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DATING TASMANIA'S OLDEST GEOLOGICAL EVENTS

by

L. P. BLACK, D. B. SEYMOUR, K. D. CORBETT, S. E. COX, J. E. STREIT, R. S. BOTTRILL, C. R. CALVER, J. L. EVERARD, G. R. GREEN, M. P. McCLENAGHAN, J. PEMBERTON, J. TAHERI and N. J. TURNER

TASMANIA
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AND RESOURCES

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(authorship is alphabetical after Streit)

A contribution to the Tasmania National Geoscience Mapping Accord Project ("TASGO")
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SUMMARY
This document discusses methodology and reports the results of extensive SHRIMP U-Pb zircon dating of Cambro-Ordovician and older events in western Tasmania. Rocks of both igneous and sedimentary origin have been studied.

The results confirm the presence of Neoproterozoic granitic rocks on King Island, and suggest that these formed during an interval of geological activity that extended between about 760 Ma and 750 Ma.

Following a period of relative quiescence, the end phase of magmatism that produced the Heazlewood Ultramafic Complex occurred at about 514 Ma. High-grade metamorphism in the Forth Metamorphic Complex was at least approximately coincident with that event.

Much of the Mount Read Volcanic belt, including a postulated correlative (the Noddy Creek Volcanics), formed about 10 million years later. There appears to have been a subsequent northwards progression of igneous activity over the next 10 million years. The individual ages are presented in Table 23 of this article.

Zircons from six widely separated quartzites are dominated by varied proportions of 1700 Ma and 1800 Ma zircon components. It is likely that rocks of those ages still occur as unexposed basement in western Tasmania. A few Archaean zircons, which range back to about 3200 Ma, are interpreted to have survived more than one sedimentary cycle. A well documented 1400 Ma detrital zircon component provides an older limit for the depositional age of the quartzites. Although one of the quartzites contains zircons with ages as young as 900 Ma, these probably reflect isotopic resetting as a result of pressure solution. If this interpretation is correct, it serves as a general caution against the uncritical assignment of detrital zircon ages to pre-depositional events.

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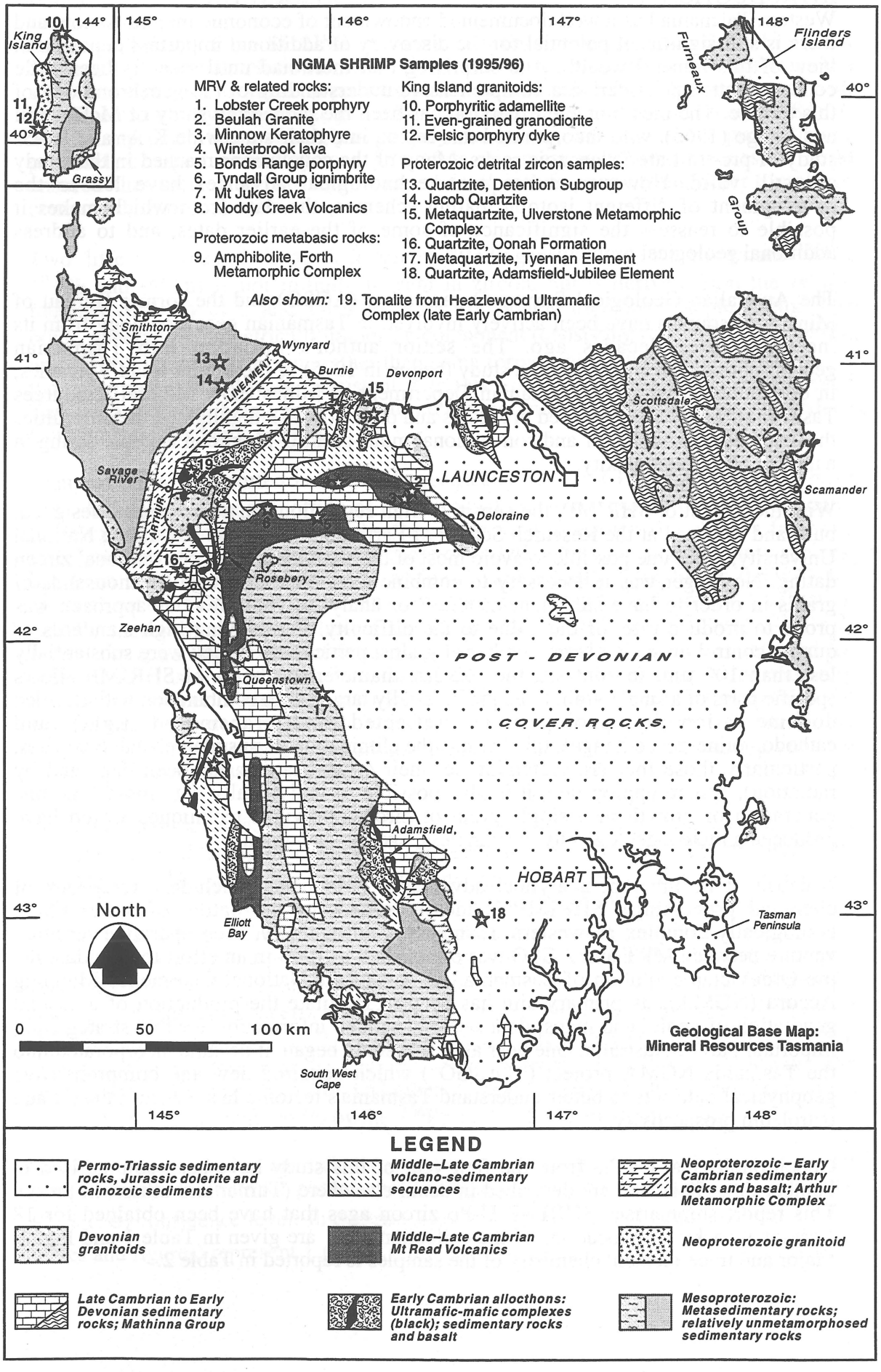

1. Geological map of Tasmania showing the location of all samples collected for this study.

INTRODUCTION

Western Tasmania has a well documented endowment of economic mineralisation, and there is still significant potential for the discovery of additional important deposits. In view of this mineral wealth, it is surprising that there had until recently been little concerted attempt to derive a comprehensive understanding of the geochronology of this terrane. The most notable exception has been the pioneering study of McDougall and Leggo (1965), who incorporated this region into their state-wide K-Ar and Rb-Sr study of pre- to Late Palaeozoic rocks. Many of the conclusions reached in that study are still valid. However, subsequent technological advances have led to the development of different isotopic dating schemes, the data from which makes it possible to reassess the significance of some of the earlier dates, and to address additional geological problems.

The Australian Geological Survey Organisation (AGSO) and the former Bureau of Mineral Resources have been actively involved in Tasmanian geochronology from its inception three decades ago. The senior author's initiation into Tasmanian geochronology was by means of a study (begun in 1975) of the Mount Read Volcanics, in collaboration with the Tasmanian Department of Mines (now Mineral Resources Tasmania). That study, reported in Adams and others (1985), highlighted the difficulties that can beset K-Ar, Rb-Sr and conventional multi-grain U-Pb zircon isotopic dating in a terrane of this complexity.

With the advent of SHRIMP, the **s**ensitive **h**igh **r**esolution **i**on **m**icro **p**robe, designed, built and operated at the Research School of Earth Sciences at the Australian National University, it became possible to avoid most of the shortcomings of conventional zircon dating. No longer was it necessary to combine tens, hundreds, or even thousands of grains in order to have sufficient material for analysis. That previous approach was prone to produce inferior data, due to the difficulty of achieving high standards of quality control on such a large number of grains, particularly if they were substantially less than 100 μm. In contrast, the ~25 μm-diameter ion beam of SHRIMP allows specific parts of a single grain to be preferentially targeted. In combination with detailed documentation by photographic (reflected and transmitted light) and cathodoluminescence images, this permits the elimination of unsuitable analytical sites, particularly those that are metamict (ie. their crystal lattice has been damaged by radiation). Where appropriate, it is also possible to individually date more than one generation of growth in a single grain of zircon. Previous techniques would have produced a mixed, geologically meaningless, age for such grains.

Because of its inherent analytical advantages (which also include a total lack of chemical processing), SHRIMP is ideally suited for the dating of a terrane as geologically complex as western Tasmania. Consequently, a co-operative research venture between MRT and AGSO was established in 1993 in an effort to elucidate the pre-Ordovician evolution of Tasmania. As part of the National Geoscience Mapping Accord (NGMA), its primary aim has been to facilitate the production of a second generation of geological maps, data sets and related information for this strategically important part of Australia. One year after this study began, it became incorporated into the Tasmania NGMA project ("TASGO") which acquired new and comprehensive geophysical data sets to better understand Tasmania's tectonic history and mineral and petroleum prospectivity.

Geochronological results from the first year of this study have been summarised in Pemberton (1994), and are described in detail elsewhere (Turner and others, in press). This report summarises SHRIMP U-Pb zircon ages that have been obtained for 18 additional rocks. The locations of the collection sites are given in Table 1 and Fig. 1. Major and trace-element chemistry of the samples is reported in Table 2.

ANALYTICAL METHODOLOGY

General

Both the SHRIMP I and SHRIMP II ion micro probes at the Research School of Earth Sciences, Australian National University, Canberra, were used for analysis, the selection of either instrument depending purely on its availability. The operation of both instruments broadly follows the procedures outlined in Compston and others (1984). A 20-25 μm primary beam of singly negatively-charged O_2 was used for the production of positively-charged secondary ions. Operation at a mass resolution in excess of 6500 ensured that there were no significant spectral interferences from either simple or compound isotopic species.

Two different types of Pb occur in zircon. "Radiogenic Pb" (which comprises ^{206}Pb, ^{207}Pb and ^{208}Pb) is not initially present in zircon, but is derived from the *in situ* radioactive decay of U and Th. This is the component used for isotopic dating. The other, generally volumetrically-minor Pb component (consisting of ^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb) is of exotic origin, rather than being formed within the zircon. Modelling of the data presented below is consistent with this exotic Pb component in the analysed Tasmanian zircons being equivalent to contemporaneous common Pb, as defined by Cumming and Richards (1975).

Many of the ages reported below, and specifically those for Palaeozoic zircons, have been derived from the proportion of ^{206}Pb (daughter isotope) to ^{238}U (parent isotope). Differential fractionation, caused by the preferential ionisation (by about a factor of three) of each of the Pb isotopes over those of U during the production of these species, has been calibrated by reference to assigned values (0.0928 for SL13; 0.33241 for QGNG) for the proportion of the same two species in the standard zircons. Calibration was by means of the power-law relationship $^{206}Pb^{+}/^{238}U^{+} = a(^{238}U\,^{16}O^{+}/^{238}U^{+})^{2})$, where a is generally a constant for a single session of analyses. The constant need for monitoring this fractionation is accomplished by the taking of an approximately equivalent number of (interspersed) analyses of the standard(s) as that of each of the concurrently analysed unknowns. To correct for fractionation between Th and U, the measured $^{232}Th^{16}O^{+}$ is converted to actual $^{232}Th^{16}O/^{238}U$ by multiplying by $0.03446(^{238}U^{16}O^{+}/^{238}U^{+}) + 0.868$.

An alternative scheme, based on two of the isotopes of Pb, provides a much more reliable means of dating older zircons. The proportion of ^{207}Pb to ^{206}Pb (the respective daughters of ^{235}U and ^{238}U) is unique for any moment of time (as a consequence of the different decay rates of the U isotopes, which have caused $^{238}U/^{235}U$ to increase with time). This dating system is more robust than that based on $^{206}Pb/^{238}U$ and, in particular, is totally unaffected by Recent migration of U and/or Pb. It suffers from the difficulty of obtaining precise measurements of the small increments in $^{207}Pb/^{206}Pb$ that have accrued in Phanerozoic zircon, a limitation which is avoided by $^{206}Pb/^{238}U$ dating. As a consequence, $^{207}Pb/^{206}Pb$ ages are reported below for Precambrian zircons, whereas Phanerozoic ages are derived from $^{206}Pb/^{238}U$. Following the procedures outlined in Compston and others (1984), pooled ages have been determined after correction for common Pb by the ^{204}Pb and ^{207}Pb methods, respectively.

Decay constants used in age calculations are those recommended by Steiger and Jäger (1977). Precision limits for pooled ages (in diagrams and in the text) are reported at the 95 % (t σ) confidence level. In contrast, precision limits for individual analyses (in the tables and figures) represent 1 σ.

The standards

As prefaced above, the derivation of Palaeozoic SHRIMP ages is vitally dependent on the precise and accurate monitoring and comparison of $^{206}Pb^{+}/^{238}U^{+}$ and $^{238}U^{16}O^{+}/^{238}U^{+}$ in the zircons being dated and in a well-documented standard zircon of known age. Over the past decade, SHRIMP U-Pb zircon dating at the RSES has almost exclusively relied on a 572 Ma gem-quality zircon (SL13) from Sri Lanka for this purpose. This standard is now in short supply, and alternative zircon standards are being investigated. One of these, known as QGNG, has been separated from a quartz gabbronorite from the Lincoln Complex, Eyre Peninsula, South Australia (Mortimer and others, 1988). High precision, conventional U-Pb zircon dating by G.E. Mortimer (personal communication) has shown that most of the zircon in this rock is 1850 Ma old, and has been little affected by isotopic disturbance since that time. In combination with a ready supply, and relatively high concentrations of U and radiogenic Pb (together with low common Pb) this makes QGNG a prime candidate for a replacement standard. Therefore, both it and SL13 were jointly mounted with all of the newly analysed zircon, serving not only to assess the suitability of this zircon as a standard in its own right, but also to provide a control on the reliability of the SL13 standard.

During the course of this study some samples were re-analysed as a check of quality control. This was generally done either when an insufficient quantity of data for precise dating had been acquired during an analytical session, or when SHRIMP performance was considered to have been significantly less than optimal. The procedure for re-analysis generally involved the preparation of new resin disks, containing different combinations of the samples being dated. This approach allows the derivation of the relative age differences between the samples, independent of any uncertainty associated with normalisation to the standard analyses (however, the absolute ages of any sample can only be determined by comparison with a zircon of known age). In several instances there was no agreement between repeated analyses of the same samples when calibrated with the SL13 standard. In contrast, ages produced for any particular sample by calibration with QGNG were always in agreement with each other. These results appear to indicate that the fragments of the SL 13 standard used in this study have a compositional heterogeneity that is not properly understood. To overcome this problem, all of the new analyses (and resultant ages) reported below have been calibrated with QGNG. Unfortunately, this procedure has an undesirable side-effect, for the two standards produce ages that are on average about 1.3 % different from each other. For meaningful comparison we need to adjust upwards by 1.3% any Tasmanian $^{206}Pb/^{238}U$ SHRIMP ages that have been derived by calibration with SL 13, or to perform the reverse operation.

PREVIOUS SHRIMP DATING

In order to best understand the rationale behind this, the last phase of this geochronological study, it is appropriate to summarise our prior understanding (based on SHRIMP dating) of the geochronology of western Tasmania.

The oldest igneous rocks yet discovered in the region are an altered 777±7 Ma granite intruding the Bowry Formation and a 760±12 Ma granite from King Island. These granites, roughly contemporaneous with deformation of the thick turbidite sequences of the Burnie and Oonah Formations are considered by Turner and others (in press) to be related to the Wickham Orogeny .

Although the succeeding late Neoproterozoic was tectonically quiet, extensive geological activity was associated with the eruption of the Mount Read Volcanics and associated rocks during the Middle Cambrian, about 500 Ma ago (Perkins and Walshe, 1993). This event closely followed the 510±6 Ma (also calibrated to SL 13, Turner and others, in press) emplacement of ultramafic-mafic magmas and their felsic differentiates in the Heazlewood Ultramafic Complex (which previously had been dated by conventional U-Pb zircon procedures at about 520 Ma by Kimbrough and Brown,

1992). A broadly similar, but relatively imprecise age (502±8 Ma, calibrated to SL 13) was obtained for eclogite-grade metamorphism in the Franklin Metamorphic Complex. Probably the most important feature to be identified in the Turner and others (in press) SHRIMP study is this diversity of approximately coeval geological activity during Cambrian times.

Although no rocks older than 777±7 Ma have been directly dated, there is data from which the presence and age of such rocks can be deduced. This indirect evidence is provided by xenocrystic (and/or restitic) zircon within igneous rocks, and detrital zircon from the metasediments. Components as young as 1200 Ma have been recognised; these probably represent an older limit for the depositional age of the host metasediments. Most of the inherited zircon is between about 1400 Ma and 1900 Ma, although a few Archaean grains have also been detected. A conspicuous concentration of ages between about 1700 Ma and 1800 Ma suggests that these might represent the age of prominent regional basement components, though such rocks are not currently known to be exposed.

The purpose of this geochronological study is to enhance our knowledge of the tectonic and geological history summarised above to the point that it provides an authoritative understanding of the early geological evolution of western Tasmania. Further work has been directed at the Neoproterozoic and younger rocks of King Island. Additional components of the Mount Read Volcanics and their supposed correlatives have been dated. And, an attempt has been made to date mafic igneous rocks in the Rocky Cape Element and in the Forth Metamorphic Complex. Finally, the ages of the source rocks from which widely separated metasediments (mainly quartzites) were derived have been investigated.

ISOTOPIC RESULTS

King Island

Porphyritic adamellite (sample 93220010)

A K-feldspar-porphyritic biotite-muscovite adamellite was collected by J.E. Streit and S.F. Cox from a coastal outcrop of the King Island Granite near Cape Wickham at the northern end of the island. The zircon in this rock is dominated volumetrically by rounded cores and whole xenocrystic grains, at least most of which are of igneous origin. Overgrowths, which have simple euhedral pyramidal terminations, are also characterised by oscillatory prismatic zonation. All ten of the analyses of cogenetic zircon yield a combined $^{207}Pb/^{206}Pb$ age of 762±14 Ma for the crystallisation of this rock (Fig. 2). Seven of the eight analysed cores crystallised between 1600 Ma and 1900 Ma ago (Fig. 3, Table 3). The other core grew at about 2700 Ma.

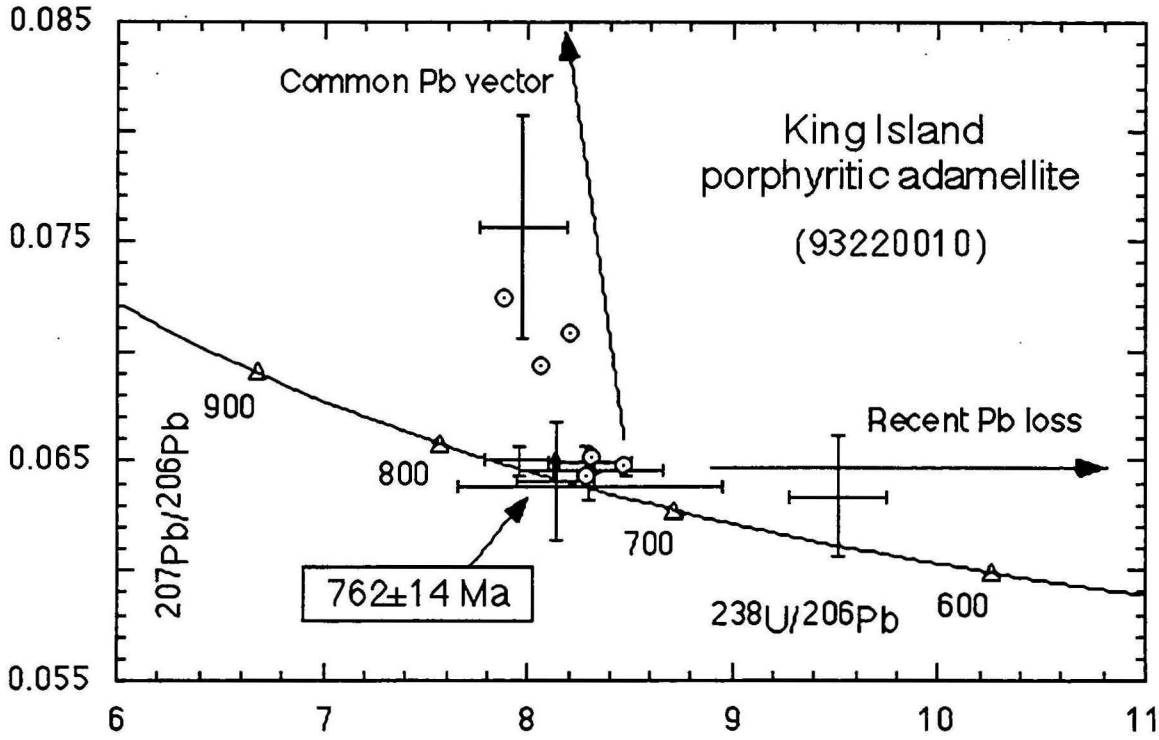

Fig. 2. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 762±14 Ma cogenetic zircons from the porphyritic adamellite (93220010) on King Island. In this and all subsequent concordia diagrams, uncorrected data are represented by circles, whereas the data that have been corrected for common Pb are represented by 1 σ error bars. For Proterozoic examples, correction has been by the ^{204}Pb technique (Palaeozoic data are corrected by ^{208}Pb). The youngest analysis fits on a recent Pb loss trajectory.

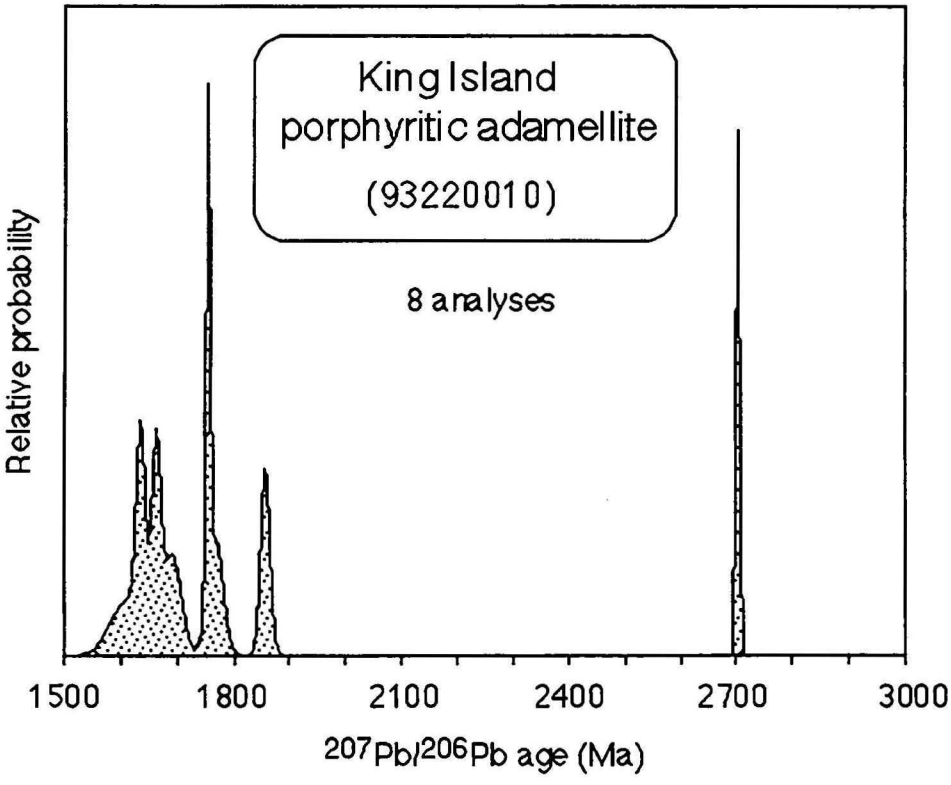

Fig. 3. Probability distribution diagram for eight cores of xenocrystic zircon from the porphyritic adamellite (93220010) on King Island. This figure is a form of histogram that takes different analytical

errors into account. All individual analyses are represented by bell-shaped curves of equal area. Relatively precise analyses yield more pronounced peaks, which are more important in defining populations. The depicted curve is derived from the accumulated sum of the individual curves at all points along the abscissa. The ordinate has no scale because it is a measure of relative probabilty.

Even-grained granodiorite (sample 93220011)
This sample was collected by J.E. Streit and S.F. Cox from an outcrop on the west coast, about 2 km S of Currie. Most of the zircon is euhedral and contains oscillatory zoning. The abundance of this cogenetic zircon permits a more precise age determination (748.2±2.0 Ma, Fig.4) than was possible for the Cape Wickham occurrence. Rounded cores are smaller and far less common than in the previous sample. Four of these yield ages between about 1400 Ma and 1800 Ma (Table 4).

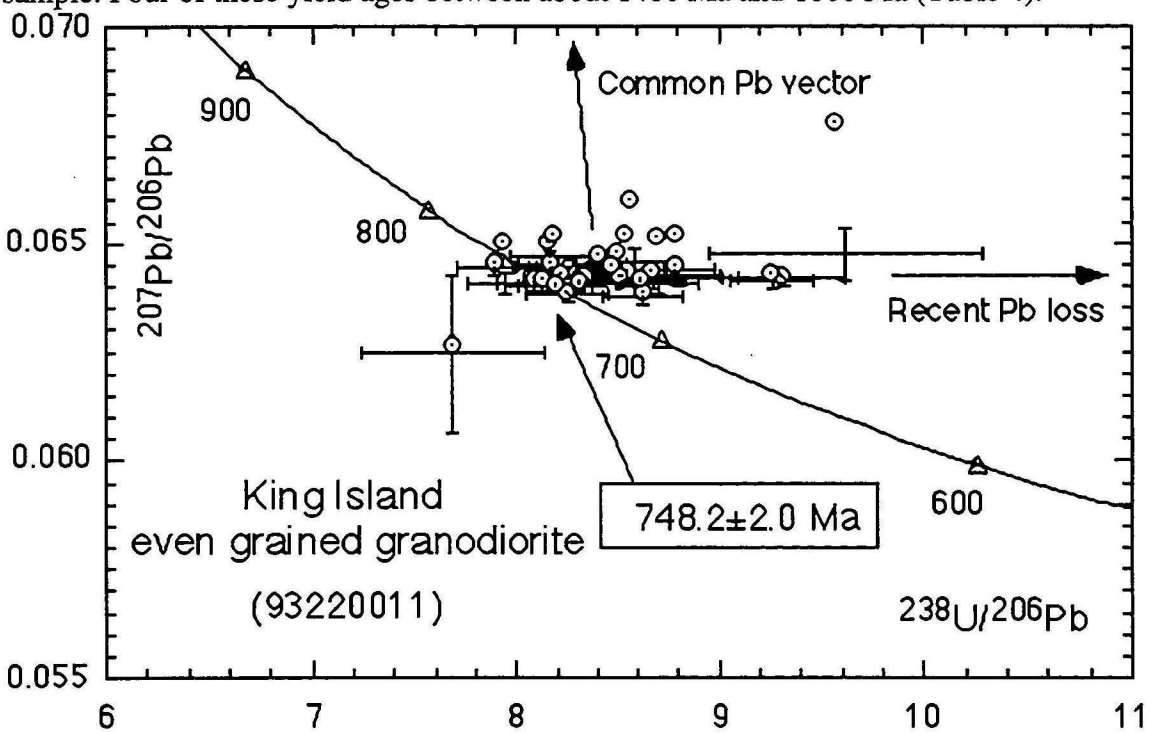

Fig. 4. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 748.2±2.0 Ma cogenetic zircons from the even-grained adamellite (93220011) on King Island. Some of the data show evidence of recent Pb loss.

Felsic porphyry dyke (sample 93220009)
This undeformed dyke was collected by J.E. Streit and S.F. Cox from coastal outcrop about 1.5 km S of Currie Wharf. Most of the zircon is zoned, and crystallised from this porphyry 350.4±4.3 Ma ago (Fig. 5). One of the 30 dated grains of this cogenetic zircon phase yields a slightly younger age, presumably because of recent Pb loss. Rounded cores are relatively common. One of these is about 1750 Ma old (Table 5). The other analysed core yields a very discordant age of about 1000 Ma, which can only be considered as a younger limit for its crystallisation.

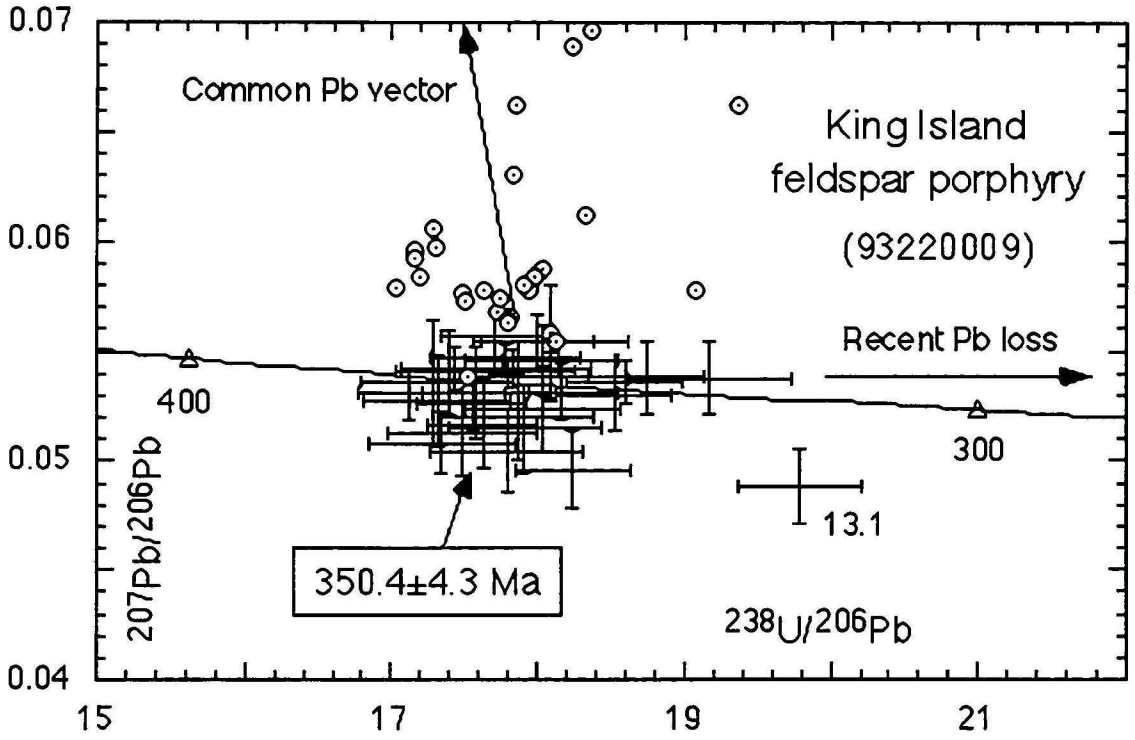

Fig.5. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 350.4±4.3 Ma cogenetic zircons from the feldspar porphyry (93220009) on King Island. Only one of these analyses (13.1) is a statistical outlier, presumably due to a small component of recent Pb loss.

Significance of the new King Island ages

The new data identify two temporally well-separated episodes of igneous activity on King Island. Although those same events were originally documented by McDougall and Leggo (1965), the new data are able to resolve several ambiguities associated with the spread of ages reported in that study. For instance, it is likely that Proterozoic magmatism continued for at least 15 million years (763Ma to 748 Ma). It is also probable that the 350.4±4.3 Ma porphyry dyke and roughly contemporaneous felsic plutons on the east coast (McDougall and Leggo, 1965) were part of a thermal event that was responsible for the partial resetting of many Rb-Sr and K-Ar mica ages. To compare the age of the porphyry (which was obtained before the QGNG standard became available) with most of the other new ages, its value should be increased by 1.3 %, making the preferred age 355.0±4.3 Ma.

Mount Read Volcanics and associated rocks

Bonds Range Porphyry (sample 95220013)

This quartz-feldspar-biotite-hornblende porphyry contains clear, elongated, euhedral and rhythmically zoned zircon that obviously crystallised *in situ*. One (#5.1) of the analysed grains, which is similarly zoned, is considerably older (about 1400 Ma, Table 6) than any of the others. Twenty seven of the remaining 28 analyses produce a pooled age of 504.6±7.0 Ma (Fig. 6) for the crystallisation age of this porphyry. Grain 25.1 is possibly slightly older.

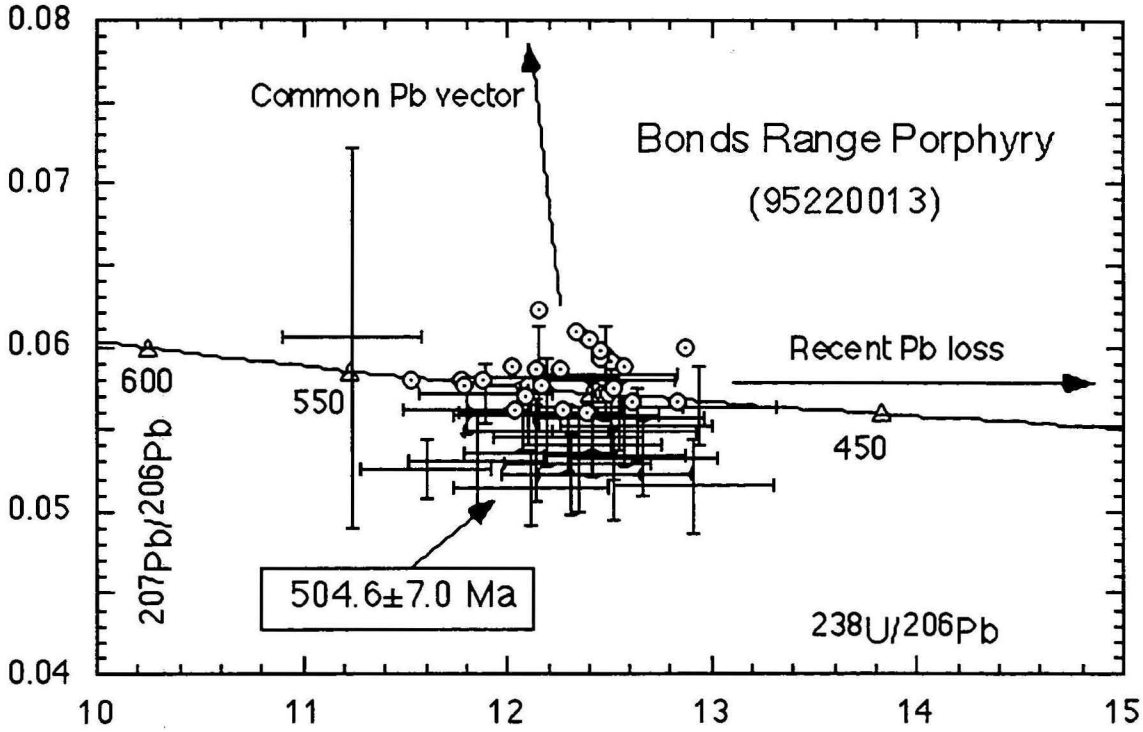

Fig. 6. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 504.6±7.0 Ma cogenetic zircons from the Bonds Range Porphyry (95220013). The analysis on the left is a little older than the other grains.

Mount Jukes lava (sample 95220028)

This grey felsophyric lava, collected from the north face of Mount Jukes, is a component of the Central Volcanic Complex. The euhedral morphology and zoning of its zircons are indicative of an igneous origin. Twenty three of the 24 analyses yield an age of 503.3±6.9 Ma (Fig. 7, Table7) for the crystallisation of this rock. There is no evidence to show that the slightly older age for analysis 222.3 is anything but a minor analytical aberration. A few small discordant cores are present, but none was analysed.

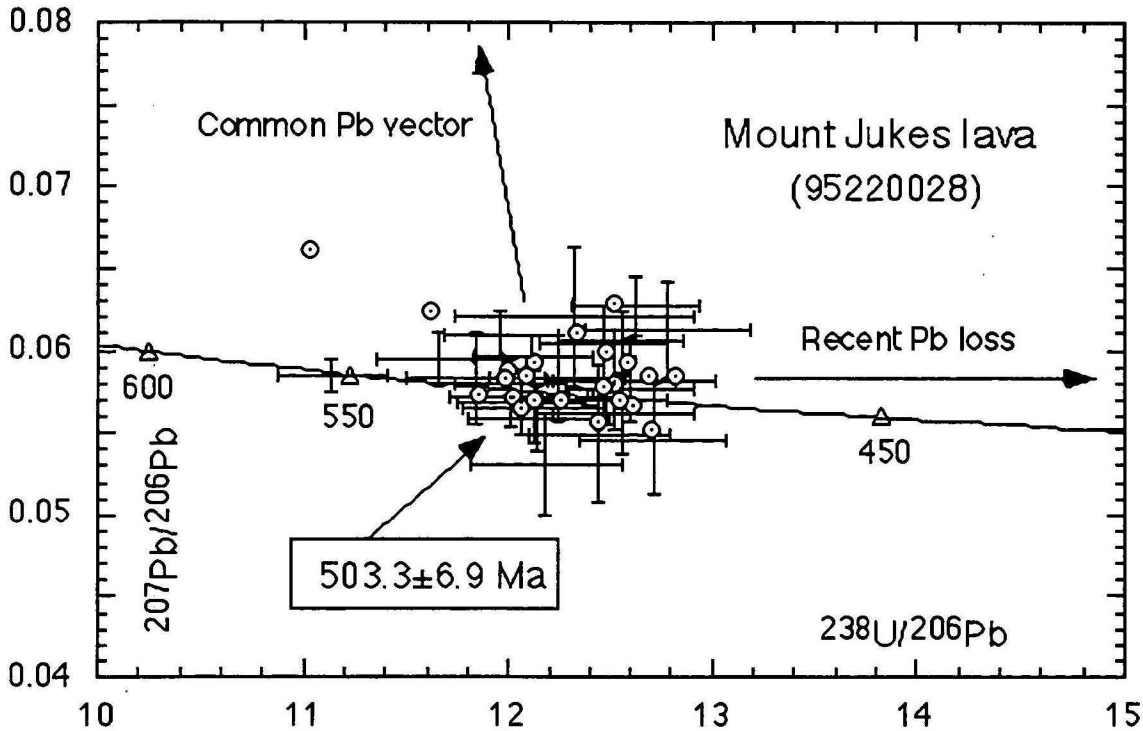

Fig. 7. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 503.3±6.9 Ma cogenetic zircons from the Mount Jukes lava (95220028). The analysis on the left is a little older than the main group.

Minnow Keratophyre (sample 95220023)
Most of the zircon in this rhyolitic lava clearly crystallised from it. However, some grains contain poorly luminescent, discordant cores, some of which are zoned. These cores were possibly inherited by the magma; none have been dated in this study.

The zircons were analysed in two separate analytical sessions, and consequently the data required more protracted processing than normal. Indistinguishable ages were obtained from the two sessions and, as they are clearly estimates of the same event, it is justifiable to combine them for a best estimate of 499.6±5.6 Ma for the age of the keratophyre (Fig. 8, Table 8).

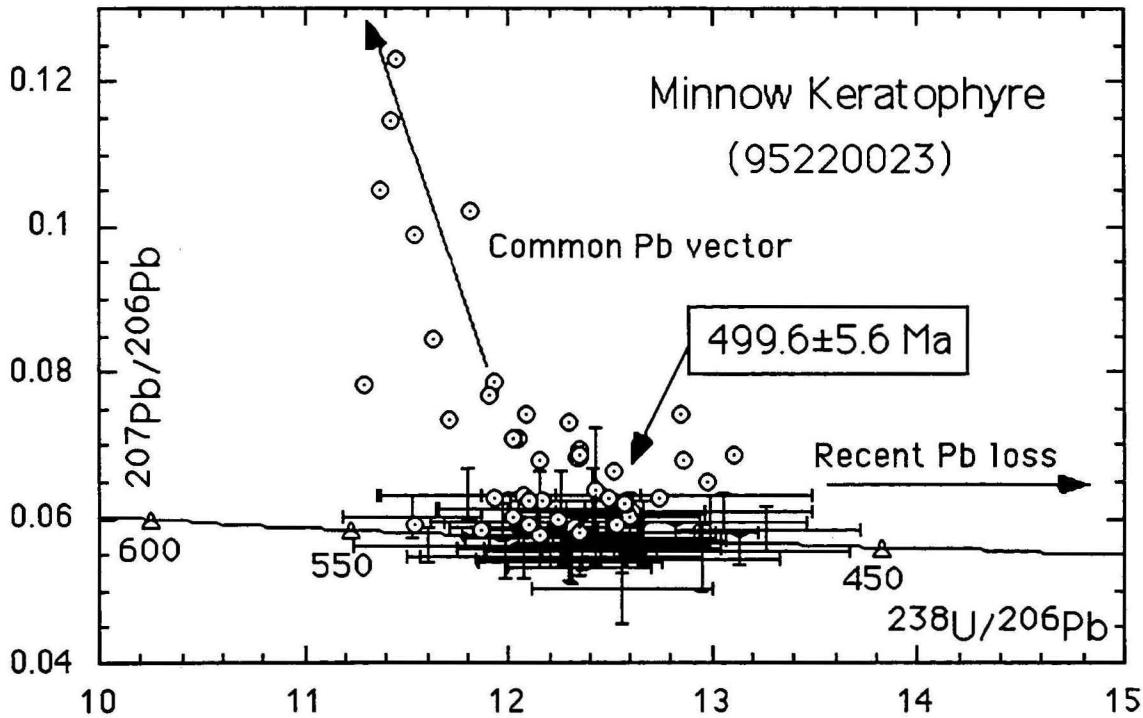

Fig. 8. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 499.6±5.6 Ma cogenetic zircons from the Minnow Keratophyre (95220023). This diagram demonstrates the effectiveness of the ^{208}Pb correction in determining radiogenic Pb compositions. The uncorrected data scatter above concordia, whereas the corrected data neatly straddle that curve.

Winterbrook lava (sample 95220025)

Based on its morphology, most of the abundant zircon in this rock can be concluded to have formed concurrently with the crystallisation of its host lava. All 24 analyses produce a combined age of 500.4±6.9 Ma (Fig. 9, Table 9) for that event. Although discordant cores are present in some grains, they were not targeted for analysis.

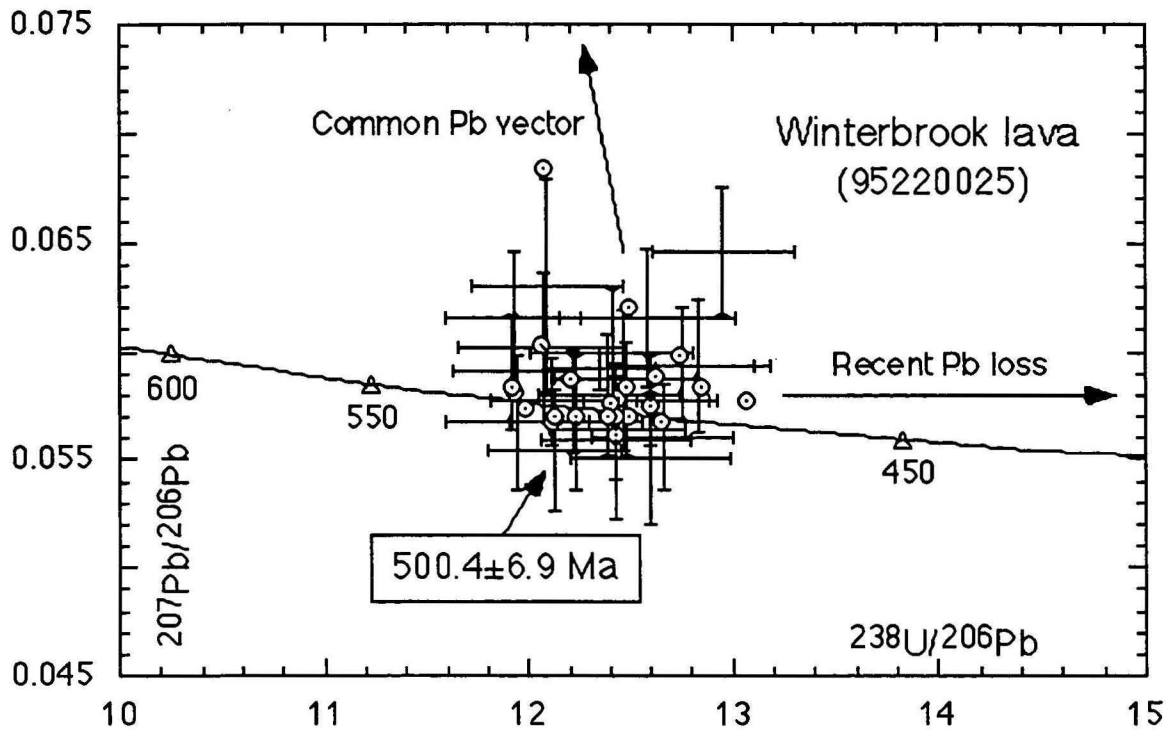

Fig. 9. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 500.4±6.9 Ma cogenetic zircons from the Winterbrook lava (95220025).

Tyndall Group ignimbrite (sample 95220026)
Although once thought to be widespread, this quartz-feldspar-phyric rock is now considered to be perhaps the only example of a true ignimbrite within the Mount Read Volcanics and their associates. Most of the zircon in this rock has the euhedral form and rhythmic zoning that is characteristic of an igneous origin. However, some discordant, poorly luminescent cores (none of which were analysed) are also present. These possibly pre-date the crystallisation of this rock.

In common with some of the other units, the zircons were analysed in two sessions (on different mounts). The ages derived from each of those sessions are within the limits of analytical error of each other, and combine to yield a preferred age of 505.3±3.6 Ma for the crystallisation of this ignimbrite (Fig. 10, Table 10).

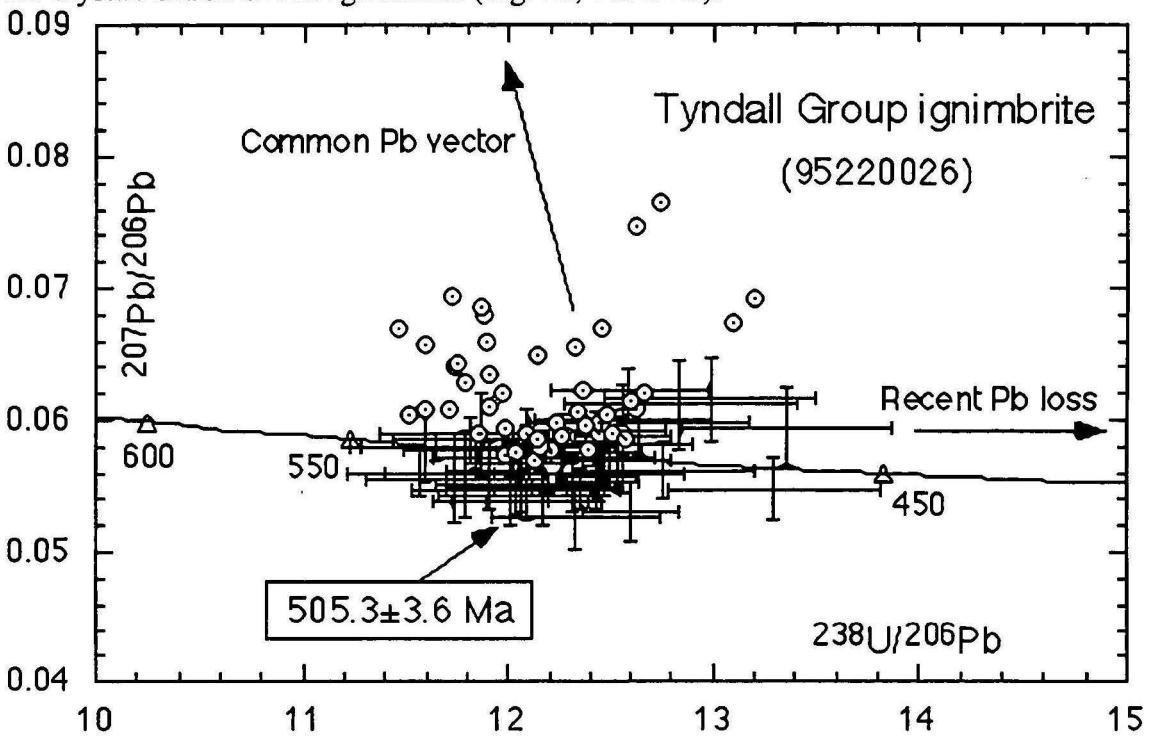

Fig. 10. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 505.3±3.6 Ma Ma cogenetic zircons from the Tyndall Group ignimbrite (95220026).

Lobster Creek Volcanics (sample 95220022)
Zircons in this andesitic feldspar-pyroxene porphyry from the Dial Range Trough mostly preserve the broad features of moderately elongated igneous grains. Although some euhedral and subhedral faces are present, there is also evidence of late- or post-magmatic resorption. Some grains contain small, anhedral, discordant, poorly luminescent cores, one of which yields an age of about 1700 Ma.

The zircons from the Lobster Creek Volcanics were also analysed in two separate sessions. Fifty four analyses were made on the volumetrically dominant, zoned zircon that co-crystallised with the other magmatic minerals in this rock. Age estimates from the two sessions are within error of each other, and can therefore validly be combined to yield a preferred age of 500.2±3.5 Ma for the crystallisation of the Lobster Creek Volcanics (Fig. 11, Table 11).

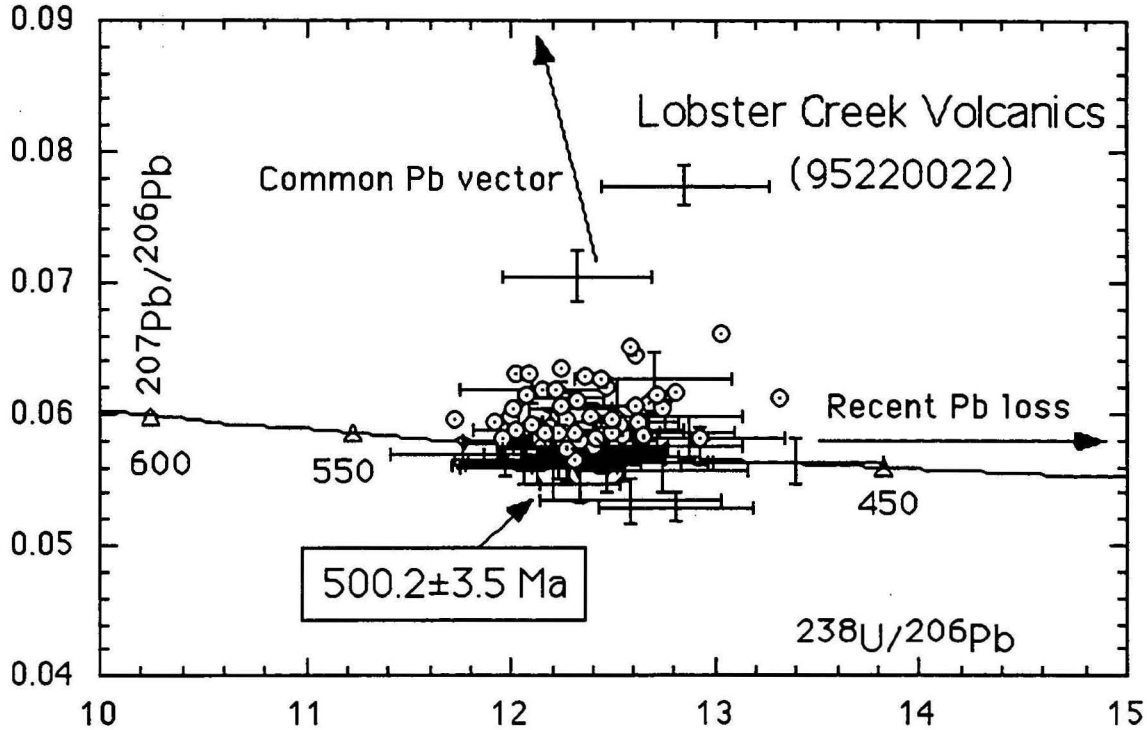

Fig. 11. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 500.2±3.5 Ma cogenetic zircons from the Lobster Creek Volcanics (95220022).

Beulah Granite (sample 95220024)

Although the Beulah Granite is very similar in hand specimen to the Lobster Creek Volcanics, most especially in its porphyritic appearance, several aspects of their chemistry are quite different (Table 2). The zircons in the two rocks are also quite different. Those in the Beulah Granite are mostly more equant, and more commonly multifaceted, although some simple prismatic and pyramidal faces are present. Zoning is readily apparent in transmitted light, but not in the poorly luminescent CL images. The poor luminescence of most of the zircon reflects its enhanced U and Th, and the consequent radiation damage.

One of the Beulah analyses (122.1) is markedly older than the rest, with an age of about 1500 Ma (Table 12). Twenty six analyses of the cogenetic zircon yield a preferred age of 493.5±3.9 Ma (Fig. 12) for the crystallisation of the Beulah Granite. Two analyses (113.1 and 102.1) are slightly younger, presumably due to a small amount of recent Pb loss.

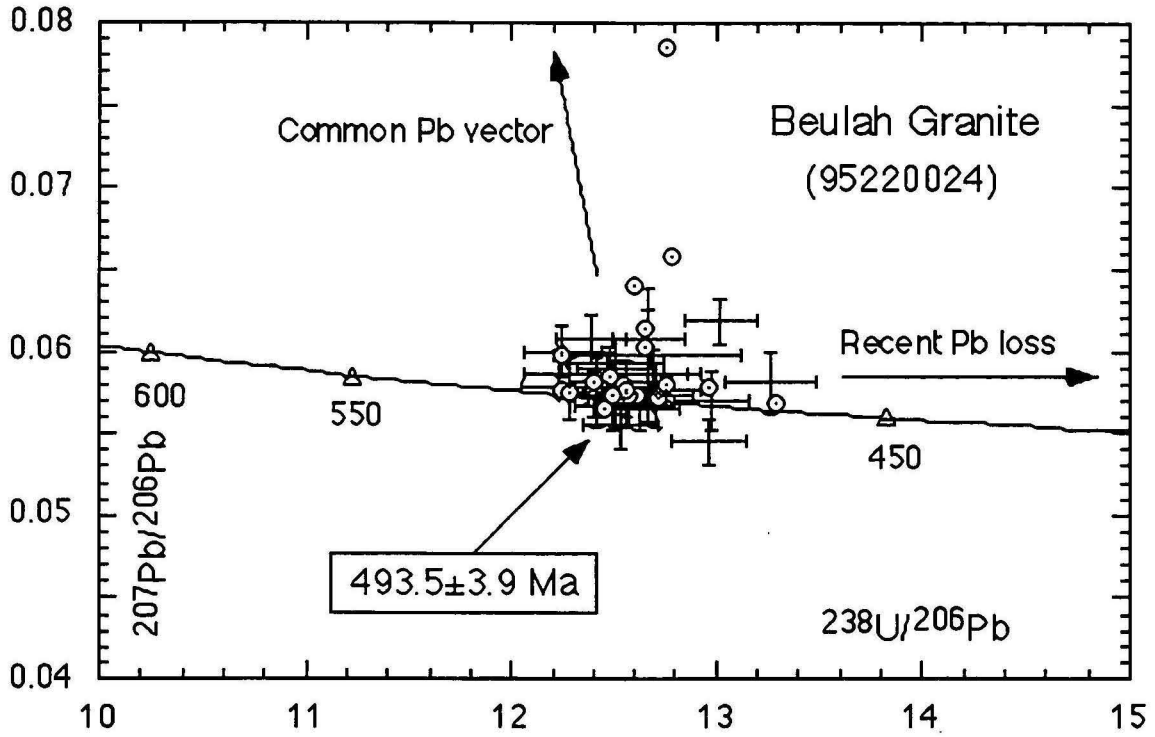

Fig. 12. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 493.5±3.9 Ma cogenetic zircons from the Beulah Granite (95220024).

Noddy Creek Volcanics (sample 96220032)

The Noddy Creek Volcanics, which occur to the west of the southern part of the main volcanic belt (Fig. 1), are a possible correlative of the Mount Read Volcanics. The zircons in the dated rhyolite have the typical igneous features described above, as well as pronounced sector zoning. Cores of older zircon are rare, if present at all. Forty five of the 48 zircon analyses (Table 13) yield an age of 502.8±4.4 Ma (Fig. 13) for the crystallisation of this rock. The three rejected analyses are a little younger. This is probably a result of analytical considerations, because the outlier analyses have the lowest values of UO/U, the critical parameter used for the calibration of $^{206}Pb/^{238}U$.

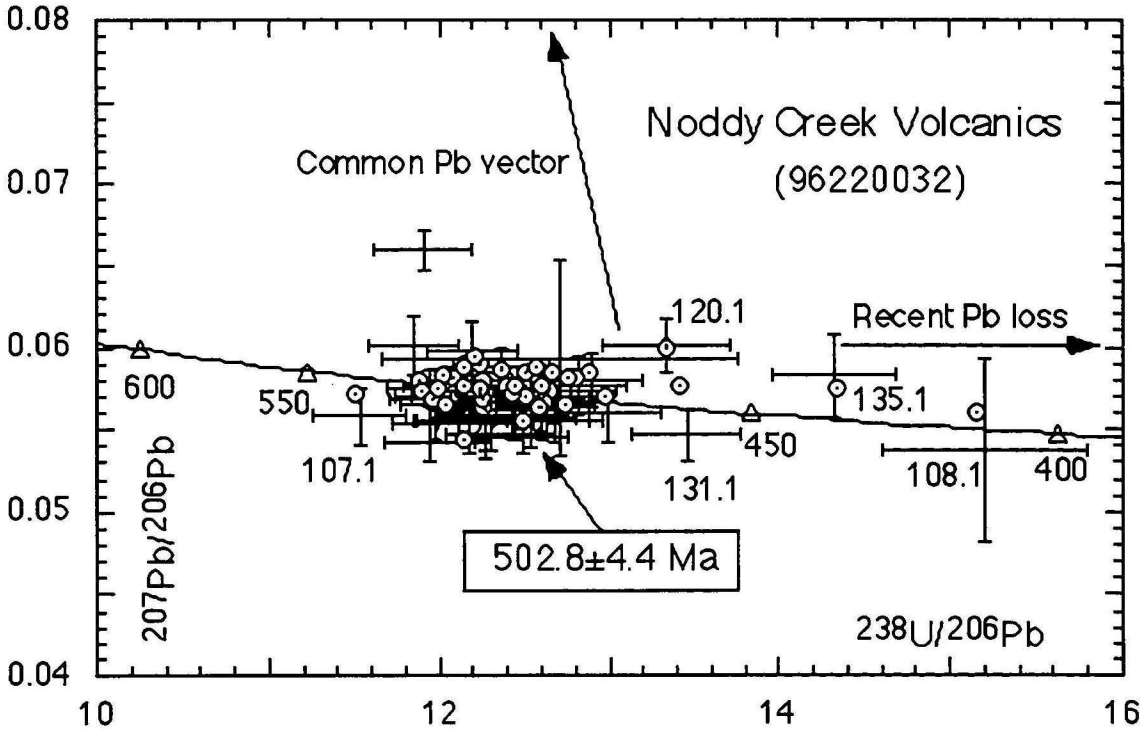

Fig. 13. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 502.8±4.4 Ma cogenetic zircons from the Noddy Creek Volcanics (96220032). There are five outlying analyses. Analysis 107.1 is a little older than the main population; analyses 120.1, 131.1, 135.1 and 108.1 are a little younger.

Significance of the new ages for the Mount Read Volcanics and their possible correlatives

The data presented above provide new U-Pb zircon SHRIMP ages (Table 23) for eight felsic igneous units from the north and west of Tasmania. There is no significant age difference (at the 95 % confidence level) between the ages for the Tyndall Group ignimbrite (505.5±3.6 Ma), the Bonds Range Volcanics (504.6±7.0 Ma) and the lava from Mount Jukes (503.3±6.9 Ma). Therefore, at least this part of the Mount Read Volcanics sequence (which excludes the possibly older "western sequence"), was formed over a very short period of time. The Noddy Creek Volcanics (502.8±4.4 Ma) are of similar age. None of these ages is significantly different from those reported by Perkins and Walshe (1993). However, any detailed attempt to compare such ages should take into account the different standards used, and the fact that the earlier study reports only one sigma precision, and not 95 % confidence levels (which are at least twice as broad). However, note that Table 23 of this study lists all errors at the 95 % confidence level.

The four other dated felsic units, which occur in the northern part of the Mount Read Volcanic belt, have younger mean ages. Although the ages for the Lobster Creek Volcanics (500.2±3.5 Ma), Minnow Keratophyre (499.6±5.6 Ma) and Winterbrook lava (500.4±6.9 Ma) are mutually indistinguishable, the Beulah Granite is younger than at least the Lobster Creek Volcanics. The data suggest that magmatism progressed northwards with time.

Mafic igneous rocks

General

Four mafic igneous rocks were collected for dating in this phase of the study. Two of those samples were taken from foreshore outcrops of the Cooee Dolerite at Burnie, but neither yielded any zircon. This is not surprising considering their low SiO_2 contents of 46.6 % and 45.5 %. A similarly coarse grained specimen of the dolerite that was collected previously had also failed to yield zircon (Turner and others, in press). In

contrast, those workers did successfully extract zircon from a fine grained variant of the dolerite; however, all of that zircon was of xenocrystic origin.

Two amphibolites were also collected for dating. One was taken from a probable metadolerite within chloritic schists of the Arthur Metamorphic Complex. It too failed to yield any zircon (this rock has 49.8 % SiO_2). The only sample to yield zircon is a garnet amphibolite from the Forth Metamorphic Complex, about 3 km to the S of Forth (see immediately below).

Garnet amphibolite, Forth Metamorphic Complex (sample 95220020)
This garnet amphibolite is moderately rich in zircon. Virtually all of the grains are composed of an anhedral core that commonly preserves remnants of oscillatory zoning, and a similarly zoned, discordant overgrowth. The overgrowths have markedly lower Th (0.1 - 7.5 µg/g, average is 1.7 µg/g) and Th/U (0.00076 - 0.0171, average is 0.0060) than the cores (38 - 303 µg/g, average is 133; 0.16-1.63, average is 0.63, respectively). Both phases are interpreted as being of igneous origin, the unusual chemistry of the overgrowths being attributed to a very small degree of partial melting.

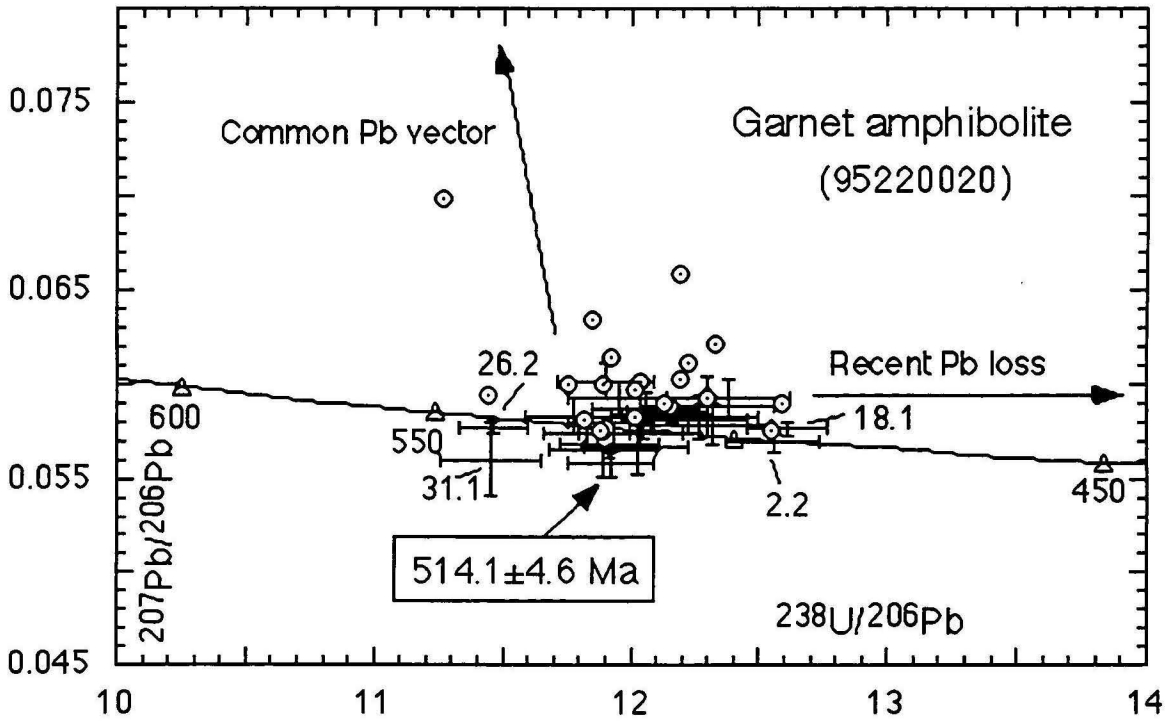

Fig. 14. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for 514.1±4.6 Ma zircon rims in the garnet amphibolite (95220020), Forth Metamorphic Complex. The labelled data are statistically separable from the main population of 19 analyses.

Nineteen of 23 rim analyses yield an age of 514.1±4.6 Ma (Fig. 14, Table 14) for the metamorphic event that produced the incipient partial melts from which the overgrowths grew and the predominant fabric in the amphibolite. Two analyses are a little younger, presumably due to a small degree of recent Pb loss. There is no obvious reason for the other two outliers being slightly older than the main grouping.

The twelve analysed cores have a distinct range of significantly older ages (Fig. 15, Table 15) than that recorded by the overgrowths. Only those analyses that are more than 90 % concordant can be considered to provide reliable age information, and these yield a range of ages from about 1400 Ma to 1800 Ma. The cores are regarded as being inherited by the low-SiO_2 (48.1 %) mafic igneous rock, and none of the constituent zircon is believed to have crystallised from the host magma.

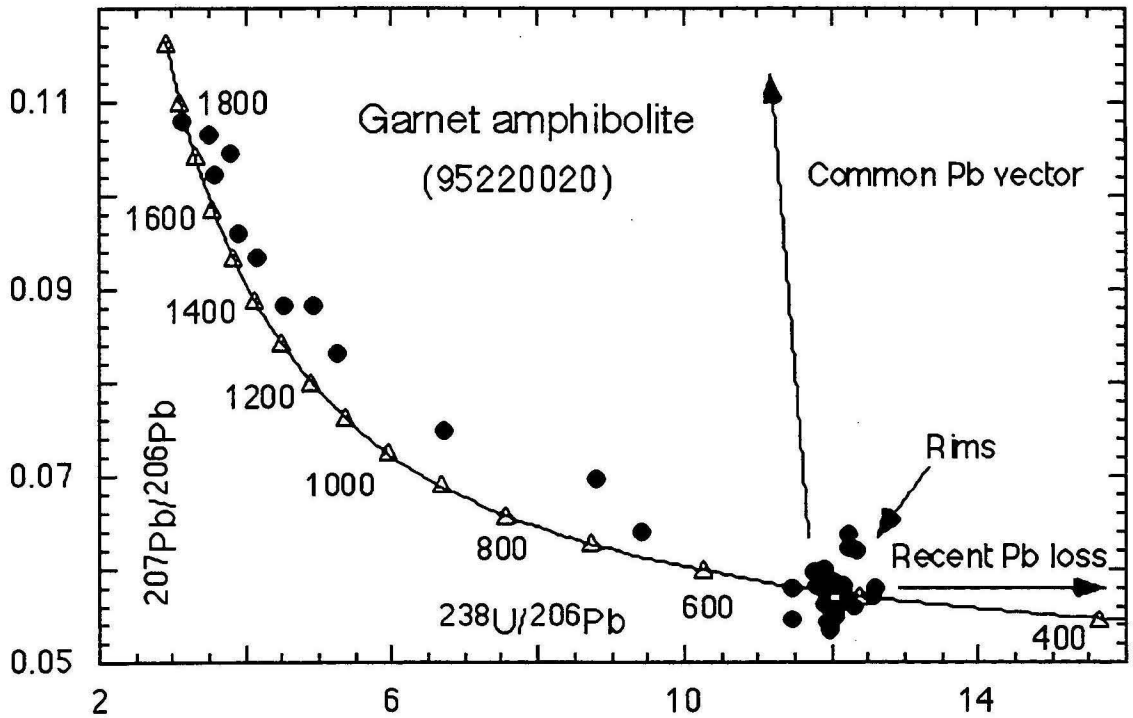

Fig. 15. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for all of the analysed zircon from the garnet amphibolite (95220020), Forth Metamorphic Complex. All data are depicted as solid circles. Rim analyses are represented by the data concentration near 500 Ma. The cores yield a range of compositions that approach concordance at about 1500 Ma to 1800 Ma.

Tonalite from the Heazlewood Ultramafic Complex (sample 93220003)
This sample was originally dated by Turner and others (in press) before the QGNG standard was in use. It was therefore considered to be desirable to re-analyse it in conjunction with QGNG, so that direct comparison could be made with the ages reported in this study. The same tonalitic differentiate was analysed, because of the low probability of finding any cogenetic zircon in the mafic or ultramafic rocks of the complex.

Some of the zircon in the tonalite is euhedral to subhedral, but anhedral grains are also common. Aspect ratios range from about 1:1 to 3:1. The presence of many small cavities and dark inclusions, and a myriad of cracks severely limit the number of sites suitable for dating. Oscillatory prismatic zoning and possible sector zoning support an igneous origin for this zircon. All 47 analyses (Table 16) produce a chi square of 4.3, a value in excess of that expected for a simple population. The skewing to younger ages in Fig. 16 strongly suggests that this results from relatively recent loss of radiogenic Pb from some grains. Deletion of the nine youngest analyses produces a statistically satisfactory distribution, with a chi square if 1.30. The resultant age of 513.6±5.0 Ma dates the crystallisation of this tonalite and the last phase of igneous activity in the Heazlewood Ultramafic Complex.

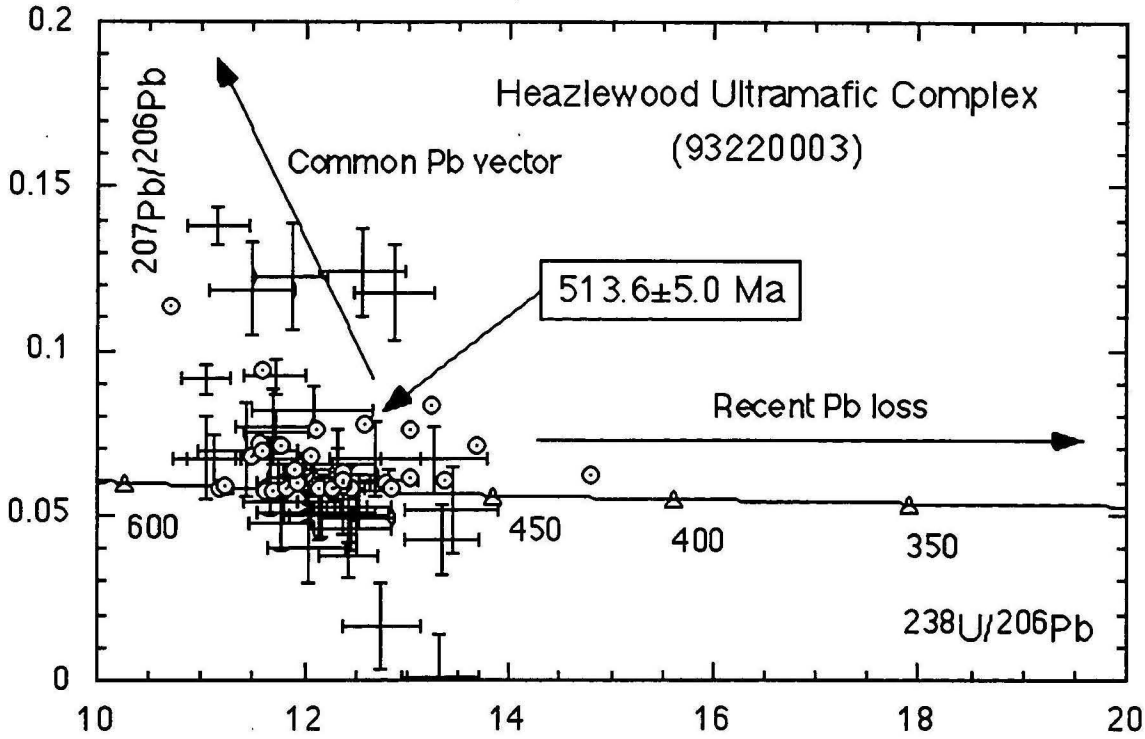

Fig. 16. $^{238}U/^{206}Pb$ - $^{207}Pb/^{206}Pb$ concordia diagram for the analysed zircon in the tonalite from the Heazlewood Ultramafic Complex (93220003), showing a skewing of data toward younger ages. A trend of this kind is attributable to recent loss of radiogenic Pb from some grains (see text). One of the (^{208}Pb-corrected) analyses plots below the diagram, due to overcorrection by this method. However, anomalies of that kind have no influence on the mean age (513.6±5.0 Ma), which has been calculated from ^{207}Pb-corrected data.

Significance of the new ages from the more mafic rocks and their correlatives

The newly measured age of 513.6±5.0 Ma for the tonalite from the Heazlewood Ultramafic Complex appears to be younger than the ages (519±7 Ma and 522±6 Ma) obtained by conventional multi grain zircon analyses (Kimbrough and Brown, 1992). However, the lack of documentation of the nature of the reported errors (1 σ, 2 σ or t σ?), does not allow meaningful comparison. The newly acquired 513.6±5.0 Ma age is within error of both the originally reported SHRIMP age of 510±6 Ma for the tonalite (Turner and others, in press), and the 1.3 % adjusted value of about 516.6 Ma required for comparison with the QGNG calibrated data presented above.

The preferred age of 513.6±5.0 Ma for the end phase of magmatism in the Heazlewood Ultramafic Complex is very similar to that (514.1±4.6 Ma) of the early amphibolite-facies metamorphism in the Forth Metamorphic Complex. Thus, these might be different geological aspects of the same event. It is also possible that the high-grade metamorphism in the Collingwood River - Lyell Highway region was part of the same event. The 502±8 Ma age obtained for that event by Turner and others (in press) requires two adjustments for best comparison with the new SHRIMP ages. First, a newly adapted method for identifiying analytical outliers indicates that the youngest of the analyses should be rejected, producing a revised mean age of 504 Ma. Upward adjustment of this by 1.3 % (to allow meaningful comparison with the QGNG-calibrated data obtained in this study) yields a preferred age of 511±8 Ma for the eclogite metamorphism. This age is clearly within error of those derived above for the tonalite and the amphibolite. It would be preferable to have reanalysed zircon from the eclogite directly with the QGNG standard but, unfortunately, all of the separate was used for the original analyses.

The newly acquired ages for the Heazlewood Ultramafic Complex and the amphibolite from the Forth Metamorphic Complex are significantly older than all of the other ages obtained in this study. They therefore represent an earlier event (or events) than that responsible for the production of the Mount Read Volcanics, and extend the range of Early Palaeozoic igneous activity in the region to about 20 Ma. At least three temporally discrete igneous events occurred during that time.

The quartzite samples

General

The relative resistance of zircon to physical and chemical breakdown makes it a particularly useful mineral to determine the provenance of sedimentary rocks. In some cases such zircon will have withstood more than one sedimentary cycle. In other instances it will allow an assessment of basement age, even if that basement is not now exposed. Another useful attribute of detrital zircon grains is that under most circumstances they would be expected to provide an older limit for the depositional age of their host sediment. The oldest Tasmanian granite to be isotopically dated (777±7 Ma, Turner and others, in press) provides a younger age limit for the deposition of the enclosing (meta) sedimentary sequence. One of the aims of the quartzite dating was to derive an older limit for that event.

Large numbers of zircon analyses are required to ensure that no significant age populations are missed in the analysis of a detrital rock. According to Dodson and others (1988), about 60 analyses are necessary to guarantee there is only a 5 % chance of any particular age component being undetected. It is also crucial that there is no bias in the selection of grains for dating. Although all analyses are given in Table 1, only those analyses that are at least 90 % concordant (Table 1) are used in data assessment. Analyses that plot further from concordia would yield erroneous ages if any of their Pb loss occurred in other but recent times.

One disadvantage of normal histograms is that thay can be influenced by the widths of the chosen bins. Another disadvantage is their inability to individually weight data according to their precision. Consequently, this study uses the probability distribution diagram, which provides a means of avoiding both of these shortcomings. Each analysis contributes an equal area of Normal Distribution to this diagram. The conformation of these individual areas is governed by precision; more precise ages produce more pronounced peaks. The final complex curve represents a cumulative summation of the individual analyses. In this report the significance of the generated peaks is discussed only in general terms. Future publication of the data will involve a detailed analysis on whether or not they are compound and, if so, whether they can be convincingly subdivided into discrete populations.

Rocky Cape Element (sample 95220016)

This sample of the Detention Subgroup was collected from a quarry near the intersection of Newhaven road with Newhaven track. This is a quite pure (99.05 % SiO_2), even grained quartzite, whose zircons are mostly well rounded and heavily pitted. The zircon is of igneous origin. Eighty two of the 87 zircon grains that were dated are at least 90 % concordant, and therefore should provide reliable estimates of their time of crystallisation.

The probability distribution diagram (Fig. 17) shows two marked Proterozoic age concentrations and some Archaean ages (Table 17). The latter represent seven individual ages, which range from about 2500 Ma to nearly 2900 Ma. The prominent peak at about 1710 Ma obviously defines the age of the predominant source rocks for this quartzite. However, this peak is complex, with a definite skewing to older ages. This indicates the presence of a slightly older, subordinate population. The youngest data concentration is at about 1450 Ma.

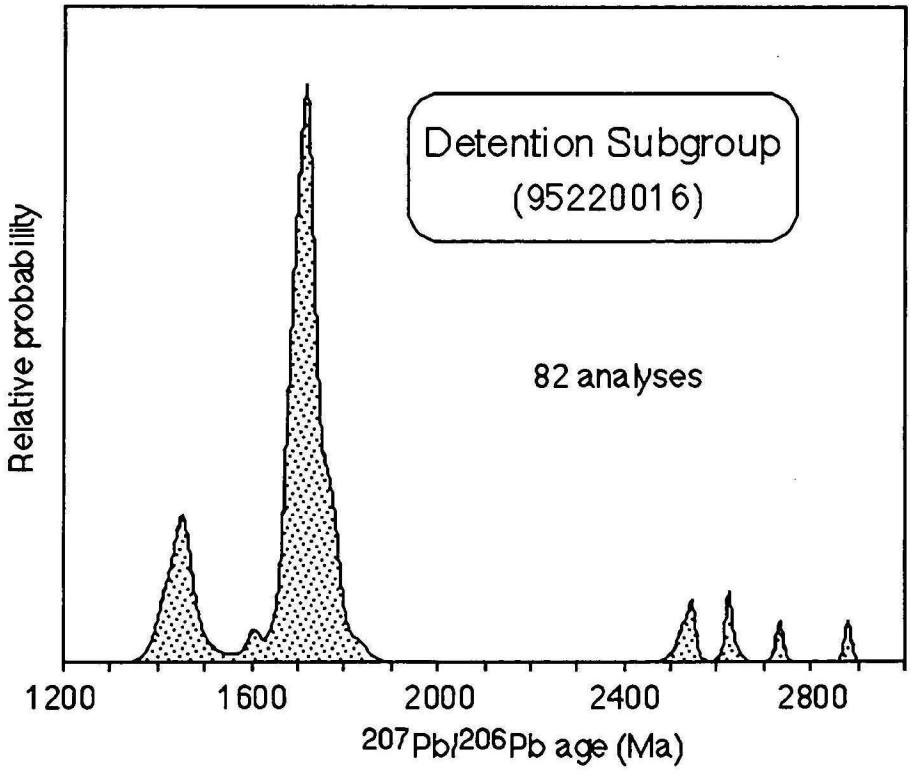

Fig. 17. Probability distribution diagram for detrital zircon grains from the Detention Subgroup quartzite (95220016), Rocky Cape Element. Note the prominent data concentrations at about 1450 Ma and 1700 Ma.

Rocky Cape Element (sample 95220017)
This sample, of the relatively pure (98.59 % SiO_2), even-grained Jacob Quartzite, was collected from a gravel quarry adjacent to the Meunna Hills road. The grains are of igneous origin. They are more rounded and pitted than those from the Detention Subgroup, but some subhedral and euhedral grains are also present. A most important distinguishing feature from all of the other studied quartzite samples is the pronounced presence of small stylolites. Six of 87 grains that were dated are less than 90 % concordant (Table 18), and are discussed no further. Most of the age spectrum (Fig. 18) is distinctly different from that of the other Rocky Cape Element quartzite (and from the other Proterozoic quartzite samples dated below), even though these rocks are closely related. One similarity between the two occurrences is their roughly comparable Archaean component. Five such grains were identified in this rock, four of which crystallised at about 2650 Ma; the other grew at about 3100 Ma.

Not only does the Proterozoic age spectrum of this sample have a different and less intense maximum than that of the other quartzite samples, but it also covers a considerably wider range, particularly at younger ages. The complete failure of the spectrum to return to the baseline anywhere over a 1200 Ma interval is not duplicated by any of the other five quartzite samples. This feature is believed to have arisen by a secondary process that had little if any influence on the other quartzite samples. The stylolites noted above provide the textural evidence for that process. These structures are believed to result from the solution, under directed pressure, of a considerable proportion of material from consolidated, relatively monomineralic rock (Pettijohn, 1957). The fluids generated during such a process would facilitate the leaching of radiogenic Pb from zircon. Consequently there has to be some doubt on the authenticity of the age concentrations in this rock. The two major peaks in the Jacob Quartzite, at about 1250 Ma and 1850 Ma, are not present in the Detention quartzite. However, it is probable that such prominent peaks must at least broadly reflect source rock ages, regardless of any isotopic resetting. If this is so, the two relatively adjacent and penecontemporaneous quartzite samples were formed in substantial part from the

erosion of different source rocks. The data concentration at 1250 Ma would then provide an older limit for the time of deposition. But it would not be appropriate to extend that logic to the scatter of analyses extending down to about 1000 Ma.

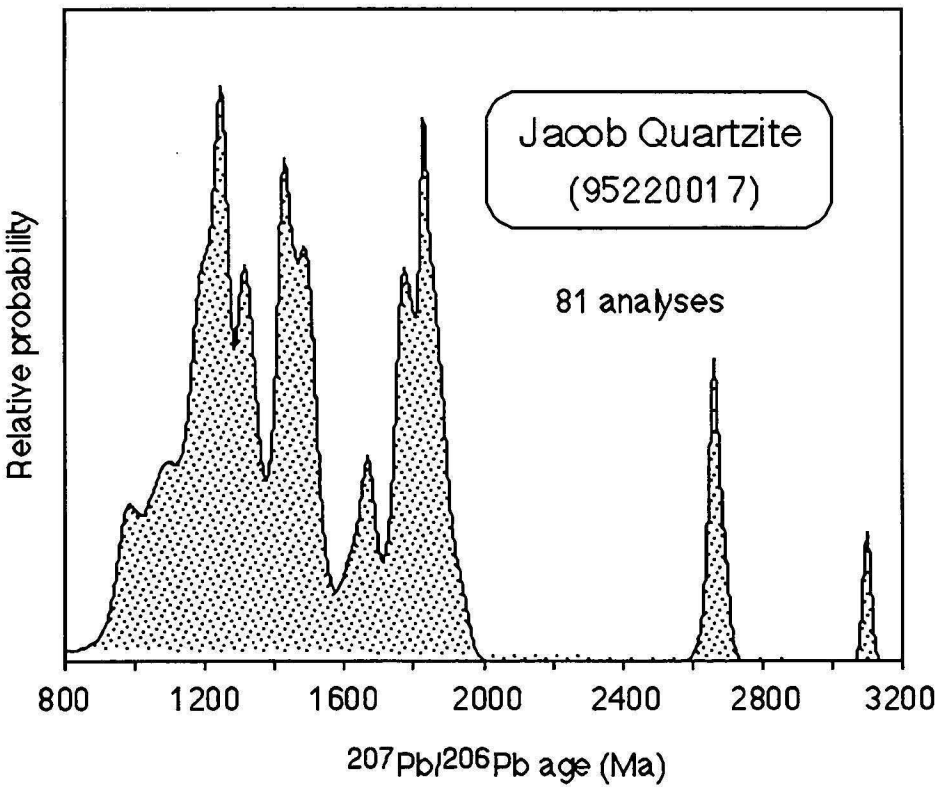

Fig. 18. Probability distribution diagram for detrital zircon grains from the Jacob Quartzite (95220017), Rocky Cape Element. The smearing of analyses between about 900 Ma and 2000 Ma does not occur in the other quartzite samples, and probably reflects a degree of *in situ* isotopic resetting (see text).

Needles Quartzite (sample 96220031)

This sample is a very pure, ripple-marked quartzite from a quarry in the Jubilee region of southern Tasmania. Pitting is variably developed on the quartz grains, which are all well rounded. The included zircon contains the oscillatory zoning that is typical of an igneous origin. Only two of the 131 zircon analyses proved to be less than 90 % concordant (Table 19). The remaining analyses define an age distribution (Fig. 19) that is broadly comparable with all of the other metasediments, excepting the stylolitised Jacob Quartzite. The four oldest grains yield Archaean ages between 2500 Ma and 3200 Ma. The twelve youngest analyses yield a combined age of 1412±11 Ma. But the very prominent data concentration is late Palaeoproterozoic. Although most of those analyses are close to 1700 Ma in age, that peak is obviously compound, and defines more than one source.

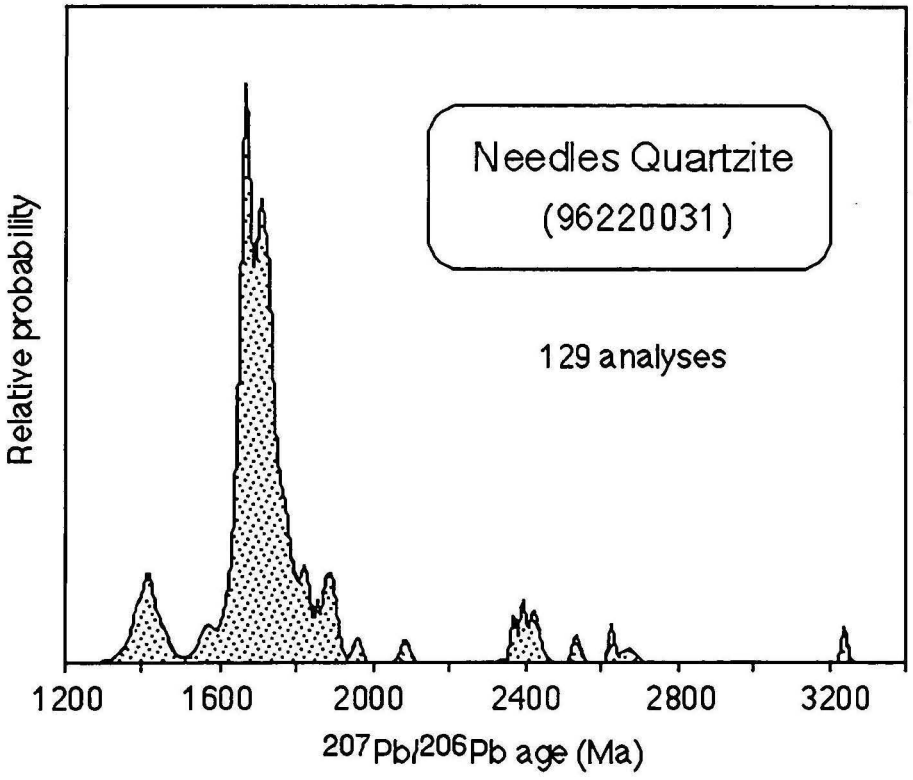

Fig. 19. Probability distribution diagram for detrital zircon grains from the Needles Quartzite (96220031). Most of the grains are about 1700 Ma old, but the approximately 1400 Ma peak is also important (see text).

Tyennan Element (sample 95220029)
This quite pure quartzite (98.86 % SiO_2) was collected from an old quarry adjacent to the Lyell Highway at the beginning of the walking track to Frenchmans Cap. The angular quartz grains in this rock are fairly poorly sorted. Most of the zircon, which is igneous in origin, is very well rounded and severely pitted.

Six of the 83 zircon analyses (Table 20) are less than 90 % concordant, and are discarded from further discussion. This sample has less Archaean content (only one or two latest Archaean ages) than the previously discussed quartzite samples. In addition, the youngest recognised (ie., ~1400 Ma and ~1200 Ma) components in the other quartzite samples are not present, with the most recent zircon in this rock being three grains that crystallised about 1590 Ma ago. Most of the data define a strongly bimodal distribution (Fig. 20) with contributing peaks at about 1700 Ma and 1770 Ma. There is also the suggestion of a small concentration of ages at about 1860 Ma.

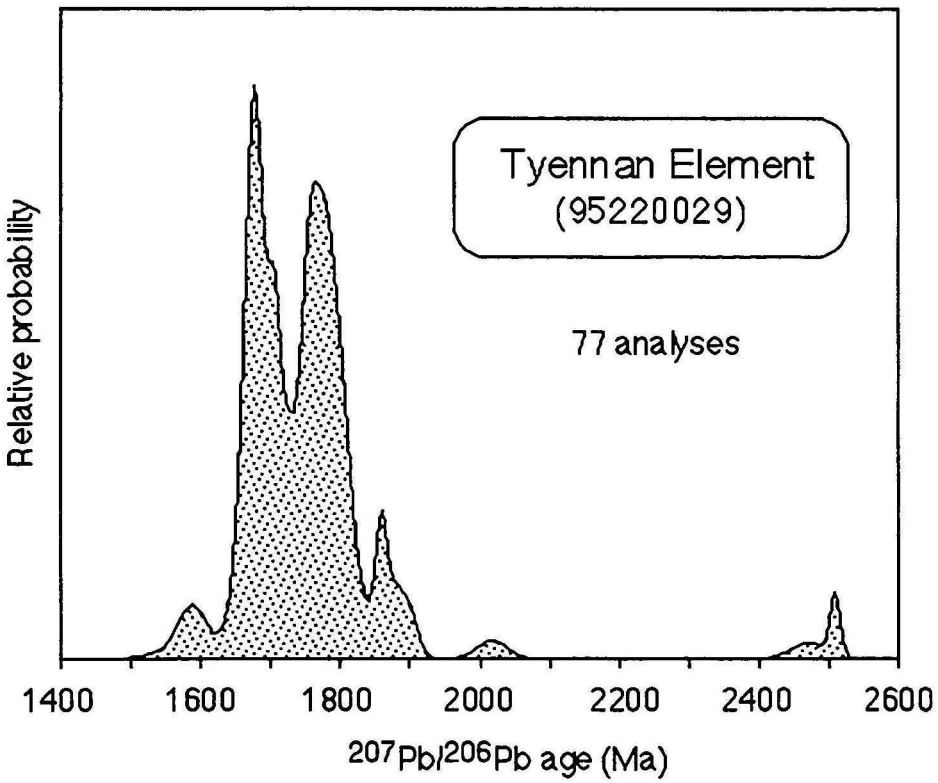

Fig. 20. Probability distribution diagram for detrital zircon grains from the Tyennan Element quartzite (95220029). The most prominent data concentrations are at about 1700 Ma and 1800 Ma. A distinctive feature of the diagram is a lack of ages less than about 1600 Ma (see text).

Oonah Formation (sample 95220027)
In contrast to the other samples, this is a very impure quartzite (79.84 % SiO_2) that is probably best described as a quartzwacke. It was collected from a turbiditic sequence adjacent to the Heemskirk road, about 7 km N of Zeehan. The angular to moderately rounded quartz grains in this rock coexist with biotite, muscovite, chlorite and ?limonite. Most of the zircon is well rounded, relatively equant, and moderately to strongly pitted.

Only three of the 84 analysed grains are less than 90 % concordant (Table 21). As before, the probability distribution diagram (Fig. 21) is broadly similar to all but the Jacob Quartzite. The Archaean component is more abundant, with at least 12, and perhaps 14, grains being of that age. These range from about 2500 Ma to more than 3100 Ma.

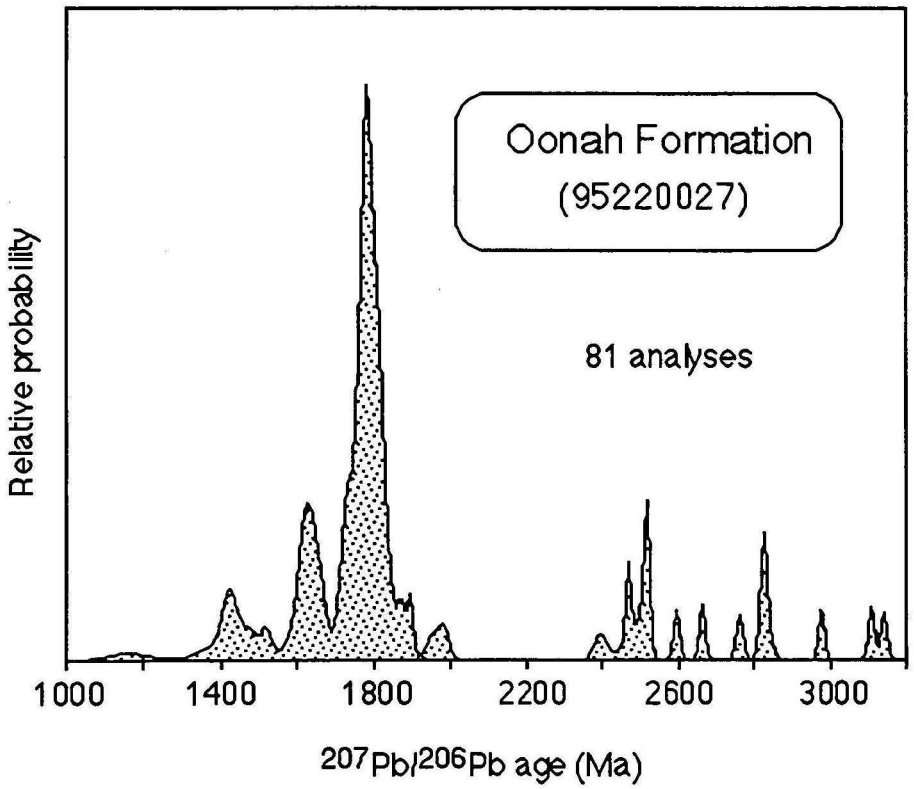

Fig. 21. Probability distribution diagram for detrital zircon grains from the Oonah Formation quartzite (95220027), revealing a major age concentration at about 1800 Ma.

Although the single (approximately 1200 Ma) grain at the young end of the age spectrum might provide a maximum age for the deposition of the quartzite, the Detention quartzite data demonstrate the possibility of post-depositional isotopic resetting, and it would therefore be unwise to rely on a single data point. The next five youngest analyses are at about 1400 Ma, which would form a more reliable older estimate of the depositional age. There is also an obvious concentration of data at about 1620 Ma. But it is the peak at about 1780 Ma, which encompasses more than half of the analyses, that dominates the data. Although it might not be apparent at this scale, this peak is composite, with complexities on both of its sides, signifying that it probably represents at least three different events.

Ulverstone Metamorphic Complex (sample 95220021)
This very pure (99.57 % SiO_2), well sorted quartzite was collected from Picnic Point at Ulverstone. Virtually all of the zircon in this rock is both well rounded and heavily pitted, in keeping with a quartzite of this maturity. The grains are of igneous derivation; a few are composed of distinct cores and overgrowths.

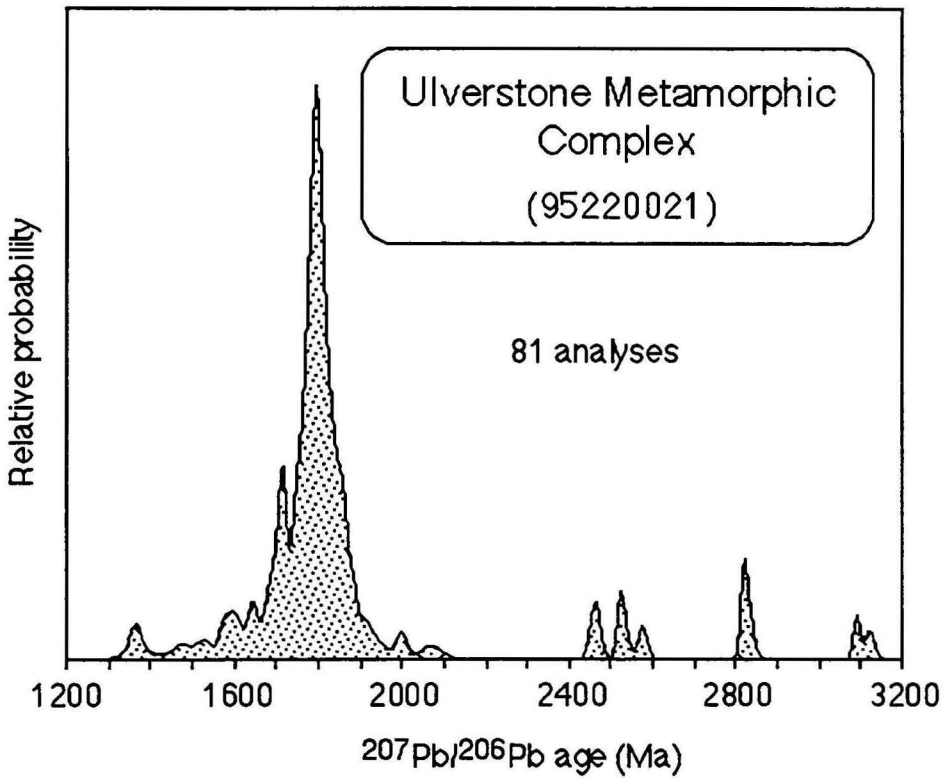

Fig. 22. Probability distribution diagram for detrital zircon grains from the quartzite from the Ulverstone Metamorphic Complex (95220021). The major peak is at about 1800 Ma, though a subordinate data concentration at about 1700 Ma is also apparent.

Only four of the 85 analysed grains are less than 90 % concordant (Table 22). As with the previous samples, the zircons are predominantly of Proterozoic age (Fig. 22). Eight are Archaean, and another two are possibly slightly younger. Two of the grains crystallised at about 3100 Ma, and another three at about 2800 Ma. The two youngest grains are slightly less than 1400 Ma, a relatively common feature for the quartzite samples. Above this there is a broad spread of individual ages up to the secondary peak at about 1710 Ma, and then the dominant peak at about 1800 Ma. Fig. 20 also reveals a subtle skewing of the main peak to older values, which is an indicator of the presence of a slightly older population.

Significance of the quartzite ages

Normally, the ages of detrital grains in a sedimentary rock are interpreted as providing an older limit for the time of deposition. Naturally, the younger the grains that are identified, the tighter the constraint. The data reported above for the Jacob Quartzite from the Rocky Cape Element show that caution must be exercised when applying this logic. It seems certain that fluids generated during pressure solution of quartzites are capable of causing significant loss of radiogenic Pb from zircon. Consequently, it would be most unwise to use any individual age, or even a small group of individual zircon ages, to define an older limit for sedimentation. The problem is partly overcome by using only concordant or near-concordant analyses. But this can be a relatively insensitive criterion for detecting Pb loss, because the resultant vectors are often sub parallel to, and therefore never particularly divergent from, the concordia curve.

The most contentious aspect of the quartzite dating is the significance of the 1200 Ma ages. If these faithfully record the original igneous crystallisation of those grains, they provide a valuable older limit for sedimentation. But, they might alternatively result from some degree of isotopic resetting. There are some relevant points to consider on this matter. First, the only quartzite to record that age with any regularity is the one which appears to have been isotopically disturbed. However, a substantial proportion

(23 %) of the zircon in that rock is within error of an age of 1220 Ma. Conversely, the other five quartzites yielded only two other grains of that age; only one of those occurred in the related Detention Subgroup sample. In their earlier study, Turner and others (in press) found five ~1200 Ma zircon grains in a metasedimentary rock from the Bowry Formation, and another grain in an adjacent granitoid. 1200 Ma grains have not been documented elsewhere in the region. If these ages reflect a real igneous event, it is likely to have been of a localised nature. Otherwise, such grains would be much more common not only in the other quartzites, but also as xenocrysts in the igneous rocks.

The significance of the ~1400 Ma zircons is much clearer. Zircons of that age are present in five of the six studied quartzite samples (Tables 17-22, Figs. 17-22). This component constitutes nearly 20 % of the Detention quartzite zircon, and a similar proportion is apparently present in the contentious Jacob Quartzite sample, which is also from the Rocky Cape Element. It represents about 9 %, 6 % and 2% of the Needles, Oonah and Ulverstone zircon populations, respectively. 1400 Ma must therefore have been a time of significant regional geological activity, especially in the vicinity of the Rocky Cape Element. On the basis of detrital and xenocrystic zircon data, Turner and others (in press) also identified 1400 Ma as an important time in the geological evolution of this part of Tasmania. The presence of 1400 Ma detrital zircons in all but one of the quartzite samples indicates that this is a reliable older estimate for their sedimentary deposition. But does their absence in the Tyennan quartzite signify that rocks of that age were not locally available as a source terrane? Or could the Tyennan succession be older than the others? This intriguing matter is currently unresolved.

Regionally important ages would be expected to be frequent and more widely represented in the detrital zircon from the different samples. On that reasoning, a ~1710 Ma event can be argued to be fundamentally important to western Tasmania. Significant populations of that age occur in all but the enigmatical Jacob Quartzite. Using the same argument, the ~30 million-year interval following 1800 Ma was also most important to the evolution of western Tasmania. A significant proportion of zircon from each of the five non-problematical quartzite samples records an age during that interval.

It is even more difficult to correlate earlier Proterozoic igneous activity between the different source terranes. Not only is there a wider spread of ages in the 100 million years prior to 1800 Ma, but there is also less zircon recording those ages. The Detention quartzite preserves essentially no evidence at all of that interval.

Considering the elapsed time since the growth of the oldest recorded zircon (3200 Ma) in this region, the Archaean is under-represented in its contribution to the analysed rocks. This is because even though zircon is relatively resistant to chemical and physical breakdown, it still has a finite life. If the clastic sediments were directly sourcing Archaean rocks they would be expected to contain more zircon of that age. Therefore, the remaining Archaean grains are the survivors of more than one sedimentary cycle, which has destroyed most similarly aged grains. The relative frequency of 1400 Ma - 1900 Ma zircons should signify derivation from relatively nearby igneous rocks of that age, and it is unlikely that considerable lateral transportation was involved.

The probability distribution diagrams (Figs. 17-22) and Tables 17 to 22 demonstrate variation in the relative proportions of the ~1700 Ma and ~1800 Ma components in the different quartzites. Both the Ulverstone and Oonah occurrences are dominated by ~1800 Ma zircon, whereas the ~1700 Ma component is dominant in the Needles and the Detention quartzite samples. The Tyennan quartzite has an approximately equal proportion of those populations. The most logical interpretation of these and younger ages (at least to ~1400 Ma) from the quartzite samples is to conclude that similarly aged rocks existed (and presumably still exist) as basement beneath the Proterozoic sedimentary sequences of northern and western Tasmania. It was beyond the scope of

this study to determine whether any of the igneous source rocks for the quartzite samples still crop out in the region, although no likely candidates have yet been discovered in regional mapping programs. However, a significant portion of northwestern Tasmania has never been subject to systematic geological mapping at any scale, and so the possibility of outcropping pre-Mesoproterozoic basement rocks cannot be discounted.

FUTURE DIRECTIONS

The prime objective of this study has been to better define and more precisely date the main tectonic events in the geological evolution of western Tasmania. The accomplishment of this goal has raised some new issues, and identified ways in which these might be examined. Listed below, in decreasing order of priority, are the thirteen most pressing matters to be addressed by future geochronology.

1. Re-analysis of the Lyell Highway eclogite with the QGNG standard would allow direct comparison with the ages obtained for the Heazlewood Ultramafic Complex and the amphibolite-facies metamorphism in the Forth Metamorphic Complex.
2. If the relatively mafic volcanics in the Glenorchy DDH crystallised zircon, it would be possible to confirm or refute their correlation with the Mount Read Volcanics.
3. Resampling the Jacob Quartzite away from the strain effects of the Arthur Lineament would reveal if the young part of its zircon age spectrum is either related to that structure or is of purely detrital origin.
4. Determining the age pattern of detrital zircons from quartzite in the Burnie Formation should show if it is of comparable age to the Oonah Formation.
5. Determining the age pattern of detrital zircons from the top of the Oonah Formation would allow comparison with previously obtained detrital K-Ar mica ages.
6. The study of detrital zircon populations in fault-bounded Precambrian blocks on the Sorell Peninsula, western Tasmania, would provide important information for the correlation of these rocks with the Precambrian elements investigated in this study.
7. The study of detrital zircon populations in sandstones from the top, middle and base of the Palaeozoic Mathinna Group of northeastern Tasmania, would allow comparison with patterns in the Proterozoic quartzite samples, and the changing nature of source terranes in that time. The data might also facilitate the modelling of the zircon age-patterns in the Precambrian metasediments.
8. Examining detrital zircon patterns in the Wings Quartzite (from a fault-bounded block of the ?Jubilee Element) and in metaquartzite from Mount Arrowsmith should help in correlation with currently studied regions.
9. The comparison of inherited zircon patterns in S- and I-type granites from western and eastern Tasmania could provide relevant information for the interpretation of deep seismic data.
10. Crustal xenoliths from Tertiary basalts near Weldborough and Scottsdale should provide information on the age of the deep crust in that region.
11. Should they contain cogenetic zircon, it will be possible to date mafic lavas and associated gabbros in the Togari Group of the ?Smithton Synclinorium .
12. High-grade metamorphic xenoliths within lamprophyre dykes at Point Hibbs, southwest Tasmania, could provide important information on the age of the deep crust in that region.
13. Acid volcanic clasts from diamictites in the Togari Group are of unknown age and origin, but should contain zircon for direct dating.

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Table 1. Grid references of the samples analysed in this study.

Sample number	Rock type	metres east	metres north
93220003	tonalite, Heazlewood Ultramafic Complex	358200	5405760
93220009	feldspar porphyry dyke, King Island	743100	5574600
93220010	porphyritic adamellite, King Island	753650	5614200
93220011	even grained granodiorite, King Island	744200	5573600
95220013	Bonds Range Porphyry	408967	5398668
95220015	Cooee Dolerite*	407700	5455786
95220016	quartzite, Detention Subgroup	370072	5459892
95220017	Jacob Quartzite	371272	5452026
95220018	amphibolite, Arthur Metamorphic Complex*	368626	5441912
95220019	Cooee Dolerite*	406932	5455384
95220020	garnet amphibolite, Forth Metamorphic Complex	436457	5437531
95220021	quartzite, Ulverstone Metamorphic Complex	429590	5445193
95220022	Lobster Creek Volcanics	420701	5441978
95220023	Minnow Keratophyre	444428	5408747
95220024	Beulah Granite	447437	5410830
95220025	Winterbrook lava	416504	5412064
95220026	ignimbrite, Tyndall Group	395419	5398629
95220027	quartzwacke, Oonah Formation	356626	5366793
95220028	Mount Jukes lava	382921	5331297
95220029	quartzite, Tyennan Nucleus	415599	5326676
96220031	Needles Quartzite	477000	5234900
96220032	Noddy Creek Volcanics	368700	5296200

* no zircons were recovered from these samples

Table 2. Major and trace element analyses of the newly dated samples.

Sample	0009	0010	0011	0013	0028	0023	0025	0026	0022	0024	0020	0016	0017	0029	0027	0021
Major elements (%)																
SiO_2	62.27	72.45	67.78	65.21	73.19	64.75	70.71	70.41	67.74	59.55	48.12	99.05	98.59	98.86	79.84	99.57
TiO_2	0.69	0.27	0.55	0.61	0.29	0.67	0.4	0.44	0.4	0.57	1.23	0.02	0.02	0.03	0.61	0.05
Al_2O_3	15.65	14.51	14.87	13.72	12.62	14.92	14.12	14.13	15.36	15.18	14.69	0.32	0.46	0.54	9.92	0.25
Fe_2O_3	1.28	2.15	3.56	1.75	1.2	1.52	1.22	1.17	1.56	2.47	2.65	0	0.06	0.02	0.98	0.06
FeO	3.41			2.93	1.63	4.04	1.56	1.17	3.01	4.12	8.99	0	0	0.01	2.31	0
MnO	0.07	0.03	0.06	0.07	0.15	0.11	0.05	0.04	0.13	0.11	0.2	0	0	0	0.03	0
MgO	2.21	0.63	1.29	3.21	0.68	1.39	0.97	0.82	1.42	2.85	8.95	0.03	0.02	0.04	1.06	0.02
CaO	4.6	1.23	2.55	3.32	0.81	3.86	1.14	0.89	0.19	4.47	9.76	0.01	0	0	0.01	0
Na_2O	3.47	2.58	2.65	2.01	2.52	3.43	4.64	4.9	6.43	2.7	2.5	0	0	0	0.08	0
K_2O	2.04	5.42	4.75	4.13	4.57	2.48	3.51	3.68	2.04	5.01	0.33	0.12	0.18	0.2	2.26	0.12
P_2O_5	0.29	0.12	0.14	0.16	0.05	0.14	0.08	0.09	0.1	0.34	0.12	0.01	0.01	0.01	0.06	0.01
loi	3.82			2.35	2.39	2.39	1.5	1.71	1.78	2.34	1.66	0.39	0.14	0.17	2.84	0.1
rest	0.25			0.28	0.2	0.31	0.19	0.28	0.11	0.26	0.06	0.02	0.03	0.03	0.12	0.04
Total	100.25	99.47	98.30	99.75	100.30	100.07	100.09	99.73	100.27	99.97	99.26	99.97	99.51	99.91	100.12	
	100.22															
Trace elements (ppm)																
Ag	3			-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
As	-0.5			2	0.3	3.3	1.3	0.4	-0.2	3.2	-0.2	-0.2	-0.2	-0.2	2.8	-0.2
Ba	693			1016	1156	867	1026	1371	202	1200	114	10	53	9	283	89
Be	3			3	2.1	2.4	1.8	1.4	0.8	3.7	0.6	-0.1	0.2	0.1	1.6	-0.1
Bi	-2			-2	0.1	-0.1	0.1	-0.1	-0.1	0.2	-0.1	-0.1	-0.1	-0.1	0.2	-0.1
Ce	95			98	106.4	97.1	99.6	105	58.1	132.1	19.4	11.7	11.3	12.7	88.5	19.3
Cr	47			134	2	5	4	9	21	50	393	3	2	8	37	5
Cs	3			6	2.7	1.4	5.8	0.8	0.5	1.6	-0.1	0.1	0.5	0.4	4.1	0.2
Cu	40			17	2	6	5	1	2	18	88	2	2	3	13	2
Dy					6.5	6.4	5.7	5.3	3.6	5.3	4.8	0.9	0.9	0.6	4.5	1.1
Er					4.3	4.1	3.7	3.3	2.5	2.9	3.3	0.5	0.6	0.4	2.8	0.7
Eu					1.5	2.3	1.7	1.8	0.9	2.4	1.1	0.1	0.2	0.2	1.1	0.3
F					1000	500	1300	-200	-200	1100	900	-200	-200	-200	600	-200
Ga	20	20	18	16	13.8	17.2	13.8	13.3	15.7	15.9	14.6	1	0.6	0.8	12.1	0.5
Gd					7.2	7.4	6.6	6.7	3.9	7.9	4.3	1	0.9	0.8	5.2	1.3
Ge	1			2	1.4	1.3	1.7	0.7	1.2	1.5	1.4	0.9	1	1.1	1.9	1.1
Hf	6			2.3	6.2	8.7	4.8	4.5	3	4.1	0.7	0.9	0.8	2	6	1.6
Ho					1.5	1.4	1.3	1.1	0.8	1.1	1.1	0.2	0.2	0.1	1	0.2
La	48			49	49.6	45.1	49.5	49.6	26.9	66.1	8.6	5.7	61	6.3	40.2	8.9
Li	29			14	5	17	10	5	14	21.5	17.5	-0.5	0.5	0.5	21.5	-0.5
Lu					0.6	0.6	0.5	0.5	0.4	0.4	0.5	-0.1	-0.1	-0.1	0.4	-0.1
Mo	-2			-2	0.2	1.3	0.4	0.4	0.8	101	0.6	0.8	0.9	0.6	0.6	1
Nb	30	20	22	16	11.8	17.8	13.6	13	7.8	12	10.9	-0.1	-0.1	0.1	12.2	-0.1
Nd	34			44	43	41.5	39.7	41.3	23.5	51.8	11.2	5.6	5.3	5.9	35	8.6
Ni	22			47	1	0.5	0.5	1	30.5	15.5	137	1	1.5	0.5	16.5	1
Pb	16	38	23	38	6.5	45	4.5	2	3	5.5	2	1	1	1.5	6	-0.5
Pr	8			11	11.6	10.8	10.7	11.3	6.3	14.2	2.4	1.4	1.4	1.5	9.5	2.2
Rb	76	290	278	174	144	65	103	79	48	188	6	3	6	5	91	4
S	350			730	70	250	150	60	50	100	4340	50	30	30	100	30
Sb					0.7	0.3	0.4	0.6	0.4	0.8	-0.1	-0.1	-0.1	0.2	0.3	0.1
Sc	11			14	7	16.5	10.5	10.5	9	19	42	-0.5	-0.5	-0.5	8	-0.5
Sm					8.2	8	7.2	7.8	4.3	9.3	3.1	1.1	1.1	1.3	6.4	1.6
Sn	4			4	2.5	1.5	2	1.5	-0.5	2	0.5	-0.5	-0.5	-0.5	2.5	-0.5
Sr	458	92	103	269	63	513	245	188	42	172	77	2	2	1	10	4
Ta	-2			3	1.2	1.4	1.3	1.3	0.9	1.1	1	-0.1	-0.1	-0.1	1.5	-0.1
Tb					1.1	1.1	1	1	0.6	1.1	0.8	0.2	0.2	0.1	0.8	0.2
Th	16	24	20	25	21.7	13.9	15.8	14.6	8.6	26.1	1.2	1.5	1.3	2.1	13.7	0.8
U	4.5	5	4	7.5	5.1	3.6	4	3.5	1.7	5.2	0.5	0.5	0.3	0.6	3.2	0.4
V	87			99	9	46	34	40	65	158	305	-1	2	3	41	3
Y	25	35	37	38	38	37	33.5	29	22	28	28.5	5	5	3	24	6.5

Yb					4	3.8	3.5	3.1	2.5	2.5	3.1	0.4	0.5	0.4	2.8	0.6
Zn	70	42	44	58	47	204	44	27	36	81	102	-1	-1	-1	20	-1
Zr	231	115	158	247	288	616	269	269	169	197	73	36	65	101	337	99

The first three sample numbers are prefixed by 9322, the others by 9522. Analyses of 93220010 and 93220011 are from Streit (1994); in these, total iron concentrations are expressed in terms of Fe_2O_3. All of the other analyses were done in the AGSO geochemical laboratories. Except for FeO being measured by titrimetry, all major elements were determined by XRF. Trace elements for samples 93220009 and 95220013 were determined by XRF. Most of the trace elements for the remaining samples were determined by ICPMS, though some were measured by XRF. These details are available from the author on request. loi is loss on ignition; rest is a summation of the trace elements as oxides. An absence of a value means that no attempt was made to analyse that element in the particular sample (the saamples being analysed in four different batches over a period of several years). Analyses which failed to detect any particular element are prefaced with a negative value, the positive counterpart of which is the limit of detection for that element.

Table 3. U-Th-Pb isotopic composition of zircons from the porphyritic adamellite (93220010) at King Island.

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
1.1	2125	178	0.084	66	26.888	0.1051±.0026	0.918±.048	0.0633±.0027	719±95	89
2.1	5542	684	0.123	48	36.506	0.2305±.0105	2.264±.146	0.0712±.0029	964±84	138
3.1	317	149	0.471	68073	0.026	0.1201±.0026	1.075±.025	0.0649±.0004	771±13	94
3.2	569	198	0.348	62500	0.029	0.1178±.0025	1.050±.023	0.0646±.0003	761±9	94
4.1	1950	123	0.063	52	34.103	0.1254±.0034	1.308±.099	0.0756±.0051	1084±141	70
5.1	305	160	0.525	29274	0.061	0.1204±.0094	1.059±.084	0.0638±.0005	734±17	99
5.2	488	202	0.414	2476	0.720	0.1208±.0025	1.082±.027	0.0650±.0007	773±22	95
6.1	528	174	0.330	2982	0.598	0.1231±.0025	1.095±.024	0.0645±.0004	759±13	98
7.1	401	260	0.649	1977	0.902	0.1256±.0027	1.126±.028	0.0650±.0007	775±22	98
8.1	492	205	0.417	265	6.715	0.1229±.0028	1.087±.054	0.0641±.0027	745±90	100
9.1	154	180	1.162	108577	0.016	0.5320±.0121	13.605±.312	0.1855±.0003	2702±2	101
10.1	418	187	0.449	636942	0.003	0.3343±.0072	5.233±.117	0.1135±.0005	1856±8	100
11.1	133	74	0.556	14972	0.119	0.2789±.0061	3.869±.089	0.1006±.0004	1635±7	96
12.1	531	144	0.271	173	10.264	0.2058±.0043	2.819±.076	0.0993±.0015	1611±28	74
13.1	222	110	0.496	19361	0.080	0.3264±.0114	4.865±.178	0.1081±.0008	1767±13	103
14.1	101	47	0.469	96339	0.016	0.2751±.0064	3.875±.093	0.1021±.0004	1663±7	94
15.1	536	146	0.272	1000000	0.001	0.2928±.0065	4.335±.098	0.1073±.0002	1755±2	94
16.1	211	75	0.353	1794	0.876	0.2660±.0060	3.805±.095	0.1037±.0009	1691±15	89

Table 4. U-Th-Pb isotopic composition of zircons from the even grained granodiorite (93220011) on King Island.

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
51.1	1404	366	0.261	4731	0.377	0.1040±.0072	0.929±.066	0.0648±.0006	766±19	121
52.1	1004	672	0.670	27770	0.064	0.1174±.0024	1.041±.022	0.0643±.0002	750±5	95
53.1	1665	352	0.212	1000000	0.000	0.1208±.0039	1.074±.035	0.0645±.0002	758±5	97
54.1	735	247	0.336	77519	0.023	0.1152±.0055	1.019±.049	0.0642±.0002	747±8	94
55.1	1421	435	0.306	143472	0.012	0.1209±.0026	1.069±.023	0.0641±.0001	745±4	98
56.1	1090	269	0.247	1000000	0.000	0.1209±.0026	1.074±.023	0.0645±.0001	756±4	97
57.1	1586	342	0.216	1000000	0.000	0.1169±.0024	1.038±.022	0.0644±.0001	753±3	94
58.1	721	303	0.421	127713	0.014	0.1073±.0035	0.950±.031	0.0642±.0002	746±5	88
59.1	2525	640	0.254	135685	0.013	0.1173±.0025	1.038±.022	0.0641±.0001	746±2	95
60.1	550	486	0.885	91575	0.019	0.1180±.0024	1.047±.022	0.0643±.0002	752±6	95
61.1	1076	352	0.328	256410	0.007	0.1212±.0030	1.066±.027	0.0638±.0001	734±4	100
62.1	1624	511	0.314	293255	0.006	0.1204±.0027	1.064±.024	0.0641±.0001	745±3	98
63.1	688	228	0.332	144508	0.012	0.1217±.0027	1.077±.024	0.0642±.0002	748±5	99
63.2	965	275	0.285	105708	0.017	0.1080±.0024	0.955±.022	0.0641±.0002	746±5	88
64.1	1186	351	0.296	22456	0.078	0.1225±.0027	1.088±.025	0.0644±.0003	755±8	98
64.2	821	367	0.448	14277	0.123	0.1136±.0026	1.007±.024	0.0642±.0002	749±7	92
65.1	1281	247	0.193	15021	0.117	0.1259±.0029	1.112±.027	0.0641±.0002	744±7	102
66.1	708	197	0.279	120192	0.015	0.1237±.0028	1.092±.025	0.0641±.0002	743±6	101
66.2	1106	224	0.203	303951	0.006	0.1221±.0027	1.078±.025	0.0640±.0001	741±4	100
67.1	1090	286	0.263	112739	0.016	0.1267±.0028	1.126±.026	0.0644±.0002	755±5	101
67.2	1046	264	0.253	9845	0.178	0.1165±.0026	1.037±.024	0.0646±.0003	759±10	93
68.1	585	335	0.574	1000000	0.000	0.1225±.0030	1.092±.027	0.0646±.0002	762±6	97
69.1	931	361	0.388	100000	0.018	0.1230±.0027	1.086±.025	0.0640±.0001	742±4	100
70.1	609	214	0.352	74850	0.023	0.1200±.0027	1.060±.025	0.0641±.0003	744±8	98
71.1	984	530	0.539	104931	0.017	0.1160±.0026	1.020±.023	0.0638±.0002	734±6	96
72.1	841	295	0.352	26609	0.066	0.1190±.0029	1.053±.026	0.0642±.0002	748±5	96
73.1	1429	834	0.584	17003	0.103	0.1221±.0027	1.085±.025	0.0644±.0002	755±5	98
74.1	523	177	0.339	401606	0.004	0.1162±.0030	1.027±.027	0.0641±.0002	746±5	94
75.1	1174	342	0.292	68870	0.025	0.1301±.0077	1.120±.077	0.0625±.0018	690±62	114
75.2	155	94	0.612	11792	0.133	0.2855±.0114	4.025±.166	0.1022±.0007	1665±12	97
76.1	2113	558	0.264	14402	0.122	0.1171±.0027	1.037±.025	0.0642±.0002	749±7	95
77.1	749	118	0.157	257731	0.007	0.1204±.0027	1.063±.024	0.0641±.0002	743±5	98
78.1	1496	313	0.209	12616	0.139	0.1150±.0026	1.015±.024	0.0640±.0002	743±8	94
78.2	161	63	0.390	36954	0.044	0.2373±.0055	2.962±.071	0.0905±.0004	1436±8	95
79.1	441	208	0.471	167504	0.010	0.1138±.0025	1.011±.023	0.0644±.0002	754±7	92
80.1	105	50	0.476	2682	0.608	0.1676±.0039	2.036±.054	0.0881±.0009	1384±20	72
81.1	187	40	0.215	1000000	0.023	0.2801±.0065	4.104±.101	0.1063±.0006	1736±11	91

Table 5. U-Th-Pb isotopic composition of zircons from the porphyry dyke (93220009) on King Island.

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
1.1	617	273	0.443	1718	0.302	0.0556±.0012	0.424±.014	0.0554±.0013	349±7	-
2.1	1059	758	0.715	2592	0.593	0.0584±.0012	0.427±.014	0.0531±.0012	366±7	-
3.1	763	203	0.266	2059	0.689	0.0574±.0012	0.429±.012	0.0542±.0009	360±7	-
4.1	943	776	0.824	1468	1.016	0.0540±.0011	0.394±.015	0.0530±.0016	339±7	-
5.1	666	477	0.716	297	5.783	0.0575±.0012	0.429±.019	0.0540±.0019	360±7	-
6.1	1209	1281	1.059	289	6.014	0.0565±.0012	0.434±.017	0.0557±.0018	354±7	-
7.1	702	350	0.498	4735	0.331	0.0551±.0012	0.403±.014	0.0531±.0013	346±7	-
8.1	1511	909	0.601	834	1.909	0.0538±.0011	0.398±.012	0.0536±.0010	338±7	-
9.1	676	335	0.496	4527	0.151	0.0570±.0012	0.413±.014	0.0526±.0013	357±7	-
10.1	759	502	0.661	4711	0.3	0.0559±.0012	0.417±.015	0.0541±.0014	351±7	-
11.1	283	157	0.553	1771	0.569	0.0569±.0012	0.417±.020	0.0531±.0021	357±7	-
12.1	458	268	0.586	1176	1.124	0.0548±.0012	0.375±.016	0.0496±.0017	344±7	-
13.1	626	365	0.583	1134	2.15	0.0505±.0011	0.341±.015	0.0489±.0017	318±7	-
14.1	303	159	0.524	4623	0.694	0.0567±.0012	0.404±.019	0.0517±.0020	356±7	-
15.1	1043	278	0.267	7252	0.104	0.0551±.0012	0.415±.011	0.0546±.0008	346±7	-
16.1	456	193	0.423	605	1.97	0.0534±.0011	0.396±.016	0.0538±.0017	335±7	-
17.1	532	379	0.712	2817	0.904	0.0562±.0016	0.391±.020	0.0505±.0019	353±10	-
18.1	1212	209	0.173	4792	0.267	0.0562±.0016	0.424±.014	0.0547±.0007	353±10	-
19.1	550	105	0.191	2002	0.566	0.0553±.0016	0.411±.015	0.0539±.0011	347±10	-
20.1	238	163	0.687	2421	0.746	0.0578±.0017	0.427±.027	0.0536±.0028	362±10	-
21.1	1550	630	0.407	2590	0.269	0.0561±.0016	0.419±.014	0.0542±.0008	352±10	-
22.1	706	84	0.118	7996	0.211	0.0936±.0027	0.941±.031	0.0729±.0009	1011±27	57
23.1	452	277	0.613	4522	0.6	0.0558±.0016	0.396±.020	0.0515±.0020	350±10	-
24.1	570	259	0.454	958	1.049	0.0555±.0016	0.417±.018	0.0546±.0016	348±10	-
25.1	705	553	0.784	1521	0.699	0.0555±.0016	0.401±.020	0.0524±.0019	348±10	-
26.1	389	182	0.469	2183	0.677	0.0560±.0016	0.401±.020	0.0520±.0019	351±10	-
27.1	228	98	0.428	2277	1.336	0.0553±.0016	0.423±.024	0.0554±.0025	347±10	-
28.1	213	183	0.856	4465	0.348	0.3107±.0091	4.730±.157	0.1104±.0013	1806±22	97
29.1	457	280	0.614	882	0.709	0.0577±.0017	0.420±.022	0.0527±.0021	362±10	-
30.1	676	371	0.549	2161	0.498	0.0522±.0015	0.387±.017	0.0538±.0016	328±9	-
31.1	522	255	0.488	2013	1.037	0.0577±.0017	0.404±.017	0.0508±.0014	361±10	-
32.1	291	135	0.466	1480	1.151	0.0572±.0017	0.404±.020	0.0512±.0019	358±10	-

Table 6. U-Th-Pb isotopic composition of zircons from the Bonds Range Porphyry (95220013).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 s error	$^{207}Pb/^{235}U$ ±1 s error	$^{207}Pb/^{206}Pb$ ±1 s error	Age (Ma) ±1 s error	% conc
1.1	183	134	0.730	4818	0.580	0.0826±.0026	0.586±.034	0.0515±.0023	511±15	–
2.1	264	173	0.656	2859	0.526	0.0795±.0022	0.601±.030	0.0548±.0020	493±13	–
3.1	317	185	0.585	4731	0.244	0.0805±.0022	0.600±.029	0.0540±.0019	499±13	–
4.1	224	110	0.493	1000000	0.093	0.0841±.0023	0.663±.029	0.0572±.0018	520±13	–
5.1	243	101	0.418	11231	0.160	0.1679±.0043	2.073±.092	0.0896±.0030	1416±65	70
6.1	224	127	0.565	4093	0.445	0.0823±.0024	0.607±.040	0.0535±.0030	510±14	–
7.1	317	182	0.575	1000000	0.455	0.0799±.0022	0.589±.025	0.0535±.0016	495±13	–
8.1	191	122	0.638	2441	1.229	0.0812±.0022	0.585±.034	0.0522±.0025	503±13	–
9.1	350	296	0.847	10762	0.656	0.0862±.0024	0.624±.029	0.0525±.0018	532±14	–
10.1	153	91	0.597	1000000	0.433	0.0773±.0023	0.602±.032	0.0564±.0023	480±13	–
11.1	168	145	0.868	27809	0.622	0.0774±.0023	0.550±.037	0.0516±.0029	480±14	–
12.1	276	197	0.714	8322	0.373	0.0828±.0023	0.637±.031	0.0558±.0021	513±13	–
13.1	296	178	0.603	1000000	0.159	0.0801±.0022	0.640±.029	0.0580±.0019	496±13	–
14.1	284	187	0.658	6646	0.633	0.0806±.0022	0.620±.030	0.0558±.0021	499±12	–
15.1	169	104	0.617	8944	0.426	0.0792±.0023	0.603±.032	0.0553±.0022	491±13	–
16.1	145	122	0.838	8964	0.076	0.0823±.0027	0.659±.044	0.0581±.0032	509±15	–
17.1	297	190	0.640	19643	0.410	0.0790±.0023	0.580±.032	0.0533±.0023	489±13	–
18.1	315	169	0.537	39017	0.220	0.0847±.0022	0.655±.026	0.0561±.0015	524±13	–
20.1	256	190	0.741	9149	0.558	0.0844±.0024	0.617±.040	0.0530±.0029	522±14	–
21.1	249	136	0.546	4007	0.206	0.0813±.0024	0.611±.031	0.0545±.0020	503±14	–
22.1	182	119	0.656	1000000	0.989	0.0798±.0023	0.576±.038	0.0523±.0029	495±14	–
23.1	144	98	0.678	3466	0.706	0.0810±.0024	0.591±.039	0.0529±.0030	502±14	–
24.1	220	160	0.729	4767	0.100	0.0800±.0023	0.622±.038	0.0564±.0028	495±13	–
25.1	226	153	0.677	1000000	6.563	0.0890±.0027	0.744±.146	0.0606±.0116	549±16	–
26.1	401	250	0.624	8718	0.206	0.0797±.0027	0.613±.033	0.0558±.0021	494±15	–
27.1	289	179	0.620	1000000	0.337	0.0824±.0024	0.623±.031	0.0549±.0020	510±14	–
28.1	135	74	0.553	1000000	0.214	0.0820±.0026	0.633±.043	0.0560±.0032	508±15	–
29.1	297	173	0.581	18629	0.131	0.0826±.0023	0.638±.029	0.0560±.0018	511±13	–
30.1	168	112	0.670	100000	0.172	0.0802±.0023	0.645±.039	0.0583±.0029	497±13	–

Table 7. U-Th-Pb isotopic composition of zircons from the Mount Jukes lava.

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
202.2	205	105	0.511	4975	0.291	0.0796±.0019	0.665±.028	0.0605±.0019	493±11	–
203.2	108	44	0.408	100000	0.128	0.0793±.0026	0.637±.037	0.0582±.0026	492±15	–
204.2	274	195	0.713	1000000	0.000	0.0794±.0019	0.631±.028	0.0576±.0020	492±11	–
211.2	247	156	0.629	1000000	0.000	0.0833±.0019	0.666±.024	0.0580±.0014	515±11	–
212.2	163	84	0.518	5987	0.140	0.0823±.0023	0.635±.031	0.0559±.0020	510±13	–
214.2	113	70	0.620	1000000	0.000	0.0817±.0022	0.657±.037	0.0583±.0027	506±13	–
220.2	148	92	0.625	1000000	0.000	0.0782±.0025	0.661±.039	0.0613±.0029	485±14	–
222.3	264	69	0.262	1709	0.942	0.0897±.0022	0.723±.023	0.0584±.0010	554±12	–
222.4	101	50	0.496	4286	0.067	0.0787±.0022	0.592±.042	0.0546±.0033	488±13	–
224.2	127	86	0.677	1000000	0.000	0.0799±.0019	0.641±.038	0.0582±.0030	495±11	–
225.2	190	149	0.783	4925	0.000	0.0792±.0020	0.684±.028	0.0627±.0018	491±11	–
226.2	66	44	0.666	1000000	0.000	0.0845±.0024	0.678±.040	0.0583±.0028	522±14	–
226.3	130	43	0.327	2335	0.362	0.0858±.0023	0.703±.028	0.0594±.0016	530±13	–
227.2	130	83	0.635	4924	0.108	0.0796±.0022	0.616±.033	0.0561±.0024	493±13	–
229.1	134	73	0.544	100000	0.232	0.0825±.0023	0.643±.033	0.0566±.0022	511±13	–
230.1	189	249	1.318	7952	0.096	0.0803±.0022	0.608±.051	0.0549±.0041	498±13	–
231.1	56	32	0.568	2665	0.000	0.0812±.0039	0.694±.061	0.0620±.0043	502±23	–
232.1	123	78	0.633	341	4.689	0.0821±.0025	0.600±.041	0.0531±.0030	508±14	–
233.1	273	193	0.706	9409	0.000	0.0836±.0020	0.702±.025	0.0609±.0014	517±11	–
234.1	133	88	0.661	28360	0.000	0.0829±.0022	0.650±.030	0.0568±.0020	513±12	–
235.1	176	117	0.663	10547	0.000	0.0802±.0020	0.668±.032	0.0604+.0023	497±11	–
236.1	235	111	0.471	9368	0.118	0.0801±.0020	0.629±.023	0.0569±.0014	496±11	–
237.1	300	152	0.506	1000000	0.047	0.0825±.0020	0.679±.023	0.0597±.0013	511±11	–
238.1	153	87	0.567	1000000	0.135	0.0833±.0020	0.657±.027	0.0572±.0017	515±12	-

Table 8. U-Th-Pb isotopic composition of zircons from the Minnow Keratophyre (95220023).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
1.1	279	116	0.416	4383	0.620	0.0780±.0025	0.623±.025	0.0579±.0013	484±14	–
1.2	146	135	0.922	111	16.912	0.0772±.0022	0.580±.053	0.0544±.0045	479±13	–
2.1	287	160	0.557	4697	0.358	0.0819±.0025	0.671±.027	0.0594±.0014	507±14	–
2.2	104	49	0.476	4525	0.000	0.0794±.0023	0.669±.034	0.0611±.0024	492±13	–
3.1	94	43	0.458	1217	1.525	0.0801±.0032	0.671±.043	0.0608±.0027	496±18	–
3.2	74	39	0.531	1370	1.036	0.0770±.0028	0.631±.047	0.0595±.0036	477±16	–
4.1	155	75	0.485	6972	1.155	0.0762±.0031	0.583±.034	0.0555±.0020	473±18	–
4.2	173	84	0.485	9912	0.000	0.0823±.0020	0.662±.027	0.0583±.0017	509±11	–
5.1	60	31	0.517	540	4.927	0.0824±.0029	0.669±.044	0.0589±.0030	510±17	–
5.2	143	55	0.385	1000000	0.076	0.0792±.0022	0.661±.028	0.0605±.0018	491±12	–
6.1	294	138	0.470	3449	1.058	0.0819±.0024	0.616±.023	0.0545±.0011	507±14	–
7.1	229	117	0.509	1272	0.663	0.0820±.0027	0.646±.030	0.0571±.0016	508±16	–
8.1	82	33	0.412	552	2.305	0.0835±.0033	0.630±.046	0.0547±.0031	516±19	–
8.2	90	46	0.511	249	5.605	0.0830±.0025	0.681±.043	0.0595±.0031	513±14	–
9.1	53	24	0.449	1078	3.008	0.0813≠.0029	0.607±.039	0.0541±.0026	503±17	–
9.2	68	32	0.476	406	1.381	0.0816±.0026	0.709±.046	0.0631±.0033	505±15	–
10.1	278	131	0.474	5955	0.792	0.0789±.0023	0.605±.021	0.0557±.0010	489±13	–
11.1	284	157	0.554	4219	0.809	0.0810±.0023	0.594±.022	0.0532±.0011	501±13	–
11.2	95	50	0.534	1804	0.401	0.0790±.0025	0.620±.035	0.0569±.0025	490±14	–
12.1	98	54	0.552	1412	2.341	0.0820±.0027	0.652±.033	0.0576±.0019	508±16	–
13.1	70	37	0.528	1197	1.853	0.0815±.0026	0.625±.033	0.0557±.0021	504±15	–
13.2	74	35	0.472	1058	1.289	0.0799±.0026	0.640±.047	0.0581±.0036	495±15	–
14.1	88	41	0.470	1613	1.632	0.0766±.0025	0.644±.037	0.0610±.0026	475±14	–
14.2	55	29	0.526	1000000	0.376	0.0823±.0027	0.635±.040	0.0559±.0028	509±16	–
15.1	133	120	0.903	1354	1.657	0.0796±.0025	0.602±.033	0.0548±.0023	493±14	–
15.2	55	30	0.542	2189	0.280	0.0809±.0029	0.628±.048	0.0563±.0035	501±17	–
16.1	167	70	0.423	7399	0.799	0.0794±.0024	0.616±.025	0.0563±.0013	492±14	–
17.1	54	31	0.574	1195	3.624	0.0828±.0035	0.627+.048	0.0549±.0032	512±20	–
17.2	175	73	0.419	1000000	0.000	0.0810±.0020	0.656±.024	0.0587±.0014	502±12	–
18.1	73	47	0.646	629	2.690	0.0861±.0027	0.668±.038	0.0563±.0025	532±16	–
19.1	103	55	0.540	2163	1.226	0.0754±.0026	0.609±.041	0.0586±.0032	468±15	–
20.1	86	44	0.509	6421	1.437	0.0799±.0029	0.625±.037	0.0567±.0025	495±17	–
21.1	90	40	0.450	4573	1.128	0.0801±.0029	0.667±.040	0.0604±.0026	496±17	–
22.1	115	73	0.635	1911	0.713	0.0799±.0032	0.640±.043	0.0581±.0028	495±19	–
23.1	254	206	0.813	163	4.847	0.0805±.0069	0.700±.126	0.0630±.0093	499±41	–
24.2	68	31	0.462	1242	0.000	0.0832±.0025	0.702±.037	0.0612±.0025	515±15	–
28.1	96	79	0.824	311	7.250	0.0812±.0027	0.622±.058	0.0555±.0046	503±16	–
29.1	65	32	0.504	100000	0.000	0.0847±.0031	0.740±.051	0.0633±.0034	524±18	–
30.1	103	51	0.493	3121	0.582	0.0791±.0023	0.626±.035	0.0574±.0025	490±14	–
31.1	185	76	0.414	97	19.392	0.0806±.0020	0.693±.054	0.0624±.0044	499±12	–
32.1	71	41	0.582	938	1.101	0.0814±.0025	0.661±.048	0.0589±.0037	504±14	–
33.1	39	23	0.600	586	1.158	0.0822±.0034	0.697±.067	0.0614±.0050	509±20	–
34.1	90	49	0.547	806	1.155	0.0790±.0025	0.621±.043	0.0570±.0033	489±14	–
35.1	83	51	0.621	3219	0.127	0.0797±.0025	0.638±.046	0.0581±.0036	494±14	–
36.1	73	37	0.511	276	8.862	0.0796±.0028	0.554±.059	0.0505±.0049	493±16	–
37.1	62	33	0.532	11623	0.000	0.0868±.0026	0.721±.044	0.0602±.0030	536±15	–
38.1	61	31	0.517	2705	0.417	0.0835±.0025	0.685±.037	0.0595±.0025	516±14	–

Table 9. U-Th-Pb isotopic composition of zircons from the Winterbrook lava (95220025).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
101.2	73	43	0.587	1000000	0.000	0.0795±.0027	0.675±.044	0.0616±.0032	492±16	-
102.2	155	147	0.950	3813	0.000	0.0779±.0022	0.637±.040	0.0593±.0031	483±13	-
103.2	71	39	0.551	1000000	0.000	0.0806±.0026	0.666±.041	0.0600±.0029	499±15	-
105.2	91	55	0.605	5553	0.000	0.0839±.0021	0.683±.036	0.0590±.0026	519±12	-
106.2	116	92	0.790	10707	0.000	0.0802±.0022	0.649±.042	0.0587±.0032	497±13	-
107.2	90	51	0.570	2407	0.087	0.0790±.0022	0.610±.033	0.0560±.0024	490±12	-
108.2	127	49	0.387	1000000	0.063	0.0804±.0022	0.626±.033	0.0564±.0023	498±12	-
109.2	98	78	0.800	100000	0.205	0.0837±.0025	0.655±.043	0.0567±.0031	518±14	-
121.2	87	52	0.595	4329	0.015	0.0829±.0028	0.688±.048	0.0602±.0034	513±16	-
124.2	94	54	0.581	1000000	0.173	0.0824±.0022	0.629±.038	0.0554±.0028	510±13	-
126.2	116	103	0.887	8944	0.250	0.0818±.0022	0.639±.041	0.0567±.0031	506±13	-
127.2	71	47	0.665	100000	0.030	0.0804±.0023	0.620±.046	0.0559±.0036	498±13	-
128.1	76	48	0.634	2858	0.851	0.0794±.0025	0.603±.040	0.0551±.0031	492±14	-
129.1	82	43	0.519	2831	0.058	0.0784±.0022	0.642±.036	0.0594±.0027	486±13	-
130.1	118	62	0.525	3731	0.066	0.0801±.0026	0.638±.037	0.0578±.0026	496±15	-
131.1	77	45	0.593	293	4.053	0.0827±.0026	0.718±.063	0.0630±.0049	512±15	-
132.1	88	51	0.575	1000000	0.000	0.0838±.0023	0.711±.042	0.0615±.0030	518±13	-
133.1	99	74	0.746	1000000	0.000	0.0807±.0023	0.645±.038	0.0580±.0028	500±13	-
134.1	148	89	0.606	1000000	0.000	0.0825±.0021	0.656±.030	0.0577±.0020	511±12	-
135.1	122	69	0.567	1000000	0.000	0.0794±.0021	0.632±.030	0.0578±.0021	492±12	-
136.1	148	117	0.794	1442	0.000	0.0837±.0021	0.890±.037	0.0771±.0023	518±12	-
137.1	134	70	0.522	3646	0.000	0.0818±.0021	0.651±.033	0.0577±.0024	506±12	-
138.1	106	75	0.710	6171	0.000	0.0772±.0021	0.687±.038	0.0646±.0029	479±12	-
139.1	614	398	0.648	29550	0.000	0.0809±.0018	0.661±.019	0.0593±.0010	501±10	-

Table 10. U-Th-Pb isotopic composition of zircons from the Tyndall Group ignimbrite (95220026).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
101.1	123	69	0.562	100000	0.172	0.0803±.0012	0.637±.025	0.0575±.0020	497±7	–
102.1	92	58	0.628	1724	0.336	0.0840±.0015	0.651±.030	0.0562±.0022	520±8	–
103.1	142	98	0.691	5106	0.050	0.0827±.0014	0.668±.029	0.0586±.0022	512±8	–
104.1	127	72	0.572	1827	0.324	0.0801±.0015	0.632±.026	0.0572±.0019	496±8	–
105.1	393	173	0.441	19596	0.018	0.0820±.0011	0.652±.013	0.0577±.0008	507±6	–
106.1	113	71	0.628	6263	0.279	0.0822±.0016	0.619±.033	0.0547±.0026	509±9	–
107.1	129	72	0.558	5287	0.499	0.0810±.0013	0.612±.020	0.0548±.0015	501±7	–
108.1	358	223	0.624	38955	0.000	0.0818±.0011	0.668±.015	0.0592±.0009	506±6	–
109.1	369	163	0.444	83752	0.330	0.0820±.0011	0.624±.013	0.0552±.0008	508±6	–
110.1	67	32	0.485	5882	0.221	0.0815±.0017	0.651±.032	0.0580±.0024	505±10	–
111.1	98	58	0.599	3367	0.489	0.0812±.0013	0.614±.024	0.0549±.0019	503±7	–
112.1	128	72	0.566	5662	0.103	0.0830±.0014	0.650±.024	0.0568±.0017	513±8	–
113.1	83	48	0.588	8095	0.802	0.0794±.0015	0.581±.028	0.0531±.0022	492±8	–
114.1	80	38	0.478	2217	0.432	0.0798±.0017	0.627±.028	0.0569±.0021	494±10	–
115.1	153	122	0.795	1000000	0.309	0.0804±.0013	0.613±.024	0.0552±.0019	498±7	–
116.1	232	93	0.404	6428	0.174	0.0822±.0012	0.649±.016	0.0572±.0010	509±7	–
117.1	116	44	0.381	1000000	0.277	0.0808±.0013	0.651±.020	0.0584±.0015	500±7	–
118.1	164	133	0.807	2785	0.462	0.0804±.0012	0.619±.025	0.0558±.0020	498±7	–
119.1	127	70	0.553	5799	0.016	0.0796±.0015	0.646±.022	0.0588±.0015	493±8	–
120.1	188	98	0.525	4621	0.374	0.0796±.0013	0.615±.021	0.0560±.0016	493±7	–
121.1	164	111	0.681	19432	0.000	0.0796±.0013	0.650±.021	0.0593±.0016	493±7	–
122.1	224	139	0.621	1000000	0.430	0.0831±.0010	0.616±.017	0.0538±.0012	514±6	–
123.1	139	56	0.403	6654	0.280	0.0832±.0012	0.656±.018	0.0572±.0013	515±6	–
201.1	188	125	0.666	100000	0.128	0.0791±.0034	0.653±.041	0.0598±.0025	490±20	–
202.1	94	46	0.489	2075	0.908	0.0804±.0030	0.645±.039	0.0582±.0025	498±17	–
203.1	65	35	0.548	1034	1.843	0.0770±.0030	0.654±.045	0.0616±.0032	478±18	–
204.1	99	59	0.598	2870	0.835	0.0796±.0027	0.660±.038	0.0601±.0025	493±16	–
205.1	83	51	0.625	908	1.255	0.0852±.0032	0.653±.049	0.0556±.0033	527±18	–
206.1	92	44	0.477	766	1.537	0.0752±.0029	0.568±.035	0.0548±.0024	467±17	–
207.1	86	57	0.662	5097	1.581	0.0829±.0029	0.630±.037	0.0551±.0024	513±17	–
208.1	131	75	0.574	3136	0.999	0.0827±.0025	0.616±.027	0.0540±.0016	512±14	–
209.1	124	68	0.546	2512	1.131	0.0831±.0026	0.623±.028	0.0544±.0016	514±15	–
210.1	93	56	0.599	1000000	0.541	0.0864±.0027	0.668±.032	0.0560±.0018	534±15	–
211.1	86	52	0.603	765	1.510	0.0811±.0027	0.588±.035	0.0526±.0024	502±16	–
212.1	117	68	0.579	8837	0.682	0.0847±.0027	0.683±.031	0.0585±.0016	523±15	–
213.1	89	41	0.459	1174	0.785	0.0844±.0025	0.673±.029	0.0578±.0016	522±15	–
214.1	85	45	0.533	865	1.659	0.0829±.0026	0.628±.031	0.0550±.0019	513±15	–
215.1	84	47	0.568	2235	1.130	0.0862±.0028	0.688±.040	0.0579±.0026	533±16	–
216.1	104	67	0.651	1943	0.606	0.0849±.0028	0.655±.047	0.0559±.0034	525±16	–
217.1	109	67	0.618	3617	0.872	0.0833±.0026	0.619±.030	0.0539±.0018	515±15	–
218.1	191	136	0.713	9839	0.760	0.0802±.0025	0.620±.028	0.0560±.0017	497±15	–
219.1	96	58	0.604	1071	0.000	0.0794±.0024	0.681±.031	0.0622±.0018	492±14	–
220.1	105	57	0.542	1457	1.057	0.0832±.0027	0.657±.031	0.0573±.0018	515±16	–
221.1	277	133	0.480	10716	0.356	0.0859±.0027	0.688±.026	0.0580±.0010	531±15	–
222.1	135	66	0.486	4920	0.994	0.0840±.0027	0.633±.028	0.0547±.0014	519±15	–
223.1	98	52	0.530	2768	0.731	0.0784±.0027	0.607±.033	0.0562±.0022	486±16	–
224.1	51	22	0.426	655	1.683	0.0779±.0035	0.657±.049	0.0611±.0033	483±20	–
225.1	85	47	0.557	1324	1.199	0.0749±.0028	0.614±.041	0.0595±.0030	465±17	–
226.1	82	53	0.641	986	1.284	0.0842±.0036	0.684±.050	0.0589±.0032	521±21	–

Table 11. U-Th-Pb isotopic composition of zircons from the Lobster Creek Volcanics (95220022).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 s error	$^{207}Pb/^{235}U$ ±1 s error	$^{207}Pb/^{206}Pb$ ±1 s error	Age (Ma) ±1 s error	% conc
1.1	148	56	0.380	16121	0.061	0.0792±.0013	0.643±.018	0.0589±.0012	491±8	–
2.1	119	57	0.477	6348	0.277	0.0824±.0013	0.646±.018	0.0569±.0012	510±7	–
3.1	93	39	0.425	4394	0.045	0.0807±.0016	0.660±.022	0.0594±.0015	500±9	–
4.1	196	76	0.392	100000	0.207	0.0810±.0013	0.612±.020	0.0548±.0015	502±7	–
5.1	158	57	0.360	100000	0.105	0.0814±.0013	0.659±.017	0.0587±.0011	504±7	–
6.1	133	46	0.350	8983	0.119	0.0815±.0014	0.648±.022	0.0577±.0015	504±8	–
7.1	149	55	0.371	53304	0.000	0.0816±0016	0.654±.027	0.0582±.0019	505±9	–
8.1	253	120	0.475	14074	0.362	0.0818±.0012	0.633±.015	0.0562±.0010	506±7	–
9.1	164	84	0.513	100000	0.000	0.0800±.0015	0.647±.020	0.0586±.0013	496±8	–
10.1	189	78	0.416	15453	0.319	0.0815±.0014	0.630±.018	0.0561±.0012	504±8	–
11.1	167	64	0.384	7993	0.000	0.0799±.0016	0.667±.027	0.0606±.0020	495±9	–
12.1	232	93	0.404	6258	0.139	0.0803±.0012	0.634±.016	0.0573±.0011	498±7	–
13.1	155	51	0.331	5308	0.089	0.0805±.0012	0.632±.017	0.0569±.0012	499±7	–
14.1	273	145	0.532	100000	0.164	0.0814±.0013	0.628±.018	0.0560±.0012	504±7	–
15.1	148	68	0.464	4029	0.394	0.0814±.0014	0.677±.019	0.0604±.0013	504±8	–
16.1	207	89	0.430	15984	0.047	0.0836±.0013	0.665±.017	0.0577±.0011	517±7	–
17.1	215	105	0.491	9349	0.075	0.0773±.0012	0.613±.019	0.0575±.0014	480±7	–
18.1	313	219	0.701	3555	0.000	0.1127±.0036	1.623±.066	0.1044±.0023	1704±41	40
19.1	192	72	0.376	5411	0.233	0.0830±.0013	0.651±.017	0.0569±.0011	514±7	–
20.1	205	83	0.406	100000	0.157	0.0792±.0012	0.648±.016	0.0593±.0011	491±7	–
21.1	183	73	0.399	10042	0.000	0.0824±.0014	0.664±.018	0.0584±.0012	510±8	–
22.1	145	57	0.392	5750	0.307	0.0819±.0029	0.634±.039	0.0561±.0026	507±17	–
23.1	228	98	0.432	14690	0.361	0.0836±.0013	0.650±.018	0.0564±.0012	517±7	–
24.1	207	86	0.416	4544	0.394	0.0796±.0013	0.622±.020	0.0566±.0014	494±7	–
25.1	207	80	0.389	14202	0.219	0.0796±.0012	0.631±.020	0.0575±.0014	493±7	–
26.1	224	91	0.410	100000	0.190	0.0799±.0014	0.627±.017	0.0570±.0011	495±8	–
27.1	236	108	0.457	41373	0.128	0.0810±.0013	0.635±.018	0.0569±.0012	502±7	–
28.1	256	101	0.394	8967	0.032	0.0805±.0013	0.644±.016	0.0580±.0010	499±7	–
29.1	191	82	0.431	8227	0.000	0.0817±.0014	0.690±.019	0.0612±.0012	506±8	–
30.1	182	64	0.354	6190	0.026	0.0790±.0014	0.635±.020	0.0582±.0014	490±8	–
31.1	259	123	0.475	100000	0.164	0.0811±.0014	0.640±.022	0.0572±.0016	502±8	–
32.1	181	69	0.380	3351	0.188	0.0799±.0013	0.639±.019	0.0581±.0013	495±7	–
101.1	201	72	0.359	1000000	0.120	0.0804±.0025	0.629±.026	0.0568±.0013	498±14	–
102.1	176	60	0.344	2927	0.354	0.0820±.0026	0.666±.028	0.0589±.0014	507±15	–
103.1	167	55	0.329	100000	0.419	0.0777±.0029	0.624±.030	0.0582±.0016	482±17	–
104.1	230	110	0.477	2454	0.803	0.0802±.0023	0.623±.034	0.0564±.0023	497±13	–
105.1	146	56	0.384	1366	1.085	0.0785±.0026	0.603±.027	0.0557±.0015	486±15	–
106.1	151	63	0.416	2766	0.785	0.0789±.0026	0.638±.027	0.0587±.0014	489±15	–
107.1	156	55	0.359	1801	0.699	0.0797±.0028	0.619±.028	0.0563±.0013	494±16	–
108.1	192	78	0.408	1962	0.974	0.0781±.0023	0.570±.022	0.0529±.0012	484±13	–
109.1	178	61	0.343	2165	0.326	0.0850±.0026	0.668±.026	0.0570±.0011	525±15	–
110.1	173	68	0.395	8437	0.456	0.0829±.0024	0.641±.026	0.0561±.0013	513±14	–
111.1	196	64	0.328	11180	0.469	0.0828±.0024	0.647±.023	0.0566±.0009	513±14	–
112.1	164	58	0.354	4890	0.437	0.0824±.0025	0.659±.024	0.0580±.0010	510±14	–
113.1	148	53	0.360	12470	0.440	0.0808±.0024	0.640±.025	0.0575±.0012	500±14	–
114.1	217	74	0.344	2819	0.559	0.0813±.0024	0.643±.026	0.0573±.0014	504±14	–
115.1	209	117	0.562	2356	0.000	0.0811±.0024	0.789±.034	0.0705±.0019	502±14	–
116.1	115	37	0.325	4759	0.867	0.0824±.0026	0.637±.027	0.0560±.0014	510±15	–
117.1	170	69	0.406	4167	0.146	0.0826±.0024	0.705±.025	0.0619±.0011	511±14	–
118.1	160	55	0.348	9253	0.090	0.0784±.0023	0.646±.024	0.0598±.0011	486±13	–
119.1	166	75	0.451	2123	0.000	0.0778±.0025	0.831±.033	0.0774±.0016	483±14	–
120.1	262	60	0.232	356	4.480	0.1139±.0051	0.937±.050	0.0597±.0014	695±29	–
121.1	205	96	0.467	13486	0.644	0.0795±.0028	0.585±.030	0.0534±.0018	492±16	–
122.1	205	102	0.498	1803	0.583	0.0747±.0024	0.581±.027	0.0564±.0017	464±14	–
123.1	217	93	0.431	6250	0.000	0.0788±.0024	0.681±.033	0.0627±.0021	488±14	–

Table 12. U-Th-Pb isotopic composition of zircons from the Beulah Granite (95220024).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 s error	$^{207}Pb/^{235}U$ ±1 s error	$^{207}Pb/^{206}Pb$ ±1 s error	Age (Ma) ±1 s error	% conc
102.1	382	286	0.749	23696	0.000	0.0754±.0013	0.604±.023	0.0581±.0019	468±7	–
103.1	730	785	1.076	4777	0.063	0.0790±.0029	0.651±.053	0.0598±.0041	489±17	–
104.1	401	328	0.817	42571	0.083	0.0801±.0011	0.625±.020	0.0566±.0015	496±6	–
105.1	761	949	1.246	100000	0.258	0.0798±.0012	0.610±.020	0.0555±.0015	494±6	–
106.1	734	715	0.975	15850	0.000	0.0817±.0011	0.661±.014	0.0587±.0009	506±6	–
107.1	810	790	0.974	20863	0.040	0.0798±.0012	0.632±.017	0.0574±.0012	495±6	–
108.1	957	1408	1.471	36982	0.000	0.0787±.0011	0.622±.024	0.0573±.0020	488±6	–
109.1	851	1091	1.283	100000	0.000	0.0802±.0012	0.643±.022	0.0582±.0017	497±7	–
110.1	712	918	1.290	163132	0.098	0.0771±.0011	0.606±.022	0.0570±.0018	478±6	–
111.1	864	745	0.862	30778	0.000	0.0802±.0013	0.655±.017	0.0593±.0010	497±7	–
112.1	220	164	0.745	23277	0.252	0.0814±.0015	0.648±.025	0.0578±.0018	504±8	–
113.1	1330	1683	1.265	689	2.076	0.0768±.0010	0.655±.018	0.0618±.0014	476±6	–
114.1	673	571	0.848	100000	0.055	0.0806±.0011	0.638±.019	0.0574±.0014	499±6	–
115.1	619	687	1.109	92592	0.000	0.0799±.0012	0.650±.024	0.0590±.0018	495±7	–
116.1	443	413	0.933	20399	0.116	0.0796±.0011	0.627±.015	0.0571±.0010	494±6	–
117.1	220	167	0.758	15039	0.078	0.0805±.0013	0.638±.027	0.0574±.0021	499±7	–
118.1	882	1278	1.449	100000	0.000	0.0807±.0011	0.676±.020	0.0608±.0015	500±6	–
119.1	956	1226	1.282	50684	0.000	0.0816±.0012	0.675±.022	0.0600±.0016	505±7	–
120.1	1015	1518	1.495	6126	0.083	0.0801±.0012	0.639±.021	0.0578±.0016	496±6	–
121.1	807	787	0.975	54764	0.054	0.0795±.0011	0.624±.018	0.0569±.0013	493±6	–
122.1	239	281	1.176	10790	0.000	0.2506±.0040	3.520±.084	0.1019±.0016	1441±20	87
123.1	604	814	1.347	5203	0.079	0.0790±.0011	0.662±.023	0.0608±.0018	489±6	–
124.1	473	337	0.712	41186	0.030	0.0784±.0011	0.623±.014	0.0576±.0009	486±6	–
125.1	457	442	0.968	1836	1.398	0.0771±.0011	0.580±.018	0.0545±.0014	479±6	–
126.1	682	931	1.366	12172	0.024	0.0796±.0012	0.630±.026	0.0574±.0021	493±7	–
127.1	1069	836	0.783	19557	0.000	0.0785±.0012	0.634±.016	0.0586±.0012	487±6	–
128.1	914	1434	1.570	1908	0.661	0.0788±.0011	0.638±.018	0.0587±.0014	489±6	–
129.1	752	668	0.888	28473	0.067	0.0800±.0012	0.626±.018	0.0567±.0013	496±7	–

Table 13. U-Th-Pb isotopic composition of zircons from the Noddy Creek Volcanics (96220032).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
100.1	297	151	0.508	23320	0.000	0.0829±.0019	0.659±.022	0.0576±.0012	513±11	–
101.1	364	177	0.486	100000	0.095	0.0827±.0018	0.650±.022	0.0570±.0013	512±10	–
102.1	185	90	0.486	7157	0.171	0.0805±.0018	0.624±.027	0.0562±.0019	499±10	–
103.1	315	157	0.497	12531	0.006	0.0832±.0019	0.653±.022	0.0569±.0012	515±11	–
104.1	251	145	0.580	5778	0.337	0.0815±.0019	0.631±.027	0.0562±.0018	504±11	–
105.1	231	128	0.556	1515151	0.323	0.0825±.0019	0.632±.022	0.0556±.0013	511±11	–
106.1	247	140	0.570	11049	0.000	0.0843±.0019	0.699±.027	0.0601±.0018	522±11	–
107.1	195	104	0.535	1000000	0.172	0.0867±.0020	0.668±.027	0.0558±.0017	536±12	–
108.1	379	305	0.804	16995	0.269	0.0658±.0026	0.488±.056	0.0538±.0055	410±15	–
109.1	317	164	0.520	51072	0.378	0.0837±.0019	0.626±.020	0.0542±.0011	518±11	–
110.1	313	154	0.492	1000000	0.165	0.0835±.0018	0.638±.020	0.0554±.0010	516±10	–
111.1	193	111	0.575	15192	0.191	0.0815±.0022	0.626±.034	0.0557±.0025	505±12	–
112.1	214	111	0.521	14084	0.229	0.0798±.0020	0.623±.030	0.0566±.0021	494±12	–
113.1	390	269	0.690	1000000	0.000	0.0787+.0065	0.644±.089	0.0593±.0060	488±39	–
113.1	304	151	0.498	1000000	0.000	0.0817±.0018	0.646±.021	0.0573±.0013	506±10	–
114.1	264	141	0.536	11030	0.058	0.0776±.0018	0.620+.024	0.0580±.0016	481±10	–
115.1	281	138	0.494	7534	0.020	0.0815±.0019	0.642±.021	0.0571±.0012	505±11	–
116.1	353	209	0.591	1000000	0.223	0.0789±.0018	0.604±.021	0.0555±.0014	489±10	–
117.1	218	109	0.501	100000	0.301	0.0793+.0017	0.615±.022	0.0563±.0014	492±10	–
118.1	360	195	0.543	10781	0.100	0.0793±.0017	0.622±.022	0.0569±.0014	491±10	–
119.1	253	126	0.497	1000000	0.000	0.0802±.0018	0.621±.021	0.0562±.0012	497±11	–
120.1	349	180	0.517	5903	0.000	0.0750±.0021	0.621±.026	0.0600±.0016	466±12	–
121.1	361	190	0.528	18328	0.154	0.0814±.0019	0.637±.021	0.0567±.0012	504±11	–
122.1	332	159	0.481	1000000	0.178	0.0788±.0019	0.620±.025	0.0570±.0017	489±11	–
123.1	234	111	0.475	1000000	0.053	0.0780±.0017	0.621±.025	0.0577±.0018	484±10	–
124.1	286	137	0.481	1000000	0.000	0.0809±.0018	0.655±.022	0.0587±.0013	501±10	–
125.1	273	129	0.472	16614	0.132	0.0769±.0018	0.594±.024	0.0560±.0017	477±10	–
126.1	458	262	0.573	1000000	0.000	0.0837±.0018	0.664±.021	0.0575±.0012	518±10	–
127.1	318	184	0.579	1000000	0.150	0.0798±.0017	0.613±.025	0.0557±.0018	494±10	–
128.1	378	188	0.497	18556	0.098	0.0783±.0017	0.619±.018	0.0573±.0010	486±10	–
129.1	237	134	0.567	1000000	0.005	0.0792±.0018	0.618±.026	0.0566±.0018	491+10	–
130.1	216	103	0.477	100000	0.118	0.0815±.0019	0.622+.025	0.0554±.0016	505±11	–
131.1	299	143	0.481	1000000	0.355	0.0743±.0018	0.560±.022	0.0547±.0015	462±10	–
132.1	466	282	0.605	20076	0.305	0.0812±.0018	0.613±.019	0.0547±.0010	503±10	–
133.1	281	152	0.541	16949	0.175	0.0804±.0019	0.618±.023	0.0558±.0015	498+11	–
134.1	389	206	0.532	20938	0.106	0.0793±.0018	0.607±.019	0.0554±.0011	492±10	–
135.1	533	318	0.596	18044	0.000	0.0698±.0017	0.561±.030	0.0582±.0025	435±10	–
136.1	400	226	0.565	1000000	0.366	0.0801±.0017	0.603±.018	0.0546±.0010	496±10	–
137.1	238	127	0.534	25687	0.000	0.0840±.0020	0.763±.025	0.0659±.0012	519±12	–
138.1	210	108	0.512	17161	0.000	0.0820±.0018	0.675±.028	0.0597±.0019	507±10	–
139.1	255	136	0.533	1000000	0.045	0.0819±.0018	0.645±.021	0.0571±.0012	507±10	–
140.1	334	186	0.557	100000	0.000	0.0826±.0018	0.652±.021	0.0572±.0012	511±10	–
141.1	209	96	0.461	9299	0.122	0.0815±.0019	0.628±.025	0.0558±.0017	505±11	–
142.1	272	155	0.572	12554	0.243	0.0821±.0021	0.630±.029	0.0556±.0020	508±12	–
143.1	298	149	0.502	1000000	0.002	0.0831±.0018	0.648±.019	0.0565±.0010	514±10	–
144.1	299	160	0.536	100000	0.105	0.0822±.0018	0.656±.023	0.0579±.0015	509±10	–
145.1	284	132	0.465	8389	0.036	0.0817±.0018	0.644±.024	0.0572±.0015	506±10	–
146.1	227	113	0.497	29010	0.068	0.0833±.0020	0.654±.024	0.0569±.0015	516±11	–

Table 14. U-Th-Pb isotopic composition of zircon rims from the garnet amphibolite (95220020).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 s error	$^{207}Pb/^{235}U$ ±1 s error	$^{207}Pb/^{206}Pb$ ±1 s error	Age (Ma) ±1 s error	%conc
1.1	142	0	0.006	9509	0.168	0.0830±.0014	0.672±.015	0.0588±.0008	513±8	–
2.2	440	2	0.005	35498	0.078	0.0796±.0012	0.625±.011	0.0570±.0005	493±6	–
3.2	459	2	0.006	36968	0.047	0.0822±.0011	0.663±.010	0.0584±.0004	509±6	–
4.1	704	4	0.006	9604	0.274	0.0830±.0010	0.658±.010	0.0575±.0004	513±6	–
6.1	272	4	0.017	3874	0.278	0.0818±.0016	0.655±.015	0.0581±.0007	506±9	–
7.1	380	3	0.008	14909	0.163	0.0839±.0012	0.646±.012	0.0558±.0007	519±6	–
8.1	246	1	0.006	1000000	0.084	0.0846±.0012	0.670±.013	0.0574±.0007	523±7	–
12.1	198	0	0.004	4341	0.110	0.0831±.0016	0.658±.016	0.0574±.0007	514±9	–
13.1	584	7	0.013	13898	0.065	0.0824±.0011	0.665±.011	0.0586±.0004	510±6	–
16.1	57	0	0.005	6576	0.859	0.0813±.0017	0.660±.024	0.0589±.0016	504±10	–
17.1	158	0	0.003	3329	0.106	0.0839±.0014	0.658±.014	0.0569±.0007	519±8	–
18.1	584	3	0.006	15943	0.157	0.0793±.0010	0.631±.009	0.0577±.0004	491±5	–
19.1	125	0	0.005	4242	0.131	0.0841±.0015	0.656±.021	0.0566±.0014	520±8	–
20.1	84	0	0.003	100000	0.207	0.0849±.0013	0.683±.016	0.0583±.0009	525±7	–
22.1	96	0	0.005	1000000	0.164	0.0812±.0016	0.648±.018	0.0579±.0010	503±9	–
23.1	179	0	0.002	6615	0.247	0.0839±.0012	0.671±.013	0.0580±.0007	519±7	–
24.1	105	0	0.001	58309	0.363	0.0808±.0016	0.660±.018	0.0593±.0010	500±9	–
26.1	102	0	0.006	4128	0.400	0.0840±.0013	0.698±.017	0.0602±.0010	520±7	–
26.2	409	1	0.004	10094	0.206	0.0872±.0010	0.695±.010	0.0578±.0004	539±5	–
27.1	83	0	0.004	5604	0.184	0.0832±.0014	0.651±.021	0.0568±.0015	515±8	–
30.1	114	0	0.005	6518	0.267	0.0837±.0014	0.684±.016	0.0593±.0009	518±8	–
31.1	116	1	0.009	970	1.690	0.0873±.0015	0.675±.027	0.0561±.0019	539±8	–
32.1	83	0	0.008	2878	0.351	0.0816±.0015	0.655±.019	0.0583±.0011	505±9	–

Table 15. U-Th-Pb isotopic composition of zircon cores from the garnet amphibolite (95220020).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 s error	$^{207}Pb/^{235}U$ ±1 s error	$^{207}Pb/^{206}Pb$ ±1 s error	Age (Ma) ±1 s error	% conc
2.1	340	65	0.193	44111	0.041	0.2851±.0037	4.189±.060	0.1066±.0005	1741±8	92
3.1	199	111	0.559	20483	0.088	0.3200±.0051	4.772±.082	0.1082±.0005	1768±9	101
5.1	153	250	1.626	10239	0.175	0.2410±.0041	3.101±.095	0.0934±.0022	1495±45	93
9.1	168	145	0.867	9704	0.185	0.2023±.0031	2.467±.045	0.0884±.0007	1392±15	85
10.1	392	63	0.162	12779	0.141	0.2806±.0038	3.961±.064	0.1024±.0008	1667±14	95
11.1	138	112	0.812	11352	0.158	0.2573±.0039	3.411±.064	0.0962±.0009	1550±17	95
14.1	220	150	0.684	4571	0.393	0.1897±.0029	2.176±.044	0.0832±.0010	1273±22	87
15.1	353	235	0.665	29922	0.060	0.2203±.0031	2.681±.043	0.0883±.0005	1388±11	92
21.1	56	37	0.669	1758	1.022	0.1488±.0044	1.538±.087	0.0750±.0033	1067±92	83
25.1	172	39	0.229	5378	0.334	0.1060±.0013	0.937±.023	0.0641±.0012	745±41	87
28.1	172	83	0.484	29325	0.061	0.2642±.0044	3.814±.071	0.1047±.0007	1709±12	88
29.1	543	302	0.557	36818	0.049	0.1136±.0012	1.090±.015	0.0696±.0005	917±15	75

Table 16. U-Th-Pb isotopic composition of zircons from the tonalite (93220003), Heazlewood Ultramafic Complex.

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f^{206}	$^{206}Pb/^{238}U$ ±1 s error	$^{207}Pb/^{235}U$ ±1 s error	$^{207}Pb/^{206}Pb$ ±1 s error	Age (Ma) ±1 s error	%conc
200.1	128	375	2.91	1478	2.30	0.0750±.0021	0.437±.112	0.0422±.0106	474±11	-
201.1	393	849	2.16	24189	0.02	0.0814±.0019	0.654±.056	0.0583±.0046	503±11	-
202.1	612	1162	1.90	3852	0.00	0.0830±.0018	0.730±.035	0.0638±.0026	509±10	-
203.1	148	318	2.14	1328	1.30	0.0797±.0020	0.580±.076	0.0527±.0066	497±11	-
204.1	99	306	3.09	4319	0.00	0.0905±.0027	0.840±.159	0.0674±.0123	551±13	-
205.1	234	844	3.60	4749	0.00	0.0900±.0022	0.830±.102	0.0669±.0078	548±11	-
206.1	374	1034	2.77	13912	0.45	0.0857±.0019	0.638±.057	0.0540±.0045	531±11	-
207.1	111	247	2.22	11948	1.14	0.0850±.0022	0.558±.098	0.0476±.0081	531±12	-
208.1	771	2403	3.12	39619	0.74	0.0848±.0018	0.597±.048	0.0510±.0038	528±10	-
209.1	62	132	2.11	117647	0.00	0.0833±.0025	0.706±.089	0.0615±.0073	513±14	-
210.1	72	142	1.98	1073	0.16	0.0811±.0025	0.694±.093	0.0621±.0078	499±14	-
211.1	80	85	1.06	6675	0.00	0.0827±.0040	0.934±.100	0.0819±.0073	497±23	-
212.1	137	372	2.70	370	0.00	0.0796±.0026	1.360±.158	0.1239±.0133	454±13	-
213.1	110	315	2.85	1451	1.49	0.0800±.0024	0.539±.122	0.0488±.0108	500±13	-
214.1	77	146	1.89	577	0.00	0.0896±.0025	1.707±.088	0.1381±.0056	500±12	-
215.1	107	211	1.97	100000	1.05	0.0804±.0025	0.556±.096	0.0501±.0083	502±14	-
216.1	66	155	2.34	5833	1.07	0.0824±.0022	0.567±.086	0.0499±.0073	514±12	-
217.1	72	143	1.97	100000	1.15	0.0821±.0021	0.567±.076	0.0501±.0064	513±12	-
218.1	519	813	1.57	5398	0.00	0.0832±.0018	0.748±.032	0.0652±.0023	510±10	-
219.1	559	1874	3.35	100000	2.59	0.0804±.0019	0.416±.077	0.0375±.0067	510±10	-
220.1	146	266	1.82	8564	0.00	0.0754±.0029	0.695±.115	0.0668±.0104	463±16	-
221.1	298	641	2.14	2019	0.00	0.0874±.0037	0.841±.182	0.0698±.0145	532±20	-
222.1	72	111	1.52	1000000	1.38	0.0803±.0024	0.505±.076	0.0456±.0065	504±14	-
223.1	204	460	2.25	17108	0.00	0.0804±.0020	0.658±.059	0.0593±.0049	497±11	-
224.1	107	326	3.03	870	2.97	0.0744±.0025	0.529±.138	0.0515±.0131	465±13	-
225.1	77	81	1.05	100	20.60	0.0812±.0024	0.728±.130	0.0650±.0112	498±15	-
226.1	74	134	1.80	3016	0.68	0.0858±.0024	0.788±.092	0.0666±.0073	524±13	-
227.1	78	188	2.41	9032	0.00	0.0788±.0028	0.725±.131	0.0668±.0115	483±15	-
228.1	406	631	1.55	11586	0.82	0.0809±.0018	0.580±.034	0.0520±.0026	504±10	-
229.1	420	787	1.87	1000000	0.00	0.0847±.0019	0.694±.041	0.0594±.0031	522±10	-
230.1	140	338	2.41	100000	0.00	0.0828±.0022	0.710±.080	0.0622±.0066	509±12	-
231.1	119	425	3.57	935	0.00	0.0777±.0023	1.262±.167	0.1178±.0148	447±10	-
232.1	550	882	1.60	27685	0.00	0.0808±.0018	0.667±.032	0.0598±.0024	499±10	-
233.1	100	266	2.67	1469	3.56	0.0831±.0026	0.455±.116	0.0397±.0099	525±14	-
234.1	75	104	1.39	1000000	0.00	0.0854±.0022	1.085±.073	0.0921±.0054	506±12	-
235.1	731	1566	2.14	5979	0.90	0.0830±.0018	0.620±.030	0.0542±.0023	515±10	-
236.1	408	1567	3.84	3726	7.13	0.0750±.0022	0.009±.133	0.0008±.0128	497±11	-
237.1	233	8958	38.31	440	9.05	0.0784±.0023	0.177±.142	0.0164±.0131	510±12	-
238.1	1186	2310	1.95	325	2.93	0.0906±.0019	1.138±.065	0.0911±.0046	536±10	-
239.1	74	189	2.55	1073	0.00	0.0855±.0026	0.906±.138	0.0768±.0112	516±14	-
240.1	311	5908	18.96	677	0.00	0.0843±.0026	1.426±.201	0.1228±.0164	480±11	-
241.1	127	289	2.28	1000000	0.86	0.0808±.0020	0.564±.071	0.0506±.0061	504±11	-
242.1	138	421	3.05	1000000	0.00	0.0870±.0032	1.423±.184	0.1186±.0142	498±15	-
243.1	123	359	2.91	-21992	13.76	0.0583±.0019	0.000±0.104	0.0671±.0131	419±11	-
244.1	545	1220	2.24	16512	1.05	0.0830±.0018	0.581±.032	0.0507±.0025	517±10	-
245.1	130	296	2.27	1792	0.00	0.0852±.0023	0.882±.085	0.0751±.0067	516±12	-
246.1	260	314	1.21	11967	0.00	0.0781±.0018	0.652±.036	0.0606±.0029	482±10	-

Table 17. U-Th-Pb isotopic composition of zircons from the Detention Subgroup quartzite (95220016).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
1.1	288	205	0.711	130378	0.012	0.3176±.0074	4.729±.118	0.1080±.0007	1765±11	100
2.1	102	65	0.639	9430	0.167	0.3113±.0087	4.540±.152	0.1058±.0016	1727±27	101
3.1	288	71	0.249	19338	0.068	0.6004±.0131	17.106±.390	0.2066±.0009	2879±7	105
4.1	100	74	0.734	100000	0.014	0.5329±.0151	13.053±.401	0.1777±.0016	2631±14	104
5.1	354	123	0.348	1000000	0.000	0.3144±.0067	4.625±.106	0.1067±.0007	1743±11	101
6.1	124	68	0.550	7510	0.210	0.3009±.0122	4.320±.226	0.1041±.0030	1699±53	99
7.1	77	40	0.519	2084	0.764	0.3028±.0157	4.282±.286	0.1026±.0037	1671±68	102
8.1	495	182	0.369	12345	0.127	0.2858±.0063	4.161±.102	0.1056±.0009	1724±15	94
9.1	76	27	0.355	7004	0.227	0.3039±.0111	4.269±.214	0.1019±.0030	1658±56	103
10.1	268	83	0.311	11657	0.135	0.3011±.0074	4.385±.133	0.1057±.0016	1725±27	98
11.1	500	261	0.522	20429	0.076	0.3218±.0068	4.794±.113	0.1080±.0009	1766±15	101
12.1	597	300	0.503	199203	0.007	0.4921±.0110	11.454±.266	0.1688±.0007	2545±6	101
13.1	417	127	0.305	7319	0.216	0.2790±.0078	3.980±.123	0.1035±.0010	1687±18	94
14.1	333	112	0.338	9954	0.158	0.3086±.0070	4.421±.114	0.1039±.0010	1695±18	102
15.1	505	244	0.483	16537	0.099	0.2410±.0054	3.010±.076	0.0906±.0008	1438±16	96
15.2	487	232	0.476	55991	0.029	0.2363±.0048	2.983±.066	0.0915±.0007	1457±13	93
15.3	1313	423	0.323	2826	0.589	0.1594±.0030	1.790±.042	0.0815±.0010	1232±24	77
16.1	489	168	0.345	31328	0.050	0.2989±.0064	4.308±.102	0.1045±.0008	1705±13	98
17.1	852	203	0.238	53879	0.029	0.2967±.0061	4.244±.092	0.1037±.0005	1692±9	99
18.1	783	228	0.291	81900	0.019	0.2548±.0050	3.683±.078	0.1048±.0006	1711±10	85
19.1	618	205	0.331	7286	0.214	0.2892±.0057	4.344±.095	0.1089±.0008	1781±13	91
20.1	189	142	0.756	16123	0.098	0.3114±.0090	4.462±.147	0.1039±.0013	1695±23	103
20.2	567	245	0.433	66622	0.024	0.2835±.0057	4.046±.089	0.1035±.0007	1687±12	95
21.1	300	90	0.302	100000	0.016	0.3067±.0068	4.504±.113	0.1065±.0010	1740±16	99
22.1	739	355	0.480	101936	0.016	0.2508±.0049	3.095±.066	0.0895±.0006	1415±12	101
23.1	342	171	0.503	1000000	0.002	0.3135±.0075	4.718±.121	0.1091±.0008	1784±12	98
24.1	347	147	0.423	1000000	0.000	0.3081±.0072	4.614±.120	0.1086±.0009	1776±15	97
25.1	279	133	0.478	100000	0.016	0.3053±.0084	4.447±.136	0.1057±.0010	1725±18	99
26.1	266	53	0.201	8556	0.184	0.3043±.0076	4.376±.127	0.1043±.0012	1701±21	100
27.1	991	644	0.651	2346	0.599	0.3454±.0072	7.851±.174	0.1648±.0009	2506±9	76
28.1	272	86	0.318	24420	0.067	0.2464±.0068	3.047±.097	0.0897±.0012	1419±24	100
29.1	169	114	0.677	30750	0.051	0.3001±.0077	4.321±.130	0.1044±.0013	1704±23	99
30.1	405	84	0.208	15019	0.104	0.3171±.0081	4.743±.133	0.1085±.0010	1774±17	100
31.1	385	229	0.595	49261	0.032	0.3182±.0071	4.569±.113	0.1041±.0009	1699±15	104
32.1	92	70	0.766	100000	0.016	0.2442±.0091	3.181±.153	0.0945±.0025	1517±50	92
33.1	442	126	0.286	14452	0.108	0.3058±.0071	4.447±.113	0.1055±.0008	1722±14	99
34.1	192	144	0.754	100000	0.015	0.3108±.0077	4.464±.122	0.1042±.0009	1699±16	102
35.1	225	153	0.681	12983	0.121	0.4813±.0119	11.085±.292	0.1671±.0011	2528±11	100
36.1	361	73	0.204	85836	0.018	0.3049±.0069	4.435±.107	0.1055±.0007	1723±12	99
37.1	378	205	0.542	41101	0.038	0.3209±.0081	4.617±.124	0.1044±.0007	1703±12	105
38.1	298	34	0.114	100000	0.015	0.3114±.0091	4.507±.139	0.1050±.0008	1714±13	102
39.1	120	87	0.732	79617	0.020	0.2959±.0117	4.333±.185	0.1062±.0013	1735±22	96
40.1	314	202	0.644	100000	0.016	0.2973±.0077	4.294±.121	0.1047±.0009	1709±15	98
41.1	97	66	0.683	18740	0.088	0.2492±.0084	3.152±.126	0.0917±.0016	1461±33	98
41.2	72	40	0.565	15835	0.103	0.2432±.0065	3.105±.102	0.0926±.0015	1479±30	94
42.1	271	63	0.233	15094	0.104	0.2906±.0065	4.144±.106	0.1034±.0010	1686±17	97
43.1	187	103	0.553	26164	0.060	0.3201±.0146	4.766±.227	0.1080±.0010	1765±16	101
44.1	166	93	0.564	22946	0.069	0.3004±.0080	4.334±.134	0.1046±.0013	1708±23	99
45.1	272	94	0.346	28710	0.054	0.3186±.0071	4.733±.115	0.1077±.0008	1761±14	101
46.1	232	15	0.067	22045	0.071	0.2999±.0067	4.360±.106	0.1055±.0008	1722±13	98
47.1	339	173	0.510	36456	0.044	0.2463±.0065	3.092±.085	0.0910±.0006	1447±11	98
48.1	172	66	0.384	13651	0.115	0.3064±.0062	4.466±.106	0.1057±.0011	1726±18	99
49.1	175	84	0.482	94161	0.017	0.3131±.0070	4.542±.110	0.1052±.0008	1717±13	102
50.1	226	84	0.375	19716	0.082	0.2488±.0048	3.136±.069	0.0914±.0008	1455±16	98
51.1	77	94	1.217	4920	0.317	0.3058±.0070	4.447±.130	0.1055±.0016	1722±28	99
52.1	104	67	0.643	1000000	0.000	0.2580±.0070	3.250±.105	0.0914±.0013	1454±28	101
53.1	47	12	0.259	1000000	0.000	0.2898±.0146	4.542±.270	0.1137±.0029	1858±46	88
54.1	99	30	0.305	15673	0.099	0.3094±.0077	4.762±.135	0.1116±.0012	1826±19	95
55.1	151	69	0.461	7519	0.216	0.2406±.0072	3.012±.103	0.0908±.0012	1442±25	96
56.1	165	98	0.596	1000000	0.000	0.3013±.0066	4.319±.105	0.1040±.0009	1696±15	100
57.1	177	65	0.366	6795	0.231	0.2628±.0083	3.832±.132	0.1058±.0011	1727±18	87

58.1	57	40	0.700	1000000	0.000	0.4280±.0228	9.855±.558	0.1670±.0022	2527±22	90
59.1	101	34	0.339	10221	0.153	0.2898±.0075	4.238±.131	0.1061±.0015	1733±26	94
60.1	355	154	0.435	21440	0.073	0.2712±.0083	3.934±.129	0.1052±.0009	1717±15	90
61.1	164	133	0.815	1000000	0.002	0.2914±.0104	4.270±.163	0.1063±.0010	1736±17	94
62.1	242	125	0.519	23724	0.066	0.3056±.0106	4.452±.167	0.1057±.0011	1725±19	99
63.1	441	158	0.360	32092	0.049	0.3096±.0096	4.495±.146	0.1053±.0007	1719±11	101
64.1	145	50	0.346	243308	0.006	0.3363±.0110	4.884±.173	0.1053±.0011	1719±18	108
65.1	199	70	0.351	561797	0.003	0.2679±.0093	3.390±.125	0.0918±.0009	1462±18	104
66.1	364	142	0.391	45248	0.035	0.2978±.0092	4.065±.132	0.0990±.0007	1605±12	104
67.1	294	49	0.167	1000000	0.000	0.2710±.0125	3.423±.165	0.0916±.0008	1459±16	106
69.1	230	44	0.195	4545454	0.000	0.3133±.0076	4.515±.116	0.1045±.0007	1706±11	103
70.1	135	100	0.740	226244	0.007	0.3010±.0068	4.231±107	0.1019±.0010	1659±1	102
71.1	668	38	0.058	100000	0.016	0.3011±.0052	4.369±.080	0.1052±.0004	1718±6	98
72.1	677	285	0.422	106837	0.015	0.2777±.0058	3.935±.085	0.1028±.0004	1675±7	94
73.1	357	557	1.558	116822	0.012	0.4854±.0106	11.839±.265	0.1769±.0006	2624±5	97
74.1	190	93	0.489	1000000	0.000	0.2885±.0066	4.197±.109	0.1055±.0010	1723±17	94
75.1	88	49	0.564	6267	0.252	0.3009±.0076	4.273±.135	0.1030±.0017	1678±30	101
76.1	209	37	0.179	12416	0.127	0.2979±.0066	4.280±.104	0.1042±.0008	1700±13	98
77.1	208	121	0.585	9889	0.163	0.2471±.0065	3.036±.091	0.0891±.0011	1406±22	101
78.1	251	73	0.292	1000000	0.000	0.5146±.0183	13.404±.487	0.1889±.0008	2732±6	97
79.1	187	136	0.729	19766	0.080	0.3032±.0074	4.328±.116	0.1035±.0009	1688±15	101
80.1	338	195	0.578	1000000	0.000	0.3024±.0058	4.408±.092	0.1057±.0006	1727±10	98
81.1	375	234	0.625	14532	0.108	0.3039±.0063	4.340±.098	0.1036±.0007	1689±11	101
82.1	63	35	0.559	100000	0.015	0.3022±.0078	4.611±.159	0.1107±.0022	1810±36	94
83.1	301	96	0.320	1000000	0.000	0.3048±.0057	4.430±.089	0.1054±.0006	1721±10	99
84.1	188	36	0.195	25542	0.061	0.2929±.0073	4.292±.118	0.1063±.0009	1736±15	95

Table 18. U-Th-Pb isotopic composition of zircons from the Jacob Quartzite (95220017).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 s error	$^{207}Pb/^{235}U$ ±1 s error	$^{207}Pb/^{206}Pb$ ±1 s error	Age (Ma) ±1 s error	% conc
101.1	474	213	0.450	18275	0.091	0.2144±.0047	2.424±.060	0.0820±.0008	1245±17	100
102.1	115	67	0.581	1000000	0.000	0.2324±.0066	2.912±.102	0.0909±.0016	1443±33	93
103.1	182	294	1.616	9000	0.171	0.3326±.0096	5.268±.167	0.1149±.0012	1878±18	98
104.1	60	58	0.976	1000000	0.002	0.2789±.0128	3.699±.185	0.0962±.0015	1551±29	102
105.1	87	51	0.588	3437	0.452	0.3331±.0099	5.022±.192	0.1094±.0023	1788±38	103
106.1	111	47	0.430	100000	0.017	0.2169±.0068	2.588±.121	0.0865±.0027	1350±60	93
107.1	52	45	0.870	1000000	0.000	0.1993±.0133	2.141±.199	0.0779±.0044	1144±117	102
108.1	212	122	0.577	5626	0.305	0.1816±.0065	1.841±.087	0.0735±.0020	1028±54	104
109.1	298	192	0.645	2021	0.773	0.2665±.0063	3.982±.123	0.1084±.0018	1772±31	85
110.1	420	104	0.249	1000000	0.000	0.1690±.0044	1.752±.057	0.0752±.0012	1073±32	93
111.1	302	158	0.525	97847	0.017	0.2068±.0047	2.266±.061	0.0795±.0009	1183±23	102
112.1	354	77	0.220	6520	0.237	0.3434±.0098	5.358±.168	0.1132±.0011	1851±17	102
113.1	306	53	0.174	20178	0.077	0.3205±.0092	4.835±.153	0.1094±.0011	1789±18	100
114.1	183	132	0.718	1000000	0.002	0.2280±.0083	2.615±.106	0.0832±.0011	1273±25	104
115.1	384	248	0.646	1727	0.937	0.2193±.0066	2.821±.109	0.0933±.0019	1494±39	85
116.1	210	180	0.859	8709	0.186	0.2605±.0089	3.267±.132	0.0910±.0016	1446±34	103
117.1	588	160	0.272	3386	0.482	0.2142±.0049	2.648±.073	0.0897±.0012	1418±25	88
118.1	344	131	0.381	100000	0.017	0.2047±.0055	2.261±.069	0.0801±.0009	1199±23	100
119.1	397	222	0.560	8344	0.198	0.2209±.0054	2.579±.083	0.0847±.0016	1308±35	98
120.1	203	110	0.546	1000000	0.000	0.3008±.0084	4.631±.148	0.1117±.0014	1826±22	92
121.1	400	318	0.796	91491	0.018	0.2301±.0063	2.715±.080	0.0856±.0008	1329±17	100
122.1	457	139	0.304	2695	0.584	0.2385±.0052	3.426±.091	0.1042±.0013	1699±23	81
124.2	76	48	0.639	100000	0.017	0.1960±.0086	2.143±.136	0.0793±.0033	1180±83	97
125.1	259	136	0.527	1000000	0.000	0.2505±.0066	3.211±.097	0.0930±.0011	1487±22	96
126.1	391	145	0.372	1000000	0.000	0.2542±.0088	3.278±.121	0.0935±.0009	1498±17	97
127.1	115	78	0.679	346020	0.004	0.5295±.0157	13.448±.429	0.1842±.0016	2691±14	101
128.1	455	223	0.491	7485	0.217	0.2447±.0055	3.060±.081	0.0907±.0010	1440±22	98
129.1	153	273	1.783	9346	0.179	0.1788±.0052	2.027±.086	0.0822±.0023	1250±55	84
130.1	176	163	0.927	17141	0.091	0.3048±.0081	4.554±.149	0.1084±.0017	1772±29	96
131.1	153	88	0.578	1000000	0.002	0.2104±.0060	2.315±.079	0.0798±.0012	1192±30	103
132.1	370	268	0.724	8407	0.188	0.3067±.0074	4.315±.121	0.1020±.0012	1661±21	103
133.1	359	264	0.734	1350	1.218	0.2296±.0050	2.791±.101	0.0882±.0023	1386±50	96
134.1	163	168	1.031	16082	0.100	0.2694±.0092	3.689±.143	0.0993±.0015	1611±28	95
135.1	158	86	0.548	9631	0.160	0.3092±.0095	4.536±.162	0.1064±.0016	1738±27	99
136.1	122	59	0.486	3250	0.484	0.2545±.0079	3.079±.136	0.0877±.0025	1376±54	106
137.1	167	120	0.718	32103	0.044	0.2506±.0075	3.157±.107	0.0914±.0012	1454±24	99
138.1	65	33	0.516	6302	0.258	0.5333±.0165	13.229±.465	0.1799±.0024	2652±21	103
139.1	103	89	0.858	15078	0.105	0.3278±.0090	4.869±.154	0.1077±.0014	1761±23	103
140.1	220	110	0.501	9597	0.163	0.1809±.0041	1.906±.055	0.0764±.0012	1105±30	97
141.1	223	70	0.317	1000000	0.000	0.3233±.0077	5.042±.132	0.1131±.0010	1849±15	97
142.1	174	257	1.471	3703700	0.000	0.3352±.0101	5.335±.175	0.1154±.0011	1886±17	98
143.1	157	43	0.277	5579	0.307	0.1898±.0060	1.911±.088	0.0730±.0022	1014±60	110
144.1	64	78	1.216	2536	0.675	0.2126±.0095	2.190±.167	0.0747±.0042	1060±118	117
144.2	156	155	0.991	7527	0.224	0.1958±.0064	2.115±.101	0.0783±.0024	1155±62	99
145.1	110	103	0.940	15133	0.103	0.3178±.0089	4.877±.157	0.1113±.0014	1820±22	97
146.1	234	89	0.382	76511	0.021	0.2576±.0069	3.692±.108	0.1040±.0009	1696±16	87
147.1	378	234	0.618	18389	0.085	0.2993±.0071	4.448±.114	0.1078±.0008	1762±13	95
150.1	135	125	0.930	100000	0.016	0.2562±.0055	3.274±.085	0.0927±.0011	1481±22	99
151.1	40	25	0.628	1979	0.822	0.2442±.0075	2.958±.158	0.0878±.0035	1379±78	102
152.1	74	65	0.880	3319	0.466	0.3226±.0079	4.961±.153	0.1115±.0018	1824±28	98
153.1	168	220	1.310	1000000	0.000	0.2411±.0053	2.989±.081	0.0899±.0012	1424±25	97
154.1	102	60	0.586	1000000	0.002	0.2166±.0052	2.542±.072	0.0851±.0010	1317±23	95
155.1	203	200	0.984	81766	0.020	0.2096±.0050	2.368±.063	0.0819±.0007	1243±17	98
156.1	203	90	0.443	12711	0.108	0.5060±.0106	12.633±.296	0.1811±.0015	2662±13	99
157.1	122	27	0.223	9315	0.148	0.4898±.0160	12.226±.418	0.1811±.0012	2662±10	96
158.1	63	51	0.809	5512	0.307	0.1990±.0103	2.319±.145	0.0845±.0025	1303±57	89
158.2	232	182	0.789	5324	0.312	0.2097±.0076	2.366±.117	0.0818±.0024	1241±58	98
159.1	60	37	0.616	5969	0.283	0.1789±.0061	1.846±.101	0.0749±.0029	1064±79	99
159.2	96	59	0.619	1000000	0.000	0.1921±.0074	2.093±.105	0.0790±.0022	1172±56	96
160.1	103	106	1.025	16189	0.098	0.2813±.0066	3.894±.113	0.1004±.0014	1630±26	98
161.1	972	251	0.259	2905	0.569	0.1994±.0062	2.326±.077	0.0846±.0007	1306±14	89

162.1	214	84	0.394	100000	0.017	0.2024±.0051	2.211±.070	0.0792±.0013	1177±33	100
163.1	197	113	0.575	1000000	0.000	0.2221±.0073	2.632±.099	0.0859±.0013	1336±29	96
164.1	385	153	0.399	22277	0.074	0.2274±.0073	2.582±.088	0.0824±.0007	1254±15	105
165.1	86	46	0.542	11632	0.110	0.6811±.0249	22.243±.847	0.2368±.0016	3098±10	108
166.1	153	71	0.465	9665	0.166	0.2662±.0100	3.428±.144	0.0934±.0014	1495±28	101
167.1	182	37	0.207	43516	0.036	0.3334±.0115	5.003±.183	0.1088±.0009	1779±15	104
168.1	152	76	0.503	15830	0.098	0.3356±.0115	5.142±.191	0.1111±.0012	1818±19	102
169.1	51	46	0.903	2786	0.610	0.1979±.0108	2.139±.150	0.0784±.0030	1156±77	100
170.1	193	118	0.614	5287	0.308	0.2600±.0083	3.221±.126	0.0899±.0017	1422±37	104
171.1	110	99	0.903	907	1.907	0.1456±.0049	1.371±.114	0.0683±.0049	877±157	99
171.2	255	296	1.161	1000000	0.000	0.1563±.0033	1.542±.038	0.0716±.0008	973±23	96
172.1	349	61	0.176	29771	0.054	0.2535±.0050	3.145±.068	0.0900±.0006	1424±12	102
173.1	65	56	0.860	109050	0.014	0.3309±.0098	5.192±.169	0.1138±.0012	1860±19	99
174.1	73	44	0.607	10263	0.153	0.2944±.0071	4.221±.126	0.1040±.0016	1696±27	98
175.1	66	45	0.690	14852	0.103	0.3258±.0103	5.324±.190	0.1185±.0015	1933±23	94
176.1	76	66	0.862	1000000	0.000	0.3276±.0088	5.252±.171	0.1163±.0018	1899±28	96
177.1	117	67	0.577	11999	0.139	0.2071±.0049	2.274±.075	0.0796±.0016	1188±40	102
178.1	217	233	1.072	274730	0.006	0.2126±.0042	2.404±.057	0.0820±.0009	1246±21	99
179.1	168	136	0.810	21901	0.076	0.1993±.0047	2.224±.063	0.0809±.0011	1219±26	96
180.1	88	33	0.374	29886	0.054	0.2528±.0060	3.279±.093	0.0941±.0012	1510±24	96
181.1	170	113	0.670	100000	0.016	0.2914±.0068	4.121±.107	0.1026±.0009	1671±16	98
182.1	488	380	0.779	125630	0.012	0.3223±.0057	4.971±.092	0.1119±.0005	1830±7	98
183.1	90	82	0.908	24468	0.066	0.2510±.0068	3.236±.108	0.0935±.0015	1498±31	96
184.1	176	115	0.654	19755	0.082	0.2462+.0066	3.057±.093	0.0901±.0010	1426±21	99
185.1	77	23	0.306	12625	0.135	0.1819±.0045	1.824±.065	0.0727±.0016	1005±46	107
186.1	165	4	0.028	100000	0.017	0.2125±.0047	2.406±.064	0.0821±.0010	1248±23	99

Table 19. U-Th-Pb isotopic composition of zircons from the Needles Quartzite (96220031).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
1.1	247	227	0.918	4032	0.385	0.2875±.0096	4.182±.159	0.1055±.0015	1722±26	94
2.1	284	112	0.395	19142	0.081	0.3314±.0108	5.236±.178	0.1146±.0008	1873±12	98
3.1	126	73	0.585	11322	0.137	0.3015±.0106	4.552±.176	0.1095±.0013	1791±21	94
4.1	531	222	0.418	35460	0.044	0.2991±.0093	4.214±.136	0.1022±.0006	1664±10	101
5.1	134	59	0.439	13363	0.116	0.2914±.0103	4.079±.167	0.1015±.0017	1651±31	99
6.1	237	194	0.819	8212	0.189	0.3150±.0104	4.737±.167	0.1090±.0010	1783±16	99
7.1	137	151	1.105	5754	0.270	0.5102±.0211	12.798±.565	0.1819±.0020	2670±18	99
8.1	336	100	0.298	22512	0.069	0.4497±.0142	9.739±.334	0.1571±.0016	2424±16	98
9.1	211	162	0.768	14384	0.108	0.2449±.0107	3.071±.143	0.0909±.0011	1445±23	97
10.1	391	193	0.495	68775	0.023	0.3072±.0103	4.381±.155	0.1034±.0009	1686±15	102
11.1	70	55	0.799	22002	0.071	0.3087±.0125	4.310±.191	0.1013±.0014	1647±26	105
12.1	176	151	0.858	9897	0.157	0.3071=.0103	4.300±.156	0.1015±.0010	1652±19	104
13.1	317	163	0.516	20296	0.076	0.2783±.0088	3.817±.126	0.0995±.0007	1614±12	98
14.1	160	165	1.028	1000000	0.016	0.6195±.0236	22.114±.858	0.2589±.0011	3239±6	95
15.1	132	79	0.595	20785	0.075	0.3244≠.0109	4.867±.175	0.1088±.0010	1779±17	101
16.1	426	65	0.153	20275	0.077	0.3355±.0114	4.922±.173	0.1064±.0006	1738±10	107
16.2	128	75	0.590	18528	0.084	0.4637±.0161	10.045±.362	0.1571±.0009	2424±10	101
17.1	118	137	1.165	8698	0.178	0.2770±.0097	3.974±.151	0.1041±.0012	1697±20	92
18.1	311	77	0.249	12810	0.121	0.3080±.0100	4.572±.154	0.1076±.0007	1759±11	98
19.1	166	101	0.608	28694	0.054	0.3086±.0103	4.449±.157	0.1045±.0008	1706±14	101
20.1	126	55	0.439	39108	0.040	0.2983±.0104	4.172±.154	0.1014±.0009	1650±16	101
21.1	190	95	0.501	39968	0.039	0.3150±.0108	4.637±.166	0.1068±.0008	1744±13	101
22.1	90	99	1.105	10909	0.142	0.2615±.0094	3.156±.128	0.0875±.0013	1372±28	109
23.1	162	51	0.319	9552	0.163	0.3057±.0105	4.399±.160	0.1044±.0009	1703±16	101
24.1	55	34	0.629	7522	0.206	0.3275±.0132	4.970±.246	0.1101±.0027	1800±44	101
25.1	202	86	0.427	14872	0.104	0.3182±.0104	4.731±.163	0.1079±.0008	1763±13	101
26.1	166	55	0.334	12896	0.120	0.4804±.0165	10.232±.434	0.1545±.0032	2396±36	105
27.1	176	70	0.398	34916	0.044	0.3108±.0114	4.435±.170	0.1035±.0008	1687±14	103
28.1	469	128	0.274	82712	0.019	0.3074±.0098	4.360±.142	0.1029±.0005	1676±8	103
29.1	143	87	0.614	1000000	0.000	0.3140±.0116	4.616±.180	0.1066±.0009	1742±15	101
30.1	141	95	0.672	36205	0.043	0.3218±.0105	4.730±.164	0.1066±.0009	1741±15	103
31.1	141	127	0.907	10160	0.153	0.2890±.0117	3.901±.170	0.0979±.0011	1584±21	103
32.1	187	86	0.460	26205	0.059	0.4832±.0155	11.170±.370	0.1677±.0009	2534±9	100
33.1	148	57	0.388	1000000	0.000	0.3073±.0109	4.399±.167	0.1038±.0011	1693±19	102
34.1	107	119	1.114	27540	0.056	0.3094±.0118	4.314±.176	0.1011±.0011	1644±19	105
35.1	175	125	0.714	9157	0.170	0.3046±.0118	4.309±.179	0.1026±.0011	1671±19	102
36.1	242	164	0.679	42158	0.037	0.3191≠.0102	4.802±.160	0.1092±.0007	1785±11	100
37.1	166	67	0.405	11048	0.141	0.3027±.0099	4.242±.148	0.1016±.0009	1654±16	103
38.1	351	139	0.396	15432	0.101	0.3263±.0104	4.784±.157	0.1063±.0005	1737±9	104
39.1	348	224	0.646	118906	0.013	0.2919±.0090	4.085±.130	0.1015±.0005	1651±9	100
40.1	177	142	0.801	19546	0.079	0.3096±.0106	4.407±.159	0.1032±.0008	1682±15	103
41.1	302	130	0.433	1000000	0.000	0.3175±.0104	4.586±.155	0.1047±.0005	1709±9	104
42.1	185	121	0.655	34722	0.045	0.3082±.0098	4.453±.148	0.1048±.0007	1710±12	101
43.1	166	153	0.923	27137	0.057	0.3071±.0106	4.490±.161	0.1060±.0007	1732±12	99
44.1	259	144	0.558	584795	0.003	0.2966±.0095	4.193±.139	0.1025±.0005	1670±9	100
45.1	103	50	0.489	40404	0.038	0.3240±.0111	4.697±.170	0.1051±.0009	1716±15	105
46.1	272	95	0.351	39541	0.039	0.3135±.0098	4.575±.148	0.1059±.0006	1729±9	101
47.1	102	162	1.583	1000000	0.000	0.2285±.0075	2.793±.102	0.0886±.0011	1396±24	95
48.1	31	32	1.047	4289	0.362	0.2934±.0124	4.101±.226	0.1014±.0031	1649±57	100
49.1	217	108	0.501	65231	0.024	0.3101±.0103	4.440±.152	0.1038=.0006	1694±10	102
50.1	119	43	0.364	1000000	0.000	0.3192±.0103	4.649±.158	0.1056±.0008	1725±14	103
51.1	243	251	1.036	24390	0.064	0.2861±.0090	4.084±.133	0.1035±.0006	1688±10	96
52.1	417	148	0.356	17733	0.088	0.2954±.0092	4.293±.138	0.1054±.0005	1720±8	97
53.1	294	129	0.439	39261	0.040	0.2968±.0094	4.277±.139	0.1045±.0005	1705±8	98
54.1	99	48	0.487	1000000	0.000	0.3032±.0102	4.353±.158	0.1041±.0011	1698±19	100
55.1	78	67	0.858	1000000	0.016	0.2764±.0095	3.689±.137	0.0968±.0010	1563±19	100
56.1	153	98	0.642	28514	0.054	0.3610±.0145	6.415±.266	0.1289±.0008	2082±11	95
57.1	212	141	0.665	32351	0.048	0.3076±.0098	4.426±.146	0.1044±.0006	1702±9	101
58.1	410	139	0.340	487804	0.003	0.3027±.0095	4.265±.137	0.1022±.0004	1664±6	102
59.1	344	113	0.330	44682	0.035	0.3241±.0100	4.841±.153	0.1083±.0004	1771±7	102
60.1	399	148	0.372	64267	0.024	0.2810±.0088	4.093±.132	0.1056±.0004	1725±7	92

61.1	220	112	0.509	3209	0.484	0.2618±.0082	3.495±.119	0.0968±.0010	1563±19	95
62.1	392	183	0.469	1000000	0.000	0.2952±.0094	4.160±.136	0.1022±.0004	1664±7	100
63.1	176	133	0.759	1000000	0.000	0.3087±.0080	4.555±.140	0.1070±.0005	1749±0	99
64.1	214	95	0.446	31897	0.049	0.3025±.0097	4.248±.142	0.1019±.0007	1658±11	102
65.1	132	88	0.669	82034	0.019	0.2950±.0108	4.148±.158	0.1020±.0008	1660±14	100
66.1	150	73	0.493	1000000	0.000	0.3276±.0103	5.004±.165	0.1108±.0008	1812±12	100
67.1	280	300	1.071	50632	0.031	0.2473±.0080	3.004±.101	0.0881±.0005	1384±10	102
68.1	76	68	0.893	100000	0.016	0.3002±.0114	4.210±.172	0.1017±.0012	1655±21	102
69.1	224	241	1.077	32195	0.048	0.3116±.0101	4.494±.150	0.1046±.0005	1707±9	102
70.1	213	46	0.218	1000000	0.000	0.4068±.0138	8.526±.295	0.1520±.0006	2368±6	92
71.1	500	365	0.729	1000000	0.000	0.2995±.0095	4.361±.141	0.1056±.0004	1725±6	97
72.1	268	107	0.402	19443	0.080	0.2995±.0098	4.239±.143	0.1026±.0005	1672±9	101
73.1	111	74	0.674	51599	0.030	0.2534±.0085	3.159±.118	0.0904±.0011	1434±23	101
74.1	205	97	0.475	23657	0.066	0.3167±.0102	4.826±.163	0.1105±.0007	1807±11	98
75.1	96	39	0.408	230946	0.007	0.3469±.0115	5.574±.195	0.1165±.0009	1903±14	100
76.1	366	21	0.059	591716	0.003	0.2993±.0094	4.433±.143	0.1074±.0005	1756±8	96
77.1	494	54	0.111	56148	0.028	0.3006±.0093	4.297±.137	0.1037±.0004	1690±7	100
78.1	240	154	0.642	28901	0.054	0.2955±.0098	4.181±.144	0.1026±.0006	1671±10	99
79.1	519	194	0.374	177619	0.009	0.3268±.0103	5.107±.164	0.1133±.0004	1853±6	98
80.1	127	45	0.354	43782	0.035	0.2901±.0095	4.083±.142	0.1021±.0009	1662±15	98
81.1	137	54	0.396	30303	0.051	0.3190±.0103	4.745±.163	0.1079±.0009	1763±14	101
82.1	337	111	0.330	37693	0.041	0.4268±.0132	9.071±.287	0.1541±.0005	2392±5	95
83.1	103	58	0.564	1000000	0.000	0.2991±.0098	4.309±.153	0.1045±.0011	1705±18	98
84.1	41	35	0.850	1000000	0.000	0.2996±.0112	4.271±.195	0.1034±.0023	1685±41	100
85.1	156	68	0.437	42771	0.036	0.3097±.0103	4.534±.158	0.1062±.0007	1735±12	100
86.1	111	105	0.941	53134	0.029	0.3283±.0112	5.075±.182	0.1121±.0009	1833±14	99
87.1	224	76	0.343	33749	0.046	0.4238±.0140	9.036±.329	0.1546±.0018	2397±20	95
88.1	277	205	0.741	19241	0.081	0.2999±.0095	4.185±.140	0.1012±.0007	1646±13	102
89.1	557	251	0.452	8565	0.181	0.2271±.0070	2.804±.089	0.0896±.0005	1416±10	93
90.1	426	129	0.303	4747	0.327	0.3223±.0102	4.520±.150	0.1017±.0007	1655±12	108
91.1	245	79	0.322	34494	0.045	0.2927±.0092	4.221±.139	0.1046±.0006	1707±11	97
92.1	566	149	0.264	26253	0.059	0.2910±.0092	4.103±.133	0.1023±.0004	1665±7	98
93.1	195	138	0.711	1000000	0.000	0.2492±.0080	3.144±.100	0.0915±.0007	1457±10	98
94.1	272	227	0.835	24324	0.064	0.2962±.0092	4.260±137	0.1043±.0005	1702±9	98
94.2	558	338	0.606	1325	1.171	0.2358±.0072	3.354±.108	0.1032±.0008	1681±14	81
95.1	183	101	0.553	72516	0.021	0.4640±.0155	11.339±.387	0.1772±.0007	2627±6	93
96.1	100	42	0.423	131233	0.012	0.2912±.0097	4.109±.145	0.1023±.0008	1666±15	98
97.1	41	82	1.996	8965	0.173	0.2414±.0089	2.938±.137	0.0883±.0021	1388±47	100
98.1	25	35	1.374	2485	0.625	0.2765±.0115	3.528±.221	0.0925±.0039	1478±82	106
99.1	60	45	0.745	1000000	0.000	0.2639±.0080	3.416±.100	0.0939±.0035	1505±10	100
100.1	145	54	0.374	1000000	0.000	0.3129±.0100	4.830±.163	0.1120±.0008	1831±12	95
101.1	500	369	0.740	100704	0.015	0.2221±.0084	2.736±.106	0.0894±.0005	1412±10	91
102.1	257	331	1.286	3521	0.441	0.2675±.0102	4.072±.164	0.1104±.0011	1806±17	84
103.1	597	43	0.073	833333	0.002	0.2968±.0094	4.276±.138	0.1045±.0003	1705±6	98
104.1	114	71	0.625	17705	0.088	0.2976±.0108	4.134±.160	0.1007±.0009	1637±17	102
105.1	471	246	0.523	13493	0.115	0.3061±.0099	4.702±.156	0.1114±.0005	1822±7	94
106.1	190	76	0.399	39123	0.040	0.3495±.0120	5.788±.205	0.1201±.0007	1957±10	98
107.1	200	179	0.895	38834	0.040	0.3240±.0102	5.173±.169	0.1158±.0007	1892±10	95
108.1	184	47	0.258	1000000	0.000	0.3045±.0106	4.447±.162	0.1059±.0007	1730±12	99
109.1	121	52	0.435	100000	0.016	0.2449±.0080	3.009±.109	0.0891±.0011	1406±23	100
110.1	81	76	0.940	19692	0.079	0.3067±.0106	4.586±.172	0.1085±.0012	1773±20	97
111.1	25	20	0.820	20669	0.075	0.2823±.0148	4.012±.239	0.1031±.0023	1679±42	95
112.1	162	139	0.863	10698	0.145	0.2518±.0080	3.157±.111	0.0909±.0010	1445±21	100
113.1	321	90	0.281	51098	0.030	0.2918±.0095	4.099±.137	0.1019±.0005	1658±8	99
114.1	212	90	0.427	8958	0.173	0.2830±.0095	3.967±.139	0.1017±.0008	1654±13	97
115.1	126	70	0.557	19920	0.078	0.2779±.0102	3.887±.152	0.1015±.0010	1650±18	95
116.1	334	98	0.294	44306	0.035	0.2907±.0090	4.106±.132	0.1024±.0005	1668±9	98
117.1	97	28	0.294	16041	0.097	0.3473±.0154	4.921±.233	0.1028±.0012	1674±21	114
118.1	722	115	0.161	34794	0.045	0.2873±.0088	4.045±.125	0.1021±.0003	1662±5	97
119.1	226	148	0.653	29735	0.052	0.2890±.0097	4.103±.144	0.1030±.0007	1678±13	97
120.1	436	278	0.639	1000000	0.000	0.3345±.0103	5.283±.166	0.1146±.0004	1873±6	99
121.1	140	69	0.493	1000000	0.000	0.2900±.0094	4.146±.141	0.1037±.0007	1690±12	97
122.1	131	54	0.411	7816	0.199	0.3011±.0098	4.283±.149	0.1032±.0009	1681±16	100
123.1	83	66	0.800	94517	0.016	0.3057±.0101	4.456±.155	0.1057±.0009	1727±15	99
124.1	191	101	0.532	34411	0.045	0.3043±.0103	4.422±.156	0.1054±.0007	1721±12	99
125.1	131	90	0.694	14450	0.107	0.2814±.0099	4.045±.151	0.1043±.0010	1701±17	93
126.1	149	137	0.920	1000000	0.000	0.3284±.0104	5.239±.172	0.1157±.0007	1890±10	96
127.1	394	310	0.788	609756	0.003	0.2892±.0099	4.190±.146	0.1051±.0004	1715±7	95
128.1	301	141	0.468	12065	0.129	0.3081±.0110	4.906±.183	0.1155±.0008	1887±12	91
129.1	280	120	0.431	1000000	0.080	0.3141±.0100	4.672±.180	0.1079±.0007	1763±7	99

Table 20. U-Th-Pb isotopic composition of zircons from the Tyennan Element quartzite (95220029).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
201.1	93	93	1.000	13879	0.115	0.2691±.0092	3.635±.136	0.0979±.0011	1585±21	96
202.1	195	100	0.515	34782	0.045	0.3143±.0092	4.700±.145	0.1085±.0007	1773±12	99
203.1	177	57	0.322	164473	0.010	0.3031±.0088	4.353±.132	0.1042±.0007	1699±11	100
204.1	264	92	0.350	161812	0.009	0.4777±.0129	10.875±.303	0.1651±.0007	2508±6	100
205.1	71	34	0.484	41305	0.038	0.3343±.0108	5.075±.178	0.1101±.0012	1801±19	103
206.1	296	53	0.179	1000000	0.000	0.2977±.0090	4.215±.132	0.1027±.0005	1673±9	100
207.1	91	77	0.845	45537	0.034	0.3151±.0095	4.722±.159	0.1087±.0012	1777±20	99
208.1	168	78	0.466	10471	0.150	0.2948±.0112	4.270±.171	0.1050±.0009	1715±16	97
209.1	115	105	0.918	1000000	0.000	0.3206±.0086	4.803±.141	0.1087±.0010	1777±16	100
210.1	129	123	0.951	48947	0.032	0.2986±.0103	4.265±.158	0.1036±.0010	1689±18	99
210.2	146	166	1.131	141643	0.011	0.2849±.0084	4.053±.129	0.1032±.0009	1682±15	96
211.1	428	109	0.256	43346	0.036	0.3196±.0099	4.574±.151	0.1038±.0009	1693±15	105
212.1	320	328	1.023	13517	0.115	0.2863±.0110	4.399±.174	0.1115±.0007	1823±10	89
213.1	236	204	0.864	25169	0.063	0.2688±.0083	3.635±.120	0.0981±.0009	1587±16	96
214.1	66	48	0.727	1000000	0.000	0.3045±.0091	4.467±.156	0.1064±.0015	1738±26	98
215.1	118	103	0.872	15812	0.097	0.3423±.0094	5.433±.160	0.1151±.0009	1881±13	100
216.1	131	51	0.390	13225	0.118	0.3228±.0092	4.845±.148	0.1089±.0009	1780±15	101
217.1	180	117	0.651	14751	0.106	0.3203±.0083	4.812±.134	0.1089±.0008	1781±13	100
218.1	560	60	0.107	97656	0.016	0.2991±.0072	4.302±.106	0.1043±.0003	1702±6	99
219.1	240	84	0.351	12156	0.130	0.3025±.0081	4.266±.121	0.1023±.0007	1665±11	102
220.1	247	119	0.481	42571	0.037	0.2986±.0076	4.260±.115	0.1035±.0007	1687±12	99
221.1	470	275	0.586	93720	0.016	0.3274±.0080	5.133±.129	0.1137±.0004	1859±6	98
222.1	36	46	1.266	4072	0.388	0.2906±.0117	4.072±.194	0.1016±.0021	1654±38	99
223.1	213	47	0.223	100000	0.016	0.3073±.0081	4.630±.127	0.1093±.0006	1787±10	96
224.1	223	58	0.261	64683	0.024	0.3077±.0076	4.400±.116	0.1037±.0007	1691±11	102
225.1	314	184	0.589	1813	0.831	0.3681±.0099	6.306±.193	0.1243±.0014	2018±20	100
226.1	130	55	0.425	19557	0.080	0.2887±.0087	4.132±.137	0.1038±.0011	1693±19	96
227.1	50	48	0.945	3587	0.436	0.3156+.0105	4.588±.184	0.1054±.0019	1721±34	102
228.1	275	90	0.328	33288	0.047	0.2908+.0071	4.125±.106	0.1029±.0005	1676±9	98
229.1	83	40	0.481	22909	0.068	0.3092±.0106	4.587±.168	0.1076±.0011	1759±18	98
230.1	299	109	0.367	2736	0.570	0.3178±.0084	4.735+.134	0.1081±.0008	1767±13	100
231.1	464	95	0.205	100000	0.016	0.2968±.0071	4.219±.105	0.1031±.0004	1680±6	99
232.1	115	66	0.574	1000000	0.000	0.3224±.0098	4.888±.158	0.1099±.0008	1798±13	100
233.1	162	78	0.485	16537	0.094	0.3196±.0093	4.885±.151	0.1109±.0008	1813±13	98
234.1	100	48	0.483	20312	0.070	0.5053±.0142	11.258±.373	0.1616±.0023	2472±24	106
235.1	587	178	0.303	134048	0.012	0.2894±.0070	4.094±.102	0.1026±.0004	1672±7	98
236.1	690	116	0.169	100000	0.016	0.3016±.0081	4.355±.120	0.1047±.0004	1709±6	99
237.1	159	82	0.519	31595	0.049	0.3119±.0080	4.674±.128	0.1087±.0007	1777±12	98
238.1	227	87	0.384	100000	0.016	0.3175±.0084	4.681±.130	0.1069±.0006	1747±10	101
239.1	227	92	0.407	1000000	0.000	0.3125±.0085	4.745±.135	0.1101±.0006	1801±10	97
240.1	210	93	0.446	6666666	0.000	0.3259±.0082	4.891±.128	0.1089±.0005	1780±9	102
241.1	228	158	0.694	14475	0.109	0.2867±.0074	4.075±.112	0.1031±.0007	1680±12	96
242.1	192	148	0.773	100000	0.016	0.3089±.0090	4.527±.144	0.1063±.0010	1736±17	99
243.1	131	83	0.630	20815	0.075	0.3239±.0096	4.808±.154	0.1076±.0009	1759±15	102
244.1	250	45	0.181	7587	0.206	0.3159±.0080	4.678±.128	0.1074±.0008	1755±13	100
245.1	276	293	1.061	53248	0.030	0.2821±.0070	3.959±.104	0.1018±.0006	1656±11	96
246.1	283	70	0.250	46707	0.033	0.2991±.0074	4.423±.117	0.1073±.0007	1753±11	96
247.1	448	83	0.185	5753	0.271	0.3119±.0087	4.632±.136	0.1077±.0006	1761±10	99
248.1	177	94	0.531	9457	0.166	0.3125±.0073	4.606±.119	0.1069±.0009	1747±15	100
249.1	341	211	0.619	26075	0.060	0.2883±.0067	4.169±.102	0.1049±.0006	1711±10	95
250.1	144	44	0.311	1000000	0.000	0.3335±.0083	5.135±.138	0.1117±.0008	1826±13	101
251.1	417	226	0.541	3143	0.504	0.2550±.0060	3.582±.095	0.1019±.0009	1658±16	88
252.1	591	230	0.390	3208	0.489	0.2644±.0076	3.811±.118	0.1046±.0008	1706±14	88
253.1	325	154	0.474	14312	0.107	0.3327±.0077	5.337±.132	0.1164±.0007	1901±10	97
254.1	367	128	0.348	35945	0.043	0.3226±.0071	5.056±.118	0.1137±.0006	1858±9	97
255.1	146	60	0.412	26212	0.059	0.3240±.0079	4.912±.139	0.1100±.0013	1798±21	100
256.1	369	162	0.440	115074	0.014	0.3060±.0066	4.458±.101	0.1057±.0005	1725±8	99
257.1	547	346	0.632	39904	0.040	0.2833±.0061	4.006±.090	0.1026±.0004	1671±8	96
258.1	222	108	0.490	20329	0.077	0.2951±.0082	4.305±.128	0.1058±.0008	1728±14	96

259.1	151	86	0.568	12012	0.131	0.2962±.0090	4.152±.139	0.1017±.0011	1654±20	101
260.1	395	222	0.562	7634	0.207	0.2767±.0060	3.903±.091	0.1023±.0007	1666±11	94
261.1	257	79	0.309	100000	0.016	0.3276±.0076	4.942±.123	0.1094±.0007	1789±11	102
262.1	490	177	0.362	1000000	0.000	0.2632±.0078	3.764±.115	0.1037±.0005	1691±8	89
263.1	274	94	0.346	86580	0.018	0.2817+.0126	3.978±.185	0.1024±.0008	1668±14	95
264.1	293	94	0.320	37023	0.042	0.3050±.0073	4.830±.122	0.1149+.0007	1877±10	91
265.1	274	330	1.204	25207	0.062	0.3057±.0073	4.657±.117	0.1105±.0007	1807±10	95
266.1	195	155	0.798	35335	0.044	0.3343±.0086	5.214±.143	0.1131±.0008	1850±12	100
267.1	96	38	0.403	9943	0.156	0.3145±.0078	4.746±.139	0.1094±.0014	1790±23	98
268.1	358	224	0.626	1000000	0.000	0.2777±.0073	3.960±.109	0.1034±.0005	1686±9	93
269.1	274	96	0.353	100000	0.016	0.3157±.0085	4.701±.133	0.1080±.0006	1765±10	100
270.1	85	55	0.647	154559	0.010	0.2792±.0074	3.991±.118	0.1037±.0011	1691±19	93
271.1	213	81	0.383	40176	0.039	0.3084±.0072	4.665±.117	0.1097±.0008	1794±12	96
272.1	189	74	0.395	12966	0.121	0.2455±.0102	3.530±.168	0.1043±.0020	1701±35	83
273.1	311	203	0.653	24673	0.064	0.2816±.0071	3.974±.105	0.1024±.0006	1667±11	95
274.1	201	216	1.073	123915	0.013	0.3131±.0095	4.467±.151	0.1035±.0012	1687±21	104
275.1	469	103	0.220	100000	0.016	0.3230±.0074	4.786±.115	0.1075±.0006	1757±9	102
276.1	92	42	0.459	9589	0.163	0.3104±.0092	4.525±.161	0.1057±.0017	1727±30	100
277.1	241	73	0.306	549450	0.003	0.2943±.0077	4.306±.125	0.1061±.0011	1733±18	95
278.1	175	65	0.372	24479	0.064	0.3105±.0123	4.630±.200	0.1081±.0014	1768±24	98
279.1	375	139	0.371	1000000	0.000	0.3011±.0077	4.472±.122	0.1077±.0008	1761±12	96
280.1	267	120	0.451	8381	0.188	0.2519±.0072	3.588±.118	0.1033±.0014	1684±25	85
281.1	183	125	0.684	5387	0.296	0.2751±.0122	3.702±.191	0.0976±.0021	1579±40	99
282.1	247	153	0.618	1000000	0.000	0.2966±.0080	4.223±.127	0.1033±.0010	1683±18	99

Table 21. U-Th-Pb isotopic composition of zircons from the Oonah Formation quartzite.

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
101.1	223	80	0.362	120192	0.013	0.3195±.0083	4.861±.133	0.1104±.0006	1805±10	99
102.1	181	79	0.438	14590	0.112	0.2382±.0063	2.938±.085	0.0895±.0008	1413±16	97
103.1	158	50	0.319	1000000	0.000	0.2387±.0066	3.041±.092	0.0924±.0009	1475±18	93
104.1	113	163	1.443	61804	0.026	0.2753±.0093	3.783±.139	0.0997±.0011	1617±21	96
105.1	125	50	0.399	34965	0.037	0.5879±.0199	17.805±.618	0.2197±.0010	2978±7	100
106.1	87	71	0.818	8473	0.183	0.3272±.0166	4.937±.283	0.1094±.0023	1790±38	101
107.1	278	69	0.248	1000000	0.002	0.3026±.0082	4.411±.125	0.1057±.0006	1726±9	98
108.1	137	102	0.744	1000000	0.000	0.3304±.0095	4.974±.153	0.1092±.0009	1785±15	103
109.1	309	249	0.806	154559	0.009	0.5055±.0126	11.578±.296	0.1661±.0005	2518±5	104
110.1	69	45	0.661	1000000	0.000	0.3008±.0104	4.568±.173	0.1102±.0013	1802±22	94
111.1	119	59	0.495	13825	0.113	0.3311±.0093	4.980±.155	0.1091±.0011	1784±18	103
112.1	166	143	0.862	1000000	0.001	0.5348±.0197	14.773±.554	0.2003±.0008	2828±6	97
113.1	114	127	1.112	12961	0.122	0.2947±.0087	4.064±.134	0.1000±.0011	1624±21	102
114.1	76	75	0.990	1000000	0.002	0.3021±.0091	4.148±.136	0.0996±.0010	1616±18	105
115.1	240	62	0.261	14714	0.106	0.3226±.0083	4.791±.131	0.1077±.0007	1760±12	102
116.1	76	54	0.717	19904	0.078	0.3197±.0108	4.803±.180	0.1090±.0014	1782±23	100
117.1	258	129	0.502	67159	0.023	0.3252±.0082	4.884±130	0.1089±.0006	1781±10	101
118.1	205	96	0.468	1000000	0.000	0.3298±.0091	5.048±.146	0.1110±.0006	1816±9	101
119.1	165	133	0.805	1000000	0.000	0.2554±.0070	3.324±.097	0.0944±.0007	1516±14	96
120.1	84	68	0.812	841	1.868	0.3150±.0100	4.581±.195	0.1055±.0026	1722±45	102
121.1	130	38	0.296	44503	0.035	0.3277±.0093	5.019±.152	0.1111±.0009	1816±13	100
122.1	63	29	0.463	10065	0.141	0.4520±.0186	10.150±.441	0.1629±.0015	2485±16	96
123.1	191	98	0.513	9793	0.158	0.3353±.0088	5.163±.145	0.1117≠.0008	1827±12	102
124.1	393	131	0.335	1000000	0.000	0.3154±.0082	4.732±.126	0.1088±.0004	1779±6	99
125.1	117	78	0.671	1000000	0.000	0.3576±.0110	5.904±.195	0.1198±.0010	1952±15	100
126.1	182	184	1.013	3769	0.415	0.3188±.0086	4.719±.146	0.1074±.0013	1755±22	101
127.1	182	114	0.631	8614	0.180	0.3191±.0083	4.810±.134	0.1093±.0007	1788±12	99
128.1	66	83	1.242	16439	0.094	0.3242±.0135	4.973±.222	0.1112+.0013	1819±21	99
129.1	195	74	0.382	59206	0.024	0.4068±.0113	8.660±.262	0.1544±.0014	2395±15	91
130.1	121	94	0.781	20691	0.077	0.2812±.0087	3.860±.128	0.0996±.0009	1615±16	98
131.1	139	82	0.591	1000000	0.000	0.2761±.0075	3.827±.112	0.1006±.0008	1634±14	96
132.1	201	123	0.611	1000000	0.000	0.2539±.0078	3.170±.108	0.0906±.0011	1437±22	101
133.1	150	101	0.675	43725	0.031	0.5072±.0138	12.678±.355	0.1813±.0008	2664±7	99
134.1	231	114	0.495	10605	0.147	0.3190±.0092	4.754±.145	0.1081±.0007	1767±11	101
135.1	127	62	0.492	69930	0.019	0.5475±.0145	15.057±.411	0.1995±.0009	2821±7	99
136.1	96	65	0.682	33658	0.046	0.3105±.0093	4.627±.150	0.1081±.0010	1767±16	98
137.1	68	52	0.775	5051	0.308	0.3269±.0096	4.908±.170	0.1089±.0016	1780±27	102
138.1	254	67	0.264	100000	0.016	0.3106±.0080	4.654±.126	0.1087±.0006	1777±10	98
139.1	99	74	0.751	1000000	0.000	0.3207±.0108	4.916±.178	0.1112±.0011	1818±18	98
140.1	397	156	0.394	1000000	0.000	0.3404±.0082	5.440±.135	0.1159±.0004	1893±7	99
141.1	234	91	0.393	1000000	0.002	0.3229±.0081	4.928±.129	0.1107±.0005	1810±9	99
142.1	233	81	0.347	56947	0.028	0.3043±.0082	4.445±.124	0.1059±.0005	1730±9	98
143.1	94	52	0.555	51572	0.025	0.6185±.0175	20.345±.594	0.2386±.0011	3110±7	99
144.1	150	101	0.679	1000000	0.000	0.3356±.0092	5.021±.145	0.1085±.0007	1774±11	105
145.1	194	73	0.377	5006	0.312	0.3165±.0076	4.694±.130	0.1076±.0012	1758±20	100
146.1	103	84	0.817	1000000	0.000	0.2812±.0102	3.912±.154	0.1009±.0011	1641±20	97
147.1	95	50	0.531	1000000	0.000	0.3324±.0094	4.982±.160	0.1087±.0013	1778±22	104
148.1	42	34	0.821	3154	0.515	0.2679±.0103	3.294±.187	0.0892±.0033	1408±73	108
149.1	267	253	0.947	36764	0.043	0.3000±.0072	4.209±.108	0.1018±.0007	1656±13	102
150.1	29	43	1.483	9286	0.167	0.3203±.0118	4.897±.230	0.1109±.0028	1813±45	98
151.1	113	117	1.031	1587301	0.001	0.2919±.0072	4.036±.111	0.1002±.0009	1628±17	101
152.1	187	98	0.529	1000000	0.000	0.3131±.0088	4.736±.141	0.1097±.0008	1794±13	97
153.1	102	53	0.515	4526	0.359	0.2307±.0074	2.806±.114	0.0882±.0019	1387±41	96
154.1	214	131	0.612	141043	0.010	0.4730±.0115	10.779±.272	0.1653±.0007	2510±7	99
155.1	149	60	0.407	564971	0.003	0.3377±.0108	5.665±.190	0.1217±.0009	1980±12	94
156.1	150	158	1.056	13702	0.114	0.3242±.0081	4.771±.131	0.1067±.0009	1744±15	103
157.1	345	123	0.356	14376	0.107	0.3466±.0077	5.468±.128	0.1144±.0006	1870±9	102
158.1	205	168	0.822	51733	0.027	0.4662±.0110	10.676±.265	0.1661±.0009	2518±8	97
159.1	137	128	0.935	10615	0.147	0.3108±.0082	4.650±.137	0.1085±.0011	1774±18	98
160.1	112	77	0.683	6201	0.249	0.3205±.0093	4.954±.162	0.1121±.0013	1833±21	97
161.1	318	136	0.427	13592	0.115	0.3239±.0074	4.881±.120	0.1093±.0007	1787±11	101

162.1	95	43	0.455	31999	0.040	0.6152±.0162	20.647±.566	0.2434±.0013	3142±8	98
163.1	172	65	0.377	1000000	0.000	0.2308±.0088	3.018±.136	0.0949±.0018	1525±36	87
164.1	262	106	0.405	52029	0.027	0.5495±.0249	13.182±.607	0.1740±.0008	2596±7	108
165.1	349	242	0.695	48146	0.033	0.3066±.0076	4.433±.115	0.1049±.0006	1711±10	100
166.1	105	65	0.618	13354	0.118	0.3156±.0092	4.627±.148	0.1063±.0010	1737±18	101
167.1	109	87	0.804	3354	0.501	0.1910±.0048	2.067±.078	0.0785±.0020	1158±51	97
168.1	275	180	0.656	15080	0.108	0.2533±.0077	3.144±.103	0.0900±.0008	1426±16	102
169.1	355	448	1.260	238095	0.006	0.4444±.0104	9.874±.237	0.1611±.0005	2467±5	96
170.1	209	180	0.861	3622	0.445	0.2205±.0140	2.898±.215	0.0953±.0030	1533±60	83
171.1	133	106	0.799	3464	0.462	0.2857±.0069	3.879±.125	0.0985±.0018	1595±34	101
172.1	348	139	0.401	1000000	0.000	0.3282±.0074	4.956±.117	0.1095±.0005	1791±8	102
173.1	122	85	0.698	287356	0.005	0.3275±.0095	4.961±.154	0.1099±.0009	1797±14	101
174.1	356	276	0.776	17024	0.079	0.5163±.0128	13.703±.356	0.1925±.0010	2763±8	97
175.1	130	86	0.666	15888	0.098	0.3115±.0090	4.676±.146	0.1089±.0010	1780±16	98
176.1	221	226	1.023	22878	0.069	0.3184±.0080	4.499±.128	0.1025±.0011	1669±19	106
177.1	168	134	0.799	1000000	0.000	0.3380±.0097	5.074±.161	0.1089±.0012	1780±19	105
178.1	126	73	0.579	81037	0.019	0.3276±.0091	4.883±.153	0.1081±.0012	1767±21	103
179.1	54	44	0.812	4912	0.288	0.4855±.0184	10.803±.470	0.1614±.0028	2470±29	103
180.1	97	102	1.050	40371	0.039	0.2965±.0100	4.079±.179	0.0998±.0024	1619±45	103
181.1	79	83	1.049	5506	0.281	0.2394±.0137	3.640±.283	0.1103±.0051	1803±86	76
182.1	161	88	0.548	1000000	0.000	0.4873±.0160	13.502±.469	0.2010±.0016	2834±13	90
183.1	133	65	0.490	100000	0.016	0.3089±.0108	4.673±.185	0.1097±.0016	1794±27	96
184.1	56	79	1.394	1000000	0.002	0.2971±.0137	4.616±.236	0.1127±.0019	1843±30	91

Table 22. U-Th-Pb isotopic composition of zircons from the Ulverstone Metamorphic Complex quartzite (95220021).

Grain area	U (ppm)	Th (ppm)	Th/U	$^{206}Pb/^{204}Pb$	f_{206}	$^{206}Pb/^{238}U$ ±1 σ error	$^{207}Pb/^{235}U$ ±1 σ error	$^{207}Pb/^{206}Pb$ ±1 σ error	Age (Ma) ±1 σ error	% conc
1.1	75	69	0.925	89047	0.014	0.6033±.0184	19.592±.616	0.2355±.0012	3090±7	98
2.1	171	160	0.940	23408	0.066	0.2976±.0081	4.512±.131	0.1100±.0008	1798±13	93
3.1	235	197	0.840	23212	0.066	0.3337±.0093	5.221±.152	0.1135±.0007	1856±10	100
3.2	99	67	0.673	20441	0.075	0.3233±.0091	5.185±.160	0.1163±.0011	1900±17	95
4.1	140	64	0.458	1000000	0.000	0.5370±.0161	14.770±.455	0.1995±.0009	2821±7	98
5.1	292	113	0.387	1000000	0.000	0.4533±.0134	10.037±.315	0.1606±.0012	2461±12	97
6.1	55	49	0.877	8333333	0.000	0.2576±.0090	3.285±.126	0.0925±.0011	1477±22	100
7.1	204	172	0.846	1000000	0.000	0.3302±.0086	5.012±.136	0.1101±.0006	1801±10	102
8.1	271	109	0.402	1000000	0.000	0.2713±.0075	3.643±.105	0.0974±.0006	1574±11	98
9.1	78	48	0.620	11470	0.136	0.3087±.0098	4.657±.167	0.1094±.0014	1789±24	96
10.1	170	77	0.453	34188	0.041	0.4631±.0125	10.628±.296	0.1664±.0008	2522±7	97
11.1	206	78	0.382	1000000	0.000	0.3106±.0080	4.720±.129	0.1102±.0007	1803±12	96
12.1	131	136	1.038	32520	0.049	0.2858±.0091	3.901±.136	0.0990±.0011	1604±20	101
13.1	141	54	0.389	100000	0.015	0.3191±.0091	4.902±.149	0.1114±.0008	1822±13	97
14.1	237	168	0.710	1000000	0.002	0.2349±.0065	2.822±.083	0.0871±.0006	1363±12	99
15.1	179	94	0.526	301204	0.005	0.3107±.0090	4.824±.145	0.1126±.0006	1841±9	94
16.1	139	98	0.709	1000000	0.000	0.3145±.0090	4.743±.144	0.1094±.0008	1789±13	98
17.1	132	65	0.495	19331	0.081	0.3262±.0105	4.880±.165	0.1085±.0008	1774±13	102
18.1	71	38	0.534	8334	0.183	0.3453±.0105	5.567±.188	0.1169±.0013	1909±19	100
19.1	196	102	0.521	24360	0.064	0.3229±.0086	4.800±.135	0.1078±.0007	1762±11	102
20.1	148	90	0.609	13564	0.115	0.3167±.0094	4.769±.150	0.1092±.0008	1786±13	99
21.1	118	66	0.562	1000000	0.000	0.3476±.0101	5.400±.167	0.1127±.0009	1843±13	104
22.1	48	44	0.929	100000	0.016	0.3348±.0127	5.108±.215	0.1106±.0016	1810±26	102
23.1	194	182	0.936	19638	0.081	0.2930±.0077	3.987±.112	0.0987±.0007	1599±12	103
24.1	27	19	0.728	12651	0.119	0.3632±.0142	6.406±.276	0.1279±.0018	2069±24	96
25.1	164	93	0.570	20189	0.066	0.5090±.0138	13.966±.391	0.1990±.0009	2817±7	94
26.1	139	157	1.129	19440	0.080	0.3196±.0094	4.891±.151	0.1110±.0008	1815±12	98
27.1	203	104	0.516	9264	0.173	0.2929±.0079	3.840±.113	0.0951±.0009	1529±17	108
28.1	145	61	0.425	10049	0.155	0.3117±.0083	4.742±.135	0.1103±.0008	1805±13	96
29.1	147	87	0.588	13218	0.120	0.2934±.0082	4.162±.127	0.1029±.0009	1676±16	98
30.1	181	150	0.830	113122	0.014	0.3482±.0104	5.469±.171	0.1139±.0007	1863±10	103
31.1	321	128	0.400	34435	0.045	0.3358±.0088	5.338±.144	0.1153±.0005	1884±7	99
32.1	199	102	0.514	91157	0.017	0.3014±.0084	4.307±.126	0.1036±.0006	1690±11	100
33.1	345	219	0.634	31938	0.049	0.3163±.0078	4.781±.122	0.1096±.0005	1793±8	98
34.1	158	44	0.279	100000	0.016	0.3164±.0085	4.777±.136	0.1095±.0008	1791±13	98
35.1	118	86	0.733	31525	0.044	0.4859±.0135	11.515±.337	0.1718±.0011	2575±10	99
36.1	155	121	0.782	15790	0.096	0.3575±.0107	6.060±.191	0.1229±.0009	1999±12	98
37.1	157	114	0.728	26504	0.059	0.3309±.0085	4.956±.145	0.1086±.0012	1776±20	103
38.1	83	66	0.793	28312	0.055	0.3215±.0093	4.839±.151	0.1092±.0009	1785±15	100
39.1	326	334	1.022	1000000	0.000	0.2667±.0065	3.717±.095	0.1011±.0005	1644±9	92
40.1	123	126	1.022	7288	0.216	0.2419±.0066	3.464±.108	0.1039±.0013	1694±22	82
41.1	128	127	0.990	1000000	0.000	0.3219±.0088	4.894±.145	0.1103±.0009	1803±15	99
42.1	107	86	0.807	66137	0.024	0.3198±.0101	4.824±.162	0.1094±.0008	1789±13	100
43.1	386	183	0.476	86805	0.018	0.3128±.0076	4.610±.116	0.1069±.0004	1747±7	100
44.1	256	178	0.698	7327	0.214	0.3053±.0076	4.380±.121	0.1041±.0010	1697±16	101
45.1	145	97	0.675	15915	0.098	0.3057±.0076	4.475±.126	0.1062±.0011	1734±19	99
46.1	183	28	0.157	19790	0.079	0.3069±.0077	4.559±.126	0.1077±.0010	1761±16	98
47.1	235	106	0.453	1000000	0.000	0.3162±.0079	4.861±.129	0.1115±.0007	1824±11	97
48.1	79	153	1.921	100000	0.015	0.3669±.0105	6.019±.197	0.1190±.0015	1940±22	103
49.1	379	37	0.100	17879	0.088	0.3106±.0076	4.497±.116	0.1050±.0005	1714±9	101
50.1	418	174	0.418	34734	0.045	0.3223±.0070	4.662±.106	0.1049±.0005	1712±8	105
51.1	137	78	0.567	23540	0.066	0.3227±.0088	4.990±.149	0.1121±.0011	1834±17	98
52.1	200	95	0.479	21290	0.073	0.3011±.0078	4.547±.130	0.1095±.0010	1791±17	94
53.1	144	82	0.572	70921	0.020	0.4558±.0147	10.517±.355	0.1673±.0012	2531±11	95
54.1	123	60	0.492	15748	0.099	0.3051±.0079	4.563±.139	0.1085±.0014	1773±23	96
55.1	98	72	0.732	42390	0.033	0.4590±.0118	10.167±.279	0.1607±.0011	2462±11	98
56.1	136	59	0.432	1000000	0.000	0.3185±.0095	4.820±.154	0.1097±.0009	1795±15	99
57.1	137	105	0.763	18521	0.085	0.2982±.0092	4.301±.144	0.1046±.0010	1707±18	98
58.1	139	29	0.210	12262	0.126	0.3339±.0114	5.188±.190	0.1127±.0011	1843±17	100
59.1	234	100	0.429	54945	0.028	0.3187±.0076	4.999±.126	0.1138±.0007	1860±10	95
60.1	246	42	0.173	13415	0.117	0.2971±.0070	4.402±.123	0.1075±.0013	1756±22	95

61.1	127	108	0.852	13333	0.119	0.2877±.0091	4.002±.140	0.1009±.0011	1640±21	99
62.1	125	117	0.937	6191	0.258	0.2120±.0076	3.070±.144	0.1050±.0027	1715±48	72
63.1	100	63	0.627	100000	0.016	0.2702±.0171	4.070±.267	0.1092±.0011	1786±19	86
64.1	61	49	0.807	45578	0.028	0.5793±.0168	19.187±.591	0.2402±.0018	3121±11	94
65.1	128	67	0.526	13620	0.115	0.3170±.0110	4.883±.183	0.1117±.0011	1827±18	97
66.1	241	116	0.484	52826	0.029	0.3393±.0087	5.335±.144	0.1140±.0007	1864±10	101
67.1	238	145	0.611	30349	0.052	0.2844±.0071	4.146±.117	0.1057±.0011	1727±18	93
68.1	288	140	0.487	20242	0.077	0.3115±.0076	4.767±.125	0.1110±.0008	1815±12	96
69.1	188	72	0.385	16972	0.092	0.3189±.0075	4.788±.121	0.1089±.0008	1780±12	100
70.1	203	59	0.295	1000000	0.000	0.3288±.0077	5.083±.128	0.1121±.0007	1834±11	99
71.1	153	60	0.398	68681	0.023	0.3193±.0081	4.790±.136	0.1088±.0011	1779±18	100
72.1	240	100	0.419	28530	0.054	0.3298±.0078	4.966±.129	0.1092±.0009	1786±14	102
73.1	218	58	0.268	21753	0.072	0.3182+.0076	4.733±.124	0.1079±.0009	1763±14	101
74.1	418	348	0.831	27762	0.056	0.3118±.0077	4.721±.121	0.1098±.0005	1796±8	97
75.1	756	184	0.243	1000000	0.000	0.3302±.0071	4.785±.107	0.1051±.0004	1716±7	107
76.1	153	69	0.455	92850	0.014	0.5992±.0153	16.619±.446	0.2012±.0011	2835±9	106
77.1	203	135	0.667	1000000	0.000	0.3249±.0102	4.942±.169	0.1103±.0011	1804±18	100
78.1	282	125	0.446	1000000	0.000	0.3247±.0092	4.951±.149	0.1106±.0008	1809±12	100
79.1	397	96	0.243	19809	0.078	0.2745±.0088	4.122±.141	0.1089±.0009	1781±14	87
80.1	114	50	0.439	5584	0.281	0.3229±.0104	4.727±.190	0.1062±.0022	1734±37	104
81.1	294	133	0.453	5766	0.285	0.2552±.0076	3.088±.114	0.0878±.0016	1377±35	106
82.1	170	105	0.619	11883	0.131	0.3135±.0093	4.653±.169	0.1076±.0019	1760±32	99
83.1	309	138	0.448	1000000	0.000	0.3202±.0079	4.835±.128	0.1095±.0008	1791±12	100
84.1	294	257	0.874	12102	0.128	0.3289±.0100	5.032±.164	0.1110±.0010	1815±16	101

Table 23. SHRIMP U-Pb zircon ages for igneous rocks in Tasmania.

A. Perkins and Walshe (1993)	
Comstock Tuff	494.4±8 Ma
Mount Black dacite	494.9±9 Ma
Tyndall Group volcaniclastic	502.5±7 Ma
Anthony River Andesite (basal to Tyndall Group)	502.2±7 Ma
Mount Charter Group, Western Sequence	503.2±8 Ma
B. Turner and others, in press)	
Heazlewood tonalite	510±6 Ma
Timbs Group porphyry	380±6 Ma
Franklin Metamorphic Group eclogite	502±8 Ma
King Island porphyritic adamellite	760±12 Ma
Bowry Formation granitoid	777±7 Ma
C. This study.	
King Island porphyritic adamellite	762±14 Ma
King Island even-grained granodiorite	748.4±2.0 Ma
King Island porphyry	350.4±4.3 Ma
Bonds Range Porphyry	504.6±7.0 Ma
Mount Jukes lava	503.3±6.9 Ma
Minnow Keratophyre	499.6±5.6 Ma
Winterbrook lava	500.4±6.9 Ma
Tyndall Group ignimbrite	505.5±3.6 Ma
Lobster Creek Volcanics	500.2±3.5 Ma
Beulah Granite	493.5±3.9 Ma
Noddy Creek Volcanics	502.8±4.4 Ma
garnet amphibolite, Forth Metamorphic Complex	514.1±4.6 Ma

Footnote: The analyses in A and B, which were calibrated against the SL 13 standard, should be increased by about 1.3 % to allow direct comparison with the analyses in C, which were calibrated against the QGNG standard (see text).