259	34	674	0.250	0.27086	0.00041	0.00882	0.00039	0.4825	0.0091	18.018	0.343	77	3 311	2
4.1	195	107	166	0.423	0.29326	0.00099	0.15069	0.00138	0.6764	0.0130	27.351	0.544	97	3 435	5
5.1	55	24	45	0.433	0.29165	0.00180	0.10866	0.00230	0.6668	0.0136	26.815	0.589	96	3 426	10
6.1	129	54	108	1.416	0.29061	0.00144	0.11185	0.00248	0.6653	0.0129	26.659	0.550	96	3 421	8
7.1	286	64	232	0.729	0.29060	0.00084	0.05813	0.00120	0.6836	0.0130	27.390	0.537	98	3 421	5
8.1	417	248	362	0.833	0.29197	0.00071	0.17625	0.00113	0.6717	0.0127	27.040	0.524	97	3 428	4
9.1	816	19	233	0.737	0.19969	0.00064	0.00953	0.00103	0.2680	0.0050	7.378	0.143	54	2 824	5
10.1	743	114	476	0.652	0.27688	0.00055	0.04139	0.00075	0.5540	0.0104	21.148	0.406	85	3 345	3
11.1	172	90	146	0.051	0.28923	0.00092	0.13462	0.00089	0.6902	0.0133	27.524	0.547	99	3 413	5
12.1	687	65	359	0.594	0.26641	0.00059	0.04723	0.00081	0.4540	0.0085	16.676	0.321	73	3 285	3
13.1	757	125	191	0.758	0.20507	0.00070	0.05189	0.00117	0.2283	0.0043	6.455	0.126	46	2 867	6
14.1	122	53	101	0.091	0.29479	0.00109	0.11657	0.00113	0.6824	0.0133	27.738	0.561	97	3 443	6
15.1R	879	58	292	1.092	0.21997	0.00064	0.04629	0.00111	0.2950	0.0055	8.946	0.173	56	2 980	5
15.2C	105	42	87	0.164	0.28934	0.00125	0.10518	0.00133	0.6876	0.0135	27.430	0.564	99	3 414	7
16.1	696	109	303	1.176	0.25023	0.00077	0.05692	0.00131	0.3731	0.0038	12.871	0.142	64	3 186	5
17.1	171	128	151	0.078	0.28702	0.00092	0.19488	0.00107	0.6898	0.0133	27.299	0.544	99	3 402	5
18.1	115	72	102	0.120	0.29144	0.00118	0.16553	0.00133	0.7046	0.0081	28.313	0.357	100	3 425	6
19.1	543	213	327	0.980	0.26443	0.00075	0.11584	0.00124	0.4923	0.0051	17.950	0.198	79	3 273	4
20.1	294	218	261	0.088	0.29112	0.00075	0.19721	0.00087	0.6927	0.0073	27.805	0.311	99	3 424	4
21.1	553	350	473	0.120	0.28820	0.00053	0.17708	0.00060	0.6755	0.0070	26.842	0.287	98	3 408	3
22.1	214	121	187	0.096	0.29249	0.00088	0.15145	0.00093	0.7021	0.0075	28.316	0.326	100	3 431	5
23.1	87	49	74	1.128	0.29179	0.00173	0.16209	0.00284	0.6597	0.0078	26.542	0.368	95	3 427	9
24.1	82	39	69	0.153	0.29478	0.00143	0.12622	0.00152	0.6847	0.0081	27.830	0.369	98	3 443	8
25.1	526	123	242	0.914	0.26125	0.00081	0.09824	0.00130	0.3830	0.0039	13.795	0.153	64	3 254	5
26.1	254	136	212	0.071	0.29272	0.00077	0.14057	0.00075	0.6734	0.0071	27.177	0.306	97	3 432	4

NOTE: C denotes analysis obtained on zircon core; R denotes analysis obtained on zircon rim

five analyses of the CZ3 standard indicated a Pb*/U calibration error of 0.841 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the second analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 3.1, 6.1, 7.1, 8.1, 9.1, 10.1, 12.1, 13.1, 15.1, 16.1, 19.1 and 25.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-seven analyses were obtained from 26 zircons. Results are given in Table 22 and shown on a concordia plot in Figure 35.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with multiple episodes of radiogenic-Pb loss, including several dominant recent episodes, and possibly an ancient episode. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of two groups. Concordant analyses 11.1 and 12.1 and discordant analyses 2.1 and 21.1, 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 3408 ± 7 Ma (chi-squared = 0.92). Twelve concordant and slightly discordant analyses of 12 zircons (4.1, 5.1, 6.1, 7.1, 8.1, 16.1, 18.1, 20.1, 22.1, 23.1, 24.1 and 26.1), 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 3427 ± 4 Ma (chi-squared = 1.37). The remaining analyses are highly discordant and cannot be confidently grouped.

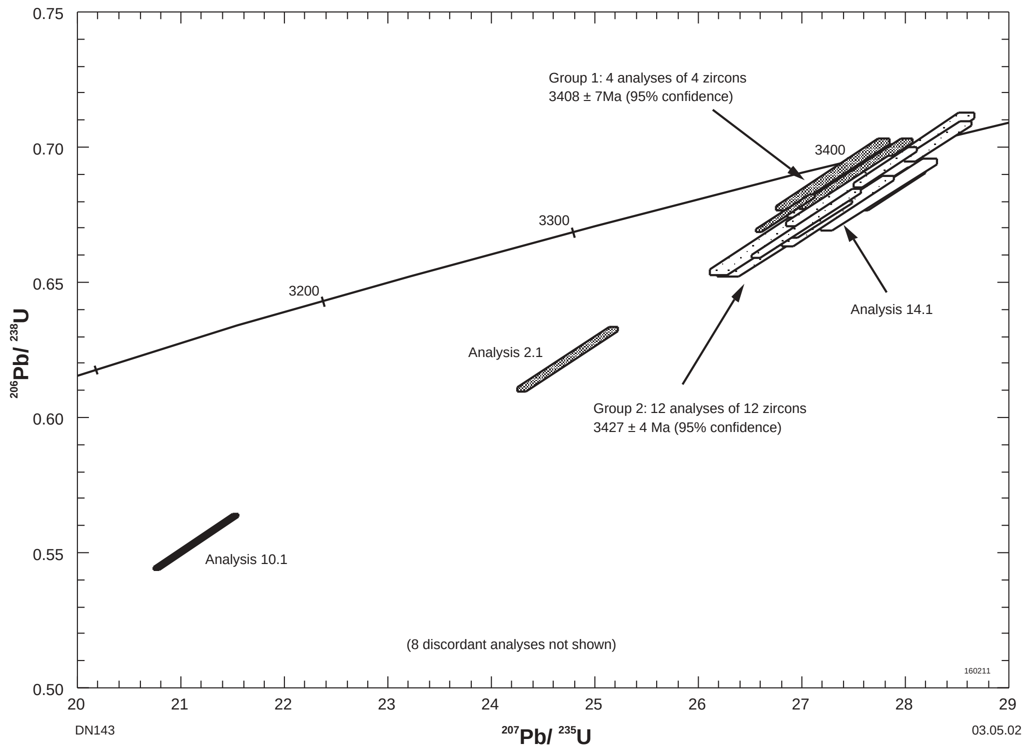

Figure 35. Concordia plot for sample 160211: altered biotite tonalite, Corunna Downs Homestead

Several interpretations of these results are possible. The date of 3408 ± 7 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the four concordant and discordant analyses of Group 1 may be interpreted as the age of igneous crystallization of the tonalite, with the older date indicated by the analyses of Group 2 attributed to the presence of xenocryst zircons. Alternatively, the date of 3427 ± 4 Ma indicated by the analyses of Group 2 may provide the age of igneous crystallization of the tonalite, with the younger analyses of Group 1 due either to the presence of indistinct veins or dykes in the sample, or to an ancient radiogenic-Pb redistribution event. Discordant analysis 14.1, which indicated an older $^{207}Pb/^{206}Pb$ date than those of Groups 1 and 2, is interpreted to be of a xenocryst zircon. The remaining discordant analyses are interpreted to be of analysis sites that have undergone radiogenic-Pb loss during several recent disturbance events.

160212: biotite–hornblende tonalite, Corunna Downs Homestead

Location and sampling

MARBLE BAR (SF 50-8), MARBLE BAR (2855) MGA Zone 50, 793270E 7623800N

Sampled on 24 September 2000.

The sample was taken from a site located on the south side of a saline claypan and 1.3 km at bearing of 275° from the Corunna Downs Homestead.

Tectonic unit/relations

This sample of the Nandingarra Granodiorite is a black and white spotted, coarse-grained, biotite–hornblende tonalite of the Corunna Downs Granitoid Complex, East Pilbara Granite–Greenstone Terrane. The sample contains dark mafic clots, up to 7 mm in diameter, of biotite and hornblende.

Petrographic description

The principal minerals present in this sample are plagioclase (55–60 vol.%), quartz (20–25 vol.%), biotite (10 vol.%), hornblende (6 vol.%), and epidote (3 vol.%), with accessory titanite (1 vol.%), opaque oxide (<1 vol.%), apatite (trace), and zircon (trace). This is a weakly foliated biotite–hornblende tonalite with epidote, allanite, titanite and rare zircon. Chlorite, clays and albite have replaced biotite, with clay veins in the hornblende. There is a weak foliation in this sample as seen in hand specimen, with abundant mafic clots and abundant coarse-grained plagioclase. The thin section shows a quartz-poor granitoid rock with plagioclase grains to 7 mm long, irregularly clouded by sericite and fine-grained epidote. Some of the plagioclase has inclusions of microcline but no other K-feldspar was seen in the rock. The quartz occurs in lenses to 10 × 5 mm with large strained, old grains, and areas of recrystallized new grains. The mafic clots are as much as 7 mm long, with biotite and green hornblende to 3 mm in grain size as well as minor epidote and granular titanite. Most of the hornblende has veins of a green mineral, probably smectite, and some of the biotite has been altered to chlorite and/or clays. The epidote is commonly spongy and inclusion-rich, but more granular epidote is present, locally enclosing altered crystals up to 1 mm long (?allanite). In some of the mafic aggregates there are poikilitic grains of altered biotite with very abundant fine-grained quartz as inclusions. An unusual characteristic is the partial replacement of biotite (or chloritized biotite) by albite as optically continuous overgrowths on adjacent plagioclase grains. Titanite, opaque oxide and apatite occur as accessory minerals, some of the opaque oxide being rimmed by titanite, and there is rare zircon.

Zircon morphology

The zircons isolated from this sample are typically dark yellowish brown or black, between 60 × 100 µm and 80 × 250 µm in size and are elongate and subhedral or euhedral in shape. Most grains have remnant internal zonation, and many are metamict.

Analytical details

This sample was analysed on 8 July 2001. The counter deadtime during the analysis session was 32 ns. Seven analyses of the CZ3 standard obtained during the analysis

Table 23. Ion microprobe analytical results for sample 160212: biotite–hornblende tonalite, Corunna Downs Homestead

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	229	116	176	0.202	0.27325	0.00103	0.13747	0.00124	0.6289	0.0129	23.695	0.505	95	3 325	6
2.1	252	115	199	0.194	0.27077	0.00096	0.12084	0.00110	0.6558	0.0134	24.482	0.519	98	3 310	6
3.1	478	329	392	0.238	0.26937	0.00068	0.18085	0.00087	0.6524	0.0132	24.230	0.503	98	3 302	4
4.1	177	101	141	0.270	0.27338	0.00121	0.14951	0.00160	0.6458	0.0133	24.342	0.527	97	3 325	7
5.1	278	141	211	0.414	0.27144	0.00097	0.13076	0.00128	0.6215	0.0127	23.262	0.492	94	3 314	6
6.1	182	104	141	0.207	0.27099	0.00115	0.14874	0.00141	0.6272	0.0129	23.435	0.506	95	3 312	7
7.1	198	66	150	0.175	0.27124	0.00109	0.08843	0.00114	0.6435	0.0132	24.065	0.516	97	3 313	6
8.1	233	97	181	0.332	0.27195	0.00103	0.10887	0.00127	0.6464	0.0133	24.239	0.517	97	3 317	6
9.1	174	41	131	0.252	0.27054	0.00117	0.05869	0.00129	0.6521	0.0135	24.324	0.525	98	3 309	7
10.1	864	784	423	0.277	0.22472	0.00057	0.20900	0.00087	0.3933	0.0079	12.185	0.252	71	3 015	4
11.1	181	45	131	0.828	0.27134	0.00137	0.06143	0.00203	0.6158	0.0127	23.039	0.503	93	3 314	8
12.1	436	199	324	0.243	0.26972	0.00074	0.12424	0.00086	0.6136	0.0125	22.821	0.475	93	3 304	4
13.1	410	220	315	0.370	0.26849	0.00077	0.14854	0.00102	0.6212	0.0126	22.996	0.480	94	3 297	5
14.1	292	146	233	0.273	0.27234	0.00092	0.12951	0.00113	0.6565	0.0134	24.651	0.521	98	3 320	5
15.1	415	251	316	0.443	0.26868	0.00080	0.15880	0.00114	0.6117	0.0124	22.661	0.473	93	3 298	5
16.1	220	62	162	0.214	0.27125	0.00102	0.07602	0.00107	0.6322	0.0129	23.645	0.503	95	3 313	6
17.1	362	300	300	0.114	0.27101	0.00076	0.21403	0.00097	0.6458	0.0131	24.130	0.504	97	3 312	4
18.1	200	61	153	0.235	0.27028	0.00112	0.07537	0.00121	0.6569	0.0135	24.481	0.527	98	3 308	6
19.1	160	66	127	0.184	0.27128	0.00120	0.10720	0.00136	0.6656	0.0138	24.895	0.540	99	3 313	7
20.1	161	38	120	0.233	0.27338	0.00120	0.06073	0.00120	0.6469	0.0134	24.384	0.528	97	3 325	7

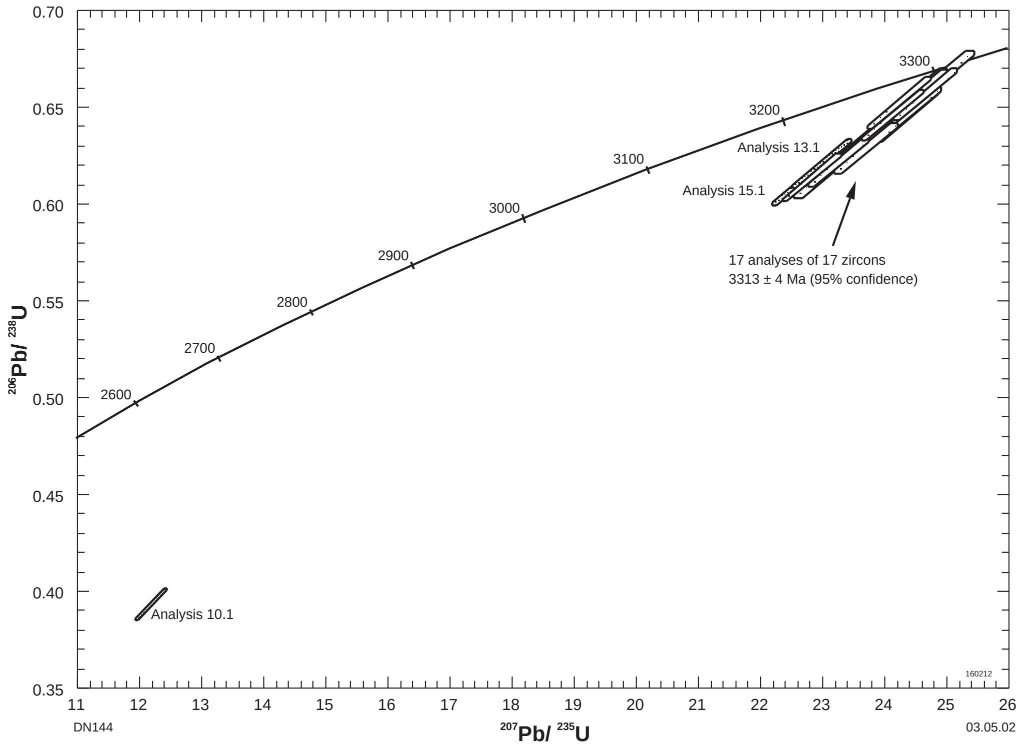

Figure 36. Concordia plot for sample 160212: biotite–hornblende tonalite, Corunna Downs Homestead

session indicated a Pb*/U calibration error of 2.01 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty analyses were obtained from 20 zircons. Results are given in Table 23 and shown on a concordia plot in Figure 36.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic Pb loss, including a dominant recent episode. Seventeen concordant and highly discordant analyses of 17 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3313 ± 4 Ma (chi-squared = 1.46). Discordant analyses 10.1, 13.1 and 15.1 indicate younger $^{207}Pb/^{206}Pb$ dates.

The date of 3313 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 17 analyses of Group 1 is interpreted as the age of igneous crystallization of the tonalite. Discordant analyses 10.1, 13.1 and 15.1 are interpreted to be of analysis sites that have undergone ancient radiogenic-Pb loss.

160218: porphyritic dacite, Fieldings Gully Well

Location and sampling

MARBLE BAR (SF 50-8), MARBLE BAR (2855) MGA Zone 50, 783660E 7639530N

Sampled on 4 October 2000.

The sample was taken from a boulder located 70 m west of a creek bed and 3.5 km at a bearing of 234° from Fieldings Gully Well.

Tectonic unit/relations

This sample is from a dark grey dacite or rhyolite flow or sill containing rare scattered up to 2 mm-diameter quartz phenocrysts, which occurs interbedded with a pillowed high-Mg basalt unit 200 m stratigraphically above the base of the Wyman Formation, East Pilbara Granite–Greenstone Terrane (Hickman and Van Kranendonk, in prep.).

Petrographic description

This is a plagioclase porphyritic dacite with altered mafic phenocrysts and an altered spherulitic groundmass. It had an alteration assemblage consisting of albite, sericite, chlorite, carbonate, leucoxene and quartz. Rare zircon was seen. The thin section has abundant plagioclase phenocrysts to 4 mm long, partly albitized and partly with various proportions of sericite, carbonate and chlorite as well as albite. Less abundant mafic phenocrysts to 4 mm long have been altered to sericite and chlorite, with or without carbonate and quartz, with inclusions of leucoxenized opaque oxide and prismatic apatite. Rare, mostly rounded microphenocrysts of quartz occur, to 1 mm in diameter, and there are sparsely disseminated, albite to sericite-altered and/or carbonate-altered microphenocrysts of plagioclase. The groundmass is mostly composed of albite- and sericite-altered spherulites, about 0.5 mm in diameter, with interstitial quartz and disseminated aggregates of leucoxene after microphenocrysts of opaque oxide, similar to the oxide enclosed by the mafic phenocrysts. Altered plagioclase phenocrysts make up about 10–12 vol.%, of this rock, with 3–5 vol.% altered mafic phenocrysts and a groundmass of quartz, albite and sericite. The original lithology is uncertain, but is more likely to have been a dacitic lava flow than a rhyolitic tuff.

Zircon morphology

The zircons isolated from this sample are typically light pinkish brown to dark brown, between 60 × 100 µm and 80 × 250 µm in size and are elongate and subhedral in shape. Most grains lack any obvious internal zonation, although fluid and mineral inclusions are common.

Analytical details

This sample was analysed on 8 and 11 July 2001. The counter deadtime during both analysis sessions was 32 ns. Seven analyses of the CZ3 standard obtained during the first analysis session indicated a Pb^*/U calibration error of 2.01 (1σ%). Analyses 1.1 to 4.1 were obtained during the first analysis session. Six analyses of the CZ3 standard obtained during the second analysis session indicated a Pb^*/U calibration error of 0.768 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the second analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 24. Ion microprobe analytical results for sample 160218: porphyritic dacite, Fieldings Gully Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	178	122	147	0.203	0.27212	0.00115	0.18206	0.00150	0.6565	0.0135	24.630	0.531	98	3 318	7
2.1	161	102	132	0.278	0.27037	0.00122	0.16429	0.00160	0.6577	0.0136	24.520	0.532	98	3 308	7
3.1	174	86	142	0.345	0.27334	0.00122	0.12867	0.00156	0.6700	0.0138	25.251	0.547	99	3 325	7
4.1	165	102	135	0.192	0.27368	0.00116	0.16539	0.00143	0.6575	0.0136	24.810	0.536	98	3 327	7
5.1	144	71	115	0.376	0.26974	0.00121	0.12637	0.00161	0.6541	0.0073	24.327	0.306	98	3 304	7
6.1	107	71	87	0.115	0.26908	0.00133	0.17790	0.00175	0.6463	0.0075	23.977	0.317	97	3 301	8
7.1	145	80	117	0.313	0.26584	0.00120	0.14367	0.00161	0.6571	0.0074	24.085	0.304	99	3 282	7
8.1	151	92	125	0.391	0.27216	0.00120	0.15953	0.00166	0.6606	0.0074	24.791	0.311	99	3 318	7
9.1	145	73	115	0.229	0.26817	0.00121	0.12674	0.00147	0.6567	0.0074	24.282	0.306	99	3 295	7
10.1	72	40	61	0.972	0.28304	0.00201	0.14127	0.00322	0.6770	0.0084	26.421	0.396	99	3 380	11
11.1	137	70	109	0.318	0.27066	0.00121	0.13178	0.00159	0.6534	0.0074	24.382	0.308	98	3 310	7
12.1	123	65	98	0.282	0.26653	0.00127	0.13526	0.00164	0.6523	0.0074	23.973	0.308	99	3 286	7
13.1	100	56	81	0.231	0.27053	0.00144	0.14790	0.00191	0.6634	0.0078	24.746	0.334	99	3 309	8
14.1	131	94	110	0.277	0.27087	0.00125	0.19032	0.00174	0.6628	0.0075	24.753	0.314	99	3 311	7
15.1	135	70	110	0.306	0.26835	0.00122	0.13262	0.00160	0.6646	0.0075	24.590	0.312	100	3 296	7
16.1	121	62	98	0.250	0.26851	0.00127	0.13385	0.00157	0.6680	0.0076	24.731	0.320	100	3 297	7
17.1	125	59	101	0.174	0.26747	0.00126	0.12331	0.00158	0.6681	0.0076	24.639	0.317	100	3 291	7
18.1	131	63	105	0.315	0.26156	0.00123	0.11797	0.00165	0.6720	0.0076	24.235	0.309	102	3 256	7
19.1	100	51	81	0.304	0.26886	0.00147	0.12933	0.00192	0.6641	0.0079	24.620	0.336	100	3 299	9
20.1	123	61	98	0.152	0.26819	0.00123	0.13064	0.00142	0.6617	0.0075	24.469	0.311	99	3 295	7
21.1	143	93	118	0.266	0.26392	0.00115	0.16806	0.00156	0.6650	0.0074	24.198	0.303	100	3 270	7
22.1	143	77	114	0.098	0.26020	0.00111	0.13772	0.00128	0.6604	0.0074	23.692	0.295	101	3 248	7
23.1	95	56	77	0.240	0.26735	0.00149	0.15217	0.00205	0.6600	0.0078	24.329	0.332	99	3 291	9
24.1	129	66	104	0.241	0.27001	0.00122	0.13709	0.00154	0.6654	0.0075	24.770	0.314	99	3 306	7
25.1	143	85	117	0.189	0.27283	0.00113	0.15752	0.00138	0.6590	0.0073	24.789	0.306	98	3 322	6

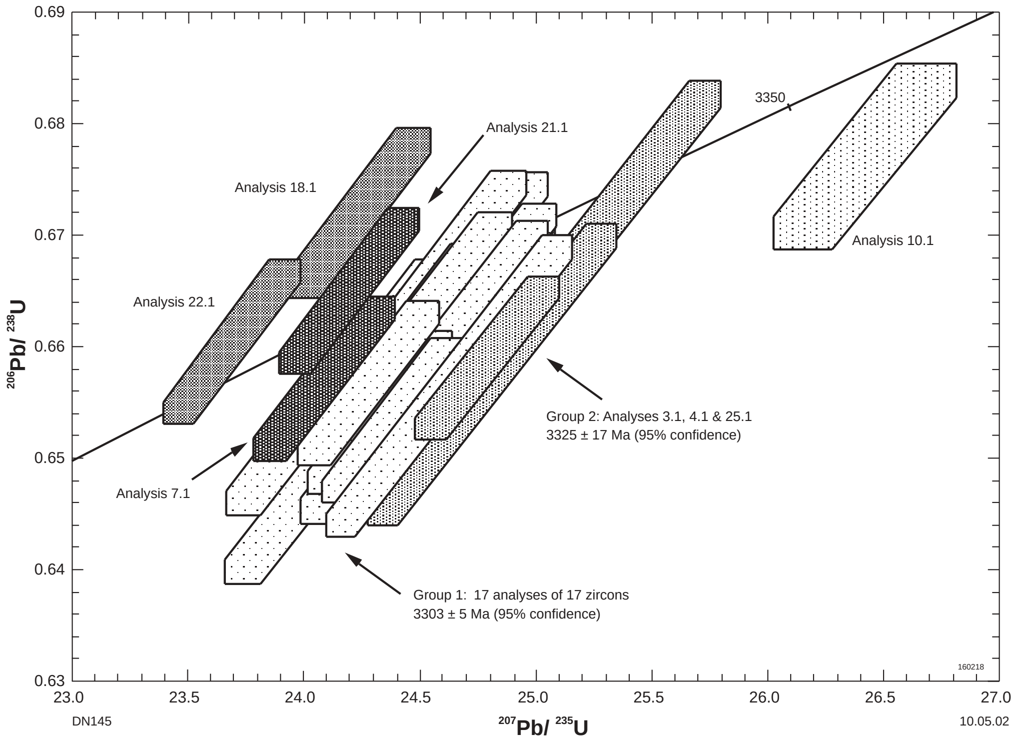

Figure 37. Concordia plot for sample 160218: porphyritic dacite, Fieldings Gully Well

Results

Twenty-five analyses were obtained from 25 zircons. Results are given in Table 24 and shown on a concordia plot in Figure 37.

Interpretation

The analyses are concordant to slightly discordant, with the discordance pattern consistent with a dominant recent episode of radiogenic-Pb loss, possibly combined with an ancient episode. Seventeen concordant and slightly discordant analyses of 17 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 3303 ± 5 Ma (chi-squared = 1.63). Analyses 3.1, 4.1 and 25.1, 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 3325 ± 17 Ma (chi-squared = 0.10). Concordant analyses 7.1, 18.1, 21.1 and 22.1 indicate significantly younger $^{207}Pb/^{206}Pb$ dates, whereas near-concordant analysis 10.1 indicates a significantly older $^{207}Pb/^{206}Pb$ date than the main population.

Two interpretations of these results are possible. The preferred interpretation is that the date of 3303 ± 5 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 17 analyses of Group 1 provides the age of igneous crystallization of the dacite. Concordant analyses 7.1, 18.1, 21.1 and 22.1, which indicate significantly younger $^{207}Pb/^{206}Pb$ dates than the main population, may then be interpreted to be of analysis sites that have undergone ancient radiogenic-Pb loss. However, the U and Th contents and $^{207}Pb/^{206}Pb$ date are not negatively correlated, as might be anticipated if the younger $^{207}Pb/^{206}Pb$ dates were attributable to ancient radiogenic-Pb loss that takes place preferentially from high U and Th analysis sites. If the dacite was extrusively emplaced, it is possible that it was reworked following its eruption. If this were the case, the youngest

$^{207}Pb/^{206}Pb$ date of 3248 ± 7 Ma (1σ error), indicated by analysis 22.1, would provide a maximum age for a reworking event and thus, for its original eruption.

Similar results indicating either ancient disturbance events, or volcanic or sedimentary reworking and redeposition shortly following emplacement, have been obtained for other samples of felsic volcanic rocks from the Wyman Formation and other formations of similar age within the Pilbara Craton (for example, results for samples 168909, 168910, 168913 and 168914 given in Nelson (2001), and samples 169000 and 160220 given in this volume).

160220: tuffaceous rhyolite, Fieldings Gully Well

Location and sampling

MARBLE BAR (SF 50-8), MARBLE BAR (2855) MGA Zone 50, 782320E 7674040N

Sampled on 5 October 2000.

The sample was taken from a boulder located 80 m south of unnamed gold workings and 4.4 km on a bearing of 251° from Fieldings Gully Well.

Tectonic unit/relations

This sample is a dark grey, altered dacitic agglomerate containing phenocrysts of quartz up to 3 mm in diameter and angular lithic fragments up to 1 cm long, from near the stratigraphic top of the Wyman Formation, Warrawoona Group, East Pilbara Granite–Greenstone Terrane (Hickman and Van Kranendonk, in prep.).

Petrographic description

This sample is a dacitic agglomerate containing abundant quartz phenocrysts and volcanic fragments. The thin section has a large fragment, 50 × 25 mm, containing only plagioclase phenocrysts and very minor quartz, surrounded by an area rich in quartz phenocrysts and small volcanic fragments. The large fragment is a bomb fragment with various types of plagioclase phenocrysts (rounded to euhedral and partly fritted), largely albitized, with minor to common sericite and carbonate in some phenocrysts. There are rare, rounded bipyramidal quartz phenocrysts to 2 mm in diameter, which are partly fractured to fragmented. Clay, carbonate and leucoxene pseudomorphs of biotite microphenocrysts are also disseminated, but are not abundant. Other mafic microphenocrysts have been altered to quartz and sericite, with inclusions of apatite and leucoxenized opaque oxide. The groundmass is mostly microcrystalline and quartzofeldspathic (with albite) but there are disseminated plagioclase laths, altered to albite or to sericite and carbonate. Minor sericite and carbonate are also disseminated through the groundmass, with leucoxene after small grains of opaque oxide. The adjacent rock has abundant quartz and albitized plagioclase phenocrysts to 6 mm in diameter, partly fractured and fragmented, as well as areas and fragments of altered volcanic groundmass as described above. Biotite flakes, altered to an assemblage of sericite, clay, leucoxene and limonite, are also present, with interstitial aggregates of quartz, sericite and carbonate.

Zircon morphology

The zircons isolated from this sample are typically dark yellowish or greenish brown or black, between 40 × 85 µm and 80 × 250 µm in size and are elongate and euhedral in shape. Most grains have remnant internal zonation and many are metamict.

Analytical details

This sample was analysed on 30 June and 14 July 2001. The counter deadtime during both analysis sessions was 32 ns. Ten analyses of the CZ3 standard obtained during the first analysis session indicated a Pb^*/U calibration error of 1.52 (1σ%). Analyses 1.1 to 14.1 were obtained during the first analysis session. Four analyses of the CZ3 standard obtained during the second analysis session indicated a Pb^*/U calibration error of 0.741 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns

Table 25. Ion microprobe analytical results for sample 160220: tuffaceous rhyolite, Fieldings Gully Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	137	122	116	0.196	0.27255	0.00101	0.22679	0.00144	0.6496	0.0103	24.411	0.409	97	3 321	6
2.1	211	147	179	0.213	0.27351	0.00079	0.18588	0.00101	0.6709	0.0105	25.301	0.412	99	3 326	5
3.1	136	71	104	0.425	0.27242	0.00107	0.12580	0.00146	0.6279	0.0099	23.586	0.395	95	3 320	6
4.1	172	112	139	0.131	0.27199	0.00088	0.16796	0.00109	0.6498	0.0103	24.368	0.402	97	3 318	5
5.1	518	329	361	0.320	0.26264	0.00054	0.15147	0.00073	0.5678	0.0087	20.561	0.324	89	3 263	3
6.1	193	118	153	0.224	0.27101	0.00083	0.16253	0.00106	0.6378	0.0100	23.831	0.388	96	3 312	5
7.1	450	295	363	0.199	0.27097	0.00053	0.17192	0.00066	0.6450	0.0099	24.098	0.380	97	3 312	3
8.1	186	157	160	0.096	0.27388	0.00081	0.22114	0.00104	0.6671	0.0105	25.193	0.411	99	3 328	5
9.1	208	98	167	0.678	0.27049	0.00090	0.11757	0.00134	0.6568	0.0103	24.496	0.401	98	3 309	5
10.1	87	37	70	0.431	0.27130	0.00132	0.10803	0.00178	0.6642	0.0107	24.845	0.433	99	3 314	8
11.1	90	45	72	0.241	0.27418	0.00128	0.13171	0.00164	0.6557	0.0106	24.789	0.430	98	3 330	7
12.1	627	315	456	0.088	0.26459	0.00044	0.13104	0.00046	0.6032	0.0093	22.006	0.344	93	3 274	3
13.1	101	60	76	1.182	0.26995	0.00154	0.13226	0.00260	0.6058	0.0097	22.549	0.398	92	3 306	9
14.1	147	72	118	0.659	0.27178	0.00108	0.13100	0.00165	0.6518	0.0103	24.424	0.409	98	3 316	6
15.1	271	126	222	0.690	0.27168	0.00101	0.12910	0.00155	0.6649	0.0072	24.906	0.296	99	3 316	6
16.1	180	86	141	0.322	0.27338	0.00102	0.12523	0.00131	0.6458	0.0072	24.342	0.297	97	3 326	6
17.1	154	85	126	0.482	0.27330	0.00123	0.14781	0.00176	0.6575	0.0075	24.775	0.315	98	3 325	7
18.1	113	64	90	0.693	0.26246	0.00146	0.13160	0.00227	0.6489	0.0077	23.483	0.322	99	3 262	9
19.1	109	51	86	0.393	0.27271	0.00136	0.11741	0.00176	0.6500	0.0077	24.439	0.328	97	3 322	8
20.1	95	62	79	1.241	0.26992	0.00173	0.18097	0.00301	0.6412	0.0076	23.863	0.339	97	3 306	10

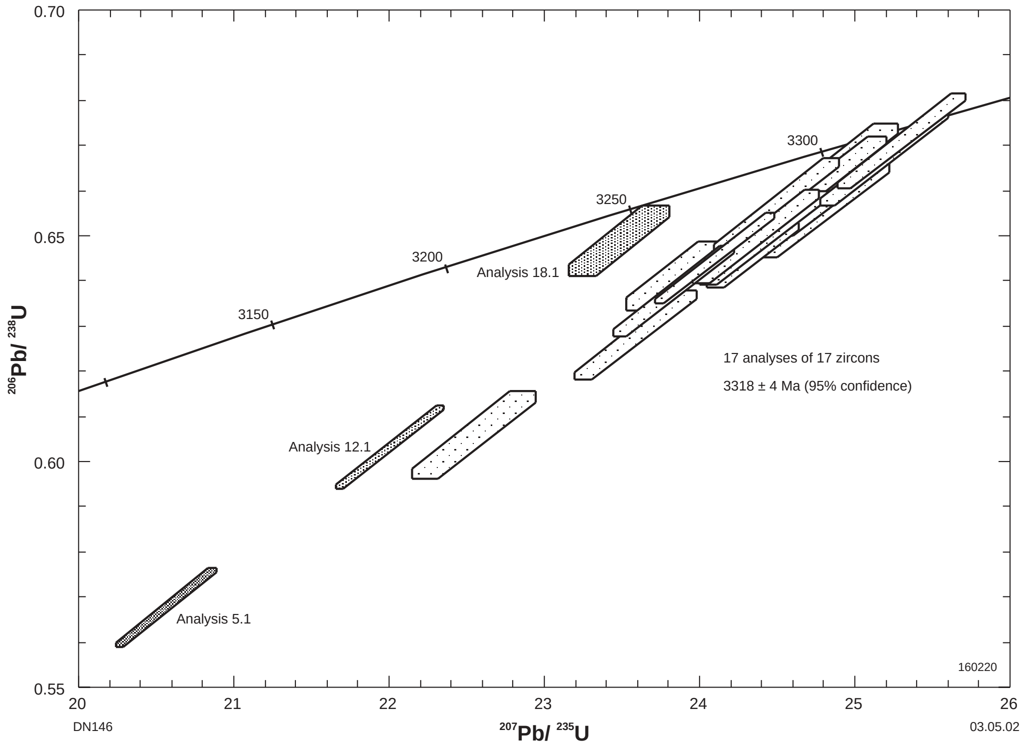

Figure 38. Concordia plot for sample 160220: tuffaceous rhyolite, Fieldings Gully Well

obtained during the second analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty analyses were obtained from 20 zircons. Results are given in Table 25 and shown on a concordia plot in Figure 38.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic Pb loss, including a dominant recent episode. Seventeen concordant and highly discordant analyses of 17 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3318 ± 4 Ma (chi-squared = 1.59). Near-concordant analysis 18.1 and discordant analyses 5.1 and 12.1 indicate significantly younger $^{207}Pb/^{206}Pb$ dates.

The date of 3318 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 17 concordant and highly discordant analyses of 17 zircons is interpreted as the time of igneous crystallization of the rhyolite. Near-concordant analysis 18.1 and discordant analyses 5.1 and 12.1 are interpreted to be of analysis sites that have undergone ancient and recent radiogenic-Pb loss.

160221: tuffaceous rhyolite, Shark Well

Location and sampling

MARBLE BAR (SF 50-8), MARBLE BAR (2855) MGA Zone 50, 774470E 7623650N

Sampled on 10 October 2000.

The sample was taken from a boulder within a gully located 75 m south of a gorge on Glen Herring Creek, and 5.7 km on a bearing of 152° from Shark Well.

Tectonic unit/relations

This sample is a medium grey, altered rhyolite containing angular lithic fragments up to 1 cm long, from near the stratigraphic top of the Panorama Formation, Warrawoona Group, East Pilbara Granite–Greenstone Terrane (Hickman and Van Kranendonk, in prep.).

Petrographic description

This is a porphyritic, pale siliceous rock with some lithic fragments visible in hand specimen. In thin section, the rock is composed of fragments from 0.5 to 10 mm in diameter. Most fragments are of porphyritic volcanic rock with albite- to sericite-altered plagioclase phenocrysts, commonly rectangular in outline, with patches of quartz in some altered phenocrysts up to 2 mm long. Clay, quartz and leucoxene aggregates have also replaced mafic (?hornblende) phenocrysts to 2 mm long, and one fragment has rounded quartz phenocrysts to 1.5 mm long. The groundmass consists of granular quartz, clouded by sericite, with minor leucoxene and rare microphenocrysts of apatite. There are large fragments composed of quartz- and sericite-altered, glassy and lithic shards and fragments to 1.5 mm in diameter, each fragment rimmed by leucoxene. There is an abundant matrix largely consisting of chalcedony, but with areas of sericite or of microsparry quartz. This is a lapilli tuff with acid volcanic lava and vitric tuff fragments, in a chalcedony-rich matrix.

Zircon morphology

The zircons isolated from this sample are typically dark brown or black, between 60 × 85 µm and 100 × 200 µm in size and are equant to slightly elongate and euhedral, or irregular in shape. Most grains have remnant internal zonation and mineral inclusions, and many are metamict.

Analytical details

This sample was analysed on 30 June 2001. The counter deadtime during the analysis session was 32 ns. Ten analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.52 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty-two analyses were obtained from 22 zircons. Results are given in Table 26 and shown on a concordia plot in Figure 39.

Table 26. Ion microprobe analytical results for sample 160221: tuffaceous rhyolite, Shark Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	50	45	47	0.945	0.29285	0.00214	0.23022	0.00361	0.6970	0.0119	28.145	0.547	99	3 433	11
2.1	79	79	73	0.442	0.29259	0.00144	0.25824	0.00227	0.6836	0.0112	27.578	0.487	98	3 431	8
3.1	154	135	139	0.966	0.28941	0.00117	0.21934	0.00195	0.6754	0.0107	26.952	0.455	97	3 414	6
4.1	187	134	165	0.172	0.29220	0.00085	0.18435	0.00103	0.6920	0.0109	27.878	0.456	99	3 429	5
5.1	98	77	88	0.433	0.29121	0.00126	0.20610	0.00180	0.6935	0.0112	27.846	0.479	99	3 424	7
6.1	168	171	157	0.554	0.29423	0.00101	0.27046	0.00160	0.6834	0.0108	27.723	0.459	98	3 440	5
7.1	192	129	167	0.493	0.29219	0.00094	0.17658	0.00133	0.6787	0.0107	27.342	0.449	97	3 429	5
8.1	90	62	78	0.735	0.29244	0.00139	0.18638	0.00213	0.6689	0.0108	26.973	0.468	96	3 431	7
9.1	105	80	94	1.044	0.29314	0.00143	0.19719	0.00236	0.6741	0.0108	27.245	0.473	97	3 434	8
10.1	127	147	119	0.365	0.29243	0.00111	0.31036	0.00174	0.6731	0.0107	27.138	0.457	97	3 431	6
11.1	156	126	140	0.418	0.29230	0.00102	0.21234	0.00145	0.6848	0.0108	27.601	0.457	98	3 430	5
12.1	106	79	95	0.388	0.29102	0.00120	0.19075	0.00169	0.6908	0.0111	27.720	0.472	99	3 423	6
13.1	165	129	146	0.250	0.29411	0.00093	0.20714	0.00122	0.6769	0.0106	27.448	0.451	97	3 439	5
14.1	193	128	167	0.133	0.29328	0.00081	0.17357	0.00092	0.6834	0.0107	27.635	0.448	98	3 435	4
15.1	138	127	126	0.545	0.29024	0.00109	0.24016	0.00169	0.6847	0.0109	27.401	0.459	98	3 419	6
16.1	158	105	137	0.553	0.29291	0.00104	0.17853	0.00151	0.6737	0.0106	27.207	0.451	97	3 433	6
17.1	116	95	104	0.352	0.29006	0.00119	0.20315	0.00169	0.6872	0.0110	27.485	0.468	99	3 418	6
18.1	77	67	72	0.330	0.29835	0.00141	0.21760	0.00193	0.7021	0.0115	28.882	0.509	99	3 462	7
19.1	128	92	95	1.804	0.28984	0.00157	0.20011	0.00285	0.5515	0.0087	22.041	0.382	83	3 417	8
20.1	146	91	125	0.930	0.29365	0.00123	0.16790	0.00197	0.6629	0.0105	26.840	0.453	95	3 437	6
21.1	68	56	62	0.458	0.29874	0.00153	0.21545	0.00217	0.6919	0.0115	28.500	0.511	98	3 464	8
22.1	138	192	140	0.152	0.30010	0.00101	0.36286	0.00158	0.7095	0.0113	29.356	0.489	100	3 471	5

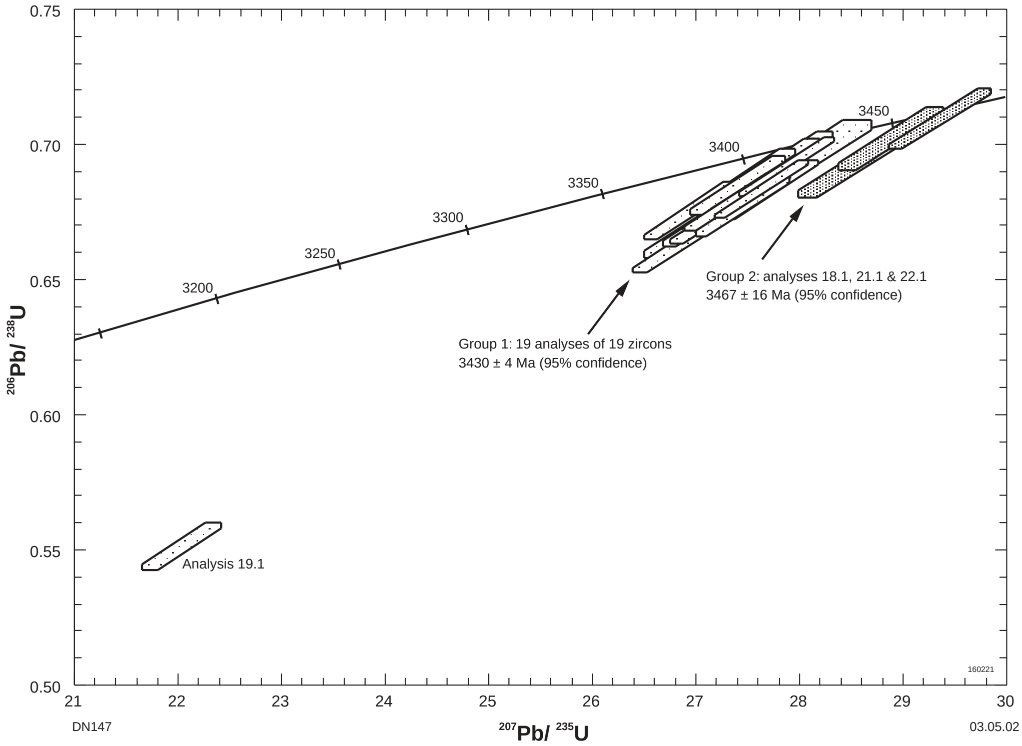

Figure 39. Concordia plot for sample 160221: tuffaceous rhyolite, Shark Well

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a single recent episode of radiogenic-Pb loss. On the basis of their $^{207}Pb/^{206}Pb$ ratios, all analyses may be assigned to one of two groups. Nineteen concordant and highly discordant analyses of 19 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 3430 ± 4 Ma (chi-squared = 1.50). Concordant analyses 18.1, 21.1 and 22.1, 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 3467 ± 16 Ma (chi-squared = 0.44).

The date of 3430 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 19 concordant and highly discordant analyses of Group 1 is interpreted as the age of igneous crystallization of the rhyolite. Concordant analyses 18.1, 21.1 and 22.1 of Group 2 are interpreted to be of xenocryst zircons.

168989: coarse volcaniclastic metasandstone, Cooke Bluff Hill

Location and sampling

PORT HEDLAND – BEDOUT ISLAND (SF 50-4), CARLINDIE (2756) MGA Zone 50, 747810E 7685040N

Sampled on 30 June 2000.

The sample was taken from the western side of a low rocky hill and at the base of a northeast-trending ridge, 100 m east of the access track and 4 km north of Cooke Bluff Hill.

Tectonic unit/relations

This sample is a white, coarse sandstone consisting of 1 to 2 mm-diameter, clear quartz grains set within a white siliceous matrix. The sandstone occurs as a 0.5 m-thick lens within a sequence of altered felsic volcanic rocks of the Panorama Formation, Warrawoona Group, East Pilbara Granite–Greenstone Terrane (Van Kranendonk, in prep.a). The sampling site is 20 m stratigraphically below a prominent conglomerate unit. Coarse barite veins occur near the sampling site.

Petrographic description

This sample consists principally of detrital quartz (55–60 vol.%), lithic grains (5 vol.%), siliceous cement (35 vol.%), limonite (2–3 vol.%), and barite (1–2 vol.%), with accessory zircon (trace). This is a coarse-grained, quartz-rich sandstone with sparse, partly volcanic, lithic fragments, an extensive intergranular cement of cherty to chalcedonic quartz, with barite and rare sparry quartz. Abundant rounded single crystal quartz grains, 1 to 2 mm in diameter, are scattered through a chalcedonic matrix or cement. Some of these quartz grains may be of volcanic origin. There are rare lithic grains, one of massive fine-grained sericite and quartz with decussate muscovite, and limonite after carbonate. At least two are fine-grained cherty quartz, partly representing silicified acid volcanic fragments with limonite that has replaced microlites, and one is composed of albitized plagioclase with decussate, fine-grained muscovite. The cement consists of cherty to chalcedonic silica with sparse patches of microsparry quartz. Minor granular barite occurs in the cherty to chalcedonic quartz and in the sparry quartz. Some fragments have been cut by veins of quartz and barite. Limonite, after carbonate and pyrite, is disseminated both within quartz and lithic grains and in the cement. The limonite is commonly rimmed by sericite. An irregular vein, to 1.5 mm wide, has crystals and fragments of quartz to 0.8 mm long with sparse interstitial cherty quartz and a limonite-rich rim. This vein cuts across the single crystal quartz grains. The cement suggests an exhalative or low-temperature hydrothermal or epithermal setting.

Zircon morphology

The zircons isolated from this sample are typically colourless, yellowish or greenish brown or black fragments and whole grains, between 35 × 50 µm and 120 × 250 µm in size, and equant to elongate and euhedral or irregular in shape. Many grains have remnant internal zonation and fluid inclusions, and many are metamict. A minority of grains are rounded and have pitted terminations, suggesting detrital transport.

Table 27. Ion microprobe analytical results for sample 168989: coarse volcaniclastic metasandstone, Cooke Bluff Hill

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	169	95	133	0.205	0.28596	0.00136	0.13419	0.00174	0.6372	0.0120	25.123	0.501	94	3 396	7
2.1	154	74	131	0.127	0.30284	0.00129	0.12558	0.00130	0.6917	0.0131	28.884	0.574	97	3 485	7
3.1	285	147	226	0.145	0.29053	0.00093	0.13051	0.00096	0.6439	0.0119	25.793	0.495	94	3 420	5
4.1	267	119	217	0.140	0.29001	0.00096	0.11264	0.00096	0.6706	0.0124	26.813	0.516	97	3 418	5
5.1	227	151	201	0.131	0.30268	0.00106	0.17073	0.00117	0.6944	0.0129	28.982	0.561	98	3 484	5
6.1	186	132	167	0.141	0.30469	0.00117	0.18657	0.00131	0.6978	0.0131	29.317	0.576	98	3 494	6
7.1	253	97	207	0.178	0.29762	0.00099	0.09922	0.00099	0.6790	0.0126	27.866	0.536	97	3 458	5
8.1	212	112	186	0.103	0.30139	0.00107	0.13889	0.00111	0.7062	0.0132	29.344	0.571	99	3 477	5
9.1	119	94	107	0.162	0.30792	0.00152	0.20401	0.00194	0.6881	0.0131	29.215	0.594	96	3 511	8
10.1	131	49	113	0.157	0.30833	0.00140	0.09949	0.00136	0.7075	0.0135	30.078	0.606	98	3 513	7
11.1	130	52	113	0.236	0.30590	0.00142	0.10581	0.00148	0.7144	0.0136	30.132	0.608	99	3 500	7
12.1	124	67	119	0.153	0.30837	0.00169	0.14290	0.00186	0.7657	0.0148	32.557	0.675	104	3 513	8
13.1	131	51	114	0.197	0.30542	0.00141	0.10066	0.00143	0.7117	0.0136	29.972	0.604	99	3 498	7
14.1	197	89	172	0.108	0.30213	0.00111	0.11597	0.00103	0.7121	0.0133	29.664	0.579	100	3 481	6
15.1	330	120	272	0.180	0.29313	0.00095	0.09626	0.00096	0.6873	0.0127	27.779	0.533	98	3 434	5
16.1	108	53	93	0.195	0.30200	0.00149	0.12866	0.00153	0.6932	0.0134	28.865	0.591	98	3 481	8
17.1	137	94	124	0.088	0.30919	0.00135	0.18304	0.00148	0.7036	0.0134	29.995	0.600	98	3 517	7
18.1	229	152	180	0.095	0.29041	0.00103	0.16298	0.00110	0.6292	0.0117	25.193	0.488	92	3 420	6
19.1	115	43	98	0.168	0.30199	0.00151	0.09978	0.00157	0.7031	0.0135	29.274	0.599	99	3 480	8
20.1	119	48	100	0.171	0.30314	0.00147	0.10181	0.00138	0.6924	0.0133	28.941	0.589	97	3 486	8
21.1	163	66	105	0.243	0.30636	0.00142	0.12300	0.00160	0.5188	0.0098	21.913	0.437	77	3 503	7
22.1	60	27	52	0.425	0.30296	0.00226	0.10718	0.00290	0.7095	0.0143	29.638	0.662	99	3 485	12
23.1	97	55	80	0.273	0.30488	0.00170	0.12901	0.00201	0.6647	0.0129	27.943	0.581	94	3 495	9
24.1	185	61	156	0.112	0.30562	0.00115	0.08291	0.00107	0.7049	0.0132	29.705	0.582	98	3 499	6
25.1	474	326	415	0.092	0.29566	0.00072	0.17556	0.00081	0.6891	0.0126	28.091	0.528	98	3 448	4
26.1	52	22	45	0.429	0.30181	0.00245	0.10368	0.00328	0.7040	0.0144	29.297	0.673	99	3 480	13
27.1	34	30	33	0.759	0.30694	0.00330	0.22316	0.00531	0.7197	0.0156	30.457	0.773	100	3 506	17
28.1	179	75	155	0.157	0.30389	0.00117	0.10821	0.00115	0.7062	0.0133	29.592	0.582	99	3 490	6
29.1	220	136	199	0.106	0.30768	0.00107	0.15883	0.00114	0.7136	0.0133	30.272	0.588	99	3 509	5
30.1	240	162	213	0.095	0.30610	0.00100	0.16935	0.00105	0.6977	0.0130	29.448	0.569	97	3 501	5
31.1	107	60	89	0.249	0.31136	0.00169	0.14640	0.00189	0.6613	0.0127	28.391	0.585	93	3 528	8
32.1	220	131	128	0.194	0.29666	0.00156	0.10718	0.00180	0.4796	0.0089	19.619	0.391	73	3 453	8
33.1	262	150	186	0.209	0.29763	0.00107	0.14143	0.00116	0.5703	0.0106	23.404	0.452	84	3 458	6
4.2	220	104	178	0.142	0.28062	0.00106	0.12670	0.00115	0.6648	0.0123	25.720	0.498	98	3 366	6
15.2	350	126	289	0.035	0.30231	0.00073	0.08967	0.00060	0.6896	0.0126	28.746	0.540	97	3 482	4
3.2	172	134	163	0.043	0.30579	0.00094	0.19877	0.00103	0.7305	0.0136	30.798	0.591	101	3 500	5
18.2	274	221	217	0.310	0.29090	0.00078	0.18908	0.00105	0.6161	0.0113	24.711	0.466	90	3 422	4
4.3	442	197	560	0.167	0.26780	0.00063	0.13201	0.00075	1.0459	0.0191	38.617	0.724	140	3 293	4

Analytical details

This sample was analysed on 9 April 2001. The counter deadtime during the analysis session was 32 ns. Ten analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.81 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Thirty-eight analyses were obtained from 33 zircons. Results are given in Table 27 and shown on concordia and Gaussian-summation probability density plots in Figures 40 and 41.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic-Pb redistribution, including a dominant recent episode. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to three groups. Five concordant to highly discordant analyses of four zircons (3.1, 4.1, 15.1, 18.1 and 18.2), 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 3423 ± 8 Ma (chi-squared = 1.41). Nineteen concordant and highly discordant analyses of 19 zircons (2.1, 3.2, 5.1, 6.1, 11.1, 13.1, 14.1, 15.2, 16.1, 19.1, 20.1, 21.1, 22.1, 23.1, 24.1, 26.1, 27.1, 28.1 and 30.1), 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 3491 ± 4 Ma (chi-squared = 1.68). Six concordant and highly discordant analyses of six zircons (9.1, 10.1, 12.1, 17.1, 29.1 and 31.1), assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3514 ± 7 Ma (chi-squared = 0.67). The remaining analyses are discordant and cannot be confidently grouped.

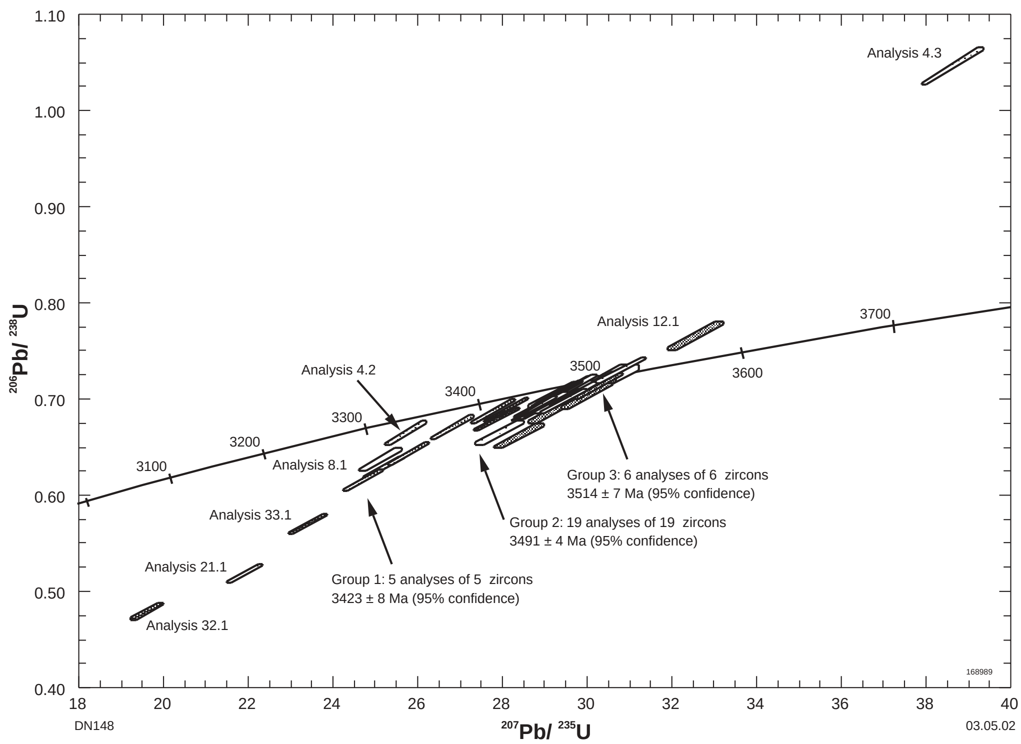

Figure 40. Concordia plot for sample 168989: coarse volcaniclastic metasandstone, Cooke Bluff Hill

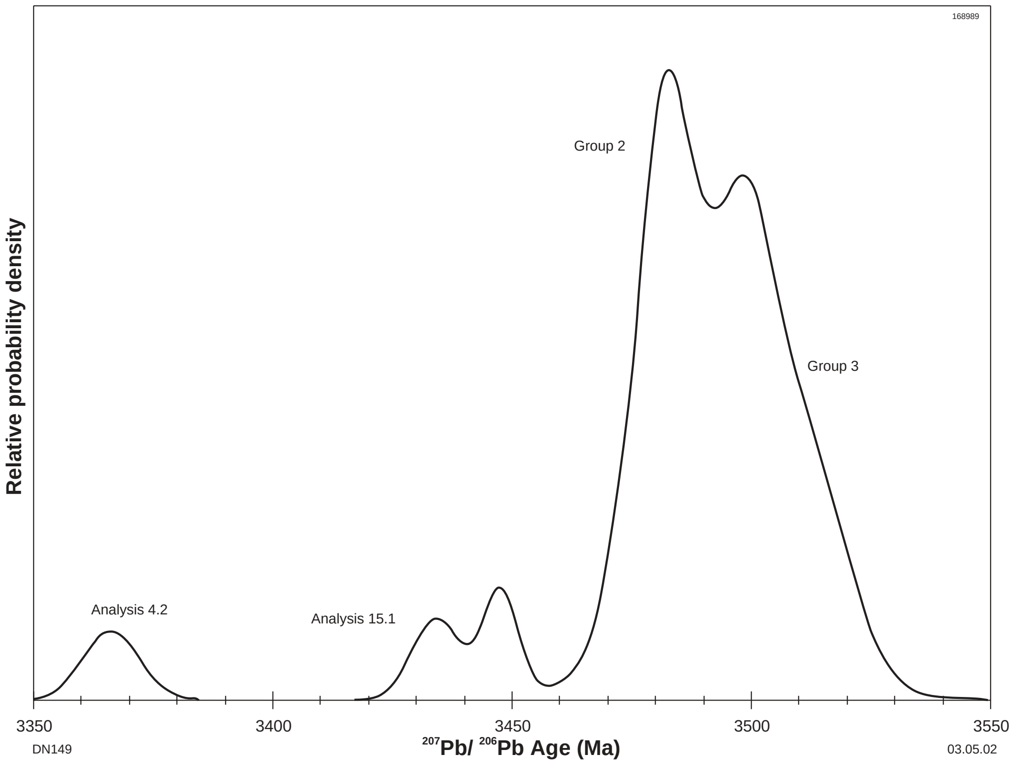

Figure 41. Gaussian-summation probability density plot for sample 168989: coarse volcaniclastic metasandstone, Cooke Bluff Hill

The date of 3491 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 19 concordant and highly discordant analyses of Group 2 is interpreted as the age of igneous crystallization of a volcanigenic component within volcanigenic sandstone. The older dates provided by the analyses of Group 3 are interpreted to be of detrital zircons. None of the analyses that indicated $^{207}Pb/^{206}Pb$ dates younger than those of Group 2, including those of Group 1, are concordant, and the younger $^{207}Pb/^{206}Pb$ dates indicated by these analyses may be due to ancient radiogenic Pb loss. If it is assumed that the observed discordance pattern (apart from that of reversely discordant analysis 4.3) is predominantly due to recent loss of radiogenic Pb from the analysis sites, then a tentative maximum depositional age of 3423 ± 8 Ma, indicated by the analyses of Group 1, may be inferred for the host volcanigenic sandstone.

168990: quartzite, Cooke Bluff Hill

Location and sampling

PORT HEDLAND – BEDOUT ISLAND (SF 50-4), CARLINDIE (2756)

MGA Zone 50, 748010E 7684310N

Sampled on 30 June 2000.

The sample was taken from a massive, irregular-shaped, 0.5 m-diameter boulder located near the base of a massive, dark grey quartzite unit exposed about halfway up a prominent, steep-sided northeast-trending ridge and 3.5 km north of Cooke Bluff Hill.

Tectonic unit/relations

This sample is a grey, massive to weakly bedded and recrystallized, medium-grey, medium- and even-grained clear quartz arenite of the Gorge Creek Group, East Pilbara Granite–Greenstone Terrane (Van Kranendonk, in prep.a).

Petrographic description

This sample consists principally of a compact aggregate of abundant single crystal quartz grains (80–85 vol.%), sericite to quartz-rich cherty polycrystalline grains (10–15 vol.%), and quartz-rich cement (5 vol.%), with accessory fine leucoxene (trace), rutile (trace), limonite (trace), and zircon (trace). The quartz grains are mostly between 0.25 and 1 mm in diameter (medium to coarse sand) and occur with sericitic to cherty lithic grains derived from a medium- to coarse-grained sandstone. There are less abundant detrital grains of decussate sericite and/or cryptocrystalline to cherty microcrystalline quartz. Minor microcrystalline quartz appears to be interstitial and may form the cement in this quartzite. There are no obvious optically continuous overgrowths but there are minor incipiently stylolitic grain boundaries. Accessory aggregates of very small leucoxene, rutile crystals and small patches of limonite are scattered. Sparse limonite occurs along stylolites.

Zircon morphology

The zircons isolated from this sample are typically pinkish brown or black fragments and whole grains, between 35 × 50 µm and 120 × 250 µm in size and equant to slightly elongate and rounded or irregular in shape. Most grains lack remnant internal zonation. A minority of grains have pitted termination surfaces, consistent with detrital transport.

Analytical details

This sample was analysed on 26 and 29 November 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, 12 analyses of the CZ3 standard indicated a Pb^*/U calibration error of 2.82 (1σ%). Analyses 1.1 to 10.1 were obtained during the first analysis session. During the second analysis session, six analyses of the CZ3 standard indicated a Pb^*/U calibration error of 2.02 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 28. Ion microprobe analytical results for sample 168990: quartzite, Cooke Bluff Hill

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	164	107	138	0.681	0.30561	0.00164	0.14204	0.00235	0.6602	0.0191	27.818	0.836	93	3 499	8
2.1	306	160	147	0.655	0.30208	0.00147	0.11315	0.00204	0.3862	0.0110	16.087	0.476	60	3 481	8
3.1	81	49	66	0.531	0.30107	0.00225	0.14395	0.00297	0.6473	0.0192	26.872	0.845	93	3 476	12
4.1	128	52	104	0.759	0.30710	0.00197	0.10709	0.00276	0.6525	0.0191	27.628	0.849	92	3 506	10
5.1	190	113	166	0.436	0.29791	0.00136	0.15333	0.00179	0.6928	0.0200	28.457	0.847	98	3 459	7
6.1	181	132	155	0.440	0.30322	0.00146	0.19219	0.00200	0.6586	0.0190	27.536	0.822	94	3 487	7
7.1	98	41	92	0.962	0.30333	0.00251	0.11730	0.00371	0.7450	0.0219	31.156	0.983	103	3 487	13
8.1	84	34	77	0.822	0.32272	0.00231	0.10432	0.00324	0.7288	0.0216	32.429	1.015	98	3 583	11
9.1	85	20	75	1.183	0.29032	0.00231	0.05273	0.00347	0.7328	0.0217	29.333	0.927	104	3 419	12
10.1	60	40	60	2.256	0.30502	0.00330	0.16684	0.00597	0.7423	0.0223	31.218	1.035	102	3 496	17
11.1	96	45	83	0.082	0.30427	0.00158	0.12123	0.00157	0.7068	0.0151	29.652	0.672	99	3 492	8
12.1	181	124	144	0.028	0.30114	0.00126	0.18864	0.00129	0.6211	0.0129	25.790	0.561	90	3 476	6
13.1	123	41	104	0.070	0.30520	0.00143	0.08602	0.00118	0.7090	0.0150	29.834	0.664	99	3 497	7
14.1	73	24	62	0.025	0.30182	0.00200	0.08818	0.00239	0.7044	0.0154	29.312	0.691	99	3 480	10
15.1	108	61	96	0.061	0.30508	0.00191	0.14502	0.00299	0.7115	0.0152	29.927	0.688	99	3 496	10
16.1	110	41	97	0.059	0.30514	0.00149	0.09686	0.00129	0.7307	0.0156	30.743	0.690	101	3 497	8
17.1	42	23	37	0.490	0.30642	0.00273	0.13859	0.00354	0.6927	0.0160	29.268	0.753	97	3 503	14
18.1	114	82	103	0.162	0.30404	0.00157	0.18959	0.00191	0.7008	0.0149	29.380	0.662	98	3 491	8
19.1	96	30	79	0.085	0.30743	0.00168	0.08070	0.00139	0.6903	0.0148	29.261	0.665	96	3 508	8
20.1	200	122	170	0.033	0.30501	0.00113	0.16657	0.00110	0.6690	0.0139	28.136	0.606	94	3 496	6
21.1	91	65	81	-0.022	0.30887	0.00172	0.19012	0.00173	0.6894	0.0149	29.360	0.674	96	3 515	9
22.1	90	41	82	0.101	0.30633	0.00172	0.11846	0.00184	0.7415	0.0160	31.319	0.720	102	3 503	9
23.1	68	24	59	0.072	0.30376	0.00205	0.09084	0.00238	0.7134	0.0156	29.878	0.708	99	3 490	10
24.1	114	51	101	0.023	0.30707	0.00145	0.11710	0.00118	0.7200	0.0153	30.482	0.683	100	3 506	7
25.1	131	91	126	0.156	0.30476	0.00139	0.18002	0.00160	0.7506	0.0159	31.540	0.700	103	3 495	7
26.1	98	51	89	0.139	0.30396	0.00169	0.13485	0.00184	0.7285	0.0156	30.530	0.697	101	3 491	9
27.1	144	96	131	0.044	0.30425	0.00132	0.17302	0.00133	0.7143	0.0151	29.963	0.661	99	3 492	7
28.1	68	53	63	0.111	0.31125	0.00206	0.20569	0.00260	0.7072	0.0155	30.349	0.720	98	3 527	10
29.1	91	58	86	0.065	0.30760	0.00172	0.16593	0.00191	0.7432	0.0160	31.519	0.724	102	3 509	9
30.1	59	25	52	0.246	0.30519	0.00227	0.11493	0.00267	0.7172	0.0160	30.182	0.734	100	3 497	11
31.1	65	30	59	0.100	0.30694	0.00215	0.11852	0.00253	0.7373	0.0164	31.203	0.751	102	3 506	11
32.1	44	17	39	0.193	0.30147	0.00257	0.10283	0.00304	0.7304	0.0168	30.359	0.773	102	3 478	13

Results

Thirty-two analyses were obtained from 32 zircons. Results are given in Table 28 and shown on concordia and Gaussian-summation probability density plots in Figures 42 and 43.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes, including a dominant recent episode, of radiogenic-Pb redistribution. Twenty-seven concordant and slightly discordant analyses of 27 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3496 ± 4 Ma (chi-squared = 0.72). Concordant analyses 8.1 and 28.1 indicate slightly older $^{207}Pb/^{206}Pb$ dates than the main population, whereas near-concordant analyses 9.1 and 5.1, and discordant analysis 12.1, indicate slightly younger $^{207}Pb/^{206}Pb$ dates than the main population.

The date of 3496 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 19 concordant and highly discordant analyses is interpreted as the age of igneous crystallization of a magmatic (probably volcanigenic) component within the sandstone precursor to the quartzite. This date therefore also provides a maximum age for deposition of the sandstone precursor to the quartzite. The $^{207}Pb/^{206}Pb$ date of 3459 ± 7 Ma (1σ error) indicated by concordant analysis 5.1, obtained on an irregular-shaped, structureless grain fragment, may tentatively be interpreted as a younger maximum age for deposition of the sandstone precursor to the quartzite. The older dates

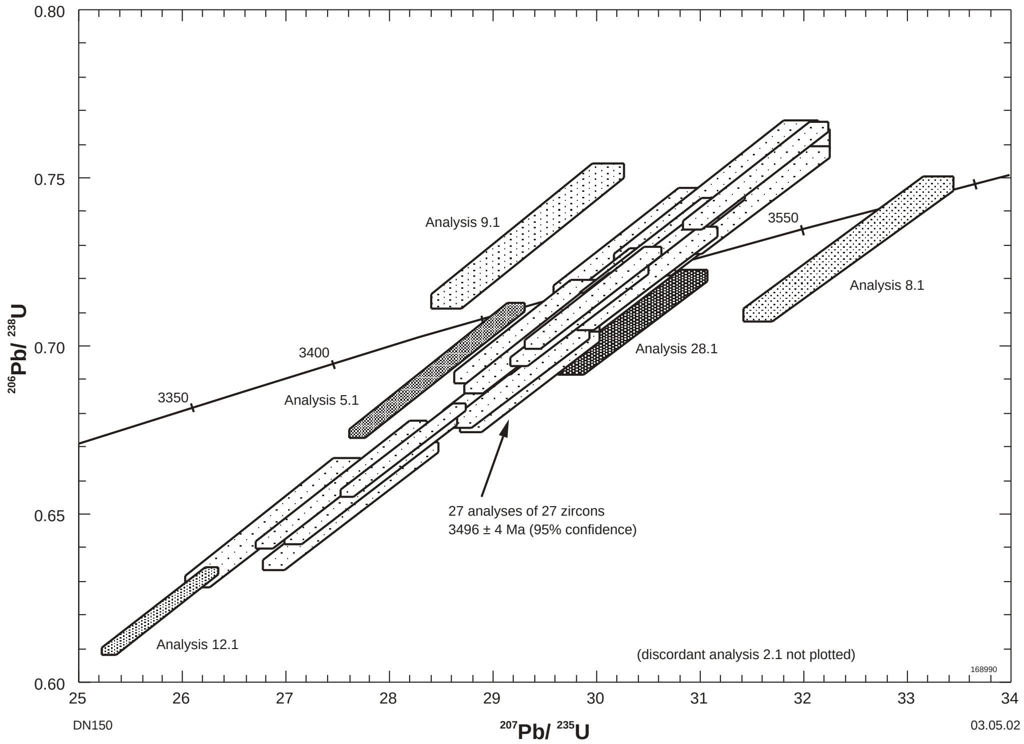

Figure 42. Concordia plot for sample 168990: quartzite, Cooke Bluff Hill

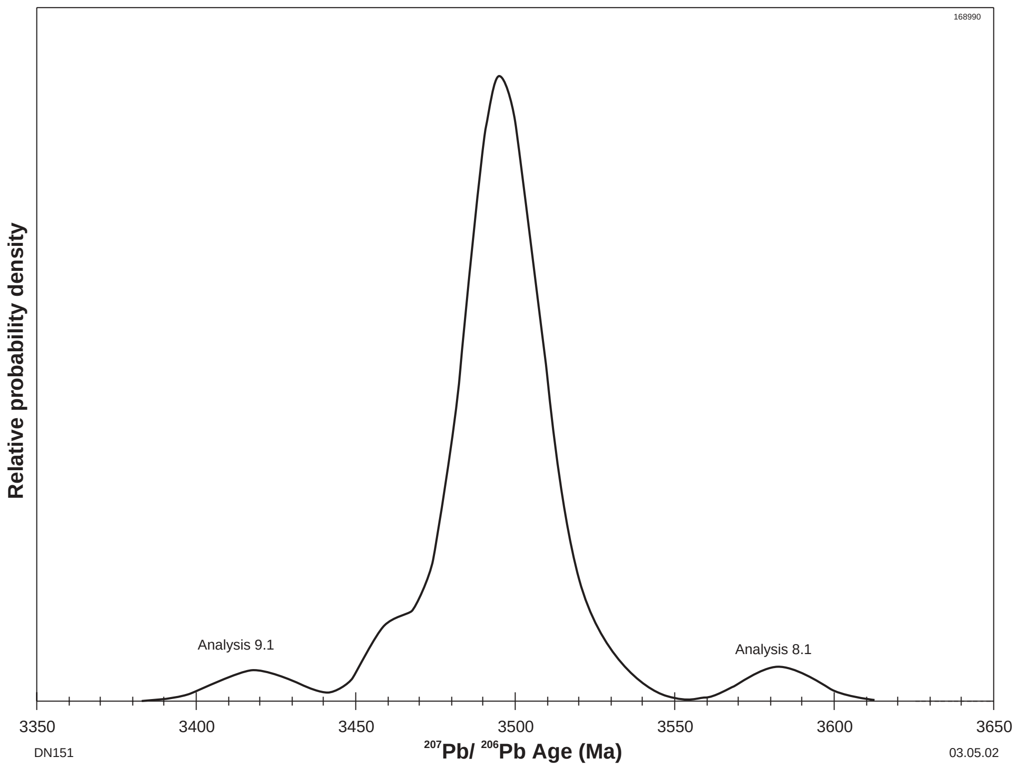

Figure 43. Gaussian-summation probability density plot for sample 168990: quartzite, Cooke Bluff Hill

indicated by analysis 25.1 and 28.1 are interpreted to be of detrital zircons, whereas the younger $^{207}Pb/^{206}Pb$ dates indicated by discordant analyses 9.1 and 12.1 may be due to ancient loss of radiogenic Pb from these analysis sites.

168991: volcaniclastic metasandstone, Montey Bore

Location and sampling

PORT HEDLAND – BEDOUT ISLAND (SF 50-4), CARLINDIE (2756)   MGA Zone 50, 749170E 7687070N

Sampled on 30 June 2000.

The sample was taken from several 0.5 m-diameter boulders in a small creek bed on the southwestern side of a northeast-trending ridge and 6 km east of Montey Bore.

Tectonic unit/relations

This sample is a massive, light grey, white and light yellow silicified volcaniclastic sandstone of the Coonterunah Group or Warrawoona Group, East Pilbara Granite–Greenstone Terrane. The sandstone consists of 1 to 4 mm-diameter, clear quartz grains and chert fragments set within a white structureless siliceous matrix. The sandstone lies within a felsic volcanic unit up to 750 m thick, which overlies pillowed basalts of the Coonterunah Group or Warrawoona Group, and unconformably underlies shales of the Gorge Creek Group (Van Kranendonk, in prep.a).

Petrographic description

This sample consists principally of single crystal quartz grains (60 vol.%), lithic fragments (35 vol.%), and altered biotite (3–4 vol.%), with accessory apatite (trace), and rare zircon (trace). This is a massive, siliceous and silicified lithic sandstone, with abundant angular coarse quartz grains and subordinate sericite to quartz-rich altered mafic and felsic volcanic clasts, that was possibly derived from a bimodal volcanic source. Abundant single crystal angular to subrounded quartz grains, 1 to 3 mm in diameter, include some of volcanic phenocrystal origin. Scattered lamellar-form quartz–leucoxene and/or sericite pseudomorphs of biotite flakes, to 2 mm long, are apparently also derived from phenocrysts. Numerous lithic fragments commonly have good textural preservation, within secondary fine quartz, sericite and leucoxene in various proportions. The textures indicate replacement of a dendritic mineral, probable plagioclase, in a leucoxene-rich groundmass, locally with clearly defined opaque oxide dendrites. The abundance of leucoxene suggests a mafic source for these clasts, possibly a siliceous high-Mg basalt. Other more abundant sericite- to quartz-rich lithic fragments, with little or no textural preservation, and little or no leucoxene, coupled with a former biotite phenocryst in one fragment, indicate possible derivation from felsic volcanic source rocks. There is rare apatite and two crystals of zircon were observed. A minor matrix of indefinite cryptocrystalline quartz and sericite occurs throughout. Greenschist facies metamorphism is inferred.

Zircon morphology

The zircons isolated from this sample are typically yellowish or greenish brown or black fragments and whole grains, between 35 × 50 µm and 120 × 250 µm in size and equant to slightly elongate and rounded or irregular in shape. Many grains have remnant internal zonation and many are metamict. A minority of grains have sculpted surfaces or pitted terminations, consistent with detrital transport.

Table 29. Ion microprobe analytical results for sample 168991: volcaniclastic metasandstone, Montey Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	182	138	160	0.271	0.30394	0.00124	0.20304	0.00156	0.6736	0.0194	28.228	0.835	95	3 490	6
2.1	817	732	547	0.196	0.26131	0.00059	0.25948	0.00086	0.5087	0.0144	18.330	0.526	81	3 255	4
3.1	48	15	42	1.780	0.30029	0.00324	0.07921	0.00547	0.7126	0.0215	29.506	0.982	100	3 472	17
4.1	593	315	379	0.330	0.28305	0.00078	0.16905	0.00102	0.5056	0.0144	19.732	0.570	78	3 380	4
5.1	972	722	387	0.390	0.30701	0.00144	0.15538	0.00187	0.3130	0.0089	13.251	0.391	50	3 506	7
6.1	115	49	91	0.506	0.30733	0.00165	0.10477	0.00217	0.6407	0.0186	27.150	0.819	91	3 508	8
7.1	121	67	104	0.459	0.30508	0.00161	0.14814	0.00212	0.6736	0.0195	28.336	0.853	95	3 496	8
8.1	193	92	169	0.212	0.30406	0.00115	0.12487	0.00125	0.7080	0.0203	29.682	0.873	99	3 491	6
9.1	108	48	87	0.371	0.30652	0.00178	0.12105	0.00222	0.6482	0.0189	27.394	0.835	92	3 503	9
10.1	432	263	350	0.202	0.29469	0.00082	0.16105	0.00096	0.6422	0.0183	26.092	0.756	93	3 443	4
11.1	182	112	152	0.219	0.30533	0.00128	0.16171	0.00142	0.6580	0.0190	27.699	0.821	93	3 497	6
12.1	589	359	460	0.394	0.26644	0.00073	0.16550	0.00104	0.6253	0.0178	22.972	0.664	95	3 285	4
13.1	330	161	206	0.318	0.28235	0.00105	0.13452	0.00130	0.5068	0.0145	19.730	0.577	78	3 376	6
14.1	248	145	183	0.134	0.30126	0.00114	0.15295	0.00124	0.5858	0.0168	24.335	0.715	85	3 477	6
15.1	62	26	51	0.525	0.30366	0.00242	0.10612	0.00322	0.6692	0.0200	28.017	0.895	95	3 489	12
16.1	302	138	178	0.255	0.30497	0.00123	0.15956	0.00141	0.4651	0.0133	19.559	0.574	70	3 496	6
17.1	107	45	81	0.489	0.31188	0.00205	0.12347	0.00261	0.6021	0.0177	25.893	0.800	86	3 530	10
18.1	547	240	216	0.407	0.29998	0.00118	0.19527	0.00164	0.3035	0.0086	12.551	0.366	49	3 470	6
19.1	548	421	283	0.248	0.25944	0.00082	0.20168	0.00112	0.4078	0.0116	14.588	0.423	68	3 243	5
20.1	350	202	259	0.188	0.30139	0.00096	0.14855	0.00104	0.5903	0.0168	24.529	0.714	86	3 477	5
21.1	170	83	144	0.319	0.30512	0.00137	0.12933	0.00160	0.6805	0.0196	28.627	0.852	96	3 496	7
22.1	105	44	91	0.725	0.30384	0.00191	0.10338	0.00274	0.6989	0.0205	29.279	0.899	98	3 490	10
23.1	186	37	151	0.479	0.30565	0.00137	0.05149	0.00163	0.6849	0.0197	28.865	0.857	96	3 499	7
24.1	726	352	307	0.292	0.28787	0.00083	0.11637	0.00094	0.3472	0.0098	13.781	0.398	56	3 406	4
25.1	97	46	87	0.473	0.31062	0.00195	0.13027	0.00258	0.7106	0.0209	30.436	0.937	98	3 524	10
26.1	98	42	86	0.712	0.30351	0.00199	0.11037	0.00272	0.7078	0.0208	29.618	0.913	99	3 488	10
27.1	538	275	409	0.159	0.28337	0.00072	0.13205	0.00077	0.6220	0.0177	24.301	0.701	92	3 382	4
28.1	179	54	145	0.413	0.30420	0.00153	0.08110	0.00185	0.6717	0.0194	28.172	0.845	95	3 492	8
29.1	101	42	86	0.766	0.30713	0.00192	0.10833	0.00261	0.6823	0.0201	28.891	0.891	96	3 507	10
30.1	50	28	48	2.309	0.30096	0.00358	0.14856	0.00642	0.7266	0.0221	30.151	1.027	101	3 475	18
31.1	92	37	80	0.774	0.30509	0.00206	0.10276	0.00280	0.7003	0.0206	29.460	0.912	98	3 496	10
32.1	59	24	49	1.586	0.30840	0.00339	0.10368	0.00557	0.6435	0.0196	27.365	0.920	91	3 513	17

Analytical details

This sample was analysed on 26 November 2001. The counter deadtime during the analysis session was 32 ns. Twelve analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 2.82 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Thirty-two analyses were obtained from 32 zircons. Results are given in Table 29 and shown on concordia and Gaussian-summation probability density plots in Figures 44 and 45.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes, including a dominant recent episode, of radiogenic-Pb redistribution. Nineteen concordant and highly discordant analyses of 19 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3496 ± 4 Ma (chi-squared = 0.72). Concordant analysis 25.1 indicated a slightly older $^{207}Pb/^{206}Pb$ date than the main population, whereas the remaining analyses are discordant and cannot be confidently grouped.

The date of 3496 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 19 concordant and highly discordant analyses is interpreted as the age of igneous crystallization of a volcanigenic component within the volcanigenic sandstone. This

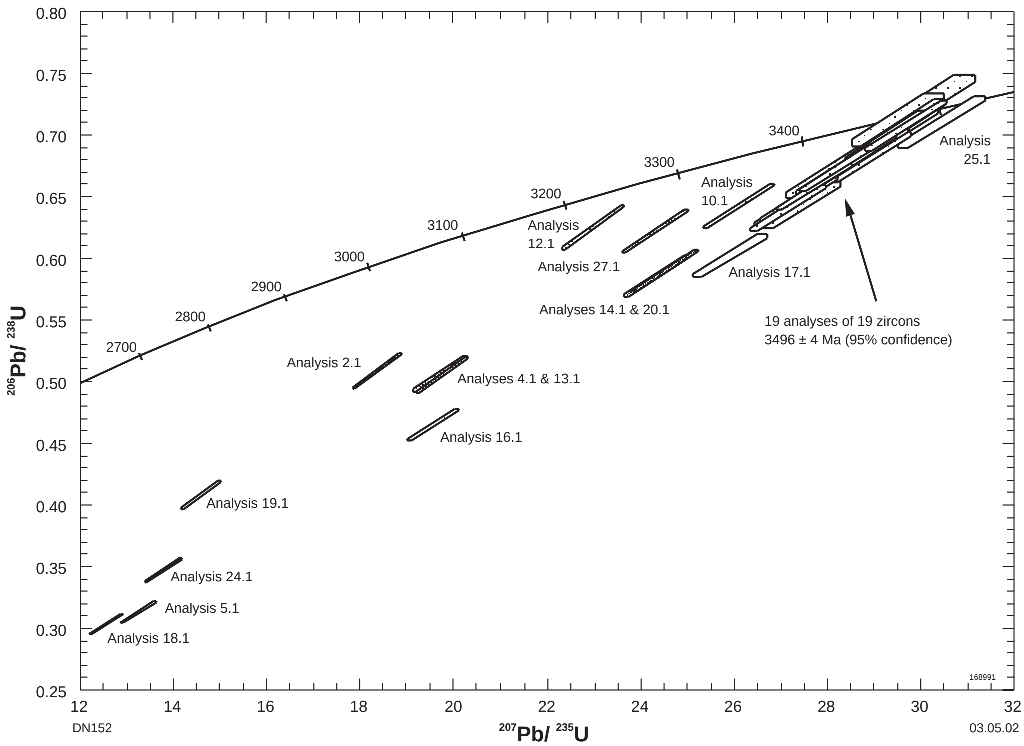

Figure 44. Concordia plot for sample 168991: volcaniclastic metasandstone, Montey Bore

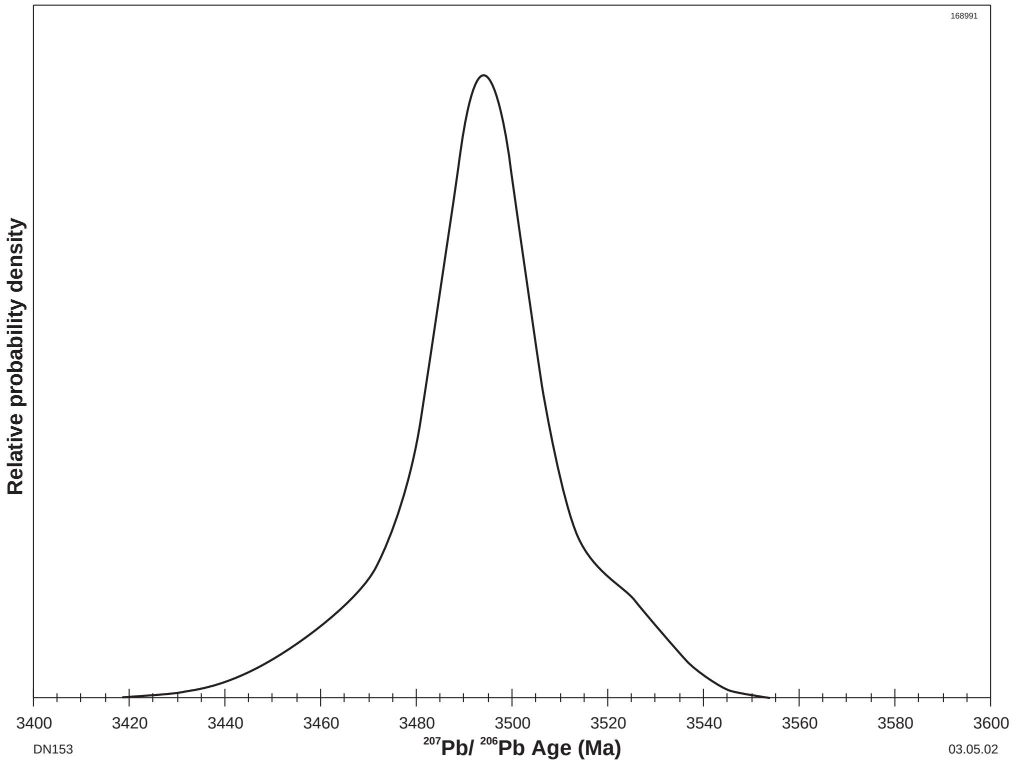

Figure 45. Gaussian-summation probability density plot for sample 168991: volcaniclastic metasandstone, Montey Bore

date therefore also provides a maximum age for deposition of the volcanigenic sandstone. The older date indicated by analysis 25.1 is interpreted to be of a detrital zircon. The younger $^{207}Pb/^{206}Pb$ dates indicated by the remaining discordant analyses are interpreted to be due to ancient loss of radiogenic Pb from these analysis sites.

168993: volcaniclastic metasandstone, Bob Bore

Location and sampling

PORT HEDLAND – BEDOUT ISLAND (SF 50-4), CARLINDIE (2756)   MGA Zone 50, 751650E 7689200N

Sampled on 30 June 2000.

The sample was taken from a low rocky outcrop located on the western side and near the southern end of a low rocky quartzite ridge, and 7 km east-southeast of Bob Bore.

Tectonic unit/relations

This sample is a strongly recrystallized, massive but fractured light grey quartzite derived from a medium- to coarse-grained sandstone, of the Coonterunah Group, East Pilbara Granite–Greenstone Terrane (Van Kranendonk, in prep.a).

Petrographic description

This sample consists principally of single crystal quartz grains (40 vol.%), silicified altered lithic grains (5 vol.%), and siliceous cement (50 vol.%). This is a coarse-grained, quartz-rich sandstone with minor altered mixed volcanic clasts, with an extensive intergranular chalcedonic cement and minor stringers of quartz and barite. The cherty to chalcedonic quartz cement may indicate an exhalative or low-temperature hydrothermal component. About 50 vol.% of this sample consists of a very loose-packed aggregate of rounded single crystal quartz grains, and silicified rounded to subrounded lithic grains, all 0.25 to 1 mm in diameter. The lithic grains have been altered to ultrafine chalcedonic silica and occur with or without sericite and/or leucoxene. A bimodal source for the lithic grains is suggested by the presence of both leucoxene-rich and leucoxene-poor clasts. The rock is cut by abundant very narrow quartz stringers. Some of these veins are purely extensional, but along others there are minor offsets in the quartz clasts, generally of no more than 0.2 mm. A poorly defined quartz vein, 0.2 to 1 mm wide, has very minor fine-grained barite and microcrystalline opaque oxide.

Zircon morphology

The zircons isolated from this sample are typically pinkish brown or black fragments and whole grains, between 35 × 40 µm and 60 × 100 µm in size and equant to slightly elongate, and rounded or irregular in shape. Most grains lack internal zonation, and many are fractured. A minority of grains have sculpted surfaces or pitted terminations, consistent with detrital transport.

Analytical details

This sample was analysed on 14 December 2001. The counter deadtime during the analysis session was 32 ns. Seven analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 3.06 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 30. Ion microprobe analytical results for sample 168993: volcaniclastic metasandstone, Bob Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	324	203	293	0.210	0.30792	0.00083	0.16352	0.00095	0.7082	0.0218	30.066	0.940	98	3 511	4
2.1	321	168	280	0.078	0.30806	0.00081	0.13685	0.00077	0.6990	0.0215	29.691	0.928	97	3 511	4
3.1	67	34	59	1.471	0.30352	0.00246	0.12533	0.00401	0.6884	0.0217	28.808	0.967	97	3 488	13
4.1	69	45	63	0.461	0.30635	0.00199	0.17126	0.00282	0.7076	0.0223	29.890	0.986	98	3 503	10
5.1	202	199	193	0.260	0.30865	0.00108	0.26702	0.00152	0.6995	0.0216	29.766	0.938	97	3 514	5
6.1	47	21	42	1.129	0.30670	0.00277	0.11738	0.00441	0.7026	0.0224	29.711	1.018	98	3 504	14
7.1	196	137	179	0.408	0.30693	0.00116	0.18928	0.00157	0.6998	0.0216	29.614	0.936	98	3 506	6
8.1	134	83	120	0.192	0.30661	0.00129	0.16238	0.00149	0.7017	0.0218	29.663	0.946	98	3 504	7
9.1	231	142	207	0.103	0.30665	0.00094	0.15773	0.00098	0.7092	0.0219	29.985	0.942	99	3 504	5
10.1	48	22	42	0.508	0.30558	0.00233	0.12436	0.00302	0.7075	0.0225	29.812	1.002	99	3 499	12
11.1	158	161	156	0.157	0.30707	0.00113	0.26599	0.00147	0.7239	0.0225	30.649	0.971	100	3 506	6
12.1	121	97	116	0.519	0.30697	0.00161	0.21193	0.00227	0.7177	0.0224	30.377	0.981	99	3 506	8
13.1	104	78	98	0.233	0.30351	0.00158	0.19378	0.00192	0.7230	0.0227	30.256	0.980	101	3 488	8
14.1	251	209	238	0.435	0.30525	0.00106	0.22204	0.00147	0.7123	0.0220	29.979	0.945	99	3 497	5
15.1	135	104	129	0.698	0.30939	0.00157	0.20302	0.00230	0.7197	0.0224	30.704	0.989	99	3 518	8
16.1	71	25	62	0.700	0.30615	0.00219	0.09481	0.00291	0.7116	0.0225	30.037	1.000	99	3 502	11
17.1	192	91	168	0.101	0.30975	0.00115	0.12607	0.00105	0.7059	0.0219	30.148	0.955	98	3 520	6
18.1	168	122	155	0.156	0.30881	0.00122	0.19282	0.00138	0.7102	0.0221	30.239	0.962	98	3 515	6
19.1	129	74	117	0.193	0.30518	0.00145	0.15099	0.00170	0.7164	0.0223	30.146	0.969	100	3 497	7
20.1	197	172	190	0.140	0.30846	0.00115	0.22809	0.00143	0.7277	0.0226	30.951	0.980	100	3 513	6
21.1	101	51	90	0.187	0.30913	0.00162	0.13444	0.00175	0.7120	0.0223	30.349	0.984	99	3 517	8
22.1	46	14	39	0.771	0.30767	0.00286	0.07697	0.00407	0.7055	0.0227	29.927	1.035	98	3 509	14
23.1	72	34	62	0.309	0.31024	0.00206	0.13002	0.00247	0.6913	0.0218	29.572	0.978	96	3 522	10
24.1	57	33	53	0.490	0.30884	0.00272	0.15145	0.00399	0.7377	0.0235	31.413	1.070	101	3 515	14
25.1	78	42	69	0.171	0.30759	0.00183	0.14177	0.00195	0.7108	0.0224	30.145	0.988	99	3 509	9
26.1	87	52	79	0.043	0.30692	0.00167	0.15982	0.00160	0.7203	0.0226	30.481	0.992	100	3 505	8
27.1	161	133	152	0.162	0.30705	0.00126	0.21467	0.00149	0.7180	0.0223	30.395	0.968	99	3 506	6
28.1	111	52	95	0.150	0.30359	0.00164	0.12483	0.00181	0.6972	0.0218	29.185	0.946	98	3 489	8
29.1	192	123	174	0.086	0.30464	0.00115	0.16614	0.00122	0.7162	0.0222	30.081	0.953	100	3 494	6
30.1	265	207	251	0.096	0.30920	0.00100	0.20580	0.00112	0.7245	0.0224	30.887	0.973	100	3 517	5

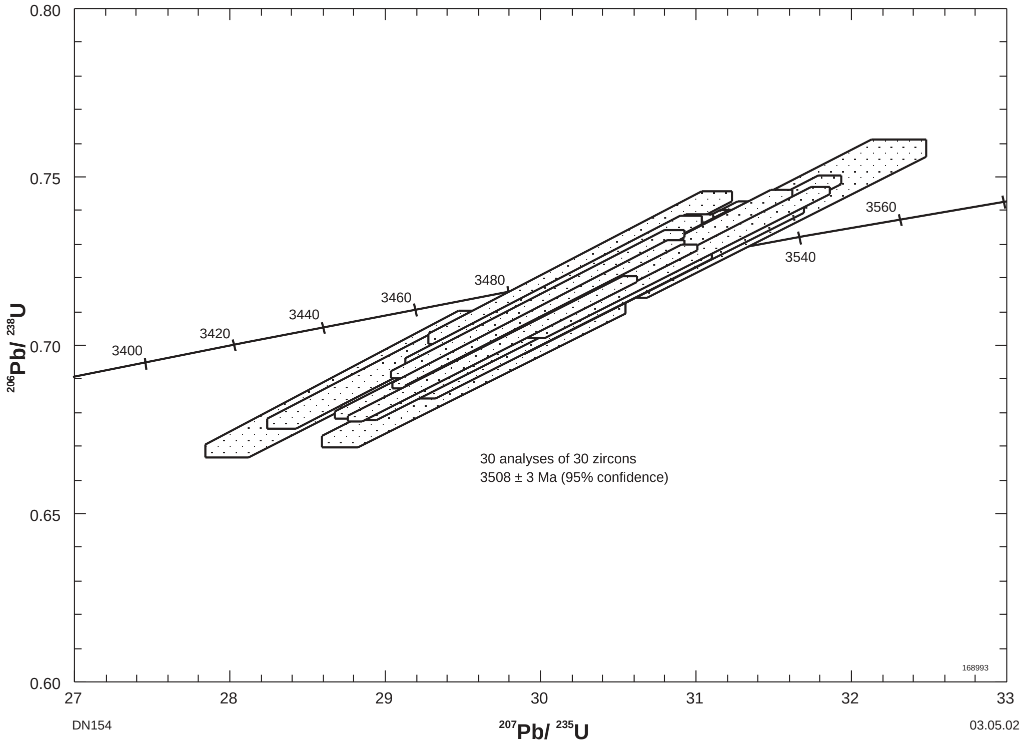

Figure 46. Concordia plot for sample 168993: volcaniclastic metasandstone, Bob Bore

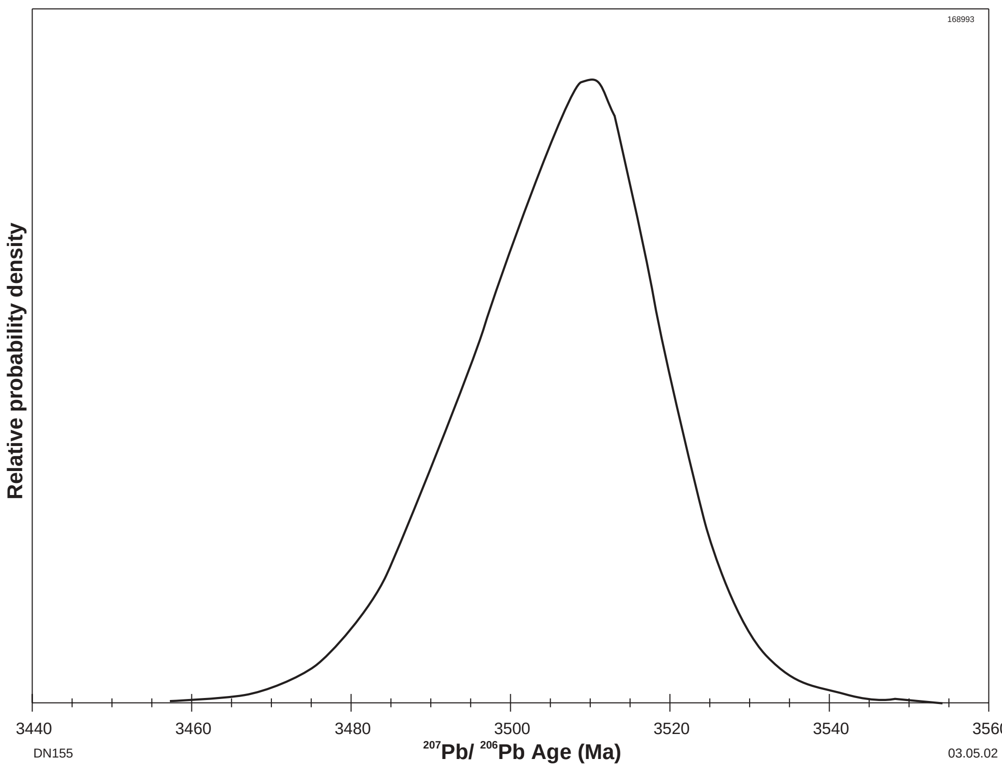

Figure 47. Gaussian-summation probability density plot for sample 168993: volcaniclastic metasandstone, Bob Bore

Results

Thirty analyses were obtained from 30 zircons. Results are given in Table 30 and shown on concordia and Gaussian-summation probability density plots in Figures 46 and 47.

Interpretation

The analyses are concordant and have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3508 ± 3 Ma (chi-squared = 1.53).

The date of 3508 ± 3 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of all 30 concordant analyses is interpreted as the age of igneous crystallization of a volcanigenic component within the volcanigenic sandstone. This date therefore also provides a maximum age for deposition of the volcanigenic sandstone.

168995: altered rhyolite, Farrel Well

Location and sampling

PORT HEDLAND – BEDOUT ISLAND (SF 50-4), CARLINDIE (2756)   MGA Zone 50, 755210E 7694250N

Sampled on 1 July 2000.

The sample was taken from the southwestern side of a small creek bed, at a site where the creek has transected a north-northeasterly trending ridge, 8 km west of Farrel Well.

Tectonic unit/relations

This sample is an altered, medium greyish white porphyritic rhyolite flow or sill from the Coonterunah Group or Warrawoona Group of the East Pilbara Granite–Greenstone Terrane (Van Kranendonk, in prep.a). The rhyolite contains sparse quartz phenocryst remnants up to 2 mm in diameter, and rectangular dark vacancies that may have contained feldspar phenocrysts. The sample contained numerous clear quartz veins up to 2 mm in thickness.

Petrographic description

This sample consists principally of phenocrysts of quartz (2–3 vol.%) and feldspar (<1 vol.%) within a groundmass of quartz, K-feldspar and sericite (>95 vol.%). This is a rhyolite that has been altered to an assemblage of quartz, sericite and minor K-feldspar and that contains a large limonite and leucoxene-rich fragment, a cross-cutting stringer of fine-grained quartz–adularia and limonite-lined fractures. Most of this hand specimen is white, with a 50 × 40 mm reddish area with cuspate boundaries that may be a rock fragment. The pale area consists of rhyolite with sparse rounded quartz phenocrysts from 0.5 to 1.5 mm in diameter and rare phenocrysts altered to K-feldspar, sericite and limonite. These occur in a massive micromosaic groundmass dominated by microgranular quartz, clouded by sericite with interstitial K-feldspar, possibly adularia. A single 4 mm-diameter fragment is richer in limonite and slightly coarser in grain size than the host rock. The large reddish area has obvious relicts of former feldspar, now altered to sericite and possibly K-feldspar, set in poikilitic secondary quartz grains, mostly to 0.2 mm in grain size. This area has more quartz and less K-feldspar, but no phenocrysts. Minor larger patches of quartz are scattered, to 0.4 mm in grain size. Both limonite and leucoxene are more abundant in these patches than in the host rock. This may represent a rock fragment that was less felsic than the host rock. There is a cross-cutting 0.5 mm-wide quartz veinlet with minor adularia, and a limonite-lined fracture.

Zircon morphology

The zircons isolated from this sample are typically dark yellowish or greenish brown or black fragments and whole grains, between 30 × 45 µm and 80 × 100 µm in size and equant to slightly elongate and euhedral in shape, but a minority of grains are rounded and have pitted terminations, suggesting detrital transport. Most grains have remnant internal zonation and fluid inclusions and many are metamict.

Table 31. Ion microprobe analytical results for sample 168995: altered rhyolite, Farrel Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	±1 σ	$^{208}Pb/^{206}Pb$	±1 σ	$^{206}Pb/^{238}U$	±1 σ	$^{207}Pb/^{235}U$	±1 σ	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	±1 σ
1.1	334	130	304	0.129	0.30604	0.00081	0.10558	0.00076	0.7471	0.0104	31.523	0.456	103	3 501	4
2.1	492	301	357	0.494	0.28564	0.00072	0.15228	0.00102	0.5776	0.0079	22.746	0.325	87	3 394	4
3.1	551	203	473	0.145	0.30596	0.00064	0.09798	0.00063	0.7065	0.0097	29.804	0.422	98	3 501	3
4.1	447	176	424	0.645	0.30240	0.00085	0.10261	0.00120	0.7697	0.0106	32.094	0.464	106	3 483	4
5.1	1 234	676	1 064	0.136	0.30395	0.00043	0.13852	0.00045	0.6918	0.0094	28.992	0.402	97	3 490	2
6.1	182	59	159	0.056	0.30732	0.00101	0.08506	0.00089	0.7273	0.0104	30.816	0.463	100	3 508	5
7.1	1474	846	1 064	0.373	0.26825	0.00040	0.14723	0.00055	0.5859	0.0080	21.672	0.301	90	3 296	2
8.1	259	110	225	0.091	0.30670	0.00093	0.10574	0.00082	0.7110	0.0100	30.064	0.442	99	3 504	5
9.1	930	579	861	0.033	0.30491	0.00046	0.16218	0.00044	0.7322	0.0100	30.784	0.428	101	3 495	2
10.1	1 328	983	1 167	0.067	0.29840	0.00039	0.19388	0.00043	0.6828	0.0093	28.094	0.389	97	3 462	2
11.1	182	81	179	0.467	0.30437	0.00118	0.11553	0.00153	0.7934	0.0112	33.298	0.503	108	3 493	6
12.1	1 000	551	758	0.311	0.29178	0.00049	0.14109	0.00061	0.6091	0.0083	24.503	0.341	89	3 427	3
13.1	1 056	547	864	0.052	0.29787	0.00045	0.12876	0.00041	0.6649	0.0091	27.309	0.380	95	3 459	2
14.1	418	195	364	0.047	0.30591	0.00068	0.11584	0.00061	0.7112	0.0098	29.998	0.428	99	3 500	3
15.1	843	381	700	0.124	0.30364	0.00040	0.12380	0.00040	0.6731	0.0150	28.178	0.634	95	3 489	2
16.1	751	534	654	0.018	0.30530	0.00042	0.19135	0.00042	0.6755	0.0151	28.434	0.641	95	3 497	2
17.1	220	85	189	0.032	0.30639	0.00080	0.10055	0.00063	0.7072	0.0159	29.878	0.687	98	3 503	4
18.1	541	186	478	0.001	0.30444	0.00052	0.09104	0.00035	0.7357	0.0165	30.881	0.699	102	3 493	3
19.1	910	440	815	0.016	0.30505	0.00039	0.12809	0.00032	0.7253	0.0162	30.505	0.687	101	3 496	2
20.1	696	355	613	0.115	0.30554	0.00045	0.13589	0.00045	0.7070	0.0158	29.786	0.672	99	3 499	2
21.1	272	190	256	0.015	0.30576	0.00071	0.18639	0.00073	0.7329	0.0165	30.897	0.707	101	3 500	4
22.1	1 194	654	1 012	0.016	0.29642	0.00036	0.14692	0.00032	0.6817	0.0152	27.863	0.627	97	3 452	2
23.1	581	338	530	0.009	0.30598	0.00049	0.15087	0.00043	0.7266	0.0162	30.654	0.693	101	3 501	2
24.1	1 179	592	1 049	0.019	0.30243	0.00034	0.13268	0.00028	0.7194	0.0160	29.998	0.674	100	3 483	2

Analytical details

This sample was analysed on 25 and 31 March 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.35 (1σ%). Analyses 1.1 to 14.1 were obtained during the first analysis session. During the second analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of 2.23 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 2.1, 5.1, 7.1, 12.1, 15.1 and 20.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-four analyses were obtained from 24 zircons. Results are given in Table 31 and shown on a concordia plot in Figure 48.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic Pb redistribution, including a dominant recent episode. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to two groups. Fourteen concordant and highly discordant analyses of 14 zircons (1.1, 3.1, 6.1, 8.1, 9.1, 11.1, 14.1, 16.1, 17.1, 18.1, 19.1, 20.1, 21.1 and 23.1), 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 3498 ± 2 Ma (chi-squared = 1.22). Discordant analyses 4.1, 5.1 and 15.1, 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 3489 ± 8 Ma (chi-squared = 1.13).

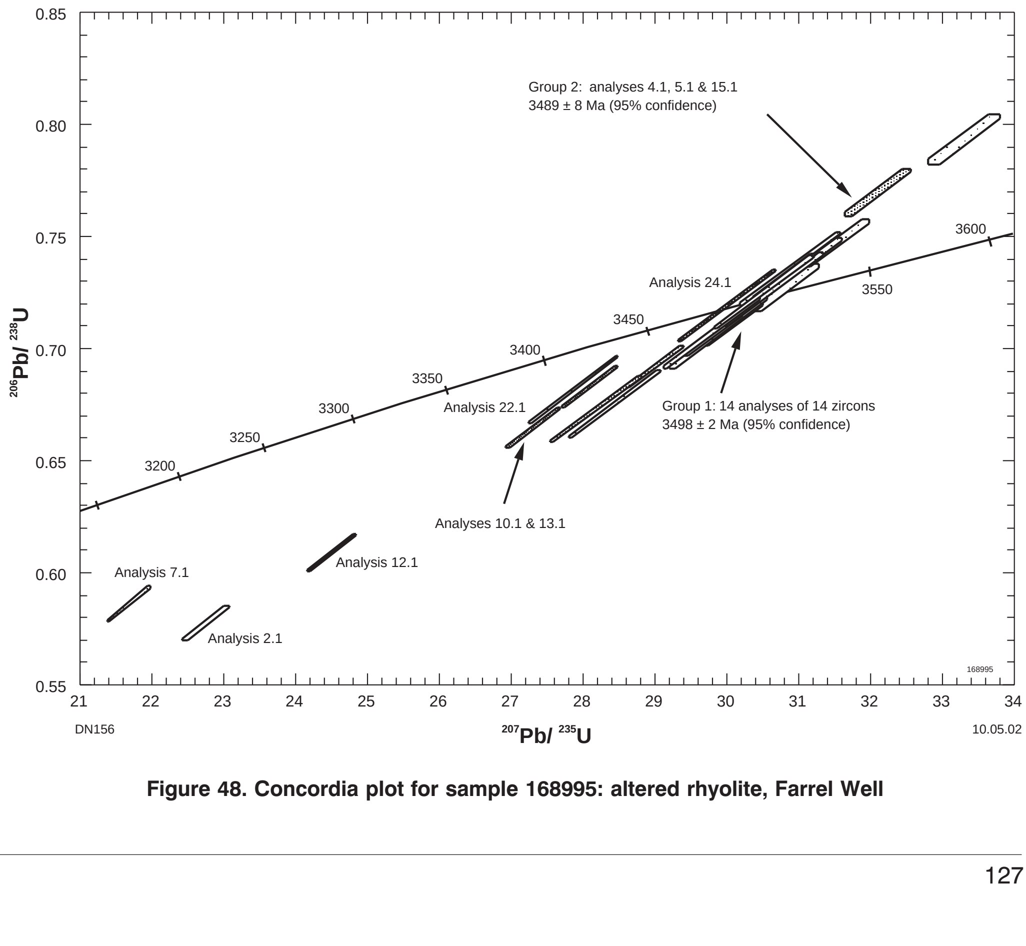

Figure 48. Concordia plot for sample 168995: altered rhyolite, Farrel Well

Analyses 2.1, 7.1, 10.1, 12.1, 13.1 and 14.1 and 24.1 are discordant and cannot be grouped.

The analyses of Group 2 are discordant and indicated generally high proportions of common Pb, and therefore the geological significance of the date of 3489 ± 8 Ma indicated by the analyses of Group 2 is not clear. The preferred interpretation is that the date of 3498 ± 2 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 14 analyses of Group 1 corresponds to the age of igneous crystallization of the felsic volcanic precursor to the altered rhyolite, with the younger date indicated by the analyses of Group 2 possibly corresponding to the timing of an ancient disturbance event during which these analysis sites lost radiogenic Pb. The remaining analyses are discordant or, in the case of 24.1, indicate high U contents, and are interpreted to be analysis sites that have lost some of their accumulated radiogenic Pb during several disturbance events.

168996: altered coarse crystal tuff, Farrel Well

Location and sampling

PORT HEDLAND – BEDOUT ISLAND (SF 50-4), CARLINDIE (2756) MGA Zone 50, 759540E 7693420N

Sampled on 1 July 2000.

The sample was taken from a 0.5 m-diameter boulder at a prominent rocky outcrop on the western side of a small creek bed, 4 km west-southwest of Farrel Well.

Tectonic unit/relations

This sample is an altered, light greenish grey, porphyritic rhyolite tuff of the Warrawoona Group, East Pilbara Granite–Greenstone Terrane (Van Kranendonk, in prep.a). The tuff contains sparse remnant quartz phenocrysts up to 2 mm diameter and 1–2 mm black chert fragments. At the sampling site, the abundance of quartz phenocrysts is highly variable over a stratigraphic thickness of less than 1 m. The tuff contains bleached white and pink alteration zones and numerous quartz veins up to 1 mm thick.

Petrographic description

This sample consists principally of altered felsic lithic material and former feldspar phenocrysts (50 vol.%) in a cryptocrystalline siliceous matrix (20–25 vol.%), with quartz phenocrysts (25 vol.%), and former biotite phenocrysts (1–2 vol.%). This is an altered coarse crystal tuff or coarse volcaniclastic sedimentary rock, containing numerous single quartz crystals derived from quartz phenocrysts, more abundant sericitized feldspar phenocrysts and fragments, and minor altered biotite. In thin section, this rock is a crystal-rich tuff or volcanic sedimentary rock containing numerous single-crystal quartz grains that represent phenocrysts with a variety of grain sizes and habits. Their grain size varies from 0.1 to 3 mm, the smaller crystals being mostly bipyramidal, although some are rounded and resorption is also observed. The larger crystals are more irregular in outline, but resorption is rare. More abundant sericitized ?feldspar crystals, from 0.3 to 3 mm in diameter, are mostly euhedral and rarely contain sericite and leucoxene pseudomorphs after biotite. Separate former biotite flakes, now altered to sericite and leucoxene, also occur between the quartz and altered feldspar crystals. Lithic fragments to 6 mm long occur with quartz and altered feldspar phenocrysts in a groundmass altered to quartz and sericite. There are also rare fragments of cherty to chalcedonic quartz to 4 mm long. The matrix area between the crystals and fragments consists mostly of microcrystalline to cryptocrystalline quartz with minor sericite. Small patches rich in sericite and limonite occur locally, with poorly defined areas rich in limonite, apparently after carbonate. It is not clear whether this was an unusually phenocryst-rich porphyry, a pyroclastic rock, or a coarse volcanic sedimentary rock. Greenschist facies metamorphism is indicated.

Zircon morphology

The zircons isolated from this sample are typically dark yellowish brown or black fragments and whole grains, between 30 × 45 µm and 80 × 100 µm in size and are equant to slightly elongate and euhedral in shape, or are irregular-shaped fragments. A minority are colourless and structureless. Most grains have remnant internal zonation. Many grains are metamict and the reflected light surfaces of many have abundant black

Table 32. Ion microprobe analytical results for sample 168996: altered coarse crystal tuff, Farrel Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	67	38	60	0.025	0.30233	0.00145	0.15002	0.00148	0.7089	0.0122	29.552	0.545	99	3 482	7
2.1	128	46	110	0.159	0.30095	0.00103	0.09475	0.00105	0.7128	0.0119	29.576	0.515	100	3 475	5
3.1	181	122	132	0.257	0.28121	0.00097	0.16627	0.00129	0.5825	0.0097	22.587	0.392	88	3 370	5
4.1	531	245	322	0.544	0.27877	0.00072	0.10215	0.00102	0.5033	0.0082	19.344	0.324	78	3 356	4
5.1	263	36	214	0.041	0.30173	0.00078	0.03353	0.00067	0.7078	0.0116	29.446	0.500	99	3 479	4
6.1	942	491	243	1.083	0.29763	0.00107	0.07862	0.00171	0.2112	0.0034	8.666	0.147	36	3 458	6
7.1	271	72	90	0.108	0.11013	0.00066	0.07836	0.00108	0.3231	0.0053	4.906	0.089	100	1 802	11
8.1	45	24	41	0.400	0.31022	0.00191	0.13875	0.00250	0.7243	0.0128	30.981	0.604	100	3 522	10
9.1	281	59	231	0.071	0.30127	0.00069	0.05619	0.00058	0.7022	0.0115	29.168	0.490	99	3 477	4
10.1	213	75	188	0.026	0.31062	0.00077	0.09475	0.00061	0.7268	0.0119	31.129	0.527	100	3 524	4
11.1	56	36	55	0.267	0.32038	0.00166	0.17168	0.00204	0.7578	0.0132	33.474	0.630	102	3 572	8
12.1	68	42	65	0.165	0.31919	0.00146	0.16529	0.00172	0.7359	0.0126	32.385	0.592	100	3 566	7
13.1	105	52	94	0.190	0.30022	0.00114	0.13059	0.00121	0.7242	0.0122	29.977	0.531	101	3 471	6
14.1	110	80	107	0.078	0.32118	0.00109	0.19141	0.00125	0.7429	0.0125	32.898	0.578	100	3 575	5
15.1	58	33	57	0.448	0.31913	0.00180	0.14234	0.00239	0.7715	0.0135	33.945	0.648	103	3 566	9
16.1	24	10	22	0.703	0.29857	0.00299	0.10234	0.00463	0.7456	0.0143	30.695	0.696	104	3 463	16
17.1	352	117	199	0.406	0.30054	0.00075	0.11595	0.00097	0.4588	0.0075	19.012	0.319	70	3 473	4
18.1	44	20	41	0.249	0.30528	0.00180	0.12116	0.00220	0.7524	0.0134	31.669	0.615	103	3 497	9
19.1	153	42	127	0.139	0.30752	0.00097	0.06910	0.00092	0.6984	0.0116	29.611	0.510	97	3 508	5
20.1	157	116	155	0.101	0.32024	0.00094	0.19732	0.00106	0.7570	0.0126	33.424	0.575	102	3 571	5
21.1	118	82	114	0.138	0.32004	0.00110	0.18243	0.00126	0.7450	0.0125	32.875	0.575	101	3 570	5
22.1	545	210	309	0.420	0.29434	0.00078	0.05088	0.00097	0.4846	0.0079	19.668	0.330	74	3 441	4
23.1	47	19	42	0.307	0.30502	0.00183	0.10754	0.00232	0.7238	0.0127	30.439	0.587	100	3 496	9

spots, zones and fractures that are interpreted to be due to breakdown and recrystallization of the crystal microstructure.

Analytical details

This sample was analysed on 31 March 2001. The counter deadtime during the analysis session was 32 ns. Seven analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.61 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 4.1, 6.1, 17.1 and 22.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-three analyses were obtained from 23 zircons. Results are given in Table 32 and shown on a concordia plot in Figure 49.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic Pb redistribution, including a recent episode. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to three groups. Nine concordant and highly discordant analyses of nine zircons (1.1, 2.1, 5.1, 9.1, 13.1, 16.1, 17.1, 18.1 and 23.1), 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 3477 ± 5 Ma (chi-squared = 1.49). Concordant analyses 8.1 and 10.1, assigned to Group 2, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean

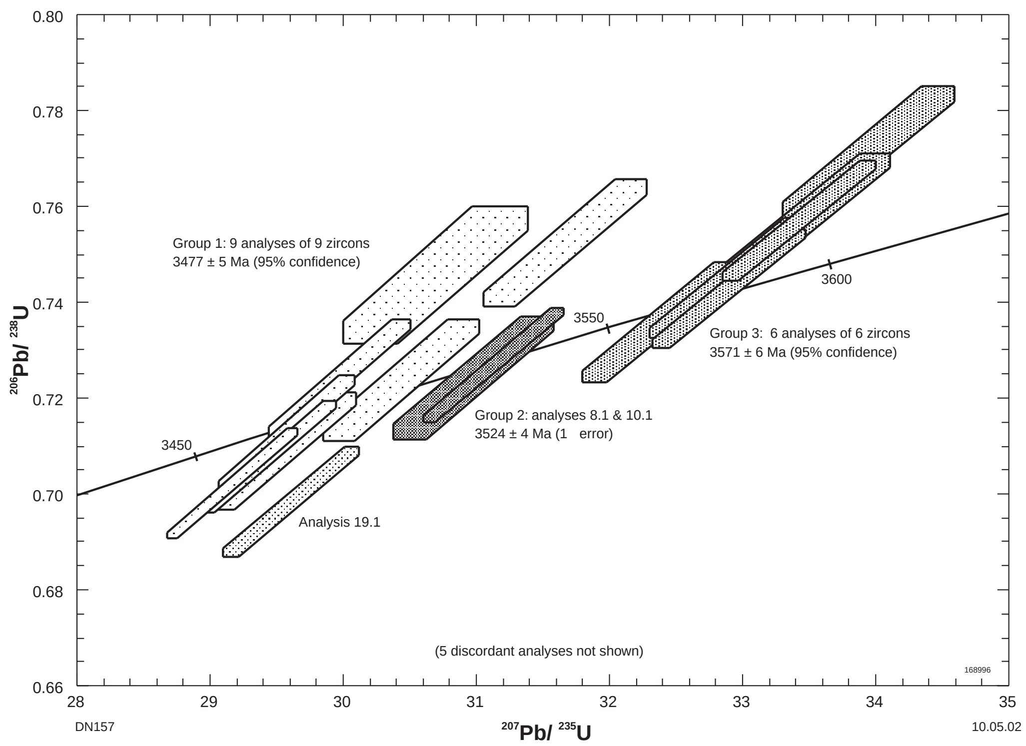

Figure 49. Concordia plot for sample 168996: altered coarse crystal tuff, Farrel Well

$^{207}Pb/^{206}Pb$ date of 3524 ± 4 Ma. Six concordant analyses of six zircons (11.1, 12.1, 14.1, 15.1, 20.1 and 21.1), assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3571 ± 6 Ma (chi-squared = 0.29). The remaining analyses — discordant analyses 3.1, 4.1, 6.1, 19.1 and 22.1, and concordant analysis 7.1 — cannot be grouped.

The date of 3477 ± 5 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the nine analyses of Group 1 is interpreted as the age of igneous crystallization of the felsic volcanic precursor to the altered tuff. The analyses of Groups 2 and 3 are interpreted to be of xenocrystic or possibly detrital zircons. The younger $^{207}Pb/^{206}Pb$ dates indicated by the remaining analyses are interpreted to be analysis sites that may have lost some of their accumulated radiogenic Pb during several disturbance events.

168997: quartzite, Farrel Well

Location and sampling

PORT HEDLAND – BEDOUT ISLAND (SF 50-4), COONGAN (2856)

MGA Zone 50, 762160E 7693550N

Sampled on 1 July 2000.

The sample was taken from a 0.5 m-diameter block from the northern edge of an outcrop of massive quartzite located on the northern side of an east-striking quartzite ridge, 1 km south-southeast of the Marble Bar road where it crosses Gorge Creek, and 2 km south of Farrel Well.

Tectonic unit/relations

This sample is a white to pale grey, massive, coarse-grained and recrystallized quartzite from a vertically dipping thickly bedded quartzite unit at the base of the Gorge Creek Group, East Pilbara Granite–Greenstone Terrane (Van Kranendonk, in prep.b).

Petrographic description

This sample consists principally of single crystal quartz grains (40 vol.%), and sericitized grains of feldspar and lithic grains (25 vol.%), within a fine siliceous matrix (35 vol.%), with accessory leucoxene (trace), and zircon (trace). This is a homogeneous, massive coarse grained quartzite, with single crystal quartz grains largely derived from volcanic phenocrysts, lesser detrital sericitized grains and rare mafic lithic grains, within a fine siliceous matrix or cement of cherty to microsparry quartz, mostly less than 0.05 mm in grain size, that may be of diagenetic or low-temperature hydrothermal origin. There are abundant single crystal quartz grains from 0.2 to 1 mm in diameter (medium to coarse sand), many of which may be of volcanic origin. These are randomly dispersed through an extremely fine-grained quartzose matrix. Subordinate numbers of sericitized grains, mostly about 0.5 mm in diameter, are also scattered and may include former feldspar and possible altered lithic fragments. Lithic clasts constitute less than 1 vol.% of the rock and contain leucoxene after opaque oxide dendrites in a sericite to quartz-rich matrix, indicating derivation from a mafic source. Small accessory aggregates of leucoxene and crystals of zircon are disseminated in the matrix.

Zircon morphology

The zircons isolated from this sample are typically colourless, pale yellowish or greenish brown, dark yellow-brown or black, between 30 × 45 µm and 80 × 150 µm in size and are elongate irregular-shaped fragments or, less commonly, euhedral, whole grains. Many grains are metamict. Very few grains show any evidence of surface pitting or abrasion consistent with extensive detrital transport.

Analytical details

This sample was analysed on 31 May 2001. The counter deadtime during the analysis session was 32 ns. Seven analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.65 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 2.1, 7.1, 11.1 and 12.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Table 33. Ion microprobe analytical results for sample 168997: quartzite, Farrel Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	$\pm 1\sigma$	$^{208}Pb/^{206}Pb$	$\pm 1\sigma$	$^{206}Pb/^{238}U$	$\pm 1\sigma$	$^{207}Pb/^{235}U$	$\pm 1\sigma$	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	$\pm 1\sigma$
1.1	221	170	184	0.201	0.28855	0.00150	0.20629	0.00185	0.6423	0.0114	25.553	0.487	94	3 410	8
2.1	609	658	252	2.449	0.29293	0.00207	0.43211	0.00438	0.2626	0.0044	10.606	0.203	44	3 433	11
3.1	66	35	56	0.845	0.28639	0.00312	0.12997	0.00460	0.6765	0.0139	26.714	0.653	98	3 398	17
4.1	44	27	37	1.098	0.28221	0.00452	0.16381	0.00756	0.6630	0.0149	25.796	0.751	97	3 375	25
5.1	87	31	74	0.679	0.28829	0.00274	0.09083	0.00395	0.6960	0.0135	27.666	0.627	100	3 408	15
6.1	127	105	110	0.712	0.28920	0.00221	0.21901	0.00340	0.6563	0.0122	26.170	0.549	95	3 413	12
7.1	688	288	230	2.891	0.26219	0.00190	0.09620	0.00378	0.2623	0.0044	9.483	0.182	46	3 260	11
8.1	115	53	101	0.503	0.28713	0.00218	0.12075	0.00284	0.7144	0.0134	28.283	0.596	102	3 402	12
9.1	53	53	43	1.768	0.28891	0.00526	0.24553	0.00965	0.5870	0.0128	23.383	0.704	87	3 412	28
10.1	52	22	44	0.761	0.28790	0.00346	0.11812	0.00498	0.6746	0.0145	26.781	0.694	98	3 406	19
11.1	1 072	521	268	2.037	0.25509	0.00166	0.12722	0.00320	0.1985	0.0033	6.982	0.130	36	3 217	10
12.1	117	73	109	5.026	0.29050	0.00406	0.14710	0.00846	0.6545	0.0125	26.217	0.656	95	3 420	22
13.1	6	2	6	6.560	0.29524	0.02033	0.07486	0.04111	0.6263	0.0292	25.496	2.239	91	3 445	107
14.1	106	48	98	0.923	0.32255	0.00263	0.10384	0.00372	0.7335	0.0141	32.621	0.710	99	3 582	13
15.1	125	114	84	0.809	0.28791	0.00262	0.23035	0.00419	0.4991	0.0093	19.813	0.429	77	3 406	14
16.1	95	143	97	0.480	0.29031	0.00242	0.39027	0.00422	0.6968	0.0135	27.892	0.615	100	3 419	13
17.1	129	72	111	0.630	0.28821	0.00214	0.14348	0.00292	0.6818	0.0127	27.092	0.565	98	3 408	12
18.1	109	85	96	0.284	0.28936	0.00224	0.20780	0.00303	0.6786	0.0129	27.073	0.581	98	3 414	12
19.1	116	64	101	0.477	0.28792	0.00219	0.14847	0.00293	0.6979	0.0132	27.705	0.588	100	3 406	12
20.1	118	95	100	0.462	0.29288	0.00224	0.18619	0.00316	0.6579	0.0124	26.568	0.563	95	3 433	12
21.1	52	29	47	1.184	0.30215	0.00392	0.14043	0.00617	0.7025	0.0153	29.266	0.780	99	3 481	20
22.1	192	246	187	0.418	0.28739	0.00170	0.32633	0.00274	0.6914	0.0125	27.396	0.540	100	3 404	9
23.1	105	87	97	0.738	0.28847	0.00249	0.21148	0.00383	0.7013	0.0136	27.896	0.619	100	3 409	13
24.1	130	14	101	0.688	0.28759	0.00225	0.02142	0.00296	0.6737	0.0126	26.714	0.565	98	3 405	12
25.1	81	64	73	0.639	0.28579	0.00275	0.19670	0.00410	0.6926	0.0140	27.292	0.640	100	3 395	15
26.1	65	54	58	1.288	0.28244	0.00352	0.21554	0.00607	0.6662	0.0138	25.944	0.660	97	3 376	19
27.1	16	2	12	3.299	0.29860	0.00962	0.03363	0.01744	0.6163	0.0198	25.373	1.224	89	3 463	50
28.1	153	193	100	0.510	0.28966	0.00240	0.37253	0.00417	0.4503	0.0082	17.985	0.375	70	3 416	13

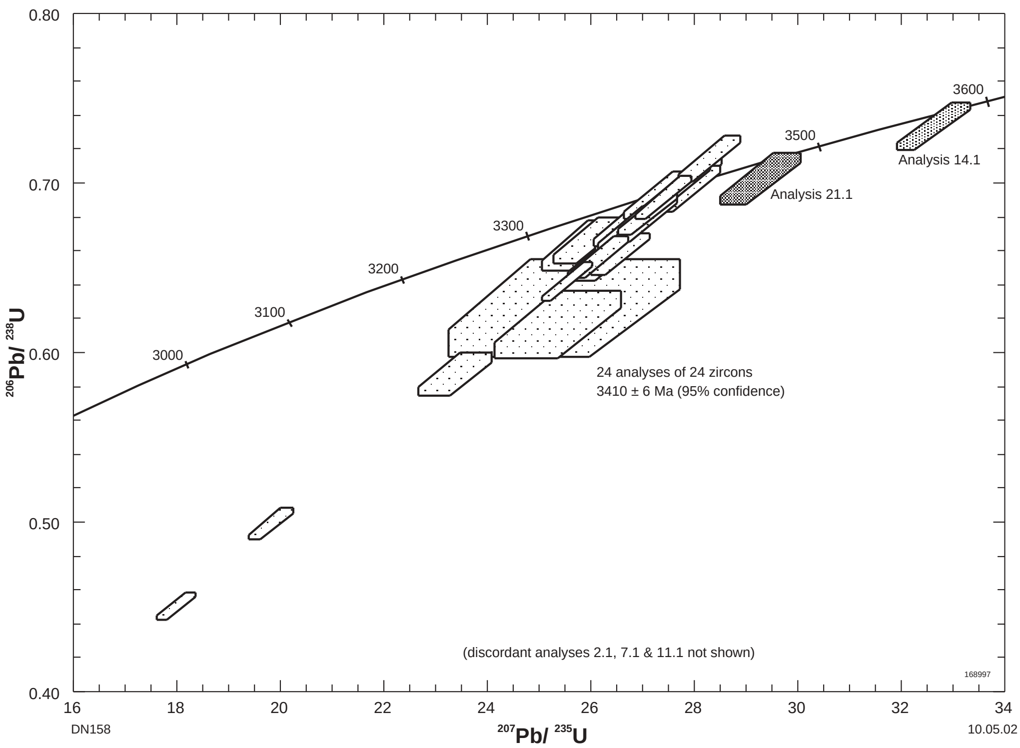

Figure 50. Concordia plot for sample 168997: quartzite, Farrel Well

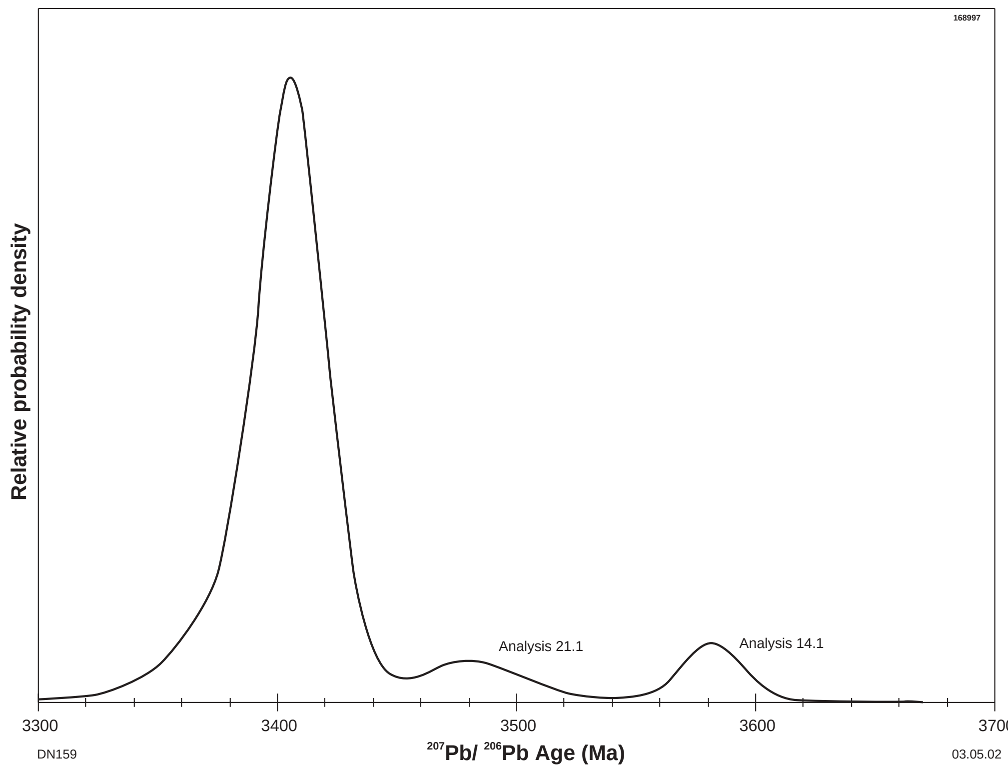

Figure 51. Gaussian-summation probability density plot for sample 168997: quartzite, Farrel Well

Results

Twenty-eight analyses were obtained from 28 zircons. Results are given in Table 33 and shown on concordia and Gaussian-summation probability density plots in Figures 50 and 51.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic-Pb loss, including a dominant recent episode. Twenty-four concordant and highly discordant analyses of 24 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3410 ± 6 Ma (chi-squared = 0.77). Concordant analyses 14.1 and 21.1, and highly discordant analysis 2.1, indicate older $^{207}Pb/^{206}Pb$ dates, whereas highly discordant analyses 7.1 and 11.1 indicate younger $^{207}Pb/^{206}Pb$ dates than the main population.

The date of 3410 ± 6 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 24 concordant and highly discordant analyses of 24 zircons is interpreted as the age of igneous crystallization of a volcanic component within the source region, and therefore provides a maximum age for deposition of the sedimentary precursor to the quartzite. The older $^{207}Pb/^{206}Pb$ dates indicated by concordant analyses 14.1 and 21.1, and possibly also by highly discordant analysis 2.1, are interpreted to be of detrital zircons, whereas the younger $^{207}Pb/^{206}Pb$ dates indicated by highly discordant analyses 7.1 and 11.1 are interpreted to be of analysis sites that have lost some of their accumulated radiogenic Pb during several disturbance events.

169000: volcaniclastic sandstone, Cork Tree Well

Location and sampling

MARBLE BAR (SF 50-8), SPLIT ROCK (2854) MGA Zone 50, 783480E 7578840N

Sampled on 3 July 2000.

The sample was taken from near the top of a low, rounded, rocky hill located 9 km south-southwest of Cork Tree Well.

Tectonic unit/relations

This sample is from an altered, light grey, fine- to medium-grained volcaniclastic sandstone of the Wyman Formation in the Warrawoona Group, East Pilbara Granite–Greenstone Terrane (Bagas and Van Kranendonk, in prep.). The sandstone contains sparse remnant quartz up to 2 mm in diameter and altered feldspar phenocrysts, and angular black chert fragments up to 4 mm long. The sandstone is interbedded with beds of altered rhyolite and dacite that are up to 10 cm thick.

Petrographic description

This sample consists principally of sericite-altered lithic or vitric fragments and shards (70 vol.%) together with quartz phenocrysts and fragments (5 vol.%), in a clay- and quartz-rich matrix (25 vol.%, including 7–8 vol.% clay minerals). There is accessory leucoxene after opaque oxide (trace), and zircon (trace). This rock is either a crystal-lithic or vitric tuff, or a reworked medium-grained volcaniclastic sandstone, with limonitized to leached areas. In thin section, much of the rock consists of a weakly bedded, reasonably well sorted aggregate of sparsely disseminated quartz phenocryst fragments (5 vol.%), from 0.2 to 0.8 mm in diameter (medium to coarse sand), with abundant sericite- to quartz-rich altered lithic or vitric fragments of similar size to the quartz. Most of the lithic fragments are rimmed by leucoxene and were probably shards, but some have diffuse leucoxene throughout and may have been derived from a volcanic groundmass. Rare leucoxene occurs after discrete opaque oxide crystals, and some areas are stained by diffuse limonite. Leached voids to 4 mm long are scattered parallel to the layering. The interstitial matrix consists of variable concentrations of colourless to pale orange-brown clay (sericite or illite with ?smectite and limonite), and of cryptocrystalline to microcrystalline quartz. This sample may be a primary crystal-lithic/vitric tuff, but the relatively good sorting indicates some reworking and possible transition to a volcaniclastic sandstone.

Zircon morphology

The zircons isolated from this sample are typically dark yellowish or greenish brown or black fragments and whole grains, between 40 × 65 µm and 80 × 100 µm in size and are equant to slightly elongate and euhedral in shape. Most grains have remnant internal zonation and many are metamict.

Analytical details

This sample was analysed on 25 March 2001. The counter deadtime during the analysis session was 32 ns. Eleven analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.13 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with

Table 34. Ion microprobe analytical results for sample 169000: volcaniclastic sandstone, Cork Tree Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	220	94	166	0.232	0.27211	0.00106	0.08112	0.00108	0.6426	0.0079	24.109	0.321	96	3 318	6
2.1	241	218	179	0.872	0.27186	0.00133	0.23466	0.00232	0.5606	0.0069	21.015	0.288	87	3 317	8
3.1	136	86	107	0.342	0.26946	0.00140	0.15323	0.00183	0.6354	0.0081	23.609	0.339	96	3 303	8
4.1	177	112	124	0.528	0.27079	0.00142	0.15710	0.00210	0.5629	0.0070	21.018	0.295	87	3 311	8
5.1	153	76	86	1.225	0.27329	0.00214	0.12333	0.00358	0.4493	0.0056	16.930	0.262	72	3 325	12
6.1	177	131	148	0.183	0.27181	0.00135	0.18946	0.00174	0.6599	0.0084	24.731	0.352	99	3 316	8
7.1	213	160	165	0.455	0.27226	0.00137	0.17179	0.00195	0.6139	0.0077	23.044	0.324	93	3 319	8
8.1	121	101	104	0.049	0.27287	0.00155	0.22413	0.00185	0.6642	0.0088	24.991	0.378	99	3 323	9
9.1	163	92	130	0.073	0.26807	0.00135	0.13636	0.00144	0.6583	0.0085	24.333	0.351	99	3 295	8
10.1	63	23	51	0.241	0.26690	0.00229	0.09472	0.00275	0.6935	0.0104	25.522	0.465	103	3 288	13
11.1	132	75	97	0.428	0.27078	0.00179	0.15425	0.00266	0.5903	0.0077	22.038	0.340	90	3 311	10
12.1	219	83	170	0.065	0.27359	0.00121	0.10319	0.00131	0.6548	0.0081	24.701	0.338	98	3 327	7
13.1	195	120	150	0.375	0.26601	0.00144	0.16920	0.00220	0.6152	0.0078	22.565	0.323	94	3 283	8
14.1	78	54	66	0.300	0.25903	0.00205	0.18697	0.00290	0.6719	0.0096	23.995	0.412	102	3 241	12
15.1	135	64	106	0.249	0.27287	0.00159	0.12875	0.00203	0.6490	0.0085	24.418	0.367	97	3 323	9
16.1	126	47	97	0.211	0.26675	0.00167	0.09014	0.00214	0.6528	0.0086	24.009	0.368	99	3 287	10
17.1	303	129	448	34.413	0.25688	0.00818	0.01363	0.01911	0.5121	0.0079	18.137	0.672	83	3 228	50
18.1	165	81	133	0.079	0.26877	0.00132	0.13310	0.00137	0.6666	0.0085	24.702	0.353	100	3 299	8
19.1	168	54	129	0.354	0.26934	0.00145	0.08340	0.00182	0.6487	0.0082	24.092	0.346	98	3 302	8
20.1	163	113	129	0.420	0.27130	0.00150	0.14983	0.00202	0.6393	0.0082	23.912	0.348	96	3 314	9
21.1	78	34	60	0.543	0.26136	0.00232	0.11567	0.00350	0.6352	0.0091	22.891	0.408	97	3 255	14
22.1	286	150	212	0.762	0.26816	0.00117	0.12399	0.00177	0.6053	0.0073	22.381	0.299	93	3 295	7
23.1	113	61	92	0.108	0.26824	0.00177	0.14312	0.00242	0.6691	0.0091	24.746	0.391	100	3 296	10
24.1	92	51	77	0.151	0.26355	0.00233	0.14288	0.00246	0.6937	0.0109	25.210	0.479	104	3 268	14
25.1	84	32	66	0.118	0.27461	0.00215	0.10143	0.00267	0.6599	0.0094	24.985	0.427	98	3 333	12
26.1	129	78	104	0.098	0.27122	0.00160	0.16734	0.00187	0.6507	0.0087	24.334	0.372	98	3 313	9
27.1	201	382	158	0.582	0.27258	0.00152	0.19137	0.00238	0.6109	0.0077	22.959	0.331	93	3 321	9
28.1	161	88	127	0.087	0.27496	0.00140	0.14406	0.00147	0.6454	0.0083	24.470	0.354	96	3 335	8
29.1	170	89	138	0.210	0.27144	0.00146	0.13888	0.00184	0.6637	0.0086	24.840	0.363	99	3 314	8
30.1	98	61	81	0.209	0.27393	0.00184	0.16988	0.00229	0.6626	0.0092	25.025	0.404	98	3 329	11
31.1	215	198	108	2.049	0.27331	0.00228	0.15557	0.00436	0.3843	0.0047	14.484	0.228	63	3 325	13
32.1	134	73	109	0.236	0.27224	0.00166	0.15084	0.00217	0.6607	0.0087	24.799	0.377	99	3 319	10
33.1	152	140	124	0.250	0.26790	0.00149	0.23839	0.00217	0.6245	0.0081	23.067	0.340	95	3 294	9
9.2	170	113	146	0.137	0.27225	0.00109	0.16782	0.00135	0.6879	0.0098	25.823	0.395	102	3 319	6
13.2	189	78	155	0.170	0.27085	0.00106	0.10500	0.00122	0.6887	0.0098	25.720	0.391	102	3 311	6
27.2	220	843	170	1.507	0.27069	0.00152	0.27002	0.00298	0.5620	0.0080	20.976	0.333	87	3 310	9

the exception of analyses 2.1, 17.1, 22.1, 27.2 and 31.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Thirty-six analyses were obtained from 33 zircons. Results are given in Table 34 and shown on concordia and Gaussian-summation probability density plots in Figures 52 and 53.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic Pb loss, including a dominant recent episode. On the basis of their $^{207}Pb/^{206}Pb$ ratios, most analyses may be assigned to two groups. Thirty concordant and highly discordant analyses of 28 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 3312 ± 4 Ma (chi-squared = 1.66). Discordant analyses 13.1, 16.1 21.1 and 24.1, 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 3278 ± 21 Ma (chi-squared = 1.23). Analyses 14.1 and 28.1 are discordant and cannot be grouped.

Several interpretations of these results are possible. The date of 3312 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 30 concordant and highly discordant analyses of Group 1 may be interpreted as the age of igneous crystallization of the felsic volcanic precursor to the volcaniclastic sandstone, with the younger date indicated by the discordant analyses of Group 2 corresponding to the timing of an ancient disturbance event during which these analysis sites lost radiogenic Pb. However,

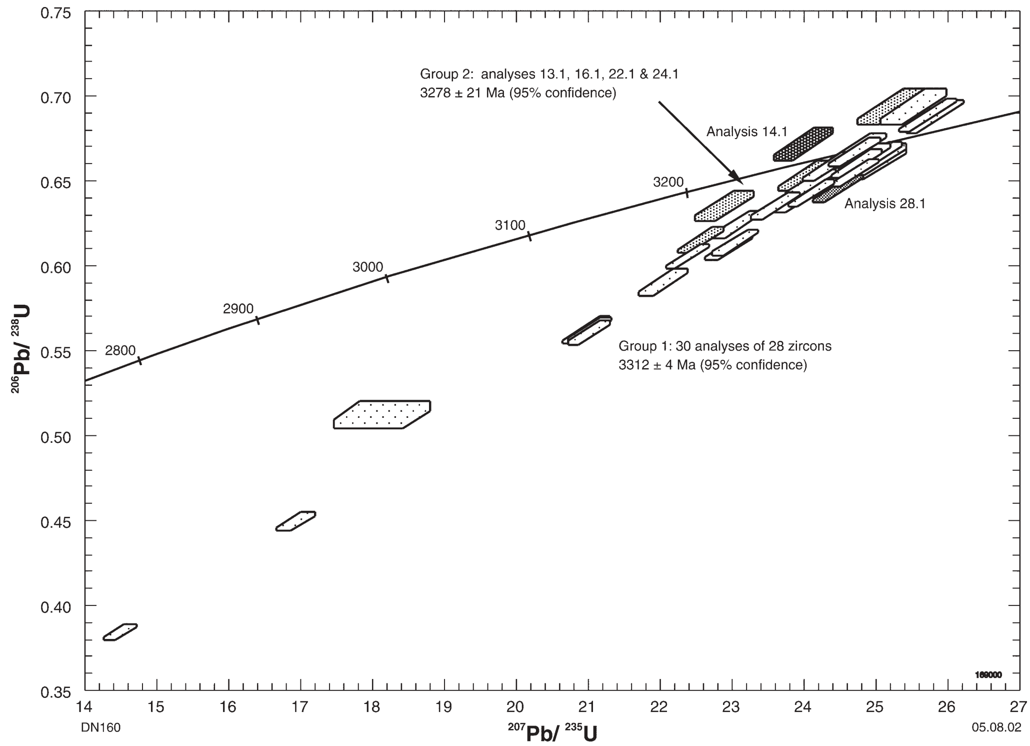

Figure 52. Concordia plot for sample 169000: volcaniclastic sandstone, Cork Tree Well

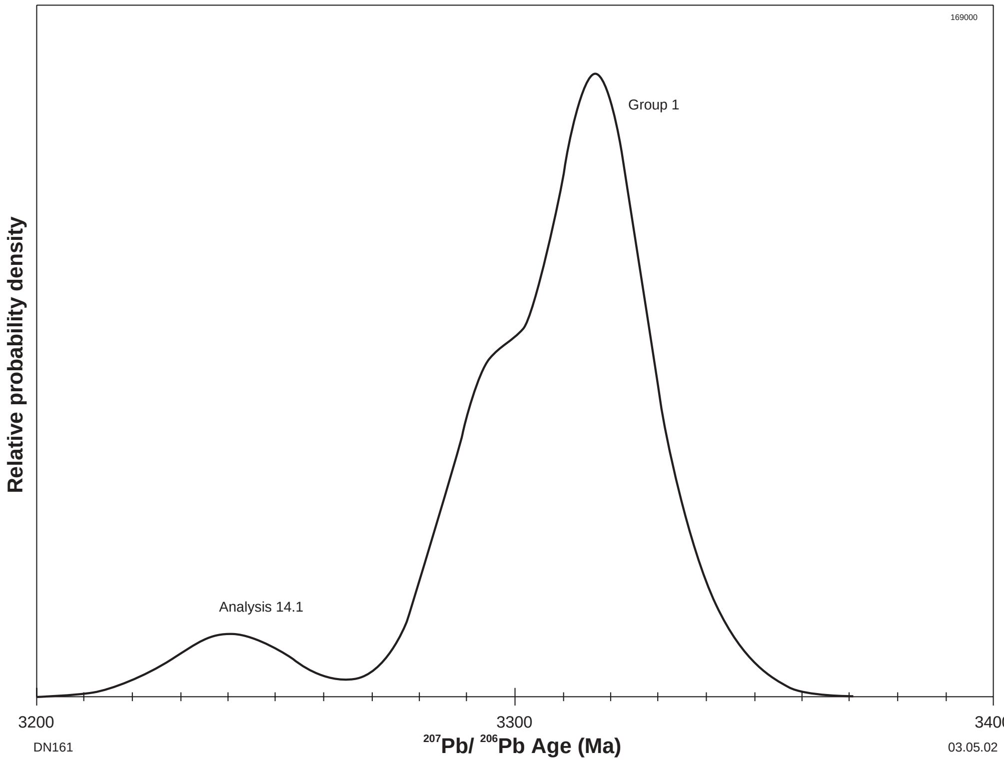

Figure 53. Gaussian-summation probability density plot for sample 169000: volcaniclastic sandstone, Cork Tree Well

analyses belonging to Group 2 indicate generally low U and Th contents at these analysis sites, and it is unclear why these sites should have lost radiogenic Pb when those of Group 1 did not. An alternative explanation is that the date of 3278 ± 21 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the four analyses of Group 2, or perhaps the younger date indicated by analysis 14.1, provides a maximum age for reworking and redeposition of a predominantly 3312 ± 4 Ma volcanic precursor rock. Analysis 28.1 is interpreted to be of a detrital or xenocrystic zircon.

169008: quartz–sericite schist, Coongan Belt Well

Location and sampling

MARBLE BAR (SF 50-8), SPLIT ROCK (2854) MGA Zone 50, 773760E 7600840N

Sampled on 4 July 2000.

The sample was taken from a 0.5 m-diameter block located about half way up the eastern side of a north-striking ridge and on the west side of Withnell Creek, 4.5 km north of Coongan Belt Well.

Tectonic unit/relations

This sample is from an altered, light greenish-grey, schistose felsic metavolcanic rock of the Panorama Formation in the Warrawoona Group, East Pilbara Granite–Greenstone Terrane (Bagas and Van Kranendonk, in prep.). The schist contains scattered remnant quartz phenocrysts.

Petrographic description

The principal minerals present in this sample are quartz (60 vol.%) and sericite (40 vol.%), with accessory leucoxene (trace) and zircon (trace). This is a quartz–sericite schist derived by shearing and alteration of a felsic ignimbrite and metamorphism in the greenschist facies. The hand specimen is a fine quartz-rich schist with a vague braided network of fine sericite-rich lenses and foliae. The thin section shows abundant (35 vol.%) sericite-rich altered fiamme, from 1 to 10 mm long and up to 4 mm thick. These retain their primary orientation/elongation and are evenly distributed throughout the rock, but they are completely altered to very fine sericite, with an internal very fine schistosity parallel to the host fiamme length. They occur throughout a homogeneous fine schistose matrix of microgranular quartz, to 0.1 mm in grain size, incorporating subordinate schistose sericite. Some of the quartz may represent microphenocrysts to 0.2 mm in diameter. Rare disseminated leucoxene, lenses of generally microcrystalline, recrystallized quartz to 3 mm long, and rare zircon crystals about 50 µm in diameter were observed.

Zircon morphology

The zircons isolated from this sample are typically pinkish brown or dark brown, equant to slightly elongate and multifaceted in shape, and between 30 × 35 µm and 60 × 80 µm in size. Most grains have remnant internal zonation and fluid and mineral inclusions are common.

Analytical details

This sample was analysed on 26 February 2001. The counter deadtime during the analysis session was 32 ns. Six analyses of the CZ3 standard were obtained during the analysis session. Following deletion of one standard analysis as an outlier, the remaining five analyses indicated a Pb^*/U calibration error of 0.847 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 35. Ion microprobe analytical results for sample 169008: quartz–sericite schist, Coongan Belt Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	89	109	90	0.452	0.30035	0.00149	0.32640	0.00247	0.7106	0.0081	29.427	0.382	100	3 472	8
2.1	126	163	123	0.138	0.29752	0.00101	0.33715	0.00156	0.6917	0.0074	28.375	0.331	98	3 457	5
3.1	89	111	88	0.159	0.29176	0.00133	0.33376	0.00208	0.6979	0.0078	28.076	0.354	100	3 427	7
4.1	142	132	131	0.071	0.30010	0.00093	0.24834	0.00119	0.6915	0.0074	28.611	0.329	98	3 471	5
5.1	115	106	106	0.230	0.29932	0.00115	0.23840	0.00163	0.6921	0.0076	28.565	0.345	98	3 467	6
6.1	212	232	180	0.094	0.30462	0.00135	0.29988	0.00192	0.6130	0.0070	25.745	0.327	88	3 494	7
7.1	153	228	157	0.116	0.29865	0.00090	0.38853	0.00146	0.7019	0.0075	28.901	0.332	99	3 463	5
8.1	172	195	164	0.087	0.29991	0.00092	0.29992	0.00134	0.6865	0.0073	28.388	0.323	97	3 470	5
9.1	163	223	153	0.140	0.29588	0.00094	0.35657	0.00149	0.6577	0.0070	26.830	0.308	94	3 449	5
10.1	103	95	97	0.140	0.29006	0.00112	0.23612	0.00156	0.7141	0.0078	28.560	0.344	102	3 418	6
11.1	100	141	97	0.199	0.29205	0.00116	0.34960	0.00190	0.6839	0.0075	27.539	0.332	98	3 429	6
12.1	95	90	91	0.188	0.29897	0.00120	0.24616	0.00168	0.7104	0.0079	29.284	0.360	100	3 465	6
13.1	125	125	116	0.117	0.29799	0.00111	0.26217	0.00154	0.6899	0.0075	28.347	0.340	98	3 460	6
14.1	124	126	119	0.241	0.29796	0.00108	0.26990	0.00158	0.7076	0.0076	29.069	0.343	100	3 460	6
15.1	132	141	129	0.144	0.29876	0.00103	0.28337	0.00148	0.7116	0.0077	29.313	0.344	100	3 464	5
16.1	114	120	110	0.089	0.29828	0.00107	0.27641	0.00150	0.7127	0.0077	29.310	0.347	100	3 461	6
17.1	150	213	156	0.122	0.29953	0.00091	0.37395	0.00144	0.7154	0.0076	29.547	0.339	100	3 468	5
18.1	110	150	111	0.307	0.29841	0.00121	0.34389	0.00202	0.7049	0.0077	29.003	0.350	99	3 462	6
19.1	110	160	107	0.142	0.29768	0.00117	0.38843	0.00196	0.6684	0.0073	27.436	0.329	95	3 458	6

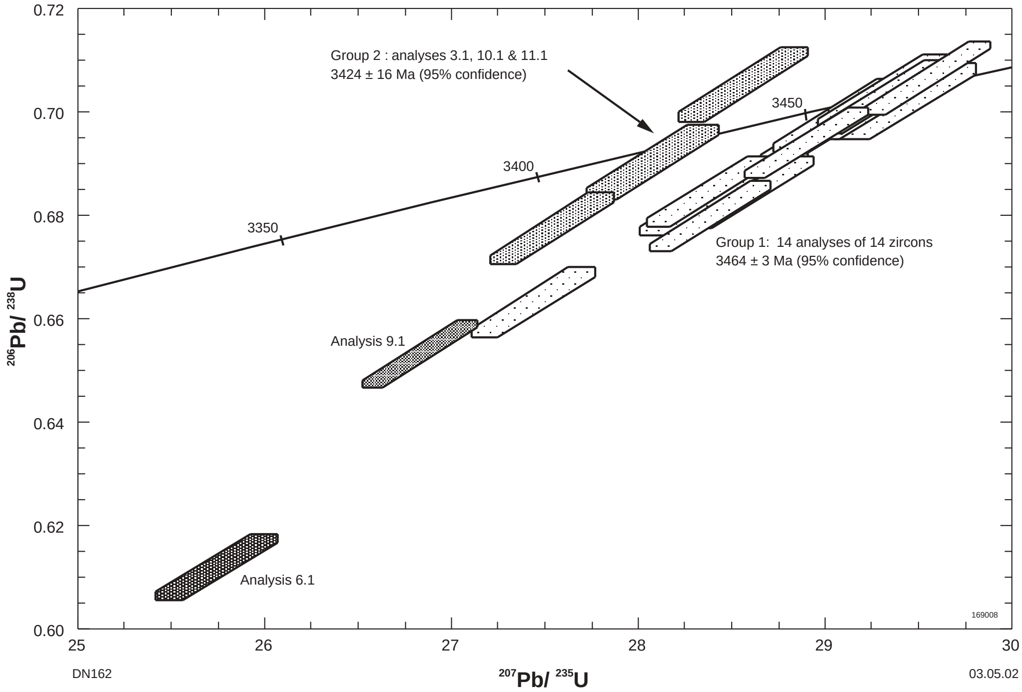

Figure 54. Concordia plot for sample 169008: quartz–sericite schist, Coongan Belt Well

Results

Nineteen analyses were obtained from 19 zircons. Results are given in Table 35 and shown on a concordia plot in Figure 54.

Interpretation

Most analyses are near-concordant, with the exception of analyses 6.1 and 9.1. On the basis of their $^{207}Pb/^{206}Pb$ ratios, most analyses may be assigned to one of two groups. Fourteen concordant analyses of 14 zircons (1.1, 2.1, 4.1, 5.1, 7.1, 8.1, 12.1, 13.1, 14.1, 15.1, 16.1, 17.1, 18.1 and 19.1), 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 3464 ± 3 Ma (chi-squared = 0.67). Concordant analyses 3.1, 10.1 and 11.1, 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 3424 ± 16 Ma (chi-squared = 0.64). Analyses 6.1 and 9.1 are discordant and cannot be grouped.

Several interpretations of these results are possible. The date of 3464 ± 3 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 14 concordant analyses of Group 1 may be interpreted as the age of igneous crystallization of the felsic volcanic precursor to the schist, with the younger date indicated by the concordant analyses of Group 2 corresponding to the timing of a disturbance event during which these analysis sites lost radiogenic Pb. However, analyses belonging to Group 2 indicate generally low U and Th contents at these analysis sites and it is unclear why these sites should have lost radiogenic Pb whereas those of Group 1 have not. An alternative explanation is that the date of 3424 ± 16 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the three analyses of Group 2 provides a maximum age for reworking and redeposition of a predominantly 3464 ± 3 Ma volcanic precursor rock. The remaining discordant analyses (6.1 and 9.1) are interpreted to be of analysis sites that have lost radiogenic Pb.

169014: foliated biotite–hornblende quartz diorite, Mount Gratwick

Location and sampling

MARBLE BAR (SF 50-8), WHITE SPRINGS (2654) MGA Zone 50, 675720E 7595740N

Sampled on 7 September 2000.

The sample was taken from a 1 m-diameter boulder located on the northern slopes of a low rocky hill, 12 km southeast of Mount Gratwick. The sampling site is 10 m north of the site of sample 169016.

Tectonic unit/relations

This sample is from a dark grey, medium- and even-grained foliated diorite phase that occurs as rafts and xenoliths within the Cockeraga Leucogranite of the Yule Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Smithies, in prep.a).

Petrographic description

The principal minerals present in this sample are plagioclase (60 vol.%), biotite (10–15 vol.%), hornblende (10–15 vol.%), quartz (7–8 vol.%), opaque oxide (3 vol.%), titanite (2 vol.%), epidote (1 vol.%), allanite (1 vol.%), apatite (1 vol.%), and zircon (trace). One joint has a feldspathic or quartzofeldspathic vein. In thin section, abundant weakly zoned plagioclase to 2.5 mm in diameter has minor, very irregular alteration to sericite. The foliation is defined by flakes of fresh to chloritized biotite to 2 mm long, with equally abundant, less well-oriented green hornblende. Some of the biotite has been altered to feldspar in optical continuity with adjacent plagioclase. Quartz is not abundant, but is present as grains to 2 mm long. Minor epidote occurs, 0.2 to 1 mm in grain size, with pale cores and yellow, more pistacite-rich rims. Inclusions of a zoned, altered mineral (?allanite) occur locally, and some of the epidote has partly replaced biotite. Opaque oxide grains are disseminated and rimmed by titanite, with separate grains of titanite, especially in and adjacent to the hornblende. Apatite is also common, but there are few zircon grains. The rock is a fine-grained and foliated biotite–hornblende–quartz diorite, with low-grade alteration possibly after amphibolite-facies metamorphism.

Zircon morphology

The zircons isolated from this sample are typically pale greenish brown or dark brown, equant to elongate with subrounded terminations and between 30 × 35 µm and 50 × 180 µm in size. Most grains have faint internal zonation and some have fluid and mineral inclusions.

Analytical details

This sample was analysed on 3, 10 and 14 June 2001. The counter deadtime during all three analysis session was 32 ns. Ten analyses of the CZ3 standard were obtained during the first analysis session. Following deletion of one standard analysis as an outlier, the remaining nine analyses indicated a Pb^*/U calibration error of 2.17 ($1\sigma\%$). Analyses 1.1 to 14.1 were obtained during the first analysis session. During the second analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.79

Table 36. Ion microprobe analytical results for sample 169014: foliated biotite–hornblende quartz diorite, Mount Gratwick

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	158	55	114	0.198	0.24783	0.00086	0.09306	0.00103	0.6191	0.0136	21.156	0.480	98	3 171	6
2.1	228	112	154	0.093	0.25962	0.00071	0.13837	0.00080	0.5625	0.0123	20.135	0.450	89	3 244	4
3.1	105	55	88	0.207	0.27739	0.00105	0.14147	0.00130	0.6808	0.0150	26.040	0.596	100	3 348	6
4.1	207	79	161	0.170	0.26450	0.00073	0.08476	0.00080	0.6663	0.0146	24.299	0.545	101	3 274	4
5.1	203	78	153	0.197	0.27550	0.00078	0.09064	0.00088	0.6364	0.0139	24.173	0.542	95	3 338	4
6.1	107	60	93	0.248	0.28317	0.00105	0.14711	0.00128	0.7043	0.0156	27.499	0.629	102	3 380	6
7.1	183	69	136	0.118	0.25236	0.00072	0.10574	0.00077	0.6340	0.0139	22.060	0.495	99	3 200	5
8.1	66	47	60	0.613	0.28922	0.00148	0.18992	0.00230	0.7001	0.0156	27.920	0.657	100	3 413	8
9.1	252	81	173	0.129	0.25238	0.00063	0.08358	0.00063	0.5963	0.0130	20.749	0.463	94	3 200	4
10.1	104	76	78	0.350	0.26769	0.00109	0.21827	0.00166	0.5814	0.0128	21.458	0.490	90	3 293	6
11.1	281	256	254	0.127	0.29060	0.00060	0.23790	0.00079	0.6831	0.0149	27.372	0.607	98	3 421	3
12.1	133	49	105	0.377	0.25465	0.00096	0.09779	0.00127	0.6668	0.0147	23.412	0.533	102	3 214	6
13.1	251	102	198	0.169	0.26777	0.00065	0.11206	0.00070	0.6599	0.0144	24.365	0.543	99	3 293	4
14.1	182	75	140	0.283	0.25508	0.00079	0.11692	0.00104	0.6441	0.0141	22.655	0.509	100	3 217	5
15.1	140	131	96	0.515	0.24581	0.00145	0.06103	0.00204	0.6036	0.0114	20.458	0.419	96	3 158	9
16.1	284	176	228	0.249	0.26655	0.00095	0.16445	0.00125	0.6472	0.0119	23.784	0.456	98	3 286	6
17.1	300	157	239	0.114	0.26385	0.00088	0.14142	0.00103	0.6553	0.0120	23.840	0.455	99	3 270	5
18.1	287	154	230	0.104	0.26605	0.00090	0.14278	0.00102	0.6592	0.0121	24.181	0.463	99	3 283	5
19.1	184	107	148	0.280	0.26801	0.00123	0.14453	0.00165	0.6569	0.0123	24.275	0.480	99	3 294	7
20.1	134	9	90	0.499	0.23224	0.00142	0.01484	0.00183	0.6184	0.0117	19.801	0.409	101	3 068	10
21.1	204	125	163	0.266	0.26208	0.00112	0.14798	0.00146	0.6537	0.0122	23.623	0.463	99	3 259	7
22.1	146	7	95	0.344	0.23173	0.00126	0.01705	0.00154	0.5999	0.0113	19.169	0.387	99	3 064	9
23.1	432	463	367	0.190	0.28285	0.00077	0.27160	0.00111	0.6309	0.0115	24.605	0.461	93	3 379	4
24.1	215	159	180	0.536	0.27587	0.00094	0.22361	0.00144	0.6409	0.0188	24.379	0.729	96	3 340	5
25.1	116	10	77	0.446	0.23595	0.00124	0.02253	0.00161	0.6048	0.0178	19.676	0.602	99	3 093	8
26.1	114	17	79	0.402	0.24734	0.00119	0.04148	0.00142	0.6192	0.0183	21.116	0.644	98	3 168	8
27.1	331	170	267	0.121	0.26299	0.00067	0.14037	0.00073	0.6663	0.0195	24.161	0.716	101	3 265	4
28.1	126	12	85	0.379	0.23282	0.00113	0.02670	0.00139	0.6124	0.0180	19.658	0.599	100	3 072	8
29.1	282	221	204	0.445	0.26418	0.00083	0.21172	0.00127	0.5615	0.0164	20.453	0.609	88	3 272	5

(1σ%). Analyses 15.1 to 23.1 were obtained during the second analysis session. During the third analysis session, three analyses of the CZ3 standard indicated a Pb^*/U calibration error of 2.90 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty-nine analyses were obtained from 29 zircons. Results are given in Table 36 and shown on a concordia plot in Figure 55.

Interpretation

The analyses are concordant to slightly discordant, with the discordance pattern consistent with at least one recent episode of radiogenic-Pb loss. The analyses indicate a range of $^{207}Pb/^{206}Pb$ dates from c. 3060 to 3420 Ma. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of four groups. Concordant analyses 20.1, 22.1 and 28.1, 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 3068 ± 22 Ma (chi-squared = 0.15). Concordant to slightly discordant analyses 1.1, 15.1 and 26.1, 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 3168 ± 18 Ma (chi-squared = 0.57). Five concordant analyses of five zircons (4.1, 17.1, 21.1, 17.1, 27.1 and 29.1), assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3269 ± 7 Ma (chi-squared = 1.00). Concordant and discordant analyses 3.1, 5.1 and 24.1, assigned to Group 4, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3341 ± 14 Ma (chi-squared = 0.84). The remaining analyses cannot be grouped.

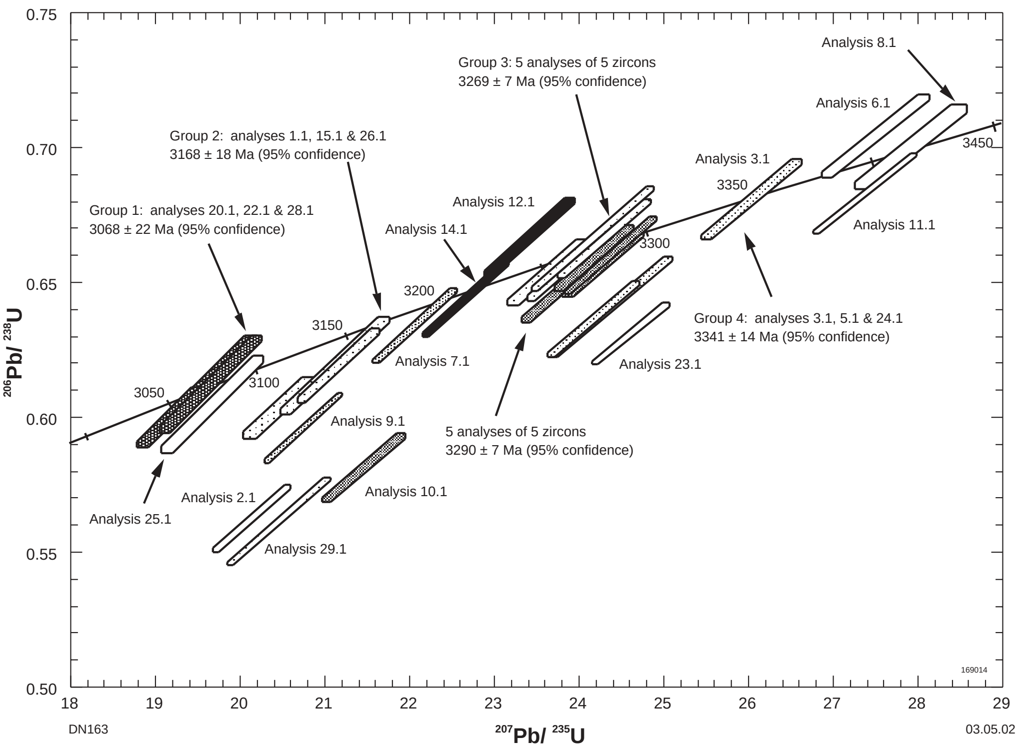

Figure 55. Concordia plot for sample 169014: foliated biotite–hornblende quartz diorite, Mount Gratwick

The dispersion of analyses along the concordia implies that most, or possibly all, of the zircons present in the diorite may be xenocrystic in origin. The date of 3068 ± 22 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the three analyses of Group 1 is therefore interpreted as a maximum age for igneous crystallization of the diorite.

169016: foliated leucocratic biotite quartz diorite, Mount Gratwick

Location and sampling

MARBLE BAR (SF 50-8), WHITE SPRINGS (2654) MGA Zone 50, 675720E 7595740N

Sampled on 7 September 2000.

The sample was taken from a 1 m-diameter boulder located on the northern slopes of a low rocky hill and 12 km southeast of Mount Gratwick. The sampling site is 10 m south of the site of sample 169014.

Tectonic unit/relations

This sample of the Cockeraga Leucogranite is a white, coarse-grained, leucocratic, biotite quartz diorite with 2 cm-long lenses of black biotite in the Yule Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Smithies, in prep.a).

Petrographic description

The principal minerals present in this sample are plagioclase (75–80 vol.%), quartz (15–20 vol.%), and biotite (5 vol.%), with accessory opaque oxide (trace), titanite (trace), apatite (trace), and zircon (trace). This is a heterogeneous, foliated leucocratic quartz diorite to tonalite/trondhjemite, with possible amphibolite-facies metamorphism and low-grade alteration. Biotite-rich lenses to 10 mm long occur within a white, possibly plagioclase-rich, quartzofeldspathic host rock. The thin section shows lenses rich in foliated, fresh to chloritized biotite, to 3 mm in grain size, with abundant plagioclase. The plagioclase is anhedral to subhedral, with irregular patches of clay and sericite alteration, and is up to 5 mm in grain size. There is relatively little quartz for what is a leucocratic granitoid rock, partly as optically continuous, poikilitic, interstitial grains to 5 mm in diameter, partly finer-grained and granular. Accessory minerals are rare, with opaque oxide, titanite, apatite and zircon mostly in, and adjacent to, biotite.

Zircon morphology

The zircons isolated from this sample are typically pale brown or dark brown, equant to elongate with subrounded terminations and between 60 × 80 µm and 100 × 250 µm in size. Most grains have faint internal zonation and fluid and mineral inclusions are common. Some grains have mottled cores surrounded by structureless, radially cracked rims.

Analytical details

This sample was analysed on 18 and 20 October 2001. The counter deadtime during both analysis session was 32 ns. Eleven analyses of the CZ3 standard were obtained during the first analysis session. Following deletion of one standard analysis as an outlier, the remaining ten analyses indicated a Pb^*/U calibration error of 1.70 (1σ%). Analyses 1.1 to 11.1 were obtained during the first analysis session. During the second analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.71 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 14.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Table 37. Ion microprobe analytical results for sample 169016: foliated leucocratic biotite–quartz diorite, Mount Gratwick

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	$\pm 1\sigma$	$^{208}Pb/^{206}Pb$	$\pm 1\sigma$	$^{206}Pb/^{238}U$	$\pm 1\sigma$	$^{207}Pb/^{235}U$	$\pm 1\sigma$	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	$\pm 1\sigma$
1.1	224	96	155	0.179	0.23325	0.00075	0.11546	0.00093	0.5940	0.0103	19.103	0.343	98	3 074	5
2.1C	235	115	169	0.256	0.23156	0.00075	0.13237	0.00098	0.6085	0.0105	19.429	0.349	100	3 063	5
3.1	215	90	148	1.190	0.23213	0.00105	0.10492	0.00181	0.5773	0.0100	18.478	0.340	96	3 067	7
4.1	458	307	263	0.596	0.21732	0.00067	0.16725	0.00112	0.4725	0.0081	14.159	0.252	84	2 961	5
5.1	118	39	82	0.157	0.23278	0.00106	0.08895	0.00133	0.6091	0.0107	19.550	0.366	100	3 071	7
6.1R	532	175	155	0.835	0.17166	0.00092	0.08991	0.00163	0.2606	0.0045	6.169	0.115	58	2 574	9
7.1	463	243	316	0.256	0.23191	0.00057	0.13834	0.00077	0.5741	0.0098	18.356	0.324	95	3 065	4
8.1R	204	66	140	0.258	0.23068	0.00082	0.08447	0.00103	0.6014	0.0104	19.129	0.347	99	3 057	6
9.1	188	56	121	0.436	0.23121	0.00095	0.08325	0.00136	0.5578	0.0097	17.782	0.326	93	3 060	7
10.1	201	56	134	0.152	0.23258	0.00079	0.07319	0.00084	0.5886	0.0102	18.876	0.341	97	3 070	5
11.1	237	108	163	0.093	0.23320	0.00070	0.12376	0.00079	0.5869	0.0101	18.871	0.338	97	3 074	5
12.1	161	49	107	0.216	0.23181	0.00086	0.08258	0.00108	0.5812	0.0101	18.577	0.339	96	3 065	6
13.1	257	110	181	0.631	0.23273	0.00076	0.11365	0.00120	0.5957	0.0103	19.114	0.344	98	3 071	5
14.1	460	63	238	2.908	0.24326	0.00100	0.06352	0.00201	0.4222	0.0073	14.159	0.258	72	3 141	7
15.1R	153	52	108	0.832	0.22983	0.00102	0.08863	0.00164	0.6089	0.0106	19.297	0.357	100	3 051	7
16.1C	141	42	101	0.461	0.23009	0.00088	0.07593	0.00121	0.6244	0.0109	19.810	0.362	102	3 053	6
17.1	410	312	314	0.254	0.27392	0.00052	0.20133	0.00071	0.5981	0.0103	22.588	0.396	91	3 329	3
18.1	281	147	218	0.119	0.26618	0.00062	0.14131	0.00068	0.6383	0.0110	23.425	0.415	97	3 284	4
19.1	90	33	63	0.509	0.23107	0.00123	0.09933	0.00183	0.6006	0.0106	19.137	0.364	99	3 059	9
20.1C	124	70	100	0.250	0.26464	0.00100	0.15255	0.00130	0.6577	0.0115	23.999	0.440	100	3 275	6
21.1C	57	20	43	0.433	0.23463	0.00146	0.09856	0.00215	0.6451	0.0115	20.869	0.410	104	3 084	10
22.1R	56	22	41	0.541	0.23024	0.00154	0.11071	0.00245	0.6311	0.0113	20.035	0.398	103	3 054	11
23.1R	335	205	234	0.799	0.22479	0.00067	0.16050	0.00115	0.5711	0.0098	17.702	0.316	97	3 015	5
24.1C	66	30	56	0.374	0.26550	0.00132	0.12478	0.00184	0.7031	0.0125	25.740	0.491	105	3 280	8

NOTE: C denotes analysis obtained on zircon core; R denotes analysis obtained on zircon rim

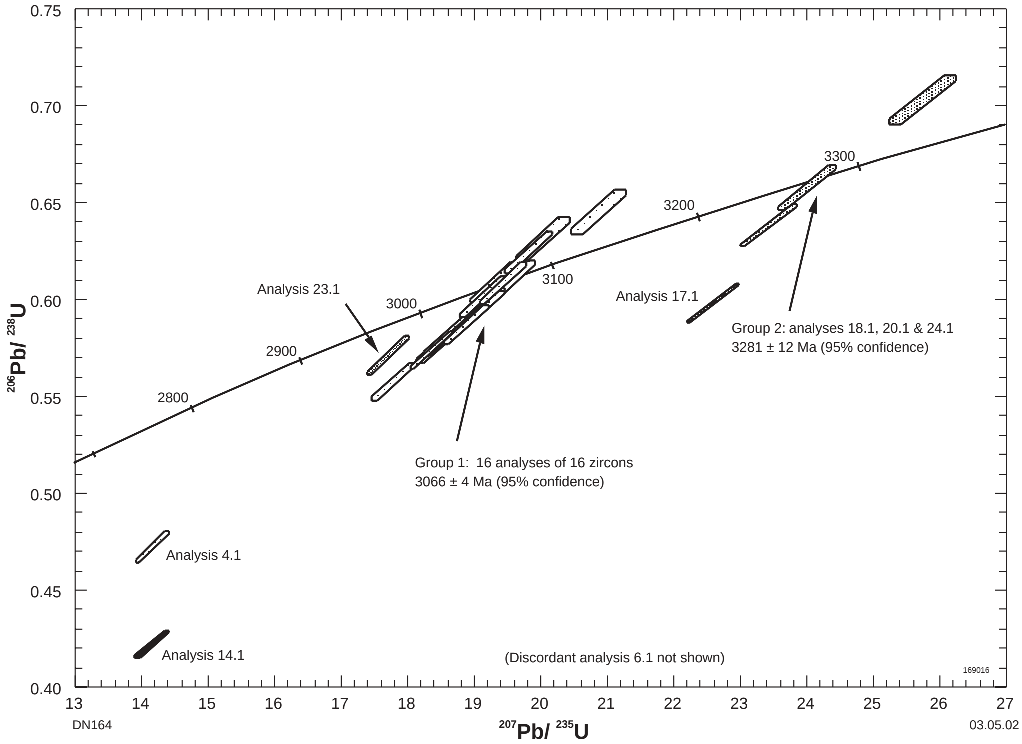

Figure 56. Concordia plot for sample 169016: foliated leucocratic biotite quartz diorite, Mount Gratwick

Results

Twenty-four analyses were obtained from 24 zircons. Results are given in Table 37 and shown on a concordia plot in Figure 56.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic-Pb loss, including a dominant recent episode. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of two groups. Sixteen concordant to slightly discordant analyses of 16 zircons (1.1, 2.1, 3.1, 5.1, 7.1, 8.1, 9.1, 10.1, 11.1, 12.1, 13.1, 15.1, 16.1, 19.1, 21.1 and 22.1), 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 3066 ± 4 Ma (chi-squared = 1.62). Concordant to slightly discordant analyses 18.1, 20.1 and 24.1, 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 3281 ± 12 Ma (chi-squared = 0.65). The remaining analyses (4.1, 6.1, 14.1, 17.1 and 23.1) are slightly to highly discordant and cannot be grouped.

The date of 3066 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 16 concordant to slightly discordant analyses of Group 1 is interpreted as a maximum age for igneous crystallization of the diorite. The older date indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of concordant to slightly discordant analyses (18.1, 20.1 and 24.1) of Group 2 is interpreted to be of a xenocryst zircon population, whereas the younger dates indicated by the slightly to highly discordant analyses 4.1, 6.1, 14.1, 17.1 and 23.1 are interpreted to be of sites that have undergone at least one ancient episode of radiogenic Pb loss.

169018: biotite monzogranite, Cunmagnunna Hill

Location and sampling

MARBLE BAR (SF 50-8), WHITE SPRINGS (2654)   MGA Zone 50, 694890E 7585210N

Sampled on 7 September 2000.

The sample was taken from a 2 m-diameter boulder located near the top of the southern side of a long north-northwesterly trending ridge, 8 km southeast of White Springs and 8 km south of Cunmagnunna Hill.

Tectonic unit/relations

This sample of the Beabea Monzogranite is a light grey, undeformed, medium- and even-grained to seriate biotite monzogranite of the Yule Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Smithies, in prep.a).

Petrographic description

The principal minerals present in this sample are plagioclase (35 vol.%), quartz (30 vol.%), K-feldspar (30 vol.%), and altered biotite (3–4 vol.%), with accessory sericite (trace), chlorite (trace), epidote (trace), muscovite (trace), prehnite (trace), opaque oxide (trace), apatite (trace), and zircon (trace). This is an altered, fine-grained and inequigranular biotite monzogranite with sericite, chlorite, epidote, muscovite and prehnite, as well as minor opaque oxide and apatite, and rare fine-grained zircon. There are large grains of both plagioclase and microcline, to 8 mm in diameter, with inclusions of quartz, altered plagioclase and altered biotite in the microcline. Ragged interstitial quartz grains are also abundant, and as much as 6 mm in diameter. These commonly have undulose extinction and subgrains, with areas of recrystallization. Finer grained areas are also evident throughout the thin section, with feldspar grains to 3 mm in diameter and completely chloritized or clay-altered biotite less than 1 mm in grain size. The plagioclase has irregular patches of alteration to sericite with clouded clinozoisite, with epidote or limonite-stained prehnite present in some grains. Some plagioclase grains also contain secondary muscovite to 0.5 mm in grain size. Epidote also occurs in some patches of altered biotite and enclosing limonite, possibly after pyrite. Rare opaque oxide is disseminated, locally enclosing apatite or rare small crystals of zircon. Minor apatite occurs away from the opaque oxide grains. Weak deformation has affected this sample, prior to low-grade alteration.

Zircon morphology

The zircons isolated from this sample are typically yellowish brown, dark brown or black, elongate and euhedral, and between 60 × 80 µm and 100 × 250 µm in size. Many grains are fractured and have faint internal zonation. Fluid, mineral, and dark amorphous inclusions are common. Some grains have mottled, zoned cores surrounded by weakly zoned rims. Many are metamict.

Analytical details

This sample was analysed on 29 October 2001. The counter deadtime during the analysis session was 32 ns. Eight analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.86 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for

Table 38. Ion microprobe analytical results for sample 169018: biotite monzogranite, Cunmagnunna Hill

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	196	231	159	2.299	0.21484	0.00107	0.22770	0.00230	0.6144	0.0116	18.200	0.365	105	2 942	8
2.1	102	114	88	0.568	0.26523	0.00114	0.26665	0.00193	0.6439	0.0122	23.549	0.470	98	3 278	7
3.1	431	122	318	0.198	0.26516	0.00050	0.07813	0.00052	0.6334	0.0118	23.156	0.440	97	3 278	3
4.1	161	90	111	0.169	0.21476	0.00075	0.14894	0.00099	0.5820	0.0110	17.232	0.338	101	2 942	6
5.1	394	116	250	0.600	0.24808	0.00059	0.08070	0.00087	0.5445	0.0102	18.625	0.356	88	3 173	4
6.1	106	117	92	0.265	0.26702	0.00102	0.28416	0.00161	0.6443	0.0122	23.722	0.470	97	3 289	6
7.1	217	103	167	0.520	0.25595	0.00073	0.09783	0.00101	0.6490	0.0122	22.904	0.443	100	3 222	5
8.1	155	65	103	0.551	0.21328	0.00086	0.10543	0.00133	0.5761	0.0109	16.942	0.335	100	2 931	7
9.1	44	135	52	0.493	0.26726	0.00166	0.75503	0.00414	0.6785	0.0133	25.002	0.532	101	3 290	10
10.1	211	98	183	3.060	0.26402	0.00116	0.13376	0.00237	0.6615	0.0124	24.081	0.478	100	3 271	7
11.1	78	38	53	0.294	0.21582	0.00113	0.12465	0.00172	0.5798	0.0111	17.253	0.353	100	2 950	8
12.1	107	74	91	0.229	0.28274	0.00099	0.16359	0.00129	0.6762	0.0128	26.360	0.519	99	3 378	5
13.1	73	98	68	0.240	0.26470	0.00121	0.34103	0.00209	0.6723	0.0129	24.536	0.498	101	3 275	7
14.1	352	66	229	0.103	0.22501	0.00049	0.04801	0.00043	0.5910	0.0111	18.334	0.350	99	3 017	3
15.1	105	45	71	0.335	0.21342	0.00094	0.10733	0.00135	0.5881	0.0111	17.306	0.346	102	2 932	7
16.1	183	10	117	0.137	0.21981	0.00066	0.01402	0.00064	0.6015	0.0113	18.229	0.353	102	2 979	5
4.2	227	162	158	0.162	0.21495	0.00059	0.17936	0.00083	0.5768	0.0108	17.094	0.330	100	2 943	4
8.2	107	48	74	0.357	0.21556	0.00093	0.11709	0.00134	0.5964	0.0113	17.725	0.354	102	2 948	7
15.2	127	58	85	0.418	0.21397	0.00096	0.11770	0.00149	0.5752	0.0109	16.969	0.339	100	2 936	7

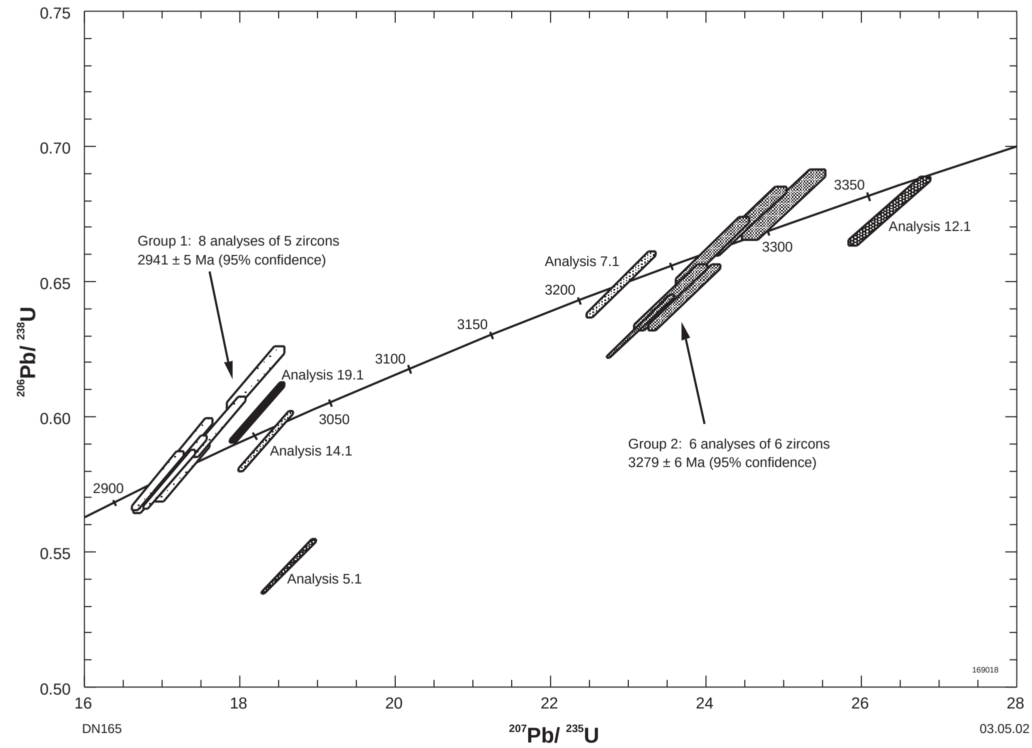

Figure 57. Concordia plot for sample 169018: biotite monzogranite, Cunmagnunna Hill

all analyses, with the exception of analyses 1.1, 5.1 and 10.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Nineteen analyses were obtained from 16 zircons. Results are given in Table 38 and shown on a concordia plot in Figure 57.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic-Pb loss, including a dominant recent episode. On the basis of their ^{207}Pb/^{206}Pb ratios, many analyses may be assigned to one of two groups. Eight concordant to slightly reverse discordant analyses of five zircons (1.1, 4.1, 4.2, 8.1, 8.2, 11.1, 15.1 and 15.2), 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 2941 ± 5 Ma (chi-squared = 0.90). Six concordant to slightly discordant analyses of six zircons (2.1, 3.1, 6.1, 9.1, 10.1 and 13.1), 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 3279 ± 6 Ma (chi-squared = 1.05). The remaining analyses (5.1, 7.1, 12.1, 14.1 and 17.1) cannot be grouped.

The date of 2941 ± 5 Ma indicated by the weighted mean ^{207}Pb/^{206}Pb ratio of the eight concordant to slightly reverse discordant analyses of five zircons of Group 1 is interpreted as the age of igneous crystallization of the monzogranite. The remaining analyses, which indicate older ^{207}Pb/^{206}Pb dates, are interpreted to be of xenocryst zircons.

169019: recrystallized biotite–hornblende quartz diorite, Redmont Camp

Location and sampling

MARBLE BAR (SF 50-8), TAMBOURAH (2754) MGA Zone 50, 707340E 7569120N

Sampled on 7 September 2000.

The sample was taken from a 0.5 m-diameter boulder located on a rock pile at the base of a vertical rock face within a quarry, 2 km north of Redmont Camp.

Tectonic unit/relations

This sample of the Tambourah Monzogranite is a dark grey-black, coarse-grained, recrystallized biotite diorite of the Yule Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Van Kranendonk and Pawley, 2002). At the sampling site, the diorite has been intensively veined by grey pegmatite. The sample taken was free of obvious pegmatite veins.

Petrographic description

The principal minerals present in this sample are plagioclase (70–75 vol.%), quartz (10–15 vol.%), biotite (7–8 vol.%), hornblende (5 vol.%), apatite (1 vol.%), titanite (1 vol.%), and allanite (0.5 vol.%), with accessory zircon (trace). An L–S fabric, with feldspathic or quartzofeldspathic rods in a foliated mafic matrix, is present in this biotite–hornblende quartz diorite gneiss. In thin section, there is a strong foliation defined by biotite and hornblende, although some of the mafic grains are aligned at a high angle to the foliation. The dominant mineral is granular plagioclase, to 4 mm in grain size, with relatively minor quartz. Some of the quartz is fine-grained, but there are large interstitial grains, to 4 mm in diameter, with undulose extinction. The foliation is largely defined by flakes of biotite, to 2 mm long, weakly altered to chlorite or to K-feldspar and leucoxene. Less abundant hornblende is less strongly aligned and occurs as anhedral grains to 2 mm long. The only primary K-feldspar occurs as small inclusions in the plagioclase. Apatite is the main accessory mineral, although fine-grained titanite is also disseminated, and there are altered, zoned crystals of allanite to 2 mm long. Rare rounded zircon grains are present. Initial amphibolite-facies metamorphism was followed by low-grade alteration.

Zircon morphology

The zircons isolated from this sample are typically pale yellowish brown, dark brown or black, equant to elongate with subrounded terminations and between 100 × 140 µm and 100 × 250 µm in size. Most grains have faint internal zonation and dark inclusions are common. Some grains have dark mottled cores surrounded by structureless or finely zoned, radially cracked rims.

Analytical details

This sample was analysed on 18 and 20 October 2001. The counter deadtime during both analysis session was 32 ns. Eleven analyses of the CZ3 standard were obtained during the first analysis session. Following deletion of one standard analysis as an outlier, the remaining ten analyses indicated a Pb^*/U calibration error of 1.70 (1σ%).

Table 39. Ion microprobe analytical results for sample 169019: recrystallized biotite–hornblende quartz diorite, Redmont Camp

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	193	145	166	0.203	0.28476	0.00084	0.19366	0.00108	0.6736	0.0117	26.449	0.474	98	3 389	5
2.1R	323	283	279	0.129	0.28621	0.00062	0.22451	0.00078	0.6610	0.0114	26.086	0.460	96	3 397	3
3.1	296	347	223	0.172	0.28001	0.00076	0.30068	0.00115	0.5494	0.0095	21.210	0.377	84	3 363	4
4.1	302	156	266	0.201	0.29236	0.00069	0.13500	0.00079	0.7132	0.0123	28.749	0.509	101	3 430	4
5.1	210	102	155	0.298	0.27826	0.00084	0.11424	0.00102	0.6116	0.0106	23.465	0.421	92	3 353	5
6.1	448	686	449	0.457	0.28219	0.00057	0.39933	0.00102	0.6835	0.0117	26.596	0.466	99	3 375	3
7.1	311	496	184	0.259	0.25717	0.00075	0.34608	0.00129	0.4251	0.0073	15.074	0.268	71	3 229	5
8.1	432	17	301	0.132	0.25845	0.00053	0.01171	0.00043	0.6366	0.0109	22.685	0.398	98	3 237	3
9.1	241	225	219	0.232	0.29044	0.00077	0.25184	0.00109	0.6789	0.0117	27.187	0.484	98	3 420	4
10.1	504	419	334	0.220	0.25952	0.00059	0.22088	0.00086	0.5166	0.0089	18.486	0.325	83	3 244	4
11.1	234	208	202	0.327	0.28951	0.00085	0.22992	0.00122	0.6536	0.0113	26.090	0.467	95	3 415	5
12.1	315	314	294	0.124	0.29142	0.00064	0.25436	0.00085	0.6988	0.0120	28.080	0.495	100	3 425	3
12.2	311	307	270	0.076	0.29327	0.00064	0.25123	0.00081	0.6503	0.0112	26.296	0.463	94	3 435	3
13.1	115	83	99	0.437	0.29236	0.00117	0.19665	0.00169	0.6619	0.0116	26.680	0.492	95	3 430	6
14.1	442	620	345	0.861	0.24968	0.00072	0.37447	0.00141	0.5450	0.0094	18.761	0.333	88	3 183	5
15.1	341	381	286	0.486	0.28168	0.00073	0.26623	0.00115	0.6221	0.0107	24.160	0.428	92	3 372	4
16.1	143	125	126	0.406	0.28839	0.00105	0.22375	0.00152	0.6731	0.0118	26.763	0.490	97	3 409	6
17.1	296	267	255	0.389	0.29125	0.00077	0.23890	0.00112	0.6470	0.0112	25.981	0.462	94	3 424	4
7.2	194	187	159	0.330	0.28374	0.00081	0.22627	0.00115	0.6256	0.0109	24.475	0.439	93	3 384	4
8.2	609	3	363	0.092	0.22584	0.00040	0.00475	0.00028	0.5608	0.0096	17.461	0.305	95	3 023	3
10.2	484	327	346	0.133	0.27150	0.00050	0.18156	0.00061	0.5687	0.0098	21.288	0.373	88	3 315	3
18.1R	150	168	143	0.776	0.28615	0.00100	0.30079	0.00175	0.6817	0.0119	26.896	0.489	99	3 397	5

NOTE: R denotes analysis obtained on zircon rim

Analyses 1.1 to 17.1 were obtained during the first analysis session. During the second analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.71 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty-two analyses were obtained from 18 zircons. Results are given in Table 39 and shown on a concordia plot in Figure 58.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with both ancient and recent radiogenic-Pb loss. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of three groups. Six concordant to slightly discordant analyses of five zircons (4.1, 9.1, 12.1, 12.2, 13.1 and 17.1), 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 3428 ± 6 Ma (chi-squared = 1.68). Concordant to slightly discordant analyses 11.1 and 16.1, 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 3413 ± 4 Ma (1σ error). Concordant to slightly discordant analyses 1.1, 2.1 and 18.1, assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3395 ± 11 Ma (chi-squared = 0.79). Concordant analysis 6.1 indicates a $^{207}Pb/^{206}Pb$ date of 3375 ± 3 Ma (1σ error). The remaining analyses (3.1, 5.1, 7.1, 7.2, 8.1, 8.2, 10.1, 10.2, 14.1 and 15.1) are slightly to highly discordant and cannot be confidently grouped.

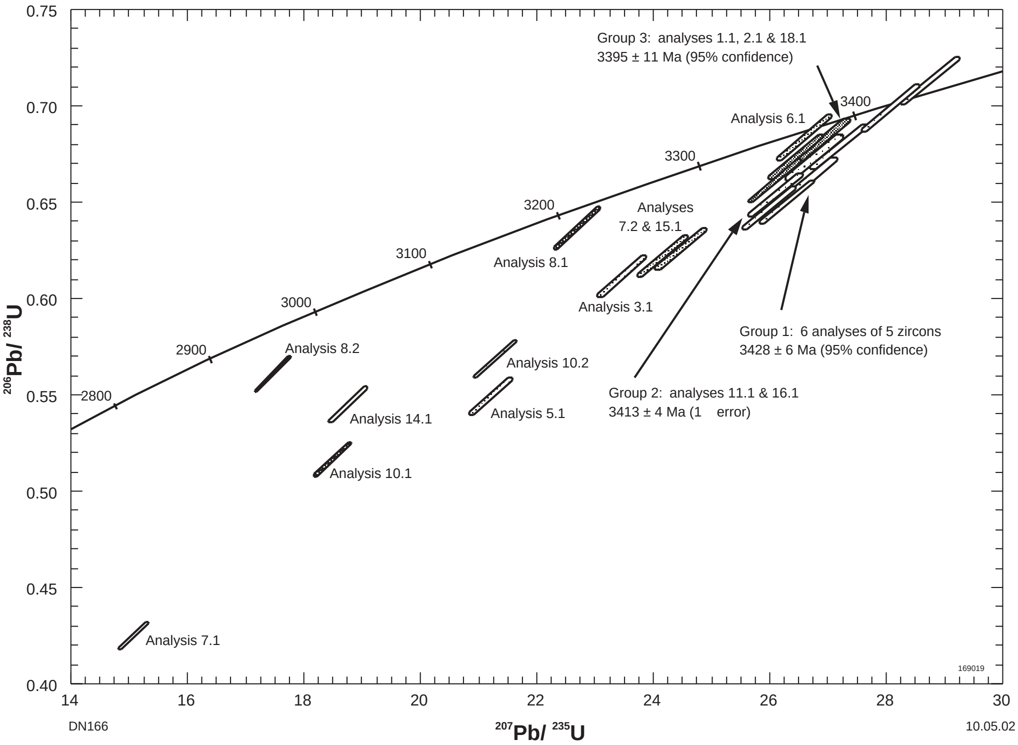

Figure 58. Concordia plot for sample 169019: recrystallized biotite–hornblende quartz diorite, Redmont Camp

For analyses with U concentrations greater than 300 ppm, $^{207}Pb/^{206}Pb$ ratios are negatively correlated with U concentration. This implies that analyses from high U analysis sites may have lost some of their accumulated radiogenic Pb during an ancient disturbance event.

Although several alternative interpretations of these results are possible, the preferred interpretation is that the date of 3428 ± 6 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the six concordant to slightly discordant analyses of five zircons of Group 1 is the age of igneous crystallization of the diorite. The younger dates indicated by the remaining analyses are interpreted to be of sites that have undergone at least one episode of ancient radiogenic Pb loss.

169021: leucocratic syenogranite gneiss, Birthday Gift mine

Location and sampling

PORT HEDLAND (SF 50-4), WALLARINGA (2656) MGA Zone 50, 700110E 7678220N

Sampled on 8 September 2000.

The sample was taken from a 1 m-diameter, low boulder located in the bed of a creek among an area of low, uneven pavements and 500 m west of the Birthday Gift mine.

Tectonic unit/relations

This sample is from a light grey, homogeneous, fine- and even- grained, strongly foliated to gneissic syenogranite phase of the Carlindi Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Smithies et al., 2001b). The sampling site is close to the western margin of the Pilgangoora greenstone belt.

Petrographic description

The principal minerals present in this sample are microcline (50 vol.%), quartz (30 vol.%), plagioclase (15 vol.%), and biotite (5 vol.%), with accessory muscovite (trace), apatite, (trace), sericite (trace), limonite (trace), clinozoisite (trace), opaque oxide (trace), zircon (trace), and monazite (trace). This is a syenogranite gneiss, metamorphosed in the amphibolite facies and with weak alteration. There is a strong foliation in this fine-grained leucocratic granitoid gneiss, with possibly quartz-rich and feldspar-rich lamellae. The thin section shows that the quartz occurs partly as ribbon-like grains and lenses from 1 to 7 mm long and up to 4 mm wide, alternating with more feldspathic areas. Elongate grains of microcline, to 5 mm long, occur adjacent to some of the quartz lenses. Plagioclase is not abundant, and occurs as rounded augen-like grains to 3 mm in diameter with weak alteration to sericite, limonite and clouded clinozoisite. Leached patches in the plagioclase may have contained carbonate, but this is not certain. The main feldspar is fine-grained microcline, mostly 0.1 to 1 mm in grain size, with minor myrmekite against plagioclase. Fresh to chloritized biotite, to 1 mm in grain size, defines a layer-parallel foliation, and is partly interlaminated with muscovite. Apatite is rare, but there is also rare accessory opaque oxide, slender prisms of zircon and rounded grains that may be monazite.

Zircon morphology

The zircons isolated from this sample are typically pale yellowish brown, dark brown or black, elongate with euhedral terminations and between 60 × 120 µm and 100 × 240 µm in size. Most grains have faint internal zonation and dark inclusions are common.

Analytical details

This sample was analysed on 14 December 2001. The counter deadtime during the analysis session was 32 ns. Five analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.08 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for

Table 40. Ion microprobe analytical results for sample 169021: leucocratic syenogranite gneiss, Birthday Gift mine

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	510	489	367	0.039	0.21302	0.00050	0.26108	0.00077	0.5651	0.0062	16.598	0.191	99	2 929	4
2.1	463	331	324	0.276	0.21130	0.00059	0.19385	0.00092	0.5741	0.0063	16.725	0.196	100	2 916	5
3.1	300	220	200	0.210	0.21239	0.00073	0.20430	0.00113	0.5449	0.0061	15.957	0.193	96	2 924	6
4.1	421	262	283	0.314	0.21250	0.00061	0.17338	0.00093	0.5588	0.0062	16.373	0.193	98	2 925	5
6.1	180	97	141	-0.013	0.25738	0.00103	0.14689	0.00157	0.6464	0.0074	22.940	0.289	99	3 231	6
7.1	325	198	219	0.154	0.21238	0.00063	0.16500	0.00087	0.5657	0.0063	16.566	0.197	99	2 924	5
8.1	757	496	527	0.459	0.21192	0.00048	0.18587	0.00083	0.5710	0.0062	16.684	0.191	100	2 920	4
9.1	1 199	870	850	0.020	0.21195	0.00031	0.20077	0.00041	0.5823	0.0063	17.017	0.190	101	2 920	2
10.1	624	117	381	0.709	0.21245	0.00057	0.05219	0.00091	0.5483	0.0060	16.062	0.186	96	2 924	4
11.1	461	399	293	0.732	0.21363	0.00068	0.22029	0.00128	0.5047	0.0056	14.866	0.176	90	2 933	5
1.2	318	247	224	0.073	0.21270	0.00064	0.20606	0.00092	0.5742	0.0064	16.840	0.200	100	2 926	5
12.1	518	392	350	0.137	0.21173	0.00050	0.21169	0.00074	0.5478	0.0060	15.993	0.184	96	2 919	4
5.1	761	494	529	0.055	0.21273	0.00041	0.16500	0.00051	0.5855	0.0064	17.174	0.195	102	2 926	3

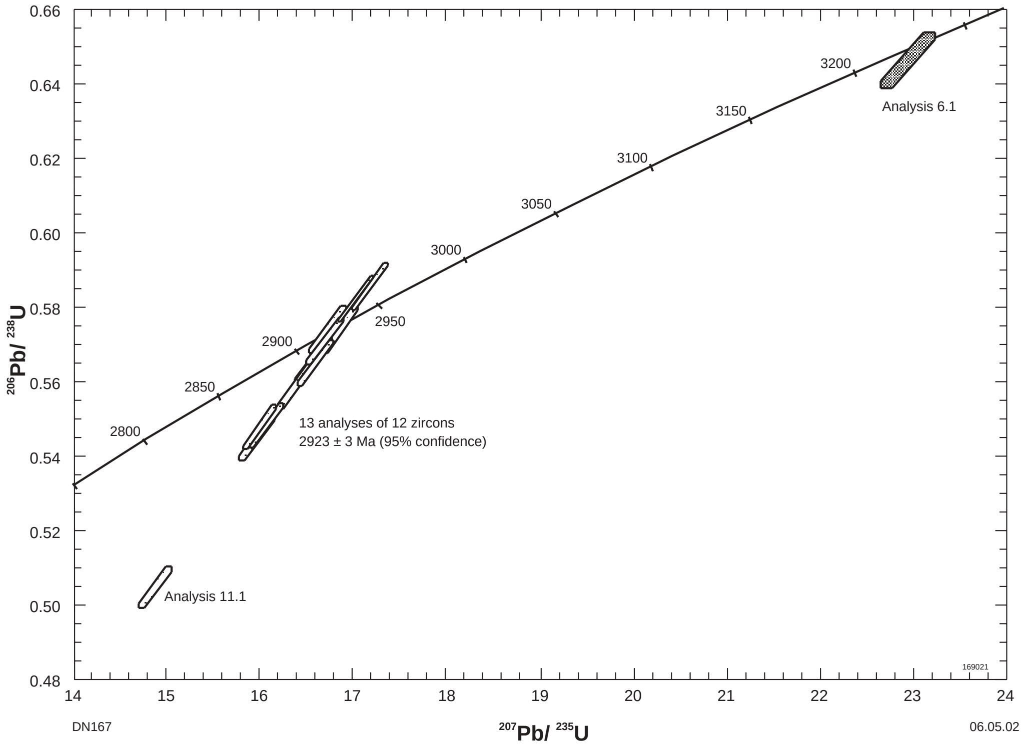

Figure 59. Concordia plot for sample 169021: leucocratic syenogranite gneiss, Birthday Gift mine

all analyses, with the exception of analyses 8.1, 10.1 and 11.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Fourteen analyses were obtained from 12 zircons. Results are given in Table 40 and shown on a concordia plot in Figure 59.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a single episode of recent radiogenic-Pb loss. Thirteen concordant to slightly discordant analyses of 12 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2923 ± 3 Ma (chi-squared = 1.14). Concordant analysis 6.1 indicates a significantly older $^{207}Pb/^{206}Pb$ date than the main population.

The date of 2923 ± 3 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 13 concordant to slightly discordant analyses of 12 zircons is interpreted as the age of igneous crystallization of the syenogranite precursor to the gneiss. The older date indicated by analysis 6.1 is interpreted to be of a xenocryst zircon.

169031: biotite tonalite gneiss, Limestone Well

Location and sampling

NULLAGINE (SF 51-5), MOUNT EDGAR (2955) MGA Zone 51, 189900E 7651150N

Sampled on 13 September 2000.

The sample was taken from an exfoliated sheet of a large area of low sloping pavement on the west bank of a creek bed, and 500 m north of Limestone Well.

Tectonic unit/relations

This sample of the Fig Tree Gneiss Complex is a dark grey, medium- to coarse-grained, seriate gneiss of the Mount Edgar Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Williams and Bagas, in prep.). At the sampling site, the gneiss has been intruded by pegmatite veins up to 5 cm thick. Both phases were subsequently deformed, with the pegmatite veins aligned parallel to the foliation. The sample taken was free of any obvious pegmatite veins.

Petrographic description

The principal minerals present in this sample are plagioclase (65 vol.%), quartz (30 vol.%), biotite (5 vol.%), epidote (3 vol.%), chlorite (2 vol.%), and hornblende (<1 vol.%), with accessory magnetite (trace), titanite (trace), apatite (trace), allanite (trace), and zircon (trace). This is an altered, fine-grained grey biotite tonalite gneiss, with patches of epidote and chlorite, and a planar foliation. In thin section, the foliation is defined by lenses and lamellae of biotite, set in a granuloblastic quartzofeldspathic aggregate. The main mineral is plagioclase, with less abundant quartz, both largely anhedral and 0.5 to 3 mm in grain size, and with very weak sericite clouding in some areas of plagioclase. Fresh to chloritized biotite occurs as flakes to 1.5 mm long in lamellae anastomosing around plagioclase- to quartz-rich domains on a millimetre to centimetre scale. Aggregates of epidote and iron-rich chlorite, to 3 mm in diameter, locally contain minor green hornblende. Fine-grained lenses of recrystallized quartz and plagioclase accompany the biotite and the epidote–chlorite aggregates, indicating zones of shearing. Titanite, opaque oxide and apatite are the most common accessory minerals, but there are also altered prisms of allanite to 1 mm long, partly rimmed by epidote, and rare zircon crystals. The sample has undergone greenschist to low amphibolite facies metamorphism, followed by low temperature alteration.

Zircon morphology

The zircons isolated from this sample are typically pale yellowish brown or dark brown, elongate with subrounded terminations and between 35 × 80 µm and 60 × 280 µm in size. Many grains have faint internal zonation and some have fluid and mineral inclusions. Many are metamict.

Analytical details

This sample was analysed on 22 and 26 July 2001. The counter deadtime during both analysis sessions was 32 ns. Nine analyses of the CZ3 standard obtained during the first analysis session indicated a Pb^*/U calibration error of 1.12 (1σ%). Analyses 1.1 to 14.1 were obtained during the first analysis session. During the second analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of

Table 41. Ion microprobe analytical results for sample 169031: biotite tonalite gneiss, Limestone Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	707	240	446	0.178	0.27582	0.00051	0.08876	0.00052	0.5339	0.0060	20.303	0.238	83	3 339	3
2.1	900	57	449	0.073	0.24677	0.00046	0.01875	0.00031	0.4570	0.0052	15.548	0.181	77	3 164	3
3.1	529	42	354	0.162	0.26565	0.00055	0.02116	0.00046	0.6010	0.0068	22.012	0.260	92	3 281	3
4.1	272	99	220	0.164	0.29131	0.00077	0.09552	0.00074	0.6754	0.0078	27.127	0.330	97	3 425	4
5.1	542	132	377	0.212	0.28198	0.00059	0.06391	0.00059	0.5960	0.0068	23.173	0.274	89	3 374	3
6.1	727	127	505	0.092	0.28275	0.00045	0.05370	0.00035	0.6020	0.0068	23.469	0.273	90	3 378	2
7.1	553	68	398	0.148	0.27334	0.00053	0.03499	0.00046	0.6360	0.0072	23.970	0.282	95	3 325	3
8.1	338	18	260	0.121	0.29199	0.00068	0.01316	0.00051	0.6814	0.0078	27.434	0.329	98	3 428	4
9.1	218	95	171	0.319	0.28298	0.00088	0.11821	0.00108	0.6454	0.0075	25.180	0.312	95	3 379	5
10.1	81	57	73	0.420	0.29554	0.00152	0.18395	0.00213	0.7026	0.0088	28.629	0.404	100	3 447	8
11.1	1 072	12	340	0.107	0.22597	0.00047	0.00407	0.00036	0.2986	0.0034	9.305	0.109	56	3 024	3
12.1	275	94	229	0.241	0.29324	0.00077	0.08568	0.00081	0.6965	0.0081	28.163	0.343	99	3 435	4
13.1	618	14	432	0.115	0.27135	0.00061	0.00599	0.00039	0.6328	0.0072	23.676	0.282	95	3 314	3
14.1	738	177	406	0.103	0.26694	0.00050	0.05488	0.00041	0.4825	0.0055	17.757	0.208	77	3 288	3
15.1	846	462	766	0.115	0.29610	0.00042	0.10375	0.00039	0.7492	0.0085	30.586	0.354	104	3 450	2
16.1	476	71	346	0.184	0.28408	0.00056	0.03767	0.00050	0.6343	0.0106	24.846	0.423	94	3 385	3
17.1	529	19	324	0.114	0.27760	0.00051	0.01021	0.00037	0.5511	0.0092	21.093	0.358	84	3 349	3
18.1	296	143	245	0.153	0.29205	0.00073	0.12529	0.00081	0.6751	0.0113	27.187	0.470	97	3 429	4
19.1	243	128	213	0.172	0.29677	0.00084	0.12919	0.00093	0.7080	0.0120	28.971	0.506	100	3 453	4
20.1	73	30	62	0.507	0.29144	0.00173	0.10232	0.00250	0.6967	0.0123	27.995	0.542	99	3 425	9
21.1	163	154	143	0.135	0.29279	0.00109	0.25097	0.00161	0.6568	0.0111	26.513	0.472	95	3 432	6
22.1	193	151	176	0.204	0.29166	0.00098	0.20152	0.00132	0.7080	0.0120	28.473	0.505	101	3 426	5
23.1	63	37	56	0.412	0.29334	0.00196	0.15565	0.00296	0.6955	0.0125	28.132	0.559	99	3 435	10
24.1	102	65	86	0.297	0.29134	0.00153	0.16587	0.00207	0.6651	0.0116	26.717	0.505	96	3 425	8

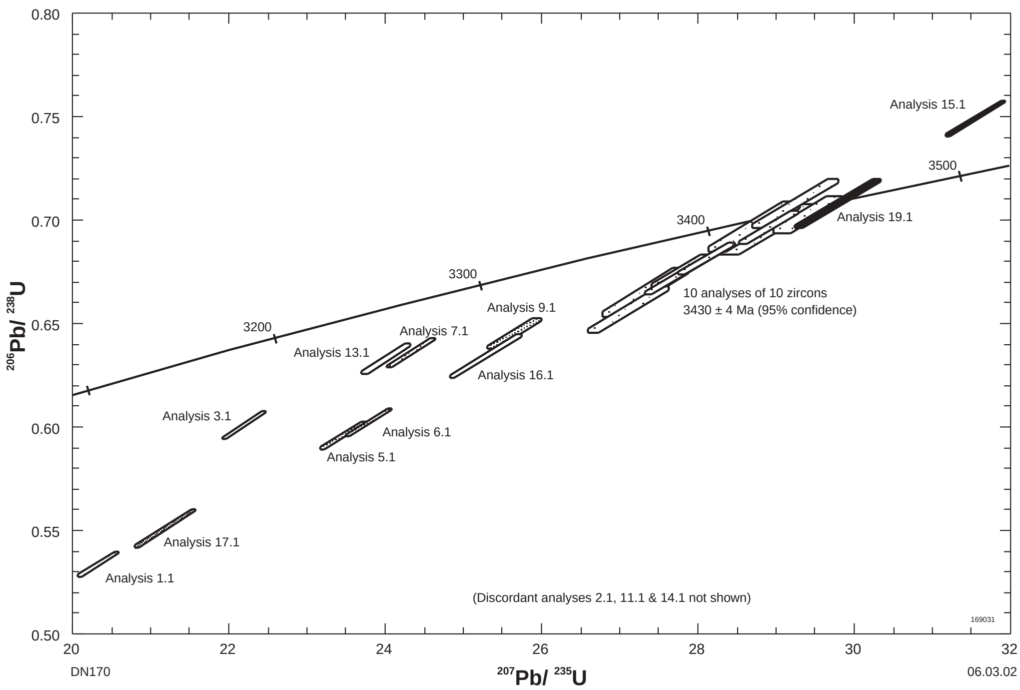

Figure 60. Concordia plot for sample 169031: biotite tonalite gneiss, Limestone Well

1.65 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty-four analyses were obtained from 24 zircons. Results are given in Table 41 and shown on a concordia plot in Figure 60.

Interpretation

The analyses are concordant to slightly discordant, with the discordance pattern consistent with several episodes of radiogenic-Pb loss, including a recent episode. Ten concordant and discordant analyses of ten zircons (4.1, 8.1, 10.1, 12.1, 18.1, 20.1, 21.1, 22.1, 23.1 and 24.1) have ^{207}Pb/^{206}Pb ratios defining a single population and indicating a weighted mean ^{207}Pb/^{206}Pb date of 3430 ± 4 Ma (chi-squared = 0.98). Concordant analysis 19.1 indicates a slightly older ^{207}Pb/^{206}Pb date than the main population, whereas the remaining analyses are discordant and cannot be grouped.

The date of 3430 ± 4 Ma indicated by the weighted mean ^{207}Pb/^{206}Pb ratio of ten concordant and discordant analyses of ten zircons is interpreted as the age of igneous crystallization of the tonalite precursor to the gneiss. The slightly older ^{207}Pb/^{206}Pb date indicated by concordant analysis 19.1 is interpreted to be of a xenocryst zircon, whereas the younger ^{207}Pb/^{206}Pb dates indicated by the remaining discordant analyses are attributed to radiogenic-Pb loss from these analysis sites.

169038: biotite–hornblende granodiorite, Outcamp Bore

Location and sampling

NULLAGINE (SF 51-5), MOUNT EDGAR (2955) MGA Zone 51, 211560E 7645700N

Sampled on 14 September 2000.

The sample was taken from a 1 m-diameter boulder located in an area of 1 to 2 m-high whalebacks and tors, 75 m north of the access track to Outcamp Bore, 10 km south of the Rippon Hills road and 1 km southwest of Outcamp Bore.

Tectonic unit/relations

This sample of the Yandicoogina Granodiorite is a light grey, medium- and even-grained, unfoliated to weakly foliated granodiorite of the Mount Edgar Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Williams and Bagas, in prep.). The sample taken was free of any obvious veins.

Petrographic description

The principal minerals present in this sample are plagioclase (50–55 vol.%), quartz (30 vol.%), microcline (7–8 vol.%), biotite (4 vol.%), hornblende (3 vol.%), titanite (1 vol.%), and opaque oxide (1 vol.%), with accessory apatite (trace), and zircon (trace). This is a weakly altered biotite–hornblende granodiorite to tonalite, with titanite, opaque oxide, apatite and rare zircon, and displaying a weak low-grade alteration assemblage of sericite, epidote and chlorite. Large crystals and clots of mafic minerals are scattered through this rock, with sparse larger feldspar grains to 10 mm long, all in a slightly finer groundmass. The thin section shows relatively few large mafic grains and clots, but has abundant anhedral to subhedral plagioclase and less abundant quartz to 7 mm in grain size. Zones of sericitic to saussuritic alteration are common, with coarser muscovite and/or epidote in some areas. Plates of biotite, to 4 mm long, are weakly aligned along a probable flow foliation, and are irregularly altered to chlorite and/or epidote. Prisms of green hornblende, to 5 × 3 mm, are fresh and have inclusions of quartz, magnetite, biotite, and titanite. Microcline occurs rarely as interstitial grains to 4 mm in diameter, and as films between plagioclase and quartz. Myrmekite has developed adjacent to some areas of microcline. Mostly rounded grains of titanite occur, to 3 mm in diameter, with inclusions of magnetite and apatite. Separate magnetite and apatite grains and crystals also occur. Zircon commonly occurs within biotite and hornblende, or adjacent to magnetite.

Zircon morphology

The zircons isolated from this sample are typically light brown or dark brown, elongate with subrounded terminations and between 45 × 80 µm and 60 × 280 µm in size. Many grains have faint internal zonation, or have strongly zoned interiors surrounded by weakly zoned or unzoned exterior zones. Fluid and mineral inclusions are common.

Analytical details

This sample was analysed on 15 August 2001. The counter deadtime during the analysis session was 32 ns. Six analyses of the CZ3 standard obtained during the analysis session

Table 42. Ion microprobe analytical results for sample 169038: biotite–hornblende granodiorite, Outcamp Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	214	53	160	0.101	0.27108	0.00079	0.06196	0.00072	0.6499	0.0069	24.292	0.276	97	3 312	5
2.1	189	82	148	0.209	0.27061	0.00085	0.11618	0.00098	0.6527	0.0070	24.354	0.280	98	3 310	5
3.1	181	59	130	0.386	0.27233	0.00096	0.09766	0.00124	0.6001	0.0064	22.532	0.263	91	3 319	6
4.1	246	87	191	0.081	0.27238	0.00072	0.09851	0.00066	0.6583	0.0069	24.722	0.277	98	3 320	4
5.1	228	89	175	0.069	0.27160	0.00074	0.10506	0.00068	0.6465	0.0068	24.209	0.272	97	3 315	4
6.1	164	74	130	0.068	0.27124	0.00089	0.11929	0.00090	0.6577	0.0071	24.597	0.287	98	3 313	5
7.1	271	120	210	0.263	0.27111	0.00072	0.12133	0.00088	0.6436	0.0067	24.057	0.267	97	3 312	4
8.1	180	83	139	0.159	0.27235	0.00087	0.12189	0.00096	0.6429	0.0069	24.141	0.279	96	3 320	5
9.1	222	46	166	0.123	0.27156	0.00077	0.05372	0.00067	0.6525	0.0069	24.432	0.277	98	3 315	4
10.1	192	27	141	0.106	0.27266	0.00084	0.03896	0.00067	0.6503	0.0069	24.448	0.280	97	3 321	5
11.1	209	133	177	1.211	0.29178	0.00106	0.18261	0.00183	0.6428	0.0068	25.858	0.301	93	3 427	6
12.1	157	79	124	0.077	0.27287	0.00088	0.13547	0.00092	0.6513	0.0070	24.504	0.284	97	3 323	5
13.1	183	29	138	0.204	0.27209	0.00089	0.04238	0.00091	0.6608	0.0071	24.792	0.287	99	3 318	5
14.1	128	27	96	0.098	0.27042	0.00100	0.05716	0.00098	0.6561	0.0072	24.463	0.293	98	3 308	6
15.1	116	42	92	0.152	0.27287	0.00108	0.09839	0.00119	0.6676	0.0074	25.118	0.307	99	3 323	6
16.1	157	37	120	0.108	0.27198	0.00088	0.05974	0.00075	0.6643	0.0072	24.912	0.291	99	3 317	5
17.1	100	24	77	0.243	0.27154	0.00117	0.06061	0.00128	0.6614	0.0074	24.761	0.310	99	3 315	7
18.1	187	49	144	0.117	0.27041	0.00081	0.06907	0.00074	0.6677	0.0071	24.894	0.285	100	3 308	5
19.1	243	114	165	0.108	0.26368	0.00070	0.12284	0.00072	0.5681	0.0060	20.656	0.230	89	3 269	4
20.1	208	32	153	0.294	0.26975	0.00083	0.03584	0.00087	0.6482	0.0069	24.108	0.275	97	3 305	5
21.1	116	38	89	0.074	0.27028	0.00108	0.09103	0.00114	0.6563	0.0073	24.456	0.299	98	3 308	6
23.1	93	30	73	0.119	0.27323	0.00116	0.08747	0.00115	0.6696	0.0076	25.225	0.317	99	3 325	7
22.1	151	48	115	0.140	0.27118	0.00090	0.08268	0.00090	0.6531	0.0070	24.419	0.284	98	3 313	5

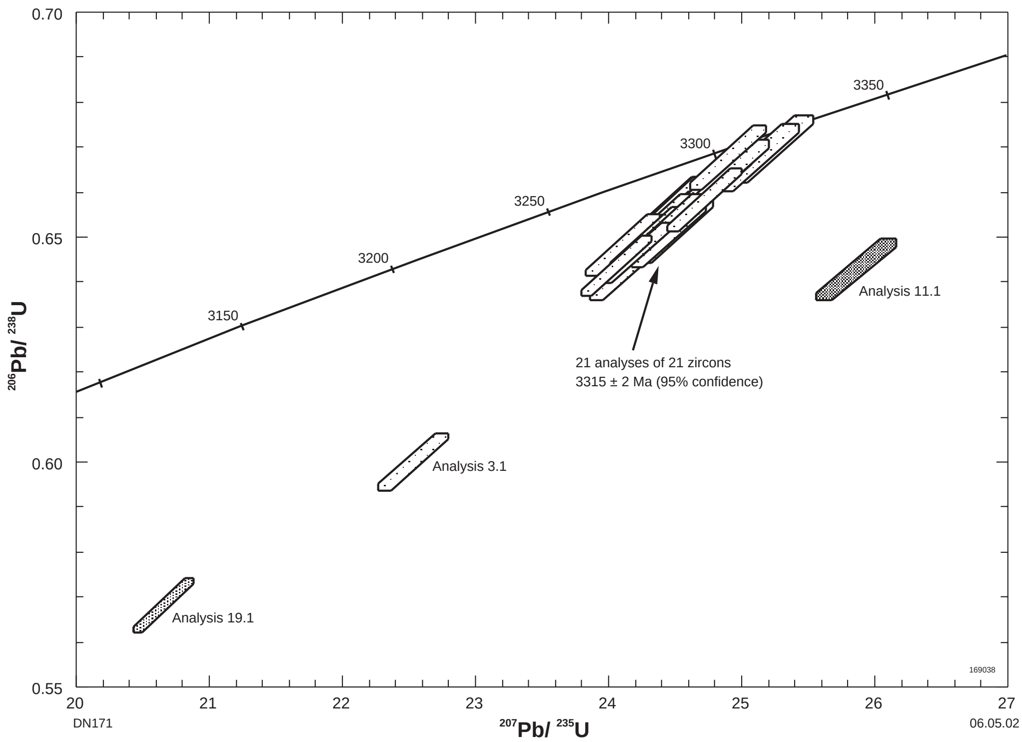

Figure 61. Concordia plot for sample 169038: biotite–hornblende granodiorite, Outcamp Bore

indicated a Pb*/U calibration error of 0.869 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during this analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 11.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-two analyses were obtained from 22 zircons. Results are given in Table 42 and shown on a concordia plot in Figure 61.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several recent episodes of radiogenic-Pb loss. Twenty-one concordant and discordant analyses of 21 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3315 ± 2 Ma (chi-squared = 1.08). Discordant analysis 11.1 indicates a significantly older $^{207}Pb/^{206}Pb$ date, whereas discordant analysis 19.1 indicates a significantly younger $^{207}Pb/^{206}Pb$ date, than the main population.

The date of 3315 ± 2 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 21 concordant and discordant analyses of 21 zircons is interpreted as the age of igneous crystallization of the granodiorite. The slightly older $^{207}Pb/^{206}Pb$ date indicated by concordant analysis 11.1 is interpreted to be of a xenocryst zircon, whereas the younger $^{207}Pb/^{206}Pb$ date indicated by analysis 19.1 is attributed to radiogenic-Pb loss from this analysis site.

144683: hornblende–quartz monzonite, Pelican Pool

Location and sampling

NULLAGINE (SF 51-5), MOUNT EDGAR (2955) MGA Zone 51, 227203E 7642437N

Sampled on 25 September 2000.

The sample was taken from a site located 30 m above a creek bed, and 5.1 km bearing 015° from Pelican Pool on the Nullagine River.

Tectonic unit/relations

This sample is from an unfoliated, pinkish grey hornblende–quartz monzonite that has intruded basalts of the Kylena Formation, Fortescue Group, Hamersley Basin (Williams and Bagas, in prep.). The monzonite contains numerous scattered mafic xenoliths, composed largely of hornblende. The sample was taken from the northwestern side of the monzonite pluton, about 50 m from the basalt contact.

Petrographic description

The principal minerals present in this sample are orthoclase (35–40 vol.%), plagioclase (30 vol.%), quartz (15–20 vol.%), altered chlorite, carbonate, and epidote (7–8 vol.%), magnetite (2–3 vol.%), and apatite (<1 vol.%), with accessory titanite (trace), carbonate (trace), and zircon (trace). This is an altered, hornblende-bearing quartz monzonite, transitional towards monzogranite, with chlorite, epidote, carbonate and sericite. Pink and cream coloured feldspars are visible in hand specimen, as well as a disseminated mineral, possibly amphibole. The thin section shows abundant feldspar to 3 mm in grain size. Brownish, iron-stained orthoclase is more abundant than fresh to sericite-clouded plagioclase, but its form is anhedral, whereas the plagioclase is euhedral. Crystals of a mineral, possibly amphibole, from 0.4 to 4 mm long, have been replaced by aggregates of chlorite, quartz, carbonate and epidote in various proportions, with rarely found carbonate in the same aggregate as epidote. Chlorite in this sample has a very low birefringence, with anomalous brown and blue interference colours. Interstitial quartz is common to abundant, with anhedral grains and subhedral, partly resorbed crystals suggesting a low pressure, possibly subvolcanic intrusion. Magnetite is disseminated as grains and aggregates to 0.5 mm in diameter, with minor apatite and rare titanite. Rare possible cavities contain quartz and carbonate, consistent with subvolcanic intrusion.

Zircon morphology

The zircons isolated from this sample are typically colourless, pale yellowish brown, greenish brown or dark brown, elongate with subrounded terminations and between 20 × 35 µm and 180 × 280 µm in size. Most grains are fractured and internally structureless, although a minority have fractured cores surrounded by unzoned rims that are radially fractured in a few examples. Fluid and mineral inclusions are common.

Analytical details

This sample was analysed on 23 October 2001. The counter deadtime during the analysis session was 32 ns. Seven analyses of the CZ3 standard obtained during the

Table 43. Ion microprobe analytical results for sample 144683: hornblende–quartz monzonite, Pelican Pool

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	120	48	98	0.256	0.27061	0.00084	0.10771	0.00101	0.6842	0.0157	25.528	0.602	102	3 310	5
2.1	192	105	149	0.383	0.26726	0.00071	0.14986	0.00099	0.6305	0.0145	23.233	0.544	96	3 290	4
3.1	158	85	130	0.123	0.26648	0.00073	0.14662	0.00085	0.6706	0.0154	24.641	0.579	101	3 285	4
4.1	250	63	191	0.060	0.27077	0.00059	0.06643	0.00050	0.6616	0.0152	24.701	0.575	99	3 310	3
5.1	112	76	94	0.156	0.27394	0.00091	0.18073	0.00114	0.6675	0.0154	25.214	0.598	99	3 329	5
6.1	108	47	88	0.041	0.26396	0.00085	0.11553	0.00094	0.6829	0.0157	24.855	0.588	103	3 271	5
7.1	96	40	78	0.070	0.27033	0.00091	0.11410	0.00100	0.6780	0.0157	25.272	0.600	101	3 308	5
8.1	83	33	70	0.086	0.27110	0.00098	0.10732	0.00101	0.7114	0.0165	26.591	0.635	105	3 312	6
9.1	152	20	115	0.115	0.26791	0.00072	0.03471	0.00061	0.6695	0.0154	24.732	0.580	100	3 294	4
10.1	149	56	90	0.082	0.19305	0.00068	0.10313	0.00086	0.5391	0.0124	14.348	0.340	100	2 768	6
11.1	160	74	129	0.077	0.27142	0.00071	0.12265	0.00073	0.6716	0.0154	25.133	0.589	100	3 314	4
12.1	80	41	65	0.159	0.27215	0.00105	0.13518	0.00125	0.6674	0.0154	25.044	0.599	99	3 318	6
13.1	516	222	311	0.041	0.19241	0.00034	0.11790	0.00038	0.5339	0.0122	14.165	0.327	100	2 763	3
14.1	506	251	312	0.039	0.20055	0.00035	0.13655	0.00040	0.5358	0.0122	14.815	0.342	98	2 831	3
15.1	26	22	17	0.548	0.18858	0.00207	0.22666	0.00399	0.5340	0.0128	13.885	0.382	101	2 730	18
16.1	112	35	67	0.153	0.19158	0.00080	0.08518	0.00100	0.5401	0.0124	14.266	0.341	101	2 756	7
17.1	166	54	131	0.052	0.27289	0.00067	0.08521	0.00059	0.6740	0.0155	25.359	0.593	100	3 323	4
18.1	369	183	237	0.063	0.20059	0.00041	0.13517	0.00049	0.5560	0.0127	15.377	0.357	101	2 831	3
19.1	142	204	104	0.097	0.19352	0.00069	0.39204	0.00142	0.5329	0.0122	14.221	0.337	99	2 772	6
20.1	70	21	57	0.325	0.27269	0.00114	0.07597	0.00136	0.6877	0.0160	25.858	0.623	102	3 322	7
21.1	77	23	59	0.328	0.27150	0.00113	0.07775	0.00135	0.6536	0.0151	24.469	0.588	98	3 315	7
22.1	169	177	117	0.075	0.19224	0.00062	0.28916	0.00110	0.5441	0.0125	14.423	0.340	101	2 761	5
23.1	210	231	150	0.084	0.20165	0.00056	0.29809	0.00098	0.5542	0.0127	15.407	0.361	100	2 840	5
24.1	104	42	62	0.039	0.19267	0.00079	0.11285	0.00098	0.5345	0.0123	14.199	0.339	100	2 765	7
25.1	515	249	323	0.027	0.20059	0.00034	0.13107	0.00038	0.5458	0.0125	15.096	0.349	99	2 831	3

analysis session indicated a Pb*/U calibration error of 2.28 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty-five analyses were obtained from 25 zircons. Results are given in Table 43 and shown on a concordia plot in Figure 62.

Interpretation

The analyses are concordant to slightly discordant, with the discordance pattern consistent with recent radiogenic-Pb loss. On the basis of their $^{207}Pb/^{206}Pb$ ratios, most analyses may be assigned to one of four groups. Seven concordant analyses of seven zircons (10.1, 13.1, 15.1, 16.1, 19.1, 22.1 and 24.1), 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 2764 ± 6 Ma (chi-squared = 1.26). Concordant analyses 14.1, 18.1, 23.1 and 25.1, 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 2832 ± 6 Ma (chi-squared = 0.95). Discordant analysis 2.1 and concordant analyses 3.1 and 9.1, assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3290 ± 10 Ma (chi-squared = 0.73). Ten concordant analyses of ten zircons (1.1, 4.1, 5.1, 7.1, 8.1, 11.1, 12.1, 17.1, 20.1 and 21.1), assigned to Group 4, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3316 ± 5 Ma (chi-squared = 1.73). Concordant analysis 6.1 cannot be confidently assigned to any of these groups.

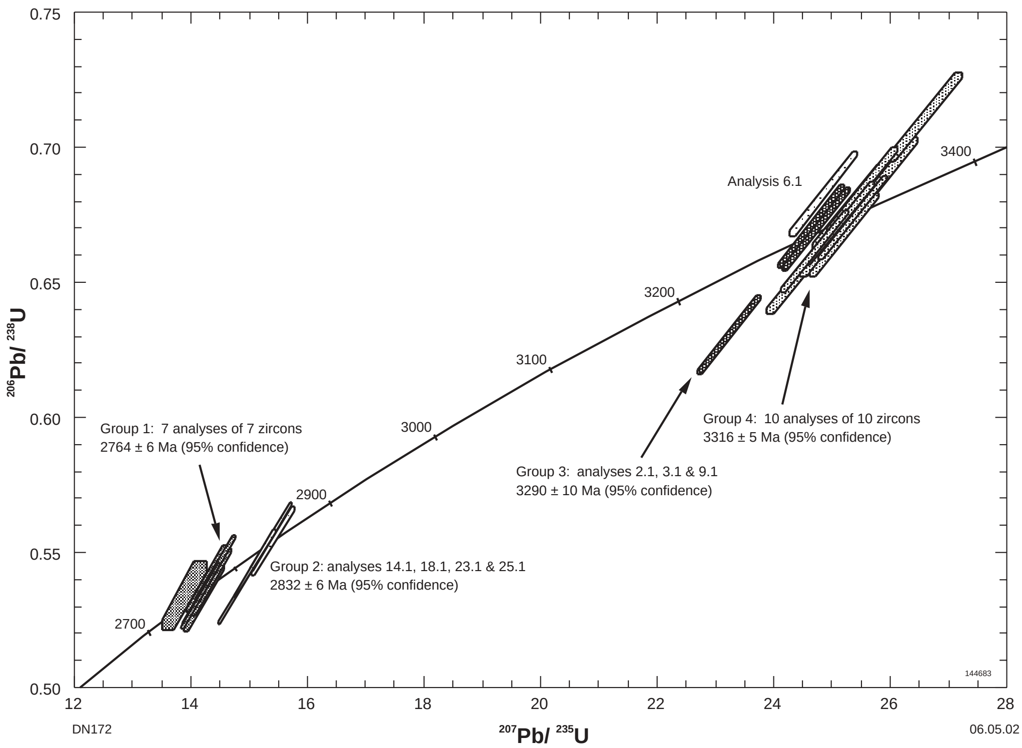

Figure 62. Concordia plot for sample 144683: hornblende–quartz monzonite, Pelican Pool

The date of 2764 ± 6 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of seven concordant analyses of seven zircons of Group 1 may be interpreted as the age for igneous crystallization of the monzonite. However, the spread of analytical data along the concordia curve indicates a high ratio of xenocrystic to magmatic zircons in the sample and it is possible that the analyses of Group 1 are also xenocrysts. Therefore, the preferred interpretation is that the date of 2764 ± 6 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of seven concordant analyses of seven zircons of Group 1 provides a maximum age for igneous crystallization of the monzonite. This interpretation is also consistent with the inferred intrusive relationship of the monzonite with the (c. 2740 Ma) Kylena Formation. The remaining analyses, indicating older $^{207}Pb/^{206}Pb$ dates, are interpreted to be of xenocryst zircons.

K–Ar results obtained for this sample are also given within this Record (see p. 262).

169025: rhyolite, Knaptons Well

Location and sampling

PORT HEDLAND – BEDOUT ISLAND (SF 50-4), PARDOO (2857) MGA Zone 50, 753140E 7757060N

Sampled on 10 September 2000.

The sample was taken from a low 0.5 m-diameter boulder from a rocky outcrop on a low rise situated 25 m east of the access track, 3 km south-southeast of Knaptons Well and 5.5 km north-northwest of the Port Hedland – Broome Coastal Highway.

Tectonic unit/relations

This sample is a light grey, very fine grained rhyolite with rare, scattered clear quartz phenocrysts up to 1 mm diameter. The sample taken had rare veins of quartz up to 1 mm thick. The rhyolite is found within a sequence of felsic volcanic and sedimentary rocks of the Mallina Basin (Smithies, in prep.b).

Petrographic description

This sample consists principally of alkali feldspar and/or plagioclase (70 vol.%), quartz (25 vol.%), and limonite (5 vol.%), with accessory zircon (trace). This is a fine-grained aggregate consisting mainly of altered quartz, K-feldspar and plagioclase, with quartz-rich areas and quartz- to limonite/hematite-filled veins and stylolites, apparently derived from an acid volcanic rock. Limonite-lined fractures are common in this sample, which has a subconchoidal fracture in hand specimen and a glassy, siliceous appearance. In thin section, there is abundant quartz, ranging from microcrystalline to about 0.5 mm in grain size, set in a matrix of felted feldspar microlites, but not obviously representing quartz phenocrysts. The stained offcut indicates that most of the matrix is K-feldspar, but there may be microlites of plagioclase rimmed by K-feldspar in much of the matrix. Areas of silicification occur, especially adjacent to veins and irregular stylolites containing quartz and/or limonite. Earthy hematite is present in some areas, as well as, or instead of limonite, and elongate voids are present. The present mineralogy is at least partly of hydrothermal origin and the original lithology is unclear, although an acid volcanic protolith is inferred.

Zircon morphology

The zircons isolated from this sample are typically colourless to pale yellowish brown, between 20 × 25 µm and 30 × 80 µm in size and are elongate irregular-shaped fragments or, less commonly, fractured euhedral oval-shaped whole grains.

Analytical details

This sample was analysed on 28 September 2001. The counter deadtime during the analysis session was 32 ns. Nine analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 2.14 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 1.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Table 44. Ion microprobe analytical results for sample 169025: rhyolite, Knaptons Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	147	98	103	2.019	0.21501	0.00124	0.17411	0.00254	0.5539	0.0121	16.420	0.382	97	2 944	9
2.1	183	130	131	0.153	0.21577	0.00068	0.19212	0.00097	0.5890	0.0128	17.522	0.391	101	2 949	5
3.1	106	62	74	0.172	0.21577	0.00092	0.15756	0.00128	0.5880	0.0129	17.492	0.400	101	2 949	7
4.1	114	68	82	0.225	0.21609	0.00094	0.16185	0.00140	0.6036	0.0132	17.986	0.411	103	2 952	7
5.1	117	66	82	0.285	0.21619	0.00091	0.15087	0.00136	0.5934	0.0130	17.688	0.403	102	2 953	7
6.1	162	115	112	0.405	0.21485	0.00084	0.18928	0.00136	0.5651	0.0123	16.739	0.379	98	2 942	6
7.1	126	90	89	0.233	0.21492	0.00088	0.18970	0.00134	0.5797	0.0127	17.179	0.391	100	2 943	7
8.1	192	141	137	0.200	0.21578	0.00069	0.19558	0.00101	0.5844	0.0127	17.388	0.388	101	2 949	5
9.1	150	112	110	0.165	0.21609	0.00079	0.19973	0.00118	0.5984	0.0130	17.829	0.402	102	2 952	6
10.1	115	66	79	0.288	0.21654	0.00093	0.15267	0.00140	0.5785	0.0127	17.273	0.394	100	2 955	7
11.1	168	115	117	0.146	0.21678	0.00076	0.18302	0.00113	0.5746	0.0125	17.176	0.385	99	2 957	6
12.1	195	144	136	0.197	0.21549	0.00068	0.19369	0.00100	0.5709	0.0124	16.962	0.378	99	2 947	5
13.1	160	105	109	0.173	0.21483	0.00074	0.17395	0.00105	0.5662	0.0123	16.771	0.377	98	2 942	6
14.1	139	88	96	0.266	0.21532	0.00086	0.17112	0.00129	0.5714	0.0125	16.964	0.385	99	2 946	6
15.1	143	89	97	0.170	0.21598	0.00082	0.16742	0.00118	0.5667	0.0124	16.876	0.381	98	2 951	6
16.1	1 422	768	884	0.153	0.21135	0.00025	0.14694	0.00033	0.5292	0.0114	15.422	0.334	94	2 916	2
17.1	137	81	94	0.158	0.21560	0.00082	0.15913	0.00112	0.5764	0.0126	17.134	0.388	100	2 948	6
18.1	130	66	106	0.153	0.27195	0.00088	0.13363	0.00102	0.6720	0.0147	25.197	0.566	100	3 317	5
19.1	127	73	84	0.206	0.21442	0.00086	0.15287	0.00121	0.5607	0.0123	16.576	0.377	98	2 939	6
20.1	150	93	102	0.198	0.21553	0.00081	0.16584	0.00118	0.5701	0.0124	16.941	0.382	99	2 948	6
21.1	90	48	61	0.376	0.21478	0.00113	0.14047	0.00174	0.5774	0.0127	17.100	0.398	100	2 942	8

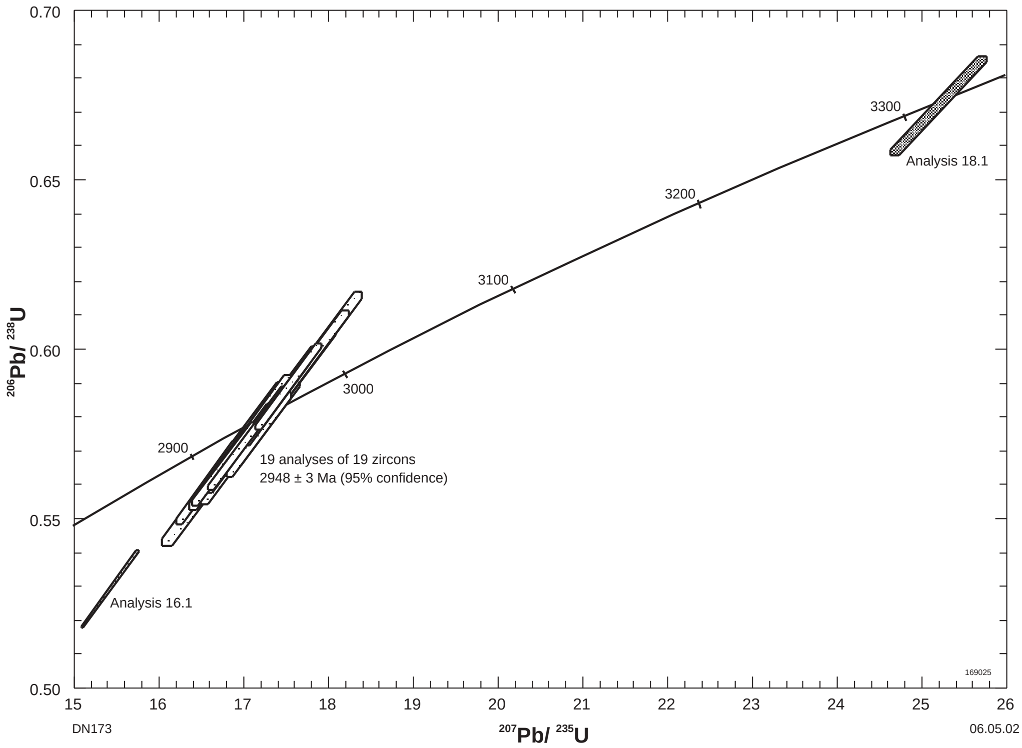

Figure 63. Concordia plot for sample 169025: rhyolite, Knaptons Well

Results

Twenty-one analyses were obtained from 21 zircons. Results are given in Table 44 and shown on a concordia plot in Figure 63.

Interpretation

With the exception of discordant analysis 16.1, all analyses are concordant. Nineteen concordant analyses of 19 zircons have ^{207}Pb/^{206}Pb ratios defining a single population and indicating a weighted mean ^{207}Pb/^{206}Pb date of 2948 ± 3 Ma (chi-squared = 0.54). Concordant analysis 18.1 indicates a substantially older ^{207}Pb/^{206}Pb date, whereas highly discordant analysis 16.1 indicates a younger ^{207}Pb/^{206}Pb date than the main population.

The date of 2948 ± 3 Ma indicated by the weighted mean ^{207}Pb/^{206}Pb ratio of 19 concordant analyses of 19 zircons is interpreted as the age of igneous crystallization of the rhyolite. The older ^{207}Pb/^{206}Pb date indicated by concordant analysis 18.1 is interpreted to be of a xenocryst or detrital zircon. Analysis 16.1 indicates an anomalously high U content and the younger ^{207}Pb/^{206}Pb date indicated by this highly discordant analysis is interpreted to be due to the loss of some of accumulated radiogenic Pb from this analysis site.

169030: hornblende–biotite quartz monzodiorite, Granite Hill Well

Location and sampling

NULLAGINE (SF 51-5), NULLAGINE (2954) MGA Zone 51, 240380E 7583600N

Sampled on 12 September 2000.

The sample was taken from a 2 m-diameter boulder located on the northern side of a cluster of prominent 5 m-high tors, 100 m south of the Mosquito Creek – Nullagine road and 250 m south of Granite Hill Well.

Tectonic unit/relations

This sample is from a porphyritic, hornblende–biotite quartz monzodiorite with pink, cubic K-feldspar phenocrysts up to 0.5 cm in size. The monzodiorite phase is the coarser of two closely associated granitoid phases that have intruded the Mosquito Creek Formation, Mosquito Creek Basin (Bagas and Farrell, in prep.).

Petrographic description

The principal minerals present in this sample are plagioclase (60 vol.%), quartz (10 vol.%), microcline (15 vol.%), hornblende (7–8 vol.%), biotite, and chlorite (2–3 vol.%), opaque oxide (3 vol.%), titanite (2 vol.%), and apatite (<1 vol.%), with accessory zircon (trace), carbonate (trace), stilpnomelane (trace), and fluorite (trace). This is a weakly altered hornblende–biotite quartz monzodiorite with large pink K-feldspar grains and a common elongation direction parallel to prisms of amphibole and lamellae of biotite. In thin section, there are scattered large grains of perthitic orthoclase to 10 × 5 mm, with primary inclusions of quartz, plagioclase, hornblende and titanite, as well as patches of secondary carbonate. Plagioclase is abundant as subhedral to euhedral laths to 4 mm long, irregularly dusted with sericite and clouded clinozoisite. There is minor quartz, partly as granular aggregates but partly euhedral against orthoclase, suggesting a transition towards a shallow (subvolcanic) emplacement level. Hornblende was also common as prisms to 7 mm long, but may have been partly resorbed during the crystallization of the rock. The amphibole is partly skeletal and has inclusions of plagioclase and quartz that may be of replacement origin, as well as inclusions of magnetite, apatite, and titanite. Alteration to chlorite, actinolite, and carbonate has affected much of the remaining hornblende, and all of the minor biotite, to 1 mm in grain size, has been altered to chlorite. Titanite, up to 1 mm in grain size, and magnetite are the main accessory minerals, with secondary fine-grained titanite rimming magnetite, and in the altered mafic silicates. Apatite is also disseminated, with rare, small zircon grains, mostly within hornblende. Patches of oxidized stilpnomelane occur, as well as rare small grains of fluorite. The rock may possess a weak flow foliation.

Zircon morphology

The zircons isolated from this sample are typically colourless, pale yellow, yellowish brown or dark brown, elongate with subrounded terminations and between 20 × 35 µm and 80 × 280 µm in size. Most grains are extensively fractured and have faint internal zonation. Fluid and mineral inclusions are common. Structureless cores are distinguishable in a small proportion of grains.

Table 45. Ion microprobe analytical results for sample 169030: hornblende–biotite quartz monzodiorite, Granite Hill Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	255	216	223	0.178	0.27584	0.00082	0.22531	0.00110	0.6733	0.0078	25.607	0.317	99	3 340	5
2.1	283	406	110	1.569	0.10883	0.00138	0.49309	0.00359	0.2707	0.0031	4.061	0.074	87	1 780	23
3.1	109	87	63	0.433	0.21664	0.00145	0.19608	0.00239	0.4662	0.0056	13.926	0.202	83	2 956	11
4.1	93	59	43	0.709	0.15807	0.00171	0.17487	0.00333	0.3909	0.0048	8.519	0.147	87	2 435	18
5.1	508	287	165	0.285	0.10783	0.00060	0.16026	0.00118	0.2944	0.0033	4.377	0.058	94	1 763	10
6.1	303	163	105	0.686	0.11033	0.00096	0.16475	0.00202	0.3095	0.0036	4.709	0.072	96	1 805	16
7.1	699	485	186	1.028	0.10005	0.00079	0.20960	0.00177	0.2283	0.0026	3.149	0.046	82	1 625	15
8.1	598	341	179	0.339	0.10670	0.00056	0.16692	0.00113	0.2703	0.0031	3.976	0.052	88	1 744	10
9.1	971	882	230	0.709	0.09263	0.00064	0.25408	0.00151	0.2001	0.0023	2.555	0.036	79	1 480	13
10.1	212	142	74	0.538	0.11033	0.00101	0.18891	0.00213	0.3052	0.0035	4.643	0.072	95	1 805	17
11.1	736	556	253	0.180	0.10760	0.00044	0.21529	0.00093	0.3000	0.0034	4.451	0.056	96	1 759	8
12.1	357	219	103	0.386	0.10498	0.00078	0.18513	0.00164	0.2569	0.0029	3.718	0.053	86	1 714	14
13.1	494	289	160	0.170	0.10779	0.00053	0.16504	0.00103	0.2943	0.0033	4.375	0.057	94	1 762	9
14.1	438	473	165	0.056	0.11018	0.00049	0.30895	0.00119	0.3071	0.0035	4.666	0.059	96	1 802	8
15.1	226	242	86	1.473	0.10888	0.00142	0.32680	0.00337	0.2953	0.0033	4.433	0.080	94	1 781	24
16.1	754	623	197	0.296	0.09850	0.00052	0.22376	0.00116	0.2279	0.0024	3.094	0.038	83	1 596	10
17.1	331	379	113	0.581	0.10803	0.00084	0.34332	0.00207	0.2680	0.0029	3.992	0.056	87	1 766	14
18.1	470	220	147	0.228	0.10850	0.00055	0.14473	0.00104	0.2887	0.0031	4.319	0.054	92	1 774	9
19.1	532	496	188	0.239	0.10697	0.00053	0.27332	0.00123	0.2951	0.0032	4.352	0.054	95	1 748	9
20.1	57	32	46	0.497	0.26471	0.00182	0.15828	0.00275	0.6533	0.0085	23.844	0.369	99	3 275	11
21.1	308	179	99	0.731	0.10833	0.00088	0.17317	0.00189	0.2844	0.0031	4.247	0.061	91	1 771	15
22.1	312	146	194	0.065	0.20317	0.00063	0.12842	0.00076	0.5406	0.0059	15.143	0.178	98	2 852	5
23.1	140	155	90	0.261	0.20287	0.00118	0.30164	0.00223	0.4930	0.0057	13.791	0.187	91	2 849	9
24.1	484	380	123	0.634	0.10639	0.00076	0.16803	0.00160	0.2270	0.0024	3.330	0.045	76	1 738	13
25.1	806	655	247	0.472	0.10249	0.00050	0.23622	0.00113	0.2621	0.0028	3.704	0.045	90	1 670	9
26.1	150	171	59	0.103	0.11013	0.00089	0.32677	0.00220	0.3140	0.0035	4.768	0.070	98	1 802	15
27.1	455	87	208	0.182	0.19998	0.00077	0.05218	0.00086	0.4212	0.0046	11.613	0.139	80	2 826	6
28.1	101	75	69	0.227	0.20184	0.00117	0.20622	0.00189	0.5597	0.0067	15.577	0.217	101	2 841	9

Analytical details

This sample was analysed on 18 and 22 August 2001. The counter deadtime during both analysis sessions was 32 ns. Eight analyses of the CZ3 standard obtained during the first analysis session indicated a Pb^*/U calibration error of 1.12 (1σ%). Analyses 1.1 to 14.1 were obtained during the first analysis session. During the second analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.04 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty-eight analyses were obtained from 28 zircons. Results are given in Table 45 and shown on concordia plots in Figures 64 and 65.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with one ancient, and several recent episodes of recent radiogenic-Pb loss. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of three groups. Eleven discordant analyses of 11 zircons (2.1, 5.1, 8.1, 11.1, 13.1, 15.1, 17.1, 18.1, 19.1, 21.1 and 24.1), 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 1759 ± 8 Ma (chi-squared = 1.10). Slightly discordant analyses 6.1, 10.1, 14.1 and 26.1, 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 1803 ± 19 Ma (chi-squared = 0.01). Concordant analysis 28.1 and discordant analyses 22.1 and 23.1, assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining

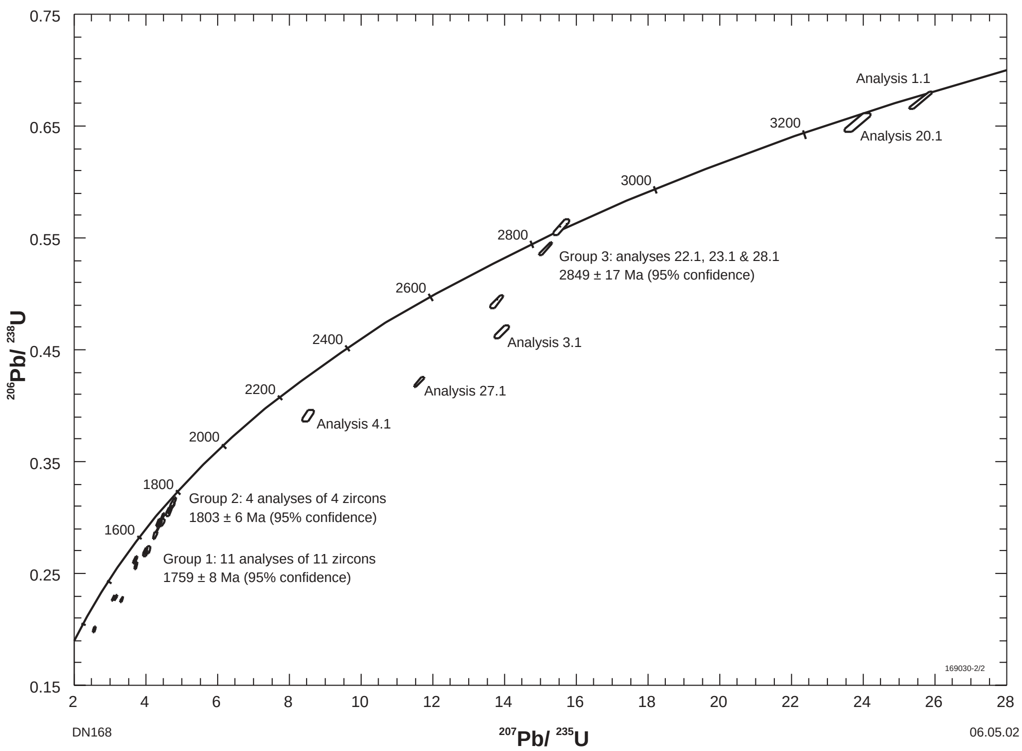

Figure 64. Concordia plot for sample 169030: hornblende–biotite quartz monzodiorite, Granite Hill Well

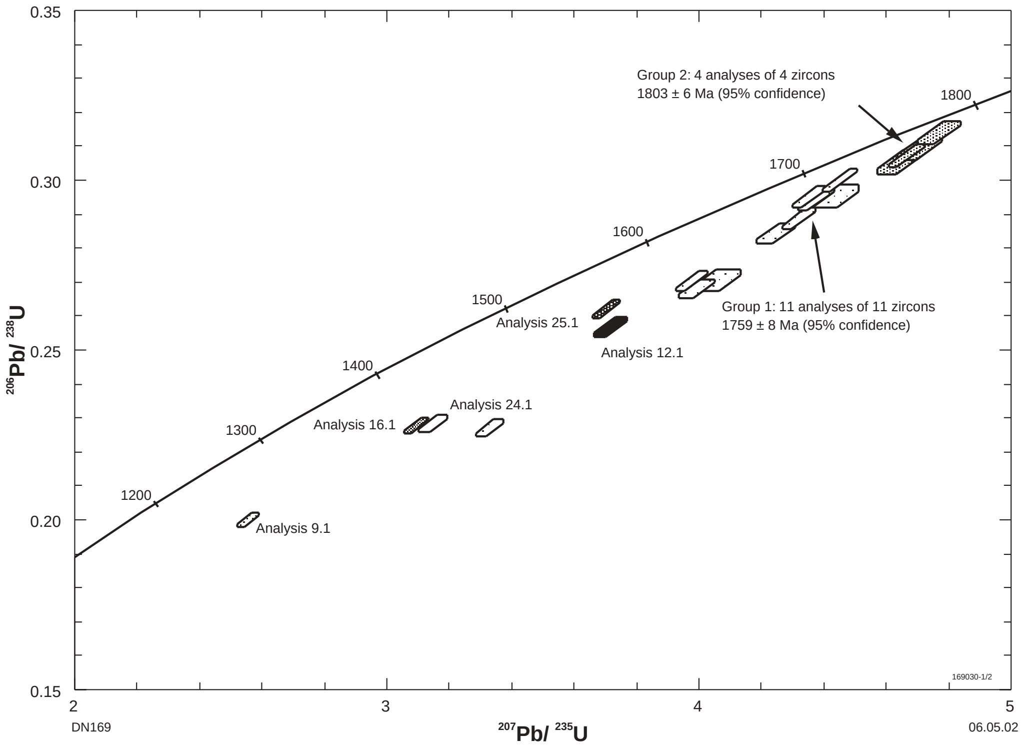

Figure 65. Concordia plot enlargement for sample 169030: hornblende–biotite quartz monzodiorite, Granite Hill Well

a single population and indicating a weighted mean ^{207}Pb/^{206}Pb date of 2849 ± 17 Ma (chi-squared = 0.40). The remaining analyses cannot be grouped.

The discordance trends displayed by the analyses of Groups 1 and 2 are consistent with several recent episodes of radiogenic-Pb loss. Two interpretations of these results are possible. The preferred interpretation is that the date of 1803 ± 19 Ma, indicated by the weighted mean ^{207}Pb/^{206}Pb ratio of the four slightly discordant analyses of Group 2, provides an estimate of the age of igneous crystallization of the monzodiorite. Alternatively, the date of 1759 ± 8 Ma indicated by the weighted mean ^{207}Pb/^{206}Pb ratio of the 11 highly discordant analyses of Group 1 may provide an estimate of the age for igneous crystallization of the monzodiorite, with the date of 1803 ± 19 Ma indicated by the weighted mean ^{207}Pb/^{206}Pb ratio of the four slightly discordant analyses of Group 2 corresponding to the age of crystallization of a xenocryst zircon population within the monzodiorite. The remaining analyses, including those of Group 3, are interpreted to be of xenocryst zircons.

169001: biotite–hornblende–clinopyroxene syenogranite gneiss, Sugarloaf Rock

Location and sampling

Busselton (SI 50-5), Busselton (1930) MGA Zone 50, 314700E 6284700N

Sampled on 2 February 2000.

The sampling site is at the top of a rocky ridge located on the eastern part of a headland about 100 m south of Sugarloaf Rock. The sampling site is about 40 m north-northeast of the site of sample 169002.

Tectonic unit/relations

The sample is a heterogeneous syenogranitic gneiss of the Leeuwin Complex. It was taken from the crest of an antiform composed of granitic gneiss that occurs with disrupted layers of amphibolite and anorthosite within a north-plunging fold core of Cowaramup Gneiss (Myers, 1994).

Petrographic description

The principal minerals present in this sample are K-feldspar (65–70 vol.%), quartz (20–25 vol.%), plagioclase (5–7 vol.%), biotite (3 vol.%), and hornblende (2 vol.%), with accessory opaque oxide (1 vol.%), clinopyroxene (trace), limonite (trace), and zircon (trace). This is a biotite-, hornblende- and clinopyroxene-bearing syenogranite of amphibolite- to granulite-facies mineralogy. The hand specimen consists of abundant greasy feldspar, characteristic of granulite-facies rocks. The stained offcut consists of quartz and K-feldspar, with lesser amounts of plagioclase and possibly some mafic silicate minerals. The thin section shows an inequigranular granuloblastic rock with grains 0.2 to 5 mm in diameter. K-feldspar is apparently homogenous but has fine microscopic to cryptic exsolution, and may be orthoclase. Quartz and plagioclase are less than 2 mm in grain size. The plagioclase has some limonite staining and veining, and passes into areas of myrmekite. There is disseminated biotite to 1 mm in grain size, and green hornblende, as irregular poikiloblastic grains commonly enclosing kernels of clinopyroxene. Some of the biotite, as well as most of the hornblende, has vermiform inclusions of quartz or feldspar, suggesting a subsolidus or retrograde origin. Small grains of opaque oxide are disseminated and there are rare, very small, red-altered grains that may have been metamict and radioactive. Rare zircon crystals are scattered throughout.

Zircon morphology

The zircons isolated from this sample are typically dark yellowish brown or black, generally between 30 × 30 µm and 50 × 160 µm in size and are spherical or ovoid in shape. Many grains are structureless, although strong internal zonation is also present in some grains. A minority of grains have rounded cores and thin, radially cracked rims. The surfaces of many grains are textured. A substantial majority of grains are metamict. Many have mottled interiors and abundant small black spots and zones on their polished surfaces. These features are attributed to extensive radiation damage and recrystallization of parts of the crystal microstructure. Fluid and mineral inclusions are common.

Table 46. Ion microprobe analytical results for sample 169001: biotite–hornblende–clinopyroxene syenogranite gneiss, Sugarloaf Rock

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{206}Pb/^{238}U$ *age*	*±1 σ*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	3 401	2 740	349	0.137	0.05870	0.00023	0.0950	0.0013	0.769	0.012	105	585	8	556	9
2.1	2 466	248	234	0.451	0.06112	0.00035	0.0967	0.0014	0.815	0.013	92	595	8	644	12
3.1	2 047	2 188	282	0.108	0.06244	0.00026	0.1144	0.0016	0.985	0.015	101	698	9	689	9
4.1	873	118	70	0.546	0.05936	0.00073	0.0824	0.0012	0.674	0.013	88	510	7	580	27
5.1	667	53	56	0.684	0.05885	0.00101	0.0873	0.0012	0.708	0.017	96	539	7	562	37
6.1	2 238	1 864	280	0.570	0.06077	0.00038	0.1057	0.0015	0.886	0.014	103	648	9	631	13
7.1	1 951	459	184	0.142	0.05989	0.00030	0.0965	0.0013	0.797	0.012	99	594	8	600	11
8.1	1 669	464	156	0.166	0.05947	0.00033	0.0922	0.0013	0.756	0.012	97	569	8	584	12
9.1	2 932	1 170	296	0.128	0.05980	0.00023	0.0964	0.0013	0.794	0.012	99	593	8	596	8
10.1	3 686	7 682	706	0.106	0.06038	0.00018	0.1236	0.0017	1.029	0.015	122	751	10	617	7
11.1	1 783	221	142	0.182	0.05854	0.00035	0.0834	0.0012	0.673	0.011	94	516	7	550	13
12.1	2 256	677	235	0.194	0.06049	0.00026	0.1050	0.0015	0.875	0.013	104	643	9	621	9
13.1	1 674	133	161	0.162	0.06064	0.00032	0.1004	0.0014	0.840	0.013	98	617	8	626	11
14.1	1 147	81	91	0.435	0.05762	0.00055	0.0835	0.0012	0.664	0.012	100	517	7	515	21
15.1	1 907	725	193	0.247	0.06161	0.00032	0.1002	0.0014	0.851	0.013	93	615	8	661	11
16.1	278	244	38	0.312	0.06386	0.00102	0.1181	0.0017	1.040	0.023	98	720	10	737	3

Analytical details

This sample was analysed on 30 April 2001. The counter deadtime was 32 ns. Thirteen analyses of the CZ3 standard were obtained during the analysis session. Following deletion of one outlier, the remaining 12 standard analyses indicated a Pb^*/U calibration error of 1.40 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analysis 6.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Sixteen analyses were obtained from 16 zircons. Results are given in Table 46 and shown on Wetherill and Tera-Wasserburg concordia plots (Tera and Wasserburg, 1974) in Figures 66 and 67.

Interpretation

Most analyses are concordant to slightly discordant in a normal sense (analyses 2.1 and 15.1) or reverse sense (analysis 10.1) and indicate $^{206}Pb/^{238}U$ dates between c. 510 and 750 Ma. Analyses 4.1, 11.1 and 14.1, assigned to Group 1, have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of 515 ± 19 Ma (chi-squared = 0.21). The $^{207}Pb/^{206}Pb$ ratios of these analyses indicate an imprecise weighted mean $^{207}Pb/^{206}Pb$ date of 546 ± 68 Ma (chi-squared = 1.60). Concordant analyses 7.1 and 9.1, assigned to Group 2, have $^{207}Pb/^{206}Pb$ and $^{206}Pb/^{238}U$ ratios within error of single mean values corresponding to weighted mean $^{207}Pb/^{206}Pb$

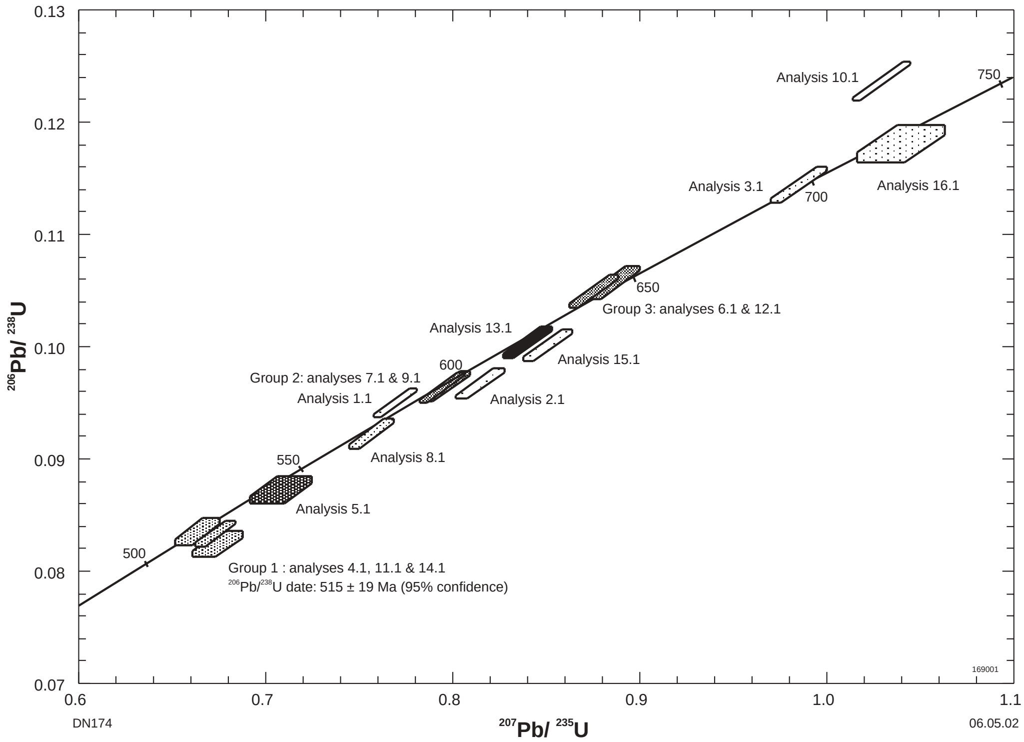

Figure 66 Concordia plot for sample 169001: biotite–hornblende–clinopyroxene syenogranite gneiss, Sugarloaf Rock

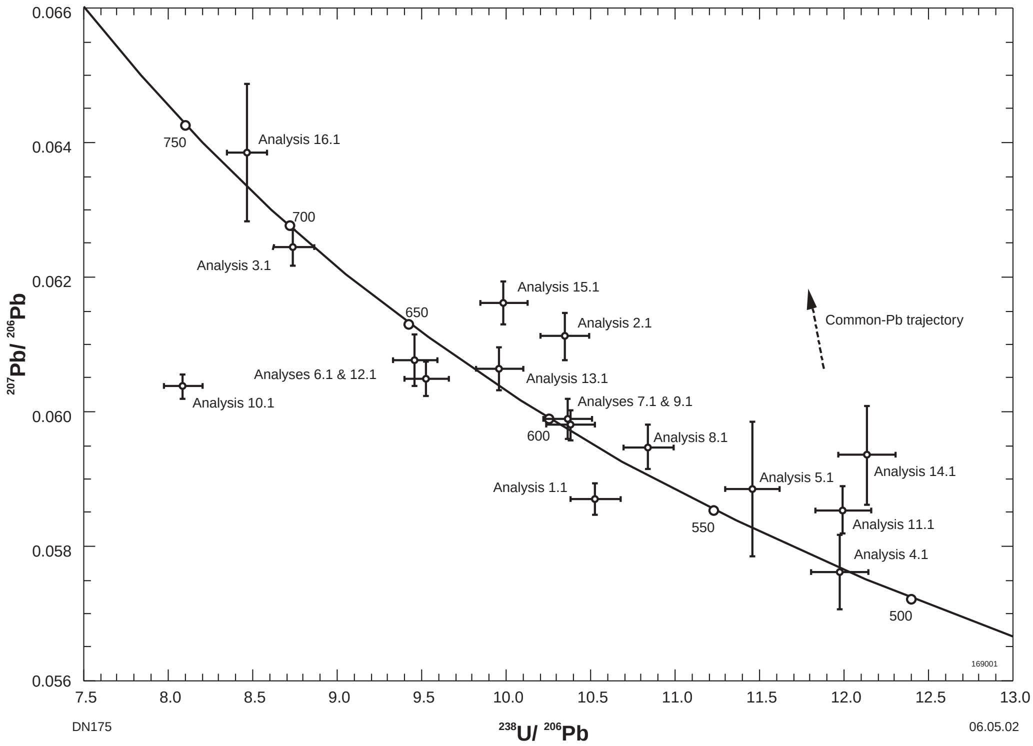

Figure 67. Tera-Wasserburg concordia plot for sample 169001: biotite–hornblende–clinopyroxene syenogranite gneiss, Sugarloaf Rock

and $^{206}Pb/^{238}U$ dates of 598 ± 7 Ma (1σ error) and 593 ± 6 Ma (1σ error). Concordant analyses 6.1 and 12.1, assigned to Group 3, have $^{207}Pb/^{206}Pb$ and $^{206}Pb/^{238}U$ ratios defining single populations and indicating weighted mean $^{207}Pb/^{206}Pb$ and $^{206}Pb/^{238}U$ dates of 624 ± 8 Ma (1σ error) and 646 ± 7 Ma (1σ error). On a Tera-Wasserburg diagram, analyses 1.1, 10.1, and 12.1 fall below the concordia curve, indicating that these analyses have been overcorrected for common Pb. The remaining analyses cannot be grouped.

The distribution of analyses along the concordia curve is interpreted to be due to variable loss of radiogenic Pb from analysis sites of zircons that probably crystallized at, or prior to, 737 ± 3 Ma (1σ error), the oldest concordant $^{207}Pb/^{206}Pb$ date obtained (analysis 16.1). An estimate of the timing of the disturbance event is provided by the $^{206}Pb/^{238}U$ date of 515 ± 19 Ma indicated by the three analyses of Group 1. Groups 2 and 3 consist of only two analyses and the geological significance of the dates indicated by the analyses of these groups is unclear.

U–Pb zircon results from Sugarloaf Rock were reported by Collins and Fitzsimons (2001).

169002: biotite–hornblende–clinopyroxene–magnetite syenogranite gneiss, Sugarloaf Rock

Location and sampling

BUSSELTON (SI 50-5), BUSSELTON (1930) MGA Zone 50, 314700E 6284700N

Sampled on 2 February 2000.

The sampling site is on the southern slope of a rocky ridge located on the eastern part of a headland and about 100 m south of Sugarloaf Rock. The sampling site is about 40 m south-southwest of the site of sample 169001.

Tectonic unit/relations

The sample is a heterogeneous syenogranitic gneiss of the Leeuwin Complex. It was taken from the western flank of a north-plunging antiform composed of Cowaramup Gneiss (Myers, 1994) associated with disrupted layers of amphibolite and anorthosite.

Petrographic description

The principal minerals present in this sample are K-feldspar (50 vol.%), quartz (25 vol.%), plagioclase (10–15 vol.%), biotite (5 vol.%), clinopyroxene (3 vol.%), magnetite (2–3 vol.%), hornblende (2 vol.%), and apatite (<1 vol.%), with accessory zircon (trace), and possibly monazite (trace). This is a syenogranite containing biotite, hornblende, clinopyroxene and magnetite. The hand specimen consists of abundant greasy, feldspar characteristic of granulite-facies rocks. The thin section shows an inequigranular and granuloblastic texture, with grains 0.2 to 3 mm in diameter, the largest of which are quartz. The K-feldspar is mostly homogeneous orthoclase, but may be a microperthite or cryptoperthite, and there is abundant myrmekite between the K-feldspar and granular plagioclase. Quartz is also granular to poikilitic in character. Biotite and clinopyroxene have a grain size of 0.2 to 1 mm, and there is minor brownish green hornblende, partly as poikiloblastic grains to 3 mm in diameter. Magnetite is common and there is disseminated apatite, as well as rare, rounded grains of zircon and ?monazite.

Zircon morphology

The zircons isolated from this sample are typically colourless, pale yellow to dark yellowish brown or black, generally between 30 × 30 µm and 50 × 160 µm in size and are irregular, spherical or slightly ovoid in shape. Many grains are structureless, although grains displaying strong internal zonation are also present. A minority of grains have rounded cores and thin, radially cracked rims. The surfaces of many grains are textured. Fluid and mineral inclusions are common.

Analytical details

This sample was analysed on 30 April 2001. The counter deadtime was 32 ns. Thirteen analyses of the CZ3 standard were obtained during the analysis session. Following deletion of one outlier, the remaining 12 standard analyses indicated a Pb^*/U calibration error of 1.40 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 47. Ion microprobe analytical results for sample 169002: biotite–hornblende–clinopyroxene–magnetite syenogranite gneiss, Sugarloaf Rock

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	$\pm 1\sigma$	$^{206}Pb/^{238}U$	$\pm 1\sigma$	$^{207}Pb/^{235}U$	$\pm 1\sigma$	*% concordance*	$^{206}Pb/^{238}U$ *age*	$\pm 1\sigma$	$^{207}Pb/^{206}Pb$ *age*	$\pm 1\sigma$
1.1	59	36	8	1.637	0.06479	0.00387	0.1181	0.0018	1.055	0.067	94	720	10	768	126
2.1	87	21	9	0.991	0.06510	0.00322	0.1000	0.0015	0.898	0.048	79	615	9	778	104
3.1	206	173	28	0.613	0.06709	0.00141	0.1169	0.0017	1.081	0.029	85	713	10	841	44
4.1	136	106	18	0.928	0.06279	0.00210	0.1127	0.0016	0.975	0.037	98	688	9	701	71
5.1	105	93	15	1.014	0.06499	0.00226	0.1194	0.0017	1.070	0.042	94	727	10	774	73
6.1	98	55	13	1.916	0.06085	0.00313	0.1183	0.0017	0.993	0.055	114	721	10	634	111
7.1	497	191	62	0.380	0.06340	0.00072	0.1222	0.0017	1.068	0.020	103	743	10	722	24
8.1	259	65	23	0.751	0.06023	0.00151	0.0884	0.0012	0.734	0.022	89	546	7	612	54
9.1	97	93	14	0.719	0.06613	0.00236	0.1194	0.0017	1.089	0.044	90	727	10	811	75
10.1	73	65	11	1.677	0.06485	0.00363	0.1261	0.0019	1.127	0.067	99	766	11	769	118
11.1	89	29	11	2.924	0.06067	0.00382	0.1118	0.0017	0.935	0.062	109	683	10	628	136
12.1	102	36	12	1.220	0.06606	0.00288	0.1057	0.0015	0.963	0.046	80	648	9	808	91
13.1	134	122	19	1.118	0.06398	0.00208	0.1214	0.0018	1.071	0.040	100	738	10	741	69
14.1	636	99	53	0.490	0.05736	0.00077	0.0859	0.0012	0.679	0.014	105	531	7	505	30
15.1	107	49	13	0.761	0.06715	0.00245	0.1119	0.0016	1.036	0.042	81	684	9	842	76
16.1	121	121	18	0.408	0.06659	0.00179	0.1223	0.0018	1.123	0.036	90	744	10	825	56
17.1	210	54	19	1.370	0.05612	0.00198	0.0892	0.0013	0.690	0.027	121	551	8	457	78
18.1	158	94	17	1.266	0.06185	0.00228	0.0971	0.0014	0.828	0.034	89	597	8	669	79
19.1	69	63	10	1.679	0.06492	0.00347	0.1210	0.0018	1.083	0.062	95	736	10	772	113
20.1	74	55	11	1.629	0.06708	0.00332	0.1273	0.0019	1.177	0.063	92	772	11	840	103

Results

Twenty analyses were obtained from 20 zircons. Results are given in Table 47 and shown on Wetherill and Tera-Wasserburg concordia plots (Tera and Wasserburg, 1974) in Figures 68 and 69.

Interpretation

Most analyses are concordant to slightly discordant and indicate $^{206}Pb/^{238}U$ dates of c. 530 to 770 Ma. On the basis of their $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of three groups. Nine concordant analyses of nine zircons (1.1, 3.1, 5.1, 6.1, 7.1, 9.1, 13.1, 16.1 and 19.1), assigned to Group 1, have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of 730 ± 11 Ma (chi-squared = 1.12). The weighted mean $^{207}Pb/^{206}Pb$ date for the analyses of Group 1 is 756 ± 45 Ma (chi-squared = 0.97). Concordant analyses 4.1, 11.1 and 15.1, assigned to Group 2, have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of 685 ± 26 Ma (chi-squared = 0.06). Concordant analyses 8.1, 14.1 and 17.1, assigned to Group 3, have $^{206}Pb/^{238}U$ ratios defining a single population and indicating a weighted mean $^{206}Pb/^{238}U$ date of 542 ± 28 Ma (chi-squared = 1.54). The $^{207}Pb/^{206}Pb$ ratios of these analyses indicate an imprecise weighted mean $^{207}Pb/^{206}Pb$ date of 521 ± 169 Ma (chi-squared = 1.52). Analyses 10.1 and 20.1 indicate $^{206}Pb/^{238}U$ dates that are slightly older than those of Group 1. The remaining analyses (2.1, 12.1 and 18.1) cannot be grouped.

The $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ dates of 730 ± 11 Ma and 756 ± 45 Ma indicated by the nine concordant analyses of Group 1 are interpreted as the age of igneous crystallization of the syenogranitic precursor to the gneiss. Analyses indicating dates

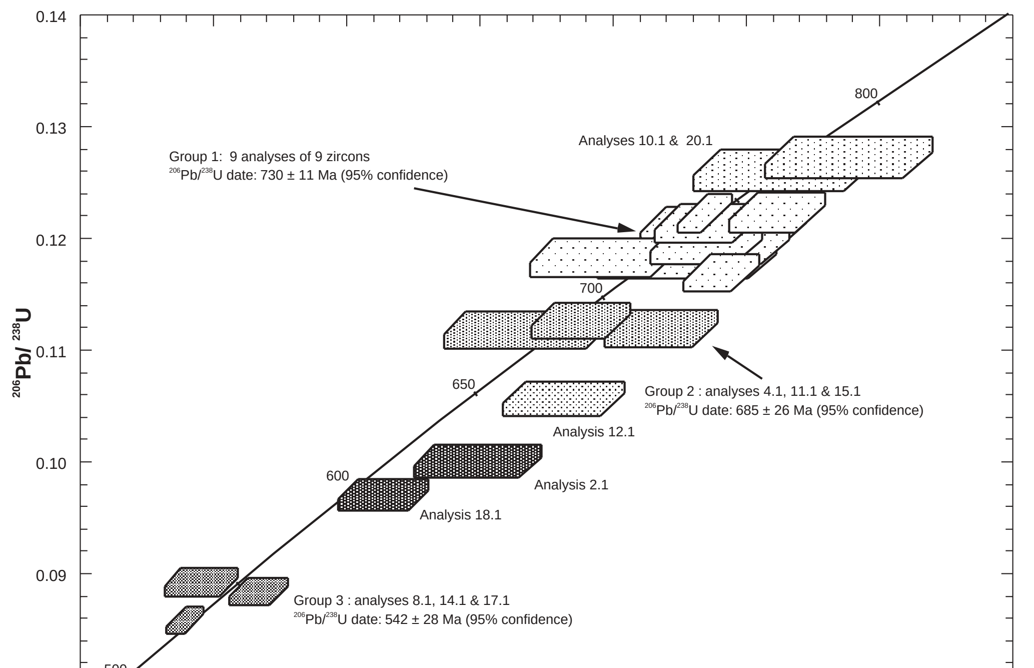

Figure 68. Concordia plot for sample 169002: biotite–hornblende–clinopyroxene–magnetite syenogranite gneiss, Sugarloaf Rock

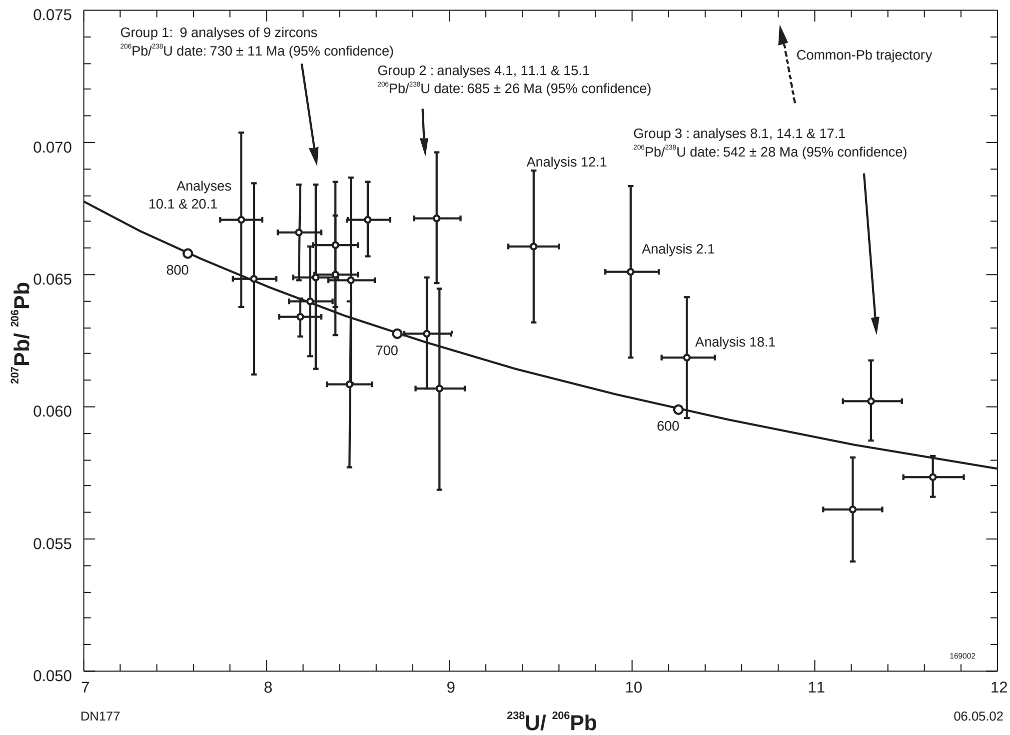

Figure 69. Tera-Wasserburg concordia plot for sample 169002: biotite–hornblende–clinopyroxene–magnetite syenogranite gneiss, Sugarloaf Rock

younger than those of Group 1 and their distribution along the concordia curve are interpreted to be due to variable loss of radiogenic Pb from analysis sites of zircons that probably crystallized at, or prior to, the date indicated by analyses of Group 1. Analyses 10.1 and 20.1, which indicate slightly older dates than those of Group 1, may be of xenocryst zircons. An estimate of the timing of the disturbance event is provided by the $^{206}Pb/^{238}U$ date of 542 ± 28 Ma indicated by the three analyses of Group 3.

U–Pb zircon results from Sugarloaf Rock were reported by Collins and Fitzsimons (2001).

168984: biotite monzogranite, Mount Sir James

Location and sampling

STANLEY (SG 51-6), LEE STEERE (3346) MGA Zone 51, 413570E 7179510N

Sampled on 27 June 2000.

The sample was taken from the southeastern side of a 20 m^2 low granite pavement located 6 km north of a telecommunications tower and 8 km north-northeast of Mount Sir James in the Lee Steere Range. The sampling site is 30 m east of the site of sample 168985.

Tectonic unit/relations

This sample of the Malmac Granite is a light grey, fine- to medium-grained, even-grained biotite monzogranite exposed within the Malmac Dome, Yilgarn Craton (Hocking and Pirajno, in prep.). The sample taken was free of obvious veins.

Petrographic description

The principal minerals present in this sample are plagioclase (35 vol.%), quartz (30–35 vol.%), microcline (30 vol.%), and biotite (2–3 vol.%), with accessory muscovite (trace), apatite (trace), titanite (trace), and zircon (trace). This rock is a massive to very weakly laminated, inequigranular fine- to medium-grained leucocratic monzogranite, with minor chloritized biotite, accessory muscovite, apatite, titanite and rare clouded zircon grains. It has irregularly scattered larger grains of quartz and microcline to 7 mm long, within an allotriomorphic mosaic of smaller grains of quartz, microcline and plagioclase from 1 to 4 mm in size. The plagioclase has a dusting of sericite and occurs as grains mostly 1 to 4 mm long, but smaller plagioclase grains are present as inclusions in microcline, together with quartz and minor altered biotite. Minor biotite occurs as random flakes less than 1 mm long, and is largely altered to chlorite. Sparse muscovite occurs as irregular grains within altered plagioclase and is also interlaminated with biotite and muscovite. The muscovite may be entirely of subsolidus origin. Apatite is rare, and leucoxene has in part replaced rare titanite.

Zircon morphology

The zircons isolated from this sample are of two morphological types. The majority of grains are generally about 20 × 60 µm and are internally structureless and colourless, and thin and rod-like. A minority are pinkish brown, light greenish brown or dark brown, 120 × 250 µm in size and are subhedral and irregular to equant in shape.

Analytical details

This sample was analysed on 20 January 2001. The counter deadtime during the analysis session was 32 ns. Six analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 0.523 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 1.1, 2.1, 4.1 and 17.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Table 48. Ion microprobe analytical results for sample 168984: biotite monzogranite, Mount Sir James

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	1 056	1321	571	0.919	0.16524	0.00061	0.40429	0.00145	0.3905	0.0040	8.896	0.100	85	2 510	6
2.1	748	575	330	2.099	0.15403	0.00103	0.29240	0.00241	0.3344	0.0034	7.101	0.092	78	2 391	11
3.1	608	617	286	0.474	0.15293	0.00062	0.29511	0.00131	0.3726	0.0039	7.857	0.091	86	2 379	7
4.1	871	1082	341	1.181	0.12110	0.00068	0.35818	0.00171	0.2977	0.0031	4.971	0.062	85	1 972	10
5.1	118	61	63	0.524	0.17465	0.00143	0.14243	0.00241	0.4640	0.0054	11.173	0.169	94	2 603	14
6.1	121	72	41	0.864	0.10415	0.00164	0.16157	0.00348	0.3021	0.0035	4.338	0.090	100	1 699	29
7.1	105	29	58	0.578	0.17739	0.00148	0.06773	0.00238	0.5031	0.0060	12.305	0.190	100	2 629	14
8.1	190	160	69	0.329	0.10511	0.00114	0.24507	0.00258	0.3120	0.0035	4.521	0.075	102	1 716	20
9.1	29	91	16	2.611	0.10161	0.00543	0.84621	0.01587	0.3041	0.0050	4.260	0.246	103	1 654	99
10.1	77	115	33	0.731	0.10873	0.00204	0.40741	0.00525	0.3256	0.0041	4.881	0.116	102	1 778	34
11.1	43	31	26	0.850	0.18475	0.00297	0.21363	0.00594	0.4877	0.0073	12.423	0.289	95	2 696	27
12.1	97	55	61	0.384	0.19609	0.00145	0.14746	0.00232	0.5397	0.0066	14.593	0.220	100	2 794	12
13.1	125	58	62	0.862	0.17924	0.00167	0.14342	0.00311	0.4250	0.0050	10.504	0.167	86	2 646	16
14.1	185	48	98	1.207	0.16644	0.00133	0.07860	0.00251	0.4722	0.0053	10.836	0.158	99	2 522	13
15.1	237	86	106	0.388	0.17323	0.00104	0.10263	0.00162	0.3999	0.0044	9.552	0.126	84	2 589	10
6.2	70	60	26	1.084	0.10432	0.00248	0.23811	0.00563	0.3066	0.0039	4.410	0.125	101	1 702	44
8.2	197	184	73	0.338	0.10707	0.00109	0.26572	0.00250	0.3114	0.0034	4.597	0.073	100	1 750	19
9.2	19	46	10	1.637	0.11125	0.00601	0.71415	0.01698	0.3166	0.0056	4.857	0.286	97	1 820	98
16.1	566	535	335	0.340	0.16871	0.00063	0.27580	0.00123	0.4704	0.0049	10.943	0.126	98	2 545	6
17.1	1 001	300	392	0.981	0.12793	0.00058	0.10950	0.00120	0.3568	0.0037	6.293	0.074	95	2 070	8
8.3	173	161	62	0.324	0.10486	0.00122	0.25160	0.00277	0.3044	0.0034	4.401	0.075	100	1 712	21
6.3	71	68	27	1.516	0.10618	0.00287	0.27440	0.00665	0.3018	0.0038	4.418	0.138	98	1 735	50
8.4	121	147	44	1.801	0.10081	0.00272	0.15326	0.00601	0.3165	0.0036	4.399	0.135	108	1 639	50

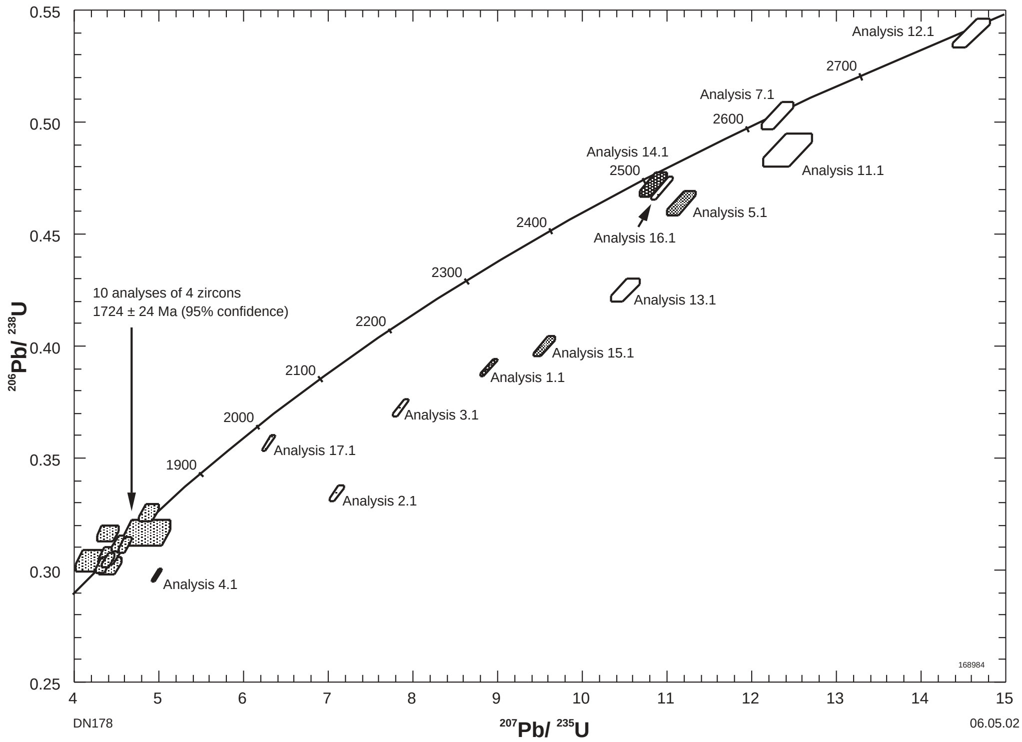

Figure 70. Concordia plot for sample 168984: biotite monzogranite, Mount Sir James

Results

Twenty-three analyses were obtained from 17 zircons. Results are given in Table 48 and shown on a concordia plot in Figure 70.

Interpretation

Analyses are concordant to highly discordant and indicate a wide range of $^{207}Pb/^{206}Pb$ dates from c. 1724 to 2794 Ma. Ten analyses of four zircons (6.1, 6.2, 6.3, 8.1, 8.2, 8.3, 8.4, 9.1, 9.2 and 10.1), assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios within error of a single value indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 1724 ± 24 Ma (chi-squared = 1.06). Analyses 14.1, 16.1 17.1 and 12.1 are near-concordant and indicate $^{207}Pb/^{206}Pb$ dates between c. 2794 and 2512 Ma. The remaining analyses plot along a poorly defined discordia trend with intercepts at c. 2700 and c. 1200 Ma.

Analyses belonging to Group 1 were obtained on light greenish brown, structureless and equant grains that have generally low U (29 to 197 ppm) and Th (46 to 184 ppm) concentrations. Even though no younger igneous phases were observed in the sample taken, the preferred interpretation is that the weighted mean $^{207}Pb/^{206}Pb$ date of 1724 ± 24 Ma, indicated by the ten analyses of Group 1 obtained on four zircons, corresponds to the age of igneous crystallization of an indistinct granitic dyke phase present in this sample. The host monzogranite is interpreted to have crystallized during the Archaean, possibly at a date indicated by either concordant analyses 14.1 or 16.1, or by concordant analyses 7.1 or 12.1. The remaining analyses, which plot along a poorly defined discordia trend with a lower intercept of c. 1200 Ma, are interpreted to correspond to the age of a disturbance event during which many analysis sites with high concentrations lost a substantial proportion of their radiogenic Pb.

139463: pegmatite-banded gneiss, Bunty Well

Location and sampling

GLENBURGH (SG 50-6), ERONG (2246) MGA Zone 50, 479100E 7174560N

Sampled on 1 November 1998.

The sample was taken from the edge of a small pavement at the southwestern end of a rocky ridge, and about 2.5 km northeast of Bunty Well. The site is Locality 6 of Occhipinti et al. (2001).

Tectonic unit/relations

This sample is from a complex polyphase granitic gneiss, which was interpreted to be part of the Narryer Terrane, Yilgarn Craton (Occhipinti et al., 2001). The gneiss consists of dark greenish grey, medium- and even-grained layers containing sparse rounded feldspar grains up to 10 mm in diameter alternating with leucocratic and coarse pinkish white pegmatitic layers, typically 2 to 3 mm thick. Banding is folded about steeply plunging, tight, northeasterly trending folds. Two generations of pegmatite are present, the oldest subparallel to the banding and deformed with it, and the youngest that follow axial planes of the folds.

Petrographic description

The dark green-grey banded phases present within this sample consist of altered and recrystallized granodiorite gneiss with biotite, sericite, and epidote, and accessory zircon (trace), and apatite (trace). These phases comprise a banded gneiss, with compositional layering on a scale of 1 to 5 mm, which are alternately rich in biotite and plagioclase, or in microcline. They consist of quartz (35–40 vol.%), residual plagioclase (20 vol.%), microcline (15–20 vol.%), muscovite and sericite (20 vol.%), epidote (3 vol.%), and biotite (3 vol.%), originally derived from a granodiorite gneiss. The plagioclase is generally less than 2 mm in grain size, with some areas containing very minor sericite and epidote, but mostly clouded by abundant sericite, and less abundant fine-grained granular epidote. The abundant quartz occurs as an inequigranular mosaic of grains from 0.1 to 1.5 mm in diameter. Inequigranular microcline is disseminated, somewhat irregularly, with some grains to 4 mm long, found commonly in small aggregates. Minor fine-grained microcline also accompanies the altered plagioclase in less biotite-rich layers. Biotite occurs within altered plagioclase and as separate, poorly oriented flakes to 0.5 mm long, accompanied by granular epidote. Zircon crystals also occur in sericite- and epidote-rich areas and enclosed in quartz. Rare apatite was also noted. This rock is a gneiss originally metamorphosed under low amphibolite facies conditions, possibly passing into greenschist facies metamorphism. The pegmatite phases present within this sample comprise even dark and light banded, fine-grained augen gneiss of monzogranite to syenogranite composition. These contain an alteration assemblage of biotite, epidote and muscovite, with localized chlorite–titanite after biotite, quartz veins, and epidote–albite veins. These pegmatite phases consist of banded fine-grained gneiss with pale and dark bands. Two thin sections were made to cover the variation seen in hand specimen, one covering mostly dark material and one with mostly pale material. The pale bands are quartzofeldspathic with some plagioclase-rich layers but are mostly rich in microcline. Averaged over the thin section, these consist of perthitic microcline (35–40 vol.%), quartz (30–35 vol.%), plagioclase (20–25 vol.%), sericite and muscovite (4 vol.%), epidote (2 vol.%), and biotite (<1 vol.%). The dark material is more uniform, with quartz (25–30 vol.%), plagioclase (20 vol.%), microcline (45 vol.%), sericite and muscovite (5 vol.%), epidote (2-3 vol.%), and biotite (<1 vol.%). These layers correspond to monzogranite and syenogranite respectively. The pale material has abundant weakly perthitic microcline as augen to 3 mm long. There are also areas of fine-grained, recrystallized microcline, usually with fine-grained quartz and plagioclase. The plagioclase occurs partly as augen to 3 mm and is mostly dusted by sericite and/ or epidote, indicating weak saussuritic alteration. There are lenses and semi-continuous lamellae rich in sericite or fine-grained muscovite and granular to prismatic epidote, mostly less than 0.5 mm in grain size. Patches of biotite occur within some of the altered plagioclase grains, but most of the biotite is in a single dark layer, with muscovite and epidote. A matrix of quartz is present with some of the quartz grains to 2 mm long in parallel orientation, defining a foliation, and parallel to sericite and biotite orientations. In some areas, the biotite has been altered to chlorite and/or titanite. Rare altered fine-grained allanite is present. The dark material has more elongate augen of plagioclase and microcline to 5 or 6 mm long, some of which have been pulled apart and veined by quartz and/or biotite, as well as some smaller grains of plagioclase that may have been replaced by microcline. Lenses of fine-grained recrystallized microcline occur, usually with minor altered plagioclase and quartz. The plagioclase has similar alteration, with sericite and epidote as well as rare patches of biotite, but lamellae of muscovite, biotite and epidote are more abundant and continuous than in the paler areas. The quartz is ribbon-like, in discrete lenses parallel to the foliation, and occurs as elongate grains to 3 mm long, some of which are polygonized. There is accessory altered allanite and rare limonite, apparently after pyrite. The pale area has a quartz vein parallel to the foliation and the dark area has a later vein of epidote and albite. These samples represent syenogranite and monzogranite gneisses that have been metamorphosed under low amphibolite-facies conditions possibly persisting into high greenschist facies. Neither phase is specifically pegmatitic, but layering or magma mixing may be involved in the genesis of these rocks. Rare small zircons occur in the pale area.

Zircon morphology

The zircons isolated from this sample are pale yellow, yellow-brown, dark green-brown and black, generally between 25 × 30 µm and 80 × 200 µm in size, and elongate and subrounded in shape. Many are metamict or contain dark, strongly metamict zones. Most grains show internal growth zoning.

Analytical details

This sample was analysed on 28 May 2001. The counter deadtime was 32 ns. Twelve analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.46 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 1.1, 3.1, 4.1, 6.1 and 13.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Seventeen analyses were obtained from 17 zircons. Results are given in Table 49 and shown on a concordia plot in Figure 71.

Interpretation

Most analyses are concordant to slightly discordant with the discordance patterns consistent with at least one episode of recent radiogenic-Pb redistribution. A range of $^{207}Pb/^{206}Pb$ dates of from c. 2000 to 2800 Ma is indicated. Five concordant to highly

Table 49. Ion microprobe analytical results for sample 139463: pegmatite-banded gniess, Bunty Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	2 008	48	713	0.304	0.12312	0.00028	0.00721	0.00041	0.3613	0.0053	6.134	0.093	99	2 002	4
2.1	1 615	44	795	0.034	0.16658	0.00027	0.00669	0.00016	0.4871	0.0071	11.188	0.167	101	2 524	3
3.1	581	331	227	4.413	0.16708	0.00128	0.08520	0.00289	0.3167	0.0047	7.296	0.128	70	2 529	13
4.1	1 252	154	697	0.502	0.18706	0.00035	0.03652	0.00052	0.5207	0.0076	13.430	0.202	99	2 716	3
5.1	724	50	393	0.186	0.18477	0.00043	0.01795	0.00046	0.5219	0.0077	13.296	0.202	100	2 696	4
6.1	424	340	273	0.902	0.18898	0.00072	0.21866	0.00144	0.5175	0.0077	13.484	0.213	98	2 733	6
7.1	111	67	61	0.273	0.16502	0.00124	0.15100	0.00215	0.4862	0.0075	11.062	0.200	102	2 508	13
8.1	133	86	77	0.239	0.17585	0.00105	0.14307	0.00165	0.5037	0.0077	12.212	0.210	101	2 614	10
9.1	397	172	219	0.102	0.17217	0.00055	0.10829	0.00070	0.4993	0.0074	11.852	0.185	101	2 579	5
10.1	373	107	200	0.460	0.18725	0.00068	0.03839	0.00098	0.5006	0.0074	12.924	0.203	96	2 718	6
11.1	300	122	160	0.136	0.17080	0.00065	0.09196	0.00088	0.4877	0.0073	11.486	0.182	100	2 566	6
12.1	144	58	76	0.369	0.16657	0.00105	0.10061	0.00166	0.4808	0.0074	11.042	0.191	100	2 523	11
13.1	356	269	211	1.416	0.19065	0.00091	0.17465	0.00186	0.4846	0.0072	12.738	0.206	93	2 748	8
14.1	1 263	73	694	0.160	0.18517	0.00031	0.01720	0.00031	0.5281	0.0078	13.484	0.202	101	2 700	3
15.1	144	88	76	1.390	0.16516	0.00149	0.10983	0.00294	0.4619	0.0071	10.518	0.197	98	2 509	15
16.1	216	83	131	0.285	0.19467	0.00084	0.09885	0.00121	0.5420	0.0082	14.549	0.236	100	2 782	7
17.1	377	184	232	0.197	0.19394	0.00061	0.12361	0.00085	0.5396	0.0080	14.430	0.225	100	2 776	5

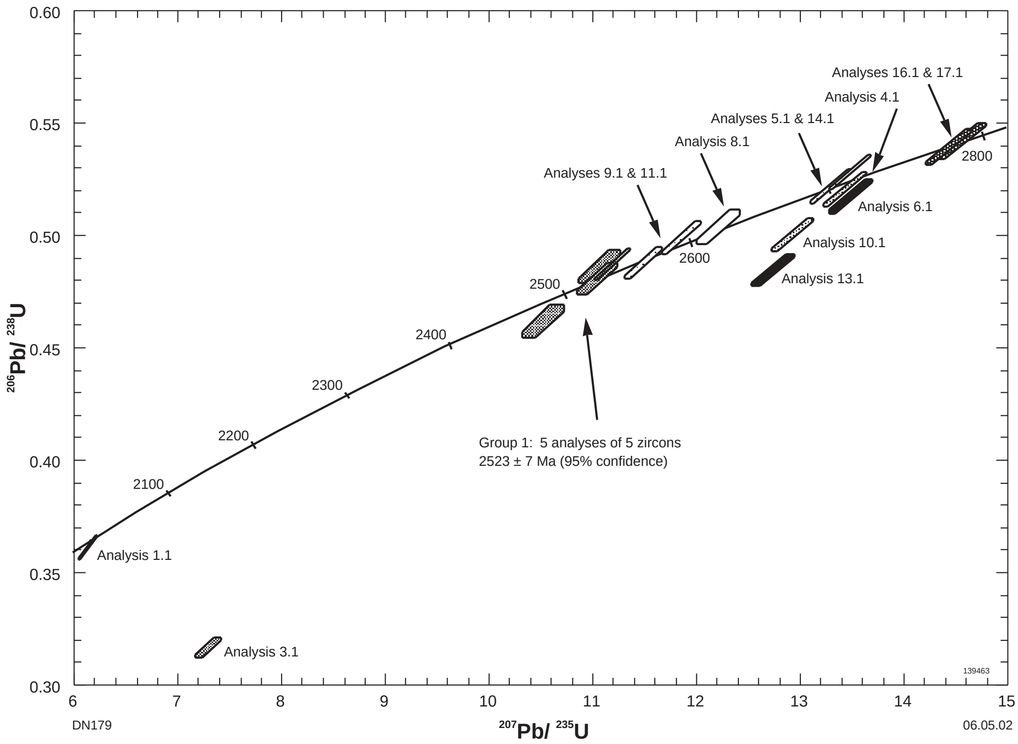

Figure 71. Concordia plot for sample 139463: pegmatite-banded gneiss, Bunty Well

discordant analyses of five zircons (2.1, 3.1, 7.1, 12.1 and 15.1), assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean date of 2523 ± 7 Ma (chi-squared = 0.60). The remaining analyses cannot be confidently grouped.

At least four igneous phases, any one or more of which may have contained complex xenocryst zircon populations, were identified within this sample. The range of $^{207}Pb/^{206}Pb$ dates between c. 2000 to 2800 Ma obtained is therefore interpreted to provide an indication of the age of igneous crystallization of these igneous phases, and of incorporated xenocryst zircons.

168964: foliated monzogranite, Elvire Rock

Location and sampling

BARLEE (SH 50-8), MARMION (2839) MGA Zone 50, 767440E 6735480N

Sampled on 25 November 1999.

The sample was taken from the western edge of a 4 m-wide, 10 m-long whaleback located about 200 m west of a prominent north-trending quartz vein ridge and 15 km east of Elvire Rock. The site is 25 m north of the sampling site of sample 168965 (see Nelson, 2001).

Tectonic unit/relations

This sample is from a pink and grey, fine- to coarse-grained foliated monzogranite phase of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Chen and Greenfield, 2001). The monzogranite contains bands of dark grey, medium- and even-grained granodiorite up to 2 cm thick.

Petrographic description

The principal minerals present in this sample are plagioclase (40 vol.%), microcline (30–35 vol.%), quartz (25 vol.%), and biotite (3 vol.%), with accessory opaque oxide (trace), titanite (trace), sericite (trace), and zircon (trace). This is a strongly foliated monzogranite or monzogranitic augen gneiss, with coarse augen of plagioclase and microcline, lenses of quartz, and small patches of microcline in a quartzofeldspathic micromosaic, with minor biotite defining a foliation. The hand specimen has numerous scattered coarse plagioclase and microcline augen. The stained offcut indicates that plagioclase is more abundant than microcline, with some microcline apparently rimmed by plagioclase. Abundant augen of microcline (30 vol.%) to 6 × 4 mm, rarely with narrow rims of plagioclase and/or myrmekite, and abundant augen of plagioclase (25–30 vol.%) mostly 2 to 4 mm long, have irregular clouding of clay and sericite. Inclusions of plagioclase or quartz occur in the microcline, and there are inclusions of sericite within the plagioclase. Small lenses of recrystallized microcline, and 5 mm-long lenses and ribbons of quartz grains to 1 mm in length are also scattered throughout. The matrix is composed of a plagioclase-rich quartzofeldspathic micromosaic, with disseminated fresh or clay–chlorite altered very fine-grained biotite (7–10 vol.%) defining an irregular foliation. Rare opaque oxide and titanite commonly occur together, and there is rare zircon.

Zircon morphology

The zircons isolated from this sample are yellowish brown, greenish brown and black, generally between 30 × 60 µm and 50 × 180 µm in size, and are elongate and euhedral in shape. Most grains have faint internal zonation and a minority have small unzoned structural cores. Many are metamict.

Analytical details

This sample was analysed on 13 March and 31 April 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, three analyses of the CZ3 standard indicated a Pb^{*}/U calibration error of 2.17 (1σ%). Analyses 1.1 to 9.1 were obtained during the first analysis session. During the second analysis session,

Table 50. Ion microprobe analytical results for sample 168964: foliated monzogranite, Elvire Rock

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	1 732	122	1079	0.525	0.18450	0.00028	0.04362	0.00044	0.5800	0.0126	14.754	0.324	109	2 694	3
2.1	84	71	55	0.640	0.18607	0.00161	0.22803	0.00310	0.5212	0.0117	13.372	0.334	100	2 708	14
3.1	64	93	46	0.756	0.18575	0.00189	0.39923	0.00420	0.5180	0.0117	13.266	0.344	99	2 705	17
4.1	104	104	70	0.215	0.18690	0.00125	0.27848	0.00241	0.5294	0.0118	13.642	0.328	101	2 715	11
5.1	195	95	107	9.475	0.18668	0.00357	0.44414	0.00875	0.3122	0.0069	8.035	0.250	65	2 713	32
6.1	90	73	55	2.192	0.18482	0.00213	0.24862	0.00454	0.4648	0.0104	11.845	0.313	91	2 697	19
7.1	84	120	60	0.856	0.18537	0.00164	0.39793	0.00365	0.5083	0.0114	12.992	0.326	98	2 701	15
8.1	81	76	54	0.538	0.18612	0.00158	0.25193	0.00312	0.5295	0.0119	13.587	0.339	101	2 708	14
8.2	81	55	54	8.131	0.18656	0.00401	0.36821	0.00968	0.4067	0.0093	10.461	0.347	81	2 712	35
9.1	67	85	47	0.868	0.18479	0.00189	0.34699	0.00408	0.5142	0.0116	13.102	0.340	99	2 696	17
3.2	82	122	59	0.416	0.18796	0.00131	0.39685	0.00285	0.5179	0.0060	13.422	0.192	99	2 724	12
2.2	87	78	58	1.089	0.18675	0.00156	0.24417	0.00316	0.5249	0.0061	13.516	0.204	100	2 714	14
5.2	101	86	60	0.669	0.18829	0.00139	0.24446	0.00270	0.4679	0.0054	12.147	0.175	91	2 727	12
7.2	81	112	60	0.617	0.18410	0.00149	0.32964	0.00310	0.5576	0.0065	14.154	0.213	106	2 690	13
8.3	109	90	80	1.069	0.18808	0.00153	0.23064	0.00303	0.5838	0.0065	15.139	0.222	109	2 725	13
10.1	55	55	35	0.676	0.18327	0.00170	0.22510	0.00325	0.5164	0.0065	13.049	0.216	100	2 683	15
11.1	92	86	59	0.558	0.18737	0.00127	0.23993	0.00242	0.5102	0.0058	13.180	0.184	98	2 719	11
12.1	701	46	371	0.124	0.18058	0.00036	0.01417	0.00032	0.5127	0.0052	12.766	0.136	100	2 658	3

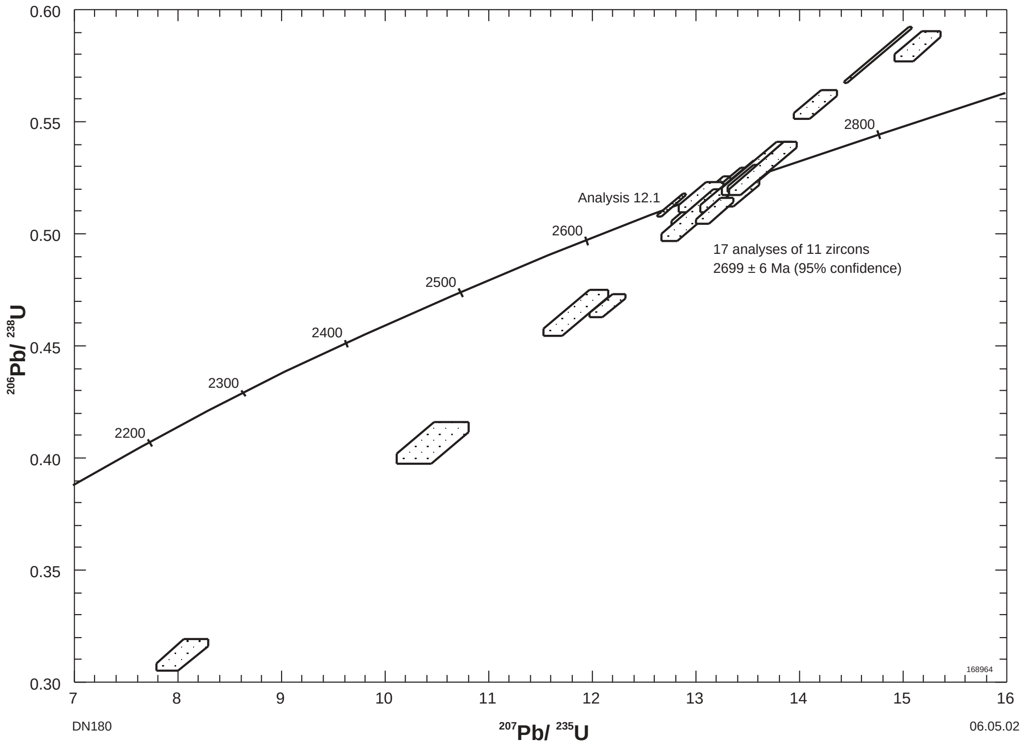

Figure 72. Concordia plot for sample 168964: foliated monzogranite, Elvire Rock

four analyses of the CZ3 standard indicated a Pb*/U calibration error of 0.801 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the second analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 1.1, 5.1 and 8.2, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Eighteen analyses were obtained from 12 zircons. Results are given in Table 50 and shown on a concordia plot in Figure 72.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a dominant recent episode of radiogenic-Pb redistribution. Seventeen analyses of 11 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2699 ± 6 Ma (chi-squared = 1.56). Concordant analysis 12.1 indicated a slightly younger $^{207}Pb/^{206}Pb$ date than the main population.

The date of 2699 ± 6 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 17 analyses is interpreted as the age of igneous crystallization of the monzogranite. Analysis 12.1 indicated a high U concentration and the younger $^{207}Pb/^{206}Pb$ date indicated by this analysis may be due to ancient loss of radiogenic Pb from this analysis site. Alternatively, this grain may have been derived from the granite dykes identified within this sample.

168972: quartz monzodiorite gneiss, Willow Bore

Location and sampling

BARLEE (SH 50-8), BARLEE (2739)   MGA Zone 50, 706760E 6779780N

Sampled on 31 May 2000.

The sample was taken from an exfoliated sheet of a low pavement located about 10 m south of the access track and 3.3 km southeast of Willow Bore.

Tectonic unit/relations

This sample is from a light grey and white banded monzodiorite gneiss, with 2 cm- to 2 m-thick layering, of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Riganti, 2001). At least four igneous phases are represented at the sampling site: a fine- to medium-grained, even-grained biotite-rich phase, which is interlayered with a fine- to medium-grained, even-grained leucocratic phase. A third phase consists of medium-grained, feldspar-phyric leucocratic gneissic granite. These three phases were represented in the sample taken. A dark, fine-grained phase, which occurs as 5 to 10 cm-thick bands at the sampling site, was not present in the sample. All phases present at the sampling locality pre-date development of the gneissic fabric, which strikes at 180°.

Petrographic description

The principal minerals present in this sample are plagioclase (65 vol.%), microcline (15 vol.%), quartz (10–15 vol.%), and biotite (5 vol.%), with accessory magnetite (trace), apatite (trace), and zircon (trace). This is a layered quartz diorite gneiss, with biotite-poor and biotite-rich layers in a plagioclase-rich host rock, that has been metamorphosed in the amphibolite facies. Alternate grey and white bands, 5 to 10 mm thick, contain various amounts of biotite, with a fine-grained quartzofeldspathic component throughout. The bulk of the rock is composed of rounded grains of plagioclase and less abundant microcline, from 0.4 to 3 mm in diameter (mostly 1 – 1.5 mm), with relatively minor quartz and biotite. Minor myrmekite is found adjacent to the microcline grains, and some of the plagioclase (including that within myrmekite) has been sericitized. Patches of fine-grained quartzofeldspathic micromosaic occur between the larger feldspar grains, as well as interstitial quartz as grains and lenses to 5 mm long. Biotite occurs as poorly oriented flakes from 0.2 to 0.8 mm long, with up to 7 to 8 vol.% biotite in the more biotite-rich layers compared with about 5 vol.% overall. Weak alteration to chlorite occurs in some areas. Accessory magnetite crystals are up to 2 mm in grain size and there is accessory fine-grained apatite. The bulk composition indicates a quartz monzodiorite gneiss that has undergone amphibolite facies metamorphism.

Zircon morphology

The zircons isolated from this sample are colourless, pale yellow, yellowish brown and black, generally between 30 × 60 µm and 50 × 180 µm in size, and have a wide range of shapes, including both equant and rounded, and elongate and euhedral. Most grains are metamict, and many have faint internal zonation. A minority have unzoned structural cores.

Table 51. Ion microprobe analytical results for sample 168972: quartz monzodiorite gneiss, Willow Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	603	156	232	1.001	0.17055	0.00083	0.06475	0.00156	0.3511	0.0036	8.257	0.098	76	2 563	8
2.1	223	68	121	0.413	0.18459	0.00097	0.07563	0.00148	0.4946	0.0053	12.590	0.156	96	2 695	9
3.1	307	170	182	1.405	0.18644	0.00097	0.08934	0.00188	0.5176	0.0054	13.305	0.164	99	2 711	9
4.1	362	31	212	2.879	0.20623	0.00125	0.05659	0.00263	0.4932	0.0052	14.024	0.179	90	2 876	10
5.1	351	171	202	1.441	0.18385	0.00098	0.14639	0.00200	0.4815	0.0050	12.206	0.150	94	2 688	9
6.1	304	122	176	2.007	0.18328	0.00125	0.06584	0.00258	0.5067	0.0053	12.805	0.170	99	2 683	11
7.1	201	67	119	1.088	0.18712	0.00123	0.11093	0.00241	0.5142	0.0055	13.267	0.176	98	2 717	11
8.1	216	364	129	1.042	0.18777	0.00111	0.09782	0.00211	0.5208	0.0055	13.482	0.173	99	2 723	10
9.1	200	103	118	0.445	0.18781	0.00101	0.14628	0.00168	0.5053	0.0054	13.085	0.164	97	2 723	9
10.1	517	132	200	4.872	0.15596	0.00194	0.08638	0.00445	0.3120	0.0033	6.709	0.116	73	2 412	21
11.1	147	162	102	3.999	0.18678	0.00254	0.15562	0.00572	0.5354	0.0062	13.788	0.260	102	2 714	22
12.1	624	65	288	2.847	0.17401	0.00105	0.04572	0.00226	0.4017	0.0041	9.637	0.121	84	2 597	10
3.2	237	219	133	4.491	0.18377	0.00165	0.12881	0.00371	0.4347	0.0046	11.014	0.163	87	2 687	15
3.3	208	170	119	3.464	0.18299	0.00157	0.09961	0.00345	0.4663	0.0050	11.764	0.171	92	2 680	14
8.2	184	128	112	2.481	0.18735	0.00167	0.10256	0.00337	0.5048	0.0056	13.039	0.196	97	2 719	15
9.2	190	113	114	2.529	0.18456	0.00163	0.17774	0.00341	0.4754	0.0052	12.098	0.180	93	2 694	15
9.3	223	114	133	0.268	0.18783	0.00090	0.14505	0.00138	0.5156	0.0056	13.353	0.166	98	2 723	8

Analytical details

This sample was analysed on 26 November 2000 and 14 July 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 0.718 (1σ%). Analyses 1.1 to 11.1 were obtained during the first analysis session. During the second analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 0.889 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during both analysis sessions. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 1.1, 3.1, 4.1, 5.1, 6.1, 7.1, 8.1, 10.1, 11.1, 12.1, 3.2 and 3.3, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Seventeen analyses were obtained from 12 zircons. Results are given in Table 51 and shown on a concordia plot in Figure 73.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several recent episodes of radiogenic-Pb redistribution. Ten analyses of five zircons (3.1, 3.2, 3.3, 7.1, 8.1, 8.2, 9.1, 9.2, 9.3 and 11.1) have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2714 ± 10 Ma (chi-squared = 1.49). Discordant analysis 4.1 indicates an older $^{207}Pb/^{206}Pb$ date, whereas the remaining analyses are discordant and indicate younger $^{207}Pb/^{206}Pb$ dates than the main population.

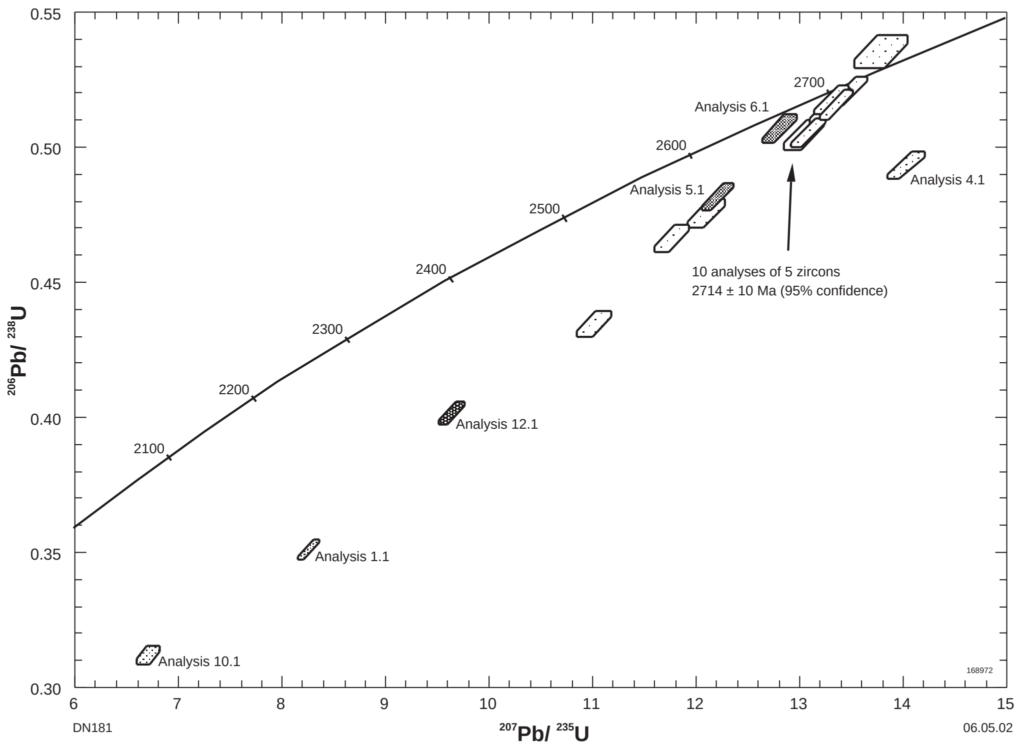

Figure 73. Concordia plot for sample 168972: quartz monzodiorite gneiss, Willow Bore

The date of 2714 ± 10 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of ten analyses of five zircons is tentatively interpreted as the age of igneous crystallization of one or more of the igneous phases present in this sample. The older $^{207}Pb/^{206}Pb$ date indicated by discordant analysis 4.1 may indicate that this grain is a xenocryst or was derived from one of the other igneous phases present in this sample. The younger $^{207}Pb/^{206}Pb$ dates indicated by the remaining analyses are attributed to loss of radiogenic Pb from these analysis sites.

168976: recrystallized biotite monzogranite, Kurrajong Rockhole

Location and sampling

JACKSON (SH 50-12), BUNGALBIN (2837) MGA Zone 50, 777750E 6657930N

Sampled on 2 June 2000.

The sample was taken from the eastern edge of a low undulating pavement about 120 m east of Kurrajong Rockhole.

Tectonic unit/relations

This sample is from a grey, even-grained, unfoliated, recrystallized biotite monzogranite, located on eastern side of the Hunt Range greenstone belt, of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Chen and Wyche, 2001b).

Petrographic description

The principal minerals present in this sample are plagioclase (35 vol.%), quartz (30 vol.%), microcline (30 vol.%), biotite (4 vol.%), and magnetite (1 vol.%), with accessory opaque oxide (trace), apatite (trace), titanite (trace), allanite (trace), and zircon (trace). The hand specimen is an equigranular, fine- to medium-grained, grey biotite monzogranite, with disseminated fine biotite that has been recrystallized, probably under amphibolite-facies conditions. In thin section, abundant primary plagioclase and microcline grains from 1 to 6 mm long are randomly dispersed through an irregular, patchy matrix of fine-grained, recrystallized plagioclase, microcline and/or quartz, about 0.2 mm in grain size. Coarser scattered primary quartz occurs as lobate grains 0.3 to 4 mm in diameter and is less commonly recrystallized than the feldspars. There is abundant myrmekite, and some of the plagioclase has been altered to irregular patches of sericite and clay. Minor biotite also occurs as primary crystals up to 2 mm long and as small, fine-grained recrystallized aggregates. Accessory magnetite to 0.6 mm in diameter is disseminated, with small apatite crystals commonly attached. Rare zircon is also locally attached to magnetite. Rare fine-grained titanite is disseminated in the biotite-rich areas and there are rare altered grains that may have been allanite.

Zircon morphology

The zircons isolated from this sample are yellowish brown, greenish brown and black, generally between 30 × 60 µm and 50 × 180 µm in size, and are elongate and euhedral. Most grains have faint internal zonation and a minority have small unzoned structural cores. Many are metamict.

Analytical details

This sample was analysed on 13 March and 30 April 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, three analyses of the CZ3 standard indicated a Pb^*/U calibration error of 2.17 (1σ%). Analyses 1.1 to 13.1 were obtained during the first analysis session. During the second analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of 0.801 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the second analysis session. Common-Pb corrections were applied assuming Broken

Table 52. Ion microprobe analytical results for sample 168976: recrystallized biotite monzogranite, Kurrajong Rockhole

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	476	332	266	1.257	0.18426	0.00086	0.18187	0.00177	0.4573	0.0053	11.619	0.152	90	2 692	8
2.1	772	446	467	0.317	0.18889	0.00054	0.15967	0.00086	0.5159	0.0060	13.437	0.164	98	2 733	5
3.1	2 818	2 477	1013	0.680	0.14728	0.00034	0.28891	0.00077	0.2854	0.0032	5.795	0.069	70	2 315	4
4.1	526	454	336	0.422	0.18797	0.00063	0.24612	0.00117	0.5101	0.0059	13.221	0.165	98	2 725	6
5.1	1 232	414	594	0.535	0.16530	0.00046	0.11463	0.00081	0.4310	0.0049	9.823	0.119	92	2 511	5
6.1	206	109	121	2.249	0.18564	0.00151	0.16686	0.00327	0.4720	0.0056	12.081	0.184	92	2 704	13
7.1	1 299	827	750	0.162	0.18629	0.00036	0.17600	0.00054	0.4899	0.0056	12.582	0.149	95	2 710	3
8.1	525	338	329	0.190	0.18824	0.00056	0.18159	0.00085	0.5288	0.0061	13.724	0.169	100	2 727	5
9.1	491	252	294	0.026	0.18677	0.00052	0.14554	0.00064	0.5218	0.0060	13.438	0.164	100	2 714	5
10.1	365	162	215	0.056	0.18677	0.00062	0.12218	0.00074	0.5214	0.0061	13.426	0.168	100	2 714	5
11.1	214	94	124	1.779	0.18803	0.00139	0.13940	0.00290	0.4819	0.0057	12.493	0.184	93	2 725	12
12.1	291	152	180	0.017	0.18852	0.00070	0.14478	0.00083	0.5376	0.0063	13.974	0.178	102	2 729	6
13.1	262	213	164	0.519	0.18695	0.00095	0.23096	0.00177	0.5054	0.0060	13.027	0.175	97	2 716	8
14.1	1 109	605	688	0.369	0.18782	0.00034	0.14878	0.00055	0.5335	0.0057	13.816	0.152	101	2 723	3
15.1	540	368	331	0.174	0.18786	0.00045	0.18474	0.00069	0.5162	0.0055	13.371	0.150	99	2 724	4
16.1	238	166	148	0.818	0.18839	0.00094	0.15122	0.00170	0.5249	0.0057	13.634	0.171	100	2 728	8
17.1	68	94	56	0.611	0.22467	0.00161	0.38476	0.00330	0.5814	0.0070	18.011	0.266	98	3 014	12
18.1	278	158	165	0.106	0.18730	0.00061	0.15567	0.00087	0.5117	0.0056	13.215	0.155	98	2 719	5
19.1	369	300	221	0.229	0.18813	0.00057	0.21887	0.00096	0.4923	0.0053	12.770	0.148	95	2 726	5
20.1	653	428	394	0.045	0.18804	0.00038	0.17661	0.00051	0.5124	0.0055	13.286	0.147	98	2 725	3

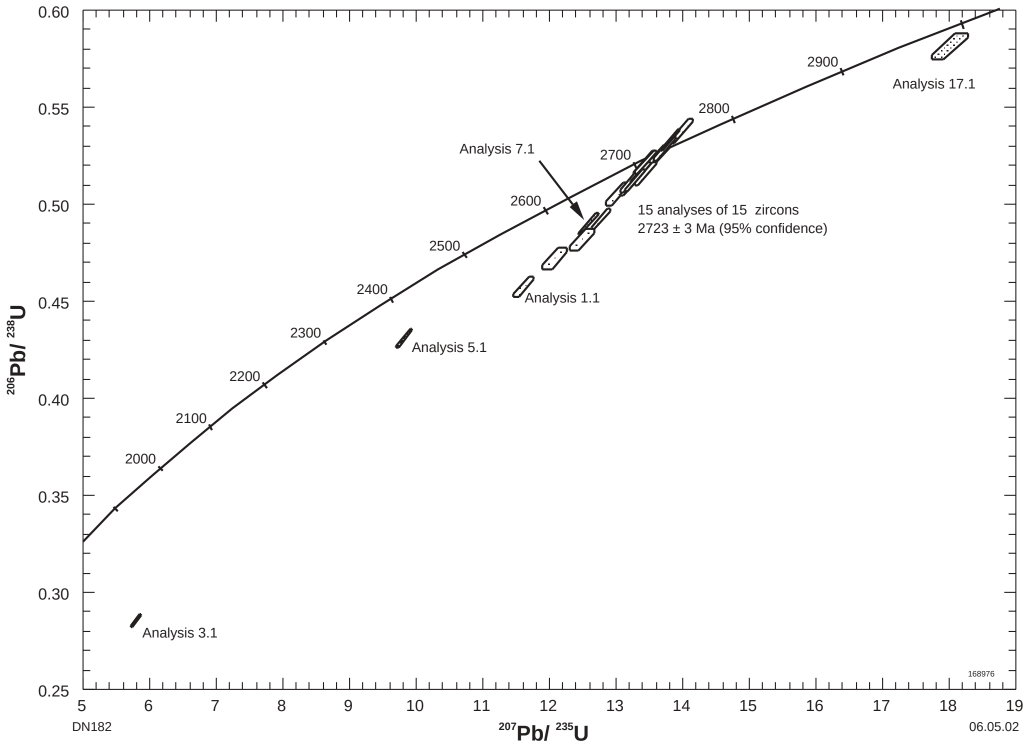

Figure 74. Concordia plot for sample 168976: recrystallized biotite monzogranite, Kurrajong Rockhole

Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 1.1, 3.1, 5.1, 6.1, 11.1 and 14.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty analyses were obtained from 20 zircons. Results are given in Table 52 and shown on a concordia plot in Figure 74.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes, including a dominant recent episode, of radiogenic-Pb loss. Fifteen analyses of 15 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2723 ± 3 Ma (chi-squared = 1.16). Discordant analysis 17.1 indicates a substantially older $^{207}Pb/^{206}Pb$ date, whereas discordant analyses 1.1, 3.1, 5.1 and 7.1 indicate younger $^{207}Pb/^{206}Pb$ dates, than the main population.

The date of 2723 ± 3 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 15 analyses is interpreted as the age of igneous crystallization of the monzogranite. Analysis 17.1 is interpreted to be of a xenocryst zircon, whereas the younger $^{207}Pb/^{206}Pb$ dates indicated by discordant analyses 1.1, 3.1, 5.1 and 7.1 are interpreted to be due to ancient loss of radiogenic Pb from these analysis sites.

169064: foliated porphyritic monzogranite, Woglin Soak

Location and sampling

BARLEE (SH 50-8), LAKE GILES (2838) MGA Zone 50, 770590E 6683070N

Sampled on 24 October 2000.

The sample was taken from a 1 m-diameter, partly submerged boulder in an area of low rocky boulders, located 2 km east of an abandoned stone hut and 6.5 km northeast of Woglin Soak. The site is 20 m east of the sampling site of sample 169065.

Tectonic unit/relations

This sample is from a light to medium grey, fine- to medium-grained monzogranite of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Greenfield, 2001). The monzogranite contains cubic to tabular, white or brown feldspar phenocrysts up to 2 cm long and tabular hornblende phenocrysts up to 3 mm long. A foliation trends at 015°. The monzogranite is associated with a medium to coarse, even-grained syenogranite, of which 169065 is representative.

Petrographic description

The principal minerals present in this sample are microcline (35 vol.%), quartz (30 vol.%), plagioclase (25 vol.%), biotite (5 vol.%), hornblende (1 vol.%), and titanite (1 vol.%), with accessory apatite (trace), zircon (trace), limonite (trace), opaque oxide (trace), and altered allanite (trace). This is a foliated porphyritic micromonzogranite with fine-grained, disseminated mafic grains. The thin section has phenocrysts from 2 to 6 mm long, including plagioclase, microcline, green hornblende and quartz, although quartz is anhedral and is not as clearly porphyritic as the other minerals. The largest phenocryst, a crystal of microcline, is at least 10 × 5 mm. An aggregate composed of magnetite, titanite, granular apatite, limonite, altered ?allanite and at least one grain of zircon occurs adjacent to a hornblende phenocryst and is about 3 mm long. Disseminated biotite, to 0.5 mm in grain size, defines a foliation and is accompanied by fresh to leucoxenized titanite to 1 mm in grain size and fine-grained opaque oxide. The groundmass is mostly a fine-grained aggregate of quartz, microcline and plagioclase to 1 mm in grain size. Accessory apatite is common and there are rare zircon grains. An altered mineral, possibly allanite is also present. The mineralogy indicates a porphyritic micromonzogranite that was deformed under amphibolite-facies conditions.

Zircon morphology

The zircons isolated from this sample are dark brown and black, generally between 350 × 120 µm and 50 × 180 µm in size, and are elongate and euhedral. Many grains are strongly striated and most have internal zonation and irregular dark inclusions. A minority have small unzoned structural cores and some have radially cracked, unzoned rims. Many are metamict.

Analytical details

This sample was analysed on 27 August 2001. The counter deadtime during the analysis session was 32 ns. Eight analyses of the CZ3 standard obtained during the analysis

Table 53. Ion microprobe analytical results for sample 169064: foliated porphyritic monzogranite, Woglin Soak

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	651	219	364	0.025	0.18277	0.00039	0.09049	0.00039	0.5106	0.0052	12.869	0.138	99	2 678	4
2.1	1 096	1027	514	0.185	0.17496	0.00036	0.24477	0.00063	0.3818	0.0039	9.209	0.097	80	2 606	3
3.1	719	392	338	0.461	0.17304	0.00048	0.15681	0.00086	0.4054	0.0041	9.671	0.105	85	2 587	5
4.1	440	566	291	0.053	0.18354	0.00047	0.34815	0.00092	0.4999	0.0052	12.650	0.139	97	2 685	4
5.1	602	434	333	0.221	0.17819	0.00048	0.22341	0.00084	0.4558	0.0047	11.199	0.122	92	2 636	5
6.1	312	364	205	0.330	0.18356	0.00065	0.31379	0.00128	0.5064	0.0053	12.816	0.147	98	2 685	6
7.1	372	378	218	0.345	0.18055	0.00060	0.28103	0.00115	0.4622	0.0048	11.505	0.129	92	2 658	5
8.1C	172	160	107	0.273	0.18884	0.00093	0.24490	0.00165	0.4976	0.0054	12.957	0.160	95	2 732	8
8.2R	89	80	48	0.668	0.18825	0.00159	0.29063	0.00320	0.4147	0.0048	10.765	0.163	82	2 727	14
9.1	121	102	73	0.411	0.18384	0.00106	0.23760	0.00193	0.4880	0.0054	12.370	0.162	95	2 688	10
10.1	528	47	280	0.049	0.18370	0.00044	0.02359	0.00037	0.5100	0.0052	12.917	0.140	99	2 687	4
11.1	591	60	309	0.042	0.18440	0.00041	0.02778	0.00030	0.5014	0.0051	12.748	0.137	97	2 693	4
12.1	234	239	148	0.128	0.18204	0.00069	0.26890	0.00122	0.5035	0.0053	12.638	0.148	98	2 672	6
13.1	70	76	45	0.361	0.18322	0.00144	0.30008	0.00285	0.4973	0.0059	12.563	0.189	97	2 682	13
14.1	564	98	304	0.082	0.18384	0.00044	0.04672	0.00041	0.5078	0.0052	12.872	0.139	98	2 688	4
14.2	494	137	251	0.083	0.18268	0.00048	0.07635	0.00052	0.4680	0.0048	11.788	0.129	92	2 677	4
15.1	781	209	221	0.112	0.15505	0.00045	0.06396	0.00054	0.2689	0.0027	5.749	0.063	64	2 402	5
16.1	70	99	49	0.378	0.18461	0.00143	0.39342	0.00310	0.5117	0.0061	13.023	0.195	99	2 695	13
17.1	121	200	87	0.285	0.18573	0.00107	0.45321	0.00245	0.5064	0.0057	12.968	0.172	98	2 705	10
18.1	109	135	63	0.444	0.18805	0.00132	0.36240	0.00277	0.4282	0.0048	11.103	0.155	84	2 725	12
19.1	54	74	38	0.460	0.18494	0.00181	0.37901	0.00390	0.5139	0.0065	13.104	0.221	99	2 698	16
20.1	196	153	120	0.073	0.18404	0.00074	0.21645	0.00117	0.5097	0.0055	12.934	0.154	99	2 690	7
21.1	1 090	41	541	1.197	0.18530	0.00050	0.03033	0.00096	0.4564	0.0046	11.660	0.126	90	2 701	4
22.1	90	135	63	0.404	0.18180	0.00127	0.40422	0.00279	0.5063	0.0059	12.691	0.181	99	2 669	12
23.1	135	202	96	0.166	0.18467	0.00094	0.41280	0.00204	0.5116	0.0057	13.026	0.166	99	2 695	8

NOTE: C denotes analysis obtained on zircon core; R denotes analysis obtained on zircon rim

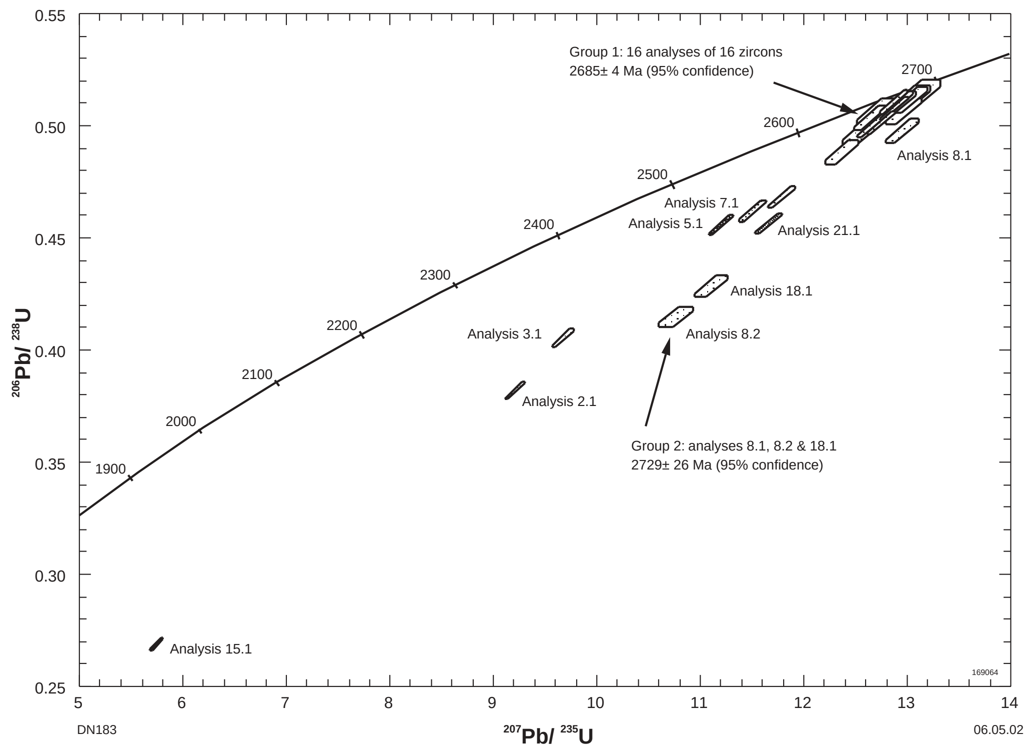

Figure 75. Concordia plot for sample 169064: foliated porphyritic monzogranite, Woglin Soak

session indicated a Pb*/U calibration error of 0.967 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 3.1 and 21.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-five analyses were obtained from 23 zircons. Results are given in Table 53 and shown on a concordia plot in Figure 75.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with several episodes of radiogenic-Pb loss, including a dominant recent episode. Sixteen analyses of 16 zircons, assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2685 ± 4 Ma (chi-squared = 1.63). Analyses 8.1, 8.2 and 18.1, assigned to Group 2, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2729 ± 26 Ma (chi-squared = 0.10). The remaining analyses are highly discordant and, apart from analysis 21.1, indicate younger $^{207}Pb/^{206}Pb$ dates than the main population.

The date of 2685 ± 4 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 16 analyses is interpreted as the age of igneous crystallization of the monzogranite. The higher $^{207}Pb/^{206}Pb$ ratios indicated by analyses 8.1, 8.2 and 18.1 of Group 2, and possibly also of discordant analysis 21.1, are interpreted to be of xenocryst zircons, whereas the lower $^{207}Pb/^{206}Pb$ ratios indicated by the remaining discordant analyses are interpreted to be of analysis sites that have lost some radiogenic Pb.

169065: biotite syenogranite, Woglin Soak

Location and sampling

BARLEE (SH 50-8), LAKE GILES (2838) MGA Zone 50, 770570E 6683070N

Sampled on 24 October 2000.

The sample was taken from a 1 m-high, 3 m-diameter boulder in an area of low rocky boulders, located 2 km east of an abandoned stone hut and 6.5 km northeast of Woglin Soak. The site is 20 m west of the sampling site of sample 169064.

Tectonic unit/relations

This sample is from a medium grey-brown, medium- to coarse-grained biotite syenogranite of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Greenfield, 2001).

Petrographic description

The principal minerals present in this sample are microcline (40–45 vol.%), quartz (30 vol.%), plagioclase (20 vol.%), and biotite (5 vol.%), with accessory magnetite (trace), titanite (trace), allanite (trace), epidote (trace), apatite (trace), opaque oxide (trace), and zircon (trace). This is a relatively coarse-grained, foliated syenogranite with recrystallized zones. In thin section, this sample consists of abundant microcline to 7 mm in grain size, with clouded plagioclase and granular quartz to 5 mm in grain size. Lenticular foliae of fine-grained biotite and/or recrystallized plagioclase and microcline, with minor myrmekite in the feldspathic lenses, indicate some deformation of this sample. In other areas, the biotite is less strongly foliated and occurs in lenses with magnetite, altered ?allanite, and apatite. The biotite has been variably altered to chlorite. Epidote occurs as a rim on the altered allanite. Grains of apatite and, in some areas, zoned zircon crystals occur in, and adjacent to, opaque oxide grains, and minor titanite is disseminated. This is a syenogranite that has been deformed under amphibolite facies metamorphic conditions.

Zircon morphology

The zircons isolated from this sample are dark brown and black, generally between 350 × 120 µm and 50 × 180 µm in size, and are elongate and commonly euhedral. Many grains have internal zonation, some with unzoned interiors and strongly zoned exterior margins, and others with strongly zoned interiors surrounded by unzoned margins. Irregular dark inclusions are common. Many are metamict.

Analytical details

This sample was analysed on 27 August and 28 September 2001. The counter deadtime during the analysis session was 32 ns. During the first analysis session, five analyses of the CZ3 standard obtained indicated a Pb^*/U calibration error of 2.06 ($1\sigma\%$). Analyses 1.1 to 11.1 were obtained during the first analysis session. During the second analysis session, eight analyses of the CZ3 standard indicated a Pb^*/U calibration error of 0.708 ($1\sigma\%$). A calibration error of 1.0 ($1\sigma\%$) was applied to analyses of unknowns obtained during the second analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 4.1, 6.1, 7.1 and 8.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Table 54. Ion microprobe analytical results for sample 169065: biotite syenogranite, Woglin Soak

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	250	1 686	521	-0.030	0.22590	0.00213	1.38476	0.00889	0.9243	0.0347	28.789	1.145	140	3 023	15
2.1	638	1 266	475	0.155	0.18484	0.00040	0.54190	0.00102	0.4980	0.0103	12.692	0.268	97	2 697	4
3.1	164	224	110	0.161	0.18501	0.00083	0.36908	0.00171	0.4979	0.0105	12.701	0.280	97	2 698	7
4.1	170	217	136	5.002	0.18252	0.00284	0.43158	0.00692	0.5091	0.0109	12.813	0.358	99	2 676	26
5.1	187	213	124	0.069	0.18436	0.00080	0.32812	0.00156	0.5094	0.0107	12.949	0.285	99	2 692	7
6.1	130	121	81	1.558	0.18165	0.00142	0.24803	0.00307	0.4822	0.0102	12.078	0.284	95	2 668	13
7.1	463	168	215	0.844	0.18338	0.00070	0.08043	0.00127	0.4161	0.0086	10.522	0.227	84	2 684	6
8.1	346	649	259	0.603	0.18464	0.00067	0.50368	0.00165	0.5064	0.0105	12.892	0.278	98	2 695	6
9.1	117	110	72	0.239	0.18428	0.00117	0.26065	0.00218	0.4910	0.0104	12.475	0.285	96	2 692	10
10.1	592	651	395	0.099	0.18450	0.00042	0.29819	0.00077	0.5214	0.0108	13.264	0.280	100	2 694	4
11.1	160	155	102	0.106	0.18473	0.00081	0.26742	0.00142	0.5064	0.0106	12.898	0.284	98	2 696	7
12.1	221	59	121	0.124	0.18448	0.00062	0.06612	0.00074	0.5047	0.0053	12.837	0.146	98	2 694	6
13.1	94	154	68	0.319	0.18794	0.00111	0.42512	0.00245	0.5144	0.0057	13.329	0.176	98	2 724	10
14.1	193	125	114	0.133	0.18294	0.00069	0.16079	0.00102	0.5071	0.0053	12.791	0.148	99	2 680	6
15.1	1 486	572	857	0.056	0.18637	0.00023	0.09936	0.00024	0.5205	0.0052	13.374	0.138	100	2 710	2
16.1	258	259	162	0.133	0.18476	0.00060	0.24657	0.00102	0.5078	0.0053	12.936	0.146	98	2 696	5
17.1	135	126	86	0.172	0.18428	0.00086	0.24401	0.00153	0.5121	0.0055	13.011	0.159	99	2 692	8
18.1	152	165	96	0.148	0.18574	0.00080	0.27848	0.00148	0.4990	0.0053	12.779	0.153	96	2 705	7
19.1	263	52	140	0.090	0.18343	0.00052	0.04540	0.00053	0.5018	0.0052	12.691	0.140	98	2 684	5
20.1	152	182	100	0.133	0.18417	0.00076	0.30047	0.00145	0.5151	0.0055	13.079	0.155	100	2 691	7
21.1	102	91	63	0.296	0.18256	0.00103	0.22587	0.00186	0.5065	0.0056	12.750	0.165	99	2 676	9

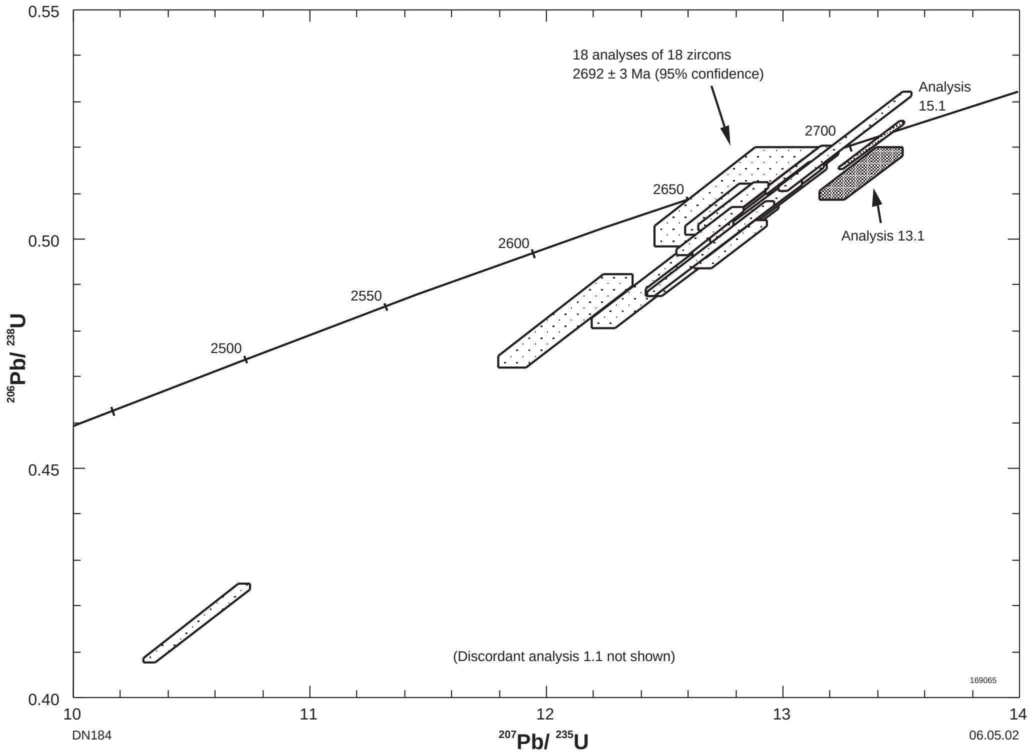

Figure 76. Concordia plot for sample 169065: biotite syenogranite, Woglin Soak

Results

Twenty-one analyses were obtained from 21 zircons. Results are given in Table 54 and shown on a concordia plot in Figure 76.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a single recent episode of radiogenic-Pb loss. Eighteen analyses of 18 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2692 ± 3 Ma (chi-squared = 1.10). Highly reversely discordant analysis 1.1, discordant analysis 13.1, and concordant analysis 15.1 indicate higher $^{207}Pb/^{206}Pb$ ratios than the main population.

The date of 2692 ± 3 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 18 analyses is interpreted as the age of igneous crystallization of the syenogranite. The higher $^{207}Pb/^{206}Pb$ ratios of analyses 1.1, 13.1 and 15.1 are interpreted to be of xenocryst zircons.

169066: quartz–feldspar porphyry, Yerilgee greenstone belt

Location and sampling

BARLEE (SH 50-8), LAKE GILES (2838) MGA Zone 50, 781650E 6690480N

Sampled on 25 October 2000.

The sample was taken from a 0.5 m-diameter submerged boulder located on the eastern side of a northwest-trending ridge on the western side of the Yerilgee greenstone belt, 10 km south of the Menzies–Evanston road.

Tectonic unit/relations

This sample is from a medium grey porphyry of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Greenfield, 2001). The porphyry contains rare quartz and feldspar phenocrysts up to 2 mm in diameter, and has intruded high-Mg basaltic rocks of the Yerilgee greenstone belt.

Petrographic description

The principal minerals present in this sample are feldspar (65–70 vol.%), quartz (20 vol.%), hornblende (10 vol.%), and titanite (3 vol.%). This is a quartz–feldspar porphyritic rock of andesitic or dacitic composition, with hornblende and titanite. There are large quartz grains, apparently phenocrysts, in this sample, as well as feldspar phenocrysts. In thin section, there are abundant sericite-clouded plagioclase phenocrysts, from 0.5 to 3 mm long, and relatively rare quartz phenocrysts, mostly less than 0.5 mm in diameter. One grain is 4 mm in diameter and rounded. However, there is little or no quartz in the groundmass, suggesting that these may be xenocrysts. Small clusters of green hornblende prisms are common and from 0.3 to 1.5 mm long, with microcrystalline opaque oxide in, and adjacent to, the amphibole patches. The groundmass has abundant clear or sericite-clouded plagioclase laths, to 0.3 mm long, in a microgranular, possibly albite-rich (or albitized) aggregate, with some microgranular to microgranophyric areas that may contain quartz. Microcrystalline titanite is disseminated. The very fine-grained nature of this interstitial material makes it difficult to determine the mineralogy, especially the quartz content. This sample has not been deformed, but the hornblende may have been recrystallized under amphibolite-facies conditions.

Zircon morphology

The zircons isolated from this sample are colourless, light pink, pinkish brown, dark brown and black, generally between 50 × 70 µm and 100 × 180 µm in size, and are equant to slightly elongate and rounded and rectangular in shape, or are irregular grain fragments. The majority of grains lack internal zonation, and many are fractured. Irregular dark inclusions are common. Many zircons are metamict.

Analytical details

This sample was analysed on 20, 23 and 27 October 2001. The counter deadtime during all three analysis sessions was 32 ns. During the first analysis session, three analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.00 (1σ%). Analyses 1.1 to 7.1 were obtained during the first analysis session. During the second analysis session,

Table 55. Ion microprobe analytical results for sample 169066: quartz–feldspar porphyry, Yerilgee greenstone belt

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	73	51	54	0.598	0.22686	0.00137	0.19246	0.00233	0.5955	0.0066	18.625	0.247	99	3 030	10
2.1	118	95	79	1.252	0.22593	0.00127	0.15627	0.00232	0.5395	0.0058	16.805	0.214	92	3 023	9
3.1	125	90	87	0.314	0.20432	0.00090	0.19301	0.00147	0.5703	0.0060	16.065	0.193	102	2 861	7
4.1	63	54	48	0.352	0.22643	0.00139	0.23084	0.00240	0.6065	0.0067	18.934	0.253	101	3 027	10
5.1	84	295	95	0.473	0.21906	0.00115	0.94885	0.00358	0.5959	0.0065	17.998	0.227	101	2 974	8
6.1	153	45	100	0.841	0.21805	0.00099	0.09332	0.00164	0.5633	0.0059	16.934	0.202	97	2 966	7
7.1	49	134	41	1.019	0.22089	0.00203	0.57381	0.00479	0.5265	0.0060	16.034	0.249	91	2 987	15
8.1	52	68	43	0.665	0.22630	0.00166	0.33974	0.00328	0.6081	0.0246	18.975	0.798	101	3 026	12
9.1	63	101	53	0.173	0.21913	0.00127	0.42565	0.00263	0.5886	0.0238	17.785	0.739	100	2 974	9
10.1	55	66	46	0.573	0.22572	0.00148	0.31102	0.00282	0.6177	0.0250	19.223	0.803	103	3 022	11
11.1	37	50	33	0.832	0.22848	0.00198	0.36860	0.00405	0.6384	0.0259	20.111	0.857	105	3 041	14
12.1	147	88	99	0.209	0.20492	0.00080	0.16257	0.00124	0.5687	0.0229	16.069	0.658	101	2 866	6
13.1	33	39	27	1.551	0.22316	0.00241	0.31280	0.00493	0.6076	0.0247	18.696	0.811	102	3 004	17
14.1	56	151	53	0.338	0.21913	0.00157	0.69828	0.00410	0.5732	0.0099	17.317	0.337	98	2 974	12
15.1	234	80	143	0.076	0.20666	0.00061	0.08950	0.00068	0.5486	0.0090	15.633	0.267	98	2 880	5
16.1	129	175	102	0.191	0.22554	0.00090	0.34633	0.00164	0.5795	0.0097	18.021	0.317	98	3 021	6
17.1	273	97	172	0.606	0.20504	0.00071	0.10483	0.00114	0.5486	0.0090	15.510	0.267	98	2 867	6
18.1	127	57	88	0.214	0.22041	0.00089	0.12207	0.00123	0.5961	0.0099	18.115	0.319	101	2 984	7
19.1	74	120	63	0.239	0.22460	0.00120	0.42826	0.00245	0.5884	0.0099	18.223	0.335	99	3 014	9
20.1	40	25	25	0.399	0.18748	0.00183	0.16046	0.00325	0.5191	0.0091	13.419	0.283	99	2 720	16
21.1	159	77	102	0.170	0.20746	0.00078	0.13251	0.00105	0.5511	0.0091	15.765	0.275	98	2 886	6
22.1	46	11	27	0.983	0.19075	0.00198	0.05579	0.00348	0.5263	0.0091	13.843	0.294	99	2 749	17
23.1	100	106	66	0.792	0.18749	0.00120	0.24725	0.00238	0.5211	0.0087	13.472	0.251	99	2 720	11
24.1	56	43	36	0.263	0.19097	0.00138	0.21060	0.00242	0.5285	0.0090	13.916	0.268	99	2 751	12
25.1	99	91	76	0.260	0.22818	0.00105	0.24662	0.00170	0.5974	0.0100	18.795	0.337	99	3 039	7

three analyses of the CZ3 standard indicated a Pb*/U calibration error of 4.01 (1σ%). Analyses 8.1 to 13.1 were obtained during the second analysis session. During the third analysis session, four analyses of the CZ3 standard indicated a Pb*/U calibration error of 1.63 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twenty-five analyses were obtained from 25 zircons. Results are given in Table 55 and shown on a concordia plot in Figure 77.

Interpretation

The analyses are concordant to slightly discordant, with the discordance pattern mainly consistent with a single, recent episode of radiogenic-Pb loss. On the basis of their $^{207}Pb/^{206}Pb$ ratios, most analyses may be assigned to one of four groups. Concordant analyses 20.1, 22.1, 23.1 and 24.1, assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2733 ± 27 Ma (chi-squared = 1.33). Concordant analyses 3.1, 12.1, 15.1 and 17.1, assigned to Group 2, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2870 ± 4 Ma (chi-squared = 1.60). Concordant analyses 5.1, 6.1, 9.1 and 18.1, and slightly discordant analysis 14.1, assigned to Group 3, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2975 ± 10 Ma (chi-squared = 0.62). Eleven concordant analyses of 11 zircons (1.1, 2.1, 4.1, 7.1, 8.1, 10.1, 11.1, 13.1, 16.1, 19.1 and 25.1), assigned to Group 4, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3024 ± 8 Ma (chi-squared = 1.46). Slightly discordant analysis 21.1 cannot be assigned to any of these groups.

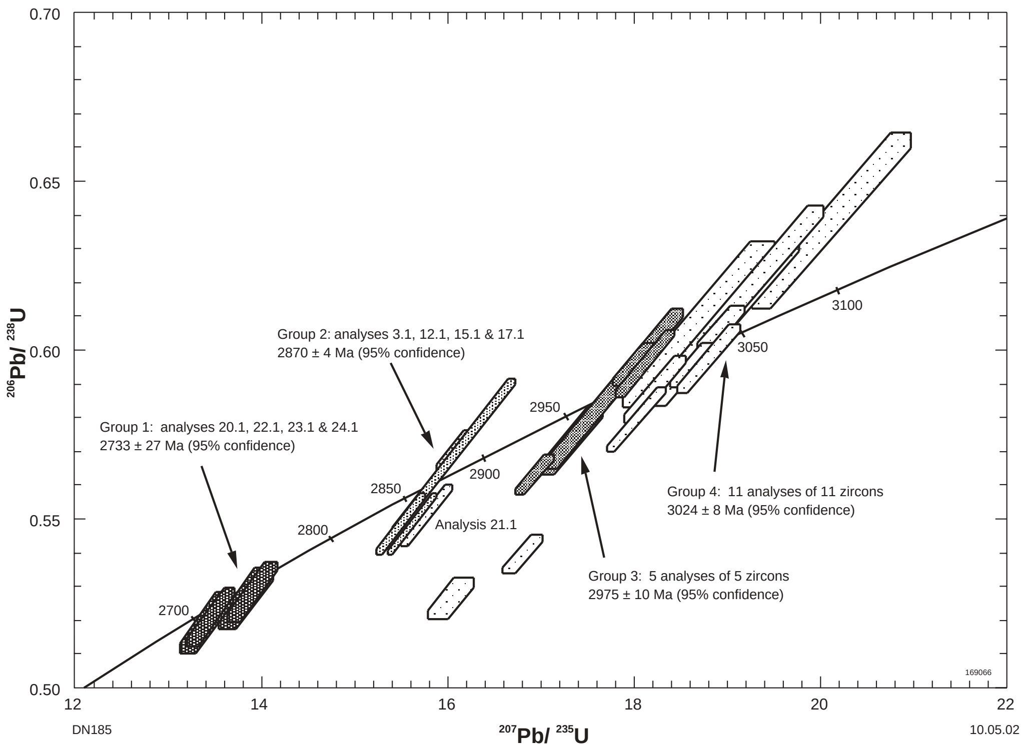

Figure 77. Concordia plot for sample 169066: quartz–feldspar porphyry, Yerilgee greenstone belt

Analysis 20.1 was obtained on a 100 µm-diameter, rounded, colourless and internally structureless grain fragment. Analyses 22.1, 23.1 and 24.1 were obtained on c. 50 µm-diameter rounded to irregular, internally structureless grains. The date of 2733 ± 27 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of concordant analyses 20.1, 22.1, 23.1 and 24.1 of Group 1 may be interpreted as the age of igneous crystallization of the quartz–feldspar porphyry. The remaining analyses indicating higher $^{207}Pb/^{206}Pb$ ratios may then be interpreted to be of xenocryst zircons. However, the date of 2733 ± 27 Ma was indicated by only four of the 25 analyses obtained and it is possible that these were also obtained on xenocrystic zircons. Therefore, a more conservative interpretation of these results is that the date of 2733 ± 27 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of concordant analyses of Group 1 provides a maximum age for igneous crystallization of the quartz–feldspar porphyry.

169067: quartz–chlorite schist, Pincher Well

Location and sampling

YOUANMI (SH 50-4), YOUANMI (2640) MGA Zone 50, 675230E 6821660N

Sampled on 25 October 2000.

The sample was taken from a small boulder in an area of low rocky foliated outcrops located about 2 km north of Pincher Hill and 1 km southwest of Pincher Well.

Tectonic unit/relations

This sample is from a dark grey to olive green, fine-grained, foliated homogeneous rock inferred to be derived from a felsic volcanic precursor, of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Stewart et al., 1983).

Petrographic description

The principal minerals present in this sample are chlorite (50 vol.%), quartz (45 vol.%), opaque oxide, and leucoxene (5 vol.%), with accessory apatite (trace). This is a massive, dark grey quartz–chlorite schist containing fresh opaque oxide, leucoxene, carbonate and rare apatite, probably derived from a mafic rather than andesitic precursor. It may have been derived from a sheared and altered quartz dolerite from a greenschist facies, chlorite-rich shear zone. In thin section, there are abundant, very irregular masses of quartz-rich material, to 1 mm in grain size, intergrown with chlorite in a heterogeneous matrix of quartz–chlorite schist. There is abundant fresh and leucoxene-altered opaque oxide to 0.3 mm in grain size, and the quartz resembles late magmatic quartz and altered granophyre inherited from a quartz dolerite. Grains and patches of carbonate and sericite occur locally and there is rare apatite in some of the quartz.

Zircon morphology

Very few zircons were recovered from this sample. The two largest zircons recovered are colourless to pale yellowish green, internally structureless, irregular-shaped fragments between 30 × 60 µm and 50 × 80 µm in size. A high proportion of colourless, internally structureless and irregular-shaped fragments, averaging 10 × 15 µm in size and too small to analyse, were also recovered.

Analytical details

This sample was analysed on 10 June and 8 July 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of 0.560 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the first analysis session. Analyses 1.1 to 2.5 were obtained during the first analysis session. During the second analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.06 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Results

Twelve analyses were obtained from two zircons. Results are given in Table 56 and shown on a concordia plot in Figure 78.

Table 56. Ion microprobe analytical results for sample 169067: quartz–chlorite schist, Pincher Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	48	22	29	1.321	0.19849	0.00285	0.12906	0.00541	0.5156	0.0074	14.112	0.303	95	2 814	23
2.1	55	30	37	1.076	0.20560	0.00245	0.15340	0.00454	0.5551	0.0076	15.736	0.303	99	2 871	19
2.2	90	62	59	0.778	0.20080	0.00179	0.18600	0.00328	0.5316	0.0065	14.718	0.235	97	2 833	15
1.2	94	57	61	0.487	0.19686	0.00157	0.16689	0.00267	0.5440	0.0067	14.766	0.229	100	2 800	13
2.3	78	47	50	0.835	0.19943	0.00208	0.16202	0.00386	0.5347	0.0069	14.703	0.258	98	2 822	17
1.3	96	61	65	1.019	0.19700	0.00182	0.16981	0.00339	0.5579	0.0069	15.154	0.248	102	2 801	15
2.4	56	29	35	0.722	0.20247	0.00227	0.14205	0.00386	0.5374	0.0073	15.002	0.280	97	2 846	18
2.5	71	42	47	0.909	0.19532	0.00216	0.15330	0.00395	0.5464	0.0070	14.716	0.265	101	2 788	18
1.4	48	23	31	1.255	0.19864	0.00285	0.12184	0.00528	0.5480	0.0077	15.010	0.321	100	2 815	23
1.5	97	62	63	0.898	0.19710	0.00178	0.16771	0.00319	0.5361	0.0066	14.568	0.235	99	2 802	15
1.6	120	90	79	0.516	0.19676	0.00150	0.20111	0.00269	0.5373	0.0065	14.577	0.220	99	2 800	12
2.6	82	52	53	0.398	0.20310	0.00185	0.17356	0.00315	0.5416	0.0068	15.166	0.250	98	2 851	15

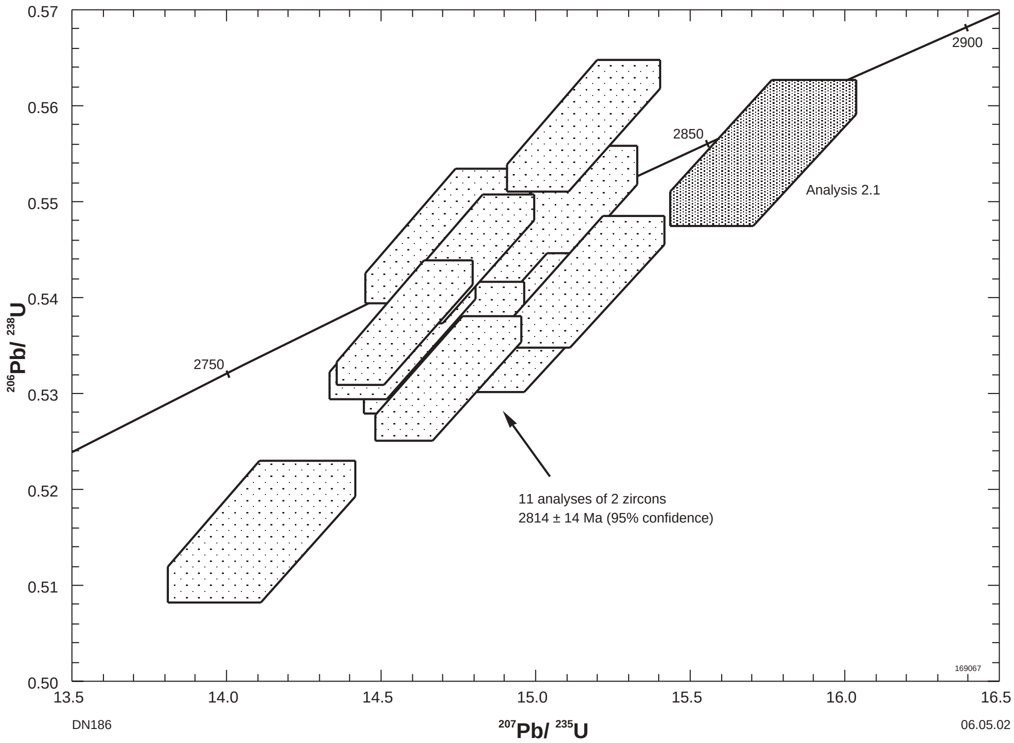

Figure 78. Concordia plot for sample 169067: quartz–chlorite schist, Pincher Well

Interpretation

The analyses are concordant to slightly discordant, with the discordance pattern consistent with a recent dominant episode of radiogenic-Pb loss. Eleven analyses of two zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2814 ± 14 Ma (chi-squared = 1.55). Concordant analysis 2.1 indicates a substantially older $^{207}Pb/^{206}Pb$ date than the main population.

The date of 2814 ± 14 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 11 analyses of two zircons is tentatively interpreted as the age of igneous crystallization of the andesitic precursor to the quartz–chlorite schist. Analysis 2.1, which indicates a slightly higher $^{207}Pb/^{206}Pb$ ratio than the main population, is interpreted to be of an analysis site that has gained some radiogenic Pb.

169068: granodiorite gneiss, Yuinmery Homestead

Location and sampling

YOUANMI (SH 50-4), RAYS ROCKS (2740) MGA Zone 50, 695710E 6837960N

Sampled on 26 October 2000.

The sample was taken from a 1 m-diameter, 40 cm-thick slab adjacent to the access road to, and 1.9 km west-southwest of, the Yuinmery Homestead.

Tectonic unit/relations

This sample is from a light- to medium-grey, medium- and even-grained, strongly foliated granodiorite of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Stewart et al., 1983). A vertical foliation strikes at 330°. The sample has epidotized zones and fractures.

Petrographic description

The principal minerals present in this sample are plagioclase (65 vol.%), quartz (25 vol.%), microcline (5–15 vol.%), biotite (4 vol.%), and opaque oxide (1 vol.%), with accessory allanite (trace), sericite (trace), epidote (trace), leucoxene (trace), apatite (trace), and zircon (trace). This is a mylonitic tonalite or granodiorite gneiss, with biotite, magnetite, titanite and epidote. There is a strong foliation in this weakly porphyritic or augen-bearing microgranite gneiss. In thin section, there are abundant augen of plagioclase from 0.5 to 3 mm in diameter, as well as rare microcline grains, separated from plagioclase by myrmekite. There is an S–C fabric defined by quartz-rich and micaceous foliae, with a monoclinic quartz fabric related to the almost mylonitic matrix. Lamellae of biotite, sericite, epidote, opaque oxides and leucoxene define the fabric, as do fine-grained recrystallized quartz in lenses parallel to the micaceous foliae. There is some microcrystalline K-feldspar in and between the quartz-rich lamellae, but its abundance in uncertain. Biotite, opaque oxide and epidote are disseminated, with limonite- and clay-altered ?allanite and rare apatite. This is an amphibolite-facies tonalite gneiss, although there may be enough microcrystalline K-feldspar to indicate a granodiorite gneiss.

Zircon morphology

The zircons isolated from this sample are yellowish brown, dark brown and black, generally between 30 × 60 µm and 50 × 180 µm in size, and are irregular, slightly elongate and euhedral in shape. Most grains have faint internal zonation and many are metamict.

Analytical details

This sample was analysed on 26 July 2001. The counter deadtime during the analysis session was 32 ns. Six analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 0.835 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 3.1, 4.1, 12.1, 16.1 and 18.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Table 57. Ion microprobe analytical results for sample 169068: granodiorite gneiss, Yuinmery Homestead

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	118	82	70	1.910	0.18416	0.00192	0.17587	0.00395	0.4754	0.0053	12.071	0.196	93	2 691	17
2.1	213	121	128	1.276	0.18547	0.00125	0.16344	0.00247	0.4952	0.0053	12.664	0.169	96	2 702	11
3.1	159	124	105	4.593	0.18409	0.00209	0.21071	0.00480	0.4834	0.0054	12.269	0.206	94	2 690	19
4.1	150	115	105	7.129	0.18678	0.00287	0.21482	0.00672	0.4760	0.0054	12.260	0.248	92	2 714	25
5.1	148	100	96	3.102	0.18530	0.00213	0.19650	0.00454	0.4975	0.0055	12.710	0.215	96	2 701	19
6.1	135	100	86	2.728	0.17871	0.00202	0.20273	0.00433	0.4926	0.0054	12.138	0.203	98	2 641	19
7.1	40	63	28	2.025	0.18768	0.00402	0.36862	0.00904	0.4993	0.0068	12.920	0.346	96	2 722	35
8.1	171	96	84	2.203	0.18447	0.00186	0.17009	0.00385	0.3912	0.0042	9.951	0.156	79	2 693	17
9.1	219	154	132	0.404	0.18483	0.00100	0.19440	0.00185	0.5001	0.0053	12.743	0.159	97	2 697	9
10.1	107	115	69	0.435	0.18659	0.00133	0.29730	0.00266	0.5012	0.0056	12.895	0.180	97	2 712	12
11.1	117	74	70	1.115	0.18678	0.00176	0.17532	0.00354	0.4916	0.0055	12.661	0.197	95	2 714	16
12.1	229	199	148	2.206	0.18071	0.00126	0.23326	0.00278	0.4982	0.0053	12.412	0.167	98	2 659	12
13.1	117	77	70	0.680	0.18677	0.00165	0.18758	0.00320	0.4981	0.0055	12.827	0.192	96	2 714	15
14.1	213	171	138	2.038	0.18316	0.00143	0.22727	0.00302	0.5028	0.0054	12.698	0.178	98	2 682	13
15.1	228	170	131	1.444	0.18382	0.00121	0.16796	0.00241	0.4730	0.0051	11.987	0.159	93	2 688	11
16.1	144	97	90	4.388	0.18198	0.00245	0.18376	0.00562	0.4712	0.0053	11.822	0.220	93	2 671	22
17.1	272	169	167	0.770	0.18781	0.00092	0.17066	0.00171	0.5134	0.0054	13.294	0.162	98	2 723	8
18.1	166	113	106	4.589	0.18165	0.00214	0.18053	0.00490	0.4784	0.0053	11.983	0.205	94	2 668	20

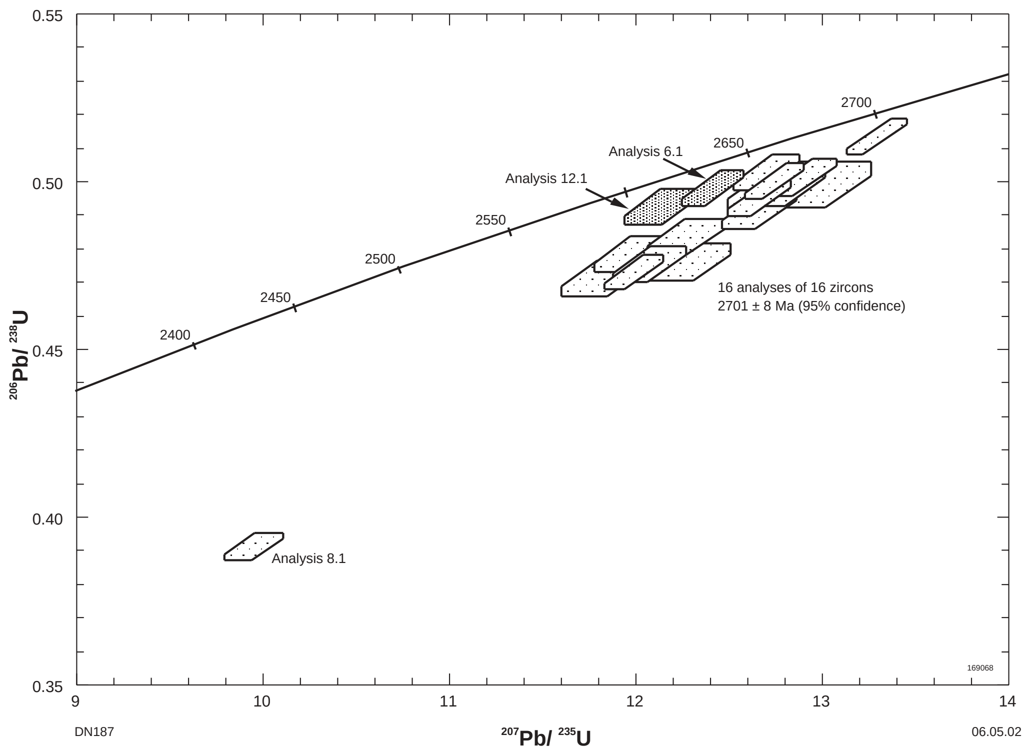

Figure 79. Concordia plot for sample 169068: granodiorite gneiss, Yuinmery Homestead

Results

Eighteen analyses were obtained from 18 zircons. Results are given in Table 57 and shown on a concordia plot in Figure 79.

Interpretation

The analyses are slightly to highly discordant, with the discordance pattern consistent with several episodes, including a dominant recent episode, of radiogenic-Pb redistribution. Sixteen analyses of 16 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population and indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2701 ± 8 Ma (chi-squared = 1.22). Discordant analyses 6.1 and 12.1 indicate slightly younger $^{207}Pb/^{206}Pb$ dates than the main population.

The date of 2701 ± 8 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 16 analyses is interpreted as the age of igneous crystallization of the tonalite or granodiorite precursor to the gneiss. The younger $^{207}Pb/^{206}Pb$ dates indicated by discordant analyses 6.1 and 12.1 are interpreted to be due to ancient loss of radiogenic Pb from these analysis sites.

169069: foliated biotite syenogranite, Bell Chambers Well

Location and sampling

YOUANMI (SH 50-4), ATLEY (2741) MGA Zone 50, 708100E 6888160N

Sampled on 27 October 2000.

The sample was taken from a 15 m-long, 1 m-high whaleback on the eastern side of a low hill located northwest of the Black Range and 1 km northwest of Bell Chambers Well (abandoned).

Tectonic unit/relations

This sample is from a medium- to dark-grey, strongly foliated, porphyritic syenogranite of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Chen, in prep.). The syenogranite contains abundant cubic feldspar phenocrysts up to 3 mm-diameter and rare, scattered larger (typically 2 cm-diameter) cubic feldspar phenocrysts. At the sampling locality, a foliation strikes at 25° and dips at 85° to the west, and may be related to movement along the Youanmi Fault. A mineral lineation plunges at 10° to the south. The syenogranite has rare, pink-altered fractures up to 2 mm thick with diffuse pinkish alteration and contains white pegmatite veins up to 10 cm thick, that are aligned parallel to the foliation. The sample taken was free of any obvious veins.

Petrographic description

The principal minerals present in this sample are microcline (50–55 vol.%), quartz (25–30 vol.%), plagioclase (10–15 vol.%), biotite (5 vol.%), titanite (1 vol.%), opaque oxide (≤1 vol.%), and apatite (≤1 vol.%), with a rare altered mineral, possibly allanite (trace), leucoxene (trace), and zircon (trace). This is an amphibolite-facies biotite syenogranite (augen) gneiss, with titanite and apatite. The gneiss has rounded to subhedral crystals of microcline 5 to 10 mm long. Plagioclase is less abundant as grains to 3 mm in diameter, locally veined by microcline. There is an anastomosing foliation defined by mostly fresh, fine-grained biotite, accompanied by granular opaque oxide and euhedral crystals of titanite to 1 mm long. Lamellae rich in quartz are also abundant, with the quartz c-axes mostly at a high angle to the overall trend of the foliation. Fine-grained microcline and less abundant plagioclase are also disseminated, along with rare altered ?allanite. Some of the titanite has been altered to leucoxene. Apatite occurs as grains from 0.05 to 0.4 mm long.

Zircon morphology

The zircons isolated from this sample are pale brown, dark brown and black, generally between 30 × 60 µm and 50 × 180 µm in size, and are elongate and euhedral in shape. Most grains have faint internal zonation. Cores and rims can be distinguished in many grains. Many grains are metamict.

Analytical details

This sample was analysed on 29 July 2001. The counter deadtime during the analysis session was 32 ns. Seven analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.40 (1σ%). Common-Pb corrections were

Table 58. Ion microprobe analytical results for sample 169069: foliated biotite syenogranite, Bell Chambers Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	323	104	176	0.352	0.17959	0.00077	0.08918	0.00113	0.4943	0.0071	12.240	0.190	98	2 649	7
2.1	199	274	134	2.245	0.18233	0.00167	0.41877	0.00400	0.4625	0.0068	11.626	0.213	92	2 674	15
3.1	253	377	181	2.245	0.17359	0.00141	0.42412	0.00341	0.4906	0.0071	11.743	0.206	99	2 593	14
4.1	141	168	83	1.006	0.17907	0.00163	0.26928	0.00334	0.4597	0.0069	11.350	0.209	92	2 644	15
5.1	146	134	88	0.325	0.17947	0.00126	0.25019	0.00236	0.4858	0.0072	12.021	0.207	96	2 648	12
6.1	195	144	98	1.607	0.17887	0.00186	0.23002	0.00386	0.3924	0.0058	9.678	0.184	81	2 642	17
7.1	154	188	98	0.723	0.17562	0.00139	0.33833	0.00296	0.4780	0.0071	11.575	0.204	96	2 612	13
8.1	130	75	69	1.251	0.18127	0.00175	0.14556	0.00335	0.4476	0.0067	11.186	0.210	89	2 664	16
9.1	121	163	80	0.210	0.18272	0.00128	0.35006	0.00262	0.4950	0.0075	12.471	0.217	97	2 678	12
10.1	303	405	167	3.008	0.17543	0.00175	0.40862	0.00422	0.3751	0.0054	9.074	0.168	79	2 610	17
11.1	156	183	106	4.343	0.17382	0.00261	0.44053	0.00642	0.4391	0.0066	10.524	0.238	90	2 595	25
12.1	238	109	134	0.908	0.18095	0.00119	0.12644	0.00219	0.4849	0.0071	12.098	0.202	96	2 662	11
13.1	275	177	140	9.734	0.18466	0.00371	0.39442	0.00901	0.2953	0.0044	7.519	0.199	62	2 695	33
14.1	169	17	89	0.325	0.18233	0.00116	0.02338	0.00154	0.5005	0.0074	12.584	0.212	98	2 674	11
15.1	201	44	107	0.635	0.18334	0.00115	0.05260	0.00186	0.4908	0.0072	12.406	0.206	96	2 683	10
16.1	72	48	42	0.465	0.18140	0.00179	0.17895	0.00317	0.4891	0.0077	12.234	0.240	96	2 666	16
17.1	268	85	147	0.808	0.18306	0.00105	0.02925	0.00174	0.5106	0.0074	12.889	0.209	99	2 681	9
18.1	187	210	121	0.246	0.18247	0.00108	0.30240	0.00209	0.5040	0.0074	12.679	0.210	98	2 675	10
19.1	149	88	87	0.343	0.18319	0.00126	0.16819	0.00214	0.4953	0.0074	12.511	0.215	97	2 682	11
20.1	98	143	62	0.269	0.18229	0.00152	0.41667	0.00339	0.4566	0.0070	11.478	0.211	91	2 674	14

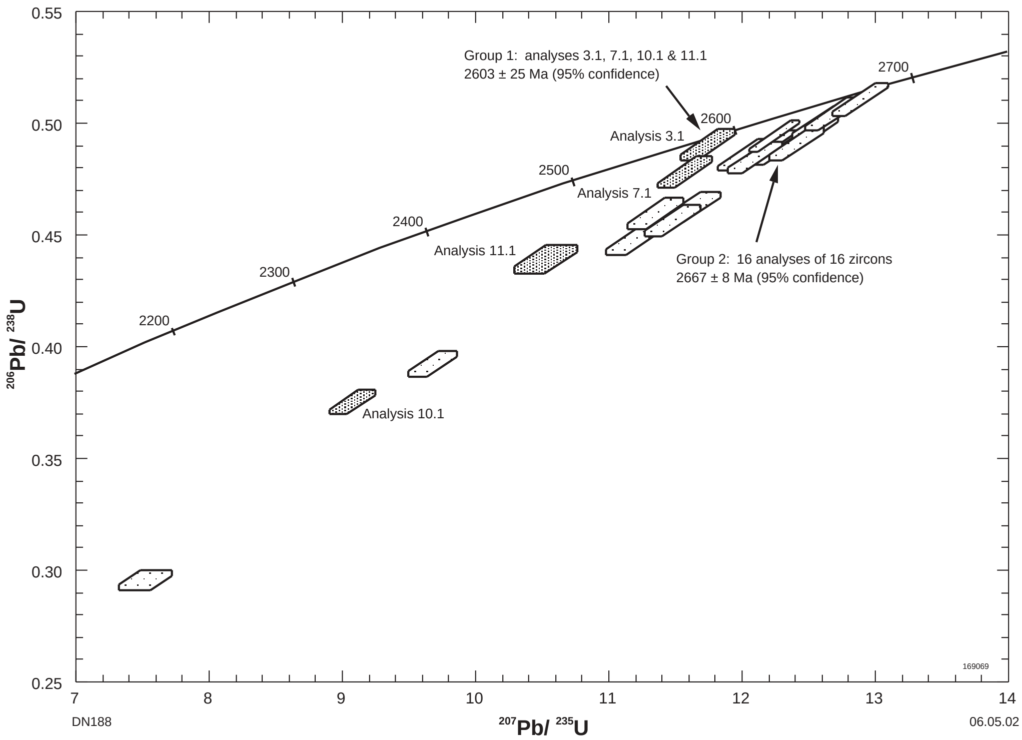

Figure 80. Concordia plot for sample 169069: foliated biotite syenogranite, Bell Chambers Well

applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 2.1, 3.1, 10.1, 11.1 and 13.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty analyses were obtained from 20 zircons. Results are given in Table 58 and shown on a concordia plot in Figure 80.

Interpretation

The analyses are slightly to highly discordant, with the discordance pattern consistent with several episodes of radiogenic-Pb loss, including a dominant recent episode. On the basis of their $^{207}Pb/^{206}Pb$ ratios, all analyses may be assigned to one of two groups. Sixteen analyses of 16 zircons, assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2667 ± 8 Ma (chi-squared = 1.42). Concordant analysis 3.1 and discordant analyses 7.1, 10.1 and 11.1, assigned to Group 2, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2603 ± 25 Ma (chi-squared = 0.35).

The analyses of Group 1 were obtained on small (≤ 25 × 40 µm), euhedral and structureless grains that are morphologically similar to many of those of Group 2. The date of 2667 ± 8 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of the 16 analyses of Group 2 is interpreted as the age of igneous crystallization of the syenogranite. The younger $^{207}Pb/^{206}Pb$ date indicated by concordant analysis 3.1 and discordant analyses 7.1, 10.1 and 11.1 of Group 1, is interpreted to be due to either the possible presence of a pegmatite vein in the sample processed, or to episodic ancient loss of radiogenic Pb from these analysis sites.

169070: foliated biotite granodiorite, Coomb Bore

Location and sampling

YOUANMI (SH 50-4), EVERETT CREEK (2841) MGA Zone 50, 746410E 6893600N

Sampled on 27 October 2000.

The sample was taken from a 2 m-long, 1 m-high boulder at the base, and on the southeastern side, of a prominent rocky hill, 400 m north of the Black Hill road and 1 km east of Coomb Bore.

Tectonic unit/relations

This sample of the Coomb Bore Monzogranite is from a light pinkish grey, medium- and even-grained to porphyritic, foliated biotite granodiorite of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Riganti, in prep.). The granodiorite contains rare lenses and fractures, aligned with the foliation, that are filled with milky quartz. At the sampling locality, the foliation strikes at 155° and dips vertically. The sampling site lies within the Edale Shear Zone. Near the sampling site, the granodiorite contains irregular-shaped feldspar phenocrysts up to 1 cm in diameter. The sample taken was free of any obvious veins.

Petrographic description

The principal minerals present in this sample are plagioclase (45–50 vol.%), quartz (25–30 vol.%), microcline (20 vol.%), biotite (5 vol.%), opaque oxide (1 vol.%), epidote (<1 vol.%), and titanite (<1 vol.%), with accessory apatite (trace), zircon (trace), and allanite (trace). This is an augen gneiss of biotite granodiorite composition, with plagioclase and microcline as augen to 5 mm in diameter in a recrystallized, quartzofeldspathic matrix. There is an anastomosing foliation paralleled by lamellae of fine-grained, recrystallized quartz in which the quartz c-axes are mainly at a low angle to the foliation. The foliation is defined by mostly fine-grained, fresh or chloritized biotite with opaque oxide, epidote and rare titanite. Grains of apatite and lenses of recrystallized feldspar also occur in the foliation planes with the quartz-rich lamellae. This is a strongly foliated granodiorite, metamorphosed in the amphibolite facies.

Zircon morphology

The zircons isolated from this sample are pale brown, dark brown and black, generally between 30 × 60 µm and 100 × 280 µm in size, and are elongate and euhedral in shape. Most grains have faint internal zonation, and cores and rims can be distinguished in many grains. The polished surfaces of many grains have dark irregular-shaped inclusions. Many are metamict.

Analytical details

This sample was analysed on 30 August 2001. The counter deadtime during the analysis session was 32 ns. Eight analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 0.708 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the analysis session. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses.

Table 59. Ion microprobe analytical results for sample 169070: foliated biotite granodiorite, Coomb Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	189	168	116	0.868	0.18519	0.00090	0.22344	0.00175	0.4957	0.0052	12.657	0.153	96	2 700	8
2.1	169	229	115	0.309	0.18460	0.00079	0.34694	0.00162	0.5106	0.0054	12.996	0.155	99	2 695	7
3.1	184	146	111	0.336	0.18493	0.00077	0.19346	0.00128	0.5049	0.0053	12.875	0.152	98	2 698	7
4.1	304	169	179	0.092	0.18398	0.00051	0.14664	0.00068	0.5128	0.0053	13.009	0.144	99	2 689	5
5.1	246	154	146	0.398	0.18382	0.00068	0.16407	0.00113	0.5070	0.0053	12.850	0.147	98	2 688	6
6.1	141	90	83	0.476	0.18428	0.00094	0.16437	0.00163	0.5006	0.0054	12.719	0.158	97	2 692	8
7.1	274	54	148	0.070	0.18436	0.00055	0.04195	0.00049	0.5103	0.0053	12.970	0.145	99	2 692	5
8.1	126	74	56	1.516	0.18254	0.00150	0.13356	0.00295	0.3697	0.0040	9.305	0.133	76	2 676	14
9.1	795	467	414	0.083	0.17791	0.00032	0.14703	0.00043	0.4557	0.0046	11.179	0.117	92	2 634	3
10.1	75	57	46	0.272	0.18399	0.00119	0.19777	0.00206	0.5135	0.0058	13.026	0.178	99	2 689	11
11.1	128	110	80	0.210	0.18351	0.00086	0.21172	0.00144	0.5168	0.0056	13.077	0.160	100	2 685	8
12.1	221	204	138	0.087	0.18476	0.00060	0.21996	0.00096	0.5137	0.0054	13.088	0.148	99	2 696	5
13.1	295	153	171	0.181	0.18381	0.00056	0.13271	0.00080	0.5093	0.0053	12.907	0.144	99	2 688	5
14.1	118	76	70	0.216	0.18294	0.00089	0.15424	0.00136	0.5126	0.0056	12.929	0.161	100	2 680	8
15.1	146	106	88	0.143	0.18528	0.00077	0.18137	0.00116	0.5107	0.0054	13.048	0.155	98	2 701	7
16.1	190	188	123	0.122	0.18426	0.00066	0.24842	0.00113	0.5199	0.0055	13.210	0.153	100	2 692	6
17.1	250	125	146	0.040	0.18413	0.00055	0.12329	0.00066	0.5189	0.0054	13.174	0.147	100	2 690	5
18.1	135	115	82	0.108	0.18326	0.00079	0.20733	0.00125	0.5077	0.0054	12.827	0.154	99	2 683	7

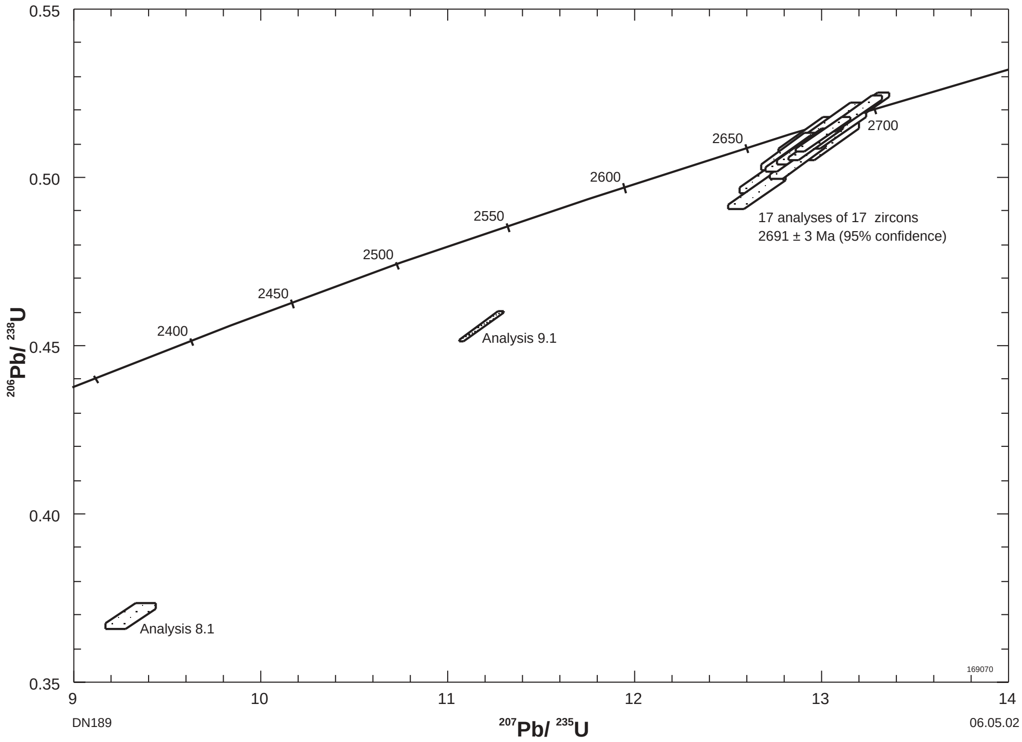

Figure 81. Concordia plot for sample 169070: foliated biotite granodiorite, Coomb Bore

Results

Eighteen analyses were obtained from 18 zircons. Results are given in Table 59 and shown on a concordia plot in Figure 81.

Interpretation

Apart from analyses 8.1 and 9.1, the analyses are concordant to slightly discordant, with the discordance pattern consistent with several episodes of radiogenic-Pb redistribution, including a dominant recent episode. Seventeen analyses of 17 zircons have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2691 ± 3 Ma (chi-squared = 0.69). Discordant analysis 9.1 indicates a significantly lower $^{207}Pb/^{206}Pb$ ratio than the main population.

The date of 2691 ± 3 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 17 concordant to slightly discordant analyses is interpreted as the age of igneous crystallization of the granodiorite. The younger $^{207}Pb/^{206}Pb$ date indicated by discordant analysis 9.1 is interpreted to be due to ancient loss of radiogenic Pb from this analysis site.

169071: porphyritic biotite monzogranite, Satan Well

Location and sampling

YOUANMI (SH 50-4), EVERETT CREEK (2841) MGA Zone 50, 768690E 6880050N

Sampled on 28 October 2000.

The sample was taken from the edge of a 1 m-high pavement on the eastern side of an area of prominent boulders and tors up to 5 m high, located 1 km southwest of Satan Well.

Tectonic unit/relations

This sample is from a light grey, coarse- and even-grained to porphyritic, foliated biotite monzogranite of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Riganti, in prep.). The monzogranite contains rare scattered cubic to tabular feldspar phenocrysts up to 4 cm long. A weak, steeply dipping foliation, which trends at 180°, is defined mainly by the alignment of biotite.

Petrographic description

The principal minerals present in this sample are microcline (35–40 vol.%), quartz (30 vol.%), plagioclase (25 vol.%), biotite (5 vol.%), magnetite (1–2 vol.%), and apatite (<1 vol.%), with accessory allanite (trace), and zircon (trace). This is a relatively coarse-grained, inequigranular to porphyritic, foliated biotite monzogranite with opaque oxide, apatite and zircon. The largest microcline grain is 12 mm long and the largest plagioclase is 8 × 6 mm. Inclusions of biotite, plagioclase, and quartz occur in the microcline, with quartz and biotite in the plagioclase, as well as patches of microcline possibly formed by replacement or exsolution. Irregular weak alteration to sericite occurs in the plagioclase, with some grains exhibiting zoning. Quartz also reaches 8 mm in grain size but is anhedral and interstitial to the feldspar grains. The foliation is defined by fresh or chloritized biotite to 1 mm in grain size, although there is some biotite oriented at about 90° to the foliation. Magnetite is abundant as grains and aggregates 0.5 to 1.5 mm in diameter, with apatite and altered allanite in and adjacent to the magnetite. Amphibolite facies metamorphism and later low temperature alteration are evident.

Zircon morphology

The zircons isolated from this sample are pale brown, dark brown and black, generally between 30 × 60 µm and 100 × 280 µm in size, and are elongate and euhedral in shape. Most grains have faint internal zonation and fractured cores and rims can be distinguished in many grains. The polished surfaces of many grains have dark irregular-shaped inclusions, and some have a mottled appearance. Many are metamict.

Analytical details

This sample was analysed on 7 August 2001. The counter deadtime during the analysis session was 32 ns. Seven analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.11 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with

Table 60. Ion microprobe analytical results for sample 169071: porphyritic biotite monzogranite, Satan Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	*$^{207}Pb/^{206}Pb$*	*±1 σ*	*$^{208}Pb/^{206}Pb$*	*±1 σ*	*$^{206}Pb/^{238}U$*	*±1 σ*	*$^{207}Pb/^{235}U$*	*±1 σ*	*% concordance*	*$^{207}Pb/^{206}Pb$ age*	*±1 σ*
1.1	245	290	175	1.198	0.21226	0.00101	0.38483	0.00223	0.5039	0.0058	14.747	0.192	90	2 923	8
2.1	68	88	45	0.153	0.18200	0.00146	0.36102	0.00305	0.5012	0.0062	12.576	0.196	98	2 671	13
3.1	1 091	877	547	0.178	0.16031	0.00034	0.21992	0.00060	0.4195	0.0047	9.271	0.108	92	2 459	4
4.1	241	379	166	0.369	0.18110	0.00079	0.39692	0.00173	0.4997	0.0057	12.479	0.160	98	2 663	7
5.1	585	238	321	0.616	0.17704	0.00056	0.13460	0.00102	0.4769	0.0054	11.641	0.141	96	2 625	5
6.1	1 239	505	539	0.211	0.15081	0.00031	0.11790	0.00048	0.3960	0.0044	8.234	0.096	91	2 355	4
7.1	114	98	69	0.417	0.18095	0.00117	0.22794	0.00217	0.4933	0.0059	12.308	0.175	97	2 662	11
8.1	2 100	2 551	951	0.248	0.14684	0.00027	0.33715	0.00060	0.3517	0.0039	7.122	0.082	84	2 309	3
9.1	75	94	53	1.336	0.18310	0.00199	0.48858	0.00469	0.4789	0.0059	12.089	0.211	94	2 681	18
10.1	1 221	510	494	0.204	0.15115	0.00034	0.12340	0.00053	0.3664	0.0041	7.636	0.089	85	2 359	4
11.1	103	143	75	1.455	0.18030	0.00178	0.51546	0.00426	0.4806	0.0058	11.948	0.197	95	2 656	16
12.1	277	388	191	0.861	0.18453	0.00091	0.39731	0.00210	0.4962	0.0057	12.626	0.165	96	2 694	8
13.1	96	137	67	0.714	0.18064	0.00169	0.38214	0.00370	0.5103	0.0063	12.710	0.208	100	2 659	15
14.1	1 264	933	1 397	-0.045	0.18806	0.00123	0.18618	0.00185	0.9355	0.0180	24.259	0.510	156	2 725	11
15.1	16	10	8	0.025	0.18812	0.00154	0.18570	0.00303	0.3913	0.0046	10.149	0.153	78	2 726	13
16.1	195	390	142	0.308	0.18153	0.00088	0.54777	0.00223	0.4852	0.0056	12.144	0.159	96	2 667	8
17.1	511	336	304	0.092	0.18197	0.00048	0.17715	0.00070	0.5067	0.0057	12.714	0.151	99	2 671	4
18.1	82	174	56	0.710	0.17955	0.00160	0.50444	0.00387	0.4580	0.0056	11.339	0.181	92	2 649	15
19.1	177	149	98	0.561	0.18251	0.00107	0.27088	0.00211	0.4357	0.0051	10.963	0.150	87	2 676	10

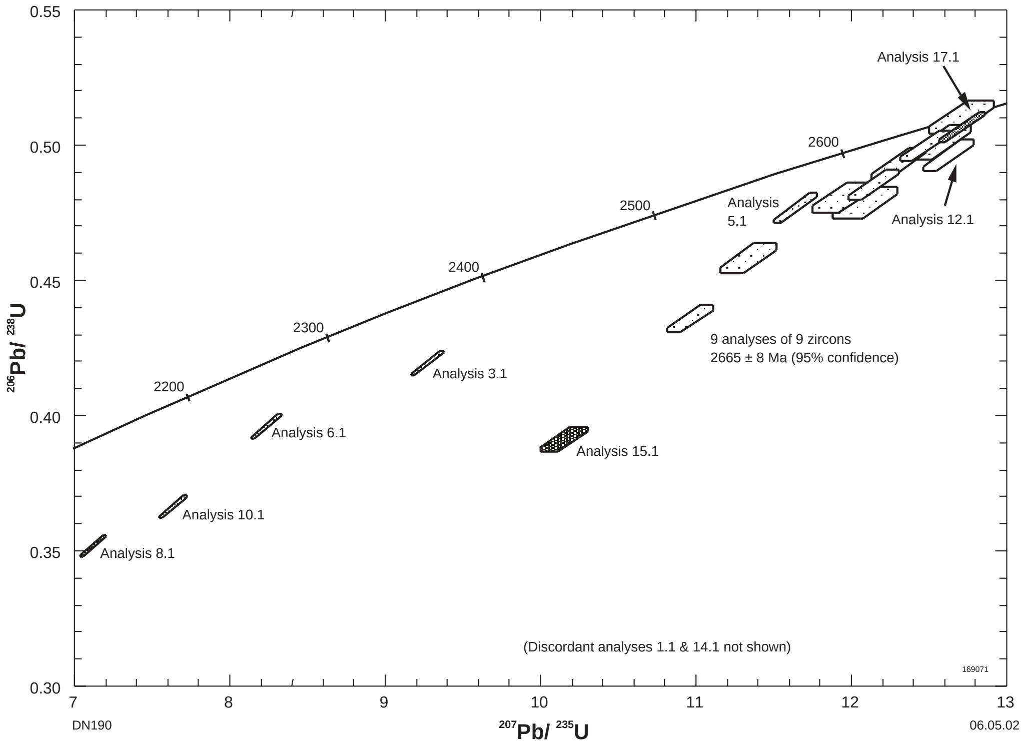

Figure 82. Concordia plot for sample 169071: porphyritic biotite monzogranite, Satan Well

the exception of analyses 1.1, 5.1, 6.1, 8.1 and 12.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Nineteen analyses were obtained from 19 zircons. Results are given in Table 60 and shown on a concordia plot in Figure 82.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with both an ancient and a recent episode of radiogenic-Pb redistribution. Nine concordant to slightly discordant analyses of nine zircons (2.1, 4.1, 7.1, 9.1, 11.1, 13.1, 16.1, 18.1 and 19.1) have ^{207}Pb/^{206}Pb ratios defining a single population and indicating a weighted mean ^{207}Pb/^{206}Pb date of 2665 ± 8 Ma (chi-squared = 0.48). Discordant analyses 3.1, 5.1, 6.1, 8.1 and 10.1 indicate significantly lower ^{207}Pb/^{206}Pb ratios, whereas analyses 1.1, 12.1, 14.1, 15.1 and 17.1 indicate significantly higher ^{207}Pb/^{206}Pb ratios, than the main population.

The date of 2665 ± 8 Ma indicated by the weighted mean ^{207}Pb/^{206}Pb ratio of nine concordant or slightly discordant analyses is interpreted as the age of igneous crystallization of the monzogranite. The younger ^{207}Pb/^{206}Pb dates indicated by discordant analyses 3.1, 5.1, 6.1, 8.12 and 10.1 are interpreted to be due to ancient loss of radiogenic Pb from these analysis sites, whereas the significantly older ^{207}Pb/^{206}Pb dates of analyses 1.1, 12.1, 14.1, 15.1 and 17.1 are interpreted to be of xenocryst zircons.

169074: quartzite, Kohler Bore

Location and sampling

YOUANMI (SH 50-4), EVERETT CREEK (2841) MGA Zone 50, 777080E 6845000N

Sampled on 28 October 2000.

The sample was taken from a 1 m-long, 0.2 × 0.3 m block located on the top of a southeast-trending ridge, and 2.5 km west-southwest of Kohler Bore.

Tectonic unit/relations

This sample is from a light pinkish grey, coarse-grained, massive, recrystallized quartzite of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Riganti, in prep.). The quartzite contains clear, rounded and interlocking grains of quartz and forms massive blocks with surfaces that are strongly lineated, suggesting strong deformation. The sample taken was free of any obvious veins and dykes.

Petrographic description

The principal mineral present in this sample is quartz (99 vol.%), with accessory biotite (trace), muscovite (trace), kaolin (trace), limonite (trace), and rare zircon (trace). This is a pale pinkish grey quartzite with exaggerated grain growth, containing accessory kaolin–limonite altered biotite and rare fine-grained muscovite. It has interlocking irregular quartz grains, to 4 mm long, formed by exaggerated grain growth. Kaolin and limonite have replaced minor schistose biotite to 1 mm in grain size and rare small fresh biotite flakes occur to 0.1 mm long.

Zircon morphology

The zircons isolated from this sample are colourless to pale yellowish brown, dark brown and black, generally between 30 × 60 µm and 100 × 280 µm in size, and are slightly elongate and anhedral to rounded in shape. Most grains are internally structureless or have faint internal zonation. Many grains have sculpted and pitted surfaces, consistent with detrital transport. Many grains have irregular zones or patches of yellowish brown discolouration and many are metamict. Fluid and mineral inclusions are common.

Analytical details

This sample was analysed on 19 November 2001. The counter deadtime during the analysis session was 32 ns. Twelve analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 2.17 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 18.1, 19.1, 21.1 and 23.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Twenty-five analyses were obtained from 23 zircons. Results are given in Table 61 and shown on concordia and Gaussian-summation probability density plots in Figures 83 and 84.

Table 61. Ion microprobe analytical results for sample 169074: quartzite, Kohler Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	21	20	17	0.410	0.29843	0.00354	0.22272	0.00607	0.6036	0.0147	24.838	0.705	88	3 462	18
2.1	473	85	345	0.169	0.26388	0.00053	0.05683	0.00055	0.6380	0.0139	23.211	0.515	97	3 270	3
3.1	115	85	104	0.114	0.30708	0.00113	0.19771	0.00133	0.6934	0.0154	29.360	0.675	97	3 506	6
4.1	150	144	115	0.218	0.27107	0.00103	0.20647	0.00144	0.5997	0.0133	22.413	0.514	91	3 312	6
5.1	295	256	208	0.195	0.26477	0.00075	0.23477	0.00107	0.5423	0.0119	19.799	0.444	85	3 275	4
6.1	73	109	80	0.401	0.32137	0.00162	0.36805	0.00263	0.7406	0.0169	32.816	0.785	100	3 576	8
7.1	97	65	81	0.147	0.28896	0.00127	0.18069	0.00170	0.6578	0.0147	26.209	0.610	96	3 412	7
8.1	170	173	115	0.082	0.27755	0.00095	0.15476	0.00114	0.5456	0.0120	20.880	0.474	84	3 349	5
9.1	210	125	177	0.211	0.28100	0.00084	0.15801	0.00105	0.6791	0.0150	26.310	0.595	99	3 369	5
10.1	647	1 286	631	0.073	0.26831	0.00047	0.52018	0.00093	0.6307	0.0138	23.333	0.517	96	3 296	3
11.1	145	281	154	0.241	0.30054	0.00106	0.51029	0.00199	0.6743	0.0150	27.943	0.640	96	3 473	5
12.1	198	307	187	0.287	0.28168	0.00088	0.40648	0.00155	0.6457	0.0142	25.076	0.568	95	3 372	5
13.1	53	20	43	0.716	0.29907	0.00199	0.03264	0.00273	0.6993	0.0160	28.835	0.711	99	3 465	10
14.1	209	298	206	0.133	0.30007	0.00086	0.37505	0.00136	0.6796	0.0150	28.116	0.635	96	3 471	4
15.1	95	64	79	0.313	0.27150	0.00131	0.18069	0.00187	0.6598	0.0148	24.698	0.580	99	3 315	8
16.1	142	97	139	0.228	0.35220	0.00115	0.17903	0.00128	0.7356	0.0163	35.723	0.817	96	3 717	5
17.1	146	210	131	0.201	0.29967	0.00124	0.47316	0.00223	0.5823	0.0130	24.059	0.557	85	3 468	6
18.1	355	698	110	1.671	0.27741	0.00139	0.24919	0.00267	0.2255	0.0049	8.625	0.199	39	3 348	8
19.1	750	955	614	0.413	0.24164	0.00044	0.28035	0.00076	0.6172	0.0135	20.562	0.455	99	3 131	3
20.1	628	270	392	0.187	0.24259	0.00047	0.12822	0.00057	0.5262	0.0115	17.600	0.390	87	3 137	3
21.1	246	178	150	1.692	0.27089	0.00122	0.23890	0.00235	0.4485	0.0099	16.751	0.385	72	3 311	7
22.1	238	311	110	1.202	0.26980	0.00140	0.27231	0.00257	0.3368	0.0074	12.530	0.291	57	3 305	8
23.1	534	354	547	0.353	0.22947	0.00042	0.12620	0.00060	0.8683	0.0190	27.473	0.609	132	3 048	3
20.2	415	155	256	0.206	0.23649	0.00042	0.11428	0.00052	0.5271	0.0115	17.187	0.380	88	3 096	3
19.2	379	260	303	0.132	0.25681	0.00042	0.17727	0.00052	0.6458	0.0141	22.868	0.505	100	3 227	3

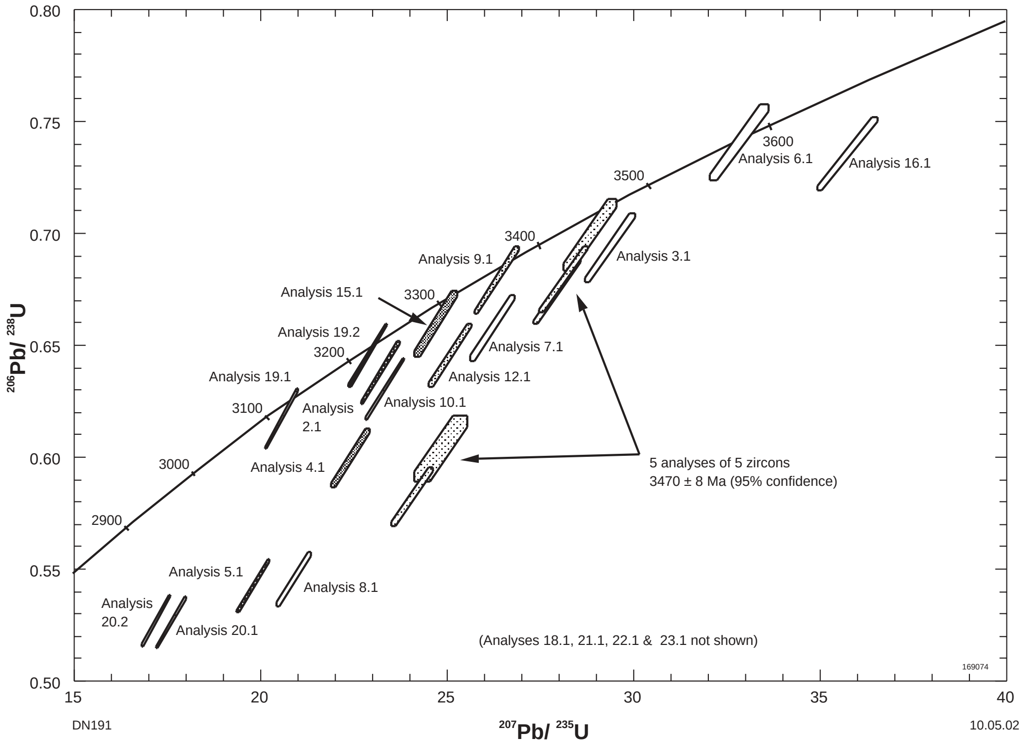

Figure 83. Concordia plot for sample 169074: quartzite, Kohler Bore

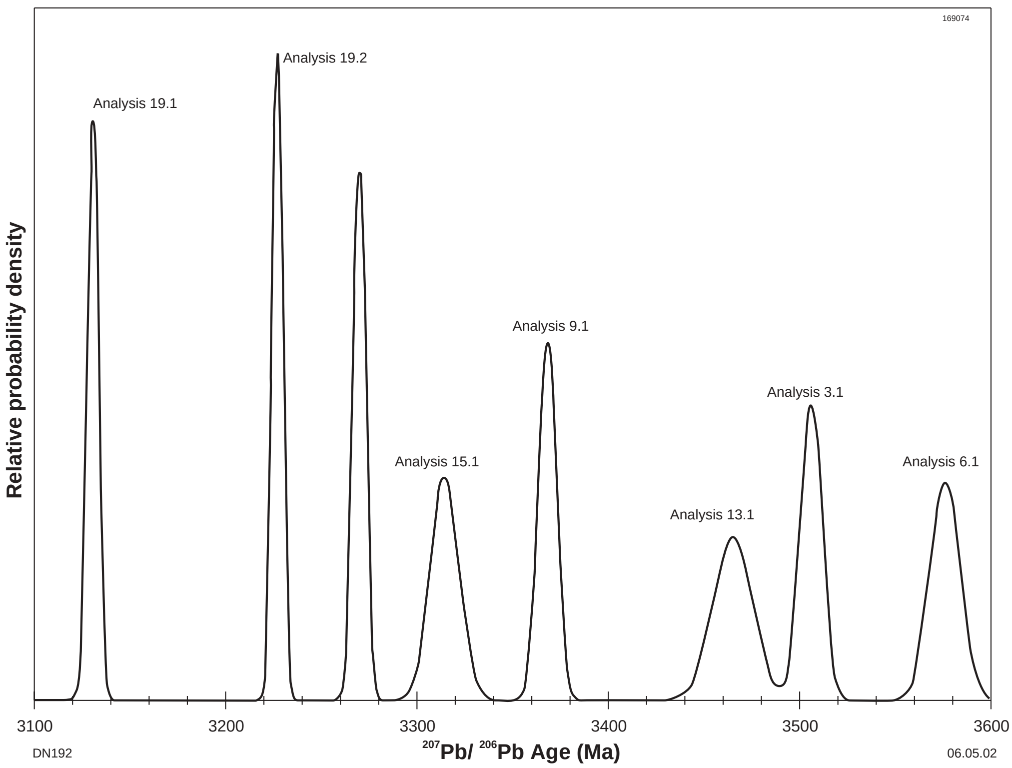

Figure 84. Gaussian-summation probability density plot for sample 169074: quartzite, Kohler Bore

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a dominant recent episode of radiogenic-Pb loss. Five concordant to slightly discordant analyses of five zircons (1.1, 11.1, 13.1, 14.1 and 17.1) have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 3470 ± 8 Ma (chi-squared = 0.17). The remaining analyses cannot be confidently grouped.

Grain 19 is an irregular, fractured grain fragment with rounded grain terminations that have intensively pitted surfaces, consistent with a detrital origin. Analysis 19.1 indicates the youngest concordant $^{207}Pb/^{206}Pb$ date of 3131 ± 3 Ma (1σ error). Analysis 19.2, from the same grain, indicates a concordant but significantly older $^{207}Pb/^{206}Pb$ date of 3227 ± 3 Ma (1σ error). The disparity in the $^{207}Pb/^{206}Pb$ dates obtained from grain 19 implies that zones within this grain may consist of an older core or may have undergone ancient radiogenic-Pb loss. The $^{207}Pb/^{206}Pb$ date of 3131 ± 3 Ma (1σ error) indicated by concordant analysis 19.1 is therefore tentatively interpreted as a maximum age for deposition of the sedimentary precursor to the quartzite. The remaining analyses are also interpreted to have been obtained from detrital zircons. Source rocks within the western part of Australia having ages similar to those of the zircons within this sample include the Narryer Gneiss Complex (Nelson, 1996, 1997, 1999) and the Pilbara Craton (Nelson, 1998, 1999, 2000, 2001b).

169075: quartzite, Kohler Bore

Location and sampling

YOUANMI (SH 50-4), EVERETT CREEK (2841) MGA Zone 50, 777070E 6845090N

Sampled on 28 October 2000.

The sample was taken from a 0.5 m-diameter block located on the top of a southeast-trending ridge, and 2.5 km west-southwest of Kohler Bore.

Tectonic unit/relations

This sample is from a pale pinkish grey, coarse-grained, massive recrystallized quartzite with thin (<1 mm thick) red-yellow clay-rich layers (Riganti, in prep.). The quartzite forms massive blocks with surfaces that are strongly lineated, suggesting strong deformation. The sample taken was free of any obvious veins and dykes.

Petrographic description

The principal minerals present in this sample are quartz (98–99 vol.%) and biotite (1–2 vol.%). This is a pale pinkish grey quartzite with limonite- and kaolin-altered schistose biotite and exaggerated grain growth. It has interlocking quartz grains, to 2.5 mm long, with undulose extinction and subgrains. Lamellae of limonitized, ?kaolinized foliated biotite are scattered and connected by limonite-lined fractures parallel to the foliation.

Zircon morphology

The zircons isolated from this sample are pale yellowish brown, dark brown and black, generally between 30 × 60 μm and 100 × 280 μm in size, and are slightly elongate and anhedral to rounded and irregular in shape. Most grains are internally structureless or have faint internal zonation. Many grains have irregular zones or patches of yellow discolouration. Fluid and mineral inclusions are common. Many grains are metamict. Many grains have sculpted or irregular surfaces and have pitted terminations, consistent with detrital transport.

Analytical details

This sample was analysed on 29 October, and 13 and 29 November 2001. The counter deadtime during all analysis sessions was 32 ns. During the first analysis session, four analyses of the CZ3 standard indicated a Pb^*/U calibration error of 0.360 (1σ%). Analyses 1.1 to 14.1 were obtained during the first analysis session. During the second analysis session, six analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.30 (1σ%). Analyses 15.1 to 32.1 were obtained during the second analysis session. During the third analysis session, six analyses of the CZ3 standard indicated a Pb^*/U calibration error of 0.868 (1σ%). A calibration error of 1.0 (1σ%) was applied to analyses of unknowns obtained during the first and third analysis sessions. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 6.1, 7.1, 24.1 and 10.9 for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Table 62. Ion microprobe analytical results for sample 169075: quartzite, Kohler Bore

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	$\pm 1\sigma$	$^{208}Pb/^{206}Pb$	$\pm 1\sigma$	$^{206}Pb/^{238}U$	$\pm 1\sigma$	$^{207}Pb/^{235}U$	$\pm 1\sigma$	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	$\pm 1\sigma$
1.1	552	263	457	0.165	0.26881	0.00052	0.12562	0.00058	0.6854	0.0070	25.402	0.271	102	3 299	3
2.1	182	149	167	0.218	0.31989	0.00115	0.26196	0.00159	0.6690	0.0071	29.509	0.345	93	3 569	6
3.1	112	149	104	0.176	0.27183	0.00122	0.35092	0.00201	0.6629	0.0074	24.847	0.313	99	3 317	7
4.1	374	120	332	0.106	0.34101	0.00072	0.08139	0.00057	0.7245	0.0075	34.064	0.369	96	3 667	3
5.1	29	23	27	0.591	0.30143	0.00274	0.20259	0.00398	0.7049	0.0099	29.298	0.518	99	3 478	14
6.1	212	88	184	1.783	0.26296	0.00156	0.10999	0.00293	0.6966	0.0073	25.256	0.320	104	3 265	9
7.1	164	186	86	7.720	0.27209	0.00334	0.17960	0.00741	0.3426	0.0039	12.853	0.227	57	3 318	19
8.1	55	61	63	0.300	0.38430	0.00201	0.28155	0.00256	0.7964	0.0098	42.198	0.588	98	3 849	8
9.1	163	92	133	0.139	0.28187	0.00100	0.14676	0.00112	0.6571	0.0071	25.539	0.301	97	3 373	6
10.1	123	67	170	0.089	0.53361	0.00148	0.13237	0.00101	0.9594	0.0107	70.588	0.833	100	4 337	4
11.1	73	90	75	0.045	0.31752	0.00154	0.32102	0.00209	0.7245	0.0085	31.720	0.421	99	3 558	7
12.1	233	335	218	0.065	0.27134	0.00082	0.37566	0.00134	0.6580	0.0070	24.619	0.279	98	3 314	5
13.1	141	121	121	0.079	0.27119	0.00106	0.22461	0.00135	0.6636	0.0073	24.812	0.300	99	3 313	6
14.1	142	112	122	0.100	0.28149	0.00107	0.21048	0.00131	0.6673	0.0073	25.897	0.312	98	3 371	6
15.1	85	107	93	0.014	0.34897	0.00148	0.32243	0.00189	0.7544	0.0087	36.300	0.463	98	3 703	6
16.1	125	57	121	0.390	0.34618	0.00135	0.11558	0.00156	0.7584	0.0085	36.201	0.444	99	3 690	6
33.1	125	115	110	0.459	0.28505	0.00115	0.24051	0.00177	0.6621	0.0091	26.022	0.386	97	3 391	6
17.1	89	41	74	0.120	0.28129	0.00121	0.12024	0.00134	0.6919	0.0097	26.835	0.408	101	3 370	7
18.1	106	80	90	0.134	0.27237	0.00114	0.19549	0.00156	0.6683	0.0093	25.096	0.377	99	3 320	7
19.1	78	33	51	0.226	0.28015	0.00148	0.10512	0.00180	0.5501	0.0078	21.250	0.336	84	3 364	8
20.1	96	31	79	0.056	0.28269	0.00114	0.08407	0.00097	0.6946	0.0097	27.073	0.408	101	3 378	6
21.1	83	64	72	0.099	0.28163	0.00124	0.19762	0.00153	0.6811	0.0096	26.450	0.404	99	3 372	7
22.1	121	88	106	0.060	0.28282	0.00101	0.19001	0.00118	0.6872	0.0095	26.797	0.394	100	3 379	6
23.1	141	47	113	0.034	0.28228	0.00098	0.08314	0.00103	0.6829	0.0094	26.579	0.387	99	3 376	5
24.1	191	132	162	0.435	0.28422	0.00089	0.18476	0.00127	0.6630	0.0090	25.980	0.370	97	3 386	5
25.1	128	65	135	0.035	0.38058	0.00110	0.12936	0.00090	0.8098	0.0112	42.495	0.614	100	3 834	4
26.1	127	35	102	0.029	0.28117	0.00097	0.07342	0.00079	0.6888	0.0095	26.703	0.390	100	3 369	5
27.1	122	49	116	0.085	0.34564	0.00113	0.10157	0.00107	0.7564	0.0105	36.046	0.527	98	3 688	5
28.1	356	151	335	0.007	0.34337	0.00062	0.11012	0.00044	0.7512	0.0100	35.567	0.485	98	3 678	3
29.1	73	41	61	0.019	0.28138	0.00127	0.14460	0.00125	0.6853	0.0098	26.588	0.414	100	3 371	7
30.1	62	15	40	0.256	0.24907	0.00150	0.07264	0.00180	0.5534	0.0080	19.004	0.311	89	3 179	10
31.1	97	36	80	0.109	0.27924	0.00116	0.09441	0.00125	0.6987	0.0098	26.900	0.406	102	3 359	6
32.1	134	132	144	0.073	0.34403	0.00102	0.25136	0.00119	0.7757	0.0107	36.795	0.531	101	3 681	5
30.2	98	26	73	0.228	0.28397	0.00124	0.06723	0.00131	0.6420	0.0073	25.138	0.319	94	3 385	7
30.3	34	13	26	0.045	0.28236	0.00216	0.10625	0.00256	0.6548	0.0086	25.491	0.407	96	3 376	12
10.2	257	195	357	0.070	0.53849	0.00099	0.19577	0.00072	0.9283	0.0097	68.928	0.749	97	4 350	3
10.3	143	80	199	0.091	0.54359	0.00137	0.14165	0.00095	0.9552	0.0106	71.590	0.836	99	4 364	4
10.4	137	73	188	0.083	0.53665	0.00140	0.13369	0.00090	0.9513	0.0107	70.392	0.838	99	4 345	4
10.5	108	62	150	0.078	0.54104	0.00130	0.14211	0.00096	0.9574	0.0105	71.418	0.819	99	4 357	4
10.6	174	115	254	0.051	0.53845	0.00105	0.16750	0.00074	0.9891	0.0105	73.435	0.812	102	4 350	3
10.7	194	130	277	0.129	0.52681	0.00103	0.17078	0.00077	0.9729	0.0103	70.664	0.777	101	4 318	3
10.8	178	70	197	0.201	0.53028	0.00120	0.11726	0.00089	0.7787	0.0082	56.931	0.626	86	4 328	3
10.9	892	663	293	0.764	0.45573	0.00106	0.12972	0.00129	0.2358	0.0024	14.816	0.157	33	4 104	3
34.1	127	113	137	0.459	0.34339	0.00175	0.22960	0.00231	0.7852	0.0096	37.179	0.513	102	3 678	8
35.1	252	200	222	0.125	0.28296	0.00110	0.21280	0.00135	0.6821	0.0076	26.610	0.327	99	3 379	6
36.1	149	101	132	0.145	0.28622	0.00146	0.17731	0.00175	0.6971	0.0083	27.511	0.373	100	3 397	8
37.1	214	171	190	0.661	0.34248	0.00158	0.23870	0.00229	0.6412	0.0073	30.278	0.389	87	3 674	7
38.1	259	426	258	0.114	0.27433	0.00105	0.43858	0.00187	0.6718	0.0075	25.409	0.311	99	3 331	6
39.1	133	78	113	0.238	0.27924	0.00154	0.15456	0.00190	0.6851	0.0083	26.378	0.367	100	3 359	9

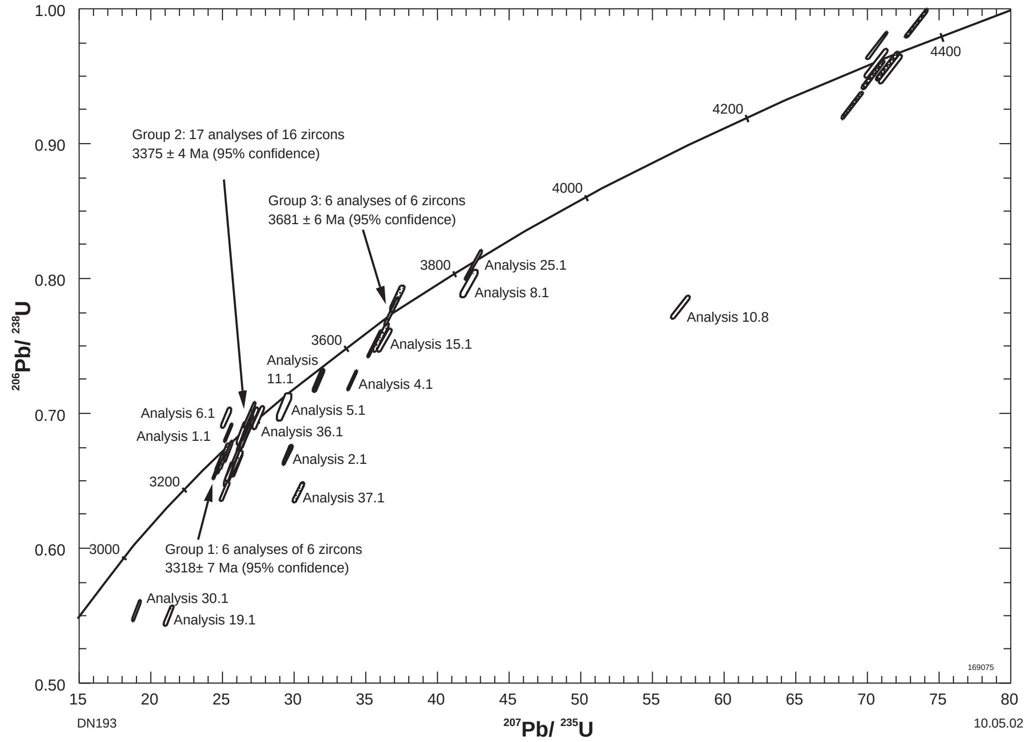

Figure 85. Concordia plot for sample 169075: quartzite, Kohler Bore

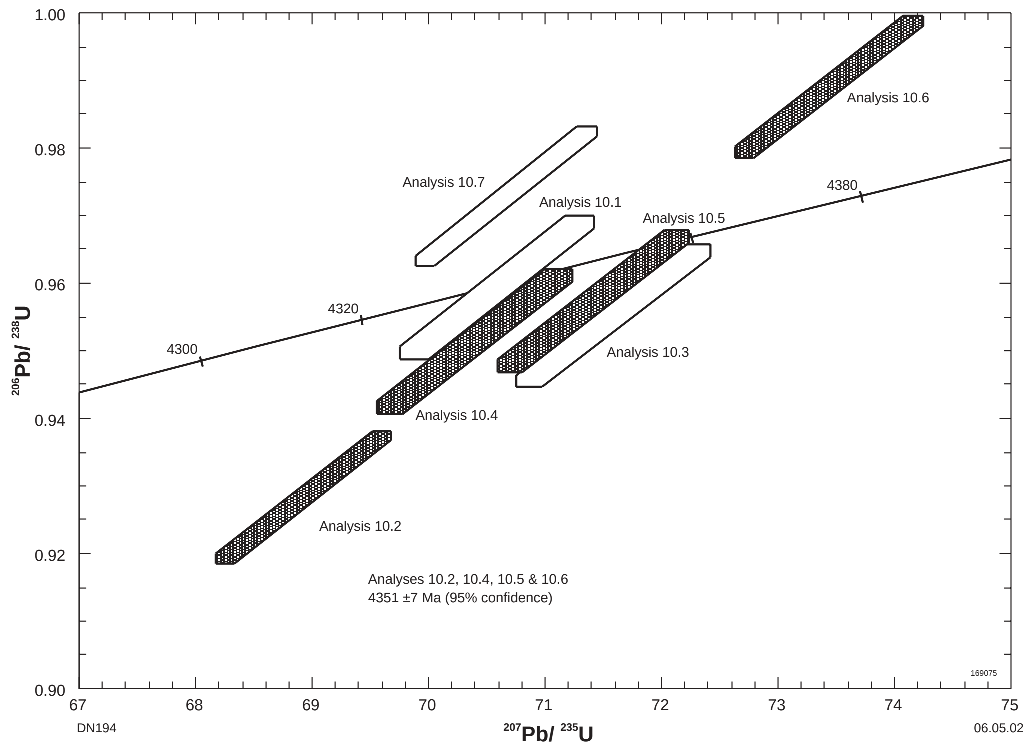

Figure 86. Concordia plot enlargement for sample 169075: quartzite, Kohler Bore

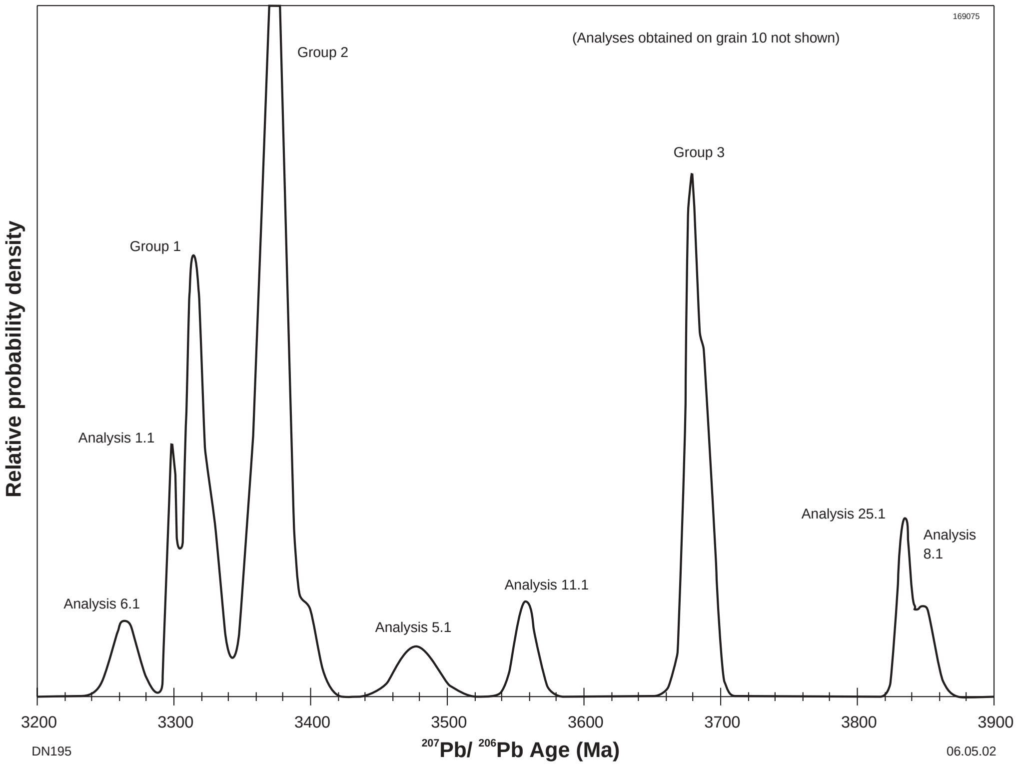

Figure 87. Gaussian-summation probability density plot for sample 169075: quartzite, Kohler Bore

Results

Sixty-six analyses were obtained from 39 zircons. Results are given in Table 62 and shown on concordia and Gaussian-summation probability density plots in Figures 85, 86 and 87.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a dominant recent episode of radiogenic-Pb loss. On the basis of their ^{207}Pb/^{206}Pb ratios, many analyses may be assigned to one of three groups. Six concordant to slightly discordant analyses of six zircons (3.1, 7.1, 12.1, 13.1, 18.1 and 38.1), assigned to Group 1, have ^{207}Pb/^{206}Pb ratios defining a single population indicating a weighted mean ^{207}Pb/^{206}Pb date of 3318 ± 7 Ma (chi-squared = 1.03). Seventeen concordant to slightly discordant analyses of 16 zircons (9.1, 14.1, 17.1, 19.1, 20.1, 21.1, 22.1, 23.1, 24.1, 26.1, 29.1, 30.2, 30.3, 31.1, 33.1, 35.1 and 39.1), assigned to Group 2, have ^{207}Pb/^{206}Pb ratios defining a single population indicating a weighted mean ^{207}Pb/^{206}Pb date of 3375 ± 4 Ma (chi-squared = 1.73). Six concordant to slightly discordant analyses of six zircons (16.1, 27.1, 28.1, 32.1, 34.1 and 37.1), assigned to Group 3, have ^{207}Pb/^{206}Pb ratios defining a single population indicating a weighted mean ^{207}Pb/^{206}Pb date of 3681 ± 6 Ma (chi-squared = 1.18). Apart from analyses obtained on grain 10, the remaining analyses cannot be confidently grouped.

Grain 10 consisted of a 120 × 100 µm pale brown, irregular, internally structureless grain fragment. Nine analyses were obtained from grain 10. Concordant analyses 10.4 and 10.5, and slightly discordant analyses 10.2 and 10.6, have ^{207}Pb/^{206}Pb ratios defining a single population indicating a weighted mean ^{207}Pb/^{206}Pb date of 4351 ± 7 Ma (chi-squared = 1.53). Concordant analysis 10.3 indicates a slightly older $^{207}Pb/^{206}Pb$ date of 4364 ± 4 Ma (1σ error), whereas concordant analysis 10.1 and slightly reversely discordant analysis 10.7 indicate slightly younger $^{207}Pb/^{206}Pb$ dates of 4337 ± 4 Ma and 4318 ± 3 Ma (1σ errors) respectively. Highly discordant analysis 10.8 indicates a $^{207}Pb/^{206}Pb$ date of 4328 ± 3 Ma (1σ error).

The analyses of Group 1 were obtained on rounded and internally structureless grains that have morphological features (such as sculpted surfaces and surface pitting that is more intensive at grain terminations) consistent with detrital transport. The weighted mean $^{207}Pb/^{206}Pb$ date of 3318 ± 7 Ma indicated by the six concordant to slightly discordant analyses of the six zircons of Group 1 is interpreted as a maximum age for deposition of the sedimentary precursor to the quartzite. Analyses 1.1 and 6.1 were obtained on clear, internally structureless and slightly elongate grains. Both analyses are slightly reversely discordant and indicated slightly younger $^{207}Pb/^{206}Pb$ dates (3299 ± 3 and 3265 ± 9 Ma respectively, 1σ errors) than those of Group 1. These analyses may tentatively be interpreted as providing younger constraints on the maximum age for deposition of the sedimentary precursor to the quartzite. The remaining analyses are also interpreted to have been obtained from detrital zircons. The range and distribution of the analyses obtained on grain 10 closely resemble that reported by Wilde et al. (2001) for their grain W74/2-36 from a conglomerate from the Jack Hills, Narryer Gneiss Complex. Source rocks within the western part of Australia having ages similar to those of the zircons within this sample include the Narryer Gneiss Complex (Nelson, 1996, 1997, 1999) and (with the exception of grain 10) the Pilbara Craton (Nelson, 1998, 1999, 2000, 2001b).

169076: biotite monzogranite gneiss, One Mile Well

Location and sampling

YOUANMI (SH 50-4), RICHARDSON (2840) MGA Zone 50, 754420E 6791260N

Sampled on 29 October 2000.

The sample was taken from a 2 m-diameter boulder located within a creek bed, 70 m north of a fenceline track, and 1 km southeast of One Mile Well.

Tectonic unit/relations

This sample is from a medium grey, medium- and even-grained biotite monzogranite gneiss of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Chen and Greenfield, in prep.). A foliation trends at 165° and dips at 75° to the east, and a mineral lineation plunges at 60° towards 40°. The gneiss has been intruded by abundant pegmatite dykes up to 10 cm thick that are generally aligned with the gneissic foliation. The sample taken was free of any obvious pegmatite dykes.

Petrographic description

The principal minerals present in this sample are plagioclase (40 vol.%), quartz (35 vol.%), microcline (20 vol.%), and biotite (4 vol.%), with accessory magnetite (trace), apatite (trace), and zircon (trace). This is a foliated biotite monzogranite transitional to granodiorite. The thin section shows an inequigranular, foliated rock with grains of plagioclase, quartz and microcline from 0.1 to 4 mm in diameter. Almost all of these grains are anhedral, and myrmekite is unusually abundant in, and adjacent to, the microcline grains, suggesting subsolidus modification. Areas of fine-grained feldspar, especially those with myrmekite, may have been recrystallized. The disseminated, mostly fine-grained biotite is weakly foliated although lenses of biotite defining an anastomosing foliation are common. Some of the larger biotite flakes, to 1 mm long, are poorly oriented. Minor secondary muscovite occurs but sericite alteration in the plagioclase is minor. Chloritization of the biotite is also uncommon to rare. Anhedral grains of opaque oxide occur to 1 mm in diameter with less abundant, smaller grains of apatite and zircon. Deformation under amphibolite facies conditions was followed by weak alteration.

Zircon morphology

The zircons isolated from this sample are pale yellowish brown, dark brown and black, generally between 30 × 60 µm and 100 × 280 µm in size, and are slightly elongate and anhedral to rounded in shape. Most grains are internally structureless or have faint internal zonation. Many grains have irregular zones or patches of yellow discolouration. Fluid and mineral inclusions are common. Many grains are metamict.

Analytical details

This sample was analysed on 16 October 2001. The counter deadtime during the analysis session was 32 ns. Ten analyses of the CZ3 standard obtained during the analysis session indicated a Pb^*/U calibration error of 1.29 (1σ%). Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for

Table 63. Ion microprobe analytical results for sample 169076: biotite monzogranite gneiss, One Mile Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	±1 σ	$^{208}Pb/^{206}Pb$	±1 σ	$^{206}Pb/^{238}U$	±1 σ	$^{207}Pb/^{235}U$	±1 σ	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	±1 σ
1.1	205	165	121	4.624	0.18689	0.00234	0.17585	0.00533	0.4420	0.0061	11.390	0.225	87	2 715	21
2.1	196	277	118	3.996	0.19808	0.00219	0.06234	0.00479	0.4909	0.0068	13.407	0.252	92	2 810	18
3.1	62	29	36	0.206	0.19283	0.00179	0.11794	0.00264	0.5182	0.0078	13.778	0.258	97	2 766	15
4.1	183	241	182	0.122	0.30044	0.00113	0.32571	0.00162	0.7073	0.0097	29.301	0.431	99	3 472	6
5.1	90	51	55	0.616	0.18872	0.00174	0.14445	0.00299	0.5271	0.0077	13.714	0.250	100	2 731	15
6.1	95	95	62	11.678	0.19579	0.00524	-0.00100	0.01210	0.4469	0.0069	12.063	0.392	85	2 791	44
7.1	102	63	61	0.610	0.19097	0.00174	0.10613	0.00296	0.5276	0.0076	13.891	0.250	99	2 750	15
8.1	152	147	73	1.685	0.19313	0.00203	0.14324	0.00399	0.3974	0.0055	10.581	0.196	78	2 769	17
9.1	102	166	54	1.440	0.20172	0.00218	0.03391	0.00397	0.4766	0.0068	13.256	0.252	88	2 840	18
10.1	56	24	33	0.117	0.19341	0.00143	0.06866	0.00174	0.5313	0.0076	14.169	0.239	99	2 771	12
10.2	55	39	34	0.312	0.18909	0.00197	0.14059	0.00328	0.5350	0.0080	13.947	0.269	101	2 734	17
10.3	47	23	28	0.297	0.19384	0.00204	0.06812	0.00294	0.5449	0.0082	14.562	0.283	101	2 775	17
4.2	85	91	76	0.119	0.30729	0.00153	0.20632	0.00196	0.6873	0.0097	29.118	0.451	96	3 507	8
3.2	48	57	30	0.175	0.19466	0.00225	0.19883	0.00405	0.5256	0.0080	14.106	0.285	98	2 782	19
3.3	46	43	28	0.591	0.19071	0.00254	0.16864	0.00474	0.5077	0.0079	13.350	0.290	96	2 748	22
7.2	113	60	68	0.172	0.19177	0.00118	0.11280	0.00156	0.5344	0.0075	14.129	0.226	100	2 757	10
7.3	61	37	35	0.746	0.19060	0.00227	0.06603	0.00389	0.5132	0.0078	13.486	0.275	97	2 747	20

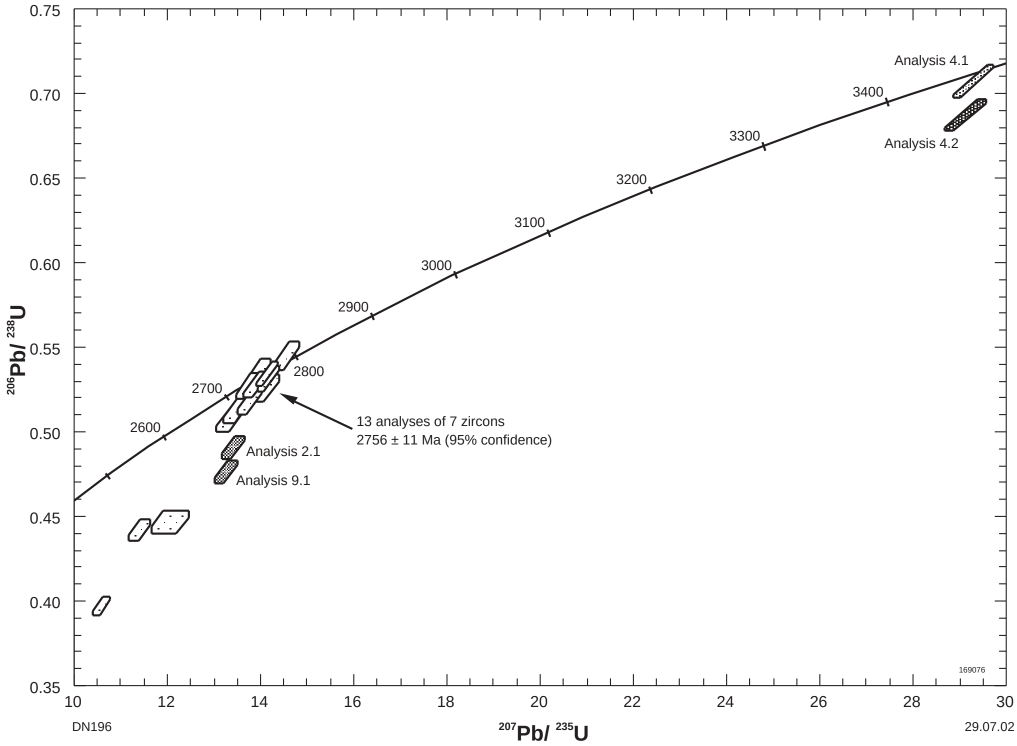

Figure 88. Concordia plot for sample 169076: biotite monzogranite gneiss, One Mile Well

all analyses, with the exception of analyses 1.1, 2.1 and 6.1, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Seventeen analyses were obtained from 10 zircons. Results are given in Table 63 and shown on a concordia plot in Figure 88.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a dominant recent episode of radiogenic-Pb loss. Thirteen concordant to slightly discordant analyses of seven zircons (1.1, 3.1, 3.2, 3.3, 5.1, 6.1, 7.1, 7.2, 7.3, 8.1, 10.1, 10.2 and 10.3) have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2756 ± 11 Ma (chi-squared = 1.18). Discordant analyses 2.1, 9.1 and 4.2, and concordant analysis 4.1 indicate significantly higher $^{207}Pb/^{206}Pb$ ratios than the main population.

The date of 2756 ± 11 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 13 concordant to slightly discordant analyses of seven zircons is interpreted as the age of igneous crystallization of the monzogranite. The significantly higher $^{207}Pb/^{206}Pb$ ratios of discordant analyses 2.1, 9.1 and 4.2, and concordant analysis 4.1 are interpreted to be of xenocryst zircons.

169078: quartz–feldspar porphyry, Fifty One Mile Well

Location and sampling

MENZIES (SH 51-5), MOUNT MASON (2939) MGA Zone 51, 255310E 6762700N

Sampled on 29 October 2000.

The sample was taken from a 0.5 m-high boulder located on the top of a low bouldery outcrop, 2 km northwest of Fifty One Mile Well.

Tectonic unit/relations

This sample is from a medium grey quartz–feldspar porphyry of the Southern Cross Granite–Greenstone Terrane, Yilgarn Craton (Duggan, 1995). The porphyry contains abundant rounded quartz and feldspar phenocrysts up to 5 mm in diameter. The porphyry has intruded the eastern part of the Ida Fault and is interpreted to have been deformed during movement along this fault. The porphyry has a weak, steeply dipping foliation that trends at 155°.

Petrographic description

This sample consists of plagioclase phenocrysts (20 vol.%), quartz phenocrysts (10 vol.%), decussate biotite (5 vol.%), and opaque oxide (trace) within a fine-grained quartzofeldspathic groundmass (65 vol.%). This is a quartz–plagioclase porphyritic dacite porphyry with albite- to sericite-altered plagioclase, decussate biotite with or without tourmaline after mafic phenocrysts, and a fine-grained quartzofeldspathic groundmass with biotite and opaque oxide. There are abundant phenocrysts of feldspar and quartz visible in hand specimen. The thin section has abundant albite- to sericite-altered plagioclase phenocrysts to 4 mm long and less abundant quartz phenocrysts to 5 mm in diameter. The quartz phenocrysts range from rounded to bipyramidal and resorbed, with channels filled by groundmass material. Aggregates of fine-grained, decussate biotite to 2 mm long represent metamorphosed hornblende or pyroxene phenocrysts and locally contain opaque oxide grains. Prisms of pale bronze to dark greenish brown tourmaline occur in some of the biotite aggregates, and are as much as 1 mm long. The groundmass is mostly fine grained and quartzofeldspathic, with quartz and plagioclase to 0.1 mm in grain size, as well as minor disseminated biotite and opaque oxide. This is a dacite porphyry containing no obvious K-feldspar, metamorphosed in the amphibolite or hornblende–hornfels facies.

Zircon morphology

The zircons isolated from this sample are pale yellowish brown, dark brown and black, generally between 30 × 60 µm and 100 × 280 µm in size, and are elongate and euhedral to subhedral in shape. Most grains display strong internal zonation. Many have dark irregular inclusions and zones that follow the internal zonation patterns, or are metamict.

Analytical details

This sample was analysed on 27 October and 24 November 2001. The counter deadtime during both analysis sessions was 32 ns. During the first analysis session, five analyses of the CZ3 standard indicated a Pb^*/U calibration error of 1.88 ($1\sigma\%$). Analyses 1.1 to

Table 64. Ion microprobe analytical results for sample 169078: quartz–feldspar porphyry, Fifty One Mile Well

Grain .spot	*U (ppm)*	*Th (ppm)*	*Pb (ppm)*	*f206%*	$^{207}Pb/^{206}Pb$	*±1 σ*	$^{208}Pb/^{206}Pb$	*±1 σ*	$^{206}Pb/^{238}U$	*±1 σ*	$^{207}Pb/^{235}U$	*±1 σ*	*% concordance*	$^{207}Pb/^{206}Pb$ *age*	*±1 σ*
1.1	184	140	118	0.483	0.20010	0.00079	0.21104	0.00139	0.5207	0.0099	14.366	0.287	96	2 827	6
2.1	105	54	70	5.694	0.18944	0.00243	0.16712	0.00558	0.4835	0.0094	12.630	0.310	93	2 737	21
3.1	98	19	58	2.564	0.18581	0.00164	0.06244	0.00350	0.5051	0.0097	12.941	0.287	97	2 705	15
4.1	109	230	56	2.330	0.18503	0.00162	0.07413	0.00341	0.4439	0.0085	11.326	0.250	88	2 698	14
5.1	109	22	61	0.146	0.18435	0.00090	0.05357	0.00121	0.5197	0.0100	13.210	0.269	100	2 692	8
6.1	129	100	78	1.512	0.18530	0.00119	0.20198	0.00251	0.4888	0.0094	12.488	0.262	95	2 701	11
7.1	167	70	105	0.028	0.19976	0.00067	0.11640	0.00075	0.5565	0.0106	15.328	0.303	101	2 824	5
8.1	104	106	59	3.622	0.18530	0.00185	0.07620	0.00406	0.4668	0.0090	11.927	0.271	91	2 701	16
9.1	167	113	109	4.255	0.19899	0.00156	0.18720	0.00349	0.4846	0.0093	13.296	0.286	90	2 818	13
10.1	108	58	61	1.244	0.18555	0.00132	0.15426	0.00256	0.4721	0.0091	12.078	0.257	92	2 703	12
11.1	123	198	87	3.713	0.18566	0.00179	0.27696	0.00413	0.5105	0.0098	13.068	0.295	98	2 704	16
12.1	182	70	118	2.898	0.19816	0.00129	0.10679	0.00276	0.5288	0.0101	14.447	0.302	97	2 811	11
13.1	178	87	149	3.076	0.33664	0.00185	0.07708	0.00345	0.6335	0.0123	29.407	0.611	87	3 648	8
14.1	107	77	69	0.454	0.19539	0.00102	0.19766	0.00180	0.5312	0.0102	14.310	0.294	99	2 788	9
14.2	108	111	77	3.781	0.19336	0.00189	0.30030	0.00436	0.4993	0.0096	13.312	0.302	94	2 771	16
15.1	136	62	100	0.420	0.27004	0.00097	0.11065	0.00127	0.6122	0.0117	22.794	0.453	93	3 306	6
3.2	74	14	44	5.405	0.18564	0.00298	0.07860	0.00637	0.4619	0.0098	11.823	0.334	91	2 704	27
6.2	130	105	70	1.875	0.18493	0.00170	0.18770	0.00348	0.4292	0.0090	10.943	0.263	85	2 698	15
11.2	89	134	60	3.494	0.18350	0.00241	0.28773	0.00530	0.4811	0.0054	12.172	0.223	94	2 685	22

14.1 were obtained during the first analysis session. During the second analysis session, analyses of the CZ3 standard were obtained into two separate intervals of two standard analyses each, for which calibration errors of 2.05 and 2.38 (1σ%) were determined. Analyses 3.2 and 6.2 were obtained during the first interval and analysis 11.2 during the second interval. Common-Pb corrections were applied assuming Broken Hill common-Pb isotopic compositions for all analyses, with the exception of analyses 2.1, 3.1, 4.1, 6.1, 8.1, 9.1, 11.1, 12.1, 13.1 and 13.2, for which isotopic compositions determined using the method of Cumming and Richards (1975) were assumed.

Results

Nineteen analyses were obtained from 15 zircons. Results are given in Table 64 and shown on a concordia plot in Figure 89.

Interpretation

The analyses are concordant to highly discordant, with the discordance pattern consistent with a dominant recent episode of radiogenic-Pb loss. On the basis of their $^{207}Pb/^{206}Pb$ ratios, many analyses may be assigned to one of two groups. Eleven concordant to slightly discordant analyses of nine zircons (2.1, 3.1, 3.2, 4.1, 5.1, 6.1, 6.2, 8.1, 10.1, 11.1 and 11.2), assigned to Group 1, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2700 ± 9 Ma (chi-squared = 0.44). Discordant analyses 1.1, 9.1 and 12.1, and concordant analysis 7.1, assigned to Group 2, have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean $^{207}Pb/^{206}Pb$ date of 2823 ± 12 Ma (chi-squared = 0.53). Analyses 14.1 and 14.2 have $^{207}Pb/^{206}Pb$ ratios defining a single population indicating a weighted mean

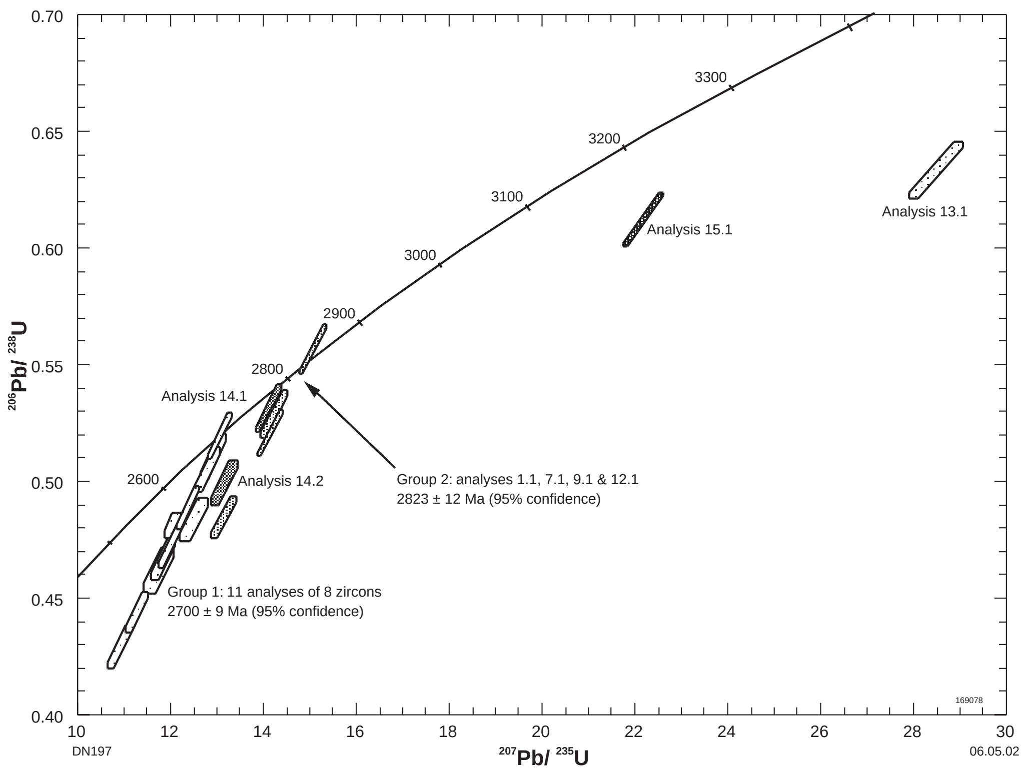

Figure 89. Concordia plot for sample 169078: quartz–feldspar porphyry, Fifty One Mile Well

$^{207}Pb/^{206}Pb$ date of 2784 ± 8 Ma (1σ error). The remaining analyses (13.1, 15.1) indicate significantly older $^{207}Pb/^{206}Pb$ dates than the main population and cannot be grouped.

The date of 2700 ± 9 Ma indicated by the weighted mean $^{207}Pb/^{206}Pb$ ratio of 11 concordant to slightly discordant analyses of nine zircons is interpreted as the age of igneous crystallization of the porphyry. The remaining analyses, which indicated significantly older $^{207}Pb/^{206}Pb$ dates, are interpreted to be of xenocryst zircons.

169057: lamprophyre dyke, Spider Hill

Location and sampling

EDMUND (SF 50-14), EDMUND (2158) MGA Zone 50, 425420E 7353930N

Sampled on 14 October 2000.

The sample was taken from a 10 cm-thick dyke on the north side of a large area of pavement on the north side of Spider Hill.

Tectonic unit/relations

This sample is from a phlogopite-bearing lamprophyric dyke that has intruded granitic rocks of the Pimbyana Granite (Pearson et al., 1996; Martin et al., 2002), Gascoyne Complex, as veins up to 25 cm thick. The pavement from which the dyke sample was taken consisted of granite with tabular feldspar phenocrysts up to 6 cm long and lesser amounts of a fine, even-grained granite.

Petrographic description

The principal minerals present in this sample are phlogopite (55–60 vol.%), ?plagioclase (20 vol.%), limonite-stained epidote (15 vol.%), opaque oxide (possibly hematite, 5 vol.%), quartz (2–3 vol.%), and fluorite (1 vol.%). Abundant mica is visible in hand specimen and in thin section this mineral is nearly colourless but uniaxial, indicating phlogopite. The phlogopite is decussate and inequigranular, and is 0.2 to 1.5 mm in grain size. Interstitial areas have abundant microgranular probable plagioclase as well as limonite-stained decussate prisms of probable epidote and small aggregates of opaque oxide, possibly hematite. The epidote is mostly about 0.5 mm in grain size and is iron-rich. Patches of quartz also occur, especially adjacent to some of the phlogopite flakes. Grains and aggregates of fluorite are disseminated, somewhat irregularly, locally reaching 0.3 mm in grain size. Fibrous inclusions in the phlogopite are length-fast but remain unidentified.

Analytical details

The sample was coarsely crushed and screened to produce fractions in the size range less than 0.710 and greater than 0.420 mm within the Carlisle Laboratory of the GSWA. Phlogopite flakes were hand-picked from the crushed material. K–Ar analyses were undertaken on 3 July 2001 within the CSIRO K–Ar laboratory at Curtin University of Technology. The analysts were H. Zwigmann and A. J. Todd.

Results

Analyses were obtained from two phlogopite mineral fractions. The K and Ar results are given in Table 65.

Table 65. K–Ar analytical results for sample 169057: lamprophyre dyke, Spider Hill

GSWA Number # aliquot	*%K*	*$^{40}Ar^*$ (× 10^{-9} moles/g)*	*$^{40}Ar^*/^{40}Ar_{total}$ (%)*	*Age (Ma)*	*±2 σ*
169057 #1 phlogopite	7.22	1.1971	98.34	767	15
169057 #2 phlogopite	7.31	1.1519	98.83	736	15

Interpretation

The two K–Ar analyses are within error of a single value, corresponding to a weighted mean K–Ar date of 752 ± 11 Ma (2σ error).

The date of 752 ± 11 Ma is interpreted as a minimum age for igneous crystallization of the lamprophyre.

142863: coarse dolerite, No. 2 Well

Location and sampling

WILUNA (SG 51-9), CUNYU (SG 51-9) MGA Zone 51, 222750E 7090240N

Sampled on 7 August 1997.

The sample was taken from the south side of a 40 m-high dolerite hill and about 1.6 km east of No. 2 Well.

Tectonic unit/relations

This sample is from a coarse-grained dolerite sill of the Killara Formation, Yerrida Group (Pirajno and Adamides, 2000) that has intruded clastic sedimentary rocks of the Juderina Formation, Yerrida Basin.

Petrographic description

The principal minerals present in this sample are plagioclase (53 vol.%), clinopyroxene (42 vol.%), opaque oxides (2 vol.%), prehnite (2 vol.%), quartz (1 vol.%), and K-feldspar (1 vol.%), with accessory saussurite (trace) and chlorite (trace). The plagioclase has been almost completely obscured. Much of the clinopyroxene is fresh, but some mafic grains have been replaced. Despite a trace amount of quartz and K-feldspar there is no evidence of granophyric intergrowth. Opaque minerals are abundant and coarse. Secondary materials include saussurite, prehnite and chlorite. The saussurite has severely altered the plagioclase. Prehnite is both a product of alteration of plagioclase and occurs as intergranular fine-grained aggregates. Chlorite forms rare, small intergranular grains. The primary texture is that of a coarse dolerite with elongate or platy plagioclase and stubby to moderately elongate (length/width = 3) clinopyroxene grains. There is no evidence of granophyric intergrowth, or of deformation or grain orientation. This is a coarse dolerite typical of a moderately large dyke or sill, heavily saussuritized at low metamorphic grade.

Analytical details

Samples were trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed to cm-sized fragments using a hydraulic press. Between 0.5 and 3 kg of rock fragments were ground in a tungsten carbide ring-mill using the minimum grinding time necessary for the resultant powder to pass through a 400 µm mesh size disposable nylon sieve cloth. The sieved powder was then ‘elutriated’ in 300 g batches with filtered water, under controlled flow conditions (400–2400 ml/min), using a 2000 ml glass funnel apparatus designed and constructed within the GSWA Carlisle Laboratory (see Nelson, 1999, for further details). The residue was then dried in an oven. Less than 150 g quantities of the heavy fraction were then thoroughly mixed by shaking with concentrated sodium polytungstate solution ($Na_6[H_2W_{12}O_{40}].H_2O$, density 2.9 g/cm^3) in 1000 ml glass separating funnels. The funnels were periodically shaken by hand and left overnight to facilitate density separation. The low-density (≤2.9 g/cm^3) concentrate, consisting of K-feldspar and quartz, was then washed thoroughly and dried in an oven. K–Ar analyses were undertaken on 2 July 2001 within the CSIRO K–Ar laboratory at Curtin University of Technology. The analysts were H. Zwigmann and A. J. Todd.

Table 66. K–Ar analytical results for sample 142863: coarse dolerite, No. 2 Well

GSWA Number # aliquot	*%K*	*$^{40}Ar^*$ (× 10^{-9} moles/g)*	*$^{40}Ar^*/^{40}Ar_{total}$ (%)*	*Age (Ma)*	*±2 σ*
142863 #1 K-feldspar	0.93	4.2700	98.19	1630	32
142863 #2 K-feldspar	0.93	4.4666	97.96	1676	33

Results

Analyses were obtained from two K-feldspar mineral fractions. The K and Ar results are given in Table 66.

Interpretation

The two K–Ar analyses are within error of a single value, corresponding to a weighted mean K–Ar date of 1652 ± 23 Ma (2σ error).

In the absence of evidence of thermal metamorphism of the sample, the date of 1652 ± 23 Ma is interpreted as a minimum age for crystallization of the dolerite.

118770: olivine basalt, Shell Lakes

Location and sampling

JUBILEE (SH 52-5), SHELL LAKES (4339)   MGA Zone 52, 343083E 6770045N

Sampled during 1993.

The sample was taken from CRA Exploration drillhole WD1 (Weedy 1 or AC/DD92WE001), depth 196 m, located in the Great Victoria Desert Nature Reserve to the west of Shell Lakes.

Tectonic unit/relations

This sample is from a slightly weathered, fine-grained olivine basalt that is not exposed at the surface but occurs as a north-northeasterly trending, sinuous, 1–2 × 130 km magnetic anomaly, within the southern part of the Officer Basin.

Petrographic description

This sample is a fine-grained, partly altered basaltic rock with fresh plagioclase laths of well-twinned bytownite (An_{70}), interstitial areas of augite and plagioclase microlites, olivine that has been completely altered to brown iddingsite and minute opaque grains. Small laths and euhedra of ilmenite are partly leucoxenized.

Analytical details

The sample was analysed on 11 November 1993 for K–Ar by Amdel Laboratories Limited. The analyst was A. W. Webb. The sample was trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed and screened to produce a fraction in the size range greater than 100 µm and less than 200 µm. This material was washed in an ultrasonic bath, dried, and then passed through a Franz isodynamic separator at a setting of 0.45 A. The non-magnetic fraction, which consisted largely of feldspar and clinopyroxene, was used for radiogenic argon analysis. Representative portions of the fractions were pulverized and used for determination of K content, in duplicate, by atomic adsorption spectrometry.

Results

Analyses were obtained from two fractions. The K and Ar results are given in Table 67.

Table 67. K–Ar analytical results for sample 118770: olivine basalt, Shell Lakes

GSWA Number # aliquot	*%K*	*$^{40}Ar^*$ (× 10^{-9} moles/g)*	*$^{40}Ar^*/^{40}Ar_{total}$ (%)*	*Age (Ma)*	*±2 σ*
118770 #1	1.572	2.1588	98.5	657	8
118770 #2	1.571	–	–	–	–

Interpretation

The K–Ar analysis indicates a weighted mean K–Ar date of 657 ± 8 Ma (2σ error). In the absence of evidence of thermal metamorphism of the sample, the date of 657 ± 8 Ma is interpreted as a minimum age for igneous crystallization of the basalt.

118771: olivine basalt, Shell Lakes

Location and sampling

JUBILEE (SH 52-5), SHELL LAKES (4339) MGA Zone 52, 343083E 6770045N

Sampled during 1993.

The sample was taken from CRA Exploration drillhole WD1 (Weedy 1 or AC/DD92WE001), depth 206 m, located in the Great Victoria Desert Nature Reserve to the west of Shell Lakes.

Tectonic unit/relations

This sample is from a slightly weathered, coarse-grained olivine basalt that is not exposed at the surface but occurs as a north-northeasterly trending, sinuous, 1–2 × 130 km magnetic anomaly, within the southern part of the Officer Basin.

Petrographic description

This sample is a relatively coarse-grained, partly altered basaltic rock with fresh plagioclase laths of well-twinned labradorite up to 1.5 mm long, olivine relicts as minute grains enclosed by secondary nontronite, and ilmenite as small euhedra and rare acicular crystals. There is abundant dark-coloured titanaugite, in masses to 2 mm across, that enclose many small plagioclase laths and abundant small apatite crystals.

Analytical details

The sample was analysed for K–Ar on 11 November 1993 by Amdel Laboratories Limited. The analyst was A. W. Webb. The sample was trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed and screened to produce a fraction in the size range >100 µm and <200 µm. This material was washed in an ultrasonic bath, dried, and then passed through a Franz isodynamic separator at a setting of 0.45 A. The non-magnetic fraction, which consisted largely of feldspar and clinopyroxene, was used for radiogenic argon analysis. Representative portions of the fractions were pulverized and used for determination of K content, in duplicate, by atomic adsorption spectrometry.

Results

Analyses were obtained from two aliquots. The K and Ar results are given in Table 68.

Table 68. K–Ar analytical results for sample 118771: olivine basalt, Shell Lakes

GSWA Number # aliquot	*%K*	*$^{40}Ar^*$ (× 10^{-9} moles/g)*	*$^{40}Ar^*/^{40}Ar_{total}$ (%)*	*Age (Ma)*	*±2 σ*
118771 #1	1.973	2.6330	99.3	640	10
118771 #2	1.979	–	–	–	–

Interpretation

The K–Ar analysis indicates a weighted mean K–Ar date of 640 ± 10 Ma (2σ error). In the absence of evidence of thermal metamorphism of the sample, the date of 640 ± 10 Ma is interpreted as a minimum age for igneous crystallization of the basalt.

168980: granophyric dolerite, Glenayle Homestead

Location and sampling

STANLEY (SG 51-6), GLENAYLE (3347) MGA Zone 51, 408670E 7203630N

Sampled on 26 June 2000.

The sample was taken from a 0.5 m-diameter boulder located on the north side of a low rocky hill and 5.9 km southeast of Glenayle Homestead.

Tectonic unit/relations

This sample is from a dark grey-black and pink, medium- and even-grained granophyric dolerite of the Glenayle Dolerite (Hocking et al., 2000), Collier Basin.

Petrographic description

The principal minerals present in this sample are plagioclase (45 vol.%), clinopyroxene (25 vol.%), granophyre (15–20 vol.%), opaque oxide (7–8 vol.%), and chlorite (5 vol.%), with accessory quartz (trace), altered biotite (trace), prehnite (trace), limonite (trace), and apatite (trace). This is a massive, medium grained and altered dolerite, rich in reddish granophyre, with abundant disseminated opaque oxide and secondary chlorite patches containing quartz and altered biotite. This massive, medium-grained dolerite is unusual in having abundant feldspar that is reddish in hand specimen. The thin section indicates abundant plagioclase to 2 mm in grain size, most of which is fresh, but microfissured and veined by limonite. Abundant scattered areas of granophyre are rich in reddish alkali feldspar and rimmed by reddish limonite/hematite-stained alkali feldspar. Clinopyroxene is mostly prismatic to subophitic, to 3 mm in grain size, and with areas containing microcrystalline alteration products largely as lamellae parallel to (001). Subhedral grains and small clusters (commonly about 0.5 mm) of opaque oxide are disseminated in and adjacent to the pyroxene, and were co-precipitated with the pyroxene. Scattered interstitial areas, some of which may have been miarolitic cavities, are up to 2 mm long, mostly filled with chlorite and quartz with less abundant altered biotite. Patches of interstitial chlorite, without quartz, are also disseminated, and there is very rare prehnite. There are commonly visible pleochroic haloes in the chlorite, rarely around crystals to 100 µm long.

Analytical details

Samples were trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed to cm-sized fragments using a hydraulic press. Between 0.5 and 3 kg of rock fragments were ground in a tungsten carbide ring-mill using the minimum grinding time necessary for the resultant powder to pass through a 400 µm mesh size disposable nylon sieve cloth. The sieved powder was then ‘elutriated’ in 300 g batches with filtered water, under controlled flow conditions (400–2400 ml/min), using a 2000 ml glass funnel apparatus designed and constructed within the GSWA Carlisle Laboratory (see Nelson, 1999, for further details). The residue was then dried in an oven. Less than 150 g quantities of the heavy fraction were then thoroughly mixed by shaking with concentrated sodium polytungstate solution ($Na_6[H_2W_{12}O_{40}].H_2O$, density 2.9 g/cm^3) in 1000 ml glass separating funnels. The funnels were periodically shaken by hand and

left overnight to facilitate density separation. The low-density (≤2.9 g/cm^3) concentrate, consisting of K-feldspar and quartz, was then washed thoroughly and dried in an oven. K–Ar analyses were undertaken on 27 September 2001 within the CSIRO K–Ar laboratory at Curtin University of Technology. The analysts were H. Zwigmann and A. J. Todd.

Results

Analyses were obtained from two K-feldspar mineral fractions. The K and Ar results are given in Table 69.

Table 69. K–Ar analytical results for sample 168980: granophyric dolerite, Glenayle Homestead

GSWA Number # aliquot	*%K*	*$^{40}Ar^*$ (× 10^{-9} moles/g)*	*$^{40}Ar^*/^{40}Ar_{total}$ (%)*	*Age (Ma)*	*±2 σ*
168980 #1 K-feldspar	2.77	5.5846	96.01	897	18
168980 #2 K-feldspar	2.77	5.9238	97.50	940	19

Interpretation

The two K–Ar analyses are within error of a single value, corresponding to a weighted mean K–Ar date of 917 ± 13 Ma (2σ error).

In the absence of evidence of thermal metamorphism of the sample, the date of 917 ± 13 Ma is interpreted as a minimum age for crystallization of the dolerite.

168982: granophyric dolerite, Midway Bore

Location and sampling

STANLEY (SG 51-6), MUDAN (3247) MGA Zone 51, 370320E 7225280N

Sampled on 27 June 2000.

The sample was taken from a 0.5 m-diameter boulder located on the top of a low rocky ridge, 250 m north of the access track and 4.5 km west of Midway Bore.

Tectonic unit/relations

This sample is from a dark grey-black and pink, medium- and even-grained granophyric dolerite of the Glenayle Dolerite (Hocking et al., 2000; Pirajno and Hocking, 2001), Collier Basin. The sample contained 2 to 4 mm zones of granophyric feldspar and quartz.

Petrographic description

The principal minerals present in this sample are plagioclase (55–60 vol.%), pyroxene and chlorite (30 vol.%), opaque oxide (5 vol.%), granophyre and late magmatic quartz (3–5 vol.%) and chlorite (5 vol.%), with accessory apatite (trace). This is a massive, homogeneous fine- to medium-grained, quartz-bearing granophyric dolerite. Abundant inequigranular, intricately interlocking plagioclase grains occur as crystals from 0.1 to 2 mm in size, and are partly clouded by clays. Pyroxene occurs as evenly scattered prismatic to subophitic crystals from 0.2 to 3 mm long. Some of this pyroxene is fresh, but some (about 10 vol.%) has been altered to chlorite, with total alteration in some grains, but with altered cores and partly fresh rims in others. Some grains (2–3 vol.%) have cores with alteration products (amphibole and/or ?chlorite) apparently interlaminated with pyroxene. All of the fresh material is clinopyroxene, but the variously altered material may have been orthopyroxene and/or pigeonite. Inequigranular opaque oxide is disseminated as crystals from 0.1 mm to 2 mm in diameter, with some grains partly altered to leucoxene. About 2 to 3 vol.% of the thin section is comprised of granophyre and granular late magmatic quartz. Rare brown to pale green amphibole, altered biotite and interstitial chlorite are disseminated. Some of the chlorite is interlaminated with prehnite. The chlorite and some amphibole patches contain pleochroic haloes, mostly around grains a few microns in diameter.

Analytical details

Samples were trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed to cm-sized fragments using a hydraulic press. Between 0.5 and 3 kg of rock fragments were ground in a tungsten carbide ring-mill using the minimum grinding time necessary for the resultant powder to pass through a 400 µm mesh size disposable nylon sieve cloth. The sieved powder was then ‘elutriated’ in 300 g batches with filtered water, under controlled flow conditions (400–2400 ml/min), using a 2000 ml glass funnel apparatus designed and constructed within the GSWA Carlisle Laboratory (see Nelson, 1999, for further details). The residue was then dried in an oven. Less than 150 g quantities of the heavy fraction were then thoroughly mixed by shaking with concentrated sodium polytungstate solution ($Na_6[H_2W_{12}O_{40}].H_2O$, density 2.9 g/cm^3) in 1000 ml glass separating funnels. The funnels were periodically shaken by hand and left overnight to facilitate density separation. The low-density (≤2.9 g/cm^3) concentrate, consisting of K-feldspar and quartz, was then washed thoroughly and dried in an oven. K–Ar analyses were undertaken on 2 October 2001 within the CSIRO K–Ar laboratory at Curtin University of Technology. The analysts were H. Zwigmann and A. J. Todd.

Results

Analyses were obtained from three K-feldspar mineral fractions. The K and Ar results are given in Table 70.

Table 70. K–Ar analytical results for sample 168982: granophyric dolerite, Midway Bore

GSWA Number # aliquot	*%K*	*$^{40}Ar^*$ (× 10^{-9} moles/g)*	*$^{40}Ar^*/^{40}Ar_{total}$ (%)*	*Age (Ma)*	*±2 σ*
168982 #1 K-feldspar	2.21	4.3219	92.84	876	17
168982 #2 K-feldspar	2.21	4.9130	93.58	968	19
168982 #3 K-feldspar	2.21	4.5900	93.58	918	18

Interpretation

The weighted mean K–Ar date of all three analyses is 917 ± 10 Ma (2σ error). However, the three K–Ar analyses are not within error of a single value, indicating that the K and/or Ar within the K-feldspar fractions analysed may have been disturbed since crystallization. The oldest K–Ar date of 968 ± 19 Ma (2σ error) indicated by the analysis of K-feldspar fraction #2 is therefore interpreted as a minimum age for crystallization of the dolerite.

153995A: ophitic basalt, Neale Junction

Location and sampling

NEALE (SH 51-4), DISAPPOINTED HILL (3941)   MGA Zone 51, 739100E 6873800N

Sampled on 21 October 1998.

The sample was taken from an outcrop within a small creek bed, located at 5.3 m in measured section NL98/1, 53 km on a bearing of 105° from the site of drillhole NJD 1 and 38 km on a bearing of 279° from Neale Junction.

Tectonic unit/relations

This sample is a slightly weathered, massive, dark purple to dark grey, fine-grained basalt that may be correlated with the Table Hill Volcanics of the Gunbarrel Basin. The basalt contains rare, thin pale veins. No contacts were observed and it is not known whether the basalt was emplaced as an extrusion or as a shallow intrusion.

Petrographic description

The principal minerals present in this sample are plagioclase (60 vol.%), clinopyroxene (25 vol.%), chlorite and smectite (7–8 vol.%), clouded feldspathic mesostasis (3–4 vol.%), opaque oxide (3 vol.%), and albite (1–2 vol.%). Fresh ophitic pyroxene to 1 mm in grain size is abundant in this sample, with zones of subcalcic augite and pigeonite with 2V from 0 to 30°, and normal augite with 2V from 40 to 50°. Some zones are altered to an assemblage of chlorite, smectite and/or limonite. Abundant plagioclase, as laths to 0.5 mm long, is strongly sericitized. There are interstitial patches of chlorite–smectite–limonite composition as well as limonite-stained feldspathic areas (mesostasis). Opaque oxide grains are disseminated, to 0.3 mm in diameter. There are patches of low-temperature albite, mostly less than 0.4 mm in grain size, with smectite with or without chlorite as aggregates to 0.3 mm in diameter. This ophitic tholeiitic basalt is free of olivine but has a range of pyroxene compositions indicated by a range of optic axial angles, from 0 to 50°, as well as sericitized plagioclase, opaque oxide, interstitial chlorite–smectite, limonite-stained interstitial feldspathic areas and patches of low-temperature albite, and chlorite with or without smectite. The albite may have been upgraded from zeolites, but in general the alteration was at low temperature.

Analytical details

Samples were trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed and screened to produce fractions in the size range less than 0.710 and greater than 0.420 mm. K–Ar analyses were undertaken on 8 October 2001 within the CSIRO K–Ar laboratory at Curtin University of Technology. The analysts were H. Zwigmann and A. J. Todd.

Results

Analyses were obtained from three aliquots. The K and Ar results are given in Table 71.

Table 71. K–Ar analytical results for sample 153995A: ophitic basalt, Neale Junction

GSWA Number *# aliquot*	*%K*	$^{40}Ar^*$ ($\times 10^{-9}$ moles/g)	$^{40}Ar^*/^{40}Ar_{total}$ (%)	*Age* (Ma)	$\pm 2\sigma$
153995A #1 WR	3.70	2.6491	92.83	372	7
153995A #2 WR	3.71	2.6274	89.18	368	7
153995A #3 WR	4.68	3.5719	94.41	393	8

Interpretation

The weighted mean K–Ar date of all three analyses is 376 ± 4 Ma (2σ error). However, the K–Ar analyses are not within error of a single value, indicating that the K and/or Ar within the fractions analysed have been disturbed since crystallization. The oldest K–Ar date of 393 ± 8 Ma (2σ error) indicated by the analysis of fraction #3 is therefore interpreted as a minimum age for igneous crystallization of the basalt.

142825: coarse-grained syenite, No. 3 Well

Location and sampling

YARRIE (SF 51-1), MUCCAN (2956) MGA Zone 51, 202580E 7678820N

Sampled on 19 September 1996.

The sample was taken from the eastern side of the east knoll of a double knoll hill, located about 2 km east-northeast of No. 3 Well. U–Pb zircon results for this sample were previously given in Nelson (1998).

Tectonic unit/relations

The sample is a even, coarse-grained syenite that has intruded granitic rocks of the Mount Edgar Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Williams, 1999).

Petrographic description

The principal mineral in this sample is plagioclase, with abundant K-feldspar, quartz and hornblende, minor chlorite and sericite/clay and accessory opaques, apatite, carbonate, epidote, ?albite, titanite, pyroxene, leucoxene and zircon. This is a medium-grained, hypidiomorphic granular granodiorite composed of randomly oriented, lightly sutured, subhedral and commonly zoned plagioclase, subhedral to euhedral green hornblende and interstitial quartz and K-feldspar, with accessory subhedral to euhedral apatite, opaques and titanite. The K-feldspar is commonly poikilitic and antiperthitic. Hornblende forms an aggregate over 1 cm across composed of subhedral crystals enveloping a larger, ragged, colourless pyroxene crystal in excess of 6 mm in grain size. Smaller pyroxene relicts are seen in the cores of two or three other hornblende crystals elsewhere in the thin section. The plagioclase is moderately altered to sericite/clay with minor epidote and carbonate and the K-feldspar is cloudy with brownish clay and/or oxide dust and contains a few inclusions of carbonate. Hornblende shows extensive fracture- and cleavage-controlled alteration to green chlorite and minor epidote, leucoxene and carbonate. Locally, plagioclase is pseudomorphed by chlorite embedded with epidote granules. No metamorphic modification of the igneous texture is apparent, but the rock has undergone moderate propylitic alteration. Two possible zircons, about 0.03 mm in size, are embedded in plagioclase and quartz and there are a few pleochroic haloes in hornblende around small unidentified inclusions.

Analytical details

Samples were trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed to cm-sized fragments using a hydraulic press. Between 0.5 and 3 kg of rock fragments were ground in a tungsten carbide ring-mill using the minimum grinding time necessary for the resultant powder to pass through a 400 µm mesh size disposable nylon sieve cloth. The sieved powder was then ‘elutriated’ in 300 g batches with filtered water, under controlled flow conditions (400–2400 ml/min), using a 2000 ml glass funnel apparatus designed and constructed within the GSWA Carlisle Laboratory (see Nelson, 1999, for further details). The residue was then dried in an oven. Less than 150 g quantities of the heavy fraction were then thoroughly mixed by shaking with concentrated sodium polytungstate solution ($Na_6[H_2W_{12}O_{40}].H_2O$, density 2.9 g/cm^3) in 1000 ml glass separating funnels. The funnels were periodically shaken by hand and

left overnight to facilitate density separation. The low-density (≤2.9 g/cm^3) concentrate, consisting of K-feldspar and quartz, was then washed thoroughly and dried in an oven. The high-density (≤2.9 g/cm^3) concentrate was also washed thoroughly and dried in an oven and then passed through a Frantz isodynamic magnetic separator to concentrate amphibole. K–Ar analyses were undertaken on 26 November 2001 within the CSIRO K–Ar laboratory at Curtin University of Technology. The analysts were H. Zwigmann and A. J. Todd.

Results

Analyses were obtained from two hornblende fractions and one K-feldspar fraction. The K and Ar results are given in Table 72.

Table 72. K–Ar analytical results for sample 142825: coarse-grained syenite, No. 3 Well

GSWA Number # aliquot	*%K*	*$^{40}Ar^*$ (× 10^{-9} moles/g)*	*$^{40}Ar^*/^{40}Ar_{total}$ (%)*	*Age (Ma)*	*±2 σ*
142825 #1 hornblende	1.08	4.2713	97.35	1474	29
142825 #2 hornblende	1.08	4.8163	97.85	1598	32
142825 #3 K-feldspar	3.35	6.9932	93.37	992	18

Interpretation

The weighted mean K–Ar date of both hornblende analyses is 1564 ± 15 Ma (2σ error). However, the hornblende and K-feldspar K–Ar analyses are not within error of a single value, indicating that the K and/or Ar within the fractions analysed have been disturbed since crystallization. The oldest K–Ar date of 1598 ± 32 Ma (2σ error) indicated by the analysis of hornblende fraction #1 is therefore interpreted as a minimum age for igneous crystallization of the syenite.

169032: hornblende–clinopyroxene–quartz micromonzonite, Mount Edgar

Location and sampling

NULLAGINE (SF 51-5), MOUNT EDGAR (2955) MGA Zone 51, 205880E 7648190N

Sampled on 13 September 2000.

The sample was taken from a 1 m-diameter, 30 cm-thick slab located about one third of the way up the southern side of Mount Edgar.

Tectonic unit/relations

This sample is from a dark pinkish grey, hornblende-porphyritic micromonzonite that has intruded the Mount Edgar Granitoid Complex, East Pilbara Granite–Greenstone Terrane (Williams and Bagas, in prep.). The intrusion at Mount Edgar is one of several irregular-shaped syenitic plugs that have intruded the complex. A fine-grained hornblende trachyandesite phase is also present at the sampling site but was not sampled. The sample taken was free of obvious veins.

Petrographic description

The principal minerals present in this sample are hornblende (35 vol.%), orthoclase (20–25 vol.%), clinopyroxene and actinolite (15–20 vol.%), plagioclase (10–15 vol.%), quartz (7–8 vol.%), magnetite (3 vol.%), titanite (2 vol.%), and apatite (1 vol.%). This is a lamprophyric hornblende–clinopyroxene–quartz micromonzonite, with accessory magnetite, titanite, apatite, secondary carbonate, epidote, sericite and actinolite, and minor chlorite. There is a lamprophyric character to this rock, with dark greenish brown to black hornblende prisms to 10 mm long in a fine-grained groundmass of hornblende and pink feldspar. In thin section, the largest hornblende crystal is 8 mm long, but most of the crystals are less than 2 mm wide. Minor clinopyroxene is also present, to 3 mm in grain size, partly to completely replaced by uralitic actinolite. There is also a quartzofeldspathic component to 1.5 mm in grain size, with irregularly disseminated quartz as well as brown, iron-stained K-feldspar (orthoclase) and altered plagioclase. The plagioclase has been altered to albite, sericite and clouded clinozoisite, with or without clear granular epidote. Carbonate occurs as interstitial patches and in the orthoclase, and there is a possible vesicle rimmed by actinolite, with an inner zone of chlorite and titanite. Primary magnetite, titanite and apatite are the main accessory minerals. The mineralogy indicates a lamprophyric quartz monzonite, transitional towards quartz syenite.

Analytical details

Samples were trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed to cm-sized fragments using a hydraulic press. Between 0.5 and 3 kg of rock fragments were ground in a tungsten carbide ring-mill using the minimum grinding time necessary for the resultant powder to pass through a 400 µm mesh size disposable nylon sieve cloth. The sieved powder was then 'elutriated' in 300 g batches with filtered water, under controlled flow conditions (400–2400 ml/min), using a 2000 ml glass funnel apparatus designed and constructed within the GSWA Carlisle Laboratory (see Nelson, 1999, for further details). The residue was then dried in an oven. Less than 150 g quantities of the heavy fraction were then thoroughly mixed by shaking with concentrated sodium polytungstate solution ($Na_6[H_2W_{12}O_{40}].H_2O$, density 2.9 g/cm^3) in 1000 ml glass separating funnels. The funnels were periodically shaken by hand and left overnight to facilitate density separation. The low-density (≤2.9 g/cm^3) concentrate, consisting of K-feldspar and quartz, was then washed thoroughly and dried in an oven. The high-density (≤2.9 g/cm^3) concentrate was also washed thoroughly and dried in an oven and then passed through a Frantz isodynamic magnetic separator to concentrate amphibole. K–Ar analyses were undertaken on 28 November 2001 within the CSIRO K–Ar laboratory at Curtin University of Technology. The analysts were H. Zwigmann and A. J. Todd.

Results

Analyses were obtained from one hornblende fraction and one K-feldspar fraction. The K and Ar results are given in Table 73.

Table 73. K–Ar analytical results for sample 169032: hornblende–clinopyroxene–quartz micromonzonite, Mount Edgar

GSWA Number # aliquot	*%K*	*$^{40}Ar^*$ (× 10^{-9} moles/g)*	*$^{40}Ar^*/^{40}Ar_{total}$ (%)*	*Age (Ma)*	*±2 σ*
169032 #1 hornblende	0.76	3.6116	97.09	1674	33
169032 #2 K-feldspar	3.75	9.0006	95.36	1027	20

Interpretation

The K–Ar analyses are not within error of a single value, indicating that the K and/or Ar within either or both fractions analysed have been disturbed since crystallization. The oldest K–Ar date of 1674 ± 33 Ma (2σ error) indicated by the analysis of hornblende fraction #1 is therefore interpreted as a minimum age for igneous crystallization of the micromonzonite.

144683: hornblende–quartz monzonite, Pelican Pool

Location and sampling

NULLAGINE (SF 51-5), MOUNT EDGAR (2955) MGA Zone 51, 227203E 7642437N

Sampled on 25 September 2000.

The sample was taken from a site located 30 m above a creek bed, and 5.1 km bearing 015° from Pelican Pool on the Nullagine River.

Tectonic unit/relations

This sample is from an unfoliated, pinkish grey hornblende–quartz monzonite that has intruded basalts of the Kylena Formation, Fortescue Group, Hamersley Basin (Williams and Bagas, in prep.). The monzonite contains numerous scattered mafic xenoliths, composed largely of hornblende. The sample was taken from the northwestern side of the monzonite pluton, about 50 m from the basalt contact.

Petrographic description

The principal minerals present in this sample are orthoclase (35–40 vol.%), plagioclase (30 vol.%), quartz (15–20 vol.%), altered chlorite, carbonate and epidote (7–8 vol.%), magnetite (2–3 vol.%), and apatite (<1 vol.%), with accessory titanite (trace), carbonate (trace), and zircon (trace). This is an altered, hornblende-bearing quartz monzonite, transitional towards monzogranite, with chlorite, epidote, carbonate and sericite. Pink and cream feldspars are visible in hand specimen, as well as disseminated possible amphibole. The thin section shows abundant feldspar to 3 mm in grain size. Brownish, iron-stained orthoclase is more abundant than fresh to sericite-clouded plagioclase, but is anhedral, whereas the plagioclase is euhedral. Possible amphibole crystals, from 0.4 to 4 mm long, have been replaced by aggregates of chlorite, quartz, carbonate and epidote in various proportions, with carbonate rarely in the same aggregate as epidote. Chlorite has a very low birefringence, with anomalous brown and blue interference colours. Interstitial quartz is common to abundant, with anhedral grains and subhedral, partly resorbed crystals suggesting a low pressure, possibly subvolcanic intrusion. Magnetite is disseminated as grains and aggregates to 0.5 mm in diameter, with minor apatite and rare titanite. Rare possible cavities contain quartz and carbonate, consistent with subvolcanic intrusion.

Analytical details

Samples were trimmed of all weathered surfaces and secondary veins using a rock saw. Following thorough washing in distilled water and drying, the trimmed material was then crushed to cm-sized fragments using a hydraulic press. Between 0.5 and 3 kg of rock fragments were ground in a tungsten carbide ring-mill using the minimum grinding time necessary for the resultant powder to pass through a 400 µm mesh size disposable nylon sieve cloth. The sieved powder was then ‘elutriated’ in 300 g batches with filtered water, under controlled flow conditions (400–2400 ml/min), using a 2000 ml glass funnel apparatus designed and constructed within the GSWA Carlisle Laboratory (see Nelson, 1999, for further details). The residue was then dried in an oven. Less than 150 g quantities of the heavy fraction were then thoroughly mixed by shaking with concentrated sodium polytungstate solution ($Na_6[H_2W_{12}O_{40}].H_2O$, density 2.9 g/cm^3) in 1000 ml glass separating funnels. The funnels were periodically shaken by hand and

left overnight to facilitate density separation. The low-density (≤2.9 g/cm^3) concentrate, consisting of K-feldspar and quartz, was then washed thoroughly and dried in an oven. The high-density (≤2.9 g/cm^3) concentrate was also washed thoroughly and dried in an oven and then passed through a Frantz isodynamic magnetic separator to concentrate amphibole. K–Ar analyses were undertaken on 27 November 2001 within the CSIRO K–Ar laboratory at Curtin University of Technology. The analysts were H. Zwigmann and A. J. Todd.

Results

Analyses were obtained from one hornblende fraction and one K-feldspar fraction. The K and Ar results are given in Table 74.

Table 74. K–Ar analytical results for sample 144683: hornblende–quartz monzonite, Pelican Pool

GSWA Number # aliquot	*%K*	*^{40}Ar* (× 10^{-9} moles/g)*	*^{40}Ar*/^{40}Ar$_{total}$ (%)*	*Age (Ma)*	*±2 σ*
144683 #1 hornblende	0.26	0.8577	87.86	1310	27
144683 #2 K-feldspar	3.05	9.0689	95.70	1205	24

Interpretation

The weighted mean K–Ar date of both analyses is 1251 ± 18 Ma (2σ error). However, the K–Ar analyses are not within error of a single value, indicating that the K and/or Ar within either or both fractions analysed have been disturbed since crystallization. The oldest K–Ar date of 1310 ± 27 Ma (2σ error) indicated by the analysis of hornblende fraction #1 is therefore interpreted as a minimum age for igneous crystallization of the monzonite.

Ion-microprobe U–Pb zircon analytical results for this sample are given elsewhere in this Record (see p. 167).

Acknowledgments

Sample preparation was competently undertaken by John Williams and Marianna Brzusek of the GSWA Carlisle Laboratories. R. Adam Frew (Department of Applied Physics, Curtin University of Technology) provided diligent and capable technical assistance in the operation of the SHRIMP and Matthew Rowles (Department of Applied Physics, Curtin University of Technology) assisted in the preparation of mineral mounts prior to analysis. K–Ar analyses were undertaken by A. W. Webb (formerly of Amdel Laboratories Limited), H. Zwigmann and A. J. Todd (C.S.I.R.O.). Alan Purvis (Pontifex and Associates Pty Ltd) prepared many of the petrographic descriptions given in this report. The Perth Sensitive high-resolution ion microprobe (SHRIMP) is maintained by Allen Kennedy (Curtin University of Technology) and operated by a consortium consisting of Curtin University, the Geological Survey of Western Australia, and the University of Western Australia with support from the Australian Research Council.

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Appendix 1

Index of geochronology samples analysed 1994–2001 (Nelson, 1995, 1996, 1997, 1998, 1999, 2000, 2001, this issue)

GSWA sample no. and rock type		*Map sheet (1:250 000)*	*GSWA Record*	*Page*
83649	granite pegmatite	RAVENSTHORPE (SI 51-5)	1995/3	33
83651	biotite–hornblende monzogranite gneiss	RAVENSTHORPE (SI 51-5)	1995/3	37
83652	biotite–hornblende granodiorite gneiss	RAVENSTHORPE (SI 51-5)	1995/3	41
83657A	porphyritic biotite monzogranite	ESPERANCE (SI 51-6)	1995/3	63
83658	hornblende–biotite granodiorite gneiss	ESPERANCE (SI 51-6)	1995/3	30
83659	recrystallized leucogranite	ESPERANCE (SI 51-6)	1995/3	59
83662	biotite–hornblende monzogranite gneiss	MALCOLM (SI 51-7)	1995/3	67
83663	granodiorite gneiss	MALCOLM (SI 51-7)	1995/3	75
83666	garnet–biotite monzogranite gneiss	NORSEMAN (SI 51-2)	1995/3	45
83667	porphyritic biotite granite	BALLADONIA (SI 51-3)	1995/3	71
83676A	hornblende syenogranite gneiss	NORSEMAN (SI 51-2)	1995/3	49
83690	biotite granodiorite gneiss	RAVENSTHORPE (SI 51-5)	1995/3	26
83691	biotite monzogranite gneiss	RAVENSTHORPE (SI 51-5)	1995/3	12
83696A	biotite monzogranite gneiss	RAVENSTHORPE (SI 51-5)	1995/3	23
83697	biotite monzogranite gneiss	ESPERANCE (SI 51-6)	1995/3	56
83700A	hornblende–biotite syenogranite gneiss	ESPERANCE (SI 51-6)	1995/3	53
83701A	biotite monzogranite gneiss	RAVENSTHORPE (SI 51-5)	1995/3	15
83702	biotite tonalite gneiss	RAVENSTHORPE (SI 51-5)	1995/3	19
91591	porphyritic rhyolite	COLLIER (SG 50-4)	1995/3	5
93901	granodiorite	KALGOORLIE (SH 51-9)	1995/3	176
98255	muscovite–biotite monzogranite	KALGOORLIE (SG 51-9)	1998/2	29
98256	biotite syenogranite	KALGOORLIE (SH 51-9)	1995/3	185
98258	biotite monzogranite	KALGOORLIE (SG 51-9)	1998/2	35
98260	biotite–muscovite monzogranite	KALGOORLIE (SG 51-9)	1998/2	38
98267	biotite monzogranite	KALGOORLIE (SH 51-9)	1995/3	182
98268	biotite monzogranite	KALGOORLIE (SG 51-9)	1998/2	32
100710	felsic tuff	KURNALPI (SH 51-10)	1995/3	92
100726	felsic tuff	KURNALPI (SH 51-10)	1995/3	96
100758	felsic volcanic breccia	KURNALPI (SH 51-10)	1995/3	104
101348	biotite monzogranite	EDJUDINA (SH 51-6)	1995/3	172
101381	monzogranite	EDJUDINA (SH 51-6)	1995/3	179
104932	garnet–biotite–muscovite syenogranite gneiss	RUDALL (SF 51-10)	1995/3	188
104934	biotite syenogranite gneiss	RUDALL (SF 51-10)	1995/3	192
104937	coarse-grained biotite monzogranite	PATERSON RANGE (SF 51-6)	1995/3	209
104938	pegmatite	RUDALL (SF 51-10)	1995/3	212
104940A	porphyritic metadacite	KURNALPI (SH 51-10)	1995/3	165
104948A	schistose metadacite	KURNALPI (SH 51-10)	1996/5	47
104949C	metatrachyte	KURNALPI (SH 51-10)	1995/3	150
104951	porphyry	KALGOORLIE (SH 51-9)	1995/3	118
104958	metadacite	KURNALPI (SH 51-10)	1995/3	109
104958	metadacite	KURNALPI (SH 51-10)	1996/5	75
104963	biotite rhyolite	NORSEMAN (SI 51-2)	1995/3	146
104964	biotite granodiorite gneiss	WIDGIEMOOLTHA (SH 51-14)	1995/3	114
104967	quartz–feldspar porphyry	KURNALPI (SH 51-10)	1995/3	132
104970	dacite breccia	KURNALPI (SH 51-10)	1995/3	141
104971	metatonalite	KURNALPI (SH 51-10)	1996/5	43
104973	metadacite porphyry	KURNALPI (SH 51-10)	1995/3	158
104975	rhyodacite porphyry	KURNALPI (SH 51-10)	1995/3	123
104979	metadacite breccia	KURNALPI (SH 51-10)	1995/3	162
104980	monzogranite gneiss	RUDALL (SF 51-10)	1995/3	219
104981	biotite–muscovite monzogranite gneiss	RUDALL (SF 51-10)	1995/3	237
104989	muscovite quartzite	RUDALL (SF 51-10)	1995/3	202
105001	coarse-grained recrystallized monzogranite	BYRO (SG 50-10)	1996/5	87
105002	dark inclusion phase in orthogneiss	BYRO (SG 50-10)	1996/5	91
105004	monzogranite	BYRO (SG 50-10)	1996/5	95
105005	leucocratic orthogneiss	BYRO (SG 50-10)	1996/5	99
105005	leucocratic orthogneiss	BYRO (SG 50-10)	1999/2	9
105007	leucocratic orthogneiss	BYRO (SG 50-10)	1996/5	103
105007	leucocratic orthogneiss	BYRO (SG 50-10)	1997/2	12
105007	leucocratic orthogneiss	BYRO (SG50-10)	1999/2	13

Appendix 1 (continued)

GSWA sample no. and rock type		Map sheet (1:250 000)	GSWA Record	Page
105009	dark inclusion phase in leucocratic gneiss	Byro (SG 50-10)	1996/5	119
105010	leucocratic orthogneiss	Byro (SG 50-10)	1996/5	107
105011	leucocratic granite	Byro (SG 50-10)	1996/5	111
105012	coarse-grained granite	Byro (SG 50-10)	1996/5	131
105014	biotite granite gneiss	Byro (SG 50-10)	1996/5	127
105015	fine-grained porphyritic granite dyke	Byro (SG 50-10)	1996/5	115
105016	granodiorite gneiss	Byro (SG 50-10)	1996/5	135
105017	fine-grained granite	Byro (SG 50-10)	1996/5	123
105018A	leucocratic gneiss	Byro (SG 50-10)	1996/5	139
105018A	leucocratic gneiss	Byro (SG 50-10)	1997/2	18
110056	biotite–hornblende granodiorite gneiss	Rudall (SF 51-10)	1995/3	240
110225	porphyritic metadacite	Menzies (SH 51-5)	1996/5	51
111843	biotite–muscovite monzogranite gneiss	Rudall (SF 51-10)	1995/3	226
111854	biotite–muscovite granodiorite gneiss	Rudall (SF 51-10)	1995/3	205
112101	biotite–epidote monzogranite gneiss	Rudall (SF 51-10)	1996/5	35
112102	seriate biotite metamonzogranite	Rudall (SF 51-10)	1996/5	25
112106	foliated monzogranite	Paterson Range (SF 51-6)	1995/3	222
112107	granodiorite	Collier (SG 50-4)	1995/3	9
112110	felsic volcanic rock	Widgiemooltha (SH 51-14)	1995/3	85
112112	K-feldspar volcanic rock	Edjudina (SH 51-6)	1995/3	99
112114	felsic volcanic rock	Menzies (SH 51-5)	1995/3	154
112117	biotite monzogranite	Menzies (SH 51-5)	1996/5	55
112128	muscovite–biotite–sillimanite paragneiss	Malcolm (SI 51-7)	1995/3	78
112131	hornblende granite gneiss	Augusta (SI 50-9)	1996/5	10
112132	hornblende granite gneiss	Augusta (SI 50-9)	1996/5	4
112134	granite gneiss	Augusta (SI 50-9)	1996/5	7
112135	garnet–biotite–quartz–feldspar augen gneiss	Augusta (SI 50-9)	1999/2	194
112136	garnet–biotite–quartz–feldspar augen gneiss	Augusta (SI 50-9)	1999/2	197
112140	biotite–hornblende monzogranite dyke	Busselton (SI 50-5)	1996/5	13
112143	hornblende–biotite monzogranite gneiss	Busselton (SI 50-5)	1996/5	17
112144A	hornblende–biotite monzogranite gneiss	Busselton (SI 50-5)	1996/5	21
112145	aegirine–augite–quartz syenite gneiss	Busselton (SI 50-5)	1999/2	200
112147	porphyritic dacite	Kurnalpi (SH 51-10)	1995/3	89
112151	felsic volcanic rock	Kurnalpi (SH 51-10)	1995/3	169
112153	foliated porphyritic microgranodiorite	Edjudina (SH 51-6)	1996/5	67
112159	porphyritic dacite	Leonora (SH 51-1)	1995/3	128
112160	garnet microgneiss	Rudall (SF 51-10)	1996/5	39
112163	rhyolite	Ravensthorpe (SI 51-5)	1995/3	82
112168	fine-grained sandstone	Ravensthorpe (SI 51-5)	1996/5	80
112170	metasandstone	Ravensthorpe (SI 51-5)	1996/5	84
112175	volcaniclastic rock	Edjudina (SH 51-6)	1996/5	59
112176	monzodiorite	Edjudina (SH 51-6)	1996/5	63
112177	foliated tonalite	Edjudina (SH 51-6)	1996/5	71
112179	orthogneiss	Edjudina (SH 51-6)	1995/3	136
112310	granodiorite gneiss	Rudall (SF 51-10)	1995/3	230
112341	micromonzogranite (meta-aplite) dyke	Rudall (SF 51-10)	1995/3	216
112379	biotite monzogranite (augen) gneiss	Rudall (SF 51-10)	1995/3	195
112397	porphyritic biotite monzogranite (augen) gneiss	Rudall (SF 51-10)	1995/3	199
113002	granodiorite gneiss	Rudall (SF 51-10)	1995/3	234
113035	orthogneiss	Rudall (SF 51-10)	1996/5	31
114305	bedded felsic tuff	Roebourne (SF 50-3)	1996/5	160
114350	metadacite	Dampier (SF 50-2)	1996/5	164
114356	rhyolite	Dampier (SF 50-2)	1996/5	156
114358	porphyritic rhyolite	Dampier (SF 50-2)	1997/2	134
118580	autolithic quartz–tourmaline mudstone	Rudall (SF 51-10)	1999/2	185
118770	olivine basalt	Jubilee (SH 52-5)	2002/2	248
118771	olivine basalt	Jubilee (SH 52-5)	2002/2	250
118914	foliated granite	Rudall (SF 51-10)	1996/5	28
118916	biotite monzogranite	Paterson Range (SF 51-6)	1999/2	203
118920	alkali granite	Nullagine (SF 51-5)	1996/5	143
118923	granophyre	Nullagine (SF 51-5)	1996/5	146
118924	hornblende–biotite granite augen gneiss	Nullagine (SF 51-5)	1996/5	149
118925	biotite monzogranite	Nullagine (SF 51-5)	1999/2	94
118936	recrystallized granite	Sir Samuel (SG 51-13)	1997/2	24
118937	metasandstone	Sir Samuel (SG 51-13)	1997/2	29
118937	metasandstone	Sir Samuel (SG 51-13)	2000/2	211
118940	porphyritic monzogranite	Sir Samuel (SG 51-13)	1997/2	33

Appendix 1 (continued)

GSWA sample no. and rock type		*Map sheet (1:250 000)*	*GSWA Record*	*Page*
118945	granite gneiss	DUKETON (SG 51-14)	1997/2	37
118946	recrystallized leucogranite	DUKETON (SG 51-14)	1997/2	41
118947	porphyritic monzogranite	DUKETON (SG 51-14)	1997/2	45
118948	hornblende–biotite monzogranite	SIR SAMUEL (SG 51-13)	1997/2	49
118950	biotite granodiorite	SIR SAMUEL (SG 51-13)	1997/2	53
118951	hornblende–biotite granodiorite	SIR SAMUEL (SG 51-13)	1997/2	57
118953	porphyritic rhyolite	SIR SAMUEL (SG 51-13)	1997/2	61
118954	feldspar–quartz–mica schist	SIR SAMUEL (SG 51-13)	1997/2	65
118956	glauconite-bearing arenite	PEAK HILL (SG 50-8)	1997/2	106
118957	coarse-grained augen gneiss	PEAK HILL (SG 50-8)	1997/2	94
118958	meta-quartz wacke	PEAK HILL (SG 50-8)	1997/2	102
118961	coarse-grained fragmental chert	ROBINSON RANGE (SG50-7)	1997/2	118
118963	porphyritic syenogranite	PEAK HILL (SG 50-8)	1997/2	90
118964	foliated granite	ROEBOURNE (SF 50-3)	1997/2	163
118965	equigranular biotite monzogranite gneiss	ROEBOURNE (SF 50-3)	1997/2	171
118966	porphyritic granodioritic gneiss	ROEBOURNE (SF 50-3)	1997/2	138
118967	equigranular hornblende–biotite tonalite	ROEBOURNE (SF 50-3)	1997/2	142
118969	fine-grained greywacke sandstone	ROEBOURNE (SF 50-3)	1997/2	146
118972	porphyritic biotite monzogranite	ROEBOURNE (SF 50-3)	1997/2	167
118974	foliated porphyritic hornblende granodiorite	DAMPIER (SF 50-2)	1997/2	150
118975	porphyritic rhyolite	DAMPIER (SF 50-2)	1997/2	154
118976	porphyritic dacite	DAMPIER (SF 50-2)	1997/2	175
118979	quartz–feldspar porphyry	DAMPIER (SF 50-2)	1997/2	179
118990	silicified laminated shale	GLENGARRY (SG 50-12)	1997/2	122
118992	fine-grained quartzite sandstone	PEAK HILL (SG 50-8)	1997/2	110
118995	fine-grained arenite	NABBERU (SG 51-5)	1997/2	114
118996	anhedral-granular hornblende syenite	NABBERU (SG 51-5)	1997/2	74
124755	biotite granodiorite	YARRIE (SF 51-1)	1996/5	153
127320	quartz granophyre	ROEBOURNE (SF 50-3)	1997/2	183
127327	dacite porphyry	ROEBOURNE (SF 50-3)	1998/2	136
127330	volcaniclastic sedimentary rock	ROEBOURNE (SF 50-3)	1998/2	52
127378	welded tuff	ROEBOURNE (SF 50-3)	1998/2	111
132415	quartz–feldspar porphyry	STANLEY (SG 51-6)	2001/2	72
132918	medium-grained seriate quartz syenite	EDJUDINA (SH 51-6)	1997/2	70
136819	quartz–mica schist	ROEBOURNE (SF 50-3)	1998/2	99
136826	equigranular biotite–hornblende tonalite gneiss	DAMPIER (SF 50-2)	1997/2	158
136844	granite	DAMPIER (SF 50-2)	1998/2	105
136899	volcanigenic sedimentary rock	ROEBOURNE (SF 50-3)	1998/2	120
137251	volcaniclastic sedimentary rock	EDJUDINA (SH 51-6)	1998/2	25
137655	metasandstone	PATERSON RANGE (SF 51-6)	2000/2	235
137657	metasandstone	PATERSON RANGE (SF 51-6)	2001/2	181
137664	biotite monzogranite	PATERSON RANGE (SF 51-6)	2001/2	185
139459	foliated porphyritic biotite monzogranite	GLENBURGH (SG 50-6)	2000/2	10, 18
139463	pegmatite-banded gneiss	GLENBURGH (SG 50-6)	2002/2	189
139464	foliated porphyritic biotite monzogranite	GLENBURGH (SG 50-6)	2000/2	14, 22
139466	foliated biotite–muscovite–garnet granodiorite	GLENBURGH (SG 50-6)	2000/2	26
139467	pegmatite-banded monzogranitic gneiss	GLENBURGH (SG 50-6)	2000/2	30
139468	foliated porphyritic biotite monzogranite	GLENBURGH (SG 50-6)	2000/2	34
139507	fine lithic conglomerate	TRAINOR (SG 51-2)	1997/2	126
139508	thinly laminated quartz siltstone	TRAINOR (SG 51-2)	1997/2	130
141936	welded tuff	ROEBOURNE (SF 50-3)	1998/2	56
141973	biotite monzogranite	PYRAMID (SF 50-7)	1998/2	123
141977	granite	PYRAMID (SF 50-7)	1998/2	126
142170	foliated biotite monzogranite	MARBLE BAR (SF 50-8)	1999/2	97
142176	megacrystic foliated biotite monzogranite	PYRAMID (SF 50-7)	1999/2	101
142188	subarkose	PYRAMID (SF 50-7)	1999/2	104
142430	monzogranite	ROEBOURNE (SF 50-3)	1999/2	108
142433	tonalite	DAMPIER (SF 50-2)	1998/2	102
142436	micromonzonite dyke	YARRALOOLA (SF 50-6)	1998/2	90
142438	granodiorite	YARRALOOLA (SF 50-6)	1999/2	112
142535	foliated hornblende–biotite tonalite	YARRALOOLA (SF 50-6)	1998/2	93
142657	granodiorite	YARRALOOLA (SF 50-6)	1999/2	115
142661	foliated biotite tonalite	YARRALOOLA (SF 50-6)	1998/2	96
142802	biotite–muscovite monzogranite gneiss	BOORABBIN (SH 51-13)	1997/2	86
142803	biotite monzogranite	BOORABBIN (SH 51-13)	1997/2	98
142807	foliated tonalite	EDJUDINA (SH 51-6)	1997/2	78
142810	quartz syenite	SIR SAMUEL (SG 51-13)	1998/2	22

Appendix 1 (continued)

GSWA sample no. and rock type		*Map sheet (1:250 000)*	*GSWA Record*	*Page*
142811	quartz diorite	Sir Samuel (SG 51-13)	1998/2	15
142813	granite gneiss	Sir Samuel (SG 51-13)	1998/2	6
142815	foliated biotite monzogranite	Kingston (SG 51-10)	1998/2	12
142816	biotite monzogranite	Wiluna (SG 51-9)	1998/2	9
142817	porphyritic dacite	Wiluna (SG 51-9)	1998/2	19
142821	porphyritic rhyolite	Sir Samuel (SG 51-13)	1997/2	82
142825	coarse-grained syenite	Yarrie (SF 51-1)	1998/2	148
142825	coarse-grained syenite	Yarrie (SF 51-1)	2002/2	258
142828	heterogeneous granodiorite gneiss	Yarrie (SF 51-1)	1998/2	81
142830	volcanigenic sedimentary rock	Roebourne (SF 50-3)	1998/2	63
142832	metamorphosed intermediate rock	Yarraloola (SF 50-6)	2000/2	66
142835	tonalitic gneiss	Yarraloola (SF 50-6)	1999/2	119
142836	volcaniclastic sedimentary rock	Port Hedland (SF 50-4)	1998/2	66
142842	volcaniclastic sedimentary rock	Pyramid (SF 50-7)	1998/2	59
142847	granite gneiss	Robinson Range (SG 50-7)	1998/2	172
142848	foliated biotite monzogranite	Robinson Range (SG 50-7)	1999/2	17
142849	coarse-grained granite gneiss	Robinson Range (SG 50-7)	1998/2	176
142850	foliated monzogranite	Robinson Range (SG 50-7)	1999/2	21
142851	recrystallized monzogranite	Robinson Range (SG 50-7)	1998/2	180
142852	recrystallized monzogranite dyke	Robinson Range (SG 50-7)	1998/2	183
142853	granite gneiss	Robinson Range (SG 50-7)	1998/2	186
142854	foliated granite dyke	Robinson Range (SG 50-7)	1998/2	190
142855	porphyritic monzogranite	Robinson Range (SG 50-7)	1998/2	194
142856	monzogranite	Robinson Range (SG 50-7)	1998/2	198
142858	granophyre phase in dyke	Kalgoorlie (SG 51-9)	1998/2	41
142859	medium-grained granophyric dolerite	Sir Samuel (SG 51-13)	1998/2	45
142860	conglomeratic metasandstone	Sir Samuel (SG 51-13)	1998/2	48
142863	coarse dolerite	Wiluna (SG 51-9)	2002/2	246
142865	alkali granite	Marble Bar (SF 50-8)	1998/2	151
142867	volcaniclastic sedimentary rock	Yarrie (SF 51-1)	1999/2	122
142869	porphyritic biotite–oligoclase granodiorite	Yarrie (SF 51-1)	1999/2	126
142870	banded biotite tonalite gneiss	Yarrie (SF 51-1)	1999/2	129
142871	porphyritic biotite–oligoclase granodiorite	Yarrie (SF 51-1)	1999/2	133
142874	hornblende–oligoclase granodiorite	Yarrie (SF 51-1)	1999/2	136
142875	quartz–feldspar porphyry dyke	Yarrie (SF 51-1)	1999/2	140
142878	foliated biotite monzogranite	Marble Bar (SF 50-8)	1998/2	154
142879	biotite monzogranite	Marble Bar (SF 50-8)	1998/2	157
142882	biotite monzogranite	Marble Bar (SF 50-8)	1998/2	160
142883	foliated porphyritic syenogranite dyke	Marble Bar (SF 50-8)	1998/2	163
142884	schlieric biotite syenogranite	Marble Bar (SF 50-8)	1998/2	166
142885	biotite monzogranite	Marble Bar (SF 50-8)	1998/2	169
142889	foliated alkali granite	Roebourne (SF 50-3)	1999/2	144
142892	porphyritic rhyolite	Roebourne (SF 50-3)	1999/2	148
142893	schlieric pegmatite-veined monzogranite	Yarraloola (SF 50-6)	1999/2	152
142896	leucocratic gneiss	Robinson Range (SG 50-7)	1998/2	201
142897	schlieric monzogranite	Robinson Range (SG 50-7)	1998/2	204
142900	muscovite–biotite monzogranite	Robinson Range (SG 50-7)	1998/2	207
142901	foliated porphyritic monzogranite	Robinson Range (SG 50-7)	1998/2	211
142902	foliated porphyritic monzogranite dyke	Robinson Range (SG 50-7)	1998/2	215
142903	foliated porphyritic biotite monzogranite	Robinson Range (SG 50-7)	1999/2	24
142905	paragneiss	Robinson Range (SG 50-7)	1998/2	218
142906	coarse porphyritic monzogranite	Robinson Range (SG 50-7)	1998/2	222
142907	biotite monzogranite dyke	Robinson Range (SG 50-7)	1998/2	230
142908	paragneiss	Glenburgh (SG 50-6)	1999/2	28
142909	biotite trondjhemite	Glenburgh (SG 50-6)	1999/2	32
142910	foliated quartz–andesine–biotite–muscovite–garnet paragneiss	Glenburgh (SG 50-6)	1999/2	36
142911	foliated porphyritic biotite monzogranite	Glenburgh (SG 50-6)	1998/2	226
142912	foliated biotite monzogranite	Glenburgh (SG 50-6)	1999/2	40
142913	foliated biotite monzogranite	Robinson Range (SG 50-7)	1999/2	44
142914	biotite–hornblende monzogranite	Robinson Range (SG 50-7)	1999/2	48
142915	foliated biotite monzogranite	Barlee (SH 50-8)	1999/2	173
142919	foliated biotite monzogranite	Barlee (SH 50-8)	1999/2	177
142920	quartz–feldspar porphyry	Barlee (SH 50-8)	1999/2	181
142923	biotite monzogranite	Glenburgh (SG 50-6)	1999/2	51
142924	biotite–muscovite granodiorite	Glenburgh (SG 50-6)	1999/2	55
142925	biotite monzogranite	Glenburgh (SG 50-6)	1999/2	59
142926	foliated biotite tonalite	Glenburgh (SG 50-6)	1999/2	63

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GSWA sample no. and rock type		*Map sheet (1:250 000)*	*GSWA Record*	*Page*
142927	foliated biotite–oligoclase granodiorite	GLENBURGH (SG 50-6)	1999/2	67
142928	biotite tonalite	GLENBURGH (SG 50-6)	1999/2	71
142929	biotite trondjhemite dyke	GLENBURGH (SG 50-6)	1999/2	75
142930	coarse leucocratic (monzogranite) pegmatite	GLENBURGH (SG 50-6)	1999/2	79
142931	biotite–muscovite–oligoclase granodiorite dyke	GLENBURGH (SG 50-6)	1999/2	82
142932	porphyritic granodiorite	GLENBURGH (SG 50-6)	1999/2	86
142933	biotite–hypersthene–clinopyroxene–andesine mafic granulite	GLENBURGH (SG 50-6)	1999/2	90
142934	biotite monzogranite	PORT HEDLAND (SF 50-4)	2000/2	70
142935	hornblende granodiorite	PORT HEDLAND (SF 50-4)	2000/2	74
142936	leucocratic monzogranite	PYRAMID (SF 50-7)	2000/2	78
142937	leucocratic monzogranite	PYRAMID (SF 50-7)	2000/2	82
142938	biotite–hornblende tonalite	PYRAMID (SF 50-7)	2000/2	86
142941	feldspar–hornblende porphyry	PYRAMID (SF 50-7)	2000/2	90
142942	metasandstone	ROEBOURNE (SF 50-3)	2000/2	93
142943	metasandstone	PYRAMID (SF 50-7)	2000/2	97
142945	plagioclase–hornblende–pyroxene andesite porphyry	PYRAMID (SF 50-7)	2000/2	101
142946	foliated biotite tonalite	PYRAMID (SF 50-7)	2000/2	105
142948	tonalite	PYRAMID (SF 50-7)	2000/2	109
142949	metasandstone	ROEBOURNE (SF 50-3)	2000/2	113
142950	porphyritic biotite monzogranite	ROEBOURNE (SF 50-3)	2000/2	117
142951	sandstone	MARBLE BAR (SF 50-8)	2000/2	121
142952	porphyritic felsic tuff	MARBLE BAR (SF 50-8)	2000/2	126
142962	tonalite	MARBLE BAR (SF 50-8)	2000/2	129
142964	quartz–feldspar gneiss	MARBLE BAR (SF 50-8)	2000/2	133
142965	monzogranite	MARBLE BAR (SF 50-8)	2000/2	137
142966	heterogeneous schlieric granodiorite	MARBLE BAR (SF 50-8)	2000/2	141
142967	biotite monzogranite	MARBLE BAR (SF 50-8)	2000/2	145
142968	foliated biotite tonalite	MARBLE BAR (SF 50-8)	2000/2	148
142972	volcanigenic sedimentary rock	MARBLE BAR (SF 50-8)	2001/2	111
142974	hornblende granodiorite	MARBLE BAR (SF 50-8)	2000/2	152
142975	crystal-lithic tuff	MARBLE BAR (SF 50-8)	2000/2	156
142976	porphyritic granophyre	MARBLE BAR (SF 50-8)	2000/2	160
142977	monzogranite	MARBLE BAR (SF 50-8)	2000/2	164
142978	monzogranite	MARBLE BAR (SF 50-8)	2000/2	168
142980	magnetite monzogranite	NULLAGINE (SF 51-5)	2000/2	172
142981	foliated biotite–hornblende tonalite	NULLAGINE (SF 51-5)	2000/2	175
142982	foliated biotite granodiorite	NULLAGINE (SF 51-5)	2000/2	178
142983	foliated biotite monzogranite	NULLAGINE (SF 51-5)	2000/2	181
142984	pegmatite-banded even-grained orthogneiss	NULLAGINE (SF 51-5)	2000/2	184
142985	coarse-grained foliated biotite tonalite	MARBLE BAR (SF 50-8)	2000/2	188
142986	metasandstone	BYRO (SG 50-10)	2000/2	62
142988	biotite tonalite	GLENBURGH (SG 50-6)	2000/2	38
142994	biotite monzogranite	MENZIES (SH 51-5)	2000/2	217
142999	metasandstone	MENZIES (SH 51-5)	2000/2	221
143803	biotite granodiorite	YARRIE (SF 51-1)	1998/2	139
143805	biotite monzogranite	YARRIE (SF 51-1)	1998/2	142
143806	biotite monzogranite	YARRIE (SF 51-1)	1998/2	145
143807	tonalite	YARRIE (SF 51-1)	1998/2	84
143809	biotite monzogranite	YARRIE (SF 51-1)	1998/2	87
143810	foliated porphyritic biotite monzogranite	YARRIE (SF 51-1)	1998/2	108
143994	quartzite	YARRIE (SF 51-1)	1998/2	73
143995	quartzite	YARRIE (SF 51-1)	1998/2	77
143996	quartzite	YARRIE (SF 51-1)	1998/2	69
144210	rhyodacite	ROEBOURNE (SF 50-3)	1998/2	117
144224	dacite porphyry	ROEBOURNE (SF 50-3)	1999/2	157
144256	rhyolite tuff	ROEBOURNE (SF 50-3)	1998/2	114
144261	rhyolite	ROEBOURNE (SF 50-3)	1998/2	129
144681	agglomeratic rhyolite	NULLAGINE (SF 51-5)	2002/2	89
144683	hornblende–quartz monzonite	NULLAGINE (SF 51-5)	2002/2	167, 262
144993	dacite	YARRALOOLA (SF 50-6)	1998/2	133
148397	hornblende monzogranite	NABBERU (SF 51-5)	1999/2	170
148498	tuffaceous chert	MARBLE BAR (SF 50-8)	2000/2	192
148500	lapilli tuff	PORT HEDLAND (SF 50-4)	1999/2	160
148502	porphyritic tuffaceous rhyolite	NULLAGINE (SF 51-5)	2000/2	195
148509	porphyritic tuffaceous andesite	MARBLE BAR (SF 50-8)	2000/2	199
152956	metasandstone	EDMUND (SF 50-14)	2000/2	231
153188	biotite granodiorite	MARBLE BAR (SF 50-8)	1999/2	163

Appendix 1 (continued)

GSWA sample no. and rock type		*Map sheet (1:250 000)*	*GSWA Record*	*Page*
153190	biotite granodiorite	Marble Bar (SF 50-8)	1999/2	166
153903	basalt	Westwood (SG 51-16)	1999/2	207
153904	basalt	Westwood (SG 51-16)	1999/2	209
153995A	ophitic basalt	Neale (SH 51-4)	2002/2	256
154109	quartz–carbonate diamictite	Westwood (SG 51-16)	1999/2	190
154880	sandstone	Cooper (SG 52-10)	2002/2	67
154881	sandstone	Cooper (SG 52-10)	2002/2	71
156750	granophyric quartz dolerite	Edmund (SF 50-14)	2001/2	10
156751	coarse dolerite	Edmund (SF 50-14)	2001/2	13
159724	foliated biotite monzogranite	Glenburgh (SG 50-6)	2000/2	42
159987	foliated porphyritic biotite granodiorite	Mount Phillips (SG 50-2)	2000/2	46
159995	biotite granodiorite	Glenburgh (SG 50-6)	2000/2	50
159996	biotite monzogranite	Glenburgh (SG 50-6)	2000/2	54
160211	altered biotite tonalite	Marble Bar (SF 50-8)	2002/2	92
160212	biotite–hornblende tonalite	Marble Bar (SF 50-8)	2002/2	96
160218	porphyritic dacite	Marble Bar (SF 50-8)	2002/2	99
160220	tuffaceous rhyolite	Marble Bar (SF 50-8)	2002/2	103
160221	tuffaceous rhyolite	Marble Bar (SF 50-8)	2002/2	106
160442	foliated biotite monzogranite	Pyramid (SF 50-7)	2000/2	203
160498	hornblende–biotite granodiorite	Roebourne (SF 50-3)	2000/2	207
160727	biotite granodiorite	Port Hedland – Bedout Island (SF 50-4)	2001/2	114
160728	biotite monzogranite	Port Hedland – Bedout Island (SF 50-4)	2001/2	117
160730	foliated biotite granodiorite	Port Hedland – Bedout Island (SF 50-4)	2001/2	120
160744	foliated biotite–hornblende granodiorite	Port Hedland – Bedout Island (SF 50-4)	2001/2	123
160745	foliated biotite granodiorite	Port Hedland – Bedout Island (SF 50-4)	2001/2	126
164309	foliated porphyritic biotite granodiorite	Glenburgh (SG 50-6)	2000/2	58
168751	biotite monzogranite	Robinson Range (SG 50-7)	2001/2	21
168901	biotite–hornblende granodiorite	Menzies (SH 51-5)	2000/2	224
168903	biotite monzogranite	Barlee (SH 50-8)	2000/2	228
168908	crystal-lithic tuff	Marble Bar (SF 50-8)	2001/2	129
168909	vitric tuff	Marble Bar (SF 50-8)	2001/2	133
168910	volcaniclastic rock	Marble Bar (SF 50-8)	2001/2	137
168913	dacite	Nullagine (SF 51-5)	2001/2	140
168914	felsic agglomerate	Nullagine (SF 51-5)	2001/2	143
168915	rhyolite	Marble Bar (SF 50-8)	2001/2	140
168918	volcaniclastic sandstone	Marble Bar (SF 50-8)	2001/2	143
168920	porphyritic dacite	Marble Bar (SF 50-8)	2001/2	152
168921	felsic agglomerate	Marble Bar (SF 50-8)	2001/2	155
168922	biotite tonalite	Marble Bar (SF 50-8)	2001/2	158
168923	pegmatite-banded diorite gneiss	Marble Bar (SF 50-8)	2001/2	161
168924	volcaniclastic sedimentary rock	Roebourne (SF 50-3)	2001/2	164
168932	porphyritic granodiorite	Pyramid (SF 50-7)	2001/2	167
168934	biotite monzogranite	Pyramid (SF 50-7)	2001/2	171
168935	volcaniclastic sandstone	Pyramid (SF 50-7)	2001/2	175
168936	monzodiorite	Roebourne (SF 50-3)	2001/2	178
168937	metasandstone	Glenburgh (SG 50-6)	2001/2	24
168939	biotite monzogranite	Glenburgh (SG 50-6)	2001/2	28
168941	biotite tonalite dyke	Glenburgh (SG 50-6)	2001/2	31
168942	porphyritic biotite–muscovite monzogranite gneiss	Glenburgh (SG 50-6)	2001/2	34
168944	quartz–plagioclase–biotite–muscovite paragneiss	Glenburgh (SG 50-6)	2001/2	38
168945	coarse-grained metasandstone	Glenburgh (SG 50-6)	2001/2	42
168946	biotite–muscovite tonalite gneiss	Glenburgh (SG 50-6)	2001/2	46
168947	biotite–muscovite monzogranite gneiss	Glenburgh (SG 50-6)	2001/2	49
168948	porphyritic biotite–muscovite trondhjemite	Glenburgh (SG 50-6)	2001/2	52
168949	porphyritic biotite–muscovite monzogranite	Glenburgh (SG 50-6)	2001/2	55
168950	pegmatite-banded biotite tonalite gneiss	Glenburgh (SG 50-6)	2001/2	58
168951	foliated biotite–muscovite monzogranite	Glenburgh (SG 50-6)	2001/2	62
168952	biotite–hornblende tonalite	Glenburgh (SG 50-6)	2001/2	66
168953	hornblende–biotite microdiorite	Glenburgh (SG 50-6)	2001/2	69
168956	foliated porphyritic biotite granodiorite	Jackson (SH 50-12)	2001/2	75
168959	porphyritic granophyre	Jackson (SH 50-12)	2001/2	78
168960	meta-ignimbrite	Jackson (SH 50-12)	2001/2	81
168961	welded tuffaceous rhyolite	Jackson (SH 50-12)	2001/2	84
168962	metasandstone	Barlee (SH 50-8)	2001/2	87
168963	mylonitized syenogranite	Barlee (SH 50-8)	2001/2	90
168964	foliated monzogranite	Barlee (SH 50-8)	2002/2	193
168965	foliated biotite granodiorite	Barlee (SH 50-8)	2001/2	93

Appendix 1 (continued)

GSWA sample no. and rock type		*Map sheet (1:250 000)*	*GSWA Record*	*Page*
168966	foliated biotite tonalite gneiss	BARLEE (SH 50-8)	2001/2	96
168970	porphyritic biotite syenogranite	BARLEE (SH 50-8)	2001/2	99
168972	quartz diorite gneiss	BARLEE (SH 50-8)	2002/2	196
168973	biotite monzogranite	BARLEE (SH 50-8)	2001/2	102
168974	foliated porphyritic biotite monzogranite	BARLEE (SH 50-8)	2001/2	105
168976	recrystallized biotite monzogranite	JACKSON (SH 50-12)	2002/2	200
168979	metasandstone	WILUNA (SG 51-9)	2002/2	63
168980	granophyric dolerite	STANLEY (SG 51-6)	2002/2	252
168982	granophyric dolerite	STANLEY (SG 51-6)	2002/2	254
168983	metasandstone	STANLEY (SG 51-6)	2002/2	16
168984	biotite monzogranite	STANLEY (SG 51-6)	2002/2	186
168985	biotite pegmatite	STANLEY (SG 51-6)	2002/2	12
168989	coarse volcaniclastic metasandstone	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	109
168990	quartzite	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	113
168991	volcaniclastic metasandstone	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	117
168993	volcaniclastic metasandstone	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	121
168995	altered rhyolite	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	125
168996	altered coarse crystal tuff	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	129
168997	quartzite	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	133
169000	volcaniclastic sandstone	MARBLE BAR (SF 50-8)	2002/2	137
169001	biotite–hornblende–clinopyroxene syenogranite gneiss	BUSSELTON (SI 50-5)	2002/2	178
169002	biotite–hornblende–clinopyroxene–magnetite syenogranite gneiss	BUSSELTON (SI 50-5)	2002/2	182
169003	vesicular rhyolite	KIRKALOCKA (SH 50-3)	2001/2	108
169008	quartz–sericite schist	MARBLE BAR (SF 50-8)	2002/2	141
169011	quartz dolerite	EDMUND (SF 50-14)	2001/2	17
169014	foliated biotite–hornblende quartz diorite	MARBLE BAR (SF 50-8)	2002/2	144
169016	foliated leucocratic biotite quartz diorite	MARBLE BAR (SF 50-8)	2002/2	148
169018	biotite monzogranite	MARBLE BAR (SF 50-8)	2002/2	151
169019	recrystallized biotite–hornblende quartz diorite	MARBLE BAR (SF 50-8)	2002/2	154
169021	leucocratic syenogranite gneiss	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	158
169025	rhyolite	PORT HEDLAND – BEDOUT ISLAND (SF 50-4)	2002/2	171
169030	hornblende–biotite quartz monzodiorite	NULLAGINE (SF 51-5)	2002/2	174
169031	biotite tonalite gneiss	NULLAGINE (SF 51-5)	2002/2	161
169032	hornblende–clinopyroxene–quartz micromonzonite	NULLAGINE (SF 51-5)	2002/2	260
169038	biotite–hornblende granodiorite	NULLAGINE (SF 51-5)	2002/2	164
169048	leucocratic gneiss	MOUNT EGERTON(SG 50-3)	2002/2	24
169050	tonalite gneiss	MOUNT EGERTON(SG 50-3)	2002/2	28
169052	biotite–muscovite monzogranite	MOUNT EGERTON(SG 50-3)	2002/2	31
169053	biotite–muscovite monzogranite	EDMUND (SF 50-14)	2002/2	35
169054	quartz–plagioclase–biotite–orthoclase–muscovite schist	EDMUND (SF 50-14)	2002/2	39
169055	biotite–muscovite monzogranite	EDMUND (SF 50-14)	2002/2	43
169056	quartz–muscovite–biotite–plagioclase–epidote schist	EDMUND (SF 50-14)	2002/2	46
169057	lamprophyre dyke	EDMUND (SF 50-14)	2002/2	244
169058	augen orthogneiss	EDMUND (SF 50-14)	2002/2	50
169059	muscovite–biotite monzogranite	EDMUND (SF 50-14)	2002/2	53
169060	porphyritic syenogranite	EDMUND (SF 50-14)	2002/2	56
169061	lithic quartz sandstone	EDMUND (SF 50-14)	2002/2	20
169062	porphyritic syenogranite	EDMUND (SF 50-14)	2002/2	59
169064	foliated porphyritic monzogranite	BARLEE (SH 50-8)	2002/2	203
169065	biotite syenogranite	BARLEE (SH 50-8)	2002/2	206
169066	quartz–feldspar porphyry	BARLEE (SH 50-8)	2002/2	209
169067	quartz–chlorite schist	YOUANMI (SH 50-4)	2002/2	213
169068	granodiorite gneiss	YOUANMI (SH 50-4)	2002/2	216
169069	foliated biotite syenogranite	YOUANMI (SH 50-4)	2002/2	219
169070	foliated biotite granodiorite	YOUANMI (SH 50-4)	2002/2	222
169071	porphyritic biotite monzogranite	YOUANMI (SH 50-4)	2002/2	225
169074	quartzite	YOUANMI (SH 50-4)	2002/2	228
169075	quartzite	YOUANMI (SH 50-4)	2002/2	232
169076	biotite monzogranite gneiss	YOUANMI (SH 50-4)	2002/2	237
169078	quartz–feldspar porphyry	MENZIES (SH 51-5)	2002/2	240
169117	metasandstone	RUDALL (SF 51-10)	2002/2	75
169118	metasandstone	RUDALL (SF 51-10)	2001/2	189
169119	metasandstone	RUDALL (SF 51-10)	2002/2	80
169120	metasandstone	RUDALL (SF 51-10)	2002/2	84

Appendix 2

Index of map sheets sampled for geochronology data 1994–2001 (Nelson, 1995, 1996, 1997, 1998, 1999, 2000, 2001, this issue)

Map sheet (1:250 000)	*GSWA sample no. and rock type*		*GSWA Record*	*Page*
Augusta (SI 50-9)	112131	hornblende granite gneiss	1996/5	10
Augusta (SI 50-9)	112132	hornblende granite gneiss	1996/5	4
Augusta (SI 50-9)	112134	granite gneiss	1996/5	7
Augusta (SI 50-9)	112135	garnet–biotite–quartz–feldspar augen gneiss	1999/2	194
Augusta (SI 50-9)	112136	garnet–biotite–quartz–feldspar augen gneiss	1999/2	197
Balladonia (SI 51-3)	83667	porphyritic biotite granite	1995/3	71
Barlee (SH 50-8)	142915	foliated biotite monzogranite	1999/2	173
Barlee (SH 50-8)	142919	foliated biotite monzogranite	1999/2	177
Barlee (SH 50-8)	142920	quartz–feldspar porphyry	1999/2	181
Barlee (SH 50-8)	168903	biotite monzogranite	2000/2	228
Barlee (SH 50-8)	168962	metasandstone	2001/2	87
Barlee (SH 50-8)	168963	mylonitized syenogranite	2001/2	90
Barlee (SH 50-8)	168964	foliated monzogranite	2002/2	193
Barlee (SH 50-8)	168965	foliated biotite granodiorite	2001/2	93
Barlee (SH 50-8)	168966	foliated biotite tonalite gneiss	2001/2	96
Barlee (SH 50-8)	168970	porphyritic biotite syenogranite	2001/2	99
Barlee (SH 50-8)	168972	quartz diorite gneiss	2002/2	196
Barlee (SH 50-8)	168973	biotite monzogranite	2001/2	102
Barlee (SH 50-8)	168974	foliated porphyritic biotite monzogranite	2001/2	105
Barlee (SH 50-8)	169064	foliated porphyritic monzogranite	2002/2	203
Barlee (SH 50-8)	169065	biotite syenogranite	2002/2	206
Barlee (SH 50-8)	169066	quartz–feldspar porphyry	2002/2	209
Boorabbin (SH 51-13)	142802	biotite–muscovite monzogranite gneiss	1997/2	86
Boorabbin (SH 51-13)	142803	biotite monzogranite	1997/2	98
Busselton (SI 50-5)	112140	biotite–hornblende monzogranite dyke	1996/5	13
Busselton (SI 50-5)	112143	hornblende–biotite monzogranite gneiss	1996/5	17
Busselton (SI 50-5)	112144A	hornblende–biotite monzogranite gneiss	1996/5	21
Busselton (SI 50-5)	112145	aegirine–augite–quartz syenite gneiss	1999/2	200
Busselton (SI 50-5)	169001	biotite–hornblende–clinopyroxene syenogranite gneiss	2002/2	178
Busselton (SI 50-5)	169002	biotite–hornblende–clinopyroxene–magnetite syenogranite gneiss	2002/2	182
Byro (SG 50-10)	105001	coarse-grained recrystallized monzogranite	1996/5	87
Byro (SG 50-10)	105002	dark inclusion phase in orthogneiss	1996/5	91
Byro (SG 50-10)	105004	monzogranite	1996/5	95
Byro (SG 50-10)	105005	leucocratic orthogneiss	1996/5	99
Byro (SG 50-10)	105005	leucocratic orthogneiss	1999/2	9
Byro (SG 50-10)	105007	leucocratic orthogneiss	1996/5	103
Byro (SG 50-10)	105007	leucocratic orthogneiss	1997/2	12
Byro (SG 50-10)	105009	dark inclusion phase in leucocratic gneiss	1996/5	119
Byro (SG 50-10)	105010	leucocratic orthogneiss	1996/5	107
Byro (SG 50-10)	105011	leucocratic granite	1996/5	111
Byro (SG 50-10)	105012	coarse-grained granite	1996/5	131
Byro (SG 50-10)	105014	biotite granite gneiss	1996/5	127
Byro (SG 50-10)	105015	fine-grained porphyritic granite dyke	1996/5	115
Byro (SG 50-10)	105016	granodiorite gneiss	1996/5	135
Byro (SG 50-10)	105017	fine-grained granite	1996/5	123
Byro (SG 50-10)	105018A	leucocratic gneiss	1996/5	139
Byro (SG 50-10)	105018A	leucocratic gneiss	1997/2	18
Byro (SG 50-10)	142986	metasandstone	2000/2	62
Byro (SG50-10)	105007	leucocratic orthogneiss	1999/2	13
Collier (SG 50-4)	91591	porphyritic rhyolite	1995/3	5
Collier (SG 50-4)	112107	granodiorite	1995/3	9
Cooper (SG 52-10)	154880	sandstone	2002/2	67
Cooper (SG 52-10)	154881	sandstone	2002/2	71
Dampier (SF 50-2)	114350	metadacite	1996/5	164
Dampier (SF 50-2)	114356	rhyolite	1996/5	156
Dampier (SF 50-2)	114358	porphyritic rhyolite	1997/2	134
Dampier (SF 50-2)	118974	foliated porphyritic hornblende granodiorite	1997/2	150
Dampier (SF 50-2)	118975	porphyritic rhyolite	1997/2	154
Dampier (SF 50-2)	118976	porphyritic dacite	1997/2	175
Dampier (SF 50-2)	118979	quartz–feldspar porphyry	1997/2	179

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Map sheet (1:250 000)	*GSWA sample no. and rock type*		*GSWA Record*	*Page*
Dampier (SF 50-2)	136826	equigranular biotite–hornblende tonalite gneiss	1997/2	158
Dampier (SF 50-2)	136844	granite	1998/2	105
Dampier (SF 50-2)	142433	tonalite	1998/2	102
Duketon (SG 51-14)	118945	granite gneiss	1997/2	37
Duketon (SG 51-14)	118946	recrystallized leucogranite	1997/2	41
Duketon (SG 51-14)	118947	porphyritic monzogranite	1997/2	45
Edjudina (SH 51-6)	101348	biotite monzogranite	1995/3	172
Edjudina (SH 51-6)	101381	monzogranite	1995/3	179
Edjudina (SH 51-6)	112112	K-feldspar volcanic rock	1995/3	99
Edjudina (SH 51-6)	112153	foliated porphyritic microgranodiorite	1996/5	67
Edjudina (SH 51-6)	112175	volcaniclastic rock	1996/5	59
Edjudina (SH 51-6)	112176	monzodiorite	1996/5	63
Edjudina (SH 51-6)	112177	foliated tonalite	1996/5	71
Edjudina (SH 51-6)	112179	orthogneiss	1995/3	136
Edjudina (SH 51-6)	132918	medium-grained seriate quartz syenite	1997/2	70
Edjudina (SH 51-6)	137251	volcaniclastic sedimentary rock	1998/2	25
Edjudina (SH 51-6)	142807	foliated tonalite	1997/2	78
Edmund (SF 50-14)	152956	metasandstone	2000/2	231
Edmund (SF 50-14)	156750	granophyric quartz dolerite	2001/2	10
Edmund (SF 50-14)	156751	coarse dolerite	2001/2	13
Edmund (SF 50-14)	169011	quartz dolerite	2001/2	17
Edmund (SF 50-14)	169053	biotite–muscovite monzogranite	2002/2	35
Edmund (SF 50-14)	169054	quartz–plagioclase–biotite–orthoclase–muscovite schist	2002/2	39
Edmund (SF 50-14)	169055	biotite–muscovite monzogranite	2002/2	43
Edmund (SF 50-14)	169056	quartz–muscovite–biotite–plagioclase–epidote schist	2002/2	46
Edmund (SF 50-14)	169057	lamprophyre dyke	2002/2	244
Edmund (SF 50-14)	169058	augen orthogneiss	2002/2	50
Edmund (SF 50-14)	169059	muscovite–biotite monzogranite	2002/2	53
Edmund (SF 50-14)	169060	porphyritic syenogranite	2002/2	56
Edmund (SF 50-14)	169061	lithic quartz sandstone	2002/2	20
Edmund (SF 50-14)	169062	porphyritic syenogranite	2002/2	59
Esperance (SI 51-6)	83657A	porphyritic biotite monzogranite	1995/3	63
Esperance (SI 51-6)	83658	hornblende–biotite granodiorite gneiss	1995/3	30
Esperance (SI 51-6)	83659	recrystallized leucogranite	1995/3	59
Esperance (SI 51-6)	83697	biotite monzogranite gneiss	1995/3	56
Esperance (SI 51-6)	83700A	hornblende–biotite syenogranite gneiss	1995/3	53
Glenburgh (SG 50-6)	139459	foliated porphyritic biotite monzogranite	2000/2	10, 18
Glenburgh (SG 50-6)	139463	pegmatite-banded gneiss	2002/2	189
Glenburgh (SG 50-6)	139464	foliated porphyritic biotite monzogranite	2000/2	14, 22
Glenburgh (SG 50-6)	139466	foliated biotite–muscovite–garnet granodiorite	2000/2	26
Glenburgh (SG 50-6)	139467	pegmatite-banded monzogranitic gneiss	2000/2	30
Glenburgh (SG 50-6)	139468	foliated porphyritic biotite monzogranite	2000/2	34
Glenburgh (SG 50-6)	142908	paragneiss	1999/2	28
Glenburgh (SG 50-6)	142909	biotite trondjhemite	1999/2	32
Glenburgh (SG 50-6)	142910	foliated quartz–andesine–biotite–muscovite–garnet paragneiss	1999/2	36
Glenburgh (SG 50-6)	142911	foliated porphyritic biotite monzogranite	1998/2	226
Glenburgh (SG 50-6)	142912	foliated biotite monzogranite	1999/2	40
Glenburgh (SG 50-6)	142923	biotite monzogranite	1999/2	51
Glenburgh (SG 50-6)	142924	biotite–muscovite granodiorite	1999/2	55
Glenburgh (SG 50-6)	142925	biotite monzogranite	1999/2	59
Glenburgh (SG 50-6)	142926	foliated biotite tonalite	1999/2	63
Glenburgh (SG 50-6)	142927	foliated biotite–oligoclase granodiorite	1999/2	67
Glenburgh (SG 50-6)	142928	biotite tonalite	1999/2	71
Glenburgh (SG 50-6)	142929	biotite trondjhemite dyke	1999/2	75
Glenburgh (SG 50-6)	142930	coarse leucocratic (monzogranite) pegmatite	1999/2	79
Glenburgh (SG 50-6)	142931	biotite–muscovite–oligoclase granodiorite dyke	1999/2	82
Glenburgh (SG 50-6)	142932	porphyritic granodiorite	1999/2	86
Glenburgh (SG 50-6)	142933	biotite–hypersthene–clinopyroxene–andesine mafic granulite	1999/2	90
Glenburgh (SG 50-6)	142988	biotite tonalite	2000/2	38
Glenburgh (SG 50-6)	159724	foliated biotite monzogranite	2000/2	42
Glenburgh (SG 50-6)	159995	biotite granodiorite	2000/2	50
Glenburgh (SG 50-6)	159996	biotite monzogranite	2000/2	54
Glenburgh (SG 50-6)	164309	foliated porphyritic biotite granodiorite	2000/2	58
Glenburgh (SG 50-6)	168937	metasandstone	2001/2	24
Glenburgh (SG 50-6)	168939	biotite monzogranite	2001/2	28
Glenburgh (SG 50-6)	168941	biotite tonalite dyke	2001/2	31
Glenburgh (SG 50-6)	168942	porphyritic biotite–muscovite monzogranite gneiss	2001/2	34

Appendix 2 (continued)

Map sheet (1:250 000)	GSWA sample no. and rock type		GSWA Record	Page
Glenburgh (SG 50-6)	168944	quartz–plagioclase–biotite–muscovite paragneiss	2001/2	38
Glenburgh (SG 50-6)	168945	coarse-grained metasandstone	2001/2	42
Glenburgh (SG 50-6)	168946	biotite–muscovite tonalite gneiss	2001/2	46
Glenburgh (SG 50-6)	168947	biotite–muscovite monzogranite gneiss	2001/2	49
Glenburgh (SG 50-6)	168948	porphyritic biotite–muscovite trondhjemite	2001/2	52
Glenburgh (SG 50-6)	168949	porphyritic biotite–muscovite monzogranite	2001/2	55
Glenburgh (SG 50-6)	168950	pegmatite-banded biotite tonalite gneiss	2001/2	58
Glenburgh (SG 50-6)	168951	foliated biotite–muscovite monzogranite	2001/2	62
Glenburgh (SG 50-6)	168952	biotite–hornblende tonalite	2001/2	66
Glenburgh (SG 50-6)	168953	hornblende–biotite microdiorite	2001/2	69
Glengarry (SG 50-12)	118990	silicified laminated shale	1997/2	122
Jackson (SH 50-12)	168956	foliated porphyritic biotite granodiorite	2001/2	75
Jackson (SH 50-12)	168959	porphyritic granophyre	2001/2	78
Jackson (SH 50-12)	168960	meta-ignimbrite	2001/2	81
Jackson (SH 50-12)	168961	welded tuffaceous rhyolite	2001/2	84
Jackson (SH 50-12)	168976	recrystallized biotite monzogranite	2002/2	200
Jubilee (SH 52-5)	118770	olivine basalt	2002/2	248
Jubilee (SH 52-5)	118771	olivine basalt	2002/2	250
Kalgoorlie (SG 51-9)	98255	muscovite–biotite monzogranite	1998/2	29
Kalgoorlie (SG 51-9)	98258	biotite monzogranite	1998/2	35
Kalgoorlie (SG 51-9)	98260	biotite–muscovite monzogranite	1998/2	38
Kalgoorlie (SG 51-9)	98268	biotite monzogranite	1998/2	32
Kalgoorlie (SG 51-9)	142858	granophyre phase in dyke	1998/2	41
Kalgoorlie (SH 51-9)	93901	granodiorite	1995/3	176
Kalgoorlie (SH 51-9)	98256	biotite syenogranite	1995/3	185
Kalgoorlie (SH 51-9)	98267	biotite monzogranite	1995/3	182
Kalgoorlie (SH 51-9)	104951	porphyry	1995/3	118
Kingston (SG 51-10)	142815	foliated biotite monzogranite	1998/2	12
Kirkalocka (SH 50-3)	169003	vesicular rhyolite	2001/2	108
Kurnalpi (SH 51-10)	100710	felsic tuff	1995/3	92
Kurnalpi (SH 51-10)	100726	felsic tuff	1995/3	96
Kurnalpi (SH 51-10)	100758	felsic volcanic breccia	1995/3	104
Kurnalpi (SH 51-10)	104940A	porphyritic metadacite	1995/3	165
Kurnalpi (SH 51-10)	104948A	schistose metadacite	1996/5	47
Kurnalpi (SH 51-10)	104949C	metatrachyte	1995/3	150
Kurnalpi (SH 51-10)	104958	metadacite	1995/3	109
Kurnalpi (SH 51-10)	104958	metadacite	1996/5	75
Kurnalpi (SH 51-10)	104967	quartz–feldspar porphyry	1995/3	132
Kurnalpi (SH 51-10)	104970	dacite breccia	1995/3	141
Kurnalpi (SH 51-10)	104971	metatonalite	1996/5	43
Kurnalpi (SH 51-10)	104973	metadacite porphyry	1995/3	158
Kurnalpi (SH 51-10)	104975	rhyodacite porphyry	1995/3	123
Kurnalpi (SH 51-10)	104979	metadacite breccia	1995/3	162
Kurnalpi (SH 51-10)	112147	porphyritic dacite	1995/3	89
Kurnalpi (SH 51-10)	112151	felsic volcanic rock	1995/3	169
Leonora (SH 51-1)	112159	porphyritic dacite	1995/3	128
Malcolm (SI 51-7)	83662	biotite–hornblende monzogranite gneiss	1995/3	67
Malcolm (SI 51-7)	83663	granodiorite gneiss	1995/3	75
Malcolm (SI 51-7)	112128	muscovite–biotite–sillimanite paragneiss	1995/3	78
Marble Bar (SF 50-8)	142170	foliated biotite monzogranite	1999/2	97
Marble Bar (SF 50-8)	142865	alkali granite	1998/2	151
Marble Bar (SF 50-8)	142878	foliated biotite monzogranite	1998/2	154
Marble Bar (SF 50-8)	142879	biotite monzogranite	1998/2	157
Marble Bar (SF 50-8)	142882	biotite monzogranite	1998/2	160
Marble Bar (SF 50-8)	142883	foliated porphyritic syenogranite dyke	1998/2	163
Marble Bar (SF 50-8)	142884	schlieric biotite syenogranite	1998/2	166
Marble Bar (SF 50-8)	142885	biotite monzogranite	1998/2	169
Marble Bar (SF 50-8)	142951	sandstone	2000/2	121
Marble Bar (SF 50-8)	142952	porphyritic felsic tuff	2000/2	126
Marble Bar (SF 50-8)	142962	tonalite	2000/2	129
Marble Bar (SF 50-8)	142964	quartz–feldspar gneiss	2000/2	133
Marble Bar (SF 50-8)	142965	monzogranite	2000/2	137
Marble Bar (SF 50-8)	142966	heterogeneous schlieric granodiorite	2000/2	141
Marble Bar (SF 50-8)	142967	biotite monzogranite	2000/2	145
Marble Bar (SF 50-8)	142968	foliated biotite tonalite	2000/2	148
Marble Bar (SF 50-8)	142972	volcanigenic sedimentary rock	2001/2	111
Marble Bar (SF 50-8)	142974	hornblende granodiorite	2000/2	152

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Map sheet (1:250 000)	*GSWA sample no. and rock type*		*GSWA Record*	*Page*
MARBLE BAR (SF 50-8)	142975	crystal-lithic tuff	2000/2	156
MARBLE BAR (SF 50-8)	142976	porphyritic granophyre	2000/2	160
MARBLE BAR (SF 50-8)	142977	monzogranite	2000/2	164
MARBLE BAR (SF 50-8)	142978	monzogranite	2000/2	168
MARBLE BAR (SF 50-8)	142985	coarse-grained foliated biotite tonalite	2000/2	188
MARBLE BAR (SF 50-8)	148498	tuffaceous chert	2000/2	192
MARBLE BAR (SF 50-8)	148509	porphyritic tuffaceous andesite	2000/2	199
MARBLE BAR (SF 50-8)	153188	biotite granodiorite	1999/2	163
MARBLE BAR (SF 50-8)	153190	biotite granodiorite	1999/2	166
MARBLE BAR (SF 50-8)	160211	altered biotite tonalite	2002/2	92
MARBLE BAR (SF 50-8)	160212	biotite–hornblende tonalite	2002/2	96
MARBLE BAR (SF 50-8)	160218	porphyritic dacite	2002/2	99
MARBLE BAR (SF 50-8)	160220	tuffaceous rhyolite	2002/2	103
MARBLE BAR (SF 50-8)	160221	tuffaceous rhyolite	2002/2	106
MARBLE BAR (SF 50-8)	168908	crystal-lithic tuff	2001/2	129
MARBLE BAR (SF 50-8)	168909	vitric tuff	2001/2	133
MARBLE BAR (SF 50-8)	168910	volcaniclastic rock	2001/2	137
MARBLE BAR (SF 50-8)	168915	rhyolite	2001/2	140
MARBLE BAR (SF 50-8)	168918	volcaniclastic sandstone	2001/2	143
MARBLE BAR (SF 50-8)	168920	porphyritic dacite	2001/2	152
MARBLE BAR (SF 50-8)	168921	felsic agglomerate	2001/2	155
MARBLE BAR (SF 50-8)	168922	biotite tonalite	2001/2	158
MARBLE BAR (SF 50-8)	168923	pegmatite-banded diorite gneiss	2001/2	161
MARBLE BAR (SF 50-8)	169000	volcaniclastic sandstone	2002/2	131
MARBLE BAR (SF 50-8)	169008	quartz–sericite schist	2002/2	141
MARBLE BAR (SF 50-8)	169014	foliated biotite–hornblende quartz diorite	2002/2	144
MARBLE BAR (SF 50-8)	169016	foliated leucocratic biotite quartz diorite	2002/2	148
MARBLE BAR (SF 50-8)	169018	biotite monzogranite	2002/2	151
MARBLE BAR (SF 50-8)	169019	recrystallized biotite–hornblende quartz diorite	2002/2	154
MENZIES (SH 51-5)	110225	porphyritic metadacite	1996/5	51
MENZIES (SH 51-5)	112114	felsic volcanic rock	1995/3	154
MENZIES (SH 51-5)	112117	biotite monzogranite	1996/5	55
MENZIES (SH 51-5)	142994	biotite monzogranite	2000/2	217
MENZIES (SH 51-5)	142999	metasandstone	2000/2	221
MENZIES (SH 51-5)	168901	biotite–hornblende granodiorite	2000/2	224
MENZIES (SH 51-5)	169078	quartz–feldspar porphyry	2002/2	240
MOUNT EGERTON(SG 50-3)	169048	leucocratic gneiss	2002/2	24
MOUNT EGERTON(SG 50-3)	169050	tonalite gneiss	2002/2	28
MOUNT EGERTON(SG 50-3)	169052	biotite–muscovite monzogranite	2002/2	31
MOUNT PHILLIPS (SG 50-2)	159987	foliated porphyritic biotite granodiorite	2000/2	46
NABBERU (SF 51-5)	148397	hornblende monzogranite	1999/2	170
NABBERU (SG 51-5)	118995	fine-grained arenite	1997/2	114
NABBERU (SG 51-5)	118996	anhedral-granular hornblende syenite	1997/2	74
NEALE (SH 51-4)	153995A	ophitic basalt	2002/2	256
NORSEMAN (SI 51-2)	83666	garnet–biotite monzogranite gneiss	1995/3	45
NORSEMAN (SI 51-2)	83676A	hornblende syenogranite gneiss	1995/3	49
NORSEMAN (SI 51-2)	104963	biotite rhyolite	1995/3	146
NULLAGINE (SF 51-5)	118920	alkali granite	1996/5	143
NULLAGINE (SF 51-5)	118923	granophyre	1996/5	146
NULLAGINE (SF 51-5)	118924	hornblende–biotite granite augen gneiss	1996/5	149
NULLAGINE (SF 51-5)	118925	biotite monzogranite	1999/2	94
NULLAGINE (SF 51-5)	142980	magnetite monzogranite	2000/2	172
NULLAGINE (SF 51-5)	142981	foliated biotite–hornblende tonalite	2000/2	175
NULLAGINE (SF 51-5)	142982	foliated biotite granodiorite	2000/2	178
NULLAGINE (SF 51-5)	142983	foliated biotite monzogranite	2000/2	181
NULLAGINE (SF 51-5)	142984	pegmatite-banded even-grained orthogneiss	2000/2	184
NULLAGINE (SF 51-5)	144681	agglomeratic rhyolite	2002/2	89
NULLAGINE (SF 51-5)	144683	hornblende–quartz monzonite	2002/2	167, 262
NULLAGINE (SF 51-5)	148502	porphyritic tuffaceous rhyolite	2000/2	195
NULLAGINE (SF 51-5)	168913	dacite	2001/2	140
NULLAGINE (SF 51-5)	168914	felsic agglomerate	2001/2	143
NULLAGINE (SF 51-5)	169030	hornblende–biotite quartz monzodiorite	2002/2	174
NULLAGINE (SF 51-5)	169031	biotite tonalite gneiss	2002/2	161
NULLAGINE (SF 51-5)	169032	hornblende–clinopyroxene–quartz micromonzonite	2002/2	260
NULLAGINE (SF 51-5)	169038	biotite–hornblende granodiorite	2002/2	164
PATERSON RANGE (SF 51-6)	104937	coarse-grained biotite monzogranite	1995/3	209
PATERSON RANGE (SF 51-6)	112106	foliated monzogranite	1995/3	222

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Paterson Range (SF 51-6)	118916	biotite monzogranite	1999/2	203
Paterson Range (SF 51-6)	137655	metasandstone	2000/2	235
Paterson Range (SF 51-6)	137657	metasandstone	2001/2	181
Paterson Range (SF 51-6)	137664	biotite monzogranite	2001/2	185
Peak Hill (SG 50-8)	118956	glauconite-bearing arenite	1997/2	106
Peak Hill (SG 50-8)	118957	coarse-grained augen gneiss	1997/2	94
Peak Hill (SG 50-8)	118958	meta-quartz wacke	1997/2	102
Peak Hill (SG 50-8)	118963	porphyritic syenogranite	1997/2	90
Peak Hill (SG 50-8)	118992	fine-grained quartzite sandstone	1997/2	110
Port Hedland – Bedout Island (SF 50-4)	160727	biotite granodiorite	2001/2	114
Port Hedland – Bedout Island (SF 50-4)	160728	biotite monzogranite	2001/2	117
Port Hedland – Bedout Island (SF 50-4)	160730	foliated biotite granodiorite	2001/2	120
Port Hedland – Bedout Island (SF 50-4)	160744	foliated biotite–hornblende granodiorite	2001/2	123
Port Hedland – Bedout Island (SF 50-4)	160745	foliated biotite granodiorite	2001/2	126
Port Hedland – Bedout Island (SF 50-4)	168989	coarse volcaniclastic metasandstone	2002/2	109
Port Hedland – Bedout Island (SF 50-4)	168990	quartzite	2002/2	113
Port Hedland – Bedout Island (SF 50-4)	168991	volcaniclastic metasandstone	2002/2	117
Port Hedland – Bedout Island (SF 50-4)	168993	volcaniclastic metasandstone	2002/2	121
Port Hedland – Bedout Island (SF 50-4)	168995	altered rhyolite	2002/2	125
Port Hedland – Bedout Island (SF 50-4)	168996	altered coarse crystal tuff	2002/2	129
Port Hedland – Bedout Island (SF 50-4)	168997	quartzite	2002/2	133
Port Hedland – Bedout Island (SF 50-4)	169021	leucocratic syenogranite gneiss	2002/2	158
Port Hedland – Bedout Island (SF 50-4)	169025	rhyolite	2002/2	171
Port Hedland (SF 50-4)	142836	volcaniclastic sedimentary rock	1998/2	66
Port Hedland (SF 50-4)	142934	biotite monzogranite	2000/2	70
Port Hedland (SF 50-4)	142935	hornblende granodiorite	2000/2	74
Port Hedland (SF 50-4)	148500	lapilli tuff	1999/2	160
Pyramid (SF 50-7)	141973	biotite monzogranite	1998/2	123
Pyramid (SF 50-7)	141977	granite	1998/2	126
Pyramid (SF 50-7)	142176	megacrystic foliated biotite monzogranite	1999/2	101
Pyramid (SF 50-7)	142188	subarkose	1999/2	104
Pyramid (SF 50-7)	142842	volcaniclastic sedimentary rock	1998/2	59
Pyramid (SF 50-7)	142936	leucocratic monzogranite	2000/2	78
Pyramid (SF 50-7)	142937	leucocratic monzogranite	2000/2	82
Pyramid (SF 50-7)	142938	biotite–hornblende tonalite	2000/2	86
Pyramid (SF 50-7)	142941	feldspar–hornblende porphyry	2000/2	90
Pyramid (SF 50-7)	142943	metasandstone	2000/2	97
Pyramid (SF 50-7)	142945	plagioclase–hornblende–pyroxene andesite porphyry	2000/2	101
Pyramid (SF 50-7)	142946	foliated biotite tonalite	2000/2	105
Pyramid (SF 50-7)	142948	tonalite	2000/2	109
Pyramid (SF 50-7)	160442	foliated biotite monzogranite	2000/2	203
Pyramid (SF 50-7)	168932	porphyritic granodiorite	2001/2	167
Pyramid (SF 50-7)	168934	biotite monzogranite	2001/2	171
Pyramid (SF 50-7)	168935	volcaniclastic sandstone	2001/2	175
Ravensthorpe (SI 51-5)	83649	granite pegmatite	1995/3	33
Ravensthorpe (SI 51-5)	83651	biotite–hornblende monzogranite gneiss	1995/3	37
Ravensthorpe (SI 51-5)	83652	biotite–hornblende granodiorite gneiss	1995/3	41
Ravensthorpe (SI 51-5)	83690	biotite granodiorite gneiss	1995/3	26
Ravensthorpe (SI 51-5)	83691	biotite monzogranite gneiss	1995/3	12
Ravensthorpe (SI 51-5)	83696A	biotite monzogranite gneiss	1995/3	23
Ravensthorpe (SI 51-5)	83701A	biotite monzogranite gneiss	1995/3	15
Ravensthorpe (SI 51-5)	83702	biotite tonalite gneiss	1995/3	19
Ravensthorpe (SI 51-5)	112163	rhyolite	1995/3	82
Ravensthorpe (SI 51-5)	112168	fine-grained sandstone	1996/5	80
Ravensthorpe (SI 51-5)	112170	metasandstone	1996/5	84
Robinson Range (SG 50-7)	142847	granite gneiss	1998/2	172
Robinson Range (SG 50-7)	142848	foliated biotite monzogranite	1999/2	17
Robinson Range (SG 50-7)	142849	coarse-grained granite gneiss	1998/2	176
Robinson Range (SG 50-7)	142850	foliated monzogranite	1999/2	21
Robinson Range (SG 50-7)	142851	recrystallized monzogranite	1998/2	180
Robinson Range (SG 50-7)	142852	recrystallized monzogranite dyke	1998/2	183
Robinson Range (SG 50-7)	142853	granite gneiss	1998/2	186
Robinson Range (SG 50-7)	142854	foliated granite dyke	1998/2	190
Robinson Range (SG 50-7)	142855	porphyritic monzogranite	1998/2	194
Robinson Range (SG 50-7)	142856	monzogranite	1998/2	198
Robinson Range (SG 50-7)	142896	leucocratic gneiss	1998/2	201
Robinson Range (SG 50-7)	142897	schlieric monzogranite	1998/2	204

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ROBINSON RANGE (SG 50-7)	142900	muscovite–biotite monzogranite	1998/2	207
ROBINSON RANGE (SG 50-7)	142901	foliated porphyritic monzogranite	1998/2	211
ROBINSON RANGE (SG 50-7)	142902	foliated porphyritic monzogranite dyke	1998/2	215
ROBINSON RANGE (SG 50-7)	142903	foliated porphyritic biotite monzogranite	1999/2	24
ROBINSON RANGE (SG 50-7)	142905	paragneiss	1998/2	218
ROBINSON RANGE (SG 50-7)	142906	coarse porphyritic monzogranite	1998/2	222
ROBINSON RANGE (SG 50-7)	142907	biotite monzogranite dyke	1998/2	230
ROBINSON RANGE (SG 50-7)	142913	foliated biotite monzogranite	1999/2	44
ROBINSON RANGE (SG 50-7)	142914	biotite–hornblende monzogranite	1999/2	48
ROBINSON RANGE (SG 50-7)	168751	biotite monzogranite	2001/2	21
ROBINSON RANGE (SG50-7)	118961	coarse-grained fragmental chert	1997/2	118
ROEBOURNE (SF 50-3)	114305	bedded felsic tuff	1996/5	160
ROEBOURNE (SF 50-3)	118964	foliated granite	1997/2	163
ROEBOURNE (SF 50-3)	118965	equigranular biotite monzogranite gneiss	1997/2	171
ROEBOURNE (SF 50-3)	118966	porphyritic granodioritic gneiss	1997/2	138
ROEBOURNE (SF 50-3)	118967	equigranular hornblende–biotite tonalite	1997/2	142
ROEBOURNE (SF 50-3)	118969	fine-grained greywacke sandstone	1997/2	146
ROEBOURNE (SF 50-3)	118972	porphyritic biotite monzogranite	1997/2	167
ROEBOURNE (SF 50-3)	127320	quartz granophyre	1997/2	183
ROEBOURNE (SF 50-3)	127327	dacite porphyry	1998/2	136
ROEBOURNE (SF 50-3)	127330	volcaniclastic sedimentary rock	1998/2	52
ROEBOURNE (SF 50-3)	127378	welded tuff	1998/2	111
ROEBOURNE (SF 50-3)	136819	quartz–mica schist	1998/2	99
ROEBOURNE (SF 50-3)	136899	volcanigenic sedimentary rock	1998/2	120
ROEBOURNE (SF 50-3)	141936	welded tuff	1998/2	56
ROEBOURNE (SF 50-3)	142430	monzogranite	1999/2	108
ROEBOURNE (SF 50-3)	142830	volcanigenic sedimentary rock	1998/2	63
ROEBOURNE (SF 50-3)	142889	foliated alkali granite	1999/2	144
ROEBOURNE (SF 50-3)	142892	porphyritic rhyolite	1999/2	148
ROEBOURNE (SF 50-3)	142942	metasandstone	2000/2	93
ROEBOURNE (SF 50-3)	142949	metasandstone	2000/2	113
ROEBOURNE (SF 50-3)	142950	porphyritic biotite monzogranite	2000/2	117
ROEBOURNE (SF 50-3)	144210	rhyodacite	1998/2	117
ROEBOURNE (SF 50-3)	144224	dacite porphyry	1999/2	157
ROEBOURNE (SF 50-3)	144256	rhyolite tuff	1998/2	114
ROEBOURNE (SF 50-3)	144261	rhyolite	1998/2	129
ROEBOURNE (SF 50-3)	160498	hornblende–biotite granodiorite	2000/2	207
ROEBOURNE (SF 50-3)	168924	volcaniclastic sedimentary rock	2001/2	164
ROEBOURNE (SF 50-3)	168936	monzodiorite	2001/2	178
RUDALL (SF 51-10)	104932	garnet–biotite–muscovite syenogranite gneiss	1995/3	188
RUDALL (SF 51-10)	104934	biotite syenogranite gneiss	1995/3	192
RUDALL (SF 51-10)	104938	pegmatite	1995/3	212
RUDALL (SF 51-10)	104980	monzogranite gneiss	1995/3	219
RUDALL (SF 51-10)	104981	biotite–muscovite monzogranite gneiss	1995/3	237
RUDALL (SF 51-10)	104989	muscovite quartzite	1995/3	202
RUDALL (SF 51-10)	110056	biotite–hornblende granodiorite gneiss	1995/3	240
RUDALL (SF 51-10)	111843	biotite–muscovite monzogranite gneiss	1995/3	226
RUDALL (SF 51-10)	111854	biotite–muscovite granodiorite gneiss	1995/3	205
RUDALL (SF 51-10)	112101	biotite–epidote monzogranite gneiss	1996/5	35
RUDALL (SF 51-10)	112102	seriate biotite metamonzogranite	1996/5	25
RUDALL (SF 51-10)	112160	garnet microgneiss	1996/5	39
RUDALL (SF 51-10)	112310	granodiorite gneiss	1995/3	230
RUDALL (SF 51-10)	112341	micromonzogranite (meta-aplite) dyke	1995/3	216
RUDALL (SF 51-10)	112379	biotite monzogranite (augen) gneiss	1995/3	195
RUDALL (SF 51-10)	112397	porphyritic biotite monzogranite (augen) gneiss	1995/3	199
RUDALL (SF 51-10)	113002	granodiorite gneiss	1995/3	234
RUDALL (SF 51-10)	113035	orthogneiss	1996/5	31
RUDALL (SF 51-10)	118580	autolithic quartz–tourmaline mudstone	1999/2	185
RUDALL (SF 51-10)	118914	foliated granite	1996/5	28
RUDALL (SF 51-10)	169117	metasandstone	2002/2	75
RUDALL (SF 51-10)	169118	metasandstone	2001/2	189
RUDALL (SF 51-10)	169119	metasandstone	2002/2	80
RUDALL (SF 51-10)	169120	metasandstone	2002/2	84
SIR SAMUEL (SG 51-13)	118936	recrystallized granite	1997/2	24
SIR SAMUEL (SG 51-13)	118937	metasandstone	1997/2	29
SIR SAMUEL (SG 51-13)	118937	metasandstone	2000/2	211
SIR SAMUEL (SG 51-13)	118940	porphyritic monzogranite	1997/2	33

Appendix 2 (continued)

Map sheet (1:250 000)	*GSWA sample no. and rock type*		*GSWA Record*	*Page*
Sir Samuel (SG 51-13)	118948	hornblende–biotite monzogranite	1997/2	49
Sir Samuel (SG 51-13)	118950	biotite granodiorite	1997/2	53
Sir Samuel (SG 51-13)	118951	hornblende–biotite granodiorite	1997/2	57
Sir Samuel (SG 51-13)	118953	porphyritic rhyolite	1997/2	61
Sir Samuel (SG 51-13)	118954	feldspar–quartz–mica schist	1997/2	65
Sir Samuel (SG 51-13)	142810	quartz syenite	1998/2	22
Sir Samuel (SG 51-13)	142811	quartz diorite	1998/2	15
Sir Samuel (SG 51-13)	142813	granite gneiss	1998/2	6
Sir Samuel (SG 51-13)	142821	porphyritic rhyolite	1997/2	82
Sir Samuel (SG 51-13)	142859	medium-grained granophyric dolerite	1998/2	45
Sir Samuel (SG 51-13)	142860	conglomeratic metasandstone	1998/2	48
Stanley (SG 51-6)	132415	quartz–feldspar porphyry	2001/2	72
Stanley (SG 51-6)	168980	granophyric dolerite	2002/2	252
Stanley (SG 51-6)	168982	granophyric dolerite	2002/2	254
Stanley (SG 51-6)	168983	metasandstone	2002/2	16
Stanley (SG 51-6)	168984	biotite monzogranite	2002/2	186
Stanley (SG 51-6)	168985	biotite pegmatite	2002/2	12
Trainor (SG 51-2)	139507	fine lithic conglomerate	1997/2	126
Trainor (SG 51-2)	139508	thinly laminated quartz siltstone	1997/2	130
Westwood (SG 51-16)	153903	basalt	1999/2	207
Westwood (SG 51-16)	153904	basalt	1999/2	209
Westwood (SG 51-16)	154109	quartz–carbonate diamictite	1999/2	190
Widgiemooltha (SH 51-14)	104964	biotite granodiorite gneiss	1995/3	114
Widgiemooltha (SH 51-14)	112110	felsic volcanic rock	1995/3	85
Wiluna (SG 51-9)	142816	biotite monzogranite	1998/2	9
Wiluna (SG 51-9)	142817	porphyritic dacite	1998/2	19
Wiluna (SG 51-9)	142863	coarse dolerite	2002/2	246
Wiluna (SG 51-9)	168979	metasandstone	2002/2	63
Yarraloola (SF 50-6)	142436	micromonzonite dyke	1998/2	90
Yarraloola (SF 50-6)	142438	granodiorite	1999/2	112
Yarraloola (SF 50-6)	142535	foliated hornblende–biotite tonalite	1998/2	93
Yarraloola (SF 50-6)	142657	granodiorite	1999/2	115
Yarraloola (SF 50-6)	142661	foliated biotite tonalite	1998/2	96
Yarraloola (SF 50-6)	142832	metamorphosed intermediate rock	2000/2	66
Yarraloola (SF 50-6)	142835	tonalitic gneiss	1999/2	119
Yarraloola (SF 50-6)	142893	schlieric pegmatite-veined monzogranite	1999/2	152
Yarraloola (SF 50-6)	144993	dacite	1998/2	133
Yarrie (SF 51-1)	124755	biotite granodiorite	1996/5	153
Yarrie (SF 51-1)	142825	coarse-grained syenite	1998/2	148
Yarrie (SF 51-1)	142825	coarse-grained syenite	2002/2	258
Yarrie (SF 51-1)	142828	heterogeneous granodiorite gneiss	1998/2	81
Yarrie (SF 51-1)	142867	volcaniclastic sedimentary rock	1999/2	122
Yarrie (SF 51-1)	142869	porphyritic biotite–oligoclase granodiorite	1999/2	126
Yarrie (SF 51-1)	142870	banded biotite tonalite gneiss	1999/2	129
Yarrie (SF 51-1)	142871	porphyritic biotite–oligoclase granodiorite	1999/2	133
Yarrie (SF 51-1)	142874	hornblende–oligoclase granodiorite	1999/2	136
Yarrie (SF 51-1)	142875	quartz–feldspar porphyry dyke	1999/2	140
Yarrie (SF 51-1)	143803	biotite granodiorite	1998/2	139
Yarrie (SF 51-1)	143805	biotite monzogranite	1998/2	142
Yarrie (SF 51-1)	143806	biotite monzogranite	1998/2	145
Yarrie (SF 51-1)	143807	tonalite	1998/2	84
Yarrie (SF 51-1)	143809	biotite monzogranite	1998/2	87
Yarrie (SF 51-1)	143810	foliated porphyritic biotite monzogranite	1998/2	108
Yarrie (SF 51-1)	143994	quartzite	1998/2	73
Yarrie (SF 51-1)	143995	quartzite	1998/2	77
Yarrie (SF 51-1)	143996	quartzite	1998/2	69
Youanmi (SH 50-4)	169067	quartz–chlorite schist	2002/2	213
Youanmi (SH 50-4)	169068	granodiorite gneiss	2002/2	216
Youanmi (SH 50-4)	169069	foliated biotite syenogranite	2002/2	219
Youanmi (SH 50-4)	169070	foliated biotite granodiorite	2002/2	222
Youanmi (SH 50-4)	169071	porphyritic biotite monzogranite	2002/2	225
Youanmi (SH 50-4)	169074	quartzite	2002/2	228
Youanmi (SH 50-4)	169075	quartzite	2002/2	232
Youanmi (SH 50-4)	169076	biotite monzogranite gneiss	2002/2	237