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Mount Read Volcanics Compilation

A review of geology and exploration in the Macquarie Harbour–Elliott Bay area, South West Tasmania

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Contents

Summary

1. This report summarises and synthesises the geology of the area between Macquarie Harbour and Elliott Bay using recent mapping and the geophysical surveys conducted for the Western Tasmanian Regional Minerals Program (WTRMP). It also gives an historical summary of mineral exploration carried out in the area, and reviews the potential for further exploration in the light of new geological interpretations.
2. A new compilation map (fig. 2) of the geology at 1:100 000 scale has been prepared which also shows prospects and drill holes. Maps of the new WTRMP aeromagnetics and radiometrics over the same area and at the same scale have also been produced (fig. 3, 4).
3. The area contains representatives of most of the important geological elements of western Tasmania. On the Cape Sorell peninsula, a quartzite sequence correlated with the Rocky Cape Group is thrust over correlates of the late Proterozoic Crimson Creek Formation and Success Creek Group, and a correlate of the Oonah Formation is also present. A major structural zone between Point Hibbs and Asbestos Point, containing sheared ultramafic-mafic rocks and slivers of Middle Cambrian, Late Cambrian, Ordovician and Siluro-Devonian sedimentary rocks (including limestone), forms the western boundary of a major belt of Middle Cambrian andesite-rich volcano-sedimentary rocks referred to as the Noddy Creek Volcanics. A fault-bounded basement block of allochthonous basaltic rocks, the Mainwaring Group, lies within this belt, which abuts the main belt of felsic Mt Read Volcanics along the Copper Creek Fault. An Owen Group siliciclastic sequence overlies the MRV, and is cut by the large Macquarie Harbour Graben filled with Tertiary sedimentary rocks.
4. Recognition of the full extent and nature of the Noddy Creek Volcanics sequence, which forms a belt about 10 km wide and 50 km long, and represents the western half of the general Mt Read Volcanics zone, is a major contribution from this study. Stratigraphic evidence, and the presence of granite clasts in places, suggests that much of the sequence is of Tyndall Group age (i.e. younger than the bulk of the Mt Read sequence elsewhere), but older rocks are probably also present.
5. The andesites of the Noddy Creek belt are petrologically and geochemically similar to the host andesite sequence to the Que River and Hellyer massive sulphide deposits, and to andesites in the western Henty Fault Wedge. Their geochemical characteristics overlap those of Suites I and II of Crawford *et al*. (1992), the strongest affinity being with Suite I.
6. A major volcanic-intrusive complex occurs within the Noddy Creek belt at Thomas Creek–Timbertops, where exploration to date shows sulphide mineralisation associated with brecciation and porphyry-type veining and alteration. Overall, the belt has had little exploration in comparison with similar rock sequences to the north, and parts of it are still very poorly known.
7. The main sequence within the eastern MRV belt consists of quartz-phyric volcanic and volcaniclastic rocks, with abundant quartz-feldspar-biotite porphyries (including a large linear body along the eastern side), several granite bodies, and basal siliciclastic rocks correlated with the Sticht Range Beds. This sequence is a correlate of the Eastern Quartz-Phyric Sequence (EQPS) of the Lake Dora–Mt Murchison area, and has zones of gold and base metal anomalism mostly related to the porphyry intrusive rocks.
8. The EQPS passes west into a volcano-sedimentary sequence in the Wart Hill–Stony Creek area, correlated with the Western Volcano-Sedimentary Sequences (including the Yolande River Sequence) of the area north of Macquarie Harbour. It comprises quartz-phyric volcanic and volcaniclastic rocks with some siliciclastic sandstone and conglomerate units and a thick siltstone unit. Several zones of gold and base metal anomalism and alteration (mostly granite-related) are present, but the most significant unit is a volcaniclastic breccia containing clasts or rafts of VHMS-type Zn-Pb-rich massive sulphide at Wart Hill. Considerable exploration effort has been directed at this unit, including some fifteen drill holes, but the source of the clasts remains elusive. The most recent mapping (1991) suggests some potential for an extension of the host rock unit to the east, towards the Owen Group contact, in a fault block.
9. The Macquarie Harbour–Elliott Bay area has most of the major elements of the heavily mineralised central West Coast, including an expanded Mt Read Volcanics belt, but is relatively under-explored.

Introduction

Scope of study

This report, on part of South West Tasmania, is the second part of a project within the Western Tasmanian Regional Minerals Program (WTRMP) to update the geology of the Mt Read Volcanics belt using new geophysical data obtained as part of WTRMP, but also incorporating new geological data from other available sources. The latter include company exploration reports, Geological Survey maps and reports, research theses, and recent unpublished work where available. The project was initiated by Dr Geoff Green, with the author as contractor. The first phase, on the central west area between South Darwin Peak and Hellyer, was completed in July 2002 (Corbett, 2002). A third phase, on the extension of the Mt Read belt into the Sheffield area, is planned for early 2003. Each phase is to include an updated compilation map of the geology at 1:100 000 scale (fig. 2), and accompanying maps of the new aeromagnetic (fig. 3) and radiometric data (fig. 4).

The present study has encompassed not just the continuation of the main Mt Read Volcanics belt south of Macquarie Harbour, but also the other Cambrian and adjacent Proterozoic rocks of the Cape Sorell peninsula area, as these include equivalents of the Mt Read sequence (the Noddy Creek Volcanics) and have traditionally been explored as a unit.

Most of the area (fig. 1) has been covered by fairly recent geological mapping by the Tasmanian Geological Survey, including maps by McClenaghan and Findlay (1989) of the Cape Sorell peninsula, Brown (1988) of the Montgomery (Mainwaring River) area, Seymour (2001*a, b, c*) of the Hibbs area, and three maps produced for the Mt Read Volcanics Project in the early 1990's (Pemberton *et al*., 1991; Vicary *et al*., 1992; Bradbury *et al*., 1992). These maps give a nearly complete coverage of the area of interest. Early regional mapping by exploration companies has been superseded by these maps, and subsequent exploration has mostly used the Survey data. Very few research theses have been done in the area.

No field work was done by the author for this phase, because of time and cost limitations, but some relevant observations have been made by Dr David Green during a January 2003 expedition to ground-check features visible on the new geophysical images. Of most significance is the discovery of a new window of Middle Cambrian volcano-sedimentary rocks, surrounded by Tertiary sedimentary rocks, in the upper reaches of the Spero River.

The geology of the area has been reviewed in the light of recent improvements in understanding of the Lower Palaeozoic geology of Tasmania, including advances arising from the first phase of this WTRMP project, adding to fairly recent reviews by Seymour and Calver (1995) and Brown *et al*. (1991). A summary is also given of the exploration carried out in the area, as this has involved a fairly small number of companies and operations, and provides a useful background to consideration of exploration issues.

Conditions related to working in South West Tasmania

Most of South West Tasmania is now included in the World Heritage Area. The WHA boundary lies just east of the D'Aguilar Range and Elliott Bay areas, and includes some of the area of Tertiary sedimentary rocks south and east of Birchs Inlet. The boundary takes in a 100 m-wide strip of coastline from Birchs Inlet to Steadman Point, where Cambrian rocks occur. Apart from this, most of the Cambrian rocks, and all of the Cape Sorell peninsula area, are outside the WHA. This remaining area is part of the Southwest Conservation Area, and exploration is monitored by the Mineral Exploration Working Group.

Exploration in South West Tasmania tends to be more expensive than elsewhere, and typically involves the use of helicopters. There are no permanent settlements and no roads except for some rough four-wheel-drive tracks. A sheltered boat landing is available at the southern end of Birchs Inlet, giving access to the Low Rocky Point track, nowadays mainly used for recreational motorbike and mountain bike riding. There is another fairly sheltered landing at Cowrie Beach on Elliott Bay, and a hut camp is present near Wart Hill. A bulldozed airstrip is located at Moores Valley.

The landscape of the Macquarie Harbour–Elliott Bay area is dominated by old Tertiary marine surfaces at around 100–200 m above sea level, through which the many streams have cut meagre gorges. Many of the surfaces are covered with light to dense scrub and forest, such that physical movement can be difficult without cut tracks. Some of the surfaces also have a shallow cover of superficial deposits obscuring the bedrock and affecting geophysical techniques. Thus, while the topography is generally more benign than in much of western Tasmania to the north, the scrub cover creates some problems for exploration. A clear avenue of buttongrass plains is present along the zone of Tertiary rocks stretching south from Birchs Inlet and over the felsic volcanic zones of the D'Aguilar Range and Elliott Bay areas, but between this avenue and the west coast is a wide zone of forest in which access is more difficult.

Acknowledgements

The author is again pleased to acknowledge the co-operation and helpfulness of Mineral Resources Tasmania personnel. Dr Geoff Green provided overall guidance, many useful discussions, and productive comments on a first draft of this report. Drs Marcus McClenaghan and David Seymour gave freely of their extensive knowledge of the Cape Sorell peninsula and Point Hibbs areas, and also commented on drafts of the geological map and report. Dr David Green gave freely of information gained from his ground checking expedition, and provided a number of useful images of the area. Ken Bird, Jo-Anne Bowerman, Bob Richardson, and particularly Chris Meech co-operated cheerfully and efficiently in production of the maps. Kylie Lau and Greg Dickens are thanked for helpful provision of library services.

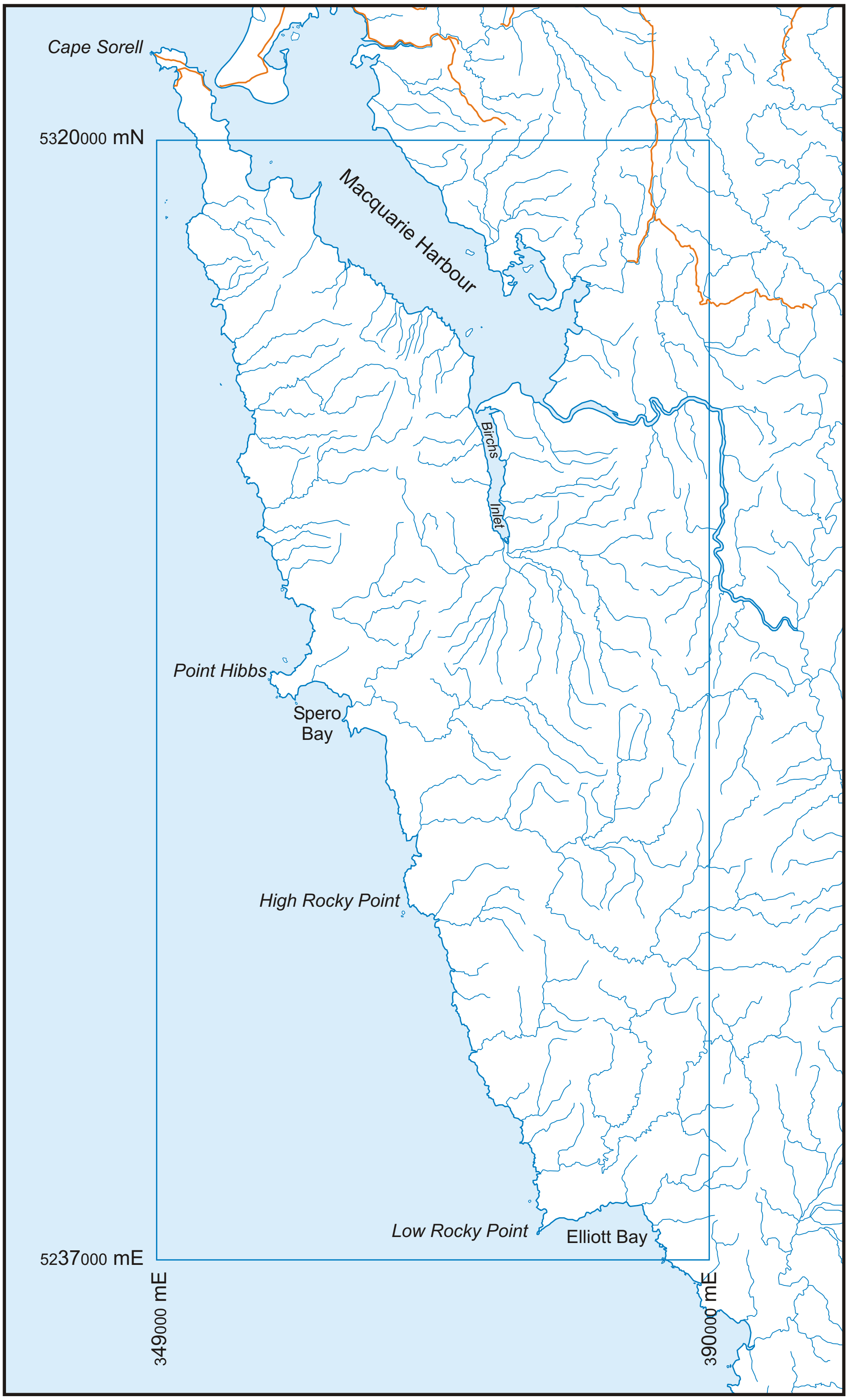

Figure 1
Area covered in this report

Major elements of the geology

Introduction

This area encompasses most of the key elements of the Lower Palaeozoic geology of western Tasmania, including:

1. Segments of the Mesoproterozoic basement (Rocky Cape Group quartzites on Cape Sorell; quartzite-phyllite-schist sequences of Tyennan region);
2. Representatives of the late Proterozoic rift sequences of proto-Tasmania (correlates of Oonah Formation, Success Creek Group, Crimson Creek Formation);
3. Representatives of the allochthonous units introduced into Tasmania in the early Middle Cambrian (ultramafic-mafic rocks and associated boninitic lavas; Mainwaring Group and Birchs Inlet ocean-floor basaltic sequences);
4. Middle Cambrian post-collisional volcanic and volcano-sedimentary sequences (Mt Read Volcanics correlates, including Noddy Creek Volcanics);
5. Late Cambrian–Ordovician siliciclastic-dominated Owen Group sequences on Mt Osmund and D'Aguilar Range, and marine fossiliferous sequence at Modder River);
6. Ordovician Gordon Group and Siluro-Devonian Eldon Group sedimentary sequences;
7. Minor Permo-Carboniferous beds and Jurassic dolerite, the latter in two separate areas;
8. A large graben-fill sequence of Tertiary sedimentary rocks.

Many of the units are somewhat compressed in outcrop compared to their equivalents north of Macquarie Harbour, but the sequence of Middle Cambrian andesite-bearing volcano-sedimentary rocks (Noddy Creek Volcanics) appears to better developed and exposed here than elsewhere.

Mesoproterozoic Rocky Cape Group Correlates on Cape Sorell

A multiply-folded sequence of clean orthoquartzite beds, with minor interbedded phyllitic siltstone and locally developed siliceous conglomerate lenses, occupies Cape Sorell at the northern end of Cape Sorell peninsula (McClenaghan and Findlay, 1993; Baillie and Corbett, 1985). Many of the quartzite beds are cross-bedded, with tidal-type herringbone cross-bedding in places, and there are abundant ripple marks. The sequence has a shallow marine aspect, and is similar to orthoquartzite sequences in the Rocky Cape Group. The purity of some of the quartzites has led to their investigation as a possible source of high-grade silica.

Along its eastern margin, between Liberty Creek and Lagoon Creek, the quartzite sequence overlies younger sequences of Neoproterozoic rocks, including dolomite, on an almost flat thrust structure referred to as the Liberty Creek Thrust (McClenaghan and Findlay, 1993). This thrust was drilled and confirmed in several places west of Liberty Creek (fig. 2), where there are also several small windows of the underlying rocks exposed. A number of outliers of the quartzite sequence, bound by the sub-horizontal thrust surface, occur up to five kilometres east of the main contact.

Neoproterozoic rift-related sequences of the central Cape Sorell peninsula area

These three sequences, correlated with the Oonah Formation, Success Creek Group and Crimson Creek Formation, occupy the central part of the Cape Sorell peninsula west of the Hibbs ultramafic belt. The easternmost, and presumably oldest, unit forms a coherent block between two major faults, whereas the two western units are structurally interfingered by faulting.

Oonah-type sequence in the Modder River–Nielson River area

This consists of metamorphosed interbedded quartzwacke, siltstone and mudstone, of turbidite type for the most part, similar to the Oonah and Burnie formations of northwest Tasmania. In the southwest part of the area, around Varna Bay, a sequence of fine to coarse-grained, parallel-bedded dolomite is well exposed, and has a gradational relationship to the quartzwacke sequence.

Success Creek-type sequence of the Birthday Bay– Pelias Cove area

This consists mainly of interbedded, variably calcareous sandstone, siltstone and mudstone in which many of the thicker sandstone beds show cross bedding. Beds of coarse sandstone with interbedded siliceous pebble-cobble conglomerate occur on the north coast. These clastic sequences are intercalated, both structurally and stratigraphically, with sequences of poorly-bedded to massive pale crystalline dolomite, found mainly in the southern part of the area at Birthday Bay and Lagoon Creek. Minor amounts of chert, mudstone and conglomerate, and rare beds rich in algal oncolites, occur within the dolomite.

Crimson Creek-type sequence of the Albina Creek– Lucas Creek area

This consists of a central belt of basaltic volcanic rocks flanked by more voluminous sedimentary units. The basaltic rocks have been referred to as the Lucas Creek Volcanics (White, 1975; McClenaghan and Corbett, 1985). They include massive and pillowed flows, usually with intercalated basaltic breccias and tuffs, and bands of siltstone-mudstone. The fresher basalts are plagioclase-pyroxene-olivine (altered to chlorite)-phyric, but alteration to epidote-chlorite-actinolite-carbonate assemblages is widespread. The sedimentary sequences consist dominantly of interbedded grey mudstone, siltstone and lithicwacke sandstone in which graded bedding is common. Minor dolomite beds also occur. Some sandstones contain mixed detritus from intermediate to acid volcanic and metamorphic rocks (McClenaghan and Findlay, 1993).

Geochemical data indicate that the basalts are dominantly tholeiitic, with minor alkalic and picritic varieties, with slight LREE-enrichment and Within-Plate Basalt affinities, making them good correlates of the Crimson Creek Formation of the Zeehan area.

Early Cambrian allochthonous sequences

Several lithological units which are considered to be exotic or allochthonous to western Tasmania, and which were introduced during a major collisional event in about the early Middle Cambrian, have now been recognised in South West Tasmania. The two most obvious of these are the ultramafic-mafic rocks, including serpentinite, pyroxenite and gabbro, which occur as structural slivers in the Point Hibbs–Asbestos Point area, and the more extensive sequence of tholeiitic basalts and associated sedimentary rocks in the Mainwaring River and Birchs Inlet areas. A third unit has been established for the talc-rich (high-Mg) boninitic mafic-intermediate lavas and associated sedimentary rocks occurring in the Timbertops area and extending southwards in company with the ultramafic rocks to Spero Bay.

Ultramafic-mafic rocks

These occur as a complex series of fault slivers and lenses within a NNE-trending zone of faults, 1-2 km wide, referred to as the Hibbs ultramafic belt or the Point Hibbs Melange Belt (McClenaghan and Findlay, 1993). The belt divides into two at Hibbs Lagoon, possibly on a fold structure, with the inland belt being mainly mapped from aeromagnetic data (Seymour, 2001*b*). The main rock types are sheared serpentinite, serpentinised pyroxenite, peridotite, gabbro, and sheared altered basaltic rocks.

Minor asbestos mineralisation occurs in the ultramafic rocks around Noddy Creek and at Asbestos Point, and minor nickel, chrome, osmiridium and gold have also been reported (Pemberton, 1993).

Boninitic sequence ('Timbertops Volcanics')

A boninitic sequence of Mg-rich mafic–intermediate lavas intercalated with sandstone and mudstone has been mapped around the Timbertops area (McClenaghan and Findlay, 1989, 1993), and is inferred to be present in the Spero Bay–Thomas Creek area (Seymour, 2001*b*). The lavas at Timbertops are typically massive pyroxene-phyric rocks heavily altered to talc, chlorite and carbonate. The similarity to high-Mg boninitic rocks associated with the ultramafic complexes of the Zeehan area (Brown, 1986) has been confirmed by the presence of distinctive high-Cr spinels (Brown *et al*., 1991; McClenaghan and Findlay, 1993).

The relationship of the poorly-exposed boninitic sequence to the (presumably younger) Noddy Creek andesite sequence at Timbertops is puzzling and difficult to determine from available outcrops and mapping. Several small patches (? windows) of boninite surrounded by andesite have been mapped just north of Timbertops (McClenaghan and Findlay, 1989), while to the west the boninite sequence appears to occupy the limbs of a north-trending synclinal fold, with the andesitic sequence in the core of the fold (Seymour, 2001*a*). The contact between the two sequences is apparently overlapped unconformably by the Ordovician sandstone of the Timbertops Syncline.

Mainwaring Group

This group comprises a belt of tholeiitic basalts and associated sedimentary rocks extending north from Veridian Point across the Mainwaring River, and was first described by BHP geologists (E. B. Corbett, 1968; W. D. M. Hall *et al*., 1969). Similar basalts at Birchs Inlet appear to be a continuation of the same belt. Descriptions of the rocks have been given by E. B. Corbett (1968), Brown (1988), Brown *et al*. (1991), and McClenaghan and Findlay (1993), with the latter also including some geochemical data (including rare earth element plots).

The basalts include vesicular, pillowed and sheet flows interlayered with breccia, hyaloclastite and volcaniclastic sandstone and siltstone. A sill-like shallow intrusive body is exposed at Veridian Point. Epidote-chlorite alteration is widespread. Phenocrysts of plagioclase and pyroxene are present in some lavas, while some picritic varieties contain spinel and chlorite pseudomorphs after olivine. A range of compositions is also evident in the geochemistry, with island-arc and MORB types recognised. Native copper is commonly present in the lavas as small blebs, and the resultant copper soil anomalies stimulated some intensive exploration in the Cypress Creek area by BHP.

The interbedded sedimentary rocks include laminated chert and mudstone in the Cypress Creek area, including a ridge-forming unit of laminated black and white chert about 100 m thick (Brown, 1988).

The sequence is correlated with the belt of similar basalts extending from Waratah through the Cleveland mine to the Pieman River and Colebrook Hill area, and with the Miners Ridge Basalt near Queenstown (Corbett, 2002).

Middle Cambrian post-collisional sequences

Sequences present and their correlation

Two major sequences are considered to be of Middle Cambrian age, although no fossils of this age have been discovered in the area. The sequences post-date the allochthonous units, and can be correlated with known Middle Cambrian units north of Macquarie Harbour. A U-Pb zircon date of 503 ± 4 Ma has been obtained from one unit. They are the major belt of felsic volcanic rocks in the eastern part of the area, which is clearly a continuation of the main Mt Read Volcanics belt to the north, and a somewhat larger belt of andesite-bearing volcano-sedimentary rocks to the west, extensively exposed along the coast, which is referred to as the Noddy Creek Volcanics.

The eastern belt of felsic volcanic rocks (the 'Lewis River Volcanics' of White, 1975) includes basal correlates of the Sticht Range Beds (siliciclastic conglomerate and sandstone resting on, or faulted against, Precambrian basement), a large tabular quartz-feldspar-biotite porphyry body like the Bond Range Porphyry, several granitic bodies, a main sequence of quartz-feldspar-phyric volcanic rocks, volcaniclastic and intrusive rocks, and a sequence west of this containing abundant sedimentary units.

Although correlation to units of the main Mt Read belt has been the subject of some discussion and speculation (Large *et al*., 1987; Corbett, 1989), recent opinion (Corbett, 1992; Pemberton and Corbett, 1992; this report) favours correlation of the main quartz-phyric sequence with the Eastern Quartz-Phyric Sequence of the Lake Dora–Mt Murchison area. Both have a basal siliciclastic unit, large and small bodies of intrusive quartz-feldspar-biotite porphyry, multiple small granitic intrusive rocks, and very sparse andesitic-basaltic rocks. The volcano-sedimentary sequence of the Wart Hill–Stony Creek area is correlated with the Western Volcano-Sedimentary Sequences of the Yolande River –Bulgobac area to the north.

Correlates of the fairly distinctive feldspar-phyric rocks of the Central Volcanic Complex of the Darwin–Mt Block area have not been recognised, suggesting that the CVC in that area may represent a local variant of the more normal quartz-phyric rocks.

Correlates of the Tyndall Group (the uppermost part of the Mt Read sequence, of post-granite age, usually occupying a position between older volcanic rocks below and Owen Group siliciclastic rocks above) have not been clearly identified in the eastern volcanic belt of the Elliott Bay–D'Aguilar Range area. A possible Tyndall Group equivalent is the volcaniclastic conglomerate-sandstone unit which lies at the base of the Owen Group rocks between Mt Osmund and D'Aguilar Range. This unit reaches its maximum thickness of about 150 m in a local basin on the western side of Mt Osmund, and is overlain by laminated shale in most areas, passing gradationally up into siltstone-sandstone-conglomerate sequences of the Owen Group. The volcaniclastic unit is herein regarded as a basal phase of the Owen Group, similar to the Jukes Conglomerate elsewhere.

The most extensively exposed Middle Cambrian sequence south of Macquarie Harbour is that associated with andesitic volcanic rocks in the Noddy Creek–Timbertops area, known as the Noddy Creek Volcanics (White, 1975). This sequence includes widespread conglomerate-greywacke-mudstone successions with intercalated andesitic and minor felsic volcanic rocks, and extends from Macquarie Harbour to south of the Mainwaring River in a belt about 10 km wide. The newly discovered outcrop of interbedded sandstone, siltstone and andesitic volcanic rocks in the upper Spero River is also assigned to this group. The post-collisional age of the group has been confirmed by the discovery of a pebble of typical boninitic lava, with distinctive high-Cr spinels, within a conglomerate in the sequence near High Rocky Point (Brown, in Brown *et al*., 1991), and by a date of 503 ± 4 Ma obtained by Black *et al*. (1997) for an intrusive rock in this sequence at Timbertops. The belt of Noddy Creek Volcanics and associated rocks occupies an area of some 400 km^2, roughly twice the area of exposure of the main belt of Mt Read Volcanics correlates to the east.

Several lines of evidence suggest that some of the Noddy Creek sequence is likely to be equivalent to the Tyndall Group. Firstly, a correlative of the sequence on the lower King River, just north of Macquarie Harbour, lies conformably beneath Owen Group rocks, and has been regarded as a Tyndall Group correlate (Corbett *et al*., 1997; Corbett, 2002). Secondly, the sequence in the Copper Creek–Mt Osmund area appears to overlie the Western Volcano-Sedimentary Sequence, in an area of general westerly facings, suggesting that the Noddy Creek sequence may be somewhat younger and therefore likely to overlap the late Middle Cambrian Tyndall Group in age. Thirdly, thin sections of conglomerate from the sequence in the Thomas Creek area contain clasts of granite and granitic rocks (D. B. Seymour, pers. comm.), indicating that the sequence post-dates at least some, if not all, of the Cambrian granites, as does the Tyndall Group north of Macquarie Harbour.

A number of fault-bounded sedimentary sequences in the melange belt between Spero Bay and Macquarie Harbour have been grouped with the Noddy Creek sequence on the grounds of general similarity and for the sake of convenience in this study, although clear evidence for their age and association may be lacking. Some of the fault slivers may relate to the (?) Early Cambrian allochthonous sequences or to the Proterozoic autochthonous sequences in the area.

Eastern Quartz-Phyric Sequence correlate (Lewis River Volcanics)

This sequence contains a large tabular intrusive body of quartz-feldspar-biotite porphyry close to its eastern margin, separating off a narrow strip of Sticht Range Beds rocks (siliciclastic sandstone and granule-pebble conglomerate with interbedded volcaniclastic sandstone and siltstone in the upper part) abutting the Precambrian basement rocks. The main part of the sequence consists of felsic quartz-feldspar ± biotite-phyric lavas intercalated with volcaniclastic rocks, including sandstone, siltstone and minor conglomerate, of similar composition. Thick units of well-bedded sandstone and siltstone occur in places. A mineralised and gossanous vein-like body containing hematite, pyrite, arsenopyrite, chlorite, sericite, quartz, and tourmaline is associated with a narrow body of quartz-feldspar-biotite porphyry in the upper Lewis River area, and has been drilled at the Voyager 2 and Voyager 12 prospects.

Bodies of medium to coarse-grained biotite granite and microgranite intrude the sequence to the east and west of Elliott Bay. The eastern body (Little Rocky River granite) has an extensive metamorphic aureole to its north, with associated alteration consisting of quartz, sericite, microcline, epidote, and chlorite with minor biotite, garnet and muscovite (Pemberton *et al.*, 1991). The larger granite body at Low Rocky Point has several major faulted contacts, and includes a possible roof pendant of volcanic rocks near its northern margin.

Andesitic-basaltic volcanic rocks are conspicuously absent in this eastern belt, the only andesitic rocks mapped being a 400 m-long dyke-like body against the western bounding fault at Stony Creek, and a few smaller bodies to the north. Small dyke-like bodies of chlorite-altered mafic rock occur in places.

The western contact of the sequence is probably gradational, but for convenience is taken as the major fault in the Stony Creek area. This fault is apparently overlapped by the Owen Group sequence in the southern part of the Osmund Syncline, and may continue northwards as a sub-Owen structure.

Western Volcano-Sedimentary Sequence ('Wart Hill Pyroclastics')

This sequence consists largely of quartz-feldspar-phyric lavas and volcaniclastic rocks similar to those to the east, but becomes increasingly sedimentary in aspect to the west, and includes a number of units of siliciclastic sandstone and/or conglomerate. Numerous facings indicate that the sequence faces west towards the Copper Creek Fault.

The siliciclastic rocks include two unusual conglomerate units. One of these is a major unit (100 m+ thick) of granule to cobble-grade conglomerate and sandstone in the Copper Creek–Sassy Creek area, in which the conglomerate ranges from dominantly siliciclastic to dominantly volcaniclastic. The second is a distinctive mass-flow unit of siliciclastic conglomerate, sandstone and breccia lying along the western margin of the Stony Creek granite body. This unit contains clasts of Precambrian-derived quartzite up to 30 cm across, and rip-up clasts of volcaniclastic sandstone, and has been strongly silicified by the granite.

Near Wart Hill, in the eastern part of the sequence, a felsic volcaniclastic breccia-sandstone unit contains scattered sulphide clasts and several large blocks or lenses of massive Pb-Zn-rich sulphide up to 6 m wide and 20 m long (Large *et al.*, 1987). Much of the exploration at Elliott Bay has centred on this unit.

The westernmost part of the sequence, against the Copper Creek Fault, comprises a thick unit (200 m+) of black to grey siltstone with minor volcaniclastic sandstone. This siltstone sequence appears to pass laterally, and rapidly, into a felsic volcaniclastic sequence to the south of Sassy Creek, suggesting deposition at the margin of the felsic volcanic edifice. A similar siltstone sequence, with intercalations of felsic to intermediate volcaniclastic sandstone, is present on the western side of the Copper Creek Fault, and appears to pass gradationally into the andesite-bearing sequence correlated with the Noddy Creek Volcanics. A gradational relationship between the Western Sequence and Noddy Creek Volcanics is thus implied, with the implication that a siltstone-rich sedimentary zone separates the westerly-derived andesitic volcaniclastic rocks from the easterly-derived felsic material.

Andesite-bearing volcano-sedimentary sequences — Noddy Creek Volcanics and correlates

Descriptions of the petrology and/or geochemistry of these rocks have been given by Brown (1988, notes attached to map), Brown *et al*. (1991), McClenaghan and Findlay (1993), and McClenaghan and Corbett (1985). Some details of the lava-intrusive complex in the Thomas Creek area are given in a thesis by Reid (2001), and in company reports by Close and Reid (1995), Reid and Close (1997) and MacDonald (1993). Dr David Green has supplied some notes on the new outcrop at Spero River.

The compilation map (fig. 2) suggests that the sequence overall consists of about 25% lavas/intrusive rocks and 75% sedimentary rocks, particularly sandstone, siltstone and conglomerate. The composition of the sedimentary rocks appears to range from predominantly andesitic to mixed andesitic/felsic to mixed metamorphic/felsic, as in the Birchs Inlet area. The actual relationship of the sequence to the Western Volcano-Sedimentary Sequence in areas where the contact is not faulted has not yet been resolved.

There is a strong suggestion of a central zone of proximal volcanic rocks centred on the large intrusive-extrusive complex at Thomas Creek–Timbertops and extending southwards to the coast at High Rocky Point and perhaps northwards through the Noddy Creek area, flanked by more sediment-rich zones. The contact against the boninite sequence just west of Timbertops may represent an original basin margin (note the boninite clast reported by Brown from the High Rocky Point area), and there is a suggestion that the Hibbs fault zone may be close to the original western limit of the depositional basin.

Geochemistry

The andesites are calc-alkaline rocks similar to those of other parts of the Mt Read Volcanic belt. Comparison with the suites recognised by Crawford *et al*. (1992) shows that the range of Noddy Creek rocks overlaps Suites I, II and III on the SiO_2 vs TiO_2 diagram, and Suites I and II and the lower part of Suite III on the SiO_2 vs P_2O_5/TiO_2 diagram (McClenaghan and Findlay, 1993). The Noddy Creek rocks do not show the more extreme compositions from Suite III with high P_2O_5 and high P_2O_5/TiO_2 ratios, i.e. the 'shoshonitic' end of the range is lacking.

Comparison of rare earth elements (REE) shows that the Noddy Creek rocks strongly overlap with, and have similar LREE-enrichment levels to, the Suite I rocks of Crawford *et al*. (1992), but have slightly less LREE-enrichment than Suite II rocks, and much less than Suite III rocks (McClenaghan and Findlay, 1993).

The strongest geochemical comparison is with Suite I, which includes the Tyndall Group, Que–Hellyer footwall andesites, the western Henty Fault Wedge andesites, and most of the Central Volcanic Complex and Eastern Quartz-Phyric Sequence felsic rocks. The strongly LREE-enriched, P_2O_5-rich 'shoshonitic' rocks such as occur in the Hellyer hangingwall, at Lynch Creek and at Howards Plains, have not been seen in the Noddy Creek sequence.

Noddy Creek–Timbertops area

The area originally described as the Noddy Creek Volcanics (White, 1975) is within the fault block north of Timbertops, where a central unit of andesitic volcanic rocks is flanked to the north and south by mainly felsic rocks. The andesites here are mostly massive to brecciated flows of plagioclase-pyroxene(augite)-phyric lava, with some chlorite, sericite, epidote and actinolite alteration. Plagioclase-phyric and aphyric lava varieties also occur. The adjacent felsic rocks, which tend to be deeply weathered, pale coloured and poorly exposed, typically have small phenocrysts of quartz and feldspar in a fine-grained groundmass. A possible welded tuff, consisting of very fine flattened glass shards and fine lithic fragments, was reported from the southern area by McClenaghan and Findlay (1993).

The adjacent sedimentary sequence to the east, between Sarah Island and the Timbertops Syncline, consists of interbedded mudstone, siltstone and sandstone with minor conglomerate. The conglomerate is well exposed on Grummet Island, and has clasts to boulder size of quartz and quartzite, and minor red chert. The sandstone also typically consists of quartz and quartzite grains in a matrix of quartz, muscovite, chlorite and opaque minerals. Some sandstone also contains clasts of felsic to intermediate lava, but the sedimentary sequence appears to be predominantly siliciclastic, indicating derivation largely from Precambrian metamorphic rocks; whether from the east or west is not certain. Two small units of andesitic lava and an area of plagioclase-pyroxene-phyric 'basalt' are mapped in the southern part of this zone.

Andesite in the Timbertops area is mostly massive, fine to medium-grained aphyric or rarely plagioclase-phyric lava with pyroxene and rarely hornblende. It is associated with felsic volcanic rocks and two stock-like felsic intrusive bodies of fine to medium-grained quartz-feldspar-biotite porphyry. The larger of these porphyry bodies has yielded a zircon age of 503 ± 4 Ma (Black *et al*., 1997).

Thomas Creek intrusive–extrusive complex

This major complex on the southern side of the Timbertops Syncline is dominated by strongly magnetic rocks, and the aeromagnetic data indicate that it extends under the Ordovician syncline (fig. 2). The rocks are generally poorly exposed, and most boundaries in the area have been drawn from the aeromagnetic data. Exploration work at the Thomas Creek prospect indicates that a mixture of intrusive and extrusive andesitic rocks is present, with minor felsic lavas and crystal-rich volcaniclastic sandstone (Reid and Close, 1997). The range of intrusive rocks includes feldspar-augite-phyric diorite, microdiorite, granodiorite, quartz-tonalite and possible monzonite, with abundant thin dykes of plagioclase-pyroxene-phyric andesite in places. Considerable brecciation is associated with the intrusions, and some of the breccias are mineralised with sulphides. There is also widespread K-feldspar–silica alteration, and tourmaline veining.

A petrological study of some of the rocks by Crawford (in MacDonald, 1993) suggests that the various diorites are co-magmatic with the andesites, and that the complex is comparable to andesitic complexes in the Que River, Leven Gorge, Preston, and Beulah areas.

Hibbs River–Wanderer River area

Limited reconnaissance mapping in this area (Seymour, 2001*b,c*) indicates a dominantly sedimentary sequence in which units of probable andesitic lava can be picked out by their magnetic signature, as well as some volcaniclastic conglomerate-sandstone units, and some ridge-forming non-magnetic sandstone units. Thin sections of several conglomerates in the Thomas Creek area show clasts of granitic rocks as well as andesitic volcanic rocks (D. B. Seymour, pers. comm., 2003). A north-trending graben-like structure in the centre of this area just southwest of the Thomas Creek prospect has a negative radiometric signature, possibly indicating a shallow cover of Tertiary sedimentary rocks.

The sedimentary sequence in the area immediately north of Spero Bay, bounded by ultramafic rocks to the east and west, appears to differ somewhat from the other sequences. According to D. B. Seymour (pers. comm., 2003) the sequence consists mainly of grey siltstone and mudstone, with minor graded sandstone beds containing felsic and other volcanic detritus. The sequence appears to lack any mafic rocks or cherts or carbonate rocks such as would be expected in pre-Middle Cambrian sequences, and is provisionally included in the Noddy Creek Volcanics.

A fairly simple stratigraphy appears to be present south of the Spero River, with reasonably continuous NNW-striking, west-dipping units apparently folded about a major synclinal fold axis overturned from the west.

Upper Spero River window

The recently discovered window of sub-Tertiary rocks in this area includes good exposures in the Spero River, consisting of grey-green siltstone and volcaniclastic sandstone interbedded with andesitic breccia, conglomerate and lavas, and some minor felsic volcanic rocks (D. C. Green, pers. comm.). The sequence dips and faces west for the most part. The proportion of volcanic rocks appears to increase eastwards, where some strong epidote-carbonate alteration is evident in places. Further examination and analysis of these rocks is underway at the time of writing.

Urquhart River–Mainwaring River area

Excellent exposures of the sequence are available along the coast in the High Rocky Point–Veridian Point area, and in the Urquhart and Mainwaring rivers and coastal creeks. Brown (1988) describes the section at High Rocky Point–Urquhart River as being mainly east-facing and comprising four units. The oldest unit, on the coast just north of High Rocky Point, consists of massive and pillowed flows of pyroxene-feldspar-phyric andesite interbedded with volcaniclastic sandstone, siltstone and conglomerate. Sedimentary features include scoured bases, flame structures, cross bedding, slump folds and sediment rip-ups, suggesting a proximal turbidite environment on a volcanic cone. A pebble of boninite was recovered from one of these conglomerate beds. The unit is at least 700 m thick (base not exposed), and is overlain by a 400 m-thick unit consisting dominantly of andesite lava flows and breccias with minor interbeds of sandstone and siltstone. Some flows have flow-banded tops. An extension of this unit on Montgomery Rocks, just offshore, consists of massive andesitic breccia.

Overlying the lava-rich unit is a dominantly sedimentary unit of mudstone, volcaniclastic sandstone, crystal and vitric-crystal ‘tuffs’, and hyaloclastite, with thin flows and intrusive sills of andesitic to rhyodacitic composition. Some of the flows are hornblende-phyric. This sequence is also exposed along the coast south of Urquhart River to Abo Creek, where it includes a unit of volcaniclastic pebble conglomerate. The Acacia Rocks, some 2 km offshore in this area, consist of dacitic-rhyolitic autobreccia, probably representing a felsic unit within the Noddy Creek sequence.

Dip readings and aeromagnetic data (fig. 3) suggest that there may be a synclinal fold axis in this sequence near the mouth of the Urquhart River, giving an approximate thickness for the unit on the west limb of the fold of 1500 metres. The next unit east, exposed along the Urquhart River, is mainly sedimentary, and comprises felsic volcaniclastic sandstone and granule conglomerate interbedded with siltstone and mudstone. A 50 m thick flow of pyroxene-feldspar-phyric andesite exposed in the river in the middle part of this unit (Brown, 1988) appears to correspond to a linear aeromagnetic feature in the area (fig. 3).

Late Cambrian to Ordovician Owen Group and Gordon Group Rocks

Mt Osmund–D’Aguilar Range area

A thick sequence of siliciclastic conglomerate, sandstone and siltstone developed in the Mt Osmund area and along the D’Aguilar Range is referable to the Owen Group. The sequence abuts a major fault on the western side, against older Cambrian rocks in the Mt Osmund area but against younger Tertiary rocks at the D’Aguilar Range. The sequence is folded into a single broad synclinal fold (Osmund Syncline) in the south, with a gentle northerly plunge, and a more complex north-plunging synclinal structure in the north, where there is considerable disruption by faulting. The sequence terminates in a broad, fault-disrupted anticlinal structure at the northern end of the D’Aguilar Range, where a northeast-trending cross-fault places Siluro-Devonian rocks against the Owen Group.

A broadly similar stratigraphic sequence is present in both areas. At the base is a unit of locally-derived volcaniclastic conglomerate and sandstone, usually a few tens of metres thick but having a maximum thickness of about 150 m in a local basin west of Mt Osmund. This is overlain by a remarkably continuous unit, 100–150 m thick, of black to grey shale and siltstone with some micaceous sandstone. A poorly exposed lens of felsic quartz-feldspar-phyric lava or intrusive is present within the unit just east of Mt Osmund. The black shale is typically pyritic.

The shale and volcaniclastic units make up the 'Waterloo Creek Group' of Large and Wilson (1982) and Large *et al*. (1987), who suggested correlation with the Tyndall Group. In the absence of fossils, and considering the similarity to the marine siltstone-rich sections of the Owen Group immediately above, the sequence is included as part of the Owen Group.

Conformably above the black shale unit at Mt Osmund is a unit of some 850 m of interbedded sandstone, siltstone and granule-pebble conglomerate, with units of laminated grey-green micaceous siltstone up to 200 m thick in places (e.g. Vicary *et al*., 1992). Pebbly slump sheets are present in places, and the general aspect is of a proximal flysch to deltaic sequence. Comparison may be made with the Newton Creek Sandstone of the Tyndall Range area (Corbett and Jackson, 1987). In the D'Aguilar Range area, this unit is dominated by granule to cobble-grade conglomerate, with the siltstone facies wedging out northwards.

Above the marine siltstone-rich unit is a formation of grey to pink cross-bedded sandstone with minor pebble conglomerate and siltstone, of the order of 450–500 m thick. Abundant trough cross bedding is typical of the unit, which resembles the Middle Owen Sandstone of the Mt Lyell area (Corbett, 2001*a*). A shallow marine depositional environment is indicated. This is followed conformably by a unit of thick-bedded pink pebble-cobble conglomerate and minor sandstone, of the order of 150 m thick in the Osmund Syncline but probably thicker than this on Mt Discovery. This unit resembles the Middle Owen Conglomerate and parts of the Lower Owen Conglomerate of the Mt Lyell area, and is probably a non-marine fluvial deposit.

The exposed upper part of the sequence is a unit of grey to pink thin-bedded sandstone which is commonly bioturbated and which contains marine fossils, particularly brachiopods, of Ordovician aspect in several areas. This unit occupies the core of the Osmund Syncline at its northern end, where it is overlapped by Tertiary sedimentary rocks, and also lies in the synclinal core at the northern end of the D'Aguilar Range. A probably equivalent unit on the eastern side of the northern D'Aguilar Range is a thick sandstone sequence which transgresses onto Precambrian basement rocks and is overlain by Gordon Group limestone in Kinghorn Creek, a tributary of the Gordon River.

In summary, the Owen Group sequence in this area is quite similar to that on the West Coast Range in terms of facies and thickness, and has a similar relationship to a major bounding fault. It differs in the presence of a fairly thick and continuous sequence of Lower (?) Ordovician sandstone below the Gordon Group, rather than the thin Pioneer Sandstone (of probable Middle Ordovician age; Laurie, 1996) lying above the Haulage Unconformity on earlier Owen beds, as seen at Queenstown.

Point Hibbs–Modder River area

Fossiliferous Late Cambrian and younger Ordovician rocks occur in a fault-bounded strip about one kilometre wide along the western margin of the Hibbs ultramafic belt from Bryans Bay to Hibbs Lagoon. The Late Cambrian sequence consists dominantly of grey to green siltstone and fine sandstone, with minor granule-pebble conglomerate, and is of the order of 600 m thick. A major unit of granule-pebble conglomerate, about 150 m thick, occurs within the sequence at Modder River. Graded bedding and rip-up mud clasts are seen in some of the coarser units, suggesting density current deposition and a proximal flysch environment. The sandstone and siltstone vary from tuffaceaus to micaceous, and clast compositions indicate derivation of the sequence largely from felsic to intermediate volcanic rocks and carbonate rocks (McClenaghan and Findlay, 1993).

The fossils include agnostid and polymerid trilobites, dendroids and inarticulate brachiopods, and were discovered by BHP geologists on a bulldozed track in 1967. They were first described by Clarke (1968), who suggested a Middle Cambrian age, but this was disputed by Jago (1972), who identified several Late Cambrian trilobite species, and Quilty (1971), who described the dendroids. A recent detailed account of the trilobites (Bao and Jago, 2000) indicates a late Late Cambrian age (Payntonian–earliest Datsonian), similar to that of the sandstone-siltstone unit near the top of the 'Dundas Group' at Misery Hill near Zeehan (Jago and Corbett, 1990).

The Late Cambrian siltstone sequence is apparently overlain more or less conformably by, but may be faulted against, a siliciclastic sandstone and pebble conglomerate unit to the east, assumed to be of Ordovician age (McClenaghan and Findlay, 1993). Heavy mineral bands (chromite?), reminiscent of those in the Pioneer Beds, are present in the sandstone in places. Carbonate rocks of the Gordon Group overlie the sandstone in two narrow belts to the east.

Gordon Group limestone and Ordovician-type sandstone are involved in a series of east-dipping thrust sheets at Point Hibbs, in association with Siluro-Devonian sandstone and fossiliferous Devonian limestone (Carey and Berry, 1988; Brown *et al*., 1991).

Timbertops Syncline

A sandstone-siltstone sequence here is about 1200 m thick, with Gordon Group limestone in the core of the fold. The sequence rests unconformably on Cambrian rocks. Three formations have been mapped; a lower one of siliceous sandstone and minor conglomerate, followed by a middle unit of mainly grey siltstone, and an upper unit of siliceous sandstone with interbedded pebble conglomerate (McClenaghan and Findlay, 1993). Dark heavy mineral bands were noted in the upper unit by Findlay.

Fossils gastropods, nautiloids and asaphid-type trilobites occur in the lower unit, and the siltstone has yielded orthid brachiopods and a cystoid. Clarke (1968) has suggested a Lower Ordovician age.

Permo-Carboniferous and Jurassic rocks

A narrow strip of Permo-Carboniferous sedimentary rocks (tillite, glendonitic siltstone, sandstone, minor limestone; Banks, 1970) is faulted against Siluro-Devonian rocks at Point Hibbs, and intruded by dolerite on its western side. The beds dip moderately to steeply west, and appear to have been dragged by west-side-down movement on the bounding fault to the east.

The dolerite–Permian contact is linear and trends northwest, but must swing easterly to include Hibbs Pyramid. The aeromagnetic image (fig. 3) shows an unusually strong magnetic anomaly down the eastern side of the dolerite body, presumably on the basal contact.

A second area of dolerite, three kilometres long, has been mapped well inland near the head of the Wanderer River (Vicary *et al*., 1992), and is elongated along the southern boundary fault of the Tertiary graben. This suggests that the intrusion may have been controlled by the fore-runner of this major graben fault. The dolerite intrudes the large quartz-feldspar-biotite porphyry body and what appears to be Sticht Range Beds sandstone, the latter being folded away from the Precambrian contact in a puzzling fashion. (There is a faint possibility that this very poorly exposed siliceous sandstone could be a Permo-Carboniferous sequence).

Tertiary sedimentary rocks

A thick Tertiary sequence (Scott, 1960*b*; Spry and Banks, 1962) occupies the Macquarie Harbour Graben, which is 10–12 km wide over most of its length, narrowing to six kilometres in the southern dog-leg section. The sediments are bounded by a major fault along the eastern margin, but the western margin is onlapping. The sediments are semi-consolidated, consisting of pale-coloured interbedded sand, pebble-cobble gravel, silt, and clay, with coarser conglomerate up to large boulder grade around the margins in many areas.

The clastic material is predominantly siliceous, of Precambrian or Owen Group derivation, but a significant amount of Jurassic dolerite detritus is present in some areas. Extensive dolerite boulder deposits, with deeply weathered clasts, are exposed around the Conder River where crossed by the Low Rocky Point Track, and in terraces west of the old Lyell-EZ Explorations (LEE) camp at Moores Valley (Vicary *et al*., 1992). The one hole drilled in the Tertiary sequence, by LEE at Moores Valley in the early 1960's (fig. 2), encountered these dolerite boulder beds at a depth of about 100 m, and penetrated them for some 45 m, before bottoming, still in the Tertiary sequence, at 152 m (Hudspeth and Scott, 1962; Vicary *et al*., 1992). Dolerite boulder beds have also been mapped in the Tertiary sequence in the Teepookana Plateau area (Baillie *et al*., 1977).

Thin superficial gravel (mostly less than 5 m thick) of possible late Tertiary or early Quaternary age is widespread in the Elliott Bay area, where it forms a veneer over the Cambrian volcanic rocks on a surface about 50 m above sea level (Pemberton *et al*., 1991). Some of the gravel is in the form of a lag of vein quartz fragments, suggesting considerable erosion of the bedrock sequences. Minor concentrations of cassiterite and ilmenite, of uncertain origin, are found in these deposits (e.g. Burlinson, 1979).

Outline of proposed tectonic–depositional history

Introduction

The available mapping and structural descriptions make it clear that the area is highly complex structurally, with numerous major faults, thrusts and shear zones, and up to six folding/cleavage events recorded in some sequences. Many structural problems remain to be resolved through further field work, and a structural analysis is beyond the scope of this report. An outline of a tectonic-depositional history is presented which brings together many of the major structural features without becoming too involved in structural descriptions. Reference may be made to McClenaghan and Findlay (1993) for details of the Cape Sorell peninsula area, and to the notes of Brown (1988) and Brown *et al*. (1991) for the Montgomery and Hibbs areas. The main stages in the tectonic evolution of the area, as envisaged by the author, are outlined below.

1: Allochthon emplacement in early Middle Cambrian

Evidence from elsewhere in Tasmania indicates that the ultramafic-mafic complexes, with their associated boninitic lava sequences, were emplaced onto a proto-Tasmanian passive margin continental block in about the early Middle Cambrian, following a collision between the passive margin and an island arc somewhere to the east (Berry and Crawford, 1988; Brown and Jenner, 1988, 1989; Crawford and Berry, 1992; Seymour and Calver, 1995; Turner *et al*., 1998). The proto-Tasmanian block consisted of regions of Mesoproterozoic quartz-rich sedimentary rocks (Rocky Cape Group, Tyennan region rocks) separated by rift sequences of turbidites, carbonate rocks and tholeiitic rift basalts (Oonah Formation, Success Creek Group and Crimson Creek Formation and their correlates) such as now form much of the Cape Sorell peninsula.

Meffre *et al*. (2000) have recently suggested that the amphibolite-bearing and garnet-bearing metamorphic complexes which occur in several areas around the western and northern margins of the Tyennan region represent the equivalents of these passive margin rift sequences (Crimson Creek-type basalts, etc.) which have been metamorphosed during the collisional emplacement event. The much higher metamorphic grade shown by these 'complexes' attached to the Tyennan region compared to their equivalents on the western side of the 'Dundas trough' raises questions about the original position of the Tyennan region in the passive margin–collision sequence.

In addition to the ultramafic complexes and associated boninitic lavas (high-Mg andesites, low-Ti basalts), which are thought to be derived from the forearc part of the island arc, a series of basalt-bearing sedimentary sequences also appear to have been introduced as allochthons. The basalts in these units are also tholeiitic, but have ocean-floor characteristics, and the associated sedimentary rocks include mudstone, mafic greywacke and laminated chert. These rocks probably represent ocean floor materials from the area fronting the island arc. The type example of the sequence is the Cleveland–Waratah Association from the Waratah area, but others include the Ragged Basin Complex at Adamsfield, the Motton Spilite and Barrington Chert from the Sheffield–Penguin area, and the Mainwaring Group and Birchs Inlet Volcanics from southwest Tasmania.

The obduction-emplacement event, which is considered to have involved mostly westerly transport (Berry and Crawford, 1988), resulted in considerable disruption, folding and faulting of both the local sequences and the allochthonous materials. It is likely, therefore, that much of the folding, cleavage development, faulting and thrusting seen in the Rocky Cape Group, Oonah Formation, Success Creek Group and Crimson Creek Formation correlates on the Cape Sorell peninsula resulted from this event. Similarly, much of the intense deformation seen in the Mainwaring Group, such as the early isoclinal folding reported by Brown (1988) and Brown *et al*. (1991), and in the ultramafic and associated rocks, probably relates to this event.

2. Post-collisional volcanism, sedimentation and tectonism in the later Middle Cambrian

The Mt Read–Noddy Creek volcanic-sedimentary sequences were erupted and deposited on the variable, and probably unstable, basement produced by the obduction event. The role of the Tyennan region, particularly whether it represents autochthonous basement or an allochthonous block, or has elements of both, is still to be clarified, but it must have been exhumed and begun shedding siliciclastic detritus, in the form of the Sticht Range Beds, quite early in the post-collisional phase.

The general westerly change in composition of the volcanic rocks seems to reflect the nature of the basement rocks to a large extent, i.e. felsic-dominated to the east, where there is mainly Precambrian metamorphic basement, and andesite-dominated in the west, where allochthonous mafic rocks (Mainwaring Group) and ultramafic rocks dominate the basement, although the reason for this is unclear. The dividing line between these two appears to be the Copper Creek Fault (with measured dips of 75° west in several places), which in this sense seems to be an equivalent structure (and could have been a continuation, as suggested by Campana *et al*., 1958) to the Great Lyell Fault of the Darwin–Murchison area. The general westerly facing seen in the eastern volcanic sequences suggests that volcanism may have progressed westwards with time, but this is difficult to confirm without fossil control.

Widespread intrusion of felsic porphyries and associated granite bodies followed the main volcanism in the eastern belt, but the post-granite Tyndall Group phase of volcanism and volcaniclastic deposition, which is so important north of Macquarie Harbour, is not seen in this area. It may be represented in the western andesite-rich Noddy Creek sequences, which contain granitic detritus in places and probably extend to somewhat younger ages than the more felsic sequences in the east.

A period of uplift and erosion followed the granite intrusion phase in the eastern area, resulting in stripping and exposure of the granites and removal of much of the volcanic pile prior to siliciclastic deposition in the Late Cambrian.

3. Late Cambrian siliciclastic deposition in fault-controlled basins

Deposition of the 1700 m thick Owen Group siliciclastic sequence of the Mt Osmund–D'Aguilar Range area appears to have been largely controlled by the Copper Creek Fault, which probably formed a half-graben or trap-door style structure, as did the Great Lyell Fault in the Queenstown area (Corbett, 1990, 2001*a*). The sequence appears comparable to that on the West Coast Range, with a mixture of non-marine coarse conglomerate, shallow marine sandstone, and deeper marine (proximal fan to deltaic) siltstone-sandstone-conglomerate units. Derivation appears to have been predominantly from the Tyennan Precambrian rocks. Although the only fossils found in this area have been Ordovician ones at the top of the section, the age of the bulk of the sequence is considered to be Late Cambrian.

A second belt of Owen Group rocks is present as a narrow fault-bounded strip along the Hibbs fault zone. This sequence is thinner and more marine in aspect, and the conglomerates appear to have been derived largely from volcanic and other local sources rather than the Precambrian. Deposition of the sequence may have been in a narrow basin developed along the major fault which now forms the western boundary of the sequence, as the rocks are notably absent from beneath the Ordovician beds of the nearby Timbertops Syncline to the east.

4. Late Cambrian–Early Ordovician movements prior to Ordovician transgression

The Haulage Unconformity of the Queenstown area, beneath the Pioneer Sandstone and associated Gordon Group limestone, is probably reflected in this area by the unconformity beneath the transgressive Ordovician sandstone of the Timbertops Syncline and elsewhere (e.g. head of Rocky Sprent River). Some folding and faulting related to this period can be identified. The Timbertops sandstone transgresses across an enigmatic NNE-trending synclinal fold structure in the Noddy Creek Volcanics and adjacent boninitic sequence, suggesting that this may be a Haulage-age fold, and also transgresses the faulted contact of the Birchs Inlet Volcanics against Noddy Creek rocks. This suggests that upfaulting of at least some of the basement strips of Mainwaring Group rocks through the cover of Noddy Creek rocks also occurred at this time.

5. Deposition of the Ordovician–Silurian–Devonian transgressive marine sequence

Deposition of these rocks appears to mark a period of relative stability in the area, although little information is available on the nature of the depositional basins or their boundaries. A red bed-type Devonian sandstone unit was deposited at Point Hibbs, with Cambrian detritus in associated conglomerate, and a highly fossiliferous Devonian limestone (Banks, 1962; Carey and Berry, 1988) is also present here.

6. Late Devonian Tabberabberan deformation

The Ordovician–Devonian sequences, and older units, are strongly affected by Tabberabberan structures in most areas. Devonian limestone and sandstone at Point Hibbs form part of an eastward-dipping series of thrust sheets which has been folded into a westward-verging synform, possibly as a result of the same westward transport process (Carey and Berry, 1988; Brown *et al*., 1991; Seymour, 2001*b*). Some of the steeper N-S to NNE-trending thrusts bring the ultramafic-mafic rocks to the surface. Further north on the Hibbs fault zone, there appears to be a mixture of vertical faults and moderately to shallowly west-dipping (and east-dipping?) thrusts, with late stage transcurrent movement evident on some of the steep structures (McClenaghan and Findlay, 1993).

Slivers of Ordovician rocks are involved with the steep NNE-trending faults along the Hibbs zone and provide a striking contrast to the remarkably undisrupted Timbertops Syncline structure nearby. This northwest-trending syncline is associated with development of a widespread NW cleavage (McClenaghan and Findlay, 1993), and presumably relates to a later phase of Tabberabberan deformation than the steep NNE structures. Preservation of the undisturbed Timbertops structure probably relates to its position on a 'platform' of massive intrusive rocks.

A sliver of Gordon Group limestone lies along the Copper Creek Fault northwest of Mt Osmund, indicating significant Tabberabberan movement on this structure. The large Osmund Syncline, which parallels this fault, is probably related to the same movement phase, and the presence of locally steeper dips along the west limb of this structure suggests eastwards-directed transport. It might be speculated whether the eastwards-directed Liberty Creek Thrust, on the Cape Sorell peninsula, could be related to this 'early Tabberabberan' movement — a possibly similar flat thrust is present at Mt Discovery (northern D'Aguilar Range), and displaces Owen Group conglomerate eastwards over Ordovician sandstone (Bradbury *et al.*, 1992). Another structure indicating eastwards transport is the large arcuate 'Henrietta thrust' surrounding the Noddy Creek Volcanics in the type area north of Timbertops (McClenaghan and Findlay, 1993). Such examples provide a confusing picture of apparently opposite directions of tectonic transport and thrusting over a fairly small area in the early Tabberabberan.

Northwest-oriented macro-structures related to the second Tabberabberan phase, such as the Timbertops Syncline, are only weakly developed over most of the area, although cleavage of this orientation is quite widespread (e.g. Vicary *et al.*, 1992; Pemberton *et al.*, 1991; Brown, 1988). A distinction may be drawn with the Queenstown area, where northwest-trending folds and faults (mostly southwest-dipping) are almost the dominant structures, and have strongly overprinted the earlier N-S structures.

7. Post-Devonian history

Further extensive erosion probably occurred prior to deposition of the Carboniferous-Permian sedimentary rocks seen at Point Hibbs, and their intrusion by Jurassic dolerite. The latter was accompanied by further faulting, and probably resulted in the initiation of the Macquarie Harbour Graben structure, which links offshore to the large Cretaceous–Tertiary Sorell Basin (Baillie *et al.*, 1989). Significant northwest-trending faulting probably accompanied the dolerite intrusion at Point Hibbs. Dolerite in the head of the graben was eroded to produce extensive dolerite boulder beds in the Tertiary sequence. Erosion and peneplanation during the Tertiary resulted in further removal of the Cambrian volcanic rocks.

Notes on aeromagnetic features from the WTRMP survey

The Mainwaring Group — Birchs Inlet Zone

The most outstanding feature of the aeromagnetics (fig. 3) is the 3–4 km wide strongly positive anomaly following the belt of Mainwaring Group basalts from Veridian Point north to the Wanderer River, and extending north from this, under the Tertiary cover, to the area just east of Thomas Creek. The western margin of the zone is close to the outcrop of Noddy Creek Volcanics rocks in the upper Spero River, but outcrops in the river are of intermediate-felsic rocks only (D. C. Green, pers. comm.). The belt pinches and swells, and shrinks to a narrow lumpy zone in the area where it joins a major anomaly zone associated with the Thomas Creek intrusive complex. The 'smoothed' nature of the anomaly over the Tertiary rocks resembles the anomaly produced by the Thomas Creek complex, but it seems more likely that the N-S zone represents the magnetic basalts of the Mainwaring Group.

Several northeast-trending faults cross the area east of Thomas Creek, and it is suggested that the Mainwaring belt is displaced dextrally on one of these faults to resume as the similar major anomaly associated with the Birchs Inlet Volcanics. The latter anomaly extends NNE along the eastern side of Birchs Inlet and terminates in a rounded 'nose' near the mouth of the Gordon River (as shown by an earlier survey). The close similarity between the Mainwaring belt anomaly and that associated with the Thomas Creek intrusive-extrusive andesite complex suggests some connection or association between the two, e.g. did the andesite complex develop above an older basaltic complex in some way?

At its southern end, the Mainwaring zone possibly wedges out just off the coast as the bounding faults converge. A somewhat similar anomaly zone with a NNW trend is present just offshore, but appears to be connected to the Noddy Creek andesitic sequence at The Shank.

Hibbs Ultramafic Belt

A second linear belt of very strong magnetics follows the ultramafic belt across the Cape Sorell peninsula, becoming narrower and more broken up southwards. Although the belt divides at Hibbs Lagoon, the magnetics suggest that the eastern belt is much larger at surface. The two belts appear to be connected by an arcuate gabbro-rich zone at Spero Bay (some ultramafic rocks have been shown in this zone to account for the magnetic signature and for the descriptions given by BHP and Cyprus geologists), but a northeast-trending offshore anomaly at Endeavour Bay may also be a continuation.

The ultramafic zone anomaly continues northwards under Macquarie Harbour and under the Tertiary rocks south of the King River. The zone merges with anomalies associated with Noddy Creek andesitic rocks along its eastern margin.

Noddy Creek Volcanics anomalies

A series of magnetic features is associated with the belt of Noddy Creek rocks, but in some cases at least the features may be more related to 'basement' rocks (particularly ultramafic rocks). A zone of very powerful anomalies coincides with the intrusive-extrusive complex at Thomas Creek–Timbertops. The magnetic features clearly extend under the Ordovician rocks of the western limb of the Timbertops Syncline.

Three main features are apparent, separated by saddles. The northern feature has its centre near the contact with the Ordovician rocks, but does not seem to correspond to any particular mapped body. The central feature lies largely beneath the syncline, but is closely connected with the larger southern feature, which corresponds with the main zone of intrusive rocks and lavas at Thomas Creek (but note that boundaries in this area have mostly been inferred from the aeromagnetics). A sub-circular high 'plateau' on this feature is interpreted as a major intrusive body. The zone diminishes to the southeast, where it is affected by several northeast-trending cross faults. Overall, the zone is remarkably similar to the Mainwaring zone anomaly.

To the north of Timbertops, in the type area of Noddy Creek rocks, a strong anomaly over the northern unit of felsic rocks looks most likely to be related to underlying ultramafic rocks. The unit of andesitic volcanic rocks here has a 'busy' signature which is also seen in andesitic units elsewhere in the belt, e.g. around the Urquhart River. Many small andesite units along the belt have been inferred from their magnetic signature, including a number of linear flow-like bodies which outline the general strike of the sequence. One of these, on the coast north of the Wanderer River, is traceable for seven kilometres, and others appear to indicate fold hinges.

An area of strong anomalies near The Shank coincides only partly with mapped conglomerate (Brown, 1988), and is probably partly due to unmapped lavas inland from the coast. This active magnetic zone continues offshore as a major NNW-trending zone which probably overlaps Acacia Rocks, a felsic breccia complex presumed to be linked to the Noddy Creek andesitic sequence.

Lucas Creek Belt

A belt of lumpy magnetics coincides with the Lucas Creek basalts and associated sedimentary rocks. The distribution of magnetic highs suggests that there may be some unmapped units of basaltic lavas.

Rocky Cape Group area

A number of small magnetic highs and 'clumps' of highs are present in and around this sequence on Cape Sorell. Most prominent is a multi-peaked feature just offshore at Sloop Point, forming a north-trending arc. There is nothing in the mapped geology to indicate a source for this anomaly. The emergence of Cambrian rocks from beneath the Liberty Creek Thrust is one possibility. A northeast-trending line of several small highs inland from Liberty Point may have some relationship to a mapped conglomerate unit in the sequence.

Eastern margin of Success Creek Belt

A series of small highs and linear features in this area appear to be mainly related to dykes and faults. A northern linear feature relates to a gabbro dyke (extended from that shown by McClenaghan and Findlay, 1989), and a central linear feature to a dyke-like body of peridotite along the boundary fault. A major spot anomaly at Iron Creek coincides with the fault-related hematite-magnetite-pyrite body drilled by BHP in 1967. Two spot anomalies on the coast at Varna Bay correspond with a Cretaceous (?) lamprophyre and a Cambrian gabbro. A larger double-peaked kidney-shaped anomaly just offshore from the dolomite at Pennerowne Point is puzzling, but could be due to a larger lamprophyric body.

By contrast, the belt of Oonah Formation correlate rocks is remarkably quiet magnetically.

Main Mt Read Volcanics Belt from Elliott Bay to D'Aguilar Range

Most of the magnetic activity on this belt seems to be related to the granites and porphyries, with a few enigmatic features. A SSW-trending zone of strong activity on the western margin of the Low Rocky Point Granite continues offshore to meet the major NNW-trending zone probably related to Noddy Creek rocks. A number of mafic dykes, and the chlorite alteration of Penders prospect, lie close to this magnetic trend. The main part of this granite is magnetically quiet, although a low ridge extending offshore at Cowrie Beach follows the faulted eastern margin.

An intense kidney-shaped high lies just off the eastern margin of the Stony Creek Granite body, and is related to a major zone of chlorite-magnetite alteration, and some mafic dykes, at Voyager 9 prospect. The major fault in this area has probably acted as a conduit for some of this alteration.

Another intense high is located near the Voyager 16 prospect, corresponding to chlorite-magnetite-epidote-quartz alteration and some mafic dykes.

The eastern (Little Rocky River) granite body is magnetically quiet, although there is some moderate activity within the extensive aureole area.

The large quartz-feldspar-biotite porphyry body at the eastern margin of the volcanic belt has a number of small magnetic features, and a notable high on the contact at Wanderer River (Voyager 20).

In the D'Aguilar Range area, a prominent magnetic ridge feature at the southern end of the belt (Conder River) appears to dip under the Owen Group rocks and has no obvious source. It could be related to buried granite. A separate spot anomaly within Precambrian rocks to the east (Hazel Hill) is also a puzzle. At the northern end of the D'Aguilar belt, a lumpy ridge feature follows the northern part of the large porphyry body.

Jurassic dolerite

A ridge of moderate intensity lies over the exposed dolerite at Wanderer River and extends under the Tertiary rocks to the northwest for several kilometres, indicating that the intrusion follows the edge of the Tertiary graben. This dolerite is much less magnetic than that at Point Hibbs, which has a prominent magnetic ridge along its eastern (basal) contact.

Notes on the radiometric image

1. The felsic-dominated Mt Read Volcanics belt in the Elliott Bay and D'Aguilar Range areas has a strong radiometric response (fig. 4), although not as strong as that at Jukes–Darwin. The response is strongest in the Wanderer River area, where there is generally more exposure of the volcanic rocks with less superficial cover. Distinct holes in the response in the Elliott Bay area correspond mainly to areas of cover by superficial gravel.
2. A second belt of strong radiometrics follows the Noddy Creek Volcanics belt from The Shank to Macquarie Harbour, including the narrow belt beside the Osmund Syncline. This fairly distinctive mottled signature also extends over the belt of sedimentary rocks between Spero Bay and Hibbs Lagoon, supporting the inclusion of this unit with the Noddy Creek sequence. An anomalous zone within this belt is formed by the graben-like structure extending SSW from Thomas Creek, where the radiometric response is distinctly low. This zone has a similar response to the ultramafic-mafic rocks, but is quite different magnetically from those. A thin cover of Tertiary gravel could be responsible.
3. An elongated anomaly within the area of Tertiary sedimentary rocks at upper Spero River corresponds to the window of Noddy Creek Volcanics discovered by D. C. Green when ground checking this feature. Several small 'spot' anomalies to the north suggest possible continuation of this bedrock feature.
4. A belt of distinctly low response follows the Mainwaring Group basaltic sequence, with a strike unit of chert-bearing sedimentary rocks picked out as slightly more responsive. The same negative response is shown by the Birchs Inlet Volcanics.
5. The Owen Group sequence is mostly negative except for the siltstone-rich units, which are picked out by their stronger response.
6. The Tertiary sedimentary rocks are generally negative, except for a few small areas in the lower reaches of some of the river valleys, where there are blebby higher zones. One of these, at the western edge of Moores Valley, has a NNW strike-type trend, and may relate to a bedrock feature.
7. The ultramafic-mafic rocks of the Hibbs belt generally have a negative response.
8. On the Cape Sorell peninsula, an active zone over Rocky Cape Group quartzite inland from Betsys Bay is rather unexpected, as siliceous rocks are generally unresponsive. Pelite units within the quartzite-rich sequence could be responsible. The three Neoproterozoic sequences in this area all have patchy responses, typically accentuated along waterways. Of some interest is the fact that the fault block of Success Creek Group correlates at Birchs Inlet has a lower response than this unit on the main peninsula, further clouding the correlation of this enigmatic fault block.

History of exploration south of Macquarie Harbour

Introduction

The lack of road access, absence of any permanent settlements, the difficult and scrubby nature of much of the country, and the cost of expeditions, have all served to inhibit exploration of the area, and continue to do so. Knowledge and understanding of the highly complex geology has mostly come in the last four decades from several major mineral exploration programs by large companies, and by regional mapping surveys by the Mineral Resources Tasmania through the 1990's.

Prospectors such as T. B. Moore traversed the country in the latter half of the 19th century, and there were reconnaissance visits by Government geologists such as Gould (1866) to the Gordon River, Hills (1914) to the Cape Sorell–Point Hibbs area, and Nye (1926) to prospects in the Low Rocky Point area. Sporadic small-scale mining/prospecting was carried out around the beginning of the 20th century for asbestos at Asbestos Point, copper at Birthday Bay (where a few tonnes of chalcopyrite, bornite and copper carbonates were produced from near-shore workings no longer visible; Hall *et al*., 1969), and copper at Penders Prospect near Low Rocky Point , where about four tonnes of ore was mined and left on site from two zones of chlorite schist carrying pyrite and chalcopyrite, at average grade of 0.16% Cu (Nye, 1926; McGregor, 1969).

Lyell-EZ Explorations (LEE), 1956–1962

A large helicopter-based exploration program was undertaken by Lyell-EZ Explorations (LEE) over an area stretching from Queenstown to Port Davey from 1956 to 1962. This ambitious program greatly expanded knowledge of the geology of South West Tasmania, which was largely unknown country at that time, but did not result in any commercial mineral discoveries. Airborne magnetics (the first over the southwest), EM and scintillometer surveys were flown over much of the area in 1958, and a variety of ground geophysical methods were used. The ultramafic belt between Point Hibbs and Macquarie Harbour was discovered.

A four-wheel-drive road was bulldozed from Birchs Inlet to a large camp at Moores Valley, and this track was later extended to Low Rocky Point to service the lighthouse. Six shallow holes were drilled on a fault-related hematite-sulphide zone at Pelias Cove, on Macquarie Harbour, and a single hole was drilled in the Tertiary sequence at Moores Valley, on an IP anomaly. The latter hole reached 152 m, still in Tertiary sedimentary rocks. Much work was also done on the hematite/magnetite body at Iron Creek, where a resource of some 4.7 Mt of iron ore was estimated.

Summaries of the project are contained in reports by Hudspeth and Scott (1957, 1959, 1962). An estimate of expenditure to 1960 of £300,000 was given in the last of these reports.

Much of the geological material was summarised in a series of short publications by Scott (1960*a*, *b*, *c*; 1962). Several dozen company reports were also produced on the area (now in the MRT library). In one of these, Solomon (1957) reported on a coastal traverse from Albina Creek to the Wanderer River, but notes that no significant mineralisation was found. Consultant B. Campana visited the area during this program and used some of the geological results in his interpretation of the 'mineralised rift valleys' of west Tasmania (Campana, 1957; Campana *et al*., 1958). Many of the results of the LEE work were incorporated in a volume on the geology of Tasmania produced in 1962 (Spry and Banks, 1962).

BHP Exploration, 1964–1972

A second major helicopter-based exploration program, covering most of South West Tasmania, followed soon after, and was conducted by BHP between 1964 and 1972. The project resembled a geological survey in many ways, and much regional mapping was done and summarised in a series of 1 inch to 1 mile (1:63,360) scale map sheets covering most of the area. An airstrip was constructed at Moores Valley, the LEE camp rejuvenated, and a major base camp was established at Birchs Inlet. Of the order of 100 km of tracks and costeans were bulldozed through scrub and forest across the Cape Sorell peninsula and the Cypress Creek area. A new aeromagnetic survey was flown, as was a scintillometer survey of parts of the area.

Much of the work in the early part of this program was of a reconnaissance geological nature, but later exploration was focussed on the asbestos potential of the ultramafic rocks of the Hibbs belt (e.g. Close, 1972), the copper potential of the Mainwaring Group basalts, and the Mt Read Volcanics in the Jukes–Darwin area. Considerable costeaning with bulldozers was done on the first two, neither of which proved economic. The Jukes–Darwin area was eventually joint ventured with the International Nickel Company. Little exploration effort was directed to the Mt Read Volcanics rocks in the Elliott Bay area, which McGregor (1969) considered did not contain any mineralisation of economic significance.

Drilling was carried out on the iron ore bodies at Iron Creek, showing an increase in sulphides at depth but no economic potential, and on the ultramafic rocks at Noddy Creek, where an EM anomaly was found to be caused by graphitic shale.

Important summary reports of the program are those of Hall (1966), Hall *et al*. (1969*a*, 1969*b*), and McGregor (1969). E. B. Corbett (1968) described the Mainwaring Group rocks. A company-funded Ph.D. project by N. C. White (1975) studied the volcanic rocks of South West Tasmania, including those at Lewis River, Noddy Creek, Lucas Creek and Birchs Inlet, and provided much useful petrological and geochemical data.

Total expenditure by BHP over the eight-year program seems to have been of the order of $1 million.

Post-1972 company operations

A wave of new companies moved into the southwest following the exit of BHP in 1972, with exploration taking place in three more-or-less separate areas; Elliott Bay, D'Aguilar Range, and the Cape Sorell peninsula–Mainwaring River. The exploration received considerable stimulation from Aberfoyle's 1974 discovery of the Que River massive sulphide deposit in a relatively unexplored area of the Mt Read Volcanics belt, and from a generally improved understanding of the geology of such deposits and the effectiveness of various exploration techniques

Elliott Bay area

Geopeko took out a large exploration licence (EL 27/76) over the Elliott Bay–Mt Osmund area in 1976, and carried out an intensive program of investigations focussed on volcanic-hosted deposits in the Mt Read Volcanics from 1977 to 1984. A major base camp was established south of Wart Hill, and much use was made of tracked bombardier vehicles over the largely open countryside. Geologically, the program resulted in regional and locally detailed mapping and understanding of much of the volcanics belt and adjacent rocks, and delineation of many of the alteration and mineralisation features (e.g. Large, 1981; Large and Wilson, 1982). Much of the work was summarised in a published paper by Large *et al*. (1987), and collaborative work with CSIRO using lead isotopes to elucidate the nature of the various styles of mineralisation was published by Gulson *et al*. (1987).

Mapping, stream sediment sampling, and airborne magnetics and EM were used as reconnaissance methods, and thirty-four prospective areas were initially located. Seventeen of these were selected for follow-up involving gridding, detailed mapping, soil geochemistry and geophysics. Seven were ultimately drill tested.

A number of altered and mineralised zones were discovered, and a number of styles identified, including:

- lenses of VHMS-type Pb-Zn–rich sulphide in volcaniclastic breccia (Voyager 19);
- stratabound disseminated and quartz vein-type gold in felsic volcaniclastic rocks, with values up to 17 g/t Au (Voyager 24,30);
- magnetite-chlorite alteration zones in volcanic rocks, possibly related to granites (Voyager 9, 16);
- disseminated Pb-Zn-Ag at the contact between felsic pyroclastic rocks and tuffaceous sedimentary rocks (Voyager 2, 3, 10);
- gold and silver-bearing gossanous veins near the margin of an intrusive porphyry body (Voyager 12);
- stratiform magnetite-pyrite-minor chalcopyrite 'exhalites' (Penders, Voyager 21);
- vein-style galena-sphalerite-arsenopyrite along the Copper Creek Fault (Voyager 31, 33); and
- disseminated chalcopyrite in Mainwaring Group rocks (Voyager 18, 21).

Of most interest was the discovery at Wart Hill (Voyager 19) of two large lenses, up to six metres wide and 20 m long, of high-grade massive sulphide, comprising 20–30 mass% galena, 30–50% sphalerite, 5–20% pyrite, plus minor chalcopyrite, chlorite, quartz and barite (Large *et al*., 1987). These lenses gave promise of a Que River, Hellyer or Rosebery-style deposit, and were intensively investigated. Drilling and a gravity survey showed that the bodies were indeed isolated lenses, not associated with a footwall alteration zone, and had probably been transported in a mass-flow deposit from a fairly distant source (Wilson *et al*., 1981; Callaghan, 1989). There did not seem to be any useable vectors to determine the source. Minor galena-sphalerite-carbonate alteration in the host rocks was associated with intrusive quartz porphyry bodies, and was considered to be later and unrelated to the massive sulphides (Gulson *et al*., 1987).

Although the program was highly successful in locating the many zones of alteration and mineralisation, none of the prospects showed enough promise to continue drilling after eight years. The final phase of Geopeko's program involved the use of deep-seeking UTEM in the Wart Hill area, but this did not detect any significant conductors (Herrmann and Sumpton, 1984). No joint venture partner could be found at this late stage, and the licence was relinquished in 1986 (Herrmann, 1985*b*).

Cyprus Minerals took up the challenge in 1986 when they added the Elliott Bay area (EL 40/85) to a series of EL's (35, 36, 37/83) covering much of the ground from the Cape Sorell peninsula to the Mainwaring River. Cyprus carried out a large Dighem survey over the poorly explored northern part of the area (northeast of Mt Osmund), but follow-up of the numerous surficial anomalies indicated they were due to black shale, faults or weak alteration zones of little interest, and the company was drawn back to the known prospects at Elliott Bay (Torrey *et al*., 1987). Previous geophysical surveys were reviewed (Bishop, 1987, 1988), but a recommendation for blanket IP coverage over unexplored areas was not followed up.

Instead, Cyprus drilled a series of twelve more diamond holes over the zone of sulphide lenses at Wart Hill, looking for undetected sulphides at depth. The drilling confirmed the nature of the volcaniclastic host unit, with clastic sulphides giving intervals of up to a few metres of 1–5% Pb + Zn. An interpretation of a major fault at the Owen Group ('Waterloo Creek Group') contact, which might have acted as a major mineralising conduit, was disproved, and the contact was shown to be depositional-unconformable. A search for extensions of favourable 'exhalative' horizons, i.e. cherty or barite-bearing units, and for possible down-dip and along-strike extensions of the massive sulphide zone, was not successful, and while more intersections of the main zone were achieved, no trends in alteration zonation or clast size or frequency were apparent (Torrey *et al.*, 1988; summary in Herrmann, 1996).

A study of the Wart Hill sulphide-bearing unit (Callaghan, 1989) detailed the considerable variability in the sulphide clasts, indicating derivation from different parts of a complex zoned deposit or several deposits, and their wide distribution within the mass-flow breccia package.

Aberfoyle Resources Ltd joint ventured into the Elliott Bay area with Cyprus (later Arimco) in 1991. They did not pursue further work at Wart Hill, but carried out a regional EM survey with the latest Questem method (fixed wing, high terrain clearance), and undertook a collaborative research program on Pb isotopes with CSIRO and CODES. Two Questem anomalies, at Cowrie Beach and Wanderer River, were followed up with gridding and ground EM (Wallace, 1991*a*, *b*).

The Cowrie Beach prospect (Voyager 3), located within a fault zone near the margin of a quartz-feldspar-biotite porphyry body, features strong silica-chlorite-sericite-pyrite alteration on the coast, with some chalcopyrite-galena-sphalerite-pyrite veining. Two west-dipping angle holes were drilled by Aberfoyle, the first being aborted at 59 m and the second going to 312 m but showing only minor traces of mineralisation (Richardson, 1993). No further work was done, and the area was relinquished.

Plutonic Operations Ltd was granted the larger part of the tendered area, as EL53/94, in 1995, and undertook a major review of previous work. This suggested that there may be scope for further work at Wart Hill to achieve a better understanding of the volcanic facies, alteration and structural setting, and to provide drilling targets. Ground magnetics, Sirotem and geochemical sampling were done at Wart Hill and East Camp; drill core from Wart Hill was re-logged to re-interpret the volcanic facies and infer directions to the sulphide source, and the Voyager 3 Questem anomaly was re-evaluated.

After this preliminary work, and a very comprehensive review, it was concluded that:

(I) that the previous exploration had been more thorough than at first thought;

(ii) that no good untested geophysical targets remained in the Wart Hill area;

(iii) that there were no obvious conceptual geological targets that could be tested without high-risk deep diamond drilling; and

(iv) the Questem anomaly could be attributed to a broad fault zone with a difficult offshore extension, in which shallow drilling was unlikely to be conclusive (Herrmann, 1996).

It was decided to relinquish the area after only one year of operation.

Subsequent exploration at Elliott Bay has mainly involved small programs and small companies with an eye to joint venturing.

A group of companies operated by R. and P. McNeil, including ***Macmin NL***, ***Exploration and Management Consultants Pty Ltd***, and ***TasGold Ltd***, have progressively obtained licences in the Elliott Bay–D'Aguilar Range area, and are the sole landholders in the area as at December 2002. Macmin was granted EL5/95, partially encircling Plutonic's 53/94, in the Lewis River area, in 1995 for a gold-orientated program. A review by Hall (1995) recommended gold sampling at the 'Three Creeks prospect' near the northern margin of the Little Rocky River granite body. Auger sampling in the area did not enhance the prospect (McNeil, 1995), and the licence was allowed to lapse in 1997 (Hall, 1997). Exploration and Management Consultants Pty Ltd won the ETA over the main Elliott Bay area (EL20/96) in 1996, and was initially involved in a joint venture with Fimiston Mining NL. Much of this licence has been relinquished, but the area is now surrounded by the larger EL's 21/99 and 24/01, both held by TasGold, which extend up the west coast taking in the Mainwaring Group and much of the Noddy Creek sequence (but not the Thomas Creek area) on one side, and to the D'Aguilar Range on the other.

D'Aguilar Range area

Australasian Minerals Inc. came into the D'Aguilar Range area in 1972 (EL2/72), with an airborne EM-magnetic survey, soil sampling and ground mapping. Mapping was able to subdivide the volcanic sequence, and a distinction was made (for the first time) between the Sticht Range Beds and the Owen Group conglomerate. The program failed to delineate significant mineralisation, and the licence was dropped after 12 months (Martin, 1974).

Union Oil Development Corporation followed in 1974 (EL9/74), the company establishing an access track from Birchs Inlet and cutting a large grid. Geophysical and geochemical surveys delineated a number of

Pb-Zn-Cu anomalous areas (McGregor-Dawson, 1975). The company joint ventured this lease in 1977 with Geopeko, which had also taken up a large area at Elliott Bay. Follow-up work, including a Dighem survey and some auger drilling, was done and zones of patchy sericite-pyrite alteration in the felsic volcanic rocks with some Pb-Zn soil anomalies were further delineated (e.g. Pemberton, 1981). After a period of joint venture with Aquitaine Australia Minerals Pty Ltd, the area was relinquished in 1985 without drill testing, as Geopeko concentrated on its Elliott Bay licence (Herrmann, 1985).

In 1985, CSR were allowed to sample 13 stream sites in the area for gold. The four panned concentrate samples were all anomalous (up to 10 g/t), but the 13 BLEG samples were low (Herrmann, 1985; McNeil, 1993), and no follow-up work was done.

Exploration in the area then lapsed until 1992, when ***Macmin NL*** was granted EL3/92, mainly on the basis of the gold potential, and immediately entered a joint venture with Anglo Australian Resources NL. A major stream sediment sampling program defined two areas with significant levels of gold, one in the southern part of the area and one in the north. A-horizon (Huminex) soil sampling defined anomalous zones over each of these areas. Follow-up work on the southern area, which lies on the contact zone of an intrusive porphyry body, culminated in the drilling of six shallow diamond holes with a portable rig. A zone with disseminated and veinlet pyrite in felsic volcaniclastic rocks, and some chlorite-altered porphyry, were intersected, with barely anomalous gold to 82 ppb (MacDonald, 1995).

The joint venture with Anglo Australian lapsed during 1997/1998. Macmin resumed exploration in 1997, and carried out some follow-up at the northern prospect, where a siliceous breccia body was associated with strongly chlorite-sericite-quartz-altered volcanic rocks. Rock-chip sampling of the area was disappointing (Fulton, 1996, 1997). Two diamond holes were drilled in 1998 at the Conder prospect in the southern part of the area, on a coincident soil–EM target. Both intersected a small, weakly mineralised silicified breccia zone along a NNW-trending fracture with silica-feldspar-chlorite-carbonate veins and rare galena and pyrite. No further work was recommended (Simmons, 1998; Hall, 1999), and the area was relinquished in 1999.

Cape Sorell peninsula

Comalco Ltd took up EL1/71 over Cape Sorell in 1971, to explore the potential of the Rocky Cape Group quartzite as a source of silica for silicon metal manufacture (Picken, 1971). Diamond drilling at several sites showed that the quartzites were indeed of high purity, and produced a resource estimate of 2.78 Mt at 99.13% SiO_2, 0.34% Al_2O_3, 0.05% Fe_2O_3 (Picken, 1975; Bartlett, 1978). An alternative deposit of quartzite at Glovers Bluff, near the Huon River, was favoured as the source for a short-lived silicon smelter at Electrona, near Hobart, and the Cape Sorell venture lapsed.

Amoco Minerals Australia Company (later ***Cyprus Gold Australia Corp***.), in joint venture with Placer Development Ltd and Poseidon Minerals Ltd, was granted three large Exploration Licences (35, 36, 37/83) over the area from the Cape Sorell peninsula to the Mainwaring River in 1983. Their targets included volcanic-hosted massive sulphides (greater than 15 Mt of 20% Pb + Zn); intrusive-related stockwork/breccia/vein and replacement/skarn-style gold mineralisation; gold/platinoids in ultramafic rocks; and Renison-style replacement tin deposits in Cambrian carbonate rocks affected by the offshore Devonian granite mapped by the Tasmanian Geological Survey at Cape Sorell (Baillie *et al*., 1977).

Amoco flew a new aeromagnetic survey over part of the area, and a Dighem survey over the Lucas Creek and Mainwaring Group belts (Ferris, 1984). The Dighem survey was later extended to cover the Noddy Creek belt and the volcanic rocks of the Elliott Bay area when the company acquired EL40/85. The surveys over the Cape Sorell peninsula were interpreted by Bishop (1984), who noted many features for follow-up. The Noddy Creek Volcanics in the areas north and south of Timbertops were given some attention, and some geochemical sampling was done in Thomas Creek which produced some copper anomalies. A coincident magnetic-EM anomaly along the Copper Creek Fault zone at Wanderer River North, where quartz veins with minor base metal sulphide minerals occur in the schistose rocks, was gridded and covered by soil and rock-chip sampling, but did not return any significant assays (Poltock, 1988).

Cyprus Minerals relinquished these areas in 1988 to concentrate on its exploration at Elliott Bay.

Plutonic Operations Ltd were granted EL's 4/92 and 7/92 over the Cape Sorell peninsula–High Rocky Point area in 1992. There was considerable conservation interest in South West Tasmania at this time because of World Heritage Area issues, and some uncertainty concerning the future development of any major resource discovery in the area. To gain assurance, the company submitted a hypothetical mining proposal to the Tasmanian Government to test the political climate, and received strong support and encouragement to go ahead.

The Noddy Creek Volcanics were specially targeted in this program. Follow-up geochemical sampling was done over several Dighem anomalies in the type area of the volcanic rocks around Briggs Creek with no encouragement, and stream BLEG sampling at a prospect on the lower Wanderer River also proved negative. Further work at Thomas Creek, where a large Cu-anomalous alteration zone in andesitic lavas and intrusive rocks was confirmed, provided considerable encouragement (MacDonald, 1993; Rea, 1994; Close and Reid, 1995). A major volcanic centre seemed to be present, with potential for caldera-related proximal massive sulphide deposits and/or porphyry-style Cu-Au mineralisation in the intrusive rocks. A GeoTem survey was flown over the area in early 1996, but did not produce any major features for follow up.

The southern EL (7/92) was relinquished in 1996 (Close, 1996), and an active program carried out at Thomas creek, including an eight-hole diamond drilling program using a portable 'Gopher' rig. Grades from the drilling were disappointing, with values of 0.1–0.2% Cu and less than 0.1g/t Au. Moderate pyritic mineralisation was found in creeks to the east and northeast of the area, and thirteen AEM anomalies were recorded (Reid and Close, 1997; Reid, 2001). After failing to attract a joint venture partner, the company relinquished the area in 1998.

New Holland Mining NL, in joint venture with W. C. Cromer Pty Ltd, obtained a licence (EL31/87) over Cape Sorell in 1988 to investigate the potential for tin-tungsten, base metals and gold related to the offshore Devonian granite and to Cambrian lithologies beneath the Liberty Creek Thrust. An adjacent licence (30/87) on the lower King River was joint ventured with BHP in 1989. No significant work appears to have been done on Cape Sorell.

Pacific-Nevada Mining Pty Ltd took up the Cape Sorell peninsula–Spero Bay area (EL9/98) in 1998, with exploration concepts including Homestake-style gold deposits in Proterozoic iron formations; Selwyn/Starra-style Proterozoic Cu-Au pipes; Proterozoic sediment-hosted Cu; Beaconsfield-type gold associated with ultramafic-bearing thrust packages; and nickel associated with ultramafic rocks. The northern part of the Hibbs ultramafic belt was targeted, and reconnaissance stream-sediment and rock-chip sampling defined two prospective areas for gold and nickel at 'Hill 99' and 'West Baylee'.

Hill 99 was inland from an outcrop of massive pyrite-quartz mineralisation on the coast near Asbestos Point. West Baylee included a serpentinite-sediment contact and a zone of strong nickel anomalies in ultramafic rocks. Grid-based soil sampling and geophysics (IP, magnetics) were carried out over both, as well as further stream-sediment and rock-chip sampling. Both prospects were tested with diamond drilling, but no significant mineralisation was intersected. The nickel anomalies were thought to be caused by surface lateritisation-concentration processes (Newnham, 2000; Westbrook, 1999).

The licence was relinquished in 2001, and the area was still vacant at December 2002.

Geological Survey of Tasmania activities

Early work by the Tasmanian Geological Survey in the area was of a reconnaissance nature. Hills (1914) reported on the Cape Sorell to Point Hibbs area while Nye (1926) reported on the Low Rocky Point district.

The Survey's regional mapping program extended into the Cape Sorell area in the 1970's, with the production of the Strahan 1:50 000 scale sheet (Baillie *et al.*, 1977). This work resulted in the discovery of a Devonian granite body just off the west coast of Cape Sorell (3 km north of the present map boundary of fig. 2), intruding the Rocky Cape Group quartzite (Baillie and Corbett, 1985).

A regional aeromagnetic survey of western Tasmania was conducted in 1981, with Commonwealth Government funding, and included the Cape Sorell peninsula area (Corbett *et al.*, 1982).

A major mapping program was carried out in the area in the mid-1980's, culminating in publication of the 1:50 000 scale map sheets of Montgomery (covering the coastal strip between the Urquhart River and Low Rocky Point; Brown, 1988) and Macquarie Harbour (covering the Cape Sorell peninsula between Liberty Point and Varna Bay; McClenaghan and Findlay, 1989, 1993). Mapping of the Point Hibbs sheet, between these two, was initiated in 1989/1990, but was unfortunately not completed before work was suspended in 1990 because of a major rationalisation of the mapping programs. The data collected were later incorporated into a compilation of three digital map sheets at 1:25 000 scale, in which the geology of the unmapped areas was largely inferred from interpretation of geophysical data (Seymour, 2001*a*, *b*, *c*). These sheets have now been replaced by the Hibbs, Birchs, Endeavour and Montgomery 1:25 000 scale map sheets (fig. 2).

A summary report outlining the major sequences of Cambrian rocks in the Cape Sorell peninsula–Low Rocky Point area, and their geochemical characteristics, was published in 1991 (Brown *et al.*, 1991), but detailed reports for the Montgomery and Hibbs areas are yet to be produced.

The Mt Read Volcanics Project, begun as a special project in 1986, undertook several programs in the southwest. A 1:50 000 scale map of mineral deposits and prospects in the Elliott Bay–Wanderer River area, incorporating work by Geopeko and other companies, was produced by Taheri and Green (1988). Water sampling and geophysical programs were also conducted. A geological mapping team mapped the main belt of volcanic rocks from Elliott Bay to the D'Aguilar Range during the summers of 1990 and 1991, and produced three maps at 1:25 000 scale covering the area (Pemberton *et al.*, 1991; Vicary *et al.*, 1992; Bradbury *et al.*, 1992). At that stage it was not realised that the Noddy Creek belt was probably also a Mt Read equivalent. Reports on the map sheets were not produced.

Summary and review of exploration

Exploration south of Macquarie Harbour has been carried out more or less continuously for 40 years from 1956 to 1996, by a relatively small number of major and minor companies. No major economic discovery has been made, although many indications of mineralisation have been found. Much of the early work, by Lyell-EZ and BHP in the 1950's and 1960's, was of a reconnaissance nature, with much of the resources expended in getting to grips with the geology and physical environment. An element of 'adventure in the wilderness' went with these early programs, with a suggestion that advancing the knowledge of the geology was almost a sufficient justification in itself. In addition to improving the understanding of the geology, the infrastructure developed by these companies has been of considerable benefit to later comers. The Low Rocky Point track, initiated by LEE, became a vital access for later explorers (and for bushwalkers and others). The many kilometres of tracks bulldozed by BHP in the 1960's have also been a godsend to later explorers and mappers, although the practice of 'bulldozer exploration' has long since become environmentally unacceptable and even illegal.

These two early programs did not produce a great deal of economic significance. A small iron ore resource (4.2 Mt) at Iron Creek, and the asbestos resource in the Hibbs ultramafic belt, were shown to be uneconomic, and work on the copper potential of the Mainwaring Group basalts was not encouraging. BHP's final focus was on the Jukes–Darwin area, north of Macquarie Harbour, where indications of mineralisation were easier to find.

The program undertaken by Geopeko at Elliott Bay in the 1970's and 1980's was much more focussed on economic results, although considerable weight was also given to understanding the geology. Examples of interesting alteration and mineralisation (many of them related to granites or porphyries) were soon discovered by the competent application of a range of techniques, and many of these were pursued to drilling stage within a few years.

The technical success of the Geopeko program is demonstrated by the discovery of the small lenses of high-grade massive sulphide at Wart Hill. This is the most significant discovery in the southern Mt Read belt, as it demonstrates that at least one genuine sulphide deposit of Que River/Hellyer/Rosebery-type was formed in the area at some time. Unfortunately, the lenses are probably transported clasts, and appear to have travelled some distance from an unknown source. Despite intensive further exploration, including drilling of more than a dozen holes, no good indication of a vector to the source deposit of these clasts has yet been found, and no other example of this kind of massive sulphide mineralisation has been discovered.

Geopeko's comprehensive and thorough exploration, although it did not produce an economic deposit, showed that a style of potentially economic mineralisation was present, and this continues to stimulate explorers.

The 1986 Dighem survey by Cyprus at Elliott Bay, and the associated follow-up work, again showed up 'sniffs' of alteration and base metal anomalism in many areas of the volcanic rocks, only some of which were followed up. The company returned to the known prospect at Wart Hill to concentrate on further drilling, adding to the detailed knowledge of the host unit of the sulphide clasts but not seeming to get any closer to the source.

Aberfoyle, the most successful of the western Tasmanian exploration companies of the 1970's and 1980's, with Que River and Hellyer under its belt, made a brief foray into the southwest in a joint venture with Cyprus in 1991. They ignored Wart Hill and put their faith in the latest Questem EM technique. Their drilling of a favoured anomaly at Cowrie Beach, using a barge and helicopter-transported rig, was not productive, showing only a poorly mineralised fault zone, and they withdrew.

Another attempt to find a VHMS-type deposit at Elliott Bay was made by Plutonic Operations in the mid-1990's. An in-depth review and some reconnaissance ground work led back to Wart Hill, where drill core was re-logged and facies analysis done on the volcanic sequence to try and determine vectors to the source of the sulphide clasts. But Herrmann (1996), with wide experience in the mineralised systems of the Mt Read Volcanics and elsewhere, was unable to decipher any trends in alteration, clast size or clast frequency which could be used to give such vectors, and Plutonic moved quickly on. Exploration since then has been mainly for gold by the Macmin group.

The D'Aguilar Range area has provided a somewhat similar story, except that no examples of VHMS-style mineralisation have been found. There are zones and patches and 'sniffs' of alteration and mineralisation, with geophysical and geochemical anomalies, but the two attempts at drilling these have shown relatively minor mineralisation probably related to the intrusive porphyries. There are also zones of gold anomalism in streams, but follow-up to date has brought no joy. A close relationship with the large porphyry body is indicated or implied for many of these occurrences.

Comalco's 1970's exploration in the Cape Sorell peninsula–Mainwaring River area has produced the most significant resource so far established in the area — 2.78 Mt of good quality quartzite silica at Cape Sorell. Unfortunately the resource is rather remote, and the generally steep dips of the source beds do not provide for efficient mining. Cyprus (Amoco) approached this diverse area with a good range of possible targets and a useful Dighem survey in the 1980's, eventually homing in on the Noddy Creek Volcanics for their VHMS potential. They discovered but did not follow up on the Thomas Creek porphyry copper-type prospect, leaving this for Plutonic to further explore in the 1990's. Plutonic's final drilling program was disappointing, but there is clearly much more to be learned about this large andesite-diorite complex.

Pacific-Nevada introduced some new thinking and target models to exploration on the Cape Sorell peninsula in the late 1990's, and a basic field approach quickly led to the drilling of gold and nickel prospects in the Hibbs ultramafic belt. The company did not persevere after initial results were not encouraging.

Overview of the geology and exploration

Exploration to date in South West Tasmania has focussed on the following units:

- The southern end of the Mt Read Volcanics belt in the Elliott Bay–D'Aguilar Range area;
- The Noddy Creek Volcanics belt, particularly the Thomas Creek intrusive complex;
- The Hibbs ultramafic belt;
- The Mainwaring Group basalts, mainly for their copper potential;
- The Cape Sorell quartzites;
- The Iron Creek hematite bodies;
- The Copper Creek fault zone.

Southern Mt Read belt

The main sequence at Elliott Bay and D'Aguilar Range is a correlate of the **Eastern Quartz-Phyric Sequence** of the Lake Dora–Mt Murchison area, distinguished by quartz-phyric volcanic rocks, basal Sticht Range Beds, large quartz-feldspar-biotite porphyry intrusive bodies, small granite bodies, and virtually no intermediate-mafic volcanic rocks. Much of the alteration and mineralisation in the Dora–Murchison area, where there are a number of major copper ± gold prospects (e.g. Lake Dora, Selina, Murchison), is related to the granite-porphyry intrusive rocks, and the same seems to apply to the Elliott Bay–D'Aguilar area. Areas of gold and base metal anomalism, some associated with alteration, are widespread in the latter areas, but exploration to date has not been rewarded. The amount of exposure of the granite bodies at Elliott Bay suggests moderately deep erosion of the volcanic pile.

The **Western Volcano-Sedimentary Sequence** correlate ('Wart Hill Pyroclastics') at Elliott Bay contains the most interesting alteration systems in the area. Several of these are clearly related to the granites and involve magnetite. It is notable that the granites in this area are only patchily magnetic (fig. 3) compared to the Darwin and Murchison Granites, although there is a particularly strong magnetic anomaly associated with one side of the Stony Creek Granite.

The **Wart Hill VHMS horizon** is certainly the most interesting feature discovered in the exploration sense. While the general depth of erosion indicated by the exposure of the granites suggests that the source massive sulphide deposit may have been removed, there are many uncertainties regarding the structure of the sequence and the attitude of the host horizon. The mapping by Pemberton *et al*. (1991) suggests that there is an anticlinal fold to the east of the sulphide lenses, in an upfaulted block which displaces the base of the Owen Group to the east, raising the possibility that the source might still be preserved to the east. It is possible that the host horizon dips under the Owen Group in this area, and has some continuity in that direction.

The Noddy Creek Volcanics belt

The significance of this belt as an extension of the Mt Read Volcanics, with abundant andesites of Que–Hellyer type, seems not to have been properly recognised. The present study shows the belt to join up with the main Mt Read belt in the Copper Creek area, and it appears to represent the larger western half of the overall volcanic zone. It may be largely younger than the eastern half, and much of it is probably equivalent to the Tyndall Group further north. This could be a positive feature in the exploration sense, as it is now known that the upper exhalative part of the Mt Lyell system, and the host sequence at Henty, are within the Tyndall Group (Corbett, 2001*a*,*b*; Callaghan, 2001). Geochemical comparisons support a Tyndall Group correlation, but also indicate overlap with andesite from Que–Hellyer and the western Henty Fault Wedge. The 'shoshonitic' basaltic rocks, seen in the Hellyer hangingwall and other areas, are apparently lacking.

The Noddy Creek belt is dominated by andesitic rocks, and may represent a separate 'offshore' chain of andesitic volcanoes, as opposed to the almost purely felsic composition of the eastern half of the Mt Read belt at Elliott Bay and D'Aguilar Range. There is a suggestion of a siltstone-rich zone with mixed andesitic, felsic and metamorphic detritus in the central part of the volcanic 'basin' (Copper Creek–Birchs Inlet area), grading westward to a more andesite-dominated province with a volcanic 'axis' stretching north and south from the Thomas Creek complex. The Noddy Creek belt apparently overlies a complex basement which includes mafic and ultramafic rocks, possibly providing a more fertile source for leaching of base and precious metals than the metamorphic basement further east (Stolz and Large, 1992).

The belt is poorly mapped for the most part, partly because of the rather difficult terrain and forest cover away from the coast. Most of the sub-units shown on the maps are based on interpretation of geophysical data. The 14 × 6 km intrusive-volcanic complex in the Thomas Creek–Timbertops area represents a very large volcanic centre by Mt Read standards, significantly larger than the Que–Hellyer complex, and is perhaps the most obvious target in the belt. Sulphide mineralisation associated with brecciation, veining and 'porphyry'-style K-feldspar-silica and magnetite-chlorite alteration has been documented at Thomas Creek (Reid and Close, 1997), but the only drilling (eight shallow holes) so far has produced low grades of copper and gold.

Exploration on the belt has been fairly limited, and a great deal remains unknown. There would seem to be scope for good quality aerial geophysical surveys to locate targets for follow up (some previous Dighem anomalies await investigation; MacDonald, 1993). Previous experience suggests that exploration needs to be accompanied by extensive track cutting to provide access through the difficult scrub and forest.

Hibbs Ultramafic Belt

BHP spent considerable resources cutting tracks and costeans across this belt and exploring for asbestos, for little reward. Some exploration for gold, platinum group minerals and nickel has also been attempted (e.g. Pacific-Nevada), but has not been systematic. Little, if anything, has been done on the southern part of the belt inland from Spero Bay. The very sheared and disrupted nature of the rocks is a negative feature in some areas, but some reasonably large unsheared bodies also exist.

Mainwaring Group basalts

Native copper, chalcopyrite and minor bornite, as well as minor zinc and nickel, occur in the basalts and associated breccias and sedimentary rocks (including dolomite) of this sequence, which is geophysically and geochemically 'active'. The mineral potential of these rocks was investigated by BHP via an extensive network of tracks and costeans in the Urquhart–Cypress Creek–Mainwaring area, by Cyprus (Amoco) in the same general area, and to a lesser extent by Geopeko in the Copper Creek–Veridian Point area. No significant deposits have been found. The rocks are mostly covered by dense rainforest and scrub, and access away from the coast can be difficult. Major faults bound this sequence on either side.

Cape Sorell area

A silica resource is present in the quartzite sequence on Cape Sorell, and is fairly easily accessible from Macquarie Harbour. In addition, the presence of a Devonian granite body on the west coast eight kilometres north of Sloop Point raises the possibility of granite-related mineralisation in reactive Cambrian rock units lying beneath the thrust sheet of Rocky Cape Group quartzite. The series of magnetic anomalies offshore from Sloop Point is of interest in this regard.

Iron Creek hematite bodies

The largest of these unusual fault-related hematite-magnetite-pyrite bodies of is about 450 m long, with an average width of about 50 m, and contains an estimated resource of 4.4 Mt of oxide iron ore to local stream level (Hall *et al*., 1969*b*). This body was drilled by BHP in 1968, with a west-dipping hole of 100 m depth. This gave an intersection of only one metre of massive sulphide/oxide (70% pyrite, 30% hematite) at 96 m, indicating a downwards-narrowing body in which much of the hematite was probably produced by surface oxidation of sulphide minerals. Other smaller bodies and veins with hematite, chlorite, pyrite and quartz occur in the area, and indicate a mineralising event possibly related to the faulting (McClenaghan and Findlay, 1993), and a later period of intense oxidation.

Copper Creek Fault and other structures

Extensive shearing and veining are associated with the Copper Creek Fault, and mineralisation has been investigated in two areas. Vein-style galena-sphalerite-arsenopyrite mineralisation was drilled by Geopeko at Voyager 33, west of Mt Osmund. Lead isotope work (Gulson *et al*., 1987) showed this mineralisation to be of probable Devonian age.

At the Wanderer River, where the structure disappears under Tertiary gravel, Cyprus investigated a coincident EM/magnetic anomaly on the Tertiary (which had also been explored by LEE in the 1950's), and some minor base metal mineralisation and gold anomalism related to quartz veins (with pyrite, galena and hematite) in the schistose bedrock further south. Cyprus carried out extensive soil and bedrock sampling, including 'Wacker' percussion drilling, after gridding, but obtained little encouragement (Poltock, 1988).

There are marked similarities between the Copper Creek Fault and the Great Lyell Fault, and the two are quite possibly connected. The Great Lyell Fault has been a major plumbing structure for the huge hydrothermal alteration system at Mt Lyell (Corbett, 2001*b*), and probably also for the gold-rich Henty system further north. Its buried extension under

Tyndall Group rocks to the south of Mt Lyell, in the Jukes–Darwin area, represents a significant new exploration target for Mt Lyell-type copper-gold orebodies (Morrison, 2002; Corbett, 2002).

The Copper Creek Fault is just one of many major fault structures in the southwest area which have potentially been associated with mineralising systems of Cambrian and/or Devonian age. There would also appear to be potential for other types of structurally-hosted mineralisation, for which this structurally complex region is clearly under-explored.

Conclusions

- The geological framework of the Macquarie Harbour– Elliott Bay area is now reasonably well known from Geological Survey mapping and work by exploration companies, and the major sequences and units are reasonably well defined. However there are considerable gaps in knowledge because of lack of field studies in some areas, and much of the structural history is poorly understood.
- The area has most of the geological features of the heavily mineralised central part of Western Tasmania (Queenstown–Zeehan–Hellyer area), including the extension of the major host unit, the Mt Read Volcanics belt. The western andesite-rich part of the MRV is particularly well exposed in this area. There are also late Proterozoic carbonate rocks like the Renison Bell host rocks, a Devonian granite (offshore just north of the mapped area), ultramafic rocks similar to the host rocks of the recent Allegiance Mining nickel discovery west of Zeehan, and numerous structural features of interest as potential mineralised features. The area can be viewed as an under-explored extension of the West Coast (Large, 1987).
- The newly appreciated extent of the andesite-rich Noddy Creek Volcanics (approximately 400 km^2 exposed), including a major volcanic-intrusive complex at Thomas Creek–Timbertops, opens up a large and poorly explored area of Que–Hellyer-type volcanic rocks with potential for both porphyry-style and VHMS-type deposits.
- There is further exploration potential for gold and base metals in the main Mt Read belt, including the possible eastwards extension of the Wart Hill VHMS horizon, nickel and platinoids in the ultramafic-mafic rocks, and structurally-controlled mineralisation on some of the many major structures in the area.

Exploration in South West Tasmania can be difficult and expensive, and programs need to be carefully thought out and focussed. Track cutting and clearing of vegetation is likely to be a necessary prelude to ground work in the western forested areas.

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[10 April 2003]

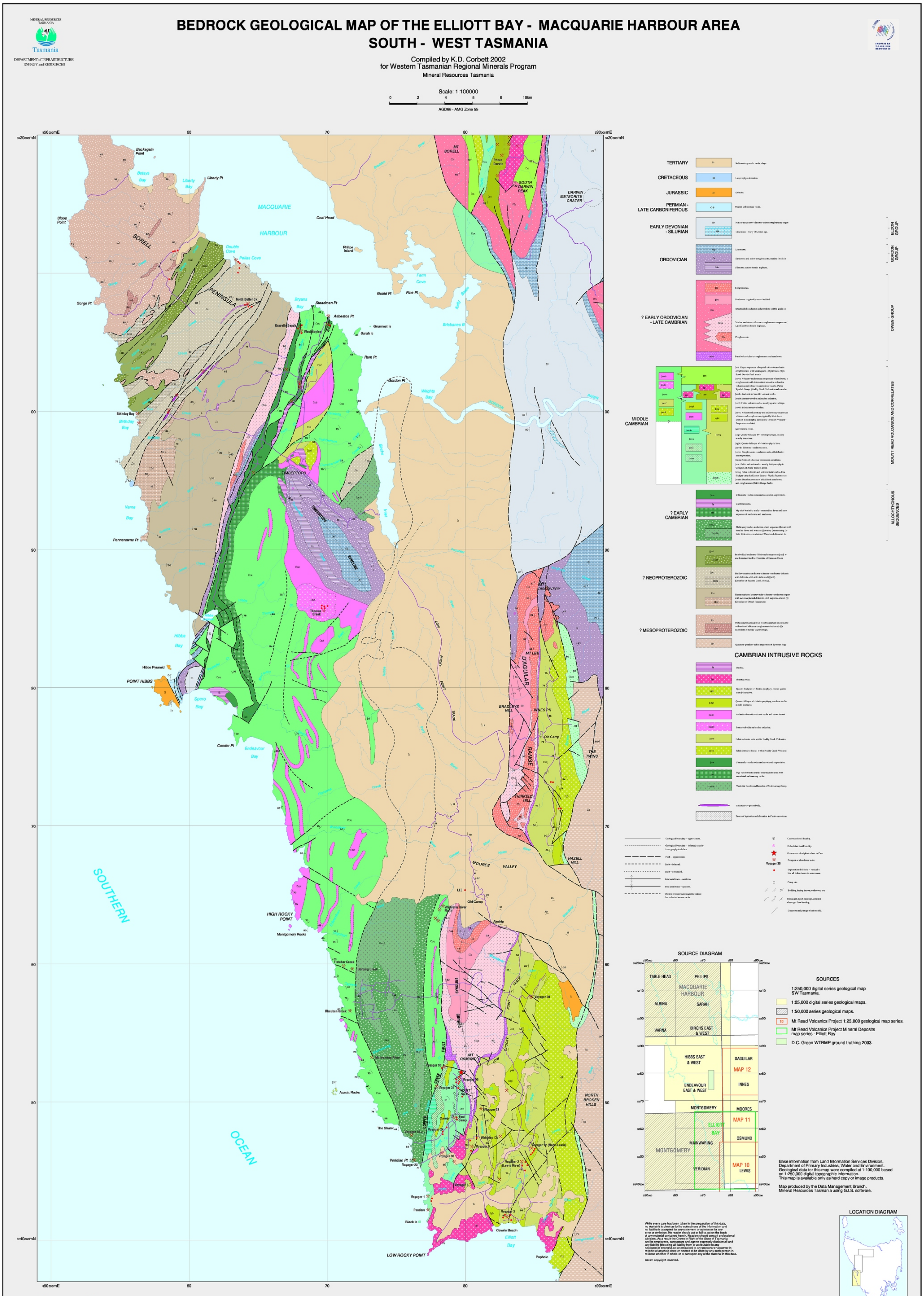
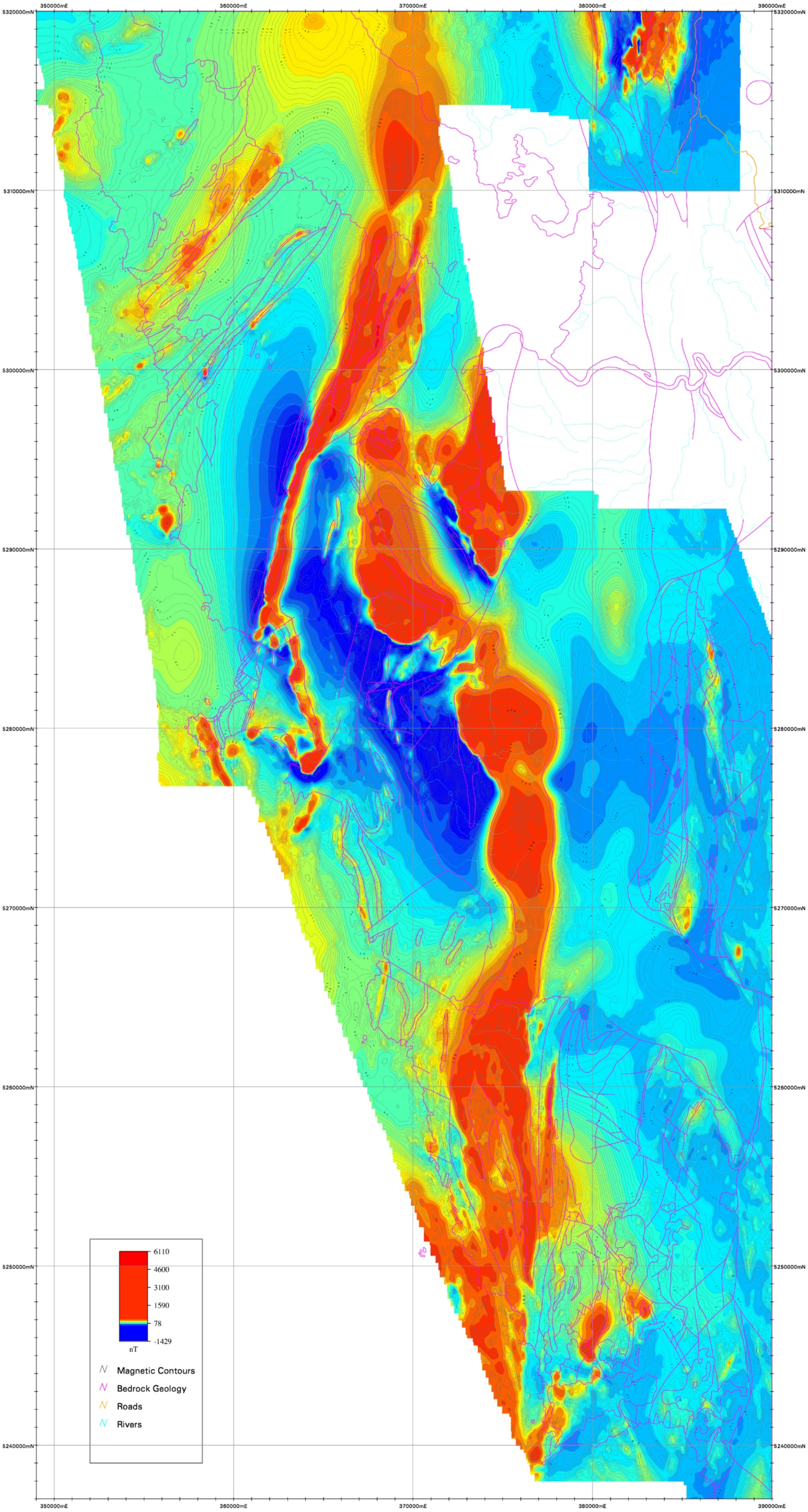

BEDROCK GEOLOGICAL MAP OF THE ELLIOTT BAY - MACQUARIE HARBOUR AREA
SOUTH - WEST TASMANIA
Compiled by K.D. Corbett 2002
for Western Tasmanian Regional Minerals Program
Mineral Resources Tasmania
Scale: 1:100000
0 2 4 6 8 10km
AGD66 - AMG Zone 55
Tasmania
TERTIARY
CRETACEOUS
JURASSIC
PERMIAN - LATE CARBONIFEROUS
EARLY DEVONIAN - SILURIAN
ORDOVICIAN
? EARLY ORDOVICIAN - LATE CAMBRIAN
MIDDLE CAMBRIAN
? EARLY CAMBRIAN
? NEOPROTEROZOIC
? MESOPROTEROZOIC
CAMBRIAN INTRUSIVE ROCKS
ELDON GROUP
GORDON GROUP
OWEN GROUP
MOUNT READ VOLCANICS AND CORRELATES
ALLOCHTHONOUS SEQUENCES
MACQUARIE HARBOUR
SORELL PENINSULA
SOUTH DARWIN PEAK
DARWIN METEORITE CRATER
TIMBERTOPS
MT DISCOVERY
DAGUILAR RANGE
MT LEE
BRADLEYS HILL
INNES PK
THIRKELL HILL
HAZELL HILL
MOORES VALLEY
HIGH ROCKY POINT
POINT HIBBS
NORTH BROKEN HILLS
LOW ROCKY POINT
SOUTHERN OCEAN
SOURCE DIAGRAM
SOURCES
LOCATION DIAGRAM
Plotfile generated 13-MAY-2003

Figure 2



WESTERN TASMANIAN REGIONAL MINERALS PROGRAM
South West Tasmania
Total Magnetic Intensity

Scale: 1:100000

0 2 4 6 8 10km

AGD66 - AMG Zone 55.
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MINERAL RESOURCES TASMANIA
Tasmania
DEPARTMENT of INFRASTRUCTURE ENERGY and RESOURCES

INDUSTRY TOURISM RESOURCES

Figure 3

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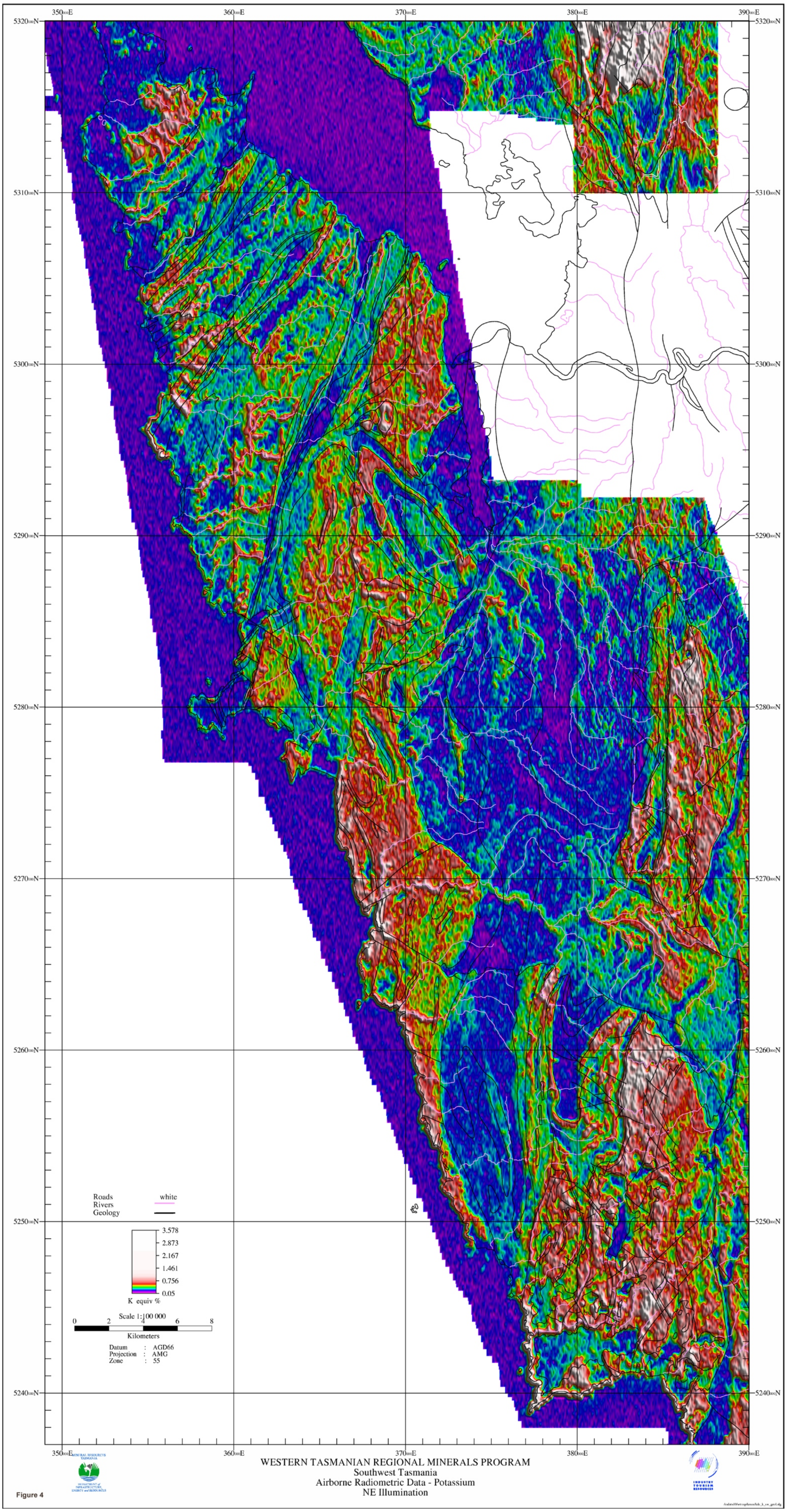
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2.167
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K equiv %
Scale 1:100 000
0 2 4 6 8
Kilometers
Datum : AGD66
Projection : AMG
Zone : 55
MINERAL RESOURCES TASMANIA
DEPARTMENT of INFRASTRUCTURE, ENERGY and RESOURCES
WESTERN TASMANIAN REGIONAL MINERALS PROGRAM
Southwest Tasmania
Airborne Radiometric Data - Potassium
NE Illumination
INDUSTRY TOURISM RESOURCES

Figure 4