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National Geoscience Mapping Accord Sub-Project 2: Dating Tasmania's Geological Events

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INTRODUCTION

As an initial part of the National Geoscience Mapping Accord (NGMA) project in Tasmania six rocks from the northwest of the State were dated in 1992/93 using the ion probe U-Pb method. The results from this dating appear as Appendix 1. As a result of this work and in consideration of the planned future work of the NGMA, Sub-Project 2 was designed to provide dates for tectonic events and poorly-dated parts of the geochronological timescale.

Recent zircon dating has revealed the presence of a previously unknown basement beneath the rocks exposed at the surface in northwestern Tasmania. The significance of this basement will be assessed, especially during interpretation of the seismic surveys.

More dating by this technique will be carried out where such work can be justified in terms of the projects purpose. Priority will be accorded to dating that can constrain the timing of poorly-dated tectonic events and which can improve the geochronological timescale through ascertaining the duration of key fossil zones.

BACKGROUND

In the first phase of this project six different rocks were dated by Lance Black using the SHRIMP technique at ANU. The results from some of the rocks yielded crystallisation ages, whereas others provided information on source or basement ages (see Appendix 1 and Black, 1994).

Inheritance was seen in the King Island Granite, which gave a crystallisation age of 760 ± 12 Ma, and in a correlate of the Cooee Dolerite. A spread of ages with concentrations at ~1900 Ma, ~1800–1700 Ma, ~1600 Ma and ~1400 Ma was indicated. A sample from the Arthur Metamorphic Complex (Bowry Formation) had an abundance of 1200 Ma detrital zircon, indicating that this metasediment is younger than the country rock surrounding or sampled by the King Island Granite and Cooee Dolerite correlate, or that a nearby source was not contributing to the more distant sites. In either case deposition of the Bowry Formation occurred no earlier than 1200 Ma.

A date of 510 ± 6 Ma from the Heazlewood Ultramafic Complex is younger than that previously obtained by conventional U-Pb zircon data and reflects the presence of xenocrystic grains, one of which gave an age of ~1800 Ma in this study. An eclogite from the Franklin Metamorphic Complex gave a metamorphic age of crystallisation of 502 ± 8 Ma. These two dates, plus those obtained by Perkins and Walshe (1993), demonstrate a diverse range of geological activity in a restricted time interval in the Cambrian.

FUTURE PROGRAMME

Zircon dating from the work already undertaken and reviewed above suggests the possible existence of a previously unknown basement source for the different Mesoproterozoic and older zircons obtained from northwestern Tasmania. The programme proposed for 1994/95 will, in part, address this problem, as well as dating Cambrian-aged Mt Read Volcanics (MRV) rocks which are constrained by fossil time zones or relate to the tectonic history of this highly mineralised belt. One date is proposed from the northeast of Tasmania to give an indication of the timing of the gold mineralisation and the associated period of deformation.

PROPOSED AREAS AND SAMPLES FOR DATING IN 1994/95

Rocky Cape Region

Arthur Metamorphic Complex — Bowry Formation

The initial foliated 'granite' sample from the Bowry Formation returned a spread of ages suggesting a sedimentary rock. This was later confirmed by the geochemistry. To get an age for the Bowry Formation it is necessary to resample an igneous rock which shows the effects of metamorphism. Sodic granitoids from the southern part of the Bowry Formation are deformed and metamorphosed. They also have accessory zircon to 1 mm. This rock would make an ideal sample for zircon U-Pb dating of the AMC.

Quartzite from the Rocky Cape Group

This stratigraphic unit is one of the main sequences in the Rocky Cape region of northwest Tasmania, and is one of the major units crossed by the proposed north coast offshore deep seismic traverse. The nature of its basement is unknown, and there is no existing data bearing directly on its age of deposition. Detrital zircon should be present in the orthoquartzite, and it is proposed to date these in order to provide information on the source rocks of the Rocky Cape Group. Specifically, it is hoped to determine whether the age(s) of detrital zircon match any of the clusters of old ages of inherited zircon in units such as the Cooee Dolerite, Bowry Formation and Timbs Group, discovered in the previous round of U-Pb dating. The dating will provide a basis for fingerprinting the source area, and a maximum age for the Rocky Cape Group.

Depending on the outcome of this dating, it may prove desirable to also date detrital zircon from the Burnie Formation for comparison, in the next round of dating.

Felsic dykes in the Rocky Cape region

Abundant dolerite-gabbro dykes crop out within the Rocky Cape Group in the Black River to Rocky Cape area. Some of the dykes are folded with the Cowrie Siltstone, some lie along faults parallel to the axial planes of folds, and some are intruded along joints related to cleavage within the Cowrie Siltstone.

One of the groups of dykes, which lie along fault planes parallel to the axial planes of the main folding event within the Cowrie Siltstone, is massive and unfoliated and has a calc-alkaline chemistry. In hand specimen, samples from this group are medium- to coarse-grained, leucocratic, and contain free quartz.

The age of intrusion of this group of rocks is unknown, but a magmatic age obtained from them will give a minimum age of deformation for the Rocky Cape Group.

Mt Read Volcanics (MRV) and associated rocks

Bonds Range porphyry

This quartz-feldspar-biotite-hornblende porphyry is the largest intrusive body in the MRV, cropping out from the Sophia River in the west to Lorinna in the north (a distance of some 50 km). In the Back Peak area it intrudes the Cambrian Back Peak Beds and Sticht Range Formation correlates, and is associated with gold mineralisation at Ten Mile Creek. Clasts of the porphyry have been identified in the Tyndall Group (late Middle Cambrian on fossil evidence) epiclastic conglomerates. A zircon date on this large body would give a pre-Tyndall and post-lower MRV age. No previous dates have been obtained from the Bonds Range porphyry.

Mt Jukes columnar rhyolite

This well-exposed columnar-jointed rhyolite lava is typical of the main central belt (Central Volcanic Complex) of the MRV through the Mt Darwin–Queenstown area and north through Mt Murchison on the eastern side of the Henty Fault. The host rocks for the Mt Lyell mineralisation are probably equivalent to this unit. The unit is intruded by the Cambrian Darwin Granite body at South Darwin Peak, where clasts of the granite occur in an epiclastic unit in the upper part of the volcanic sequence.

The unit represents one of the older parts of the MRV, and will be intersected by the Pieman Road seismic traverse at Tullah.

Link Road ignimbrite

Quartz-feldspar-phyric welded ignimbrite occurs in the Tyndall Group correlates on the Cradle Mountain Link Road. A zircon age of this rock would give a date for the late Middle Cambrian as it is tightly constrained between the Que River Shale (late Middle Cambrian–*Ptychagnostus punctuosus or P. nathorsti* zone) and well preserved fossils immediately above the ignimbrite (range over two or three late Middle Cambrian zones – *Lejopyge laevigata* II–III and very late Middle Cambrian *Damesella torosa–Ascionepea janitrix* zones).

Quartz porphyry in Western Sequence in Queenstown area

A number of large sill-like bodies of quartz-feldspar (± biotite) porphyry occur within the western volcano-sedimentary sequences in the Queenstown area. Several of these show some extrusive features, suggesting that they are essentially contemporaneous with the surrounding sequence. They should thus provide an age for the extensive turbidite sequences which flank the central part of the MRV through much of western Tasmania.

One of these bodies was previously sampled for zircons at No. 1 Dam on the West Queen River for Adams *et al.* (1985). Mixing with zircons of Precambrian origin resulted in no age being published. This would be resolved with the use of the SHRIMP.

Lobster Creek porphyry

The Lobster Creek Porphyry is an 8 km by 1 km mass of andesitic feldspar-pyroxene porphyry in the Dial Range Trough near the north coast. It is bounded by Cambrian sedimentary sequences, some of which contain late Middle Cambrian fossils, but contact relationships are obscured. Jago *et al.* (1977) argued for an intrusive origin on the basis of the porphyry's massive nature, lack of intercalated clastic rocks, presence of mineralisation and alteration near the contact in places, and similarity to clearly intrusive dykes in adjacent areas.

An Ordovician age (456 ± 22) has previously been obtained for this body by Rb-Sr dating (Adams *et al.*, 1985), and a similar age of 480 ± 18 Ma has been obtained for a nearby dyke by Jago *et al.* (1977), but these could be due to partial Devonian re-setting of a Cambrian age. Zircons were obtained from this rock by Black (Adams *et al.*, 1985), but gave an indeterminate age because of inheritance problems. The body is an important one in the evolution of the Dial Range Trough and of the coastal structures in this area.

Minnow Keratophyre

The Minnow Keratophyre is a widespread unit of acid and intermediate volcanic rocks in the Sheffield area in northwest Tasmania. Closely associated with it is a fossil locality at Paradise which has yielded fossils of late Middle Cambrian age (*L. laevigata* II–III zones). Dating of samples from this unit would increase knowledge about the age and correlation of units in the MRV in the north where there has been little previous dating.

Fresh rhyolitic lava from this unit can easily be obtained and should provide good zircon samples.

Northeastern Tasmania

Dacitic quartz-porphyry dykes

A range of igneous rocks have been found in the Alberton goldfield in northeast Tasmania. They are poorly described but appear to include quartz porphyries, basalts, dacites, and lamprophyres. Some are quartz-veined, and/or deformed and altered. The dacitic rock is highly sheared, with chlorite-sericite alteration, but is relatively fresh in parts. The rocks occur in highly fractured and sheared sediments of the Mathinna Group; field relations are uncertain but they may be fault bounded in large part, although flow-banded margins to the porphyry were observed locally. The dacite appears to be in direct contact with gold lodes in the Ringarooma United mine. The porphyry is moderately pyritic and possibly mineralised, but has not been analysed.

Few deformed igneous rocks have been observed in northeast Tasmania, and this is potentially one of the oldest identified. Dating will help constrain the age of deformation and gold mineralisation in northeast Tasmania.

Other sites dependent on helicopter access

Noddy Creek Volcanics

Recent mapping of the Macquarie Harbour, parts of the Point Hibbs and the Montgomery map sheets has shown that this unit extends south from the Sorell Peninsula to High Rocky Point. It consists of calc-alkaline andesitic, dacitic, and rhyolitic lavas associated with pyroclastic, volcaniclastic, intrusive and epiclastic rocks. The petrography and geochemistry of the sequence shows similarities to the MRV of the Queenstown area and it has been presumed to be of Cambrian age. Dating of this sequence would clarify whether it should be correlated with the MRV rocks. As MRV rocks are considered highly prospective this correlation would enhance the prospectivity of this area.

Large-scale thrust faults are inferred to occur in this area and the seismic traverse parallel to the coast will test this structural model. The belt of Noddy Creek Volcanics may extend out to sea and cross the seismic traverse, so knowledge of its age would be important for the interpretation of the traverse.

Two shallow intrusive bodies of rhyolitic composition occur in the Timbertops area of the Sorell Peninsula, and should yield adequate zircon for dating. A nearby helipad would allow access by helicopter.

Xenoliths in Devonian lamprophyres

Knowledge about the age and type of rock occurring in the deep crust beneath western Tasmania will clearly be very important for interpretation of the various seismic traverses. Dating of zircons collected so far in the geochronology programme indicates inheritance of zircon from rocks of various Precambrian ages, not represented on the surface, either by inclusion as xenocrysts or as restite material. This, however, gives little indication of what types of rock the zircons came from or at what depths the rocks occurred. A Devonian lamprophyre dyke swarm in western Tasmania contains xenoliths which are samples of rock encountered by the lamprophyre magma on its rise through the crust from the mantle. Examination of these xenoliths will allow the type of rock present in the crust to be directly determined. The grade of metamorphism of the xenoliths will indicate the depth from which they came. Age determinations on zircons in the xenoliths would give useful information on crustal rock types and would be sampling *in situ* crust.

Good coastal outcrops of lamprophyre dykes at Point Hibbs provide the best area to sample these xenoliths and could be reached by helicopter.

Areas for further work

Follow-on projects from the above dating will concentrate on three areas;

1. Further dating in the northeast to establish the relationship of the eastern part of the State to the western part. This would include dating of the Devonian granites to ascertain basement histories by comparing them with the western Tasmanian granites. Mathinna Group zircons would be included in this project to give further information on the basement and a comparison with the dates obtained from the Rocky Cape Group quartzites.

2. Metasediments from other Proterozoic elements, such as the Jubilee and Tyennan, Badger Head and Forth Blocks, should be dated to obtain information on their provenance and maximum ages. This will be linked to the results obtained from the 1994 dates, and those proposed above, to give a statewide picture as to the nature of the basement, which will allow the seismic interpretation to be based on hard data. The dating of xenoliths in the lamprophyres would be an integral part of this project, as this would tie in the actual basement rock types to the signature obtained from the Proterozoic blocks and granite dating.

3. Conventional dating techniques have failed to give reliable ages for Cambrian granites. Zircon dating of these numerous bodies would give a link to the widespread Delamerian orogeny seen in Antarctica and South Australia. The age and the spread of inherited ages would show basement links between the granites both here and in the areas mentioned above. Some of these granites are reliably constrained within the Cambrian stratigraphy and would give valuable information on the Cambrian timescale and ages of mineralising events.

REFERENCES

ADAMS, C. F.; BLACK, L. P.; CORBETT, K. D.; GREEN, G. R. 1985. Reconnaissance isotopic studies bearing on the tectonothermal history of Early Palaeozoic and Late Proterozoic sequences in western Tasmania. *Australian Journal of Earth Science* 32:7–36.

BLACK, L. P. 1994. The significance of current and proposed SHRIMP dating. *Report Mineral Resources Tasmania.* 1994/16.

JAGO, J. B.; COOPER, J. A.; CORBETT, K. D. 1977. First evidence for Ordovician igneous activity in the Dial Range Trough, Tasmania. *Journal Geological Society Of Australia.* 24:81–86.

PERKINS, C; WALSHE, J. L. 1993. Geochronology of the Mt Read Volcanics, Tasmania, Australia. *Economic Geology.* 88:1176–1197.

TURNER, N. J. 1993. National Mapping Accord Programme geochronology component: 1993–94 batch of samples. *Report Mineral Resources Tasmania.* 1993/12.

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APPENDIX 1

The significance of current and proposed SHRIMP dating*

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Six different rocks have been analysed by SHRIMP in the first phase of this study. An attempt to date the Cooee Dolerite at its type locality was foiled by a lack of zircon in the submitted sample. Some of the rocks yielded crystallisation ages, whereas others provided information on basement ages.

A distinct range of crystallisation ages was observed. Tonalite within the Heazlewood Ultramafic Complex crystallised during the Cambrian, at 510 ± 6 Ma (all reported uncertainties are at 95% confidence levels). The slightly younger value of this age, compared with previously obtained conventional U-Pb zircon data, presumably reflects the presence of sparse xenocrystic grains, one of which (~1800 Ma) was identified in this study. Undeformed porphyry from the Timbs Group is considerably younger, having crystallised at 380 ± 6 Ma. It is presumed that currently undated deformed granitoids in the Timbs Group will be considerably older, being possibly of Cambrian age. Two-mica granite from King Island crystallised at 760 ± 12 Ma. This age is significantly older than K-Ar and Rb-Sr mineral ages, a consequence of partial isotopic resetting of those systems during Cambrian and/or Devonian times.

Most of the zircon from eclogite within the Franklin Metamorphics Complex crystallised at 502 ± 8 Ma, an age which is ascribed to the eclogite-grade metamorphism rather than original crystallisation, the precursor of this rock having been insufficiently enriched in SiO_2 (49.7 %) to crystallise zircon.

The preceding data (together with those obtained by Caroline Perkins for the Mt Read Volcanics) demonstrate that a diverse range of geological activity, including ultramafic emplacement, high-grade metamorphism and widespread felsic magmatism, occurred during a very restricted time interval in the Cambrian. The unrelated King Island Granite is considerably older.

A major contribution of the initial SHRIMP study has been the identification of Mesoproterozoic and older zircon in all of the studied rocks. This is presumed to indicate the presence of yet undiscovered (or non-outcropping) basement in northwestern Tasmania. The best examples of this inheritance are found in the King Island Granite, a deformed metasediment from the Bowry Formation, and a mafic porphyry thought to be a correlative of the Cooee Dolerite. A wide range of ages is indicated, from minor older components (at ~2900 Ma, ~2500 Ma and ~2000 Ma) through to a spectrum of ages between 1900 Ma and 1200 Ma in which significant events appear to be indicated at ~1900 Ma, 1800–1700 Ma, ~1600 Ma, ~1400 Ma and ~1200 Ma. The abundance of 1200 Ma detrital zircon in the Bowry Formation, and its absence in any of the other analysed samples, indicates either that the Bowry Formation is younger than the country rocks around the other dated samples, or that a nearby 1200 Ma source was not contributing detritus to the more distant sediments. In either case, deposition of the Bowry Formation sediments occurred no earlier than 1200 Ma.

Future SHRIMP study is designed to date the most significant events to have contributed to the geological evolution of northern Tasmania. Wherever possible, the isotopic data and resultant models will be used to constrain interpretations of the soon-to-be-acquired geophysical data. In particular, future SHRIMP dating could be particularly important in identifying different blocks in this geologically complex region. Such dating suggests that Mesoproterozoic and older rocks underlie at least part of northwestern Tasmania. The next phase of this study is, in part, designed to seek more evidence of, and to more quantitatively define, this Precambrian evolution.

Sample No.	*Rock type*+	*Age*
93220002	Cooee Dolerite correlate	2 grains at 1400 Ma, 2 grains at 1500 Ma, 19 grains between 1700–1800 Ma, 3 grains at 1900 Ma, 1 grain at 2400 Ma
93220003	Heazlewood tonalite	510 ± 6 Ma
93220004	Timbs Group porphyry	380 ± 6 Ma
93220006	Bowry Formation metasediment	6 grains at 1200 Ma, remaining grains range 1400–2000 Ma
93220007	Franklin Metamorphic Complex	502 ± 8 Ma
93220008	King Island granite	760 ± 12 Ma

+ For location of samples see Turner (1993)

* Extracted from Black (1994)