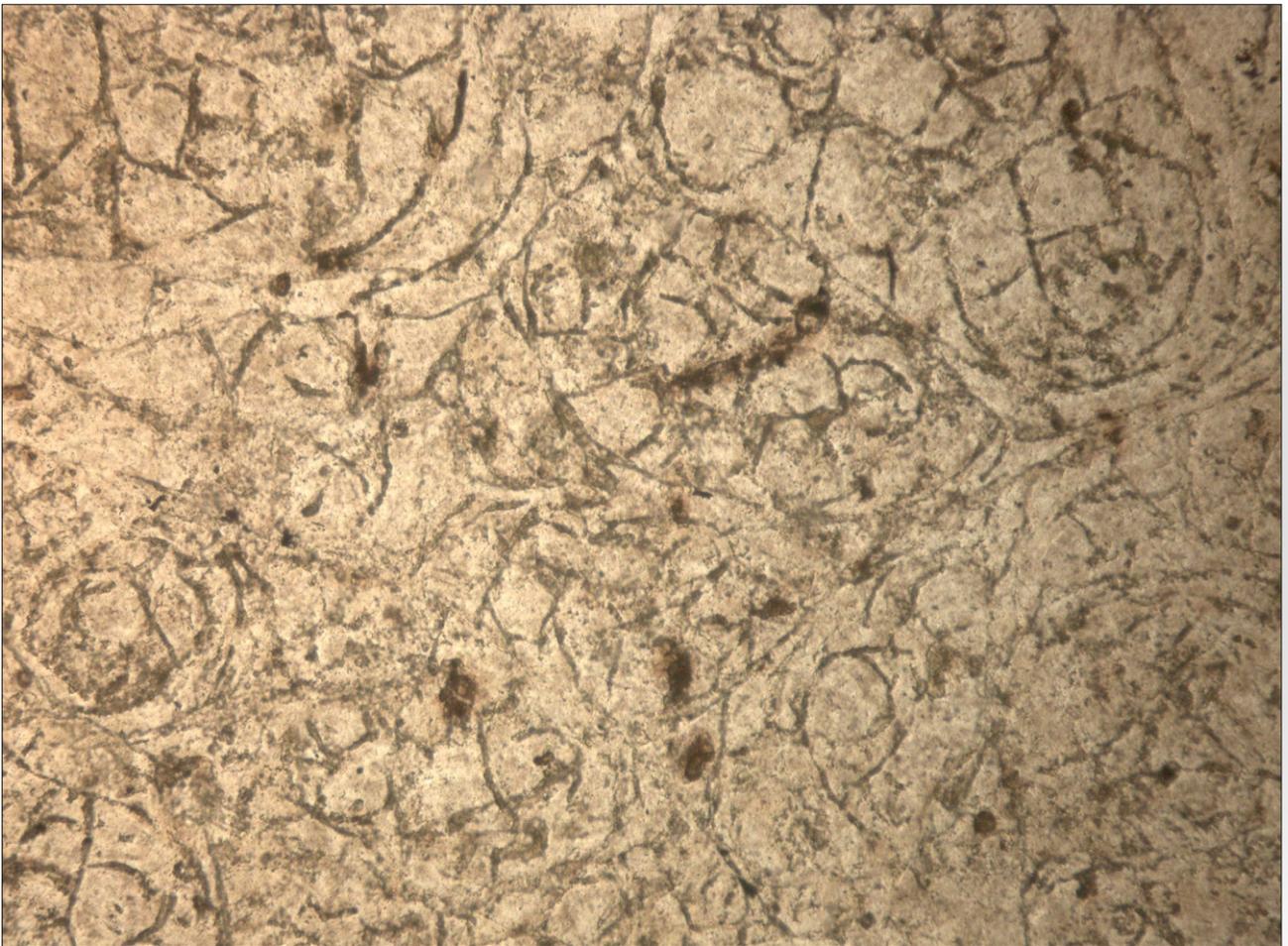


Re-interpretation of geological relationships in the Castra–Kindred area



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CONTENTS

Summary	3
Introduction	3
Acknowledgements	3
Major elements of the geology in the Castra–Kindred area	3
Proterozoic Rocks	6
Early Cambrian allochthonous sequences	6
Barrington Chert in the Devils Gate Dam area	6
Barrington Chert in the Barren Knob area	10
Motton Spilite	10
Middle Cambrian volcanic–sedimentary sequences –	
Mt Read Volcanics and Correlates	10
Western Volcano–Sedimentary Sequence and correlates	13
Isandula area	13
Castra Road–Deep Gully Creek area	14
Upper East Gawler River area	14
Kindred Road area	16
Paloona–Eardley Tor–Wilmot Road area	16
Other areas	16
Tyndall Group Correlates	16
Isandula Plantation–Carpet Plain area	17
Isandula–Motton area	17
Gunns Sugarloaf area	19
Barrington Creek area	19
Groove Creek–Lower Wilmot area	19
Poorly correlated Cambrian sequences	22
Cambrian intrusive rocks	22
Lobster Creek Intrusives	22
Quartz–feldspar porphyries	23
Late Cambrian–Ordovician Owen Group correlates	23
Ordovician Gordon Group	24
Devonian Eugenana Beds	24
Tertiary basalt and sediments	24
Quaternary deposits	25
Synthesis	25
Introduction	25
Basin architecture and mineralisation	27
Middle Cambrian to Middle Devonian structural evolution	31

Conclusion	34
References	37
Appendix 1: Sample catalogue	39

FIGURES

1. Location of study area, showing 1:25 000 scale map boundaries	4
2. Geology of the Kindred-Castra area	5
3. WTRMP total magnetic intensity image	7
4. WTRMP radiometrics. Ternary K-Th-U (red-green-blue) image (enhanced)	8
5. WTRMP radiometrics – K image	9
6. Cambrian stratigraphy of the Dial Range (Burns, 1964)	12
7. Cambrian stratigraphy in the Sheffield area (Jennings, 1979)	12
8. Cambrian stratigraphy of the Dial Range Trough (based on Sproule, 1994)... ..	12
9. Cambrian stratigraphy of the Dial Range Trough	26
10. Schematic SW-NE cross-section in the Castra area	27
11. Simplified Cambrian facies model of the Castra area	28
12. Generalised Cambrian basin architecture in the Castra-Kindred area	29
13. Sub-basin development and volcanic facies relationships at the southern margin of the Dial Range Trough during deposition of the basal Tyndall Group... ..	30
14. Structural development in the Castra-Kindred area	32
15. Interpretive tectono-stratigraphic elements in the Ulverstone-Sheffield area	35
16. Form of Devonian granite and metallogenic association	36

PLATES

<i>Cover</i> : Quenched fragmented perlitic autoclastic breccia	
1. Well-developed breccia within Barrington Chert... ..	11
2. Shallowly dipping sole-thrust zone at base of the Barrington Chert	11
3. Slickensides within a steep NW-trending minor fault parallel to the Deep Gully Fault... ..	15
4. Zone of steep, mostly brittle NW-trending faults on the main splay of the Deep Gully Fault... ..	15
5. Quartz phyric pumiceous volcanoclastic sandstone from the Western Volcano-Sedimentary Sequence	15
6. Weathered Sprent Formation conglomerate with clasts of chert and basalt	18
7. Mixed provenance derived grain-supported lithicwacke from the Sprent Formation	18
8. Fault contact between Tyndall Group volcanoclastic siltstone and Owen Group conglomerate	20
9. Pair of late-phase Devonian, NW-trending, NE-dipping brittle faults within Tyndall Group correlate	20
10. Feldspar-pyroxene phyric crystal-rich pumice breccia	21
11. Feldspar-pyroxene phyric crystal-rich andesitic volcanoclastic sandstone from the Groove Creek Formation	21
12. Quenched fragmented andesite lava from the Groove Creek Formation... ..	21
13. Columnar jointing in Tertiary basalt, Riggs Road quarry	25

Summary

Correlates of the Mount Read Volcanics in the Castra–Kindred area are a complex sequence of predominantly distal syn-volcanic facies with interbedded sedimentary facies derived mainly from extra-basinal sources. Minor proximal syn-volcanic facies consist of crystal–pumice rich andesitic volcanoclastic sandstone and comagmatic high level intrusive/lava complexes and associated autoclastic facies. The andesitic volcanoclastic sandstone facies forms a useful marker horizon and is correlated with the Lynchford Tuff from the Lower Tyndall Group in western Tasmania. The restricted distribution of andesitic centres and associated syn-volcanic sediments suggests that this phase of volcanism was confined within graben-like sub-basins.

The distribution of the crystal–pumice rich andesitic volcanoclastic sandstone facies (the Groove Creek formation) is almost exclusively confined to a series of N–NW trending fault bounded sub-basins in the Paradise–Groove Creek and Isandula areas. The Claude Road volcanic centre developed at the intersection of the Paradise sub-basin with the Nietta Fault and is possibly the source of andesitic syn-eruptive sediments in the Groove Creek and Isandula sub-basins.

In contrast the Lower Tyndall Group in the adjacent Deep Gully Creek and Barrington Creek sub-basins is characterised by a greater proportion of extra-basinal sources.

Most of the known mineralisation occurs at or near the contact between the Tyndall Group and underlying Western Volcano–Sedimentary Sequence contact. Syn-volcanic growth faults had a controlling effect on the volcanic facies and acted as conduits for hydrothermal fluids. They represent prime sites for mineralisation. Future exploration should target exhalative or sub-sea floor replacement VHMS-style mineralisation at the base of the Tyndall Group or potential Cu-rich feeder zones at a deeper stratigraphic level.

Introduction

This report documents observations made by the author while field checking in the Castra–Kindred areas in northern Tasmania (fig. 1). The main aim of the project was to examine the poorly known Cambrian rock sequences, however observations of other lithologies were made in the course of the project.

The Castra and Kindred 1:25 000 scale digital geological maps were originally compiled in 2004 as part of the Western Tasmania Regional Minerals Program (WTRMP). The compilations were largely based on original Department of Mines 1:63,360 series mapping (Burns, 1963; Jennings *et al.*, 1959) with additional information from various company and MRT reports, and air photo and WTRMP geophysical data interpretation by the author.

During the compilation process it became apparent that the geological interpretations presented in Burns (1957), Porter (1974), and Porter (1976) were significantly different to that presented in the 1:63,360 series mapping. These differences could not be adequately resolved from the available data and it was apparent that additional field checking was required.

Twenty-five days were spent in the field, using Ulverstone as a base. As the author was working alone most of the traverses were along existing roads and tracks or areas of relatively easy access. Many of the traverses were largely of a reconnaissance nature and, as a consequence, many geological boundaries could not be mapped accurately. Therefore the resultant geological maps rely heavily on extrapolation or observations by previous workers. Traverses were made over much of the Cambrian sequences and these observations have formed the base to which subsequent geophysical and air photo interpretation

and the results of previous mapping could be compared. The results have been incorporated in revised versions of the 1:25 000 scale Castra and Kindred digital geological maps (Vicary, 2005a; Vicary, 2005b) and are discussed in these notes.

A selection of various rock types from the Castra–Kindred area was collected by the author and has been incorporated into the MRT collection. Thin section descriptions of selected samples are given in the accompanying text. Location details are tabulated in Appendix 1. All grid coordinates are quoted in the Australian Geodetic Datum – Australian Map Grid Zone 55 coordinate system.

Acknowledgements

The author wishes to acknowledge the great support of Dr Geoff Green who supervised the project and Mr Chris Meech who supervised the map production and provided topographical bases for field work.

Additional thanks to:

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Major elements of the geology in the Castra–Kindred area

The general geology of the Fossey Mountains–Dial Range Tough has recently been reviewed by Corbett and McClenaghan (2003) and only a summary is presented here. They give a detailed overview of the

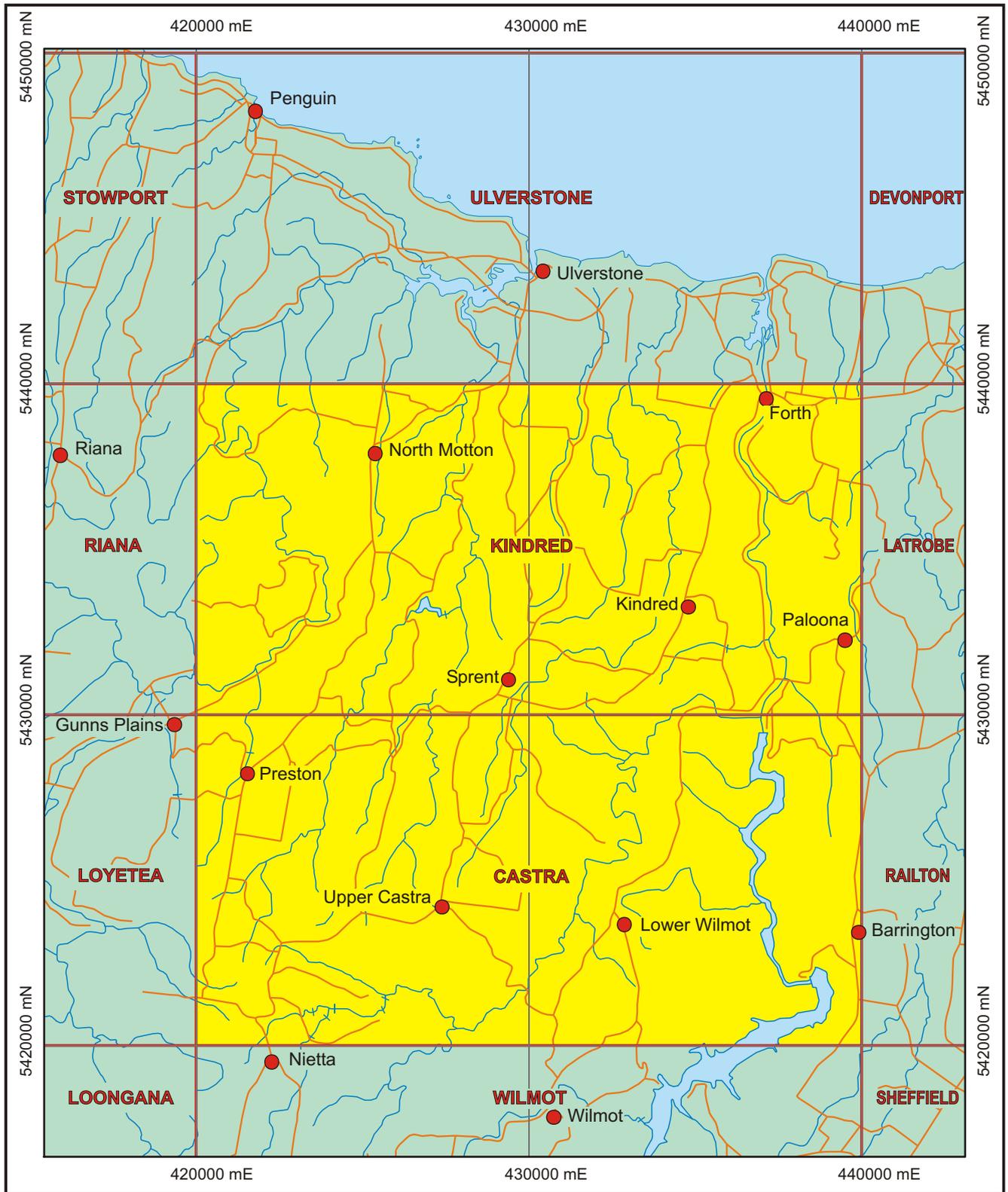


Figure 1

Location of study area, showing 1:25 000 scale map boundaries.

general stratigraphy of the Mount Read Volcanics in the Castra-Kindred and adjacent areas and discuss many of the apparent problems in stratigraphic correlation. In addition, they reviewed the mineral deposits and previous exploration.

The geology of the Castra-Kindred area is shown in Figure 2. The oldest exposed rock types are Proterozoic quartzite, schist and amphibolite of the Ulverstone-

Forth Metamorphic Complex and low grade turbiditic sedimentary rocks of the Burnie Formation.

Early Cambrian chert and basalt sequences correlated with the allochthonous Cleveland-Waratah Association crop out extensively in the Ulverstone-North Motton area and in the Barrington area to the south. They commonly have faulted contacts against Proterozoic and Middle to Late Cambrian sequences.

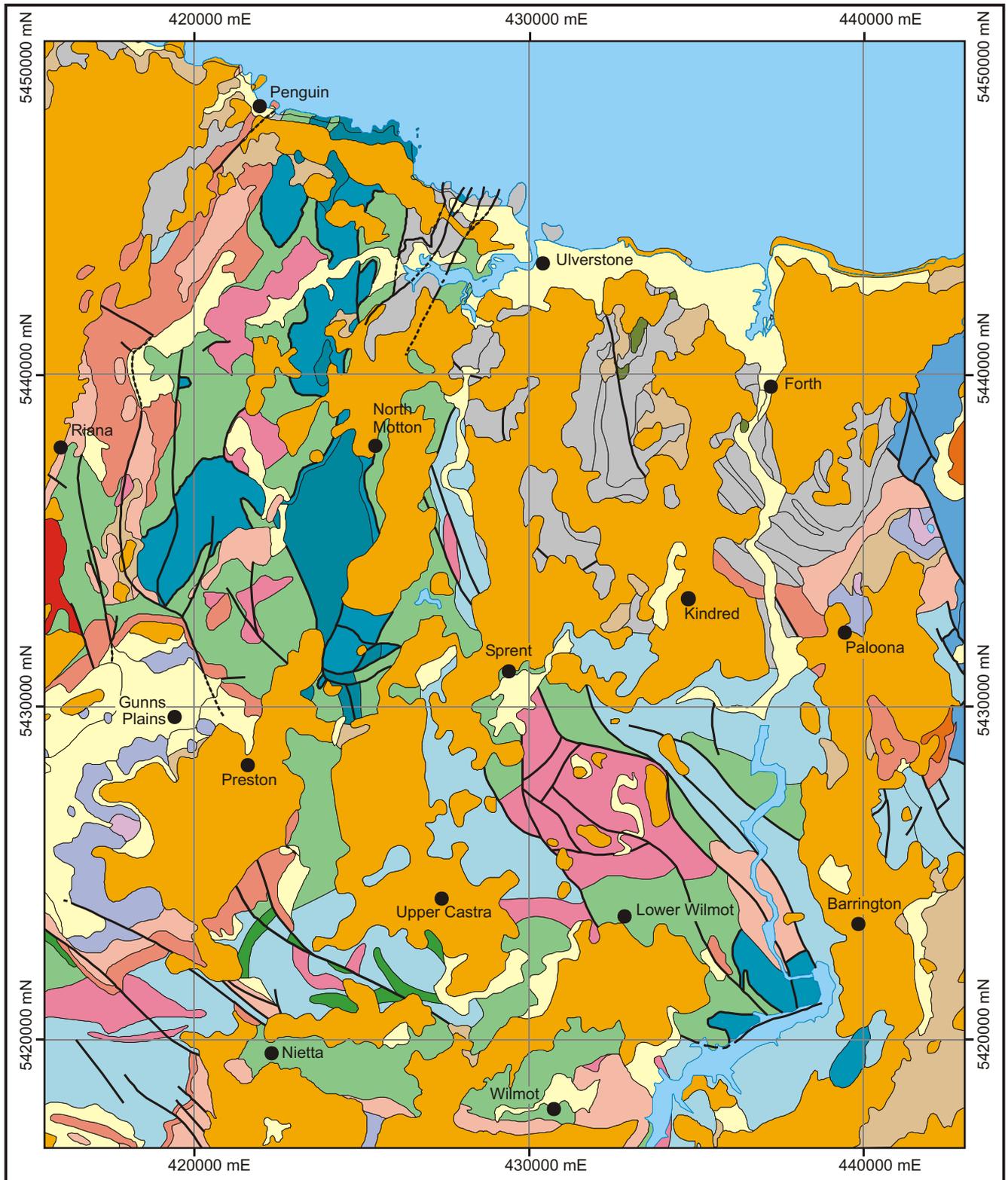


Figure 2

Geology of the Kindred-Castra area (see page 6 for legend).

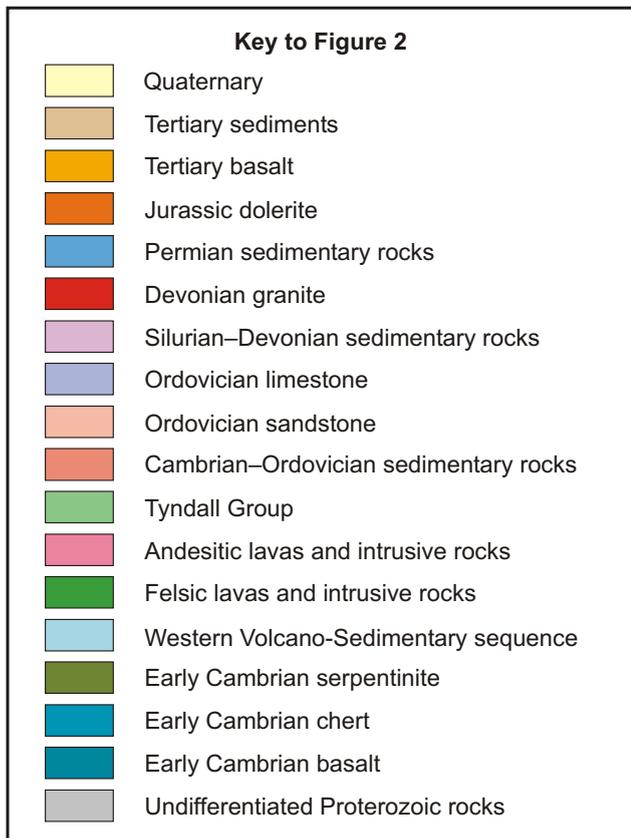
Cambrian volcano-sedimentary sequences of the Mount Read Volcanics occur as a disjointed belt of rocks between Penguin and Wilmot. These are discussed in more detail later in this report.

Late Cambrian to Ordovician siliceous sedimentary rocks of the Owen Group are unconformable over several of the older formations and define a disjointed arcuate trend between Penguin-Wilmot-Paloona.

They are overlain by shallow marine limestone of the Gordon Group in the Gunns Plains and Paloona areas.

Tertiary basalt forms extensive areas of cover and produces a fragmented outcrop pattern to the older sequences.

The WTRMP geophysical surveys over northern Tasmania (Leaman and Webster, 2002) have provided a useful tool for mapping and lithological correlation.



Three geophysical images have been produced (fig. 3 to 5) and are discussed in the succeeding sections.

Proterozoic rocks

Proterozoic rocks from the Ulverstone–Forth Metamorphics and the Burnie Formation crop out extensively in the eastern half of the Kindred map sheet. They were not reviewed as part of the present study but have been discussed by Burns (1964), Lewis (1991), Seymour and Calver (1995), Meffre *et al.* (2000) and Berry and Gray (2001). Following the work by Berry and Gray (2001) the contact between the Burnie Formation and the Ulverstone Metamorphics has been updated as a thrust fault on both the Kindred and Ulverstone map sheets.

Burns (1964) described a graphitic schist outcropping some “200 yards north of the Paloona Bridge” and noted that this was a unique occurrence within the Ulverstone Metamorphics. However graphitic units are more common within the Burnie Formation and it is quite possible that the Proterozoic rocks immediately to the north of the Paloona Bridge may include correlates of the Burnie Formation and potentially the easternmost limit of the thrust at the contact between the Burnie Formation and the Ulverstone Metamorphics. This unit has been shown as Burnie Formation rather than undifferentiated Ulverstone Metamorphics as shown on Burns’ map. These rocks were not examined during the present study, but a recent field examination of this sequence (D. Seymour, pers. comm.) has shown that the preferred correlation of the sequence with the Burnie Formation seems quite reasonable.

Some boundaries between the Proterozoic rocks and younger sequences have been modified from the original boundaries presented by Burns (1963) due to re-evaluation using WTRMP geophysics and by redrafting Burns’ original air photo interpretation on a more detailed topographic base. The internal complexity of the Proterozoic sequence has been largely unchanged.

Early Cambrian allochthonous sequences

Correlates of the Early Cambrian Cleveland–Waratah Association (the Barrington Chert and the Motton Spilite) crop out in the Devils Gate and Barren Knob–Motton areas. The geology of these sequences is discussed by Seymour and Calver (1995) and Corbett (2004). The name ‘Motton Spilite’ is retained for historical purposes but, as indicated by Crawford (1993), the name Motton Metabasalt is more suitable.

Berry and Gray (2001) and Berry and Holm (2001) have alternatively suggested that the Barrington Chert and the Motton Spilite may be possible correlates of the late Neoproterozoic Togari Group.

Barrington Chert in the Devils Gate Dam area

The WTRMP radiometric data clearly show that the chert associated with the Cleveland–Waratah Association has a characteristic low radiometric signature. This is also the case for the Barrington Chert in the Devils Gate Dam area, although it is also apparent that much of the previously mapped distribution of chert between Devils Gate Dam and Paloona is much more radiometric in character and has the typical blue-green U and Th enriched signature more typical of Cambrian lithologies (fig. 4).

Subsequent field checking in the Devils Gate–Paloona area has shown that the early work of Burns (1957) and Jennings *et al.* (1959) required revision. Fresh and variably silicified fine-grained ashy volcanoclastic sediments have been misidentified as ‘chert’ and the distribution of this lithology on the older maps is quite misleading. Definitive outcrops of chert have been located in the Devils Gate Dam area, while a previously unmapped area of chert was mapped at 436 000 mE, 5 420 500 mN. The geological interpretation in this area is based on limited field traverses and radiometric and air photo interpretation, and it is quite possible that this occurrence of chert is in fact continuous with the chert in the Devils Gate area.

The chert in the Devils Gate Dam area is well exposed on the Devils Gate access road and on forestry roads in the Kings Hill area. A thin sliver of highly cleaved red mudstone occurs interbedded(?) with the chert near the faulted contact with the Cambrian units on the Devils Gate access road. Although it was not observed elsewhere in the Castra–Kindred area, it is a lithology commonly associated with the Cleveland–Waratah Association. The contact between the Barrington Chert and the Owen Conglomerate approximately 500 m north of the Devils Gate Dam is taken directly from the

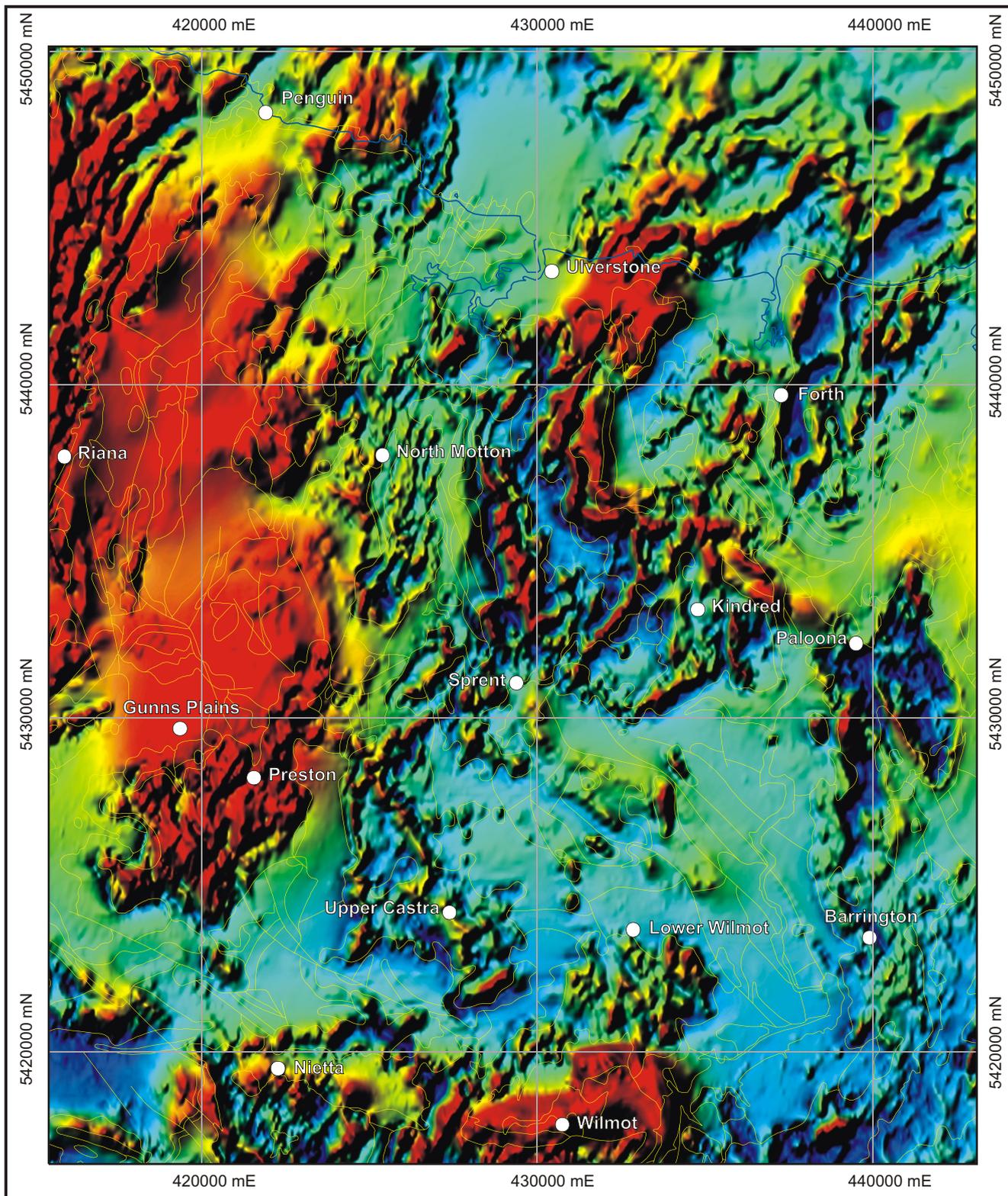


Figure 3
WTRMP total magnetic intensity image.

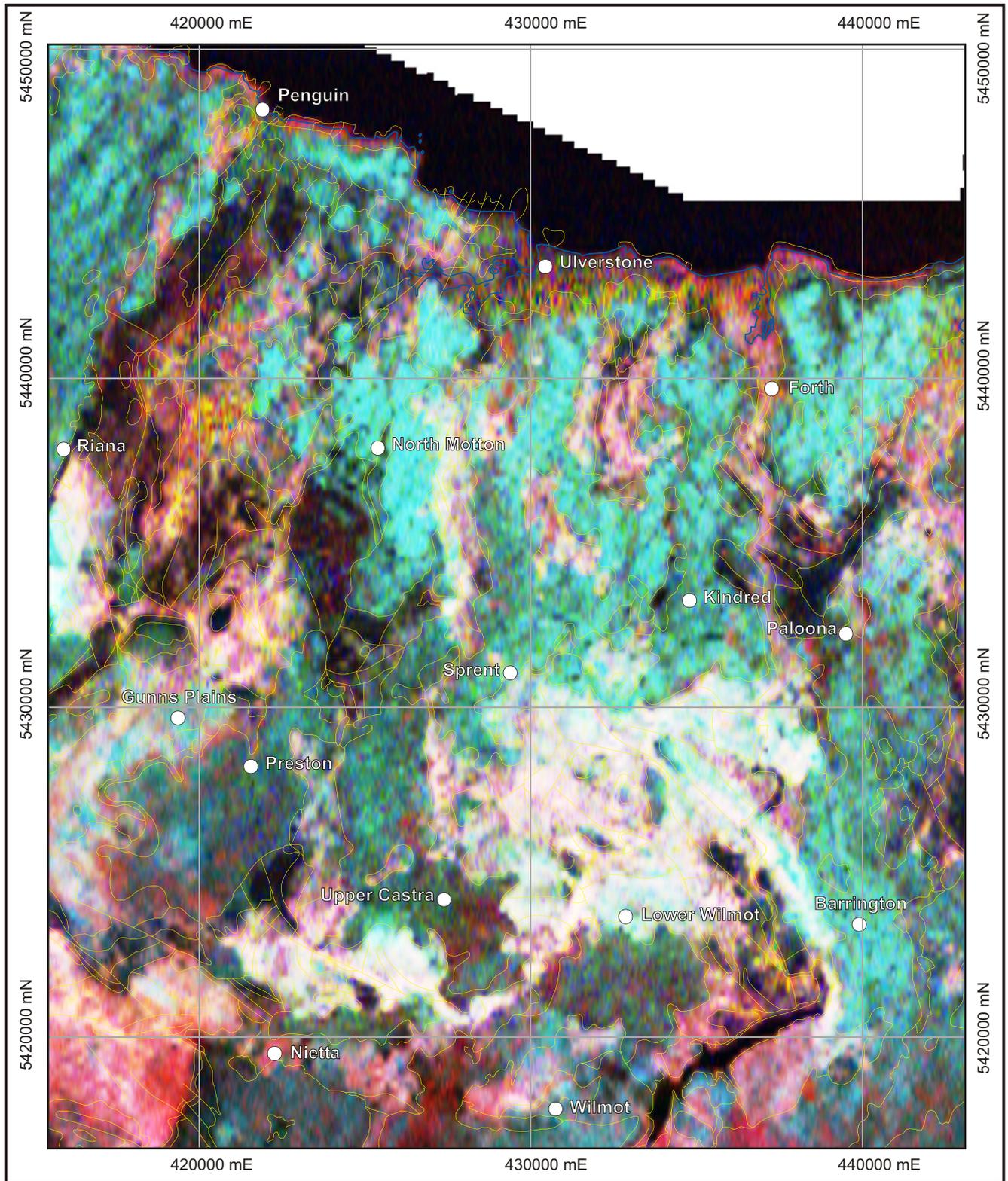


Figure 4
WTRMP radiometrics – Ternary K-Th-U (red-green-blue) image (enhanced).

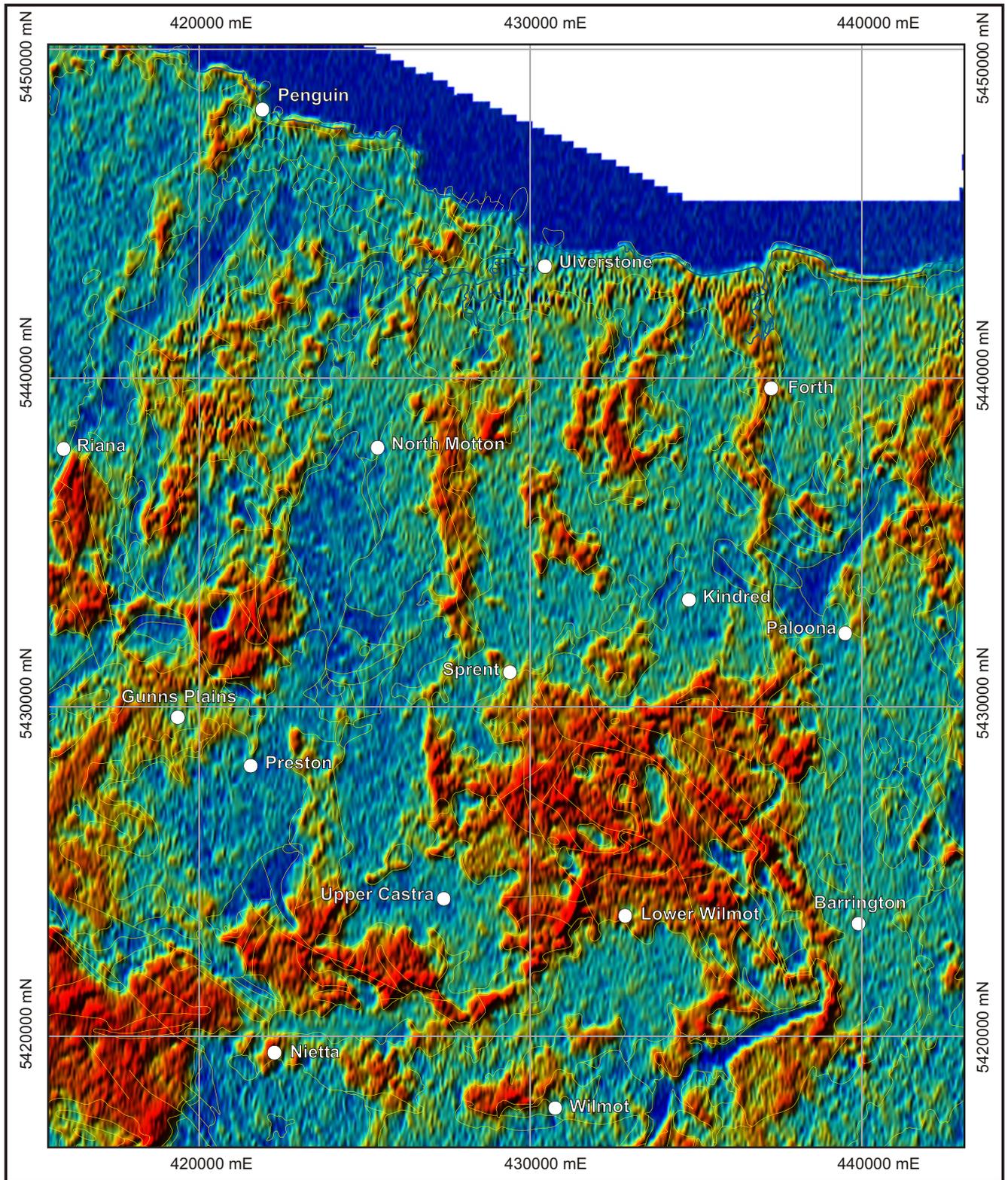


Figure 5
WTRMP radiometrics – K image.

Sheffield map (Jennings *et al.*, 1959) and is shown as a fault. This interpretation could not be substantiated by air photo interpretation and the position and nature of the contact is highly suspect.

A roughly east-trending fault has been tentatively interpreted to truncate the southern end of the chert in the Lake Barrington area. This interpretation differs to the mapping of Jennings *et al.* (1959) and Paterson (1971) and requires additional field mapping.

Barrington Chert in the Barren Knob area

The Barrington Chert crops out in the Barren Knob area where there are good exposures along the Preston Road and several excellent exposures in adjacent gravel pits. Lesser exposure also occurs to the east of Barren Knob along forestry roads in the Isandula Plantation.

The chert in the Barren Knob area varies from a white to black highly silicified chert that weathers to a grey soil to a distinct brown weathering, commonly bedded ashy siltstone (?) or chert. The brown-weathering chert occurs within a fault-bounded block at approximately 424 500 mE, 5 432 000 mN and was previously mapped by Burns (1957) as the "Isandula Formation" which he considered to conformably overly the chert. This could not be confirmed during the present study nor could this formation be resolved from the chert by the radiometrics. On this basis the brown-weathering unit has been included within the Barrington Chert as shown on the original Sheffield map (Jennings *et al.*, 1959).

Small bodies of chert within the Cambrian sequence were mapped along a forestry road in the Isandula Plantation to the east of Barren Knob. The largest body at 426 000 mE, 5 431 800 mN was mapped by Burns (1957) but was incorrectly shown as Quaternary slope deposits on the Sheffield map (Jennings *et al.*, 1959). The bodies are tentatively interpreted as structural repetitions of chert along a series of ENE-trending thrust faults, although they were not systematically mapped during the present study and additional mapping is clearly required. Plate 1 shows the highly brecciated nature of the chert at this location. D. Seymour (pers. comm.) suggests that the brecciation is tectonic and possibly indicates that the outcrop is in close proximity to the basal sole thrust.

A small patch of chert was mapped by Porter (1974) at approximately 423 100 mE, 5 428 700 mN. This was not depicted on previous mapping by Burns (1957) and Jennings *et al.* (1959). The exposure was not visited during this study, but a coarse-grained chert-rich lithicwacke was mapped on the C126 road about 200 m to the south. It is highly likely that Porter has mistaken a highly weathered or silicified chert-rich lithicwacke for a massive body of chert.

A thin unit of the Barrington Chert underlies the Motton Spilite in the Leven Hill–North Motton area. It also occurs in the Library Creek–Mt Lorymer area, but this area was not included in this study.

The contact between the Barrington Chert and the structurally underlying Cambrian lithologies has been discussed by Burns (1964) who favoured that the contact was unconformable (the "Hardstaff Unconformity"). He also noted that the contact was often obscured by deformation structures and had a flat-lying aspect that could be alternatively attributed to large scale thrusting. Given that the allochthonous nature of the Barrington Chert and Motton Spilite is now widely accepted, this contact is shown on the maps as a thrust. Plate 2 shows a shallowly dipping sole thrust within the Barrington Chert at 424 050 mE, 5 431 085 mN. Highly weathered Motton Spilite, not shown in the photo, crops out approximately 30 m to the southeast of this location.

Motton Spilite

The Motton Spilite overlies a thin unit of Barrington Chert in the Leven Hill area and there are excellent exposures of the basalt along the Gunns Plains Road. In the Barren Knob area the relationship between the basalt and the chert is less clear but it is tentatively suggested that the chert has been thrust over the Motton Spilite. The basalt in this area varies in character from highly weathered red clay to fresh kernels with weak epidote alteration of the groundmass. Positive identification of Motton Spilite was difficult in the field due to the close resemblance to Tertiary basalt when fresh. This was particularly the case on the eastern slopes of Barren Knob where Tertiary basalt overlies the Motton Spilite. A small patch of Motton Spilite mapped by Burns (1957) and Jennings *et al.* (1959) at 423 500 mE, 5 430 500 mN could not be confirmed during this study but has been retained on the map. It was shown as Tertiary basalt by Porter (1974).

Middle Cambrian volcanic-sedimentary sequences — Mt Read Volcanics and correlates

The Cambrian volcano-sedimentary succession in the Dial Range, as originally proposed by Burns (1964), is presented in Figure 6.

On the basis of limited palaeontological evidence the Cateena Group was assigned to the Middle Cambrian while the Radfords Creek Group ranges in age from late Middle to Late Cambrian (Jago, 1976; Laurie *et al.*, 1995).

An alternative stratigraphic section from the southern part of the Dial Range Trough was presented by Jennings (1979) (fig. 7). Several differences with the interpretation of Burns (1964) are apparent. The Barrington Chert is placed at the base of the sequence and is overlain by a complex interfingering sequence of Motton Spilite, Sprent Formation, Bott Conglomerate and Beulah Andesite. This is overlain by the Gog Greywacke and Minnow Keratophyre. Corbett and McClenaghan (2003) note that areas mapped as Gog Greywacke on the Sheffield map can be loosely correlated with the Cateena Group and the



Plate 1

Well-developed breccia within Barrington Chert; may indicate proximity to sole thrust (425 825 mE, 5 431 710 mN) [Photo – D. Seymour].



Plate 2

Shallowly dipping sole-thrust zone at base of the Barrington Chert, consisting of dark zone of fault gouge and underlying breccia zone at least two metres thick (424 050 mE, 5 431 085 mN) [Photo – D. Seymour].

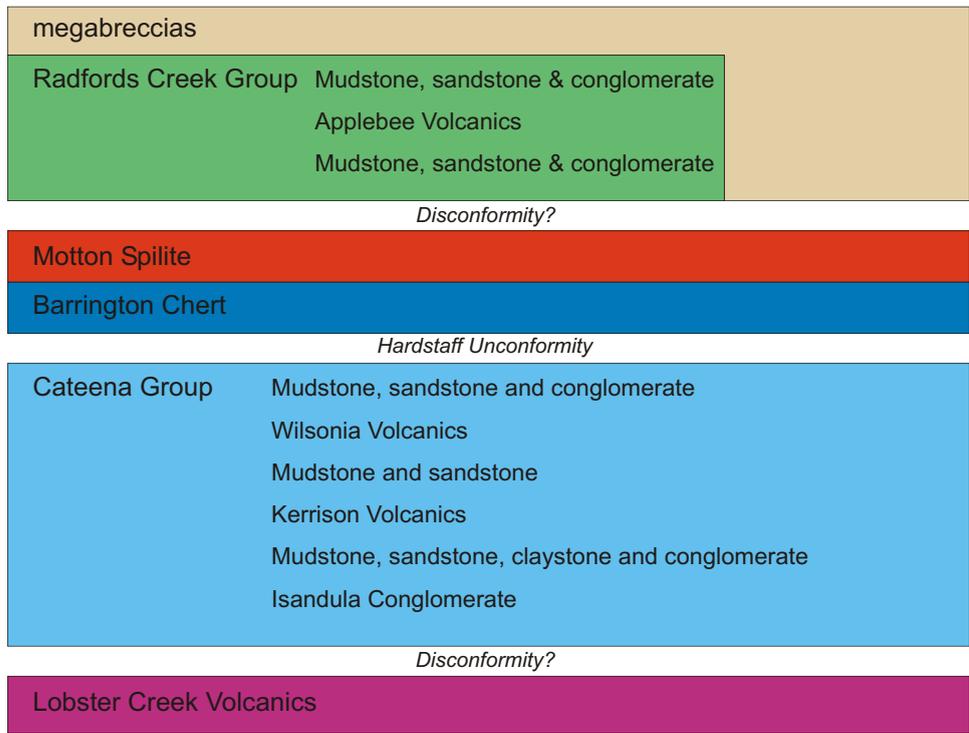


Figure 6. Cambrian stratigraphy of the Dial Range (Burns, 1964).

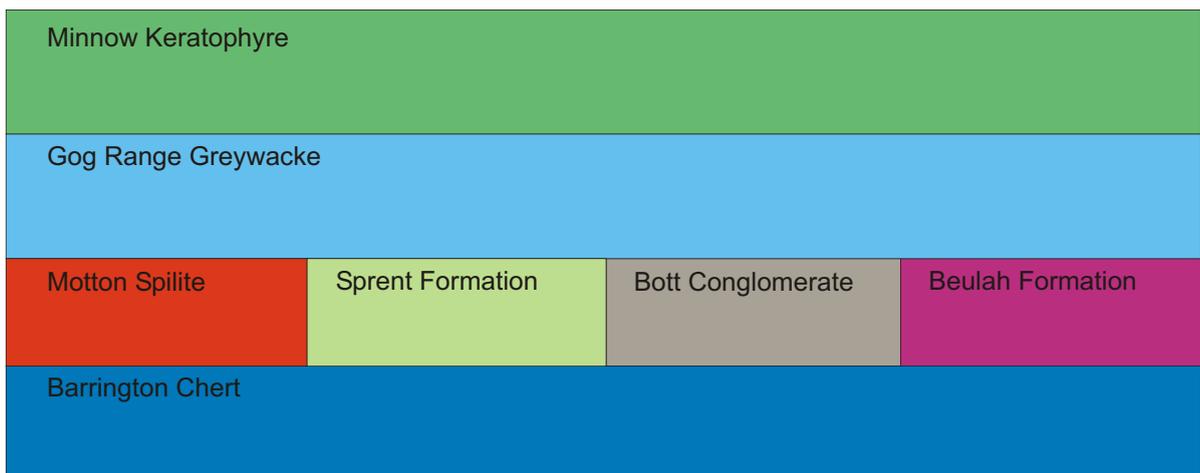


Figure 7. Cambrian stratigraphy in the Sheffield area (Jennings, 1979).

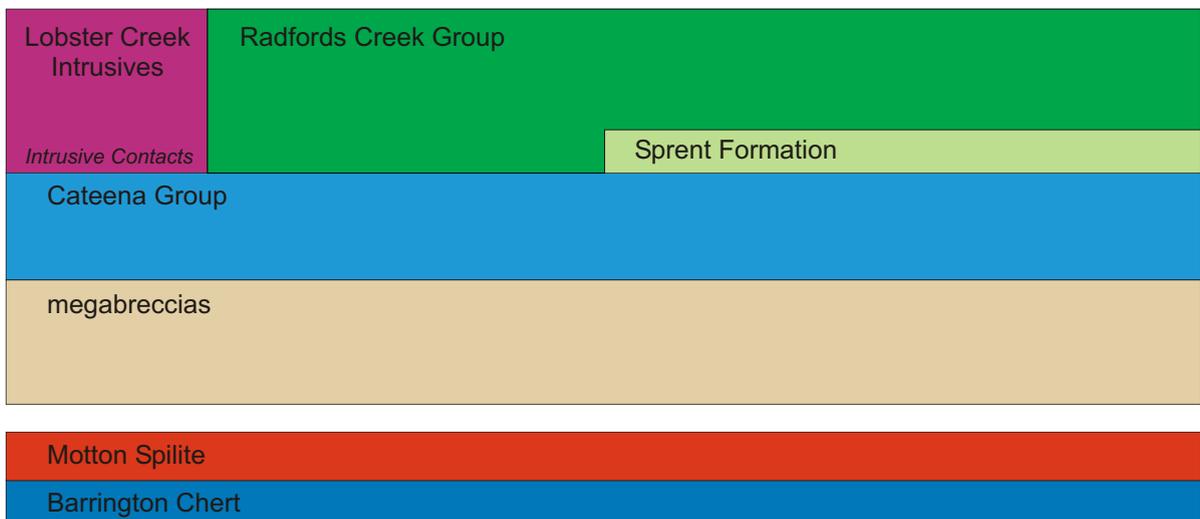


Figure 8. Cambrian stratigraphy of the Dial Range Trough (based on Sproule, 1994).

Minnow Keratophyre with the Tyndall (Radfords Creek) Group.

Burns did not differentiate the Sprent Formation in the north of the Dial Range area but considered it part of the Radfords Creek Group.

Re-examination of the Barrington Chert and Motton Spilite (Seymour and Calver, 1995; Brown, 1989; Hashimoto *et al.*, 1981) has shown that the stratigraphic position of these units is in doubt. The evidence presented suggests that both units are allochthonous, having been structurally emplaced in the late Early to early Middle Cambrian. The Motton Spilite has Ocean Floor Basalt affinities similar to that displayed by the Cleveland–Waratah Association basalts. Both the Barrington Chert and Motton Spilite pre-date Mount Read volcanism. The disconformable to unconformable contact relationships observed by Burns (1964) are probably attributed to faulting.

The Cambrian volcano-sedimentary sequences of the Dial Range area were studied by Herrmann (1993), Crawford (1993) and Sproule (1994) (fig. 8). They found that both the Cateena Group and the Radfords Creek Group contain a similar range of lithologies and that distinction between the two groups is often poor.

Crawford (1993) suggested that the Cambrian volcano-sedimentary sequence could be subdivided into two distinct sequences: pre-Mount Read Volcanics and syn-Mount Read Volcanics. The pre-Mount Read Volcanics sequence is composed entirely of allochthonous or passive margin-derived chert, carbonaceous siltstone, tholeiitic basalt and dolostone clasts and was assigned to the Cateena Group. The megabreccia units were included in this group. The syn-Mount Read Volcanics sequence was assigned to the Radfords Creek Group.

Although predominantly composed of allochthonous detritus, the Sprent Formation was considered to represent the basal unit of the syn-Mount Read Volcanics Radfords Creek Group. This was mainly based on the observation of minor amounts of felsic volcanic detritus in the upper parts of the unit (Sproule, 1994).

The Lobster Creek Intrusives are syn-Mount Read Volcanics in age and intrude all older units. Berry *et al.* (1997b) have shown that they are co-magmatic with andesitic crystal-rich sandstone (“Lynchford Tuff” type) that occurs within the Radfords Creek Group and in other Tyndall Group correlates in western Tasmania.

Recent work by Corbett (2002) and Corbett and McClenaghan (2003) has reappraised the geology of the Dial Range and Sheffield areas in terms of the current stratigraphic nomenclature widely used in western Tasmania. On the basis of palaeontological evidence the Middle Cambrian fauna from the Cateena Group in the Isandula area was correlated with the Western Volcano-Sedimentary Sequence, and the late Middle to Late Cambrian fauna in the Radfords Creek, Paradise, St Valentines Peak and Native Track Tier

areas was correlated with the Tyndall Group. The Sprent Formation of Burns (1964) was assigned to the upper parts of the Western Volcano-Sedimentary Sequence immediately underlying the Tyndall Group. The stratigraphic position of the megabreccia units in the Ulverstone area was not considered.

The discussion of previous studies in light of recent field examinations is presented in the following sections.

Western Volcano-Sedimentary Sequence and correlates

Rocks correlated with the Western Volcano-Sedimentary Sequence crop out extensively in the Castra–Kindred area. These have previously been termed the Cateena Group by Burns (1964), but the sequence has recently been correlated with the Western Volcano-Sedimentary Sequence by Corbett and McClenaghan (2003). Middle Cambrian fossils have been reported from several localities from the Isandula area (Laurie *et al.*, 1995; Burns, 1964). The sequence is composed of interbedded ashy volcanoclastic sedimentary rocks, pumiceous volcanoclastic sedimentary rocks, greywacke and lithicwacke. Many of these lithofacies are also present in the overlying Tyndall Group and correlation between the two sequences is often difficult. Recent examination in the Castra–Kindred area has shown that several areas previously correlated with the Western Volcano-Sedimentary Sequence may in fact be Tyndall Group correlates.

Burns (1964) subdivided the Cateena Group into several formations. The basal unit is the Isandula Conglomerate which unconformably overlies the Proterozoic Burnie Formation in the Isandula area. This is overlain by a thick sequence (>700 m) of largely undifferentiated interbedded sandstone, mudstone and conglomerate. Two volcanic-rich formations occur within this sequence (the Kerrison Volcanics and Wilsonia Volcanics).

Recent studies (Herrmann, 1993; Crawford, 1993; Sproule, 1994; this work) have shown that the Kerrison Volcanics is an intrusive body and not a stratigraphic marker horizon as suggested by Burns (1964). Similarly the Wilsonia Volcanics has been shown to vary widely in lithology and cannot be used for stratigraphic correlation with any confidence.

Isandula area

Recent mapping in the Isandula area has shown that all of the known Middle Cambrian fossil localities occur within one fault-bounded greywacke unit (informally called here the Isandula greywacke) which overlies and is interbedded with a laterally restricted conglomerate. Other greywacke units have previously been described throughout the Cambrian volcano-sedimentary sequence. These have been observed in the Cateena Group, Sprent Formation and Radfords Creek Group. In contrast to other

greywackes, the Isandula greywacke is commonly hematitic or limonitic.

A sequence of interbedded hematitic greywacke and siltstone in the Lake Isandula area (at 427 200 mE, 5 433 200 mN), has some similarities with the Isandula greywacke. However a direct correlation seems unlikely as the unit conformably overlies a sequence of graded volcanoclastic sedimentary rocks correlated with the Tyndall Group.

No other potential correlates of the Isandula greywacke have been observed in the Castra–Kindred area.

A sample of the Isandula greywacke was analysed by Berry *et al.* (1997a). This contained chromites with a high TiO₂ content (>1.5%) indicating a tholeiitic source. In contrast greywacke samples from the Radfords Creek Group contained only mafic-ultramafic complex derived chromites with low TiO₂ (<0.5%). This technique may prove useful in correlating between greywacke units in the Dial Trough area. (Note: one sample from the Sprent Formation was analysed by Berry *et al.* (1997a), however on the basis of the documented grid coordinates the sample is most likely from close to the base of the Radfords Creek Group).

The Isandula greywacke is faulted against correlates of the Western Volcano-Sedimentary Sequence and Tyndall Group to the west. At 427 100 mE, 5 434 100 mN, a greywacke tentatively correlated with the Isandula greywacke(?) is overlain by a sequence of interbedded ashy volcanoclastic sedimentary rocks correlated with the Western Volcano-Sedimentary Sequence.

The underlying conglomerate (the Isandula Conglomerate; Burns, 1964) is considered to be the basal unit of the Cambrian succession and is probably unconformable on the Proterozoic Burnie Formation, although Burns noted that the contact was now vertical. Descriptions of the Isandula Conglomerate are misleading. Burns (1964) suggests that it is monomict, being composed mainly of abundant clasts of purple mudstone, although field inspection also indicated an abundance of matrix-supported quartzite cobbles. Such clasts may be locally sourced from the underlying Burnie Formation or Ulverstone–Forth Metamorphics. In thin section sample R011047 is a matrix-supported lithic-rich granule conglomerate with clasts of variably fine-grained hematitic siltstone (chert?) and minor polycrystalline quartzite in a matrix of fine to medium-grained polycrystalline quartz with undulose extinction, muscovite, sericite, hematite and rare plagioclase crystals. No definitive volcanic derived quartz was observed and most of the clastic component is essentially pre-Mount Read Volcanics in origin. The source of the rare plagioclase crystals is uncertain. They could be related to Mount Read volcanism or from pre-Mount Read Volcanics sources such as the Motton Spilite (Crawford, 1993) or the Proterozoic Forth Metamorphic complex (Meffre *et al.*,

2000). In contrast to the Sprent Formation no basaltic derived clasts were observed.

The boundaries of the Isandula greywacke and the Isandula Conglomerate on the Kindred map are essentially unmodified from Burns (1964). It should be noted that near 427 400 mE, 5 437 500 mN the Isandula greywacke has a distinctly more radiometric character (fig. 4, 5). This may suggest the presence of unmapped Western Volcano-Sedimentary Sequence or Tyndall Group rocks.

Castra Road–Deep Gully Creek area

The geological interpretation in the Castra Road area is based on mapping from a variety of sources (Porter, 1974; Porter, 1976; Vicary, 1995; recent reconnaissance mapping). The sequence is well exposed in the Flints Road, White Rock Road and Ghost Hole Road areas where there have been recent forestry operations. Critical traverses along the Castra Rivulet, Deep Gully Creek and Wilmot River have not been completed and the interpretation is at best provisional.

The dominant lithology is a fine ashy siltstone with interbedded pumice-rich volcanoclastic sedimentary rocks and rhyolitic to andesitic intrusive rocks and/or lavas and associated quenched fragmented perlitic autoclastic breccias (see cover photo; Sample R011067). The sequence has been correlated with the Western Volcano-Sedimentary Sequence following Corbett and McClenaghan (2003). It is noted that the abundance of rhyolitic to andesitic intrusive rocks/lavas suggests that this sequence probably occurs very close to the Western Volcano-Sedimentary Sequence–Tyndall Group contact.

The sequence has been folded in a northwest-trending anticline that is dextrally offset in the axial zone by the Deep Gully Fault. Local sericite-pyrite alteration of the sequence along the fault zone is developed at the Castra Road prospect (Virgoe and Mathison, 1989) (Plate 3, 4).

The sequence is overlain by Sprent Formation (Tyndall Group) correlates in the Mt Minnie area and at the Preston silver mine.

Upper East Gawler River area

Correlates of the Western Volcano-Sedimentary Sequence are exposed in the upper reaches of the East Gawler River near 427 250 mE, 5 427 400 mN. These comprise a highly variable sequence of interbedded ashy siltstone, pumiceous volcanoclastic sedimentary rocks and greywacke. In thin section (Plate 5) sample R011050 is a poorly-sorted quartz phyric sandstone with a matrix of tube pumice and glass shards. Poltock (*in Vivian*, 1984) records an amygdaloidal intermediate lava(?), correlated with the Lobster Creek Intrusives, at 427 100 mE, 5 428 850 mN.

Mapping by Porter (1974) indicated the presence of an east-west fold in the upper Gawler River area. This is supported by structural measurements collected by Jennings *et al.* (1959) and recent field work. The highly variable nature of this sequence made mapping of



Plate 3

Slickensides pitching 32 degrees NW within a steep NW-trending minor fault parallel to the Deep Gully Fault (422 665 mE, 5 423 085 mN).

[Photo – D. Seymour]



Plate 4

Ten metre thick zone of steep, mostly brittle NW-trending faults on the main splay of the Deep Gully Fault (422 855 mE, 5 423 020 mN).

[Photo – D. Seymour]

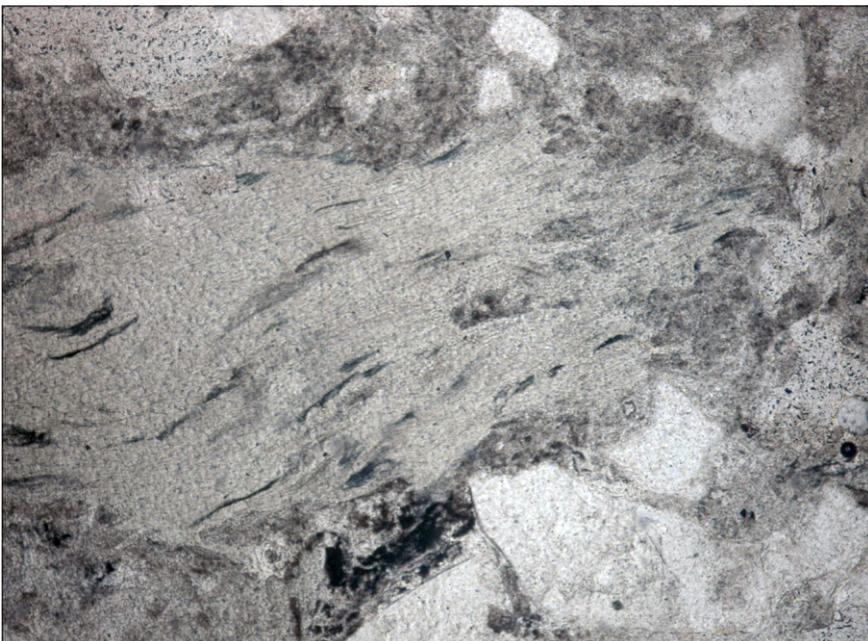


Plate 5

Quartz phyric pumiceous volcanoclastic sandstone from the Western Volcano-Sedimentary Sequence (Sample R011050) (Field of view: 1.7 x 1.1 mm).

individual lithofacies very difficult and the fold closure mapped by Porter could not be confirmed. Additional field work, including mapping of the critical East Gawler River traverse, is recommended.

Kindred Road area

Western Volcano-Sedimentary Sequence correlates crop out on the Kindred Road in the Moreton area. The sequence consists predominantly of interbedded ashy siltstones with minor greywacke. Mapping by Burns (1957) suggests that the ashy siltstone-rich units generally overlie a predominantly greywacke dominated sequence. This observation was largely confirmed by recent mapping. Burns (1957, 1964) notes that the greywacke unit (the 'Sprent Volcanics' of Burns, 1957. *Note:* This is not the same unit as the Sprent Formation. The Sprent Formation is equivalent to the 'Preston Breccia' of Burns, 1957) occurs in a similar geological setting to the Isandula greywacke, near the faulted contact with the Burnie Formation in the Paloona-Sprent area (432 500 mE, 5 431 600 mN). The basal Isandula Conglomerate unit is absent and the matrix of the greywacke is not hematitic. Any correlation with the Isandula greywacke may be misleading without further evidence.

Andesitic volcanoclastic sedimentary rocks, common in sequences to the south of Swamp Road, were not observed.

A small intrusive body of andesite was observed at 432 880 mE, 5 431 605 mN. A second body at 431 400 mE, 5 431 800 mN was taken from mapping by Poltock (*in Vivian*, 1994).

The contact with the Burnie Formation at 433 000 mE, 5 432 300 mN was not observed. It was shown as a faulted contact by Burns (1957) and Jennings *et al.* (1959).

Paloona-Eardley Tor-Wilmot Road area

The Cambrian sequence in the Paloona-Eardley Tor area has previously been mapped as Barrington Chert (Jennings *et al.*, 1959). Recent mapping has shown that this sequence underlies and is structurally conformable with rocks correlated with the Tyndall Group in the Barrington Creek area and consists predominantly of massive ashy volcanoclastic siltstone with minor greywacke. It is similar to rocks underlying Tyndall Group correlates in the Groove Creek and Nietta areas and has been tentatively correlated with the Western Volcano-Sedimentary Sequence.

Mapping by Burns (1957) suggests that this sequence can be subdivided into a lower formation (the 'Kindred Road Formation') consisting of interbedded claystone, micaceous greywacke, shale, chert, limestone and argillite. It is overlain by the 'Alma Formation', a thick sequence of bedded chert, porcellanite, greywacke and minor tuff and shale. This subdivision could not be confirmed by recent field work and additional mapping is recommended.

Mapping by Jennings *et al.* (1959) suggests that correlates of this sequence occur in the Perry Creek

area (435 500 mE, 5 424 000 mN). If the correlation by Jennings is correct then the Paloona-Eardley Tor sequence may be part of the Tyndall Group. Recent mapping has shown that the Perry Creek Sequence is quite different, with an increase in the abundance of greywacke and some andesitic volcanoclastic sedimentary rocks. The sequence conformably overlies an andesitic-dominated sequence correlated with the Tyndall Group in the Groove Creek area.

Other areas

A recent compilation of existing geology in northern Tasmania (Corbett and McClenaghan, 2003) has correlated rocks in the South Preston and southern Native Track Tier areas with the Western Volcano-Sedimentary Sequence. This correlation is presented on the new Castra 1:25 000 scale digital geological map, although the South Preston area was not examined as part of this study. Mapping by Vicary (1994, 1995) in the Native Track Tier area has shown that the Western Volcano-Sedimentary Sequence in this area consists of interbedded feldspar-quartz phytic volcanoclastic sedimentary rocks, minor siliceous conglomerate and andesitic-basaltic intrusive rocks. This description suggests that correlation of the sequence with the Western Volcano-Sedimentary Sequence is quite plausible, although a similar sequence in the Wilmot area is now considered to be part of the Tyndall Group (see *Groove Creek-Lower Wilmot area* section below) and the correlation is by no means definitive. Additional mapping in the South Preston-Native Track Tier area is required.

Tyndall Group Correlates

Overlying the Western Volcano-Sedimentary Sequence in the Riana-Sugarloaf Gorge area is a complex sequence of interbedded mudstone, greywacke, siliceous conglomerate and volcanic-derived sedimentary rocks. This has been termed the Radfords Creek Group (Burns, 1964). Late Middle Cambrian fossils have been located within this sequence from the Sugarloaf Gorge area, while a slightly younger sequence with late Middle-Late Cambrian fossils occurs in the Riana area (Laurie *et al.*, 1995). On this basis the Radfords Creek Group is a stratigraphic equivalent of the Tyndall Group (Corbett and McClenaghan, 2003) and this term is used in the following discussion.

The Sprent Formation forms the basal unit to the Tyndall Group in the Gunns Plains area (Burns, 1964; Herrmann, 1993; Sproule, 1994) and consists mainly of coarse-grained lithicwacke composed of Early Cambrian-Late Proterozoic derived chert, basalt, quartzite, schist and carbonate clasts. Sproule (1994) suggested that there is an increase in the amount of acid volcanic detritus towards the top of the unit. Recent mapping suggests that the Sprent Formation overlies the Western Volcano-Sedimentary Sequence in the Mt Minnie area, although it is not present in the Groove Creek area where andesitic volcanoclastic

mass-flows form the basal units of the Tyndall Group. Lithicwacke horizons, similar to those that characterise the Sprent Formation, have been recognised in the upper parts of the Tyndall Group in the Wilmot area. This suggests that the relationship between the Tyndall Group and Sprent Formation is highly complex, possibly interfingering. Corbett and McClenaghan (2003) considered the Sprent Formation to be the upper part of the Western Volcano-Sedimentary Sequence.

As previously noted, many of the lithofacies used to define the Tyndall Group are common within the Western Volcano-Sedimentary Sequence, and in the absence of fossil control distinction between the two groups is difficult. This has resulted in several areas of Tyndall Group rocks being mis-correlated with the Western Volcano-Sedimentary Sequence on previous geological interpretations.

Tyndall Group correlates are relatively widespread in the Castra-Kindred area and crop out in the Sugarloaf Gorge-Riana area, the Preston-Isandula area, and in the Lower Wilmot-Barrington area.

Isandula Plantation-Carpet Plain area

A thick sequence of interbedded ashy siltstone with interbedded chert-bearing medium to coarse-grained lithicwacke, conglomerate and greywacke crops out extensively in the Isandula Plantation-Carpet Plain area. This sequence has been termed the Sprent Formation (Jennings *et al.*, 1959) and is considered to represent the basal unit of the Radfords Creek Group (Sproule, 1994).

The Sprent Formation overlies the Motton Spilite in the Isandula Plantation area. The Sprent Formation contains clasts of chert, dolomitic sediments and Motton Spilite-derived basalt clasts with an increase in felsic volcanic-derived detritus up sequence (Sproule, 1994). The contact between the Sprent Formation and the underlying Motton Spilite is exposed on the Gunns Plains Road at 423 650 mE, 5 432 750 mN. Early workers (Jennings *et al.*, 1959; Porter, 1974) considered this contact to be faulted, however large clasts of basalt were observed in the Sprent Formation close to the contact and it could also be interpreted as a faulted unconformity. Plate 6 shows a typical outcrop of the Sprent Formation displaying poorly sorted sub-rounded clasts of chert and basalt. In thin section (Plate 7) sample R011048 consists of grain-supported chert, basalt, schist, hematitic siltstone, dolostone, chlorite-altered glass fragments and isolated crystals of feldspar and volcanic-derived quartz.

The Isandula Plantation-Barren Knob area is structurally complex, and the Barrington Chert and Motton Spilite have been subsequently thrust over the Sprent Formation, possibly in the Late Cambrian.

Burns (1957) described the Sprent Formation (which he termed the 'Preston Breccia') as overlying the 'West Gawler River Argillite' or 'West Gawler Formation', a sequence of interbedded claystone, shale and 'cherts'. Recent mapping has shown that the 'West Gawler

Formation' is very similar to the overlying 'Leven Argillite' (considered to be Radfords Creek Group by later workers) and probably part of the same sequence. This suggests that rather than representing a distinct basal unit of the Tyndall Group, the Sprent Formation represents a series of mass flow horizons deposited during Tyndall Group deposition, although it may form local basal units in some places.

The basal beds of the sequence in the Carpet Plain area consist of a thinly bedded grey to black siltstone, which overlies rocks correlated with the Western Volcano-Sedimentary Sequence. Although the contact was not observed, mapping by Porter (1974, 1976) suggests that bedding in the underlying sequence is largely conformable, although he included the basal unit in the underlying Western Volcano-Sedimentary Sequence. Along strike to the south this unit is folded and offset by the Deep Gully Fault and forms the host rocks of the Preston silver mine. A petrographic description of this lithology from the Preston silver mine is given in Virgoe (1990) (Sample 67823).

The basal siltstone is preceded by a sequence of interbedded ashy siltstone with interbedded chert-bearing medium to coarse-grained lithicwacke, conglomerate and greywacke. The lithicwacke-conglomerate-greywacke units form distinct mappable horizons, with the greywacke/lithicwacke ratio increasing towards the base of sequence and in a southwesterly direction along strike.

Isandula-Motton area

Tyndall Group correlates occur in the Isandula-Motton area. The occurrences are geographically isolated by Tertiary basalt cover and direct correlation is difficult.

Feldspar-pyroxene crystal-rich volcanoclastic sandstone with interbedded ashy volcanoclastic siltstone is well exposed on the Preston Road at 427 400 mE, 5 439 000 mN. These rocks have previously been correlated with the Kerrison Volcanics (Burns, 1964). Petrology and mineralogy studies by Sproule (1994) suggest a correlation with crystal-rich volcanoclastic sandstone from the Lower Tyndall Group (Lynchford Tuff, Pinnacles Sandstone). This correlation is supported by recent studies in the Native Track Tier area (Ebsworth and McPhie, 2004) where similar crystal-rich volcanoclastic sandstone is interbedded with laminated siltstone containing late Middle Cambrian fossils (Baillie and Jago, 1985). Feldspar-pyroxene crystal-rich volcanoclastic sandstone was also mapped near Lake Isandula at 427 750 mE, 5 433 150 mN and at Cateena Point on the Ulverstone map.

Middle Cambrian sponge spicules have been located from the Preston Road at 427 400 mE, 5 439 150 mN (Banks, 1956; Banks, 1982) in a siltstone immediately overlying the Isandula greywacke and underlying a potential correlate of the Kerrison Volcanics (Burns, 1964). Recent mapping could not reconcile the interpretation by Burns and the fossil locality probably



Plate 6

Weathered Sprent Formation conglomerate with clasts of chert and basalt, and indistinct stratification (423 330 mE, 5 432 795 mN). [Photo – D. Seymour]

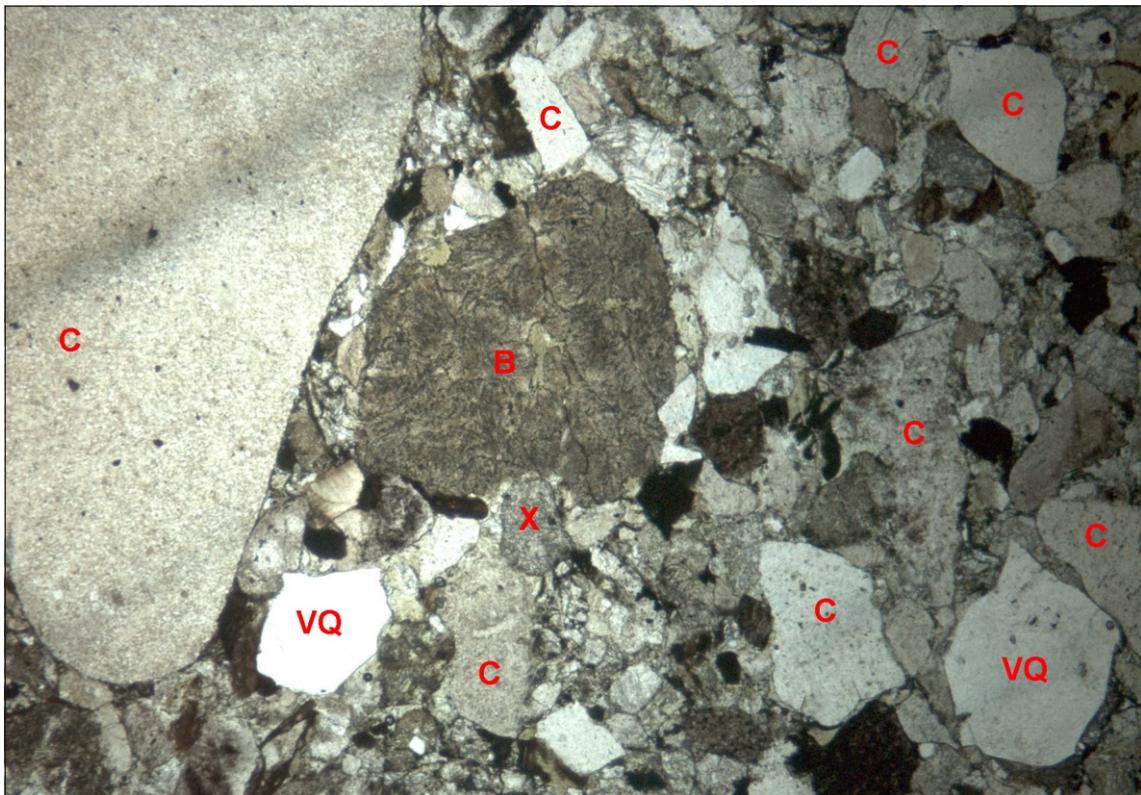


Plate 7

Mixed provenance grain-supported lithicwacke from the Sprent Formation (Sample R011048). (Note: C = chert; B = basalt; X = carbonate; VQ = volcanic quartz) (Field of view: 4.3 × 2.8 mm).

occurs within a thin horizon of ashy siltstone interbedded within the crystal-rich volcanoclastic sandstone of the Tyndall Group described above. This correlation places some doubt on the inferred age of the spicules.

A poorly exposed sequence of Cambrian rocks occurs along the Preston Road in the North Motton area. The sequence has previously been correlated by Burns (1963) as part of the Cateena Group, although there is little evidence to support this correlation. On the basis of a low radiometric response (fig. 4) the sequence is tentatively correlated with the Sprent Formation.

Gunns Sugarloaf area

Tyndall Group (previously called the Radfords Creek Group) rocks are well exposed along the Gunns Plains Road in the Gunns Plain Sugarloaf area. These were not examined in any detail during this study; detailed descriptions are documented in Burns (1964), Jago (1976) and Sproule (1994). The sequence consists of interbedded laminated feldspathic mudstone, quartz-plagioclase phyrlic vitric \pm crystal \pm lithic volcanoclastic sandstone and poorly sorted siliceous conglomerate. The conglomerate units occur in the upper parts of the sequence near the contact with the overlying Owen Conglomerate. The contact between the conglomerate horizons and the volcanic sequence is typically faulted (Plate 8) and it is unclear if the conglomerate is part of the Tyndall Group or thrust repetitions of the Owen Group. The sequence is intruded by andesitic to dacitic dykes, possibly related to the Lobster Creek Intrusives. A 48 m wide andesitic intrusive at this location was dated by Rb/Sr total rock method at 490 ± 18 Ma (Jago, Cooper and Corbett, 1977).

Barrington Creek area

A sequence of interbedded thinly laminated volcanoclastic siltstone and greywacke with minor coarse-grained lithicwacke occurs in the Barrington Creek area. This sequence is correlated with the Tyndall Group on the basis of lithofacies association and structural relationship with the underlying Western Volcano-Sedimentary Sequence. Only limited exposures of this sequence were observed, although the extent of the sequence is apparent in the radiometric data. Structural readings suggest that this sequence occurs in the core zone of a southeast-plunging syncline and conformably overlies a thick sequence of ashy siltstone correlated with the Western Volcano-Sedimentary Sequence.

At 435 300 mE, 5 428 400 mN the sequence is principally interbedded laminated micaceous-volcanoclastic siltstone and greywacke with minor coarse-grained lithicwacke. The laminated facies is identical to the basal unit of the Sprent Formation in the Carpet Plain-Mt Minnie area. A coarse-grained lithic-rich conglomerate was observed on the southeast shore of Lake Palooa at 437 300 mE, 5 427 000 mN.

This sequence forms the host to Cu-Ba mineralisation at the Barrington (Alma) mine and Devonport adit. Jennings (1979) reported an historical production of 475 kg of Cu. Apart from a soil sampling program conducted over a one kilometre gossanous zone by the Department of Mines (Cromer, 1973), the prospect has received limited modern exploration.

Groove Creek-Lower Wilmot area

Tyndall Group correlates crop out extensively in the Groove Creek-Lower Wilmot area. These comprise a highly variable sequence of interbedded andesitic volcanoclastic sedimentary rocks, andesite intrusive rocks/lavas, ashy volcanoclastic sedimentary rocks, greywacke and lithicwacke. The sequence is folded in a southeast-plunging anticline and commonly disrupted, and possibly repeated by a series of northwest-trending faults (Plate 9).

The sequence in the Groove Creek area is dominated by a series of interbedded andesitic pumiceous volcanoclastic sedimentary rocks, greywacke, and ashy volcanoclastic siltstone. The andesitic pumiceous volcanoclastic sedimentary rocks (Plates 10, 11) are similar to sequences described from the Preston, Native Track Tier and Paradise-Beulah areas (Sproule, 1994; Ebsworth and McPhie, 2004; Corbett and McClenaghan, 2003) and are correlated with the Lynchford Member of the Tyndall Group. These occur as graded mass-flow deposits with a coarse-grained massive pumiceous breccia at the base and grading to a well sorted fine to medium-grained volcanoclastic sandstone at the top. The graded top of the unit is generally relatively thin compared to the thickness of the deposit and is often hard to define in the field. Few reliable structural measurements were obtained from this unit due to the massive-poorly bedded nature of the underlying pumiceous-rich unit. Greywacke and ashy siltstone horizons are frequently interbedded with the andesitic pumiceous mass flow units. These units may represent the uppermost units of the mass flow package or could have been deposited in relatively quieter conditions between successive mass flow events. The greywacke units are typically micaceous. The mica is considered to represent a non-volcanic detrital component and was probably derived from an extra-basinal source, possibly from the adjacent Proterozoic Forth Metamorphic Complex.

Ashy volcanoclastic sedimentary rocks are interbedded with and underlie the andesitic pumiceous volcanoclastic facies. These rocks are very similar to parts of the underlying Western Volcano-Sedimentary Sequence and definitive correlation is uncertain. Potential thrust repeats of the Western Volcano-Sedimentary Sequence occur at 430 500 mE, 5 426 500 mN; 430 500 mE, 5 427 150 mN; and 431 350 mE, 5 427 200 mN. The rocks have been shown as Tyndall Group correlates on the Castra map sheet as definitive correlation could not be made in the field.



Plate 8

Fault contact between Tyndall Group thin-bedded volcaniclastic siltstone (FW) and Owen Group conglomerate (HW) (420 995 mE, 5 430 930 mN). [Photo – D. Seymour]



Plate 9

Pair of late-phase Devonian, NW-trending, NE-dipping brittle faults within Tyndall Group correlates (431 157 mE, 5 427 166 mN). [Photo – D. Seymour]



Plate 10

*Feldspar-pyroxene phyric
crystal-rich pumice breccia from the
Groove Creek formation
(431 157 mE, 5 427 166 mN).
[Photo – D. Seymour]*

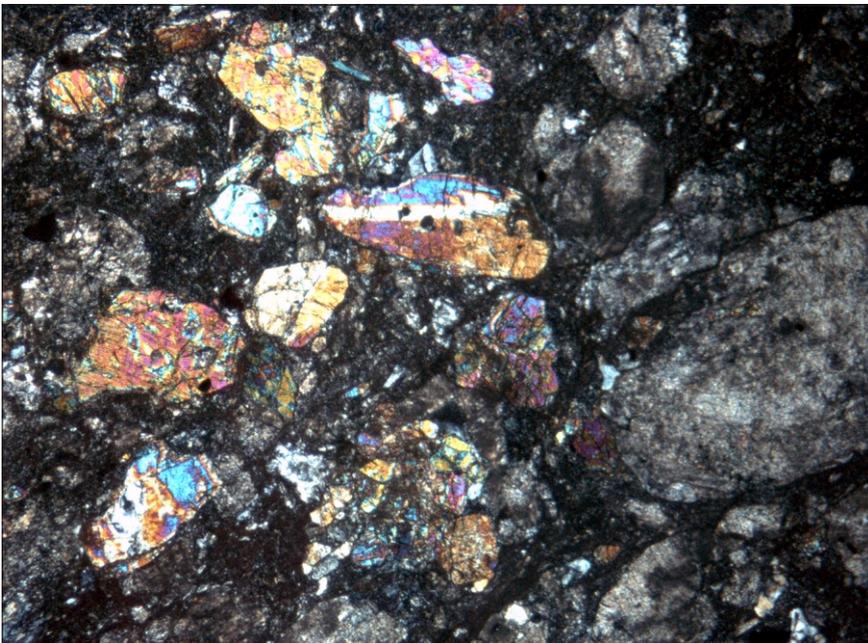


Plate 11

*Feldspar-pyroxene phyric crystal-rich
andesitic volcanoclastic sandstone
from the Groove Creek formation
(Sample R011041)
(Field of view: 4.3 2.8 mm).*



Plate 12

*Quenched fragmented andesite lava
from the Groove Creek formation
(Sample R011072)
(Field of view: 4.3 2.8 mm).*

A series of feldspar-pyroxene phyric andesite intrusive rocks/lavas are interbedded within the sequence described above. These vary widely in texture and massive, amygdaloidal, non-vesicular, and peperitic types were observed in the field. Potential hyaloclastite has been observed in thin section and is characterised by curvi-planar perlitic glass fragments (Plate 12).

A three kilometre long unit of andesitic volcanoclastic sedimentary rocks and possible intrusive rocks/lavas crops out in the Lower Wilmot area at 433 000 mE, 5 425 000 mN. This essentially defines the cessation of the andesitic-dominated sedimentation that characterises the lower parts of the Tyndall Group in this area. The unit is overlain by a thick sequence of interbedded ashy siltstone, greywacke and fine to medium-grained dacitic volcanoclastic rocks in the Perry Creek-Kings Hill area. Only rare andesitic units have been observed within this sequence at 434 550 mE, 5 423 900 mN and 432 550 mE, 5 424 300 mN.

Potential correlates of the Tyndall Group from the Groove Creek-Lower Wilmot area also occur in the Wilmot River between Spellmans Bridge and 431 100 mE, 5 4235 000 mN.

The sequence to the southwest of Kings Hill is very similar to that described from the Lower Wilmot area, although there is a noticeable increase in the relative proportion of greywacke-lithicwacke lithologies. This sequence probably continues into the Wilmot-Andersons Road-Nietta area on the adjacent Wilmot Sheet (McClenaghan and Green, 1999a). A review of thin sections of rocks collected by D. Green from this area shows that the sequence is highly variable, with a mixture of ashy siltstone, greywacke, polymict lithic sandstone, black siltstone and volcanoclastic sedimentary rocks. Quartzite clast-bearing conglomerate crops out at 431 800 mE, 5 420 000 mN. Rhyolitic lavas and andesitic-dioritic intrusive rocks are also present (McClenaghan and Green, 1999a; Poltock, 2002). The rhyolitic lavas are texturally similar to flow textured (pseudo-ignimbritic) spherulitic rhyolitic lavas described from the Tyndall Group in the Winterbrook and Black Bluff Range areas (Pemberton *et al.*, 1991; McPhie *et al.*, 1993). The andesitic to dioritic intrusive rocks are tentatively correlated with the Lobster Creek Intrusives. The polymict lithic sandstone contains abundant chert, basalt and some carbonate clasts and is similar to lithicwacke from the Sprent Formation.

The sequence in the Wilmot-Andersons Road-Nietta area has previously been correlated with the Western Volcano-Sedimentary Sequence (Corbett and McClenaghan, 2003) although recent mapping of the adjacent Castra map suggests that this sequence probably occurs at a high stratigraphic level in the Tyndall Group. Other potential correlates of this sequence may occur in the Riana-Sugarloaf Gorge area (Burns, 1964; Sproule, 1994).

Poorly correlated Cambrian sequences

Cambrian rocks crop out in the Foggs Flat-Allison Road area. This sequence has been previously correlated by Burns (1964) as part of the Cateena Group although there is no fossil control to support this correlation. Descriptions given in Sproule (1994), Herrmann (1993), and Crawford (1993) show that the sequence is highly variable, with a range of volcanic derived and chert clast-rich sedimentary rocks. Burns (1964) distinguished a volcanic rich 'facies' (the Kerrison Volcanics) within this sequence. Subsequent work by Herrmann (1993) has shown that this 'facies' includes both intrusive and volcanoclastic components and that the distribution of this unit as shown by Burns may be in error. The presence of volcanic-derived units suggests a possible correlation with either the Tyndall Group or the Western Volcano-Sedimentary Sequence. The chert-bearing clastic units are similar to coarse lithicwacke units described from the Sprent Formation (Tyndall Group), although the existence of similar facies within the Western Volcano-Sedimentary Sequence cannot be discounted.

There is insufficient information available to correlate the Cambrian sequence in the Foggs Flat-Allison Road area with any degree of confidence and the sequence is shown as undifferentiated Tyndall Group and Western Volcano-Sedimentary Sequence on the Kindred map sheet. Additional mapping of this sequence and strike extents in the prospective Dial mine area should be given a high priority.

Cambrian intrusive rocks

Lobster Creek Intrusives

Massive equigranular to porphyritic plagioclase-hornblende phyric andesite to dacite intrusive rocks intrude both the Western Volcano-Sedimentary Sequence and the Tyndall Group. These have been termed the Lobster Creek Volcanics (Burns, 1964), however the term Lobster Creek Intrusives (Sproule, 1994) is more acceptable.

The Lobster Creek Intrusives are widespread in the Castra-Kindred area, occurring as large intrusive bodies, up to two kilometres long and up to two kilometres wide, in the Foggs Flat, Gunns Sugarloaf and Isandula areas to small (generally less than 10 m wide) dyke-like bodies.

They have been dated at 500.2 ± 3.5 Ma (U-Pb Zircon age, Black *et al.*, 1997), 490 ± 18 Ma (total rock Rb-Sr age, Jago *et al.*, 1977) and 456 ± 22 Ma (total rock Rb-Sr age, Adams *et al.*, 1985). The age of 500.2 ± 3.5 Ma is the accepted intrusive age. The lower ages of 456 and 490 Ma are minimum ages and probably reflect resetting following a later thermal event.

Potential correlates of the Lobster Creek Intrusives occur in the Native Track Tier-Nietta (Crawford, 1993) and Lake Barrington-Beulah areas (Corbett and McClenaghan, 2003). The Beulah microgranodiorite (previously called the Beulah 'granite') is texturally

very similar to the Lobster Creek Intrusives in hand specimen (Corbett and McClenaghan, 2003) and has been dated at 493.5 ± 3.9 Ma (Black *et al.*, 1997). This suggests that the Beulah microgranodiorite is slightly younger than the Lobster Creek Intrusives. A preliminary review of the litho-geochemistry of the Lobster Creek Intrusives suggests that it ranges in composition from basaltic andesite-andesite-dacite and is similar to Suite 1 rock types from the Mt Read Volcanics in western Tasmania (Crawford *et al.*, 1992). A similar range in composition is displayed by most andesite-diorite-dacite bodies in northern Tasmania. Interestingly, the samples of the Lobster Creek Intrusives and Beulah microgranite that were dated by Black *et al.* (1997) have a very similar composition. This may suggest that the Lobster Creek Intrusives were emplaced over a relatively long interval of approximately 7 Ma.

Sproule (1994) and Berry *et al.* (1997b) suggest that the Lobster Creek Intrusives are possibly comagmatic with andesitic crystal-rich volcanoclastic sandstone ('Lynchford Tuff equivalents') of the Tyndall Group as shown by their similar chemical compositions. Field evidence of this relationship is well developed in the Groove Creek area where coherent bodies of Lobster Creek Intrusives have undergone marginal quench fragmentation. The resultant clastic facies, consisting of cusped perlitic glassy fragments (Plate 12), has intermixed with crystal and pumice-rich andesitic sediments which were probably derived from the explosive eruption of a similar magma.

The distribution of the Lobster Creek Intrusives on the Castra and Kindred map sheets is based on information from a variety of sources (Burns, 1963; Porter, 1974; Wilson, 1982; Poltock *in* Vivian, 1994) and recent field checking.

A small andesitic intrusive body at 430 900 mE, 5 429 650 mN has peperitic margins indicative of emplacement into wet or poorly consolidated sediments.

A small 'chilled' dacitic to microdioritic unit is intrusive into the Motton Spilite on the Gunns Plains Road at 424 300 mE, 5 432 900 mN and is considered to be a correlate of the Lobster Creek Intrusives (Herrmann, 1993; Crawford, 1993).

Several feldspar \pm hornblende? phyric andesitic to dacitic bodies intrude the Western Volcano-Sedimentary Sequence in the Watts Lookout-Ghost Hole Road area. These are typically massive and cross-cut the stratigraphy. Quench fragmented autoclastic and or vesicular varieties also occur. These are predominantly intrusive, although some probable lavas were identified by Porter (1976), and have been tentatively correlated with the Lobster Creek Intrusives.

Quartz-feldspar porphyries

Quartz-feldspar porphyry is a relatively minor intrusive phase in the Castra-Kindred area although these rocks are widespread throughout the Mount

Read Volcanics in northern Tasmania. They have been reported intruding Western Volcano-Sedimentary Sequence correlates in the Watts Lookout and Ghost Hole Road areas. At the Castra Road Prospect the porphyry is sericite-pyrite altered adjacent to the Deep Gully Fault (Purvis, 1978).

Late Cambrian-Ordovician Owen Group correlates

Correlates of the Late Cambrian-Ordovician Owen Group occur in three distinct zones in the Castra-Kindred area. In the west they form a semi-continuous belt along the west side of the Gunns Plains syncline and extend into the Mount Lorymer area at the south end of the Dial Range. At Watts Lookout white quartz sandstone (Moina Sandstone) overlies a thin unit of chert-bearing granule conglomerate (Upper Owen?). Approximately one kilometre southwest of Watts Lookout, a poorly defined sequence of interbedded quartz sandstone and granule to pebble conglomerate crops out. This has been shown as Undifferentiated Owen Group on the Castra map.

In the South Preston area, an undifferentiated sequence is unconformable across several sub-units of Cambrian rock types. No mapping of the Owen Group was attempted during this study, however outcrops on the South Preston Road (420 100 mE, 5 423 000 mN) are of a pebble-grade conglomerate. A similar pebble conglomerate was observed at 421 700 mE, 5 423 900 mN. Variably silicified hematitic granule conglomerate with chert and Proterozoic clasts crops out on a low ridge north of Rifle Range Road (422 900 mE, 5 426 500 mN). Previous mapping in this area (Jennings *et al.*, 1959) subdivided the Owen Group into two formations separated by a northwest-trending fault in the vicinity of the Preston silver mine. To the south of this structure the Owen Group was correlated with the Roland Conglomerate, while the rocks to the north were correlated with the Duncan Conglomerate, also called the Dial Group or the Dial Conglomerate (Jennings, 1979). This relationship could not be confirmed by the limited exposures examined during this study and both the formations mapped by Jennings *et al.* (1959) have been shown as undifferentiated Owen Group. No Moina Sandstone-like lithologies were observed in the South Preston area in contrast to the Watts Lookout area, but they may occur at higher stratigraphic levels than examined.

A small area of Duncan Conglomerate mapped by Jennings *et al.* (1959) at approximately 422 700 mE, 5 428 350 mN has been re-interpreted as a local silcrete developed on coarse-grained chert-rich lithicwacke.

The Owen Group correlates in the Gunns Plains Sugarloaf-Mount Lorymer area were not examined in detail. A review of the WRTMP radiometric data could not validate the current geological interpretation in the Mount Lorymer area and additional mapping is needed. Burns (1963) reported Moina Sandstone

directly overlying Cambrian rock types in this location.

Owen Group correlates also crop out in the Kings Hill-Eardley Tor area on the Castra map. Burns (1964) described the sequence on Eardley Tor as predominantly white quartzite, often bioturbated with minor interbedded conglomerate. This was shown on the Sheffield map (Jennings *et al.*, 1959) as Duncan Conglomerate, although Burns (1964) correlated the sequence as Moina Sandstone. Based on the above description and recent examination of exposures at 436 000 mE, 5 423 800 mN and 437 600 mE, 5 424 100 mN, a correlation of the sequence in the Eardley Tor area with the Moina Sandstone is most likely. This is supported by the mapping of Porter (1974).

No description of the sequence in the Kings Hill area was given in either Burns (1964) or Jennings (1979) although the Sheffield map (Jennings *et al.*, 1959) suggests a correlation with the Duncan Conglomerate. Porter (1974) suggested a potential correlation with the Roland Conglomerate. A new outcrop of Owen Group was located to the southeast of Kings Hill at approximately 436 600 mE, 5 421 900 mN. This occurrence, Kings Hill and a small outcrop approximately 500 m southwest of the Devils Gate Dam, have been tentatively designated Undifferentiated Owen Group on the revised Castra map (Vicary, 2005a) pending additional information.

Owen Group correlates also crop out in the Paloona area and straddle the boundary between the Sheffield and Devonport map sheets. Differing correlations of the sequence between adjacent map sheets has resulted in some confusion. The Owen Group on the old Sheffield map (Jennings *et al.*, 1959) is correlated with the Duncan Conglomerate, while both the Moina Sandstone and Duncan Conglomerate have been discriminated on the Devonport map (Burns, 1963). Porter (1974) correlated the entire sequence with the Moina Sandstone and his interpretation of the Owen Group-Proterozoic contact on the west slopes of Porcupine Hill is different to that mapped by Burns (1963). This discrepancy could not be resolved from the radiometric image, nor could the Moina Sandstone be adequately discriminated from the Duncan Conglomerate to improve the mapping.

The sequences in the Paloona area are briefly described by Burns (1964). At Paloona, a conglomerate strikes north and joins a strike ridge of Owen Group rocks about 1.5 km east of Kindred. This is shown as Duncan Conglomerate on the Devonport map and is shown as Undifferentiated Owen Group on the revised Kindred map (Vicary, 2005b), although as discussed by Burns (1964) it could represent a basal conglomerate to the Moina Sandstone. A separate body of Owen Group rocks with a basal white quartzite containing gastropod fossils exists approximately one kilometre south of Paloona. Burns (1964) considered this to be a correlate of the Moina Sandstone, although it was correlated with the Duncan Conglomerate on the

Sheffield map (Jennings *et al.*, 1959). It has been correlated with the Moina Sandstone following Burns (1964) on the revised Kindred map. Moina Sandstone also crops out on the main ridge of Porcupine Hill. A potential 'Florentine Valley Mudstone' equivalent occurs on a strike ridge that parallels Healeys Gully and the overlying Gordon Group approximately 1.5 km north of Paloona. This has not been depicted on the revised Kindred map but is a well defined mappable unit on the air photos. Moina Sandstone also overlies conglomerate on the strike ridge to the east of Kindred.

Ordovician Gordon Group

Limestone correlated with the Gordon Group crops out in the Raymond Road area on the eastern limb of the Gunns Plains syncline and in the Paloona area. These exposures were not examined by the author. Descriptions are given in Hughes (1957).

Devonian Eugenana Beds

A small area of Eugenana Beds crops out on the Paloona Road approximately 1.5 km northeast of Paloona. Although no specific mention of this occurrence is given, a description of the Eugenana Beds is given in Burns (1964).

Tertiary basalt and sediments

Tertiary basalt (Plate 13) crops out extensively in the Castra-Kindred area where it mantles the older sequences over an irregular pre-basalt topography. Much of the basalt occupies valley fill and several deep leads have been recognised by previous workers (Burns, 1957; Jennings, 1979). Little is known about the composition of the basalt apart from a few analyses recorded in the MRT TASROCK database (J. Everard, pers. comm.). Their location and composition is shown on the maps as minimum polygons for reference.

The basalt was not systematically mapped during this study although because of its wide distribution, it was commonly observed. Revisions to the contacts of the basalt with other rock types was made on the basis of field observation, WTRMP radiometric interpretation and/or air photo interpretation. The WTRMP radiometrics proved highly useful for delineating the basalt contacts (fig. 4, 5), although it should be noted that in some cases where there is steep topography the extent of the basalt may have been over-estimated due to downslope movement.

A potential volcanic centre or neck was previously identified in the Upper Castra area at approximately 427 300 mE, 5 427 000 mN (Burns, 1957), where basalt crops out as a roughly circular feature largely surrounded by Cambrian rock types. Recent mapping in the area suggests that the 'neck' may have formed by basalt flowing over an irregular pre-basalt topography and may not represent a volcanic centre.

Tertiary sediments were commonly observed at the base of Tertiary basalt and define the deep leads mentioned above. In the Easterly Road area, the



Plate 13

Columnar jointing in Tertiary basalt, Riggs Road quarry (435 943 mE, 5 432 356 mN).

Tertiary sediments are largely obscured by recent basalt talus and their full extent is not obvious on the map. A significant channel in the underlying rocks was mapped at approximately 427 600 mE, 5 420 400 mN. This was not shown on previous maps and some additional modification of the Tertiary basalt and sediment contacts was required on the adjacent Wilmot map (McClenaghan and Green, 1999a). Tertiary sediments at this location reach boulder grade and suggest that this deposit represents the site of a major river channel. It is not clear if this deposit is part of the Castra-Nietta lead or the Wilmot lead, as it is located mid-way between the inferred location of the leads on the map in the Sheffield Explanatory Report (Jennings, 1979). It may be possible that the Wilmot lead joins the Castra-Nietta lead at this location in contrast to the interpretation presented in Jennings (1979). Local occurrences of Tertiary ferricrete were also observed at this location.

Quaternary deposits

Quaternary deposits in the form of river gravels, alluvium, scree, talus and debris-flow deposits occur throughout the Castra-Kindred area. The boundaries presented on the revised maps may vary slightly from those depicted on Burns (1963) and Jennings *et al.* (1959), mainly due to additional air photo interpretation by the author and redrafting of the contacts from Burns' original air photo interpretation. Presentation of the geology at a larger scale has meant that several units that were too small to be displayed on the old paper map have been added.

A significant revision is that much of the alluvial flats bordering the Wilmot, Forth, and Leven rivers have been designated as Pleistocene following Burns (1957). The contact between Pleistocene and recent gravels in the River Forth was determined from air photos to be a few kilometres south of the Forth Bridge, with recent

gravels taken as being those deposited at approximately the same level as the current river level. The Pleistocene gravels tend to form distinct alluvial flats, generally elevated above the present river level. They are commonly eroded by the current stream bed.

Quaternary talus and debris flow deposits of Tertiary basalt derivation are common on steep slopes where the basalt is deeply dissected. Debris-flow deposits are most common in the Forth-Isandula areas and feature distinct hummocky surfaces and gently curving failure surfaces, some of which have been mapped from the old air photographs. Many of the basalt derived talus deposits may have originated as debris flows although the features described above are generally not obvious.

Talus deposits, consisting predominantly of clasts of Palaeozoic derivation, are commonly developed on the slopes of elevated areas with Owen Group or Barrington Chert outcrop. Cambrian-derived talus deposits are common on the sides of the steeply dissected valleys of the Wilmot, Forth and Leven rivers.

Synthesis

Introduction

The Cambrian sequence in the Castra-Kindred area is a complex sequence of interbedded felsic volcanic rocks and extra-basinal derived sedimentary rocks. The syn-volcanic derived lithologies include ashy volcanoclastic siltstone, fine to medium-grained rhyolitic volcanoclastic sandstone, dacitic pumiceous volcanoclastic sediments, medium-grained feldspar-pyroxene phyric andesitic pumiceous volcanoclastic sandstone and minor andesitic to rhyolitic intrusive rocks and lavas. Lithologies derived largely from Proterozoic and Early Cambrian extra-basinal sources include micaceous siltstone,

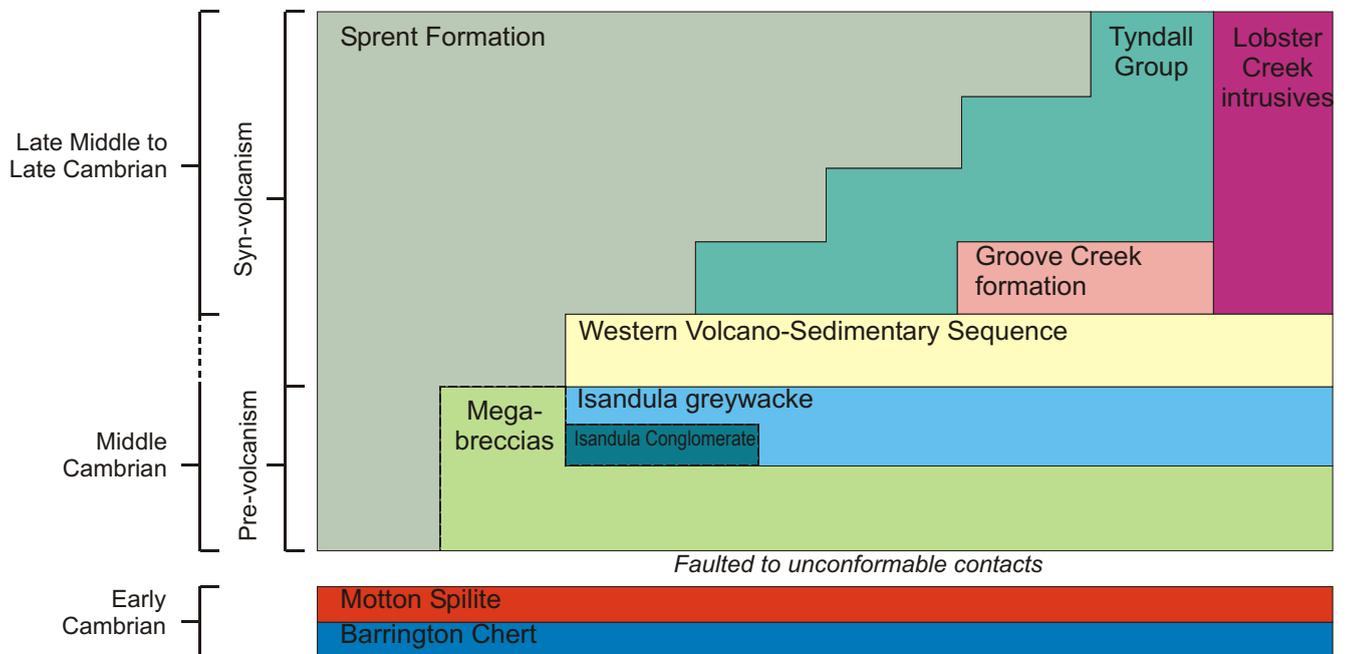


Figure 9
Cambrian stratigraphy of the Dial Range Trough.

greywacke, lithicwacke rich in chert and basalt clasts, and siliceous conglomerate.

Definitive age constraints from fossils are rare. Three spatially separated localities suggest that the sequence ranges in age from Middle Cambrian in the Isandula area, late Middle Cambrian in the Gunns Sugarloaf area, to Late Cambrian in the Riana area. A U-Pb zircon age of 500.2 ± 3.5 Ma was obtained from an andesitic intrusive rock in the Lobster Creek area (Black *et al.*, 1997).

The fossil control and U-Pb zircon age support correlation of the sequence with the Mount Read Volcanics. The presence of Middle Cambrian fossils suggests that parts of the sequence can be correlated with the Western Volcano-Sedimentary Sequence, while the late Middle-Late Cambrian assemblages favour correlation with the Tyndall Group (Corbett and McClenaghan, 2003). The major Cambrian stratigraphic subdivisions are summarised in Figure 9.

Examination of the Cambrian sequence in the Castra-Kindred area suggests that both the Western Volcano-Sedimentary Sequence and Tyndall Group have a similar range in lithotypes, and in the absence of fossil control, correlation is extremely difficult.

Distinctive andesitic pumiceous mass-flow deposits are a characteristic facies of the Tyndall Group in western and northern Tasmania (Sproule, 1994; Corbett and McClenaghan, 2003; Ebsworth and McPhie, 2004) and are generally rare in the underlying Western Volcano-Sedimentary Sequence. Similar rocks (the Groove Creek formation) have been mapped in the Castra-Kindred area and form a useful stratigraphic marker that can be traced from Lower Wilmot to the Isandula area, and may also occur in the Cateena Point area near Ulverstone.

A consequence of this correlation is that it divides a rather complex package of rock types into two distinct formations. Some areas previously correlated with the Western Volcano-Sedimentary Sequence are now known to stratigraphically overlie andesitic pumiceous mass-flow deposits and are now correlated with the Tyndall Group.

The stratigraphic position of the Sprent Formation is poorly defined and this unit was probably deposited over a wide stratigraphic interval. It conformably overlies the Western Volcano-Sedimentary Sequence in the Mt Minnie area. This formation is composed largely of clasts from Early Cambrian to Proterozoic rocks such as chert, basalt, red mudstone, dolostone, quartzite and schist. The megabreccia units are very similar to the Sprent Formation in terms of lithology and provenance and may represent a lateral facies variation. Alternatively, Crawford (1993) suggested that the megabreccia was deposited prior to the onset of Mount Read volcanism from either a westerly passive margin sequence (the Smithton Trough) or from the advancing parautochthon composed of Barrington Chert and Motton Spilite. Berry and Holm (2001) suggest that on the basis of contrasting structural style the megabreccia pre-dates the Middle Cambrian sequence in the Isandula area and may be a correlate of the late Neoproterozoic Togari Group.

In contrast the Sprent Formation in the Castra-Kindred area contains a significant component of volcanic-derived material and has a complex interfingering relationship with Tyndall Group and possibly the Western Volcano-Sedimentary Sequence. Without detailed mapping of syn-volcanic and extra-basinal derived components, correlation is extremely difficult. Distinction between syn- and

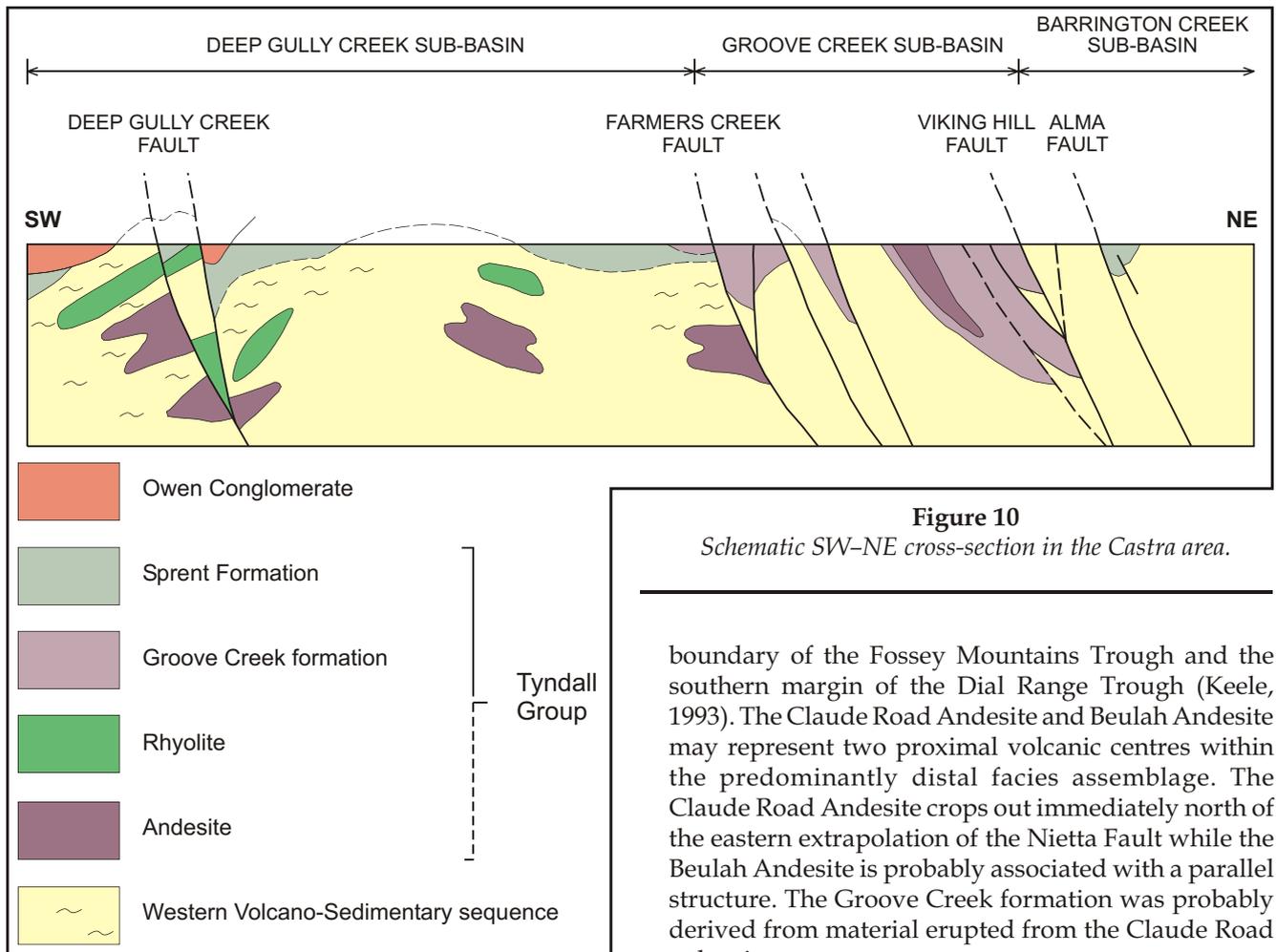


Figure 10
Schematic SW-NE cross-section in the Castra area.

pre-volcanic parts of the Sprent Formation requires additional petrographic studies.

The Middle Cambrian Isandula greywacke and Isandula Conglomerate (informally, the Isandula formation) underlie the Western Volcano-Sedimentary Sequence and are tentatively considered to be the basal part of this sequence. Alternatively they could represent parts of the Sprent Formation that were deposited prior to Mount Read volcanism.

The Tyndall Group correlates in the Castra-Kindred area have a more distal facies assemblage than the proximal facies assemblage typically displayed by the Tyndall Group in western Tasmania. This prevents direct correlation. Proximal Tyndall Group correlates also occur in the Winterbrook, Cethana and Mt Roland areas. Recent studies (Keele, 1993; Murphy *et al.*, 2004) have highlighted the presence of a series of west to northwest-trending basement structures that transect the Cambrian sequence in the Deloraine to Wilmot area. The Nietta Fault transects the Cambrian sequence in the Wilmot area and continues into the Gog Range where it has been called the 'Eastern Tyennan Margin Fault'. It essentially marks a fundamental change in volcanic facies from dominantly distal facies to the north to proximal dominated facies to the south, and was probably an active structure during Cambrian volcanism. This structure represents the northern

boundary of the Fossey Mountains Trough and the southern margin of the Dial Range Trough (Keele, 1993). The Claude Road Andesite and Beulah Andesite may represent two proximal volcanic centres within the predominantly distal facies assemblage. The Claude Road Andesite crops out immediately north of the eastern extrapolation of the Nietta Fault while the Beulah Andesite is probably associated with a parallel structure. The Groove Creek formation was probably derived from material erupted from the Claude Road volcanic centre.

The distal MRV assemblage can be traced eastwards from the 'Dial Range Trough' into the Paradise and Gog sub-basins (fig. 12 and 15), and probably continues into the Quamby area where it is overlain by post-Ordovician cover. It is tentatively suggested that this tectono-stratigraphic region be termed the Penguin-Quamby basin.

Late Cambrian-Ordovician reactivation of the Nietta Fault and Machinery Creek Fault resulted in the development of a separate sub-basin during Owen Group deposition. Similarly, Late Cambrian-Ordovician re-activation of the western continuation of the Nietta Fault controlled Owen Group deposition in the Native Track Tier area. A poorly defined west to northwest-trending basement structure (the Preston transfer zone) is inferred to occur in the Gunns Plains-Preston area where it may define the southern limit of early Cambrian allochthonous units. Late Cambrian-Ordovician reactivation of this structure resulted in the development of a sub-basin in which the Dial Conglomerate was deposited.

A series of northwest to northeast-trending late-phase Devonian faults and folds cross cut the earlier west to north-trending Cambrian structures. Such faults are well developed in the Eardley Tor-Groove Creek and Isandula areas.

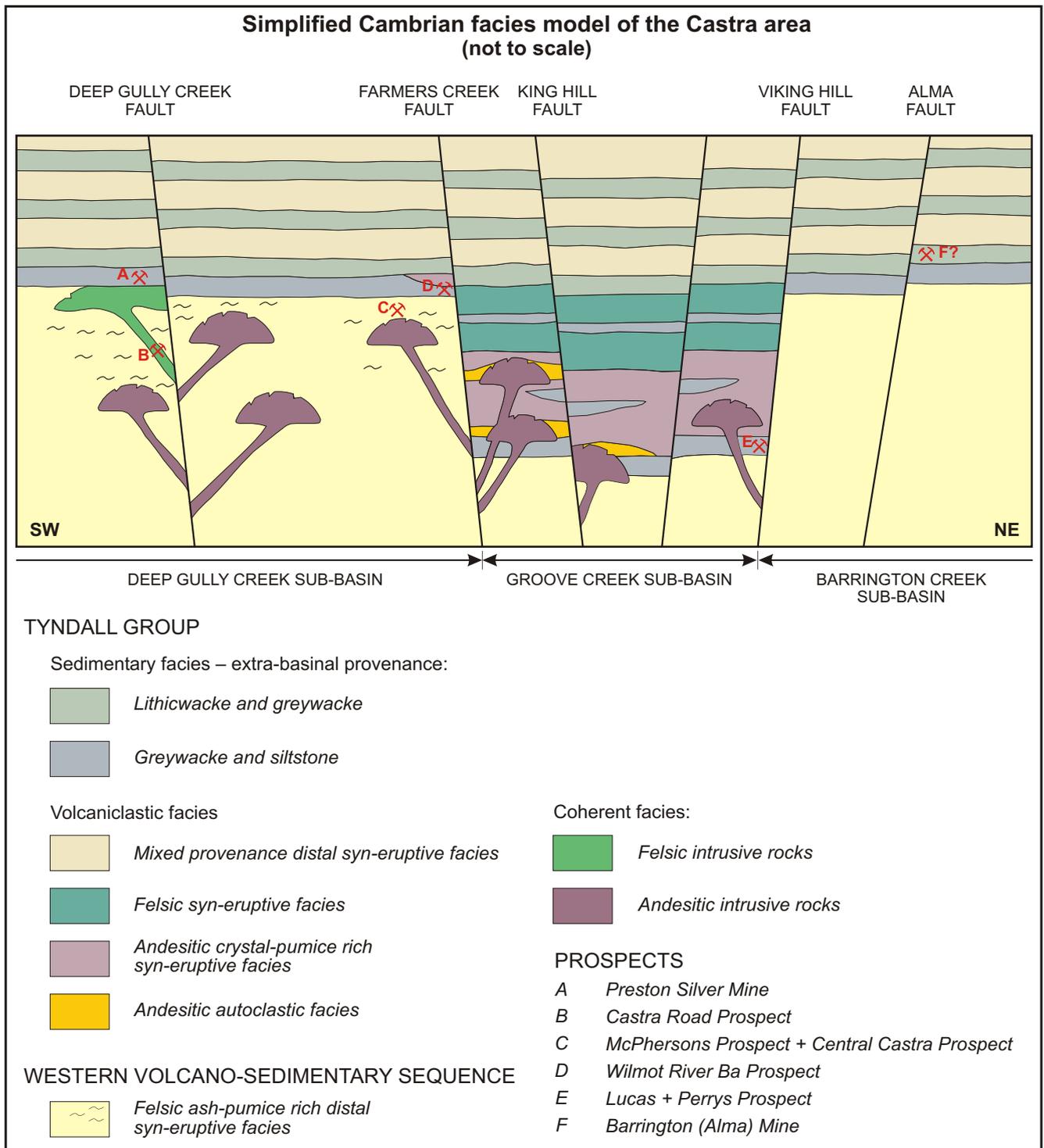


Figure 11

Simplified Cambrian facies model of the Castra area.

Basin architecture and mineralisation

A schematic cross section and facies reconstruction (fig. 10, 11) across the Castra map sheet shows that in general the Cambrian sequence can be subdivided into three distinct zones of contrasting volcanic and structural style. Major late northwest-trending faults define the boundaries of the individual sub-basins. These late structures are interpreted to be re-activated north-south Cambrian syn-volcanic growth faults. The definition of a sub-basin is strongly dependent on the facies assemblage in the basal units of the Tyndall

Group. At higher stratigraphic levels the sub-basin definition is less distinct due to a higher proportion of extra-basinal derived sediments.

Figure 12 schematically shows the Cambrian basin architecture in the Castra-Kindred area. In general there is a series of north-south trending sub-basins that are cut by two east-west trending transfer zones in the Nietta and Preston areas.

The western or Deep Gully Creek sub-basin is characterised by the presence of relatively open east-west to doubly-plunging dome-like fold hinges.

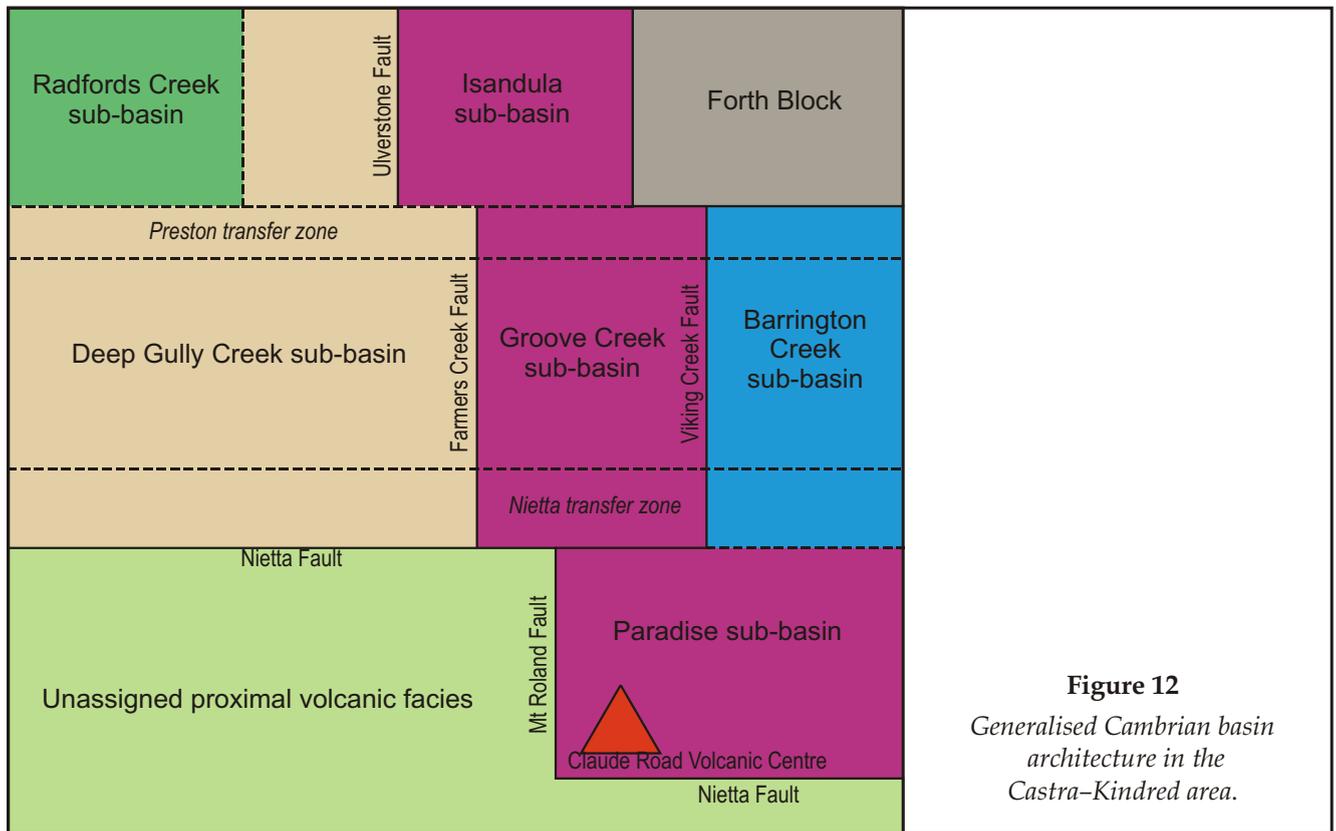


Figure 12
Generalised Cambrian basin
architecture in the
Castra-Kindred area.

The basin consists of a sequence of ashy-pumiceous volcanoclastic sedimentary rocks (Western Volcano-Sedimentary Sequence) overlain by a predominantly distal Tyndall Group assemblage of interbedded ashy siltstone and largely extra-basinal derived lithicwacke and greywacke (Sprent Formation).

Abundant high level andesitic to rhyolitic intrusive rocks/lavas occur within the Western Volcano-Sedimentary Sequence and are most abundant near the Deep Gully Creek Fault. It is tentatively suggested that the proto-Deep Gully Creek Fault was an active structure parallel to the Nietta Fault during Cambrian deposition. The andesitic to rhyolitic intrusive rocks/lavas probably formed just prior to or during the commencement of Tyndall Group deposition. In contrast to the adjacent Groove Creek sub-basin, only rare comagmatic syn-eruptive equivalents (crystal-pumice rich andesitic volcanoclastic sandstone) are known in the Deep Gully Creek area.

The base of the Tyndall Group is defined by a thin sequence of interbedded black siltstone and thinly bedded ashy siltstone which forms the host rocks to base metal mineralisation at the Preston silver mine. A Cambrian age for this mineralisation has been determined by lead isotope studies (Virgoe, 1990). Weak pyrite-sericite-(barite?) alteration hosted by a quartz porphyry occurs within the Deep Gully Creek Fault zone. Although the age of this style of alteration is not known, it is tentatively suggested that it may represent feeder-style alteration to the stratigraphically overlying base metal mineralisation at the Preston silver mine with the proto-Deep Gully Creek Fault acting as the major conduit for hydrothermal fluids.

Any future exploration of the Deep Gully Creek area could target the potential for exhalative or sub-seafloor replacement-style VHMS mineralisation along the Preston silver mine horizon, and areas near the Deep Gully Creek Fault for potential stringer-style mineralisation. A gold stream-sediment anomaly in a creek draining the Preston silver mine horizon (Virgoe, 1990; Virgoe and Mathison, 1989) in the Mt Minnie area has not received any follow-up exploration and may be a potential target.

The geology of the eastern part of the Deep Gully Creek sub-basin is relatively poorly known. Cambrian mineralisation has been identified at the McPhersons Prospect and possibly at the Central Castra barite prospect (Jennings, 1979). Both these prospects are hosted in the Western Volcano-Sedimentary Sequence. A poorly known sequence of greywacke located about 1.5 km north of Central Castra has been tentatively correlated with the Western Volcano-Sedimentary Sequence although it also has features commonly associated with the basal Tyndall Group in the Deep Gully Creek and Groove Creek areas. If this alternative correlation is correct then it is possible that both the McPhersons and Central Castra prospects occur in the upper parts of the Western Volcano-Sedimentary Sequence close to the contact with the overlying Tyndall Group. Thin barite veins have also been reported in the basal Tyndall Group at the Lower Wilmot prospect. Stream sediment values with anomalous gold and barium have been reported in the vicinity of McPhersons Prospect (Randell, 1988).

The central or Groove Creek sub-basin is characterised by tight to open folds and late-stage northwest-trending thrust faults. The lowest exposed

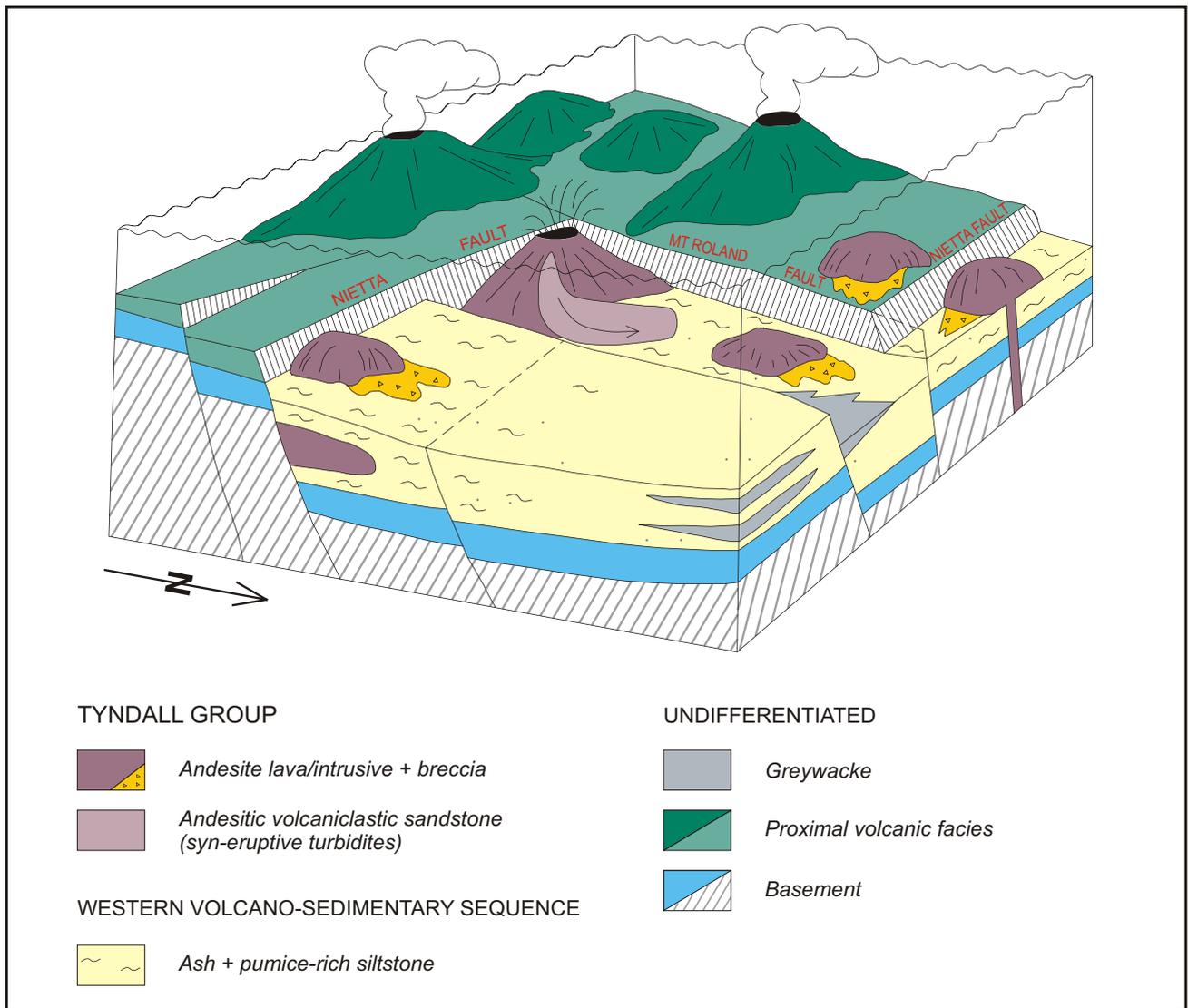


Figure 13

Sub-basin development and volcanic facies relationships at the southern margin of the Dial Range Trough during deposition of the basal Tyndall Group (modified after Gifkins, 2001).

stratigraphic unit is a thick sequence of ashy volcanoclastic siltstone correlated with the Western Volcano-Sedimentary Sequence. This is overlain by Tyndall Group correlates consisting of a highly variable sequence of greywacke, thinly bedded ashy siltstone, crystal-pumice rich andesitic volcanoclastic sandstone and andesitic intrusive rocks. There is a noticeable increase in the proportion of proximal volcanic facies in the Tyndall Group in the Groove Creek sub-basin in contrast to the distal facies which predominate in the adjacent Deep Gully Creek sub-basin. The source of the andesitic volcanoclastic sediment is probably a local volcanic centre (the Claude Road volcanic centre) which developed close to the Nietta Fault in the adjacent Paradise sub-basin (fig. 13). The geology of the Groove Creek sub-basin is quite complex due to rapid lateral facies variation and the late structural overprint. In the Groove Creek area the sequence has been folded into series of tight anticlines and synclines. The mapping of such structures is extremely difficult as the late northwest-trending thrust faults are commonly developed in the

hinge zones. The thrusting and folding has produced several repetitions of the Tyndall Group–Western Volcano-Sedimentary Sequence contact.

Folding is more open and the influence of late faulting is less apparent to the south of a poorly defined east–west structure at the junction of Groove Creek with the Wilmot River. The Tyndall Group generally strikes east–west which may reflect the influence of syn to pre-depositional east–west structures. A relatively thick sequence of Tyndall Group rocks is exposed in this area, with an increase in the proportion of distal extra-basinal derived facies at higher stratigraphic levels.

The Groove Creek sub-basin probably continues north into the Isandula area but the sub-basin is interrupted by the development of a sub-basinal east–west structural zone in the Sprent area, the Preston transfer zone. This structural zone is poorly defined but it is probably reflected by east–west faulting in the Gunns Plains Sugarloaf and Barren Knob area, and by the southern margin of the Proterozoic rocks in the

Moreton area. It has previously been called the Preston Graben (Keele, 1993). In the Isandula sub-basin a distinct unit of greywacke and lithic-rich conglomerate (the Isandula formation) underlies the Western Volcano-Sedimentary Sequence and is probably unconformable on Proterozoic basement to the east. The western margin of this sub-basin is probably defined by the southern continuation of the Ulverstone Fault.

Although only minor evidence of mineralisation is currently known within the Groove Creek and Isandula sub-basins the complex volcanic facies and the presence of potential syn-volcanic growth faults suggests that the basins may be highly prospective. Minor mineralisation has been identified at the Fork of the Gawlers and the Duncan and McClarens prospects in the Isandula area at or near the Western Volcano-Sedimentary Sequence/Tyndall Group contact. The Lucas and Perrys prospect is developed in a thrust slice of lower Tyndall Group rocks near the eastern sub-basin marginal fault (the Viking Creek Fault). Anomalous gold in stream sediments has been reported in the Groove Creek area (Randell, 1988).

To the east of the Viking Creek Fault is the Barrington sub-basin. Here the Western Volcano-Sedimentary Sequence consists of a thick sequence of ashy volcanoclastic siltstone with a poorly defined greywacke at lower stratigraphic levels. This sequence is overlain by the Tyndall Group which is folded in a southeast-plunging syncline in the Barrington Creek area. Although only limited exposure of this sequence was examined in the field, there is a noticeable abundance of laminated micaceous-volcanoclastic siltstone, greywacke and lithicwacke. No proximal facies have been observed and the sequence is probably a correlate of the Sprent Formation, although it is somewhat richer in siliceous-derived material. Minor Cu-Ba mineralisation is reported at the Barrington (Alma) mine, although this prospect has received little modern exploration.

The eastern boundary of the Barrington sub-basin is undefined due to Tertiary basalt cover but it is possible that the sub-basin continues east to the Bott Gorge-Lower Barrington area. The sequence consists of interbedded shale, greywacke and siliceous conglomerate and contains potential Late Cambrian fossils (Burns, 1957; Banks, 1982). Although it has been correlated as Western Volcano-Sedimentary Sequence (Corbett and McClenaghan, 2003), it is tentatively suggested that an alternative correlation with the upper parts of the Tyndall Group may be valid. The noticeable increase in siliceous conglomerate in this sequence probably reflects the site of deposition near the basin margin adjacent to exposed Proterozoic sequences.

The Nietta Fault effectively subdivides the northern Mount Read Volcanics into predominantly proximal facies to the south to predominantly distal facies to the north. It and its associated parallel structures were probably active Cambrian growth faults during early

basin development and cross faults at later stages. The influence of the Nietta transfer zone on the Groove Creek sub-basin is demonstrated by the east-west folding in the Lower Wilmot area. In the Deep Gully Creek sub-basin the Deep Gully Creek fault was probably an early east-trending fault parallel to the major Nietta Fault.

The Preston transfer zone probably developed in response to the southern margin of the Proterozoic Forth Block, and although poorly defined at surface its influence can be demonstrated by east-west folding in the Moreton area and by east-west faulting in the Gunns Plain Sugarloaf and Barren Knob areas. Late Cambrian reactivation of this structure had a major influence on the deposition of the Owen Conglomerate in the Gunns Plains and Dial Range area.

The Radfords Creek sub-basin is poorly defined and requires further examination. The Tyndall Group in this area consists of a relatively thick sequence of felsic syn-eruptive distal facies which overlies a basal unit correlated with the Sprent Formation. It may represent a part of the Deep Gully Creek sub-basin, although this is speculative as exposure is generally at a much higher stratigraphic level and the lower stratigraphy is not exposed. Alternatively it may represent a distinct sub-basin.

Middle Cambrian to Middle Devonian structural evolution

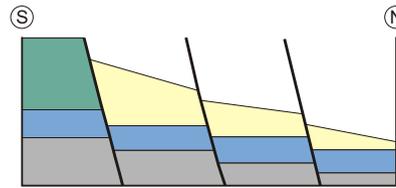
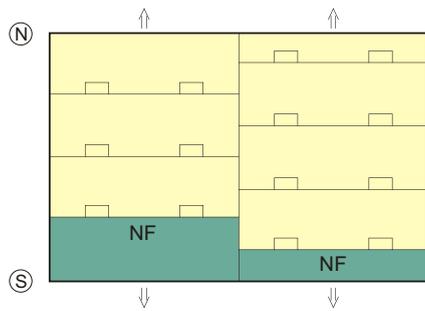
The structural evolution of the Castra-Kindred area is highly complex and records early syn-volcanic extension followed by a succession of compressional events (fig. 14).

Stage 1: Middle Cambrian extension

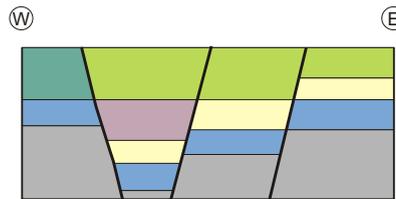
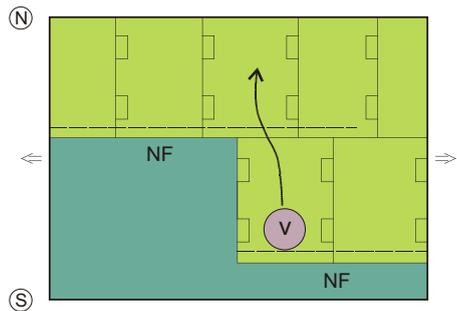
North-south extension in the Middle Cambrian led to the development of a series of east-west sub-basins and north-south cross structures which controlled deposition of the Mount Read Volcanics. The primary basin architecture is preserved in the Sheffield area by the distribution of proximal and distal facies assemblages. The Nietta Fault originated as an east-west growth fault in this event (fig. 14a).

A subsequent change in extension direction to east-west in the late Middle Cambrian led to the development of a series of north-south sub-basins and is coincident with a change to andesitic magmatism at the base of the Tyndall Group and mineralisation. Early north-south cross structures were reactivated as growth faults and represent areas of greatest extension. An andesitic volcanic centre (the Claude Road Volcanic Centre) developed at the intersection of a north-south growth fault and the earlier east-west Nietta Fault. A second andesitic volcanic centre in the Beulah area developed at the intersection of a north-south growth fault and a structure parallel to the Nietta Fault. The restricted distribution of andesitic centres and associated syn-volcanic sediments suggests that this phase of volcanism was confined within graben-like sub-basins (fig. 14b).

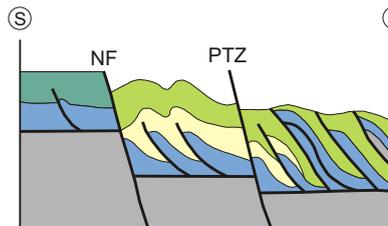
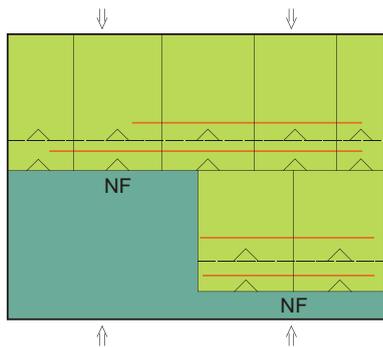
(A) Middle Cambrian N–S extension



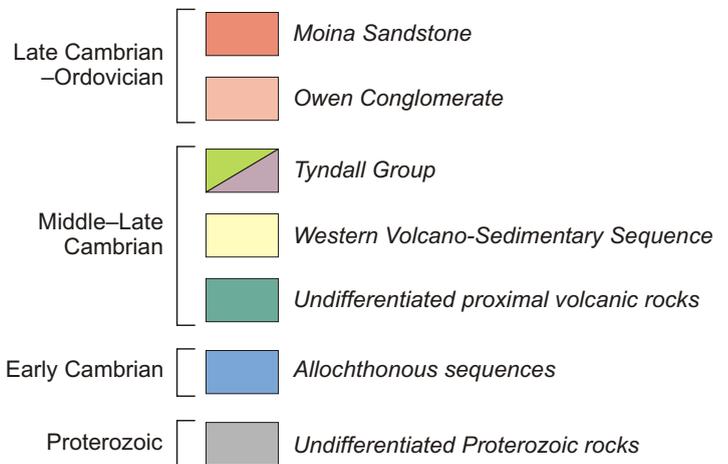
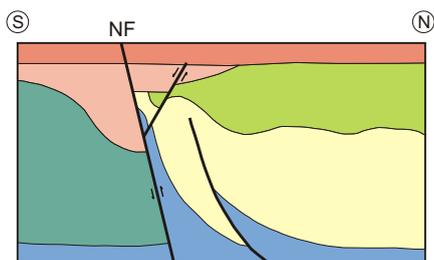
(B) Late Middle Cambrian E–W extension



(C) Late Cambrian N–S compression



(D) Late Cambrian–Ordovician extension



(E) Middle Devonian NE–SW compression

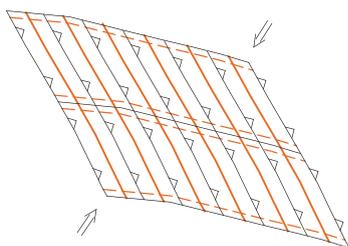


Figure 14

Structural development in the Castra–Kindred area.

Stage 2: Late Cambrian compression

A period of north-south compression in the Late Cambrian led to the reactivation of early east-west extensional faults and south-directed thrust re-emplacement of allochthonous sequences.

The south-directed thrusting event was strongly influenced by the Middle Cambrian basin geometry. Figure 14 shows the development of the basin during deposition. There is an apparent northward thinning of the Cambrian sequence across a series of north-dipping growth faults and it is quite likely that the Tyndall Group has been actively deposited on the Cleveland–Waratah Association in the north of the basin (fig. 14a). During the subsequent phase of north-south compression these faults were reactivated as reverse faults. Associated with this was the imbrication of the Cleveland–Waratah Association by reactivation of the basal sole thrust and the development of hangingwall fold structures in the overlying Cambrian rocks (fig. 14c). These folds are typically east-west parallel to the strike of the reactivated faults. Keele (1993) has shown that east-west folding is well developed immediately north of the Nietta Fault and the wavelength of the folds progressively decreases away from the structure. Similarly east-west folds are well developed adjacent to the Preston transfer structure.

To the north of the Preston transfer structure the imbrication of the Cleveland–Waratah Association is more pronounced. This is partly due to a closer proximity to the basal décollement and a thinner overlying stratigraphic sequence. This has resulted in thrusting of the Cleveland–Waratah Association to a much higher stratigraphic level than in areas to the south and thrusting into the Tyndall Group is common. In the Ulverstone area several Proterozoic blocks may have been incorporated in the imbricate structure.

Berry and Holm (2001) recorded intense deformation structures within the Cleveland–Waratah rocks and associated megabreccias in the Ulverstone area that may pre-date the Late Cambrian north-south compression event. They note that these structures are probably associated with the initial obduction event in the late Early to early Middle Cambrian and are not present in rocks further south. This implies that the megabreccia units developed prior to the Middle Cambrian and are essentially pre-Mount Read Volcanics. Alternatively the structures preserved in the Ulverstone area may reflect a close proximity to the basal décollement. Such features may not be apparent in the Middle Cambrian rocks to the south as these may be at a different structural level. Given the close textural and compositional similarity between the megabreccias and the Sprent Formation, a direct correlation cannot be ruled out.

Stage 3: Late Cambrian–Ordovician extension

The deposition of the Owen Group correlates occurred during a phase of extension in the Late Cambrian to

Ordovician. Corbett and McClenaghan (2003) have recently reviewed many aspects of the Owen Group correlates in northern Tasmania. Detailed analysis of the structural controls of deposition is hampered by the lack of good quality mapping in many places, although there is sufficient information available to make some important generalisations.

The Owen Group is comprised mainly of Proterozoic derived quartzite clasts, which suggests that large areas of exposed Proterozoic basement were adjacent to the basin at the time of deposition. Such areas probably included the Tyennan area to the south, the Burnie area to the west, and the Ulverstone–Railton areas in the north and east. Local chert-rich members within the Owen Group were probably sourced from areas of Cleveland–Waratah Association rocks that were exposed following high level thrusting in the Late Cambrian. In the Barrington area and Dial Range the Owen Conglomerate has been directly deposited on such thrust slices, indicating that the thrusting is clearly pre-Owen Group deposition in age.

The Owen Group is typically unconformable across the entire Middle–late Middle Cambrian sequence, probably due to the influence of east-west folding in the Late Cambrian. Regional facies changes within the Owen Group suggest that deposition occurred in a series of sub-basins. Deposition commenced in the Black Bluff, Mt Roland and Dial Range areas and then transgressed over other areas until the Middle Ordovician. Deposition in the Black Bluff–Dial Range area was strongly controlled by the reactivation of pre-existing north-south structures, while the early east-west Cambrian Nietta and Machinery Creek faults were active structures in the Mt Roland area.

The Nietta Fault is an enigmatic structure during Owen Group deposition and is largely concealed by the Owen Group over much of its length. Early reverse movement on the south side of the Nietta Fault probably controlled deposition of the Roland Conglomerate (fig. 14d). To the north of the fault the Owen Group is a lot thinner and is generally transgressive over the Cambrian sequence. The Cambrian rocks to the north of the Nietta Fault display well developed Late Cambrian folds and are unconformably overlain by the Owen Group. Local overturning of the Cambrian sequence immediately north of the Nietta Fault is also apparent in the Gog, Union Bridge Road, Golden Valley and possibly Wilmot areas, where slices of Early Cambrian basalt and minor Proterozoic basement are exposed.

Stage 4: Middle Devonian deformation and granite intrusion

Polyphase Middle Devonian deformation of the Tabberabberan Orogeny has been well documented in northern Tasmania (Williams, 1979; Seymour, 1989; Keele, 1993). Early deformation consisted of a variety of compressional events that were generally orthogonal to Early Cambrian fold trends. An early phase of north-south compression is recorded in the

Mole Creek and Loongana areas where it reactivated Early Cambrian east-west folds. Evidence for northwest-southeast compression is poorly recorded in the Castra-Kindred area in contrast to areas in western Tasmania, where there is strong development of northeast folds and faults. A subsequent phase of east-west compression produced north-south thrusts and folds which are well developed in the Dial Range area.

Late stage northeast-southwest compression had a major influence on the present shape of the Cambrian sub-basins as it was oblique to the earlier orthogonal structure. Features associated with this deformation event include northwest-southeast folds, northwest-trending cleavage (which often transects earlier east-west folds), rotation and steepening of early east-west and north-south structures, and the development of northeast-dipping thrust faults (fig. 14e, fig. 15). The complex array of northwest-trending east-dipping thrust faults and folds in the Groove Creek and Isandula areas occurred in this phase of deformation. This faulting has, in effect, inverted the Cambrian basin geometry. To the west of the Ulverstone Fault there is a change in structural vergence and west-dipping thrust faults are present (Woodward *et al.*, 1993).

Gravity modelling (Leaman and Richardson, 1989; Leaman, 2003; Leaman and Richardson, 2003) has defined the subsurface granite distribution in northern Tasmania. Three major granite bodies have been recognised in the Sheffield-Ulverstone area (fig. 16). The Housetop Granite is a strongly fractionated, oxidised I-type granite that has been dated at 373.6 ± 1.8 Ma (Black *et al.*, 2005). Cambrian Cu, Pb, Zn and Ba mineralisation in the Dial Range area has been overprinted by Devonian Sn-As assemblages along the eastern margin of this intrusion.

The Dolcoath Granite crops out in the Moina area. It is a strongly fractionated, moderately reduced I-type granite and has been dated at 351.0 ± 10 Ma (McDougall and Leggo, 1965). A wide variety of Devonian (Sn, W, Bi, Mo, Au, Ag, Cu, Pb, Zn and F) skarn, vein and greisen-type mineralisation has been developed within the contact aureole or within the host granite. Several prospects in the Cethana Pyrite Zone on the northeast margin of the granite are Cambrian in age.

A large boomerang-shaped intrusion (the Beulah Granite) has been inferred in the Sheffield-Preston area. This enigmatic structure has been the subject of much debate, mainly due to the poorly known geology and the poor distribution of gravity stations in the area (Leaman and Richardson, 1989; Leaman, 2003; Leaman and Richardson, 2003) (fig. 16). Most of the known mineralisation is of Cambrian age and there are no apparent metamorphic effects of the Cambrian

rocks in the area. Given the frequency of potential basement structures in the area to act as conduits for granite-derived fluids, it is unlikely that a Devonian granite is the source of the gravity anomaly. The general form of the gravity anomaly matches closely the inferred Cambrian sub-basin architecture to the north of the Nietta Fault and suggests a close relationship.

The western arm of the gravity anomaly occurs in the Deep Gully Creek-Groove Creek areas. The shallowest parts of the anomaly are coincident with the core of an anticline in the Deep Gully Creek area and a zone of thrust-related structural inversion in the Groove Creek area. The effect of potential shallow Proterozoic basement and/or Early Cambrian chert (Corbett and McClenaghan, 2003) in this area should be considered in future gravity modelling, as their presence may indicate that the granite is much deeper than currently modelled.

The shallowest part of the eastern arm of the gravity anomaly is coincident with the development of a Tertiary basin in the Sheffield area. This basin has a depth of between 50 and 100 metres (M. Latinovic; S. Forsyth, pers. comm.). It is unclear if this has been accounted for in the gravity modelling.

On the basis of current evidence a Cambrian source for the gravity anomaly seems highly likely and a variety of intrusions, ranging from andesitic to granitic, have been considered (Leaman, 2003; Corbett and McClenaghan, 2003). Possible sources include the Lobster Creek Intrusives and associated microgranodiorite, poorly exposed granitic intrusions in the Cethana area (Hicks, 1989; McClenaghan and Green, 1999b), and rhyolitic intrusive rocks in the Gog, Cethana and Deep Creek areas.

Conclusion

In conclusion this study, although of a largely reconnaissance nature, has shown that many of the volcanic and structural elements that characterise the main Mount Read Volcanics belt in western Tasmania (Corbett, 1992; McPhie and Allen, 1992; Berry and Keele, 1997) are present in the Castra-Kindred area. Most of the known mineralisation occurs at or near the contact between the Tyndall Group and underlying Western Volcano-Sedimentary Sequence. The basin architecture of the region is defined by a series of syn-volcanic growth faults and transfer structures. These had a controlling effect on the volcanic facies and acted as conduits for hydrothermal fluids. They represent prime sites for mineralisation. Future exploration should target exhalative or sub-sea floor replacement VHMS-style mineralisation at the base of the Tyndall Group or potential Cu-rich feeder zones at a deeper stratigraphic level.

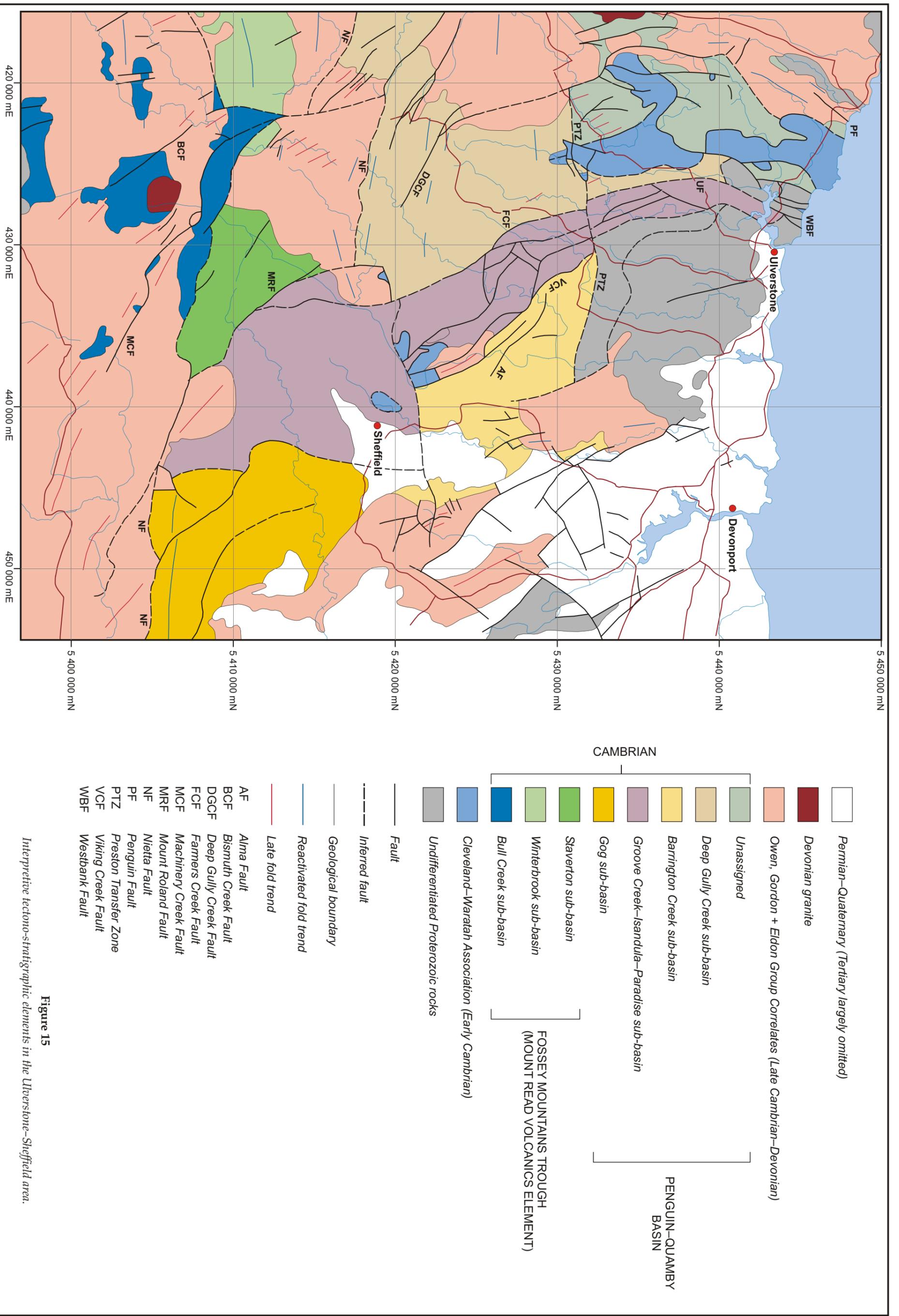


Figure 15

Interpretive tectono-stratigraphic elements in the Ulverstone-Sheffield area.

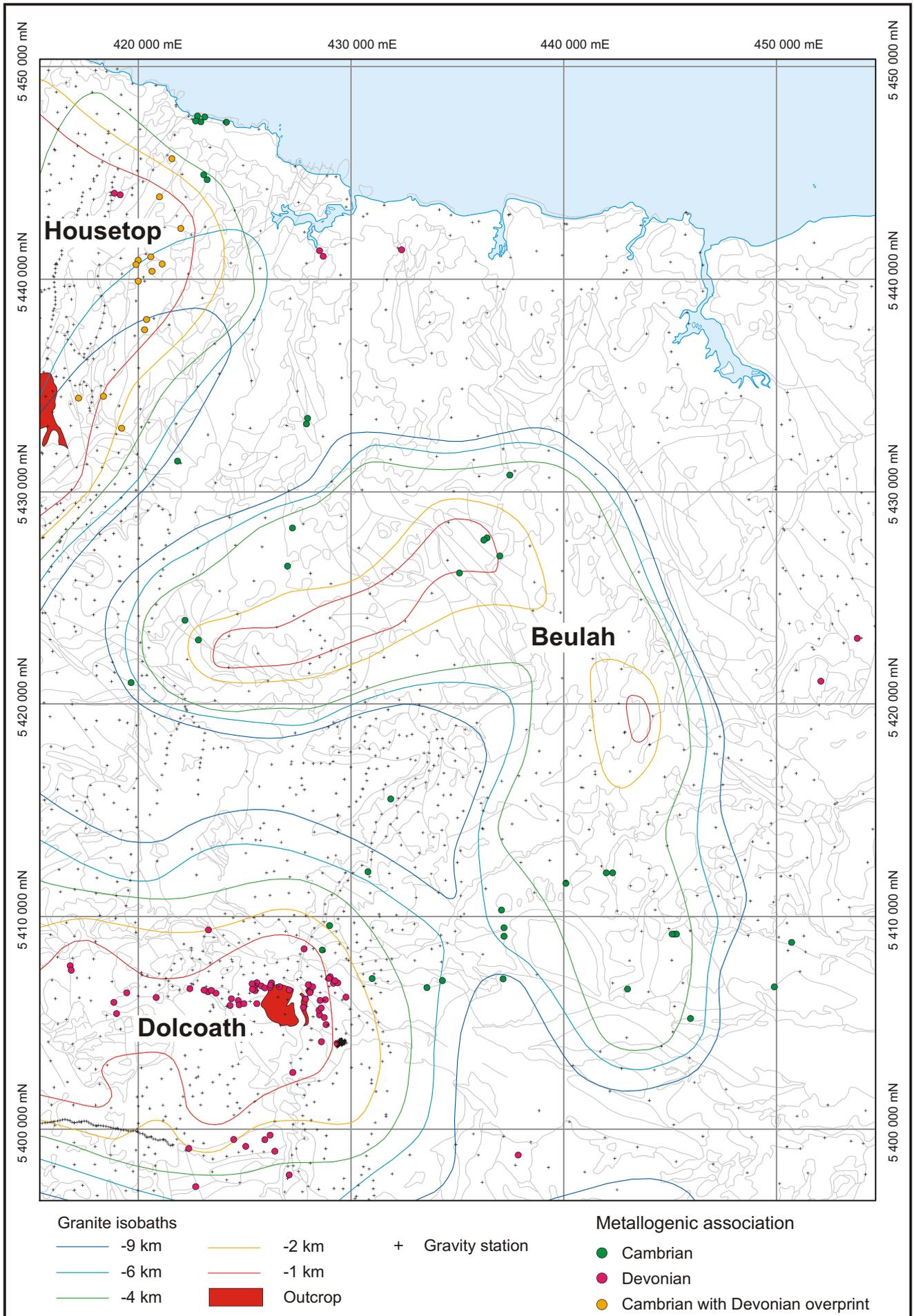


Figure 16. Form of Devonian granite and metallogenetic association.

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[8 March 2006]

Appendix 1

Sample catalogue

<i>Reg. No.</i>	<i>Field No.</i>	<i>Easting</i>	<i>Northing</i>	<i>Description</i>
R011034	na	435943	5432356	Tertiary basalt
R011035	na	435943	5432356	White joint coating on Tertiary basalt
R011036	na	435943	5432356	White joint coating on Tertiary basalt
R011037	na	435943	5432356	Green joint coating on Tertiary basalt
R011038	na	431814	5430541	Tertiary basalt
R011039	na	431416	5426242	Tertiary basalt
R011040	VDR001	431655	5430590	Ashy siltstone
R011041	VDR002	430640	5430210	Medium-grained andesitic volcanoclastic sandstone
R011042	VDR003	432880	5431605	Feldspar-F/M pseudomorph phyric andesite
R011043	VDR004	427315	5439050	Medium-grained andesitic volcanoclastic sandstone
R011044	VDR005	427620	435195	Feldspar-F/M pseudomorph phyric andesite
R011045	VDR006	427470	5432925	M gr feldspar-quartz? phyric dacitic volcanoclastic sandstone
R011046	VDR007	427570	5433000	Ashy siltstone
R011047	VDR008	428200	5434570	Hematitic polymict conglomerate (Isandula Conglomerate)
R011048	VDR009	424985	5430335	Lithicwacke
R011049	VDR010	425230	5429830	Med. grained feld-qtz? phyric dacitic volcanoclastic sandstone
R011050	VDR011	427510	5427840	Pumiceous feldspar phyric dacitic volcanoclastic sandstone
R011051	VDR012	430242	5426289	Medium to coarse-grained andesitic volcanoclastic sandstone
R011052	VDR013	430208	5426703	Medium-grained andesitic volcanoclastic sandstone
R011053	VDR014	430857	5424192	Pumiceous feldspar phyric dacitic volcanoclastic sandstone
R011054	VDR015	430020	5428860	Medium-grained andesitic volcanoclastic sandstone
R011055	VDR016	430615	5429630	Feldspar-F/M pseudomorph phyric andesite
R011056	VDR017	431035	5426970	Feldspar phyric dacitic volcanoclastic sandstone
R011057	VDR018	431410	5426690	Pumiceous feldspar phyric andesitic volcanoclastic sandstone
R011058	VDR019	431885	5427025	Feldspar-F/M pseudomorph phyric andesite
R011059	VDR020	434610	5430115	Silicified ashy siltstone
R011060	VDR021	434330	5426280	Medium-grained andesitic volcanoclastic sandstone
R011061	VDR022	437390	5426995	Polymict conglomerate
R011062	VDR023	435050	5424922	Pumiceous feldspar phyric dacitic volcanoclastic sandstone
R011063	VDR024	435615	5422041	Pumiceous feldspar phyric dacitic volcanoclastic sandstone
R011064	VDR025	435803	5421960	Black siltstone
R011065	VDR026	423654	5421991	Feldspar phyric dacitic volcanoclastic sandstone
R011066	VDR027	423660	5421873	Feldspar phyric andesite
R011067	VDR028	423047	5421497	Pumiceous feldspar phyric dacitic volcanoclastic sandstone
R011068	VDR029	422636	5428325	Silicified lithicwacke/silcrete
R011069	VDR030	422752	5426431	Silicified granule-pebble siliceous conglomerate
R011070	VDR031	422912	5426449	Hematitic granule-pebble siliceous conglomerate
R011071	VDR032	436479	5421690	Chert breccia
R011072	VDR033	433000	5428400	Feldspar-F/M pseudomorph phyric andesite
R011073	VDR034	432484	5427588	Pumiceous feldspar phyric andesitic volcanoclastic sandstone
R011074	VDR035	430637	5423073	Thinly bedded volcanoclastic siltstone, with kink fold
R011075	VDR036	435381	5428461	Thinly bedded volcanoclastic siltstone
R011076	VDR037	428372	5443173	Pumiceous feldspar phyric andesitic volcanoclastic sandstone
R011077	VDR038	427809	5435424	Hematitic siltstone
R011078	VDR039	427759	5436621	Hematitic siltstone
R011079	VDR040	427730	5436652	Hematitic greywacke
R011080	VDR041	426986	5433701	Limonitic greywacke
R011081	VDR042	427067	5434306	Hematitic siltstone