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Summary of results – joint GSQ-GA geochronology project: Monto and Maryborough 1:250 000 Sheet areas

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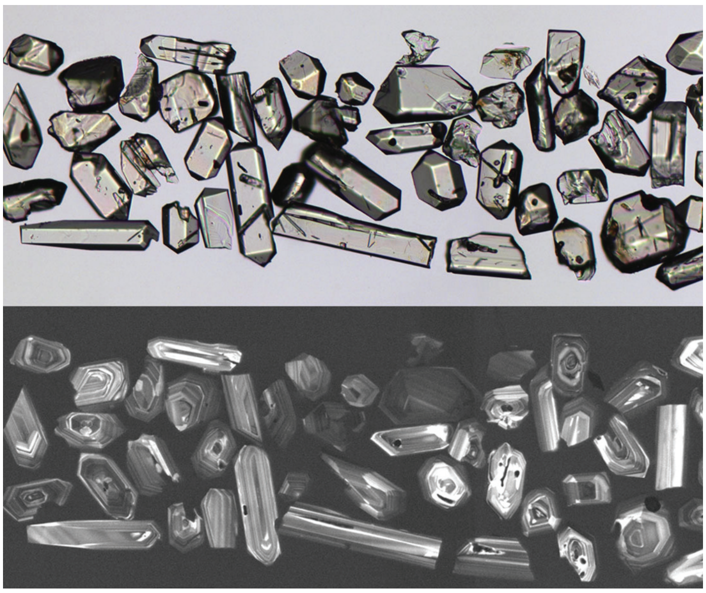

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Cover photographs: l. to r., Mungore Granite, south of Biggenden; zircon grains from the Mungore Granite

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INTRODUCTION

OVERVIEW

This report presents new SHRIMP U-Pb zircon results for twelve samples from central, south-eastern Queensland (Figure 1 and Table 1). The work was carried out under the auspices of the National Geoscience Agreement (NGA) between Geoscience Australia and the Geological Survey of Queensland. The data and age interpretations contained in this report are available in Geoscience Australia's Geochronology Delivery database (http://www.ga.gov.au/geochron-sapub-web/).

Ten of the samples reported here are a part of an extensive (>500km) north-north-west trending belt of volcanic and plutonic rocks that stretches from south of Rockhampton to the Brisbane area. These rocks have been interpreted as recording a major transition from continental convergent magmatism during the Early to Mid Triassic (Hunter-Bowen Orogeny) to extension-related magmatism and associated basin formation in the Late Triassic (Holcombe & others, 1997; Gust & others, 1993; Stephens, 1991). Volcanic rocks in the belt range from basalts to rhyolites with associated pyroclastic and epiclastic sedimentary rocks. Plutonic rocks are dominated by high-level felsic granites with granodiorite, tonalite, diorites and gabbro (occasionally in close net-vein association with felsic rocks) less abundant. Six of the Mid to Late Triassic magmatic units reported here have the same crystallisation age within their analytical uncertainties of 228 ± 1.3Ma (MSWD = 2.4). This age is very similar to previous SHRIMP U-Pb zircon age determinations of magmatic units within this belt reported by Cross & others, (2009), Carson & others, (2006) and mentioned in Purdy (2010) and confirms the very restricted temporal distribution of this event.

Three new SHRIMP U-Pb zircon ages reported here have been used to redefine the Castletower Granite. Prior to this study this unit was mapped as a single, extensive (~45 x 10km) unit comprising several plutons in the Many Peaks Range, between Lake Awonga in the north and the Boyne and Kolan River headwaters in the south. No previous geochronology had been undertaken on this unit and it had been assigned a Permian to Triassic age based on its relationship with other units. The new geochronology reported here has allowed a subdivision of this unit. The northernmost pluton has retained the name Castletower Granite and is Late Triassic in age (221.8 ± 1.3Ma, see 2003616). Granite and diorite/gabbro in central areas are contemporaneous and Late Permian in age. These are now mapped as the Many Peaks Granite (268.1 ± 1.8Ma, see 1999101) and unnamed unit PRg/b (268.3 ± 1.7Ma, see 2003617). Based on field relations (Purdy, 2010), granite in southern regions is considered Late Triassic in age and is mapped as the Bulburin Granite.

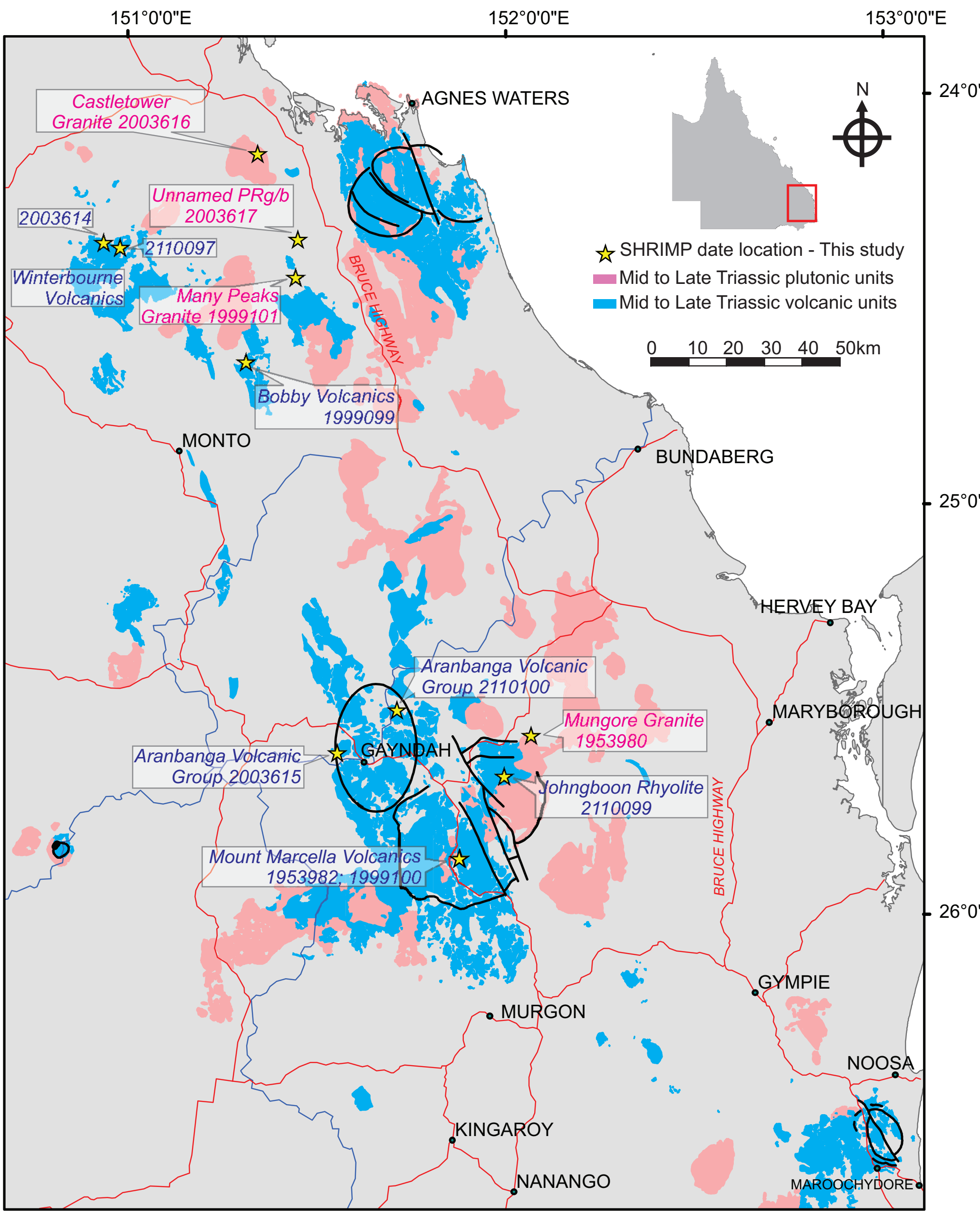

Figure 1. Map showing locations for the new SHRIMP U-Pb geochronology presented in this report

Table 1. Summary of results contained within this report

Unit	Sample ID	Sample no.	Longitude °E	Latitude °S	1:250 000 sheet	Age (Ma)	Comments
SHRIMP Mount GA6065, Analytical session 80132							
1. Mungore Granite	200701528	1953980	152.056005	-25.562166	Maryborough	**226.5 ± 1.5**	Magmatic crystallisation
2. Mount Marcella Volcanics	200701530	1953982	151.861802	-25.858546	Maryborough	~230	Reconnaissance age
SHRIMP Mount GA6096, Analytical session 90074							
3. Bobby Volcanics	200901501	1999099	151.304246	-24.646361	Monto	**229.4 ± 2.7**	Magmatic crystallisation
4. Mount Marcella Volcanics	200901506	1999100	151.860256	-25.859482	Maryborough	**228.2 ± 2.8**	Magmatic crystallisation
SHRIMP Mount GA6096, Analytical session 90102							
5. Many Peaks Granite	200701523	1999101	151.439472	-24.442876	Monto	**268.1 ± 1.8**	Magmatic crystallisation
SHRIMP Mount GA6126, Analytical session 100065							
6. Unnamed quartz diorite (PRg/b)	200901508	2003617	151.445386	-24.350036	Monto	**268.3 ± 1.7**	Magmatic crystallisation
7. Castletower Granite	200901507	2003616	151.341705	-24.140577	Monto	**221.8 ± 1.3**	Magmatic crystallisation
SHRIMP Mount GA6126, Analytical session 100066b							
8. Winterbourne Volcanics	200901503	2003614	150.930435	-24.350495	Monto	~230	Reconnaissance age
9. Aranbanga Volcanic Group	200901505	2003615	151.535694	-25.599317	Maryborough	**272.2 ± 2.6**	Inherited zircons
SHRIMP Mount GA6147, Analytical session 100142							
10. Winterbourne Volcanics	DPMR239	2110097	150.972689	-24.363579	Monto	**227.3 ± 1.4**	Magmatic crystallisation
11. Johngboon Rhyolite	DPMR399	2110099	151.984125	-25.659573	Maryborough	**227.9 ± 1.4**	Magmatic crystallisation
12. Aranbanga Volcanic Group	DPMR395	2110100	151.696631	-25.496791	Maryborough	**229.7 ± 1.4**	Magmatic crystallisation

ANALYTICAL PROCEDURES

Zircon separates were obtained using magnetic and density techniques from crushed samples. The zircons were then mounted in epoxy resin, together with the $^{206}Pb/^{238}U$ standard zircon TEMORA 2 (416.8Ma; Black & others, 2004) and the $^{207}Pb/^{206}Pb$ standard zircon OG1 (3465Ma; Stern & others, 2009). The epoxy mount was polished to reveal zircon interiors, and photomicrographs were taken in transmitted and reflected light. Cathodoluminescence (CL) images were taken of the zircons to reveal their internal zoning. These images were obtained with a JEOL JSM-6490LV scanning electron microscope located at Geoscience Australia and operating at 15kV with a working distance of 16mm.

All isotopic analyses reported here were carried out using a **S**ensitive **H**igh **R**esolution **I**on **M**icroprobe (SHRIMP IIe) which is located at Geoscience Australia and jointly owned by Geoscience Australia and Australian Scientific Instruments. Analytical procedures followed the methodology described by Compston & others, (1984), Williams & Cleason (1987) and Claoué–Long & others, (1995). The primary O_2^- beam had an intensity of between ~2.0 to 2.8nA, which resulted in a spot diameter of ~25 to 35µm. The ionised particles were extracted into the mass spectrometer with a 10kV potential and counted with a single electron multiplier. Ions were focussed into the collector by a cyclic stepping of the magnet and each analysis represents the average of six scans through the different mass stations (Table 2). All analyses were carried out with a mass resolution of approximately 5000.

The Pb/U calibration standard was analysed every fourth unknown analysis and the $^{207}Pb/^{206}Pb$ standard every eighth. Calibration of the $^{206}Pb/^{238}U$ ratios was by comparison to the zircon standard TEMORA 2 and the power law relationship of $^{206}Pb^+/^{238}U^+$ and $^{238}UO^+/^{238}U^+$ with an exponent of 2 (Claoué–Long & others, 1995). Six separate analytical sessions were used to calibrate the $^{206}Pb/^{238}U$ ratios of the unknowns analysed. The calibration parameters for each session are shown in Table 3 and displayed in Figure 2. Additionally, information for each calibration session is listed in Appendix 1.

Table 2. Mass stations and count times for the SHRIMP U-Pb zircon analyses carried out during this study

Mass Station	Isotope	Mass (amu)	Count time (s)	Delay for magnetic settling (s)
1	$^{196}Zr_2O$	195.804	2	7
2	^{204}Pb	203.973	20	2
3	Background	204.1	20	1
4	^{206}Pb	205.974	10	2
5	^{207}Pb	206.976	40	1
6	^{208}Pb	207.977	10	1
7	^{238}U	238.051	5	2
8	^{248}ThO	248.033	2	3
9	^{254}UO	254.046	2	3
10	$^{270}UO_2$	270.041	2	3

Table 3. SHRIMP $^{206}Pb/^{238}U$ standard information for the samples reported
Standard used: TEMORA 2; 416.8 Ma (Black & others, 2004)

Mount No.	LIMS session No.	Analysis date	Standard analyses (n)	Rejections	Exponent used	Reproducibility (1σ)	Standard error (1σ)
GA6065	80132	10-Oct—13-Oct-2008	31	0	2	0.98%	0.22%
GA6096	90074	11-Aug—13-Aug-2009	21	0	2	1.75%	0.47%
GA6096	90102	27-Oct—01-Nov-2009	41	0	2	0.94%	0.21
GA6126	100065	28-Apr—30-Apr-2010	22	0	2	0.79%	0.24%
GA6126	100066b	02-May—03-May-2010	10	0	2	1.0%	0.40%
GA6147	100142	11-Nov—13-Nov-2010	23	0	2	1.0%	0.23%

Uranium abundances were calculated with reference to SL13 (238ppm) or M257 (840ppm) and are subject to an uncertainty of at least ± 20%. Th/U ratios were calculated using the linear relationship $^{232}Th/^{238}U = {}^{232}ThO^+/^{238}UO^+*[0.03446(UO^+/U^+)+0.868]$. Data reduction was carried out using Squid2.50_r21, and Isoplot_r5 Microsoft Excel-based macros of Ludwig (2008; 2009) downloaded from the Sourceforge website (http://sourceforge.net/projects/squid2) and (http://sourceforge.net/projects/isoplot). Individual analyses in this report have uncertainties listed in the tables and plotted on Concordia and $^{206}Pb/^{238}U$ temporal trend diagrams as ^{204}Pb corrected shaded ellipses and error bars at the 1σ level. The ages for the zircon populations were calculated from a weighted average of the ^{204}Pb corrected $^{206}Pb/^{238}U$ ages using ISOPLOT 3 (Ludwig, 2008) and the final ages are given at the 95% confidence interval.

Wherever possible the zircons from geologically related samples were mounted together. To ensure the best age comparisons between the samples, the zircons were analysed during the same analytical session in a round-robin fashion. For all the samples reported here, zircon regions considered to represent igneous growth were preferentially targeted for SHRIMP U-Pb analysis.

ACKNOWLEDGEMENTS

We would like to acknowledge the meticulous care and professionalism taken with the crushing of samples, SHRIMP mount preparation, photography and SEM imaging of zircons undertaken by members of the Geoscience Australia Geochronology Laboratory: David DiBugnara, Emma Chisholm, Chris Foudoulis, Stephen Ridgeway and Benjamin Lineham. Patrick Burke ensured the SHRIMP was optimally tuned during all analytical sessions and Les Sullivan's readiness to assist with any computer related or data storage issues is much appreciated. We also appreciate the thorough desktop publishing work of Sharon Beeston at the Geological Survey of Queensland.

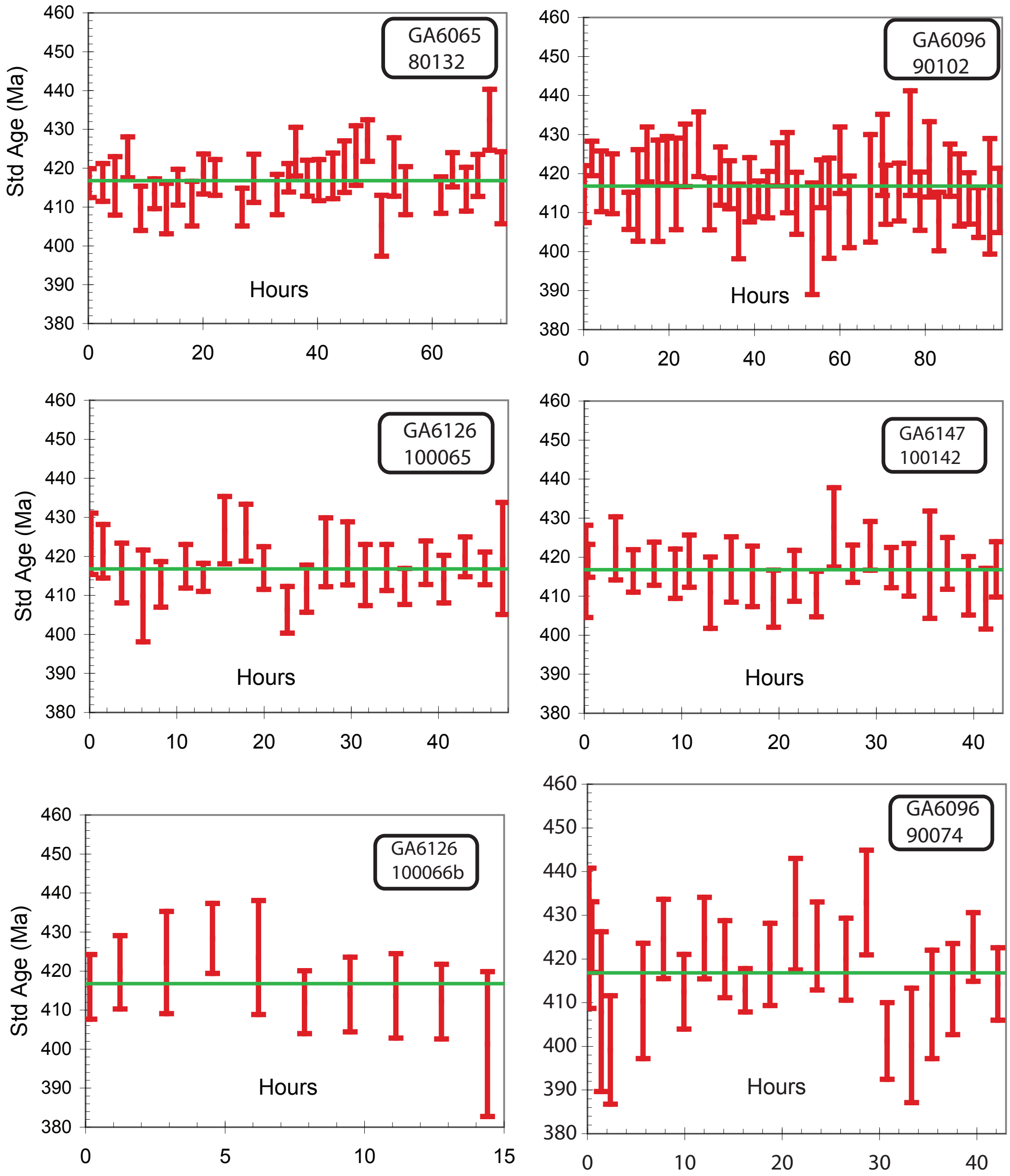

Figure 2. Temporal trend of the $^{206}Pb/^{238}U$ ages for the TEMORA 2 zircon standard for the analytical sessions used in this study (error bars are 2σ). See Table 2 and Appendix 1 for further session details.

SAMPLES ANALYSED

1. MUNGORE GRANITE 1953980

GA SAMPLEID:	200701528
GA SAMPLENO:	1953980
GSQ SITEID:	
Formal Name:	Mungore Granite
Informal Name:	
Lithology:	Granophyric alkali feldspar granite
1:250 000 SHEET:	MARYBOROUGH (SF5606)
1:100 000 SHEET:	BIGGENDEN (9346)
REGION:	New England Region
LOCATION (GDA94):	152.056005°E, -25.562166°S
LOCATION (MGA 94 Zone 56):	405177 mE, 7172465 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6065
ANALYTICAL SESSION:	80132
INTERPRETED AGE:	226.5 ± 1.5Ma (95% confidence, 26 analyses on 26 zircons)
GEOLOGICAL ATTRIBUTION:	Magmatic crystallisation
ISOTOPIC RATIO(S) USED:	$^{206}Pb/^{238}U$

Sample details

The subunit Mungore Granite/g (Cranfield, 1994), or Type 4 Granite (Stephens, 1991) is a high level granite that crops out in rugged terrain south of Biggenden (Figure 3). This is the youngest of all intrusions associated with the Mungore Cauldron and intrudes 400m into co-genetic, intra-caldera ignimbrite of the Aranbanga Volcanic Group (Johngboon Rhyolite) (Stephens, 1991). No U-Pb SHRIMP zircon geochronology has been completed for any of the Mungore Granites or Aranbanga Volcanic Group rocks. Other dating methods have yielded a wide range of ages for the main part of the Mungore Granite (from ~212Ma to 230Ma) including an anomalously young age of 172.2 ± 2.2Ma (K-Ar biotite) for the Mungore Granite/g subunit (see Cranfield, 1994, table 10 for compilation).

To test these ages, and to constrain the age of the Mungore Granite and associated Aranbanga Volcanic Group, the subunit Mungore Granite/g was selected for geochronology. The sample selected is a biotite ± hornblende, granophyric and miarolitic, leucocratic alkali feldspar granite from the area adjacent to Mount Walsh. It comprises anhedral alkali feldspar and intergrowths of quartz and alkali feldspar, with very rare plagioclase and minor biotite ± hornblende.

Figure 3. Rugged terrain formed by the high-level Mungore Granite south of Biggenden

Zircons

Zircons recovered from 1953980 are clear and colourless euhedral grains. They range in diameter between ~30 and ~90µm and range in aspect ratio from 1 to 5. The majority are moderately to strongly luminescent and concentric growth zoning predominates (Figure 4).

U-Pb isotopic results

Twenty-six SHRIMP U-Pb isotopic analyses were carried out on 26 zircons from this sample (Figure 5 and Table 4). Uranium concentrations are low to moderate (75 to 484ppm; median = 187ppm) and Th/U ratios range from 0.52 to 1.55 (median = 0.76). Common $^{206}Pb_c$ concentrations range up to 2.93 however, there is no correlation between common Pb content and $^{206}Pb/^{238}U$ ratios. All 26 analyses have the same radiogenic $^{206}Pb/^{238}U$ within their analytical uncertainties (MSWD = 1.09) and contribute to a weighted mean age of **226.5 ± 1.5Ma**, which is interpreted as the crystallisation age of these zircons.

The crystallisation age of 226.5 ± 1.5Ma obtained for the Mungore Granite/g is much older than the previously reported K-Ar biotite age (172.2 ± 2.2Ma) and marginally older than most previous dates for other parts of the Mungore Granite. This new date for the Mungore Granite/g has wider implications. It indicates that the Aranbanga Volcanic Group, which is intruded by this granite, is significantly older than previously reported ages of ~221 to 224Ma (Cranfield, 1994) and much closer in age to the Mount Marcella Volcanics (228.2 ± 2.8Ma) as presented in this report (see 1999100).

Figure 4. Selected transmitted light (top) and cathodoluminescence (bottom) images of zircon grains from the Mungore Granite (1953980)

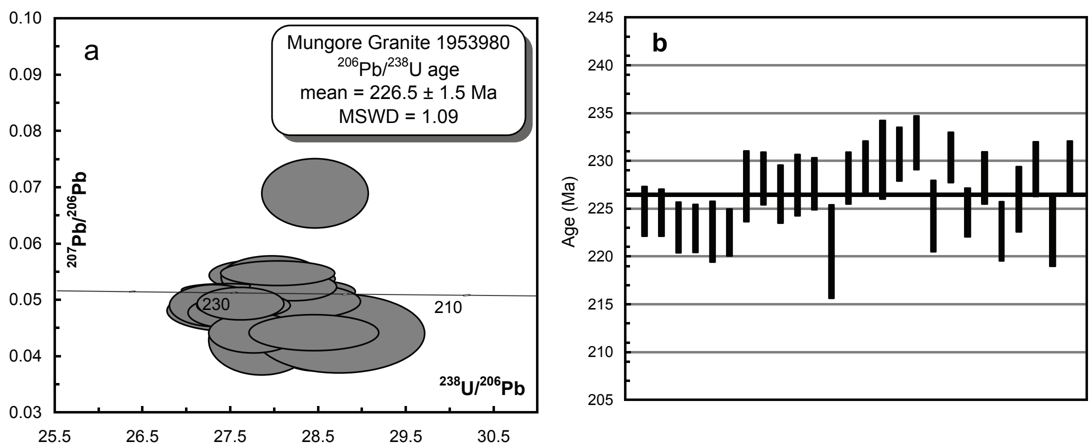

Figure 5. (a) Tera-Wasserberg concordia plot and (b) temporal trend of the $^{206}Pb/^{238}U$ ages from the Mungore Granite (1953980)

Table 4. SHRIMP U-Pb isotopic data from the Mungore Granite (1953980)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
528.Z.9.1.1	0.24	222	202	0.94	28.193	1.2	0.053	2.3	224.7	2.6
528.Z.10.1.1	0.38	355	213	0.62	28.209	1.1	0.051	2.2	224.6	2.5
528.Z.11.1.1	1.15	205	105	0.53	28.409	1.2	0.047	4.6	223.0	2.7
528.Z.12.1.1	0.38	218	121	0.57	28.424	1.2	0.051	2.6	222.9	2.5
528.Z.13.1.1	2.93	83	56	0.70	28.466	1.5	0.044	11.2	222.6	3.2
528.Z.14.1.1	0.53	281	198	0.73	28.480	1.1	0.049	2.7	222.5	2.5
528.Z.15.1.1	1.05	102	87	0.88	27.861	1.7	0.049	5.7	227.3	3.7
528.Z.16.1.1	0.45	135	202	1.55	27.761	1.2	0.054	3.2	228.1	2.8
528.Z.17.1.1	0.57	78	90	1.19	27.962	1.4	0.054	4.7	226.5	3.1
528.Z.18.1.1	1.85	82	63	0.79	27.847	1.4	0.042	9.7	227.4	3.2
528.Z.19.1.1	0.86	165	83	0.52	27.828	1.2	0.048	4.2	227.6	2.7
528.Z.20.1.1	2.35	87	62	0.74	28.741	2.3	0.043	10.7	220.5	4.9
528.Z.21.1.1	1.08	178	125	0.73	27.753	1.2	0.045	4.9	228.2	2.7
528.Z.22.1.1	0.82	179	131	0.75	27.607	1.2	0.048	4.0	229.4	2.7
528.Z.23.1.1	0.97	136	112	0.84	27.519	1.8	0.048	5.2	230.1	4.1
528.Z.24.1.1	0.21	484	308	0.66	27.449	1.2	0.051	1.5	230.7	2.8
528.Z.1.2.1	1.22	156	117	0.77	27.304	1.2	0.048	5.1	231.9	2.8
528.Z.25.1.1	1.06	194	276	1.47	28.254	1.7	0.049	4.2	224.2	3.7
528.Z.26.1.1	0.97	230	237	1.06	27.489	1.2	0.047	3.8	230.3	2.6
528.Z.27.1.1	0.70	241	230	0.98	28.209	1.2	0.052	3.1	224.6	2.6
528.Z.28.1.1	1.46	231	165	0.74	27.753	1.2	0.043	5.4	228.2	2.7
528.Z.29.1.1	0.00	75	73	1.00	28.461	1.4	0.069	6.0	222.6	3.1
528.Z.30.1.1	0.25	165	211	1.32	28.031	1.5	0.054	2.7	226.0	3.4
528.Z.33.1.1	0.81	336	204	0.63	27.640	1.3	0.049	3.0	229.1	2.9
528.Z.34.1.1	1.38	320	475	1.53	28.446	1.7	0.044	4.8	222.7	3.8
528.Z.35.1.1	0.83	204	110	0.56	27.606	1.2	0.049	3.9	229.4	2.7

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

2. MOUNT MARCELLA VOLCANICS 1953982

GA SAMPLEID:	200701530
GA SAMPLENO:	1953982
GSQ SITEID:	
Formal Name:	Mount Marcella Volcanics
Informal Name:	
Lithology:	Andesite
1:250 000 SHEET:	MARYBOROUGH (SF5606)
1:100 000 SHEET:	GAYNDAH (9246)
REGION:	New England Region
LOCATION (GDA94):	151.861802°E, -25.858546˚S
LOCATION (MGA 94 Zone 56):	385951 mE, 7139487 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6065
ANALYTICAL SESSION:	80132

RECONNAISSANCE AGE: ~230Ma
GEOLOGICAL ATTRIBUTION: Magmatic crystallisation
ISOTOPIC RATIO(S) USED: $^{206}Pb/^{238}U$

Sample details

The Mount Marcella Volcanics are generally considered to represent the northern part of the Esk Trough and crop out extensively in the Gayndah and Biggenden 1:100 000 sheet areas. They form the upper part of the Toogoolawah Group and are considered to be equivalent to the extensive Neara Volcanics (Cranfield, 1989) that extend further south. Recent detailed mapping (Buck, 2008) identifies two stages in the development of the Mount Marcella Volcanics; 1) the Penwhaupell Volcanic Centre, comprising interbedded lavas and pyroclastic deposits dominated by dacite, and 2) the Ettiewyn Caldera, dominated by andesitic ignimbrite related to caldera formation. These are separated by a period of sedimentation. An early to middle Triassic age is widely accepted for the Mount Marcella Volcanics and equivalent Neara Volcanics (Cranfield, 1989; Gust & others, 1996; Holcombe & others, 1997; Campbell, 2005; Buck, 2008). However, this is based on poorly constrained plant fossils and limited radiometric age data with a wide range (see compilation in Campbell, 2005, table 5.4). The sample collected for analysis is an andesitic lava from the upper Ettiewyn Caldera. It consists of partly sericitised plagioclase and pyroxene phenocrysts in a finer grained groundmass of plagioclase laths with a trachytic texture.

The Mount Marcella Volcanics were selected for geochronology for several reasons: 1) no other SHRIMP U-Pb geochronology exists for any unit of the Esk Trough; 2) the Mount Marcella Volcanics have not been dated by any method and existing radiometric dates for the equivalent Neara Volcanics have a wide range; and 3) Triassic magmatism is voluminous in the Gayndah region, constraining ages allows investigation of the relationships between units and the progression of styles of magmatism/volcanism. Of particular interest is the relationship between the mafic to intermediate–dominated Mount Marcella Volcanics and silicic-dominated, caldera-forming Aranbanga Volcanic Group.

Zircons

Only eleven zircons were separated from 1953982. Five grains appear similar. These are clear and colourless, euhedral, equant and range in diameter from ~50 to ~100µm. They also have a moderate luminescence with faint concentric growth zones and thin (~1 to 3µm), often discontinuous, strongly luminescent rims. The other grains are more variable. They range from colourless to pale pink and are sub-rounded to rounded. In CL they are also variable, one grain (530.Z.5.1.1) has a strongly luminescent core surrounded by a weakly luminescent rim, whereas the other grains have weaker luminescence with faint oscillatory growth zones (Figure 6).

U-Pb isotopic results

Ten SHRIMP U-Pb isotopic analyses were carried out on nine zircons from this sample (Figure 7 and Table 5). Uranium concentrations range from 40 to 233ppm and Th/U from 0.52 to 1.26. Common $^{206}Pb_c$ contents are variable, ranging from 0.12 to 8.73%. Omitting the analysis with the highest common Pb content leaves just 9 analyses to consider. The three oldest grains are clearly inherited components and have ages of ~1880Ma, ~554Ma and ~440Ma. The remaining six analyses on five grains are dispersed in radiogenic $^{206}Pb/^{238}U$ (MSWD = 2.8). The robust median age of these grains which ignores the underlying distribution is 231 +9/-3.0Ma. With so few analyses, this result, by itself, can only be considered as a reconnaissance-level age determination. An additional sample from the Mount Marcella Volcanic Group, analysed during this study (GA6096; 1999100, this report) is within error of this result (MSWD = 1.3), indicating that the robust age derived here is a reasonable estimate for this unit.

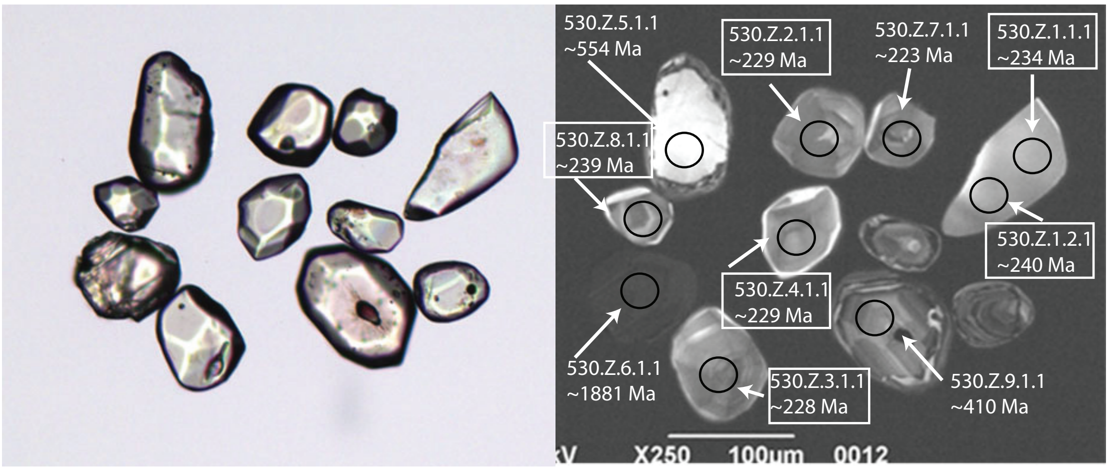

Figure 6. Transmitted light (left) and cathodoluminescence images (right) of all zircon grains recovered from the Mount Marcella Volcanics (1953982). Positions of the SHRIMP U-Pb analytical spots and ages are also shown. Ages within boxes are those used for the age interpretation (see text).

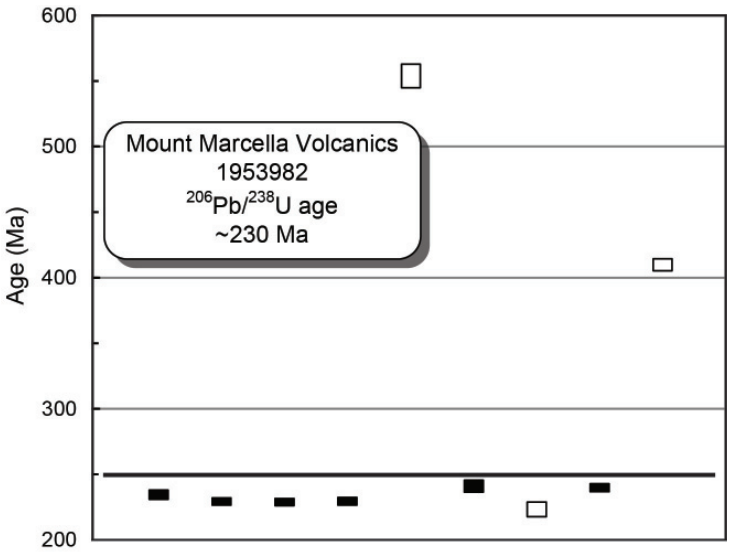

Figure 7. Temporal trend of the $^{206}Pb/^{238}U$ ages for the Mount Marcella Volcanics (1953982). The low unfilled bar has a high common Pb content and the two high unfilled bars are inherited.

Table 5. SHRIMP U-Pb isotopic data from the Mount Marcella Volcanics (1953982)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
530.Z.1.1.1	3.08	72	88	1.26	27.073	1.6	0.040	14.3	233.8	3.6
530.Z.2.1.1	0.22	129	148	1.18	27.696	1.3	0.058	2.8	228.6	2.8
530.Z.3.1.1	1.78	145	134	0.95	27.745	1.3	0.044	6.9	228.3	2.9
530.Z.4.1.1	1.62	145	163	1.16	27.699	1.3	0.047	6.5	228.6	2.9
530.Z.8.1.1	0.62	161	170	1.08	26.463	1.2	0.052	3.9	239.1	2.9
530.Z.1.2.1	0.60	87	105	1.25	26.325	2.0	0.063	4.3	240.3	4.6
Inherited zircons										
530.Z.5.1.1	1.76	41	38	0.95	11.143	1.7	0.056	6.7	554.0	9.0
530.Z.6.1.1	0.12	150	76	0.52	2.926	1.2	0.115	0.5	1895.2	20.3
530.Z.9.1.1	0.20	233	193	0.86	15.244	1.2	0.056	2.2	409.6	4.6
high common Pb										
530.Z.7.1.1	8.73	176	209	1.22	28.459	2.6	0.046	34.0	222.6	5.6

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

3. BOBBY VOLCANICS 1999099

GA SAMPLEID:	200901501
GA SAMPLENO:	1999099
GSQ SITEID:	DPMR158
Formal Name:	Bobby Volcanics
Informal Name:	
Lithology:	Fine-grained rhyolitic airfall deposit
1:250 000 SHEET:	MONTO (SG5601)
1:100 000 SHEET:	MONTO (9148)
GEOLOGICAL REGION:	New England Region
LOCATION (GDA94):	151.304246°E, -24.646361°S
LOCATION (MGA94 zone 56):	328379 mE, 7273150 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6096
ANALYTICAL SESSION:	90074
INTERPRETED AGE:	229.4 ± 2.7 Ma (95% confidence, 33 analyses on 32 zircons)
GEOLOGICAL ATTRIBUTION:	Magmatic crystallisation
ISOTOPIC RATIO(S) USED:	$^{206}Pb/^{238}U$

Sample details

The Bobby Volcanics crop out in the Many Peaks and Kalpowar areas, ~80km south of Gladstone in central Queensland. They form high-relief, densely vegetated terrain and comprise basaltic to andesitic lava flows with extensive autoclastic deposits, fluvial volcaniclastic sediments, pyroclastic deposits including ignimbrites and airfall deposits, and coherent autoclastic rhyolite in lava domes/cryptodomes (Purdy, 2010). In previous geologic mapping (Dear & others, 1971; Ellis & Whitaker, 1976) these deposits, along with many other Triassic volcanic sequences, were mapped as the widespread Muncon Volcanics. An Early to Middle Triassic age was suggested based on plant fossil collections, however, the species identified also have been considered to be Middle to Late Triassic in age (Hill & others, 1965).

The Bobby Volcanics were selected for geochronology to examine their relationship with the adjacent Agnes Water Volcanics, with which they share many similarities (Purdy, 2010), and to further constrain the distribution and character of Late Triassic magmatism highlighted in recent work (Carson & others, 2006; Cross & others, 2009; Purdy, 2009). The sample selected for geochronology is from an ash-rich, moderately stratified, rhyolitic airfall deposit comprising heavily altered, unwelded former glass shards, small pumice fragments and sparse crystal fragments including quartz, completely altered feldspar, and possible biotite (Figure 8). This deposit crops out in cuttings along the Gladstone–Monto railway at the northern margin of Kalpowar State Forest. The sequence is in direct unconformable contact with underlying Rockhampton Group sediments (Carboniferous) and therefore represents the base of the Bobby Volcanics in this area (Figure 9).

Figure 8. Fine grained rhyolitic airfall tuff of the Bobby Volcanics (1999099)

Figure 9. Unconformity between the Rockhampton Group (maroon) and tuffaceous sediments (including air fall deposits) of the Bobby Volcanics exposed in cuttings of the Gladstone–Monto railway line near Kalpowar State Forest.

Zircons

Zircons separated from 1999099 are clear and colourless crystals and broken fragments with sharp crystal faces. Intact crystals are typically euhedral and have a range in diameter between ~30 to 100µm and aspect ratios of between 2 to 3. There is also a minor portion of grains with aspect ratios of up to 6. Almost all zircons have inclusions that can extend along their entire length or breadth. In CL the grains are predominantly concentrically zoned and moderately luminescent (Figure 10).

U-Pb isotopic results

Thirty-three SHRIMP U-Pb isotopic analyses were carried out on 32 zircons from this sample (Figure 11, Table 6). Uranium concentrations are low to moderate (74 to 387ppm) and Th/U ratios range from 0.48 to 1.50. The common $^{206}Pb_c$ contents of the grains range up to 3.44%. However, there is no correlation between common ^{206}Pb and radiogenic $^{206}Pb/^{238}U$. All 33 analyses have the same radiogenic $^{206}Pb/^{238}U$ within their analytical uncertainties (MSWD = 0.61) and combine to give an age of **229.4 ± 2.7Ma**. This is interpreted as the crystallisation age of these grains.

The Late Triassic date obtained for the Bobby Volcanics overlaps with the adjacent Agnes Water Volcanics. Along with strong lithological and geochemical similarities, this suggests that these units may have originally formed a single volcanic field.

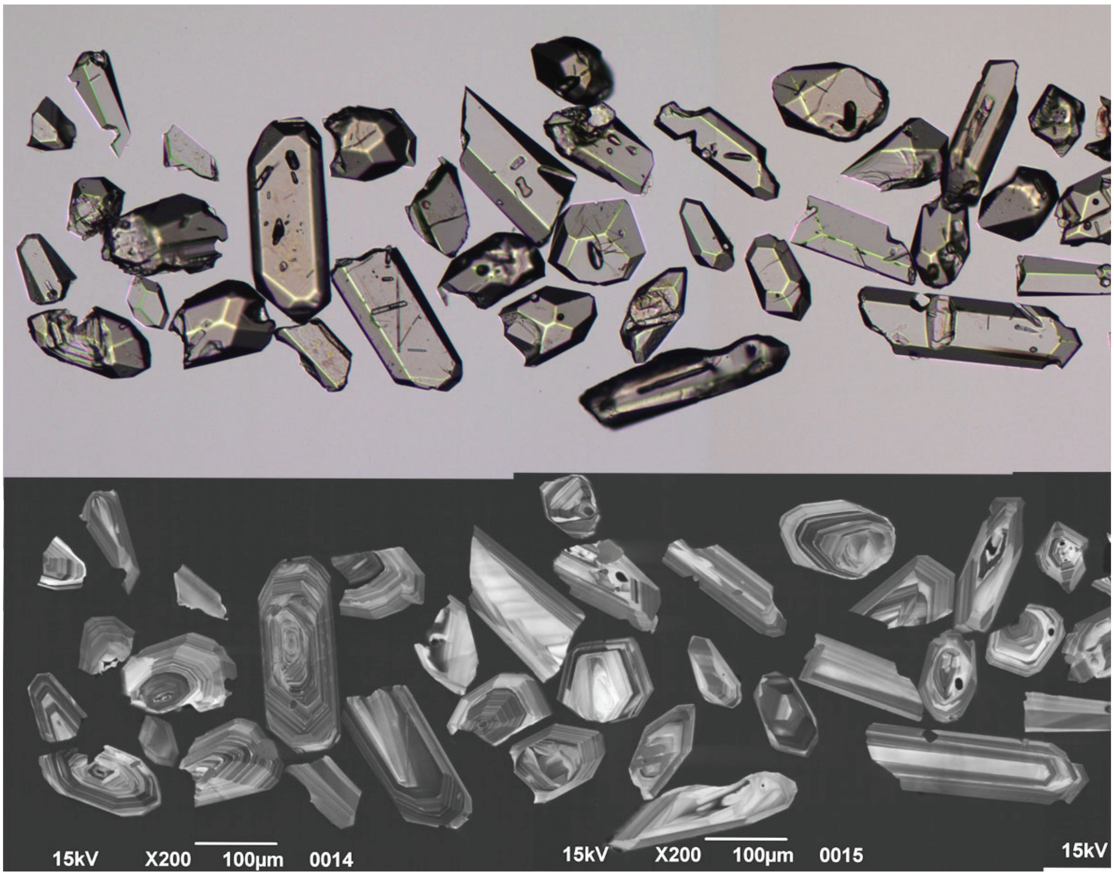

Figure 10. Selected transmitted light (top) and cathodoluminescence (bottom) images of zircon grains from the Bobby Volcanics (1999099)

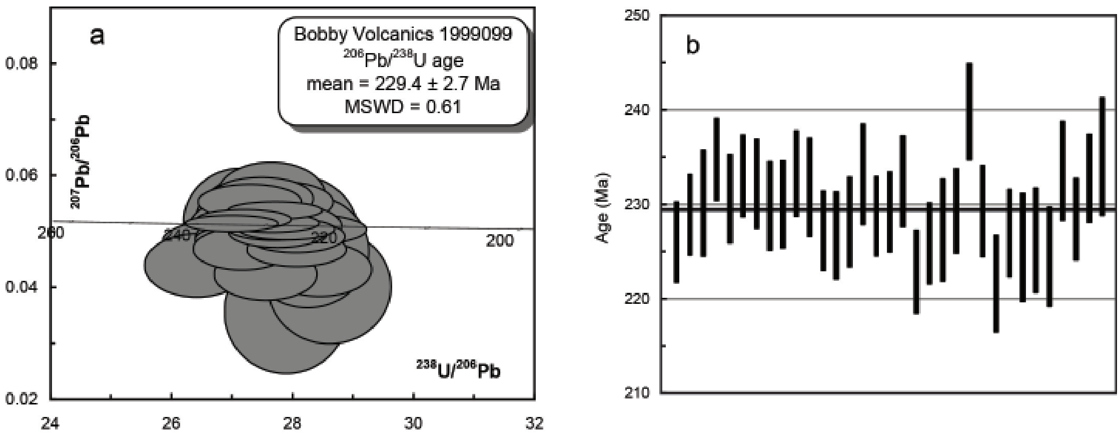

Figure 11. (a) Tera-Wasserberg concordia plot and (b) temporal trend of the $^{206}Pb/^{238}U$ ages from the Bobby Volcanics (1999099)

Table 6. SHRIMP U-Pb isotopic data from the Bobby Volcanics (1999099)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
099.Z.7.1.1	0.73	257	109	0.44	28.031	1.9	0.049	4.0	226.0	4.3
099.Z.8.1.1	0.47	254	184	0.75	27.669	1.9	0.050	3.1	228.9	4.3
099.Z.9.1.1	1.91	122	65	0.55	27.520	2.5	0.045	8.6	230.1	5.7
099.Z.12.1.1	0.05	261	220	0.87	26.962	1.9	0.051	1.9	234.8	4.4
099.Z.10.1.1	0.57	114	104	0.94	27.462	2.1	0.056	4.6	230.6	4.7
099.Z.13.1.1	0.15	256	226	0.91	27.170	1.9	0.052	2.2	233.0	4.3
099.Z.14.1.1	0.25	107	71	0.68	27.269	2.1	0.055	3.8	232.2	4.8
099.Z.15.1.1	1.11	115	91	0.81	27.553	2.1	0.051	6.4	229.8	4.7
099.Z.16.1.1	1.24	132	159	1.25	27.533	2.0	0.042	7.4	230.0	4.6
099.Z.17.1.1	1.02	179	191	1.11	27.140	2.0	0.046	5.4	233.3	4.5
099.Z.18.1.1	1.32	75	35	0.48	27.313	2.3	0.052	10.4	231.8	5.2
099.Z.19.1.1	0.31	329	303	0.95	27.881	1.9	0.050	2.5	227.2	4.2
099.Z.20.1.1	1.21	126	96	0.79	27.941	2.1	0.048	6.9	226.7	4.6
099.Z.21.1.1	0.39	107	65	0.62	27.764	2.1	0.055	4.4	228.1	4.7
099.Z.22.1.1	1.58	74	74	1.02	27.151	2.3	0.048	10.3	233.2	5.4
099.Z.23.1.1	0.16	390	246	0.65	27.688	1.9	0.053	2.0	228.7	4.2
099.Z.24.1.1	0.18	347	239	0.71	27.634	1.9	0.051	2.2	229.2	4.3
099.Z.25.1.1	0.80	309	147	0.49	27.239	2.1	0.048	3.9	232.4	4.9
099.Z.26.1.1	1.62	198	105	0.55	28.431	2.0	0.043	7.5	222.8	4.4
099.Z.27.1.1	0.78	283	153	0.56	28.047	1.9	0.046	4.4	225.8	4.3
099.Z.28.1.1	3.44	92	81	0.91	27.872	2.4	0.035	20.9	227.2	5.4
099.Z.29.1.1	0.98	223	221	1.02	27.618	2.0	0.049	5.2	229.3	4.5
099.Z.30.1.1	1.64	173	125	0.75	26.383	2.2	0.044	8.7	239.8	5.1
099.Z.31.1.1	0.57	128	92	0.74	27.622	2.2	0.056	7.0	229.3	4.9
099.Z.32.1.1	2.64	100	121	1.26	28.598	2.4	0.040	17.1	221.6	5.1
099.Z.33.1.1	0.66	175	168	0.99	27.915	2.1	0.051	5.1	226.9	4.6
099.Z.34.1.1	0.50	268	153	0.59	28.103	2.6	0.050	3.8	225.4	5.7
099.Z.35.1.1	2.53	83	67	0.83	28.006	2.5	0.050	13.5	226.2	5.6
099.Z.36.1.1	2.27	95	53	0.57	28.226	2.4	0.046	14.5	224.4	5.3
099.Z.37.1.1	2.19	115	59	0.53	27.109	2.3	0.051	12.8	233.5	5.3
099.Z.38.1.1	0.73	322	417	1.34	27.727	1.9	0.050	3.9	228.4	4.4
099.Z.39.1.1	1.14	210	304	1.50	27.199	2.0	0.048	6.0	232.8	4.7
099.Z.12.2.1	0.94	234	199	0.88	26.926	2.7	0.048	5.5	235.1	6.2

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

4. MOUNT MARCELLA VOLCANICS 1999100

GA SAMPLEID: 200901506
GA SAMPLENO: 1999100
GSQ SITEID: DPMR216

Formal Name: Mount Marcella Volcanics
Informal Name:
Lithology: Crystal-rich dacitic ignimbrite

1:250 000 SHEET: MARYBOROUGH (SG5606)
1:100 000 SHEET: GAYNDAH (9246)
REGION: New England Region

LOCATION (GDA94):	151.860256°E, -25.859482°S
LOCATION (MGA94 zone 56):	385797 mE, 7139382 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6096
ANALYTICAL SESSION:	90074
INTERPRETED AGE:	228.2 ± 2.8Ma (95% confidence, 33 analyses on 33 zircons)
GEOLOGICAL ATTRIBUTION:	Magmatic crystallisation
ISOTOPIC RATIO(S) USED:	$^{206}Pb/^{238}U$

Sample details

A previous attempt at dating an andesitic lava from the Mount Marcella Volcanics yielded an inconclusive age of ~230Ma based on only five SHRIMP U-Pb zircon analyses on four grains from an andesitic lava (1953982, this report). The unit was resampled and a crystal-rich, densely welded dacitic ignimbrite from immediately below the andesitic lava (1953982) was selected (Figure 12). Both samples are from the upper ‘Ettiewyn Caldera’ (Buck, 2008) part of the Mount Marcella Volcanics sequence.

Zircons

Zircons recovered from 1999100 consist of clear colourless crystals and their broken equivalents, many with numerous randomly orientated acicular inclusions. They are ~20 to ~120µm in diameter and although the majority have aspect ratios of 2, the whole range extends to those with aspect ratios of up to 6. Most are moderately luminescent with well defined concentric growth zones, while a minor portion are sector zoned (Figure 13).

Figure 12. Crystal rich densely welded ignimbrite of the Mount Marcella Volcanics (1999100)

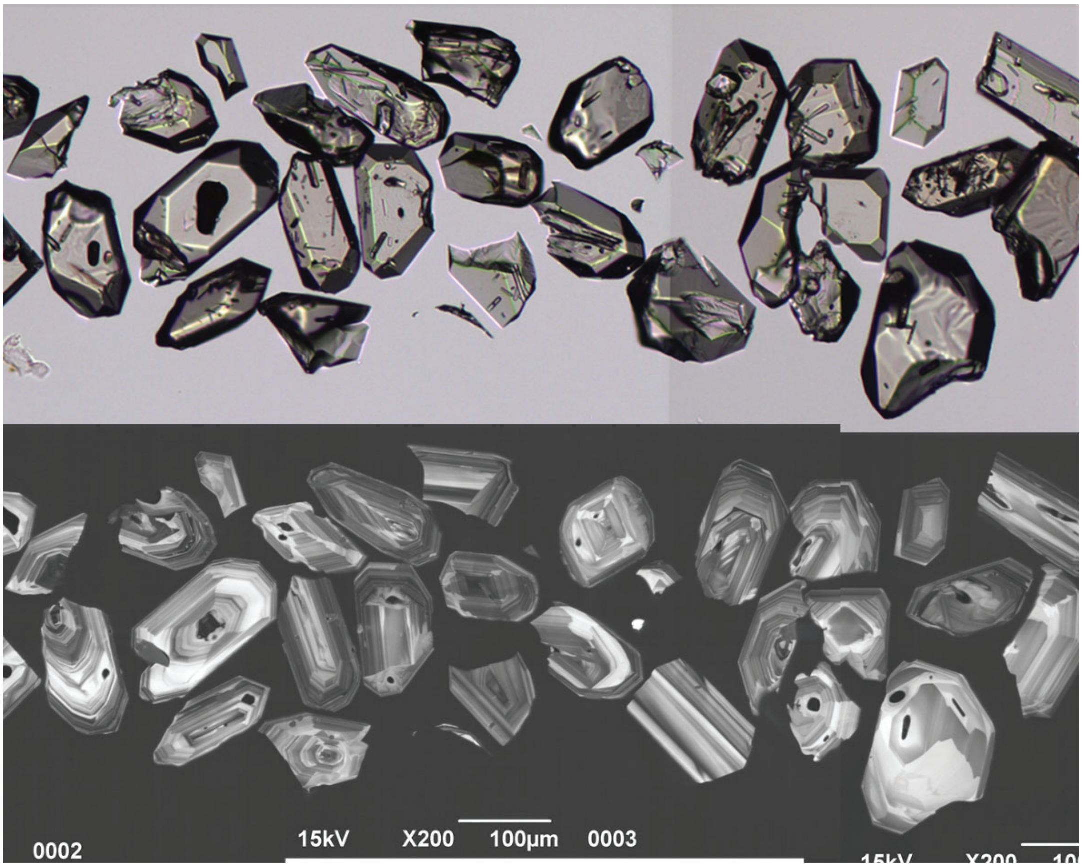

Figure 13. Selected transmitted light (top) and cathodoluminescence (bottom) images of zircon grains from the Mount Marcella Volcanics (1999100)

U-Pb isotopic results

Thirty-four SHRIMP U-Pb isotopic analyses were carried out on 32 zircons from this sample (Figure 14 and Table 7). Uranium concentrations are low to moderate (52 to 280ppm) and Th/U ratios are moderate to high (0.54 to 1.64). The zircon common $^{206}Pb_c$ concentrations range up to 4.3% but show no correlation with radiogenic $^{206}Pb/^{238}U$. Consequently, all analyses have been retained for age considerations. All 34 analyses have the same radiogenic $^{206}Pb/^{238}U$ within their analytical uncertainties (MSWD = 1.37) and combine to give an age of **228.2 ± 2.8Ma**. This is interpreted as the crystallisation age of these zircons.

The 228.2 ± 2.8Ma age reported here for the Mount Marcella Volcanics is within error of the previous dating attempt (GA6065: 1953982, this report: MSWD = 1.3) and is the preferred age for this unit. This result is significantly younger than the previously accepted Early to Middle Triassic age. This date is within error of those obtained further north for the Bobby Volcanics (1999099, this report), Agnes Water Volcanics (Cross & others, 2009), and various granitoids (Cross & others, 2009; Carson & others, 2006) and greatly extends the spatial range of this Late Triassic magmatic event. Additionally, it places the Mount Marcella Volcanics much closer in time to the overlying Aranbanga Volcanic Group and questions the age of the extensive Neara Volcanics. It should be noted however that this date is for the upper part of the sequence and the time gap between the lower and upper parts remains unknown. Clearly, more geochronology is required in this area.

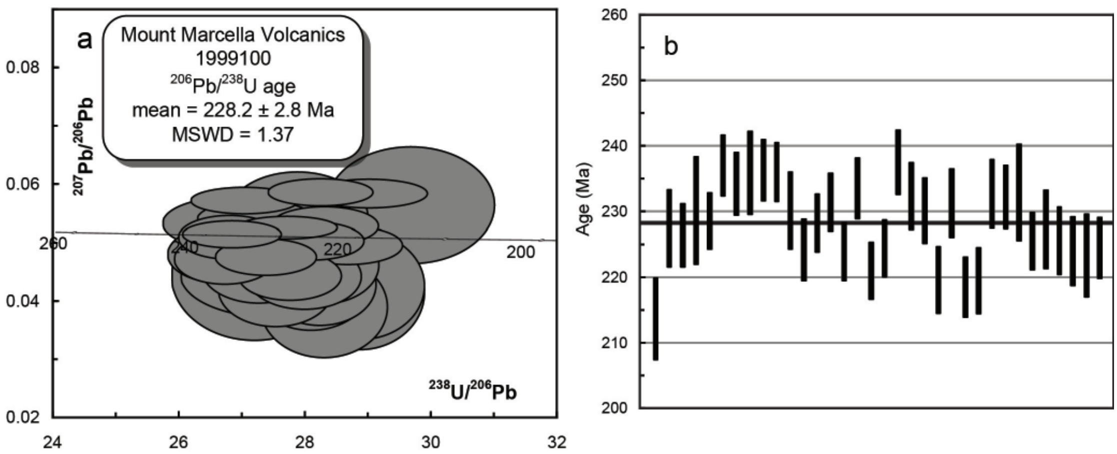

Figure 14. (a)Tera-Wasserberg concordia plot and (b) temporal trend of the $^{206}Pb/^{238}U$ ages from the Mount Marcella Volcanics (1999100)

Table 7. SHRIMP U-Pb isotopic data from the Mount Marcella Volcanics (1999100)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb*$	± (%)	$^{207}Pb*/^{206}Pb*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
100.Z.7.1.1	0.65	64	61	0.98	29.668	3.0	0.056	11.9	213.7	6.2
100.Z.8.1.1	4.31	53	39	0.76	27.843	2.6	0.024	39.7	227.5	5.9
100.Z.9.1.1	1.32	101	109	1.12	27.975	2.1	0.044	8.6	226.4	4.8
100.Z.1.2.1	1.55	69	77	1.16	27.500	3.6	0.044	11.1	230.3	8.2
100.Z.10.1.1	0.21	238	125	0.54	27.698	1.9	0.052	2.4	228.6	4.3
100.Z.14.1.1	0.86	154	130	0.88	26.698	2.0	0.047	6.1	237.0	4.6
100.Z.12.1.1	0.00	92	83	0.92	27.019	2.1	0.057	2.7	234.3	4.8
100.Z.11.1.1	0.91	105	92	0.91	26.823	2.8	0.053	5.7	236.0	6.4
100.Z.13.1.1	0.83	145	95	0.68	26.776	2.0	0.051	4.9	236.4	4.7
100.Z.15.1.1	0.31	195	181	0.96	26.810	1.9	0.051	3.0	236.1	4.5
100.Z.16.1.1	1.47	131	93	0.73	27.506	2.6	0.045	8.4	230.2	5.9
100.Z.17.1.1	1.59	114	72	0.66	28.255	2.1	0.046	9.8	224.2	4.7
100.Z.18.1.1	1.60	234	261	1.15	27.740	2.0	0.044	6.3	228.3	4.4
100.Z.19.1.1	0.83	238	318	1.38	27.355	1.9	0.047	4.4	231.5	4.4
100.Z.19.2.1	0.53	178	219	1.27	28.293	2.0	0.053	4.1	223.9	4.4
100.Z.20.1.1	0.73	158	146	0.96	27.104	2.0	0.050	5.0	233.6	4.7
100.Z.21.1.1	0.68	231	149	0.67	28.668	2.0	0.049	4.4	221.0	4.3
100.Z.22.1.1	-0.27	221	262	1.22	28.225	2.0	0.058	2.6	224.4	4.3
100.Z.23.1.1	1.13	134	105	0.81	26.641	2.1	0.048	6.8	237.5	4.9
100.Z.24.1.1	1.15	96	58	0.62	27.242	2.2	0.045	8.9	232.4	5.1
100.Z.25.1.1	1.64	121	89	0.76	27.508	2.2	0.042	10.2	230.2	5.0
100.Z.26.1.1	3.07	96	88	0.95	28.856	2.4	0.041	16.0	219.6	5.1
100.Z.27.1.1	-0.00	219	221	1.04	27.371	2.3	0.055	4.2	231.3	5.2
100.Z.27.2.1	0.00	137	158	1.20	29.004	2.1	0.058	2.9	218.5	4.6
100.Z.28.1.1	2.60	104	56	0.56	28.868	2.3	0.042	14.5	219.5	5.1
100.Z.29.1.1	0.13	282	256	0.94	27.203	2.3	0.054	3.9	232.7	5.2
100.Z.30.1.1	1.09	163	113	0.72	27.259	2.1	0.049	6.8	232.3	4.8
100.Z.31.1.1	2.18	102	74	0.75	27.174	3.2	0.044	16.9	233.0	7.3
100.Z.32.1.1	0.80	276	439	1.64	28.084	2.0	0.050	4.4	225.5	4.4
100.Z.33.1.1	1.10	207	222	1.11	27.857	2.7	0.054	9.6	227.4	6.0
100.Z.34.1.1	2.23	109	120	1.13	28.074	2.3	0.043	12.9	225.6	5.1
100.Z.35.1.1	2.43	112	115	1.06	28.283	2.4	0.039	15.1	224.0	5.2
100.Z.36.1.1	2.22	129	68	0.55	28.363	2.9	0.043	13.6	223.4	6.3
100.Z.37.1.1	2.18	197	194	1.02	28.220	2.1	0.042	11.0	224.5	4.6

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

5. MANY PEAKS GRANITE 1999101

GA SAMPLEID:	200701523
GA SAMPLENO:	1999101
GSQ SITEID:	
Formal Name:	Many Peaks Granite
Informal Name:	
Lithology:	leucocratic syenogranite
1:250 000 SHEET:	MONTO (SG5601)
1:100 000 SHEET:	CALLIOPE (9149)
REGION:	New England Region
LOCATION (GDA94):	151.439472°E, -24.442876°S
LOCATION (MGA94 zone 56):	341812 mE, 7295848 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6096
ANALYTICAL SESSION:	90102
INTERPRETED AGE:	268.1 ± 1.8Ma (95% confidence, 24 analyses on 25 zircons)
GEOLOGICAL ATTRIBUTION:	Magmatic crystallisation
ISOTOPIC RATIO(S) USED:	$^{206}Pb/^{238}U$

Sample details

In previous regional geological mapping, the Castletower Granite is shown as an extensive unit comprising several plutons in a belt ~45km long and up to 10km wide in the rugged Many Peaks Range, between Lake Awoonga in the north and the Boyne River and Kolan River headwaters in the south. The unit was assigned a Permian to Triassic age on the basis of relationships with other units, however, no geochronology existed for any units in this region. The unit was targeted for geochronology here because recent detailed mapping in the Bobby Volcanics (Purdy, 2010) and along the Many Peaks range suggested that parts of the unit intruded the Bobby Volcanics and therefore may be Late Triassic or younger. Additionally, aspects of the Castletower Granite, including high-level emplacement and intimate association with mafic intrusives, are very similar to adjacent units recently confirmed as Late Triassic (e.g. Eurimbula Granite, 226.4 ± 2.3Ma, Cross & others, 2009).

As a result of the geochronology presented here, the name Castletower Granite is now restricted to the northernmost pluton (2003616 this report), with central areas now mapped as Many Peaks Granite and southern areas, intruding the Bobby Volcanics, mapped as Bulburin Granite. Small areas dominated by diorite and gabbro are mapped as an unnamed unit PRg/b.

The sample selected for geochronology from the new Many Peaks Granite unit is from a centrally located area, in the vicinity of Blackmans Gap, along Blackmans Gap road. The sample is a fine- to medium-grained, equigranular hornblende, biotite, miarolitic, leucocratic syenogranite with abundant anhedral alkali feldspar, abundant quartz, commonly intergrown with alkali feldspar, and less abundant plagioclase, sparse and minor biotite and very sparse hornblende.

Zircons

Zircons recovered from 1999101 are clear, colourless, generally blocky, broken fragments with sharp crystal faces and between about ~80 to 100µm in diameter. They are uniform in CL images and have a moderate luminescence, typically with faint and fine to diffuse concentric growth zoning (Figure 15).

U-Pb isotopic results

Twenty-five SHRIMP U-Pb isotopic analyses were conducted on 25 zircons from this sample (Figure 16 and Table 8). Uranium concentrations are low to moderate (124 to 522 ppm) and the Th/U ratios uniform and range from 0.40 to 0.70 (median = 0.58). Common $^{206}Pb_c$ concentrations are also low and below 1%. One analysis (101.Z.2.1.1) has an anomalously low $^{254}UO^+/^{238}U^+$ ratio of 4.63 (population average = 6.01) suggesting that there has been a problem with the ionisation of $^{238}U^+$ or $^{254}UO^+$ ions during this analysis. The low $^{254}UO^+/^{238}U^+$ ratio of this analysis renders its $^{206}Pb/^{238}U$ age unreliable, it has therefore been removed from further age considerations.
The remaining 24 analyses all have the same radiogenic $^{206}Pb/^{238}U$ within their uncertainties (MSWD = 0.72) and combine to give an age of **268.1 ± 1.8Ma**, which is interpreted as the crystallisation age of this rock.

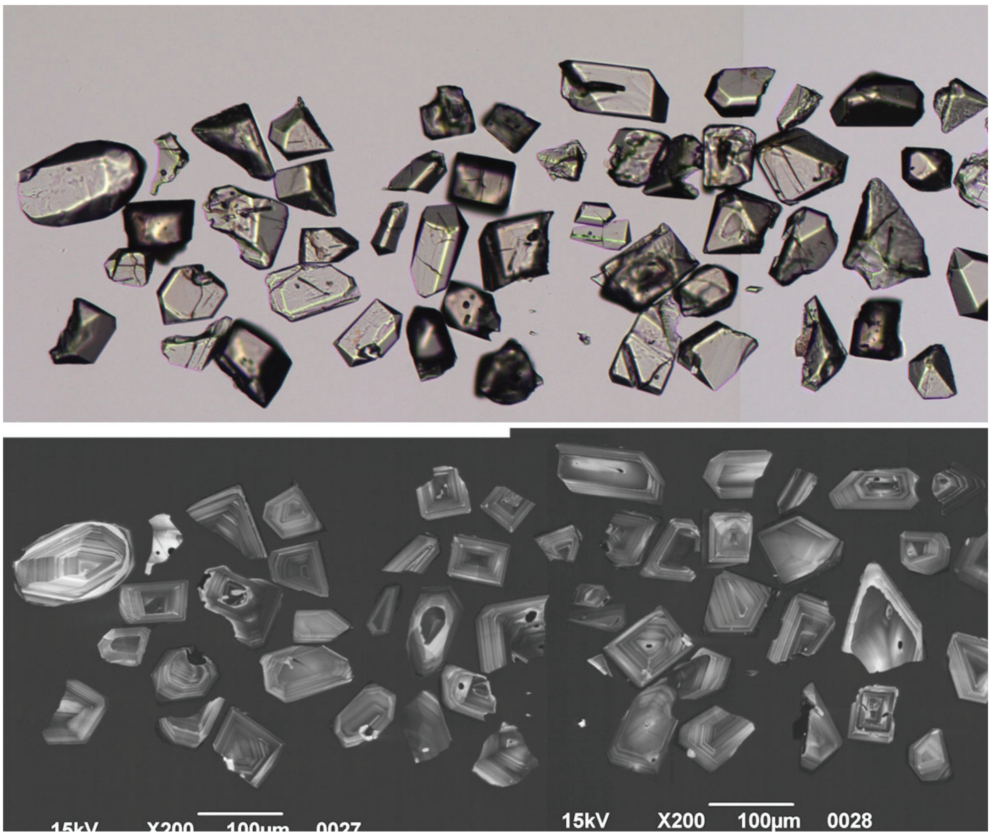

Figure 15. Selected transmitted light (top) and cathodoluminescence (bottom) images of zircon grains from the Many Peaks Granite (1999101)

The date reported here (268.1 ± 1.8Ma) for the Many Peaks Granite confirms that parts of the former Castletower Granite are Late Permian in age. However, other geochronology (2003616, this report) and intrusive relationships (Purdy, 2010) indicate that Late Triassic intrusions also exist. This has led to division of the formerly extensive unit.

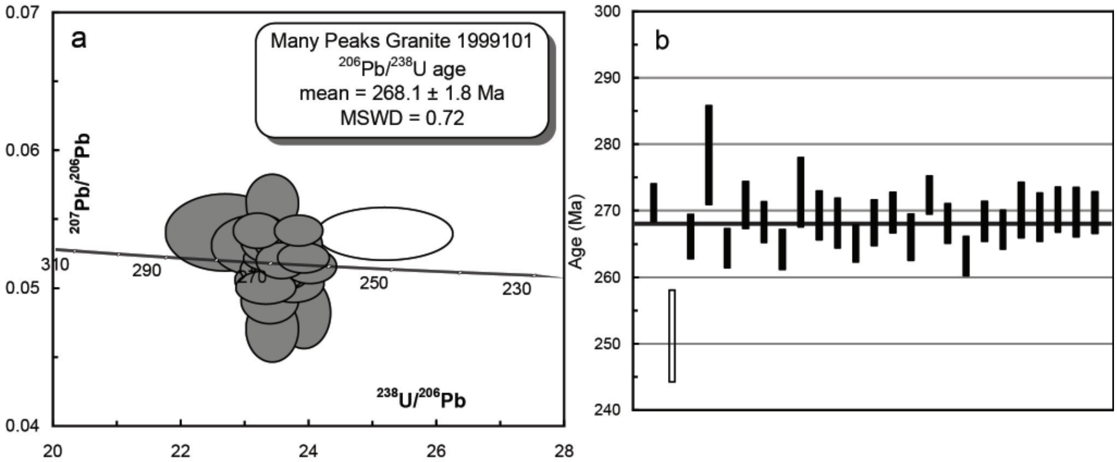

Figure 16. (a)Tera-Wasserberg concordia plot and (b) temporal trend of the $^{206}Pb/^{238}U$ ages from the Many Peaks Granite (1999101). The unfilled ellipse in 'a' and bar in 'b' were excluded from the pooled age calculation (see text).

Table 8. SHRIMP U-Pb isotopic data from the Many Peaks Granite (1999101)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
101.Z.1.1.1	0.53	357	233	0.67	23.278	1.1	0.053	2.1	271.1	2.8
101.Z.3.1.1	-0.08	124	63	0.52	23.731	1.3	0.053	2.5	266.1	3.3
101.Z.4.1.1	-0.30	309	144	0.48	22.662	2.7	0.054	3.4	278.4	7.4
101.Z.5.1.1	-0.00	280	184	0.68	23.896	1.1	0.052	1.4	264.3	2.9
101.Z.6.1.1	0.23	417	257	0.64	23.306	1.3	0.050	1.6	270.8	3.5
101.Z.7.1.1	0.14	206	112	0.56	23.535	1.2	0.051	2.1	268.2	3.0
101.Z.8.1.1	0.58	262	148	0.58	23.909	1.2	0.048	3.6	264.1	3.0
101.Z.9.1.1	-0.12	233	104	0.46	23.139	2.0	0.053	2.7	272.7	5.2
101.Z.10.1.1	-0.00	388	224	0.60	23.442	1.4	0.052	1.3	269.3	3.6
101.Z.11.1.1	-0.03	522	352	0.70	23.547	1.4	0.052	1.1	268.1	3.7
101.Z.12.1.1	-0.07	393	224	0.59	23.824	1.1	0.054	1.3	265.1	2.7
101.Z.13.1.1	0.22	387	228	0.61	23.542	1.3	0.051	1.7	268.2	3.4
101.Z.14.1.1	0.65	215	88	0.43	23.404	1.2	0.047	3.4	269.7	3.1
101.Z.15.1.1	0.15	333	195	0.60	23.738	1.3	0.050	1.8	266.0	3.5
101.Z.16.1.1	-0.12	320	172	0.55	23.175	1.1	0.054	1.6	272.3	2.9
101.Z.17.1.1	-0.04	245	110	0.46	23.552	1.1	0.052	1.7	268.1	2.9
101.Z.18.1.1	-0.04	267	123	0.48	23.998	1.1	0.051	1.6	263.2	3.0
101.Z.19.1.1	-0.08	241	121	0.52	23.523	1.1	0.053	1.7	268.4	3.0
101.Z.20.1.1	0.35	283	142	0.52	23.636	1.1	0.052	2.3	267.1	2.9
101.Z.21.1.1	0.24	335	217	0.67	23.370	1.6	0.050	1.8	270.1	4.2
101.Z.22.1.1	0.33	233	90	0.40	23.465	1.4	0.050	2.5	269.0	3.6
101.Z.23.1.1	0.40	335	200	0.62	23.364	1.3	0.049	2.3	270.2	3.4
101.Z.24.1.1	0.11	351	230	0.68	23.401	1.4	0.051	1.6	269.7	3.7
101.Z.25.1.1	-0.41	203	85	0.43	23.405	1.2	0.056	2.5	269.7	3.1

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

6. UNNAMED QUARTZ DIORITE PRg/b 2003617

GA SAMPLEID:	200901508
GA SAMPLENO:	2003617
GSQ SITEID:	BB5138
Formal Name:	
Informal Name:	Unnamed unit PRg/b
Lithology:	Quartz diorite
1:250 000 SHEET:	MONTO (SG5601)
1:100 000 SHEET:	CALLIOPE (9149)
GEOLOGICAL REGION:	New England Region
LOCATION (GDA94):	151.445386°E, -24.350036°S
LOCATION (MGA94 zone 56):	342296.296 mE, 7306136.486 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6126
ANALYTICAL SESSION:	100065
INTERPRETED AGE:	268.3 ± 1.7Ma (95% confidence, 25 analyses on 25 zircons)
GEOLOGICAL ATTRIBUTION:	Magmatic crystallisation
ISOTOPIC RATIO(S) USED:	$^{206}Pb/^{238}U$

Sample details

In the Many Peaks Range area, unnamed unit PRg/b generally comprises fine- to medium-grained gabbro to quartz diorite. These lithologies occur both as small pod-like bodies (mapped as PRg/b) and locally in spectacular net-vein association within the felsic Many Peaks Granite. Most of these bodies are only recently mapped and were previously incorporated in the formerly extensive Castletower Granite (now remapped as Castletower Granite, Many Peaks Granite, Bulburin Granite and unit PRg/b). The unnamed unit PRg/b in the Many Peaks Range area was selected for geochronology as part of a larger investigation of the former Castletower Granite unit. Nearby granite had yielded a Permian age (Many Peaks Granite, 1999101, this report) but the close association between mafic and felsic phases in this area is also characteristic of some Late Triassic units (e.g. Eurimbula Granite; Cross & others, 2009).

The sample site comprises scattered boulders beside an access track in Bulburin National Park. The rocks appear massive, and unfoliated. The sample selected is a dark grey, fine- to medium-grained, slightly uneven-grained quartz diorite (Figure 17). The main mafic mineral is brown hornblende (~30%). Minor to trace amounts of pale green hornblende, quartz, clinopyroxene (as relict cores in hornblende grains), K-feldspar, biotite (completely replaced by chlorite ± muscovite ± epidote ± secondary titanite), opaque oxide, titanite and zircon are also present. Sericite, chlorite, epidote and titanite are the main secondary minerals.

Figure 17. Quartz diorite, unnamed unit PRg/b (2003617)

Zircons

Zircons recovered from 2003617 are a homogenous population of clear, colourless, euhedral grains that mostly comprise broken fragments. Intact grains are usually large (100 to 200µm diameter) with aspect ratios of between 2 to 4. Many of the larger grains, especially those with aspect ratios > 2.5, have axial inclusions that extend along their entire length. Growth zoning is not apparent in either transmitted or reflected light images. In CL images, the zircons have a moderate luminescence and normal growth banding predominates. There are no cores apparent in either CL, transmitted or reflected light images (Figure 18).

U-Pb isotopic results

Twenty-five SHRIMP U-Pb isotopic analyses were carried out on 25 zircons from this sample (Figure 19 and Table 9). The zircon U concentrations range from 100 to 500ppm and Th/U ratios from 0.30 to 0.70. Common $^{206}Pb_c$ proportions are generally low however, five analyses have common ^{206}Pb of greater than 1% and one analysis (618.Z.12.1.1), 2.23%. There is no correlation between common $^{206}Pb_c$ and $^{206}Pb/^{238}U$ ages however, and therefore all analyses are included in the pooled age interpretation. All 25 analyses have the same radiogenic $^{206}Pb/^{238}U$ within their analytical uncertainties (MSWD = 1.21) and combine to give an age of **268.3 ± 1.7Ma** which is interpreted as the crystallisation age of these zircons.

The date obtained for unit PRg/b (268.3 ± 1.7Ma) is essentially identical to that obtained for the enclosing Many Peaks Granite (1999101, this report) (MSWD = 0.03) and confirms the close association between mafic and felsic phases in this area.

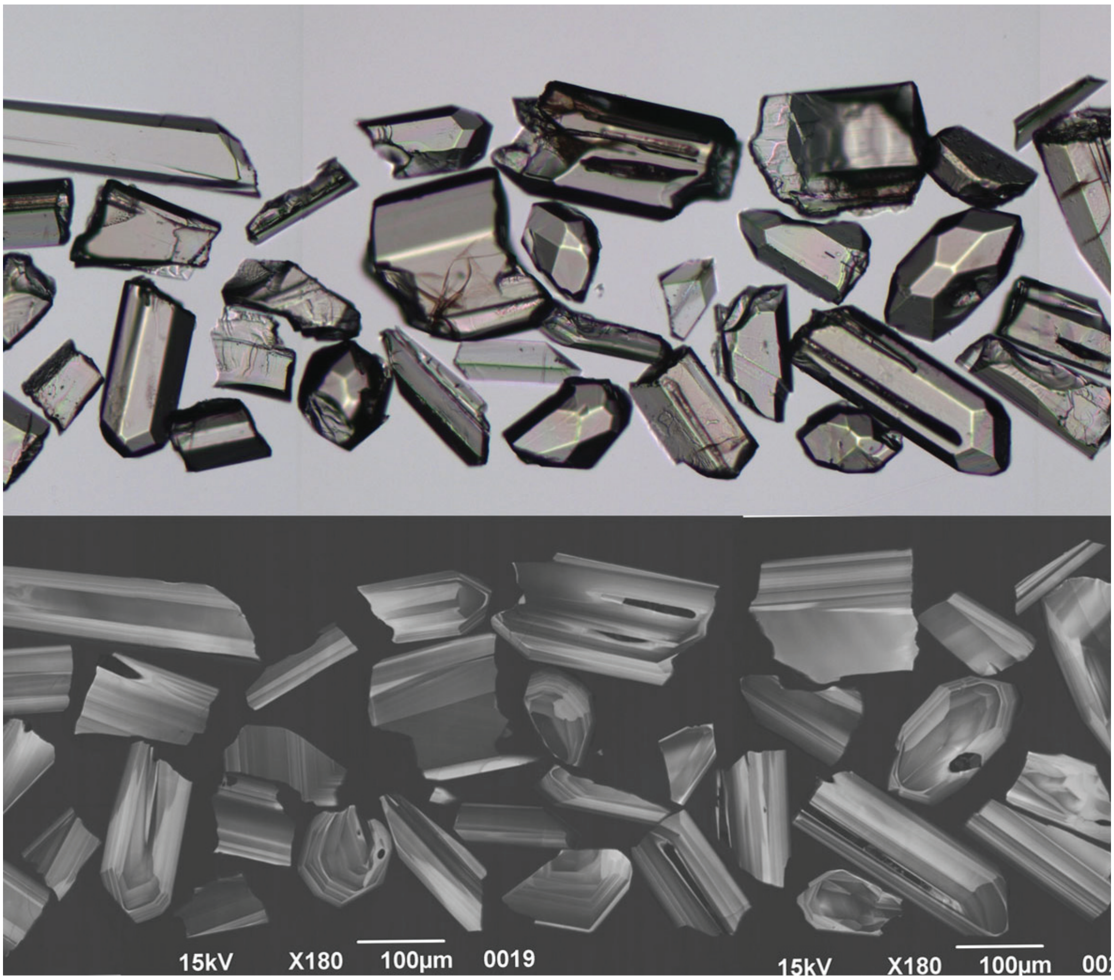

Figure 18. Selected transmitted light (top) and cathodoluminescence (bottom) images of zircon grains from the unnamed unit PRg/b (2003617)

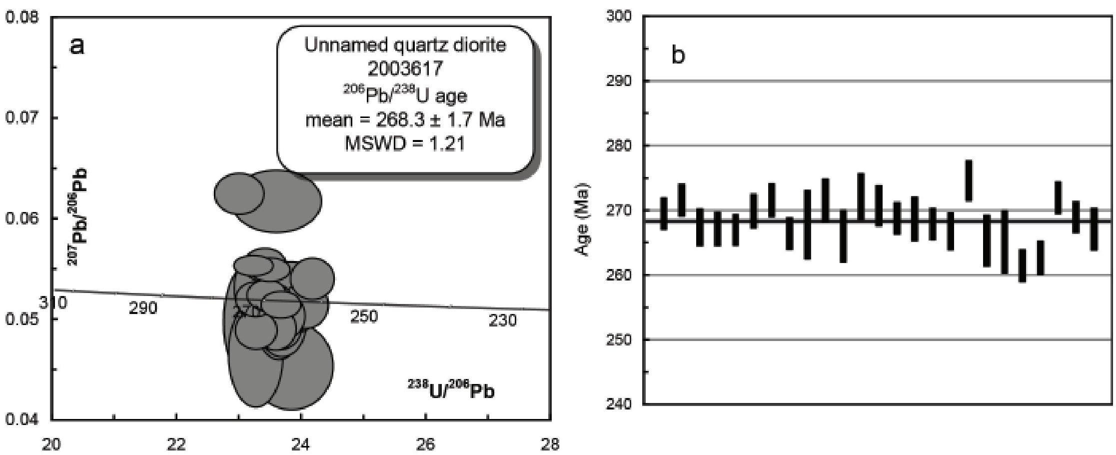

Figure 19. (a) Tera-Wasserberg concordia plot and (b) temporal trend of the 206Pb/238U ages from the unnamed unit PRg/b (2003617)

Table 9. SHRIMP U-Pb isotopic data from the unnamed unit PRg/b (2003617)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
617.Z.1.1.1	0.49	498	274	0.57	23.426	0.9	0.052	1.9	269.5	2.4
617.Z.2.1.1	0.62	446	201	0.47	23.243	0.9	0.052	2.2	271.5	2.5
617.Z.3.1.1	1.35	206	67	0.33	23.617	1.1	0.050	5.5	267.3	2.8
617.Z.4.1.1	0.84	264	150	0.59	23.639	1.0	0.049	3.2	267.1	2.6
617.Z.5.1.1	0.31	538	305	0.59	23.652	0.9	0.051	1.7	267.0	2.4
617.Z.7.1.1	0.26	287	189	0.68	23.392	1.0	0.055	2.0	269.9	2.6
617.Z.6.1.1	0.61	353	196	0.57	23.248	1.0	0.049	2.6	271.5	2.5
617.Z.8.1.1	0.79	445	172	0.40	23.706	0.9	0.050	3.1	266.4	2.4
617.Z.9.1.1	0.44	132	65	0.51	23.581	2.0	0.062	3.3	267.7	5.3
617.Z.10.1.1	1.91	119	44	0.38	23.246	1.2	0.046	7.6	271.5	3.3
617.Z.11.1.1	0.65	305	147	0.50	23.738	1.5	0.050	2.8	266.0	4.0
617.Z.12.1.1	2.23	105	31	0.31	23.193	1.3	0.049	8.2	272.1	3.5
617.Z.13.1.1	0.88	136	62	0.47	23.317	1.2	0.053	4.5	270.7	3.1
617.Z.14.1.1	0.34	395	159	0.42	23.492	0.9	0.052	1.9	268.7	2.5
617.Z.15.1.1	0.26	388	218	0.58	23.500	1.3	0.051	1.9	268.6	3.4
617.Z.16.1.1	0.78	451	238	0.55	23.569	0.9	0.049	2.9	267.9	2.4
617.Z.17.1.1	1.04	160	64	0.41	23.672	1.1	0.049	4.4	266.7	2.8
617.Z.18.1.1	-0.07	120	37	0.32	22.983	1.1	0.062	2.2	274.6	3.1
617.Z.19.1.1	0.41	223	82	0.38	23.805	1.5	0.053	2.5	265.3	3.9
617.Z.20.1.1	1.75	137	58	0.44	23.823	1.9	0.045	6.4	265.1	4.8
617.Z.21.1.1	0.58	301	114	0.39	24.163	1.0	0.054	2.5	261.4	2.5
617.Z.22.1.1	0.70	239	112	0.48	24.054	1.0	0.051	3.0	262.6	2.6
617.Z.23.1.1	0.03	381	141	0.38	23.212	0.9	0.055	1.2	271.9	2.4
617.Z.24.1.1	0.15	386	144	0.38	23.479	0.9	0.055	1.4	268.9	2.4
617.Z.25.1.1	0.87	235	124	0.55	23.645	1.2	0.050	3.2	267.0	3.2

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

7. CASTLETOWER GRANITE 2003616

GA SAMPLEID:	200901507
GA SAMPLENO:	2003616
GSQ SITEID:	RJB1267
Formal Name:	Castletower Granite
Informal Name:	
Lithology:	Alkali feldspar granite
1:250 000 SHEET:	MONTO (SG5601)
1:100 000 SHEET:	CALLIOPE (9149)
GEOLOGICAL REGION:	New England Region
LOCATION (GDA94):	151.341705°E, -24.140577°S
LOCATION (MGA94 zone 56):	331501 mE, 7329212 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6126
ANALYTICAL SESSION:	100065

INTERPRETED AGE:	221.8 ± 1.3Ma (95% confidence, 25 analyses on 25 zircons)
GEOLOGICAL ATTRIBUTION:	Magmatic crystallisation
ISOTOPIC RATIO(S) USED:	$^{206}Pb/^{238}U$

Sample details

This sample is a pale pink, fine- to medium-grained, uneven-grained, leucocratic alkali feldspar granite. The granite contains scattered granophyric intergrowths between quartz and K-feldspar, and miarolitic cavities up to ~2.5cm across. Arfvedsonite (~2–3%) is the main mafic mineral. The sample site is the crest of a low ridge (near the margin of the pluton) ~6km north-east of Mount Castletower.

Zircons

Zircons recovered from 2003616 are dominated by clear, colourless, euhedral and fragmented grains that are between ~60 to ~130µm in diameter, however about 10% of the population are turbid. They have a moderate to weak luminescence with faint concentric growth zones. There is no sign of zircon cores in either the transmitted, reflected or CL images (Figure 20).

U-Pb isotopic results

Twenty-five SHRIMP U-Pb analyses were carried out on 25 zircons from this sample (Figure 21 and Table 10). The zircons have moderate U concentrations (300 to 1000ppm) and moderate Th/U (0.40 to 0.80). Common $^{206}Pb_c$ proportions are typically low, however, four grains have common $^{206}Pb_c$ proportions of about 1%. There is no correlation between the proportion of common ^{206}Pb and $^{206}Pb/^{238}U$ age and it is for this reason that all age determinations have been included in the pooled age calculation. All 25 analyses have the same radiogenic $^{206}Pb/^{238}U$ within their analytical uncertainties (MSWD = 0.60) and contribute to a weighted mean age of **221.8 ± 1.3Ma** which is interpreted to be the crystallisation age of these zircons.

A Late Triassic age (221.8 ± 1.3Ma) for the Castletower Granite confirms that Late Permian and Late Triassic intrusives share similar characteristics, in the Many Peaks Range area. The date is similar but slightly younger than other Late Triassic units in the region (e.g. Eurimbula Granite, Agnes Water Volcanics (Cross & others, 2009), Bobby Volcanics (1999099, this report) and the Robert Granite (Yarrol Project Team, in press — Appendix 1).

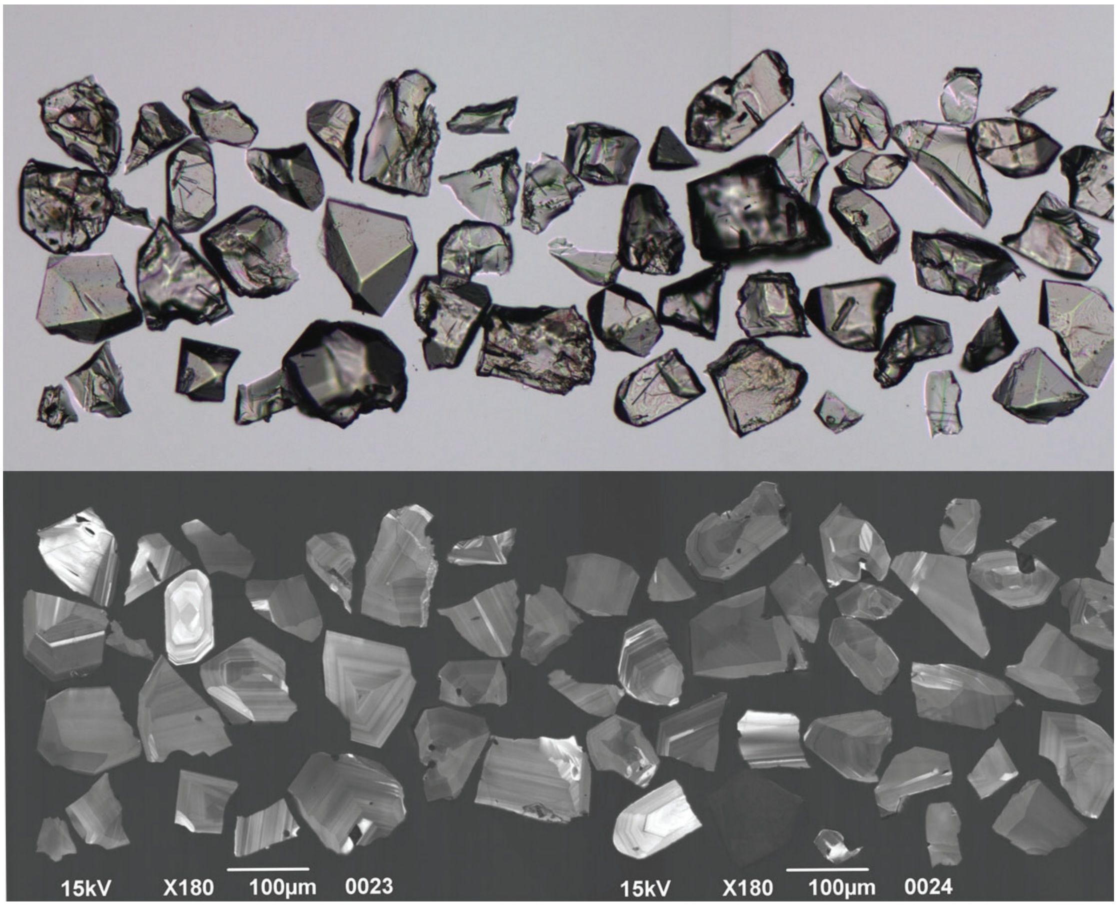

Figure 20. Selected transmitted light (top) and cathodoluminescence (bottom) images of zircon grains from the Castletower Granite (2003616)

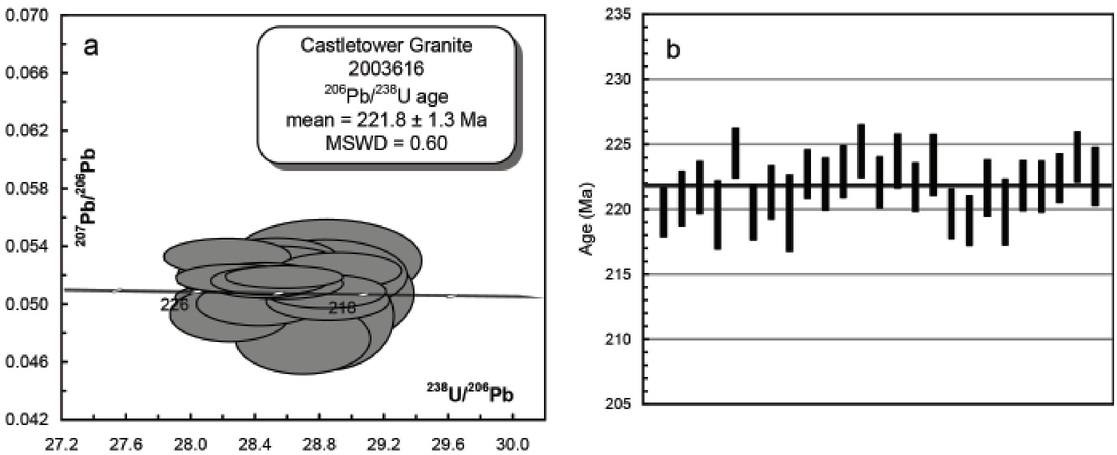

Figure 21. (a) Tera-Wasserberg concordia plot and (b) temporal trend of the $^{206}Pb/^{238}U$ ages from the Castletower Granite (2003616)

Table 10. SHRIMP U-Pb isotopic data from the Castletower Granite (2003616)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
616.Z.1.1.1	0.28	843	461	0.56	28.833	0.9	0.051	1.5	219.8	1.9
616.Z.2.1.1	0.90	317	144	0.47	28.693	1.0	0.047	3.4	220.8	2.1
616.Z.3.1.1	0.54	482	261	0.56	28.579	0.9	0.051	2.3	221.7	2.0
616.Z.4.1.1	1.11	414	237	0.59	28.858	1.2	0.051	4.7	219.6	2.6
616.Z.5.1.1	0.79	851	402	0.49	28.237	0.9	0.049	2.5	224.3	1.9
616.Z.6.1.1	1.82	396	196	0.51	28.833	1.0	0.049	5.1	219.8	2.1
616.Z.7.1.1	1.24	453	257	0.59	28.627	0.9	0.049	4.0	221.3	2.1
616.Z.8.1.1	1.01	423	237	0.58	28.840	1.4	0.053	3.6	219.7	2.9
616.Z.9.1.1	0.35	1044	830	0.82	28.444	0.9	0.051	1.6	222.7	1.9
616.Z.10.1.1	0.20	459	255	0.57	28.542	0.9	0.053	1.7	222.0	2.0
616.Z.11.1.1	0.41	515	285	0.57	28.419	0.9	0.050	2.0	222.9	2.0
616.Z.12.1.1	0.11	437	233	0.55	28.219	0.9	0.053	1.6	224.5	2.0
616.Z.13.1.1	0.42	541	281	0.54	28.528	0.9	0.053	1.9	222.1	2.0
616.Z.14.1.1	0.26	406	210	0.54	28.312	0.9	0.052	2.1	223.8	2.1
616.Z.15.1.1	0.06	1012	700	0.71	28.574	0.9	0.052	1.0	221.7	1.9
616.Z.16.1.1	0.32	756	481	0.66	28.352	1.1	0.050	1.5	223.5	2.3
616.Z.17.1.1	0.46	697	327	0.48	28.848	0.9	0.050	1.8	219.7	1.9
616.Z.18.1.1	0.25	599	319	0.55	28.917	0.9	0.052	1.6	219.2	1.9
616.Z.19.1.1	0.32	865	531	0.63	28.585	1.0	0.050	1.4	221.7	2.2
616.Z.20.1.1	0.31	453	212	0.48	28.830	1.2	0.052	3.2	219.8	2.5
616.Z.21.1.1	0.28	755	452	0.62	28.560	0.9	0.051	1.4	221.9	1.9
616.Z.22.1.1	0.45	486	194	0.41	28.569	0.9	0.052	2.4	221.8	2.0
616.Z.23.1.1	0.32	973	774	0.82	28.484	0.9	0.051	1.3	222.4	1.9
616.Z.24.1.1	0.21	709	426	0.62	28.273	0.9	0.052	1.3	224.1	1.9
616.Z.25.1.1	0.12	740	448	0.63	28.465	1.0	0.051	1.1	222.6	2.2

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

8. WINTERBOURNE VOLCANICS 2003614

GA SAMPLEID: 200901503
GA SAMPLENO: 2003614
GSQ SITEID: DPMR212

Formal Name: Winterbourne Volcanics
Informal Name:
Lithology: Rhyolite

1:250 000 SHEET: MONTO (SG5601)
1:100 000 SHEET: BILOELA (9049)
GEOLOGICAL REGION: New England Region
LOCATION (GDA94): 150.930435°E, -24.350495°S
LOCATION (MGA94 zone 56): 290046 mE, 7305404 mN

GEOCHRONOLOGIST: Andrew Cross
MOUNT ID: GA6126
ANALYTICAL SESSION: 100066b

RECONNAISSANCE AGE: ~230Ma
GEOLOGICAL ATTRIBUTION:

Sample details

The Winterbourne Volcanics crop out in the far north-western edge of the band of Late Triassic igneous rocks in central to south-east Queensland (see Purdy, 2010, figure 1). They form the elevated (~900m asl) and densely vegetated plateau of Kroombit Tops. Regional mapping in this area (Murray & others, in press) indicates that the Winterbourne Volcanics comprise a lower eruption sequence dominated by basaltic to andesitic lavas and pyroclastic deposits, and an upper eruption sequence dominated by rhyolitic lavas, ignimbrites, breccias and tuffs. A caldera ~10km in diameter is also proposed although the extent of this feature are unclear. The unit was originally considered to be Early to Middle Triassic in age (Dear & others, 1971), although more recent reporting indicates a Late Triassic Rb-Sr whole rock age of 218 ± 3Ma (Murray & others, in press).

The Winterbourne Volcanics were selected for geochronology to define the extent of Late Triassic volcanism in central Queensland. The Agnes Water Volcanics which crop out ~100km to the east were recently dated at 228.6 ± 1.7Ma (Cross & others, 2009), and the adjacent Bobby Volcanics have a similar age of 229.4 ± 2.7Ma (1999099, this report). The sample selected is from a rhyolitic lava in the upper eruption sequence which forms the spectacular northern escarpment of Kroombit Tops. The lava is a sparsely porphyritic, flow-banded coherent rhyolite with rare, scattered, heavily altered remnants of medium-sized feldspar phenocrysts in a recrystallised, micropoikilitic groundmass (Figure 22). In thin section, intricate flow banding is defined by variation in the size and geometry of micropoikilocrysts.

Zircons

Only eleven zircons were recovered from 2003614. They are anhedral, turbid, variably fractured and about half of them have what appear to be partially resorbed surfaces. All grains appear similar in CL images and have a moderate luminescence with fine concentric growth zones (Figure 23).

U-Pb isotopic results

Eight SHRIMP U-Pb analyses were undertaken on eight zircons from this sample (Figure 24, Table 11). U contents are low (25 to 170ppm) and Th/U high (0.9 to 1.50). The zircons have high proportions of common $^{206}Pb_c$ ranging from ~3 to ~29%. All analyses have the same radiogenic $^{206}Pb/^{238}U$ within their analytical uncertainties (MSWD = 1.3) and combine to give an age of 229.5 ± 5.5Ma.

There is considerable uncertainty with this age determination as the few zircons that were analysed are high in common Pb. However, the pooled age is very similar to other Late Triassic volcanics in central Queensland that the Winterbourne volcanics have previously been associated with such as the Agnes Water Volcanics (228.6 ± 1.7Ma) and Bobby Volcanics (229.4 ± 2.7Ma). This may suggest that the somewhat imprecise age determined here may be close to the crystallisation age of these zircons. However, it is suggested that the age of 229.5 ± 5.5Ma interpreted here be considered as a reconnaissance-level age. Further work is recommended to better establish the age of this unit.

Figure 22. Rhyolitic lava of the Winterbourne Volcanics (2003614)

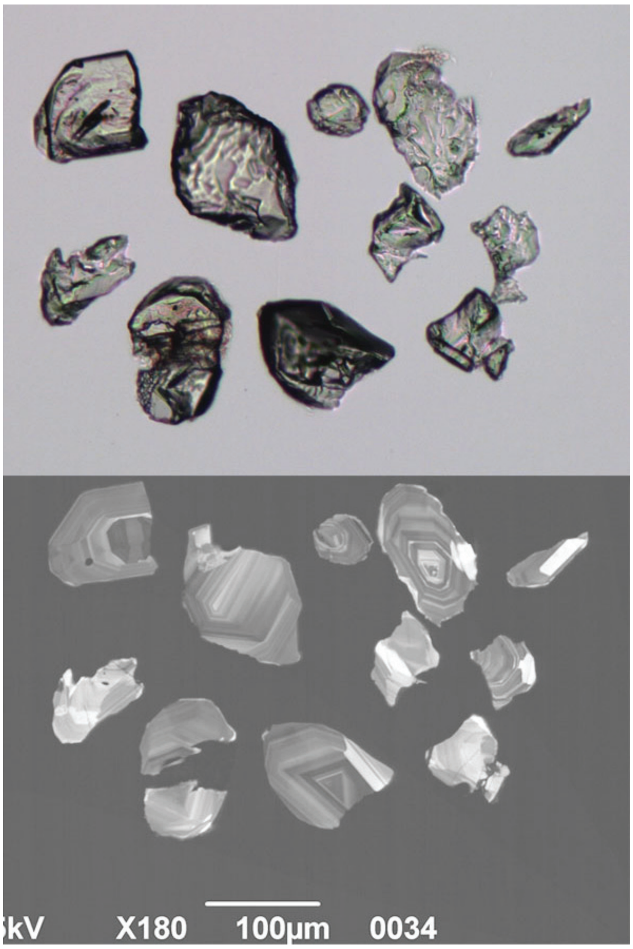

Figure 23. Transmitted light (top) and cathodoluminescence (bottom) images of the zircon grains recovered from the Winterbourne Volcanics rhyolite (2003614)

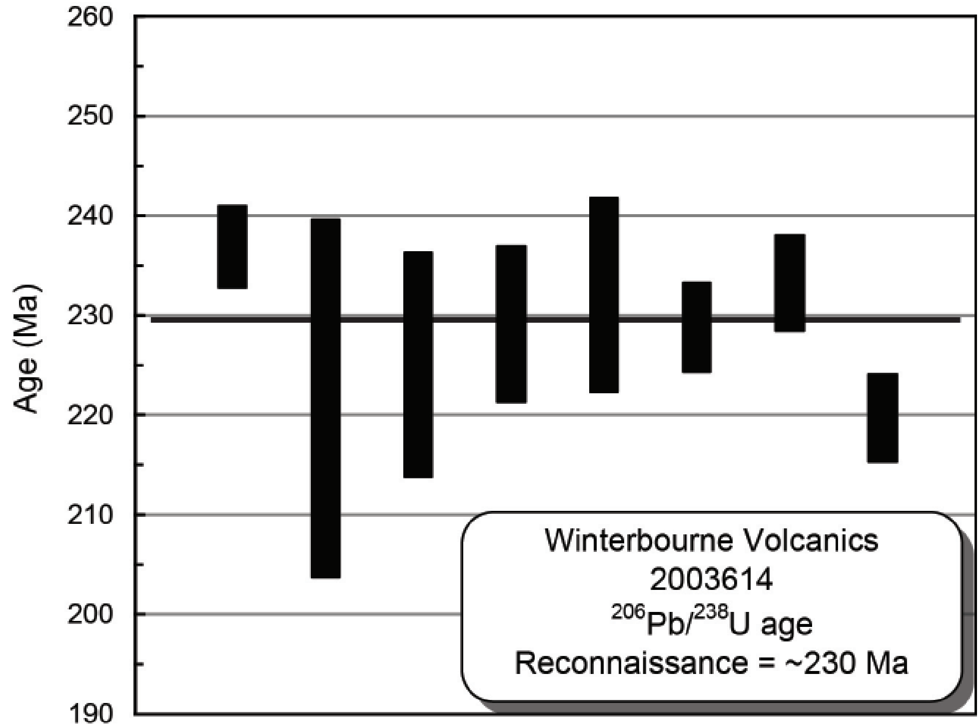

Figure 24. Temporal trend of the $^{206}Pb/^{238}U$ ages for the Winterbourne Volcanics (2003614). This result is interpreted as reconnaissance in nature as the few zircons that were analysed have very high $^{206}Pb_c$ proportions.

Table 11. SHRIMP U-Pb isotopic data from the Winterbourne Volcanics (2003614)

Grain. area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
614.Z.1.1.1	5.67	116	149	1.32	26.717	1.8	0.054	18.1	236.9	4.1
614.Z.2.1.1	28.90	33	29	0.88	28.588	8.3	0.006	1181.2	221.6	18.0
614.Z.3.1.1	15.12	25	29	1.21	28.153	5.1	0.092	44.4	225.0	11.3
614.Z.4.1.1	7.04	118	140	1.23	27.640	3.5	0.060	34.3	229.1	7.8
614.Z.6.1.1	16.33	41	44	1.10	27.285	4.3	0.069	42.6	232.0	9.8
614.Z.7.1.1	6.24	98	142	1.50	27.687	2.0	0.056	19.9	228.7	4.5
614.Z.8.1.1	2.94	172	235	1.42	27.140	2.1	0.059	10.4	233.3	4.8
614.Z.9.1.1	7.31	139	141	1.05	28.853	2.0	0.044	30.3	219.6	4.4

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

9. ARANBANGA VOLCANIC GROUP 2003615

GA SAMPLEID:	200901505
GA SAMPLENO:	2003615
GSQ SITEID:	DPMR214
Formal Name:	Aranbanga Volcanic Group
Informal Name:	
Lithology:	Rhyolite
1:250 000 SHEET:	Maryborough (SG5606)
1:100 000 SHEET	GAYNDAH (9246)
GEOLOGICAL REGION:	New England Region
LOCATION (GDA94):	151.535694°E, -25.599317°S
LOCATION (MGA94 zone 56):	352952 mE, 7167876 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6126
ANALYTICAL SESSION:	100066b
INTERPRETED AGE:	Inherited population
GEOLOGICAL ATTRIBUTION:	Inheritance

Sample details

Unit Ri_r in the Gayndah region comprises rhyolitic lava domes and cryptodomes that represent the youngest phase of volcanism in the widespread Aranbanga Volcanic Group. This group is a major component of the Late Triassic volcanic sequences in eastern Queensland and is associated with the Mungore Caldera (Stephens, 1991). Previous K-Ar dates from the Aranbanga Volcanic Group range from ~221 to ~224Ma (Stephens, 1991; Department of Mines and Energy, 1980). However, these are in conflict with a recent U-Pb SHRIMP date from the Mungore Granite/g (226.5 ± 1.5Ma; 19531980, this report), which is interpreted to intrude the volcanic sequence. To investigate this problem, and to compare timing with the recently dated Mount Marcella Volcanics (1999100, this report), the Aranbanga Volcanic Group was selected for geochronology.

The dome comprising unit Ri_r at Mount Gayndah was chosen for geochronology in particular because of the felsic composition and the easy access to relatively fresh material. Most other felsic units within the Aranbanga Volcanic Group are lithic-bearing ignimbrites. The sample selected is an aphanitic, finely flow banded, locally spherulitic rhyolite (Figure 25). In thin section, the rhyolite is completely recrystallised and comprises broadly alternating bands that exhibit micropoikiolitic and granophyric recrystallisation textures.

Zircons

Only about thirty zircons were recovered from 2003615. They are clear to partially turbid, colourless and variably cracked grains that range from about 10 to 140µm in

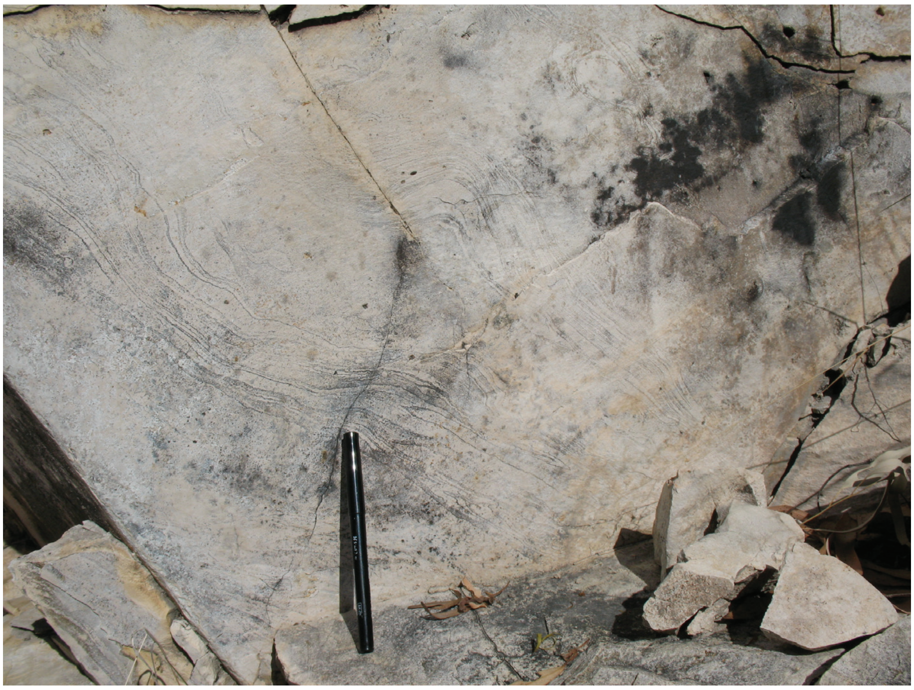

Figure 25. Aphanitic, finely flow banded, locally spherulitic rhyolite of the Aranbanga Volcanic Group (2003615)

diameter. The majority have rounded margins, however, there are two fragments that have sharp crystal faces. The zircons range in luminescence from strong to weak and have a variety of internal zoning patterns. The variation in morphology and internal zoning patterns observed in these zircons is consistent with them being derived from a range of sources (Figure 26).

U-Pb isotopic results

Ten SHRIMP analyses were carried out on zircons from 2003615 (Figure 27 and Table 12). U concentrations are low-moderate to high (190 to 1330ppm) and Th/U ratios range from 0.27 to 1.35. Common $^{206}Pb_c$ concentrations are generally high with the majority greater than 1% and the highest 7.51%. The zircons range in $^{206}Pb/^{238}U$ age between ~440Ma and ~250 Ma. Seven grains have the same $^{206}Pb/^{238}U$ within their analytical uncertainties (MSWD = 1.69) and give a weighted mean age of 272.2 ± 2.6Ma. Previous K-Ar dates for the Aranbanga Volcanic Group and associated intrusives indicate an age of between ~234 and ~214Ma (Cranfield, 1989). Therefore, the mainly Permian age of the few zircons recovered from this sample are interpreted as inherited components of this rock.

The 272.2 ± 2.6Ma age obtained for inherited grains within unit Ri_r may derive from Permian granitoids. The extensive Wigton Granite crops out in the vicinity and is considered Permian in age, although radiometric dates for this unit vary considerably (see Ellis, 1968; Cranfield, 1994). The date for unit Ri_r is slightly older than a major period of magmatism (~260 to 270Ma) identified in recent geochronology further north (Carson & others, 2006). Interestingly, the Early Triassic phase of magmatism associated with the Esk Trough (e.g. Neara Volcanics, ~240Ma) is not represented in the inherited grain population.

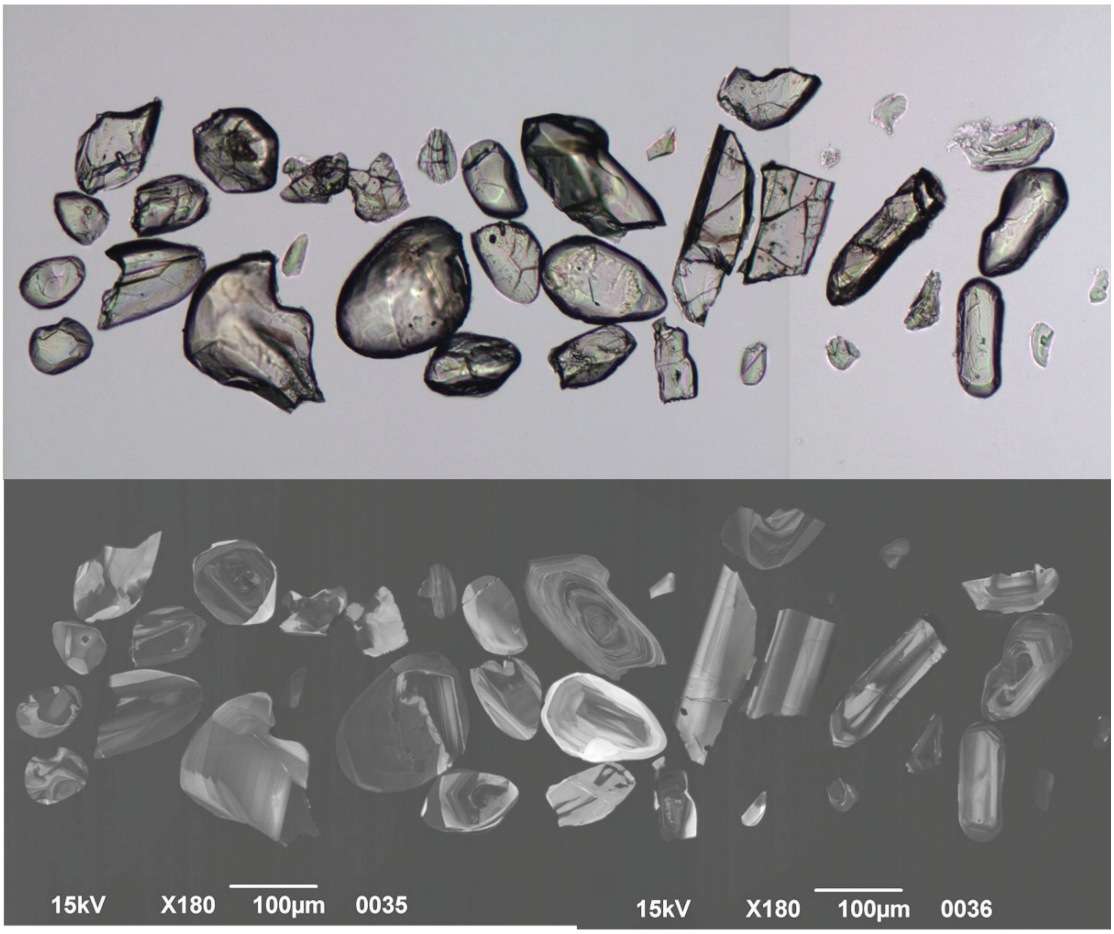

Figure 26. Transmitted light (top) and cathodoluminescence (bottom) images of the zircon grains recovered from the Aranbanga Volcanic Group rhyolite (2003615)

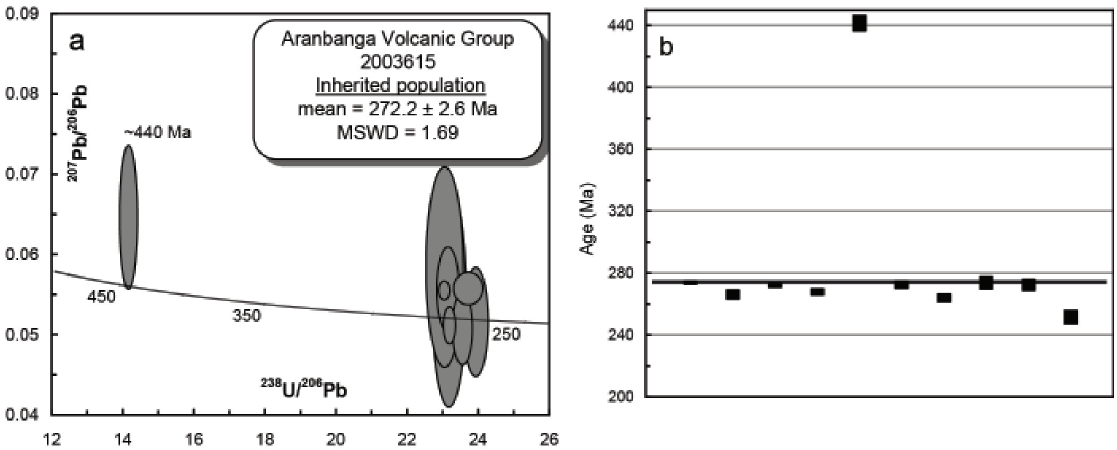

Figure 27. (a) Tera-Wasserberg concordia plot and (b) temporal trend of the $^{206}Pb/^{238}U$ ages from the Aranbanga Volcanic Group (2003615)

Table 12. SHRIMP U-Pb isotopic data from the Aranbanga Volcanic Group (2003615)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Inherited zircons										
615.Z.1.1.1	0.89	1328	452	0.35	23.175	0.5	0.051	3.0	272.3	1.3
615.Z.2.1.1	1.76	423	306	0.75	23.551	0.8	0.050	6.0	268.1	2.1
615.Z.3.1.1	0.34	1325	350	0.27	23.035	0.4	0.055	1.4	273.9	1.2
615.Z.4.1.1	5.86	205	61	0.31	23.167	1.4	0.054	16.9	272.4	3.7
615.Z.5.1.1	1.95	252	102	0.42	14.092	1.2	0.064	9.3	441.9	4.9
615.Z.6.1.1	2.92	344	450	1.35	23.924	1.0	0.051	8.8	264.0	2.5
615.Z.7.1.1	4.55	190	56	0.31	23.036	1.5	0.058	14.3	273.9	4.0
615.Z.8.1.1	0.73	1057	716	0.70	23.709	1.2	0.055	2.4	266.3	3.0
615.Z.9.1.1	2.25	571	224	0.41	23.143	0.9	0.055	6.4	272.7	2.4
615.Z.10.1.1	7.51	241	97	0.41	25.113	1.8	0.036	36.6	251.7	4.4

1. %$^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

10. WINTERBOURNE VOLCANICS 2110097

GA SAMPLEID: DPMR239
GA SAMPLENO: 2110097
GSQ SITEID: DPMR239

Formal Name: Winterbourne Volcanics
Informal Name:
Lithology: Rhyolitic ignimbrite

1:250 000 SHEET: MONTO (SG5601)
1:100 000 SHEET: BILOELA (9049)
GEOLOGICAL REGION: New England Region
LOCATION (GDA94): 150.972689°E, -24.363579°S
LOCATION (MGA94 zone 55): 294355 mE, 7304018 mN

GEOCHRONOLOGIST: Andrew Cross
MOUNT ID: GA6147
ANALYTICAL SESSION: 100142

INTERPRETED AGE: 227.3 ± 1.4Ma (95% confidence, 25 analyses on 25 zircons)
GEOLOGICAL ATTRIBUTION: Magmatic crystallisation
ISOTOPIC RATIO(S) USED: $^{206}Pb/^{238}U$

Sample details

This sample of Winterbourne Volcanics was selected following inconclusive results from sample 2003614 (this report). It was collected from Kroombit Tops National Park on a small rise adjacent to the eastern end of the Razorback fire trail. It is a moderately crystal- and pumice-rich, strongly welded dacitic ignimbrite with small- to medium-sized, altered plagioclase and alkali feldspar fragments, minor heavily altered biotite, rare and completely altered garnet, sparse and small mafic volcanic lithic fragments and abundant pumice fragments (Figure 28).

Zircons

Zircons recovered from this sample are a uniform population of clear and colourless euhedral grains. The majority of grains have aspect ratios of about 2 and range from ~80 to ~100µm in diameter. They have a moderate luminescence and are oscillatory zoned (Figure 29).

U-Pb isotopic results

Twenty-five SHRIMP U-Pb analyses were carried out on zircons from this sample (Figure 30 and Table 13). Uranium contents are low to moderate (83 to 354ppm, median = 209) and Th/U ratios, moderate to high (0.65 to 1.39, median = 0.92). Common $^{206}Pb_c$ proportions range up to 1.5% however, there is no correlation between common Pb and age. All 25 zircons have the same radiogenic $^{206}Pb/^{238}U$ within their analytical errors (MSWD = 1.06) and combine to give a weighted mean age of **227.3 ± 1.4Ma**, which is interpreted to be the crystallisation age of these grains.

Figure 28. Dacitic ignimbrite, Winterbourne Volcanics (2110097)

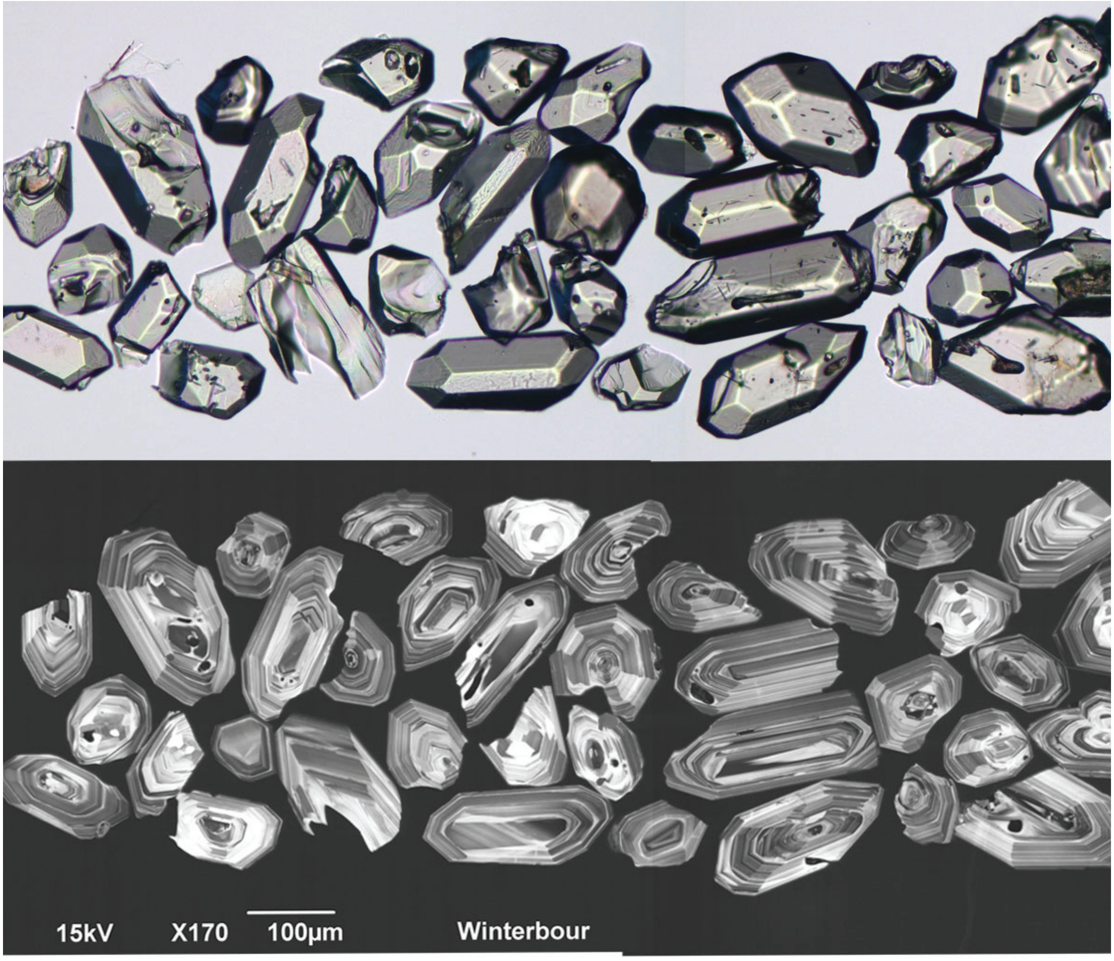

Figure 29. Transmitted light (top) and cathodoluminescence (bottom) images of the zircon grains recovered from the Winterbourne Volcanics (2110097)

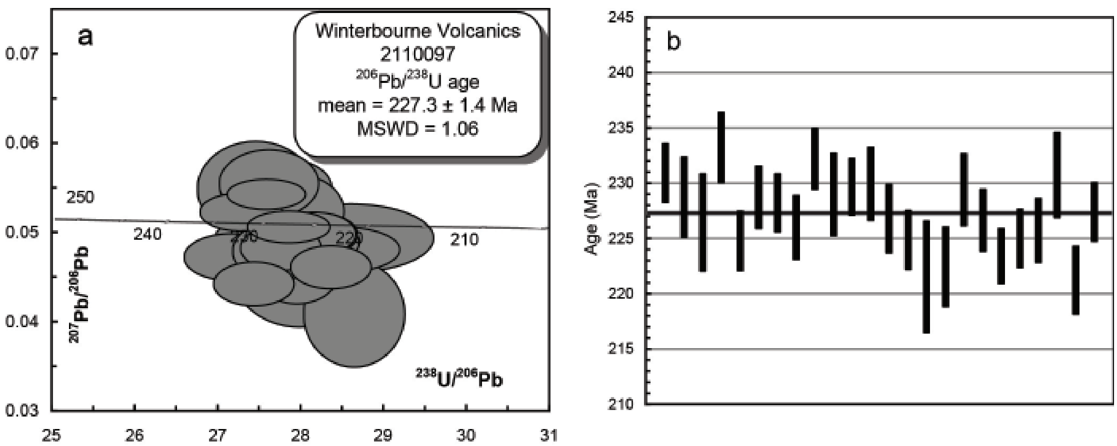

Figure 30. (a) Tera-Wasserberg concordia plot and (b) temporal trend of the $^{206}Pb/^{238}U$ ages from the Winterbourne Volcanics (2110097)

Table 13. SHRIMP U-Pb isotopic data from the Winterbourne Volcanics (2110097)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
097.Z.1.1.1	0.41	249	188	0.78	27.418	1.2	0.044	3.7	230.9	2.7
097.Z.2.1.1	-0.55	156	116	0.76	27.683	1.6	0.055	4.1	228.8	3.6
097.Z.3.1.1	1.08	106	98	0.96	27.968	2.0	0.046	9.7	226.5	4.4
097.Z.5.1.1	0.60	277	317	1.18	27.142	1.4	0.047	3.7	233.2	3.2
097.Z.4.1.1	0.32	181	128	0.73	28.178	1.2	0.049	3.7	224.8	2.7
097.Z.7.1.1	0.53	169	106	0.65	27.686	1.3	0.048	4.7	228.7	2.8
097.Z.8.1.1	0.40	248	214	0.89	27.746	1.2	0.048	3.5	228.2	2.6
097.Z.9.1.1	0.31	353	255	0.75	28.025	1.3	0.048	2.8	226.0	2.9
097.Z.10.1.1	-0.08	196	148	0.78	27.261	1.2	0.052	2.7	232.2	2.8
097.Z.11.1.1	-0.06	238	258	1.12	27.654	1.7	0.049	2.5	229.0	3.7
097.Z.12.1.1	0.05	305	222	0.75	27.569	1.1	0.054	2.1	229.7	2.6
097.Z.13.1.1	0.32	237	280	1.22	27.533	1.5	0.047	3.4	230.0	3.3
097.Z.14.1.1	0.30	255	267	1.08	27.924	1.4	0.052	5.3	226.8	3.1
097.Z.15.1.1	0.22	211	217	1.06	28.167	1.2	0.050	3.3	224.9	2.7
097.Z.16.1.1	0.62	157	109	0.72	28.597	2.3	0.049	5.2	221.6	5.0
097.Z.17.1.1	0.33	208	209	1.04	28.480	1.6	0.048	3.6	222.5	3.6
097.Z.18.1.1	0.18	83	46	0.57	27.602	1.4	0.055	4.5	229.4	3.3
097.Z.19.1.1	0.85	182	181	1.03	27.944	1.2	0.046	5.7	226.7	2.8
097.Z.20.1.1	0.56	354	476	1.39	28.353	1.1	0.046	3.5	223.4	2.5
097.Z.21.1.1	0.27	220	220	1.03	28.149	1.2	0.050	3.3	225.0	2.6
097.Z.22.1.1	0.74	144	124	0.89	28.058	1.3	0.047	5.8	225.8	2.9
097.Z.23.1.1	-0.34	138	122	0.91	27.439	1.7	0.055	6.5	230.8	3.8
097.Z.24.1.1	1.56	113	101	0.92	28.638	1.4	0.041	9.7	221.3	3.1
097.Z.25.1.1	-0.00	215	263	1.26	27.845	1.2	0.050	2.4	227.4	2.7

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

11. JOHNGBOON RHYOLITE 2110099

GA SAMPLEID: DPMR399
GA SAMPLENO: 2110099
GSQ SITEID: DPMR399

Formal Name: Johngboon Rhyolite
Informal Name:
Lithology: Rhyolitic ignimbrite

1:250 000 SHEET: MAYBOROUGH (SG5606)
1:100 000 SHEET: GAYNDAH (9246)
GEOLOGICAL REGION: New England Region
LOCATION (GDA94): 151.984125°E, -25.659573°S
LOCATION (MGA94 zone 55): 398039 mE, 7161624 mN

GEOCHRONOLOGIST: Andrew Cross
MOUNT ID: GA6147
ANALYTICAL SESSION: 100142

INTERPRETED AGE:	227.9 ± 1.4Ma (95% confidence, 25 analyses on 25 zircons)
GEOLOGICAL ATTRIBUTION:	Magmatic crystallisation
ISOTOPIC RATIO(S) USED:	$^{206}Pb/^{238}U$

Sample details

Sample 2110099 is a moderately weathered, pink, lithic- and crystal-rich ignimbrite. Lithic fragments consist of blocky rhyolite clasts as well as rounded mafic volcanic clasts up to ~3cm in diameter. Crystals include euhedral quartz and euhedral orange feldspar. The sample was collected from a loose boulder at the base of the eastern side of the Coongarra Rock face in the Mount Walsh National Park (Figure 31).

Figure 31. Outcrop and sample photo of lithic- and crystal-rich ignimbrite, Johngboon Rhyolite (2110099)

Zircons

Zircons recovered from this sample are clear and colourless euhedral grains and their broken equivalents. Intact grains are between ~20 to ~120µm in diameter and most have aspect ratios between 2 to 3 however, the full range extends between 1 to 4. The majority of grains have a moderate luminescence and are oscillatory zoned (Figure 32).

U-Pb isotopic results

Twenty-five SHRIMP U-Pb isotopic measurements were carried out on this sample (Figure 33, Table 14). Uranium concentrations are low to moderate (78 to 781ppm, median = 195) and Th/U ratios moderate (0.49 to 1.41, median = 0.82). Common $^{206}Pb_c$ proportions are all low and <1%. All 25 analyses have the same radiogenic $^{206}Pb/^{238}U$ within their analytical uncertainties (MSWD = 1.22) and combine to give a weighted mean age of **227.9 ± 1.4Ma**. This is interpreted as the crystallisation age of these grains.

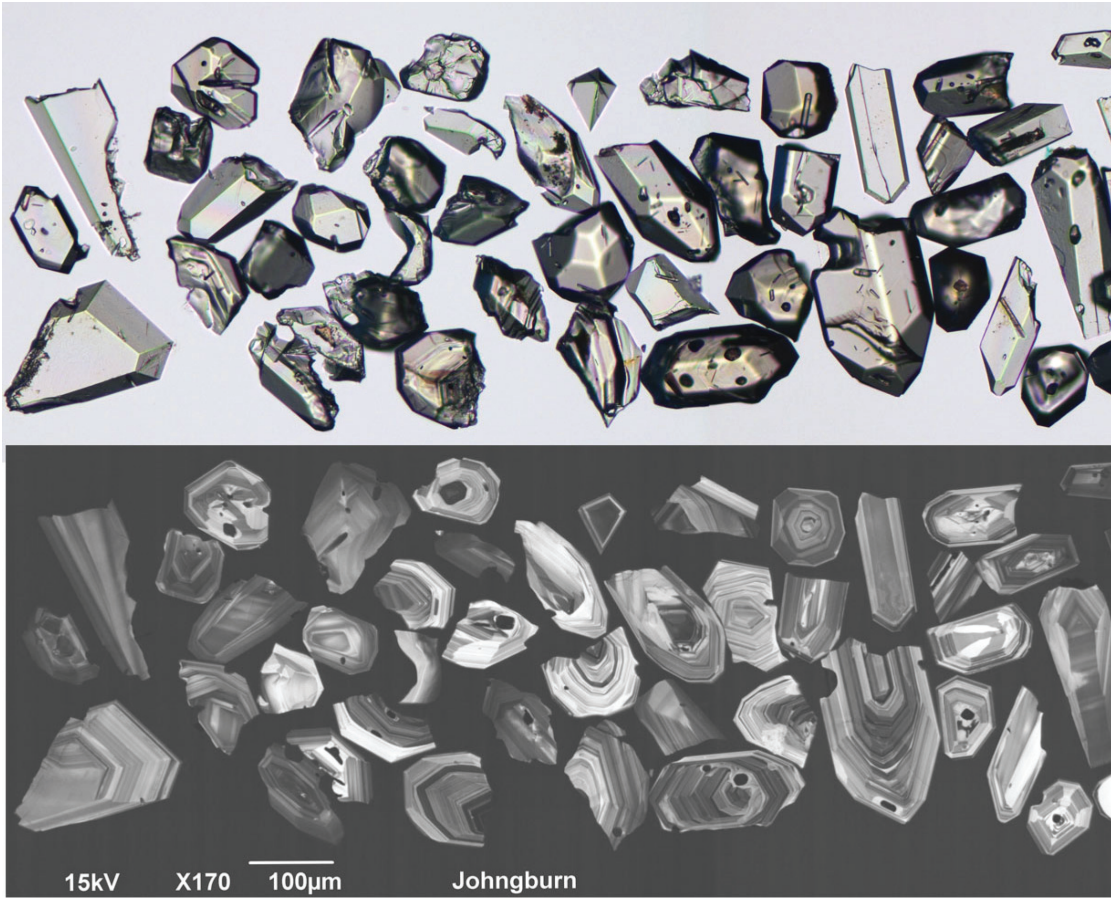

Figure 32. Transmitted light (top) and cathodoluminescence (bottom) images of the zircon grains recovered from the Johngboon Rhyolite (2110099)

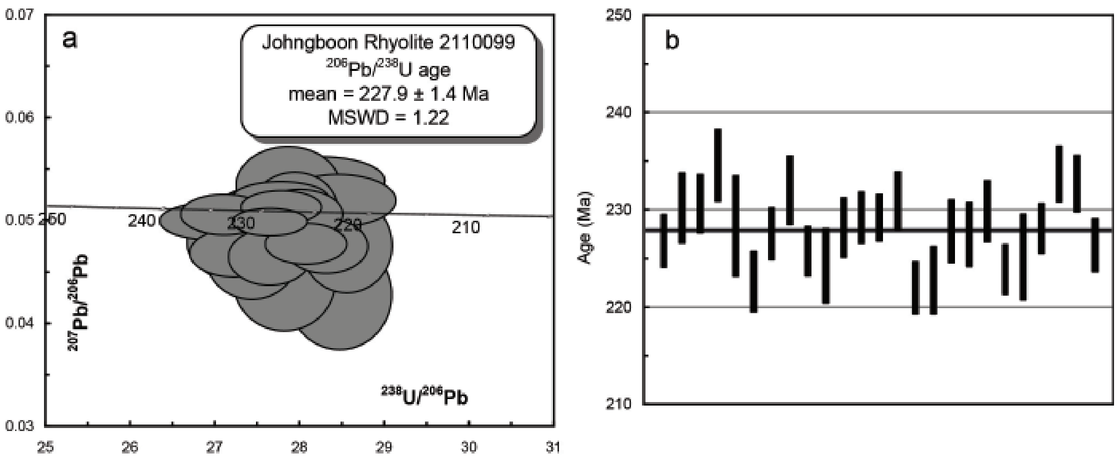

Figure 33. (a) Tera-Wasserberg concordia plot and (b) temporal trend of the $^{206}Pb/^{238}U$ ages from the Johngboon Rhyolite (2110099)

Table 14. SHRIMP U-Pb isotopic data from the Johngboon Rhyolite (2110099)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
099.Z.1.1.1	0.29	197	121	0.64	27.931	1.2	0.051	4.7	226.8	2.7
099.Z.2.1.1	0.04	363	480	1.37	27.511	1.6	0.050	1.9	230.2	3.6
099.Z.3.1.1	0.35	127	127	1.04	27.455	1.3	0.050	4.7	230.6	3.0
099.Z.4.1.1	0.06	240	127	0.55	26.987	1.6	0.050	2.4	234.5	3.7
099.Z.5.1.1	2.04	101	94	0.97	27.738	2.3	0.032	14.7	228.3	5.2
099.Z.6.1.1	0.92	95	64	0.70	28.466	1.4	0.043	8.3	222.6	3.1
099.Z.7.1.1	0.20	228	164	0.74	27.836	1.2	0.050	4.5	227.5	2.6
099.Z.8.1.1	0.16	186	107	0.59	27.293	1.6	0.048	5.3	232.0	3.5
099.Z.9.1.1	0.27	301	267	0.92	28.064	1.1	0.048	2.8	225.7	2.5
099.Z.10.1.1	-0.08	188	122	0.67	28.256	1.7	0.054	2.8	224.2	3.8
099.Z.11.1.1	-0.00	317	337	1.10	27.761	1.4	0.052	2.0	228.1	3.0
099.Z.12.1.1	0.60	269	161	0.62	27.634	1.2	0.046	3.9	229.2	2.6
099.Z.13.1.1	0.28	781	461	0.61	27.632	1.1	0.050	1.7	229.2	2.4
099.Z.14.1.1	0.73	147	103	0.72	27.424	1.3	0.046	5.9	230.9	3.0
099.Z.15.1.1	0.73	186	199	1.11	28.547	1.2	0.047	6.4	222.0	2.7
099.Z.16.1.1	0.28	213	179	0.87	28.443	1.6	0.052	3.3	222.7	3.5
099.Z.17.1.1	0.66	89	71	0.82	27.807	1.4	0.044	7.4	227.8	3.2
099.Z.18.1.1	-0.19	78	42	0.56	27.848	1.5	0.053	4.9	227.4	3.3
099.Z.19.1.1	0.07	424	577	1.41	27.553	1.4	0.050	1.9	229.8	3.1
099.Z.20.1.1	0.50	278	276	1.02	28.302	1.2	0.047	3.7	223.8	2.6
099.Z.21.1.1	0.28	112	71	0.66	28.141	2.0	0.052	4.6	225.1	4.4
099.Z.22.1.1	0.05	315	326	1.07	27.771	1.1	0.051	2.1	228.0	2.6
099Z..23.1.1	-0.00	191	178	0.96	27.096	1.3	0.050	2.6	233.6	2.9
099.Z.24.1.1	0.09	166	78	0.49	27.212	1.3	0.047	3.4	232.6	2.9
099.Z.25.1.1	0.16	195	176	0.93	27.988	1.2	0.050	3.2	226.3	2.7

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

12. ARANBANGA VOLCANIC GROUP 2110100

GA SAMPLEID:	DPMR395
GA SAMPLENO:	2110100
GSQ SITEID:	DPMR395
Formal Name:	Aranbanga Volcanic Group
Informal Name:	
Lithology:	porhyritic rhyolite
1:250 000 SHEET:	MARYBOROUGH (SG5606)
1:100 000 SHEET:	MOUNT PERRY (9247)
GEOLOGICAL REGION:	New England Region
LOCATION (GDA94):	151.696631°E, -25.496791°S
LOCATION (MGA94 zone 55):	369004 mE, 7179400 mN
GEOCHRONOLOGIST:	Andrew Cross
MOUNT ID:	GA6147
ANALYTICAL SESSION:	100142

INTERPRETED AGE:	229.7 ± 1.4 Ma (95% confidence, 24 analyses on 24 zircons)
GEOLOGICAL ATTRIBUTION:	Magmatic crystallisation
ISOTOPIC RATIO(S) USED:	^{206}Pb/^{238}U

Sample details

This sample is a light grey porphyritc rhyolite with pale, weathered feldspar phenocrysts and scattered biotite in a recrystallised quartz-rich groundmass. It was collected from low-lying outcrop about 100m west of the Wetheron to Benyenda Road (Figure 34). Adjacent exposure of lithic-rich ignimbrite is anomalously steeply dipping suggesting that the rhyolite may have been emplaced as a cryptodome. The sample was collected to constrain the age of the Aranbanga Volcanics in this region.

Figure 34. Outcrop and sample photo of porphyritic rhyolite, Aranbanga Volcanic Group (2110100)

Zircons

Zircons recovered from this sample are clear, colourless to light brown euhedral crystals and their broken equivalents. Intact grains range in diameter from ~20 to ~140µm and aspect ratios from 1 to 5. They have a moderate to strong luminescence with typically faint, diffuse concentric growth zones and about 1% of the population have what appear to be cores that are only visible in CL images (Figure 35).

U-Pb isotopic results

Twenty-five SHRIMP U-Pb isotopic analyses were carried out on zircons from this sample (Figure 36 and Table 15). Uranium concentrations are moderate (116 to 534ppm, median = 292ppm) and Th/U ratios moderate (0.39 to 1.13, median = 0.51). Common $^{206}Pb_c$ proportions are all below 1%. One analysis (100.Z.13.1.1) is of an inherited core and has an age of ~259Ma. The remaining 24 analyses all have the same radiogenic ^{206}Pb/^{238}U within their analytical uncertainties (MSWD = 0.84) and combine to give a weighted mean age of **229.7 ± 1.4Ma**. This is interpreted to be the crystallisation age of these zircons.

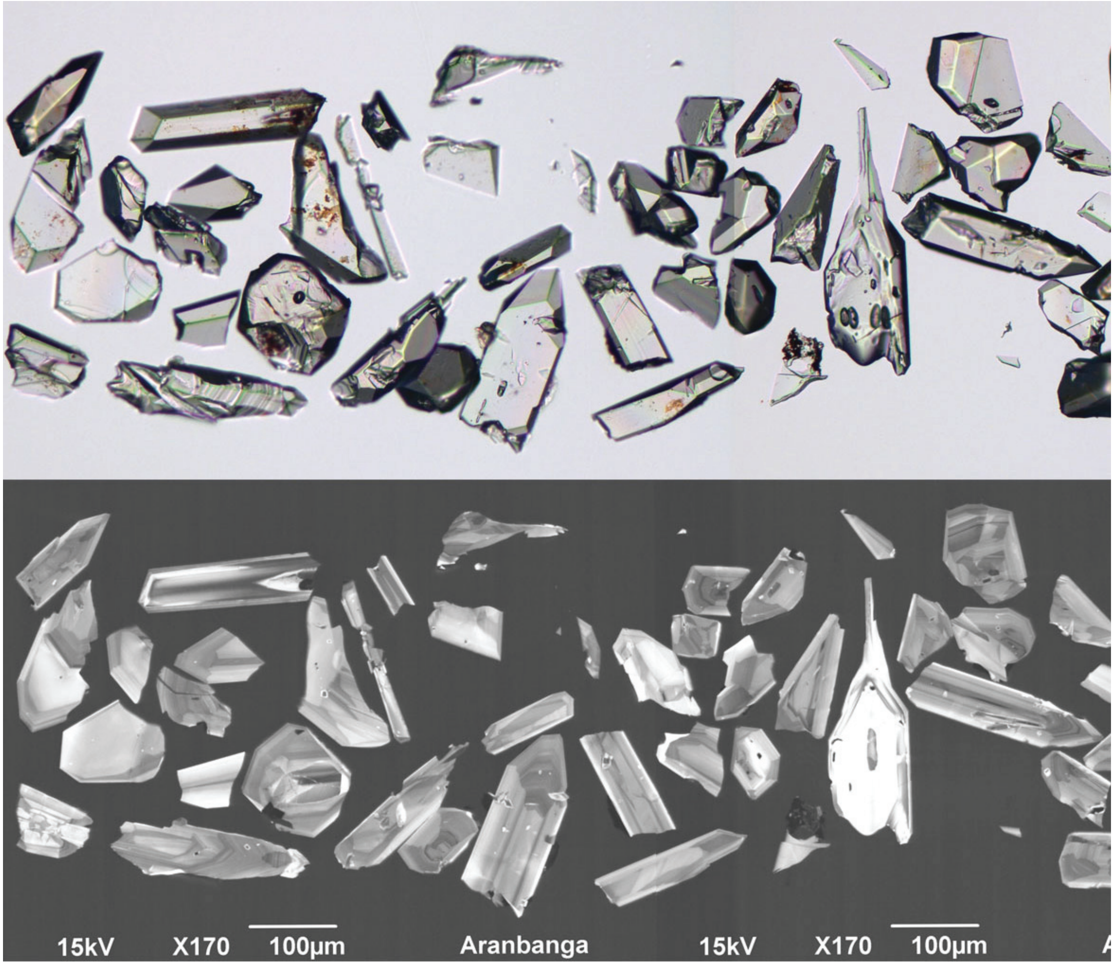

Figure 35. Transmitted light (top) and cathodoluminescence (bottom) images of the zircon grains recovered from the Aranbanga Volcanic Group (2110100)

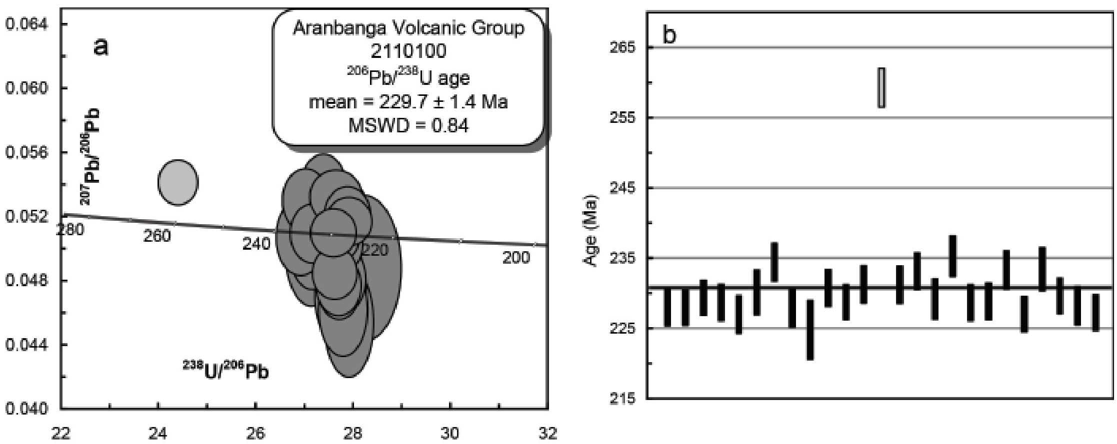

Figure 36. (a) Tera-Wasserberg concordia plot and (b) temporal trend of the ^{206}Pb/^{238}U ages from the Aranbanga Volcanic Group (2110100)

Table 15. SHRIMP U-Pb isotopic data from the Aranbanga Volcanic Group (2110100)

Grain.area	$^{206}Pb_c$ (%)	U (ppm)	Th (ppm)	$^{232}Th/^{238}U$	$^{238}U/^{206}Pb^*$	± (%)	$^{207}Pb^*/^{206}Pb^*$	± (%)	$^{206}Pb/^{238}U$ Age (Ma)	± (1σ)
Magmatic zircons										
100.Z.2.1.1	0.47	213	85	0.41	27.786	1.2	0.046	4.2	227.9	2.7
100.Z.1.1.1	0.44	381	417	1.13	27.796	1.1	0.048	2.8	227.8	2.5
100.Z.3.1.1	0.18	405	197	0.50	27.618	1.1	0.048	2.2	229.3	2.5
100.Z.4.1.1	0.50	292	145	0.51	27.703	1.2	0.048	3.5	228.6	2.6
100.Z.5.1.1	0.82	222	115	0.53	27.914	1.2	0.045	5.0	226.9	2.7
100.Z.6.1.1	0.08	345	266	0.80	27.524	1.4	0.050	2.1	230.1	3.2
100.Z.7.1.1	-0.07	232	108	0.48	27.008	1.2	0.053	2.5	234.4	2.7
100.Z.8.1.1	-0.00	186	87	0.48	27.802	1.2	0.052	2.6	227.8	2.7
100.Z.9.1.1	0.76	116	43	0.39	28.191	1.9	0.049	6.3	224.7	4.2
100.Z.10.1.1	-0.33	272	138	0.53	27.448	1.2	0.053	2.9	230.7	2.6
100.Z.11.1.1	0.35	402	201	0.52	27.697	1.1	0.048	2.6	228.6	2.5
100.Z.12.1.1	-0.27	275	134	0.50	27.385	1.2	0.054	2.7	231.2	2.6
100.Z.14.1.1	0.17	267	130	0.50	27.390	1.2	0.051	4.4	231.2	2.6
100.Z.15.1.1	-0.15	299	151	0.52	27.165	1.1	0.051	2.4	233.0	2.6
100.Z.16.1.1	-0.16	376	182	0.50	27.637	1.3	0.053	2.1	229.1	2.9
100.Z.17.1.1	0.09	161	85	0.55	26.909	1.2	0.051	3.2	235.2	2.9
100.Z.18.1.1	0.19	309	155	0.52	27.706	1.1	0.050	2.5	228.6	2.6
100.Z.19.1.1	0.46	294	146	0.51	27.684	1.2	0.047	4.4	228.7	2.6
100.Z.20.1.1	0.51	205	117	0.59	27.139	1.2	0.050	4.0	233.3	2.8
100.Z.21.1.1	0.04	368	197	0.55	27.907	1.1	0.052	1.9	227.0	2.5
100.Z.22.1.1	0.37	122	56	0.47	27.129	1.3	0.050	4.8	233.3	3.1
100.Z.23.1.1	0.00	331	159	0.50	27.584	1.1	0.051	2.0	229.6	2.6
100.Z.24.1.1	0.62	197	94	0.49	27.754	1.2	0.047	4.6	228.2	2.8
100.Z.25.1.1	0.14	322	173	0.55	27.879	1.1	0.052	2.3	227.2	2.5
Inherited zircons										
100.Z.13.1.1	-0.14	534	444	0.86	24.367	1.1	0.054	1.7	259.3	2.8

1. $\%^{206}Pb_c$ indicates the proportion of common ^{206}Pb in the total measured ^{206}Pb
2. Pb isotopic ratios corrected for common Pb by reference to the measured ^{204}Pb
3. All errors quoted as 1σ.

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APPENDIX 1

ADDITIONAL ANALYTICAL SESSION METADATA

Units that are underlined and bold, are presented in this report, while other units are reported elsewhere. SHRIMP U-Pb age interpretations for all samples are available in Geoscience Australia's Geochronology Delivery database (http://www.ga.gov.au/geochron-sapub-web/).

Mount GA6065 (session: 80132)

1954023 (200701537): Ballendean Granite
1954024 (200701548): Ruby Creek Granite
1957222 (200801501): Pyramid Rhyolite
1953980 (200701528): Mungore Granite
1953982 (200701530): Mount Marcella Volcanics

U-Pb standard information for GA6065 (session 80132)

The zircons on this mount were analysed between the 10th to 13th of October 2008 (session 80132). A previous attempt to analyse zircons on this mount was stopped due to poor machine stability and it is for this reason that the unknowns do not start at 1. Thirty-one SHRIMP U-Pb analyses of the zircon standard TEMORA 2 analysed during this session all combine to give a 1σ $^{206}Pb/^{238}U$ reproducibility of 0.98% and a 1σ standard error of 0.22% (see Table 3 and Figure 2).

Mount GA6096 (session: 90074)

1999099 (200901501): Bobby Volcanics
1999100 (200901506): Mount Marcella Volcanics

U-Pb standard information GA6096 (session: 90074)

Zircons from the Bobby Volcanics and Mount Marcella Volcanics were analysed between the 11th to 13th of August 2009. Machine instability had stopped an earlier attempt to analyse the zircons on this mount and it is for this reason that for both samples, the numbering system does not start at 1. Twenty-one SHRIMP U-Pb analyses of the zircon standard TEMORA 2 during this session all combine to give a 1σ $^{206}Pb/^{238}U$ reproducibility of 1.75% and a 2σ standard error of 0.47% (see Table 3 and Figure 2).

Mount GA6096 (session: 90102)

1980488 (200801505B): Key Creek Gneiss
1980509 (200801505C): leucocratic lens in Key Creek Gneiss
1980489 (200801506): East Creek Tonalite
1999101 (200701523): Many Peaks Granite

U-Pb standard information for GA6096 (session: 90102)

This session took place between October 27th to November 1st 2009. Forty-one SHRIMP U-Pb analyses of the zircon standard TEMORA 2 undertaken during this session all combine to give a 1σ $^{206}Pb/^{238}U$ reproducibility of 0.94% with a 2σ standard error of 0.21% (see Table 3 and Figure 2).

Mount GA6126 (session: 100065)

2003617 (200901508): Unnamed unit PR/b
2003616 (200901507): Castletower Granite
2003618 (200901509): Eulo Ridge Granite

U-Pb standard information for GA6126 (session: 100065)

SHRIMP U-Pb analyses during this session were collected during an unbroken analytical session between the 28th to 30th of April 2010. All twenty-two analyses of the TEMORA 2 zircon standard analysed combine to give a 1σ $^{206}Pb/^{238}U$ reproducibility of 0.79% and a 2σ standard error of 0.24% (see Table 3 and Figure 2).

Mount GA6126 (session: 100066b)

2003614 (200901503): Winterbourne Volcanics
2003615 (200901505): Aranbanga Volcanics

U-Pb standard information for GA6126 (session: 100066b)

The very low yield and uniformly poor quality of the zircons separated from samples of the Winterbourne Volcanics (2003614) and Aranbanga Volcanics (2003615) has meant that only a relatively few SHRIMP U-Pb isotopic analyses were carried out during this session. The data is sparse and derived ages, reconnaissance in nature.

SHRIMP U-Pb analyses during 100066b were carried out between the 2nd and 3rd of May 2010. Ten analyses of the TEMORA 2 zircon standard all have the same radiogenic $^{206}Pb/^{238}U$ within their analytical uncertainties (ie. 0% reproducibility). However, an arbitrary reproducibility of 1% has been applied to the $^{206}Pb/^{238}U$ uncertainties of the unknowns given the relatively small number of standards analysed during this session and the long term typical $^{206}Pb/^{238}U$ reproducibility expected from

GA's SHRIMP IIe. A 2σ standard error of 0.40% was also applied to the final pooled ages (see Table 3 and Figure 2).

Mount GA6147 (session:100142)

2110097 (DPMR 239): Winterbourne Volcanics
2110099 (DPMR 399): Johngboon Rhyolite
2110100 (DPMR 395): Aranbanga Volcanics

U-Pb standard information for GA6147 (session: 100142)

The zircons on this mount were analysed between the 11th to the 13th of November 2010. Twenty-three SHRIMP U-Pb analyses of the zircon standard TEMORA 2 undertaken during this session gave a 1σ $^{206}Pb/^{238}U$ reproducibility of 0% (see Table 3 and Figure 2). This value is considered unrealistic for routine SHRIMP U-Pb zircon geochronology therefore, a value of 1% has been applied to the uncertainties of the unknown analyses. Additionally, the 23 standards contributed to a 1σ standard error of 0.23% which was added in quadrature to the pooled age of each unknown (see Table 3 and Figure 2).