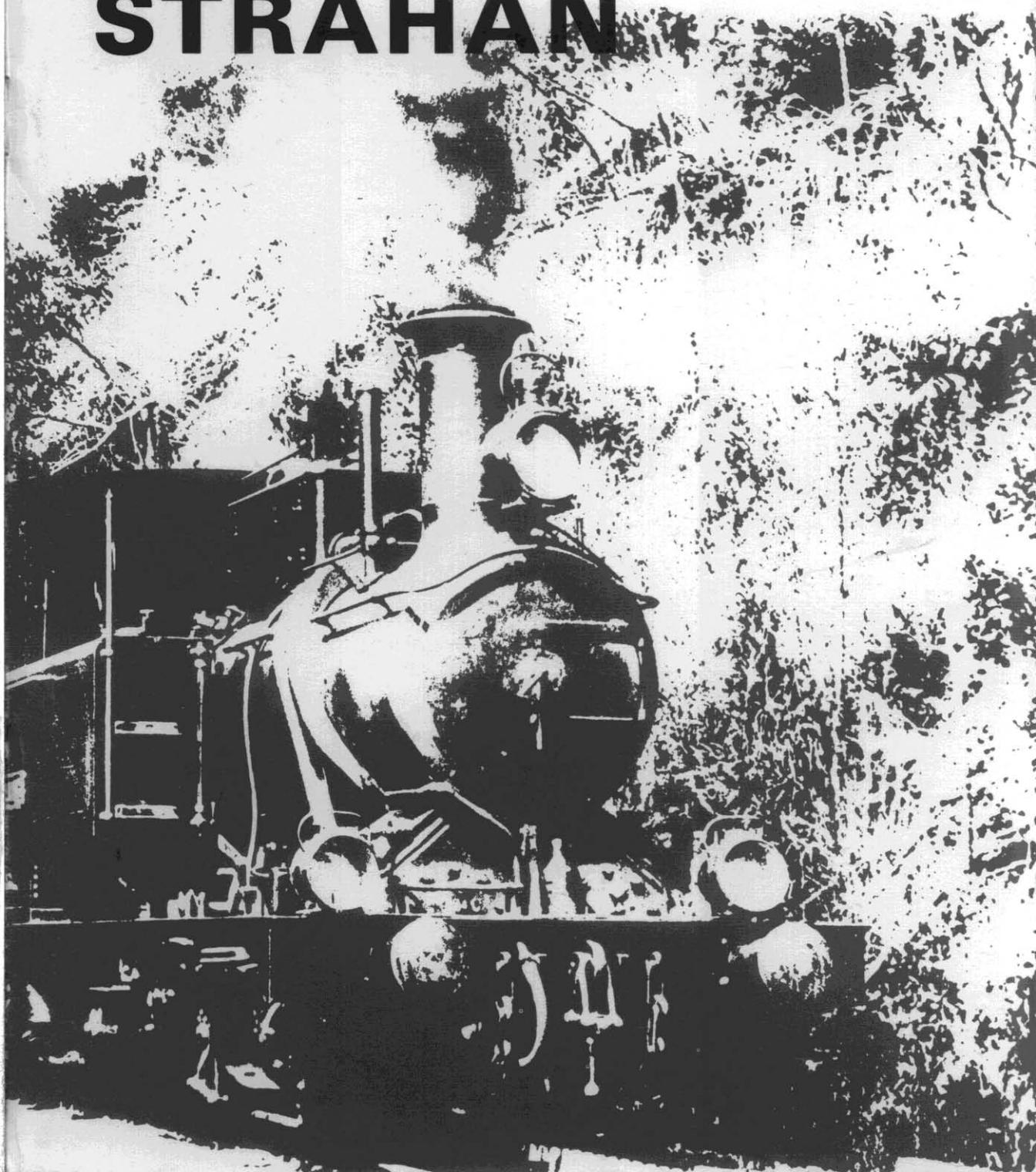


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**GEOLOGICAL SURVEY  
EXPLANATORY REPORT**

**SHEET 57**

**STRAHAN**





1985

TASMANIA DEPARTMENT OF MINES

# GEOLOGICAL SURVEY EXPLANATORY REPORT

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SHEET 57(7913N)

# STRAHAN

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*with an appendix on Economic Geology by G. R. GREEN, B.Sc.(Hons), Ph.D.*

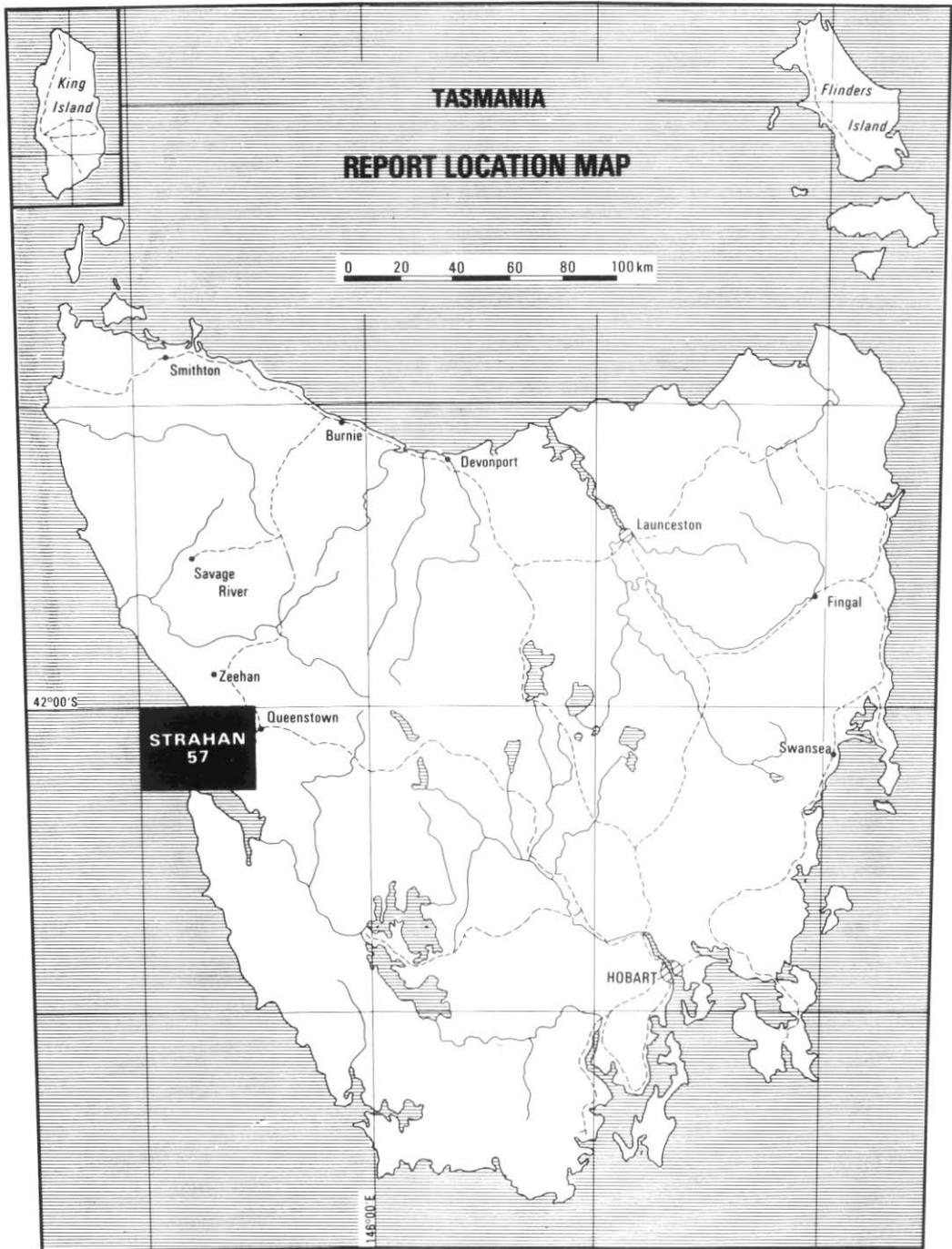


Figure 1. Location of the Strahan Quadrangle.

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## INTRODUCTION

The Strahan Quadrangle is situated on the West Coast of Tasmania and is bounded by latitudes 42° 00' and 42° 15' S, and longitudes 145° 00' and 145° 30' E. It includes the northern extremity of the Cape Sorell peninsula.

The only permanent settlement on the Quadrangle is the township of Strahan [615320]\*, which serves the tourism, fishing and forestry industries. The former influence of mining is attested by the abandoned wharf facilities at Strahan and by the deserted railway settlements of Teepookana [703277], Dubbill Barrill [745286], and Rinadeena [756320]. The Abt section of the now defunct railway built by the Mt Lyell Mining and Railway Company extended between Dubbill Barrill and Rinadeena, then down to Halls Creek (off the map sheet).

Vegetation is very variable, ranging from dense rain forest dominated by myrtle beech (*Nothofagus cunninghami*) with minor King Billy pine (*Arthrotaxis selaginoides*) or Huon pine (*Lagostrobos franklinii*) through to coastal heaths near Cape Sorell [490260] and button grass plains on the Professor Plateau [655480]. The distribution of vegetation types is strongly influenced by fire history. A detailed account of the vegetation is given by Kirkpatrick (1977).

Precipitation occurs throughout the year but with a late-winter maximum. There is a steep positive precipitation gradient across the Quadrangle.

Mapping began in 1967 and was completed in 1975. Because of difficulties of access the Quadrangle was mapped by a large number of geologists mapping relatively small areas. The 1:50 000 map was published in 1977.

This report was compiled by P. W. Baillie and K. D. Corbett using the data of, and unpublished reports written by, P. W. Baillie, K. D. Corbett, S. F. Cox, E. B. Corbett, A. P. Bravo, R. D. Gee, A. B. Gulline, P. J. Legge, G. P. Pike, N. J. Turner, P. R. Williams, M. P. McClenaghan and A. V. Brown. The individual geologists responsible for the information given are referred to wherever possible by their initials within parentheses. The work was supervised by Dr Emyr Williams.

## PHYSIOGRAPHY

*P. W. Baillie*

The Strahan Quadrangle lies within the fold province of Davies (1965) and a summary of the geomorphology of the area is provided by Banks *et al.* (1977).

Three physiographic units may be recognised: (1) the Cape Sorell peninsula; (2) the coastal area bounded to the west by Ocean Beach; and (3) the bulk of the map sheet, forming part of the western edge of the Henty Surface.

The northern Cape Sorell peninsula is composed dominantly of Precambrian meta-sedimentary rocks, and the form of the peninsula is controlled mainly by rock unit distribution and structural trends within these rocks. Action by coastal and aeolian processes during the Quaternary has produced limited areas of superficial Quaternary sediment, and the western side of the peninsula is subject to heavy wave attack.

Ocean Beach has a total length of 32 km, the southern 26 km of which lie within the Strahan Quadrangle. A study of beach sand granulometry by Davies, in Banks *et al.* (1977), indicates a strongly compartmentalised nature of sediment movement. Deflection of the mouth of the Henty River indicates an overall sediment transport direction from the north.

Inland from Ocean Beach is a spectacular series of complex parabolic dunes. Differing degrees of soil development indicate that several episodes of dune formation have occurred. Within the dune field [600370], some 5 km NNW of Strahan, a series of lakes are ponded as a result of accumulation of impervious organic-rich matter in swales between dunes.

A series of flat terraces in the vicinity of Strahan have been interpreted as raised strandlines (Davies, 1960; Banks *et al.*, 1977).

### The Henty Surface

The remaining physiographic unit on Strahan Sheet is the apparently gently seaward-sloping surface (plate 1) which is part of the more extensive Henty Surface (Gregory, 1903). A series of superimposed E-W topographic profiles taken at 5 km intervals across the map sheet (fig. 2) demonstrates the overall westerly gradient and regularity of topography associated with the surface.

To remove the topographic effects of recent drainage systems from the apparent surface, a contoured diagram of maximum height per kilometre grid square was constructed (fig. 3). Also shown on this diagram is the major boundary between Cainozoic sediments and the older Palaeozoic rocks to the east. A series of 5 km-spaced profiles was constructed from Figure 3 and are shown as Figure 4.

\* All references lie within 100 000 metre AMG square CP.



**Plate 1.** Henty surface, looking west from Prince Lyell shaft, Mt Lyell mine.

Figures 3 and 4 indicate that the surface is younger than the Cainozoic sediments which crop out in the south-eastern part of the Quadrangle. The maximum-height contours clearly cut across the boundary of the Cainozoic and Palaeozoic sedimentary rocks. Evidence will be presented in a later section of this Bulletin which indicates that the Cainozoic sediments in that area are Eocene in age, which implies that the Henty Surface is post Eocene.

North of the King River the boundary between Cainozoic and Palaeozoic rocks follows a steeper contour gradient in the maximum height contours, suggesting that the contact may be faulted. An alternative explanation is that the steepening of contours reflects the change in lithology from lithified Palaeozoic rocks to only partially consolidated Cainozoic sediments.

## STRATIGRAPHY

### Proterozoic Rocks of Cape Sorell

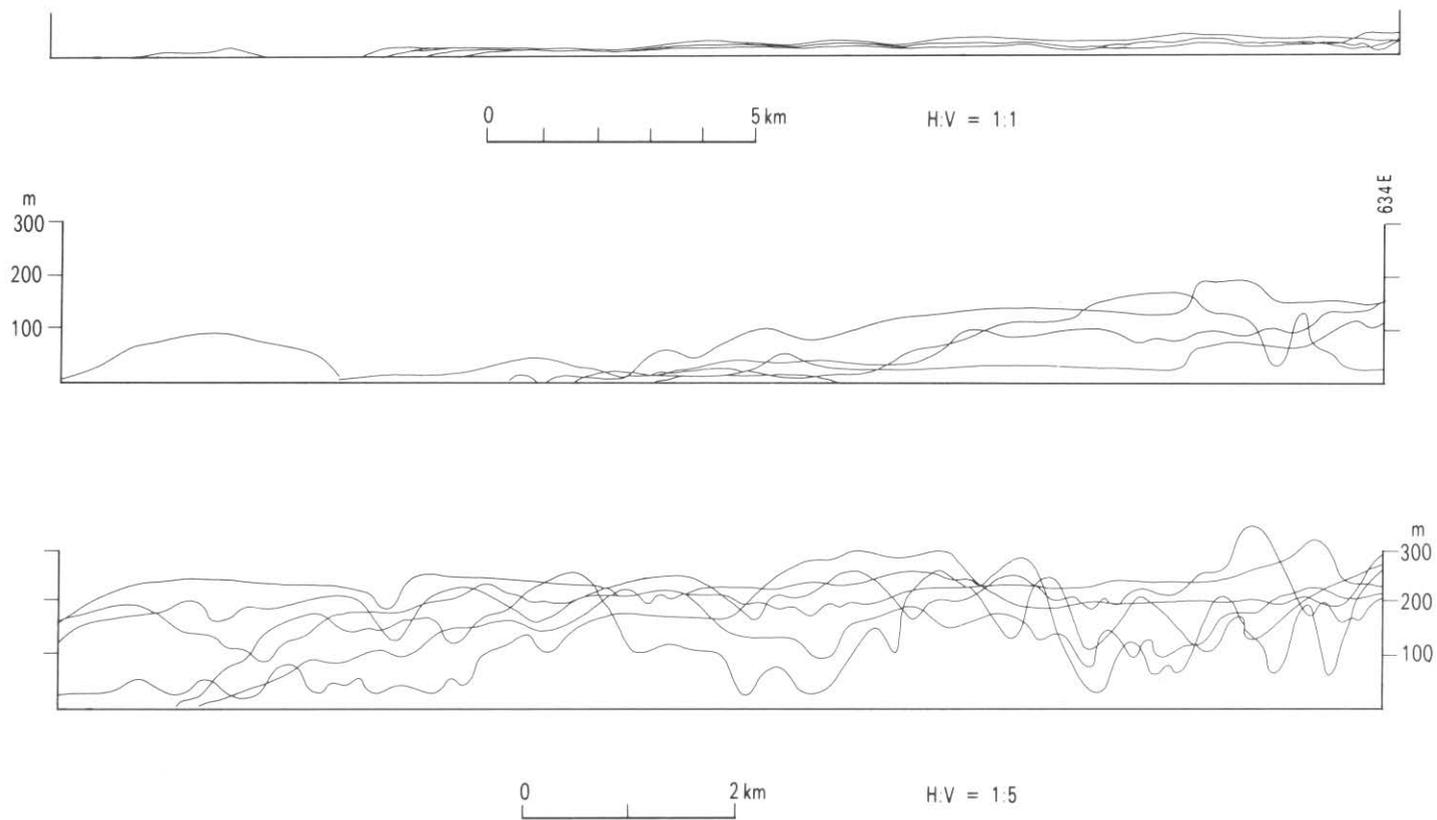
*P. W. Baillie*

A structurally complex lower greenschist-facies assemblage of inter-layered orthoquartzite, micaeous quartzite, phyllite and minor siliceous

conglomerate of Late Proterozoic age crops out at the northern end of the Cape Sorell peninsula.

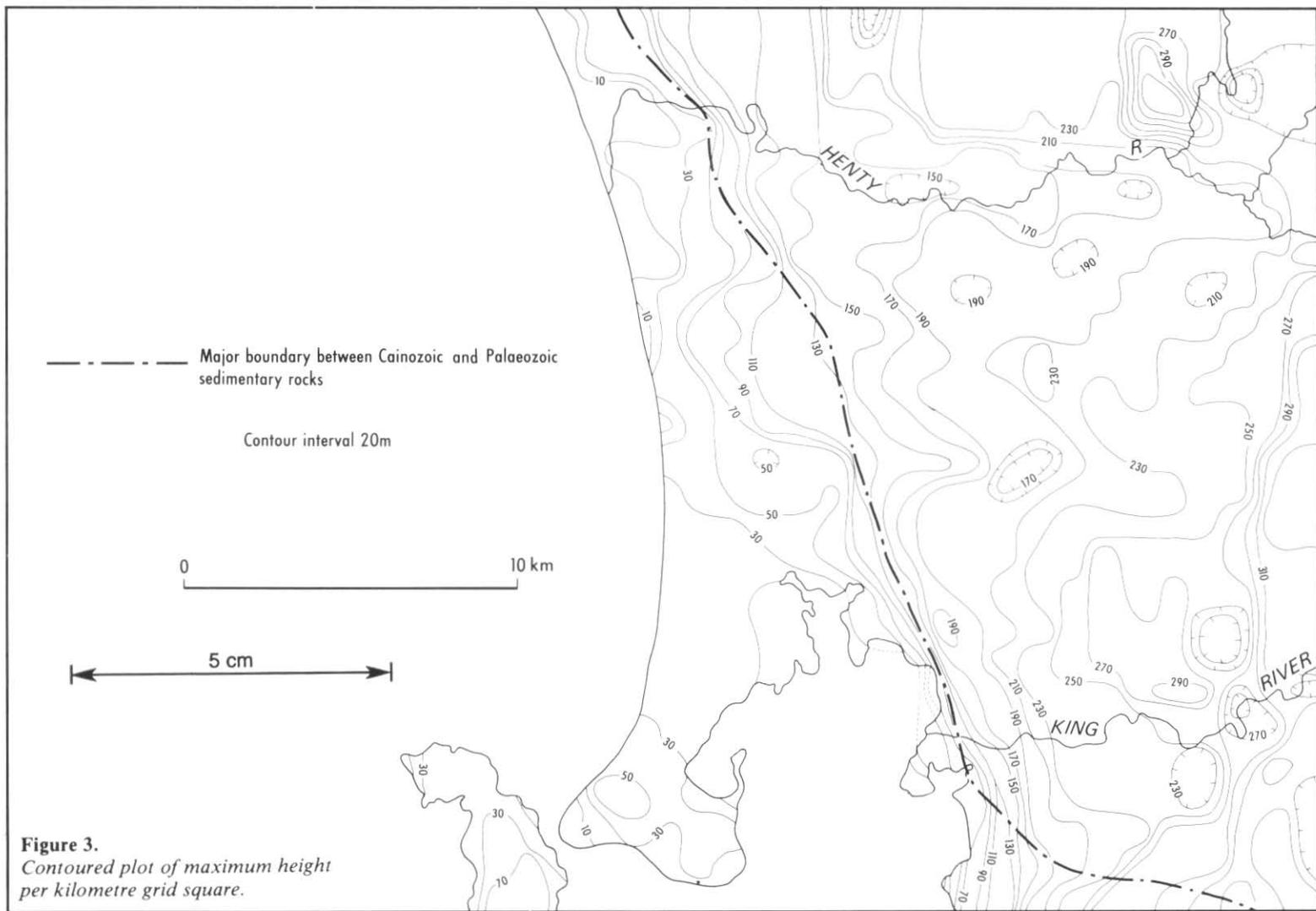
The most abundant rock type is white or occasionally pink orthoquartzite which occurs as massive, plane-laminated or cross-laminated beds, generally 100–300 mm thick and rarely reaching thicknesses of up to one metre. In thin section (*e.g.* 75–300, 75–304, 75–336, 75–344) the rock is moderately to very well sorted and composed of quartz grains that are generally well rounded. Median diameters are in the upper-fine to lower-medium range. Recrystallisation has destroyed the original detrital grain fabric so that grain boundaries are now smooth and polygonal (*e.g.* 75–344) to sutured (*e.g.* 75–304). Where even small amounts of mica are present the rocks are strongly foliated (*e.g.* 75–300).

Using the classification of Allen (1963) the cross-bedded units are solitary or grouped, lithology is homogeneous, magnitude of the units is large scale, environment is non-erosional, and the lower bounding surface is planar. The most commonly developed type is a solitary, large scale (100–300 mm) essentially planar unit. The environment is planar and the lower bounding surface is planar. This is alpha cross-stratification (Allen, 1963). Herringbone cross-bedding is not uncommon in the Cape Sorell



**Figure 2.** Superimposed E-W physiographic profiles, taken at 5 km intervals; (a) natural scale, (b) vertical exaggeration 5:1

5 cm



**Figure 3.**  
 Contoured plot of maximum height  
 per kilometre grid square.

area, and is well developed in rocks cropping out at Cape Sorell Lighthouse [488264]. Here the cross-strata are grouped and large scale (100–300 mm), and the lithology is homogeneous. This type of cross-bedding indicates a change in current direction from one bed to the next and is indicative of very shallow water deposition usually under tidal conditions (e.g. Connibear and Crook, 1968).

Ripple marks preserved on the tops of some beds are anastomosing in plan and show different orientations in adjacent beds, again indicating variable current directions and deposition in very shallow water.

The micaceous quartzites are generally more thinly-bedded than the orthoquartzites with bed thicknesses ranging from a few millimetres to about 200 mm. Strong foliations developed in these rocks have obliterated pre-existing sedimentary structures.

Pelitic and semi-pelitic units which are interlayered with the orthoquartzites form only a minor proportion of the sequence and are generally only a few metres thick. A major unit of thinly interlayered phyllite and quartzite, up to several hundred metres thick, occurs on the beach east of Olsen Reef [507235]. Tectonic transposition has usually destroyed sedimentary structures in these units, however small sandstone dykes and associated small angular detached rafts of quartzite are present in a few outcrops.

A lens of siliceous conglomerate occurs at Surging Point [495269]. At this locality cross-bedded orthoquartzite is conformably overlain by a conglomerate composed of close-packed, well-rounded, slightly elongate pebbles and cobbles (30–200 mm) of massive, randomly foliated, quartzite in a coarse, foliated, quartz matrix. The conglomerate has been deposited in a large trough eroded in the quartzite. A sand lens composed of coarse quartz is present within the conglomerate. The conglomerate is a channel fill deposit derived from a source area composed, at least in part, of foliated quartzite.

## Cambrian Sequences

*K. D. Corbett*

### NORTHERN AREA (€n)

Cambrian rocks occur extensively in the north-eastern part of the Quadrangle between the Professor Plateau and the Yolande River. Two major sequences are apparent, namely a volcano-sedimentary sequence of siltstone, greywacke and felsic tuff, and a younger sedimentary sequence of quartzwacke turbidites, siltstone and siliceous conglomerate. The latter sequence gradationally overlies the former in one area, and contains middle Late Cambrian fossils on the Queensberry mine road.

### VOLCANO-SEDIMENTARY SEQUENCE (€nt)

Sequences of interbedded tuff, greywacke and siltstone occur adjacent to the Firewood Siding Fault at the Queensberry mine, in the Henty River near the mouth of Malcolm Creek, and in a larger belt between Pearl Creek and Truscott Creek to the east of The Sisters. The sequence in the latter area passes eastwards into the Mt Read Volcanics ('western volcano-sedimentary sequence' of Corbett, 1981*b*, 1979) on the adjacent Lyell Sheet. Although the sequences in all three areas are lithologically similar, the lack of age control precluded precise correlation.

### Queensberry mine area (K.D.C., E.B.C.)

The sequence in this area occupies a wedge-shaped belt with a W-trending faulted contact to the south with Bell Shale correlate, and a linear, probably faulted contact against the quartzwacke sequence to the north. The area is entirely covered by dense rain forest, and exposures are limited to creeks and road sections. It has not been possible to trace particular units for any distance. Dips and strikes are variable, suggesting a complex structure, and

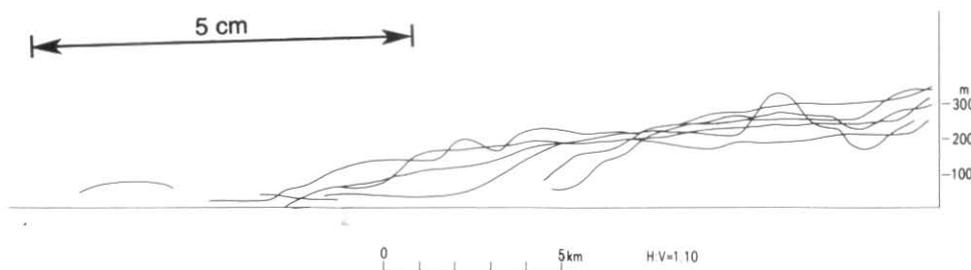


Figure 4. Superimposed profiles of maximum height per kilometre grid square, taken at 5 km intervals.

facings in several directions were noted. An arcuate, W-trending ridge of quartzose sandstone occurs near the northern boundary of the area on the Queensberry mine road, and shows overturned north facings. It is overlain by laminated siltstone similar to that of the quartzwacke sequence, and is probably near the top of the sequence. The sequence consists of interbedded siltstone, slate, fawn-weathering fine- to coarse-grained lithicwacke, and fawn to grey or greenish epiclastic felsic tuffs. The tuffs are particularly abundant in Melody Creek.

The siltstone is grey to green or fawn in colour, and generally rich in fine micaceous minerals, particularly muscovite. Some varieties are slightly calcareous. Planar lamination is common, and cross-lamination and convolute lamination are occasionally seen. The rocks are generally strongly cleaved, and some of the darker varieties grade into slate.

The lithicwackes are generally grey when fresh, with bedding thickness ranging from a few centimetres to several metres. Many beds show grading from coarse sand at the base to fine sand or silt at the top. Bouma *a-b*, *a-c*, and *b-c* sequences are common. Sole marks, such as flutes and grooves, occur on some beds, and the rocks are confidently interpreted as turbidites. Small flakes of white mica are generally visible on freshly broken surfaces, and the presence of such mica is a useful criterion for distinguishing the greywackes from the associated tuffs.

Thin sections of greywackes (*e.g.* 72-10, 72-13, 72-15, 72-17, 72-19, 72-20, 72-26) show the rocks to be rather poorly sorted, with matrix contents ranging from 5% to about 40%. The matrix material is mainly chlorite and white mica, with some fine quartz and altered feldspar. Secondary carbonate has replaced much of the matrix in some specimens, and appears to be particularly abundant in samples close to the faulted contact with the Bell Shale correlate. The granular component consists mainly of rock fragments, quartz grains and mica flakes, with minor constituents including altered plagioclase, tourmaline, and apatite. The rock fragments consist overwhelmingly of quartzite (of various grain sizes and crystallinity), quartz-schist and quartz-muscovite schist, with fragments of chert-like material, carbonate (including coarsely crystalline and schistose varieties) and fine-grained sedimentary rocks being common in some samples. Fragments of felsic to intermediate volcanic rocks, including quartz-phyric, quartz-feldspar-phyric and feldspar-phyric varieties, and fragments of felsic groundmass material, occur in a few samples, but are relatively rare. Single-crystal quartz grains (as opposed to polycrystalline aggregates which are regarded as rock fragments) occur in all samples, and are abundant in some (up to 40% of total rock).

Some of these grains show partial crystal faces, traces of original embayments, and/or remnants of original reaction rims, indicating a volcanic origin. Some, however, may have been derived from coarse-grained meta-sedimentary rocks. The mica flakes are predominantly white mica, with chlorite (as flakes and grains) common in some samples. Biotite is rare. The rocks are best termed lithic-wackes or lithic-quartz wackes.

The greywackes appear to have been derived mainly from a metasedimentary terrain, where quartzite, quartz-schist and quartz muscovite schist were major source rocks. Carbonates were also present in the source area, although some of the non-foliated carbonate fragments may have been derived from intra-basinal sources. Most of the pelitic clasts were probably also intra-basinal. The presence of volcanic rock fragments in some specimens, and of volcanic quartz and feldspar in nearly all samples, indicates a contribution from a felsic volcanic source. This source was probably the same as that from which the associated tuffs were derived — almost certainly the Mt Read Volcanics belt to the east. The main metasedimentary source area could have been the Tyennan region to the east of the Mt Read Volcanics but derivation from the Rocky Cape region to the north-west cannot be excluded.

Rocks composed entirely of detritus of volcanic origin (crystals, rock fragments, vitric ash) have been termed tuffs, although the majority of such units examined probably represent re-sedimented epiclastic deposits, in the form of sub-marine density flows, rather than primary pyroclastic fall deposits. This is evident from the occurrence in some units of irregular clasts (up to one metre across) of mudstone which have been ripped up from the substrate and incorporated in the flows. No lavas or intrusives have been identified.

The tuffs are generally greenish grey to pale grey, massive to faintly bedded granular rocks with grain size in the medium to coarse sand (0.25-1 mm) range. Fine-grained vitric tuffs, usually showing lamination, and coarse-grained varieties with lithic clasts up to several centimetres long, also occur. Some units appear to grade from coarse tuff at the base to laminated fine tuff at the top, over an interval of 10 metres or so.

The major constituents of the tuffs are grains of feldspar and quartz (commonly in 2:1 ratio) and fine-grained matrix material (5-40%). Most may be classed as crystal tuffs. The feldspar is predominantly sodic plagioclase (mainly albite) where identification is possible. Alteration of the feldspar to sericite, chlorite and carbonate is common, and ranges from spotty alteration along cleavage planes

and margins to complete replacement. In some cases, plagioclase appears to have been replaced by K-feldspar and/or a mosaic of fine albite laths. The quartz grains range from subhedral crystals to strongly corroded and embayed varieties. Small rounded quartz grains and angular broken crystal fragments also occur. Splashes of green chlorite are prominent in some units.

Tuffs occurring in Lode Creek and Bottle Creek are typified by 83-40, which is a grey-green crystal-rich tuff showing abundant flecks of chlorite up to several millimetres across. The abundant plagioclase grains are up to one millimetre long, and are either fresh or show only spotty alteration. Some are corroded and embayed. Quartz grains are slightly less abundant and slightly smaller, and commonly show corrosion and embayments. Altered and corroded opaque grains are fairly common. The matrix material (about 40%) consists of two distinct phases — clear, pale green chlorite as irregular splashes and wisps which surround and partially replace crystal grains in some places, and a pale brownish dusty phase which is sub-isotropic. The two phases interfinger with one another on a fine scale. Remnants of shard-like shapes and bubble shapes in the brownish phase suggest an original vitriclastic composition. Spots of very fine epidote are scattered through the matrix, and form concentrations at the margins of opaque grains. A penetrative foliation is particularly evident in the later chlorite patches.

Tuffs found close to the Queensberry mine and to the faulted Bell Shale correlate contact in Lode Creek (72-24, 72-25), show considerable alteration of the feldspar to chlorite and carbonate, and pervasive chloritisation of the matrix. A stronger foliation is also evident. A tuff close to the faulted contact in Bottle Creek (72-12) shows extensive alteration of feldspar to sericite, and is unusual in having abundant fine white mica flakes (0.03–0.04 mm long) which appear to have grown in the matrix.

A flat-dipping sequence of crystal tuff, crystal-lithic tuff, crystal-vitric tuff and laminated vitric tuff, with minor interbedded slate, siltstone and greywacke, crops out in Melody Creek for about one kilometre north from the faulted Bell Shale correlate contact. The coarsest units contain rock fragments up to several centimetres long, and tend to form massive units up to several tens of metres thick. Many of the fine-grained units are hard porcellaneous rocks with conchoidal fracture.

Typical coarse tuffs from Melody Creek (72-6, 72-16) are purplish grey in colour, and contain fairly numerous rock fragments and platy blebs of pale green sericite, as well as the usual quartz and

feldspar grains. The rock fragments are mostly fine-grained felsic volcanic rocks and fine-grained sedimentary rocks. The quartz grains include many angular fragments of broken crystals, and are more abundant than the feldspar grains, most of which are completely altered to felted sericite. Hematite is common as spots and coatings, particularly on rock fragments. The abundant matrix consists of granular, fine-grained indeterminate material together with scattered large blebs of felted sericite containing irregular carbonate masses (E.B.C.).

Typical crystal tuffs (72-2, 72-4, 72-5) are similar to those in the Lode Creek area, with some variation in the amount of chlorite and carbonate in the matrix. Shards are clearly evident in the matrix of (72-4), and traces of shards are evident in (72-2). The northernmost tuff unit (72-21) is unusual in having abundant epidote dispersed through the chlorite-rich matrix. A porcellaneous fine tuff (83-43) in an eastern tributary of Melody Creek shows thin dark laminae (0.1–1.5 mm thick) separating pale coarser layers 10–40 mm thick. All layers contain abundant glass shards, with delicate bubble-wall textures preserved in places. Small quartz grains occur in the coarser parts of the pale layers. Fine granular carbonate is uniformly distributed throughout the rock.

#### *Henty River west of Malcolm Creek*

Massive grey crystal tuffs similar to those of the Queensberry mine area are exposed along the north bank of the Henty River about one kilometre west of Malcolm Creek. The sequence is faulted against Bell Shale correlate on the south bank, and is conformably overlain by a N-facing greywacke sequence which appears to be gradational into a siltstone-quartzwacke sequence in Malcolm Creek. The tuffs include coarse-grained varieties with lithic clasts up to several centimetres across, and appear to be silicified and altered adjacent to the fault.

Typical tuffs from this area (72-29, 72-30) contain abundant quartz and feldspar grains, many of them cracked and broken, in a matrix rich in chlorite and carbonate. Much of the plagioclase has been replaced by mosaic secondary feldspar (K-feldspar?) and by carbonate and chlorite, and some quartz grains have been partially replaced by carbonate. Cracks and zones of comminuted material are evident in thin sections. A coarse-grained rock from the southernmost exposure (83-42) contains rock fragments of quartzite, schistose quartzite, volcanic porphyry with snowflake-textured groundmass, and pelite, as well as quartz and feldspar grains, in a silicified matrix rich in secondary

carbonate. The rock is cut by numerous quartz and quartz carbonate veins, and is unusual in containing both volcanic and metasedimentary detritus.

#### *Pearl Creek area (N.J.T., M.P.M.)*

In the Pearl Creek area, south of the Yolande River, a lower unit of mainly siltstone and greywacke is overlain to the west by a thick sequence of siltstone and mudstone with intercalated major tuff units. Samples of grewacke (72-471, 72-472, 72-473) show poor sorting, with a fairly continuous grain size range from coarsest (one millimetre) to finest. The grains consist of quartz, feldspar, muscovite and rock fragments, the latter including quartzite, quartz-muscovite schist, and chert-like material. Fine-grained rocks (e.g. 72-466, 72-468) include tuffaceous siltstone with grains of embayed quartz and feldspar, and with glass shards in the matrix. The tuff-like units range in thickness from less than half a metre to several tens of metres, and range in colour from dark grey to light greenish grey or fawn. Typical samples include 72-82, 72-87, 72-155, 72-157, 72-462 and 72-465. Quartz and plagioclase (albite, possibly some K-feldspar) are ubiquitous as anhedral to subhedral grains, and rock fragments are present in some samples. The latter are mainly volcanic types (quartz porphyry, pilotaxitic lava, augite-quartz porphyry), but also include quartz muscovite schist and muscovite schist (e.g. in 72-87). Brownish quartzo-feldspathic cryptocrystalline material is ubiquitous as a matrix component, with patches of sericite and carbonate and late-grown sheaves of chlorite. Small grains of clinopyroxene and opaque oxide occur in 72-462.

A unit of dark grey, fine-grained, banded limestone occurs at the south-west corner of the outcrop belt [728424]. Thin sections (72-85, 72-86) show very fine-grained sparite with streaks of carbonaceous material, and coarser grained carbonate (0.1 mm grains) with cleavage wrapping around the calcite grains.

#### *Yolande River-Truscott Creek area (K.D.C., E.B.C.)*

The N-striking, steeply-dipping sequence of siltstone, slate, greywacke and tuff in this area faces generally west, but reversals of facing and bending of strike ridges indicate a major synclinal axis lying east of The Sisters. A major NNE-trending fault appears to lie west of the syncline axis, but sequences to the west of this postulated fault are generally similar to those to the east. Gabbroic intrusives and basaltic lava flows occur on the Zeehan Highway north of Truscott Creek, but have not been recorded on the Strahan Sheet.

The sequence exposed in Truscott Creek includes many tuff-like units, ranging from massive, coarse-grained, crystal-rich varieties with abundant quartz and feldspar grains, to fine-grained, laminated vitric varieties. The coarser units are up to 10 m thick, and commonly show grading from coarse sand-grade material in the lower part to fine-grained vitric ash in the upper part. Clasts of dark mudstone occur in the lower parts of some units, suggesting an origin by mass-flow. The typical tuffs, e.g. 71-226 (crystal-vitric-lithic tuff), 71-228 (vitric-crystal tuff), contain abundant feldspar grains (mostly plagioclase showing partial to complete alteration to sericite and carbonate), less abundant quartz grains (some embayed, some angular broken crystal fragments), and wispy sericitic pumice-like fragments, some of which preserve remnants of bubble texture, in a recrystallised, fine-grained sericite-chlorite matrix rich in secondary carbonate. Specimen 71-226 also contains scattered, small, quartzite rock fragments.

The greywackes in the Truscott Creek area generally have fine mica flakes visible on fresh surfaces, but some units consist predominantly of volcanic detritus and appear to be gradational to the typical tuffs. For example, 71-230, from one of a series of thick-bedded to massive units, consists mainly of feldspar and quartz grains (including many embayed grains), with only a few scattered quartzite rock fragments and mica flakes. Other greywackes (e.g. 71-227, 71-229) contain more abundant mica and quartzite fragments, as well as tourmaline grains, quartz and feldspar.

The sequence in the Yolande River near the eastern margin of the map sheet is similar to that in Truscott Creek, with units of massive crystal-vitric tuff, sometimes showing grading to laminated vitric ash at the top, alternating with units of interbedded greywacke, siltstone mudstone, and vitric ash. Conglomerate beds containing clasts up to boulder grade (0.25 m maximum) occur within the sequence at 752453. Individual conglomerate beds are 3-10 m thick, and generally have an open framework. Clasts range from sub-angular to rounded, and clast types include porphyritic felsic lava, felsic tuff, quartzite, vein quartz, vitric tuff, and greywacke.

The sequence of interbedded siltstone, greywacke and tuff immediately NNE of The Sisters, adjacent to the belt of Owen Conglomerate correlates, dips generally east, although the only facing obtained was westerly. The westernmost part of the sequence at 736470 consists mainly of siltstone, passing eastwards into a massive, pale grey quartz-feldspar crystal-vitric tuff unit about 15 m thick. East of this is a greywacke sequence, which includes beds of quartz-rich granule conglomerate, followed by a

massive coarse-grained crystal-lithic tuff (82–29) consisting of quartz and plagioclase grains and rock fragments of quartz-feldspar porphyry in a strongly-foliated sericite-chlorite matrix stained with limonite and weathered carbonate.

The Cambrian sequence exposed beneath the unconformable Owen Conglomerate correlate contact near the north-east corner of the sheet [734487] consists of interbedded grey-green mudstone, laminated micaceous fine-grained sandstone, pale vitric tuff, and vitric-crystal tuff. The rocks are strongly foliated and heavily quartz-veined adjacent to the contact. Bedding dips steeply south-east and is right way up as determined from truncated cross-laminae. The beds are obliquely truncated by the overlying conglomerate (fig. 5). Lozenge-shaped bodies of hard, fine-grained vitric material up to 600 mm long, occur within the vitric tuff in places. Some of these show concentric internal layering (e.g. 71–201), suggesting that they may represent pyroclastic bombs.

#### *QUARTZWACKE-SILTSTONE- CONGLOMERATE SEQUENCE (Cnc)*

##### *Malcolm Creek–The Sisters area (K.D.C., E.B.C.)*

The area between Malcolm Creek in the west and The Sisters to the east is covered by dense rain forest and regrowth scrub. Access is difficult, and outcrop is restricted to a few creeks and the Henty River section. A number of N-trending folds of wavelength 0.5–1 km affect the sequence in this area, but bedding information is too sparse to enable any accurate estimate of stratigraphic thickness to be made. A succession comprising a lower greywacke unit followed by a green siltstone unit followed by a unit of interbedded quartzwacke, siltstone and conglomerate, is present in the lower Malcolm Creek area. This sequence appears to pass conformably upwards into the thick bedded conglomerates of Marchfly Ridge and Ladders Lookout, but this relationship could not be confirmed.

The tuffs exposed in the Henty River downstream of Malcolm Creek pass conformably upwards into a N-facing, steeply-dipping to overturned sequence of greywacke turbidites and interbedded siltstone. The sequence is of the order of 400 m thick, and comprises beds up to one metre thick of fawn-weathering greenish grey lithic-quartzwacke separated by units of greenish to grey siltstone and fine-grained sandstone a few centimetres to several metres thick. The sandstone beds commonly show grading from coarse gritty sand at the base to fine-grained sandstone at the top. Some beds show Bouma *a-b-c* sequences.

In thin sections (72–28, 73–388) the sandstones show moderate sorting, with the grain size ranging from coarse sand to silt, and 5–10% of recrystallised matrix (mainly sericite, chlorite, quartz). Grains are quartz (60%), rock fragments (20%) and mica (15%), with minor feldspar, carbonate, chlorite, and accessory tourmaline, zircon and opaque oxide. A few quartz grains are embayed and a few have volcanic type reaction rims, but the majority have angular irregular shapes and are probably of metasedimentary origin. The rock fragments are mainly of two types — quartz-muscovite schist (and some quartzite), and fine-grained sedimentary rock. Very rare volcanic rock fragments are also present. The feldspar grains are mainly altered plagioclase. Flakes and shreds of muscovite and chlorite are common. The rocks appear to be predominantly of Precambrian derivation, with a small volcanic component.

A tuff-like rock, faulted against mudstone, and partly intrusive into mudstone, occurs in the Henty River near the eastern limit of this unit [707443]. In thin section (73–387) the rock is a crystal-rich quartz feldspar crystal tuff in which secondary carbonate replaces much of the matrix and grains. There is also much secondary chlorite, and fairly numerous opaque oxide grains.

The sandstone sequence passes gradationally into a sequence dominated by laminated green siltstone with bands of fine-grained sandstone. Load marks, flame structures and pseudonodules are common on soles of coarser beds in this sequence. The unit crops out along much of the length of Malcolm Creek, and is of the order of 200 m thick. It is overlain, apparently conformably, by a sequence rich in sandstone and fine-grained conglomerate which is exposed in a tributary creek to the east [700456]. The latter sequence consists of interbedded silicic pebble conglomerate, pebbly mudstone, quartzwacke sandstone and laminated grey-green siltstone. The conglomerate beds are up to at least 4 m thick, and the coarser beds contain rounded clasts (mainly of quartzite) up to 200 mm across. The sandstone beds are up to a metre or so thick, and include many coarse-grained, graded beds. A thin section of a sandstone (83–45) shows rather poor sorting, with abundant chloritic matrix material which has apparently replaced the margins of many grains. Grains consist mainly of quartz, with some altered feldspar, quartzite rock fragments, muscovite flakes, and chlorite grains. Derivation appears to have been mainly from a Precambrian metasedimentary source.

The sequence in the northern headwaters of Malcolm Creek (north of 694474) is folded into a broad anticlinal structure and is probably faulted against that to the south. It consists of alternating

sandstone-rich and siltstone-rich units up to 150 m thick. The sandstones are well-bedded, coarse- to fine-grained, grey to greenish grey, micaceous quartzwackes, in beds up to several metres thick commonly showing grading. Units of granule-pebble silicic conglomerate and minor units of pebbly mudstone are also present. Sandstone beds are commonly separated by thin units of laminated greenish siltstone similar to that of the siltstone-rich sequences. Load marks, graded bedding, and ripple marks (at tops of beds) are occasionally seen in the latter. Typical sandstones (83-44, 83-46) are moderately sorted, with 5-15% matrix. Grains consist mainly of quartz, including a few with embayments. Rock fragments are mainly quartzite, quartz-mica schist, and fine-grained sedimentary rocks, with only rare volcanic clasts. Muscovite and chlorite flakes and grains are common, biotite is rare, and tourmaline is a common accessory. An unusual lithic-quartz wacke (83-47) occurs at 690482. It contains clasts of fine-grained sediment up to several centimetres long, as well as grains of altered basic igneous rocks (comprising feldspar laths in a groundmass of yellow chlorite), quartz-phyric acid volcanic rocks, quartzite and quartz-mica schist, in a matrix of feldspar, muscovite and chlorite.

The north Malcolm Creek sequence is repeated eastwards by folding, and is probably broadly equivalent to that in the Henty River west of The Sisters. The latter sequence comprises units of thin-bedded to laminated grey siltstone and fine-grained sandstone alternating with units of quartzwacke turbidites and minor conglomerate. Minor folds with wavelengths of a few metres are common. The siltstones show fine-scale graded bedding and rare ripple marks and load marks. They typically consist of fine-grained quartz and white mica, with varying amounts of carbonate. Some contain thin shreds of carbonaceous material (73-376, 73-380). The fine sandstone beds show grading, cross-lamination and occasional ripple marks. They tend to be moderately to poorly sorted (73-384, 73-385), with quartz grains and white mica as dominant constituents in a dusty micaceous matrix (10-20%). Tourmaline grains are common, and a thin layer containing a concentration of tourmaline and zircon grains occurs in 73-385.

The quartzwacke occurs as beds 0.1-1 m thick, and as amalgamated units up to several metres thick, separated by thinner units of laminated siltstone and fine sandstone. Graded bedding is common, and some beds show load marks and other sole structures. A typical sample from the basal part of a graded bed (73-383) is a moderately- to poorly-sorted, coarse- to medium-grained, quartzwacke consisting of angular to subrounded grains of quartz, quartzite and quartz-muscovite schist, in a

matrix (10-20%) of murky brown and opaque material with flakes and shreds of white mica. Some grain boundaries are partly sutured. A single felsic volcanic clast was noted.

A mappable unit of white sandy pebble conglomerate, about 50 m thick, occurs within the sequence on the west flank of West Sister [724455]. Clasts are up to 150 mm across, and consist of quartzite, quartz-muscovite schist, vein quartz, and felsic volcanics, including quartz-porphry. Similar polymict conglomerate, in beds up to 10 m thick, is exposed in sections of Clifford Creek at the southern foot of The Sisters. The matrix of a conglomerate from this area (73-378) is a lithicwacke containing rock fragments of quartzite, quartz-mica schist, porphyritic and aphyric felsic volcanics of Mt Read type (including one clast of snowflake-textured rhyolite in which the snowflakes have cores of quartz, identical to the texture shown by rhyolites at Mt Jukes). The smaller grains consist of quartz, feldspar, muscovite and chlorite.

#### *Bottle Creek-Melody Creek area* (K.D.C., E.B.C.)

A sequence of interbedded green, grey and reddish siltstone, white to grey quartzwacke, silicic pebble-cobble conglomerate, and pebbly mudstone, is well exposed in Bottle Creek and along the Queensberry mine access road. Only sparse exposures occur east of the road, and the relationship to the sequence in the Malcolm Creek area has not been clearly established. The similarity of lithologies suggests the two are broadly equivalent. The sequence is overlain abruptly, but generally conformably, by the Owen Conglomerate correlate to the west. Most of the sequence dips and faces west at 40-60°, but some reversals of facing are apparent in the northern part of the area. A NW-trending fault, which offsets the base of the Owen Conglomerate correlate, probably transects the sequence to connect with a fault in the Melody Creek area. The part of the sequence west of this fault, to the base of the Owen Conglomerate correlate, is of the order of one kilometre thick.

Trilobites have been found at two localities within the sequence on the Queensberry mine road. These have been examined by Dr J. B. Jago, who states (1979, p. 226): 'Poorly preserved fossils include *Pseudagnostus* and other agnostids, olenids, asaphiscids and other trilobites of a late Idamean or early post-Idamean age'. This time range overlaps with that of the Climie Formation of the Dundas Group, and is similar to that of the basal Newton Creek Sandstone Member of the Owen Conglomerate.

The upper 300–400 m of the sequence consists predominantly of laminated to massive siltstone and mudstone. Of this, the uppermost 100–200 m, adjacent to the overlying conglomerate, is reddish brown in colour, while the lower part shows the normal green to greenish grey colour. Observations suggest that the red coloration is a secondary feature related to oxidation, since the colour change occurs along an irregular, poorly-defined boundary within a uniform siltstone-mudstone lithology. This oxidation of originally green or grey sediment probably occurred as a result of uplift of the sequence prior to deposition of the shallow-water facies of the Owen Conglomerate correlate.

The brown siltstone in thin section (83–41) consists essentially of silt grade quartz grains (including some polycrystalline grains) and mica flakes. The mica flakes are dominantly oriented parallel to bedding, and comprise about equal proportions of muscovite and chlorite, the latter seeming to be largely an alteration product of the muscovite. The brown coloration of the rock is produced by numerous spots and films of sub-translucent brownish yellow material. The more pelitic layers show a cleavage formed by finely-recrystallised micaceous material at an angle to bedding. The typical green siltstone generally shows lamination at a scale of 1–10 mm, with green pelitic laminae alternating with slightly coarser grained (and commonly graded) grey green laminae.

Beneath the upper mudstone unit, the sequence consists essentially of interbedded siltstone, quartzwacke and conglomerate. Some thicker conglomerate-sandstone units (up to 200 m) form low strike ridges and are mappable for 1–2 km. The quartzwacke beds are up to several metres thick, and typically show grading, sole marks (including flute casts) and other turbidite features. Thinner beds commonly have ripple-marked tops. Some coarser beds have granule to pebble grade material in the basal part.

The conglomerate units generally consist of beds of pebble-cobble conglomerate and quartzwacke, with slump sheets of pebbly mudstone and some intercalations of siltstone and fine-grained sandstone. The conglomerates include both open framework and closed framework types, and form beds ranging from 0.3 m up to at least 10 m thick. Outcrops tend to be bleached white, but the fresh rock is generally greenish grey. Some thinner beds show grading, and rare beds show erosional sole marks. Clasts range up to cobble grade (200 mm maximum), and are predominantly silicic and well rounded. Clast types include quartzite, quartz-mica schist, vein quartz, jasper (red and occasionally green varieties), chert, sandstone, pelite (including ripped-up mud clasts), and very rare felsic volcanic clasts.

A typical pebble conglomerate in thin section (83–39) shows well-rounded to angular rock fragments in a coarse-sand grade matrix consisting of rock fragments, quartz grains, white mica flakes, and dusty indeterminate material. The rock fragments are mainly quartzite and quartz-mica schist or brownish fine-grained sedimentary rocks, including pelite and chert. One larger clast consists of quartzose greywacke. Two clasts of volcanic rock are present, and there is some accessory tourmaline.

Slump sheets consisting of pebbles and cobbles dispersed in a sandy mudstone matrix, and containing lumps and rafts of contorted mudstone and sandstone up to 3 m long, occur in several of the conglomeratic units. Individual sheets range in thickness from less than one metre to at least 10 m.

The sequence overall may be interpreted as proximal flysch facies of submarine fan type, and is similar to other Late Cambrian quartzwacke sequences described from the Denison Range (Corbett, 1975a) and from the Newton Creek Sandstone Member of the Owen Conglomerate (Corbett, 1975b).

#### *UNDIFFERENTIATED SEQUENCE SOUTH-WEST OF PROFESSOR PLATEAU*

A small wedge of strongly-cleaved mudstone and fine-grained sandstone is exposed beneath Permo-Carboniferous rocks in the headwaters of McCutcheons Creek [620460]. The sequence appears to be faulted against the Owen Conglomerate correlate. The dominant lithology is a laminated grey-black siltstone with scattered thin beds of paler, fine sandstone. Bedding and cleavage trend north-west and are sub-vertical. The beds could be part of the Late Cambrian sequence or possibly the Bell Shale correlate.

#### *SOUTHERN AREA (€s) (S.F.C.)*

A deformed sedimentary and volcanic succession of probable Cambrian age is exposed in the area from Strahan to the lower reaches of the King River and south-east to the western foothills of Mt Strahan. To the south and west the succession is overlain unconformably by Tertiary deposits, while to the north-east it is faulted against Ordovician and Siluro-Devonian sequences.

Large parts of the succession are well exposed in railway cuttings and cliffs along the King River west of Teepookana, and along logging tracks to the south. Limited exposure is present on the Strahan-Queenstown road. Good sections also occur south of the King River in Swift Creek, Pine

Cove Creek and its tributary Gravelly Creek. Elsewhere, apart from small creeks, outcrop is poor due to deep weathering and thick vegetation cover, and most individual rock units cannot be traced very far.

The Cambrian succession can be subdivided into two major sequences, a lower volcano-sedimentary sequence with acid to basic volcanics interbedded with slates, siltstones and sandstones, and an overlying, dominantly sedimentary sequence of slate, siltstone and sandstone. No fossils have been found, but the succession has similarities with the Cambrian sequences in the northern part of the Quadrangle.

### *VOLCANO-SEDIMENTARY SEQUENCE* (€sv)

This sequence occupies the western half of the area of Cambrian rocks, and underlies the sedimentary sequence to the east. It is best described in three parts, *viz.* (1) a sequence of basaltic and andesitic volcanics which occurs in the south-west part of the area, around Pine Cove Creek and Gravelly Creek, and also in the lower reaches of several creeks running into Lettes Bay north of the King River; (2) the main sequence of interbedded felsic tuffs, sandstones and mudstones in the King River area, in which four stratigraphic units can be differentiated; and (3) undifferentiated correlates of this latter sequence north of the King River to the Strahan-Queenstown road area.

#### *Basalt-andesite sequence*

Near the confluence of Pine Cove Creek and Gravelly Creek [673245], and cropping out intermittently for about 1.5 km up Pine Cove Creek and several hundred metres across strike up Gravelly Creek, is a sequence of unbedded, but sometimes strongly-cleaved, green basalts. Typically this rock type (75-348) is a fine-grained intersertal to hyalopilitic-textured basalt with abundant plagioclase laths up to 0.5 mm in length, and intersertal dark coloured devitrified glass or mesostasis. Partly altered intergranular augitic pyroxene occurs as grains up to 0.2 mm in diameter. Chlorite and deformed sparry carbonate fill some vesicles, and prehnite and pumpellyite(?) are also present in minor amounts. In places where the basalt is strongly cleaved (*e.g.* 75-349), most of the plagioclase is altered to fine-grained carbonate, which forms elongate blebs parallel to the penetrative cleavage. The pyroxene is generally altered to chlorite, and much free quartz is also present.

Interlayered with the basalts are some intensely cleaved and altered pyroxene andesites (*e.g.* 75-347)

and minor intermediate tuffs. Only one thin siltstone bed has been found.

To the east of the basalt sequence [680242] in Gravelly Creek are massive outcrops of pyroxene andesite (75-346) with coarse phenocrysts of plagioclase and pyroxene in a fine-grained devitrified hyalopilitic groundmass. A few hundred metres upstream is a pyroxene andesite (75-345) with a very fine-grained grey, fluidal-textured, groundmass with feldspar microlites enveloping euhedral to subhedral phenocrysts of augitic pyroxene and plagioclase up to 6 mm long. The plagioclase is heavily saussuritized, but the clinopyroxene is often quite fresh and occurs as partly resorbed simple twinned crystals or as glomeroporphyritic clusters.

Over the next 700 m in an easterly direction, and presumably overlying these andesites, are more calc-alkaline volcanics. Though they are often deeply weathered, altered and cleaved andesites and crystal-lithic tuff may be recognised.

Sediments are very rare throughout this intermediate-basic volcanic sequence, suggesting that it may be partly sub-aerial. Some of the andesites may be shallow intrusives.

To the east of the volcanics in Gravelly Creek are about 100 m of openly folded and probably younger interbedded laminated siltstone, pyritic slates, and minor micaceous quartzwacke. One or possibly two thin units (<5 m) of fine-grained acidic vitric-crystal tuff are present. This sequence is overlain to the east by about 400 m of moderately E-dipping and largely pyroclastic acid-intermediate volcanics with minor interbedded pyritic mudstone, which together form the southern extension of Unit D in the volcano-sedimentary sequence 4 km to the north in the King River.

Near the mouth of Beehive Creek, north of the King River, there are massive to poorly layered intermediate lavas and pyroclastics. Amongst these is a porphyritic biotite dacite (74-236) containing bipyramidal to globular subhedral quartz phenocrysts (1.0-0.2 mm diameter) often with partly resorbed margins. Also present in this rock are tabular to chunky and euhedral to subhedral plagioclase phenocrysts (4 mm-0.1 mm), and minor light brown biotite in a fine-grained dusty matrix containing abundant altered feldspar microlites which impart a pilotaxitic fabric to the rock. Fluidal texture is particularly distinct around some phenocrysts. Much of the altered matrix is probably devitrified glass.

Specimen 74-237 is a fine-grained porphyritic andesite containing about 25% subhedral to tabular plagioclase phenocrysts (0.2-2 mm) and partly

chloritised subhedral to euhedral hornblende. Some of the plagioclase is extensively sericitised. The groundmass is a pilotaxitic to hyalopilitic aggregate of small plagioclase laths in a very fine dusty brown mesh of sericite and iron oxides which is interpreted as devitrified glass.

One example of crystal-lithic tuff (74-238) from this area contains 55% subhedral to angular sand-grade sericitised and carbonated plagioclase, as well as angular lava clasts, minor sedimentary rock fragments, a few per cent quartz and chloritised ferromagnesian minerals, in about 10% dusty brown matrix rich in fine layer silicates.

About 700 m north of Beehive Creek near the mouth of Blackwood Creek, various intermediate to acid volcanics unconformably underlie Tertiary deposits. Light coloured, unbedded, and often coarse fragmental volcanics extend for about 250 m up the creek. These are largely coarse-grained crystal-lithic, and crystal-lithic-vitric tuffs and lapilli tuffs, sometimes with included laminated siltstone clasts up to 0.4 m in diameter. Features such as this suggest deposition of at least some of the volcanics by sub-aqueous density flow.

#### *Lower King River area*

Along the lower reaches of the King River where a large part of volcano-sedimentary sequence is well exposed, the openly folded succession may be summarised as follows:

		m
Unit D	felsic volcanics with minor interbedded pyritic mudstone	350
Unit C	interbedded laminated siltstone, fine sandstone, slate and minor quartzwacke	180
Unit B	felsic volcanics	10-30
Unit A	laminated siltstones, slates and thinly bedded sandstone	20
	Base not exposed	

*Unit A:* The oldest part of the Cambrian succession exposed along the lower King River occurs in the core of an open anticline at the bottom of Kingfisher Creek [675271], where at least 20 m of thinly interbedded laminated grey siltstones and slates, and pinkish brown fine-grained sandstone and siltstones are exposed.

*Unit B:* Overlying Unit A in Kingfisher Creek are more than 10 m of felsic volcanoclastics, starting with 7 m of coarse vitric-crystal lapilli tuff (74-227) which contains large flammate aggregates up to 10 mm long of fine phyllosilicates with included subhedral

to anhedral quartz and feldspar. These clasts, which are interpreted to be devitrified pumice fragments, are set in a fine-grained recrystallised siliceous matrix which contains some coarser polygonal quartz aggregates (grains <0.5 mm), together with altered 1-2 mm diameter plagioclase grains. The feldspar in particular has been replaced by carbonate which now forms irregular blebs and grain aggregates. The tuff also contains some angular mudstone clasts up to 100 mm long. A slight upwards decrease in grain size occurs in this unit.

In the top part of Unit B is a massive unit containing several metres of altered and cleaved, very fine-grained felsic tuff (74-613). The rock is light coloured, has a silky lustre when fresh, and is composed of a fine aggregate of quartz, sericite and carbonate. The extensive alteration, recrystallisation and cleavage development has obliterated original textures.

Further west, in Lucky Creek [669272], where Unit B is repeated by folding, there are also present some thinly bedded (20-30 mm), cleaved, and altered volcanics such as 74-612. In thin section this rock is a strongly-cleaved mesh of fine quartz and mica with some included larger (1-2 mm) angular to subhedral quartz grains. Common cloudy 'fiamme'-shaped mixtures of very fine quartz and phyllosilicates are interpreted as flattened and devitrified pumice fragments. This composition and texture, together with remnant contorted banding in some relict vitric clasts suggests that the rock is a vitric tuff which originally may have been welded. However, extensive devitrification and cleavage development makes it difficult to assess the degree of welding.

Specimens 74-611 and 74-610 are examples of very altered medium- to fine-grained felsic tuffs occurring at the top of Unit B. The rocks have been strongly sericitised and carbonated, with the elongation of fine-grained layer silicates defining a penetrativesend stop cleavage. Remnant contorted banding is also present in some relict vitric clasts.

About 500 m further west, at 663270, Unit B retains the same overall features except that the thick lapilli tuff bed which elsewhere forms the base of the unit is underlain by several metres of ash tuff (74-229). This tuff contains angular to subhedral clasts of plagioclase, quartz and K-feldspar(?), together with a few fragments of fluidal-textured microlitic lavas and altered volcanic glass in a sparse recrystallised matrix of fine quartz and micas. The closed framework and abundance of unabraded crystal and lava fragments is suggestive of an ash-fall origin.

A probable lateral equivalent of Unit B occurs in road cuttings near 657271, where there are exposed about 30 m of acid-intermediate volcanics overlying laminated siltstones. Near the base of this volcanic sequence is a very fine-grained and strongly-altered and cleaved felsic volcanic rock (74–608), composed of a fine interlocking aggregates of quartz and layer silicates with a few larger fragments of quartz and white mica up to 0.05 mm in diameter. This is overlain by about 10 m of well bedded, fine-grained and altered vitric tuff or lava, and then a unit of strongly-cleaved ash to lapilli grade devitrified vitric-crystal tuff. Overlying this are a few metres of light coloured, poorly sorted, fine- to medium-grained vitric crystal tuffs. Sixty metres east, overlying these rocks, are at least 10 m of cleaved vitric-crystal tuffs such as 74–230. This rock contains about 20% angular to subhedral clasts of quartz, some with embayed margins. Also present are altered feldspar grains and an abundant apparent 'matrix' of very fine-grained quartz and phyllosilicates; the latter define an intense penetrative cleavage. Much of this 'matrix' is probably made of relict devitrified glass shards which are now only represented as diffuse elongate and flame grey blebs. The rock could be an ash-flow tuff.

In the core of an open anticline at 655272 the westerly continuation of the above volcanics contains only 6 m of ash to lapilli tuffs which are underlain and overlain by dark to medium grey laminated fine-grained sandstone, siltstone and slate.

*Unit C:* To the east of Kingfisher Creek and at some other localities along the Lower King River, Unit B is overlain by Unit C, a sequence comprising up to 180 m of thinly interbedded laminated grey slates and siltstones and grey to pinkish brown fine-grained arenites. Minor, more thickly bedded medium-grained micaceous quartzwackes are also present, particularly near the top of the sequence.

The fine-grained arenite layers (e.g. 74–603, 74–225) are generally less than one centimetre thick, and may be as little as 2 mm thick, and contain extremely thin internal muddy laminae. They are composed of fine-sand grade angular to sub-angular quartz clasts, and minor detrital muscovite and feldspar in a much finer grained recrystallised muddy matrix which constitutes up to 25% of the rock. Typical features of these fine-grained arenites include very poor sorting, small flame structures, convolute laminae, frequent sharp and irregular erosional soles, and diffuse tops which grade into laminated mudstone. Structureless non-graded bedding also occurs. The sedimentary structures in general suggest that the thin arenites are distal turbidite deposits.

The dark coloured siltstones and slates which are interbedded with the arenites (e.g. 74–614, 74–603) usually occur as internally laminated beds up to one centimetre thick. These contain up to 10% fine angular quartz grains (<0.05 mm), together with minor detrital muscovite disseminated in a cloudy recrystallised mesh of fine phyllosilicates, carbonate and minor opaques. The very fine-grained carbonate may constitute up to 30% of the rock. Thick sequences of laminated siltstones and slates with only minor interbedded fine arenites are common in Unit C, and may be pyritic.

*Unit D:* About 1.5 km south-west of Teepookana on the banks of the King River [690270], Unit C is overlain to the east by about 350 m of dominantly pyroclastic felsic volcanics. Laminated pyritic siltstones and mudstones are interbedded with the volcanics near the top and bottom of the sequence.

The lowermost bed of Unit D is a 10 m thick horizon of graded and possibly sub-aqueously deposited crystal-lithic volcanoclastic sandstone and granule conglomerate (74–224). At its base this bed contains 1–3 mm diameter clasts of angular to subhedral feldspar (mostly plagioclase), angular felsic lavas, and subordinate angular quartz, some of which occurs as pebbles up to 10 mm in diameter. Clasts at the top of the unit are of medium sand grade. The rock type is very poorly sorted and contains up to 10% recrystallised matrix of fine-grained quartz and mica with minor chlorite and epidote. Extensive alteration of feldspars to carbonate and sericite has also occurred.

Overlying the crystal-lithic volcanoclastic rocks are about 20 m of hard dark grey and laminated pyritic mudstone (74–222) which contains a few per cent of fine-grained pyrite cubes and minor angular quartz, mica and feldspar clasts disseminated in much finer recrystallised matrix of quartz, layer-silicates and minor carbonate. Below its contact with the overlying volcanic unit the mudstone has been altered to a very fine-grained light grey chert-like rock (74–233) which breaks with a conchoidal fracture. This effect may have been produced by heating or silicification following the deposition of the overlying 60 m of strongly-altered lapilli tuff. This tuff (74–221) has a relict coarse lithic-crystal clast structure, but now consists of a very fine-grained aggregate of quartz and carbonate together with some elongate chloritic blebs. The carbonate is present as long wispy fine-grained patches, often with much coarser grained internal patches.

The overlying 200 m or so of Unit D consists of many layers up to several metres thick of light grey to dark greyish green massive and banded medium to coarse-grained crystal-vitric and crystal-lithic-vitric tuffs and some very fine-grained felsic lava or

tuff. These rocks reflect a largely rhyolitic to dacitic source as they contain abundant subhedral to angular plagioclase, less frequent microlitic lava fragments, and quartz which sometimes shows partly resorbed margins. All the tuffs have a low ferromagnesian content. As there are no sediments intercalated with the volcanics in this part of the sequence, it is possible that the volcanics were deposited sub-aerially. This suggestion is supported by the fact that the volcanics contain no sedimentary clasts and show no evidence of sedimentary reworking or abrasion.

The plagioclase in the tuff is usually relatively fresh, but may be partly to completely sericitised or saussuritised. A feature common to all these rock types is extensive devitrification which has caused at least partial destruction of original textures. Glassy materials have been altered to very fine-grained aggregates of quartz and feldspar, with or without sericite and chlorite. Minor amounts of epidote may also be present, occurring as disseminated fine grains or skeletal to radiating aggregates up to 5 mm in diameter (*e.g.* 74-220). In some of the coarser and less altered tuffs (74-216, 74-217, 75-359) primary glass textures such as devitrified relict cusps to arcuate shards and pumice fragments with flow banding may be recognised.

The extensive devitrification makes it difficult to assess the presence of welding in the tuffs, however no relict eutaxitic textures typical of welded ash-flow deposits have been found in this part of the sequence. There are, however, some poorly-sorted and massive ungraded deposits which occur in layers up to several metres thick (74-216, 74-217). These rocks contain coarse (1-3 mm) angular to subhedral plagioclase as isolated clasts or glomeroporphyritic aggregates dispersed amongst more abundant and virtually unflattened devitrified shards and pumice. The poor sorting of these massive deposits could mean that they originated as ash-flows.

Tuffs of possible ash fall origin in this succession are moderately well-sorted and sometimes contain a well-developed and continuous planar internal compositional lamination (74-219, 74-605, 75-359). Angular to subhedral plagioclase and quartz grains, together with volcanic lithic fragments ranging in size from about 0.5-3 mm, are usually the predominant component, but devitrified glassy clasts are also present in very variable amounts.

The frequent very fine-grained volcanic horizons, each up to several metres thick in this section, are of uncertain origin, but may be fine-grained acid lavas or, more probably, vitric tuffs. Typical examples (74-220, 74-218) are light greyish green in colour

and contain a small proportion of anhedral to subhedral plagioclase and quartz grains up to one millimetre in diameter in an abundant much finer grained matrix of quartz, layer silicates, and feldspar, interpreted as devitrified glass. Irregular aggregates of fine-grained epidote impart a mottled texture to the rock.

Overlying the 200 m of possible sub-aerial volcanics is a 5 m thick layer of extremely fine-grained and irregularly fracturing chert-like material. This could be a fine-grained volcanic rock altered by fumarolic activity.

An overlying 30 m of interbedded felsic volcanoclastics and pyritic mudstones forms the uppermost part of Unit D. A 1.5 m thick moderately- to poorly-sorted sand grade tuffaceous horizon between two mudstone beds in this part of Unit D is graded and has an irregular erosional base and basal mudstone clasts. These features, and the presence of some sub-angular quartz clasts which occur together with the more abundant subhedral to angular plagioclase and some altered acid lava and pumice fragments, suggests that the deposit originated by deposition from a sub-aqueous volcanogenic debris flow.

Massive and compositionally banded ungraded volcanoclastic arenite units in this part of the succession range from one to four metres thick and have a less certain origin. Typically they contain abundant subhedral to angular plagioclase and angular quartz clasts in up to 20% fine-grained, quartz-feldspar(?) rich, matrix with minor sericite. The high percentage of quartz and frequent presence of detrital muscovite in some of the volcanoclastics indicates a mixed provenance, a point in favour of sub-aqueous deposition or reworking of a largely volcanogenic deposit.

#### *North of the King River*

To the east of, and probably faulted against, the intermediate volcanic sequence near the mouth of the Beehive Creek is a sequence of thinly interbedded grey to pinkish brown fine-grained sandstone and laminated grey siltstone and slate. The fine-grained sandstone beds are often less than one centimetre thick and are frequently graded and show basal scouring. Minor dark grey micaceous quartz-lithic wacke is also present in this sequence, which is similar to units A and C along the lower King River.

To the north-east of the volcanic rocks near the mouth of Blackwood Creek are openly folded dark grey laminated calcareous siltstones and coarsely to thinly bedded, dark coloured medium- to fine-grained sandstone which may show grading with laminated siltstone tops, basal scour structures,

and massive bottoms with included mudstone clasts. A typical quartzwacke (74-240) from a 200 mm thick bed in this sequence contains fine-sand grade equidimensional to elongate and angular quartz clasts (40%), sedimentary rock fragments (35%) and minor detrital muscovite in a recrystallised matrix of fine quartz and sericite. About 15% of the rock is made up of anhedral sparry carbonate grains up to 0.2 mm in diameter.

One kilometre north-east, in Purdys Creek, this quartzwacke siltstone sequence abuts against felsic volcanics to the east. A further 2 km to the north, in Botanical Creek, are more dark coloured inter-layered quartzwackes and siltstones. At 660316 massive acidic to intermediate volcanoclastics are present. These include ash and lapilli tuff (74-243) containing angular to subhedral plagioclase (50%) ranging in size from 0.1-3 mm, together with clasts of fine-grained lavas, devitrified pumice, and some shards. The vitric materials have been altered to a fine-grained aggregates of quartz, phyllosilicates, feldspar(?), and epidote. Another well-sorted tuff (74-244) contains clasts of euhedral to subhedral plagioclase, angular fine-grained microlitic lavas, clinopyroxene, angular quartz and cherty material, with a small amount of recrystallised matrix.

A few hundred metres to the south-east, greywackes and poorly-sorted granule- to pebble-grade breccia with abundant felsic lava clasts (*e.g.* 74-242) are present, together with laminated siltstones and slates. This sequence is overlain to the east by 300-400 m of steeply NE-dipping felsic volcanics which form the northern continuation of Unit D from the lower King River. This unit here strikes north-west between the Strahan-Queenstown road and the Burgess Rivulet, and is repeated by folding at 648335 on the Strahan-Queenstown road, where it youngs to the north-west and also dips steeply in that direction.

#### QUARTZWACKE-SILTSTONE- CONGLOMERATE SEQUENCE (C ss)

Overlying felsic volcanics of Unit D at the top of the volcano-sedimentary sequence in the lower King River area is a marine sequence comprising at least several hundred metres of quartzwacke, lithicwacke, micaceous quartz sandstone, laminated siltstone, and slate, together with minor siliceous conglomerate. The sequence is openly to closely folded, but displays an overall younging towards the east.

In the lower parts of this sequence west of Teepookana, and to the north-west between Four Mile Creek and the Strahan-Queenstown road, the predominant lithofacies is well-bedded, dark grey-

green (brown to light grey-green or white weathering), massive quartzwacke which occurs in beds usually between 0.1-0.3 m thick, but sometimes up to a metre or so thick. The quartzwackes are usually interlayered with thin beds of intensely cleaved laminated micaceous siltstones and slates, some of which are calcareous or pyritic. Sedimentary structures in the wackes are indicative of deposition largely by turbidity currents, and include sharp erosional soles and diffuse laminated tops accompanied by grading from medium sand grade upwards to fine silt grade. Flute marks on bed soles are not common; most graded beds in this area have planar soles. Some beds are structureless and ungraded. Laminated pelitic and semi-pelitic rocks interbedded with the wackes probably represent marine sedimentation from dilute suspension between the influx of turbidity currents.

The coarsest wackes present in the sequence are pebbly quartz-lithicwackes (*e.g.* 74-235) which occur in beds up to 3 m thick. These display normal grading to laminated medium sand grade wackes, and also show basal scour structures. The largest clasts in these rocks seldom exceed 7 mm and include angular quartz, quartzite and micaceous quartzite, which probably had a provenance in Precambrian rocks to the east or west. Other clasts include fine sandstone, siltstone and slate of probable intrabasinal derivation. A micaceous sandy to silty matrix makes up to 20% of this rock type.

The more usual quartzwackes (*e.g.* 74-206, 74-207, 75-408) are coarse or medium to fine-grained poorly sorted arenite consisting of angular to sub-angular quartz and fine quartzite, some mudstone and siltstone clasts, and minor detrital muscovite, chlorite and sometimes biotite, in up to 15% recrystallised matrix which is composed of fine layer silicates and quartz. The wackes sometimes contain minor amounts of plagioclase and fragments of felsic lavas derived from Cambrian volcanic sequences, but the provenance of the majority of clasts appears to have been from a metamorphosed Precambrian terrain.

Of minor occurrence in the sedimentary sequence west of Teepookana are very thinly bedded fine-grained quartzwacke sandstone and quartzwacke siltstones of probable distal turbidite origin. These occur as graded laminae 1-4 mm thick resting on top of one another over a thickness of several decimetres (*e.g.* 74-208). The lower half to two-thirds of each lamina consists of pale grey poorly-sorted quartzwacke of fine sand grade resting on a sharp erosional sole, and having a diffuse gradation upwards to darker coloured more muddy and more poorly sorted siltstone at the top of each lamina.

Within the quartzwacke-siltstone-slate sequence about 0.5 km west of Teepookana [697277] are about 30 m of submarine volcanoclastics, including well-sorted tuffaceous arenite, tuffaceous greywacke and tuffaceous pebbly greywacke (74–204, 74–205, 75–360) which rest on several metres of very fine-grained felsic tuff or lava. This lithofacies appears to lens out rapidly to the north and south.

To the south-east of Teepookana, the sedimentary sequence is essentially the same as that to the north of the King River, except that scour marks are more commonly developed at the base of graded micaceous quartzwacke beds. In some parts of the sequence there are thinly bedded and lensing micaceous siltstones and laminated mudstone interbedded with similarly lensing moderately- to poorly-sorted and cross-bedded micaceous sandstone. Also present are thinly interbedded and planar laminated grey siltstones and slates, and pinkish-brown weathering fine-grained sandstones. The sandstone layers are 1–40 mm thick, ungraded, and often have thin internal muddy laminae and convolute folds.

In Swift Creek and south-east towards Mt Strahan, well bedded micaceous quartz arenites are often graded and contain 10–15% recrystallised matrix, as well as showing the usual features of the turbidites elsewhere in the region. The laminated slate and siltstone units which are usually interbedded with the turbidites may be up to several metres thick. Ungraded and structureless, to flaggy or laminated arenites also occur (*e.g.* 75–352). These are poorly to moderately well sorted, and consist of angular to sub-angular quartz and quartzite clasts and a few per cent of detrital muscovite flakes in a sparse to moderately abundant recrystallised matrix composed of fine quartz and phyllosilicates. Ripple marks sometimes occur, and laminated fine- to medium-grained micaceous sandstone beds sometimes show small scale cross-bedding and convolute folds. The lower parts of some 200–300 mm thick sandstone beds are quite structureless and ungraded, however in their upper parts, thin muddy laminae are present and become increasingly more frequent towards the top of the bed which is capped by a few centimetres of laminated siltstone. The origin of such units is uncertain, but they may represent a turbidite facies.

Of minor occurrence within the sedimentary sequence are discontinuous composite conglomerate units which range from several metres to about 50 m thick. In Swift Creek [731240] a typical example of such a unit is made up largely of grey siliceous closed-framework conglomerate with well-rounded quartzite and quartz pebbles up to 200 mm in diameter and about 10–15% interstitial sand to granule grade matrix. Grading within

conglomerate beds is not evident. Some thin internal lenses of granule conglomerate and moderately well-sorted micaceous and calcareous quartz sandstone with angular clasts are present.

As well as the thick composite conglomerate units, thin single beds of siliceous conglomerate and siliceous pebbly sandstone interbedded with dark grey-green and sometimes graded sandstones have been recognised.

### Owen Conglomerate Correlates (Oo)

*K. D. Corbett*

#### SOUTHERN AREA (P.W.B.)

Correlates of the Owen Conglomerate crop out on the ridge to the east of Sailor Jack Creek [760300] and in the King River above Sailor Jack Creek [756291]. In the King River the rocks are thick-bedded, coarse- to very coarse-grained, buff-coloured quartz sandstones that contain abundant golden-coloured flakes of detrital mica. The beds range in thickness from 0.1–1 m.

On the ridge east of Sailor Jack Creek the rock type is coarse quartz sandstone with a few beds of granule conglomerate (seen only in float).

These rocks are correlated with the upper part of the Owen Conglomerate on lithological and stratigraphic grounds.

#### NORTHERN AREA (K.D.C.)

Rocks correlated with the Owen Conglomerate occur in two main areas in the northern part of the map sheet. On the Professor Plateau, a thick sequence of about 1700 m consists predominantly of shallow-water marine quartz sandstone, with a basal conglomerate unit. In The Sisters area, to the east, the sequence is much thinner and shows considerable variation in thickness (20–500 m) due to lensing of the lower conglomerate units. The sequences are overlain, apparently conformably, by Gordon Sub-Group correlate in both areas. Smaller areas of siliceous conglomerate occur at Marchfly Ridge and Ladders Lookout, but stratigraphic relationships are unclear in these areas.

#### THE SISTERS-HENTY RIVER AREA

A sequence of white to pale grey siliciclastic conglomerate and sandstone, with minor siltstone, overlies the Cambrian sequence at The Sisters [730460], and extends north as a narrow belt along the gorge of the Henty River. A good exposure of the basal contact of the sequence at the north-

eastern extremity of the outcrop belt [734487] shows it to be an angular unconformity, and unconformity is also suggested at the northern end of the West Sister. The sequence is folded into a tight synclinal structure with superimposed minor folds, the axial trace of the main N-trending structure lying more or less along the river. The presence of patches of limestone correlated with the Gordon Sub-Group within the axis of this structure supports the correlation of the siliceous sequence with the Owen Conglomerate.

The sequence consists predominantly of sandstone, with only minor conglomerate, along the western flank of the belt (including West Sister), and is difficult to distinguish from the underlying Cambrian quartzwacke sequence on the densely forested hills west of the Henty River. The Zeehan Sheet mapping to the north (Blissett and Guilline, 1962) shows the entire sequence as unassigned Cambrian. Generally, however, the sandstones are cleaner and better sorted, with less matrix, than the quartzwackes, and show more recrystallisation and suturing of grain boundaries. Many could be classified as quartzites.

The thickness of the sequence is highly variable, from a minimum of 10–20 m in the north-eastern part of the area to possibly 500 m at The Sisters.

The thickest conglomerates occur on Middle Sister and East Sister, and consist largely of pale pink to white pebble-cobble conglomerate in beds up to 5 m or more thick, with some intercalated pink coarse sandstone beds up to 300 mm thick. Boulder-size clasts occur in some beds, the largest clast noted being 600 mm in diameter. Clasts are predominantly well rounded, the most abundant rock types being quartzite, quartz-schist, vein quartz and dark chert. A bed containing numerous clasts of felsic volcanic rocks (including quartz-feldspar porphyry) as well as the more usual silicic clasts, was noted on the south-western flank of East Sister [735457], but in general, volcanic detritus is rare or absent. Most of the conglomerates have a closed framework, with a sandy matrix. Trough cross-bedding was noted in a sandstone unit on the northern part of Middle Sister, but is otherwise rare. The conglomerate sequence in this area thins rapidly to the north, and is of the order of only 150 m thick at the northern end of East Sister.

The West Sister, by contrast, consists largely of poorly-bedded white sandstone with only minor conglomeratic beds. A thin section (73–379) shows a clean, well-sorted, fine-grained quartz sandstone consisting of quartz grains with dominantly sutured boundaries and about 5% muscovite flakes and shreds aligned parallel to bedding. Tourmaline is the only significant accessory mineral.

The sequence exposed in the Henty River at the northern end of West Sister [729468] comprises a lower unit of thick-bedded sandstone (about 10 m thick), followed by interbedded pebble-cobble conglomerate and sandstone (about 10 m), thin-bedded micaceous quartz sandstone and siltstone (>30 m), and pebble-cobble conglomerate (5–10 m), overlain by limestone. The sequence dips and faces east, and overlies a W-dipping, W-facing sequence of quartzwacke turbidites with siltstone intercalations. The base is not exposed, but the disparity in dip and facing, and the discordance of strikes (about 40°), suggest an unconformable relationship.

In the gorge section of the Henty River north of The Sisters, the sequence consists of white, thick-bedded, coarse-grained to conglomeratic quartz sandstone with lesser thin-bedded micaceous sandstone and grey to black micaceous siltstone. Bedding is steep to overturned, and mesoscopic folds are common. A thick unit of white siliciclastic pebble-cobble conglomerate forms a prominent knob above the east bank [733474], but seems to lens rapidly to north and south. Bedding thickness in the sandstones ranges from 50 mm to 1.5 m, most beds being parallel-sided. Cross-lamination is common, and some beds up to 500 mm thick are cross-laminated throughout. Ripple marks occur on some of the thinner beds, and other sedimentary structures noted include load casts, shale pellets, and rare, poorly-developed graded bedding. Many of the thicker beds are apparently structureless. Ovoid to spherical concretion-like structures, up to 400 mm diameter, occur in some sandstone beds, and have a brown weathering surface suggesting a partially calcareous composition. Trace fossils (worm burrows) occur on the soles of some of the sandstone beds, indicating that the sequence is probably of shallow-water marine origin.

A sample from a thick-bedded sandstone unit (83–48) is a fine-grained well-sorted quartz sandstone in which most grain boundaries are sutured. Muscovite flakes and shreds constitute about 5% of the rock, the longer flakes being aligned parallel to bedding. Smaller flakes outline a second foliation at a high angle to bedding. Accessory tourmaline is common.

The basal contact of the sequence with the underlying Cambrian rocks is well exposed along a bulldozed track on a low ridge [734487] near the Zeehan Highway, where the sequence locally dips east. The basal unit is a white sandy pebble conglomerate, ranging in thickness from 200 mm to about 3 m, which erosionally truncates the underlying beds of siltstone and tuff (fig. 5). The conglomerate contains clasts of volcanic material as well as the more abundant quartzite clasts, and

black heavy mineral grains (probably chromite) are prominent in the matrix in some places. Above the conglomerate is a unit up to several metres thick of white quartz sandstone showing cross-bedding in places, followed by some 10 m or so of bioturbated grey silty sandstone and micaceous siltstone on the south bank of the Henty River. This latter is probably overlain by limestone. Bedding in the underlying Cambrian sequence trends  $015^{\circ}\text{SE}70^{\circ}$  (facing south-east), whereas bedding in the conglomerate unit trends  $147^{\circ}\text{E}60^{\circ}$ , giving a marked angular discordance. The conglomerate-sandstone sequence in this area resembles the Pioneer Beds sequence at Queenstown, which conformably underlies Gordon Limestone and rests unconformably on volcanic rocks west of the Great Lyell Fault and on the older part of the Owen Conglomerate east of the fault (Corbett *et al.*, 1974; Corbett, 1981).

### PROFESSOR PLATEAU AREA

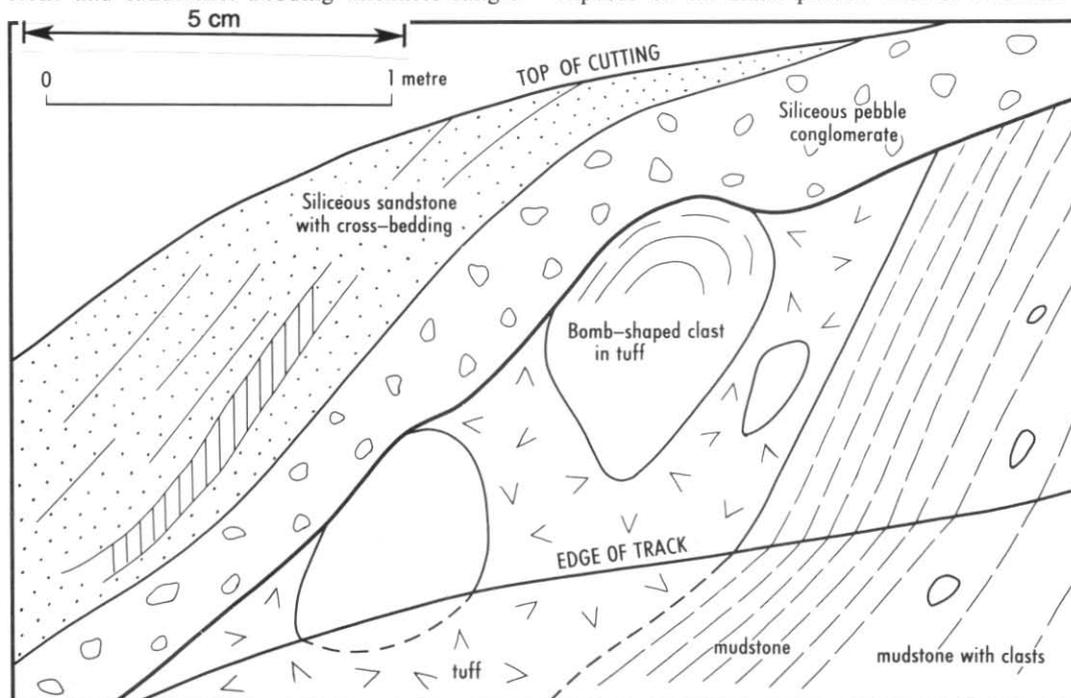
The W-dipping sequence of siliciclastic conglomerate and sandstone which overlies the Cambrian rocks at Professor Plateau has been correlated by Blissett (1962) with the Mt Zeehan Conglomerate and Moina Sandstone. The lower conglomerate unit (Oc) is of the order of 300 m thick, and consists of interbedded, pale pink to white pebble-cobble conglomerate, pebble conglomerate, pebbly sandstone and sandstone. Bedding thickness ranges

from a few centimetres to several metres. Trough cross-bedding is apparent in some sandstone units, while others show planar bedding, ripple marks and cross-lamination. Clasts are predominantly well rounded, and composed mainly of quartzite and quartz. The unit thickens markedly to the north on the Professor Range (Zeehan Sheet), where it includes major intercalations of siltstone.

The contact at the base of the sequence, where exposed on the road to Queensberry mine (north of the map sheet boundary), is abrupt, with sandy pebble conglomerate resting directly on massive, oxidised reddish mudstone. Bedding is difficult to discern in the underlying rocks, but the units appear to be sub-conformable.

The upper sandstone unit (Os) is of the order of 1.5 km thick, and consists of well-bedded, grey to white or pale pink sandstone with some interbedded pebbly sandstone and minor pebble conglomerate. Shale pellets were noted in some sandstone beds, but no outcrops of siltstone were seen. Trace fossils, particularly vertical worm burrows, are abundant in some units, and evidence of bioturbation is widespread. The sequence appears to thin markedly to the north and west. The contact with the overlying Gordon Sub-Group correlates is not exposed.

A similar conglomerate-sandstone sequence is exposed on the small plateau west of Professor



**Figure 5.** Field sketch of relationships between Owen Conglomerate correlate and underlying Cambrian beds on bulldozed track in north-eastern corner of the Quadrangle [734487], looking east.

Plateau [615480]. The lower conglomerate unit consists mainly of white to pale pink pebble conglomerate with sandy interbeds, and the upper sandstone unit of well-bedded white quartz sandstone with conglomeratic interbeds and trace fossils in places.

### **MARCHFLY RIDGE-LODDERS LOOKOUT AREA**

A thick sequence of white siliciclastic pebble conglomerate and sandstone occurs on Lodders Lookout [707467]. The sequence dips north-west, apparently oblique to bedding in a quartzwacke sequence to the north-west, but the relationship to this sequence could not be determined.

A similar sequence of white conglomerates occurs on Marchfly Ridge, to the south, in an area of very difficult access. The apparent lower part of this sequence on the south side consists of steeply W-dipping, thick-bedded pebble-cobble conglomerate with interbedded pebbly sandstone. A thin section from a coarse sandstone bed (73-389) shows a rather poorly sorted, 'dirty' sandstone with about 10% matrix of micaceous material (chlorite + muscovite) and brownish sub-opaque material. Clasts are predominantly quartzose types, including quartzite and quartz muscovite schist, but there are also fairly numerous clasts of fine-grained felsic volcanics, chert, and pelitic rocks. The relationship to the quartzwacke sequences to the north and south of this conglomerate unit could not be determined.

The conglomerate sequences are correlated with the Owen Conglomerate on general lithostratigraphic grounds, but it is possible that they represent major conglomerate units within the Late Cambrian quartzwacke sequence.

### **Gordon Sub-Group Correlates (Og)**

*P. W. Baillie*

### **SOUTHERN AREA**

In the southern part of the Strahan Quadrangle the Gordon Sub-Group correlate is subdivided into mudstone and limestone sequences. Poor outcrop and lack of biostratigraphic control does not allow for correlation with formations of the Gordon Sub-Group and its correlates in other parts of Tasmania. An area including the headwaters of Swift and Open Creeks (around 750250) is shown as probable Og on the map. This is a thickly vegetated area of low relief and virtually no outcrop. A few boulders of limestone were seen, indicating that the area is probably underlain by limestone.

### **LIMESTONE SEQUENCES (Ol)**

Massive limestone crops out on the King River on either side of the old Quarter Mile Bridge [716270]. The limestone is generally impure, with dark grey micritic patches interbedded with dark grey slate. A strong tectonic cleavage is usually present.

The limestone is usually weathered to a black pug, in which thin, impersistent mudstone bands less than one millimetre in thickness give an indication of bedding (P.W.B., S.F.C.).

### **MUDSTONE SEQUENCES (Or)**

Conformably underlying correlates of the Crotty Quartzite in the area of Sailor Jack Creek [756316] and the lower reaches of Open Creek [756285] in a sequence consisting dominantly of interbedded grey slate and siltstone, with some impure limestone horizons, considered to be a correlate of the Gordon Sub-Group.

In railway cuttings on the old Abt section immediately east of Halls Creek [754330], the sequence consists of highly cleaved brown-grey siltstone with subordinate green-white orthoquartzite in which bedding thickness ranges from 50-500 mm. The siltstone may be laminated and the tops of the quartzite beds occasionally show ripple marks.

The only fossils found were small cross-ribbed indeterminate rhynchonellid brachiopods of probable Ordovician age (M. J. Clarke, pers. comm.).

Beds of impure limestone are present in the unit in Open Creek, where the sequence consists of well-cleaved interbedded siltstone and limestone with some fine-grained sandstone beds. Thickness of beds is generally less than 100 mm. In thin section (75-288, 75-292) the limestone is seen to consist dominantly of micrite with only minor amounts of detrital calcite. Silt-size grains of clastic quartz make up approximately 20% of the rock.

The contact between this unit and the underlying Owen Conglomerate correlate was only seen at the head of the King River Gorge [755291] where mudstone belonging to this unit is highly contorted and kinked and contains numerous quartz veins, suggesting the presence of a fault.

The upper contact with the overlying formation was seen in several creeks and on the track between the Strahan-Queenstown road and the Hydro-Electric Commission's camp at Rinadeena [755320]. In each case sandstone beds become more common and thicker over a very short stratigraphic interval, and pass rapidly upwards into massive quartzite.

This unit also crops out in the King River (near 711269), where interbedded laminated fine-grained sandstone and calcareous mudstone apparently overlies massive, impure limestone.

### NORTHERN AREA (K.D.C.)

Limestone correlated with the Gordon Sub-Group crops out in three places in the Henty River north of The Sisters. Contacts with adjacent units are concealed in all cases. Near the northern foot of Middle Sister [732465], a NW-trending stretch of river exposes pale grey to dark grey, cleaved, bedded limestone which is stylolitic and dolomitic in part and dips first west and then east at 40°. Thin bands rich in brachiopods occur in places. Further north, at 730477, steeply-dipping stylolitic limestone occurs in the river bed below water level. Similar stylolitic limestone, with sub-vertical bedding, is exposed at 730488.

Exposures of the limestone sequence also occur in the upper reaches of McCutcheons Creek [615460], south-west of Professor Plateau. In this area, massive grey unfossiliferous limestone occurs to the east and west of a unit of thick-bedded quartz-sandstone with some interbedded siltstone. This clastic unit may be equivalent to a richly-fossiliferous calcareous siltstone-sandstone unit which occurs in the upper part of the limestone sequence in the Badger River valley to the north [625490].

### Siluro-Devonian Eldon Group Correlates

*P. W. Baillie*

#### INTRODUCTION

Correlates of the Eldon Group of the Zeehan area occupy a large synclinal basin in the central part of the Strahan Quadrangle. The basin is bounded to the north and south by Cambrian and Ordovician rocks, and to the west it disappears under Late Palaeozoic and Cainozoic cover.

The Eldon Group was defined by Gill and Banks (1950) to include the following formations:

	m	
Bell Shale	420	top
Florence Quartzite	490	
Keel Quartzite	120	
Amber Slate	240	
Crotty Quartzite	490	
	<hr style="width: 100%; border: 0.5px solid black;"/>	
	1760	

The top 60 m of the Keel Quartzite was re-defined as the Austral Creek Siltstone (Blissett, 1962).

The sequence in the Strahan area is dominated by correlates of the Bell, Florence and Crotty Formations, with the Bell Shale correlate being particularly extensive. Correlates of the Amber, Keel, and Austral Creek Formations occur only in a small area south of the Strahan-Queenstown road. The Crotty Formation correlate occurs only in the south-eastern part of the Quadrangle, where it overlies mudstones of probable Ordovician age. Further west, the contact with the basement Cambrian rocks is faulted and transgresses up through the Eldon Group sequence, so that correlates of the Florence and Bell Formations lie against Cambrian basement.

### CROTTY QUARTZITE CORRELATE (Sc)

A sequence of orthoquartzite, sandstone, mudstone and grit, lithologically similar to the Crotty quartzite of Zeehan, conformably overlies a mudstone sequence forming the upper part of the Gordon Sub-Group correlates in the Sailor Jack Creek-Rinadeena area. The formation in this area is of the order of 500 m thick at 750290.

The base of the formation is best exposed: (1) in the King River below Sailor Jack Creek [753291]; and (2) on the track leading up from the old railway station at Rinadeena to the Strahan-Queenstown road [756319].

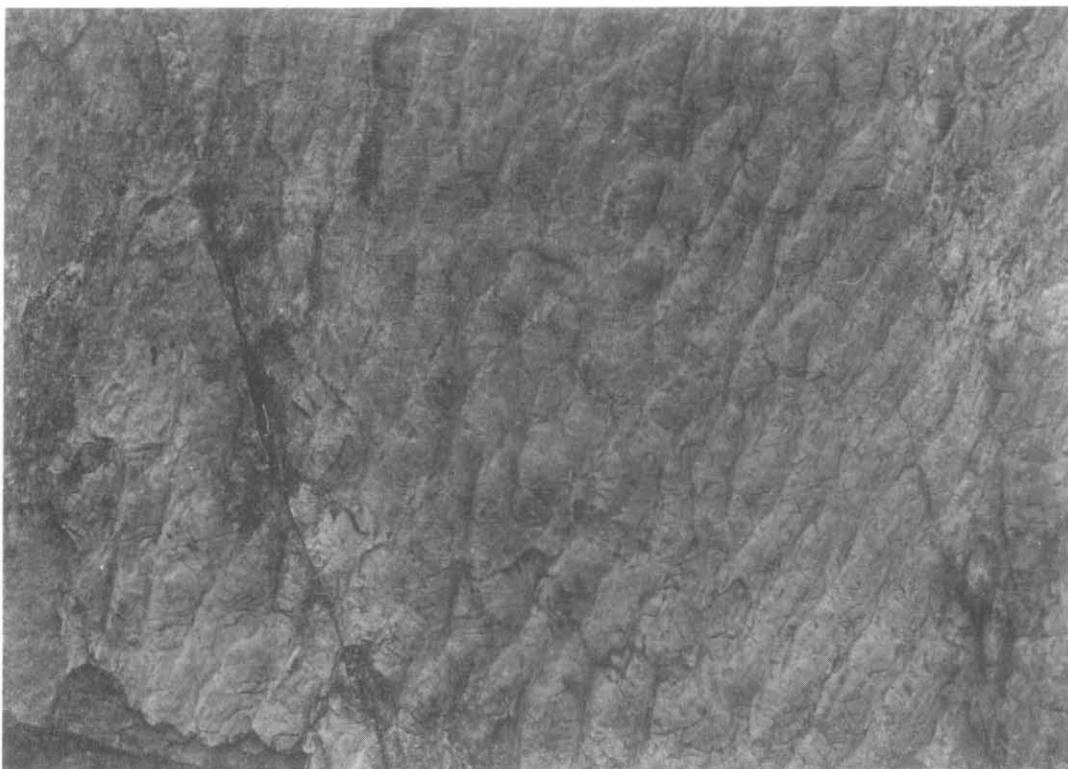
The top of the formation is nowhere exposed; the upper contact is always a fault against correlates of the Florence Quartzite (P.W.B., G.P.P.).

The sandstones of the Crotty correlates are light coloured, fine- to coarse-grained and consist of moderately well-sorted sub-angular to rounded grains of quartz and rock fragments. Some of the coarser lithic fragments have been kaolinised and give a white, speckled appearance to the rock. The overlying Florence Quartzite correlate, by contrast, has a cleaner appearance (P.W.B., G.P.P.).

In thin section (74-278) the massive sandstone is seen to be moderately well sorted, containing median-size grains 0.3 mm in diameter (range 0.1-0.8 mm) which range from sub-rounded to rounded. Individual quartz grains that often exhibit undulose extinction are the major clastic component, but lithic fragments, including quartzite grains, are also present.

Linguoid ripples are commonly developed on the upper surfaces of sandstone beds. Using the method of Komar (1974) it is suggested that these ripples were generated in water depths of 0.85-1.6 m.

Grit beds are sometimes present, and consist of coarse (1-5 mm) angular to sub-rounded, often



**Plate 2.** Ripple-marked sandstone, Crotty Quartzite correlate, Strahan-Queenstown road [755350].

poorly-sorted, quartz grains with a subordinate lithic component, occurring in beds up to 200 mm in thickness (plate 2). Such beds are invariably cross-bedded, and consist of single, medium-scale troughs that usually have a sharp, scoured lower surface and a truncated upper surface. These deposits were probably formed in a high-energy environment.

In contrast to these coarse-grained, high-energy deposits are units of grey-green mudstone, with occasional interbedded fine-grained quartz sandstone, that in places contain a fauna of magnificently preserved crinoid arms in which the smallest detail of these delicate creatures is preserved. Such mudstone units must have been deposited under very sheltered, quiet conditions.

The sandstones of the Crotty Quartzite correlate in the Strahan Quadrangle are generally poorly fossiliferous, but in places contains *Rostricellula*, a brachiopod which also occurs in the Crotty quartzite at Zeehan. At 752321, on the track leading to the Hydro-Electric Commission's camp at Rinadeena, the sandstone contains a rich but poorly-preserved and indeterminate fauna of rhynchonellids, loxomenid gastropods and bivalves.

#### 'MIDDLE ELDON GROUP' CORRELATES (Sa) (S.F.C.)

Faulted against, and stratigraphically above Gordon Sub-Group correlates in Virginia Creek and some tributaries [700290] and nearby Lilaree Creek [709281], is a clastic sequence comprising of at least 250 m of strongly-cleaved light to grey slate, siltstone and minor thin beds of laminated and often ripple-marked or cross-bedded sandstone. The sandstone is usually a buff coloured, very fine-grained, recrystallised micaceous quartz sandstone or orthoquartzite. Indeterminate fragmental bryozoans and brachiopods are sometimes present. The sequence stratigraphically underlies correlates of the Florence Quartzite and is lithostratigraphically correlated with the Austral Creek Siltstone, Keel Quartzite and Amber Slate of the Zeehan area.

#### FLORENCE QUARTZITE CORRELATES (Ds)

In tributaries of Virginia Creek [706286] the slate and siltstone of the 'Middle Eldon Group correlates' are conformably overlain by a thick sequence of quartz sandstone with minor mudstone that is correlated with the Florence Quartzite (S.F.C.).

All other contacts of this formation with older rocks are faulted.

The formation reaches its maximum thickness on the King River westwards from Camp Spur [735275] where it is of the order of 1300 m thick. Individual sandstone or orthoquartzite beds range in thickness from 60 mm to over one metre but are generally in the range 150–300 mm. Most beds are internally structureless, but some exhibit planar or cross-lamination. Tops and bottoms of beds are always sharp, although the tops may be scoured or sometimes rippled. Mudstone is a very minor part of the sequence, and occurs as beds usually less than 100 mm thick, which may be structureless, planar-laminated or cross-laminated. Load casts, flame structures and pseudo-nodules are associated with some mudstone beds.

Two diagnostic faunas are present in the King River section. The stratigraphically lower horizon occurs at a landslide on the old railway line at 735272 and the fauna is dominated by the small cuboid rhynchonellid *Phoenicitoechia* which occurs with *Molongia* c.f. *elegans* Mitchell, *Atrypa*, *Nucleospira*, *Trimerus* (*Trimerus*) sp., *Tentaculites*, loxonemid gastropods, bivalves, corals and bryozoans (M. J. Clarke, pers. comm.).

The higher horizon occurs near the top of the formation on the northern side of Camp Spur [734277] and is characterised by the presence of *Notoconchidium* and *Leptostrophia* which occur with *Eatonia*, other brachiopods, loxonemid gastropods and bivalves (M. J. Clarke, pers. comm.).

Correlates of the Florence Quartzite are also fairly well exposed at several places on the Strahan Highway [e.g. 690310, 748335], and in the Henty Plantation [595370], where a strike ridge of quartz sandstone was exposed during road-building operations in 1973. In all localities the formation consists of leached, well-bedded, usually massive beds of quartz sandstone with very minor thin beds of mudstone. On the Strahan Highway near the old 13 mile peg [746318], well-developed ball-and-pillow structure is present (plate 3). Individual pillows may be up one metre across and are separated by mudstone.

Thin section examination of rocks from this formation shows that the most common rock type is very well-sorted, very fine-grained quartz sandstone (e.g. 74–148, 74–132, 74–132). Median grain size is 0.08 mm and the grains are composed dominantly of well-rounded quartz grains, some of which show undulose extinction. Detrital mica and rare tourmaline grains are also present. A clay matrix is sometimes present and a carbonate cement was noted in one thin section (74–124).

Specimen 74–131 is a poorly-sorted medium-grained quartz sandstone. The clastic grains are very variable in shape; individual grains are angular to well rounded and are often rod-shaped, although most have a moderate sphericity. The grains are predominantly composed of quartz (often polycrystalline); also present are detrital mica and lithic grains, including schistose fragments.

## BELL SHALE CORRELATE (Db)

Conformably overlying correlates of the Florence Quartzite, and occupying about 30% of the land area of the Strahan Quadrangle, is a sequence of interbedded mudstone, siltstone and very fine-grained sandstone (plate 4) that is correlated with the Bell Shale of the Zeehan area.

A discussion of the sedimentary features of this formation has been presented by Baillie and Williams (1975). As noted by these authors, there exists a broad two-fold subdivision of the Bell Shale, both lithologically and palaeontologically, into a lower, more sandstone-rich sequence, and an upper, sandstone-poor sequence. It was not found practicable to differentiate the two sequences in mapping.

The formation crops out extensively along the Henty River and tributaries between McCutcheons Creek and The Sisters (A.V.B., E.B.C., K.D.C.). In this area it consists mostly of a monotonous alternation of fine-grained quartzite in beds 10–100 mm thick, and laminated siltstone and mudstone in beds 80–450 mm thick. The quartzite beds commonly have ripple-marked tops and flat bases, and the thicker bands show internal cross-lamination and/or planar lamination. There is a suggestion of grading in some of the quartzose bands and also in some of the siltstone beds.

Fossils recovered from near McCutcheons Creek [602447] include *Howeella*, *Atrypa*, *Isorthis* and *Meristella bellensis* Gill and are referable to the lower Bell Shale fauna (M. J. Clarke, pers. comm.).

In Clifford Creek, at the southern foot of The Sisters [730450], fossiliferous limestone is interbedded with cleaved grey micaceous and calcareous mudstone adjacent to a complex faulted contact with Cambrian rocks, (K.D.C.). The richest fossil locality is at 733449. M. J. Clarke (pers. comm.) reports that fossils are abundant, but rather fragmentary and poorly preserved, in the leached and impure limestone, and include brachiopods, trilobites, corals, bryozoans, tentaculitids, and crinoid fragments. Four genera of articulate brachiopods are present including forms similar to *Howeella* and *Phoenicitoechia*. One of the trilobites is a form like *Gravicalymene*. A form of *Favosites*



**Plate 3.** *Water escape (ball and pillow) structure, Florence Quartzite correlate, Strahan–Queenstown road [746316].*



**Plate 4.** *Interbedded light-coloured very fine-grained quartz sandstone and dark mudstone, Bell Shale correlate. Quarry off the Strahan–Queenstown road [748380].*

with very large mural pores is present, as well as abundant *Tentaculites*.

In the Tully River area [615400] the formation is a mixed succession of evenly-bedded quartzite, fine-grained sandstone, siltstone, and mudstone (A.P.B.). Sandstones are usually fine- to very fine-grained, clean, well-sorted quartz arenites, and are interlayered with grey-black micaceous siltstone and cleaved black mudstone. Average bedding thickness is 400 mm, although quartzite beds may exceed this. Sedimentary structures are plentiful. Both the sandstone and siltstone may be planar-laminated or cross-laminated. Grading may be present. Mud-pellets and streaked-out bedding in siltstone are usually associated with flame structures. Bioturbation is plentiful.

Sedimentary features for the remainder of the area have been described by Baillie and Williams (1975). These authors have suggested that the lack of coarse sand, the large amount of detrital mica, the development of flaser and lenticular bedding, the presence of carbonaceous material, and the limited development of a *Modiola* Phase fauna, indicate deposition in a shallow-water marine environment that was fed from a low-relief distal source area.

## Parmeener Super-Group

*P. W. Baillie*

### INTRODUCTION

Rocks of the Parmeener Super-Group (Banks, 1973) occupy a NNW-trending belt of country between Strahan and the lower reaches of the Henty River. Previous reports on the area by Montgomery (1891), Johnston (1892), Twelvetrees (1902a, 1902b, 1903) and Gill and Banks (1950) are summarised in Banks and Ahmad (1962). Five mappable units are present: a lower glacio-marine sequence which has been subdivided into glacial and marine sequences, a lower freshwater sequence, an upper glacio-marine sequence and an upper freshwater sequence. These rocks constitute the Lower Division of the Parmeener Super-Group. No Upper Division rocks are present in the mapped area.

The base of the Super-Group is exposed in several small tributaries of the Henty (e.g. 602447) and Tully Rivers (e.g. 603396) where glacial rocks unconformably overlie correlates of the Bell Shale (A.P.B., A.V.B., A.B.G.).

The sequence generally dips west to north-west at 10–20° in the northern part of the area, and east to north-east at 10–20° in the Strahan–Queenstown road area.

A composite section is shown in Figure 6.

## LOWER GLACIO-MARINE SEQUENCE

### GLACIAL SEQUENCE (Plgt)

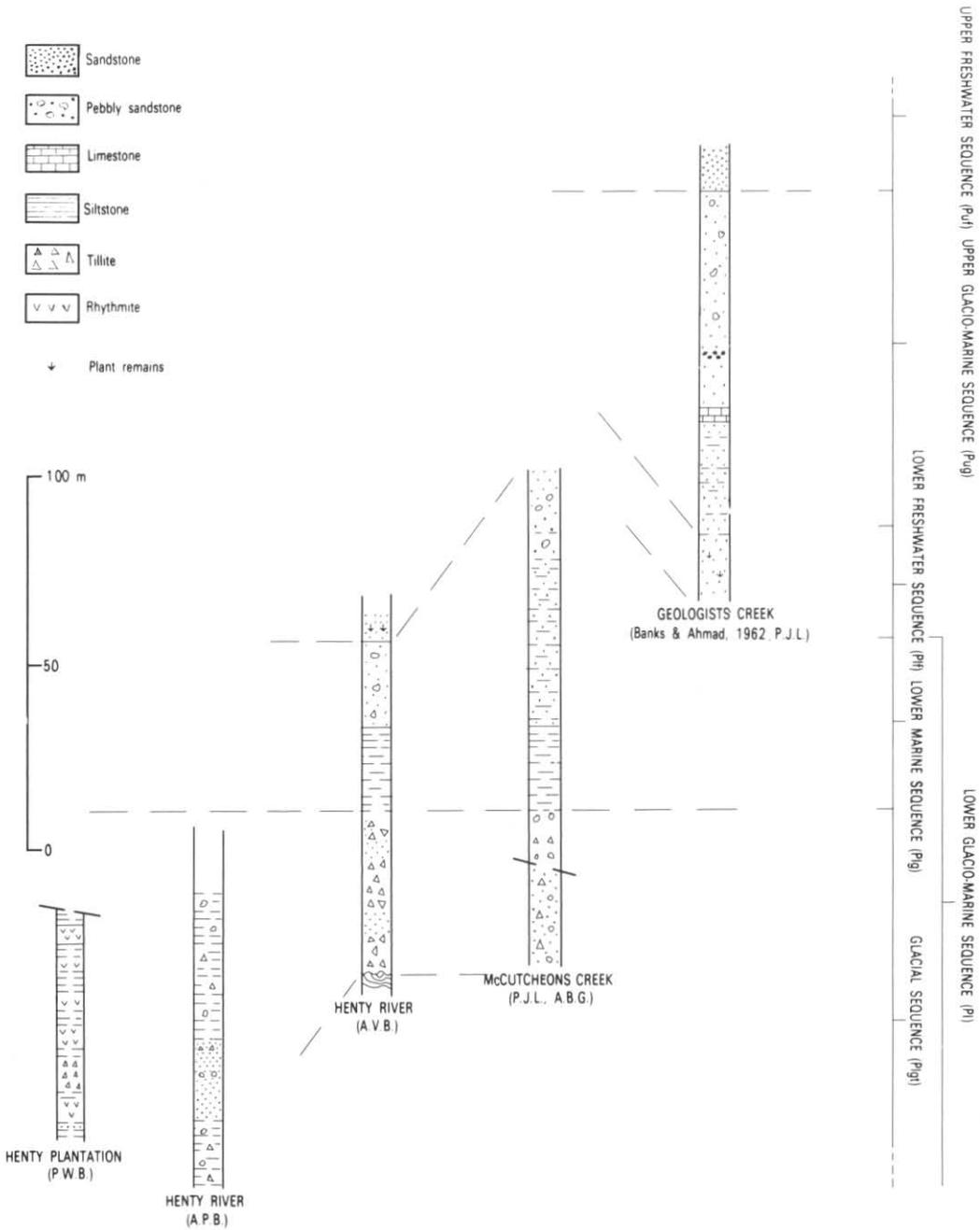
Rocks of variable lithology comprise the glacial sequence and include tillite, conglomerate, sandstone, siltstone and rhythmites.

The unit is exposed on the Strahan–Queenstown road at 635333 where it consists dominantly of grey tillite consisting of clasts of quartzite, greywacke, quartz and granite, in a clayey matrix (P.W.B., R.D.G.). Some of the clasts are striated. Rare sandy lenses are present. Microflora from a tillite sample indicate a Stage 1 age (Truswell, 1978). Also from this sample, a single specimen of the spinose acritarch, *Michrystidium* suggests that conditions were at least marginally marine during deposition of these rocks. This supports the concept of deposition from a wet-base glacier at or below sea level, as suggested by Carey and Ahmad (1961).

In the Henty Plantation [613378] tillite has also yielded a Stage 1 microflora (Truswell 1978). The dominant rock type in this area is a grey pebbly mudstone with interbedded sandstone and rhythmite horizons. Massive tillite is a minor part of the sequence (A.P.B., P.W.B.).

The pebbly mudstone is poorly sorted, with an open framework, and consists of well-rounded boulders, cobbles and pebbles in a grey clay-silt matrix. Rudimentary sorting and bedding are present. Composition of the clasts is dominantly sandstone, quartzite and chert with minor greywacke, siltstone, conglomerate and schist. Sandstone horizons occur within the pebbly mudstone, and are bioturbated in some places.

In this area rhythmite horizons are very common (Plgr on the map). The rhythmites are grey in colour, weathering to olive green or ochre, and are composed of repetitive laminae which are often disrupted by dropstones. Thickness of individual laminae ranges between one and 10 mm, and they are characteristically graded from clayey sand to clay, with an associated colour change from light to dark grey. Dropstones within the rhythmites generally have their long axes planar with the bedding lamination, but some at right angles to this lamination have been noted. The dropstones may bend or disrupt laminae on to which they have fallen. Overlying laminae are planar. Larger pebbles and cobbles up to 150 mm in diameter were noted where the rhythmites had a frequency of about three per centimetre. In places the rhythmites are interrupted by layers up to 10 mm thick of coarse grit and fine to medium pebbles, which may represent lag deposits resulting from winnowing. Thicker winnowed deposits (up to 300 mm) consist of grey pebbly mudstone containing close-packed,



Compiled by P.W. Baillie

Geology by P.W. Baillie, A.P. Bravo, A.V. Brown, A.B. Gulline, P.J. Legge, and Banks & Ahmad (1962)

**Figure 6.** Composite section of rocks of the Parmeener Super-Group.

5 cm

well-rounded, elongate pebbles in a matrix of coarse sand and clay (A.P.B., P.W.B.).

The glacial sequence reaches its maximum proved thickness in the lower reaches of the Henty River, upstream from the old railway bridge, where it is at least 130 m thick (A.B.G.).

Between the Tully River and Lost Creek [605415] the sequence is dominantly unbedded, unfossiliferous, grey tillite and pebbly mudstone which weathers to a light grey colour. Composition of the pebbles includes quartzite, hackly mudstone, quartz-mica schist, quartz schist, jasper and granite. Several current-deposited beds occur, one of which is 700 mm thick and shows grading from conglomerate with well-rounded pebbles up to 80 mm in diameter, through sandstone to siltstone. A 10 m thick siltstone bed overlying the graded bed shows well-developed cross-bedding (A.P.B.).

Near the mouth of Geologist Creek [582459], indurated tillite contains striated boulders up to one metre in length (P.J.L.). Towards the top of the tillite, beds or lenses of pebbly mudstone are intercalated with the tillite. In one creek [588442] approximately 70 m of grey sandstone occurs between tillite horizons. Along McCutcheons Creek [601450] bouldery tillite is interbedded with pebbly mudstone (P.J.L.).

The glacial sequence is correlated with the Zeehan Tillite.

### MARINE SEQUENCE (Plg)

Overlying the glacial sequence is an unfossiliferous massive black or grey fine-grained mudstone which weathers to a buff colour. It is a correlate of the Quamby Formation (P.J.L., A.V.B.).

This sequence is overlain by fossiliferous pebbly sandstone, grey mudstone, and siliceous sandstone. Lithology is variable and dropstones are abundant. Fossils include *Trigonotreta stokesi* Koenig, *Eurydesma* and *Deltopecten* (M. J. Clarke, pers. comm.).

Thickness of the marine sequence is of the order of 50 m and is best developed in McCutcheons Creek [603457] (P.J.L.).

### LOWER FRESHWATER SEQUENCE (Plf)

The lower freshwater sequence forms low strike ridges above the lower glacio-marine sequence north of the Henty River, and is best exposed in

Geologist Creek [583467], where it is of the order of 13 m thick (P.J.L., K.D.C.). The sequence consists of interbedded carbonaceous, micaceous, well-sorted quartz sandstone and thinly-bedded fossiliferous black shale containing abundant *Glossopteris* leaves and other plants (Banks and Ahmad, 1962). Some of the leaves are over 300 mm in length. This sequence is correlated with the Liffey Group of northern Tasmania.

### UPPER GLACIO-MARINE SEQUENCE (Pug)

This sequence is best exposed in Geologist Creek, where it has a thickness of a little less than 100 m and overlies the carbonaceous sandstone sequence. It consists of uniformly-textured grey siltstone interbedded with fossiliferous massive grey siltstone. Higher stratigraphically, a horizon of fossiliferous limestone containing bryozoa, stenopods, and spiriferids occurs. This rock displays prominent solution texture (P.J.L.).

The upper part of the glacio-marine sequence consists of a monotonous succession of thick-bedded, erratic-rich sandstone containing carbonaceous fragments and trace fossil burrows in places. Occasional beds of fine conglomerate may be present (K.D.C.). These rocks are correlated with the Poatina and Bogan Gap Groups of northern Tasmania.

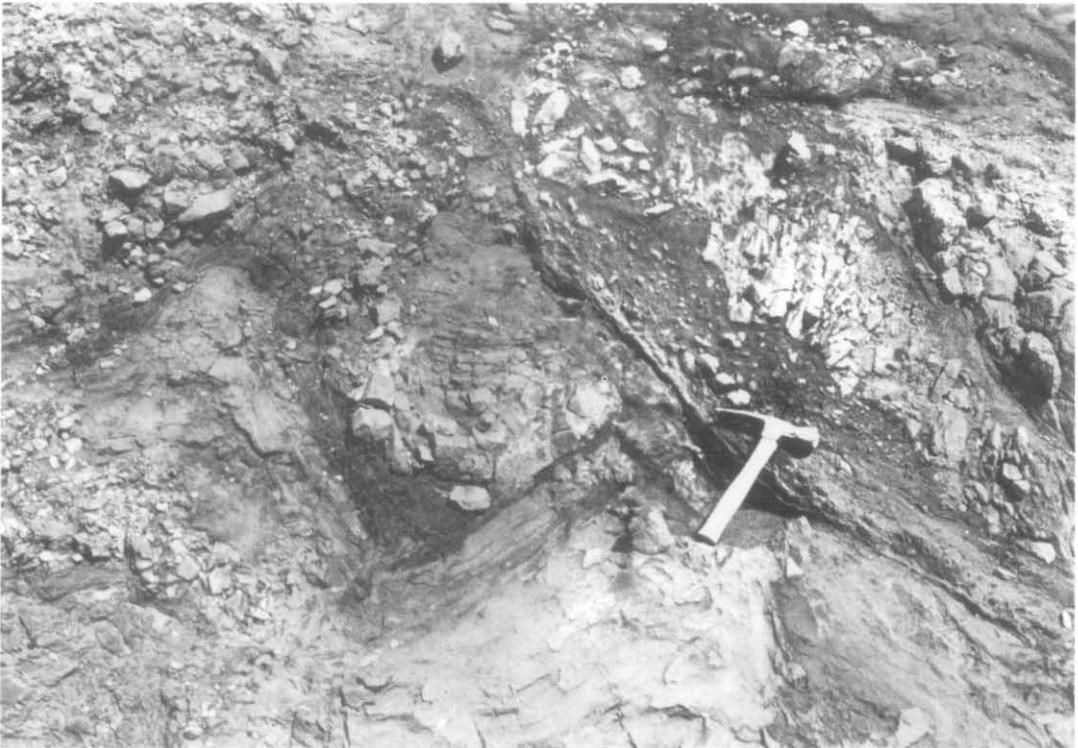
### UPPER FRESHWATER SEQUENCE (Puf)

The youngest rocks of the Parmeener Super-Group in the Strahan Quadrangle crop out on the northern edge of the sheet at 580489, and consist of cross-bedded, coarse-grained, quartz sandstones which are underlain by a distinctive unit of interbedded carbonaceous shale and sandstone (P.J.L., A.B.G., K.D.C.). The latter unit was erroneously interpreted as a Pleistocene glacial deposit by David (1926), where it occurs on the railway line north of the Quadrangle boundary. Coarse-grained, cross-bedded sandstone and grit (plate 5) in beds up to 600 mm thick, lies conformably on, and is interbedded with soft, laminated, purple-grey siltstone and carbonaceous sandstone which show numerous intra-formational faults, and hydroplastic structures (plate 6). *Vertebraria* and Upper Permian spores are recorded from these beds (Banks and Ahmad, 1962). The sandstone-grit sequence crops out along the hill tops to the east of the railway line.

These rocks are correlated with the Cygnet Coal Measures and the Jackey Formation.



**Plate 5.** *Cross-bedded sandstone, Cygnet Coal Measures correlate, Strahan-Zeehan road.*



**Plate 6.** *Syndepositional deformation structures, Cygnet Coal Measures correlate, Strahan-Zeehan road.*

## Tertiary

*P. W. Baillie*

### INTRODUCTION

Tertiary sediments and sedimentary rocks filling the northern part of the Macquarie Harbour Graben were mapped on the eastern side of Macquarie Harbour in the region of Connellys Point [648238]; in the general area of Strahan [615315]; and in a belt between Strahan and the lower Henty River [570472]. The sedimentary infill is known as the Macquarie Beds (Bradley, 1954) and is indicated by gravity data to have a minimum thickness of 450–500 m (Leaman, 1974).

During mapping of Strahan Quadrangle many difficulties were encountered in differentiating the various Cainozoic deposits with respect to age and origin. At the time of mapping only limited palynological information was available and this suggested that the sequences that contained quartz gravels were Palaeocene in age (Cookson and Eisenack, 1967). As a consequence of this the philosophy adopted during mapping was that the coarse deposits were Tertiary and finer deposits Quaternary. Recent detailed palynological studies by S.M. Forsyth and a better understanding of Quaternary geology (for summary see Banks *et al.*, 1977) have shown that the Cainozoic geology of the Strahan Quadrangle is more complex than was envisaged at the time of mapping.

The Tertiary deposits occur in three broad geographic areas and will be described from each of these.

### SOUTH OF THE KING RIVER (S.F.C.)

South of the King River, Tertiary alluvial deposits occur from below sea level to an altitude of 370 m on the north-eastern side of the Macquarie Harbour Graben. South of the mouth of the King River the margin of the alluvial basin trends SSE for 5 km, and the unconformity with the Cambrian basement dips 10–20° to the south-west. From this point [682233] the margin turns abruptly ESE, and the sediments lie on a basement slope of 30° to the SSW. At altitudes of 150–300 m a.s.l. sediments overlap the scarp to lie on a more gently sloping unconformity.

The nearly linear boundaries and relatively steep slopes at the margins of the basin suggest that initial deposition was limited by major fault scarps which were cut back and partly overlapped as the graben filled with sediment.

In cliff exposures south of the King River delta there is at least 100 m of gently-dipping, poorly- to

well-consolidated and jointed clastic sediments. On the coast about 1.5 km south of Connellys Point [551221] these sediments have yielded an Eocene microflora (W. Harris, pers. comm., 16 April 1975).

The Macquarie Beds in this area include sequences of dark to light grey thinly-bedded to plane-laminated, or sometimes cross-laminated, medium- to fine-grained sands and silts, together with inter-layered clay horizons up to 0.5 m thick. The clasts in the arenites are dominantly medium- to very fine-grained sand or silt grade, angular to sub-angular quartz and weathered rock fragments, together with minor muscovite and clay. The clays and immature arenites are often rich in carbonaceous plant fragments, and may be slightly pyritic. Bioturbation structures, small pseudo-nodules and flame structures are sometimes developed. Occasional lignite horizons up to 0.3 m thick, but usually considerably less, are also present, and indicate that the low to moderate energy environment in which the fine arenites and clays were deposited was a fluvial flood plain.

Channel deposits interlayered with the floodplain facies in the Tertiary sequence in the Pine Cove-Connellys Point area are represented by horizons of coarse- to medium-grained clastics with structures characteristic of high to moderate current velocities and insignificant biological activity. Typical of point bar deposits are piles of high angle trough cross-stratified quartz sands and micaceous quartz sands which are sometimes inter-layered with planar-bedded sands. Individual cross-stratified beds are 0.2–1 m thick, and usually indicate very variable current directions. However, at Pine Cove Creek [642262], 30 m of such sands were deposited by currents flowing to the north and north-east.

The very coarse-grained sands of these channel deposits are moderately well rounded, but grains less than one millimetre are frequently sub-angular to angular.

Point-bar deposits are represented by grit layers up to several metres thick, with cross-bedded lower parts containing very coarse sand to small pebble-grade clasts of quartz, pink and white quartzite, siltstone and slate. These horizons grade upwards to medium-grained sand in complex trough cross-stratified units 50–100 mm thick.

At the southern edge of the Quadrangle [652224] graded and plane-stratified, pebble to granule conglomerate and grit fills a 30 m wide fossil channel cut through fine-grained flood plain facies deposits. The clasts in this grit horizon are derived from the Cambrian and Ordovician sequences that occur locally, and to the west and south-west. Clay

and silt fragments of intrabasinal derivation are also present. Lithified logs up to 0.3 m in diameter and 2 m in length occur at the base of a similar deposit nearby. The planar stratification, fining upwards character, and channelled base of such deposits indicates deposition from a waning current in the upper flow regime, and could represent a crevasse-splay deposit.

At several localities within the general area bioturbated and micaceous carbonaceous sand beds over a metre thick are interlayered with cleaner channel sands. The occurrence of sharks teeth (N. Kemp, pers. comm.) together with marine dinoflagellates associated with spores and pollen (W. Harris, pers. comm.) in these sediments indicates that the environment of deposition was marginal to marine conditions, and may have been subject to limited tidal inundation.

In Pine Cove Creek [666250], sediments similar to those described above occur with interlayered closed-framework pebble and cobble conglomerate. Locally derived clasts are common near the unconformity.

Seven to eight kilometres south-east of Teepookana [713223] the Macquarie Beds lie against a basement slope which dips up to 30° SW on the margin of the basin. The lowest unit exposed (Tsb on map) consists of at least 25 m of open-framework pebble to boulder conglomerate which extends over at least 5 km<sup>2</sup> adjacent to the steep margin of the depositional trough. About 60% of the rock is made up of well-rounded boulders, cobbles and pebbles with very variable sphericity. Many of the clasts have discoidal, prolate, bladed or sub-spherical shapes with rounded convex or sometimes flat faces; concave faces are rare. Some pebbles have pyramidal 'flat-iron' shapes. Striations are absent, but slickensides on the limonite-coated clast surfaces are frequent and probably formed either during compaction or deposition.

Most of the clasts are in the 50–300 mm diameter range with a continuous size gradation down to sand grades. Only about 10% of the clasts have a diameter greater than 300 mm, with a maximum clast size of about 1.5 m. The sand, granule and smallest pebble clasts are typically angular to sub-angular and consist of quartz, weathered feldspar and various types of rock fragments such as felsic volcanics, sandstone, pink quartzite and weathered dolerite. The predominant rock types amongst the longer clasts are white, pink and purple sandstone and conglomerate derived from the West Coast Range. Also present are Cambrian volcanic and sedimentary rocks, Eldon Group sandstone, and clasts to boulder size of weathered to very fresh Jurassic dolerite. The latter constitutes up to 15% of the coarse clastic material. In places, pink

Cambrian volcanics clasts are strung out in one particular horizon. This structure, and an alignment of clast long axes, defines a crude layering in parts of this otherwise massive deposit.

Overlying the dolerite-bearing conglomerate (Tsb) are at least 50 m of poorly-sorted and coarsely-bedded to cross-bedded gritty and pebbly lithic-sand and some silt, minor clay, and frequent pebble to cobble conglomerate. Some of the grits and silts are rich in carbonaceous plant and woody matter, and contain thin, discontinuous lignite layers. The enclosed microflora and type of preservation of woody matter suggests that these rocks are of a similar age (Eocene) to those at Connellys Point (W. Harris, pers. comm.).

The conglomerate beds are usually only 1–3 m thick, and contain well-rounded sub-spherical, oblate, bladed, and some pyramidal clasts up to 0.3 m in diameter, set in a fine to very coarse gritty matrix which forms up to 40% of the bulk of the rock. Most of the conglomerates have a loosely packed closed-framework, with bedding defined by the orientation of clast long axes and occasional internal sand lenses. Clasts consist mostly of Owen-type conglomerate and sandstone derived from the West Coast Range, with some Cambrian volcanics and sediments. Dolerite is absent.

The outstanding features of the basal dolerite-bearing conglomerate in this area, namely the very poor sorting, the presence of thin, often slickensided mud skins on clasts, and the presence of large boulders, require transport by a high viscosity agent such as a debris flow on an alluvial fan. The age of the deposit and lack of any positive glacial features argue against the deposit being of glacial origin. Some of the stratigraphically higher conglomerates may also be debris flows, but the better sorted ones are either reworked debris flows or channel deposits of a low-sinuosity stream environment.

## STRAHAN AND ENVIRONS

North of the King River, Tertiary alluvial deposits occur from below sea level to heights of a little over 100 m. The contact with older basement rocks is almost linear and trends in a north-westerly direction. Actual contacts are not exposed in this area but appear to be sharp, suggesting either that the contact is faulted, or more probably, that deposition was controlled by an active fault scarp.

Two distinct microfloral assemblages are present in the Tertiary deposits at Strahan, and indicate that the deposits are Eocene and Plio–Pleistocene in age (S. M. Forsyth, pers. comm.). Younger deposits, such as the Quaternary 'raised beaches' near Strahan

first described by David (1926) and subsequently by Davies (1960) and Banks *et al.* (1977), may be present, but the absence of microflora, and similarity of lithology with proven Tertiary deposits from nearby sections is the justification for including all these deposits in the Tertiary.

Two sections near Strahan give a good insight into understanding the Tertiary stratigraphy of the area.

The first occurs at the old Mt Lyell Co. Wharf at Regatta Point [616308], where the stratigraphically lowest sediments exposed are well-consolidated, jointed, finely-laminated and thinly-bedded mudstone with abundant plant material and rare, small (*c.* 1 mm), amber clasts. The plant material is coalified and the deposit has yielded an Eocene microflora identical with that from Connelley's Point (S. M. Forsyth, pers. comm.). The top of the mudstone sequence is leached and may be a palaeosol.

The mudstone is overlain by a conglomerate-sandstone sequence consisting of thickly-bedded, strongly-imbricated pebble and cobble conglomerate containing clasts of quartzite, sandstone, siliceous conglomerate and rare felsic volcanics, in a coarse sandy matrix (plate 7). The sandstone beds are less than one metre in thickness, are often poorly sorted and generally show well developed medium- to large-scale trough cross-bedding. Palaeocurrent vectors were consistently from the east. Within this deposit are large (>1 m) clasts of lithified massive, grey mudstone containing abundant leaves and cones of *Casuarina* together with rarer *Eucryphia* and *Nothofagus* (plate 8). Microflora of the sandstone and the enclosed mudstone clasts indicates a Plio-Pleistocene age (S. M. Forsyth, pers. comm.).

The degree of consolidation and amount of jointing are greater in the Eocene deposits than in the younger deposits. This, together with the microfloral evidence, supports the interpretation that the leached part of the mudstone is a palaeosol.

A comparable sequence is exposed in cliffs immediately to the west of the Strahan Post Office. About 20 m of sediments are exposed, and the basal 5 m consist of brown-grey plant-rich mudstone that contains an Eocene microflora (S. M. Forsyth, pers. comm.). The mudstone is overlain by a sequence of interlayered cross-bedded sandstone, massive cobble conglomerate, and mudstone. Two thick conglomerate horizons are present, each exceeding 2 m in thickness. Analysis of the microflora indicates that the age of the deposits is Plio-Pleistocene, identical with the upper sequence at Regatta Point (S. M. Forsyth, pers. comm.).

By combining palynological and sedimentological information an analysis of the Tertiary history at Strahan can be attempted. Eocene deposits are fine-grained mudstones that contain abundant, coalified plant debris. The presence of marine dinoflagellates and floral elements typical of mangrove swamps, indicates that the deposit was formed in a swamp marginal to the sea. A period of soil formation? and erosion followed until continental deposition occurred in Pliocene or Pleistocene times. Conglomerate horizons are common, and where observable are seen to be laterally continuous, indicating that they probably formed during conditions of flooding. Deposition of sands occurred under conditions of lower flow regime. Muds accumulated in back-swamp areas and were ripped up and redeposited in times of flood.

An area of Tertiary sediments is shown on the map extending in a N-S belt from west of Strahan [595340] to Swan Basin [570262]. This area is shown as Tertiary because of the ubiquitous presence of cobble and boulder gravels. All samples collected were barren of microflora.

#### FABRITONG RIVULET-HENTY RIVER AREA

Tertiary deposits mapped in this tract of country are coarser than those to the south, and contain abundant, coarse, dolerite detritus. Areas where dolerite boulders are notably abundant have been differentiated on the map (Tsb).

In the vicinity of the Tully River [590430] the dolerite boulder beds contain generally well-rounded cobbles and boulders with an average diameter of 300 mm (A.P.G.). In the unnamed tributary of the Tully River at 595420 one boulder with a diameter of 2 m was observed. The conglomerates comprise a closely packed or open-framework of clasts in a matrix of friable, orange-brown clay and coarser detritus derived from decomposed dolerite. Quartzite and sandstone clasts are present but always subordinate to dolerite. Weathering of the dolerite clasts is variable, ranging from complete decomposition to weathering of a thin skin. These deposits are barren of microflora.

In the first road cutting north of the Henty River on the Strahan-Zeehan road [568465] several small-displacement faults (plate 9) are present in a sequence of dolerite boulder beds overlain by finer grained poorly to moderately-sorted coarse lithic sandstone (P.J.L., P.W.B.; plate 10). This sequence has yielded a microflora of Eocene age (S. F. Forsyth, pers. comm.).



**Plate 7.** Pliocene-Pleistocene alluvial sand and gravel, old Mt Lyell wharf, Strahan [620303].



**Plate 8.** Clast of siltstone in gravel, old Mt Lyell wharf, Strahan. Clast contains *Nothofagus* sp., *Casuarina* sp., *Eucryphia* sp. and a Pliocene-Late Pleistocene microflora.



**Plate 9.** Displacement, possibly related to an old landslide surface, Eocene deposits, Strahan–Zeehan road [568465].



**Plate 10.** Sedimentation style, Eocene deposits (Tsb), Strahan–Zeehan road [568465].

Similar dolerite-bearing boulder beds, in which nearly all clasts are completely decomposed, have been exposed in a new road cutting at the north-west foot of the Professor Range on the adjoining Zeehan Sheet (K.D.C.).

## Quaternary

*P. W. Baillie*

### ALLUVIUM AND RELATED DEPOSITS (Qa)

Recent alluvial gravels, sands and silts occur associated with major rivers and streams and as thin veneers associated with older coastal deposits. The most extensive areas are in the valley of the Badger River, north-west of Professor Plateau [625485], and at the mouth of the King River [640275] (plate 11).

Pyritic mine-waste sands originating from the Mt Lyell mine have been deposited along the lower reaches of the King River, where they form a mappable deposit (Qap).

### MOBILE BEACH DUNE SAND (Qms)

Ocean Beach consists of clean, well-sorted quartz sands with a very low carbonate content (Davies in Banks *et al.*, 1977). The beach sands are moving southwards along the beach by longshore drift, evidence for which is provided by the southward diversion of the mouth of the Henty River [550430].

As noted by Banks *et al.* (1977) the northern part of Ocean Beach (north of about 563320) has a cut profile (Davies, 1957) and the beach is receding at present. In this section the beach is backed by cliffs of horizontally-bedded sand, cross-bedded dune sand, and peats which formed in the swales of dunes (plate 12). These sands show little, if any, soil development and are regarded as Holocene in age.

South of the Henty River, large blow-out dunes have formed, and are forming, behind the beach. The largest of these [575417] has caused several diversions of the Strahan-Zeehan railway and road (plate 13). This particular dune is over 30 m in height and although parabolic in gross shape, in detail is seen to consist of a number of parabolic blowouts and a few longitudinal dunes. Orientation of individual blowouts is variable, probably reflecting variable wind patterns.

### STABILISED SAND DEPOSITS (Qos)

The degree of stabilisation was the main criterion used for subdividing the various Quaternary units

on the Strahan Sheet. Units mapped as stabilised sands are now vegetated, but this is not regarded as an indicator of age. Where possible stabilised sand dunes (Qosd) have been separated from other stabilised dunes on the map.

On the Cape Sorell peninsula, behind Pilot Bay [515253], are a series of sand ridges that have apparently formed in historical times as a result of clearing for fence construction. These sands are now vegetated, but show little soil development.

South of the Henty River, the mobile dunes are actively encroaching on a series of older, stable, dissected parabolic dunes which extend nearly to Strahan (A.P.B.) (plate 14). These dunes show strong development of the normal podsol soil profile. Banks *et al.* (1977) note an increase in dissection of these dunes together with an increase in soil development from south-east to north-west. They correlate this with increasing age and suggest a late Pleistocene age for their formation.

The older dunes have developed on an older gently seaward sloping sand surface, which has a maximum height of about 20 m a.s.l. Stranded shorelines have been recognised on this surface, and an Interglacial age is indicated (Banks *et al.*, 1977) (plate 15,16).

Probable beach gravels are well exposed in the first drainage ditch south of the terminal building at Strahan aerodrome. Interlayered coarse sand and imbricated pebble horizons dip gently seawards, and the imbrication of the pebbles indicates that they formed by swash rather than fluvial process (see also Banks *et al.*, 1977).

### TILL (Qp)

A small area of till (plate 17) at the south-western limit of the Henty moraine occurs near the north-eastern corner of the map sheet east of the Henty River [735491] (K.D.C.).

## IGNEOUS GEOLOGY

*P. W. Baillie*

### Devonian granite

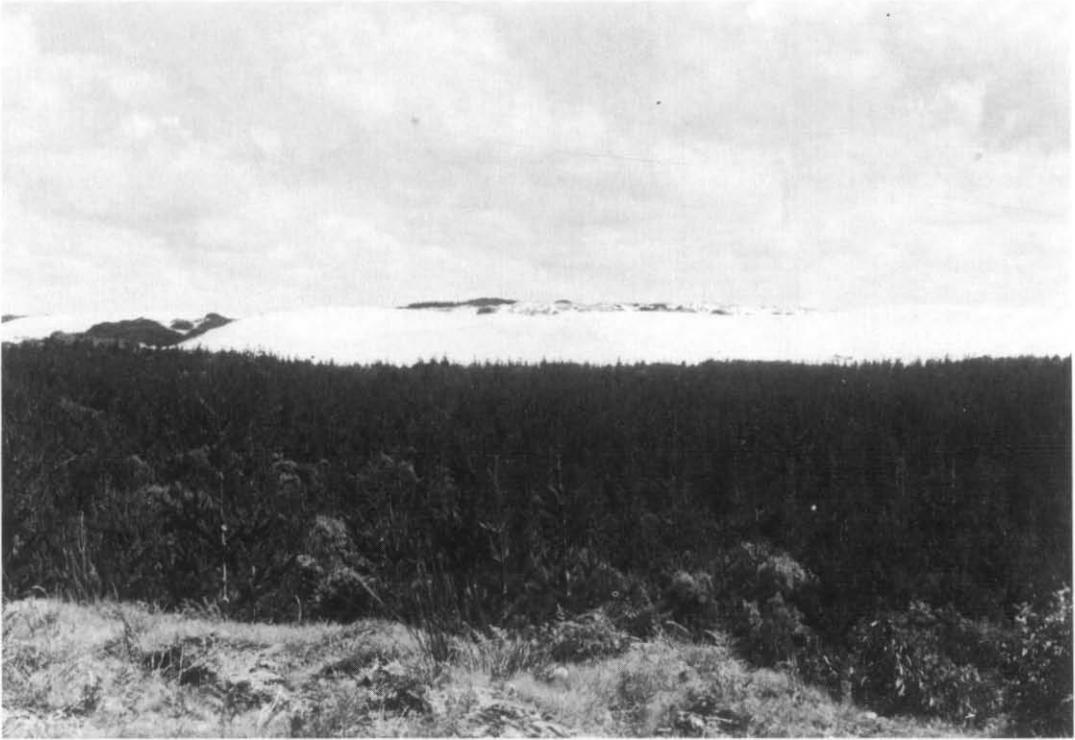
Granitic rocks crop out on the west coast of the Cape Sorell peninsula about 3 km to the west of Round Head [505213]. Contacts with the quartzite country rock are generally irregular, with large xenoliths of quartzite common near the margins of the granite body. The major rock type is an



**Plate 11.** *Aerial view of the King River delta.*



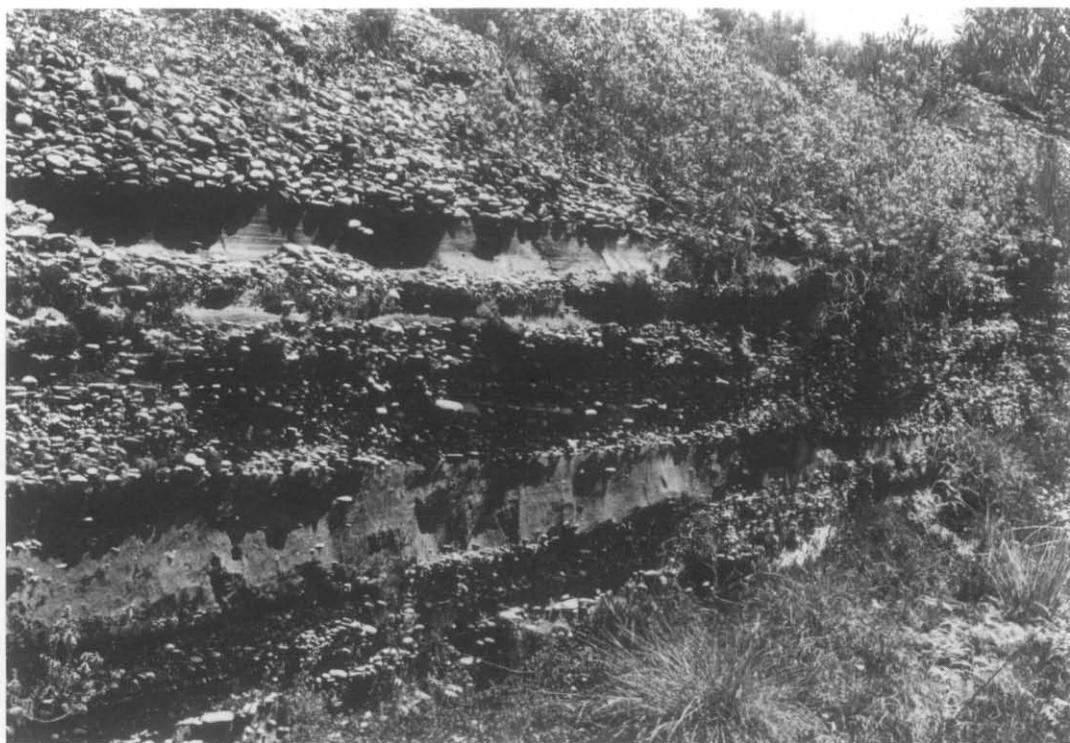
**Plate 12.** *Organic layer in Holocene sand dunes, Ocean Beach [563304].*



**Plate 13.** *Presently-encroaching compound parabolic dune, Henty Plantation.*



**Plate 14.** *Encroaching sand dunes, Henty Plantation.*



**Plate 15.** Seaward-dipping gravel layers in ?Last Interglacial beach deposit, Strahan Aerodrome [587317].



**Plate 16.** Detail of swash-type imbrication in ?Last Interglacial beach deposit, Strahan Aerodrome [587317].



Plate 17. Pleistocene till, Henty Bridge, Queenstown-Zeehan road.

unfoliated equigranular medium- to coarse-grained granite which in thin section (75-334) is seen to consist of quartz, K-feldspar plagioclase (oligoclase), biotite and muscovite (secondary after biotite), with minor zircon (usually associated with biotite) and apatite. K-feldspar is slightly more abundant than plagioclase, indicating that the rock is an adamellite (Streckeisen, 1975). Layering shown by crystals of different sizes, was observed in a one metre thick tabular body. Other granite types present include quartz-feldspar pegmatite, fine-grained porphyritic granite, and greisen. Tourmaline segregations are locally abundant.

#### METAMORPHISM (S.F.C.)

Thermal metamorphism associated with the adamellite has occurred in pelites that crop out east of Olsen Reef [507230], where dark grey phyllites become spotted due to the presence of porphyroblasts up to 2 mm in diameter. In 75-333 the porphyroblasts appear to have been crenulated by a set of late conjugate micro-kinks. However, in some fine-grained crenulated micaceous quartzites (e.g. 75-76), unstrained polygonal quartz microstructure predominates and the  $S_2$  crenulation is overprinted by growth of fine, granular, tourmaline as well as incipient porphyroblasts.

#### AGE

The granite intrusion occurred late in the structural evolution of the Cape Sorell area. The granite is undeformed. It is petrologically similar to, and contains nodular tourmaline as does, the Heemskirk Granite, which crops out a little more than 40 km to the north. The Heemskirk Granite has been radiometrically dated at 340-357 Ma. (McDougall and Leggo, 1965).

#### Proterozoic(?) dolerite

A small dyke of cleaved amphibolite is intrusive into interlayered orthoquartzite and phyllite on Cape Sorell at 500267. In thin section (75-301) it consists of relict clinopyroxene, fibrous tremolite, chlorite, epidote, albite, sphene and sericite. The rock is very fine-grained, foliated, and is probably a metabasalt.

Dolerite boulders are quite common on the coast south of Split Rock [503250]. No *in situ* outcrops have been found, indicating a probable off-shore occurrence. A boulder sample (75-65) is a dark coloured, medium-grained rock consisting of plagioclase laths (1-2 mm), augite, minor carbonate, sericite and opaque minerals. The plagioclase is

fresh to partly sericitised. Olivine has been completely sericitised.

On mineralogy and degree of alteration, together with the good cleavage developed in the small dyke, it is considered that these rocks are related to Precambrian dolerites and amphibolites found elsewhere in Tasmania.

## STRUCTURAL GEOLOGY

### Late Proterozoic of Cape Sorell peninsula (S.F.C., P.W.B.)

Abundant mesoscopic folds of various styles and orientations are present on the Cape Sorell peninsula, particularly in coastal exposures of pelitic and semi-pelitic parts of the sequence (for localities see fig. 7). Some major folds have been mapped in the orthoquartzite, where outcrop and facing evidence is often abundant. Large faults have not been recognised due to the lack of mappable lithological marker horizons.

Four major deformation events have been recognised. Chronological relations have been deduced from the interactions and relative positions of planar and linear structures and the mapping out of variation in orientation of these structures (fig. 8-12).

The gross geometry and orientation of the early major structures ( $D_1$ ,  $D_2$ ) appears to have been little effected by later deformations which have been expressed predominantly by the formation of minor folds and associated cleavages.

### FIRST DEFORMATION EPISODE AND METAMORPHISM

The earliest recognisable major deformation ( $D_1$ ) has folded the sequence into a large scale isoclinal structure.

North-west of Split rock [503250] the sequence is dominantly steeply dipping and faces west, however to the south-east and east of Edwards Beach [506235] the sequence generally faces east. A few opposing facings on the eastern limb indicate the presence of some smaller parasitic folds, but closures have not been observed in outcrop.

Separating the two major limbs of opposing facing is a belt of thinly interlayered pelite and quartzite which trends approximately north along Edwards Beach [506234], and also re-appears trending

north-east in the cove north-west of Split Rock [504253]. The gross attitude of the compositional layering in the pelitic belt parallels the proven bedding orientation in the adjacent quartzites. The compositional layering itself consists of a fine alternation of discontinuous layers ranging in composition from quartzite to pelite. These range from less than one millimetre to 100 mm or so thick, but sometimes with thicker lenses of quartzite. A penetrative foliation is present sub-parallel to the compositional layering. Internal compositional laminae within quartzite and micaceous quartzite layers are frequently sub-parallel to the external foliation.

Several mesoscopic features are present indicating that the compositional layering in the Edwards Beach area and other pelitic belts has been produced by transposition of bedding into the plane of the foliation. These include the occurrence of discontinuous forked layering, small rootless folds or hook structures with axial surfaces sub-parallel to the foliation. The latter sometimes have internal compositional laminae discordant to the external foliation. These mesoscopic features are consistent with the Edwards Beach pelitic belt occupying the core of the large isoclinal  $D_1$  fold, and that in the hinge zone transposition has largely obliterated the original bedding and hence the trace of the fold closure in the phyllite. Alternatively, the phyllite forms part of one limb of the major fold, juxtaposed against the other limb by a large fault so that the hinge zone is now faulted out.

The earliest foliation,  $S_1$ , in the pelites is microscopically expressed by a very strong dimensional preferred orientation of lenticular, fine-grained quartz and phengitic mica plates 0.2-0.5 mm long. The mineral assemblage and microstructure is typical of syntectonic low greenschist facies conditions. Small, partly chloritised, biotite porphyroblasts in pelitic rocks throughout the Cape Sorell area indicate continuing post-tectonic greenschist facies metamorphism.

Microscopically, the  $S_1$  surface in the pure quartzites is either absent or only weakly developed. In some cases intragranular deformation and recrystallisation has formed a mosaic of quartz grains (0.2-1 mm) which are slightly elongate sub-parallel to bedding. Expressed mesoscopically by a lenticular platyness, the foliation may be seen to cut across inclined compositional laminae in cross-stratified units.

With increasing amounts of mica, the quartzites become intensely foliated with fine phengitic micas

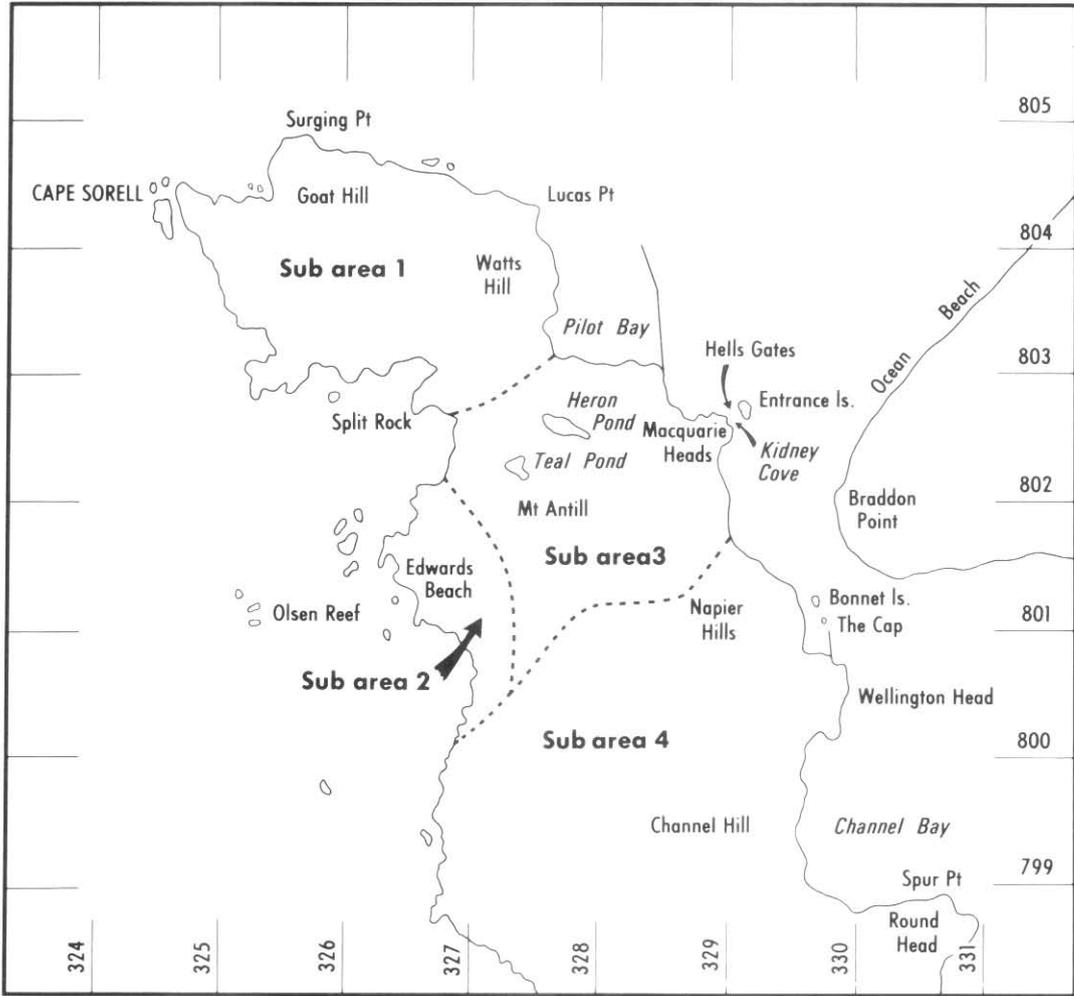
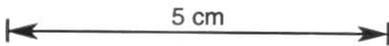
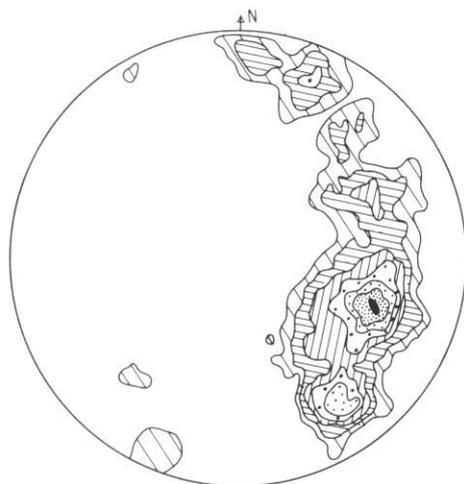


Figure 7. Locality map, Cape Sorell peninsula.

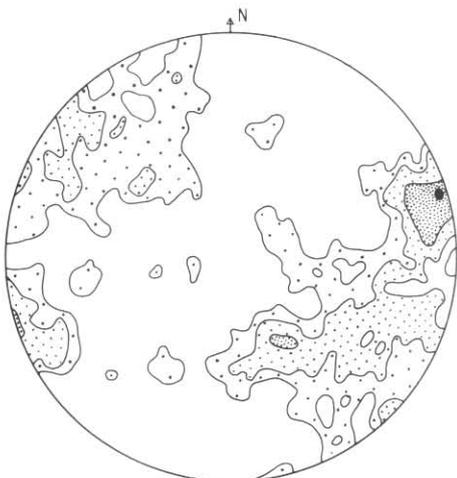




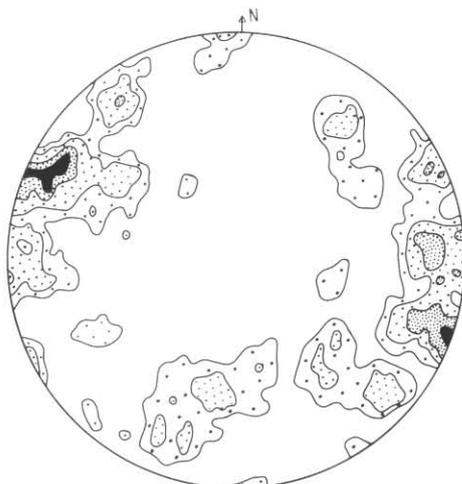
**Figure 8.** Stereoplot of 86 poles to compositional layering, sub-area 1, Cape Sorell. Contour intervals: 0.4–1%, 1–2%, 2–3%, 3–4%, 4–5%,  $\geq 5\%$ . Lower hemisphere equal area Schmidt projection plotted using FORTRAN program CONTOR.



**Figure 10.** Stereoplot of 260 poles to compositional layering, sub-area 2, Edwards Beach area. Contour intervals: 1–2%, 2–4%, 4–6%, 6–8%, 8–10%, 10–12%,  $\geq 12\%$ . Lower hemisphere equal area Schmidt projection plotted using FORTRAN program CONTOR.



**Figure 9.** Stereoplot of 260 poles to compositional layering, sub-area 1. Large scale  $D_2$  layering. Contour intervals: 1–2%, 2–4%, 4–6%,  $\geq 6\%$ . Lower hemisphere equal area Schmidt projection plotted using FORTRAN program CONTOR.



**Figure 11.** Stereoplot of 112 poles to  $S_1$ , sub-area 3. Contour intervals: 1–2%, 2–4%, 4–6%,  $\geq 6\%$ . Lower hemisphere equal area Schmidt projection plotted using FORTRAN program CONTOR.

5 cm

pinned along quartz grain boundaries and having a preferred orientation defining  $S_1$ .

## SECOND DEFORMATION EPISODE, $D_2$

Major and minor  $D_2$  folds are found commonly throughout the Cape Sorell region. They fold  $S_1$ , but are cut across by various later structures. Major  $D_2$  folds are west to north-west trending open to tight structures with upright axial surfaces and steep to moderate plunges. These folds are largely responsible for the variation in strike of the compositional layering in the area from north-west to north and north-easterly trends (fig. 13–16).

Smaller congruent  $D_2$  folds are particularly well developed in interlayered pelite and quartzite, as in the Edwards Beach area [506234]. Here open  $D_2$  folds have amplitudes and wavelengths of up to several hundred metres, and are associated with parasitic open to tight folds of very variable style, including S- and Z-shaped folds with markedly thickened hinges, cusped folds, sinusoidal parallel folds, and kink and box folds in the more intense foliated rocks. Minor  $D_2$  folds are infrequently developed in areas of dominantly quartzite lithology.

A crenulation cleavage is locally associated with minor  $D_2$  folds in phyllite. The cleavage is sub-parallel to fold axial surfaces (fig. 13), and deforms metamorphic mica porphyroblasts as well as the finer grained matrix micas and quartz. It displays a variable morphology, ranging from a coarsely spaced open cleavage. Local transposition of  $S_1$  has occurred. Cleavage development has been accompanied by the development of the stringers of phengitic micas, as well as solution, intragranular deformation, and recrystallisation of quartz.

At the southern end of Edwards Beach small kink-link folds with gently to moderately NW-dipping axial surfaces fold  $S_1$  but predate  $S_2$  (fig. 17).

## THIRD DEFORMATION EPISODE, $D_3$

Within localised zones in the phyllites near Edwards Beach the  $S_2$  crenulation and associated minor folds are cut across by an upright north-easterly trending crenulation cleavage. Large symmetrical open folds with moderately SW-plunging hinges are also present and associated with the cleavage.

The  $S_3$  crenulation cleavage has an axial surface relationship with minor folds of  $S_0$  and  $S_1$  (fig. 18) which in places fold  $D_2$  minor structures. Profiles of  $D_3$  folds range from open to tight and are commonly parallel to slightly flattened in quartzite layers within phyllite. Folds with similar structural

relationships and axial zone crenulations are developed elsewhere in interlayered phyllite and quartzite, but are not abundant.

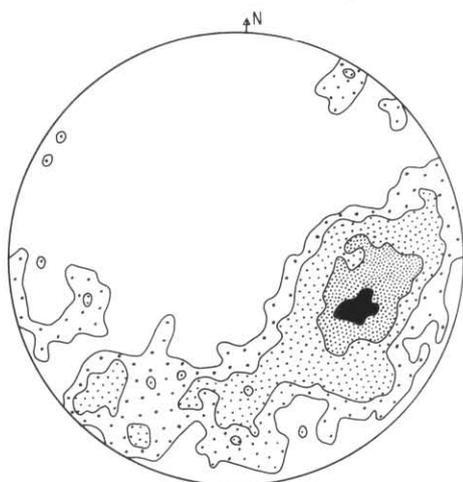
At the eastern end of Split Rock [504251] where a thin zone of phyllite abuts massive quartzite, and  $S_3$  crenulation cleavage merges into a transposition cleavage due to intense strain and tectonic sliding near the phyllite-quartzite boundary. Small scale cross faulting at the boundary predates  $D_3$  transposition of  $S_1$  and has formed a small wedge-shaped zone of little-deformed phyllite in the pressure shadow.

## FOURTH DEFORMATION EPISODE, $D_4$

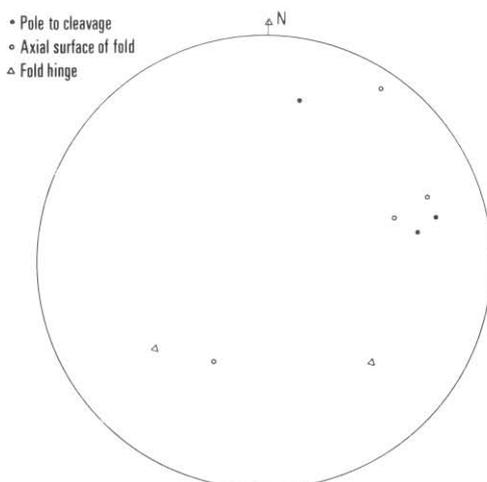
From Cape Sorell [485265] to Split Rock [503250] slightly micaceous quartzites are often cut by a strongly-developed cleavage expressed by a lenticular platyness and anastomosing closely spaced fractures. This structure is N- to NNE-trending and dips moderately to steeply west (fig. 22), cutting across both limbs of a large  $D_2$  fold. Microscopically (75–644) the cleavage is expressed by an elongation of strained lenticular quartz grains (0.5–1 mm). Grain boundaries are very sutured and often the site of aggregates of very fine-grained recrystallised polygonal quartz and small plates of fine white mica. The large old quartz grains display undulose extinction, sub-grains, and some deformation bands and lamellae. Pressure fringe intergrowths of quartz and mica at the ends of elongate old grains are often gently curved. Also present are discrete shear zones (<0.5 mm wide) which are symmetrically disposed about 45° away from the direction of grain elongation. These are associated with the curvature of the pressure fringes, the sense of movement being consistent with shortening perpendicular to grain elongation.

The more micaceous fine-grained quartzites have microfolding and crenulation of the strong  $S_1$  fabric (e.g. 75–645), or a penetrative cleavage in which fine mica strings anastomose around elongate deformed quartz grains, or groups of quartz grains.

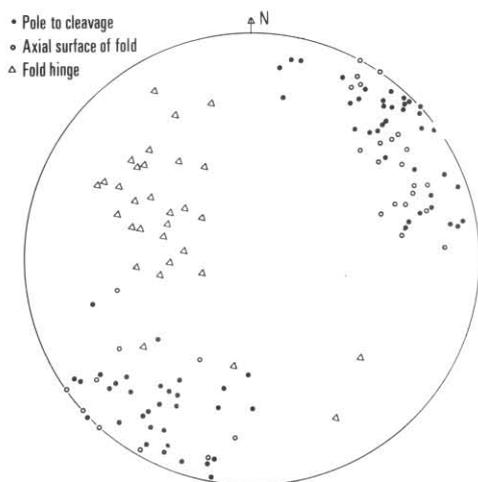
In the quartzite multilayers on the coast between Split Rock and Cape Sorell lighthouse, minor folds associated with the  $S_4$  cleavage are abundant. Near hinge zones, the cleavage may be fanned, with up to 30° divergence. Open folds with wavelengths of up to 10 m occur and are rounded. With increasing mica content or decreasing bed thickness, kink-like or chevron folds, with marked hinge thickening, occur. In thinly interlayered pure quartzites and micaceous quartzites, the latter may have a strongly-convergent crenulation or more penetrative platy cleavage in the hinge area of the fold.



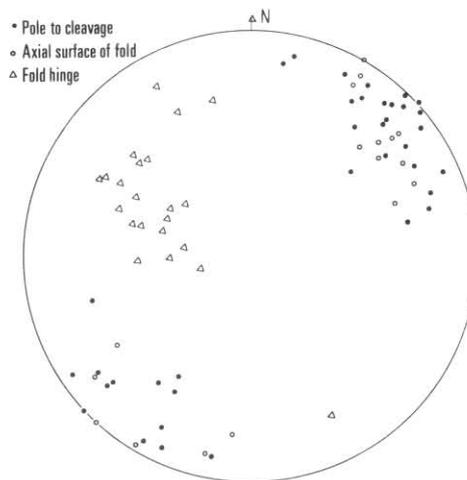
**Figure 12.** Stereoplot of 278 poles to  $S_1$ , sub-area 4. Contour intervals: 1-2%, 2-8%,  $\geq 8\%$ . Lower hemisphere equal area Schmidt projection using FORTRAN program CONTOR.



**Figure 14.** Stereoplot of  $D_2$  structural elements, sub-area 1.

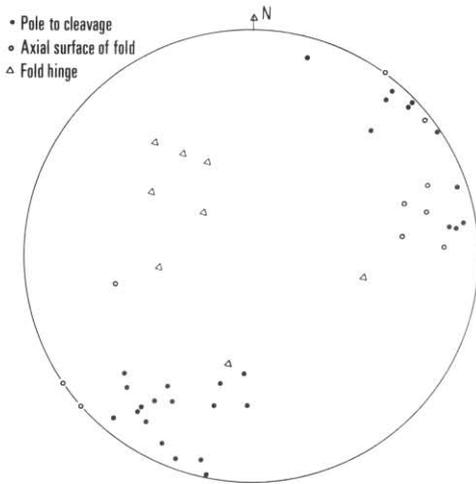


**Figure 13.** Stereoplot of  $D_2$  structural elements, Cape Sorell.

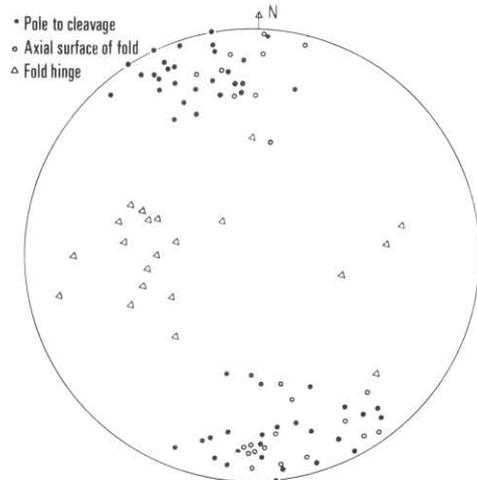


**Figure 15.** Stereoplot of  $D_2$  structural elements, sub-area 2.

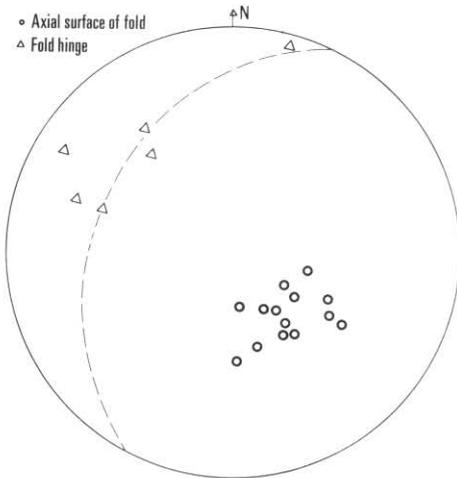
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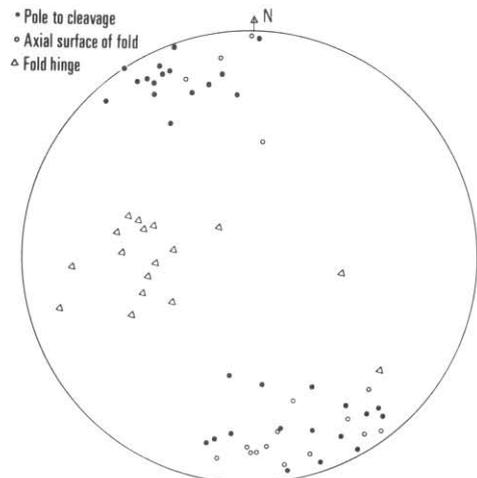
**Figure 16.** Stereoplot of  $D_2$  structural elements, sub-areas 3 and 4.



**Figure 18.** Stereoplot of total  $D_3$  structural elements, sub-area 1, Cape Sorell.

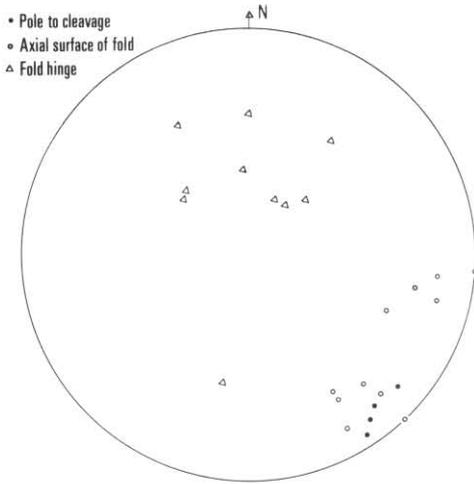


**Figure 17.** Stereoplot of  $D_2$  structural elements at the southern end of Edwards Beach showing moderate to gently-dipping folds with axial surfaces dipping more gently than bedding.

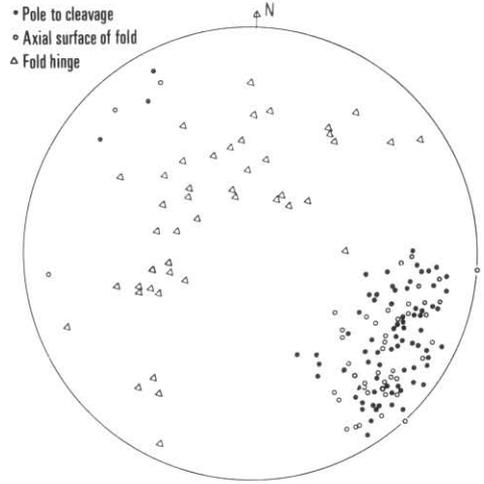


**Figure 19.** Stereoplot of  $D_3$  structural elements, sub-area 2.

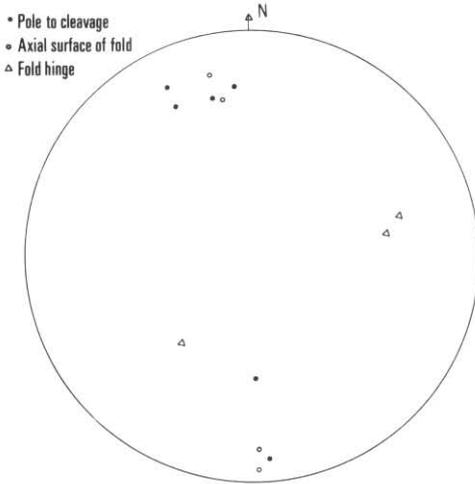
5 cm



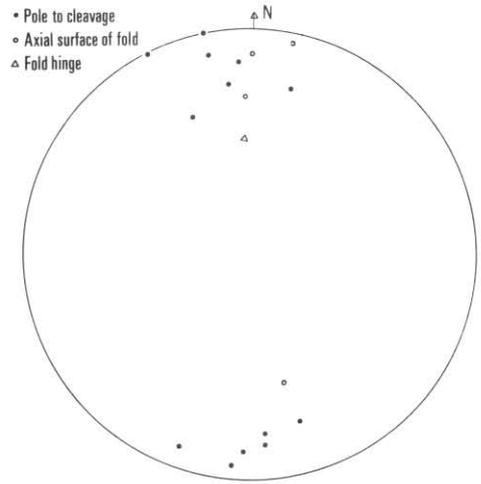
**Figure 20.** Stereoplot of  $D_3$  structural elements, sub-area 1, Cape Sorell.



**Figure 22.** Stereoplot of  $D_4$  structural elements, sub-area 1, Cape Sorell.

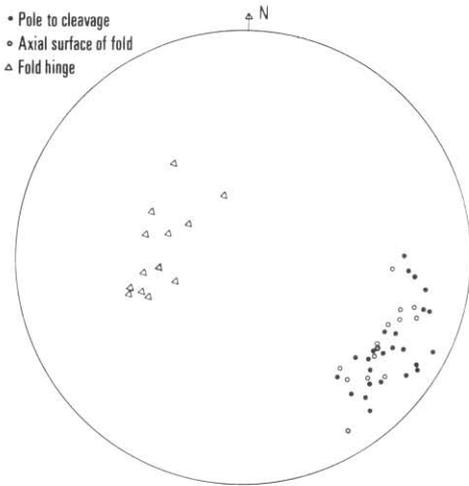


**Figure 21.** Stereoplot of  $D_3$  structural elements, sub-area 3.

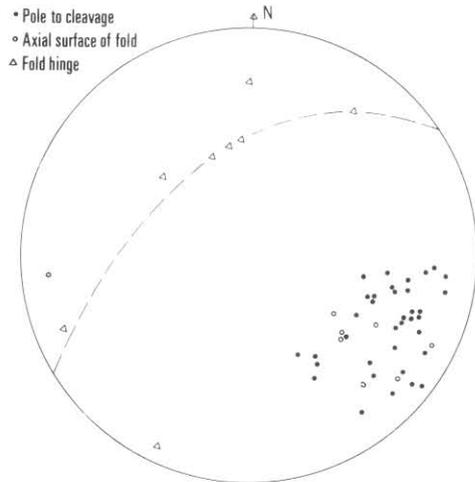


**Figure 23.** Stereoplot of  $D_4$  structural elements, sub-area 2.

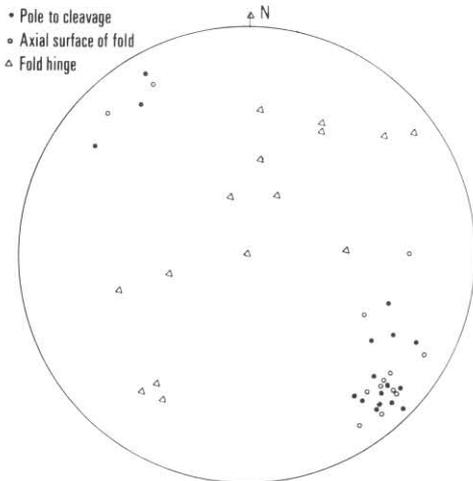
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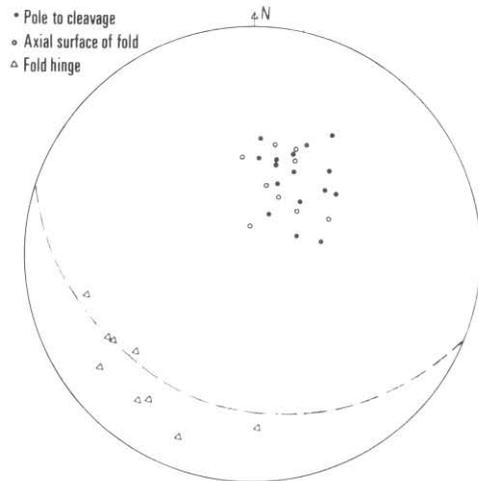
**Figure 24.** Stereoplot of  $D_4$  structural elements, sub-areas 3 and 4.



**Figure 26.** Stereoplot of  $D_4$  structural elements, Cape Sorell area, quartzite sequence.



**Figure 25.** Stereoplot of  $D_4$  structural elements, Cape Sorell area, south coast phyllite sequences.



**Figure 27.** Stereoplot of structural elements for total late structures, Cape Sorell area.



In the well-foliated phyllite north of Split Rock [505253] small  $D_4$  folds have a very variable style and associated crenulation cleavages, and type 3 (Ramsay, 1967) interference patterns with earlier minor folds.

At the northern end of Edwards Beach, both  $D_2$  and  $D_3$  structures in phyllite are cut across and refolded by a moderately to steeply W- to WNW-inclined crenulation cleavage and associated open folds up to several metres in wavelength. Minor parasitic folds are gentle to close structures. Structures of similar orientation and structural relationships occur to the north towards Split Rock, and are probably equivalent to the  $D_4$  structures of the Cape Sorell sub-area.

The  $S_4$  crenulation has developed in a low grade environment as small white micas and chloritised biotite porphyroblasts in quartz-rich microlithons (e.g. 75-61, 75-62) have been bent without recrystallisation. The boundaries of microlithons are defined by the quartz-poor attenuated limbs of microcrenulations and are composed of fine stringy micas and opaque minerals.

## LATE STRUCTURES

Throughout the area mapped, late, minor, gentle to open gently S- to SW-inclined, often cusped, folds are developed. They are frequent in the quartzites and responsible for the gentle deflection of compositional layering about the vertical. In the phyllites (e.g. the cove opposite Entrance Island [525249]) these late folds may have associated axial zone crenulations and weak cleavage development. In many places they can be shown to post date the  $S_4$  cleavage.

## PETROFABRIC OF THE ORTHOQUARTZITE

A petrofabric analysis was undertaken on two unorientated samples of a relatively pure orthoquartzite from west of Napier Hills [525233]. The results are shown in Figures 28-29 and show that the rock has developed a weak orthorhombic fabric.

## Early Palaeozoic (Cambrian-Devonian)

### INTRODUCTION

Large-scale structures present in the Cambrian to Devonian sequences of the Strahan Quadrangle include a series of upright, NNW-trending folds, a major WNW-trending fault system with numerous offsets (Firewood Siding Fault) separating Cambrian and Devonian sequences in the northern part

of the area, and a major NW-trending fault which separates Cambrian rocks from Eldon Group correlates in the southern part of the area (fig. 30).

A regionally penetrative NW-trending subvertical cleavage is present in all rocks from Cambrian to Devonian, and a later crenulation cleavage has been detected in some areas but may be more widespread than the mapping has indicated. Most of these structures are considered to have resulted from deformation in the Middle Devonian Tabberabberan Orogeny (Williams, 1978), although the presence of an angular unconformity between Cambrian and Ordovician rocks in the north-east corner of the map sheet suggests the possibility of at least local Cambrian deformation.

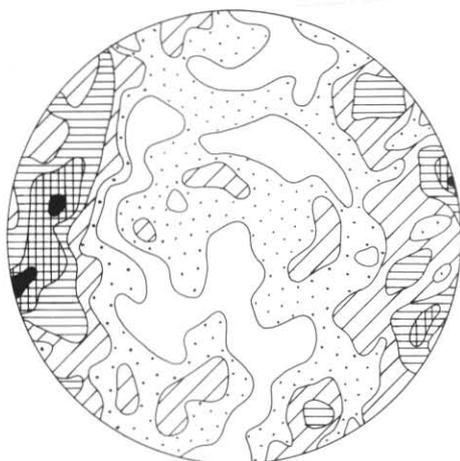
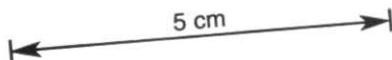
Structural features of the Bell Shale correlate have been described by Baillie and Williams (1975), who recognised two phases of folding in that deformation. The first phase produced folds plunging  $30^\circ$  to  $90^\circ$  NW, and the second phase produced folds plunging shallowly WNW or SSE. Folds of both phases produced an axial surface cleavage and the second phase produced a crenulation cleavage in some areas. The locus of strain during the second phase of deformation was the Firewood Siding Fault.

## CAMBRIAN ROCKS IN THE SOUTHERN AREA (S.F.C.)

Along the lower reaches of the King River, where the large scale structural development has been controlled predominantly by a 350 m thick competent volcanic unit (Unit D), Tabberabberan deformation has produced open and nearly symmetrical major folds with gently plunging axes and upright NNW-trending axial surfaces (fig. 31).

Approximately 7 km to the north, in the vicinity of the Strahan-Queenstown road, Unit D defines a major upright, but moderate to steeply NW-plunging anticline which has been faulted against the Eldon Group. These major folds are associated with a regionally penetrative axial surface cleavage.

West of Teepookana and stratigraphically below Unit D, in a succession of interbedded quartzwackes, siltstones and thin volcanic units, the structure is more complex, as open to tight NNW-trending folds have variable plunges and wavelengths ranging from several metres to a hundred metres or more (fig. 31). The attitudes of bedding (fig. 32) in this part of the sequence show a weak girdle pattern indicating gently NW-plunging folds; however more steeply plunging folds are also present. These minor folds are approximately coplanar with the major folds elsewhere in the region, and also have an associated cleavage. Close to tight folds are sometimes associated with breakthrusts.



**Figure 28.** Stereonet of 250 quartz optic axes for specimen 73-316, massive quartzite, Cape Sorell. Contour intervals: 0.2-1%, 1-2%, 2-3, 3-4.25%,  $\geq 4.25\%$ .



**Figure 29.** Stereonet of 250 quartz optic axes for specimen 73-317, quartzite, Cape Sorell. Contour intervals: 0.4-2.5%, 2.4-4.5%, 4.5-7.5%,  $\geq 7.5\%$ .

No regional vergence pattern of major and minor folds has been recognised.

In the dominantly sedimentary sandstone-siltstone-slate sequence which overlies Unit D, Tabberabberan deformation has produced open to tight upright folds having a NNW-trend. Folds with wavelengths up to several tens of metres are common, and are probably parasitic to larger structures. Fold axis plunges are very variable, but commonly quite steep. Axial breakthrusts are commonly developed in close to tight mesoscopic folds.

Bedding is usually upright as deduced from sedimentary structures, and generally dips steeply south-west or north-east (fig. 33), an expression of close to tight folding. Overturned fold limbs have been recognised at many localities.

In one locality at least, bedding is upright and steeply north-east dipping, yet the mesoscopically penetrative cleavage is less steeply inclined. Such an anomalous bedding-cleavage relationship suggests that more than one phase of folding has occurred. This conclusion is also borne out by the occurrence of rare examples of minor folds being refolded and cut across by a cleavage.

A regionally penetrative cleavage in the lower King River area has a NW- to NNW-trending upright attitude (fig. 35, 36) and is approximately coplanar with the axial surfaces of major and minor folds in the region. The spread of cleavage orientation to some extent reflects mesoscopic fanning and refraction of cleavage, but may also have been caused by local strain inhomogeneities and late refolding.

The predominant cleavage which could be measured in the field is revealed in thin section to be a complex structure showing variations in morphology between sandstone cleavage, slaty cleavage and crenulation cleavage. Frequently, two separate cleavages may be recognised, with one showing an overprinting relationship with the other.

The first formed cleavage,  $S_1$ , is a microscopically penetrative structure which was probably formed during flattening associated with the formation of the major, and many of the minor, folds in the region. The second, and usually dominant cleavage ( $S_2$ ), has been found as the axial surface cleavage to some minor folds of  $S_0$  and  $S_1$ , indicating that it has developed during a folding event superimposed on the early major and minor folds. The very variable plunges of major and minor folds already noted in the lower King River area may be explained by rotation of early fold limbs and hinges during the later deformation, and the superposition of late folds on a previously folded surface. The variable attitude of bedding-cleavage intersections (fig. 37, 38) may be similarly explained, but may also be due partly to late non-cylindrical folding.

In laminated siltstones the mesoscopically dominant cleavage is a distinctly domainal structure consisting of closely spaced ( $< 0.2$  mm), anastomosing, and discontinuous filaments (0.1 mm wide) which are rich in opaque minerals and very fine-grained phyllosilicates. These filaments wrap around lenticular to tabular and diffusely terminated quartz-rich microlithons up to 0.5 mm long. In some cases (e.g. 75-405, 75-410) where bedding is at a high angle to the cleavage, there is a penetrative

5 cm

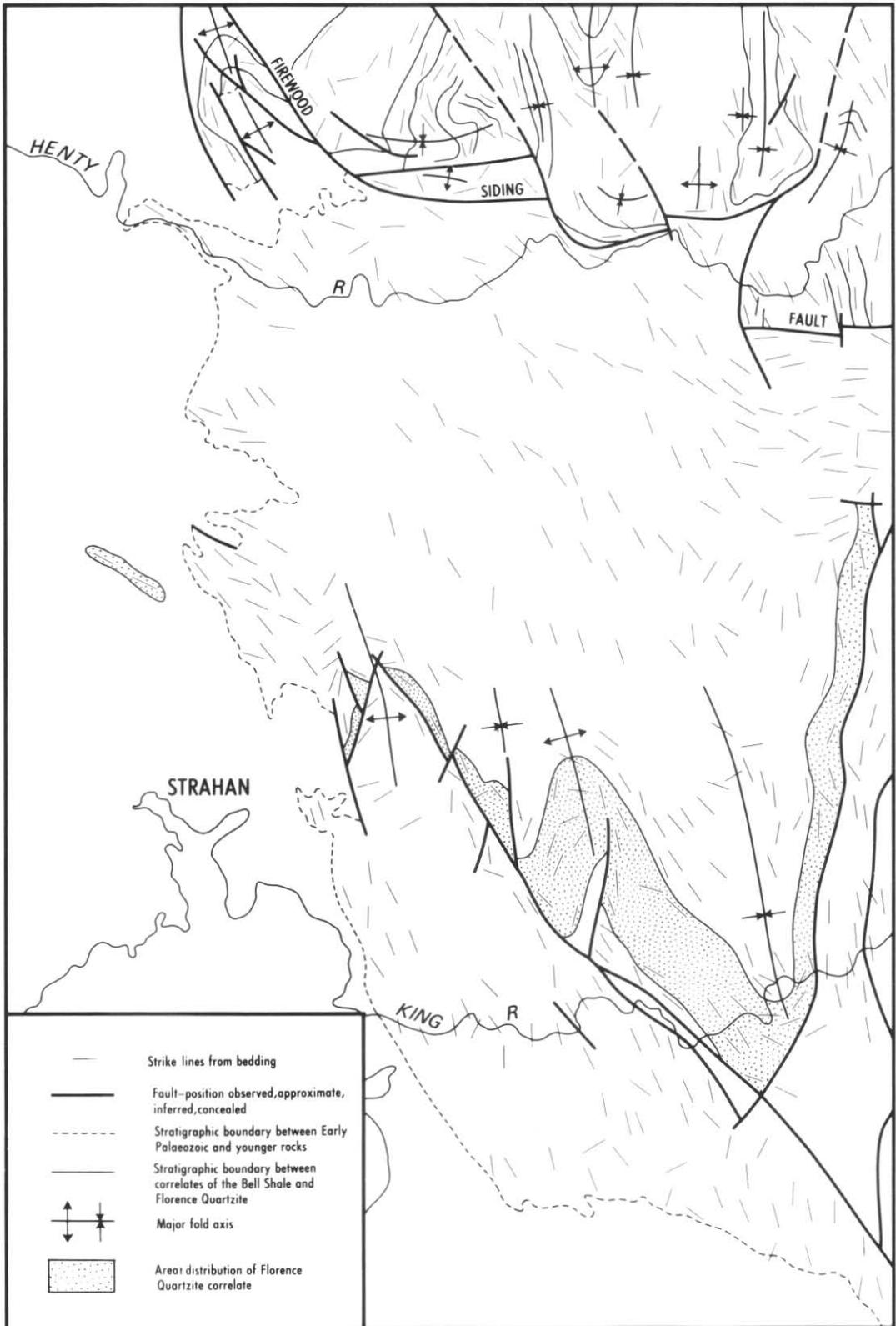


Figure 30. General structural map of Early Palaeozoic rocks.

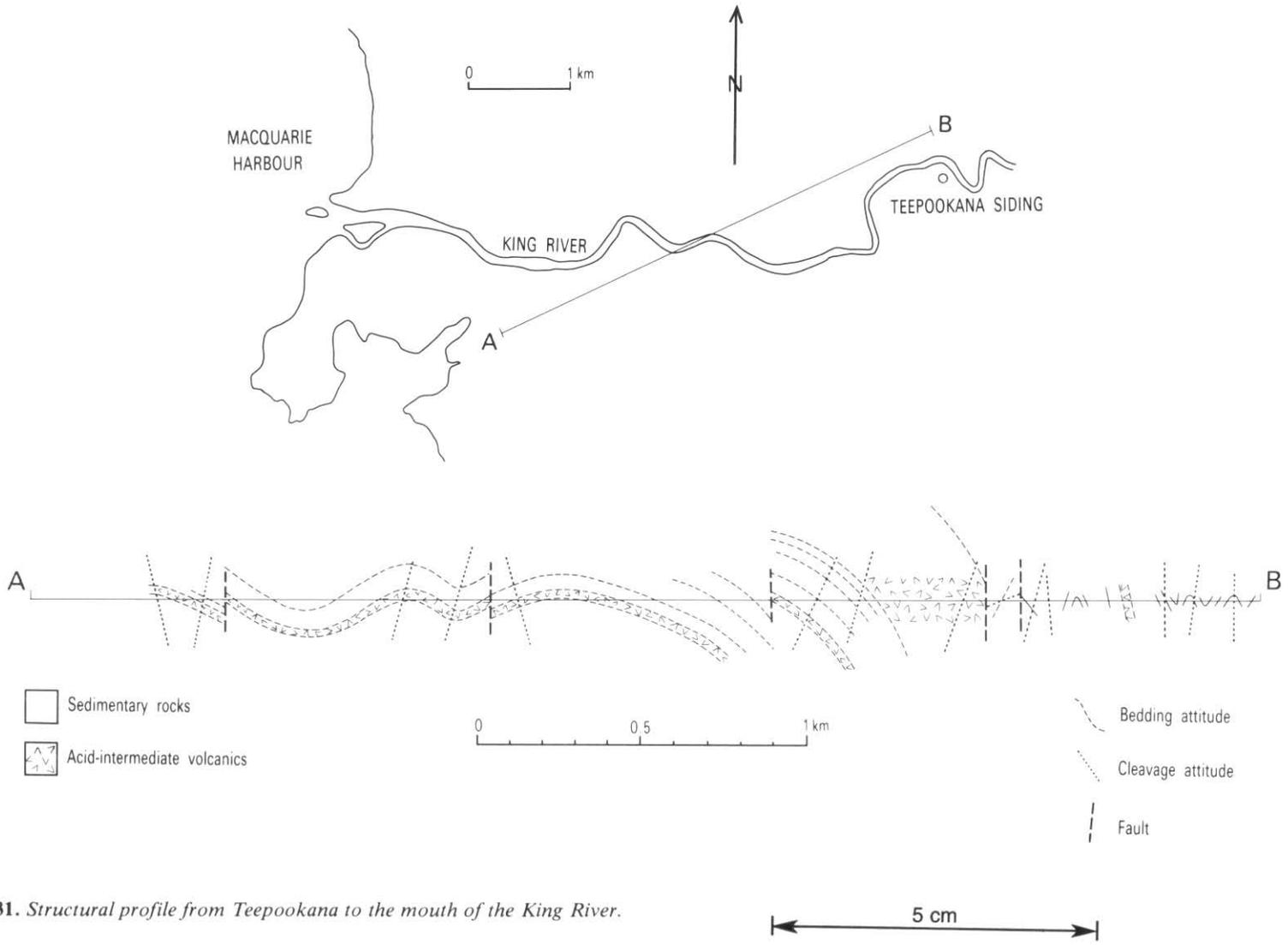
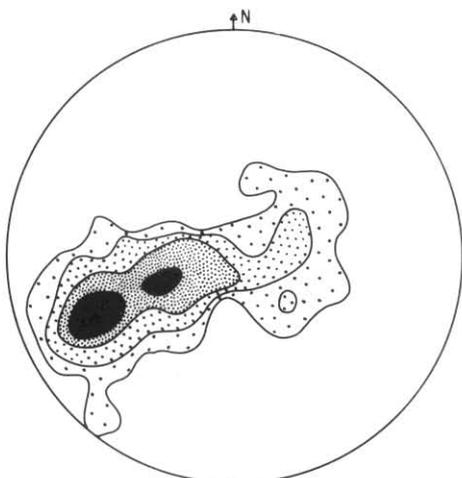
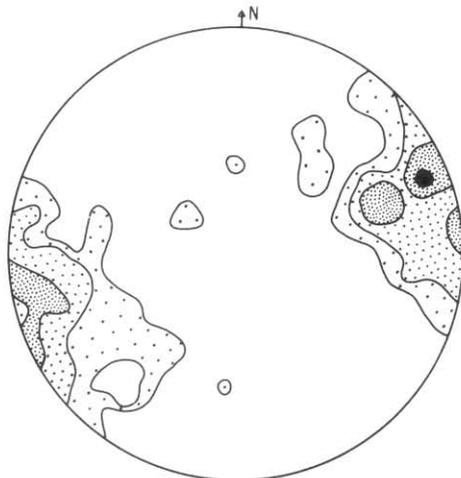


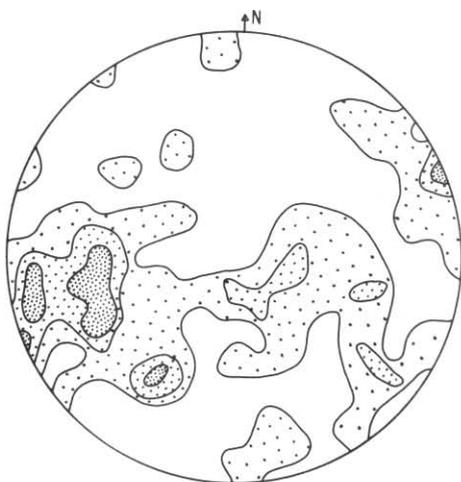
Figure 31. Structural profile from Teepookana to the mouth of the King River.



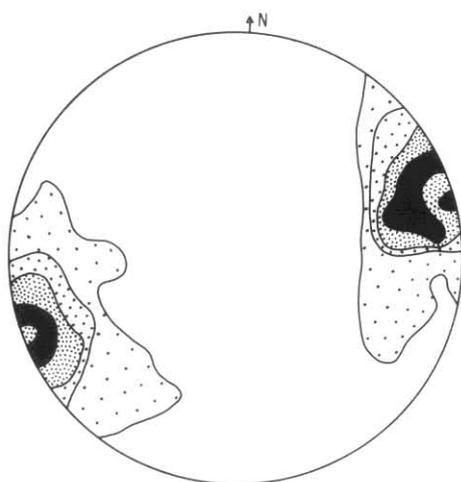
**Figure 32.** Stereoplot of 74 poles to  $S_0$  section through the Cambrian west of Teepookana. Contour intervals: 0.4–2.5%, 2.4–5%, 4–10%,  $\geq 10\%$ .



**Figure 34.** Stereoplot of 186 poles to  $S_0$ , non-volcanic Cambrian sequence, King River area. Contour intervals: 1–2.5%, 2.4–5%, 4–7.5%,  $\geq 7.5\%$ .

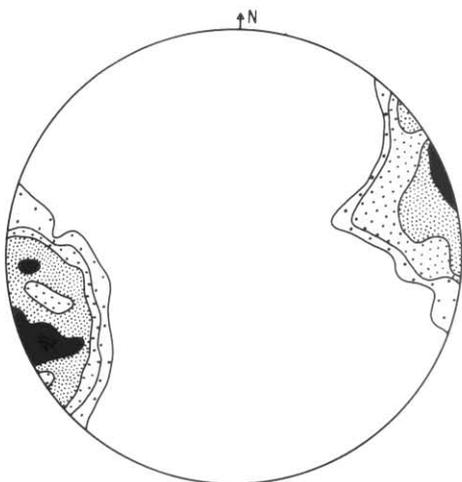


**Figure 33.** Stereoplot of 76 poles to  $S_0$ , Lettes Bay–Burgess Rivulet area. Contour intervals: 0.4–2.5%, 2.4–5%,  $\geq 5\%$ .

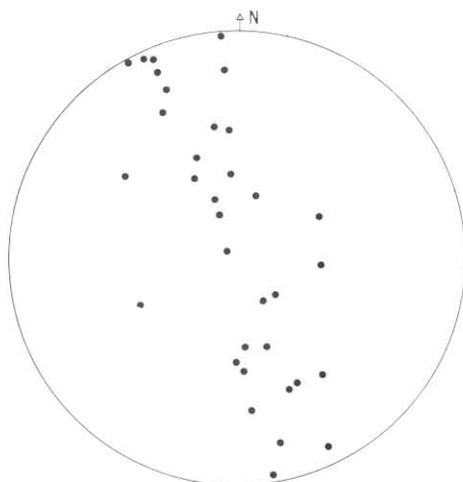


**Figure 35.** Stereoplot of 103 poles to dominant cleavage, in Cambrian succession, north of the King River. Contour intervals: 1–2.5%, 2.4–5%, 4–10%,  $\geq 10\%$ .

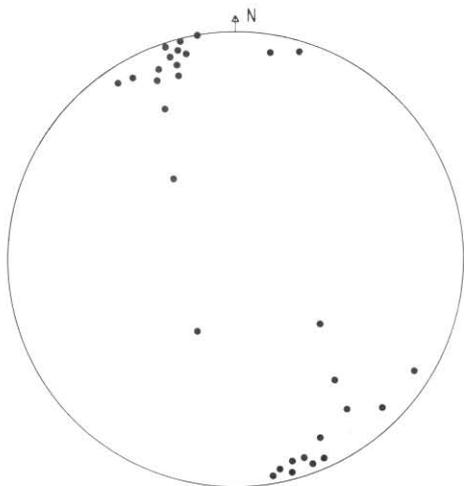
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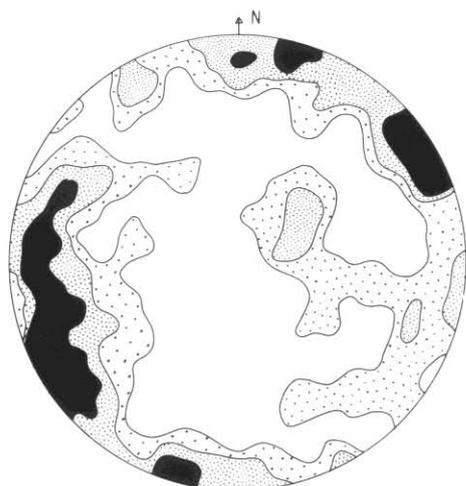
**Figure 36.** Stereoplot of 92 poles to dominant cleavage, dominantly sedimentary Cambrian succession, lower King River area, south of the King River. Contour intervals: 1-2.5%, 2.4-5%, 4-10%,  $\geq 10\%$ .



**Figure 38.** Stereoplot of 35 bedding-cleavage intersections, in Cambrian sedimentary succession south of the King River.



**Figure 37.** Stereoplot of 30 bedding-cleavage intersections, between Teepookana and the mouth of the King River.



**Figure 39.** Stereoplot of 94 poles to bedding, tuff-greywacke sequence (€ nf), northern area. Contour intervals: 0.4-1.5%, 1.4-2.5%, 2.4-3.5%,  $\geq 3.5\%$ .

5 cm

dimensional orientation of fine-grained micas within the microlithons. This internal cleavage, which is at an angle to both the bedding and the domainal cleavage, has clearly been overprinted by the domainal cleavage. In 75-405, there are coarse opaque clasts with double pressure fringes in orientations corresponding to the two cleavages.

In some laminated siltstones with the second cleavage ( $S_2$ ) at a high angle to bedding (e.g. 75-354, 75-411), relatively coarse detrital mica flakes have been bent and broken within microlithons, but have a preferred orientation sub-parallel to bedding. Very fine-grained secondary phyllosilicates also have a pronounced penetrative preferred orientation sub-parallel to bedding. In such cases, it is suggested that an initial weak alignment of detrital and diagenetic phyllosilicates parallel to the bedding has been enhanced during deformation to form  $S_1$  sub-parallel to bedding.

The domainal second cleavage may also form approximately parallel to the early penetrative cleavage, as in a laminated calcareous siltstone (74-614) from the banks of the King River. This rock has the dominant cleavage at a high angle to bedding, and shows the usual spaced and strongly-anastomosing opaque mineral and phyllosilicate-rich slivers enwrapping small lenticular microlithons. The microlithons are aggregates of very fine-grained phyllosilicates and larger grains of quartz, carbonate, and detrital mica. The detrital micas display a weak orientation sub-parallel to bedding, however the fine-grained secondary phyllosilicates possess a strong penetrative preferred orientation sub-parallel to the microlithon long axes.

Less frequently in the Cambrian succession, laminated siltstones and slates have a well-developed crenulation of a strong  $S_1$  slaty cleavage (e.g. 75-406). Buckling of the earlier penetrative cleavage which is sub-parallel to closely spaced bedding laminae, and domainal pressure solution appear to have been the dominant processes in the formation of an  $S_2$  crenulation cleavage.

Quartzwackes in the Cambrian succession usually have a mesoscopically penetrative cleavage defined by a fissility and sub-parallel orientation of micaceous minerals. In some cases a fine lozenge-shaped fabric may be recognised. The dominant cleavage in the quartzwackes is sub-parallel to the domainal  $S_2$  cleavage in the interbedded siltstones, and is probably its equivalent.

Microscopically the cleavage in the arenites is expressed by an elongation of detrital quartz, quartzite, mica and mudstone clasts where present, together with stringers of very fine-grained phyllosilicates and opaque minerals which anastomose

around grains and groups of grains and recrystallised matrix. The lenticular microlithons thus formed are also a major fabric element in defining the cleavage, and in some cases are probably equivalent to the lozenges observed at hand specimen scale.

The anastomosing stringers may locally be up to  $40^\circ$  to  $50^\circ$  away from the direction of elongation of the microlithons; this is especially so where the stringers are confined between clast boundaries. The stringers, being quartz deficient when compared with the microlithons, have probably formed by domainal pressure solution during flattening. The very variable spacing and width of the stringers even down to the thin section scale reflects inhomogeneous strain.

The microlithons may be up to one millimetre long and generally less than 0.5 mm wide. Detrital micas oblique to the cleavage are often bent or broken in the microlithons. Mica beards are commonly present, parallel to the mesoscopic cleavage at opposing ends of clasts.

In a more matrix deficient micaceous quartz sandstone of the Cambrian succession (e.g. 75-357) quartz-grain boundary pressure solution has been important in producing a grain elongation sub-parallel to the elongation of lenticular microlithons. Undulose extinction, deformation lamellae, and to a limited extent sub-grains, have formed in quartz clasts. There is also a development of thin sub-planar mica-rich domains cutting across the more frequent anastomosing mica-rich slivers which wrap around the microlithons. These sub-planar mica-rich domains symmetrically cut across the dominant cleavage direction at about  $30-50^\circ$  and possibly formed late during flattening by pressure solution and minor simple shear or fracture.

Often the quartzwackes show no clear equivalent of the penetrative  $S_1$  cleavage found in the siltstones, however in the more micaceous laminae of a fine-grained micaceous quartz sandstone (75-407), a strong and penetrative alignment of detrital and secondary micas subparallel to the bedding has been overprinted by the steeply inclined NNW-trending spaced cleavage. In some cases where the fine lozenge fabric is present in hand specimen (e.g. 75-404), an early penetrative cleavage is expressed by a very fine sub-planar intergrowth of quartz and phyllosilicates oblique to the later dominant and domainal cleavage. In such cases, the intersection of the two cleavages produces the lozenges.

The volcanic rocks in the Cambrian volcano-sedimentary sequence show a very variable intensity of cleavage development. Many crystal-lithic tuffs are quite massive or show only a weak cleavage defined by a preferred orientation of recrystallised

phyllosilicates wrapping around clasts. Vitric tuffs are usually intensely cleaved, probably because shards and pumice fragments, which have been devitrified to aggregates of fine-grained quartz, feldspar and phyllosilicates, are readily deformed. In such rocks the cleavage is defined by an elongation of the altered glassy materials, and an internal preferred orientation of wispy phyllosilicates within them. Fine-grained phyllosilicates also wrap around groups of clasts in these tuffs.

Mudstone and other lithic clasts in the coarser lapilli tuffs often show shortening perpendicular to the plane of the cleavage.

In some basalts from Pine Cove Creek, a strong penetrative cleavage is produced by an elongation of carbonate blebs and chloritic shreds formed by the alteration of feldspar and pyroxene respectively.

#### CAMBRIAN ROCKS IN THE NORTHERN AREA (K.D.C.)

Cambrian rocks in the northern area are generally too poorly exposed and too disrupted by faulting to allow structural profiles to be drawn. Bedding trends in the fault wedge of interbedded greywacke, mudstone and tuff are highly variable and include overturned bedding and bedding with E-W strike. Trends in this sequence in the Truscott Creek-Yolande River area [750460] are predominantly NNW to NW, with steep westerly dips. The presence of a NNE-trending syncline is indicated by reversals of facing, and arcuate strike ridge trends about one kilometre east of The Sisters [750460]. A plot of 94 poles to bedding in this lower sequence (mainly from Queensberry area and the area north of the Yolande River) is shown as Figure 39 and indicates the presence of dominantly upright NW to W-trending folds.

Mesoscopic folds having a wavelength of 0.75–1 km and north to NNW trend are evident from strike trends and facings in the quartzwacke-mudstone-conglomerate sequence in the central part of the northern area. Several of the folds continue into Eldon Group rocks on the Zeehan Quadrangle to the north, where the fold axes become more north-westerly. W-trending open folds are present in several areas close to the Firewood Siding Fault system, and appear to be superimposed on the earlier N-S folds. The most obvious of these folds is outlined by the strike ridges of conglomerate about one kilometre north of the Queensberry mine [663465]. Bedding trends in the quartzwacke-mudstone-conglomerate sequence are shown in Figure 40. Dominant trends in the north, north-west and NNE direction are indicated, with a minor easterly trend probably reflecting the influence of the Firewood Siding Fault.

Mesoscopic folds occur within thin-bedded siltstone-sandstone units of the quartzwacke sequence in several areas. These generally have vertical or steeply dipping axial surfaces and variably-plunging hinge-lines. Axial trends range from WNW to NNW, and the dominant cleavage is generally in the axial surface of the folds.

A regionally penetrative slaty cleavage in the Cambrian rocks has a NW-trending subvertical attitude (fig. 41). This cleavage lies in the axial surface of most minor folds and some of the major folds in the area, but is slightly oblique to major folds having N or NNE trends and is clearly unrelated to the E-W folds. Traces of a second cleavage have only been observed in thin sections.

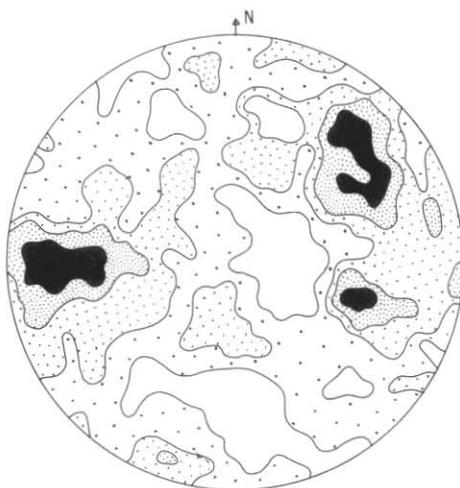


Figure 40. Stereoplot of 232 poles to bedding, quartzwacke sequence (€nc), northern area. Contour intervals: 0.24–1%, 1–2%, 2–3%,  $\geq 3\%$ .

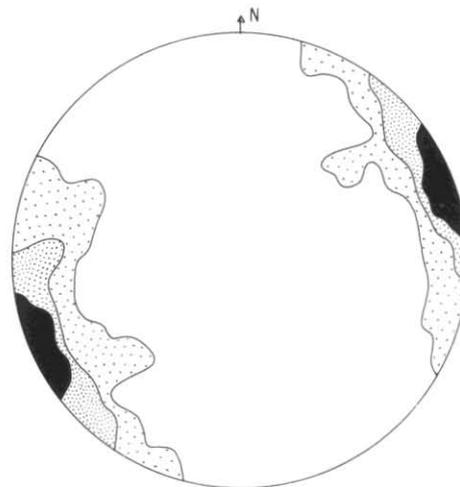
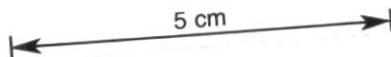


Figure 41. Stereoplot of 100 poles to dominant cleavage, Cambrian rocks, northern area. Contour intervals: 1–2.5%, 2.4–15%,  $\geq 15\%$ .



## OWEN CONGLOMERATE CORRELATES (K.D.C.)

The siliceous sandstone and conglomerate units comprising the Owen Conglomerate correlate have generally acted more competently during folding than the Cambrian rocks, and have tended to form broad open folds. This is particularly evident in the Professor Plateau area [645475] where the sequence is thickest and forms a gentle arc before being truncated by the Firewood Siding Fault. In the vicinity of the fault, bedding in the conglomerate may be overturned. West of the fault the sequence is folded into an anticline with a wavelength of about 2 km and which plunges steeply NNW.

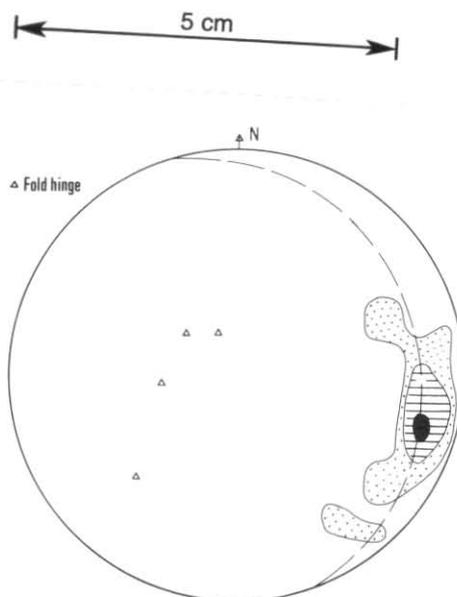
In the area of The Sisters [730460], the Owen Conglomerate correlate is folded into a N-trending syncline. The fold is broadest at the southern end where the conglomerate sequence is thickest, and plunges gently northwards towards a synclinal core occupied by Gordon Sub-Group correlate.

The syncline of Owen Conglomerate correlate in The Sisters area appears to straddle a major contact within the Cambrian succession. This contact is between an eastern greywacke-mudstone-tuff sequence and a younger, western quartzwacke-mudstone-conglomerate sequence. The base of the Owen Conglomerate correlate appears to be a major erosional surface. Where exposed near the northern margin of the map sheet [734487], this surface is seen to be an angular unconformity developed on the tuffaceous sequence, with the basalt NNW-trending conglomerate truncating NNE-trending siltstone and tuff units (p.24, fig. 5). The contact on the quartzwacke sequence in the Henty River near West Sister [729469] also shows angular discordance, with the underlying sequence dipping and facing west and the overlying sequence dipping and facing east. At least minor folding of the Cambrian sequence is indicated prior to deposition of the Owen Conglomerate correlate.

## ELDON GROUP CORRELATES (P.W.B.)

As shown by Figure 30, the Florence Quartzite clearly displays the gross geometry of the major folds in the Eldon Group correlates. The major folds plunge steeply NNW and have amplitudes of 4–5 km. Solomon (1962) named the major structure the Dubble Barril Synclinorium and considered that only one fold phase was present, which was related to the formation of the West Coast Anticlinorium.

The Bell Shale correlate has been folded during two phases (Baillie and Williams, 1975). The first phase produced folds plunging between 30° and 90° NW and the second phase produced folds plunging



**Figure 42.** Stereoplote of 32 poles to bedding, Florence Quartzite, Strahan-Queenstown road. Contour intervals: 6.24–12.5%, 12.4–25%,  $\geq 25\%$

shallowly WNW or ESE. Folds of both phases produced a primary axial surface cleavage and the second phase produced crenulation cleavage in some areas. Amplitude of folds decreases in a north-westerly direction away from the Florence Quartzite correlate. The locus of strain during the second phase of deformation was along the Firewood Siding Fault (Baillie and Williams, 1975).

Some evidence of a later E–W fold phase is also present near Woody Hill [748334], where a steeply plunging, open, ESE fold and parasitic minor folds are present on the eastern limbs of a major NNW-trending syncline (fig. 42). Because the lithology is well-bedded sandstone in this area it was not possible to prove from cleavage relationships whether refolding had taken place.

## FIREWOOD SIDING FAULT AND ASSOCIATED FAULTS (K.D.C.)

The continuous line of faults forming the northern boundary of the Bell Shale correlate between Pearl Creek in the east [745422] and Professor Plateau in the west [640457] is referred to as the Firewood Siding Fault (Banks and Ahmad, 1959; Blissett and Gulline, 1962). This fault system extends east to the Queenstown area and north-west to Trial Harbour, and is one of the major first-order tectonic features of western Tasmania. The main fault is offset by a number of secondary faults with NW to NNE trend, and has a number of splay faults in the Professor Plateau area [620472]. Although the fault surface has not been observed, the trace of the structure suggests a sub-vertical attitude. Most of the movement on the fault probably occurred during the Tabberabberan Orogeny, as indicated

by its influence on Devonian structures, but some post-Jurassic movement is also indicated by the juxtaposition of Permo-Jurassic rocks with Early Palaeozoic sequences on the adjacent Zeehan Sheet. The pronounced thickening of the Owen Conglomerate correlate north of the fault at Professor Plateau and The Sisters suggest the probability that the fault, or its precursor, may have been active during Late Cambrian and Early Ordovician times. Major changes in trend (*e.g.* from E to NW) may indicate that some folding of the fault occurred during Devonian orogenesis.

The fault juxtaposes Early Devonian Bell Shale correlate and pre-middle Late Cambrian sequences, suggesting a vertical displacement of at least 3 km. Dextral transcurrent movement of the order of 1.5 km is indicated by the displacement of the conglomerate-sandstone contact within the Owen Conglomerate correlates at Professor Plateau [630469]. The Pb-Zn-Cu mineralisation at Queensberry mine [664449] is associated with the fault.

The largest offset of the main fault is a dextral displacement of about 3 km on a NNE-trending fault on the lower Yolande River [728436]. This fault continues southwards into the Bell Shale correlate, and may continue northwards along a linear feature crossing Truscott Creek to connect with a major fault along the Henty River gorge to the north-east (South Henty Fault of Corbett, 1981).

The area of contact between Bell Shale correlate and Cambrian rocks in Clifford Creek [725448] is highly complex, but poorly exposed. It seems likely that a general W-trending faulted contact in this area is irregularly offset by a series of small N-trending faults which also disrupt the syncline of Owen Conglomerate which crops out to the north.

A NNW-trending cross-fault appears to offset the main fault in the vicinity of Marchfly Ridge [707454]. This fault probably continues northwards into the headwaters of Malcolm Creek, where a linear zone of intense cleavage is present.

A second NW-trending fault occurs in the vicinity of Melody Creek [682460], and is probably continuous with a fault which sinistrally offsets the base of the Owen Conglomerate correlate by about 350 m in the headwaters of Bottle Creek [665483]. At its southern end, this fault is associated with an apparent dextral offset of the Firewood Siding Fault of about one kilometre.

The main fault changes trend from west to north-west at the southern end of the Professor Plateau [637460], in an area where several splay faults are developed. A major NNW-trending fault (Eden Fault of Blissett and Gulline, 1962) occurs west of

the main fault in this area, and causes displacement of Parmeener Super-Group rocks against rocks belonging to the Gordon Subgroup.

### CAMBRIAN-ELDON GROUP CONTACT IN THE SOUTHERN AREA (K.D.C.)

A NW-trending, steeply-dipping fault separates the Cambrian sequences of the lower King River area from overlying Ordovician and Siluro-Devonian rocks. Progressively younger post-Cambrian units abut the fault towards the north-west, including Bell Shale correlate at its north-west extremity [651359]. The fault contact changes abruptly to a south-west trend near the Burgess Rivulet [650358], corresponding with an anticlinal structure in the underlying and overlying rocks. It is suggested that this faulted contact was folded during the major Tabberabberan deformation (S.F.C., R.D.G.) and that the fault surface has acted as a décollement in the Virginia Creek area [701284], where folded Eldon Group correlates abut the contact (S.F.C.).

### OTHER FAULTS (P.W.B.)

Large strike-slip faults are present within June and Eldon Group correlates in the south-west part of the map sheet. At several places the Strahan-Queenstown road cuts across a fault between correlates of the Florence Quartzite and Crotty Quartzite. In close proximity to the fault, bedding is overturned in rocks of the Crotty Quartzite correlate.

The fault separating Owen Conglomerate correlate and siltstones immediately underlying Crotty Quartzite correlate is exposed on the King River near the mouth of Sailor Jack Creek [755292]. At this locality the siltstone is disturbed and quartz veins are common.

### ECONOMIC GEOLOGY

*G. R. Green*  
*C. A. Bacon*  
*V. M. Threader*

Although the first discovery of coal was made in the Strahan Quadrangle in 1815, the region is not as richly endowed in mineral wealth as much of western Tasmania. Minor quantities of coal, silver, lead, zinc and gold have been won, but the activity has been intermittent and apart from road-making materials, no mining is currently being carried out, although mining leases are held for silica and silver-lead-zinc.

## Metallic minerals

G. R. Green

### GOLD

Gold was probably first discovered in the Strahan Quadrangle by Charles Gould who, in 1863, found coarse-grained alluvial gold in the King River Valley but not in payable quantities (Binks, 1980).

Prospecting in the early 1880s led to the discovery by a man employed by Conrad Lynch of a 50 kg quartz sample containing about 120 kg/t Au, in the Lynch Creek area to the east of the Strahan Quadrangle (Julen, 1981). This find resulted in a considerable heightening of activity in the area, and possibly provided the impetus for the discovery of the Mount Lyell orebody in November 1883.

In late 1887 prospecting activity led to several mining leases being pegged in the headwaters of Lost Creek. Initial optimism resulted in the erection of a battery at the Macquarie Gold mine [752379], but work lapsed after a trial crushing gave poor results (Montgomery, 1890). The nearby Woody Hill mine [755377] originally claimed by G. V. Kemp in 1887, and worked by the Woody Hill Prospecting Association in 1892–1900 and 1901–1907 by W. W. F. and T. C. Murray was the only mine from which production is recorded. Between 1898 and 1905 some 4.66 kg of Au from 265 t of ore was produced intermittently, giving an average yield of 17.6 g/t. In 1903 the Mount Lyell Company tested the quartz in the mine as a source of flux, but this was apparently unsuccessful. In 1936 C. Costain cleared out an old drive to test the reef under an old stoped area. All samples collected returned assays of less than 1.5 g/t. The mine was worked from two adits driven WSW into the hillside; the No. 2 tunnel being 33 m below the No. 1 tunnel which is connected to the surface 21 m above, by an underlay shaft (fig. 43).

A considerable amount of effort was expended in the prospecting of the Davie P.A.'s claim at 759365 in 1909–1910. A quartz reef assayed about 14 g/t Au at surface and was driven on for 150 m. A shaft was also sunk, and it was reported that considerable amounts of gold were found in the 'northern workings' (*Progr. miner Ind. Tasm. ... for quarters ending 30 March 1909 to 31 December 1910*). Despite all this activity no production was recorded. Little is known about the Coupon leases, located around the confluence of Goring and Halls Creeks [759337]. These may have been alluvial claims.

## GEOLOGY

The Woody Hill mine and the other prospects worked auriferous gold veins in the correlates of the Florence and Crotty Quartzites and no geological descriptions have been given of these deposits. Because gold deposits occur in Cambrian volcanic rocks in the Queenstown Quadrangle to the east, and because antimony prospects exist in the area, it is tempting to speculate that the gold mineralisation might represent remobilised material from deposits occurring in underlying Cambrian rocks.

### SILVER-LEAD-ZINC

#### QUEENSBERRY MINE

There are a number of Ag-Pb-Zn vein deposits in the Quadrangle. Of these the only producer was the Queensberry mine. The mine is situated on Lode Creek a tributary of the Henty River near 665459. The orebody was discovered in 1891 and the first lease 996/91M, of 80 acres (32 ha), was registered in the names of T. Martin and M. Davey in September 1891 and transferred to R. McKimmie of Zeehan the following month. Samuel Carson took over the area as lease 1500/93M in 1896 and it was transferred to the Henty Mining Co. N.L. in 1898 and became void in December 1902. These early workers excavated the lodes by adits and there is no record of any production, although Reid (1927) mentions transport costs as one of the main reasons for the mine failing. W. Grieve took over the area as lease 1050/M in November 1904 and held it until December 1911. He sank a shaft to a depth of 14 m, and constructed a wooden tramway to the Zeehan-Strahan railway, some 11 km away. Grieve repegged the area as lease 6140/M in December 1912. It was transferred to Christina Grieve in December 1913 and to Fanny Harrison in 1916 and eventually became void in early 1918. The central 10 acres of the area was pegged as lease 7845/M by J. T. Harrison, formerly Inspector of Mines at Queenstown, in January 1918 and were held until late 1924. Harrison extended the main shaft to a depth of 30 m and drove north and south on the No. 1 Lode.

The lease was taken up as mining lease (ML) 10150/M by A. Pearson between 27 December 1927 and 20 November 1928 and as 11807/M by G. W. S. Clarke between 9 March 1937 and 20 December 1939. A. R. and G. G. Smith incorporated the old 10 acre (4 ha) lease in 11M/66 and 12M/66 of 40 acres (10 ha) each. The Smith's optioned the leases to the Mount Lyell Mining and Railway Co. Ltd, who carried out geological

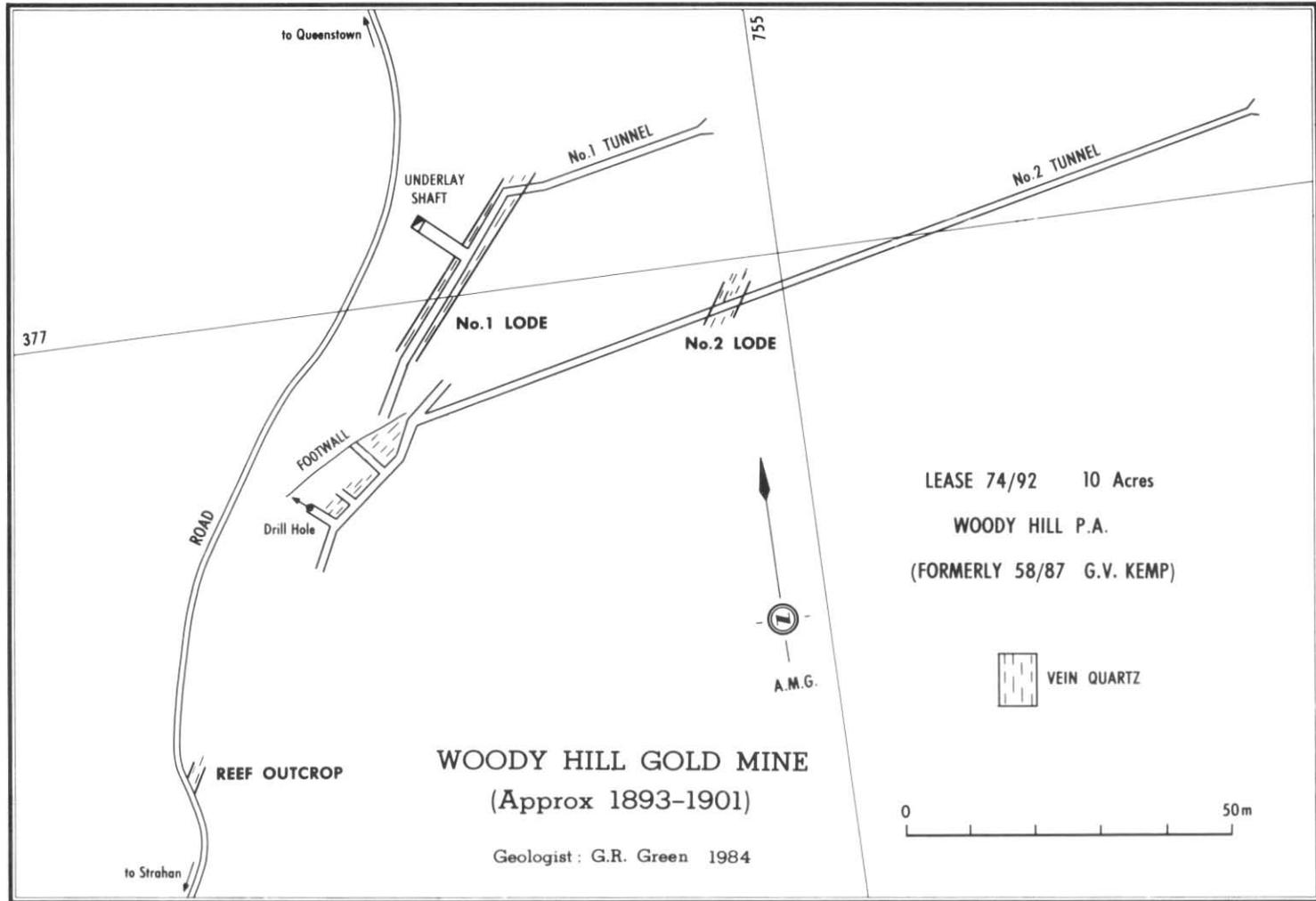


Figure 43. Plan of Woody Hill gold mine (approximately 1893-1901).

5 cm

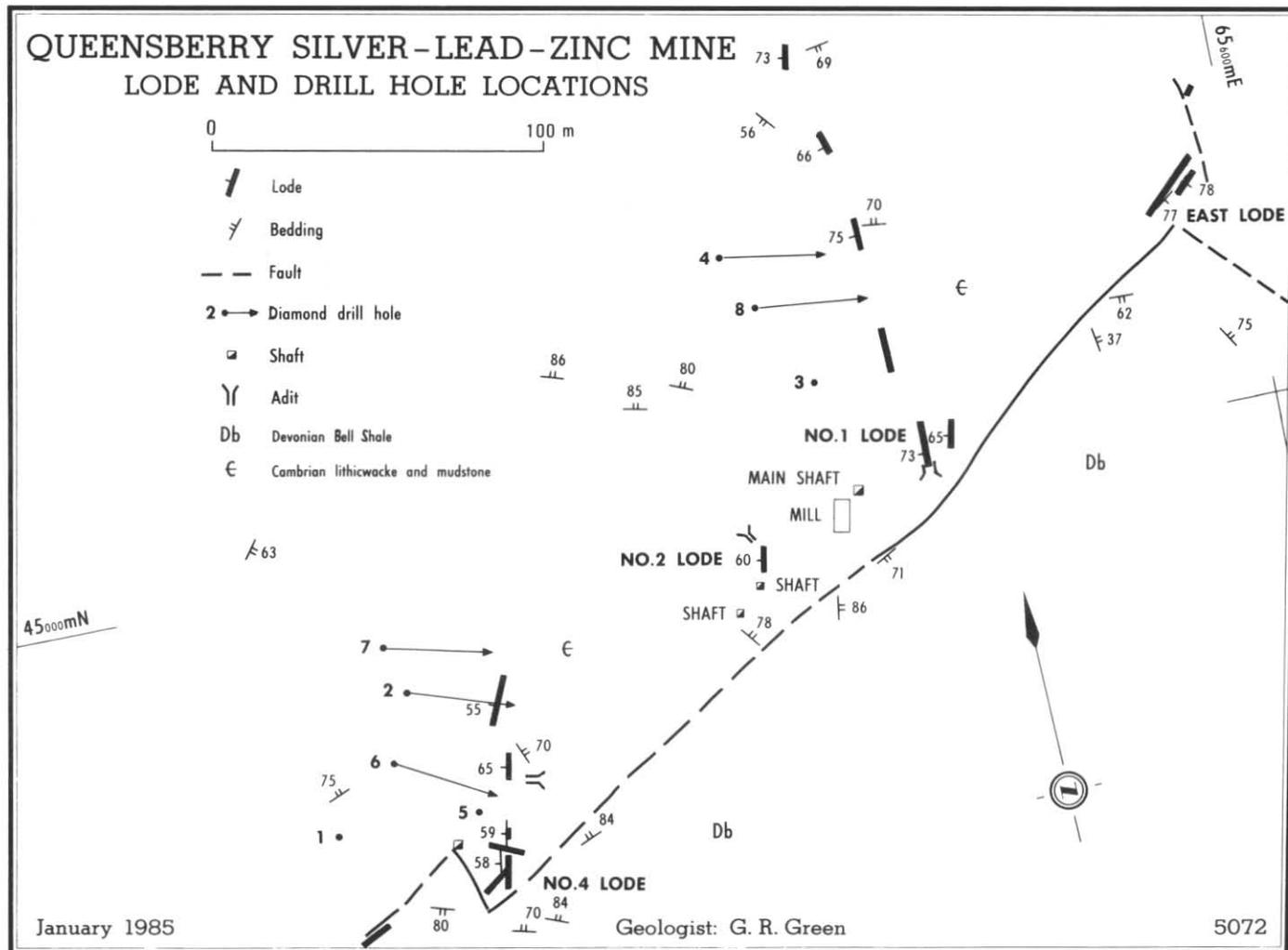


Figure 44. Queensberry mine. Lodes and drill holes. Compiled from Forsythe (1968), Lennox (1970) and work by G. R. Green.

5 cm

mapping and a geochemical survey of the surrounding area (Forsythe, 1968), before relinquishing their option. Later a vehicular track largely along the line of the old tramway was constructed and investigations including eight diamond drill holes were undertaken by Minops Pty Ltd for Apollo International Minerals in 1969–1970. (Lennox, 1970). Following a challenge in the Mining Warden's Court, the leases were taken over by Bendall's Mining Company Pty Ltd as MLs 60M/81 and 61M/81 in August 1981 and consolidated into ML 27M/83 of 32 ha in June 1983. The lease was transferred to Oceania Tasmania Pty Ltd in September 1983.

The only recorded production was by W. Grieve on the 14 m level of 344.5 t assaying 40% Pb, 184 g/t Ag and by J. Harrison who sold 423 t of ore grading 56% Pb and 214 g/t Ag. The main factors defeating these ventures were the high transport costs and the low silver tenor of the ore.

### *Geology and mineralisation*

The host rocks for the vein mineralisation comprise volcanoclastic sandstone ('crystal tuff'), lithicwacke and siltstone described by K.D. Corbett (this volume). Five main veins have been discovered. These occur adjacent to, and north of, the Firewood Siding Fault. From east to west, the veins are termed the East Lode and the Nos. 1, 2 and 4 Lodes. (fig. 44). In addition, minor galena and sphalerite occur in sheeted quartz veins some 475 m NNW of the main shaft (Forsythe, 1968).

Most of the veins strike in directions ranging from 350° to 12° and dip to the west at angles of between 53° and 75°. The East Lode is anomalous and strikes at about 045° and dips south-east at 70° to 90° and is subparallel to the local orientation of the Firewood Siding Fault. The fault itself is mineralised in places. Steely, gneissose galena occurs in the fault near No. 4 Lode. In addition a number of fractures running in approximately an easterly direction displace the lodes. There is negligible wall rock alteration and, except in the vicinity of the Firewood Siding Fault and in the other minor offsets of the lodes the mineralisation is coarse-grained and is texturally similar to vein mineralisation in the majority of the mines of the Zeehan field (e.g. Both and Williams, 1968; Green, 1973). Further, drilling has demonstrated that the widths of veins and grade of mineralisation decrease northward away from the Firewood Siding Fault (Lennox, 1970). These features indicate that the mineralisation is probably of Devonian age and that the loci of intersection of the major easterly-trending faults with the minor N- to NE-trending fractures provided the conduits for ascending hydrothermal solutions.

Post Devonian movements on the fault in the Zeehan Quadrangle to the west have been demonstrated by Blissett and Gulline (1962) who mapped Permian sedimentary rocks and Jurassic dolerite south of the fault abutting Ordovician to Devonian sequences to the north. Such movements could well account for the local deformation of the ore. This factor, and the incompetence of slates of the Bell Shale south of the Firewood Siding Fault, probably account for the absence of known mineralisation south of the structure in the Queensberry mine area. That the fault was active during the Devonian has been established by Baillie and Williams (1975), who recognised it as the locus of strain for a Devonian WNW-trending phase of deformation which produced shallowly plunging folds and, locally, intense slaty cleavage development.

The lodes are variable in nature with massive and banded mineralisation developed locally, but much of the material consists of disseminated mineralisation in a country rock breccia cemented by quartz. The lodes are mainly developed in competent volcanoclastic sandstone units, and post-date cleavage development. Features of the exposed lodes provide evidence of a prolonged and complicated history of mineralisation and fracture opening. This is shown in the 2.2 m true thickness of the No. 4 lode exposed in a cut on Lode Creek. At the hangingwall is a 200 mm thickness of greenish resinous sphalerite, structurally underlain by banded galena-sphalerite; then chalcopyrite-galena-sphalerite stringers in quartz with a weakly-mineralised footwall zone consisting of an open-framework, quartz-cemented breccia of country rock (black mudstone fragments). In detail, within a few centimetres of the footwall contact, irregular slate bands about one millimetre thick and trains of slate fragments of sub-millimetre size, separated by sections of a few millimetres of vein quartz suggest vein formation by the incremental crack seal mechanism of Ramsay (1980) (plate 18). The slate fragments in the breccia are overgrown by fine-grained quartz which passes outward into radiating prisms. The prisms are locally interrupted by thin trails of pelitic material suggesting episodic growth by a process similar to the crack seal mechanism, but in a neutral stress regime (plate 19). Siderite and sulphides were introduced after this phase of vein formation.

Sub-horizontal slickensiding and fluting on the hangingwall of the No. 4 Lode suggests a component of lateral movement during lode formation. A number of the lodes are displaced by cross faults and display an en echelon outcrop pattern. For example, the No. 4 Lode is displaced about 300 mm dextrally by a quartz-filled fault striking 310°, about 25 m north of Lode Creek.



**Plate 18.** Hand specimen of quartz-cemented country rock breccia from footwall of no. 4 lode, Queensberry mine. Specimen 75-587 (natural size).



**Plate 19.** Photomicrograph showing radiating prismatic quartz crystals around mudstone micro-inclusion. Crossed polars. Width of field is 3.5mm.

#### Mineralogy and paragenesis

The following minerals (in decreasing order of abundance) have been identified in the examination of twenty polished sections representative of all the exposed mineralisation in the mine area : quartz, galena, sphalerite, pyrite, siderite, chalcopyrite, arsenopyrite, tetrahedrite and bournonite. Minor amounts of secondary goethite, pyromorphite, cerussite, malachite, and azurite have also been identified. The mineralogy of individual lodes is summarised in Table I.

Table I  
MINERALOGY OF QUEENSBERRY MINE LODES

Lode No. and Locality	Specimen Number	Mineralogy	Comments
No. 1 Lode, near Lode Creek	72-033 A,B	sl, gn, qz	gn deformed. Reid also reports cp,py,thd present
No. 1 Lode, 60 m N of Lode Creek	71-715	sl,gn,py,cp,thd in quartz	Paragenesis: py→sl→py-cp-gn-thd
Offshoot from No. 1 Lode, Creek	71-713 A,B	gn,apy,sl,qz	Paragenesis: qz→apy→sl-gn. gn deformed
No. 2 Lode, adit	71-712	gn,qz,cp,thd, py, sl	Paragenesis: qz→sl→cp→gn, thd-py→qz
No. 2 Lode, dump near rise	72-001 A,B,C	gn,sl,cp,py,qz, thd,bo,apy	Paragenesis: qz→qz-py, apy→sl→cp, py→sid→gn-thd-bo-py
No. 2 Lode, shaft 9 m SW of rise, dump material	72-032 A,B,C, D,E	gn,qz,sl,cp,apy, thd	Paragenesis: qz-py-apy→sl→cp-py→gn-thd-py. gn deformed
No. 4 Lode, near Lode Creek	71-711 A,B,C,D	qz,gn,sl,cp, sid,thd,py,apy	Paragenesis: qz→py-qz→sl→sid→qz-cp-thd-py→gn-qz. gn deformed
East Lode	71-714 B,C	gn,sl,in qz	qz-sl-gn. gn deformed. Forsythe reports cp,apy

Abbreviations: gn = galena, sl = sphalerite, qz = quartz; cp = chalcopyrite; apy = arsenopyrite, py = pyrite, sid = siderite, thd = tetrahedrite, bo = bournonite

Pyrite and arsenopyrite are commonly associated with quartz and occur as euhedral crystals generally about 0.1 to 0.2 mm in diameter and rarely up to a few millimetres. These minerals may be fractured, veined and replaced by later minerals. Massive pale resinous sphalerite crystallised later and is associated with siderite in some sections although replacement relationships suggest the siderite formed later.

The relative abundance of these minerals varies widely between the lodes. Arsenopyrite is a major mineral in a minor off-shoot of the No. 1 Lode near Lode Creek and is present in significant proportions in material from the No. 2 Lode. Elsewhere it is either absent or is present in trace amounts.

Sphalerite is extensively replaced in many sections by chalcopyrite and galena. The chalcopyrite may occur as seams a few millimetres thick and adjacent to chalcopyrite-sphalerite contacts the sphalerite is invariably studded with minute inclusions of chalcopyrite (the effects of the chalcopyrite 'disease' of Barton, 1978). A second generation of fine-grained pyrite is a sporadic associate of the chalcopyrite. Chalcopyrite appears to be most abundant in the Nos. 2 and 4 Lodes, in the former location particularly from the shaft dump 9 m southwest of the rise at the end of the adit which extends southward from Lode Creek.

Galena is the dominant sulphide throughout the mine area. Abundance of curved cleavages in the galena testifies to minor post-mineralisation deformation. Galena replaces quartz, sphalerite and siderite, invading the latter mineral particularly along cleavage planes. Tetrahedrite occasionally occurring in massive patches a few centimetres

across is a common associate. Bournonite occurs with galena as patches up to 1.2 mm across in the No. 2 Lode. A late generation of pyrite euhedra averaging about 10  $\mu\text{m}$  across is common within sphalerite at galena-sphalerite replacement boundaries. The relationship between galena, tetrahedrite and chalcopyrite is less certain, and overlap of their deposition may have occurred. However two pieces of evidence suggest that chalcopyrite deposition may have preceded formation of the other two minerals, at least locally. In specimen 72-032A, chalcopyrite is veined by tetrahedrite with 10 to 20  $\mu\text{m}$  inclusions of pyrite occurring near the contacts. Elsewhere in the section, galena and tetrahedrite are commonly associated and occur in mutual boundaries intergrowths. In specimen 72-001C, chalcopyrite appears to be replaced by galena with the cuproan sulphosalts, bournonite and tetrahedrite present near the contacts.

Of the gangue minerals, quartz is far more abundant than siderite. Siderite occupies an intermediate position in the depositional sequence, whereas quartz, although dominantly formed early, appears to have been deposited throughout the paragenesis.

In summary, the order of crystallisation of the minerals, is very similar to that deduced by Both and Williams (1968) for the ores of the Zeehan field. The paragenetic sequence appears to be consistent throughout the mine area (table 1, fig. 45). Such zonal differences that do exist (e.g. variation in the abundance of chalcopyrite) might be a function of local variations in the temperature of the ore fluids, but given the small size of the mine area, these more probably reflect variations through time of the permeability of the various fluid channelways.

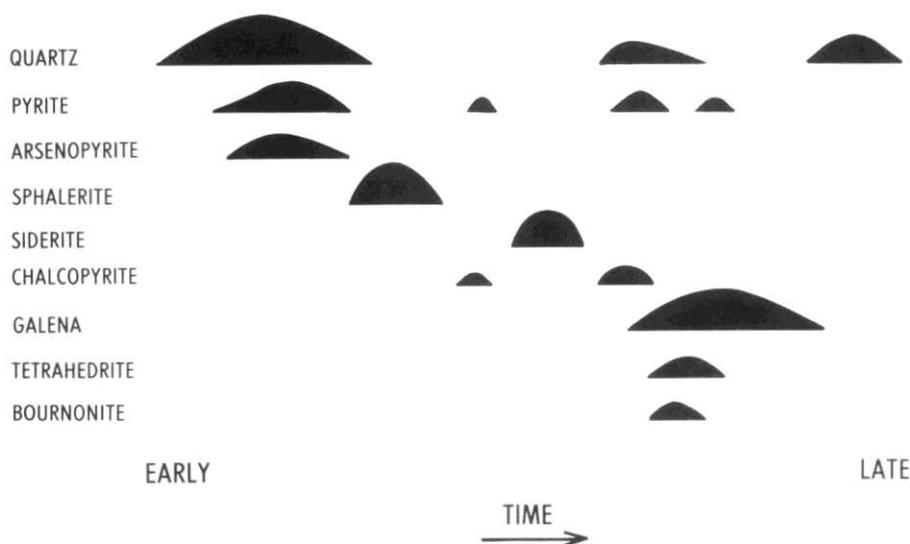


Figure 45. Paragenetic sequence, Queensberry mine.

Table 2  
ASSAY RESULTS SAMPLES FROM SOUTH END OF No. 4 LODGE

Sampler	Width of Sampling	Cu%	Pb%	Zn%	Ag(g/t)	Au(g/t)
Forsythe	1.32 m	2.02	6.8	15.3	51	0.31
Forsythe	1.02 m	0.22	3.0	3.8	21	0.15
Lennox	1.37 m	0.42	17.2	21.2	70	n.a.
Lennox	1.68 m	3.84	9.0	7.5	120	n.a.
Lennox	Grab Sample	2.46	12.6	10.3	89	n.a.
Lennox	6 tonne Bulk Sample	1.12	17.8	19.2	61	n.a.
Average of above		1.68	11.1	12.9	69	—

### Summary and resource potential

The apparent control of the mineralisation by the Firewood Siding Fault and the lack of known deposits at distances greater than 500 m from the fault suggest that this was the major structure controlling the localisation of the Queensberry veins. No systematic sampling for assay purposes was undertaken during this study, but sampling by Reid (1927), Forsythe (1968) and, in particular, the sampling and diamond drilling programme carried out by Minops Pty Ltd in early 1970 (Lennox, 1970) permits a preliminary heuristic calculation of the resource potential of the Nos. 1 and 4 Lodes. Given the tendency of Devonian vein deposits to display marked variations in grade along the strike, and with depth (for example see Waller, 1904 and Twelvetees and Ward, 1910 on the Zeehan field) the estimates below should be regarded with caution.

Minops conducted a 5 hole drilling programme on the No. 4 Lode, which has effectively placed constraints on the extent of the economically interesting mineralisation. DDH 1 was a 150 m deep vertical hole collared 48 m west of No. 4 lode, some 18 m north of the intersection of the lode with the Firewood Siding Fault. This hole intersected 0.72 m (true thickness) of subeconomic mineralisation between 93.4 and 94.3 m grading 0.05% Cu, 0.66% Pb, 0.241% Zn and 3 g/t Ag. Drill hole No. 7 collared some 76 m north of the fault-lode intersection failed to intersect significant mineralisation.

Sampling by Forsythe (1968) and Lennox (1970) of the Lode within 15 m of its southern boundary produced the results listed below in Table 2.

Diamond drill hole DDH 5 intersected 1.2 m (true thickness) of ore grading 0.45% Cu, 2.99% Pb, 13.89% Zn, and 30 g/t Ag 27 m from the southern end of the orebody at a depth of 19 m below surface. Drill hole DDH 6 intersected 0.98 m of mineralisation grading 0.22% Cu, 5.16% Pb, 1.19%

Zn and 21.4 g/t Ag 9 m further north at a depth of 43 m and DDH 2 intersected 2.04 m of ore grading 0.19% Cu, 5.4% Pb, 7.85% Zn and 29 g/t Ag 25 m north of DDH 6 at a depth of 46 m. The weighted average grade of the three intersections is 0.27% Cu, 4.66% Pb, 8.0% Zn and 28 g/t Ag. The data from Table 2 were used to compute the tonnage of mineralisation present to an arbitrary depth of 45 m for a distance of 15 m north of the Firewood Siding Fault. The specific gravity of this ore was taken to be 3.8 t/m<sup>3</sup> and the true thickness of the lode as 1.2 m. Likewise for the next 45 m to the north the data from drill holes 5, 6 and 7 were used to compute the resource assuming a true thickness of 1.5 m of mineralisation with a specific gravity of 3.3 t/m<sup>3</sup> and a vertical extent of mineralisation of 45 m. The calculation yields an inferred resource for the No. 4 Lode of 15 100 tonnes of 0.60% Cu, 6.17% Pb, 9.15% Zn and 38 g/t Ag.

Three drill holes explored the potential of the No. 1 Lode DDH No. 3 intersected a vein of 0.3 m in true thickness of 23% Pb, 2.1% Zn, 33 g/t Ag 41 m north of the Firewood Siding Fault at a depth of 75 m. DDH 8 intersected a number of closely spaced veins aggregating one metre true thickness of mineralisation grading 4.6% Pb, 13.2% Zn and 63 g/t Ag, 65 m north of the fault at a depth of 64 m. DDH 4 drilled 13 m north of DDH 8 failed to intersect significant mineralisation. The Cu content of the No. 1 Lode is much lower than that of the No. 4 Lode, most samples assaying less than 0.01% Cu. Reid (1927) sampled the main shaft area of No. 1 Lode.

The inferred resource of the No. 1 Lode calculated to a depth of 60 m using Reid's results and assays from drill holes DDH 3 and DDH 8 and over a strike length of 75 m is 13 200 t of 17.65% Pb, 8.32% Zn and 68 g/t Ag. No estimate can be made of the likely reserves of the No. 2 Lode and East Lode but they are probably substantially smaller than those of either of the other lodes. The combined inferred resource of the Nos. 1 and 4 Lodes is 28 300 t of mineralisation containing 0.32% Cu, 11.53% Pb, 8.76% Zn and 52 g/t Ag.

Although these figures are poorly constrained, it is considered that sufficient work has been done to establish that the Queensberry mineralisation is sub-economic. However, the potential exists for further vein deposits to be discovered in the area, particularly in competent rocks of pre-Carboniferous age near the Firewood Siding Fault.

### SISTERS HILLS WORKINGS

These consist of a number of old trenches, a shaft and an adit on the banks of Clifford Creek near 738455. P. Komysan (1982, in Purvis, 1983) sampled iron-rich greywacke, magnetic in hand specimen, and iron oxides from the workings. Six samples collected from the pits and the adit assayed up to 200 g/t Cu, 1400 g/t Pb, 900 g/t Zn, 2.7% Mn and 40% Fe. The area appears to offer little potential.

### ZEEHAN-STRAHAN ROAD

Scott (1957) reported a vein consisting of disseminated galena and pyrite in sandstone exposed in a 6.6 m deep shaft and a trench 6 m south of the Queenstown–Strahan road near 720317. The vein was reported to strike 140° (M?) and dip 80° W. A number of mining leases were pegged in the 1890s in a NE-trending belt approximately one kilometre to the east and among these was a silver-lead reward claim. However there is no report of any production from the area and any mineralisation present is unlikely to be significant.

### PYRITE

#### KING RIVER DELTA

Substantial quantities of pyrite derived from the tailings from the mining operations at Mount Lyell have accumulated in the delta of the King River around 639275. The pyritic sand overlies old delta deposits composed of barren sand near-shore passing outward into marine clay deposits.

The Mt Lyell Mining and Railway Co Ltd investigated the delta between 1969 and 1972. Four hundred and seventy six samples were collected by sand auger and suction auger. Over the depth interval 0–1.5 m, 257 samples showed a normal distribution of pyrite content with the mean FeS<sub>2</sub> value being 6–57%. Over the depth interval 1–5 to 3–0 m the mean FeS<sub>2</sub> value was 4.29%. The copper grade of all samples averaged 0.16%. McKibben (1971) estimated the deposit to contain 300 000 t of pyrite in the top 1.5 m of deposits in the exposed part of the delta. A more extensive drilling programme was carried out by Citco International Minerals Company in 1974 to 1976. Two hundred

and fifty two sites were drilled including 43 sites in the pro-delta area, 111 sites on the delta and 98 sites in the King River. A total of 1358 m of drilling was completed. Jinks (1976) reports that computer reserve calculations show a proven reserve of 100 million tonnes of sediment containing 3.5% sulphur mostly in the form of pyrite and 0.11% copper mostly as chalcopyrite with subsidiary amounts of bornite and chalcocite. Minor quantities of Co, Zn, Mo, Ag and Au are also present. An additional indicated reserve of 25 million tonnes was also inferred. The delta portion of the deposit accounts for some 50 million tonnes of the resource, and has a slightly higher Cu content of 0.15%. Much metallurgical testing has been done. The area is currently within Exploration Licence 2/74 held by Elisna Pty Ltd.

### Fuel minerals

#### COAL

*C. A. Bacon*

Brown coal was noted on the northern shore of Macquarie Harbour in 1815 by Capt. J. Kelly; these deposits were visited by D. McCarthy in 1816 (Hobart Town Gazette, 15 June 1816). Subsequently thin seams of brown coal were found exposed along the greater parts of the northern and eastern shores of Macquarie Harbour from Lette Bay to Farm Cove and for several miles south of Birches Inlet.

The brown coal occurs as thin beds, 125–450 mm thick, in Tertiary sediments of lightly consolidated sands, clays, shales and muds. The coaly bands are comprised of brown coal and carbonaceous shale with occasional black lignitised wood lenses. On the coast the coal is commonly overlain by 15–30 m of sediments and the thickness of overburden increases inland (Blake, 1939).

A report by G. W. Evans, Deputy Surveyor to Lt Governor Sorell dated 9 February 1822 states 'coals can be procured at a place called Coal Head and along the shore some distance south east of it' (Hobart Town Gazette, 9 February 1822).

Confessions of the convict Alexander Pearce (Sprod, 1977), who escaped from Macquarie Harbour on 20 September 1822 contain references to coal mining at Coal Head.

In tracing the route taken by Pearce and his colleagues Sprod, (1977) writes: 'The party which included Pearce met no difficulties in making their initial break by seizing a boat . . . from Logan's work gang at Kelly's Basin at the eastern end of Macquarie Harbour. From the basin they rowed

along the northern shore to the coal mines at Coal Head, midway between their starting point and the open sea'.

The initial mining attempts were apparently short lived. A despatch from Colonel Sorell to Under Secretary Horton dated 29 November 1824 reads in part: 'At the penal settlement of Macquarie Harbour, where the indications of coal were so strong as to induce the Deputy Surveyor General [Evans] to report its existence there, the want of professional research had deprived the local government of the means of working it' (*Historical Records of Australia* (3)4:583).

Leases were held in the area of Farm Cove from 1891-1903 by a number of individuals and syndicates, although no serious mining eventuated. Leases were also held at Coal Head (1888-1892) and near Eden (1902). The Government drilled two holes for the Eden Coal Company in 1902-1903 (Twelvetrees, 1902a, 1902b, 1903) to examine an outcrop of brown coal discovered near Eden by woodcutters, while dragging piles for the Strahan wharf to the railway (Twelvetrees, 1901). A third government bore was put down at Farm Cove (Twelvetrees, 1903).

In 1981 C.R.A. Exploration Pty Ltd drilled five chip holes in the Strahan area, and concluded that the potential for discovery of a major lignite horizon in the area was minimal (Clementson, 1981).

## Industrial minerals

V. M. Threader

### SILICA

Summons 1981 reports that:

'Comalco Ltd (A.H. White, pers. comm.) investigated the Cape Sorell region on the west coast, and found that the best grades of silica were obtained from the massive orthoquartzite, while the cross-bedded and finely-laminated orthoquartzite displayed inferior chemical and physical properties due to the interlayered phyllite. The average composition of the high grade orthoquartzite is approximately 99.40% SiO<sub>2</sub>, 0.35% Al<sub>2</sub>O<sub>3</sub>, 0.03% Fe<sub>2</sub>O<sub>3</sub>, 0.001% Cr<sub>2</sub>O<sub>3</sub>, 0.03% TiO<sub>2</sub>, 0.11% P<sub>2</sub>O<sub>5</sub>, 0.02% MgO, 0.01% CaO, 0.01% Na<sub>2</sub>O, with 0.15% loss on ignition. Comalco observed that only the massively bedded quartzite retained its grade of SiO<sub>2</sub> with increasing depth, and that the finely-laminated quartzite had been leached of its deleterious components at the surface, thus creating a false impression of high grade silica. The Cape Sorell area requires considerably more work to be done on it before its potential can be fully assessed, and Comalco currently hold four mineral leases in the area'.

The leases were converted to a consolidated lease 16M/75 of 400 ha in 1975 in the Mt Antill-Mt Obvious-The Grandfathers area centered near 507230.

### GRAVEL AND SAND

The sources and nature of material used in the Quadrangle for roadmaking and concrete aggregates are summarised in Table 3.

*Table 3*  
**SUMMARY OF SAND AND GRAVEL RESOURCES IN THE STRAHAN QUADRANGLE**

No.	Grid. Ref.	Name	Locality	Status*	Production m <sup>3</sup> (est.)	Reserves†	Description
1	588373	Forestry Comm.	Henty pine plantation, Garcia Rd.	W	15 000	L	Devonian sandstone
2	592371	Forestry Comm.	Henty pine plantation, Garcia Rd.	D	1 000	Nil	Devonian sandstone
3	601366	Forestry Comm.	Henty pine plantation, Lakes Rd., No. 2 Rd.	W	8 000	M	Devonian sandstone
4	604363	Forestry Comm.	Henty pine plantation, Lakes Rd.	D		S	Devonian sandstone
5	609380	Forestry Comm.	Henty pine plantation, Lakes Rd.	D	1 600	Nil	Permian tillite
6	595323	Strahan Council	Ocean Beach road	W	>500 000	VL	Tertiary sandy gravel
7	617317		Strahan Post office	D	4 000	Nil	Tertiary sandy gravel
8	624303		Strahan, Lowana Road	W	8 000	L	Tertiary sandy gravel
9	622326		Lyell Hwy, Strahan	D	3 900	S	Tertiary sandy gravel
10	687297	D.M.R.	Lyell Highway	D	2 000	S	Devonian sandstone
11	689297*	D.M.R.	Lyell Highway	W	10 000	L	Devonian sandstone
12	690299	D.M.R.	Lyell Highway	D	11 000	S	Devonian sandstone
13	699321	D.M.R.	Lyell Highway	D	2 000	S-Nil	Devonian sandstone
14	745317		Lyell Highway	D	8 000	S	Devonian sandstone
15	741339	D.M.R.	Lyell Highway	D	6 000	VL	Silurian sandstone
16	570464	George	Henty Road (new area)	W	Nil	L	Tertiary gravel
17	645334	D.M.R.	Lyell Highway	D	3 500	S	Devonian sandstone
18	650335	D.M.R.	Lyell Highway	D	600	S	Cambrian siltstone
19	754397	D.M.R.	Lyell Highway	D	6 400	S	Devonian sandstone
20	748381	D.M.R.	Lyell Highway	D	1 600	S	Devonian sandstone
S1	612342	Crown Land	Henty Road	W	<300	S	Quaternary sand
S2	613343	Forestry Comm.	Henty pine plantation, Crane No. 2 Rd.	D	<400	S	Quaternary sand
S3	599322	Strahan Council	Ocean Beach Road	W	4 000	M	Quaternary sand
S4	584318	Crown Land	Ocean Beach Road	D	1 000	S	Quaternary sand
S5	621325	Crown Land	Lyell Highway	D	<200	S	Tertiary sandy gravel

\* W = working, D = disused.

† S = small (100–10 000 m<sup>3</sup>), M = medium (10 000–1 000 000 m<sup>3</sup>), L = large (1 000 000–10 000 000 m<sup>3</sup>), VL = very large (>10 000 000 m<sup>3</sup>).

*Table 3*  
*SUMMARY OF SAND AND GRAVEL RESOURCES IN THE STRAHAN QUADRANGLE (continued)*

No.	Sizing analyses (mm) cumulative % passing														DR*	Atterburg Limits			GPS*	
	37.5	26.5	19	9.53	4.76	2.36	1.18	0.6	0.425	0.3	0.212	0.18	0.15	0.075		0.038	LL*	PI*		LS*
1	100	96	88	70	56	51			46						30	0-64	26	10	6	GC
	100	94	88	78	70	64			60						41	0-69	29	12	6	GC-SC
2	100	99	93	83	73	68			65						51	0-79	25	9	5	CL
3	100	97	87	70	57	52			46						29	0-64	22	5	3	GM-GC
	94		81	65	51	42	33	32		28			22	18	13					
4		100	94	80	66	54			46						33	0-71	26	7	4	GM-GC
5			100	94	79	68			59						56	0-94	46	25	10	CL
6	100	99	96	85	67	54			31						14	0-45	18	0	1	SMD
	100	99	98	85	65	50			24						8	0-33	16	0	1	SW-SM
	100	98	93	79	63	52			34						15	0-45	20	2	2	SMD
	100	99	93	75	58	45			29						14	0-47	21	0	2	SMD
	100	98	93	83	70	60			40						12	0-29	16	1	2	SRSM
7		100	97	87	74	65			44						14	0-33	17	0	1	SMD
8		100	97	95	88	86			71						3	0-04		NP		SP
9		100	98	80	59	48			29						17	0-47	24	1	2	SMD
10		100	96	79	65	54			40						27	0-66	20	1	2	SMD
11	100	99	96	79	67	57			48						34	0-70	23	5	3	GM-GC SM-SC
		100	96	83	59	44			30						18	0-59	21	0	0	SMD
12	100	99	95	37	67	49			31						16	0-51	22	0	0	SMD
13	100	99	96	82	61	41			22						15	0-68	24	3	3	SMD
14	87	73		51	37	25	17	13		11			9	7	4					
15		100	95	80	58	42			27						17	0-64	26	3	2	GMD
	100	99	98	89	68	49			26						13	0-50	18	0	1	SMD
16																				
17			65	28	13	10	8	6		5			5	3	2					
	71		47	36	28	20	15	13		11			9	6	3					
18	86		80	70	66	57	51	48	46	44			40	32						
19	87		86	85	84	79	75	73	73	72			70	40						
20																				
S1					100	99				79	31	14	2	0	0					
S2						100				94	40	17	2	1	0					
S3					100	99				68	30	21	12	7	6					
S4																				
S5			100	99	99	98			15						0-05	0-03		NP		SW

\* DR = dust ratio, LL = liquid limit, PI = plasticity index (NP = non plastic), LS = linear shrinkage, GPS = soil classification symbol (U.S. Corps of Engineers)

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## APPENDIX 1

## Cape Sorell No. 1 Well

*P. W. Baillie*

Cape Sorell No. 1 Well was drilled by Amoco Australia Petroleum Company between July and September 1982. The well is located some 13 km north-west of Cape Sorell in 94 m of water at 372332. The following is a summary from the well completion report (Amoco, 1982).

The well spudded in Miocene-Oligocene limestone and then penetrated a thick section of Early Eocene shallow-water marine sediments. The section then graded into a thick section of Middle to Late Palaeocene sandstone with common mudstone interbeds. At 2 835 m Early Palaeocene-Late Cretaceous shallow-water conglomerate and conglomeritic sandstone was penetrated. Lithologies of clasts reflect local derivation and include quartzite, quartz-mica schist and felsic volcanics. The well reached a final depth of 3 528 m below mean sea level in conglomerate containing clasts of quartzite, schist and chalcidony.

The following is a log of the hole (all depths below mean sea level):

*Depth (m)*

94-302 bioclastic skeletal limestone (Early Miocene).

302-374 interbedded limestone, quartz sandstone and minor dolomite (Late Oligocene).  
 374-412 dominantly mudstone with minor sandstone and dolomite (Early Oligocene).  
 412-777 dominantly sandstone with minor mudstone and limestone (Middle to Early Eocene).  
 777-1 759 dominantly sandstone, sometimes with glauconite, with minor mudstone, shale and siltstone (Early Eocene).  
 1 759-3 528 interbedded sandstone, siltstone, conglomerate and conglomeratic sandstone with minor coal and tuff (Palaeocene-?Early Cretaceous).

The well has shown a remarkable thickening of the Tertiary sequence as exposed onshore and represents deposition in the rifted continental margin as Antarctica and Australia separated. The ?Late Cretaceous-Palaeocene rocks probably indicate continental deposition in the early rift developed between Australia and Antarctica, while the marine Eocene and younger deposits reflect the marine conditions that prevailed as the continents began to drift apart. The change from continental to marine deposits implies that sea-floor spreading began at about 55 Ma ago.

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