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Summary of results. Joint NTGS-GA geochronology project: southern Arunta Region

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Northern Territory Geological Survey
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Northern Territory Government
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ABSTRACT

This record presents new SHRIMP U-Pb zircon geochronology results from the southern Arunta Region that were obtained through the NTGS-GA geochronology project in the period 2000–2003. The samples were collected as part of the geological mapping of MOUNT LIEBIG[1] and MOUNT RENNIE by the Northern Territory Geological Survey in 2000–2002.

Sixteen samples were analysed from the newly defined Warumpi Province, located along the southwestern margin of the Arunta Region. The Warumpi Province in the Northern Territory has been divided into three domains – the amphibolite facies Haasts Bluff Domain in the south, the granulite to upper amphibolite facies Yaya Domain in the north, and the greenschist facies Kintore Domain in the far west. In the Haasts Bluff Domain, the Talipata Granite has an age of 1683 ± 2 Ma, and felsic volcanic rocks of the Peculiar Complex were extruded at 1680 ± 4 Ma. A second period of magmatism in the Haasts Bluff Domain is represented by the Udor Granite, with an age of 1663 ± 4 Ma, and a sample of Glen Helen Metamorphics, which has an age of 1661 ± 8 Ma. Five samples of metasedimentary rocks from the Iwupataka Metamorphic Complex in the Haasts Bluff Domain have maximum deposition ages in the range 1670–1630 Ma. An exception is the Putardi Quartzite, which has a maximum deposition age of 1752 ± 11 Ma, with a different provenance to that of the Iwupataka Metamorphic Complex. In the Kintore Domain, the undeformed Tinki Granite has an age of 1691 ± 4 Ma, which is the oldest recorded age for an igneous rock in the Warumpi Province.

In the Yaya Domain, igneous zircons in four samples of granite and charnockite give ages that range from 1642 ± 3 Ma to 1631 ± 4 Ma. A sample of quartzite from the Yaya Metamorphic Complex has a maximum deposition age of 1760 ± 8 Ma, with a different provenance from the Putardi Quartzite. This is also different to three other samples from the Yaya Metamorphic Complex that were sampled by Kinny (2002) and have maximum deposition ages of 1660 Ma. The Yaya Metamorphic Complex has metamorphic zircon rims with an age of 1636 ± 6 Ma, and metamorphic rims in two charnockites with an age of 1637 ± 2 Ma and 1631 ± 4 Ma grew within error of the time of igneous crystallisation. These ages are interpreted to reflect the Liebig Orogeny. A number of samples from both the Yaya and Haasts Bluff Domains show evidence for resetting or new zircon growth during the Chewings Orogeny, which was previously considered to have occurred at 1610–1600 Ma (Collins *et al* 1995). The most well constrained of these ages are for zircon rims in two samples of the Warumpi Granite, which have ages of 1591 ± 4 Ma and 1585 ± 8 Ma.

Three samples have been analysed from the Aileron Province in northern MOUNT RENNIE. A granite from the Andrew Young Igneous Complex has an age of 1640 ± 6 Ma, whereas adjacent granulite facies metasedimentary rocks of the Nyirripi beds have a maximum deposition age of 1790 ± 12 Ma and metamorphic rims with an age of 1644 ± 9 Ma. Lower amphibolite facies turbiditic metasedimentary rocks of the Lander Rock beds from the Dufaur Hills have a maximum deposition age of 1858 ± 5 Ma.

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[1] Names of 1:250 000 and 1:100 000 mapsheets are shown in large and small capital letters, respectively, eg MOUNT LIEBIG, LIEBIG.

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INTRODUCTION

This record presents new SHRIMP U-Pb zircon geochronology results from the southern Arunta Region that were obtained through the NTGS-GA geochronology project in the period 2000–2003. The samples were collected as part of geological mapping of MOUNT LIEBIG and MOUNT RENNIE by the Northern Territory Geological Survey in 2000–2002. Sixteen of the samples belong to the newly defined Warumpi Province (Close *et al* 2003), and the remaining three are from adjacent regions of the Aileron Province.

The Warumpi Province is located along the southwestern margin of the Arunta Region, and has igneous and sedimentary protolith ages that are most commonly in the range 1690–1600 Ma. In contrast, the Aileron Province to the north is more typical of the Palaeoproterozoic basement of the North Australian Craton, with igneous and sedimentary protoliths that are largely in the range 1860–1710 Ma. The Warumpi Province is interpreted to be an exotic terrane that accreted to the North Australian Craton during the Liebig Orogeny at around 1640 Ma (Close *et al* 2004), and both provinces were reworked during the 1590 Ma Chewings Orogeny. The Warumpi Province in the study region can be divided into the Yaya Domain in the north, which is predominantly granulite facies with voluminous 1640–1630 Ma intrusive rocks, and the amphibolite facies Haasts Bluff Domain in the south. A third domain, known as the Kintore Domain, comprises relatively undeformed greenschist facies rocks in the far west, extending into Western Australia. More detail on the geological setting can be found in Close *et al* (2003, 2004) and detailed descriptions of the geology will be presented in the MOUNT LIEBIG and MOUNT RENNIE explanatory notes (Scrimgeour *et al* in press, Close *et al* in prep). The only previous geochronology from this region can be found in Kinny (2002).

For each sample, there is a separate report which contains a geochronological interpretation as well as sample location and geological context information. The data for each sample can be obtained from the Geoscience Australia geochronology database OZCHRON located at http://www.ga.gov.au/oracle/ozchron/frames.html. A summary of all results from this study is presented in **Table 1**.

SHRIMP analytical procedures

Zircon separates from outcrop samples were obtained using magnetic and density techniques and mounted in epoxy resin, together with standard zircons SL13 (U abundance zircon) and QGNG (Pb/U age standard). The epoxy mount was polished to reveal zircon interiors and photomicrographs were taken in transmitted and reflected light. Cathodoluminescence (CL) images were taken using a Hitachi S 2250-N SEM at the Electron Microscopy Unit of the Australian National University, Canberra.

All isotopic analyses reported here were conducted on the SHRIMP I and SHRIMP II ion microprobes at the Australian National University. The zircon analytical procedures employed are described in Compston *et al* (1984), Williams and Claesson (1987) and Claoué-Long *et al* (1995).

The primary O_2^- ion beam was in the range 2–3.5 nA in intensity for a spot diameter of 20–40 µm. Ionised particles were extracted into the mass spectrometer with a 10 kV potential and counted by a single electron multiplier. Species of Zr, U, Pb and Th were focused into the collector by a cyclic stepping of the magnet. Each analysis represents the average of five to seven scans through the different mass stations.

Calibration of Pb/U ratios was by comparison to the zircon standard QGNG and the power law relationship of Pb^+/U^+ and UO^+/U^+ (Claoué-Long *et al* 1995). The Pb/U ratios have been normalised to an assumed value for QGNG of 0.3324 (equivalent to 1850 Ma). Uranium and thorium abundances have been calculated with reference to SL13 (238 ppm U) and are subject to uncertainty of at least ± 20%, this being the range of U abundance within that reference material. Common Pb corrections were based on individual measured ^{204}Pb abundances and assuming crustal common Pb of the same age in the zircons, as modelled by Stacey and Kramers (1975). Data reduction was carried out using SQUID and ISOPLOT, Microsoft Excel-based macros of Ludwig (1999, 2001). Individual analyses have uncertainties listed in the tables at the 1σ level, whereas final ages are quoted in the text with 95% confidence limits.

Analyses of the QGNG standard were interspersed with the unknowns at the rate of approximately one in four. In addition to their use in Pb/U calibration, the QGNG analyses were used as a monitor of the long-term stability of the ^{207}Pb/^{206}Pb ratios, from which Proterozoic ages are calculated. The monitor is not ideal because the reference age for QGNG is not confidently established. From the available TIMS data an arbitrary reference age of 1850 Ma has been assumed, bearing in mind that other age interpretations are possible. However, it is the oldest of the available age monitors, and its 1850 Ma ^{207}Pb/^{206}Pb age is close to those of the Proterozoic rocks being dated here. The mean ^{207}Pb/^{206}Pb ages measured for QGNG during the 18 analytical sessions are plotted in **Figure 1**. Analytical sessions where average ^{207}Pb/^{206}Pb age results and their assigned errors for QGNG are greater than 0.05% below 1850 Ma had a mass fractionation correction factor applied to the measured ^{207}Pb/^{206}Pb ratios of the unknowns. A mass fractionation correction factor was applied to one analytical session: SHRIMP II-Z4069-February 2003, correction factor 0.68%.

Unit	GA sample no (NTGS sample ID)	Rock type	Easting	Northing	Crystallisation age	Maximum deposition age	Metamorphic age
Warumpi Province							
MOUNT LIEBIG			**(Zone 52)**				
Udor Granite	2000082002 (ML00CJE261)	Biotite granite	705974	7400709	1663 ± 4		1594 ± 12
Talipata Granite	2000082003 (ML00IRS202)	Biotite granite	739943	7413972	1683 ± 2		
Warumpi Granite	2000082004 (ML00DFC129)	Biotite granite	779787	7432504	1639 ± 3		1591 ± 4
Warumpi Granite	2000082005 (ML00IRS282)	Biotite granite	801235	7429847	1642 ± 3		1585 ± 8
Talyi-Talyi Charnockite	2000082007 (ML00IRS261)	Charnockite	722978	7429183	1631 ± 4		
unnamed charnockite	2000082010 (ML00IRS307)	Charnockite	761228	7425439	1637 ± 2		
Glen Helen Metamorphics	2000082008 (ML00IRS220)	Felsic gneiss	791274	7410384	1661 ± 8		
Peculiar Complex	2000082525 (ML00IRS231A)	Rhyolite	723171	7411802	1680 ± 4		
Yaya Metamorphic Complex (quartzite)	2000082009 (ML00DFC130B)	Quartzite	790667	7427178		1760 ± 8	1636 ± 6
Putardi Quartzite	2000082006 (ML00CJE318)	Quartzite	726665	7406448		1752 ± 11	
Ikuntji Metamorphics	2001082529 (ML01CJE354)	Quartzite	785788	7412237		1656 ± 17	
Lizard Schist	2001082528 (ML01IRS437)	Quartzite	729118	7417555		1657 ± 28	
HERMANNSBURG			**(Zone 53)**				
Chewings Range Quartzite	2001082531 (HE02DFC001)	Quartzite	203637	7406282		1669 ± 13	
Metasedimentary rock, Stokes Yard prospect	2002082522 (HE02IRS004)	Metapelite	203637	7406282		1647 ± 21	~1590
MOUNT RENNIE			**(Zone 52)**				
Nguman Metamorphics	2002082515 (MR02DFC123B)	Quartzite	626748	7403456		1630 ± 15	~1590
Tinki Granite	2002082521 (MR01IRS44)	Biotite granite	558618	7424891	1691 ± 4		
Aileron Province							
MOUNT RENNIE			**(Zone 52)**				
Lander Rock beds	2002082504 (MR02CJE107)	Metapsammite	546587	7441292		1858 ± 5	
Nyirripi beds	2002082506 (MR02IRS106)	Cordierite hornfels	578474	7439580		1790 ± 12	1644 ± 9
Andrew Young Igneous Complex (granite)	2002082507 (MR02IRS110)	Biotite granite	576125	7444904	1640 ± 6		

Table 1. Summary of all results contained within this report.

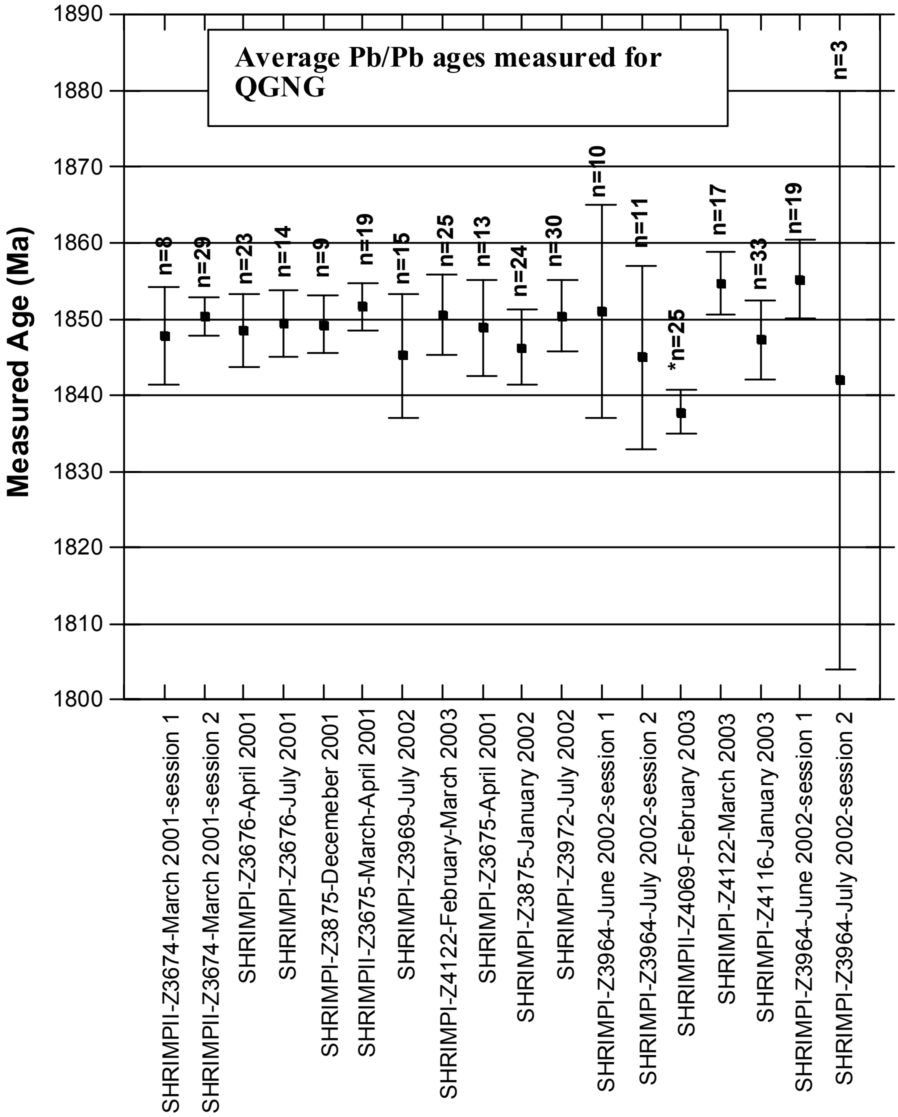

Figure 1. Average QGNG $^{207}Pb/^{206}Pb$ ages for each of the 18 analytical sessions. Error bars are 95% confidence.

SAMPLES ANALYSED

Udor Granite

GA sample ID: 2000082002
NTGS sample ID: ML00CJE261
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: Liebig
Region: Warumpi Province
Grid reference (GDA94): 705974mE, 7400709mN
Formal name: Udor Granite
Sample information (rock description, relative age constraints):
The Udor Granite is a texturally variable but geochemically and geophysically homogeneous granite that extends across a large area of southern Kuta Kuta and southwestern Liebig, with a distinctively low and flat magnetic signature. The granite is typically equigranular to weakly porphyritic, and is relatively leucocratic, commonly containing <5% mafic minerals. Biotite is the dominant mafic mineral, although the granite is distinctive for the common, but not ubiquitous, presence of muscovite. These minerals define a foliation of variable intensity. The proportion of biotite is variable, with the rock type varying from leucogranite to biotite granite. Fe oxides are rare to absent.

The dated sample is a foliated biotite granite, which is largely equigranular, but with slightly larger quartz phenocrysts. The rock has recrystallised during deformation and the mineralogy comprises biotite, quartz, plagioclase, K-feldspar, epidote and titanite.

U-Pb analytical information
Mount no: Z3674
Data acquisition: 19–22 March 2001, SHRIMP II

Zircons

Zircons in this sample are dominated by prisms with pointed to slightly rounded terminations, which are clear to brown in colour. All grains have internal concentric zoning patterns that are consistent with an igneous origin and the majority have a thin (sometimes discontinuous), low-CL-response rim. Only two SHRIMP spots could be targeted on the low-CL-response rims.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP II in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

Twenty-six analyses were carried out on zircons from this sample (**Figure 2**, **Table 2**). One analysis (D11.2) is discordant above an arbitrary threshold of 10% and was removed from further consideration. The remaining analyses are of two kinds: those that sampled the concentrically zoned zircon and two analyses that sampled the low-CL-response rims.

SHRIMP spot analyses that sampled concentrically zoned regions of the zircons range in age between 1725 Ma and 1650 Ma, but are dispersed beyond statistical error (MSWD = 2.0). A statistically significant grouping of nineteen analyses can be distinguished on a probability plot (**Figure 3**). This grouping has a weighted mean $^{207}Pb/^{206}Pb$ age of 1663.1 ± 4.1 Ma (95% confidence), and a statistically significant MSWD = 1.4; this is interpreted to be the crystallisation age of this rock. Also identified on the probability plot are two older zircons (D7.1 and D6.1) which are interpreted to be inherited, and have ages of 1725 Ma and 1715 Ma, respectively. Two analyses which have sampled the low-CL-response rims have a weighted mean $^{207}Pb/^{206}Pb$ age of 1594 ± 12 Ma (95% confidence), apparently recording the 1590 Ma Chewings Orogeny. Two analyses (D26.1 and D20.1) have apparent ages of 1602 ± 36 Ma (σ) and 1629 ± 9 Ma (σ), respectively, and are interpreted as being isotopically mixed between the 1663.1 ± 4.1 Ma magmatic and the 1594 ± 12 Ma metamorphic age defined from this sample. Alternatively, the younger apparent ages of these two analyses may indicate that they have experienced minor radiogenic Pb loss relative to other zircons sampled from the magmatic population.

Talipata Granite

GA sample ID: 2000082003
NTGS sample ID: ML00IRS202
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: Liebig

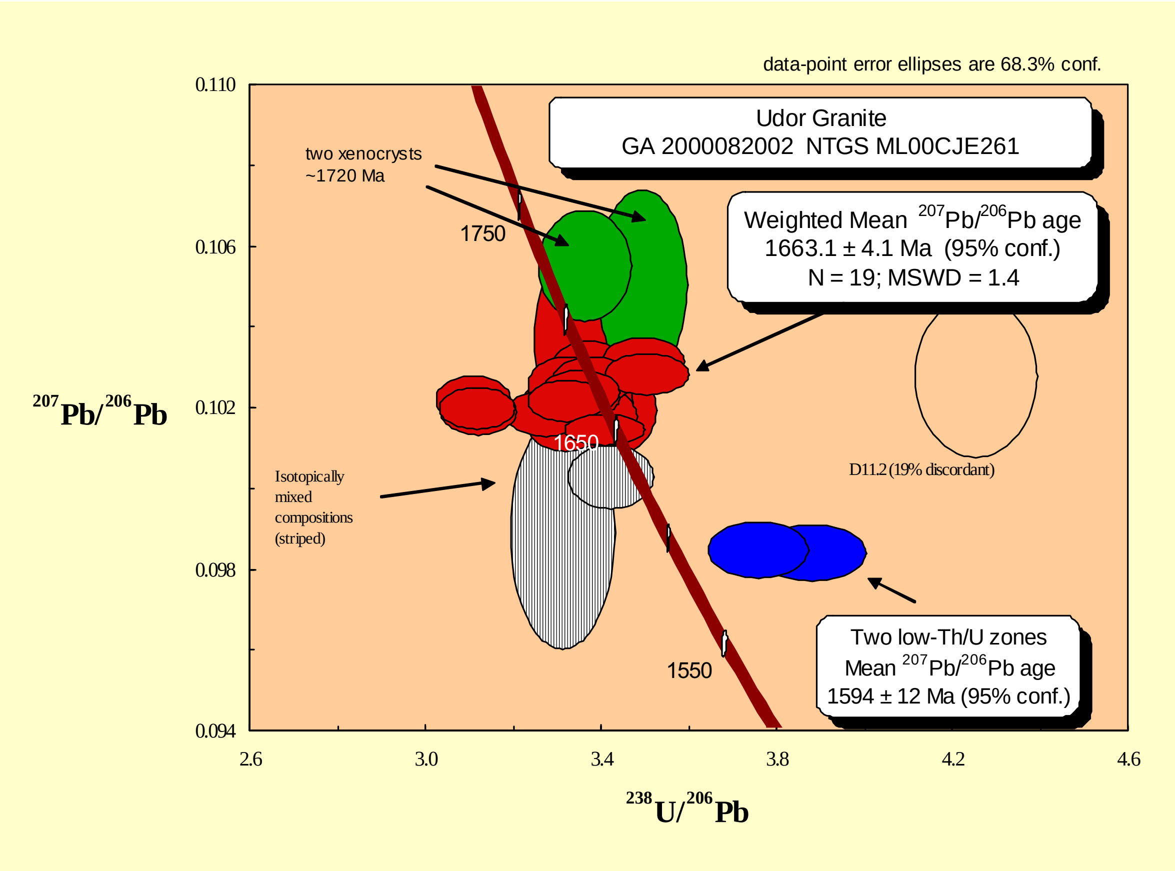

Figure 2. Terra-Wasserberg concordia plot for zircon from Udor Granite, sample GA2000082002.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
magmatic population										
D14.2	-0.04	304	160	0.55	3.401	1.8	0.10143	0.26	1650.4 ± 4.8	-1
D14.1	-0.32	110	112	1.06	3.313	1.8	0.10156	0.43	1652.8 ± 8.0	-3
D12.1	-0.03	153	144	0.98	3.384	1.8	0.10174	0.47	1656.0 ± 8.6	-1
D22.1	-0.43	194	249	1.33	3.267	1.8	0.10182	0.37	1657.5 ± 6.8	-4
D19.1	-1.01	147	156	1.10	3.111	1.8	0.10185	0.37	1658.2 ± 6.8	-8
D9.1	0.29	50	58	1.20	3.424	1.9	0.10191	0.73	1659 ± 14	0
D17.1	-0.99	206	222	1.12	3.107	1.8	0.10194	0.32	1659.7 ± 6.0	-8
D13.1	-0.03	107	111	1.07	3.377	1.8	0.10209	0.48	1662.5 ± 8.8	-1
D28.1	-0.20	292	411	1.46	3.314	2.0	0.10210	0.43	1662.6 ± 8.0	-2
D24.1	-0.22	197	121	0.64	3.314	1.8	0.10214	0.34	1663.3 ± 6.3	-2
D23.1	-0.97	161	164	1.05	3.101	1.8	0.10218	0.38	1664.0 ± 7.1	-8
D21.1	-0.11	176	225	1.32	3.345	1.8	0.10218	0.33	1664.1 ± 6.1	-1
D16.1	-0.09	181	182	1.04	3.347	1.8	0.10235	0.35	1667.1 ± 6.5	-1
D10.1	0.00	80	107	1.39	3.368	2.1	0.10245	0.77	1669 ± 14	0
D18.1	-0.09	107	97	0.94	3.318	1.8	0.10253	0.46	1,670.5 ± 8.5	-2
D15.1	0.05	144	184	1.32	3.376	1.8	0.10263	0.38	1672.3 ± 7.0	0
D11.1	0.40	235	355	1.57	3.499	1.8	0.10278	0.32	1674.9 ± 6.0	3
D8.1	0.34	183	245	1.39	3.492	1.8	0.10309	0.39	1680.5 ± 7.2	3
D27.1	0.44	50	63	1.29	3.353	2.2	0.10370	1.5	1691 ± 28	0
inherited xenocrysts										
D7.1	0.84	33	52	1.64	3.490	2.0	0.10500	1.5	1715 ± 27	5
D6.1	0.17	40	107	2.76	3.358	2.1	0.10551	0.87	1723 ± 16	2
rim										
D25.1	0.85	366	198	0.56	3.881	2.1	0.09834	0.49	1592.8 ± 9.1	7
D29.1	0.66	422	294	0.72	3.756	2.0	0.09843	0.47	1594.6 ± 8.8	5
isotopically mixed?										
D26.1	-0.20	32	58	1.87	3.304	2.4	0.09880	1.9	1602 ± 36	-6
D20.1	-0.02	111	127	1.18	3.416	1.9	0.10025	0.51	1628.7 ± 9.5	-2
discordant										
D11.2	2.36	55	68	1.27	4.260	2.2	0.10270	1.3	1674 ± 24	19

Table 2. SHRIMP analytical results for Udor Granite, sample GA2000082002. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

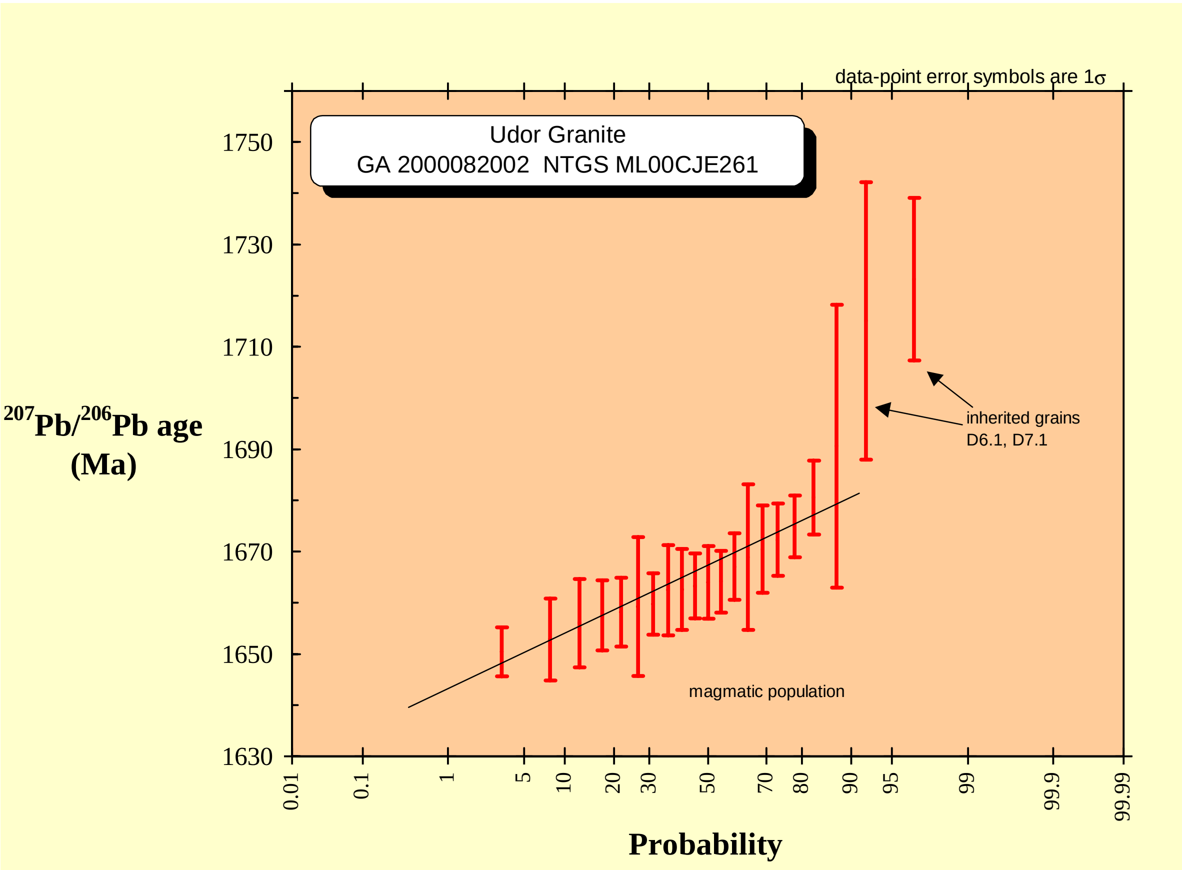

Figure 3. Probability diagram for zircon age data from Udor Granite, sample GA2000082002.

Region: Warumpi Province
Grid reference (GDA94): 739943mE, 7413972mN
Formal name: Talipata Granite
Sample information (rock description, relative age constraints):
The Talipata Granite comprises coarse-grained biotite and biotite-hornblende granite that outcrops in the valley between Berry Pass and Mount Palmer. The rock contains phenocrysts of K-feldspar, typically 1–2 cm in diameter, that are flattened and elongated in a well developed fabric, which is locally gneissic. The dominant mafic mineral is biotite, with variable amounts of hornblende, and minor titanite and Fe-Ti oxides. K-feldspar predominates over plagioclase. Contacts between the Talipata Granite and adjacent Lizard Schist are generally highly strained, but complex contacts of granite and schist, which are transgressive to bedding, and abundant veins of granite and pegmatite in the schist adjacent to the granite, suggest a possible intrusive relationship. The southern margin of the granite is a major fault, with greenschist facies chlorite, muscovite and epidote retrogression of the granite adjacent to the fault. The sample submitted for geochronology is a typical porphyritic biotite granite, which has an amphibolite facies fabric and which has undergone greenschist facies retrogression.

U-Pb analytical information
Mount no: Z3674
Data acquisition: 19–22 March 2001, SHRIMP II

Zircons
Zircons in this sample are clear to light brown and dominated by slightly rounded to subrounded grains, with aspect ratios of about 2, and broken equivalents thereof. They are predominantly concentrically zoned, which is consistent with an igneous origin.

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP II in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios, based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results
Thirty-two analyses were carried out on zircons from this sample; these range in age between 1745 Ma and 1655 Ma (**Figure 4**, **Table 3**). The oldest grain at 1745 Ma (C22.1) is a rounded core and interpreted as a xenocryst. With the exception of the youngest analysis (C26.1), which appears to have lost radiogenic Pb, the remaining thirty grains contribute to a weighted mean $^{207}Pb/^{206}Pb$ age of 1682.5 ± 2.4 Ma (95% confidence; MSWD = 1.3). This is interpreted as the crystallisation age of this rock.

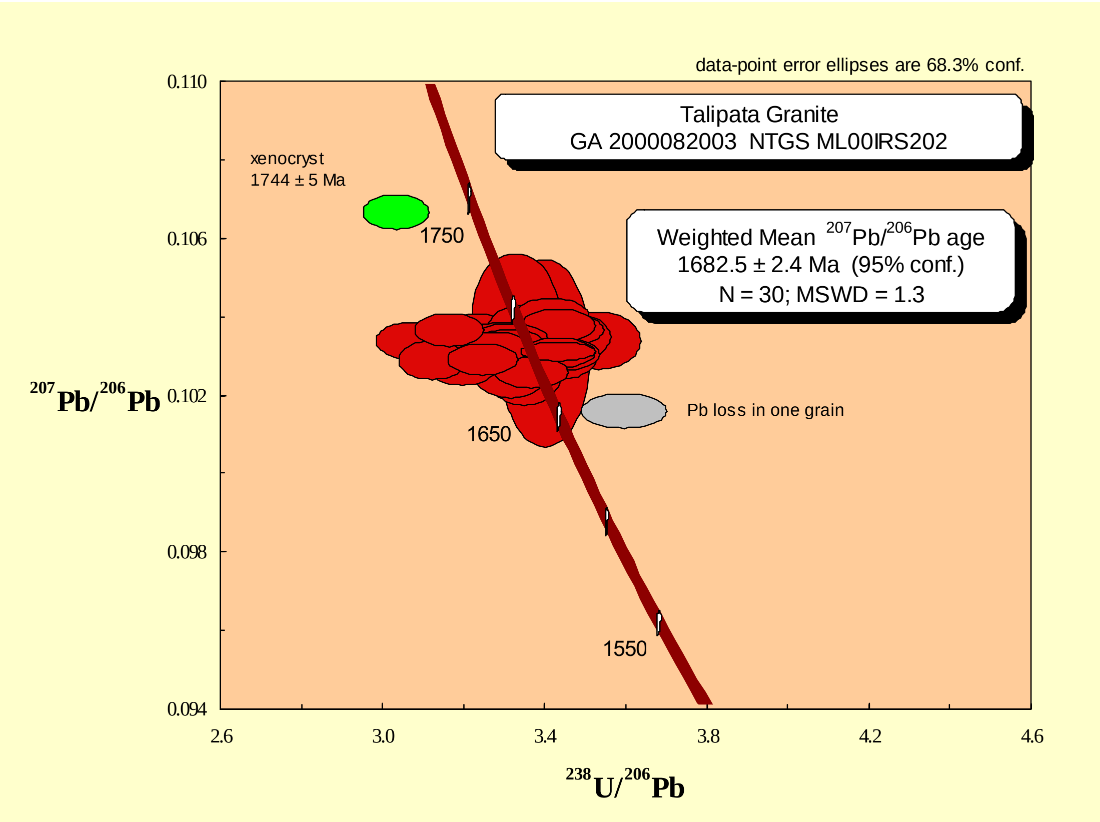

Figure 4. Terra-Wasserberg concordia plot for zircon from Talipata Granite, sample GA2000082003.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
magmatic population										
C10.1	-0.06	183	89	0.50	3.343	1.8	0.10245	0.50	1668.9 ± 9.2	-1
C9.1	-0.19	154	55	0.37	3.309	1.8	0.10253	0.41	1670.4 ± 7.5	-2
C13.1	-0.02	406	225	0.57	3.360	1.8	0.10255	0.26	1670.7 ± 4.9	-1
C19.1	-0.58	203	100	0.51	3.189	1.8	0.10268	0.31	1673.2 ± 5.7	-5
C15.1	-0.86	233	98	0.44	3.113	1.8	0.10286	0.32	1676.3 ± 5.8	-7
C21.1	-0.37	274	136	0.51	3.240	1.8	0.10289	0.26	1676.9 ± 4.8	-3
C2.1	0.24	304	147	0.50	3.430	1.8	0.10293	0.35	1677.6 ± 6.5	2
C1	0.26	349	207	0.61	3.437	1.8	0.10299	0.27	1678.8 ± 5.0	2
C12.1	0.23	246	129	0.54	3.407	1.9	0.10302	0.33	1679.2 ± 6.1	1
C30.1	0.52	44	29	0.67	3.395	2.2	0.10300	1.5	1680 ± 29	1
C4.1	0.24	514	319	0.64	3.427	1.8	0.10305	0.25	1679.9 ± 4.7	2
C18.1	-0.18	224	112	0.52	3.299	1.8	0.10308	0.29	1680.4 ± 5.4	-2
C17.1	0.23	850	377	0.46	3.428	1.8	0.10310	0.16	1680.6 ± 2.9	2
C32.1	-0.13	330	136	0.43	3.288	2.0	0.10319	0.43	1682.3 ± 8.0	-2
C14.1	-0.26	305	148	0.50	3.271	1.8	0.10320	0.25	1682.4 ± 4.7	-2
C16.1	-0.13	273	135	0.51	3.305	1.8	0.10320	0.29	1682.5 ± 5.4	-1
C20.1	-0.36	110	41	0.39	3.226	1.8	0.10333	0.47	1684.8 ± 8.7	-3
C27.1	0.55	351	223	0.66	3.527	2.0	0.10335	0.48	1685.1 ± 8.9	5
C29.1	-0.15	643	361	0.58	3.288	2.0	0.10336	0.30	1685.4 ± 5.5	-2
C24.1	-1.03	280	153	0.57	3.062	2.0	0.10337	0.30	1685.5 ± 5.6	-8
C8.1	0.09	199	89	0.46	3.362	1.8	0.10341	0.42	1686.2 ± 7.8	0
C25.1	-0.11	393	226	0.59	3.306	1.9	0.10343	0.25	1686.5 ± 4.6	-1
C5.1	0.40	252	105	0.43	3.460	1.8	0.10345	0.38	1687.0 ± 7.1	3
C7.1	0.25	184	75	0.42	3.413	1.8	0.10355	0.37	1688.7 ± 6.8	2
C28.1	0.34	938	547	0.60	3.441	1.9	0.10363	0.27	1690.2 ± 4.9	3
C23.1	-0.62	280	146	0.54	3.156	1.8	0.10364	0.26	1690.4 ± 4.8	-5
C11.1	0.08	165	89	0.56	3.343	1.8	0.10369	0.38	1691.1 ± 7.1	0
C6.1	0.34	356	195	0.57	3.426	1.8	0.10374	0.26	1692.0 ± 4.9	2
C3.1	0.30	295	152	0.53	3.411	1.8	0.10397	0.33	1696.3 ± 6.1	2
C31.1	0.12	58	34	0.61	3.322	2.2	0.10410	10	1698 ± 18	0
inherited xenocryst										
C22.1	-0.72	251	89	0.37	3.021	1.8	0.10670	0.28	1743.8± 5.1	-6
Pb loss										
C26.1	0.49	785	189	0.25	3.592	2.0	0.10155	0.28	1652.7± 5.2	4

Table 3. SHRIMP analytical results for Talipata Granite, sample GA2000082003. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Warumpi Granite, west of Papunya

GA sample ID: 2000082004
NTGS sample ID: ML00DFC129
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: Haast Bluff
Region: Warumpi Province
Grid reference (GDA94): 779787mE, 7432504mN
Formal name: Warumpi Granite
Sample information (rock description, relative age constraints):
The Warumpi Granite is a porphyritic biotite granite that forms part of the Illili Suite. It is dominated by foliated to gneissic biotite granite, with rounded phenocrysts of K-feldspar, typically 1–2 cm in diameter, which are locally flattened and elongated in the fabric. K-feldspar phenocrysts locally preserve rapakivi textures. In places, the granite contains a granulite facies fabric and has undergone local partial melting. The mineralogy of the granite comprises quartz, K-feldspar, plagioclase, biotite, titanite and Fe-Ti oxides. Less commonly, hornblende also occurs. The Warumpi Granite intrudes the Inyalinga Granulite and has intrusive contacts (with no clear timing relationships) with the Larrie Granodiorite. This sample is a foliated porphyritic biotite granite, with locally developed leucosomes aligned in the foliation. The rock has rounded K-feldspar phenocrysts and has largely recrystallised in a strain fabric defined by biotite, which may postdate coarser-grained metamorphic recrystallisation. Titanite is common throughout the rock.

U-Pb analytical information
Mount no: Z3674
Data acquisition: 19–22 March 2001, SHRIMP II

Zircons
Zircons in this sample are clear with a pearly lustre and smooth surface texture. They are subrounded to rounded in shape, and range from equant forms to others with aspect ratios of 2. Cathodoluminescence imaging shows that these zircons are

predominantly concentrically zoned. However, some grains have convoluted internal zoning patterns and a small number of grains have cores. All grains are surrounded by a low-CL-response rim that is up to 40 µm thick. The rounded to subrounded shape, smooth surface texture and low-CL-response rims are evidence that this rock has been affected by a post-crystallisation metamorphic event.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP II in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios, based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

Thirty-three analyses were carried out on thirty-one zircons from this sample (**Figures 5–6**, **Table 4**). The results fall into two categories: those that sampled the primary concentric growth zones, and others which have sampled the low-CL-response rims. Compositions measured in the zircon interiors identify one grain as a 2325 Ma xenocryst, whereas the rest group near 1640 Ma. In detail, the dominant group is dispersed beyond uncertainty, but this excess dispersion is contributed to by a second apparent xenocryst at 1675 Ma. The remaining twenty-two analyses are all within error of a weighted mean $^{207}Pb/^{206}Pb$ age of 1639.1 ± 2.9 Ma (95% confidence), which is interpreted to record their igneous crystallisation.

Seven analyses were carried out on the low-CL-response zircon rims from this sample. These analyses range in age from 1595 Ma to 1510 Ma and are characterised by high U contents (1200–2050 ppm) and low Th/U ratios (>0.07). There is a small grouping of three analyses which combine to give a weighted mean age of 1590.5 ± 3.5 Ma (95% confidence; MSWD = 0.70), apparently recording metamorphism during the Chewings Orogeny. Other younger analyses of rims range in age from 1575 Ma to 1510 Ma, indicating that this rock has been affected by a post-Chewings Orogeny event, which has not been constrained. A single analysis (B18.1), on a region of concentric zoning, has an apparent age of 1614 Ma and is interpreted to represent an isotopically mixed composition between the magmatic crystallisation age and the younger metamorphic ages.

Warumpi Granite, east of Papunya

GA sample ID: 2000082005
NTGS sample ID: ML00IRS282
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: Liebig
Region: Warumpi Province
Grid reference (GDA94): 801235mE, 7429847mN
Formal name: Warumpi Granite
Sample information (rock description, relative age constraints):

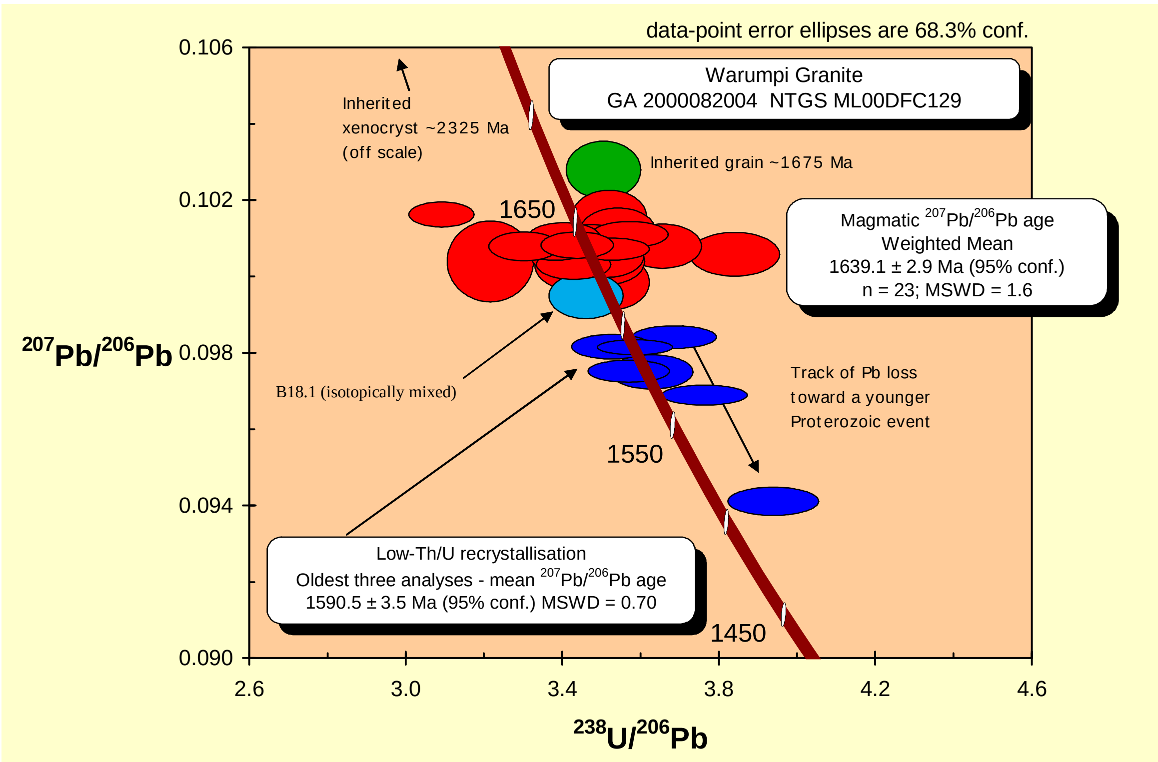

Figure 5. Terra-Wasserberg concordia plot for zircon from Warumpi Granite, sample GA2000082004.

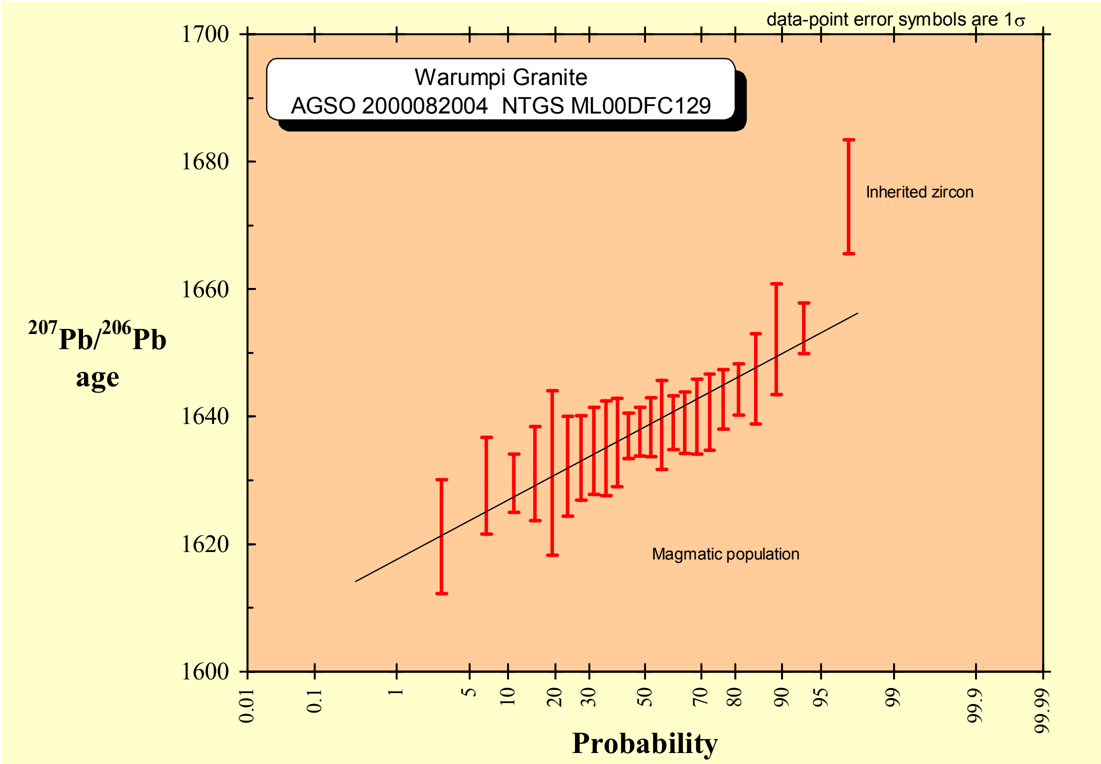

Figure 6. Probability diagram for zircon age data from Warumpi Granite, sample GA2000082004.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
magmatic population										
B4.1	0.12	170	78	0.47	3.520	1.8	0.09984	0.48	1621.2 ± 8.9	1
B19.1	-0.10	154	73	0.49	3.417	1.8	0.10028	0.41	1629.2 ± 7.6	-2
B12.1	-0.13	354	298	0.87	3.424	1.8	0.10030	0.25	1629.6 ± 4.6	-1
B3.1	0.13	225	104	0.47	3.511	1.8	0.10038	0.40	1631.1 ± 7.4	1
B24.1	-0.78	146	86	0.61	3.209	2.3	0.10038	0.69	1631 ± 13	-7
B11.1	0.18	203	95	0.48	3.489	1.8	0.10044	0.42	1632.2 ± 7.8	0
B6.1	0.16	228	122	0.55	3.510	1.8	0.10051	0.36	1633.6 ± 6.6	1
B16.2	0.96	514	79	0.16	3.838	2.0	0.10057	0.37	1634.6 ± 6.9	9
B22.1	-0.10	211	120	0.58	3.406	1.8	0.10059	0.40	1635.1 ± 7.4	-1
B16.1	0.03	193	114	0.61	3.460	1.9	0.10064	0.37	1635.9 ± 6.9	0
B9.1	0.18	649	385	0.61	3.521	1.8	0.10070	0.19	1637.0 ± 3.6	2
B20.1	-0.22	432	350	0.84	3.377	1.8	0.10073	0.21	1637.7 ± 3.8	-2
B17.1	-0.48	348	201	0.60	3.296	1.8	0.10077	0.25	1638.4 ± 4.6	-4
B1.1	0.55	676	355	0.54	3.651	1.8	0.10079	0.38	1638.7 ± 7.0	5
B14.1	-0.06	597	248	0.43	3.433	1.8	0.10081	0.23	1639.1 ± 4.2	-1
B13.1	0.16	367	210	0.59	3.501	1.9	0.10081	0.26	1639.1 ± 4.8	1
B10.1	0.09	255	131	0.53	3.467	1.8	0.10086	0.32	1640.0 ± 5.9	0
B15.1	-0.10	239	125	0.54	3.403	1.8	0.10090	0.32	1640.7 ± 6.0	-1
B21.1	-0.11	309	174	0.58	3.399	1.8	0.10101	0.25	1642.7 ± 4.6	-1
B7.1	0.35	558	296	0.55	3.568	1.8	0.10109	0.21	1644.3 ± 4.0	3
B2.1	0.28	200	103	0.53	3.537	1.8	0.10119	0.38	1646.0 ± 7.1	2
B8.1	0.26	180	85	0.49	3.516	1.8	0.10152	0.47	1652.1 ± 8.7	2
B25.1	-1.16	449	244	0.56	3.084	1.8	0.10162	0.21	1653.9 ± 3.9	-9
inherited xenocrysts										
B5.1	0.44	422	230	0.56	3.500	1.8	0.10276	0.49	1674.5 ± 9.0	3
B14.2	-0.39	397	118	0.31	2.262	2.1	0.14820	0.97	2325 ± 17	-1
rim										
B26.1	0.34	1391	58	0.04	3.937	2.0	0.09413	0.26	1510.7 ± 4.9	3
B31.1	0.31	2087	142	0.07	3.762	1.9	0.09690	0.18	1565.3 ± 3.3	3
B28.1	0.05	1187	68	0.06	3.624	1.9	0.09750	0.31	1576.9 ± 5.7	0
B29.1	-0.10	1827	82	0.05	3.565	2.0	0.09753	0.19	1577.4 ± 3.6	-1
B23.1	0.03	1327	51	0.04	3.582	1.8	0.09815	0.13	1589.2 ± 2.4	0
B27.1	-0.13	1991	113	0.06	3.523	2.0	0.09816	0.22	1589.5 ± 4.1	-1
B30.1	0.31	1812	68	0.04	3.681	1.9	0.09841	0.19	1594.2 ± 3.6	3
isotopically mixed										
B18.1	-0.13	175	88	0.52	3.450	1.8	0.09948	0.39	1614.3 ± 7.2	-2

Table 4. SHRIMP analytical results for Warumpi Granite, sample GA2000082004. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

The Warumpi Granite is a porphyritic biotite granite that forms part of the Illili Suite. It is dominated by foliated to gneissic biotite granite, with rounded phenocrysts of K-feldspar, typically 1–2 cm in diameter, which are locally flattened and elongated in the fabric. K-feldspar phenocrysts locally preserve rapakivi textures. In places, the granite contains a granulite facies fabric and has undergone local partial melting. The mineralogy of the granite comprises quartz, K-feldspar, plagioclase, biotite, titanite and Fe-Ti oxides. Less commonly, hornblende also occurs. The Warumpi Granite intrudes the Inyalinga Granulite and has intrusive contacts (with no clear timing relationships) with the Larrie Granodiorite.

This sample is from a hill (Warumpi), 3 km east of Papunya community, and is a highly strained and locally migmatitic, gneissic rapakivi granite, with rounded phenocrysts of K-feldspar up to 2–3 cm in diameter. Some coarser-grained biotite, together with hornblende, is present. The rock preserves two fabrics: an early high-grade gneissic S_1 fabric, overprinted by a variably developed, higher-strain mylonitic fabric at high angles to S_1. Feldspars and quartz are wrapped by the mylonitic fabric, which includes very fine-grained biotite. Biotite is the dominant mafic mineral, with common hornblende and opaques, and minor titanite.

U-Pb analytical information

Mount no: Z3674

Data acquisition: 4–5 March 2001, SHRIMP II; 19–22 March 2001, SHRIMP II

Zircons

Zircons in this sample have a smooth surface texture, ovoid shape, and are rounded to subrounded. They are generally equant, but also range up to zircons with aspect ratios of 2. Cathodoluminescence imaging shows that primary growth zones are concentric to convoluted. All grains have a thin, high-U, low-CL-response rim, and many have high-U, low-CL-response embayments and patches that are discordant to the primary growth zones and presumably related to the low-CL-response rims. The smooth surface texture, rounded to subrounded shape, high-U, low-CL-response rims, discordant patches and embayments are typical of zircon recrystallisation and/or growth under metamorphic conditions.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP II in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

Forty-nine analyses were made on zircons from this sample (**Figure 7**, **Table 5**). Two analyses (A33.1 and A6.1) are discordant above an arbitrary threshold of 10% and removed from further consideration. A further four analyses (A13.1, A3.2, A37.1, A13.2) are phase overlaps where a single spot has inadvertently sampled both the concentrically zoned magmatic region and

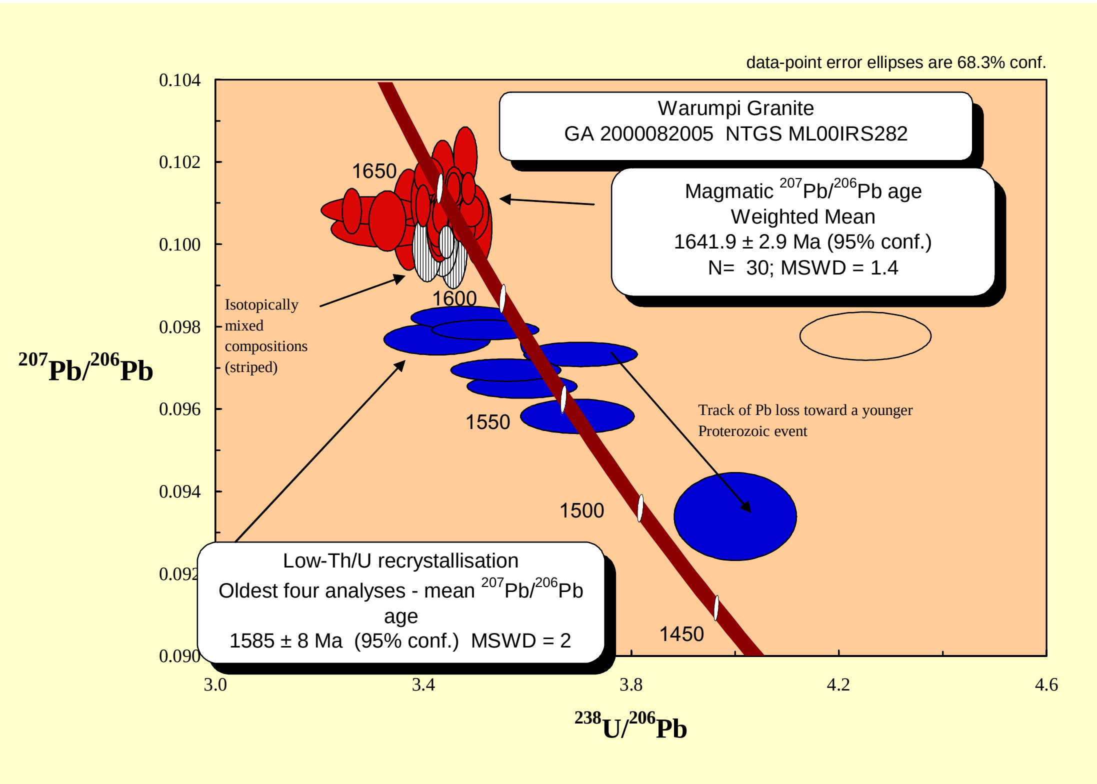

Figure 7. Terra-Wasserberg concordia plot for zircon from Warumpi Granite, sample GA2000082005.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
magmatic population										
A17.1	-0.13	372	249	0.69	3.426	0.35	0.10039	0.42	1631.2 ± 7.8	-1
A42.1	-0.44	1253	413	0.34	3.321	2.0	0.10040	0.29	1631.6 ± 5.3	-4
A22.1	0.18	185	81	0.45	3.504	0.50	0.10044	0.61	1632 ± 11	1
A31.1	-0.09	256	109	0.44	3.427	0.46	0.10045	0.55	1632 ± 10	-1
A24.1	0.04	446	260	0.60	3.480	0.33	0.10046	0.33	1632.6 ± 6.1	0
A3.1	0.06	563	306	0.56	3.467	0.30	0.10056	0.30	1634.5 ± 5.6	0
A31.2	-0.12	323	133	0.42	3.423	0.38	0.10056	0.39	1634.5 ± 7.2	-1
A26.1	-0.39	386	212	0.57	3.326	0.72	0.10061	0.49	1635.3 ± 9.0	-4
A14.1	-0.19	219	99	0.47	3.368	0.65	0.10065	0.81	1636 ± 15	-2
A25.1	-0.07	601	396	0.68	3.4295	0.28	0.10075	0.28	1637.9 ± 5.2	-1
A39.1	-0.07	1095	47	0.04	3.426	1.9	0.10078	0.23	1638.5 ± 4.2	-1
A2.1	-0.02	459	267	0.60	3.428	0.34	0.10081	0.40	1639.1 ± 7.5	-1
A21.1	0.05	404	175	0.45	3.478	0.34	0.10081	0.37	1639.1 ± 6.8	1
A15.1	0.08	231	109	0.49	3.488	0.68	0.10082	0.46	1639.3 ± 8.5	1
A9.2	-0.58	355	364	1.06	3.257	0.37	0.10085	0.36	1639.8 ± 6.7	-5
A32.1	0.13	743	416	0.58	3.489	0.44	0.10085	0.25	1639.9 ± 4.6	1
A35.1	-0.47	1266	463	0.38	3.295	2.0	0.10087	0.22	1640.2 ± 4.0	-4
A1	-0.05	561	331	0.61	3.431	0.30	0.10090	0.30	1640.8 ± 5.7	0
A27.1	-0.14	626	285	0.47	3.3961	0.28	0.10098	0.33	1642.1 ± 6.2	-1
A23.1	-0.16	248	121	0.50	3.398	0.51	0.10109	0.56	1644 ± 10	-1
A19.1	0.11	348	164	0.49	3.464	0.37	0.10117	0.41	1645.6 ± 7.5	1
A18.1	0.11	374	149	0.41	3.475	0.35	0.10117	0.64	1646 ± 12	1
A4.1	0.02	337	166	0.51	3.418	0.38	0.10137	0.54	1649 ± 10	0
A9.1	0.09	804	158	0.20	3.4547	0.25	0.10140	0.26	1650.0 ± 4.8	1
A29.1	0.16	679	326	0.50	3.4829	0.27	0.10141	0.25	1650.1 ± 4.7	1
A28.1	0.09	419	194	0.48	3.456	0.34	0.10143	0.33	1650.4 ± 6.2	1
A5.1	0.05	171	95	0.57	3.444	0.53	0.10153	0.50	1652.4 ± 9.3	1
A30.1	-0.03	452	251	0.57	3.407	0.56	0.10169	0.30	1655.3 ± 5.5	0
A8.1	0.01	265	132	0.52	3.434	0.44	0.10188	0.46	1658.7 ± 8.5	1
A12.1	0.24	263	179	0.70	3.477	0.42	0.10217	0.48	1663.9 ± 8.8	2
discordant										
A33.1	1.36	1765	111	0.06	4.253	2.0	0.09780	0.40	1582.6 ± 7.5	14
A6.1	1.50	1852	62	0.03	5.186	0.26	0.08951	0.62	1415 ± 12	20
low Th/U rims										
A36.1	0.39	1910	417	0.23	4.002	1.9	0.09339	0.76	1496 ± 14	4
A45.1	0.01	2011	137	0.07	3.695	2.0	0.09584	0.28	1544.6 ± 5.3	0
A43.1	-0.16	1443	103	0.07	3.588	1.9	0.09657	0.20	1558.8 ± 3.7	-2
A44.1	-0.19	1597	117	0.08	3.556	2.0	0.09696	0.19	1566.4 ± 3.5	-2
A38.1	0.23	1475	114	0.08	3.702	1.9	0.09736	0.21	1574.1 ± 3.8	2
Chewings-age rims										
A20.1	-0.02	1499	40	0.03	3.5939	0.19	0.09765	0.18	1,579.7 ± 3.4	0
A34.1	-0.48	1580	79	0.05	3.422	2.0	0.09771	0.25	1581.0 ± 4.8	-5
A41.1	-0.17	2181	117	0.06	3.517	1.9	0.09794	0.16	1585.3 ± 3.0	-2
A40.1	-0.26	1654	43	0.03	3.476	2.0	0.09825	0.20	1591.2 ± 3.7	-2
isotopically mixed (not used in interpretation)										
A7.1	-0.06	198	115	0.60	3.454	0.49	0.09992	0.64	1623 ± 12	-1
A11.1	-0.28	149	80	0.55	3.403	0.56	0.09996	0.55	1623 ± 10	-2
A10.1	-0.12	623	330	0.55	3.4407	0.28	0.10010	0.26	1626.0 ± 4.9	-1
A16.1	-0.14	140	70	0.52	3.434	0.57	0.10011	0.56	1626 ± 10	-1
phase overlap (not used in interpretation)										
A13.1	-0.29	264	163	0.64	3.428	0.59	0.09854	0.46	1596.8 ± 8.7	-3
A3.2	-0.07	245	135	0.57	3.482	0.59	0.09906	0.50	1606.5 ± 9.4	-1
A37.1	-0.17	873	383	0.45	3.431	2.0	0.09984	0.27	1621.2 ± 5.0	-2
A13.2	-0.51	249	120	0.50	3.312	0.43	0.10001	0.44	1624.3 ± 8.2	-5

Table 5. SHRIMP analytical results for Warumpi Granite, sample GA2000082005. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

high-U, low-CL-response region. These analyses have been excluded from the data set as they are isotopically mixed and carry no useful information.

Thirty spot analyses which have sampled the zircon primary concentric growth zones range in age between 1665 Ma and 1630 Ma, and combine to give a weighted mean age of 1641.9 ± 2.9 Ma (95% confidence; MSWD = 1.4).

Nine analyses are of the low-CL-response rims. These analyses have elevated U contents (1500–2000 ppm), low Th/U ratios (typically 0.05) and range in age between 1590 Ma and 1495 Ma. Among these analyses there is a small grouping of four grains that combine to give a weighted mean age of 1585 ± 8 Ma (95 % confidence) (MSWD = 2.0), whereas five younger analyses range from 1575 Ma to 1495 Ma and define a Pb loss trend that tracks towards an unconstrained younger age. The high U contents and low Th/U ratios of these rims are typical of, but not ubiquitous to zircon recrystallised and/or grown under metamorphic conditions.

There are also four analyses (A7.1, A11.1, A10.1, A16.1) which have apparent ages of 1625 Ma and are interpreted to represent isotopically mixed compositions between the magmatic crystallisation age and the younger metamorphic ages.

Age interpretations
The crystallisation age of this granite is interpreted to be 1641.9 ± 2.9 Ma, having been defined by thirty spot analyses on regions of concentrically zoned zircon. The nine spot analyses on the low-CL-response rims record post-crystallisation events. A group of four grains which have a weighted mean age of 1585 ± 8 Ma apparently record rim development during the Chewings Orogeny, whereas younger analyses between 1575 Ma and 1495 Ma indicate that this rock has also been affected by a subsequent event.

Talyi-Talyi Charnockite

GA sample ID: 2000082007
NTGS sample ID: ML00IRS261
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: LIEBIG
Region: Warumpi Province
Grid reference (GDA94): 722978mE, 7429183mN
Formal name: Talyi-Talyi Charnockite
Sample information (rock description, relative age constraints):
The Talyi-Talyi Charnockite forms part of the Waluwiya Suite, and outcrops in the Talyi-Talyi Hills and scattered outcrops to the east. The rock is medium grained and weakly porphyritic, with blue-grey phenocrysts of plagioclase feldspar up to 8 mm in diameter. It is generally leucosome-free, with the exception of rare hornblende-bearing incipient partial melts. Igneous ortho- and clinopyroxene are only rarely preserved, and are largely replaced by a metamorphic assemblage including hornblende, biotite, garnet and secondary clinopyroxene, associated with a variably developed fabric. Plagioclase and K-feldspar occur in approximately equal proportions.

The sample selected for geochronology is a porphyritic charnockite, in which the rock has recrystallised in a strain fabric to a hornblende-biotite-garnet-plagioclase-K-feldspar-quartz assemblage, with the exception of preserved igneous phenocrysts of multiply twinned and internally zoned plagioclase up to 5 mm. Plagioclase and K-feldspar occur in approximately equal proportions, with plagioclase forming phenocrysts, but with abundant K-feldspar in the finer-grained matrix. A well developed fabric is defined by biotite that is in textural equilibrium with hornblende and garnet.

U-Pb analytical information
Mount no: Z3676
Data acquisition: 24–27 April 2001, SHRIMP I

Zircons
Zircons in this sample comprise clear, euhedral equant prisms and their broken equivalents. All grains have concentric internal growth zones as well as a thin, structureless low-CL rim, 4–40 μm thick.

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios, based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results
Forty-six analyses were carried out on zircons from this rock (**Figure 8**, **Table 6**). All analyses contribute to a weighted mean $^{207}Pb/^{206}Pb$ age of 1630.9 ± 3.7 Ma (95% confidence; MSWD = 1.3). Although the structureless, low-CL-response zircon rims have higher relative concentrations of U and Th, compared to the oscillatory zoned phases, no difference in age can be detected. Therefore, these rims are interpreted as occurring late in the crystallisation history of this rock. The age 1631 ± 4 Ma derived here can confidently be interpreted as the crystallisation age of this rock.

Unnamed charnockite

GA sample ID: 2000082010
NTGS sample ID: ML00IRS307
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: HAAST BLUFF
Region: Warumpi Province
Grid reference (GDA94): 761228mE, 7425439mN
Informal name: unnamed charnockite
Sample information (rock description, relative age constraints):
An unnamed charnockite occurs in the vicinity of Hill 830, east of Yaya Creek, and intrudes mafic granulite and metasedimentary rocks of the Inyalinga Granulite. It is a pyroxene granite that varies from being medium grained and equigranular, to porphyritic

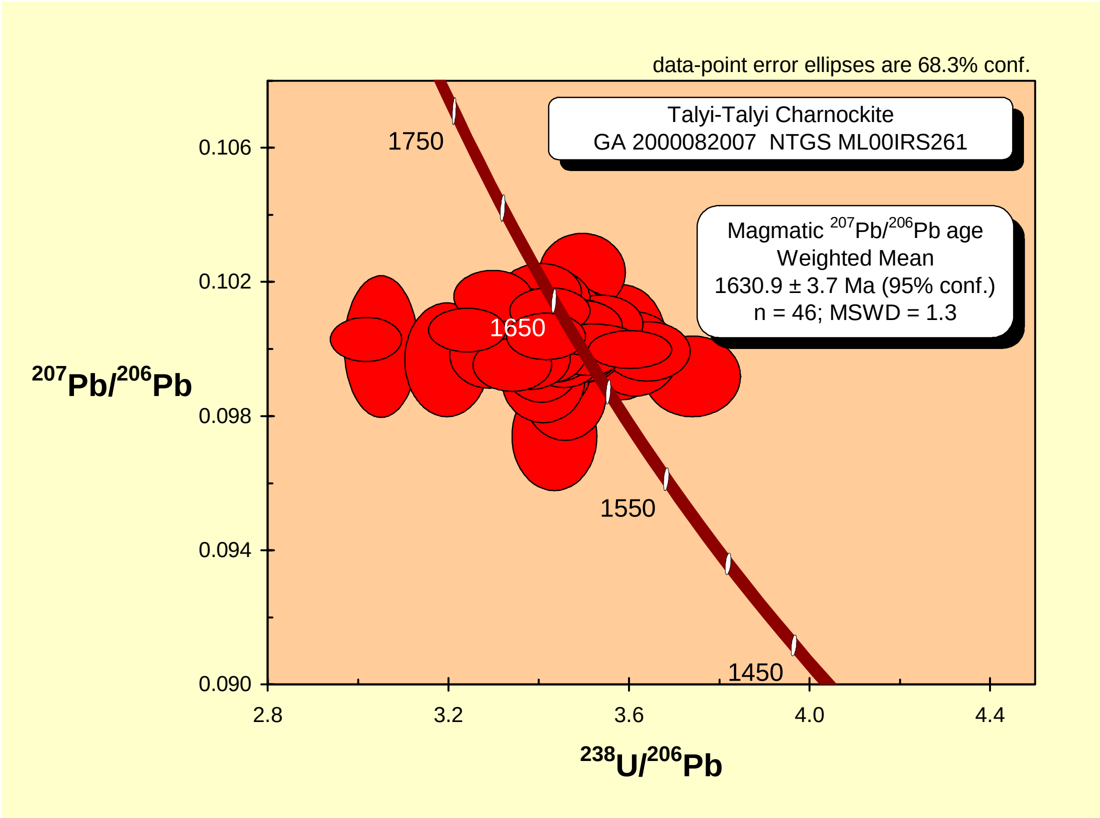

Figure 8. Terra-Wasserberg concordia plot for zircon from Talyi-Talyi Charnockite, sample GA2000082007.

with rounded phenocrysts of plagioclase up to 3 cm. The igneous mineral assemblage contains orthopyroxene, clinopyroxene, plagioclase, quartz and Fe oxides, with less abundant K-feldspar and biotite. Limited metamorphic recrystallisation has resulted in new mineral growth including pyroxenes, hornblende and biotite. The charnockite is most commonly weakly strained to undeformed, but is affected by localised granulite facies high-strain zones. It contains abundant xenoliths of mafic granulite, and also occurs as veins that intrude calc-silicate of the Inyalinga Granulite. As the charnockite intrudes rocks with a granulite facies fabric, but is itself deformed at granulite facies conditions, it is interpreted to have intruded during high-grade metamorphism.

The sample selected for geochronology is weakly porphyritic, with igneous orthopyroxene and clinopyroxene, and small phenocrysts of plagioclase up to 2 mm in diameter. Opaque minerals (magnetite?) are abundant. Between the pyroxenes and plagioclase phenocrysts is a finer-grained granoblastic texture that may have recrystallised at granulite facies. This contains ortho- and clinopyroxene, plagioclase, K-feldspar, quartz, opaques and minor hornblende.

U-Pb analytical information

Mount no: Z3676
Data acquisition: 24–27 April 2001, SHRIMP I

Zircons

Zircons in this sample are clear to pinkish-brown, the majority with embayed margins indicative of chemical corrosion. Internal zoning patterns range from crystals that have oscillatory and convoluted zoning to others that are structureless. Many grains have low-CL-response rims, with thicknesses in the range 10–100 µm. These clearly postdates the period of zircon resorption responsible for the embayed surfaces. The above textural features suggest that the zircons in this rock initially crystallised, then underwent a period of resorption, which was then followed by new zircon growth.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

Forty-three analyses were carried out on zircons from this sample (**Figure 9**, **Table 7**). Two analyses (A10.1 and A31.1) have high common Pb contents and as a result, imprecise age determinations. These analyses were removed from further consideration. Four analyses (A12.1, A13.1, A14.1, A15.1) sampled the structureless low-CL-response rims and show no difference in apparent age or U and Th contents to other analyses that sampled the oscillatory and/or convoluted zoned phases. These four analyses

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
structureless low-CL-response rims										
C34.1	0.14	1520	487	0.33	3.516	1.8	0.10024	0.31	1628.6 ± 5.8	1
C27.1	0.46	1029	473	0.48	3.599	1.7	0.09997	0.37	1623.6 ± 6.9	3
C32.1	-0.57	1011	327	0.33	3.235	1.7	0.10056	0.43	1634.4 ± 7.9	-6
C30.1	-1.56	849	357	0.43	3.010	1.7	0.10028	0.43	1629.2 ± 8.0	-14
C28.1	-0.13	632	299	0.49	3.411	1.7	0.10036	0.45	1630.7± 8.3	-2
C38.1	0.17	561	257	0.47	3.490	1.7	0.10067	0.50	1636.5 ± 9.3	1
C31.1	-0.41	561	233	0.43	3.335	1.7	0.09951	0.52	1615.0 ± 9.6	-5
C46.1	0.13	551	327	0.61	3.483	1.7	0.10069	0.51	1636.9 ± 9.5	1
C29.1	0.65	498	293	0.61	3.488	1.7	0.10057	0.78	1635 ± 14	1
C42.1	0.19	463	344	0.77	3.505	1.8	0.10013	0.61	1627 ± 11	1
C37.1	-0.22	438	276	0.65	3.374	1.7	0.09971	0.61	1619 ± 11	-3
concentric internal growth zones										
C41.1	-0.89	734	236	0.33	3.043	1.8	0.10010	1.4	1625 ± 26	-13
C2.1	0.47	400	311	0.80	3.637	1.7	0.09993	0.58	1623 ± 11	4
C40.1	0.00	386	279	0.75	3.417	1.8	0.10099	0.58	1642 ± 11	-1
C35.1	-0.18	384	213	0.57	3.362	1.8	0.10093	0.56	1641 ± 10	-2
C20.1	-0.04	373	249	0.69	3.418	1.7	0.10112	0.45	1644.8 ± 8.4	-1
C5.1	-0.23	369	270	0.76	3.355	1.7	0.10047	0.53	1632.8 ± 9.8	-3
C36.1	-0.02	347	225	0.67	3.452	1.8	0.09997	0.75	1624 ± 14	-1
C16.1	-0.08	345	212	0.64	3.412	1.7	0.09989	0.61	1622 ± 11	-2
C42.2	0.59	339	201	0.61	3.609	1.8	0.09984	0.82	1621 ± 15	3
C15.1	-0.17	324	287	0.91	3.374	1.7	0.09994	0.61	1,623 ± 11	-3
C8.1	-0.41	318	255	0.83	3.292	1.7	0.10154	0.50	1652.5 ± 9.3	-3
C39.1	0.03	308	222	0.75	3.416	1.8	0.10151	0.56	1652 ± 10	0
C19.1	-0.11	304	204	0.69	3.400	1.8	0.09968	0.84	1618 ± 16	-3
C12.1	0.28	300	181	0.62	3.532	1.8	0.10073	0.56	1638 ± 10	2
C1.1	0.10	285	178	0.64	3.458	1.8	0.10085	0.71	1640 ± 13	0
C45.1	0.41	278	214	0.79	3.491	1.8	0.10227	0.75	1666 ± 14	3
C13.1	-0.02	273	160	0.60	3.453	1.8	0.09862	0.90	1598 ± 17	-3
C23.1	-0.03	261	149	0.59	3.429	1.8	0.09996	0.63	1623 ± 12	-2
C26.1	0.78	258	178	0.71	3.738	1.9	0.09918	0.80	1609 ± 15	5
C10.1	0.31	256	188	0.76	3.502	2.2	0.10016	0.85	1627 ± 16	0
C3.1	-0.05	254	131	0.54	3.399	1.8	0.10166	0.56	1655 ± 10	0
C14.1	0.26	248	189	0.79	3.490	1.8	0.10015	0.76	1627 ± 14	0
C11.1	0.33	246	144	0.60	3.497	1.8	0.10016	0.76	1627 ± 14	0
C44.1	0.36	243	149	0.63	3.504	1.8	0.10040	0.92	1631 ± 17	1
C22.1	0.16	233	155	0.69	3.419	1.8	0.09943	0.88	1613 ± 16	-3
C6.1	-0.28	233	138	0.61	3.316	1.8	0.10094	0.62	1641 ± 11	-4
C18.1	0.07	233	159	0.71	3.413	1.8	0.10054	0.76	1634 ± 14	-1
C7.1	-0.51	231	151	0.67	3.286	1.8	0.09981	0.65	1620 ± 12	-6
C9.1	-0.87	230	151	0.68	3.189	2.0	0.09970	1.1	1618 ± 21	-9
C4.1	-0.07	230	144	0.65	3.423	1.9	0.09966	0.89	1618 ± 17	-2
C17.1	-0.15	226	152	0.70	3.405	1.8	0.09905	0.84	1606 ± 16	-3
C25.1	-0.18	222	150	0.70	3.396	1.8	0.10052	0.54	1634 ± 10	-2
C33.1	0.19	169	100	0.61	3.479	1.9	0.10000	1.0	1625 ± 19	0
C21.1	-0.05	153	81	0.55	3.429	1.8	0.09740	1.1	1575 ± 21	-5
C24.1	0.58	147	79	0.55	3.579	1.8	0.10020	1.1	1628 ± 21	2

Table 6. SHRIMP analytical results for Talyi-Talyi Charnockite, sample GA2000082007. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

were therefore included in the pooled age calculation. All forty-one analyses combine to give a weighted mean $^{207}Pb/^{206}Pb$ age of 1637.1 ± 2.4 Ma (95% confidence; MSWD = 0.94).

The textures of the zircons in this rock suggest that after initial crystallisation they underwent resorption, which was followed by new zircon growth resulting in structureless low-CL-response rims. These separate, but closely spaced events were unable to be resolved by SHRIMP I, but did occur within statistical error of 1637.1 ± 2.4 Ma. This is consistent with the interpretation that this charnockite intruded during high-grade metamorphism in the Liebig Orogeny.

Glen Helen Metamorphics

GA sample ID: 2000082008
NTGS sample ID: ML00IRS220
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: HAAST BLUFF
Region: Warumpi Province
Grid Reference (GDA94): 791274mE, 7410384mN
Formal name: Glen Helen Metamorphics
Sample information (rock description, relative age constraints):

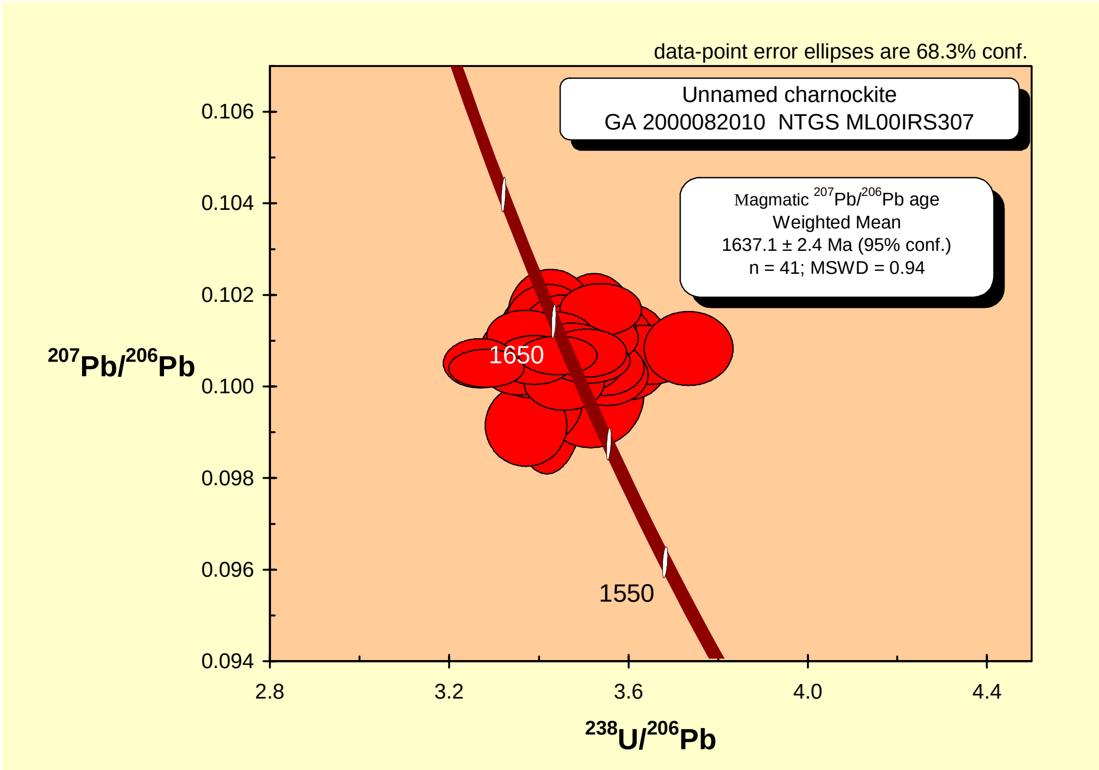

Figure 9. Terra-Wasserberg concordia plot for zircon from unnamed charnockite, sample GA2000082010.

Migmatite and granite of the Glen Helen Metamorphics outcrop on either side of the Belt Range in eastern HAAST BLUFF, and continue west into HERMANNSBURG, where they outcrop more extensively. In MOUNT LEIBIG, the Glen Helen Metamorphics comprise migmatitic felsic orthogneiss, with abundant porphyritic biotite granite, and less common metasedimentary rock and amphibolite. Throughout large regions of the Glen Helen Metamorphics, relatively homogeneous biotite-bearing migmatitic orthogneiss occurs, with variable hornblende content and with leucosomes that define a migmatitic S_1 layering. In places, the migmatitic layering is folded and contorted, whereas elsewhere, it is strongly transposed into an S_2 non-coaxial strain fabric. Foliated, leucosome-free biotite- and/or hornblende-bearing porphyritic granites are commonly intercalated with migmatite. Whole rock geochemistry on migmatite and granite from the Glen Helen Metamorphics indicates that many of the migmatites have a similar origin, although genetically distinct migmatites and granites also occur.

The sample submitted for geochronology is a medium-grained, equigranular to weakly porphyritic biotite granodiorite, with leucosomes oriented parallel to the dominant S_1 fabric, and a second generation along narrow shear bands (S_2). Locally, these appear likely to be partial melts, suggesting that the granite is weakly migmatitic, although elsewhere, they are coarser grained and more pegmatitic. Late retrogression of plagioclase and biotite to epidote, chlorite and sericite occurs through the rock. Biotite comprises 5–10% of the mineral assemblage. The rock occurs within 50 m of outcropping biotite-muscovite schist of the Ikuntji Metamorphics, but it is not clear whether this unit intrudes, or whether it forms basement to the metasedimentary rocks. The sample is geochemically different from the sample of Glen Helen Metamorphics from north of Belt Range, which has an interpreted igneous age of 1688 ± 16 Ma (Kinny 2002). Samples of Glen Helen Metamorphics from HERMANNSBURG have SHRIMP U-Pb dates of 1660 ± 4 Ma (Black and Shaw 1992) and 1678 ± 6 Ma (Black and Shaw 1995), which are interpreted to reflect the crystallisation of igneous zircon.

U-Pb analytical information
Mount no: Z3676
Data Acquisition: 5 July 2001, SHRIMP II

Zircons
Zircons in this rock are small and apparently homogeneous under the light microscope, but they have complex zonation in CL images. Oscillatory-zoned cores, some with resorbed outer shapes, are overgrown by highly luminescent rims grown into prismatic euhedral forms. These luminescent rims are in turn overgrown by a thin (5–15 µm), poorly luminescent rim (**Figure 10**).

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP II. No mass fractionation correction is indicated by concurrent analyses of the standard.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
oscillatory and convoluted zoned phases, low-CL-response rims										
A1.1	-0.32	598	538	0.93	3.345	1.7	0.10065	0.55	1636 ± 10	-3
A2.1	-0.18	541	511	0.98	3.374	1.7	0.10086	0.47	1639.9 ± 8.8	-2
A3.1	-0.05	346	222	0.66	3.389	1.8	0.10093	0.72	1641 ± 13	-2
A4.1	0.03	596	556	0.96	3.419	1.8	0.10155	0.65	1653 ± 12	0
A5.1	-0.24	661	683	1.07	3.349	1.8	0.10054	0.49	1634.2 ± 9.1	-3
A6.1	-0.20	576	569	1.02	3.379	1.9	0.10045	0.47	1632.4 ± 8.8	-2
A7.1	-0.12	403	321	0.82	3.401	1.8	0.09973	0.67	1619 ± 12	-3
A8.1	-0.05	309	163	0.54	3.412	1.8	0.10030	1.4	1629 ± 27	-2
A9.1	0.08	560	525	0.97	3.414	1.9	0.10126	0.62	1647 ± 11	-1
A11.1	-0.31	538	436	0.84	3.365	1.8	0.09911	0.60	1608 ± 11	-4
A12.1	-0.07	722	280	0.40	3.436	1.7	0.10064	0.27	1636.0 ± 5.1	-1
A13.1	0.17	684	210	0.32	3.505	1.8	0.10054	0.32	1634.0 ± 6.00	1
A14.1	-0.60	668	227	0.35	3.277	1.7	0.10037	0.27	1631.0 ± 5.1	-5
A15.1	-0.63	754	330	0.45	3.263	1.7	0.10048	0.35	1633.1 ± 6.6	-6
A16.1	0.08	386	309	0.83	3.487	1.7	0.10057	0.39	1634.7 ± 7.3	1
A17.1	-0.23	530	187	0.36	3.384	1.7	0.10055	0.35	1634.2 ± 6.5	-2
A18.1	0.19	453	369	0.84	3.513	1.7	0.10069	0.43	1636.9 ± 8.1	1
A19.1	0.22	542	536	1.02	3.541	1.7	0.10038	0.40	1631.2 ± 7.4	2
A20.1	0.20	364	304	0.86	3.523	1.8	0.10039	0.48	1631.2 ± 8.9	1
A21.1	0.11	411	279	0.70	3.471	1.7	0.10100	0.42	1642.6 ± 7.8	1
A22.1	0.49	482	460	0.99	3.635	2.2	0.10067	0.43	1636.5 ± 8.0	4
A23.1	0.31	444	403	0.94	3.533	1.7	0.10165	0.37	1654.5 ± 6.8	3
A24.1	-0.06	468	440	0.97	3.450	1.7	0.10006	0.40	1625.2 ± 7.4	-1
A25.1	0.27	508	459	0.93	3.522	1.7	0.10118	0.39	1645.8 ± 7.2	2
A26.1	0.25	510	471	0.95	3.526	1.7	0.10103	0.37	1643.2 ± 6.9	2
A27.1	0.74	447	280	0.65	3.731	1.8	0.10080	0.53	1638.9 ± 9.9	7
A28.1	0.42	293	179	0.63	3.562	1.7	0.10084	0.63	1640 ± 12	3
A29.1	0.25	478	213	0.46	3.547	1.7	0.10023	0.44	1628.3 ± 8.2	2
A30.1	-0.26	497	477	0.99	3.364	1.7	0.10110	0.36	1644.3 ± 6.7	-2
A31.2	0.47	267	163	0.63	3.597	1.8	0.10073	0.68	1638 ± 13	3
A32.1	0.16	414	267	0.67	3.507	1.7	0.10053	0.41	1633.9 ± 7.7	1
A33.1	0.11	404	343	0.88	3.479	1.7	0.10121	0.39	1646.5 ± 7.2	1
A34.1	0.01	598	568	0.98	3.467	1.7	0.10082	0.35	1639.3 ± 6.5	0
A35.1	0.10	584	510	0.90	3.496	1.8	0.10069	0.34	1636.8 ± 6.3	1
A36.1	0.11	573	538	0.97	3.502	1.7	0.10071	0.34	1637.2 ± 6.4	1
A37.1	0.12	524	511	1.01	3.489	1.7	0.10043	0.38	1632.1 ± 7.1	0
A38.1	-0.07	582	540	0.96	3.424	1.8	0.10109	0.34	1644.3 ± 6.4	0
A39.1	-0.02	509	490	0.99	3.438	1.7	0.10075	0.37	1638.0 ± 6.9	0
A40.1	0.08	410	346	0.87	3.452	1.7	0.10129	0.44	1647.9 ± 8.2	0
A41.1	0.30	534	500	0.97	3.517	1.7	0.10133	0.72	1649 ± 13	2
A42.1	0.06	572	557	1.01	3.510	2.3	0.09982	0.79	1621 ± 15	0
high common Pb										
A10.1	1.08	233	146	0.65	3.441	2.5	0.10670	4.6	1743 ± 85	6
A31.1	0.79	400	240	0.62	3.280	2.0	0.11170	6.5	1827 ± 120	6

Table 7. SHRIMP analytical results for unnamed charnockite, sample GA2001082010. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

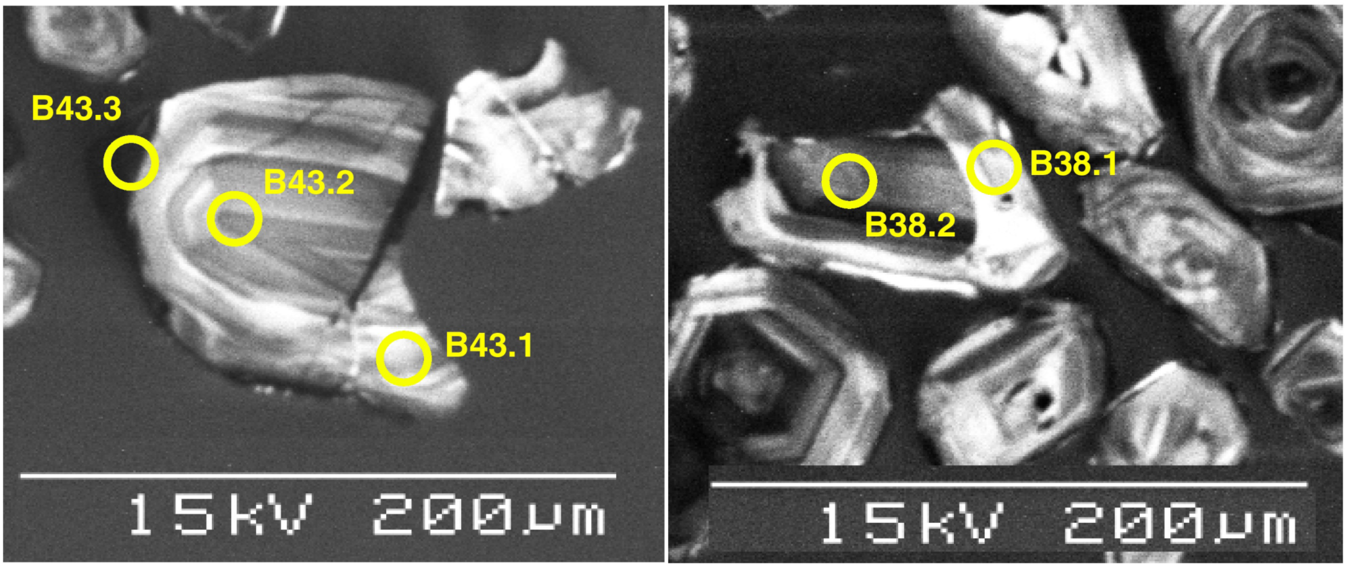

Figure 10. Cathodoluminescence images of two zircons from Glen Helen Metamorphics, sample GA2000082008 which display three separate growth zones: an inner 1680 Ma core, a 1660 Ma overgrowth and a younger, poorly luminescent (dark coloured) rim, the age of which was not determined.

U-Pb isotopic results

To unravel the ages in this sample, 55 analyses were made of core and overgrowth structures. These analyses define a tight spread of concordant ages in the range 1690–1640 Ma (**Figures 11–12**, **Table 8**). Six analyses have inadvertently sampled both a luminescent overgrowth and a poorly luminescent rim. These analyses are isotopically mixed and have been removed from age calculations.

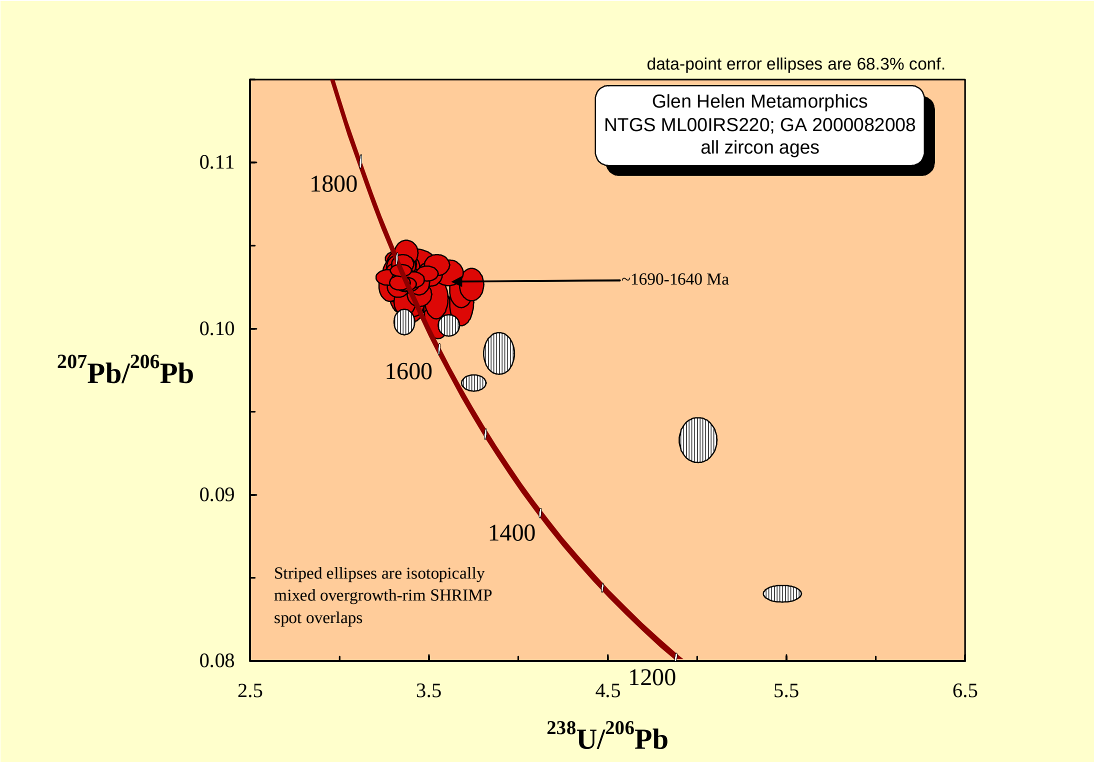

Figure 11. Terra-Wasserberg concordia plot for zircon from Glen Helen Metamorphics, sample GA2000082008.

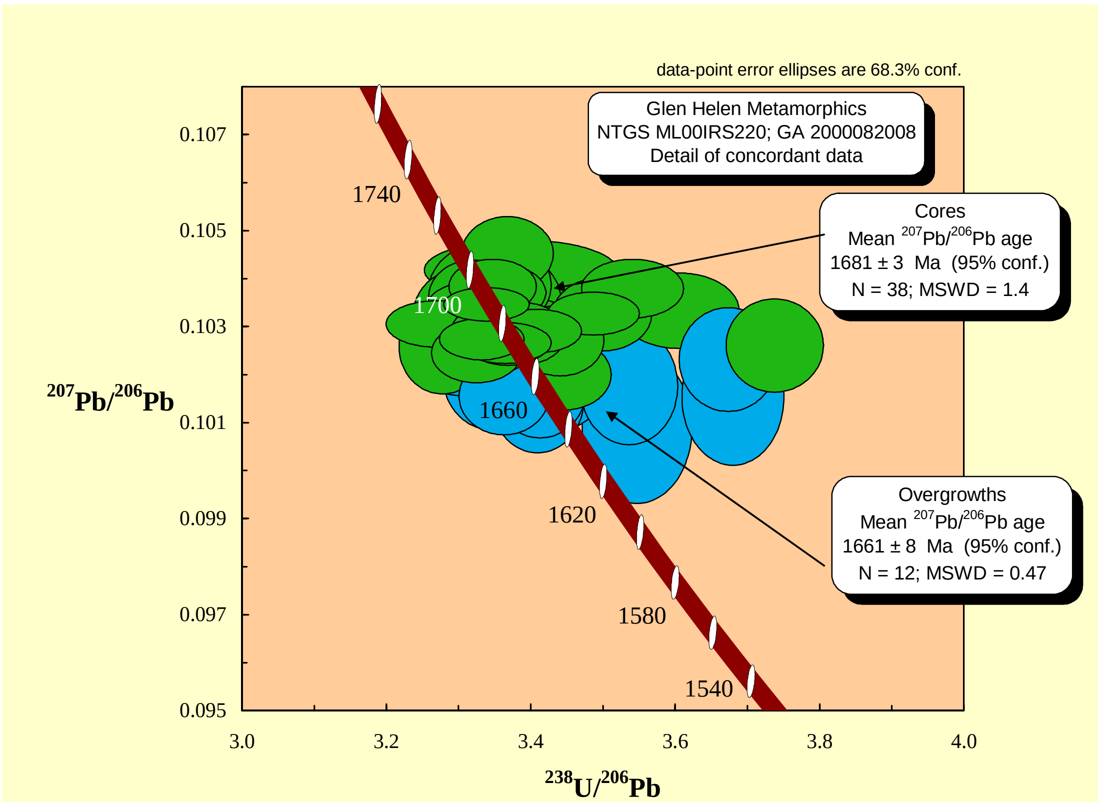

Figure 12. Enlargement of Terra-Wasserberg concordia plot for zircon from Glen Helen Metamorphics, sample GA2000082008.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
zircon cores										
B24.1	0.03	184	94	0.53	3.362	1.3	0.10453	0.49	1706.1 ± 9.0	2
B3.2	0.06	338	367	1.12	3.381	2.6	0.10418	0.40	1699.9 ± 7.4	2
B3.1	0.02	155	104	0.70	3.360	1.3	0.10387	0.55	1694 ± 10	1
B15.1	0.04	425	383	0.93	3.342	1.3	0.10384	0.36	1693.9 ± 6.7	0
B23.1	0.05	348	280	0.83	3.535	1.4	0.10380	0.39	1693.1 ± 7.2	5
B10.1	0.09	211	161	0.79	3.326	1.5	0.10374	0.62	1692 ± 11	0
B10.2	0.03	283	199	0.73	3.347	1.4	0.10371	0.39	1691.5 ± 7.1	0
B28.2	0.07	170	127	0.77	3.314	1.3	0.10362	0.50	1689.9 ± 9.2	-1
B29.1	0.06	187	151	0.83	3.332	1.3	0.10362	0.52	1689.9 ± 9.6	0
B12.2	0.10	139	79	0.59	3.369	1.4	0.10352	0.62	1688 ± 12	1
B40.1	0.02	813	710	0.90	3.332	1.2	0.10346	0.23	1687.1 ± 4.2	0
B18.1	0.13	247	157	0.66	3.600	1.6	0.10333	0.51	1684.8 ± 9.4	6
B32.1	0.05	652	512	0.81	3.481	1.3	0.10328	0.29	1683.9 ± 5.3	3
B26.2	0.05	594	460	0.80	3.42	3.1	0.10327	0.48	1683.6 ± 8.9	2
B31.2	0.07	218	156	0.74	3.493	1.4	0.10326	0.49	1683.6 ± 9.0	4
B42.1	0.07	209	151	0.75	3.307	1.3	0.10323	0.45	1682.9 ± 8.3	-1
B38.2	0.04	396	355	0.93	3.287	1.2	0.10312	0.67	1,681 ± 12	-2
B6.1	0.09	206	118	0.59	3.320	1.5	0.10309	0.55	1681 ± 10	-1
B44.1	--	390	301	0.80	3.265	1.5	0.10305	0.31	1679.8 ± 5.7	-3
B9.1	0.07	484	428	0.91	3.383	1.5	0.10303	0.38	1679.4 ± 7.0	1
B12.1	0.01	178	106	0.62	3.360	1.5	0.10297	0.63	1678 ± 12	0
B34.1	0.06	390	288	0.76	3.347	1.3	0.10291	0.36	1677.2 ± 6.6	0
B35.1	--	542	389	0.74	3.402	1.3	0.10291	0.29	1677.2 ± 5.4	1
B11.1	0.09	198	161	0.84	3.334	1.3	0.10286	0.58	1676 ± 11	-1
B26.1	0.06	442	290	0.68	3.383	1.2	0.10286	0.42	1676.3 ± 7.7	0
B37.1	0.02	623	507	0.84	3.362	1.3	0.10278	0.38	1675.0 ± 7.0	0
B36.2	0.04	638	483	0.78	3.327	1.2	0.10273	0.27	1674.1 ± 5.1	-1
B19.1	0.07	278	212	0.79	3.340	1.3	0.10273	0.46	1674.0 ± 8.6	-1
B20.1	0.08	492	370	0.78	3.435	1.3	0.10271	0.47	1673.7 ± 8.7	2
B21.1	0.09	158	140	0.92	3.346	1.6	0.10269	0.73	1673 ± 13	-1
B41.1	0.02	516	362	0.73	3.359	1.3	0.10266	0.27	1672.8 ± 5.0	0
B39.1	0.04	254	177	0.72	3.319	1.3	0.10246	0.40	1669.2 ± 7.3	-2
B28.1	0.06	235	253	1.11	3.439	1.3	0.10201	0.47	1661.0 ± 8.8	1
B17.1	0.14	149	89	0.62	3.357	1.3	0.10266	0.64	1673 ± 12	0
B45.1	0.45	264	180	0.71	3.732	1.3	0.10261	0.62	1672 ± 12	8
B7.1	0.14	183	137	0.77	3.344	1.3	0.10259	0.67	1672 ± 12	-1
B43.2	0.14	172	156	0.94	3.272	1.3	0.10259	0.64	1672 ± 12	-3
B2.1	0.06	188	113	0.62	3.344	1.3	0.10254	0.56	1671 ± 10	-1
zircon overgrowths										
B22.1	0.18	155	106	0.71	3.328	1.5	0.10274	0.95	1674 ± 17	-1
B5.1	0.07	167	94	0.58	3.300	1.5	0.10253	0.62	1670 ± 12	-2
B31.1	0.31	182	187	1.06	3.669	1.3	0.10232	0.70	1667 ± 13	7
B46.1	0.07	141	71	0.52	3.371	1.4	0.10226	0.55	1666 ± 10	-1
B33.1	0.17	93	100	1.11	3.432	1.5	0.10217	0.85	1664 ± 16	1
B8.1	0.16	122	65	0.55	3.337	1.3	0.10202	0.75	1661 ± 14	-2
B43.1	0.29	124	72	0.60	3.531	1.3	0.10177	0.79	1657 ± 15	3
B14.1	0.14	147	84	0.59	3.407	1.3	0.10173	0.68	1656 ± 13	0
B27.1	0.11	203	116	0.59	3.358	1.3	0.10156	0.52	1,52.7 ± 9.7	-2
B38.1	0.21	134	95	0.73	3.675	1.3	0.10154	0.93	1,653 ± 17	6
B1.1	0.21	205	126	0.63	3.403	1.3	0.10149	0.73	1652 ± 13	-1
B16.1	0.41	199	130	0.68	3.543	1.5	0.10090	1.0	1641 ± 19	2
SHRIMP spot overlaps (rim-overgrowth)										
B30.1	0.13	693	318	0.47	3.349	1.2	0.10035	0.50	1630.6 ± 9.3	-3
B25.1	0.11	370	155	0.43	3.601	1.3	0.10016	0.43	1627.1 ± 8.0	3
B18.2	0.36	232	61	0.27	3.885	1.6	0.09845	0.84	1595 ± 16	7
B25.2	0.24	1033	77	0.08	3.747	1.3	0.09667	0.34	1560.9 ± 6.4	2
B36.1	0.60	1314	1128	0.89	5.005	1.5	0.09322	0.97	1492 ± 18	21
B43.3	0.19	846	29	0.04	5.480	1.3	0.08393	0.39	1291.0 ± 7.7	16

Table 8. SHRIMP analytical results for Glen Helen Metamorphics, sample GA2000082008. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

In detail, this cluster unmixes into two ages, corresponding to the core and overgrowth types. The 38 compositions measured for cores include grains with moderate U contents in the range 300–800 ppm. All agree within error at a mean age of 1681 ± 3 Ma with an acceptable MSWD = 1.4, which is interpreted as the crystallisation age of the first phase of zircon growth.

The zircon overgrowth compositions have more modest U contents (below 200 ppm) and hence less precise U-Pb age measurements. As well, only 12 overgrowths large enough to target a SHRIMP spot were analysed. However, all 12 analyses agree within error at a mean age of 1661 ± 8 Ma with an acceptable MSWD = 0.47, and this imprecise age is interpreted to represent a second phase of zircon growth.

Interpretation of the meaning of the two main zircon ages, 20 my apart, depends on the significance attached to each phase of growth. The zircon cores have the oscillatory zoning pattern and distinct single age normally ascribed to magmatic zircon crystallisation. On these grounds, the 1681 ± 3 Ma age of the cores could be interpreted to represent igneous crystallisation, and the overgrowths a metamorphic overprint 20 my later. However, they share the euhedral prismatic shapes and oscillatory zoning associated with igneous growth, and are distinguished from the cores only by lower U contents and corresponding bright luminescence. These could be the characteristics of metamorphic zircon grown at less extreme metamorphic conditions (eg amphibolite grade), or could be interpreted as igneous overgrowths seeded on inherited zircon cores.

The limited development of the poorly luminescent outer zircon rims in this sample resulted in no single SHRIMP spot being able to isolate its isotopic composition. Therefore the timing of the development of these outer rims remains unconstrained. However, the six analyses that partially sampled this phase (B30.1, B25.1, B18.2, B25.2, B36.1, B43.3), although overlapping the magmatic zircon, all record younger (albeit isotopically mixed) ages than those analyses that only sampled magmatic zircon. These analyses also generally contain the highest U and common Pb contents, and have the lowest Th/U ratios. These characteristics, combined with the poorly luminescent CL response of this phase, are typical of metamorphic zircon that has either grown or recrystallised under metamorphic conditions. Therefore, the poorly luminescent outer margins of zircons in this sample are interpreted to record a post-crystallisation metamorphic event, the age of which has not been constrained.

Peculiar Complex – rhyolite

GA sample ID: 2001082525
NTGS sample ID: ML01IRS231A
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: LIEBIG
Region: Warumpi Province
Grid reference (GDA94): 723256mE, 7411875mN
Formal name: Peculiar Complex
Sample information (rock description, relative age constraints):
The dated sample is a rhyolite from the Peculiar Complex, which comprises felsic volcanic rocks, associated with shallow-level leucogranite and minor intercalated metasedimentary rocks, that outcrop west of Mount Palmer and north of Mount Peculiar and Mount Putardi. Felsic volcanic rocks of the Peculiar Complex are dominated by flow-banded rhyolite that is variably recrystallised to quartz-muscovite schist. The rhyolite comprises grey, very fine-grained to microcrystalline quartz and K-feldspar, with minor muscovite and disseminated Fe oxides. It has swirly flow-banding that is generally only visible on weathered surfaces. The rhyolite is typically aphyric, although rare porphyritic rhyolite contains small phenocrysts of K-feldspar and quartz in a purple to grey, very fine matrix. In zones of higher strain, the rhyolite is recrystallised to quartz-muscovite schist. Rare layers of biotite schist containing garnet or Fe oxide porphyroblasts, and biotite-muscovite schist with weathered porphyroblasts, suggest interbeds of sedimentary origin. The felsic volcanic interval appears to be >200 m thick, but it is difficult to resolve any structural imbrication or possible composite emplacement due to the degree of deformation and discontinuity of outcrop. Flow banding occurs at all levels and there are some features that may be flattened pumice lenticles (fiamme). The most likely interpretation is that it is a rheoignimbrite or long lava flow.

U-Pb analytical information
Mount no: Z3875
Data acquisition: 29–30 December 2001, SHRIMP I

Zircons
Zircons in this sample are euhedral to subhedral prisms, with forms ranging from equant to others with aspect ratios of 4. All zircons have concentric internal growth zones that are consistent with an igneous crystallisation.

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results
Thirty analyses were carried out on zircons from this sample (**Figure 13**, **Table 9**). Four grains are discordant above an arbitrary threshold of 10% and were removed from further consideration. The remaining twenty-six analyses combine to give a weighted mean $^{207}Pb/^{206}Pb$ age of 1679.9 ± 3.7 Ma (95% confidence; MSWD = 1.4). This can confidently be assigned as the crystallisation age of this unit.

Yaya Metamorphic Complex – quartzite

GA sample ID: 2000082009
NTGS sample ID: ML00DFC130B
1:250 000 sheet: MOUNT LIEBIG

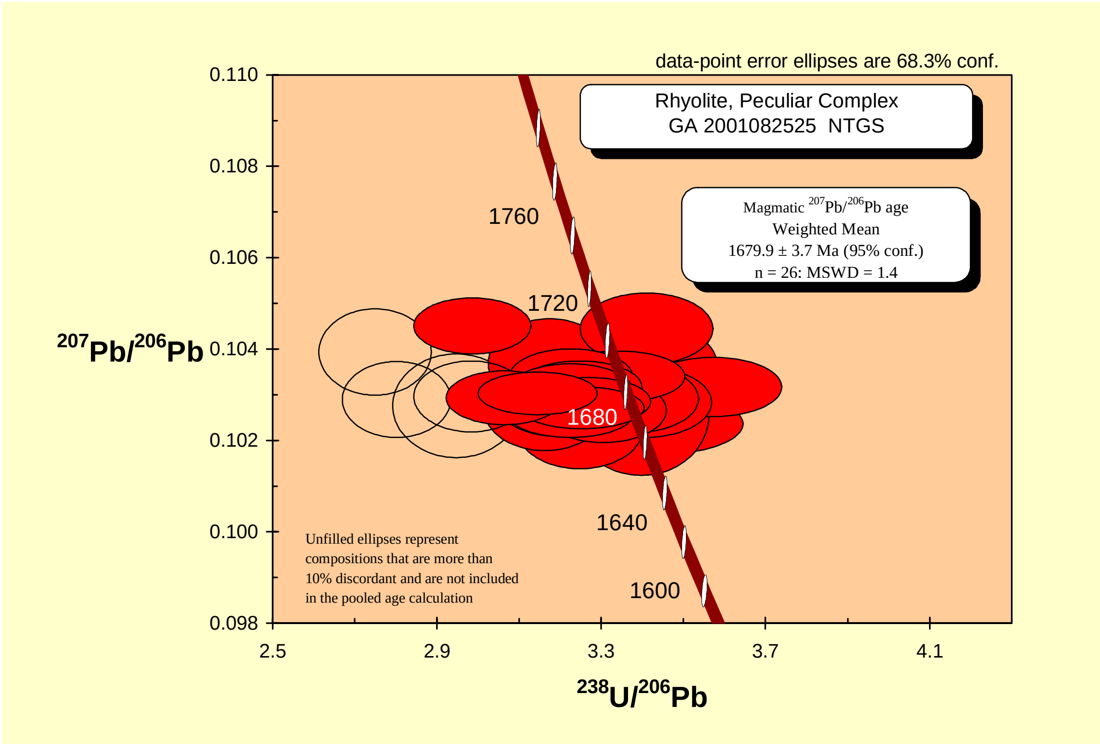

Figure 13. Terra-Wasserberg concordia plot for zircon from rhyolite of Peculiar Complex, sample GA2001082525.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
concordant										
D22.1	0.09	118	79	0.69	3.245	3.1	0.10222	0.54	1665 ± 10	-4
D17.1	0.14	237	193	0.84	3.43	4.2	0.10236	0.44	1667.4 ± 8.1	1
D24.1	0.10	397	288	0.75	3.224	3.1	0.10256	0.31	1670.9 ± 5.7	-4
D8.1	0.16	101	66	0.68	3.39	3.2	0.10257	0.86	1671 ± 16	0
D27.1	0.09	147	71	0.50	3.161	3.1	0.10265	0.56	1673 ± 10	-6
D12.1	0.02	144	63	0.45	3.30	3.1	0.10267	0.45	1672.9 ± 8.3	-2
D11.1	0.02	391	335	0.89	3.252	3.1	0.10272	0.29	1673.8 ± 5.4	-3
D26.2	0.03	129	79	0.63	3.41	3.1	0.10284	0.49	1676.0 ± 9.1	1
D16.1	0.04	229	160	0.72	3.219	3.1	0.10285	0.40	1676.1 ± 7.5	-4
D14.1	0.03	277	156	0.58	3.268	3.1	0.10286	0.34	1676.3 ± 6.2	-3
D25.1	0.02	199	136	0.70	3.188	3.1	0.10290	0.51	1677.0 ± 9.5	-5
D15.1	0.04	167	115	0.71	3.38	3.1	0.10291	0.48	1677.3 ± 8.8	0
D21.1	-0.01	257	167	0.67	3.143	3.1	0.10303	0.30	1679.4 ± 5.6	-6
D9.1	0.01	172	80	0.48	3.248	3.1	0.10307	0.44	1680.1 ± 8.2	-3
D10.1	0.02	267	141	0.54	3.224	3.1	0.10311	0.36	1680.9 ± 6.7	-4
D9.2	-0.06	243	165	0.70	3.20	3.2	0.10314	0.40	1681.4 ± 7.4	-4
D18.1	-0.01	186	128	0.71	3.246	3.1	0.10317	0.36	1681.9 ± 6.7	-3
D6.1	0.03	255	145	0.59	3.57	3.1	0.10317	0.42	1681.9 ± 7.7	5
D7.1	0.24	147	144	1.01	3.32	3.1	0.10324	0.80	1683 ± 15	-1
D3.1	0.01	252	186	0.76	3.225	3.1	0.10338	0.40	1685.8 ± 7.4	-3
D23.1	0.06	313	182	0.60	3.34	3.2	0.10340	0.35	1686.0 ± 6.5	0
D26.1	-0.05	112	66	0.61	3.41	3.2	0.10363	0.61	1690 ± 11	2
D2.1	-0.01	89	40	0.46	3.173	3.1	0.10368	0.62	1691 ± 12	-4
D4.1	-0.05	239	153	0.66	3.41	3.1	0.10445	0.49	1704.7 ± 9.1	3
D20.1	0.04	222	126	0.58	3.063	3.1	0.10293	0.38	1677.6 ± 7.0	-9
D5.1	0.00	253	147	0.60	2.983	3.2	0.10451	0.39	1705.7 ± 7.1	-9
discordant										
D19.1	0.05	200	130	0.67	2.980	3.1	0.10296	0.50	1678.2 ± 9.2	-11
D8.2	0.16	172	119	0.72	2.94	3.5	0.10276	0.73	1675 ± 13	-13
D13.1	0.04	263	156	0.61	2.798	3.1	0.10290	0.53	1677.1 ± 9.9	-17
D1.1	0.02	182	136	0.77	2.746	3.3	0.10393	0.60	1696 ± 11	-18

Table 9. SHRIMP analytical results for rhyolite of Peculiar Complex, sample GA2001082525. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

1:100 000 sheet: Haast Bluff
Region: Warumpi Province
Grid reference (GDA94): 790667mE, 7427178mN
Formal name: Yaya Metamorphic Complex
Informal name: 'Papunya quartzite'
Sample information (rock description, relative age constraints):
Massive crystalline quartzite outcrops at a number of localities north of Mount Larrie in Haast Bluff, most notably as a prominent ridge 6 km west-southwest of Papunya, which extends for 5 km along strike. These outcrops have been assigned to the Inyalinga Granulite of the Yaya Metamorphic Complex (Scrimgeour *et al* in press). The quartzite appears to be metasedimentary in origin, is clean, coarsely crystalline and is interpreted to have undergone structural repetition. Recessive zones occur in the quartzite ridge, with rare outcrops of calc-silicate rock. At its western end, the quartzite is intruded by the Larrie Granodiorite (1640–1630 Ma Waluwiya Suite). Large rafts of quartzite within Larrie Granodiorite at 788086mE, 7425567mN are interpreted to belong to the Inyalinga Granulite.

U-Pb analytical information
Mount no: Z3675
Data acquisition: 31 March–2 April 2001, SHRIMP II

Zircons
Zircons in this sample comprise rounded, concentrically zoned detrital zircon cores that are overgrown by two distinct phases of what is probably post-depositional zircon growth. The inner overgrowth is strongly luminescent, weakly zoned, with moderate Th/U ratios. This zone is in turn overgrown by a very weakly luminescent, unzoned overgrowth with low Th/U ratios (**Figure 14**).

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP II in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

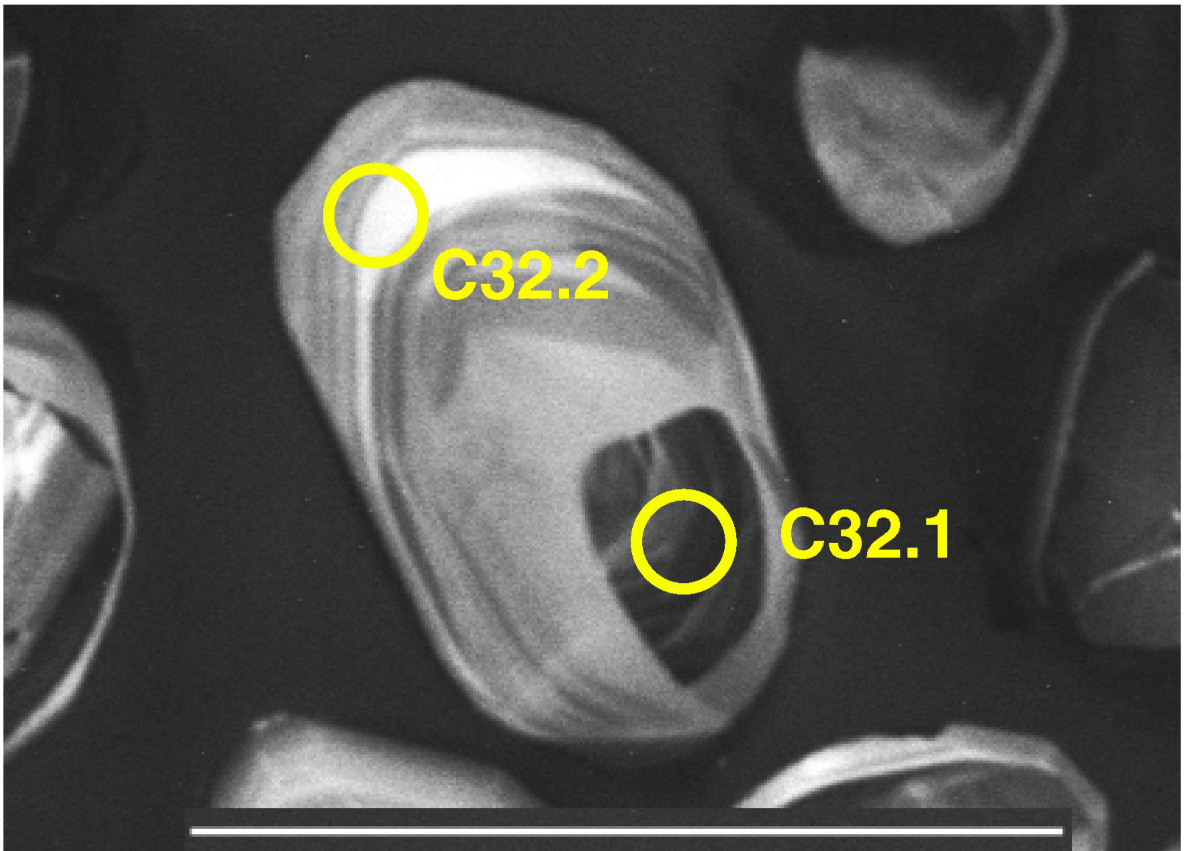

Figure 14. Cathodoluminescence image of zircon from quartzite, Yaya Metamorphic Complex, sample GA2000082009 showing an inner core, an outer luminescent region and a poorly luminescent rim.

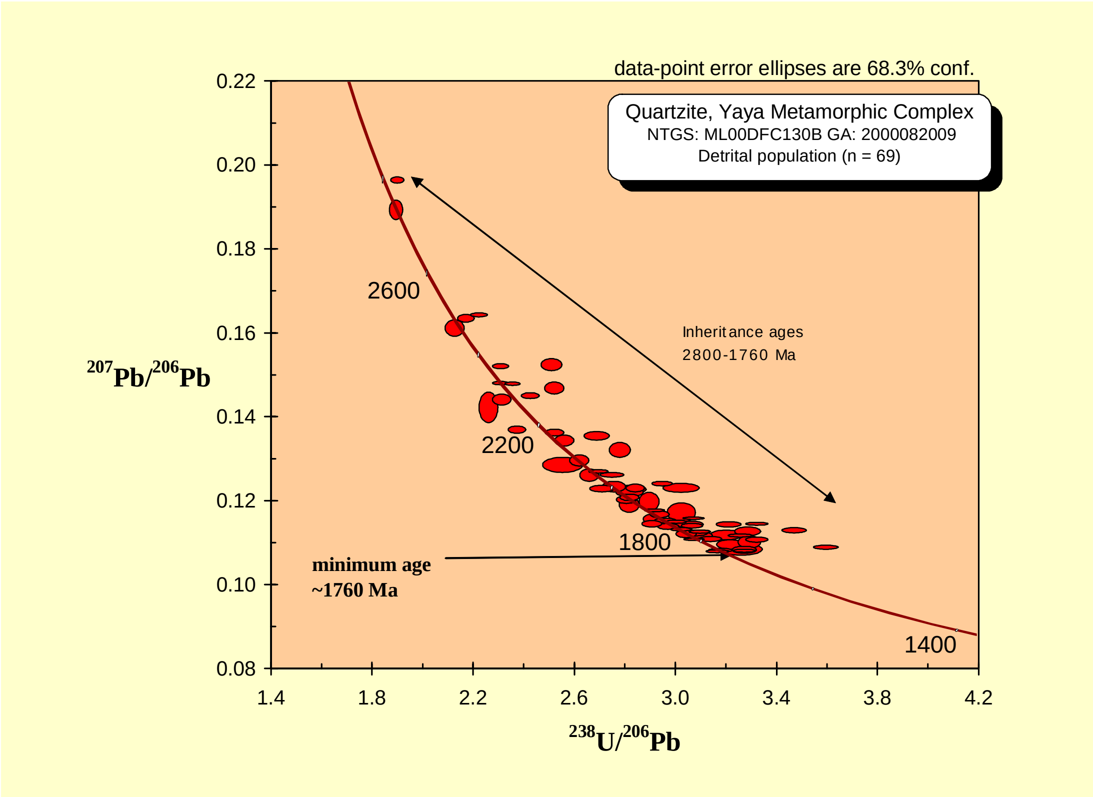

Figure 15. Terra-Wasserberg concordia plot for all zircon cores from quartzite, Yaya Metamorphic Complex, sample GA2000082009.

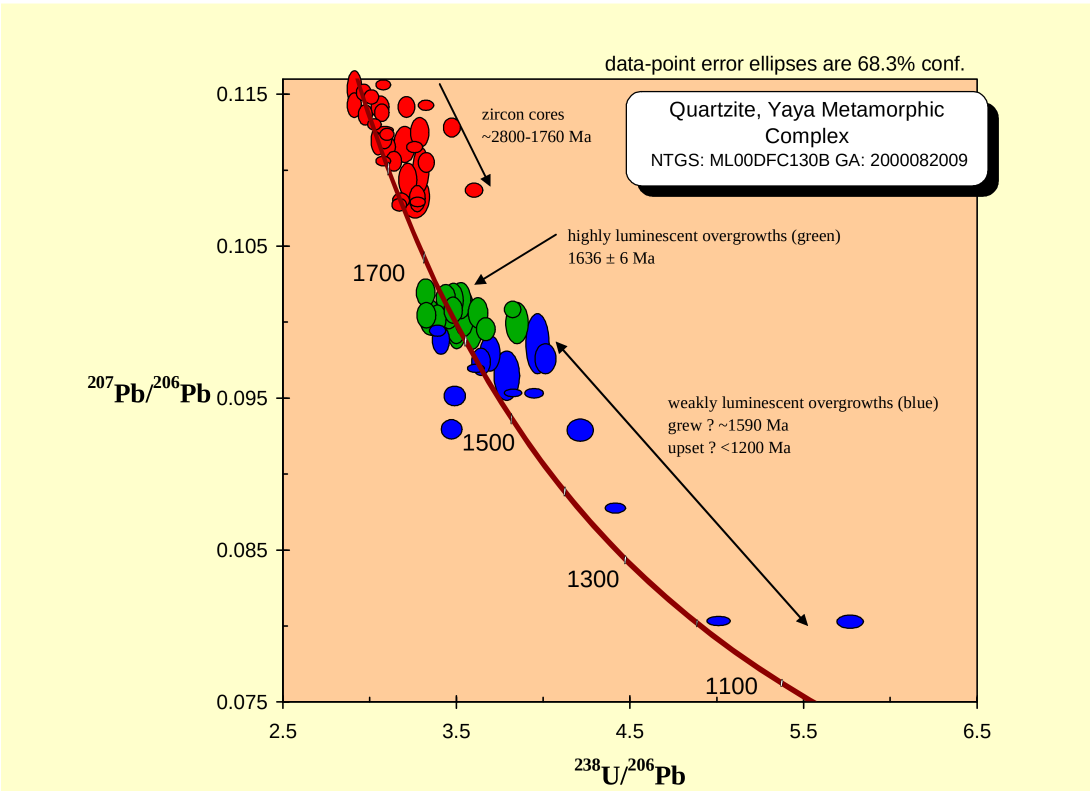

Figure 16. Terra-Wasserberg concordia plot for all zircons from quartzite, Yaya Metamorphic Complex, sample GA2000082009.

U-Pb isotopic results

Zircon cores: Sixty-nine zircon cores probed from this sample comprise a continuum of ages between 2375 Ma and 1760 Ma, with older grains within the range 2500–2470 Ma, and also at 2740 Ma and 2800 Ma (**Figures 15**, **16**, **17**, **Table 10**). These results are principally dominated by a Barramundi mode (1860–1840 Ma) and a younger mode at approximately 1765 Ma.

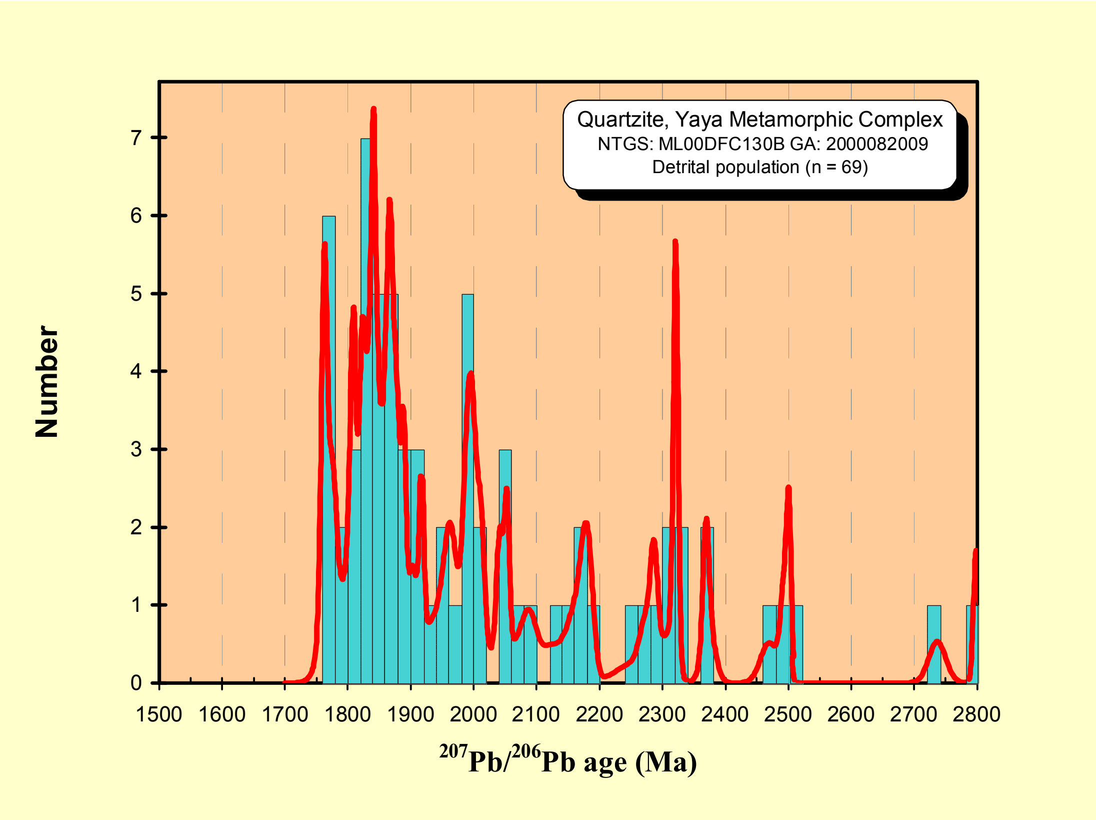

Figure 17. Cumulative probability histogram for zircon cores from quartzite, Yaya Metamorphic Complex, sample GA2000082009.

A maximum deposition age for this sample can be derived from the age of the youngest zircon, which in this case is 1760 ± 8 Ma (2σ).

Zircon overgrowths: Eighteen analyses on the inner, highly luminescent overgrowths have a weighted mean age of 1635.6 ± 5.5 Ma (95% confidence; MSWD = 1.06) and record granulite facies metamorphism during the Liebig Orogeny. In contrast, the very weakly luminescent, unzoned outer overgrowths have ages in the range 1600–1200 Ma. These apparent ages record the 1590 Ma Chewings Orogeny, and also a younger event, which has not been constrained but which may be younger than 1200 Ma.

The zircon overgrowth ages obtained here are well aligned with the 1640 Ma crystallisation age and the later 1590 Ma metamorphic overprint that has affected nearby granites. Four samples (C20.1, C18.1, C58.1 and C35.1), which have ages that are intermediate between the 1640 Ma highly luminescent overgrowths and the youngest cores, are interpreted to represent isotopically mixed compositions.

The deposition age for this sample is constrained between the youngest detrital core at 1760 Ma and the inner, strongly luminescent overgrowths at 1636 ± 6 Ma.

Lander Rock beds, Dufaur Hills

GA sample ID: 2002082504
NTGS sample ID: MR02CJE107
1:250 000 sheet: MOUNT RENNIE
1:100 000 sheet: Leisler
Region: southwestern Aileron Province (Arunta Region)
Grid reference (GDA94): 546587mE, 7441292mN
Formal name: Lander Rock beds
Sample information (rock description, relative age constraints):
The sample is a quartz-rich psammite from an interval of interlayered metapelite (muscovite-biotite schist) and lesser psammite from the Dufaur Hills, 10 km north of the Desert Bore Shear Zone. This interval occurs as low, scattered outcrops across northern MOUNT RENNIE and is bounded to the south by the Desert Bore Shear Zone, which forms the boundary with the Warumpi Province. The metamorphic grade is lower amphibolite facies, and the interval is intruded by mafic sills of the Dufaur Dolerite (Close *et al* in prep). Ten to fifteen kilometres east of the sample site, the interval is intruded by mafic rocks of the Andrew Young Igneous Complex. The sedimentary rocks are interpreted to belong to the Lander package.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
metamorphic < ~1640 Ma										
C61.3	0.27	905	62	0.07	5.773	0.87	0.08023	0.35	1202.7 ± 7.0	14
C59.3	0.02	832	30	0.04	5.013	0.87	0.08026	0.26	1203.5 ± 5.1	3
C59.1	0.03	817	31	0.04	4.420	0.87	0.08771	0.25	1376.2 ± 4.8	4
C3.1	0.07	353	56	0.16	4.215	1.2	0.09285	0.52	1484.8 ± 9.8	8
C53.2	0.07	367	34	0.10	3.469	1.1	0.09292	0.46	1486.2 ± 8.6	-10
C33.2	0.08	306	63	0.21	3.491	1.1	0.09509	0.45	1529.9 ± 8.5	-6
C61.1	0.16	1208	64	0.06	3.947	0.87	0.09526	0.22	1533.3 ± 4.1	5
C60.1	0.01	1169	36	0.03	3.827	0.86	0.09532	0.17	1534.3 ± 3.3	2
C2.2	0.21	191	62	0.34	3.793	1.3	0.09640	1.1	1556 ± 21	3
C69.2	0.02	1149	15	0.01	3.610	0.87	0.09694	0.18	1566.1 ± 3.4	-1
C45.1	0.15	175	73	0.43	3.639	0.99	0.09736	0.62	1574 ± 12	1
C30.2	0.04	223	38	0.17	4.013	0.97	0.09755	0.67	1578 ± 12	9
C1.2	0.10	160	57	0.37	3.695	1.0	0.09791	0.78	1585 ± 15	3
C69.1	0.54	98	62	0.65	3.967	1.1	0.09850	1.3	1597 ± 25	9
C7.2	0.16	153	49	0.33	3.412	0.97	0.09877	0.62	1601 ± 12	-3
C24.2	--	501	59	0.12	3.391	0.89	0.09940	0.25	1613.0 ± 4.6	-3
metamorphic 1640 Ma										
C46.2	0.00	142	48	0.35	3.666	0.97	0.09948	0.50	1614.4 ± 9.3	4
C12.1	0.14	108	115	1.10	3.592	1.1	0.09980	1.1	1620 ± 20	2
C25.2	0.21	84	37	0.46	3.500	1.1	0.09990	1.1	1621 ± 20	0
C10.1	0.03	86	45	0.54	3.847	1.1	0.09988	0.89	1622 ± 17	8
C46.1	0.13	66	44	0.70	3.500	1.2	0.10010	1.0	1626 ± 19	0
C17.1	0.06	126	102	0.84	3.369	1.6	0.10013	0.68	1627 ± 13	-3
C43.2	0.15	114	64	0.58	3.391	1.0	0.10020	0.60	1628 ± 11	-2
C32.2	0.19	57	40	0.73	3.349	1.1	0.10031	0.78	1630 ± 14	-3
C18.2	0.07	163	76	0.48	3.327	1.1	0.10041	0.54	1632 ± 10	-4
C52.2	--	72	33	0.48	3.623	1.1	0.10055	0.66	1634 ± 12	4
C75.1	0.14	98	74	0.78	3.541	1.1	0.10060	1.0	1634 ± 19	2
C5.2	0.07	75	35	0.49	3.459	1.1	0.10067	0.76	1636 ± 14	0
C84.1	0.11	144	43	0.31	3.482	1.0	0.10074	0.56	1638 ± 10	1
C55.1	0.17	4069	2074	0.53	3.824	0.87	0.10080	0.35	1638.9 ± 6.6	9
C64.2	0.07	81	44	0.56	3.524	1.1	0.10136	0.79	1649 ± 15	2
C20.2	0.02	84	39	0.48	3.483	1.0	0.10139	0.75	1650 ± 14	1
C26.2	--	86	43	0.52	3.440	1.0	0.10153	0.57	1652 ± 11	0
C17.2	--	83	46	0.57	3.323	1.1	0.10193	0.59	1659 ± 11	-2
detrital										
C4.1	0.02	789	303	0.40	3.170	0.94	0.10765	0.24	1760.1 ± 4.5	0
C57.1	0.10	1508	334	0.23	3.276	0.88	0.10783	0.19	1763.2 ± 3.5	3
C25.1	0.03	490	220	0.46	3.182	0.98	0.10795	0.31	1765.2 ± 5.7	0
C11.1	0.11	271	116	0.44	3.276	0.95	0.10806	0.53	1767.0 ± 9.7	3
C59.2	0.05	140	88	0.65	3.264	1.7	0.10818	0.85	1769 ± 16	3
C22.1	0.19	998	853	0.88	3.601	0.90	0.10862	0.31	1776.5 ± 5.6	11
C27.1	0.06	120	90	0.78	3.221	1.1	0.10929	0.66	1788 ± 12	3
C5.1	0.36	344	167	0.50	3.297	0.93	0.10997	0.87	1799 ± 16	5
C73.1	0.38	603	189	0.32	3.327	0.89	0.11044	0.38	1806.6 ± 6.9	6
C71.1	0.01	964	417	0.45	3.076	0.89	0.11054	0.19	1808.3 ± 3.5	0
C49.1	--	263	57	0.22	3.140	0.95	0.11057	0.39	1808.9 ± 7.1	1
C43.1	0.06	1530	914	0.62	3.259	0.93	0.11145	0.22	1823.3 ± 4.1	5
C36.1	0.01	236	101	0.44	3.106	0.96	0.11148	0.44	1823.6 ± 7.9	1
C7.1	--	119	65	0.56	3.205	1.3	0.11163	0.71	1826 ± 13	4
C62.1	0.11	548	160	0.30	3.045	0.90	0.11186	0.56	1830 ± 10	0
C53.1	0.02	411	93	0.23	3.087	0.92	0.11205	0.40	1832.9 ± 7.2	1
C26.1	0.03	681	271	0.41	3.100	0.89	0.11233	0.25	1837.4 ± 4.5	2
C31.1	0.05	178	61	0.35	3.289	1.0	0.11241	0.58	1839 ± 10	7
C8.1	0.03	2176	502	0.24	3.084	1.1	0.11256	0.14	1841.2 ± 2.6	2
C39.1	0.11	446	152	0.35	3.474	0.91	0.11272	0.35	1843.8 ± 6.4	12
C63.1	0.02	838	255	0.31	3.026	0.89	0.11293	0.22	1847.2 ± 4.0	0
C52.1	0.03	265	148	0.58	2.974	0.94	0.11357	0.39	1857.3 ± 7.1	-1
C47.1	--	453	182	0.42	3.068	0.91	0.11371	0.33	1859.6 ± 5.9	2
C81.1	0.02	257	87	0.35	3.059	1.2	0.11409	0.43	1865.6 ± 7.7	2
C24.1	--	397	66	0.17	3.212	1.0	0.11412	0.38	1866.0 ± 6.8	6
C6.1	--	1145	316	0.28	3.325	0.88	0.11421	0.19	1867.4 ± 3.5	9
C80.1	0.03	367	63	0.18	2.909	0.92	0.11423	0.47	1867.8 ± 8.5	-2
C41.1	0.01	541	142	0.27	3.006	0.90	0.11476	0.27	1876.2 ± 4.8	1
C38.1	0.04	381	58	0.16	2.963	0.92	0.11505	0.32	1880.7 ± 5.8	0
C30.1	0.03	275	22	0.08	2.913	0.94	0.11531	0.69	1885 ± 12	-1
C66.1	0.02	1309	26	0.02	3.075	0.88	0.11558	0.18	1888.9 ± 3.2	4
C13.1	0.03	979	176	0.19	2.940	0.88	0.11651	0.41	1903.4 ± 7.4	1
C72.1	0.13	80	4	0.06	3.026	1.2	0.11690	1.3	1910 ± 23	4
C23.1	0.01	4791	644	0.14	2.921	0.88	0.11741	0.19	1917.2 ± 3.4	1
C21.1	0.01	469	56	0.12	2.817	0.95	0.11880	1.0	1939 ± 18	-1
(continued)										

Table 10. SHRIMP analytical results for quartzite, Yaya Metamorphic Complex, sample GA2000082009. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
detrital (continued)										
C37.1	0.00	510	80	0.16	2.898	0.92	0.11950	1.2	1949 ± 22	2
C42.1	--	883	54	0.06	2.807	0.96	0.12001	0.50	1956.4 ± 9.0	0
C40.1	0.00	400	150	0.39	2.819	0.93	0.12058	0.43	1964.9 ± 7.6	0
C67.1	0.01	84	63	0.77	2.820	1.3	0.12182	0.60	1983 ± 11	1
C15.1	0.05	138	38	0.29	2.825	1.4	0.12244	0.54	1992.1 ± 9.7	2
C32.1	0.05	293	124	0.44	2.710	1.2	0.12268	0.41	1995.6 ± 7.4	-1
C74.1	0.10	126	51	0.42	3.024	1.6	0.12275	0.56	1997 ± 10	8
C28.1	0.03	990	53	0.06	2.844	0.88	0.12277	0.49	1996.9 ± 8.7	3
C79.1	0.09	109	139	1.31	2.756	1.1	0.12319	0.68	2003 ± 12	0
C44.1	0.02	348	176	0.52	2.951	0.92	0.12388	0.31	2012.8 ± 5.5	7
C70.1	0.01	361	117	0.33	2.658	0.94	0.12591	0.77	2042 ± 14	-1
C56.1	--	369	140	0.39	2.749	1.1	0.12593	0.28	2041.9 ± 5.0	2
C77.1	0.01	640	52	0.08	2.695	0.90	0.12673	0.22	2053.1 ± 3.8	1
C19.1	--	275	70	0.26	2.554	2.0	0.12830	0.91	2075 ± 16	-3
C9.1	--	221	130	0.61	2.618	0.96	0.12941	0.67	2090 ± 12	0
C78.1	0.04	191	47	0.25	2.781	1.0	0.13190	0.88	2123 ± 15	7
C54.1	0.02	591	227	0.40	2.560	0.96	0.13415	0.68	2153 ± 12	1
C29.1	0.05	119	44	0.38	2.689	1.3	0.13536	0.52	2168.6 ± 9.1	6
C48.1	0.08	257	184	0.74	2.523	0.94	0.13604	0.40	2177.4 ± 7.0	1
C67.1	0.06	165	54	0.34	2.370	1.0	0.13670	0.42	2185.8 ± 7.3	-4
C64.1	0.06	136	109	0.83	2.258	1.1	0.14220	1.7	2254 ± 29	-5
C50.1	0.02	126	61	0.50	2.312	1.1	0.14393	0.60	2275 ± 10	-2
C34.1	0.02	243	124	0.53	2.426	0.97	0.14492	0.33	2286.8 ± 5.7	3
C60.2	0.16	144	78	0.56	2.521	10	0.14680	0.72	2309 ± 12	7
C61.2	0.21	1044	379	0.38	3.231	0.88	0.14774	0.26	2320.0 ± 4.4	25
C16.1	0.01	615	313	0.53	2.355	0.89	0.14783	0.20	2321.0 ± 3.5	2
C68.1	0.02	479	240	0.52	2.305	0.92	0.14798	0.21	2322.8 ± 3.7	0
C51.1	0.05	324	141	0.45	2.309	0.92	0.15207	0.28	2369.4 ± 4.7	2
C65.1	0.16	90	49	0.56	2.509	1.1	0.15247	0.60	2374 ± 10	9
C14.1	0.01	421	150	0.37	2.124	1.2	0.16130	0.81	2469 ± 14	-1
C2.1	0.06	223	239	1.11	2.169	0.97	0.16359	0.36	2493.1 ± 6.0	2
C33.1	0.04	511	241	0.49	2.220	0.97	0.16437	0.21	2501.1 ± 3.6	4
C76.1	0.02	300	135	0.46	1.891	0.95	0.18940	0.81	2737 ± 13	0
C1.1	--	311	273	0.91	1.896	0.92	0.19660	0.25	2798.2 ± 4.1	2
mixed										
C20.1	0.06	143	99	0.71	3.422	1.0	0.10330	0.68	1684 ± 12	2
C18.1	0.08	294	117	0.41	3.432	0.95	0.10384	0.46	1693.9 ± 8.4	3
C58.1	0.04	635	194	0.32	3.310	0.92	0.10577	0.66	1728 ± 12	1
C35.1	0.02	1577	434	0.28	3.072	0.88	0.10666	0.24	1743.2 ± 4.4	-4

Table 10. (continued).

U-Pb analytical information

Mount no: Z3969
Data acquisition: 8–12 July 2002, SHRIMP I

Zircons

Zircons in this sample range from well rounded grains, with frosted surfaces typical of detrital zircons, to euhedral prisms with pointed terminations and their broken, angular equivalents (**Figure 18**). Internal zoning patterns indicate that zircons in this sample are predominantly derived from igneous sources.

U-Pb isotopic results

To establish a reliable detrital age spectrum, 70 SHRIMP analyses were carried out (**Figures 19–20**, **Table 11**). Two grains were deleted from the data set as being discordant above an arbitrary threshold of 10%, leaving 68 concordant and near-concordant analyses.

The age spectrum in this sample ranges from 2815 Ma to 1830 Ma. It is dominated by a group of 37 grains (54%) in the age range 1890–1830 Ma. There is a conspicuous gap of 100 my between the dominant population and older grains in this sample. A late Archean group of 11 grains (16%) that forms a continuum between 2520 Ma and 2415 Ma contributes to a subordinate provenance grouping in this rock.

Other provenance components include a continuum of ten zircons between 2200 Ma and 1980 Ma, three grains approximating 2265 Ma, two grains approximating 2610 Ma, four grains between 2720 Ma and 2670 Ma and a single grain at 2815 Ma.

The zircons from the dominant 1890–1830 Ma population are generally morphologically distinct from the older zircons in this sample. They are typically euhedral or angular fragments that lack the predominantly rounded to well rounded form and frosted surface texture typical of the older zircons in this sample. The youngest zircon in this sample has an age of 1831 ± 38 Ma (2σ). However, the large error associated with this analysis limits its usefulness as a constraint on the maximum deposition age. Alternatively, the dominant population combines to form a statistically significant grouping with an age of 1858 ± 5 Ma (95 % confidence; MSWD = 1.4). This result can confidently be used as a maximum deposition age for this sample.

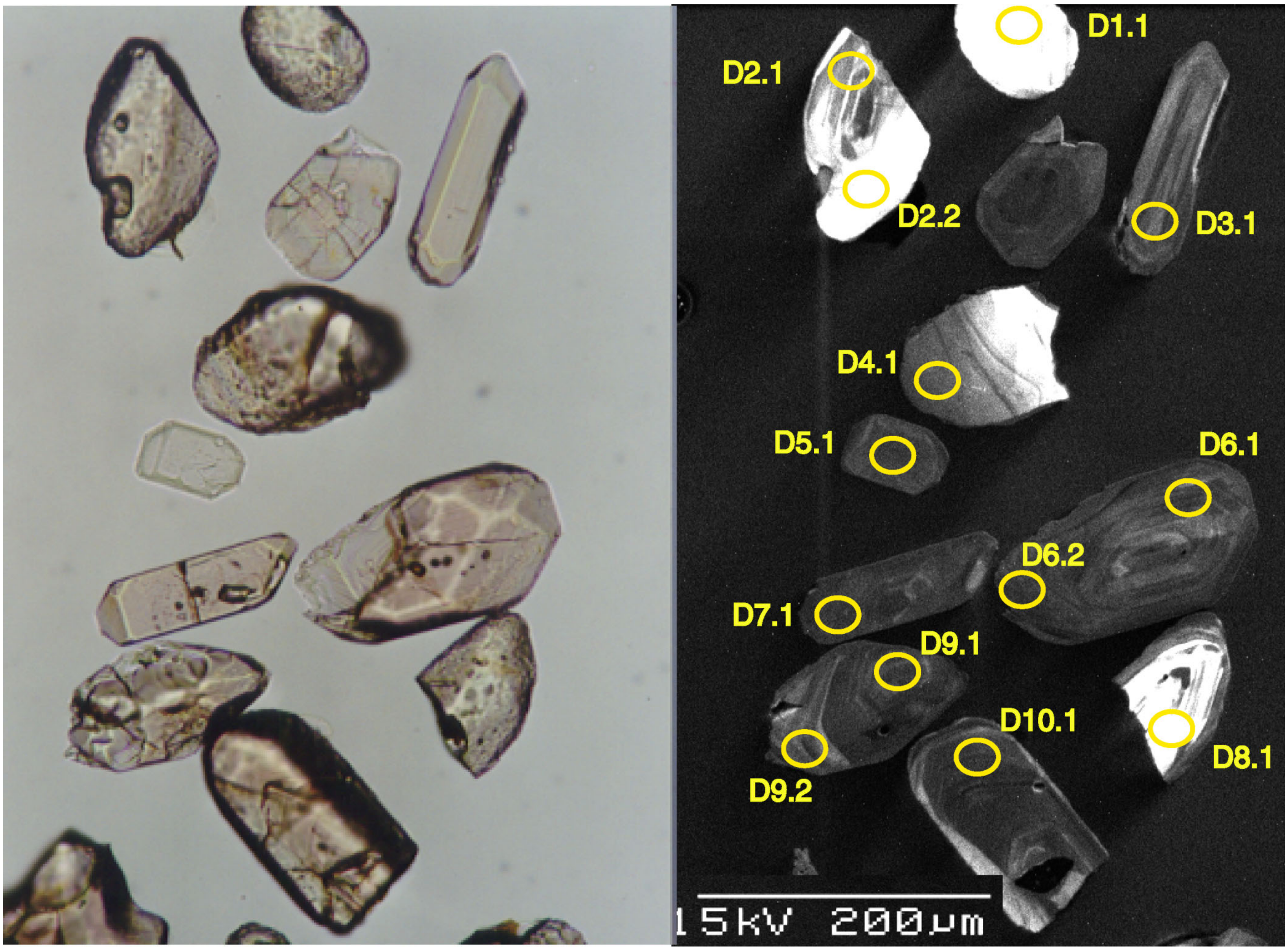

Figure 18. Representative zircons from Lander Rock beds, sample 2002082504. Transmitted light photomicrograph on left, CL image on right. SHRIMP spot locations are marked.

Metasedimentary rock, Stokes Yard base metal prospect

GA sample ID: 2002082522
NTGS sample ID: HE02DFC1
1:250 000 sheet: HERMANNSBURG
1:100 000 sheet: Glen Helen
Region: Warumpi Province
Grid reference (GDA94): 203637mE, 7406262mN
Sample information (rock description, relative age constraints):
The sample is from drillcore from NTGS Stokes Yard DDH3, at a depth of 49.3–56.0 m. The prospect is hosted in calc-silicate and forsterite marble, interlayered with pelite, psammite, amphibolite and rare quartzite. This forms part of a relatively limited area of metasedimentary rock within regionally extensive felsic migmatite of the 1690–1660 Ma Glen Helen Metamorphics. It is unclear whether this metasedimentary rock is also a constituent of the Glen Helen Metamorphics, and this sample was dated in order to test that possibility. Igneous zircon cores from a sample of felsic migmatite from the Glen Helen Metamorphics in MOUNT LEIBIG have a SHRIMP U-Pb age of 1688 ± 16 Ma (Kinny 2002). Metamorphic rims show evidence for isotopic disturbance, with the oldest single rim analysis of 1640 Ma. Migmatitic granite from south of Belt Range in MOUNT LIEBIG has zircon cores at 1681 ± 3 Ma, with oscillatory zoned prismatic overgrowths at 1661 ± 8 Ma, which may reflect 1660 Ma igneous crystallisation with an inherited 1680 Ma zircon population (this report). These ages are in agreement with SHRIMP U-Pb dates of 1660 ± 4 Ma and 1678 ± 6 Ma for igneous zircon from the Glen Helen Metamorphics in HERMANNSBURG (Black and Shaw 1992, 1995). The present result suggests that the dated metasedimentary rock may belong to the 1640–1610 Ma Iwupataka Metamorphic Complex.

The sample for dating is migmatitic pelite and psammite, selected from drillcore to have no granitic veins other than migmatitic leucosomes. The pelite contains biotite, garnet and sillimanite, with leucosomes that have been strongly deformed and transposed into the regional fabric. Localised zones of chlorite retrogression occur.

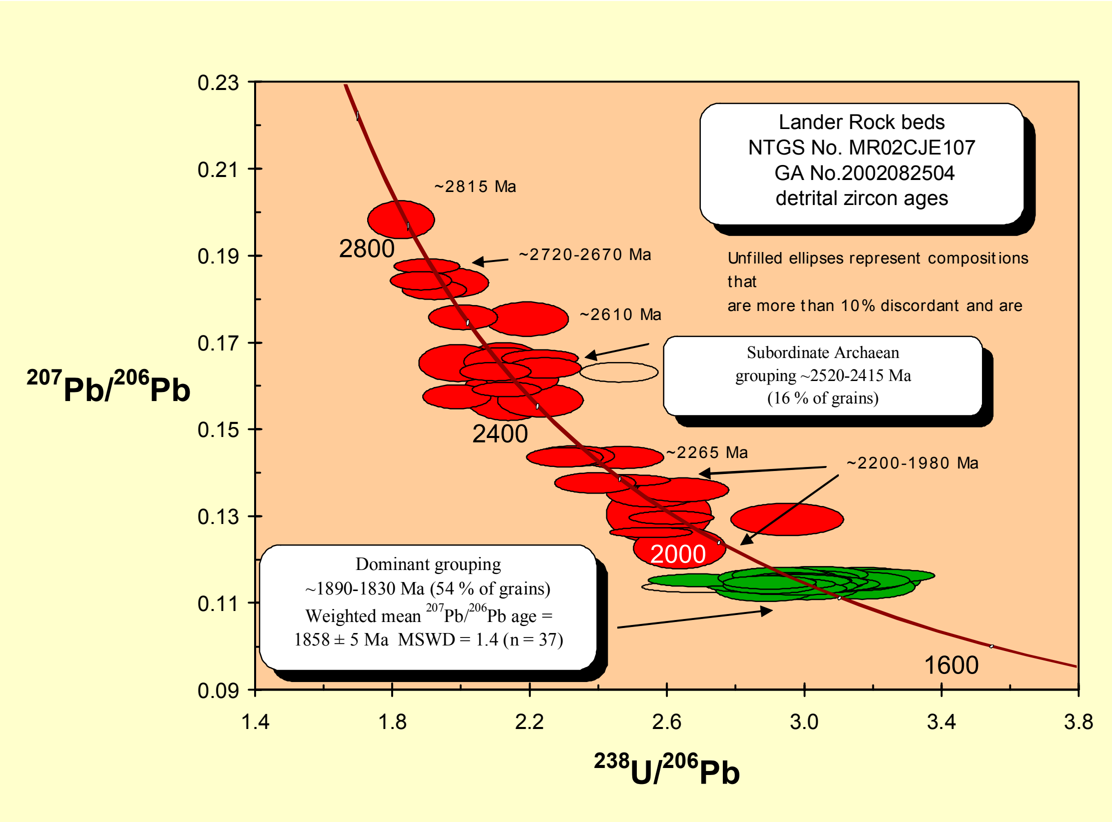

Figure 19. Terra-Wasserberg concordia plot for zircon from Lander Rock beds, sample GA2002082504.

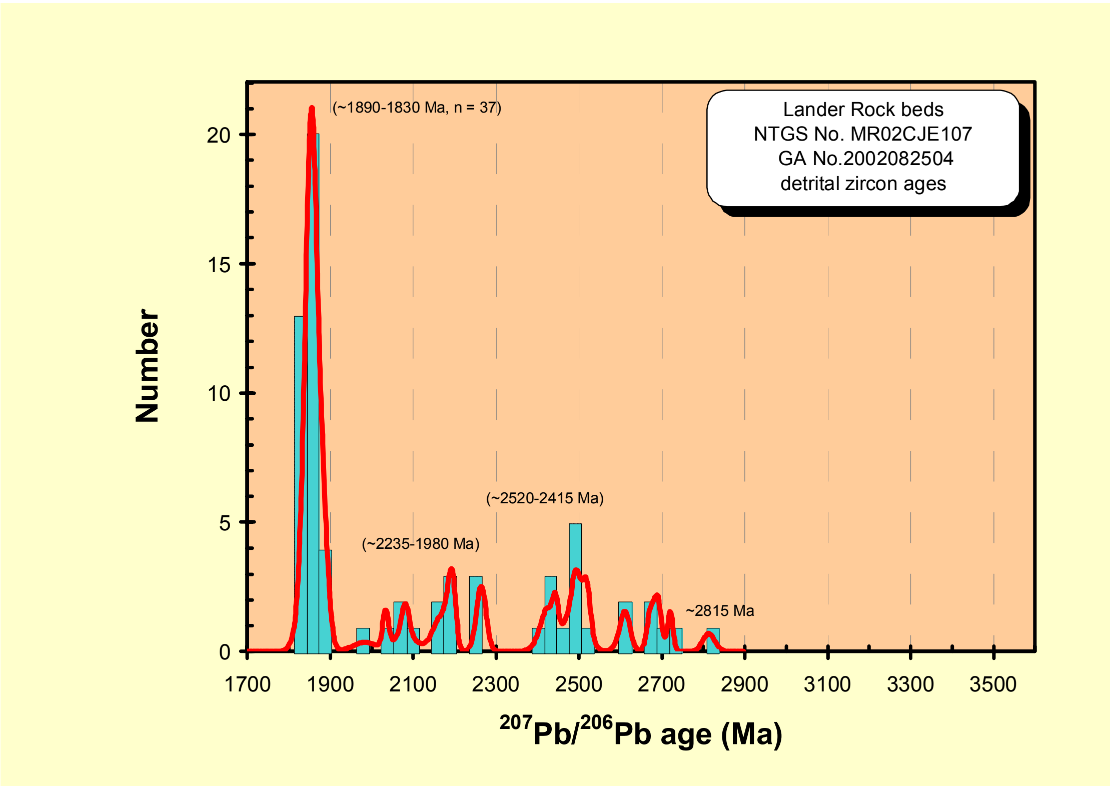

Figure 20. Cumulative probability histogram for zircon data from Lander Rock beds, sample GA2002082504.

U-Pb analytical information
Mount no: Z4122
Data acquisition: 26 February–1 March 2003, SHRIMP I

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals										
D1.1	0.06	46	39	0.87	1.984	2.3	0.16500	1.1	2507 ± 18	-5
D2.1	0.17	118	159	1.40	1.982	2.1	0.15710	0.74	2424 ± 12	-9
D2.2	-0.06	50	38	0.77	2.224	2.3	0.15620	1.0	2415 ± 17	1
D3.1	0.16	283	84	0.31	2.899	1.9	0.11364	0.56	1858 ± 10	-3
D4.1	0.09	160	83	0.54	2.467	2.0	0.14290	0.73	2262 ± 13	3
D6.1	0.08	317	153	0.50	2.985	1.9	0.11226	0.57	1836 ± 10	-1
D6.2	0.03	254	89	0.36	2.964	1.9	0.11361	0.62	1858 ± 11	-1
D7.1	0.01	344	108	0.32	3.002	1.9	0.11305	0.56	1849 ± 10	0
D8.1	0.17	61	36	0.61	1.817	2.2	0.19840	0.89	2813 ± 14	0
D9.1	-0.04	402	194	0.50	2.482	2.0	0.13755	0.41	2196.6 ± 7.1	1
D9.2	0.02	231	114	0.51	2.298	2.0	0.14300	0.64	2264 ± 11	-3
D10.1	0.02	280	285	1.05	2.127	1.9	0.15879	0.42	2442.9 ± 7.1	-2
D11.1	0.06	231	91	0.41	2.899	2.0	0.11289	0.70	1846 ± 13	-3
D12.1	-0.03	122	99	0.83	2.387	2.1	0.13693	0.71	2189 ± 12	-3
D12.2	-0.06	291	247	0.88	2.403	2.1	0.13692	0.51	2188.6 ± 8.9	-2
D13.1	0.01	174	115	0.68	1.876	2.0	0.18412	0.48	2690.4 ± 7.9	-2
D14.1	0.11	302	143	0.49	3.064	2.1	0.11266	0.63	1843 ± 11	1
D15.1	0.05	230	195	0.88	3.063	2.0	0.11315	0.66	1851 ± 12	2
D16.1	0.03	367	105	0.29	3.049	2.1	0.11348	0.53	1855.9 ± 9.5	1
D17.1	0.37	38	50	1.37	2.572	2.5	0.12960	2.2	2093 ± 38	-1
D19.1	0.10	388	68	0.18	2.996	1.9	0.11391	0.54	1862.7 ± 9.7	0
D19.2	0.04	371	61	0.17	2.999	1.9	0.11407	0.61	1865 ± 11	1
D20.1	-0.04	162	86	0.55	1.915	2.0	0.18206	0.51	2671.7 ± 8.4	-1
D21.1	-0.01	449	60	0.14	2.550	2.0	0.12532	0.40	2033.3 ± 7.0	-5
D22.1	0.01	397	85	0.22	3.028	2.0	0.11333	0.52	1853.6 ± 9.3	1
D23.1	0.15	676	65	0.10	3.233	1.9	0.11517	0.55	1882.5 ± 9.9	8
D23.2	0.13	135	48	0.36	2.951	2.3	0.12840	1.2	2076 ± 21	9
D24.1	-0.10	198	106	0.55	3.172	2.2	0.11410	1.1	1866 ± 20	5
D25.1	0.07	239	31	0.13	2.953	1.9	0.11374	0.63	1860 ± 11	-1
D26.1	0.34	95	196	2.14	2.635	2.1	0.12180	1.6	1982 ± 29	-5
D27.1	0.01	156	98	0.65	2.237	2.0	0.16370	0.56	2494.2 ± 9.5	5
D28.1	-0.07	246	126	0.53	2.961	1.9	0.11401	0.67	1864 ± 12	-1
D29.1	0.07	262	113	0.45	1.892	2.1	0.18747	0.40	2720.1 ± 6.6	-1
D30.1	0.08	227	119	0.54	2.971	2.0	0.11282	0.62	1845 ± 11	-1
D31.1	0.07	334	145	0.45	3.036	2.0	0.11308	0.58	1849 ± 10	1
D32.1	0.09	365	93	0.26	3.017	1.9	0.11285	0.59	1846 ± 11	0
D33.1	0.16	140	83	0.61	2.173	2.0	0.16110	0.73	2467 ± 12	1
D34.1	0.18	331	70	0.22	3.162	1.9	0.11413	0.71	1866 ± 13	5
D34.2	0.13	534	50	0.10	2.952	1.9	0.11337	0.49	1854.1 ± 8.8	-1
D35.1	0.03	383	68	0.18	2.611	1.9	0.12877	0.50	2081.3 ± 8.7	0
D35.2	-0.08	157	87	0.58	2.325	2.1	0.14323	0.69	2267 ± 12	-2
D36.1	0.03	333	151	0.47	2.863	2.2	0.11295	0.59	1847 ± 11	-5
D37.1	0.05	312	42	0.14	3.039	2.1	0.11527	0.75	1884 ± 13	3
D38.1	0.08	333	114	0.35	3.016	2.0	0.11479	0.60	1877 ± 11	2
D39.1	-0.01	528	64	0.12	3.045	1.9	0.11382	0.49	1861.2 ± 8.8	2
D40.1	0.18	426	196	0.48	2.224	2.1	0.16608	0.48	2518.5 ± 8.0	5
D41.1	0.04	152	91	0.62	2.001	2.1	0.17560	0.65	2612 ± 11	0
D42.1	0.01	266	39	0.15	2.960	2.0	0.11462	0.70	1874 ± 13	0
D43.1	-0.01	202	129	0.66	2.093	2.0	0.16295	0.55	2486.5 ± 9.3	-1
D44.1	0.16	236	67	0.29	3.169	2.0	0.11270	1.0	1843 ± 19	4
D45.1	0.20	124	52	0.43	2.117	2.2	0.16510	1.1	2509 ± 19	1
D46.1	0.09	207	66	0.33	2.888	2.0	0.11468	0.77	1875 ± 14	-2
D47.1	0.02	292	106	0.37	3.041	2.0	0.11550	0.66	1888 ± 12	3
D48.1	0.02	165	73	0.46	3.009	2.1	0.11220	0.91	1835 ± 16	-1
D49.1	0.06	389	128	0.34	3.140	2.0	0.11354	0.69	1857 ± 12	4
D50.1	-0.01	392	112	0.29	2.687	2.2	0.11414	0.51	1866.4 ± 9.2	-9
D51.1	-0.02	382	135	0.36	2.970	2.0	0.11386	0.54	1861.9 ± 9.7	0
D52.1	0.14	107	61	0.59	1.969	2.2	0.18370	0.75	2686 ± 12	1
D53.1	0.19	75	56	0.77	2.186	2.3	0.17520	0.94	2608 ± 16	7
D54.1	0.00	222	158	0.74	2.921	2.0	0.11282	0.69	1845 ± 12	-3
D55.1	0.46	42	17	0.42	2.132	2.5	0.15790	1.7	2434 ± 28	-2
D56.1	0.05	360	190	0.55	2.990	1.9	0.11251	0.60	1840 ± 11	-1
D57.1	-0.05	284	74	0.27	2.928	2.0	0.11532	0.65	1885 ± 12	0
D58.1	0.09	365	86	0.24	3.075	1.9	0.11319	0.61	1851 ± 11	2
D59.1	0.00	89	36	0.42	2.116	2.2	0.16520	0.82	2509 ± 14	1
D60.1	0.04	139	78	0.58	2.888	2.1	0.11200	1.0	1831 ± 19	-5
D61.1	0.29	147	55	0.39	2.555	2.2	0.13450	1.0	2158 ± 17	1
D62.1	0.03	148	74	0.51	2.643	2.1	0.13530	0.86	2168 ± 15	5
discordant compositions										
D5.1	0.03	369	394	1.10	2.711	2.8	0.11266	0.49	1842.7 ± 8.9	-10
D18.1	0.25	590	97	0.17	2.456	1.9	0.16278	0.59	2484.7 ± 9.9	11

Table 11. SHRIMP analytical results for Lander Rock beds, sample GA2002082504. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Zircons

Zircons in this sample range from generally equant forms to others with aspect ratios of 2. They are generally rounded clear grains with a smooth surface texture. Some grains retain evidence of a pitted surface texture (indicative of sedimentary transport), which grades into the smooth surface texture common to all grains. The majority of grains are oscillatory zoned and many grains have what is mostly a thin 1–5 µm rim that is high in U and has a very low CL response. Due to their small size, only a limited number of analyses were able to be carried out on these rims. The low-CL-response, high-U rims and smooth surface

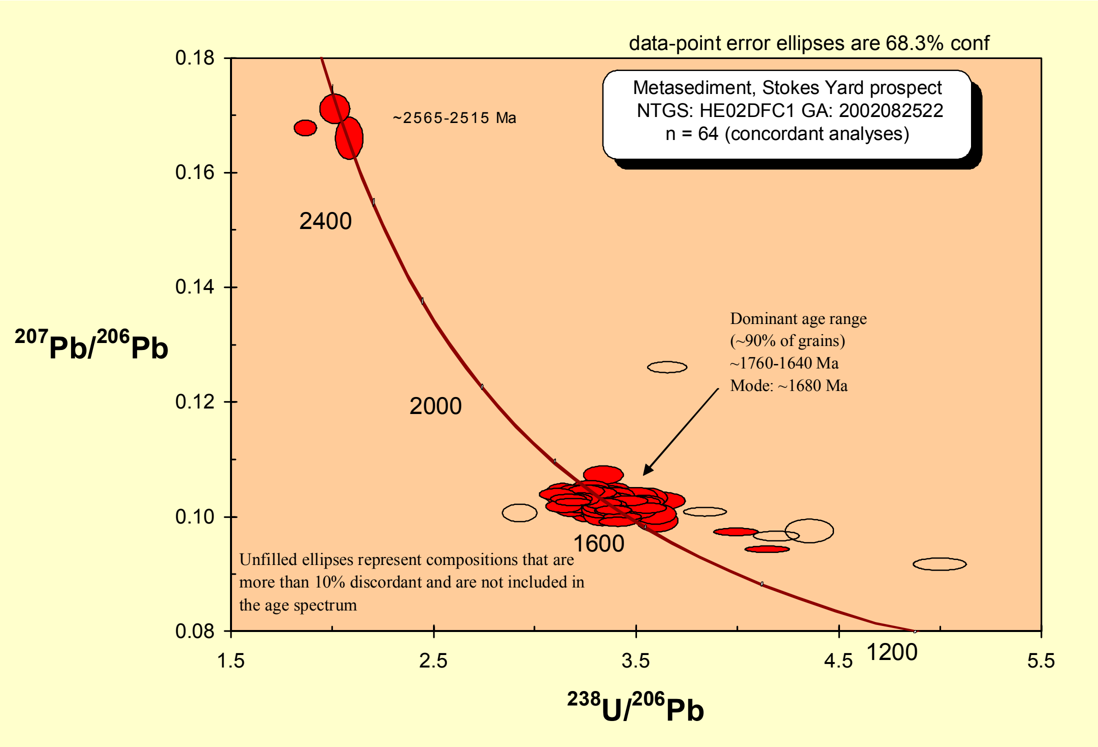

Figure 21. Terra-Wasserberg concordia plot for zircon from metasediment, Stokes Yard prospect, sample GA2002082522.

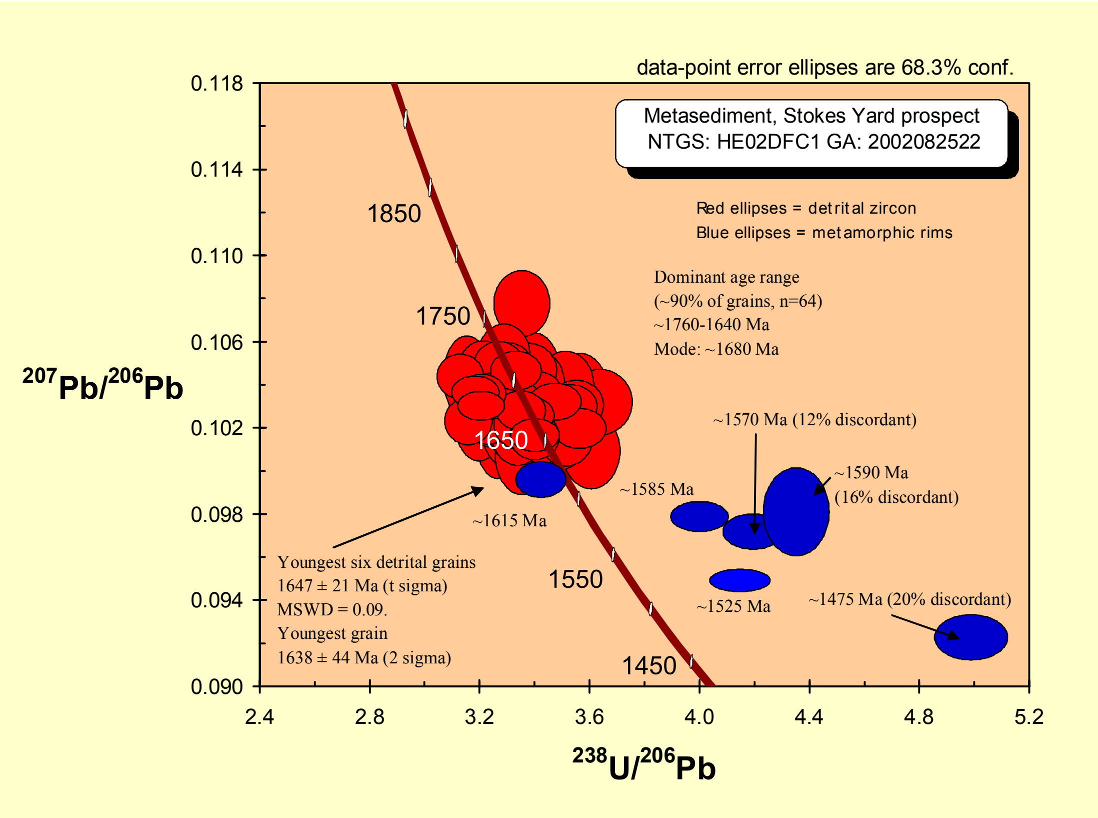

Figure 22. Enlargement of Terra-Wasserberg concordia plot for zircon from metasediment, Stokes Yard prospect, sample GA2002082522.

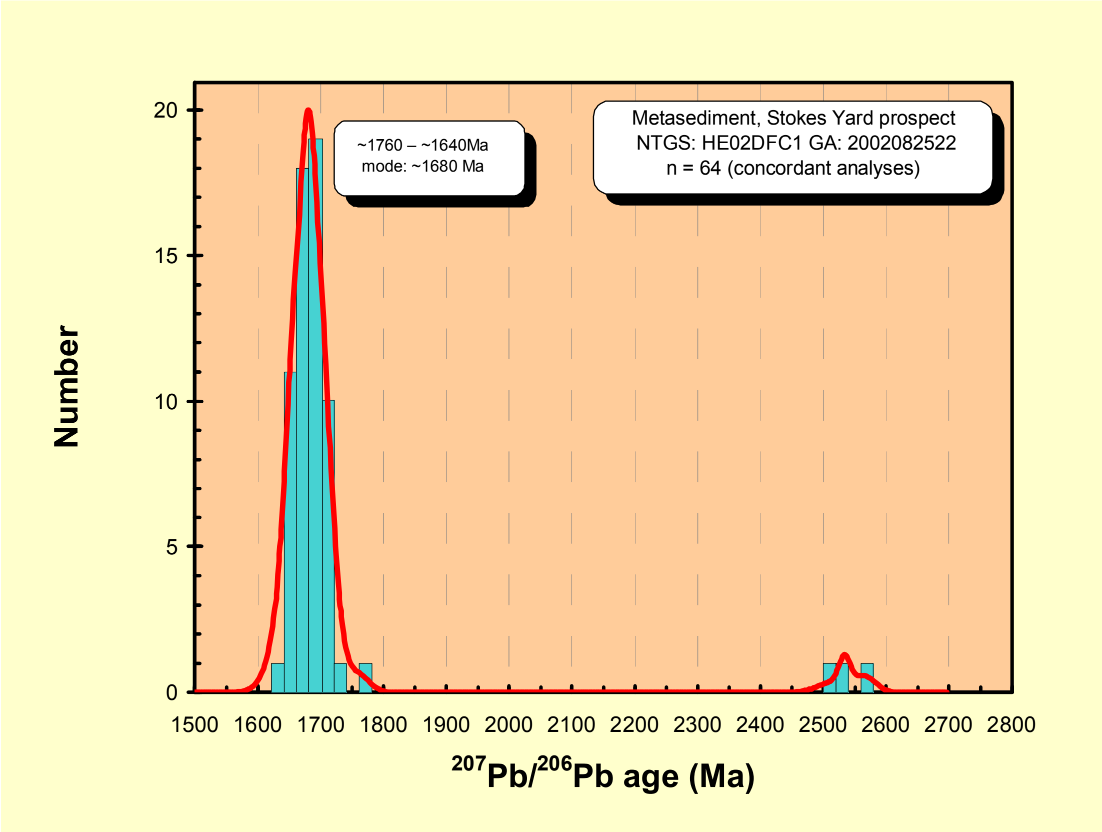

Figure 23. Cumulative probability histogram for zircon data from metasediment, Stokes Yard prospect, sample GA2002082522.

texture characteristic of the majority of zircons in this rock suggest that it has undergone a post-depositional metamorphic event, which has resulted in zircon recrystallisation and/or growth of a thin layer of metamorphic zircon.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

Seventy-eight analyses were carried out on zircons from this sample (**Figures 21**, **22**, **23**, **Table 12**). Eight analyses were removed from the dataset, as they are either discordant detrital grains above or below an arbitrary threshold of 10%, imprecise measurements, or phase overlaps where the SHRIMP spot has inadvertently sampled two separate phases of zircon growth. The remaining seventy analyses comprise 64 analyses of detrital zircon and six analyses of the metamorphically grown and/or recrystallised zircon rims.

Detrital zircons in this rock range in age between 2565 Ma and 1640 Ma, and are dominated (90% of analyses) by a continuum of apparent ages in the range 1760–1640 Ma with a mode at 1680 Ma. There are also three Archaean grains at 2515 Ma, 2535 Ma and 2565 Ma. The youngest zircon in this rock has an apparent ^{207}Pb/^{206}Pb age of 1638 ± 44 Ma (2σ), but the large error associated with this analysis renders it of little use as a constraint for the maximum deposition age of this sample. An alternative is to calculate a weighted mean ^{207}Pb/^{206}Pb age from the youngest six analyses, which in this case is 1647 ± 21 Ma (tσ; MSWD = 0.09).

Six SHRIMP spots sampled the low-CL-response metamorphic rims. These analyses generally have high U (560–1400 ppm) and/or low Th/U ratios (generally <0.05), which is typical of, but not ubiquitous to metamorphic zircon. However, only three of these six analyses (B37.1, B46.1, B36.1) are concordant and/or near-concordant below an arbitrary threshold of 10%; these have apparent ages of 1526 ± 7 Ma (σ), 1584 ± 9 Ma (σ) and 1616 ± 10 Ma (σ), respectively. Discordant compositions include: B41.1 (1571 ± 10 Ma (σ), 12% discordant); B57.1 (1588 ± 26 Ma (σ), 16% discordant); and B40.1 (1473 ± 14 Ma (σ), 20% discordant). This series of apparent ages does not combine into a single statistically significant grouping and therefore, constraining an age for the event responsible for the development of the metamorphic rims is difficult. However, it is most likely that the metamorphic rims grew during the 1590 Ma Chewings Orogeny, as four of six zircon rim analyses in this sample are within the range 1615–1585 Ma. This event has also been recorded in a number of nearby rocks from similar low-CL-response, high-U, low-Th/U rims. The two analyses that are significantly less than 1590 Ma (B40.1 and B37.1) suggest that this rock has been affected by a younger event, which has resulted in some radiogenic Pb loss.

As there is evidence that the zircons in this rock have been affected by the 1590 Ma Chewings Orogeny, the deposition age for this sample can be constrained between the youngest zircons at 1647 ± 21 Ma (tσ) and the Chewings Orogeny.

Spot	%^{206}Pb$_c$	U (ppm)	Th (ppm)	^{232}Th/^{238}U	^{238}U/^{206}Pb*	± %	^{207}Pb*/^{206}Pb*	± %	^{207}Pb/^{206}Pb age	% discordant
provenance individuals										
B47.1	-0.09	187	123	123	3.342	1.9	0.10070	1.2	1638 ± 22	-3
B15.1	0.69	248	202	202	3.601	1.9	0.10090	1.1	1641 ± 21	4
B60.1	0.38	211	152	152	3.451	1.9	0.10110	1.2	1644 ± 23	0
B55.1	0.41	385	221	221	3.506	1.8	0.10147	0.81	1651 ± 15	2
B1.1	0.36	347	274	274	3.477	1.9	0.10150	0.97	1652 ± 18	1
B50.1	0.58	125	99	99	3.479	2.0	0.10150	1.4	1652 ± 26	1
B30.1	0.07	312	288	288	3.392	1.8	0.10158	0.69	1653 ± 13	-1
B65.1	0.17	186	167	167	3.431	1.9	0.10161	0.87	1654 ± 16	0
B43.1	0.01	247	337	337	3.329	1.9	0.10164	0.89	1654 ± 16	-2
B31.1	0.10	660	299	299	3.394	1.8	0.10164	0.49	1654.4 ± 9.0	-1
B25.1	-0.07	150	79	79	3.321	2.0	0.10190	1.3	1658 ± 23	-2
B4.1	-0.14	173	143	143	3.316	1.9	0.10200	10	1660 ± 18	-2
B9.1	0.50	564	542	542	3.558	1.8	0.10196	0.59	1660 ± 11	4
B16.1	0.39	245	74	74	3.468	1.9	0.10205	0.97	1662 ± 18	2
B64.1	0.16	174	130	130	3.292	1.9	0.10210	1.2	1662 ± 23	-3
B33.1	-0.04	257	220	220	3.331	1.8	0.10217	0.75	1664 ± 14	-2
B38.2	-0.63	270	243	243	3.148	1.8	0.10231	0.70	1666 ± 13	-7
B66.2	-0.49	240	227	227	3.219	2.0	0.10242	0.76	1668 ± 14	-5
B56.1	-0.36	159	63	63	3.187	1.9	0.10240	1.3	1669 ± 24	-5
B22.1	0.25	202	168	168	3.438	1.9	0.10250	1.2	1670 ± 21	1
B23.1	0.07	620	339	339	3.367	1.8	0.10256	0.57	1671 ± 11	0
B66.1	0.32	177	92	92	3.462	1.9	0.10260	0.99	1672 ± 18	2
B3.1	-0.11	154	123	123	3.285	1.9	0.10270	1.1	1674 ± 20	-2
B59.1	0.00	402	336	336	3.340	1.8	0.10278	0.59	1675 ± 11	-1
B20.2	1.61	164	138	138	3.356	2.0	0.10280	2.3	1675 ± 43	0
B35.1	-0.39	131	100	100	3.233	2.1	0.10280	1.1	1675 ± 20	-4
B19.1	0.60	346	227	227	3.524	1.9	0.10298	0.64	1679 ± 12	4
B32.1	-0.54	494	337	337	3.195	1.8	0.10302	0.42	1679.2 ± 7.7	-5
B14.1	0.56	257	180	180	3.544	1.9	0.10303	0.75	1680 ± 14	5
B51.1	0.90	101	70	70	3.254	2.0	0.10310	2.2	1680 ± 41	-3
B20.1	-0.02	445	374	374	3.322	1.8	0.10309	0.76	1680 ± 14	-1
B36.2	-0.05	186	142	142	3.322	1.8	0.10313	0.85	1681 ± 16	-1
B13.1	0.23	138	101	101	3.355	2.0	0.10320	1.1	1682 ± 21	0
B18.1	0.83	182	106	106	3.632	2.1	0.10320	0.98	1,682 ± 18	7
B28.1	0.17	189	205	205	3.387	2.0	0.10320	0.98	1683 ± 18	1
B62.1	0.34	471	421	421	3.463	1.8	0.10321	0.55	1683 ± 10	3
B43.2	-0.36	456	362	362	3.216	1.9	0.10329	0.59	1684 ± 11	-4
B34.1	-0.38	105	78	78	3.188	2.3	0.10340	1.1	1685 ± 20	-4
B48.1	0.28	242	243	243	3.406	1.9	0.10337	0.78	1685 ± 14	2
B29.1	-0.29	224	164	164	3.236	1.8	0.10348	0.68	1687 ± 12	-3
B61.1	-0.33	349	418	418	3.198	1.8	0.10357	0.58	1689 ± 11	-4
B38.1	-0.51	393	303	303	3.174	1.8	0.10362	0.49	1689.9 ± 9.1	-4
B26.1	-0.18	210	145	145	3.266	1.9	0.10364	0.88	1690 ± 16	-2
B63.1	0.73	134	106	106	3.553	2.0	0.10370	1.1	1692 ± 20	6
B21.1	0.13	394	287	287	3.340	1.8	0.10385	0.70	1694 ± 13	0
B54.1	0.25	85	63	63	3.301	2.1	0.10390	1.7	1695 ± 31	-1
B17.1	0.62	153	120	120	3.504	2.0	0.10390	1.0	1695 ± 19	5
B53.1	0.31	213	122	122	3.399	1.9	0.10410	0.93	1699 ± 17	2
B7.1	-0.10	272	94	94	3.263	1.9	0.10418	0.82	1700 ± 15	-1
B2.1	0.30	260	204	204	3.359	2.2	0.10430	0.97	1702 ± 18	1
B37.2	0.38	267	236	236	3.142	1.8	0.10430	1.2	1703 ± 22	-5
B58.1	0.36	217	189	189	3.391	1.9	0.10430	1.3	1703 ± 24	2
B39.1	-0.59	221	175	175	3.117	1.8	0.10437	0.65	1703 ± 12	-5
B11.1	-0.11	302	270	270	3.202	1.9	0.10459	0.90	1707 ± 17	-3
B45.2	0.08	285	266	266	3.321	1.8	0.10463	0.57	1708 ± 11	1
B35.2	0.17	211	166	166	3.365	2.1	0.10469	0.78	1709 ± 14	2
B10.1	0.04	216	206	206	3.293	1.9	0.10475	0.75	1710 ± 14	0
B45.1	-0.03	137	109	109	3.260	1.9	0.10480	1.1	1710 ± 19	-1
B5.1	-0.13	280	215	215	3.259	1.8	0.10490	0.68	1713 ± 13	-1
B12.1	0.07	231	194	194	3.278	1.9	0.10540	0.88	1721 ± 16	0
B49.1	0.41	105	78	78	3.344	2.0	0.10770	0.94	1761 ± 17	4
B27.1	0.37	105	37	37	2.094	2.1	0.16590	1.5	2516 ± 25	0
B44.1	-3.50	257	69	69	1.880	1.9	0.16764	0.55	2534.2 ± 9.2	-8
B42.1	-0.31	43	18	18	2.027	2.3	0.17090	10	2567 ± 17	-1
metamorphic rims										
B37.1	0.97	1432	76	0.05	4.147	1.7	0.09492	0.36	1526.5 ± 6.8	9
B46.1	1.00	1023	283	0.29	3.997	1.8	0.09788	0.46	1584.2 ± 8.6	9
B36.1	-0.15	560	28	0.05	3.414	1.8	0.09959	0.54	1616 ± 10	-2
B41.1	1.76	1240	110	0.09	4.193	1.7	0.09719	0.56	1571 ± 10	12
B57.1	2.55	463	185	0.41	4.353	1.8	0.09810	1.4	1588 ± 26	16
B40.1	2.36	1610	28	0.02	4.995	1.7	0.09228	0.76	1473 ± 14	20
(continued)										

Table 12. SHRIMP analytical results for metasediment, Stokes Yard prospect, sample GA2002082522. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Spot	%$^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
(continued)										
discordant compositions										
B42.2	4.10	915	65	0.07	3.658	1.8	0.12630	0.51	2047.1 ± 9.1	24
B6.1	-1.55	439	358	0.84	2.933	1.9	0.10115	0.98	1645 ± 18	-15
B52.1	1.15	919	1217	1.37	3.845	1.8	0.10135	0.52	1648.9 ± 9.6	10
poor analyses										
B8.1	0.72	148	117	0.82	3.274	2.2	0.10830	3.9	1771 ± 72	3
B44.2	7.52	1303	50	0.04	4.017	1.8	0.09880	5.8	1602 ± 110	11
B39.2	0.87	295	162	0.57	3.204	1.9	0.09870	2.4	1600 ± 45	-9
phase overlap										
B24.1	0.48	357	33	0.10	3.610	1.9	0.09980	1.3	1620 ± 24	3
B16.2	-0.02	889	7	0.01	3.437	1.8	0.10052	0.46	1633.7 ± 8.5	-1

Table 12. (continued).

Putardi Quartzite

GA sample ID: 2000082006
NTGS sample ID: ML00CJE318
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: LIEBIG
Region: Warumpi Province
Grid reference (GDA94): 426584mE, 7406521mN
Formal name: Putardi Quartzite
Sample information (rock description, relative age constraints):
The Putardi Quartzite occurs as prominent ridges that include Mount Udor, Mount Putardi and Mount Peculiar, over a discontinuous strike length of 100 km. The unit is dominated by crystalline metasedimentary quartzite, often containing kyanite and/or muscovite, interlayered with quartz-muscovite and muscovite-biotite phyllite and schist. Most commonly, the Putardi Quartzite occurs within a broad zone of high non-coaxial strain (Udor Deformed Zone), in which it is structurally repeated and interleaved with granite. This high strain typically obscures the original relationship between the Putardi Quartzite and adjacent granites. However, at Mount Putardi, the Putardi Quartzite forms a large basinal structure that is relatively unaffected by non-coaxial strain, and it is interpreted to overlie the 1663 Ma Udor Granite. Strain that is associated with the Udor Deformed Zone is attributed to the 1590 Ma Chewings Orogeny, and the quartzite is truncated by undeformed dykes of Stuart Pass Dolerite. The sample is a clean, crystalline, muscovite-bearing quartzite from immediately adjacent to the Browns Bore–Mount Liebig track.

U-Pb analytical information
Mount no: Z3675
Data acquisition: 23–24 April 2001, SHRIMP I

Zircons
Zircons in this sample are generally poor in quality. They are mostly comprised of broken, subrounded fragments with pitted surface textures. Approximately 60% of grains are iron stained and many are optically turbid with numerous cracks. The majority of grains are concentrically zoned, although many are highly metamict. Some grains also have low-CL-response rims up to 10 μm thick.

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results
Fifty-six analyses were made on fifty-six zircons from this sample (**Figures 24–25**, **Table 13**). Eight grains were removed from the interpretation, as they are either discordant above an arbitrary threshold of 10% or have a high common Pb content. The remaining compositions mainly range between 1915 Ma and 1560 Ma, with a single grain at 2335 Ma. The majority of grains (85%) form a continuum of apparent ages between 1915 Ma and 1745 Ma, with a mode at 1770 Ma. A gap in the age spectrum separates this grouping from a younger, more discontinuous series of six apparent ages between 1705 Ma and 1560 Ma. This younger grouping can be interpreted in a number of ways.

Firstly, these younger grains are conspicuous, as there is a time gap between them and the main continuum of detrital zircons. This can be explained in that these younger grains may have been isotopically disturbed by the Liebig and/or Chewings orogenies, or may have lost radiogenic Pb due to some other process. Certainly, the iron-stained turbid nature

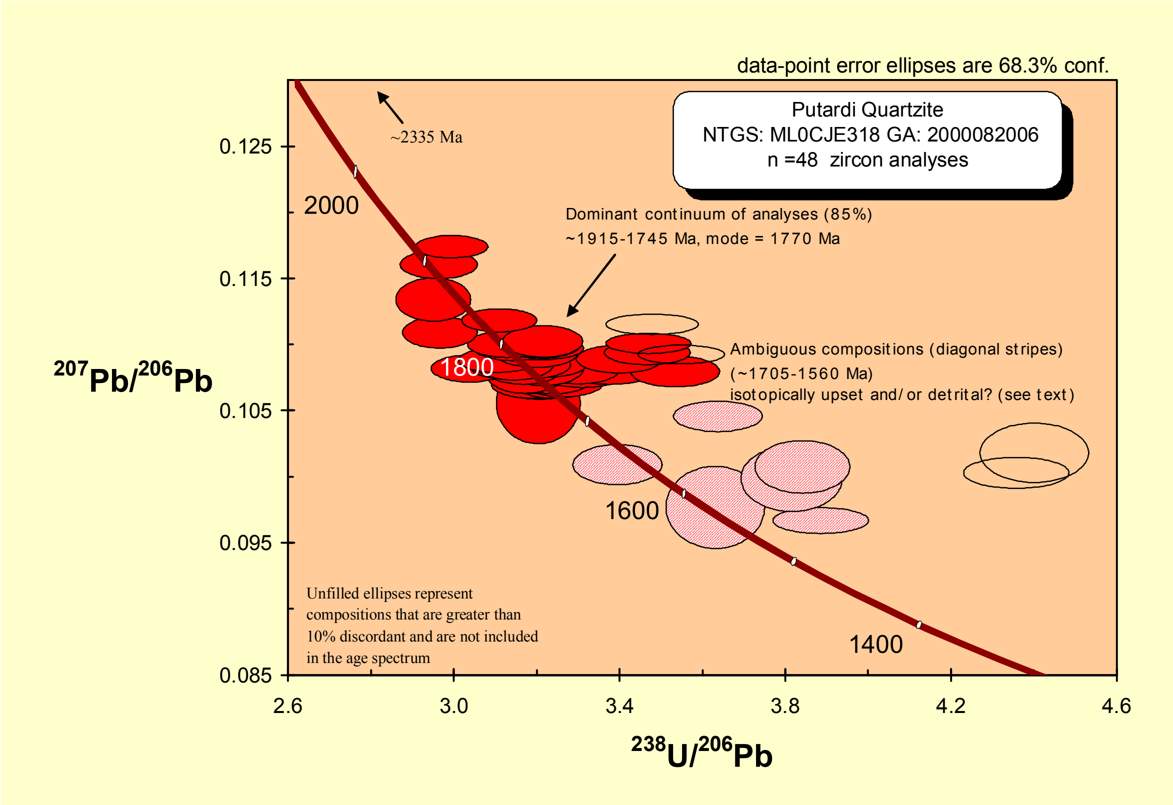

Figure 24. Terra-Wasserberg concordia plot for zircon from Putardi Quartzite, sample GA2000082006.

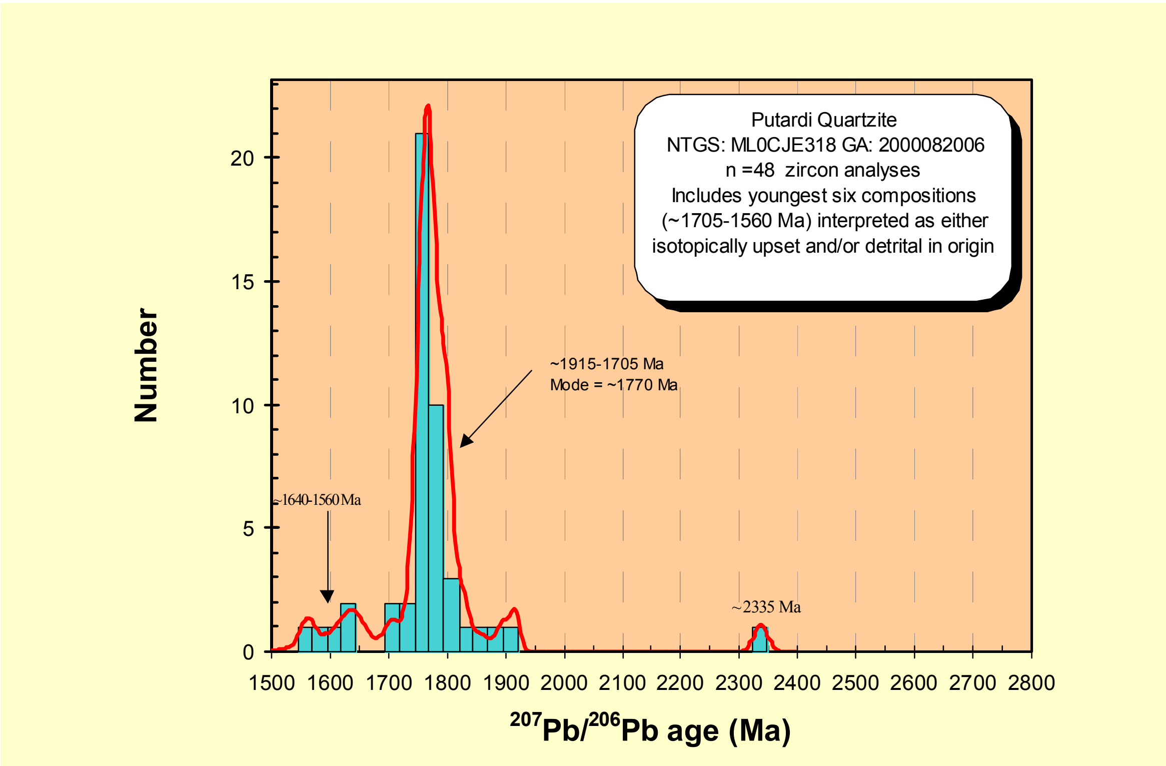

Figure 25. Cumulative probability histogram for zircon data from Putardi Quartzite, sample GA2000082006. Includes youngest six compositions (1705–1560 Ma), interpreted as either isotopically upset and/or detrital in origin.

of many of the zircons in this sample is a symptom of weathering interaction. Support for isotopic resetting is given by the youngest grain B18.1 [1561 ± 12 Ma (σ)], which, like many other zircons in this sample, has a very low CL response that could be interpreted as either metamorphic in origin or a highly metamict zircon. However, it is important to note that two of the six youngest zircons, B42.1 [1580 ± 40 Ma (σ)] and B25.1 [1641 ± 18 Ma (σ)], are concentrically zoned,

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals										
B29.1	1.33	168	68	0.42	3.195	2.1	0.10550	1.9	1724 ± 35	-2
B28.1	0.27	566	294	0.54	3.198	2.0	0.10677	0.57	1745 ± 10	-1
B52.1	0.09	315	164	0.54	3.184	2.1	0.10698	0.66	1749 ± 12	-1
B53.1	0.15	252	175	0.72	3.234	2.0	0.10718	0.76	1752 ± 14	1
B12.1	0.30	393	222	0.58	3.256	2.0	0.10718	0.70	1752 ± 13	1
B14.1	0.17	490	313	0.66	3.182	2.0	0.10719	0.57	1752 ± 10	-1
B47.1	0.31	940	158	0.17	3.283	2.0	0.10749	0.45	1757.4 ± 8.2	2
B7.1	0.16	391	156	0.41	3.175	2.0	0.10755	0.56	1758 ± 10	0
B8.1	0.16	249	102	0.42	3.233	2.0	0.10758	0.80	1759 ± 15	1
B17.1	0.26	586	296	0.52	3.302	2.0	0.10760	0.53	1759.2 ± 9.7	3
B51.1	0.22	323	114	0.36	3.165	2.0	0.10769	0.77	1761 ± 14	-1
B45.1	0.08	483	325	0.70	3.368	2.0	0.10779	0.52	1762.4 ± 9.4	5
B48.1	0.05	351	164	0.48	3.150	2.0	0.10792	0.48	1764.6 ± 8.8	-1
B46.1	0.18	437	234	0.55	3.528	2.0	0.10794	0.70	1765 ± 13	9
B44.1	0.12	286	120	0.43	3.163	2.1	0.10800	1.0	1765 ± 18	0
B49.1	0.09	397	204	0.53	3.293	2.0	0.10811	0.68	1768 ± 12	3
B37.1	0.08	302	146	0.50	3.205	2.1	0.10816	0.77	1769 ± 14	1
B24.1	0.02	212	119	0.58	3.027	2.1	0.10818	0.62	1769 ± 11	-4
B16.1	0.09	312	86	0.28	3.123	2.0	0.10825	0.53	1770.2 ± 9.8	-1
B4.1	0.08	178	112	0.65	3.159	2.1	0.10834	0.83	1772 ± 15	0
B54.1	0.01	348	135	0.40	3.130	2.0	0.10834	0.47	1771.7 ± 8.6	-1
B43.1	0.03	299	149	0.52	3.211	2.1	0.10840	0.56	1773 ± 10	1
B6.1	-0.02	475	162	0.35	3.129	2.0	0.10843	0.42	1773.1 ± 7.7	-1
B31.1	-0.01	304	174	0.59	3.176	2.0	0.10846	0.63	1774 ± 12	1
B22.1	0.01	256	124	0.50	3.136	2.0	0.10859	0.81	1776 ± 15	0
B13.1	0.02	292	160	0.57	3.095	2.0	0.10880	0.55	1779 ± 10	-1
B36.1	0.00	280	120	0.44	3.392	2.0	0.10889	0.64	1781 ± 12	6
B32.1	0.04	252	83	0.34	3.190	2.0	0.10931	0.62	1788 ± 11	2
B19.1	0.22	542	377	0.72	3.461	2.0	0.10938	0.57	1789 ± 10	9
B50.1	-0.03	342	146	0.44	3.208	2.0	0.10969	0.50	1794.3 ± 9.0	3
B5.1	0.08	345	106	0.32	3.181	2.0	0.10979	0.57	1796 ± 10	2
B55.1	0.00	149	79	0.55	3.133	2.1	0.10998	0.71	1799 ± 13	1
B26.1	0.05	255	51	0.21	3.118	2.0	0.10999	0.60	1799 ± 11	0
B41.1	0.01	325	146	0.46	3.199	2.1	0.11002	0.64	1800 ± 12	3
B34.1	0.35	849	467	0.57	3.464	2.0	0.11007	0.46	1800.5 ± 8.4	9
B21.1	0.53	408	177	0.45	3.205	2.0	0.11022	0.72	1803 ± 13	3
B11.1	0.10	218	94	0.45	2.955	2.1	0.11090	0.70	1814 ± 13	-4
B33.1	0.45	873	329	0.39	3.099	2.0	0.11177	0.51	1828.4 ± 9.2	1
B38.1	0.31	199	120	0.62	2.938	2.1	0.11340	0.95	1854 ± 17	-2
B39.1	0.00	194	75	0.40	2.951	2.1	0.11600	0.61	1896 ± 11	1
B3.1	0.57	879	201	0.24	2.984	2.0	0.11736	0.46	1916.4 ± 8.3	3
B10.1	0.08	149	62	0.43	2.269	2.1	0.14920	0.68	2337 ± 12	-1
discordant and/or high common Pb										
B40.1	0.23	696	158	0.23	2.114	2.0	0.19470	4.7	2782 ± 76	10
B23.1	2.74	689	594	0.89	4.405	2.0	0.10180	1.4	1658 ± 27	20
B15.1	10.39	1256	426	0.35	6.22	2.0	0.09510	4.4	1531 ± 83	37
B2.1	21.91	530	338	0.66	4.48	3.0	0.07800	36	1143 ± 710	-14
B9.1	1.47	1067	446	0.43	4.359	2.0	0.10032	0.76	1630 ± 14	18
B1.1	0.29	892	305	0.35	3.543	2.0	0.10924	0.43	1786.8 ± 7.9	10
B56.1	0.26	826	1002	1.25	3.472	2.1	0.11150	0.45	1824.1 ± 8.2	11
B35.1	2.60	425	256	0.62	3.360	2.0	0.11140	1.8	1823 ± 33	8
isotopically upset and/or detrital?										
B18.1	0.36	656	250	0.39	3.884	2.0	0.09667	0.66	1561 ± 12	5
B42.1	0.40	125	75	0.62	3.627	2.2	0.09770	2.1	1580 ± 39	1
B27.1	0.10	165	68	0.43	3.813	2.1	0.09980	1.6	1621 ± 31	7
B30.1	1.43	357	210	0.61	3.838	2.0	0.10080	1.3	1638 ± 24	9
B25.1	0.02	151	78	0.53	3.387	2.1	0.10092	0.99	1641 ± 18	-2
B20.1	0.75	732	357	0.50	3.633	2.0	0.10456	0.73	1707 ± 13	8

Table 13. SHRIMP analytical results for Putardi Quartzite, sample GA2000082006. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

without any evidence of metamictisation or metamorphism. If it is assumed that the six youngest grains have been isotopically upset, these grains can be removed from the detrital age spectrum and a maximum deposition age can be constrained by the youngest zircons in the dominant 1915–1745 Ma cluster. The youngest zircon in this cluster has an apparent age of 1745 ± 20 Ma (2σ). Alternatively, an arbitrarily chosen youngest six grains gives a weighted mean age of 1751.9 ± 11 Ma (tσ; MSWD = 0.2).

A further alternative is that the youngest six analyses may be entirely detrital in origin and therefore represent the youngest zircons in the sample. If this option is adopted, the youngest grains in this sample (1640–1560 Ma) can be used as a constraint for the maximum deposition age.

It is clear from the above that the assignment of a maximum deposition age, based on the apparent age of the youngest detrital zircons in this sample is ambiguous. The generally poor quality of zircons in this sample probably contributes to this ambiguity. In an attempt to resolve this problem, it may prove necessary to resample a fresher, less weathered and/or altered sample of the Putardi Quartzite, if one can be obtained.

Ikuntji Metamorphics

GA sample ID: 2001082529
NTGS sample ID: ML01CJE354
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: HAAST BLUFF
Region: Warumpi Province
Grid reference (GDA94): 785788mE, 7412237mN
Formal name: Ikuntji Metamorphics
Sample information (rock description, relative age constraints):
The Ikuntji Metamorphics are part of the Iwupataka Metamorphic Complex (Offe and Shaw 1993, Warren and Shaw 1995). They are dominated by variably feldspathic to quartzose muscovite-biotite schist, with lesser quartz-muscovite schist, quartzite, amphibolite and calc-silicate rock, grading up into massive quartzite. The dominant rock type is feldspathic biotite-muscovite schist, interlayered with quartz-muscovite schist and less common thinly bedded micaceous quartzite. Toward the upper part of the unit, the succession becomes increasingly quartz-rich and comprises quartz-biotite-muscovite meta-arkose and minor biotite-muscovite schist, interlayered with crystalline quartzite, grading up into a massive clean crystalline quartzite. The quartzite varies from being clean and massive to being relatively thinly bedded, with more schistose muscovite-bearing interbeds at a centimetre to metre scale. The quartzite may be a stratigraphic equivalent of the Chewings Range Quartzite, which is the stratigraphically highest unit of the Iwupataka Metamorphic Complex in HERMANNSBURG and ALICE SPRINGS (Offe and Shaw 1983, Warren and Shaw 1995). The thickness of the quartzite is unknown, but is likely to be >200 m. The dated sample is a massive crystalline quartzite from the upper part of the Ikuntji Metamorphics.

U-Pb analytical information
Mount no: Z3875
Data acquisition: 4–6 January 2002, SHRIMP I

Zircons
Zircons in this sample comprise broken, rounded grains, many with pitted surface textures. Approximately 30% are optically turbid. The majority of grains have concentric growth zones, which is indicative of an igneous derivation.

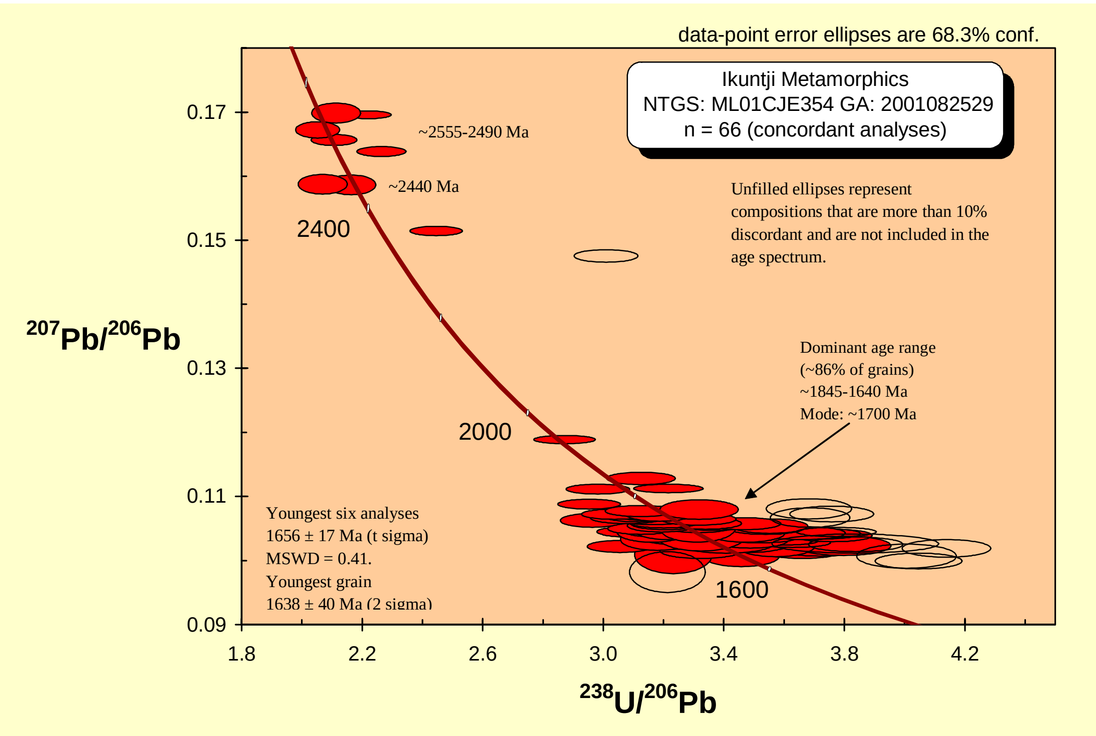

Figure 26. Terra-Wasserberg concordia plot for zircon from Ikuntji Metamorphics, sample GA2001082529.

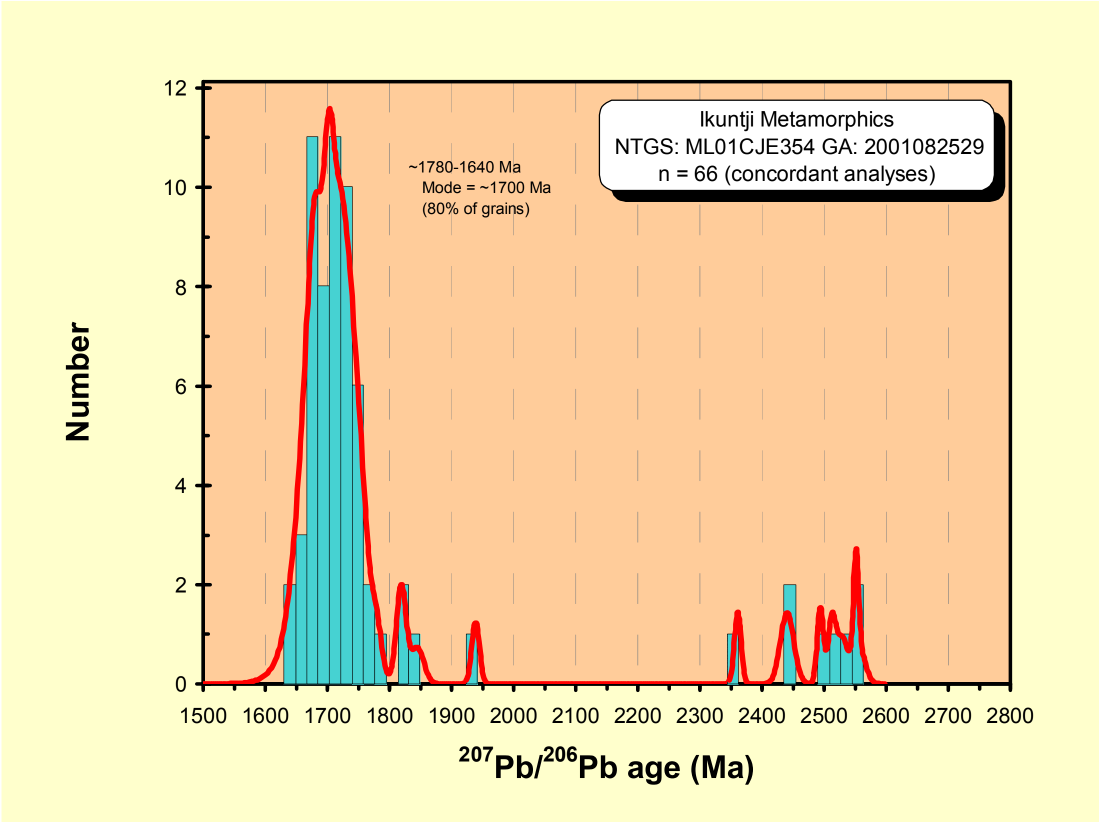

Figure 27. Cumulative probability histogram for zircon data from Ikuntji Metamorphics, sample GA2001082529.

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results
Seventy-eight analyses were carried out on seventy-eight zircons from this sample (**Figures 26–27**, **Table 14**). Twelve analyses are discordant above an arbitrary threshold of 10% and were removed from further consideration. The remaining concordant and near-concordant analyses range in age between 2555 Ma and 1640 Ma. The sample is dominated by a continuum of zircons (86%) between 1845 Ma and 1640 Ma, which has a mode at 1700 Ma. There are also individual cases at 1940 Ma and 2360 Ma and a series of seven compositions in the range 2555–2440 Ma. The youngest zircon in this sample has an apparent $^{207}Pb/^{206}Pb$ age of 1638 ± 40 Ma (2σ). However, the large error associated with this result limits its usefulness as a constraint for the maximum deposition age. Alternatively, the youngest six analyses combine to give a weighted mean $^{207}Pb/^{206}Pb$ age of 1656 ± 17 Ma (tσ; MSWD = 0.41).

Chewings Range Quartzite

GA sample ID: 2001082531
NTGS sample ID: HE01CJE1
1:250 000 sheet: HERMANNSBURG
1:100 000 sheet: MacDonnell Ranges
Region: Warumpi Province
Grid reference (GDA94): 351136mE, 7381848mN
Formal name: Chewings Range Quartzite
Sample information (rock description, relative age constraints):
This sample is a crystalline metasedimentary quartzite from the type section of the Chewings Range Quartzite, the uppermost unit of the Iwupataka Metamorphic Complex (Warren and Shaw 1995). It was selected for dating to constrain its maximum deposition age and act as a reference for comparison with metasedimentary quartzite units in MOUNT LIEBIG, including the Ikuntji Metamorphics.

U-Pb analytical information
Mount no: Z3972
Data acquisition: 8–12 July 2002, SHRIMP I

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals										
A6.1	0.30	238	149	0.65	3.456	2.4	0.10070	1.1	1638 ± 20	0
A41.1	0.07	64	48	0.78	3.233	2.6	0.10090	1.9	1641 ± 35	-6
A76.1	0.17	271	215	0.82	3.322	2.7	0.10151	0.76	1652 ± 14	-3
A54.1	-0.02	163	58	0.37	3.660	2.4	0.10155	0.78	1653 ± 14	6
A52.1	0.04	226	159	0.73	3.054	2.4	0.10220	0.60	1664 ± 11	-10
A77.1	-0.05	332	271	0.85	3.72	3.0	0.10228	0.98	1666 ± 18	8
A17.1	0.51	326	301	0.95	3.80	2.8	0.10236	0.98	1667 ± 18	10
A53.1	0.48	195	110	0.58	3.573	2.4	0.10240	1.1	1667 ± 20	5
A38.1	0.07	307	243	0.82	3.231	2.4	0.10260	0.52	1671.6 ± 9.7	-4
A27.1	0.11	293	110	0.39	3.475	2.7	0.10261	0.89	1672 ± 16	2
A28.1	0.14	192	132	0.71	3.41	3.0	0.10268	0.94	1673 ± 17	1
A32.1	0.03	266	171	0.66	3.202	2.4	0.10278	0.58	1675 ± 11	-5
A16.1	0.14	604	461	0.79	3.627	2.3	0.10282	0.50	1675.7 ± 9.2	6
A26.1	0.04	178	135	0.78	3.283	2.5	0.10293	0.68	1678 ± 13	-2
A67.1	0.21	1008	467	0.48	3.585	2.3	0.10305	0.38	1679.7 ± 7.0	6
A39.1	0.20	287	302	1.09	3.488	2.4	0.10324	0.83	1683 ± 15	3
A64.1	0.38	123	111	0.93	3.180	2.5	0.10330	1.1	1685 ± 20	-5
A70.1	0.09	519	428	0.85	3.514	2.3	0.10352	0.46	1688.2 ± 8.5	4
A20.1	0.02	331	239	0.74	3.308	2.4	0.10360	0.51	1689.7 ± 9.5	-1
A62.1	-0.02	137	184	1.39	3.243	2.5	0.10365	0.73	1690 ± 14	-2
A3.1	0.25	138	101	0.75	3.324	2.9	0.10380	1.5	1694 ± 27	0
A55.1	0.42	620	379	0.63	3.759	2.3	0.10393	0.60	1695 ± 11	10
A49.1	0.12	564	441	0.81	3.725	2.3	0.10416	0.48	1699.5 ± 8.8	10
A47.1	0.11	509	363	0.74	3.659	2.6	0.10427	0.62	1702 ± 11	8
A33.1	0.02	466	232	0.52	3.236	2.4	0.10430	0.44	1702.0 ± 8.2	-2
A29.1	0.09	152	120	0.82	3.474	2.4	0.10431	0.92	1702 ± 17	4
A56.1	0.09	640	107	0.17	3.161	2.4	0.10442	0.39	1704.2 ± 7.2	-4
A72.1	0.01	305	94	0.32	3.087	2.4	0.10446	0.49	1704.8 ± 9.1	-6
A22.1	0.09	169	113	0.69	3.162	2.4	0.10450	1.0	1705 ± 19	-4
A48.1	0.16	268	161	0.62	3.232	2.4	0.10455	0.74	1706 ± 14	-2
A14.1	0.01	253	200	0.82	3.181	2.4	0.10466	0.60	1708 ± 11	-3
A31.1	0.12	154	127	0.85	3.218	2.4	0.10487	0.94	1712 ± 17	-2
A30.1	0.01	340	292	0.89	3.126	2.4	0.10493	0.58	1713 ± 11	-4
A10.1	0.16	492	501	1.05	3.539	2.4	0.10501	0.59	1714 ± 11	6
A59.1	0.21	103	69	0.69	3.312	2.5	0.10510	1.4	1716 ± 25	1
A73.1	0.26	383	434	1.17	3.553	2.4	0.10533	0.69	1720 ± 13	7
A8.1	0.03	248	108	0.45	3.315	2.4	0.10536	0.65	1721 ± 12	1
A18.1	0.05	335	164	0.51	3.193	2.4	0.10541	0.61	1721 ± 11	-2
A74.1	0.06	424	243	0.59	3.368	2.4	0.10547	0.47	1722.4 ± 8.7	3
A13.1	0.06	258	100	0.40	3.210	2.4	0.10563	0.57	1725 ± 10	-1
A21.1	0.21	409	297	0.75	3.464	2.4	0.10568	0.58	1726 ± 11	5
A36.1	0.12	432	266	0.64	3.340	2.3	0.10575	0.55	1727 ± 10	2
A40.1	-0.03	288	233	0.84	3.201	2.4	0.10590	0.55	1730 ± 10	-1
A75.1	-0.03	313	200	0.66	2.963	2.4	0.10622	0.65	1736 ± 12	-8
A9.1	0.01	522	199	0.39	3.166	2.3	0.10627	0.40	1736.4 ± 7.3	-2
A5.1	0.05	339	200	0.61	3.314	2.5	0.10647	0.59	1740 ± 11	2
A2.1	0.02	359	316	0.91	3.080	2.6	0.10665	0.52	1743.0 ± 9.6	-4
A12.1	-0.02	363	229	0.65	3.119	2.4	0.10681	0.49	1745.6 ± 8.9	-3
A25.1	0.06	250	145	0.60	3.151	2.4	0.10721	0.61	1752 ± 11	-1
A23.1	0.05	458	267	0.60	3.037	2.4	0.10722	0.50	1752.7 ± 9.1	-5
A66.1	-0.05	218	92	0.44	3.187	2.4	0.10729	0.72	1754 ± 13	0
A24.1	0.06	334	183	0.57	3.124	2.5	0.10767	0.52	1760.4 ± 9.6	-2
A1.1	-0.11	99	59	0.62	3.317	2.6	0.10790	0.94	1765 ± 17	4
A61.1	0.03	300	74	0.25	2.952	2.4	0.10876	0.45	1778.8 ± 8.3	-6
A46.1	0.06	380	305	0.83	2.982	2.3	0.11113	0.46	1817.9 ± 8.3	-3
A43.1	0.00	480	198	0.43	3.216	2.4	0.11122	0.41	1819.4 ± 7.4	4
A35.1	0.00	231	89	0.40	3.125	2.4	0.11277	0.59	1845 ± 11	3
A58.1	0.03	516	67	0.13	2.869	2.3	0.11882	0.35	1938.5 ± 6.2	1
A42.1	0.02	707	93	0.14	2.444	2.3	0.15130	0.31	2360.6 ± 5.4	6
A7.1	0.09	129	55	0.44	2.161	2.5	0.15850	0.64	2439 ± 11	0
A63.1	0.01	99	47	0.49	2.067	2.6	0.15860	0.64	2441 ± 11	-4
A15.1	0.05	514	255	0.51	2.263	2.4	0.16362	0.30	2493.5 ± 5.1	5
A50.1	-0.03	277	264	0.98	2.105	2.4	0.16545	0.36	2512.2 ± 6.1	0
A65.1	0.08	214	113	0.55	2.051	2.4	0.16706	0.51	2528.4 ± 8.6	-1
A45.1	0.03	846	248	0.30	2.219	2.3	0.16932	0.23	2550.9 ± 3.9	6
A37.1	-0.04	117	64	0.57	2.111	2.5	0.16970	0.61	2555 ± 10	2
discordant										
A60.1	2.12	344	269	0.81	3.213	2.6	0.09820	2.2	1591 ± 40	-10
A68.1	0.15	289	242	0.86	3.84	2.7	0.10256	0.73	1671 ± 13	11
A51.1	0.10	187	216	1.19	3.83	4.8	0.10267	0.96	1673 ± 18	11
A44.1	0.06	802	218	0.28	3.773	2.3	0.10445	0.41	1704.6 ± 7.5	11
(continued)										

Table 14. SHRIMP analytical results for Ikuntji Metamorphics, sample GA2001082529. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
discordant (continued)										
A71.1	0.19	215	146	0.70	3.685	2.4	0.10667	0.93	1743 ± 17	11
A42.1	0.47	227	249	1.14	4.01	2.7	0.10070	1.2	1637 ± 23	12
A57.1	0.45	469	428	0.94	4.047	2.3	0.09995	0.81	1623 ± 15	12
A78.1	-0.05	212	162	0.79	3.682	2.6	0.10800	0.98	1767 ± 18	12
A4.1	-0.02	333	147	0.46	3.758	2.5	0.10725	0.75	1753 ± 14	13
A19.1	0.56	423	236	0.58	4.140	2.4	0.10191	0.91	1659 ± 17	16
A69.1	0.48	794	349	0.45	3.008	2.3	0.14741	0.44	2316.1 ± 7.5	20
A11.1	0.03	234	219	0.96	1.826	2.4	0.20600	7.4	2877 ± 120	2

Table 14. (continued).

Zircons

Zircons in this sample are clear to brown and approximately 20% are optically turbid. They are rounded to well rounded and many have a frosted surface texture, as is typical of detrital zircons. The majority of zircons have concentric growth zones, consistent with an igneous origin, whereas 10–15% of grains have a dark, featureless CL response. All grains have a thin (1–4 µm) high-U, low-CL-response rim and many grains have high-U, low-CL-response streaks and patchesm, which are discordant to the primary growth zones and presumably related to the thin rims. No single analysis was able to wholly sample these regions. These features suggest that this rock has been affected by a post-depositional metamorphic event that has resulted in new zircon growth and/or recrystallisation.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

Eighty-one analyses were carried out on eighty-one grains from this sample and range in age between 2525 Ma and 1360 Ma (**Figures 28–29**, **Table 15**). Five analyses are discordant above an arbitrary threshold of 10% and were removed from further consideration. The youngest results are a discontinues series of six analyses between 1600 Ma and 1360 Ma, which are separated from the main continuum of zircons by 60 my. These analyses represent isotopically mixed compositions and are therefore removed from the provenance spectrum and further discussed below. The remaining provenance grains consist of a continuum of sixty-seven zircons with apparent ages between 1825 Ma and 1660 Ma (83% of

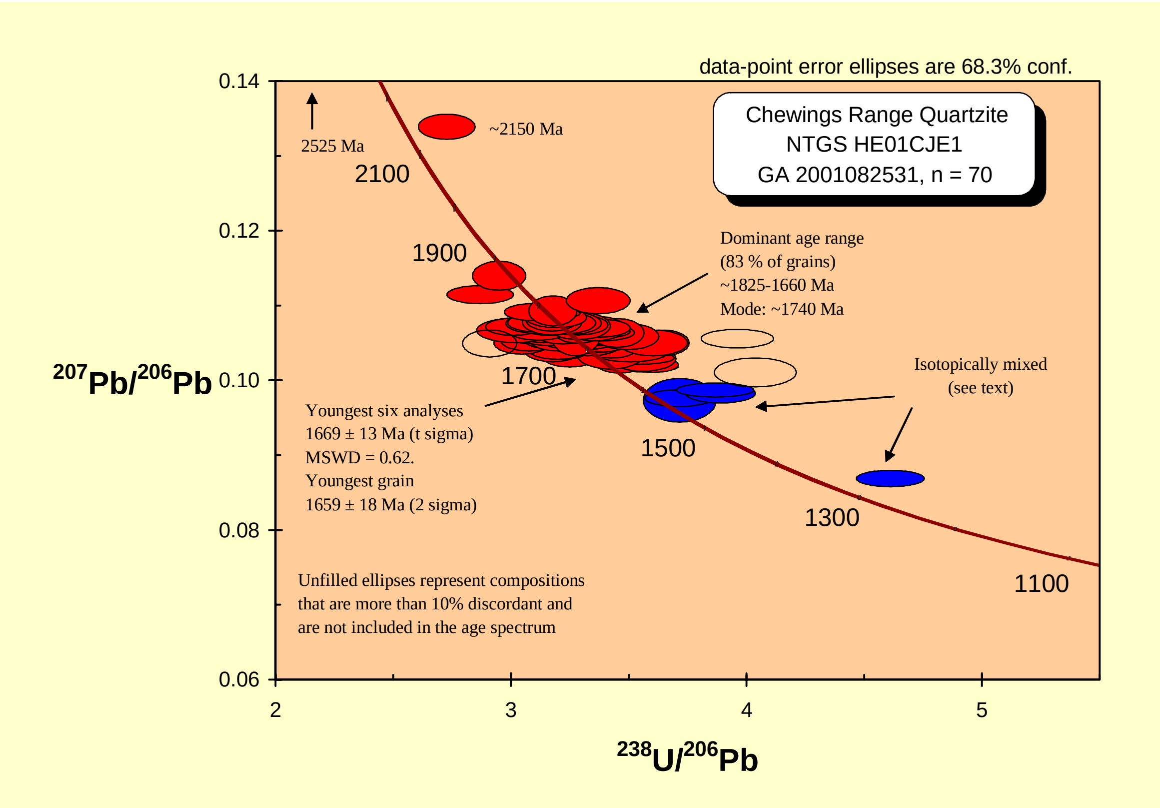

Figure 28. Terra-Wasserberg concordia plot for zircon from Chewings Range Quartzite, sample GA2001082531.

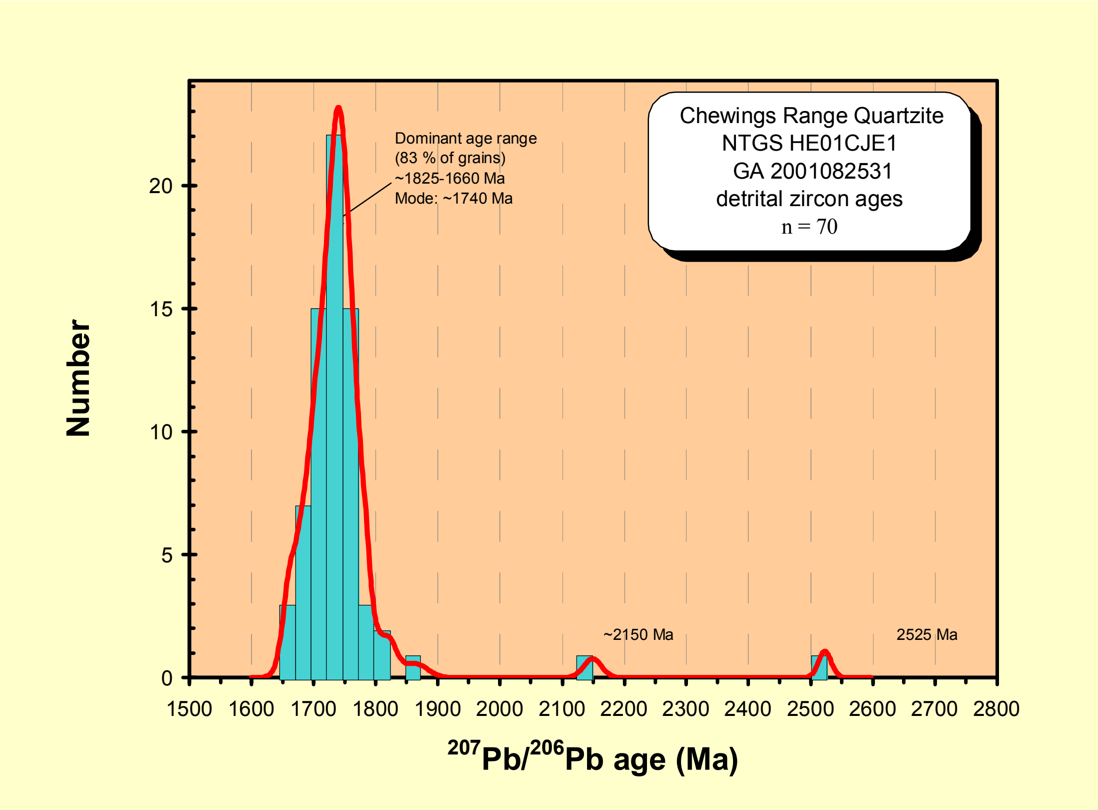

Figure 29. Cumulative probability histogram for zircon data from Chewings Range Quartzite, sample GA2001082531.

population), with a mode at 1740 Ma. There are also older individuals with apparent ages of 1865 Ma, 2150 Ma and 2525 Ma. The youngest provenance individual in this sample has an apparent $^{207}Pb/^{206}Pb$ age of 1659 ± 18 Ma (2σ); however, the large error associated with this analysis reduces its usefulness as a constraint for a maximum deposition age. An alternative is to calculate a weighted mean $^{207}Pb/^{206}Pb$ age for the youngest six analyses, which in this sample equates to an age of 1669 ± 13 Ma (tσ; MSWD = 0.62).

The six youngest analyses represent results where the SHRIMP spot has inadvertently sampled both the concentric growth zones and the low-CL-response regions of the zircons. These analyses are therefore isotopically mixed and unreliable. However, collectively, their younger ages and relatively high U contents indicate that this rock has been affected by a post-depositional metamorphic event, which has caused new zircon growth and/or recrystallisation in the form of high-U, low-CL-response rims on all of the zircons in this population. The timing of this metamorphic event has not been constrained, but it is likely to be either the 1590 Ma Chewings Orogeny or the 1150 Ma Teapot Event, and these may provide a control on the minimum age of sedimentation for this unit.

Lizard Schist

GA sample ID: 2001082528
NTGS sample ID: ML01IRS437
1:250 000 sheet: MOUNT LIEBIG
1:100 000 sheet: Liebig
Region: Warumpi Province
Grid reference (GDA94): 729118mE, 7417555mN
Formal name: Lizard Schist
Sample information (rock description, relative age constraints):
The Lizard Schist is a unit of muscovite-biotite schist and metapsammite, unconformably overlain by the Neoproterozoic Heavitree Quartzite around Warren Creek. The unit is dominated by biotite-muscovite-quartz schist, with a strong schistose S_1 fabric, overprinted by a variably developed high-angle crenulation. Muscovite-bearing quartz-rich psammite layers occur at the centimetre to metre scale within the schist, and locally preserve tight to isoclinal F_1 folds. Pegmatite veins intrude the schist, and are accompanied by tourmalinisation, with localised development of massive tourmalinite. Garnet occurs rarely as a minor constituent of the biotite-muscovite schist. At 733030mE, 7416974mN there is an ambiguous, highly strained contact with the 1683 Ma Talipata Granite. The abundance of granitic veins in the schist near the contact with the granite leads to a tentative interpretation that the granite intrudes the schist. However, the schist also has strong lithological similarities with the Ikuntji Metamorphics of the Iwupataka Metamorphic Complex. The metamorphic grade is lower to

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals										
B61.1	0.00	538	182	0.35	3.565	2.6	0.10188	0.49	1658.7 ± 9.0	4
B77.1	0.09	787	176	0.23	3.595	2.0	0.10206	0.63	1662 ± 12	5
B78.1	0.24	331	158	0.49	3.451	2.1	0.10260	1.0	1671 ± 19	2
B52.1	0.20	281	170	0.62	3.424	2.6	0.10280	0.77	1675 ± 14	1
B31.1	0.15	364	138	0.39	3.553	2.6	0.10290	1.1	1678 ± 20	5
B16.1	0.06	580	287	0.51	3.547	2.6	0.10304	0.55	1680 ± 10	5
B46.1	0.23	253	137	0.56	3.239	2.6	0.10360	1.1	1689 ± 21	-3
B1.1	0.32	185	97	0.54	3.413	2.9	0.10370	1.3	1691 ± 25	2
B48.1	-0.01	330	118	0.37	3.50	3.2	0.10392	0.90	1695 ± 17	4
B84.1	0.00	557	351	0.65	3.412	2.1	0.10407	0.67	1698 ± 12	2
B8.1	0.06	198	253	1.32	3.168	2.7	0.10420	1.1	1700 ± 20	-4
B13.1	0.16	336	155	0.48	3.205	2.6	0.10424	0.89	1701 ± 16	-3
B10.1	0.15	221	125	0.59	3.186	2.6	0.10427	0.93	1702 ± 17	-3
B15.1	0.00	643	213	0.34	3.312	2.6	0.10436	0.61	1703 ± 11	0
B11.1	0.07	324	165	0.53	3.315	2.6	0.10447	0.74	1705 ± 14	0
B75.1	0.66	676	78	0.12	3.637	2.1	0.10500	1.1	1715 ± 20	9
B70.1	-0.04	183	93	0.53	3.597	2.7	0.10500	1.1	1715 ± 20	8
B18.1	0.01	444	79	0.18	3.303	2.6	0.10505	0.90	1715 ± 16	1
B45.1	0.23	226	89	0.41	3.033	2.6	0.10506	0.94	1715 ± 17	-7
B54.1	0.17	362	123	0.35	3.367	2.6	0.10522	0.89	1718 ± 16	2
B20.1	0.15	264	122	0.48	3.065	2.6	0.10527	0.85	1719 ± 16	-6
B3.1	-0.01	226	97	0.44	3.307	2.6	0.10538	0.80	1721 ± 15	1
B22.1	0.09	278	108	0.40	3.169	2.6	0.10549	0.79	1723 ± 15	-3
B4.1	0.13	215	162	0.78	3.193	2.7	0.10550	0.97	1723 ± 18	-2
B47.1	0.09	245	128	0.54	3.243	2.6	0.10560	0.88	1725 ± 16	0
B53.1	0.00	304	228	0.78	3.192	2.6	0.10579	0.69	1728 ± 13	-2
B60.1	0.00	347	150	0.45	3.347	2.6	0.10586	0.72	1729 ± 13	3
B30.1	0.10	291	84	0.30	3.484	2.6	0.10590	1.1	1730 ± 20	6
B5.1	-0.03	430	293	0.70	3.310	2.6	0.10597	0.62	1731 ± 11	2
B21.1	0.08	381	129	0.35	3.196	2.7	0.10604	0.78	1732 ± 14	-1
B49.1	0.02	217	247	1.18	3.188	2.7	0.10613	0.81	1734 ± 15	-1
B68.1	0.04	248	127	0.53	3.338	2.7	0.10615	0.80	1734 ± 15	3
B56.1	0.08	213	110	0.53	3.087	2.6	0.10636	0.88	1738 ± 16	-4
B85.1	0.26	401	80	0.21	3.441	2.2	0.10640	1.2	1738 ± 22	5
B32.1	-0.01	344	294	0.88	3.381	2.6	0.10636	0.67	1738 ± 12	4
B12.2	-0.12	209	135	0.67	3.149	2.7	0.10640	1.1	1739 ± 20	-2
B36.1	-0.05	311	162	0.54	3.130	2.6	0.10645	0.84	1740 ± 15	-3
B83.1	0.18	214	176	0.85	3.266	2.3	0.10650	2.0	1740 ± 36	1
B62.1	-0.04	353	120	0.35	3.359	2.7	0.10654	0.58	1741 ± 11	3
B41.1	0.05	533	281	0.55	3.246	2.6	0.10654	0.57	1741 ± 10	1
B59.1	0.06	369	280	0.78	3.197	2.8	0.10667	0.68	1743 ± 12	-1
B2.1	-0.20	127	68	0.55	3.209	2.7	0.10670	1.1	1743 ± 20	0
B14.1	-0.14	185	84	0.47	3.01	3.7	0.10670	1.0	1744 ± 19	-6
B80.1	0.08	236	127	0.56	3.276	2.2	0.10680	1.1	1745 ± 20	2
B7.1	0.53	531	95	0.19	3.344	2.6	0.10690	1.0	1748 ± 18	4
B71.1	-0.02	294	98	0.34	3.364	2.6	0.10697	0.73	1748 ± 13	4
B23.1	0.06	382	202	0.55	3.255	2.6	0.10700	0.78	1749 ± 14	1
B74.1	-0.07	315	150	0.49	3.191	2.1	0.10712	0.78	1751 ± 14	0
B17.1	-0.08	227	97	0.44	3.105	3.1	0.10720	1.1	1752 ± 20	-3
B19.1	-0.02	243	72	0.31	2.998	2.6	0.10719	0.71	1752 ± 13	-6
B26.1	0.05	154	111	0.74	3.280	2.7	0.10730	1.1	1754 ± 21	2
B44.1	-0.07	258	142	0.57	3.153	2.6	0.10733	0.80	1755 ± 15	-1
B55.1	0.05	259	201	0.80	3.274	2.6	0.10741	0.83	1756 ± 15	2
B37.1	-0.06	301	220	0.76	3.184	2.6	0.10746	0.75	1757 ± 14	0
B40.1	-0.03	247	136	0.57	3.172	2.7	0.10762	0.76	1760 ± 14	0
B43.1	-0.02	199	139	0.72	3.095	2.6	0.10763	0.77	1760 ± 14	-3
B50.1	0.06	219	68	0.32	3.248	2.6	0.10768	0.92	1761 ± 17	2
B42.1	-0.03	240	112	0.48	3.098	2.6	0.10770	0.74	1761 ± 14	-2
B51.1	-0.18	153	331	2.24	3.216	2.7	0.10773	0.89	1761 ± 16	1
B34.1	0.15	235	148	0.65	3.166	2.7	0.10780	1.1	1762 ± 19	0
B81.1	-0.09	235	124	0.55	3.164	2.2	0.10820	0.98	1770 ± 18	0
B66.1	-0.04	239	139	0.60	3.182	2.7	0.10841	0.83	1773 ± 15	1
B39.1	0.02	721	395	0.57	3.160	2.5	0.10898	0.44	1782.5 ± 7.9	1
B57.1	-0.11	218	147	0.70	3.087	2.6	0.10916	0.70	1785 ± 13	-1
B73.1	0.10	287	84	0.30	3.166	2.2	0.10920	1.2	1787 ± 21	1
B72.1	-0.05	228	104	0.47	3.360	2.7	0.11070	1.0	1810 ± 19	7
B29.1	0.02	278	78	0.29	2.854	3.3	0.11142	0.67	1823 ± 12	-6
B35.1	0.17	168	68	0.42	2.938	2.7	0.11400	1.1	1864 ± 20	-1
B33.1	0.07	281	137	0.50	2.713	3.0	0.13380	0.82	2149 ± 14	6
B79.1	-0.04	231	174	0.78	1.976	2.2	0.16650	0.61	2523 ± 10	-5
(continued)										

Table 15. SHRIMP analytical results for Chewings Range Quartzite, sample GA2001082531. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
(continued)										
discordant										
B9.1	0.12	172	109	0.66	2.896	2.6	0.10490	1.1	1713 ± 21	-12
B82.1	0.45	352	186	0.55	4.03	2.9	0.10110	1.3	1644 ± 24	13
B64.1	0.04	650	146	0.23	3.95	2.6	0.10561	0.76	1725 ± 14	16
B58.1	0.01	862	263	0.32	2.387	2.6	0.16523	0.31	2509.9 ± 5.2	10
B28.1	0.35	220	87	0.41	2.629	2.6	0.17310	0.93	2588 ± 16	20
isotopically mixed										
B76.1	0.14	705	91	0.13	4.607	2.1	0.08687	0.82	1358 ± 16	7
B6.1	0.28	912	181	0.20	3.800	2.5	0.09484	0.98	1525 ± 18	1
B25.1	0.62	201	89	0.46	3.71	2.8	0.09730	2.0	1574 ± 37	2
B12.1	0.09	512	79	0.16	3.704	2.6	0.09766	0.75	1580 ± 14	2
B27.1	0.18	759	477	0.65	3.885	2.5	0.09831	0.86	1592 ± 16	7
B38.1	0.04	552	181	0.34	3.86	2.8	0.09874	0.60	1600 ± 11	7

Table 15. (continued).

middle amphibolite facies. The sample selected for geochronology is a 1 m-wide grey crystalline quartzite layer within the schist.

U-Pb analytical information

Mount no: Z3964

Data acquisition: 30 May–1 June 2002, SHRIMP I; 13 July 2002, SHRIMP I

Zircons

Zircons in this sample are clear to brown and generally rounded to well rounded. Many grains are elongated with rounded terminations and have aspect ratios up to 3. Cathodoluminescence images show that most grains are oscillatory zoned, while approximately 10% have a dark, weakly zoned CL response. All grains have a thin 1–4 µm dark CL rim that is too thin to analyse with SHRIMP. The thin, low-CL-response rims common to all grains from this sample suggest that this rock has undergone a post-depositional high-grade metamorphic event, which has resulted in new zircon growth and/or recrystallisation.

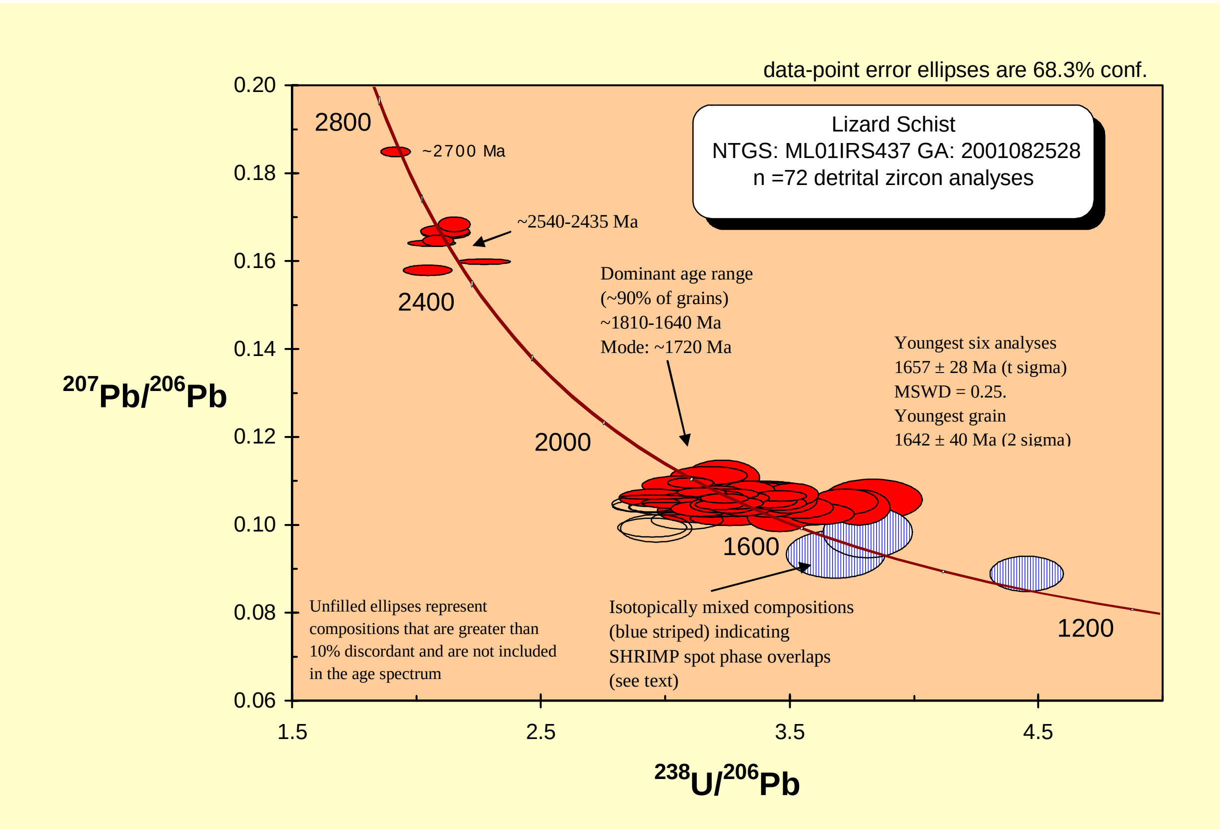

Figure 30. Terra-Wasserberg concordia plot for zircon from Lizard Schist, sample GA2001082528.

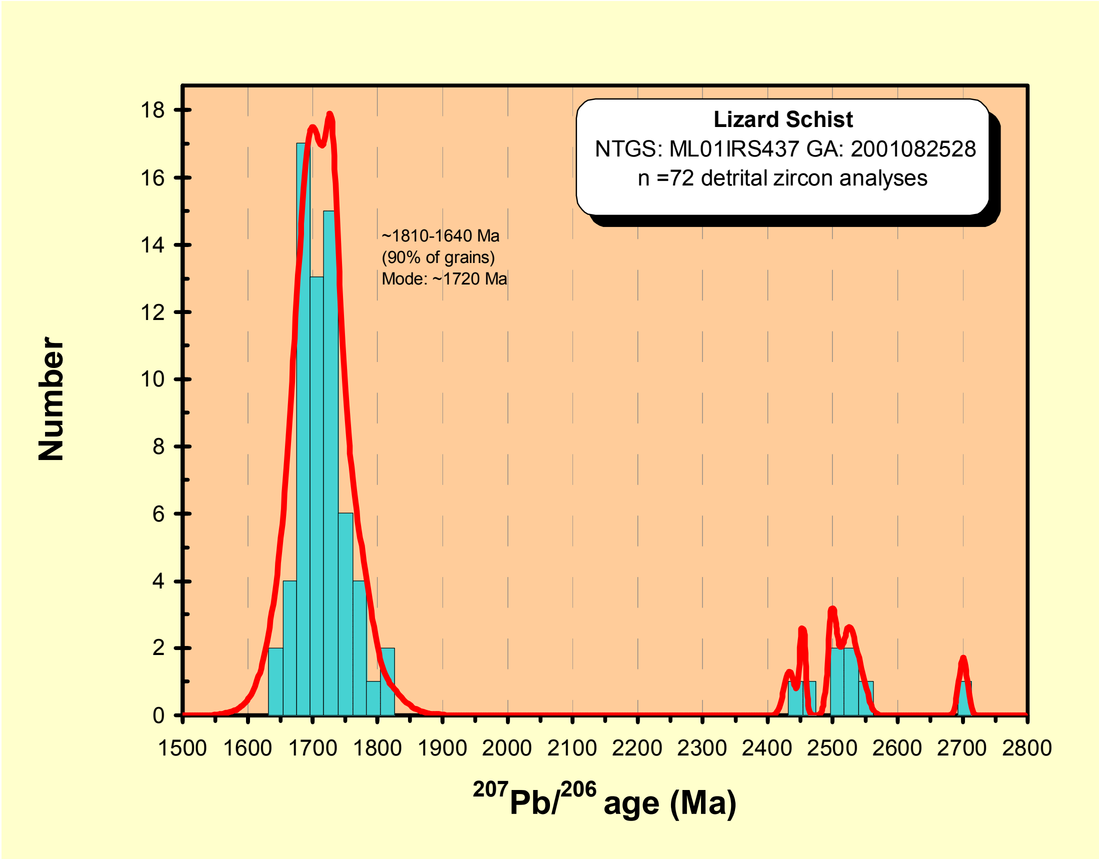

Figure 31. Cumulative probability histogram for zircon data from Lizard Schist, sample GA2001082528.

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results
Eighty-eight analyses were made on zircons from this sample (**Figures 30–31**, **Table 16**). Thirteen analyses are not considered further as they are either discordant above an arbitrary threshold of 10%, or have large analytical uncertainties that render them of little use. The remaining concordant and near-concordant detrital zircons in this sample span over 1000 my and are dominated by a continuum of ages between 1810 Ma and 1640 Ma (90% of grains), with a mode at 1720 Ma. There are also seven Archaean zircons, which are separated from the dominant cluster by over 600 my; these grains are in the range 2540–2435 Ma, with one older individual that has an apparent age of 2700 Ma. The youngest zircon in this sample has an apparent age of 1642 ± 40 Ma (2σ). An alternative constraint for the maximum deposition age can be calculated from the youngest six analyses, which in this case gives 1657 ± 28 Ma (tσ; MSWD = 0.25).

Three analyses, B26.2, B7.1 and B97.1, represent phase overlaps, where the SHRIMP spot has inadvertently sampled both the detrital zircon primary growth zone and the secondary, thin, low-CL-response rims. These analyses have isotopically mixed compositions and are therefore ambiguous. However, their relatively younger ages (1585–1390 Ma) suggest that the thin, low-CL-response rims common to all zircons from this sample are the result of a post-depositional metamorphic event. Although the age of this event has not been constrained, it is most likely to be the 1590 Ma Chewings Orogeny and/or the 1150 Ma Teapot Event, as these events have been recorded in zircons from nearby rocks in MOUNT LIEBIG (Kinny 2002, this study).

Nguman Metamorphics

GA sample ID: 2002082515
NTGS sample ID: MR02DFC123B
1:250 000 sheet: MOUNT RENNIE
1:100 000 sheet: Ehrenberg
Region: Warumpi Province
Grid reference (GDA94): 626748mE, 7403456mN
Formal name: Nguman Metamorphics
Sample information (rock description, relative age constraints):

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals										
B14.1	-0.06	157	173	1.14	3.26	3.2	0.10100	1.1	1642 ± 20	-5
B89.1	0.38	68	49	0.75	3.462	2.5	0.10130	2.2	1649 ± 40	1
B116.1	-0.05	85	83	1.02	3.629	2.4	0.10200	1.6	1661 ± 29	6
B24.1	0.31	354	444	1.30	3.65	3.2	0.10230	1.2	1665 ± 23	6
B9.1	0.86	750	45	0.06	3.57	3.6	0.10260	2.0	1672 ± 38	5
B3.2	0.02	141	98	0.72	3.12	3.3	0.10270	1.7	1673 ± 32	-7
B4.1	0.14	321	395	1.27	3.29	3.1	0.10272	0.83	1674 ± 15	-2
B12.1	0.22	285	241	0.88	3.49	3.1	0.10270	1.3	1674 ± 24	3
B22.1	0.18	179	223	1.29	3.19	3.3	0.10290	1.0	1678 ± 19	-5
B5.2	0.07	170	177	1.08	3.24	3.4	0.10310	1.3	1680 ± 23	-3
B84.1	0.30	189	123	0.67	3.141	2.5	0.10320	1.1	1683 ± 21	-6
B1.1	0.00	123	87	0.73	3.30	3.3	0.10320	1.3	1683 ± 24	-1
B21.1	0.04	304	415	1.41	3.25	3.1	0.10341	0.77	1686 ± 14	-3
B98.1	0.11	124	110	0.92	3.545	2.5	0.10340	1.6	1686 ± 29	5
B30.1	0.05	216	259	1.24	3.21	3.2	0.10349	0.87	1688 ± 16	-4
B15.1	0.29	361	413	1.18	3.42	3.1	0.10350	1.1	1688 ± 20	2
B110.1	0.49	130	111	0.88	3.779	2.2	0.10360	2.6	1689 ± 48	10
B101.1	-0.02	85	80	0.97	3.318	2.3	0.10360	1.3	1690 ± 24	0
B106.1	0.20	74	37	0.52	3.477	2.5	0.10370	2.7	1691 ± 49	4
B18.1	0.11	215	332	1.59	3.40	3.2	0.10370	1.0	1691 ± 19	2
B103.1	0.36	91	85	0.97	3.417	2.4	0.10370	1.5	1692 ± 28	2
B13.1	0.35	121	79	0.67	3.18	3.3	0.10370	1.4	1692 ± 25	-4
B25.1	0.02	448	320	0.74	3.30	3.2	0.10380	0.87	1693 ± 16	-1
B8.1	0.00	382	192	0.52	3.24	3.1	0.10403	0.64	1697 ± 12	-2
B90.1	0.02	172	131	0.79	3.265	2.1	0.10410	1.2	1698 ± 22	-1
B4.2	-0.08	170	99	0.60	3.33	3.4	0.10410	1.4	1698 ± 25	0
B87.1	0.05	147	56	0.39	3.205	2.1	0.10410	1.1	1699 ± 20	-3
B108.1	0.12	522	265	0.53	3.218	2.0	0.10412	0.69	1699 ± 13	-3
B10.2	1.14	214	154	0.74	3.45	3.2	0.10420	2.2	1701 ± 41	4
B3.1	0.06	178	172	1.00	3.61	3.2	0.10440	1.1	1704 ± 20	8
B107.1	0.02	234	186	0.82	3.291	2.1	0.10445	0.82	1705 ± 15	0
B33.1	0.02	197	181	0.95	3.045	3.2	0.10452	0.80	1706 ± 15	-7
B82.1	-0.05	145	106	0.75	3.455	2.2	0.10450	1.0	1706 ± 19	4
B89.2	0.35	125	41	0.34	3.722	2.4	0.10480	1.8	1711 ± 34	10
B114.2	0.10	192	109	0.59	3.421	2.1	0.10490	0.96	1713 ± 18	4
B113.1	0.38	105	58	0.57	3.492	2.2	0.10500	1.8	1715 ± 34	5
B27.1	0.10	456	154	0.35	3.41	3.3	0.10527	0.93	1719 ± 17	4
B26.1	0.44	134	174	1.34	3.84	3.5	0.10530	3.0	1720 ± 54	13
B92.1	0.26	238	116	0.50	3.281	2.1	0.10540	0.97	1721 ± 18	0
B104.1	0.01	82	74	0.94	3.447	2.7	0.10540	2.4	1722 ± 44	5
B20.1	-0.02	178	128	0.74	3.111	3.2	0.10550	0.96	1724 ± 18	-4
B81.1	0.03	358	138	0.40	3.230	2.0	0.10558	0.63	1724 ± 12	-1
B83.1	0.14	403	233	0.60	3.236	2.0	0.10562	0.68	1725 ± 12	-1
B23.1	-0.05	307	396	1.34	3.43	3.5	0.10570	1.1	1726 ± 20	5
B99.1	-0.02	195	88	0.46	3.315	2.1	0.10569	0.84	1726 ± 15	2
B2.1	0.12	218	113	0.54	2.952	3.2	0.10580	1.3	1728 ± 23	-9
B34.1	0.00	716	715	1.03	2.952	3.1	0.10587	0.33	1729.4 ± 6.1	-9
B16.1	0.07	492	573	1.20	3.124	3.1	0.10593	0.66	1730 ± 12	-3
B29.1	0.15	213	544	2.64	3.022	3.3	0.10600	0.97	1732 ± 18	-6
B114.1	0.17	449	206	0.47	3.461	2.0	0.10615	0.73	1734 ± 13	6
B118.1	-0.01	287	135	0.48	3.216	2.0	0.10619	0.70	1735 ± 13	-1
B86.1	-0.01	193	84	0.45	3.256	2.1	0.10642	0.81	1739 ± 15	1
B115.1	1.38	444	109	0.26	3.512	2.0	0.10640	1.6	1739 ± 30	7
B112.1	-0.11	259	175	0.70	3.276	2.0	0.10663	0.75	1743 ± 14	1
B119.1	0.03	297	93	0.32	3.145	2.1	0.10699	0.69	1749 ± 13	-2
B109.1	-0.02	198	98	0.51	3.206	2.1	0.10715	0.86	1751 ± 16	0
B100.1	0.45	194	115	0.62	3.339	2.1	0.10730	1.4	1754 ± 26	4
B9.2	-0.03	381	330	0.90	3.35	3.1	0.10800	0.78	1766 ± 14	5
B17.1	0.12	234	117	0.51	3.28	3.3	0.10808	0.89	1767 ± 16	3
B28.1	-0.03	395	173	0.45	3.39	3.2	0.10825	0.84	1770 ± 15	6
B36.2	-0.29	126	88	0.72	3.051	3.2	0.10860	1.3	1776 ± 24	-3
B88.1	-0.07	313	230	0.76	3.100	2.0	0.10915	0.70	1785 ± 13	-1
B10.1	0.16	756	277	0.38	3.23	3.1	0.11040	2.4	1805 ± 44	4
B19.1	-0.20	151	118	0.81	3.17	3.2	0.11080	1.2	1812 ± 23	3
B32.2	0.03	498	37	0.08	2.037	3.2	0.15795	0.52	2433.8 ± 8.7	-6
B11.1	0.03	1537	618	0.42	2.267	3.1	0.15984	0.25	2454.0 ± 4.2	4
B35.2	-0.02	716	794	1.15	2.051	3.1	0.16411	0.33	2498.5 ± 5.6	-2
B91.1	0.00	240	113	0.49	2.079	2.0	0.16461	0.51	2503.6 ± 8.6	-1
B32.1	0.01	607	91	0.15	2.110	3.1	0.16646	0.56	2522.3 ± 9.5	1
B35.1	-0.02	192	120	0.65	2.107	3.1	0.16683	0.59	2526.1 ± 9.9	1
B102.1	0.04	296	264	0.92	2.143	2.0	0.16840	0.62	2542 ± 10	3
B117.1	0.19	499	139	0.29	1.905	2.0	0.18527	0.40	2700.6 ± 6.6	-1
(continued)										

Table 16. SHRIMP analytical results for Lizard Schist, sample GA2001082528. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
(continued)										
isotopically mixed (SHRIMP spot overlap)										
B26.2	0.55	98	90	0.94	3.69	3.5	0.09280	3.8	1483 ± 73	-4
B7.1	2.76	431	280	0.67	3.82	3.1	0.09790	4.0	1584 ± 74	5
B97.1	2.40	258	107	0.43	4.459	2.2	0.08830	3.1	1389 ± 59	6
discordant										
B29.2	0.29	297	47	0.16	2.944	3.1	0.09890	1.4	1603 ± 27	-18
B31.1	0.38	106	128	1.24	2.962	3.2	0.09870	2.1	1600 ± 39	-17
B36.1	-0.05	144	149	1.07	2.94	3.4	0.10374	0.95	1692 ± 17	-12
B6.1	0.17	228	197	0.89	2.920	3.2	0.10440	1.2	1703 ± 22	-11
B5.1	0.59	374	95	0.26	3.084	3.1	0.10070	1.4	1636 ± 25	-11
B30.2	0.00	206	157	0.79	2.989	3.1	0.10352	0.74	1688 ± 14	-10
B33.2	0.04	101	67	0.68	3.000	3.2	0.10380	1.3	1693 ± 25	-10
B111.1	8.19	117	84	0.74	4.80	2.9	0.09000	17	1428 ± 330	15
B21.2	3.51	198	129	0.67	4.11	3.3	0.10200	4.4	1661 ± 82	15
B105.1	2.03	192	68	0.37	4.63	9.7	0.09350	3.6	1499 ± 67	16
B96.1	8.40	141	102	0.75	4.131	2.3	0.11370	7.5	1859 ± 140	25
B13.2	2.51	152	34	0.23	2.772	3.4	0.10020	6.0	1628 ± 110	-22
poor analysis										
B85.1	0.54	50	23	0.48	3.29	3.8	0.10070	3.8	1638 ± 71	-5

Table 16. (continued).

The Nguman Metamorphics occur within the Haasts Bluff Domain in MOUNT RENNIE and comprise variably quartzose to feldspathic biotite-muscovite schist and metapsammite, with minor quartzite, mafic amphibolite and tremolite schist. The unit has strong similarities with the Lizard Schist and Ikuntji Metamorphics in MOUNT LIEBIG, and is therefore considered likely to form part of the Iwupataka Metamorphic Complex. The sample is a crystalline quartzite from a succession of interlayered quartzite and quartz-muscovite schist that has a strongly developed north-northeast-dipping foliation. The contact between these sedimentary rocks and an adjacent coarsely porphyritic biotite granite is defined by a near-vertical shear zone.

U-Pb analytical information

Mount no: Z4069

Data acquisition: 2–4 February 2003, SHRIMP II

Zircons

Zircons in this sample are predominantly large (200 μm) and clear; approximately 20% are optically turbid. They are rounded to well rounded, consistent with having undergone sedimentary transport. Cathodoluminescence imaging shows that the majority of grains have oscillatory growth zones and some have thin, 10–40 μm, poorly luminescent rims, which can be typical of zircon that has grown and/or recrystallised under metamorphic conditions. Two analyses (D45.4 and D45.2) were able to sample this material.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP II in stable operating conditions. A mass fractionation correction of 0.67% has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

In generating a representative provenance spectrum for this sample, ninety-three SHRIMP analyses were undertaken on eighty-six zircons (**Figures 32**, **33**, **34**, **Table 17**). Two additional analyses (D45.4 and D45.2) were undertaken on the rim of a single grain and are not included in the provenance spectrum. Detrital zircons from this sample range in age from 3085 Ma to 1615 Ma. However, the provenance spectrum is dominated (91% of zircons) by a continuum of zircons within the range 1745–1615 Ma, and with modes at 1710 Ma and 1665 Ma. There are also older zircons at 2205 Ma, 2420 Ma, 2470 Ma, 2515 Ma, 2540 Ma and 3085 Ma. The youngest concordant detrital zircon in this sample has an apparent age of 1630 ± 15 Ma (2σ) and provides a good estimate for the maximum deposition age of this sample.

Two analyses (D45.4 and D45.2) were made on the low-CL-response metamorphic rims. These analyses have high U contents (800 ppm), and apparent ages of 1604 ± 11 Ma (σ) and 1610 ± 10 Ma, respectively. They have the youngest U-Pb compositions analysed from this sample, but do overlap in age with the two youngest detrital zircons, which have very low U contents and therefore imprecise ages. The high U contents and younger relative ages of analyses D45.4 and D45.2 indicate that many of the low-CL-response rims in this sample developed *in situ*, probably in response to the 1590 Ma Chewings Orogeny. The deposition of this sediment is therefore constrained between the youngest zircon, which has an age of 1630 ± 15 Ma, and the Chewings Orogeny.

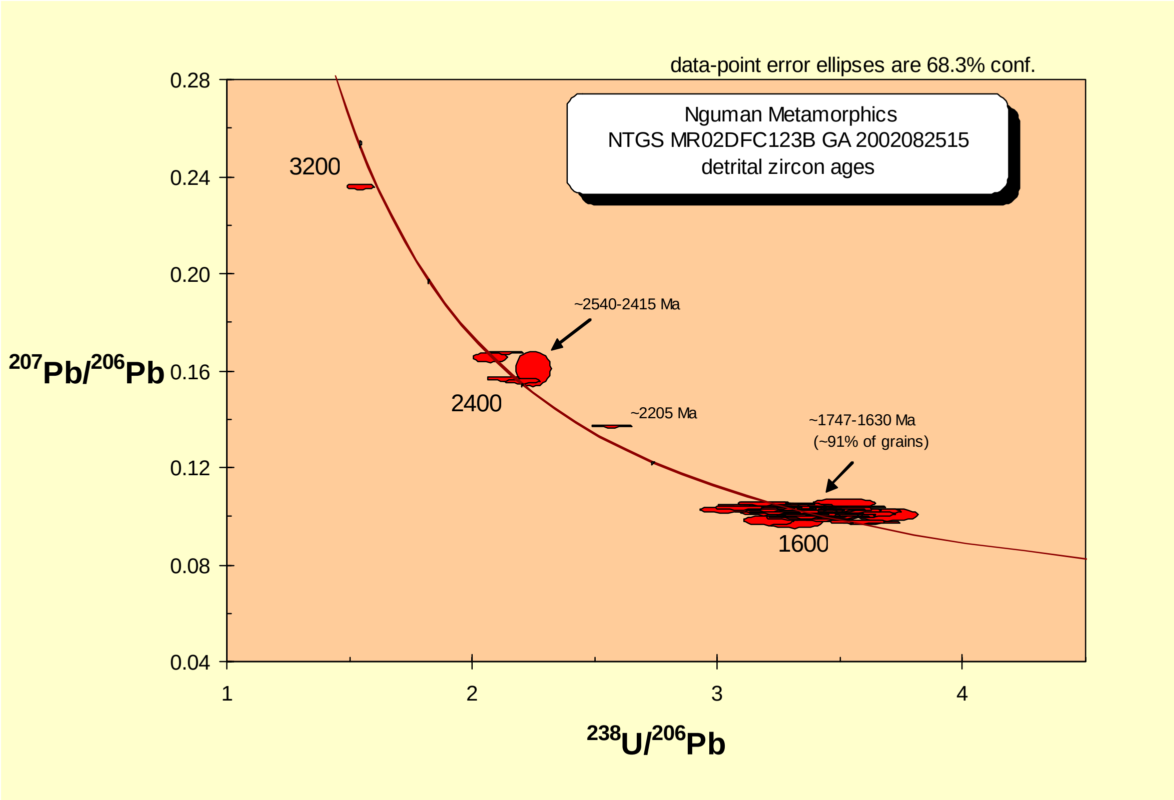

Figure 32. Terra-Wasserberg concordia plot for zircon from Nguman Metamorphics, sample GA2002082515.

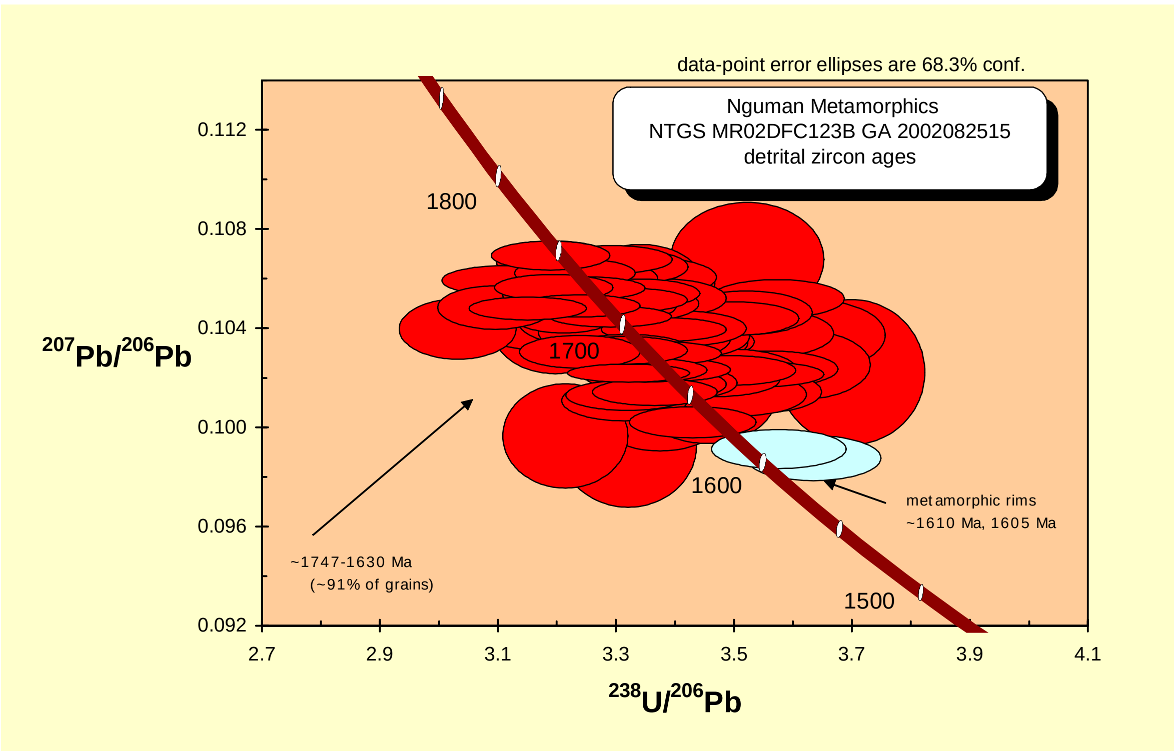

Figure 33. Enlargement of Terra-Wasserberg concordia plot for zircon from Nguman Metamorphics, sample GA2002082515.

Tinki Granite

GA sample ID: 2002082521
NTGS sample ID: MR01IRS44
1:250 000 sheet: MOUNT RENNIE
1:100 000 sheet: LIESLER

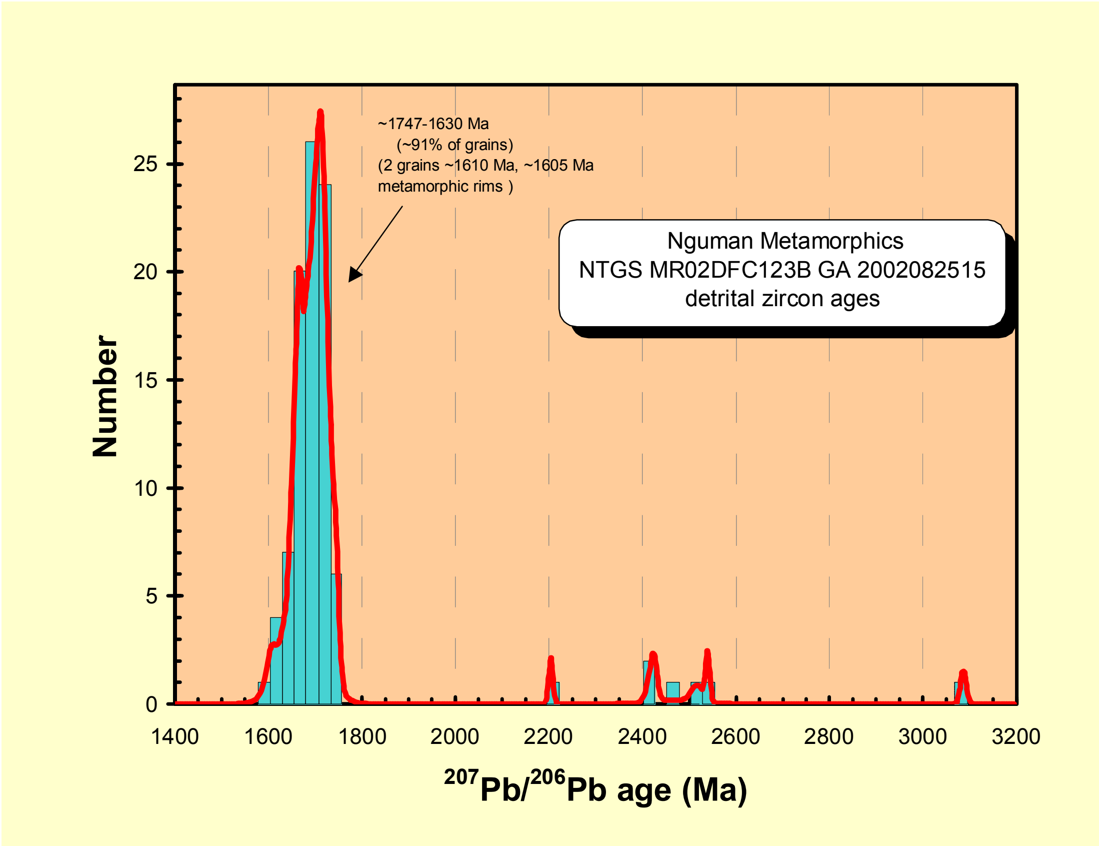

Figure 34. Cumulative probability histogram for zircon data from Nguman Metamorphics, sample GA2002082515.

Region: Warumpi Province
Grid reference (GDA94): 558618mE, 7424891mN
Formal name: Tinki Granite
Sample information (rock description, relative age constraints):
The sample is an undeformed coarse-grained, weakly porphyritic biotite monzogranite. It contains no foliation, but has undergone retrogression, with epidote, chlorite and muscovite partially replacing plagioclase and biotite. Titanite is a common accessory mineral. It has no exposed contact relationships with other units, but is conspicuously undeformed in comparison with the highly strained 1640–1630 Ma granites that occur elsewhere through the region.

U-Pb analytical information
Mount no: Z4122
Data acquisition: 24–25 March 2003, SHRIMP I

Zircons
Zircons in this sample are euhedral with pointed terminations, optically clear and in the size range 100–250 µm. The sample is dominated by grains with aspect ratios between 2 and 3, but also contains equant crystals, besides broken crystals of the above forms. Cathodoluminescence imaging reveals that grains have internal concentric zoning patterns consistent with an igneous origin.

Analytical conditions
U-Pb isotopic analyses were made using SHRIMP I. No mass fractionation correction is indicated by concurrent analyses of the standard.

U-Pb isotopic results
Thirty-one analyses on 29 individual zircons were carried out on this sample (**Figure 35**, **Table 18**). Zircon compositions show minimal Pb loss and combine to give a weighted mean age of 1690.5 ± 4.1 Ma (95 % confidence; MSWD = 0.98). This can be interpreted with confidence as the crystallisation age of this granite.

Andrew Young Igneous Complex – granite

GA sample ID: 2002082507
NTGS sample ID: MR02IRS110

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals										
D41.1	-0.20	57	57	1.04	3.324	2.3	0.09940	1.6	1613 ± 30	-5
D40.1	-0.50	91	109	1.24	3.217	2.2	0.09980	1.4	1620 ± 25	-8
D47.1	0.01	622	173	0.29	3.432	2.1	0.10032	0.40	1630.0 ± 7.5	-1
D86.1	0.19	109	129	1.23	3.376	2.4	0.10090	1.2	1641 ± 22	-2
D52.1	-0.32	190	166	0.91	3.317	2.1	0.10118	0.53	1646.0 ± 9.7	-3
D81.1	0.13	209	274	1.35	3.456	2.2	0.10130	1.1	1648 ± 21	1
D24.1	-0.31	322	397	1.27	3.323	2.1	0.10139	0.39	1649.6 ± 7.2	-3
D11.1	0.31	214	195	0.94	3.513	2.1	0.10142	0.55	1650 ± 10	2
D22.2	0.42	192	143	0.77	3.537	2.1	0.10151	0.55	1652 ± 10	3
D45.3	-0.04	675	294	0.45	3.368	2.1	0.10152	0.35	1652.1 ± 6.5	-1
D83.1	-0.08	338	380	1.16	3.381	2.1	0.10182	0.41	1657.6 ± 7.5	-1
D22.1	-0.04	262	221	0.87	3.399	2.1	0.10188	0.44	1658.6 ± 8.1	0
D12.1	0.23	297	220	0.77	3.471	2.1	0.10201	0.44	1661.1 ± 8.2	2
D15.1	0.28	192	136	0.73	3.435	2.1	0.10207	0.62	1662 ± 11	1
D66.1	0.47	508	480	0.98	3.540	2.1	0.10221	0.33	1664.6 ± 6.1	4
D44.1	-0.17	1202	383	0.33	3.324	2.0	0.10229	0.23	1666.0 ± 4.3	-2
D42.2	1.55	77	263	3.55	3.702	2.2	0.10230	1.8	1666 ± 34	7
D23.1	-0.05	199	118	0.61	3.351	2.1	0.10234	0.55	1667 ± 10	-1
D19.1	0.36	350	142	0.42	3.496	2.1	0.10238	0.38	1667.7 ± 7.1	3
D76.1	0.43	233	165	0.73	3.497	2.1	0.10238	0.54	1667.7 ± 9.9	3
D37.1	0.03	569	329	0.60	3.389	2.1	0.10240	0.30	1668.1 ± 5.5	0
D18.1	-0.09	519	207	0.41	3.352	2.1	0.10240	0.31	1668.1 ± 5.7	-1
D51.1	0.60	319	257	0.83	3.560	2.2	0.10243	0.46	1668.6 ± 8.6	4
D38.1	0.07	300	283	0.97	3.388	2.1	0.10244	0.54	1668.7 ± 10.0	0
D27.1	0.09	116	126	1.13	3.382	2.1	0.10255	0.75	1671 ± 14	0
D36.1	0.67	263	228	0.90	3.618	2.1	0.10260	0.86	1672 ± 16	6
D54.1	-0.09	389	508	1.35	3.315	2.1	0.10285	0.39	1676.2 ± 7.3	-1
D18.2	0.05	535	204	0.39	3.374	2.1	0.10304	0.29	1679.7 ± 5.4	0
D53.1	-0.35	295	191	0.67	3.242	2.1	0.10311	0.41	1680.8 ± 7.6	-3
D50.1	-0.07	573	238	0.43	3.320	2.1	0.10317	0.35	1682.0 ± 6.4	-1
D30.1	-0.05	379	178	0.48	3.322	2.1	0.10323	0.36	1683.0 ± 6.7	-1
D84.1	0.10	499	243	0.50	3.320	2.1	0.10339	0.62	1686 ± 11	-1
D3.1	0.31	204	93	0.47	3.413	2.2	0.10346	0.55	1687 ± 10	2
D80.1	0.29	212	130	0.63	3.421	2.2	0.10351	0.48	1688.1 ± 8.8	2
D82.1	0.17	298	147	0.51	3.388	2.1	0.10363	0.56	1690 ± 10	1
D7.1	0.31	275	204	0.77	3.418	2.1	0.10371	0.56	1,692 ± 10	2
D68.1	1.10	313	191	0.63	3.641	2.1	0.10375	0.86	1692 ± 16	8
D56.1	0.04	250	139	0.57	3.317	2.1	0.10380	0.49	1693.2 ± 9.1	0
D29.1	0.08	179	75	0.43	3.343	2.1	0.10383	0.54	1693.7 ± 9.9	0
D63.1	0.78	223	129	0.60	3.556	2.1	0.10385	0.59	1694 ± 11	6
D33.1	-0.12	183	175	0.99	3.276	2.1	0.10387	0.54	1694.4 ± 9.9	-1
D28.1	-0.09	182	84	0.48	3.276	2.1	0.10395	0.53	1695.9 ± 9.8	-1
D35.1	-0.31	249	126	0.52	3.201	2.2	0.10400	1.1	169 ± 206	-3
D8.1	0.21	616	340	0.57	3.383	2.1	0.10399	0.30	1696.5 ± 5.5	2
D9.1	0.35	346	416	1.24	3.413	2.1	0.10401	0.43	1696.9 ± 8.0	2
D1.2	-1.08	153	144	0.97	3.036	2.1	0.10401	0.75	1697 ± 14	-8
D17.1	0.29	169	122	0.74	3.363	2.1	0.10404	0.64	1697 ± 12	1
D73.1	-0.39	137	102	0.77	3.166	2.1	0.10427	0.69	1702 ± 13	-4
D78.1	0.27	137	96	0.73	3.367	2.1	0.10432	0.62	1702 ± 12	2
D71.1	-0.55	195	196	1.04	3.146	2.3	0.10434	0.51	1702.7 ± 9.47	-4
D65.1	0.73	837	581	0.72	3.503	2.1	0.10441	0.42	1704.0 ± 7.6	5
D6.1	0.83	317	224	0.73	3.467	2.2	0.10443	0.62	1704 ± 11	4
D45.1	-0.19	339	213	0.65	3.237	2.1	0.10443	0.66	1704 ± 12	-2
D34.1	0.00	836	568	0.70	3.295	2.1	0.10447	0.26	1705.0 ± 4.9	0
D25.1	0.12	396	169	0.44	3.325	2.1	0.10457	0.73	1707 ± 13	1
D64.1	0.69	227	222	1.01	3.522	2.1	0.10463	0.53	1707.9 ± 9.7	6
D75.1	0.31	166	136	0.85	3.361	2.1	0.10471	0.61	1709 ± 11	2
D42.1	-0.21	176	110	0.64	3.216	2.1	0.10476	0.56	1710 ± 10	-2
D46.1	-0.45	598	140	0.24	3.155	2.1	0.10482	0.28	1711.1 ± 5.2	-4
D48.1	-0.63	378	700	1.91	3.100	2.1	0.10483	0.54	1711.4 ± 9.9	-5
D70.1	0.18	150	168	1.16	3.285	2.1	0.10487	0.70	1712 ± 13	0
D4.1	0.07	382	131	0.35	3.283	2.1	0.10489	0.49	1712.3 ± 9.1	0
D69.1	0.12	381	396	1.07	3.302	2.1	0.10490	0.39	1712.7 ± 7.1	0
D34.2	-0.11	642	327	0.53	3.242	2.1	0.10492	0.28	1712.9 ± 5.1	-1
D67.1	0.21	138	68	0.51	3.315	2.1	0.10494	0.73	1713 ± 13	1
D16.1	0.25	271	220	0.84	3.338	2.1	0.10500	0.44	1714.4 ± 8.1	1
D79.1	0.05	301	157	0.54	3.288	2.1	0.10511	0.39	1716.3 ± 7.2	0
D55.1	0.17	630	370	0.61	3.320	2.1	0.10512	0.30	1716.5 ± 5.5	1
D13.1	0.94	233	205	0.91	3.575	2.1	0.10521	0.47	1717.9 ± 8.7	7
D77.1	0.43	266	197	0.77	3.382	2.1	0.10522	0.48	1718.3 ± 8.8	3
D58.1	-0.15	355	230	0.67	3.213	2.1	0.10533	0.39	1720.1 ± 7.2	-2
D74.1	0.30	439	314	0.74	3.339	2.1	0.10540	0.35	1721.3 ± 6.5	2
(continued)										

Table 17. SHRIMP analytical results for Nguman Metamorphics, sample GA 2002082515. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals (continued)										
D39.1	0.01	670	329	0.51	3.250	2.1	0.10562	0.29	1725.1 ± 5.3	0
D57.1	-0.18	489	268	0.57	3.199	2.1	0.10562	0.32	1725.2 ± 5.9	-2
D32.1	0.47	136	86	0.66	3.361	2.1	0.10579	0.67	1728 ± 12	3
D43.1	0.35	1209	1068	0.91	3.345	2.0	0.10580	0.96	1729 ± 18	2
D20.1	-0.48	515	335	0.67	3.114	2.2	0.10592	0.36	1730.3 ± 6.5	-4
D21.2	0.13	282	129	0.47	3.271	2.1	0.10600	0.42	1731.7 ± 7.6	1
D20.2	0.43	245	127	0.54	3.365	2.1	0.10605	0.47	1732.6 ± 8.6	3
D35.2	0.07	153	77	0.52	3.231	2.1	0.10612	0.63	1734 ± 12	0
D2.1	0.03	421	350	0.86	3.234	2.1	0.10621	0.36	1735.4 ± 6.6	0
D10.1	0.36	346	189	0.56	3.317	2.1	0.10644	0.43	1739.4 ± 7.9	2
D61.1	-0.01	210	175	0.86	3.202	2.1	0.10664	0.50	1742.8 ± 9.1	-1
D14.1	1.25	31	15	0.51	3.525	2.4	0.10670	1.4	1745 ± 25	8
D85.1	0.29	460	198	0.44	3.296	2.1	0.10675	0.34	1744.6 ± 6.2	2
D60.1	-0.06	375	155	0.43	3.193	2.1	0.10689	0.35	1747. ± 6.31	-1
D26.1	0.95	671	74	0.11	2.579	2.1	0.13813	0.25	2203.9 ± 4.4	4
D26.2	0.22	90	75	0.87	2.210	2.2	0.15643	0.53	2417.5 ± 9.1	0
D49.1	-0.60	613	188	0.32	2.140	2.1	0.15718	0.38	2425.6 ± 6.4	-2
D5.1	1.41	545	147	0.28	2.261	2.1	0.16120	3.0	2468 ± 51	4
D31.1	-0.07	177	117	0.68	2.084	2.1	0.16590	0.75	2517 ± 13	0
D59.1	1.13	400	249	0.64	2.152	2.1	0.16817	0.25	2539.5 ± 4.2	3
D62.1	-3.58	142	68	0.49	1.558	2.3	0.23498	0.38	3086.3 ± 6.0	-4
D72.1	1.57	356	429	1.24	3.312	2.1	0.11600	13	1900 ± 230	10
rims										
D45.4	0.65	797	535	0.69	3.634	2.1	0.09892	0.59	1604 ± 11	2
D45.2	0.34	818	381	0.48	3.577	2.1	0.09927	0.51	1610.4 ± 9.6	1

Table 17. (continued).

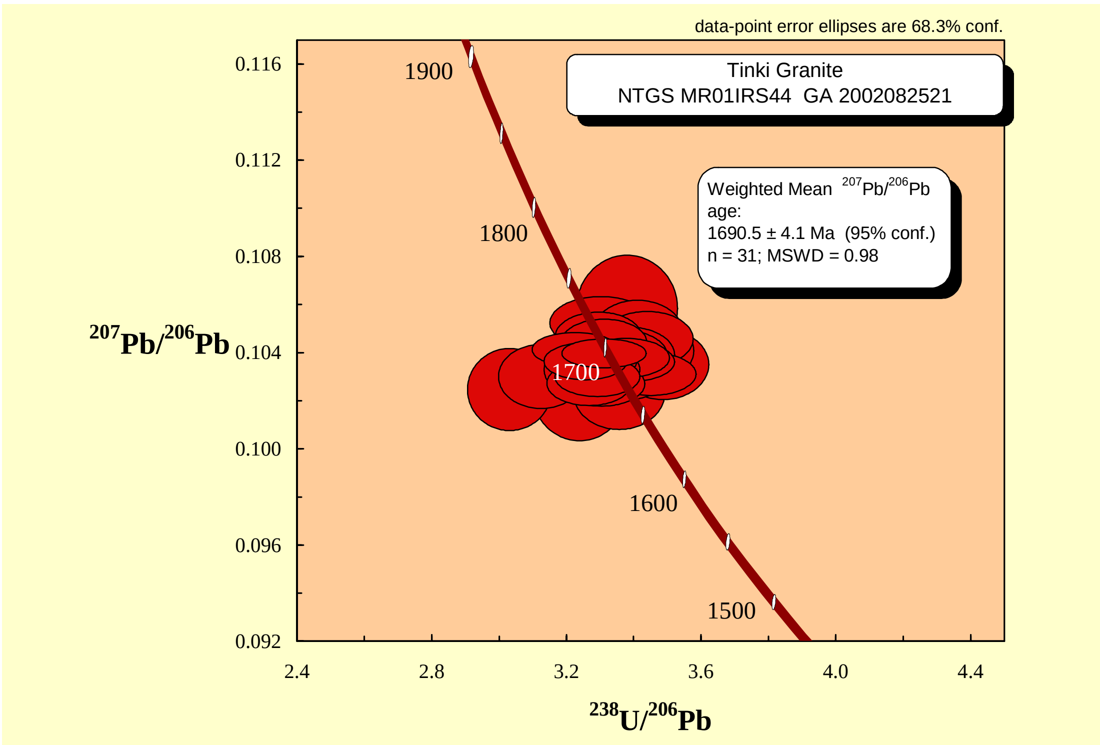

Figure 35. Terra-Wasserberg concordia plot for zircon from Tinki Granite, sample GA2002082521.

1:250 000 sheet: MOUNT RENNIE
1:100 000 sheet: WILLIE
Region: Southern Arunta
Grid reference (GDA94): 576257mE, 7445069mN
Formal name: Andrew Young Igneous Complex
Sample information (rock description, relative age constraints):
A number of isolated outcrops of undeformed to weakly foliated porphyritic biotite granite occur throughout the Andrew Young Igneous Complex (Young *et al* 1995) in MOUNT RENNIE. The granite is characterised by tabular to slightly rounded phenocrysts of K-feldspar, in a matrix dominated by K-feldspar, quartz, plagioclase and biotite. Minor muscovite

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
magmatic population										
C1.1	0.01	151	149	1.02	3.256	2.5	0.10393	0.72	1696 ± 13	-2
C2.1	0.09	247	217	0.91	3.281	2.6	0.10364	0.52	1690.2 ± 9.5	-1
C3.1	0.09	201	152	0.78	3.289	2.5	0.10329	0.58	1684 ± 11	-2
C3.2	0.08	281	267	0.98	3.254	2.5	0.10363	0.49	1690.1 ± 9.1	-2
C4.1	0.05	288	294	1.05	3.222	2.6	0.10412	0.44	1698.8 ± 8.1	-3
C5.1	0.04	624	488	0.81	3.307	2.5	0.10394	0.37	1695.7 ± 6.8	0
C6.1	-0.15	86	158	1.89	3.409	2.6	0.10472	0.9	1709 ± 17	3
C7.1	0.24	78	95	1.26	3.377	2.9	0.10580	1.4	1729 ± 25	3
C8.1	0.09	412	368	0.92	3.289	2.5	0.10297	0.52	1678.4 ± 9.5	-2
C10.1	0.15	258	248	0.99	3.484	2.6	0.10349	0.92	1688 ± 17	4
C11.1	0.07	376	292	0.80	3.383	2.6	0.10389	0.73	1695 ± 14	2
C12.1	0.12	354	240	0.70	3.298	3.0	0.10522	0.69	1718 ± 13	1
C13.1	0.39	460	382	0.86	3.439	2.6	0.10404	0.84	1697 ± 16	3
C15.1	0.15	246	405	1.70	3.366	2.6	0.10303	0.64	1679 ± 12	0
C16.1	0.03	305	381	1.29	3.373	2.5	0.10375	0.51	1692.3 ± 9.4	1
C17.1	0.02	26	25	0.99	3.236	3.0	0.10250	1.4	1671 ± 26	-4
C18.1	0.06	357	619	1.79	3.449	2.5	0.10308	0.56	1680 ± 10	2
C19.1	0.01	211	232	1.13	3.257	2.6	0.10329	0.75	1684 ± 14	-2
C20.1	0.07	258	261	1.05	3.358	2.6	0.10325	0.61	1683 ± 11	0
C21.1	0.09	275	177	0.66	3.360	2.6	0.10360	0.99	1689 ± 18	1
C22.1	0.32	172	127	0.76	3.029	2.7	0.10240	1.1	1669 ± 20	-9
C23.1	0.12	360	691	1.98	3.263	2.6	0.10272	0.59	1674 ± 11	-3
C24.1	0.07	192	188	1.01	3.292	2.6	0.10463	0.64	1708 ± 12	0
C25.1	0.11	356	479	1.39	3.307	2.6	0.10440	0.6	1704 ± 11	0
C26.1	0.08	300	300	1.03	3.365	2.6	0.10382	0.69	1694 ± 13	1
C28.1	0.10	361	522	1.49	3.299	2.6	0.10268	0.59	1673 ± 11	-2
C29.1	0.12	136	128	0.98	3.355	2.7	0.10226	0.95	1665 ± 18	-1
C27.2	0.07	242	344	1.47	3.437	2.6	0.10454	0.72	1706 ± 13	4
C30.1	0.14	157	135	0.89	3.402	2.6	0.10342	0.96	1686 ± 18	2
C27.3	0.01	329	425	1.33	3.385	2.6	0.10361	0.52	1689.7 ± 9.6	1
C9.2	0.12	114	75	0.68	3.119	2.7	0.10300	0.85	1679 ± 16	-6

Table 18. SHRIMP analytical results for Tinki Granite, sample GA2002082521. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

locally occurs. The granite is most commonly undeformed, but a weak biotite foliation is locally developed. The granite locally contains abundant mafic xenoliths ranging from centimetre-sized enclaves to large xenoliths >2 m in diameter. Therefore, the granite is interpreted to intrude at least some mafic phases of the complex. The dated sample is a weakly foliated biotite syenogranite, with minor plagioclase as well as opaque oxide, altered allanite, epidote, titanite, apatite and zircon.

U-Pb analytical information

Mount no: Z4116
Data acquisition: 24–25 January 2003, SHRIMP I

Zircons

Zircons in this sample comprise clear euhedral to subhedral prisms, with pointed terminations that range from stubby forms to others with aspect ratios of 2 and, more rarely, 3. Cathodoluminescence imaging shows that the majority of grains have concentric growth zones and approximately 25% have cores. All grains have a dark coloured, low-CL-response rim that although dominantly thin (<5 μm), can be up to 50 μm thick.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

Twenty-eight analyses were carried out on zircons from this sample (**Figure 36**, **Table 19**). Two analyses are discordant above an arbitrary threshold of 10% and were removed from further consideration. The remaining twenty-six analyses range in age between 1850 Ma and 1590 Ma, but are dominated by a grouping of twenty-four analyses within the range 1675–1590 Ma. Two analyses (B17.1 and B18.1) are of zircon cores and have apparent ages of 1835 Ma and 1850 Ma, respectively, clearly representing inherited components of this rock. The dominant population can be combined to a give a weighted mean $^{207}Pb/^{206}Pb$ age of 1635.3 ± 7.1 Ma (95% confidence), with a statistically acceptable MSWD = 1.5. However, there is a correlation between the youngest six analyses in this population and higher relative common Pb contents (**Figure 37**). This correlation may be indicative of minor radiogenic Pb loss coupled with an uptake of environmental Pb. After removal of the youngest six analyses, the population interpreted to best represent the crystallisation age of this rock reduces to eighteen analyses in the age

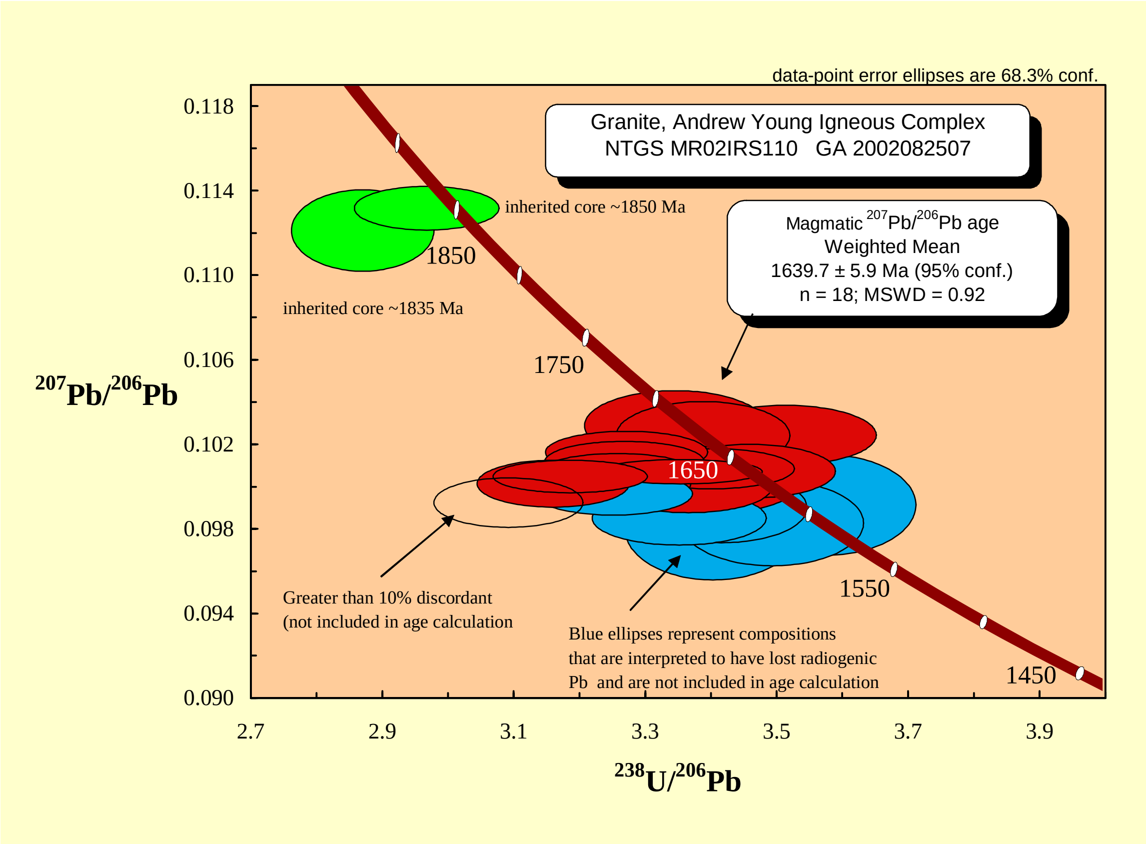

Figure 36. Terra-Wasserberg concordia plot for zircon from granite, Andrew Young Igneous Complex, sample GA2002082507.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
magmatic population										
B21.1	0.13	258	108	0.43	3.364	2.5	0.09996	0.78	1623 ± 14	-3
B1.1	0.18	150	86	0.59	3.348	2.6	0.10000	1.2	1624 ± 23	-4
B10.1	0.04	268	67	0.26	3.243	2.5	0.10013	0.64	1626 ± 12	-6
B7.2	0.13	584	117	0.21	3.156	2.5	0.10015	0.74	1627 ± 14	-8
B22.1	0.02	139	88	0.66	3.406	2.6	0.10028	0.99	1629 ± 18	-2
B4.2	0.10	819	201	0.25	3.183	2.5	0.10051	0.5	1633.6 ± 9.3	-7
B16.1	0.12	313	73	0.24	3.255	2.5	0.10065	0.62	1636 ± 11	-5
B5.2	0.06	1166	183	0.16	3.351	2.5	0.10070	0.39	1637.1 ± 7.2	-3
B3.1	0.12	257	98	0.39	3.458	2.5	0.10074	0.84	1638 ± 16	0
B9.1	0.09	359	101	0.29	3.399	2.5	0.10086	0.62	1640 ± 12	-1
B4.1	0.03	224	169	0.78	3.334	2.5	0.10092	0.73	1641 ± 14	-3
B14.1	0.09	341	117	0.36	3.374	2.6	0.10093	0.6	1641 ± 11	-2
B1.2	0.18	653	130	0.21	3.266	2.5	0.10119	0.64	1646 ± 12	-4
B13.1	0.20	95	61	0.66	3.464	2.6	0.10120	1.7	1646 ± 31	1
B6.1	-0.02	240	122	0.52	3.27	2.5	0.10165	0.64	1655 ± 12	-4
B12.1	-0.10	103	70	0.71	3.386	2.6	0.10240	1	1669 ± 19	0
B7.1	-0.08	142	78	0.57	3.513	2.6	0.10246	0.91	1669 ± 17	3
B8.1	-0.21	183	99	0.56	3.344	2.7	0.10290	1.1	1677 ± 20	-1
inherited cores										
B17.1	0.30	150	64	0.44	2.864	2.5	0.11220	1.1	1835 ± 20	-5
B18.1	0.07	250	96	0.40	2.962	2.5	0.11321	0.6	1850 ± 11	-1
Pb loss										
B20.1	0.21	83	48	0.60	3.402	2.6	0.09800	1.7	1587 ± 31	-4
B5.1	0.38	98	62	0.66	3.493	2.6	0.09830	1.4	1592 ± 26	-2
B2.1	0.19	252	119	0.49	3.35	2.6	0.09852	0.85	1596 ± 16	-5
B19.1	0.21	158	128	0.84	3.414	2.5	0.09900	1.1	1605 ± 21	-3
B11.1	0.38	122	78	0.66	3.574	2.6	0.09910	1.6	1608 ± 30	1
B13.2	0.33	721	481	0.69	3.249	2.5	0.09969	0.67	1618 ± 13	-6
discordant										
B21.2	0.20	700	153	0.23	3.088	2.5	0.09928	0.77	1611 ± 14	-11
B15.1	1.04	193	79	0.42	5	34	0.09970	2.9	1618 ± 54	37

Table 19. SHRIMP analytical results for granite, Andrew Young Igneous Complex, sample GA2002082507. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

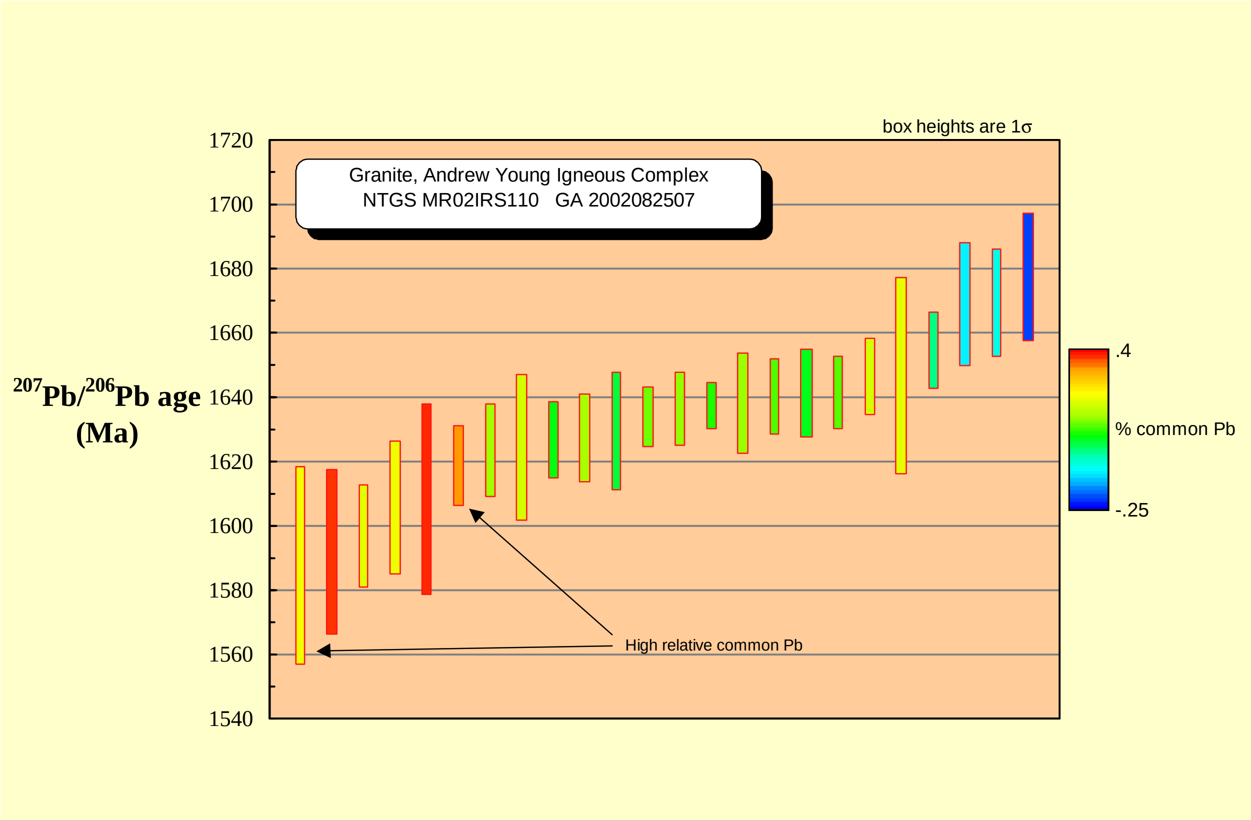

Figure 37. Age and associated error boxes with superimposed percent common Pb content colour scale for each analysis from granite, Andrew Young Igneous Complex, sample GA2002082507. This diagram clearly shows the relationship between higher relative common Pb contents and younger ages in this sample.

range 1675–1625 Ma. These analyses combine to give a weighted mean $^{207}Pb/^{206}Pb$ age of 1639.7 ± 5.9 Ma (95 % confidence; MSWD = 0.92).

Four analyses (B1.2, B4.2, B5.2 and B7.2) sampled the low-CL-response rims associated with all zircons in this sample. These analyses show that the rims have high relative U contents (585–1165 ppm), compared with the luminescent, oscillatory zoned regions, which have U contents of 85–360 ppm. However, no difference in apparent age can be detected between these two regions (**Figure 38**). Therefore, the low-CL-response, high-U rims on zircons from this sample are interpreted to represent either high-U fluids active late in the crystallisation history of this rock, or alternatively, a response to metamorphism associated with the nearby mafic rocks of the Andrew Young Igneous Complex. In the latter case, this would imply that the intrusion of the granite occurred within error of the intrusion of the mafic plutons.

Nyirripi beds

GA sample ID: 2002082506
NTGS sample ID: MR02IRS106
1:250 000 sheet: MOUNT RENNIE
1:100 000 sheet: WILLIE
Region: Southern Arunta
Grid reference (GDA94): 578606mE, 7439745.5mN
Formal name: Nyirripi beds
Sample information (rock description, relative age constraints):
Pelitic and psammitic granulite facies metasedimentary rocks form a number of small outcrops and low hills in the vicinity of the 1635 Ma Andrew Young Igneous Complex, northeast of Sandy Blight Junction. The rocks are dominated by cordierite-bearing hornfels with well preserved bedding, which has undergone *in situ* partial melting. The dated sample is a quartz-K-feldspar-cordierite-biotite-sillimanite-rutile granofels. It contains anastomosing lamellae rich in fibrolitic sillimanite, mostly about 0.5 mm wide, commonly with minor biotite, as well as, or instead of sillimanite. The remainder of the rock is inequigranular and granoblastic, with various proportions of K-feldspar, quartz, and generally untwinned and unaltered cordierite. Minor biotite and rare, fine prismatic sillimanite are present, with accessory fine-grained rutile and rare radioactive grains, apparently both zircon and monazite, up to 50 µm in diameter. The rocks have undergone granulite facies high-T, low-P metamorphism (3–4 kbar, >750°C), which is likely to be associated with the intrusion of the nearby Andrew Young Igneous Complex.

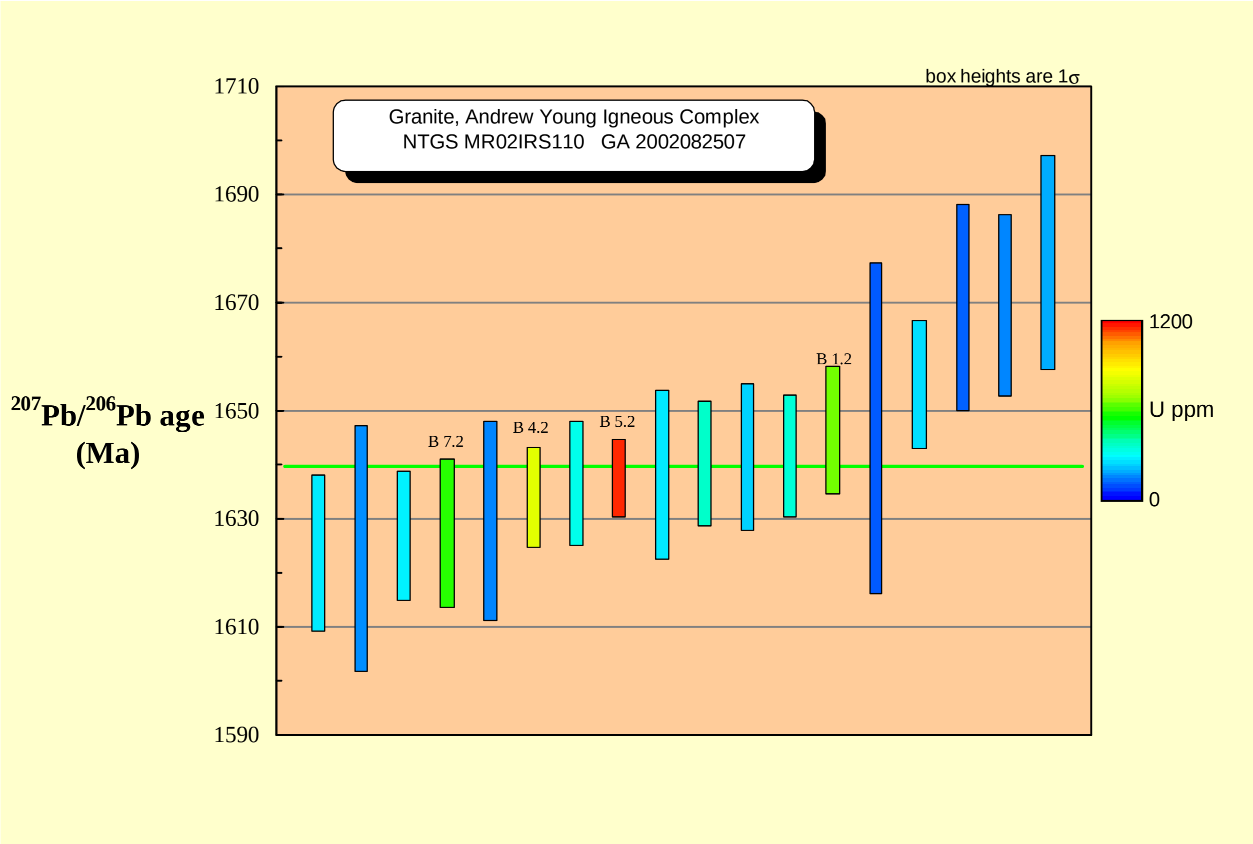

Figure 38. Age and associated error boxes with superimposed U ppm content colour scale for each analysis from granite, Andrew Young Igneous Complex, sample GA2002082507. This diagram indicates that there is no difference in age between analyses of the high-U, low-CL-response rims (B1.2, B4.2, B5.2 and B7.2) and the luminescent zoned regions.

U-Pb analytical information

Mount no: Z4123

Data acquisition: 10–12 July 2003, SHRIMP I; 29 August 2003, SHRIMP I

Zircons

Zircons in this sample comprise a heterogeneous mix of sizes, shapes and colours that range from clear to light brown. The majority of grains are rounded with a pitted surface texture, indicative of sedimentary transport. Cathodoluminescence imaging also reveals a heterogeneous array of CL responses and internal zoning patterns that range from structureless to those with clearly identifiable concentric growth zones. Approximately 60% of zircons have cores that are visible in CL images and many grains have a thin (up to 10 µm), usually discontinuous rim which has a poor (dark) CL response.

Analytical conditions

U-Pb isotopic analyses were made using SHRIMP I in stable operating conditions. No mass fractionation correction has been applied to measured Pb/Pb ratios based on values obtained on concurrent measurements of standard QGNG.

U-Pb isotopic results

In generating a representative provenance spectrum for this sample, eighty-seven SHRIMP analyses were carried out on eighty different zircons (**Figures 39–40**, **Table 20**). Seven analyses are discordant above an arbitrary threshold of 10% and were removed from further consideration. Three further analyses (A62.3, A62.1 and A73.3) are not included in the detrital age spectrum, as they are interpreted to directly or partially represent post-depositional metamorphism; these are further discussed below. Detrital zircons in this sample are in the range 3645–1785 Ma. The sample is dominated by a continuum of zircons in the range 1940–1785 Ma (44 % of grains) which has a mode at 1880 Ma. There is a discontinues series of grains between 2345 Ma and 1980 Ma and a continuum of ages between 2600 Ma and 2400 Ma (25% of zircons), which has a mode at 2500 Ma. Older zircon components in this rock occur at 2650 Ma, 3015 Ma, 3320 Ma, 3445 Ma and 3645 Ma. The youngest provenance individual sampled from this rock has an apparent age of 1784 ± 22 Ma (2σ). This can be used as an estimate for the maximum deposition age for this sample. Alternatively, the youngest six grains can be combined to give a weighted mean $^{207}Pb/^{206}Pb$ age of 1789.9 ± 11.7 Ma (tσ).

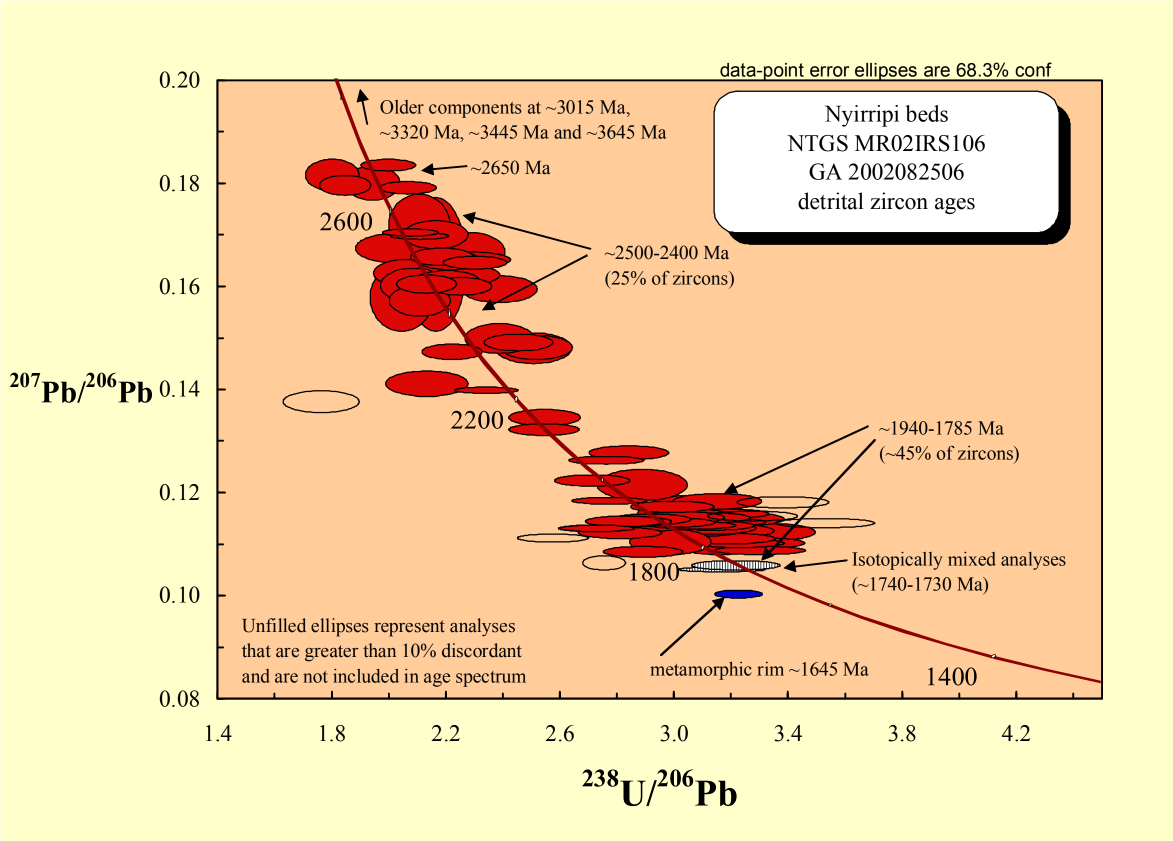

Figure 39. Terra-Wasserberg concordia plot for zircon from Nyirripi beds, sample GA2002082506.

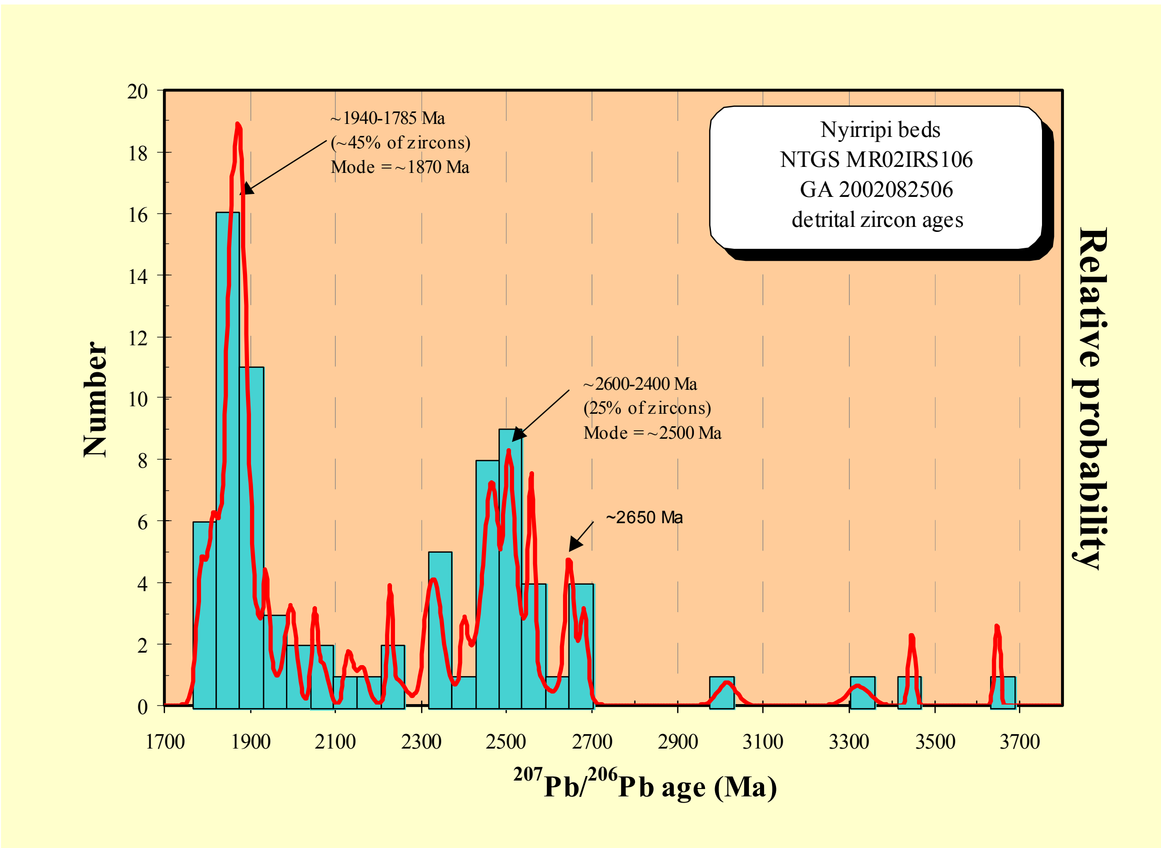

Figure 40. Cumulative probability histogram for zircon data from Nyirripi beds, sample GA2002082506.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals										
A75.2	0.01	517	101	0.20	2.899	3.2	0.10908	0.59	1784 ± 11	-7
A19.1	0.00	655	92	0.15	3.31	3.2	0.10931	0.45	1787.9 ± 8.1	5
A61.1	0.14	232	77	0.34	3.17	3.3	0.11030	1.1	1805 ± 19	2
A31.1	0.05	467	27	0.06	3.23	3.2	0.11068	0.5	1810.5 ± 9.1	4
A35.1	0.08	438	45	0.11	3.3	3.2	0.11075	0.59	1812 ± 11	6
A67.1	0.04	719	89	0.13	2.994	3.2	0.11100	1.4	1816 ± 26	-2
A73.1	-0.02	422	137	0.34	3.2	3.2	0.11161	0.59	1826 ± 11	4
A6.1	0.03	292	101	0.36	2.816	3.4	0.11269	0.63	1843 ± 11	-6
A41.1	-0.08	294	69	0.24	3.17	3.2	0.11280	1.8	1845 ± 32	4
A25.1	0.02	467	144	0.32	3.065	3.2	0.11282	0.53	1845.3 ± 9.6	1
A27.1	0.08	280	95	0.35	3.34	3.2	0.11290	0.99	1846 ± 18	9
A30.1	0.11	222	60	0.28	3.2	3.2	0.11309	0.76	1850 ± 14	5
A47.1	-0.06	278	123	0.46	3.1	3.3	0.11334	0.8	1854 ± 14	3
A13.1	0.02	966	280	0.30	2.736	3.2	0.11354	0.36	1856.9 ± 6.5	-8
A22.1	0.05	678	79	0.12	2.78	4.2	0.11361	0.44	1857.9 ± 7.9	-6
A75.1	0.00	428	78	0.19	3.144	3.2	0.11362	0.68	1858 ± 12	4
A40.1	-0.03	608	104	0.18	3.137	3.2	0.11416	0.53	1866.7 ± 9.5	5
A17.1	0.02	732	139	0.20	3.076	3.2	0.11418	0.44	1866.9 ± 7.9	3
A73.2	0.02	202	88	0.45	3.12	3.3	0.11450	0.97	1871 ± 18	4
A38.1	-0.01	554	233	0.43	2.935	3.4	0.11458	0.55	1873 ± 10	-1
A20.1	0.01	220	61	0.29	2.917	3.3	0.11460	0.93	1874 ± 17	-1
A48.1	0.22	94	2	0.02	3.03	3.7	0.11460	3	1874 ± 54	2
A10.1	-0.01	344	55	0.17	3.004	3.2	0.11471	0.54	1875.4 ± 9.8	1
A55.2	0.01	1205	596	0.51	3.178	3.1	0.11482	0.41	1877 ± 7.4	6
A14.1	-0.05	620	169	0.28	2.832	3.2	0.11492	0.59	1879 ± 11	-4
A68.1	0.05	688	83	0.13	2.86	3.2	0.11494	0.55	1879 ± 9.9	-3
A45.1	-0.03	380	96	0.26	2.924	3.2	0.11533	0.59	1885 ± 11	-1
A49.1	0.03	297	116	0.40	3.24	3.2	0.11540	0.74	1886 ± 13	9
A55.1	0.02	1201	351	0.30	3.09	3.2	0.11550	0.95	1887 ± 17	4
A54.1	0.00	372	150	0.42	3.124	3.2	0.11560	0.55	1889.2 ± 9.9	6
A23.1	-0.01	306	108	0.36	3.036	3.2	0.11570	0.64	1891 ± 12	3
A44.2	-0.01	1182	45	0.04	3.19	3.2	0.11636	0.51	1901.1 ± 9.1	8
A1.1	0.06	457	65	0.15	3	3.2	0.11774	0.62	1922 ± 11	4
A70.1	-0.02	263	177	0.69	3.16	3.2	0.11880	0.81	1938 ± 14	9
A11.1	0.02	1343	3	0.00	2.778	3.1	0.11888	0.36	1939.4 ± 6.5	-2
A43.1	-0.08	48	0	0.00	2.89	3.6	0.12190	1.6	1984 ± 28	4
A80.1	0.01	1623	130	0.08	2.529	1.6	0.12250	0.89	1992 ± 16	-7
A37.1	0.01	418	306	0.76	2.72	3.2	0.12273	0.56	1996 ± 10	-1
A58.1	-0.01	670	19	0.03	2.769	3.2	0.12663	0.35	2051.7 ± 6.1	3
A28.1	-0.02	182	82	0.46	2.847	3.2	0.12800	0.69	2071 ± 12	7
A64.1	-0.04	210	257	1.26	2.55	3.2	0.13249	0.56	2131.2 ± 9.8	0
A74.1	0.05	144	118	0.85	2.551	3.3	0.13480	0.75	2162 ± 13	1
A15.1	0.01	1107	363	0.34	2.348	3.2	0.14007	0.29	2228 ± 5	-3
A7.1	0.03	284	90	0.33	2.137	4.5	0.14140	1.1	2244 ± 20	-9
A9.1	0.00	642	123	0.20	2.228	3.2	0.14741	0.67	2316 ± 12	-3
A79.1	0.00	1424	155	0.11	2.513	3.5	0.14810	1.3	2325 ± 23	8
A21.1	0.05	105	47	0.47	2.524	3.3	0.14830	1	2326 ± 18	8
A29.1	0.16	204	86	0.43	2.459	3.2	0.14930	0.7	2337 ± 12	6
A65.1	-0.01	90	78	0.90	2.393	3.3	0.15000	1.2	2346 ± 21	4
A62.2	0.01	489	965	2.04	2.189	1.6	0.15491	0.5	2400.9 ± 8.4	-1
A2.1	0.32	93	86	0.95	2.114	3.4	0.15730	1.3	2427 ± 21	-3
A4.1	0.38	49	45	0.96	2.05	3.6	0.15790	2.7	2433 ± 46	-5
A2.2	0.07	94	85	0.93	2.394	3.7	0.15940	1.1	2450 ± 18	9
A66.1	0.05	275	354	1.33	2.258	3.2	0.16000	0.7	2455 ± 12	4
A56.1	0.00	31	43	1.42	2.091	3.6	0.16020	1.4	2458 ± 23	-2
A5.1	0.13	137	19	0.14	2.138	3.3	0.16050	0.7	2461 ± 12	-1
A12.1	-0.02	135	91	0.70	2.212	3.3	0.16130	0.72	2469 ± 12	3
A71.1	-0.01	848	752	0.92	2.261	3.9	0.16210	0.76	2478 ± 13	5
A72.1	-0.13	53	36	0.71	2.075	3.9	0.16250	1.1	2482 ± 18	-2
A39.1	-0.11	89	57	0.66	2.132	3.4	0.16310	2.5	2488 ± 42	0
A51.1	0.05	95	69	0.75	2.17	3.3	0.16420	5.1	2500 ± 86	2
A32.1	0.02	889	417	0.48	2.308	3.2	0.16447	0.48	2502.2 ± 8.1	8
A44.1	0.06	148	151	1.05	2.221	3.3	0.16480	0.7	2506 ± 12	5
A76.1	0.05	413	396	0.99	2.293	4.1	0.16508	0.6	2508 ± 10	7
A26.1	0.04	156	143	0.95	2.191	3.3	0.16560	0.67	2514 ± 11	4
A36.1	-0.31	43	29	0.71	2.291	3.5	0.16660	1.5	2524 ± 25	8
A69.1	-0.25	72	39	0.55	2.022	4.3	0.16730	1.1	2530 ± 18	-2
A18.1	0.00	1165	168	0.15	2.114	3.2	0.16960	0.24	2553.7 ± 4.1	2
A53.1	-0.03	38	23	0.64	2.171	3.4	0.16980	1	2556 ± 17	5
A57.1	0.01	591	338	0.59	2.08	3.1	0.17030	0.29	2560.6 ± 4.9	1
A33.1	0.02	75	32	0.44	2.113	3.4	0.17150	2.4	2572 ± 40	3
A77.1	0.02	649	379	0.60	2.072	3.2	0.17894	0.45	2643.1 ± 7.5	4
A42.1	0.02	599	161	0.28	1.851	3.2	0.17940	0.71	2647 ± 12	-5

(continued)

Table 20. SHRIMP analytical results for Nyirripi beds, sample GA2002082506. Pbc and Pb* indicate the common and radiogenic Pb; errors are 1σ.

Spot	% $^{206}Pb_c$	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± %	$^{207}Pb^*/^{206}Pb^*$	± %	$^{207}Pb/^{206}Pb$ age	% discordant
provenance individuals (continued)										
A16.1	-0.07	149	66	0.45	1.949	3.3	0.17980	1.2	2651 ± 20	-1
A42.2	-0.01	281	150	0.55	1.808	3.5	0.18140	1.1	2665 ± 19	-6
A3.1	0.02	666	317	0.49	2.003	3.2	0.18331	0.43	2683 ± 7.1	3
A59.1	0.08	174	50	0.30	1.743	3.2	0.22490	1.4	3016 ± 22	3
A1.2	0.11	115	114	1.02	1.404	4	0.27280	1.7	3322 ± 26	-4
A63.1	-0.01	736	328	0.46	1.505	3.2	0.29560	0.42	3447.1± 6.5	5
A24.1	0.06	182	81	0.46	1.308	3.3	0.33640	0.4	3646.4 ± 6.1	0
rim										
A62.3	0.03	934	18	0.02	3.228	1.7	0.10106	0.5	1643.6 ± 9.3	-6
discordant										
A78.1	0.11	520	83	0.16	3.28	3.2	0.11613	0.55	1897.4 ± 10	11
A46.1	-0.06	504	44	0.09	3.39	3.2	0.11880	0.59	1938 ± 10	16
A34.1	-0.01	610	82	0.14	3.53	3.2	0.11479	0.51	1876.6 ± 9.2	17
A50.1	-0.25	35	12	0.35	3.63	23	0.15960	2.1	2451 ± 36	56
A60.1	0.29	461	51	0.12	1.765	5	0.13800	10	2203 ± 17	-24
A8.1	-0.01	478	125	0.27	2.577	3.2	0.11189	0.49	1830.3 ± 8.9	-13
A73.4	0.23	843	180	0.22	2.756	1.8	0.10709	0.87	1750 ± 16	-12
SHRIMP spot phase overlap										
A62.1	-0.01	1039	58	0.06	3.169	3.1	0.10580	0.31	1728.2 ± 5.7	-2
A73.3	0.06	940	181	0.20	3.22	3.2	0.10655	0.56	1741 ± 10	0

Table 20. (continued).

Owing to their microscopic size, only one analysis (A62.3) was able to wholly sample a thin, low-CL-response rim. This analysis has an apparent age of 1644 ± 9 Ma (σ), and also a high U content (935 ppm) and low Th/U ratio (0.02), typical of zircon that has either grown or recrystallised under metamorphic conditions. The zircon rim analysed from A62.3 is approximately 140 my younger than the youngest detrital zircon analysed from this sample. The 1640 Ma age for the rim of grain A62.3 is supported by two further analyses (A62.1 and A73.3), which overlapped both a core and a thin, low-CL-response rim. These two analyses have mixed ages and are therefore ambiguous. However, their relatively high U contents and younger, albeit mixed age results of 1740–1730 Ma also indicate that many zircon rims in this sample are significantly younger than the youngest detrital zircon. Analysis A62.3 and to a lessor degree, A62.1 and A73.3, suggest that the high-grade metamorphism that this rock has undergone caused the development of thin, high-U, low-Th/U rims on many zircons in this sample at 1640 Ma. The close proximity of this sample (<1 km) to the 1640–1635 Ma Andrew Young Igneous Complex adds significant geological credibility to this interpretation. Therefore it is likely that the high-grade metamorphic event which this sample has undergone occurred at about 1640 Ma, synchronous with the intrusion and associated metamorphism of the Andrew Young Igneous Complex. This rock was therefore deposited between about 1790 Ma and 1640 Ma. It is hence too young to form part of the Lander Rock beds, and may be of a similar age to the ~1780 Ma Reynolds Range Group, elsewhere in the Aileron Province.

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