

Tasmanian Geological Survey Record 2000/02



Field excursion guide notes for the Roger, Sumac and Dempster digital 1:25 000 scale geological map sheets, northwestern Tasmania

by J. L. Everard, A. R. Reed, M. P. McClenaghan and D. B. Seymour

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The Roger, Sumac and Dempster 1:25 000 scale map sheets cover an area between Balfour and Trowutta in northwestern Tasmania (fig. 1). This report is a brief field guide to some of the more important exposures in this area.

The regional geological setting of the area is given in Figure 1, with a composite stratigraphic column given in Figure 2.

1: Black River

Unconformity between Rocky Cape Group and Togari Group (357 240 mE, 5 476 740 mN)

This introductory location is at the northeastern margin of the Smithton Synclinorium, outside the Roger–Sumac–Dempster map sheets. This location contains the best-known exposure of the unconformity between the basal unit (Forest Conglomerate and Quartzite) of the late Neoproterozoic Togari Group and the underlying Cowrie Siltstone of the ?Mesoproterozoic Rocky Cape Group (Plate 1).

The Forest Conglomerate and Quartzite is not always present, but here it comprises a siliceous boulder conglomerate containing commonly angular clasts of laminated or massive quartzite up to 0.5 m in diameter, fining upwards into a sequence of quartzarenite with common cross-bedding and minor conglomerate. Considerable erosion is evident at the contact, but the maximum discordance

recorded locally is about 22°. The contact is also strongly erosional at other localities around the margin of the Smithton Synclinorium, but is commonly concordant or with a maximum discordance of less than 10°. Regional geological mapping since the early 1980s has confirmed that the basal units of the Togari Group rest on different stratigraphic levels of the Rocky Cape Group basement at various points along the contact.

The unconformity may represent a period of gentle regional folding of the Rocky Cape Group prior to Togari Group deposition. If so, this early compressional deformation may be a distal effect of the major tectonothermal event at c. 760 Ma which affected ?Mesoproterozoic rocks on King Island (Wickham Orogeny, Turner *et al.*, 1998). However, if normal faulting accompanied Neoproterozoic extension and the onset of Togari Group sedimentation, then deposition into a graben was likely to be accompanied by erosion of topographically upstanding blocks of Rocky Cape Group rocks.



Plate 1

*Unconformity between the Rocky
Cape Group and Togari Group,
Black River*

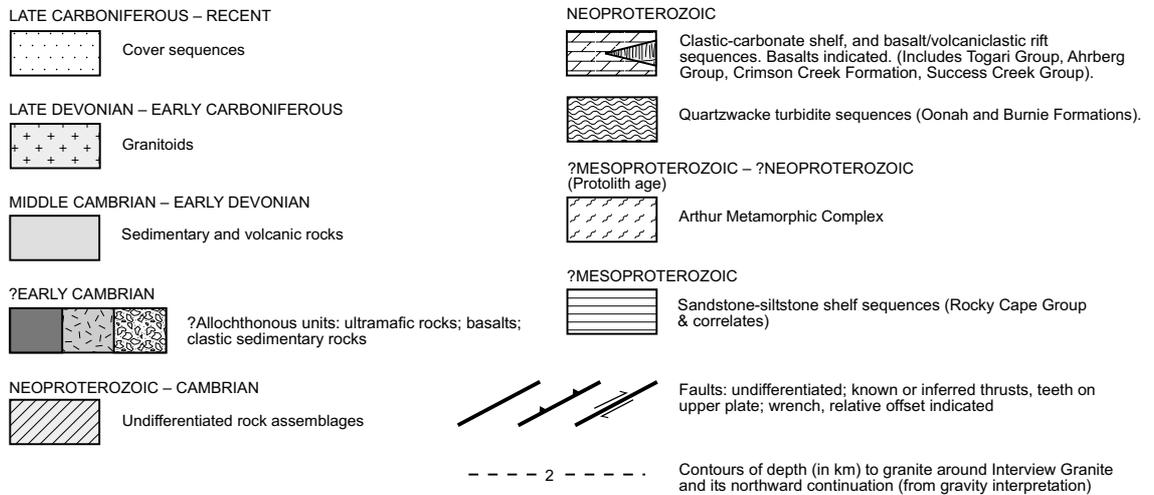
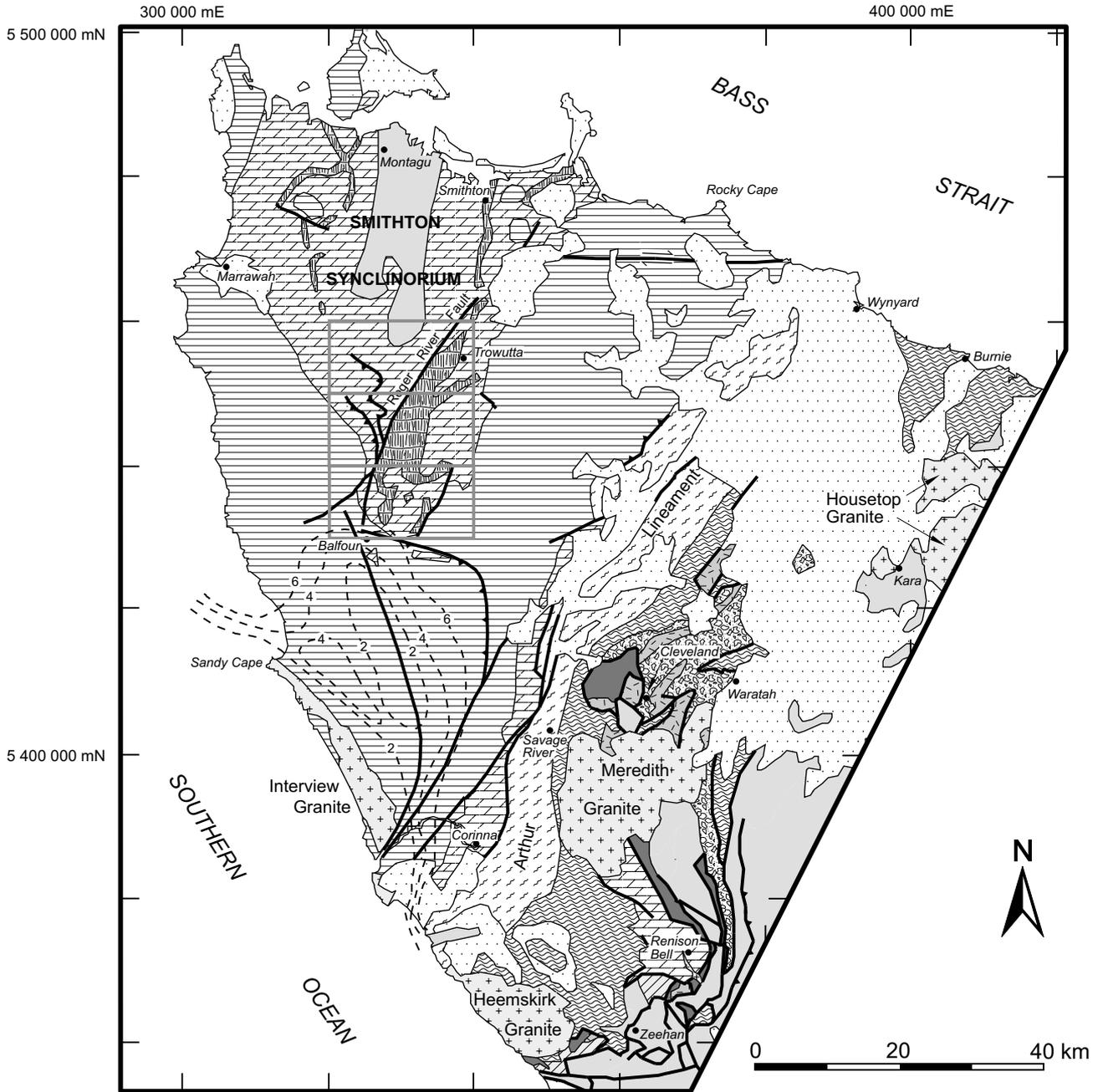


Figure 1

Regional setting of the Roger–Sumac–Dempster 1:25 000 scale geological map sheets.
 Geology adapted from Seymour and Calver (1995), with modifications from Leaman and Richardson (1992),
 Everard et al. (1996) and McClenaghan and Seymour (1996).

Juxtaposition of Togari Group sedimentary rocks with different levels in the Rocky Cape Group stratigraphy might therefore be a consequence of coincident erosion of the Rocky Cape Group during Togari Group deposition. Although the angular unconformity between the Rocky Cape and Togari Groups might be attributed to compressional deformation, it might also be the product of block rotation or 'roll-over' of hanging-wall strata above non-planar extensional faults. The irregular distribution of the basal conglomerate, and the predominance of quartzite pebbles contained within this unit, are consistent with basin compartmentalisation by normal faulting early during Togari Group deposition.

2: Quarry exposure of the Salmon River Siltstone

Unit Psr of the Togari Group (331 350 mE, 5 457 620 mN)

The Salmon River Siltstone is the uppermost formation of the Togari Group, and is a new unit first recognised during mapping of the Roger and Sumac map sheets. It is apparently confined to the southern part of the Smithton Synclinorium west of the Roger River Fault and reaches a thickness of about 350 m on the Roger and Sumac map sheets. The formation is poorly exposed on the lower slopes of the southern part of the Christmas Hills, but it is believed to rest conformably on the Smithton Dolomite, which is mostly covered by Quaternary alluvium in the low ground of Montagu Swamp and Junction Plain south of the Christmas Hills. It is overlain unconformably by the late Middle - early Late Cambrian Scopus Formation, which forms the higher parts of the Christmas Hills. The best exposures of the unit are found in roadcuts and quarries.

The rock type in the quarry is a pale grey to pale green-weathering, well-bedded finely laminated silicified siltstone with thin mudstone interbeds. In thin section a sample from this locality contains abundant small quartz grains (≤ 0.03 mm) set in a fine-grained siliceous matrix with fine opaque grains and mica flakes. Bedding lamination is present and fine quartz veining is common.

Sparse small (≤ 2 mm) oval or rod-shaped structures are present, and consist of an outer zone of microcrystalline quartz and inner zone of fibrous quartz or translucent brown cryptocrystalline (?phosphatic) material. These structures may represent some organic body in different orientations, possibly the thin section equivalents of a single small microfossil recovered from this quarry, and which was provisionally identified as the remains of a phosphatic brachiopod of possible Early or Middle Cambrian age (J. R. Laurie, Australian Geological Survey Organisation, pers. comm., 1996, 1998). This suggested age is consistent with data from another good exposure of the Salmon River Siltstone in a

quarry at 319 120 mE, 5 453 220 mN near the eastern margin of the Bluff 1:25 000 scale map sheet (west of the Sumac sheet), where recovered fossils included two species of inarticulate brachiopods, a few cruciform stauract sponge spicules, and elliptical blobs ~20 mm in diameter which may be sponge bodies (J. B. Jago, University of South Australia, pers. comm., 1999).

Away from the quarries and roadcuts, the formation has been mapped based on the presence of a pale grey sandy soil with abundant small angular chips of pale grey to white silicified siltstone. This soil and float type contrasts with the rich red-brown soil and siltstone-sandstone fragments found in the areas of the overlying Scopus Formation.

3: Scopus Formation (Unit Cm)

(331 300 mE, 5 458 000 mN)

The Scopus Formation underlies the higher areas of the Christmas Hills and is generally poorly exposed and very weathered, with outcrops confined to creeks and road cuttings. Elsewhere the unit was mapped on the basis of float and the presence of a rich red-brown soil. The formation rests unconformably on the Salmon River Siltstone, and consists of red-brown weathered, polymict lithic conglomerate, lithicwacke and siltstone-mudstone. It is generally well bedded and contains a marine fossil fauna of late Middle Cambrian age at 331 200 mE, 5 467 900 mN and early Late Cambrian age at 333 mE, 5 480 600 mN, in the northern part of the Christmas Hills to the north of the Roger map sheet.

The best exposures of conglomerate on the Roger map sheet, although very weathered, occur at this location, where the conglomerate contains rounded pebbles up to 50 mm in diameter.

The freshest rock occurs in small creeks draining east near 332 480 mE, 5 458 890 mN. In thin section, samples from this area are poorly sorted lithic sandstone and siltstone. Lithic clasts include fine-grained mudstone of various types, serpentinite, sparse fine-grained felsic lava, quartzite and chert. Monomineralic clasts include quartz, opaque mineral and rare plagioclase. The clasts are subangular to subrounded.

More complete exposure of the Scopus formation occurs on the north coast at Stony Point (Seymour and Baillie, 1992), where two lithofacies associations have previously been recognised. These are a thin-bedded association of fine or very fine-grained sandstone, siltstone and mudstone, and a coarse-grained association of thick-bedded coarse to very coarse-grained sandstone, pebbly sandstone and granule conglomerate (Baillie and Jago, 1995). The rocks are considered to have been deposited within a submarine basin-floor turbidite-fan complex. Palaeocurrents from both associations are north-directed.

The rocks in the vicinity of this locality dominantly belong to the coarse-grained association, and are distinguished from those to the north by having a much larger component of ultramafic-derived detritus in the form of conspicuous clasts of serpentinite. The nearest outcropping Early Cambrian ultramafic body which could have supplied such clasts to the Christmas Hills area is at Heazlewood River, 55 km to the southeast (Brown, 1989b). Most of the ultramafic-derived component in the rocks of the southern Christmas Hills, compared to those at Stony Point, together with the palaeocurrent directions, suggest a source to the southeast.

4: Contact between the Scopus Formation and Salmon River Siltstone

(329 500 mE, 5 456 600 mN)

Structural information in the vicinity of this location is scant because of poor outcrop and deep weathering of the Salmon River and Scopus Formations. Only bedding readings were recorded.

The mapped distribution of the Salmon River and Scopus Formations indicates that the boundary between them is gently dipping. The geometry of the boundary relative to bedding attitudes of Salmon River Formation rocks near the boundary suggests an unconformity at the base of the Scopus Formation. This is best seen at this location, where low roadside outcrops show a difference in bedding attitude above and below the contact between the Salmon River Siltstone and the Scopus Formation.

5: Spinks Creek Volcanics (Unit Pkb)

(330 600 mE, 5 446 400 mN)

Fresh basalt of the Spinks Creek Volcanics (the major volcanic unit within the Kanunnah Subgroup of the Togari Group) is exposed near Kanunnah Bridge, both in the Arthur River and in roadcuts. North of the bridge the basalt is generally massive, with some basaltic breccia in places. South of the bridge the outcrops are more weathered and include a greater proportion of fragmentary basaltic material. The volcanic rocks are probably about one kilometre thick, but thin to 150 m or less west of the Roger River Fault, suggesting that it may have been a west-side up normal fault against which the basalts ponded at the time of volcanism.

Nye *et al.* (1934) correctly established the stratigraphy of what is now termed the Togari Group, except that they thought the basalt was a younger, Devonian dolerite dyke. Carey and Scott (1952) recognised the extrusive nature of the basalt, on criteria including the local presence of pillows (as on the Smithton foreshore) and amygdaloids, although minor subvolcanic intrusions have now been identified (see Location 20). However they correlated the Black River Dolomite and Smithton Dolomite, a source of confusion for more than thirty years.

The age of the basalt is probably best constrained by the 750–650 Ma and 580–545 Ma isotope chemostratigraphic estimates on the enclosing Black River Dolomite and Smithton Dolomite respectively (Calver, 1998). These estimates are broadly consistent with three K-Ar dates (584 to 600 Ma) on dolerite dykes of the Rocky Cape Dyke Swarm (Adams *et al.*, 1985), which have been suggested as feeder dykes to the volcanic rocks. Detailed geochemical studies of the dykes suggest that many are crustally contaminated and do not support more than a general relationship with the volcanic rocks. Attempts to date the volcanic rocks directly have so far been unsuccessful.

Recent geochemistry has identified up to seven basalt suites in the Spinks Creek Volcanics (fig. 3), principally on the basis of TiO₂ content and Nb/Zr ratios. The majority of suites are low-K tholeiites and contain small plagioclase, clinopyroxene and sometimes altered olivine phenocrysts, in a groundmass weakly metamorphosed in the prehnite-pumpellyite, or less commonly greenschist facies. Chlorite is a common alteration mineral, filling amygduloids or occurring as fine-grained alteration of clinopyroxene or plagioclase phenocrysts.

Each suite probably represents a different degree of batch partial melting of mantle, but Nb/Zr and rare earth element data suggest that more than one mantle source was involved. The suggested broad correlation with the Crimson Creek Formation basalts near the Pieman River is probably still valid, although individual suites cannot be matched. The volcanic rocks were erupted onto a thin continental crust in an extensional, probably intraplate tectonic setting.

Hematitic ironstone occurs in a position which structural data suggest is the boundary between Kanunnah Subgroup sedimentary rocks and the base of the basalt sequence, near Ekberg Creek at 331 800 mE, 5 449 500 mN and 332 200 mE, 5 450 500 mN. Strong hematitic alteration of the basalt, apparently at the top of the volcanic sequence, occurs at 328 460 mE, 5 443 390 mN just north of Stephens Rivulet. Native copper mineralisation has been recorded at numerous localities (e.g., 332 300 mE, 5 448 500 mN; 332 150 mE, 5 448 800 mN; 321 000 mE, 5 444 550 mN) in the volcanic rocks, generally as very sparse disseminations or thin fracture linings, and whole-rock analyses indicate up to 590 ppm Cu (50 to 100 ppm being typical of basalts in general).

6: Julius River Member (Unit Pbr), Julius River tributary

(334 240 mE, 5 441 800 mN)

This distinctive unit of massive open framework diamictite occurs towards the top of the Black River Dolomite. It is about 200 m thick, but like the remainder of the Black River Dolomite thins markedly west of the Roger River Fault. It is very poorly sorted and consists of subangular to subrounded clasts of dolomite (including stromatolitic fragments) and chert

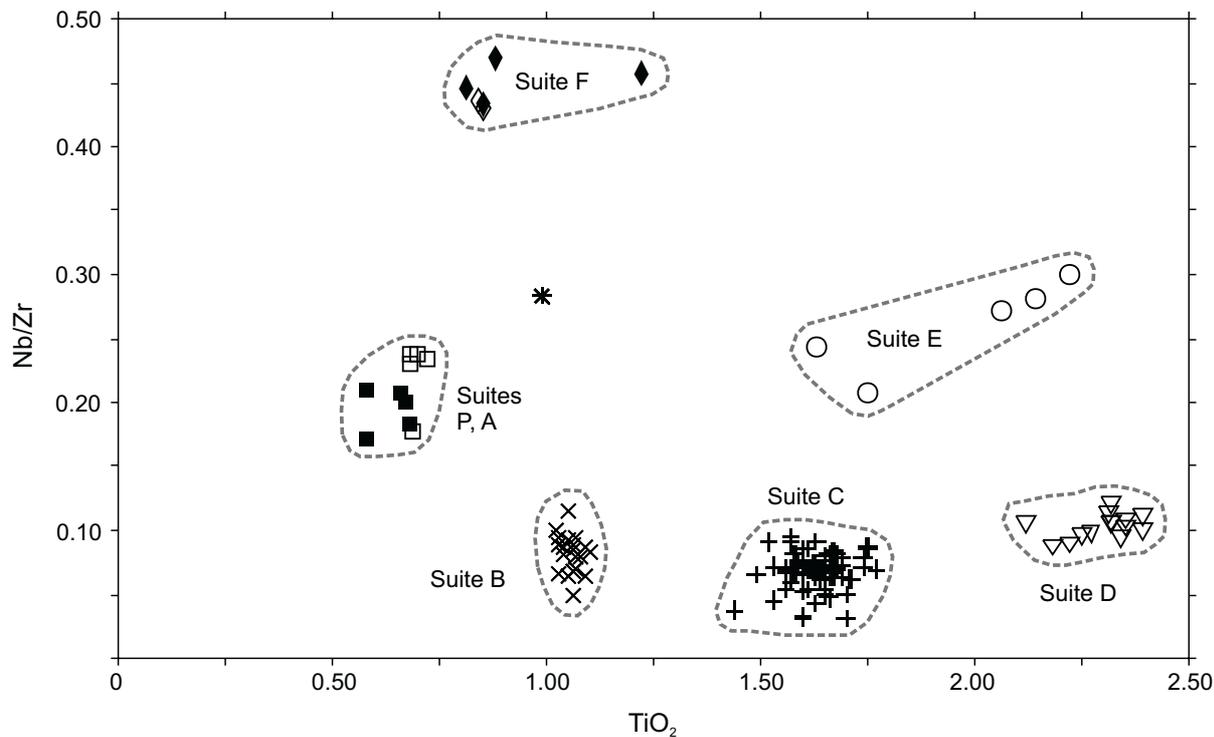


Figure 3

Nb/Zr-TiO₂ plot for Spinks Creek Volcanics

in a mainly dolomitic matrix. The presence of chert indicates that at least some of the silicification of the Black River Dolomite was very early, possibly diagenetic. Calver (1998) has shown that a negative δC^{13} excursion in the diamictite, relative to the underlying dolomite, is present, and suggests a correlation with the Sturtian glacials of the Adelaide Geosyncline (although sedimentological evidence is inconclusive). If the remainder of the Black River Dolomite is correlated with the lithologically and isotopically similar Skillogalee Dolomite (which contains similar stromatolites), a significant disconformity must be present at the base of the Julius River Member, as equivalents of the 2-3 km thick upper Burra Group are absent in Tasmania.

**7: Croles Hill Mixtite (Unit Pkx),
Sumac 3 Road**
(336 260 mE, 5 441 330 mN)

This is one of the constituent units of the Kanunnah Subgroup, generally occurring immediately below the basalt of the Spinks Creek Volcanics. It is typically a massive, unbedded, very poorly sorted, frequently very tough, dark blue-grey to green basaltic diamictite, containing 20 to 80% granule to pebble-sized (and less often cobble to small boulder-sized) clasts. The clasts are angular, often irregularly shaped, generally outweathering and conspicuous.

Mesoscopic observations and thin section studies show that basalt is the most common clast lithology and displays a wide variety of grain size, texture and alteration states, even at thin section scale. The basalt clasts are generally fine grained and similar to, or more

leucocratic than, typical basalts from the Spinks Creek Volcanics. None show glassy margins or any evidence for hyaloclastic fragmentation.

Felsic volcanic (rhyolite?) clasts are the second most abundant clast type. These are aphyric or very sparsely plagioclase-phyric and may be very fine grained and featureless. More commonly they display a well developed spherulitic 'snowflake texture', and some show well developed flow banding. Their source is problematic, as no similar rocks are known *in situ* in the region. One thin section from near this locality contains a clast of a typical snowflake-textured felsic volcanic rock which partly encloses an inclusion of basalt. The boundary between the two is welded and clearly an igneous contact. There is no sign of either magma mixing or chilling of one magma against the other, but the geometry suggests that the felsic magma incorporated a small accidental inclusion of already solidified basalt, possibly from the wall-rock of a vent. It therefore seems likely that the felsic volcanism is local and roughly coeval with the basalt, and may represent minor crustal melting induced by voluminous continental rift basaltic volcanism.

Other clast lithologies include fine to coarse-grained recrystallised dolomite and carbonaceous and calcareous mudstone (resembling lithologies in the Black River Dolomite), fine-grained sedimentary rocks including laminated siltstone and fine-grained wacke (resembling the Keppel Creek Formation), rare fine-grained white or black chert, rare gabbro and possible picrite. Monomineralic grains of plagioclase, clinopyroxene and carbonate (dolomite?), irregular opaque (magnetite?) aggregates and occasional

chromite may be present. Quartz-rich clastic sedimentary rocks, such as those dominating the Rocky Cape Group, are conspicuously absent, and single grains of quartz are rare and of possibly volcanic origin.

The matrix of the diamictite usually consists of fine-grained basaltic material (mostly plagioclase fragments) grading down to an extremely fine-grained unresolvable low birefringence material. Primary matrix carbonate is absent in nearly all samples, in contrast to the matrix of the Julius River Member of the Black River Dolomite.

A possible interpretation of the Croles Hill Mixtite is a glacial diamictite (tillite), but the lack of any clearly extrabasinal clasts suggests a mass-flow deposit in an unstable, rapidly subsiding basin. Although it tends to occur stratigraphically below the basalt, the abundance of basaltic clasts in the mixtite indicates that it is coeval with at least the early stages of volcanism. Instability and rapid subsidence may have foreshadowed the onset of volcanism.

8: Black River Dolomite chert (Unit Pbdc), Rapid River quarry (339 840 mE, 5 440 770 mN)

A variety of lithologies exposed in this quarry include very fissile thinly laminated shale and massive to blotchy or banded chert, characteristic of the more silicified parts of the Black River Dolomite.

In large tracts of the Black River Dolomite, the presence of the rock type is indicated only by an abundant cherty lag. In stream outcrops the dominant lithology is usually dolomite, with chert, siltstone and mudstone occurring mostly as thin interbeds. A drill hole at Forest, near Smithton (Brown, 1989a), encountered very little chert in a thickness of about 300 m of dominantly carbonate rocks. Thus the extensive surficial chert lag is probably derived from only thin, but highly resistant, beds of a dominantly carbonate succession.

9: Unconformity at base of Togari Group, Rapid River bridge (340 500 mE, 5 442 090 mN)

At this location, pale-coloured, rather flaggy, well-bedded quartzite (probably a quartzose and/or silicified variant of the Cowrie Siltstone) is folded into an open anticline. Ripple marking is present on bedding planes at one point. High up on the river bank the quartzite is overlain by a breccia up to a few metres thick consisting of angular, pebble to small boulder-sized quartzite clasts in a pale, also very silicified matrix. The contact with the underlying folded quartzite is sharp but irregular and transgressive to bedding, and represents the unconformity at the base of the Togari Group. The breccia is atypical of the Forest Conglomerate in the angularity of its clasts. It may have been formed by the

more-or-less *in situ* disaggregation of the underlying quartzite, with little lateral transport, followed by recementation and silicification. It is overlain by peaty soil containing chert granules, probably representing lag from Black River Dolomite-derived chert.

Typical unsilicified Black River Dolomite crops out less than 150 m away, on the left bank of the Rapid River immediately downstream from the bridge (340 400 mE, 5 421 900 mN), and in Lamprey Creek (340 510 mE, 5 442 010 mN).

10: Base of Togari Group, Lamprey Creek (340 100 mE, 5 440 460 mN)

At this locality both pale grey-green silicified Cowrie Siltstone ('quartzite') and the overlying Black River Dolomite (here unsilicified) dip gently west. In contrast to the exposure at Black River, the Forest Conglomerate and Quartzite is absent, and the contact is a disconformity or very low angle unconformity. At one locality the contact can be straddled in the creek, with 'quartzite' on the right bank and dolomite on the left.

11: Folding in Black River Dolomite chert (Unit Pbdc), Dempster Lookout (338 000 mE, 5 437 800 mN)

At this locality the gentle folding and lithologies in chert derived from the Black River Dolomite can be examined. Stromatolitic fragments have been found in white chert float in the vicinity.

12: Silicified Cowrie Siltstone (Unit Prcs) with anhydrite clasts, Sumac Road (337 570 mE, 5 437 260 mN)

Fine-grained 'quartzite' probably represents silicification of the Cowrie Siltstone close to the unconformity with the Black River Dolomite, perhaps associated with partial early diagenetic chertification of the latter. Small (5 mm) rod-shaped structures on bedding planes were at first thought to be possibly organic, but are now interpreted as anhydrite clasts, suggesting a locally shallow and evaporitic depositional environment for the Cowrie Siltstone.

13: Structures associated with a major east-directed thrust in the Rocky Cape Group, Waratah Creek bridge on Heemskirk Road (327 400 mE, 5 424 800 mN)

Regional setting

The locality where the Heemskirk Road crosses Waratah Creek coincides with a major fault above which Rocky Cape Group rocks have been thrust northeast. This fault is the southern continuation of a

north to northwest-trending corridor of thrust faults on the Dempster map sheet that separate predominantly steeply east-dipping Balfour Subgroup rocks in the west from only gently-folded Cowrie Siltstone and Togari Group rocks further east.

The fault at this location strikes north and passes to the east of Mt Frankland (the first big hill to the north). The fault separates east-facing and steeply dipping upper Balfour Subgroup siltstone from open-folded Balfour Subgroup or Cowrie Siltstone to the east.

Folds and cleavage to the west of the Waratah Creek thrust dip west and strike north and are continuous with the northwest-trending fold belt situated west of the Frankland River on the Dempster map sheet. Structures of the same age to the east of the fault trend northwest-southeast, oblique to those west of the fault. The fault is the same age as the northwest-trending folds, and is interpreted to link with similarly north and northwest-striking faults hosting mineralisation in the Balfour mineral field.

In outcrop

In outcrop, the fault appears as a highly foliated and moderately veined schist. Elongate ovoid porphyroblasts of D₂ age are recognisable in hand-specimen from the creek but are flattened into the prominent S₃ foliation (Plate 2). These rocks are, at least in part, mylonitic, with tails to rotated clasts and S-C fabrics (both apparent in thin section only) indicating reverse movement. In higher-strain rocks where bedding is not apparent, C-C' fabrics or ultramylonites dominate. There is also an overprinting S₄ crenulation cleavage, the formation of which may have accompanied fault reactivation.

Regional significance

The age of the last major deformation on this fault is well constrained relative to granite intrusion.

Pseudohexagonal porphyroblasts of chlorite and tourmaline (possibly after cordierite) overprint flattened D₂ porphyroblasts, but are also weakly deformed by the S₃ cleavage, indicating a syn to late-D₃ age for intrusion of the granites (Plate 3). Brecciated tourmaline is also present as rotated clasts within D₃ mylonites. The nearest outcropping granite (Interview Granite) at Sandy Cape has recently yielded a preliminary U-Pb age of 362 ± 2 Ma (L. P. Black, Australian Geological Survey Organisation, pers. comm. 1999), making D₃ Devonian in age.

14: Tertiary gravel channel fill, Heemskirk Road (324 030 mE, 5 427 150 mN)

Much of the subdued topography in the area west of the Frankland River on the Dempster map sheet has resulted from Tertiary erosion. The area is commonly covered by a veneer of gravel and clay that complicates interpretation of regional radiometric data.

Tertiary channels, such as that shown here, are not commonly so well exposed, this channel being somewhat unusual in that its margins are defined by erosion-resistant silicified talus deposits comprising poorly-sorted angular quartzite and shale clasts in a sandstone matrix. This channel likely drained the slopes of Mt Frankland and Mt Balfour during the Tertiary. The channel trends northeast and coincides with the Frankland River below Balfour, and appears to have controlled the Tertiary basalt flows upon which Balfour is situated.

Other than complicating the interpretation of geophysical data, these channels are of little direct importance to mineral exploration. There is, however, scope to combine Tertiary palaeocurrent data with palaeostream sediment sampling to provide vectors to mineralisation in a terrane where existing drainage patterns are otherwise poorly defined.



Plate 2

Porphyroblasts of D₂ age flattened into the S₃ foliation (parallel to the long axis of the photo, which covers an area of 4.4 × 3.0 mm).

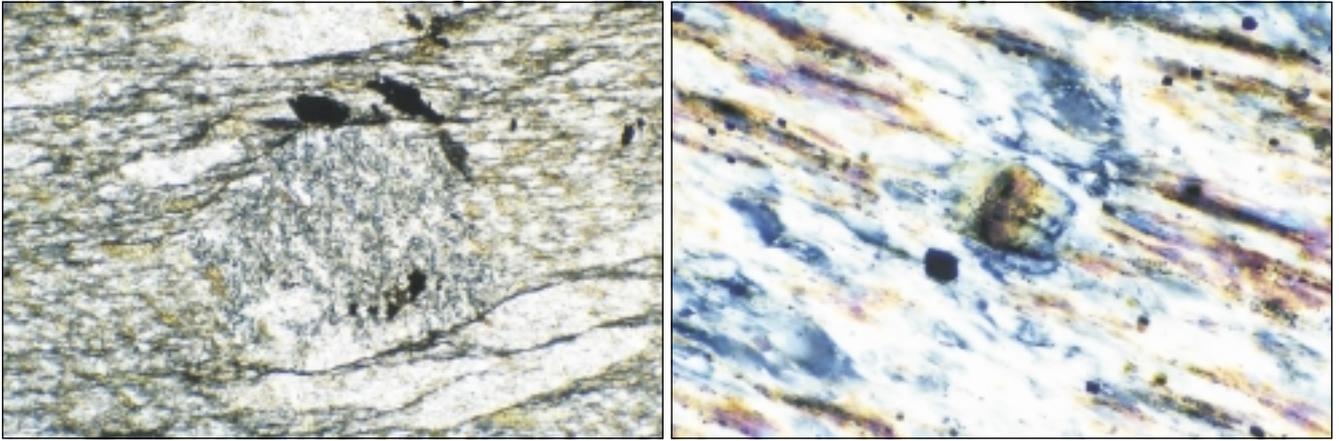


Plate 3

Photomicrograph of porphyroblast of chlorite, possibly after cordierite, and tourmaline overgrowing but also deformed by the S₃ foliation (left hand photograph – 1.8 × 1.2 mm). Tourmaline is also caught up within D₃ mylonite zones (right hand photograph – 0.28 × 0.18 mm) demonstrating a syn-D₃ timing for the introduction of granitic fluids.

15: Sedimentary structures in 'pyjama siltstone' of the Balfour Subgroup, Balfour access track (324 000 mE, 5 429 800 mN)

This exposure is part of unit Prbls and was originally included in the unit informally named the Specimen Hill siltstone by Yaxley (1981). Its characteristic striped appearance in outcrop has also earned it the local name 'pyjama siltstone' (Veska, 1993).

Unit Prbls is about 500 m thick and comprises repeated light grey fine-grained siliceous sandstone to predominantly siltstone beds upwardly gradational to dark grey weakly carbonaceous to quartzitic siltstone. The lower contacts of stratum commonly exhibit lobate textures, possibly indicative of rapid deposition on an unconsolidated substrate. Deeply incised (up to 500 mm) and rounded, internally cross-bedded channels are also common (Plate 4), with individual channels undercutting underlying stratum.



compartmentalised sedimentary system, possibly influenced by syn-sedimentary growth faulting.

Although copper mineralisation at Balfour is hosted within compressional structures, its origin remains enigmatic. Could it be that deformation has remobilised copper from some, as yet, undiscovered syngenetic or diagenetic

Plate 4

Channels in Unit Prbls, otherwise known as 'pyjama siltstone'. Hammer for scale.

sediment-hosted deposit at depth? Syn-sedimentary faults are obvious conduits for fluids that could form such deposits.

16: Murrays Reward, Balfour Mineral Field

(324 500 mE, 5 429 500 mN)

History

The history and setting of many of the mineral deposits comprising the Balfour mineral field are presented in some detail in Veska (1993) and Turner (1994). Previous exploration activities have been summarised by Russell and Tear (1997).

Copper was first discovered in the banks of what was then called Tin Creek (now Cassiterite Creek) in 1901. Mining commenced at Murrays Reward in 1910, with this and the Central Mt Balfour mine (located 300 m to the NNW) being the only operations producing any significant quantities of ore. The total ore mined from the Murrays Reward and Central Mt Balfour mines was 6,380 tons at a grade of between 12 and 35% Cu. Only the richest portions of the orebody were removed, as the ore was processed off-site and had to be transported to the coast via a horse-drawn tram.

Production ceased in 1917 despite plans to construct a mill to concentrate the ore. Dwindling finances, a typhoid epidemic, and the onset of World War I all contributed to the demise of copper mining at Balfour. Over 800 people once resided in Balfour, but today only a few shacks remain.

The workings at Murrays Reward include three adits with associated drives and crosscuts, costeans, shafts, trenches, and an open cut approximately 50 m long, 15 m wide and 5 m deep.

Wall rock alteration is only weakly developed and includes silicification, chloritisation and sericitisation.

The mineralogy of the cupriferous lode is fairly simple and mainly consists of chalcopyrite and pyrite, quartz and dolomite (mostly leached) with minor galena, sphalerite and pyrrhotite. Rich ore pockets, consisting mainly of covellite and digenite, are the common products of supergene alteration of chalcopyrite, and are common near the surface at Murrays Reward.

Thirteen diamond-drillholes were drilled by Australian Consolidated Industries Ltd (ACI) beneath the Murrays

Reward and Central Mt Balfour Mines in 1972, and delineated a zone of mineralisation $220 \times 220 \times 7$ m (0.5 Mt at 0.8% Cu). Unfortunately no core from this drilling remains, being used as road-fill soon after completion of the program.

In 1997 Rio Tinto drilled three holes in order to test for a large size, disseminated copper ore body at Murrays Reward prospect. Mineralised zones containing up to 5.4% Cu were intersected. The mineralised rocks appear to be also anomalous in tin and values up to 276 ppm have been reported (Russell and Tear, 1997).

Structural setting of Murrays Reward

The Murrays Reward and Central Mt Balfour mines lie on a northwest-trending and steeply west-dipping fault, part of what was previously referred to as the 'Balfour Transform' and is here referred to as the Balfour Fault. This fault is of D₃ age and places lower Balfour Subgroup coarse to medium-grained units over younger chloritic siltstone units. The fault appears as a 20 m silicified and brecciated zone separating contrasting rock types in the lower reaches of Cassiterite Creek.

The Balfour Fault strikes northwest and dips 80°W at the Murrays Reward mine (Plate 5). The cupriferous fault exposed in the southern end of the Murrays Reward pit is a hanging-wall splay and dips east. Quartz fibre growth in veins and on thrust surfaces consistently indicate reverse movement. The fault continues south of Murrays Reward for several hundred metres before being lost. Only one hole has been drilled in this area, returning 3.1 m at 2.1% Cu.



Plate 5

View of southern end of excavation at Murrays Reward Mine. East-dipping reverse fault separates hanging-wall chloritic siltstone from footwall carbonaceous shale. The face is about five metres high.

The location of the Murrays Reward and Mt Balfour mines coincides with increasing discordance between the Balfour Fault and stratigraphy, with the strike of Balfour Subgroup units, south of the Murrays Reward mine, swinging west to intersect the Specimen Hill Fault. The Specimen Hill Fault is also a northwest-trending thrust fault, which together with the Balfour Fault is interpreted to link with a sole structure at depth, possibly the thrust emergent at Waratah Creek (Location 13).

The main lode varied between one and three metres thick, with the main orebody inferred to be a southerly pitching shoot (Ward, 1911). This orientation roughly matches that defined by the intersection of the Balfour Fault with the stratigraphy as it changes strike further south.

The origin of the copper at Murrays Reward and other deposits of the Balfour mineral field remains somewhat enigmatic. Sulphur isotope data from sulphides at Murrays Reward range between 14‰ and 18‰, too high to be of igneous origin. Murrays Reward is anomalous in Sn (e.g. 274 ppm), suggesting a genetic link to the Sn-rich mineralisation at Specimen Hill. Veska (1993) proposed a model whereby the copper is of granitic origin, with both copper and tin forming part of a zoned system. Sulphur data were explained as a mixing between igneous and sedimentary sulphur. Both Veska (1993) and Turner (1994) also noted that the regional uniformity of Cu mineralisation was in stark contrast to the localised Sn mineralisation at Specimen Hill. Turner (1994) further concluded that another, as yet unidentified source, for the Cu remained a possibility.

A project investigating the possible origins of the mineralisation is currently underway by Mineral Resources Tasmania.

17: Specimen Hill, Balfour Mineral Field

(324 000 mE, 5 428 500 mN)

The Specimen Hill Sn-W prospect is located about 400 m southwest of Murrays Reward, adjacent to a northwest-trending fault of inferred D₃ age. The mineralisation mainly occurs as thin, 10 to 100 mm wide veins consisting of quartz + cassiterite ± wolframite ± sulphides. The sulphide minerals mainly include pyrite, arsenopyrite and chalcopyrite. Several vein types exhibiting different mineralogy or strikes have been identified in the field. Individual veins may contain significant tin and tungsten contents (average 0.8% Sn and 1.02% WO₃), but the vein density appears to be very low (0.6%) and is also erratic (Dickson, 1983).

An alteration breccia on Specimen Hill comprises sheeted quartz-arsenopyrite-cassiterite-wolframite vein systems with tourmaline alteration in the northern part of the zone (Veska, 1993). The tourmalinised rocks contain up to 200 ppm Sn and 1000 ppm WO₃ (Langsford, 1982).

Vein-type tin mineralisation also occurs at Tatlow's prospect, located about one kilometre southeast of Specimen Hill. The lode is about 200–500 mm wide and consists of thin anastomosing quartz – pyrite – cassiterite ± wolframite ± arsenopyrite ± chalcopyrite, and is hosted by chloritic siltstone. Small lenses of quartz-cassiterite containing 30–70% cassiterite also occur in the lode. A bulk sample (300 kg) of the ore contained 29% tin (Langsford, 1982).

The Specimen Hill deposit coincides with the intersection of the northwest-trending Specimen Hill Fault with an approximately 200 m thick sandstone and siltstone package. This package belongs to the Balfour Subgroup and forms a prominent topographic ridge trending north away from Specimen Hill. This unit is folded into a steeply southeast-plunging anticline immediately east of the Specimen Hill Fault. The Specimen Hill deposit lies at the point south of which the relationship between stratigraphy and the Specimen Hill Fault is discordant.

The Specimen Hill Fault forms a prominent aeromagnetic anomaly. The source of this anomaly was identified as pyrrhotite in one of the diamond-drill holes inferred to have intersected the Specimen Hill Fault.

The source of the alteration and mineralisation at Specimen Hill, and possibly in other structures in the Balfour mineral field, is inferred to be a granite. The nearest granite outcrop is about 25 km to the southwest at Sandy Cape. However modelling of gravity data (Leaman and Richardson, 1992) suggests a north-trending spine of granite occurs at about two kilometres depth beneath the Balfour mineral field. This is the most likely source for the Sn-W mineralisation.

Evidence from thin section examination of fault rocks of D₃ age (see notes for Location 13) anchors the timing of granite-related alteration to late during the D₃ deformation. The Specimen Hill fault is D₃ in age and would have been an active structure during Sn-W mineralisation.

18: Mesoscopic faulting associated with one of the splays of the Roger River Fault and lamprophyre dykes, Heemskirk Road

(321 150 mE, 5 436 150 mN)

Roger River Fault splay

The Roger, Sumac and Dempster map sheets are bisected by the Roger River Fault, a regionally significant, steeply-dipping fault that now shows perhaps 800 to 900 m of west-side-down net offset (Everard *et al.*, 1996). Although the Roger River Fault was an active structure during at least two compressional deformations, there is stratigraphic evidence to suggest that this structure originated as an

extensional fault and formed the western boundary of a half-graben into which Togari Group sedimentary and volcanic rocks were deposited.

The Roger River Fault was reactivated during compressional deformation. However that part of the Roger River Fault which experienced extension cannot be traced with certainty west of the Frankland River. Instead, the extensional Roger River Fault has probably been folded into a north-south orientation and been reactivated as a thrust. West of the Frankland River, the northwest-trending anticline and thrust system is dissected in two localities by late-D₃ age continuations of the Roger River Fault. These segments are not part of the original extensional structure. They show both dextral and sinistral offsets of earlier structures and the stratigraphy, indicating their probable role as transfer faults during northeast-directed thrusting.

Lamprophyre dykes

Weathered pale grey-green to orange-coloured dykes occupy late-D₃ age splays of the Roger River Fault, both at this locality, further south along the Heemskirk road at 321 900 mE, 5 432 000 mN, and on the Temma coast at 306 850 mE, 5 430 850 mN.

The dykes are up to about one metre wide, foliated, faulted, variably silicified, and contain angular inclusions up to 200 mm wide of country rock. They are highly weathered at this locality (Plate 6). Thin sections reveal angular to pseudo-hexagonal and tabular phenocrysts to 3 mm in length of microcrystalline quartz after what was probably originally amphibole and ?feldspar, respectively. The phenocrysts are poorly preserved and commonly fractured, and rarely show remnant zoning. The matrix is mottled pale brown and cryptocrystalline.

<i>Majors (%)</i>		<i>Minors (ppm)</i>			
SiO ₂	60.7	Th	74	W	<10
TiO ₂	4.2	Sr	<5	Cu	43
Al ₂ O ₃	20.8	U	<10	Ni	75
Fe ₂ O ₃	0.1	Rb	<5	Sn	<9
FeO	0.0	Y	21	Pb	49
MnO	0.0	Zr	370	Nd	62
MgO	0.1	Nb	100	Ce	135
CaO	0.0	Mo	7	La	63
Na ₂ O	0.0	Cr	760	Ba	<23
K ₂ O	0.0	V	170		
P ₂ O ₅	0.1	Sc	16		
SO ₃	0.0	Co	9		
CO ₂	2.1	As	<20		
H ₂ O ⁺	10.9	Bi	<5		
TOTAL	99.1	Ga	28		
L.O.I.	13.0	Zn	27		

Geochemical analysis of the dyke at this locality (Table 1) suggests a lamprophyre.

Fresh dyke material crops out on the coast at Temma, in what regional aeromagnetic data indicate is a continuation of the Roger River splay viewed at this location. The intrusive rock on the coast is massive, fractured and variably silicified in outcrop. In thin section (Plate 7), phenocrysts up to 1.5 mm in diameter of silicified quartz pseudomorphing euhedral hexagonal amphibole are supported within a fine-grained (≤25 mm) aggregate of pale brown biotite (phlogopite).



Plate 6
Lamprophyre dyke from roadside exposure near The Clump (321 150 mE, 5 436 150 mN). Hammer for scale.

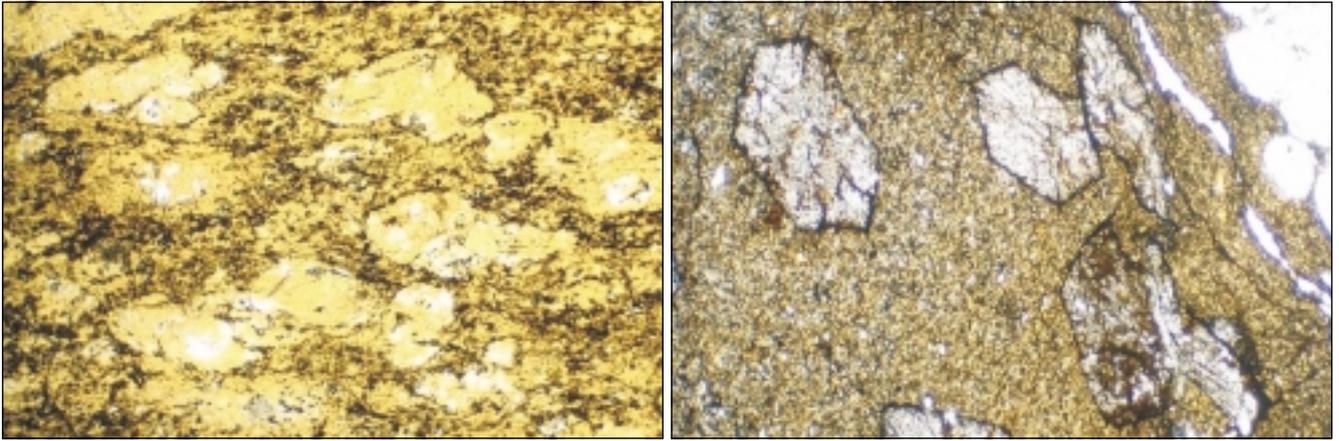


Plate 7

Photomicrographs of dyke at The Clump and what is inferred to be the same dyke where it crops out on the Temma coast (photos 4.4 × 3.0 mm). Both slides show what are inferred to be pseudomorphs of quartz after amphibole in a fine-grained matrix.

19: Spotted chloritic siltstone (Unit Prbs) of the Balfour Subgroup, Blackwater Road northeast of Frankland River bridge
(322 100 mE, 5 439 100 mN)

Porphyroblasts are common in upper Balfour Subgroup chloritic siltstone units. The porphyroblasts are typically elongate, ovoid and rarely rhombohedral in shape and up to about 2 mm in length. They comprise cores of bladed chlorite, as well as microcrystalline sericite ± albite ± quartz, and are commonly rimmed by chlorite and sericite.

Careful examination shows that the porphyroblasts are flattened into the main S₃ foliation and, consequently, pre-date the main D₃ folding event. Thin section examination has revealed that S₂ is preserved within the porphyroblasts but consistently rotated with respect to S₂ outside the porphyroblasts. The coincident rotation and preservation of S₂ through the

porphyroblasts is inferred to indicate a syn-D₂ timing for porphyroblast growth (Plate 8).

Unlike D₃, the age of the D₂ event is not known. D₂ deformation was, however, accompanied by a regional thermal metamorphic event of at least greenschist facies grade. Brown cores in metamorphic chlorite and metamorphic biotite from coastal rocks suggest that metamorphism may have been as high as biotite grade.

20: Gabbroic intrusive (Unit Pgb) in the Togari Group; contact of Rocky Cape Group and Togari Group; Blackwater Road
(325 670 mE, 5 439 830 mN)

Coarse-grained doleritic to gabbroic outcrops on the northern side of the road are examples of one of several small subvolcanic intrusions, genetically related to the Spinks Creek Volcanics, within the Black River

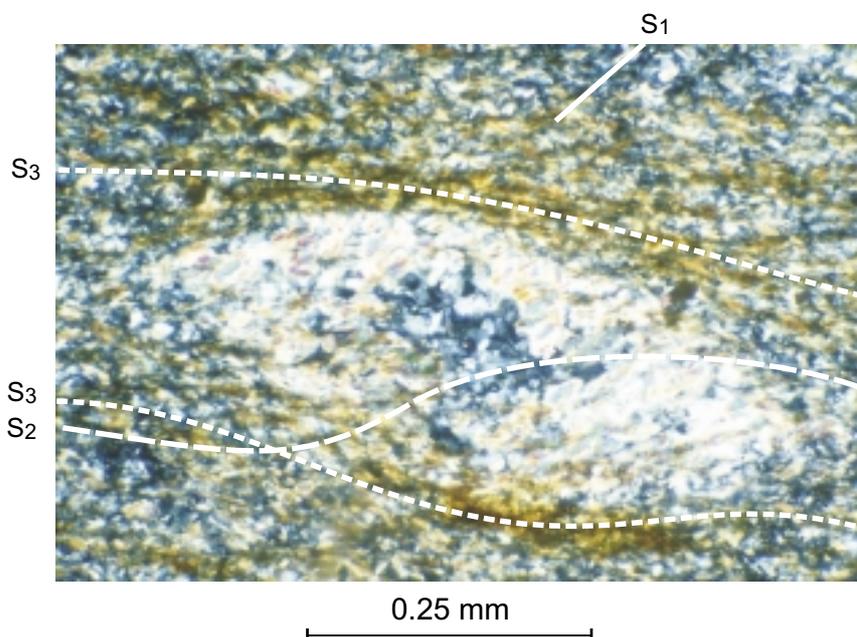


Plate 8

Porphyroblast in Balfour Subgroup siltstone (photo 0.7 × 0.45 mm). S₃ deforms the porphyroblast whereas S₂ is preserved but rotated within the porphyroblast relative to the matrix. This is inferred to indicate that the porphyroblast is D₂ in age.

Dolomite. In thin section, large clinopyroxene grains are partly altered (uralitised) to yellow-green fibrous amphibole. Epidote is present in the groundmass in addition to altered plagioclase, chlorite, tremolite-actinolite and large (≤ 1 mm) grains of sphene. This rock is assigned to the relatively alkalic Suite F on the basis of Nb/Zr and rare earth element data, but small intrusions with tholeiitic affinities (including Suite A) are also known.

The lower Togari Group units are thin in the western limb of the Smithton Synclinorium. Along the road to the west, the Black River Dolomite is only about 250 m thick and is underlain by a possible correlate of the Forest Conglomerate and Quartzite, which rests on a Cowrie Siltstone correlate. Along the road to the east, the Kanunnah Subgroup (mainly the Keppel Creek Formation with only minor basalt) is only 500 m thick.

21: Black River Dolomite chert (Unit PbdC) in Blackwater 5 quarry (326 690 mE, 5 442 290 mN)

This is a problematic exposure. The chert lithologies in this quarry are considered to be more like those of the Black River Dolomite than the Smithton Dolomite, although no stromatolite fragments have so far been found.

22: Smithton Dolomite, Blackwater 5-3 Road (325 360 mE, 5 444 560 mN)

Note: Beware of the dilapidated bridge on this short spur road: walk 150 m if necessary.

A rare roadside exposure of the Smithton Dolomite (1000 to 1500 m thick). Here (towards the base of the unit) the dolomite is diffusely laminated, although in many other places bedding cannot be recognised. Dolomicrite and dolograinstone with well-preserved primary textures occur mainly in the lower third of the formation; the upper two-thirds is commonly massive recrystallised dolospar.

Note the extensive cover of Tertiary gravel along Blackwater 5 spur, and the complete silicification of most Smithton Dolomite outcrops.

23: Thrust-related fault block of Cowrie Siltstone within Togari Group, Blackwater 4 Road (near 326 800 mE, 5 443 000 mN)

Thinly laminated black pyritic siltstone in this area generally dips steeply west, is poorly cleaved and lithologically identical to the Cowrie Siltstone to the east of the Smithton Synclinorium, although out of stratigraphic context with most of the surrounding Togari Group rocks here. It is bounded to the east and west by two major inferred faults, which form part of

the northeast-directed (D_3) thrust system which dominates the western parts of the Sumac and Dempster map sheets. The most likely interpretation of this fault block is as a pop-up structure (i.e. a basement block bounded by a thrust and a back-thrust) within the D_3 thrust system. To the south the fault block is terminated against the Roger River Fault, but reappears offset some 4–5 km in a dextral sense to the south of the Roger River Fault, on the Dempster map sheet. This section of the Roger River Fault may thus have acted as an oblique transfer during the D_3 northeast-directed thrusting.

24: Smithton Dolomite (Unit Psd), Keppel Creek Formation (Unit Pkw), lower Keppel Creek (328 750 mE, 5 445 310 mN)

This locality is close to the Roger River Fault. Corroded outcrops of Smithton Dolomite (containing minor limestone) occur below the road in Keppel Creek. Weathered, grey to orange or red volcanoclastic siltstone and mudstone, with cuboidal fracture, characteristic of the Keppel Creek Formation occur in the road cuttings to the east of the fault (see also next location).

25: Keppel Creek Formation siltstone (Unit Pkw) (328 900 mE, 5 445 500 mN)

This location shows an example of a roadside outcrop of siltstone from the Keppel Creek Formation.

Siltstone and mudstone of this formation are generally weathered red-brown or dull red-grey. The mudstone is often very massive with only very faint fine banding, while the siltstone occurs in beds up to a metre thick with generally more obvious fine banding.

In thin section, mineral clasts include quartz, opaque minerals, chlorite, plagioclase, serpentine mineral and rare muscovite. Abundant intergranular chlorite may be after clay minerals and is difficult to distinguish from clasts. Serpentine mineral clasts may be after olivine, and the chlorite clasts after clinopyroxene. Chert clasts were recognised in one sample.

The presence of both unstrained and strained quartz suggests derivation from volcanic and metamorphic terrains. Fine siltstone at 329 300 mE, 5 445 750 mN contains abundant clasts of carbonate. Two small outcrop areas near 329 960 mE, 5 444 250 mN and 329 310 mE, 5 445 170 mN are of carbonate rock with abundant opaque and sparse quartz clasts, and these appear to be partially recrystallised clastic carbonate.

Clasts of opaque material, plagioclase, chlorite and serpentine suggest derivation from basalt, probably the associated Spinks Creek Volcanics, and the small areas of carbonate suggest derivation from the underlying Black River Dolomite.

References

- ADAMS, C. J.; BLACK, L. P.; CORBETT, K. D.; GREEN, G. R. 1985. Reconnaissance isotopic studies bearing on the tectonothermal history of Early Palaeozoic and Late Proterozoic sequences in western Tasmania. *Australian Journal of Earth Sciences* 32:7–36.
- BAILLIE, P. W.; JAGO, J. B. 1995. Sedimentology of an Upper Cambrian turbidite succession, Smithton Basin, northwest Tasmania. *Australian Journal of Earth Sciences* 42:75–82.
- BROWN, A. V. 1989a. Geological Atlas 1:50 000 Series. Sheet 21 (7916S). Smithton. *Explanatory Report Geological Survey Tasmania*.
- BROWN, A. V. 1989b. Eo-Cambrian–Cambrian, in: BURRETT, C. F.; MARTIN, E. L. (ed.). *Geology and Mineral Resources of Tasmania. Special Publication Geological Society of Australia* 15:47–83.
- CALVER, C. R. 1998. Isotope stratigraphy of the Neoproterozoic Togari Group, Tasmania. *Australian Journal of Earth Sciences* 45:865–874.
- CALVER, C. R.; BAILLIE, P. W. 1990. Early diagenetic concretions associated with intrastatal shrinkage cracks in an Upper Proterozoic dolomite, Tasmania, Australia. *Journal of Sedimentary Petrology* 60:293–305.
- CAREY, S. W.; SCOTT, B. 1952. Revised interpretation of the geology of the Smithton district of Tasmania. *Papers and Proceedings Royal Society Tasmania* 86:63–70.
- DICKSON, T. W. 1983. *Final report Mineral Leases 120M/67, 121M/67, 10M/73, 1M/76, 2M/76, 93M/77, 94M/77, and 95M/77, L and L Syndicate Balfour*. CRA Exploration Pty Ltd [TCR 82-1935].
- EVERARD, J. L.; SEYMOUR, D. B.; BROWN, A. V.; CALVER, C. R. 1996. Geological Atlas 1:50 000 Series. Sheet 7915N. Trowutta. *Mineral Resources Tasmania*.
- EVERARD, J. L.; SEYMOUR, D. B.; GREEN, D. C.; MCCLENAGHAN, M. P.; BROWN, A. V. 1999. Geological Atlas 1:25 000 Digital Series. Sheet 3244. Sumac. *Mineral Resources Tasmania*.
- EVERARD, J. L.; REED, A. R.; SEYMOUR, D. B.; CALVER, C. R. 1999. Geological Atlas 1:25 000 Digital Series. Sheet 3243. Dempster. *Mineral Resources Tasmania*.
- LANGSFORD, N. R. 1982. *Geology and mineralisation, Specimen Hill area, Balfour, NW Tasmania*. CRA Exploration Pty Ltd [TCR 83-1932].
- LEAMAN, D. E.; RICHARDSON, R. G. 1992. A geophysical model of the major Tasmanian granitoids. *Report Department of Mines Tasmania* 1992/11.
- MCCLENAGHAN, M. P.; SEYMOUR, D. B. 1996. Combined interpretation of new aerial-survey geophysical datasets for northwestern Tasmania. *Record Mineral Resources Tasmania* 1996/16.
- MCCLENAGHAN, M. P.; SEYMOUR, D. B.; GREEN, D. C.; BROWN, A. V. 1999. Geological Atlas 1:25 000 Digital Series. Sheet 3245. Roger. *Mineral Resources Tasmania*.
- NYE, P. B.; FINUCANE, K. J.; BLAKE, F. 1934. The Smithton district. *Bulletin Geological Survey of Tasmania* 41:1–115.
- RUSSELL, S. A. J.; TEAR, S. J. 1997. *Third and final report – EL4/94 Balfour. Period 3 May 1996 to 11 November, 1997, Tasmania, Australia*. Rio Tinto Pty Ltd [TCR 98-4115].
- SEYMOUR, D. B.; BAILLIE, P. W. 1992. Geological Atlas 1:50 000 Series. Sheet 7816S. Woolnorth. *Department of Mines Tasmania*.
- SEYMOUR, D. B.; CALVER, C. R. 1995. NGMA TASGO Project. *Sub-Project 1 – Geological Synthesis: Stratotectonic Elements Map of Tasmania*. Mineral Resources Tasmania and Australian Geological Survey Organisation.
- TURNER, N. J. 1994. *Report on the stratigraphic and structural setting of rocks in EL18/92, Balfour District, north-western Tasmania*. CRA Exploration Pty Ltd [TCR 94-3644A].
- TURNER, N. J. 1994. *Report on geological mapping and rock chip sampling around The Clump, Murrays Reward and other localities in EL18/92, Balfour District, north western Tasmania*. CRA Exploration Pty Ltd [TCR 95-3734A].
- TURNER, N. J.; BLACK, L. P.; KAMPERMAN, M. 1998. Dating of Neoproterozoic and Cambrian orogenies in Tasmania. *Australian Journal of Earth Sciences* 45:789–806.
- VESKA, L. 1993. *Geology, mineralisation and structure of the Balfour copper occurrence, north-western Tasmania*. B.Sc. (Hons) thesis, University of Tasmania : Hobart.
- WARD, L. K. 1911. The Mount Balfour mining field. *Bulletin Geological Survey Tasmania* 10.
- YAXLEY, G. M. 1981. *The geology and mineralisation of the Balfour district – a mineralogical and fluid inclusion study*. B.Sc. (Hons) thesis, University of Tasmania.

[26 June 2000]