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GEOLOGICAL SURVEY EXPLANATORY REPORT

SHEET 80

PEDDER

TASMANIA DEPARTMENT OF RESOURCES AND ENERGY

DIVISION OF MINES AND MINERAL RESOURCES

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COVER PHOTOGRAPH

Aerial view from near the Citadel, Frankland Range, looking east across Lake Pedder to Mt Anne. Precambrian quartzite in the foreground. The eastern end of the Frankland Range (middle left) leads to Mt Solitary (the island at middle centre).

[Tasmap Photographics]

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SHEET 80 (8112S)

PEDDER

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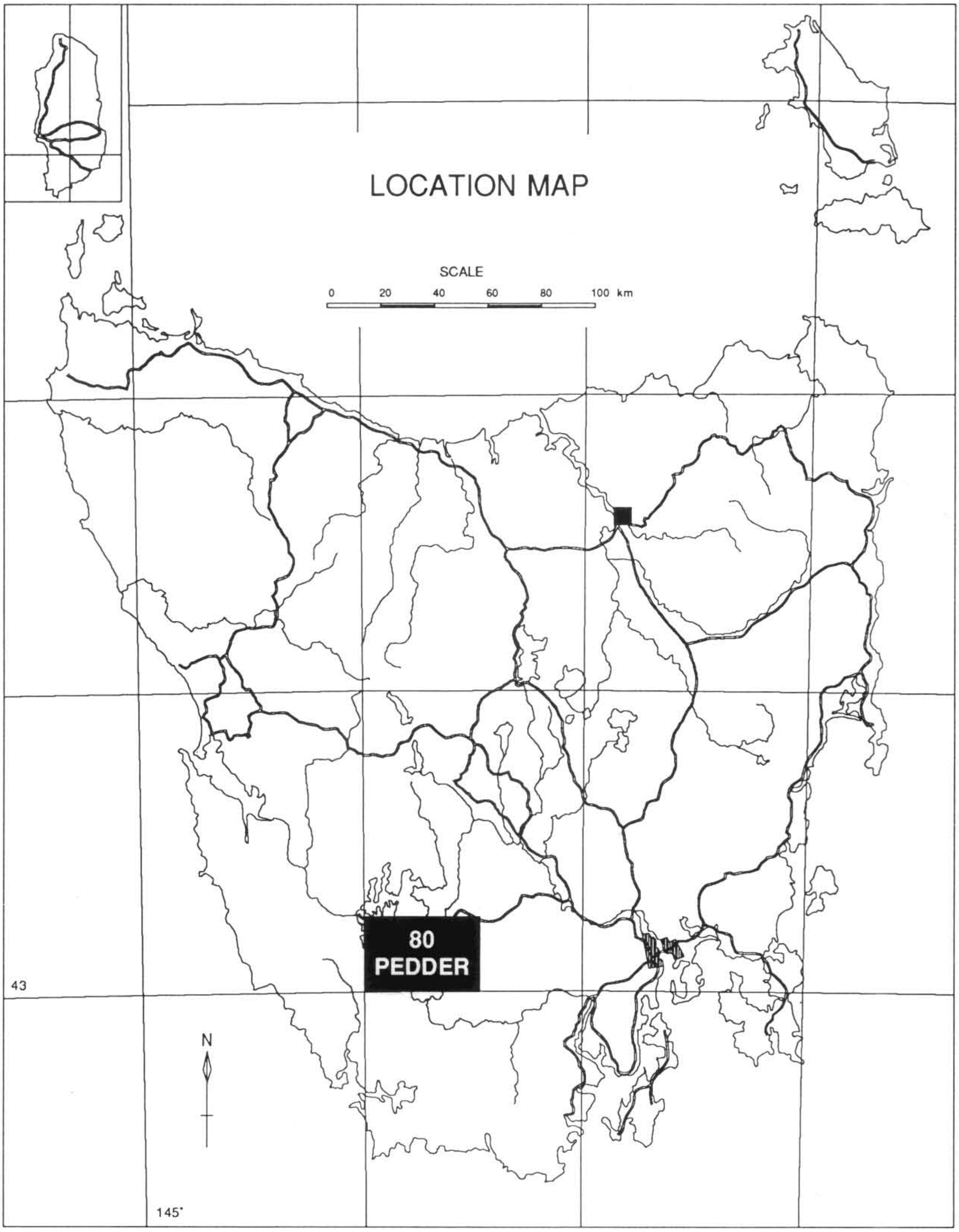
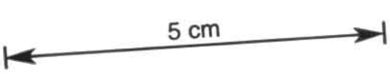


Figure 1. Location of the Pedder Quadrangle.



INTRODUCTION

The Pedder Quadrangle is situated in the rugged central part of south-west Tasmania, between latitudes 42°45′S and 43°00′S and longitudes 146°00′E and 146°30′E.

Vehicular access is by the Gordon River Road, which traverses the north of the Quadrangle, and the Scotts Peak Road which branches off to the south. These roads were constructed during the 1960s to provide access for the construction of the Middle Gordon hydro-electric power scheme, involving the Gordon and Serpentine Dams situated to the west of the map sheet, and the Scotts Peak Dam on the Huon River to the south of the map sheet. Before these roads were built the area was remote and little-known geologically. The Huon–Serpentine impoundment, named Lake Pedder after the smaller pre-existing natural lake, supplements the Lake Gordon storage via the McPartlan Canal near the centre of the map sheet. Lake Pedder was filled in 1972 and Lake Gordon in 1974. These reservoirs now occupy 24% of the area of the map sheet. The former construction village of Strathgordon, the only settlement within the Quadrangle, is now a small tourist centre and a maintenance centre for the power station at the Gordon Dam.

The area is one of rugged scenic beauty, and much of the Quadrangle is overlapped by the Southwest National Park, part of the West Tasmanian World Heritage Area inscribed by UNESCO in 1982. The Mt Anne area in the south-east of the map sheet is particularly noted for its scenic grandeur, and is frequented by walkers. Here, and on the Frankland Range, relief has been enhanced by Pleistocene glaciation. The Mt Anne–Weld River area is also noteworthy for spectacular karst developments, and a cave archaeological site of late Pleistocene age (Goede and Bada, 1985).

The area has a cool, wet maritime climate with an average annual precipitation of over 2000 mm. Temperate rainforest and wet sclerophyll forest dominated by myrtle beech and tall eucalypts cover much of the eastern part of the quadrangle. On impoverished quartzite-derived soils in the west, open sedgeland dominated by buttongrass predominates, with a dwarfed alpine flora at high elevations. Marshy buttongrass plains characterised most of the area now covered by Lake Pedder. Forestry activities are current in the area north of Mt Wedge.

No mineral deposits of present economic significance are known, although the Cambrian ultramafic rocks are the object of current interest as a source of platinum-group minerals and chromite.

Mapping began on Pedder map sheet, in conjunction with Huntley map sheet to the north, in early 1973 following a request from the Hydro-Electric Commission for geological information in the region of the hydro-electric developments then in progress. Mapping at 1:15 840 scale was conducted over most of the quadrangle by N. J. Turner, C. R. Calver, M. P. McClenaghan, J. McClenaghan, A. V. Brown and P. G. Lennox. The Frankland Range area was mapped as part of a Ph.D. study by C. A. Boulter, formerly of the University of Tasmania; and additional information on part of the area now covered by Lake Pedder is derived from HEC investigations (Godfrey, 1970). A few remote areas, notably the extreme south-west and south-east corners of the map sheet, were mapped by airphoto interpretation. The 1:50 000 geological map was published in 1985.

PHYSIOGRAPHY

C. R. Calver

The landscape of the Pedder quadrangle, typical of the Tasmanian western fold province, is characterised by a number of discontinuous, but abrupt and often extremely rugged mountain ranges 600–1400 m a.s.l. with intervening narrow to wide valley floors 250–300 m a.s.l. The ranges are strike ridges that tend to follow ancient fold trends.

In the western half of the map sheet, the Twelvetrees, Frankland, and Sentinel Ranges, and Mt Cullen, the Coronets, and Mt Solitary, are strike ridges composed of resistant, folded Precambrian quartzite. The ranges follow prevailing structural trends, and undergo a swing in orientation from NW-SE trending in the west to W-E trending (Mt Solitary, Sentinel Range) or even SW-NE trending (the Coronets) in the central parts of the quadrangle. Valleys are underlain by phyllite and schist.

On Cambrian rocks in the eastern part of the sheet, relief tends to be more subdued, although locally chert (on Ragged Range) or conglomerate (Marsden Range, Harlequin Hill) are topographically prominent.

In the south-east, Precambrian quartzites again form prominent strike ridges at Mt Bowes and around Mt Anne (Celtic Hill, Deception Ridge, and the highlands north of Mt Sarah-Jane). The ridges around Mt Anne are truncated to east and west by faults. The flats around Sandfly Creek, underlain by Precambrian mudstone and dolomite, are interrupted by low strike ridges developed on thin quartzite units.

In the north-east of the sheet, Cambro-Ordovician siliceous conglomerate and quartz sandstone rimming the southern end of the Tiger Syncline are topographically prominent, and conglomerate on the western limb forms the aptly-named Sawback Range.

The highest mountains on the map sheet are three widely-separated outliers of flat-lying Permo-Carboniferous strata capped by resistant Jurassic dolerite (Mt Wedge, Mt Mueller, and Mt Anne – the highest at 1425 m). The precipitous topography typical of dolerite areas (plate 1) is a result of glacial erosion and the characteristic vertical columnar jointing of this rock type.

Several major streams and rivers arise within the borders of the map sheet and flow outwards in various directions. The Serpentine River, now submerged by the new Lake Pedder, had a large catchment in the south and west and flowed west into the Gordon. The Huon, rising west of Mt Bowes, flows south into Lake Pedder. The Wedge River, rising in the Sentinel Range, flowed north into the Gordon River but is now largely inundated by a southern arm of Lake Gordon. The Florentine River flows north off the map sheet to ultimately join the Derwent; and the Weld River, rising south of Mt Mueller, drains south-eastward to eventually join the lower Huon. Broad, more or less flat valley floors surround parts of the upper Huon, the Florentine, the Wedge and Serpentine rivers (the latter two now shallowly inundated by Lakes Pedder and Gordon). The Florentine occupies a karst valley developed on Ordovician limestone. The Serpentine and Huon valleys are largely floored with fluvioglacial detritus derived from the surrounding highlands.

Pleistocene glacial landforms are developed on three highland areas – the Frankland Range, the Mt Anne massif and Mt Mueller. On the Frankland Range, there are many deeply-incised cirques, several of them slightly overdeepended and lake-filled. The barrier effect of the highlands on the prevailing westerly airstream is manifested by snow accumulation, and

Plate 1. Dolerite cliffs overlooking Lake Judd.

Plate 2. The original Lake Pedder

hence cirque formation, to leeward of the range. Thus between Coronation Peak and Greycap, where the range trends NW-SE, cirques are situated on the north-eastern flank of the range and divulged small valley glaciers that flowed north. East of Greycap, however, where the range trends W-E, cirques switch to the south side of the range because of the effects of insolation (Davies, 1967).

The short glacial valleys on the north side of the range are flanked in places by sharp-crested lateral moraines and end in gently north-sloping fluvioglacial fan deposits (Davies, 1967), now largely submerged by the new Lake Pedder.

The Mt Anne massif has also been greatly modified by glaciation. The dolerite highland between Mt Anne and Mt Eliza – the highest ground in the map sheet – overlooks on its eastern side two large glacial valleys: one south-directed, filled by Lake Judd, and the other extending from the lee of Mt Anne first east and then north-east almost as far as the Weld River, and featuring the smaller Lake Timk. The deep glacial trough of Lake Judd is overlooked by a sheer dolerite escarpment rising 600 m above the level of the lake (plate 1). Large lateral moraines flank both these valleys.

The narrow dolerite ridge running from Mt Lot almost continuously to Mt Sarah-Jane overlooks on its eastern side a series of small highland cirques, each holding a small lake (the Lonely Tarns). Of these, two cirques (at Lake Picone and at DNQ553428) were sources of small valley glaciers that flowed east to lower altitudes.

At Mt Mueller, a cirque and lateral moraine lie in the upper reaches of the Styx River, and to the east, a smaller cirque contains moraine-dammed Fossil Lake.

Several occurrences of deeply-weathered till were recorded at lower elevations, but are not associated with recognisable glacial landforms. These may be relics of an early, more severe glaciation whose effects on the landscape have become obscured by later erosion. The effects of the Pleistocene glaciation are more fully discussed in the Quaternary chapter.

Karst topography is developed over much of the area underlain by Precambrian dolomites of the Weld River Group, in the Weld River catchment in the east of the quadrangle. The most spectacularly developed karst occurs in a 2 km^2. area at high elevation (800–1000 m a.s.l.), north-east of Mt Anne (around DN560465). This area is riddled with large funnel-shaped vertical shafts up to 50 m wide, and the high relief has allowed development of the deepest cave systems known in Australia. The deepest, Annakananda [DN543464], is over 300 m in vertical extent. Devils Eye Cave, a large (40 m × 40 m) vertical opening in the northern wall of the cirque at DN557472 (Davis, 1988) is probably a chamber exhumed by glacial erosion.

The existence of this dolomite as a high massif is probably due to protection from erosion until geologically recent times by a capping of Jurassic dolerite, a large outlier of which still remains on nearby Mt Anne. The dolomite ridge is terminated to the north-east by a fault-line scarp.

Immediately to the south, glacial erosion has gouged a large basin ($\approx$1 km^2) in dolomite bedrock, partially filled by Lake Timk. This basin, the sink for a catchment area of slightly over 10 km^2, has no visible outlet and drains underground, possibly southwards into the Snake River catchment (K. W. Kiernan, pers. comm.).

At lower elevations in the Weld Valley, karst is more subdued and is largely obscured by dense forest. Ground traverses encountered large numbers of sinkholes. Some creeks shown as surface drainage on presently available topographic maps flow underground for much of their courses, for example between DN565534 and DN573534. The most spectacular example of stream–karst interaction involves the Weld River itself. A narrow gorge at DN555547 is bridged by a large rock arch about 30 m above river level. The arch encloses a high chamber, itself largely dry-floored as the river flows through a short restricted underground passage.

A fault scarp with a downthrow of about 5 m on its eastern side crosses the flats east of Harlequin Hill [DN468425] and continues for several kilometres to the south across an area now largely submerged. The scarp follows a major Cambrian wrench, the Lake Edgar Fault (fig. 3). The recent dip-slip movement on this fault has affected Pleistocene outwash gravels and therefore appears to be of late Pleistocene-Holocene age.

The area flooded by the new Lake Pedder consisted of a broad, remarkably flat, marshy buttongrass plain lying for the most part less than 15 m below the present lake surface. The gentleness of the longitudinal profile of the Serpentine Valley can be attributed to the barrier effect of the resistant quartzite at the downstream end and to a substantial influx of fluvioglacial detritus into the lower reaches during the Pleistocene. A series of gently north-sloping, laterally coalescing fluvioglacial fan deposits extending north from the foot of the Frankland Range pushed the Serpentine River to the northern side of the valley, and upstream ponding to the east of the fans produced the original Lake Pedder (Davies, 1967).

The original lake, which stretched across the valley south of present-day Groombridge Point [DN320450], possessed a spectacular beach of white, quartzite-derived sand along its eastern shore (plate 2). The beach, up to one kilometre wide in the summer, was seasonally covered by higher water levels in winter. Behind the beach was a narrow belt of vegetated dunes which dammed a smaller complex of shallow, marshy lakes to the east (Lake Maria). The Serpentine, which drained the lake to the west was, as a result of the gentle longitudinal profile of the valley, a strongly meandering stream with many small cut-offs and oxbow lakes.

STRATIGRAPHY AND PETROGRAPHY

Precambrian (Ꝑt)

TYENNAN REGION

INTRODUCTION

J. McClenaghan
M. P. McClenaghan

The Precambrian rocks of the western and central parts of the Pedder map sheet are part of a much larger area of regionally metamorphosed Precambrian rocks, extending over much of western Tasmania, known as the Tyennan region (Turner, 1989). Previous work on these rocks in the Pedder Map Sheet has been mainly limited to reconnaissance mapping by the B.H.P. Co. Ltd (Whitehead, 1964; Hall, 1966; Hall *et al.*, 1969). However, a number of detailed studies have also been carried out on Precambrian rocks in the north-west corner of the sheet and adjacent areas. Engineering Geological studies of the Gordon and Serpentine Dam sites were made by the H.E.C. (e.g. Andric *et al.*, 1976), as well as structural and sedimentological studies in the same area by Powell (1969) and Boulter (1978). Metamorphic conditions were determined by Råheim and Boulter (1974) and Råheim (1977), and geochronological data is presented in Råheim and Compston (1977) and Adams *et al.* (1985).

During the course of the mapping programme described in this report a fairly detailed geological coverage was achieved in the more accessible parts of the area underlain by Precambrian rocks. However coverage in the least accessible parts of the map sheet is limited to air photo interpretation.

The following description of the Precambrian stratigraphy is based on the work of C. A. Boulter for the Frankland Range, M. P. McClenaghan for Mt Solitary–Barrier Islands and Hermit Hill–Coronets–Sentinels areas, J. and M. P. McClenaghan for the Strathgordon area and N. J. Turner for the Junction Range–Mt Cullen area.

The Precambrian rocks of the Pedder sheet belong to the older Precambrian group (Spry, 1962), and consist of regionally metamorphosed phyllite, amphibolite, schistose quartzite and massive quartzite. An overall stratigraphic succession cannot be established because of the complex history of deformation.

FRANKLAND RANGE

C. A. Boulter

Stratigraphy

Exposures on the backbone of the Frankland Range are predominantly grey or slightly pink tinged quartzite though half way between Secheron and Terminal Peaks there is an isoclinally folded decametric layer of pure white quartzite. The continuous sweep of the mountain range from N-S in the north to E-W in the south reflects rotation, about a vertical axis, of structural trends created in five cleavage-forming episodes. Of these D_1 and D_4 are responsible for the largest structures though D_2 and D_3 are locally associated with kilometric scale folds. Sedimentary cross-lamination is very common and has proved vital in both sedimentological and structural analysis. Palaeocurrent analysis based on the cross-stratification showed bimodal and polymodal current patterns. Exposures with herringbone patterns on single joint faces are not necessarily bipolar (180° modes). Ripples are rare as are examples of pene-contemporaneous deformation of cross-lamination. The common availability of sedimentary younging allowed fold facing to be determined which played an important part in understanding the D_1 structures. The bulk of the quartzite layering from Frankland Peak through Greycap, Cleft Peak, Murphys Bluff, The Lion, to Double Peak is inverted on the limb of an isoclinal D_1 fold with a minimum limb length of 5 km (fig. 2). From Frankland Peak to the region of Terminal Peak, several upwards facing kilometric scale D_1 folds can be continuously mapped out. A major upright D_4 synform is located towards the western edge of the range and Remote Peak is on the easterly dipping limb. The complimentary antiform separates the general west/south-west dips of the high ridge from the easterly dips of the foothills between the range and Lake Pedder. On the continuation of this limb in the Gordon Dam region, the D_1 folds face downwards as they do on Remote Peak. This geometry results from the dispersal in D_4 of major east-facing recumbent D_1 folds.

The lower slopes on the eastern side of the Frankland Range and the ground adjacent to Lake Pedder are generally occupied by phyllite, schistose micaceous quartzite and flaggy quartzite with minor massive quartzite. Outcrop patterns defined by these lithological units are mostly simple belts parallel to the regional strike but on Starfish Hill a kilometric D_3 fold interrupts this pattern. A broad belt of phyllite occupies the saddle between the main range and Remote Peak and smaller areas of phyllite occur sporadically along the axis of the main range. Limited younging information (cross-lamination, scour-surfaces) is found in the flaggy quartzite but unequivocal sedimentary structures were not recognised in the micaceous quartzite. In contrast very small domains in the phyllite gave preservation of delicate sedimentary structures (e.g. clastic-dykes, scours and fill, ripples) but were too widely spaced to be of use in younging determination.

Petrography

Quartzite and quartzite with flaggy and platy parting (Ꝑtq, Ꝑtqf)

The bulk of the quartzite was originally a texturally and mineralogically supermature quartz arenite. Total strains are typically low to moderate and some sections have survived virtually unstrained. Textural analysis of the latter shows a very limited range of grain axial ratios which, when coupled with long axis orientation data, is comparable to aeolian dune sand. The same specimens are dominated by monocrystalline quartz grains suggesting derivation from either a high-grade metamorphic or plutonic provenance. Original grain boundaries are commonly clearly delineated by dust trails of hematite hence cements can be readily identified. The preservation of carbonate concretions and laminated quartz + iron oxide pore-space fills indicate the lack of strain in some areas. Low strain in D_1 is expressed by slight undulose extinction of the detrital grains and, at less than 10% shortening, total recrystallisation of the cement into mosaics of new grains showing moderate dimensional preferred orientation where the overgrowth was slightly argillaceous. With increasing strain, undulosity becomes more pronounced, and deformation lamellae and deformation bands develop. Recrystallisation of the detrital grains into new grains is concentrated at these sites and by 30–35% shortening about one third of the rock is formed of sub-grains and new grains. Above 50% recrystallisation it becomes difficult to determine the exact nature of the original sedimentary rock. Later deformation events tend to concentrate their effects on the new grains produced in D_1 and may totally reorient these in the later fabric plane. Quartzites with between 5 and 10% mica content show a variety of spaced disjunctive cleavages typically with rough semi-continuous seams anastomosing around detrital grains. These fabrics are best developed in D_2 and D_4. A rare variant of this fabric is the production of relatively thick ($\approx$ 0.2 mm) pure mica layers at irregular intervals.

Schistose micaceous quartzite (Ꝑtqs)

In schistose micaceous quartzite, S_1 is a pervasive fabric dominated by a perfect alignment of mica flakes. Quartz grains between the micas are about 0.05 mm in size with varying degrees of dimensional preferred orientation. Remnant cores of old grains may occupy 10–20% of a thin section.

Phyllitic microfabrics are normally complex arrays of multiply overprinted foliations. Where S_1 is preserved it is defined by a perfect alignment of mica flakes and good dimensional preferred orientation of quartz grains. D_2 through to D_5 all create crenulation cleavages in phyllite and there is a tendency for these to become more discrete in going from D_2 to D_5. D_2 crenulation cleavages are characteristically zonal with mica rich layers up to 4 mm thick; a distinctive feature in exposures. D_5 crenulation cleavages are thin sharply defined discontinuities with very limited metamorphic differentiation. North and south of the Bell Basin, original pelitic rocks are garnetiferous and though most are still phyllitic, local schists are present. Within this zone other metamorphic assemblages include quartz + chlorite + phengite + chloritoid, and quartz + chlorite + phengite + albite.

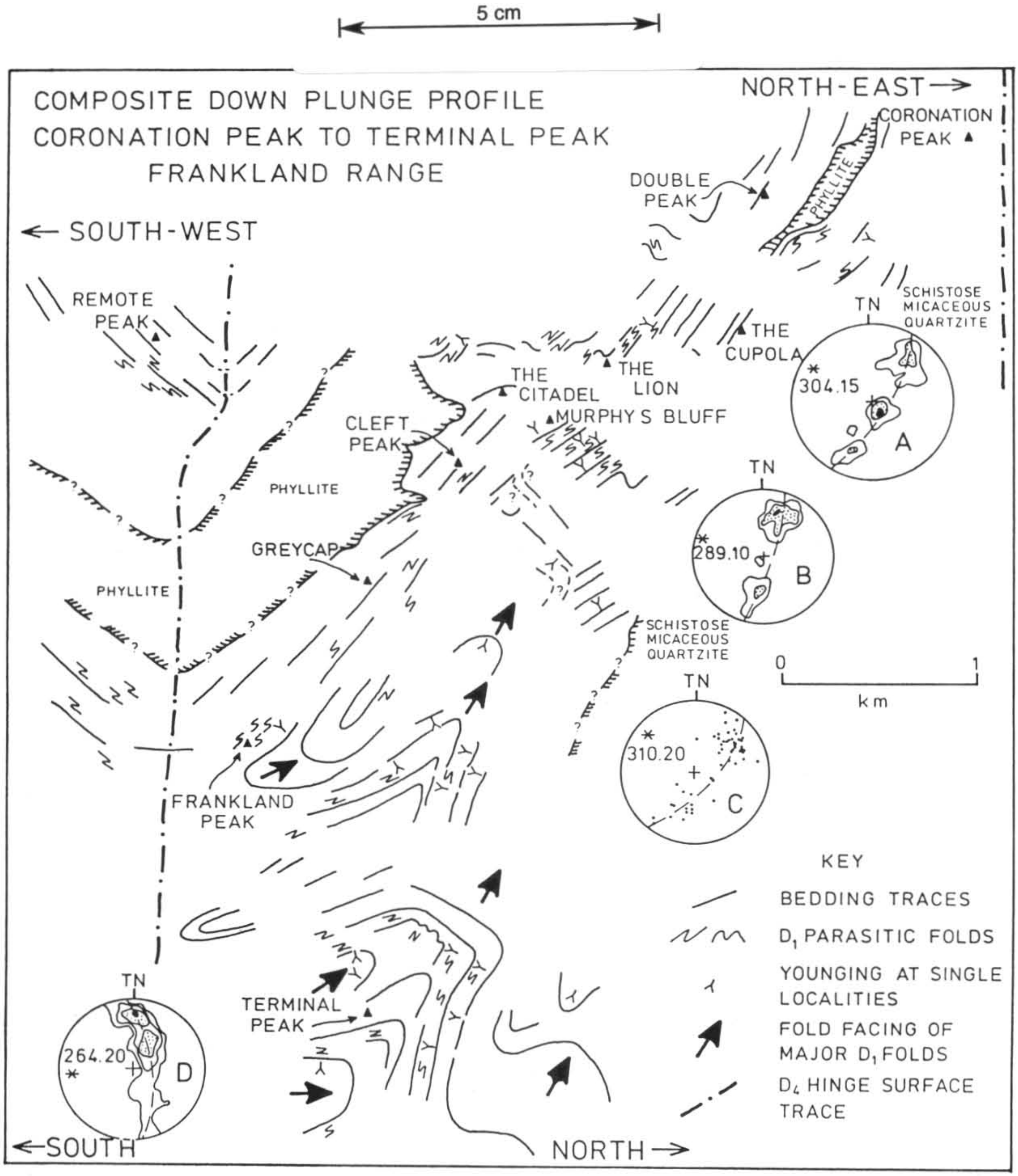


Figure 2. A composite down-plunge profile for the Frankland Range. Because of the rotation of the whole range, approximately cylindrical segments have been projected and keyed together. Stereographic projection insets (A to D) show the orientation data of poles to bedding for each segment. A – Coronation Peak–Double Peak; B – Redtop Peak to Cleft Peak; C – Cleft Peak to Frankland Saddle; D – Frankland Saddle to the eastern end of the Frankland Range. Most of the range is between a D_4 antiform to the N/NE and a D_4 synform to the S/SW and represents a single D_4 fold limb. On this limb major D_1 folds consistently face upwards but most of the bedding is overturned.

MT SOLITARY AND BARRIER ISLANDS

M. P. McClenaghan

Stratigraphy

Mt Solitary and the Barrier Islands consists dominantly of massive quartzite with very abundant well developed current bedding(Ꝑtqc). The overall strike of the steeply dipping bedding is approximately east along the length of the mountain with a younging direction to the north. Mt Solitary forms the northern limb of a large overturned anticline trending north-east with the Barrier Island forming the southern limb. Poorly exposed schistose micaceous quartzite (Ꝑtqs) occurs on the north flanks of Mt Solitary.

Petrography

Quartzite with well developed current bedding (Ꝑtqc)

The quartzites are generally very pure having only very minor amounts of accessory phengite, tourmaline, zircon and ore. In some areas where the quantity of ore is slightly greater the rock has a slight pink coloration. The quartzite is generally coarse grained with the original grains being visible in hand specimen. A fine penetrative cleavage is defined by an elongate of the large quartz crystals and an alignment of sparse thin mica flakes. The grains show straining and some of the larger grains are composite. The matrix consists of a fine mosaic of recrystallised quartz.

Schistose micaceous quartzite (Ꝑtqs)

The micaceous quartzite consists of recrystallised quartz mosaics set in a matrix of fine phengite. Ore grains are common and accessory minerals are zircon and tourmaline. Cleavage is defined by elongation of quartz mosaics and alignment of the phengite.

STRATHGORDON AREA

J. McClenaghan
M. P. McClenaghan

Stratigraphy

In the Strathgordon area, quartzite forms well defined north trending ridges and phyllitic rock occupies the intervening valleys and lower ground. The sequence of rock types encountered moving eastward from the western boundary of the map to the Twelvetrees Range is as follows: white quartzite (Ꝑtq), a sequence of mixed grey phyllite (Ꝑtp), white quartzite (Ꝑtq), light green-grey phyllite (Ꝑtl) and finally white quartzite of the Twelvetrees Range (Ꝑtq). The first two quartzite ridges merge north of the Gordon River on the Huntley map sheet and are part of the same unit. The sequence of mixed grey phyllite, found between these two quartzite ridges forms the core of a southward plunging synform. Quartzite (Ꝑtq), capping the Four O'Clock Ridge [DN223660] west of the Twelvetrees Range is a continuation of the same quartzite unit which forms the Twelvetrees Range.

The sequence of mixed grey phyllite (Ꝑtp) varies from pale to dark grey quartz-mica and mica-quartz phyllite to black carbonaceous phyllite with pyrite (Ꝑtg). The cleavage is generally strongly developed but in outcrops along the Gordon River road [DN191643] compositional layering and often a fine sedimentary lamination is preserved in dark grey massive quartz-mica phyllite. The sedimentary lamination is in places sharply truncated showing scour-and-fill structures. A common feature is soft-sediment clastic dykes (Boulter, 1974).

The light green-grey phyllite (Ꝑtl) includes quartz-mica and mica-quartz phyllite with abundant white quartz veins deformed into lenticles. The strongly developed cleavage has obliterated sedimentary structures.

The quartzite (Ꝑtq) in the Twelvetrees Range is typically massive, white and banded. In good exposures in the Gordon River gorge [DN225698] on the Huntley sheet and along a P.M.G. road at Strathgordon on the western side of the range, abundant examples of current bedding can be seen within the bands and sets of ripples on the surfaces. Although tectonic pseudoripple marks are also found, the sedimentary origin of many is shown by their complicated pattern of opposing direction in particular where there is a marked difference in the directions of ripples on the upper and lower surfaces of a particular band. The current bedding sets often show a herring-bone structure and examples of festoon current bedding can be seen. These structures indicate that the banding of the massive quartzite is in fact bedding. In places the massive, banded quartzite gives way to a schistose quartzite with a fine penetrative cleavage. This is particularly dominant along the eastern side of the Twelvetrees Range.

The quartzite bands to the west of the Twelvetrees Range are composed of massive and schistose white quartzite. Tectonic flattening appears to have accentuated the original stratification giving the quartzite a more thinly banded structure in places. The impure quartzite layers have readily developed into phyllite.

East of the Twelvetrees Range is another unit of mixed grey phyllite (Ꝑtp) which ranges from pale to dark grey and includes quartz-mica and mica-quartz phyllites. This unit is lithologically similar to the sequence of mixed grey phyllite west of the Twelvetrees Range. The strongly developed cleavage has obliterated any signs of sedimentary structures. Near the northern margin of the map sheet a thin quartzite (Ꝑtq) band occurs on the eastern side of this phyllite belt and separates the phyllite from a north trending belt of chlorite-actinolite-epidote-albite schist (Ꝑts) (amphibolite). Within and adjacent to the quartzite band at DN253659, DN261632 and DN273607 outcrops of banded ironstone (Ꝑti) occur. The iron is in the form of specular hematite, generally in thin layers along the banding in grey quartzite and is not traceable for any distance.

To the east of the amphibolite belt in the extreme north of the map [DN265665] another quartzite (Ꝑtq) unit occurs. The ridge formed by the unit extends southwards into an inaccessible area of the Atkins Range. The quartzite is a banded and schistose, white quartzite. No sedimentary structures have been found in the quartzite and it is not known whether the banding represents bedding, though it does parallel the compositional layering of the region.

In the Trappes Hill area south of the Twelvetrees Range the light green-grey phyllite (Ꝑtl) and the mixed grey phyllite (Ꝑtp) are separated by a narrow north trending band of quartzite (Ꝑtq) which is the continuation of the quartzite that forms the Twelvetrees Range.

Petrography

Chlorite-actinolite-epidote-albite schist (Ꝑts)

To the east of the Twelvetrees Range is a N-S trending belt of dull green schist containing albite, epidote, actinolite and chlorite with accessory ore. The dominant cleavage is depicted by these minerals and in places, it is seen to be an S_2 cleavage with an earlier cleavage defined by the same minerals. Porphyroblasts of epidote and chlorite appear to overgrow the dominant S_2 cleavage. At DN252708 on the Huntley sheet, large phengite crystals overgrow S_2 and at DN254688 also on the Huntley sheet there are porphyroblasts composed of a recrystallised mosaic of albite. Thin veins of more coarsely recrystallised quartz + epidote occasionally traverse the rock and show ptygmatic folding where they cross the dominant foliation suggesting a pre-S_2 formation. No relict igneous textures are seen in the schists although the composition (see table 6, Brown *et al.*, 1989) of the rock suggests an igneous origin.

Banded ironstone (Ꝑti)

In the Atkins Range area east of the Twelvetrees Range are minor dark grey phyllites and quartzites of high specific gravity, with specular hematite along the dominant cleavage. In thin section the dominant cleavage is seen to be an S_2 crenulation cleavage depicted by hematite alignment separating layers of fine, equigranular quartz-albite mosaic. The S_1 cleavage is defined by the same minerals. Small crystals of apatite are sometimes associated with the hematite layers and minor chlorite crystals define the cleavage in places. Subsequent deformation of the S_2 crenulation cleavage has produced pinch-and-swell structures in the hematite layers and conjugate fractures. Such rocks are well seen at DN253659, DN261633. Banded ironstone on the

Gordon River at DN253725 on the adjacent Huntley Sheet contains large crossite crystals.

*Black carbonaceous quartz-mica phyllite (*Ꝑtg)

Dark grey to black phyllite occurs as a narrow N-S band to the west of the White Spur ridge. S_1 cleavage and S_2 crenulation cleavage are defined by strings of fine quartz mosaic and by graphite and phengite. At DN201642 the phyllite contains porphyroblasts of pyrite and pseudomorphs after garnet (Ꝑtgg). The garnet pseudomorphs overgrow the S_1 cleavage but are contained within the S_2 cleavage. They are composed of a dark isometric material and aggregates of chlorite. Other outcrops of this dark carbonaceous phyllite occur within the mixed grey phyllites at DN192653 and DN194653 and contain pyrite porphyroblasts (Ꝑtgp) overgrowing S_2 cleavage.

Light- to dark-grey quartz-mica and mica-quartz phyllite (Ꝑtp)

The light to dark grey phyllites both to the west and east of the Twelvetrees Range are composed of quartz and phengite with accessory ore, tourmaline and zircon. A fine compositional banding defined by layers of quartz mosaic and mica is common and together with S_1 cleavage is folded into minor F_2 folds. Within the quartz layers is a marked elongation of the fine, equigranular mosaic axial planar to the F_2 folding. In the more micaceous layers this S_2 surface is seen as a pronounced crenulation cleavage. Subsequent F_3 minor open folding of the S_2 cleavage is seen but a penetrative S_3 cleavage is only rarely developed.

In places within the phyllites west of the Twelvetrees Range (eg at DN186642, DN194641 and DN196653) are garnet pseudomorphs (Ꝑtpg). These are generally rounded or six sided poikiloblastic porphyroblasts with numerous small quartz inclusions. They are frequently composed of a brown alteration material or have been pseudomorphed by chlorite and some biotite. They overgrow the S_1 cleavage, often having an helicitic texture with alignments of their inclusions, but are contained within the S_2 crenulation cleavage and are frequently augened and sometimes rotated (within S_2). At DN194641 small white porphyroblasts of altered albite occur in the phyllites (Ꝑtpa).

East of the Twelvetrees Range at DN253658 on the west side of a thin quartzite band is a zone of epidote-chlorite-quartz-mica phyllite with albite porphyroblasts (Ꝑtpe). The dominant cleavage is an S_2 crenulation cleavage depicted by mica, chlorite, ore and strings of fine quartz mosaic. An S_1 cleavage is depicted by the same minerals. Small colourless to pale yellow crystals of epidote occur throughout the rock. Rounded porphyroblasts of albite overgrow both the S_1 and S_2 cleavages. The albites sometimes have poikiloblastic texture enclosing ore defining the S_1 cleavage and in some places S_2 cleavage. Small green tourmaline crystals are an accessory constituent of the phyllite.

Light green-grey quartz-mica and mica-quartz phyllite (Ꝑtl)

The light green-grey phyllite west of the Twelvetrees Range is composed of quartz and a colourless to pale greenish phengite with accessory ore, tourmaline and zircon. Three cleavages are often readily discernible in thin section. The S_1 cleavage is seen in the more quartz-rich layers and is defined essentially by the mica separated by quartz mosaics. The S_2 cleavage, which is sometimes dominant, is seen as a crenulation cleavage defined by the mica and strings of a fine-grained, equigranular mosaic of quartz. The S_3 cleavage is developed axial planar to the minor F_3 folds and becomes dominant in places. It is a crenulation cleavage defined mainly by the mica but also by strings of quartz mosaic.

Small crystals of tourmaline, zoned and pleochroic pale pink to olive green, are seen overgrowing S_1, S_2 and occasionally S_3 and are sometimes bent and fractured by deformation.

Schistose micaceous quartzite (Ꝑtqs)

The micaceous quartzites consist of quartz and phengite and show a penetrative cleavage defined by an elongation of the recrystallised quartz mosaic and by an alignment of the phengite. Accessory minerals are ore, zircon and tourmaline.

Quartzite (Ꝑtq)

The massive quartzites are generally very pure having only very minor amounts of accessory phengite tourmaline, zircon and ore. A fine penetrative cleavage is defined by an elongation of the large quartz crystals and an alignment of sparse thin mica flakes. The quartz crystals are surrounded by fine grained polygonal elongated mosaics of quartz. These finer mosaics have formed by recrystallisation of the larger quartz crystals which show straining. A widely spaced parting in some specimens may be a parting along current bedding.

HERMIT HILL–CORONETS–SENTINELS

M. P. McClenaghan

Stratigraphy

In the Hermit Hill area quartzite bands occur in the mixed grey phyllite and a minor unit of green quartz-chlorite-mica phyllite (Ꝑtd) occurs at DN275585). A coarse bedding banding is developed in the quartzite in this area and current bedding can be recognised at a few points. Fine penetrative cleavage is strongly developed.

In the Stillwater Hill area the mixed grey phyllites (Ꝑtp) quartzite (Ꝑtq) bands are interbanded in a complex fashion with quartzite dominant. Lack of exposure makes exact tracing of boundaries impossible. The light green-grey phyllite (Ꝑtp) occurs in low outcrops along the east shore of Lake Pedder in the region of Serpentine Island and is interbanded with quartzite units.

The area from Mt Helder to the Coronets consists dominantly of massive quartzite (Ꝑtq) with minor units of light green-grey phyllite (Ꝑtl). Bedding is generally visible as a coarse banding and current bedding is present in many areas. Closely spaced penetrative cleavage is developed at Mt Cawthorn which has partly obliterated the bedding banding but in the coarser grained quartzite of the Coronet Range bedding structures dominate.

In the Sentinels Range the quartzite is coarser grained with current bedding being particularly prominent. A slight pink colour is present in the quartzite of this area. Cleavage is present but is not very prominent in the coarser grained rocks. Minor units of the light green-grey (Ꝑtl) and the light- to dark-grey phyllite (Ꝑtp) are interbanded with the quartzite.

Petrography

Green quartz-chlorite-mica phyllite (Ꝑtd)

Green phyllite interbanded with the light- to dark-grey phyllite (Ꝑtp) occurs west of Hermit Hill and consists of quartz, chlorite, phengite and ore with accessory tourmaline. Two cleavages can be seen in thin section. The S_1 cleavage is defined by mica and chlorite and the

S_2 cleavage by mica and chlorite separated by elongated quartz mosaics.

Light- to dark-grey quartz-mica and mica-quartz phyllite (Ꝑtp)

The light- to dark-grey phyllites in this area are mineralogically similar to those described in the Strathgordon area. A crenulation cleavage defined by mica and strings of fine-grained equigranular mosaics of quartz is always present and at DN286547 folding of a crenulation cleavage with development of a S_3 crenulation cleavage has taken place.

Light green-grey quartz-mica and mica-quartz phyllite (Ꝑtl)*and quartzite* (Ꝑ*tq)*

These rock types have similar petrographic character in this area as in the Strathgordon area.

MT CULLEN – JUNCTION RANGE

N. J. Turner

Ꝑtu, *etc.*

The deformed and metamorphosed rocks which underlie Mt Cullen and extend north along Junction Range comprise interbanded metasandstone and phyllite. The metasandstone is derived from quartzarenite and slightly less pure sandstone. It occurs in units which range in thickness from less than one metre to several tens of metres whilst the phyllite bands appear to range to a greater thickness. On Mt Cullen the thicker meta-sandstone bands (Ꝑtq) were delineated during mapping but on Junction Range the rocks are undifferentiated (Ꝑtqp).

The metasandstone contains fairly evenly sized, medium or coarse (1 mm) grains, predominantly of mono-crystalline quartz, which commonly appear very well rounded and of high sphericity. In thin sections either some or many of the grains can generally be seen to consist of very well rounded sedimentary grains which have authigenic overgrowths partially or completely surrounding them. The sedimentary grains may either be in direct contact with one another along curved, irregular or sutured interfaces or they may be surrounded by a matrix of very fine-grained, green-tinted mica and predominant quartz. The finely irregular and intergrown form of grain-matrix boundaries indicates that the matrix has, in part, replaced the grains. In some cases replacement appears to have been selective of the authigenic overgrowths but in other cases it has transgressed the overgrowths and affected large parts of the original sedimentary grains. There is commonly strong alignment of the matrix grains and they appear to be entirely of metamorphic origin.

Although most sedimentary grains in the metasandstone are of white to colourless monocrystalline quartz, there are subordinate pink quartz grains. Occasional detrital grains of orange-red or black chert are also present as are rare, well-rounded grains of green tourmaline with metamorphic overgrowths. Pigments in the matrix impart pink and, less commonly, purple colours to the generally white metasandstone, particularly on Junction Range. These colour variations may be expressed by bedding-parallel banding on a scale of several centimetres thickness or by colouration of tens of metres of the sequence.

Bedding in the metasandstone is well preserved in many places with bed thickness ranging from a few centimetres up to a common thickness of 300–400 mm. Parallel lamination or approximately planar, cross-lamination may be present within the beds and there is often a platy parting parallel to both types of laminae. Herringbone or chevron styles of cross-bedding are fairly common as are bifurcating, symmetrical ripple marks. At DN304604 numerous randomly oriented, irregular tubular structures about 4 mm in diameter may reflect biogenic activity.

The phyllite which is interbanded with the metasandstone appears to have experienced complete metamorphic recrystallisation. It consists predominantly of quartz and green-tinted mica with minor tourmaline, opaque minerals and very fine-grained carbonaceous matter. Quartz dominated and mica dominated types of phyllite are present and colours range from pale green to dark green or grey. Of the widespread classes of phyllite which crop out to the west, the phyllite on Mt Cullen and Junction Range apparently most closely resembles the predominantly grey subdivision - Ꝑtp (M.P. McClenaghan, pers. comm.).

In the McPartlans Pass canal [DN342556] there is an interval of dark grey to black, carbonaceous, pyritic mica phyllite (Ꝑtg) about one kilometre wide. This phyllite contains bands of light grey phyllite and micaceous quartzite. At the eastern end of the canal the phyllite is interbanded with fine-grained, grey dolomite (Ꝑtgc) at a thickness scale of up to 0.5 m.

EASTERN SENTINEL RANGE – MARIA CREEK

N. J. Turner

Cross-bedding and ripple marks are well preserved in white and subordinate pink to red metaquartzarenite (Ꝑtq) of very low metamorphic grade at the eastern end of Sentinel Range. Though cleavage is locally well developed, there appears to be relatively little metamorphic recrystallisation in the rocks. In adjacent rocks classed as Ꝑtl [DN388541] bedding surfaces on relatively impure, green, micaceous metasandstone carry what appear to be casts of polygonal mudcracks. Nearby rocks (Ꝑtgc) include richly muscovitic, black (?carbonaceous) siltstone consisting mainly of quartz but with an abundant altered mineral. Though the muscovite flakes exhibit a strong bedding-parallel alignment, they comprise large individual flakes which appear to be of detrital origin and the overall fabric of the rock appears sedimentary rather than metamorphic. Extensively recrystallised carbonate is present in Ꝑtgc. However, it crops out very poorly and its characteristics are not well known.

At DN426505, near Maria Creek, sedimentary features are again well preserved in very low grade meta-quartzarenite. In thin section the rock comprises very well-rounded, high sphericity, monocrystalline quartz grains which form a virtually continuous framework. Grain shapes are modified where their margins abut although there is little elongation of shapes. The interstices between grains are occupied by quartz, mica and, in pink to red quartzarenite, abundant very fine-grained opaque material but these minerals do not display the strong fabric or replacement characteristics evinced by the matrix in metaquartzarenite on Junction Range and Mt Cullen. Pelitic rocks in Maria Creek include very thinly laminated (2–4 mm), graded, green metasiltstone and metamudstone which are less coarsely recrystallised than rocks of similar composition on Mt Cullen and Junction Range. No chlorite was recognised in these rocks which consist of very fine-grained green-tinted muscovite and quartz. They exhibit an early penetrative mica alignment and a later cleavage defined by very thin anastomosing seams of opaque material.

Precambrian (?) (Ᵽw)

N. J. Turner

INTRODUCTION

Rocks in this category are strongly deformed and exhibit low grade regional metamorphism. They crop out poorly and their contact relationships are not exposed. Clast types provide indirect evidence of an erosional relationship between the conglomeratic Wedge River beds (Ᵽwc) and the Late Precambrian rocks (Ᵽt) which underlie the western part of Pedder quadrangle. However, the stratigraphic relationships of the other subdivisions of Ᵽw to the Wedge River beds and to Ᵽt are unknown.

The Wedge River beds, the dominantly phyllitic subdivision of Ᵽw (Ᵽwp) and Ᵽt contain multiple cleavages which appear to be equivalent. Multiple cleavages are also present in Ᵽws. However, pelitic rocks in Ᵽt and much of Ᵽp are recrystallised and phyllitic whereas most pelitic rocks in Ᵽws and some in Ᵽwp are less recrystallised and of silty and slaty appearance. These differences in apparent metamorphic grade may indicate differences in stratigraphic age or they may reflect a transition from low metamorphic grade on Junction Range and Mt Cullen to lower grade in adjacent rocks to the east. A change of the latter type occurs within Ᵽt between Junction Range – Mt Cullen and east Sentinel Range – Maria Creek.

Probably all the subdivisions in Ᵽw are older than the Middle Cambrian category (Єm) and they may all be older than the Єa category. Their relationship to the Eocambrian(?) – Early Cambrian(?) categories (Єen, Єew) in the eastern part of Pedder quadrangle is unknown. They are probably equivalent to some of the rocks classed as Eocambrian(?) – Early Cambrian(?) which occur in the central north of Huntley quadrangle.

Ᵽwc *(WEDGE RIVER BEDS)*

These deformed conglomeratic rocks crop out between DN360544 and DN385553 along the low ridge north of Sentinel Range. They were named the Wedge River Beds by Corbett (1970). Williams (1976) considered them to have been affected by the same early phases of deformation (D_1, D_2, D_3) that are present in the metasandstone-phyllite sequence on Sentinel Range and Mt Cullen. However, he interpreted the stratigraphic relationship as unconformable. Jago (1981) considered the possibility that the Wedge River Beds are glacigene but reached no definitive conclusion.

The Wedge River beds comprise a sequence of predominantly pebbly and cobbly metasandstone with bouldery intervals, thin graded sandy beds and phyllite layers. The major rock type occurs as apparently unbedded units up to about 12 m thick and contains scattered clasts of quartzite and quartz in poorly sorted material consisting of granules and sand-sized grains of quartz and quartzite supported in a matrix of very fine-grained quartz and subordinate green-tinted muscovite.

Pebbles and larger clasts are commonly discoidal due to deformation and are occasionally boudinaged. Length-breadth ratios of clast cross-sections range up to about 10:1 and long axes tend to be aligned. Some clasts preserve aspects of their original shape which was well-rounded and more spherical. Suturing, but relatively little syntectonic recrystallisation of clastic grains is evident in small quartzite clasts in thin section. They comprise very well rounded monocrystalline quartz grains cemented with quartz and they resemble the least deformed metasandstone (quartzarenite) in the sequences on Sentinel Range, Mt Cullen, Junction Range, etc. Despite their shape modification, the large clasts also consist of material resembling this least deformed metasandstone.

In hand specimen, sand grains in the conglomeratic rocks may appear well rounded but in thin section grain-matrix boundaries tend to be finely irregular whilst grain-grain boundaries range from gently curved to sutured. The sand grains are mainly monocrystalline quartz. In the fine-grained matrix between the sand grade and coarser material the quartz grains are commonly elongate and there is strong alignment of both quartz grains and mica flakes. This fabric indicates that the matrix has experienced complete metamorphic recrystallisation. Anastomosing films of relatively coarse-grained muscovite which correspond to the main cleavage (S_2) are also of metamorphic origin. These films commonly contain abundant, very fine-grained opaque material.

Scattered graded beds are exposed in cuttings along the Gordon River Road. They are generally less than 100 mm thick and may grade from granules to medium sand grade or from medium to fine sand grade. Rare sole marks are present. Dark grey phyllite is a very minor part of the conglomeratic succession.

No faceting, striation or other direct evidence of a glacigene origin was recognised in the Wedge River Beds. Isolated pebbles and cobbles in metasandstone might represent dropstones (Jago, 1981). Alternatively the conglomerate units may be density flow deposits. The apparently unbedded nature of the conglomeratic units and the presence of graded interbeds supports the latter possibility.

Ᵽwcc *AND* Єawcc

Ᵽwcc: In the legend of Pedder map Ᵽwcc is described as foliated, poorly sorted conglomerate containing clasts of quartzite and chert. Further investigation has shown that fragments previously identified as quartzite are recrystallised chert. Though the great majority of fragments are angular, the presence of uncommon rounded fragments was taken to indicate that the rocks are conglomerate. However, the microtexture of Ᵽwcc appears to be that of a post-depositional breccia and it may be that attrition during brecciation and shape modification during subsequent deformation caused the rounded appearance of a few fragments.

Outcrops of Ᵽwcc consist of unsorted, angular and uncommon, rounded fragments ranging up to 150 mm across. The fragments are siliceous and range from very fine-grained chert to fine-grained, recrystallised chert. The chert is commonly white or pale grey in colour though brownish, bright green and pink varieties are also present. Some fragments display white and grey colour banding which probably represents original bedding. An indistinct to strong main cleavage is present in Ᵽwcc and an earlier, oblique fabric due to alignment of fragments may also be present. The main cleavage is deflected around the fragments and some flattening and elongation is associated with it.

In thin section the fragments in the Ᵽwcc are angular and comprise very fine-grained chert, chert with recrystallised patches and some fragments of entirely recrystallised material. There is a strong fabric in the patches and in the fragments of recrystallised material due to parallel orientation of the elongate, recrystallised quartz grains together with minor muscovite flakes. Brecciation has caused disorientation of this fabric from fragment to fragment and deformation associated with the main cleavage has caused kinking within individual fragments. The crudely planar, main cleavage is defined by anastomosing seams of carbonate, fine-grained muscovite and opaque material.

?Єawcc: In the legend of Pedder Map Єawcc denotes chert layers which occur in an association (Єaw) of wacke, chert, red mudstone and basaltic rocks. The outcrops north-east of Mt Cullen were designated ?Єawcc because they consist of chert and because a small outcrop of coarsely micaceous, weathered wacke (?Єawf) which is similar to wacke in Єaw occurs in the same area at DN322654. Though recrystallised to a sugary texture, one outcrop of ?Єawcc [DN359610] is very similar to rocks in Єaw in that it consists of white and patchy grey chert and displays a platy parting as the main cleavage with a later, oblique, close spaced fracture. However, the other outcrops of ?Єawcc consist of cleaved chert breccia.

No rounded fragments were observed in ?Єawcc but with this exception the rocks are very similar to Pwcc. In thin section the breccia at DN348616 is virtually identical to material in Pwcc. The breccia rubble at DN358605 is also very similar in that it consists of variably recrystallised grey and white fragments but it lacks the alignment of recrystallised quartz grains. It displays a main cleavage defined by alignment of fine-grained metamorphic muscovite and there is a later, oblique (45°) swarm of subparallel quartz veinlets in which there is grain alignment perpendicular to the veinlet walls.

If the uncommon rounded fragments in Pwcc are not of clastic origin then there seems little reason to distinguish between Pwcc and ?Єwcc. Similarly, there is little difference between parts of ?Pwcc and Pwd except for the persistent yellowish colour in Pwd. The similarities between Pwd and dolomite in Pwp and Ptgc were noted previously. On the basis of the imprecise evidence that is available, it seems possible that all these categories may be expressions of a single association of chert, silicified dolomite and dolomite.

Pwcd

Strongly cleaved, very poorly sorted conglomerate (Pwcd) occurs at DN356622 and DN368571 but the stratigraphic relationships of the two exposures to one another and to other rocks is unknown. The conglomerate resembles rocks designated as Єep in Huntley quadrangles. Both conglomerate exposures are now inundated by Lake Gordon though the exposure at DN368571 is revealed at low lake levels.

At both localities the conglomerate is dolomitic. At DN356622 it comprises a variety of clast types in a sandy, micaceous, dolomitic matrix. The clasts range up to 150 mm across and are predominantly angular though larger quartzarenite clasts are rounded. A strong cleavage is developed in the matrix and the long dimensions of clasts tend to be aligned with the cleavage. In thin section the cleavage has a close-spaced, anastomosing, seamed morphology with very fine-grained, opaque material (?carbonaceous) concentrated in the seams. An earlier, highly oblique fabric is defined by strong preferred orientation of tiny, elongate grains in quartz borders which partially surround some carbonate clasts. No clear evidence of an accompanying early mica fabric was recognised.

Clasts in the conglomerate comprise dolomite, quartzarenite, siltstone and quartz. The dolomite clasts display thin bedding-lamination defined by variations in grain size and (?)carbonaceous content. Cleavage is absent or incipient. Quartzarenite clasts display a similar lack of deformation fabric. The quartzarenite has experienced compaction such that dissolution has occurred along grain-grain boundaries but little elongation of grains has resulted. Original grain boundaries are commonly preserved and are very well rounded and of high sphericity. Interstitial authigenic quartz is not recrystallised. The lack of both grain elongation and recrystallisation of authigenic quartz is in contrast with metaquartzarenite in Pt and suggests that the quartzarenite clasts in Pwcd were either derived from another source or, as in the Wedge River beds, were derived from Pt prior to deformation with most of the subsequent strain being taken up by the matrix rather than the clasts.

Siltstone is a common clast type in the conglomerate and may be dolomitic, carbonaceous or micaceous. Relatively coarse, ?detrital muscovite flakes display preferred dimensional orientation in many of these siltstone clasts. The orientation of the muscovite fabric varies from clast to clast indicating that the fabric is pre-depositional. It probably represents an original bedding fabric in the siltstone. In other siltstone clasts the strong, seamed cleavage which affects the matrix is well developed. Distortion of the clasts associated with cleavage development has caused wispy extensions of the clasts along the cleavage and into the surrounding matrix. This indicates that there was little difference in competence between siltstone and matrix at the time of cleavage formation. Such clasts may have been cannibalised from penecontemporaneous sediments.

Pwp

Most lithologies in Pwp closely resemble lithologies in Pt and similar deformation fabrics are evident in phyllite.

Phyllite is the predominant rock type in Pwp and is usually mica-rich. It is commonly dark grey in colour though green, silvery grey and banded varieties are also present. Thin (1–10 mm), relatively quartz-rich lenticular laminae related to metamorphic differentiation may lie parallel to the main cleavage in the phyllite. Interbanded with the phyllite at outcrop scale are small occurrence of metasandstone [DN360572, DN369549, around DN345565] similar to metaquartzarenite in Pt. There are scattered exposures of greenish quartz-rich phyllite and micaceous quartzite that are also similar to rocks in Pt.

Around DN370369 dolomite is interbanded with the phyllite. Some of the dolomite is the same as dolomite (Ptgc) in Pt, that is, it is characterised by a tectono-metamorphic fabric comprising thin (1-2 mm), anastomosing mica laminae separating 2–10 mm thick lenticules of fine-grained, patchily recrystallised, grey dolomite. Similar swarms of very thin, subparallel quartz veinlets also occur in the carbonate lenticules at a high angle to the bounding mica laminae. These are scattered veinlets at low angles to the mica laminae. Quartz grains in the veinlets are elongate and oriented at approximately 90° to the veinlet walls thus indicating crystal growth that was synchronous with the tensional opening of the fissures occupied by the veins.

Just north of DN370369 thin (250 mm) layers of almost completely silicified oolithic dolomite are present in the sequence. The ooliths are small (0.5 mm), elliptical in cross section with length-breadth ratios of 2:1, and are aligned. Quartz and minor carbonate inside the ooliths are very fine grained whereas in the surrounding matrix both quartz and subordinate carbonate are relatively coarse grained. The quartz grains in ooliths and matrix are elongate and aligned parallel to the oolith alignment. In hand specimen the rock is intensely fractured and mainly of a yellowish colour.

At DN358584 and in several other localities typical phyllite is intermixed with silty rocks of relatively massive, rather than foliated, texture which appear to be less metamorphosed than similar rocks in Pt on Mt Cullen and Junction Range. These silty rocks comprise silt-sized, ?detrital gains of quartz and flakes of muscovite together with much finer grained and penetratively aligned (S_1) metamorphic muscovite which is crenulated by the main anastomosing, seamed cleavage (S_2). The seams of the main cleavage comprise muscovite mixed with opaque material. Lepidoblastic and porphyroblastic chlorite and porphyroblastic, intergrown chlorite-muscovite grains predate the main cleavage and have their crystallographic cleavage aligned parallel, or subparallel, to S_1. Very minor concentration of opaque material in incipient cleavage is associated with a minor late phase of deformation (S_3).

Rocks of very low metamorphic grade at DN339583 comprise greenish-red slate and metasandstone which contains detritus of highly rounded and spherical, white and pink quartz and bright reddish-orange chert grains which are similar to the detritus in metaquartzarenite in Ꝑt. Despite the apparently lower metamorphic grade, the metasandstone has a fabric similar to metaquartzarenite in Ꝑt consisting of a penetrative grain alignment in the matrix that is slightly oblique to the later, main, seamed cleavage.

Ꝑwd

Three small, isolated occurrences of breccia and bedded breccia north-east of Mt Cullen are designated Ꝑwd. At DN357587 partially disrupted, banded chert is concordantly interlayered with completely brecciated chert. The thickness of layering is about 300 mm. In each type of layer the matrix consists of yellow, secondary quartz similar to material replacing the oolithic carbonate in Ꝑwp near DN370369. A spaced parting parallel to layering defines the main cleavage in the rocks.

The other outcrops comprise brecciated cherty material in a yellow siliceous matrix. At DN341588 the silicified material contains a swarm of very thin (1 mm), parallel quartz veinlets at a high angle to the spaced parting which defines the main cleavage. This fabric closely resembles the cleavage and veinlets in dolomite at DN370369 in Ꝑwp and, together with the similar yellowish secondary quartz, gave rise to the interpretation of these outcrops as brecciated, silicified dolomite.

Ꝑws, Ꝑwsh

Five small patches of rubble and outcrop extending from DN322654 to around DN342610 have been designated Ꝑws. They comprise strongly cleaved, very low grade metamudstone and metasiltstone of slaty appearance. Scattered outcrops of medium-grained metasandstone (?Ꝑtq) similar to metaquartzarenite in Ꝑt occur nearby.

Bedding is well preserved in Ꝑws and is cut by the main cleavage at small to large angles. The bedding is defined by very thin (2 mm) bands of metasiltstone in the grey to khaki slaty rocks and by thin slaty bands in the medium-green metasiltstone. In thin section the slaty rocks consist mostly of very fine-grained metamorphic muscovite. Dusty opaque material (?carbonaceous) is disseminated in this muscovite and may be concentrated in thin bedding laminae. It also tends to be concentrated in closely spaced anastomosing seams which define the main cleavage. Scattered silt-sized grains of quartz and muscovite predate the main cleavage and are probably of detrital origin since they do not appear to be recrystallisation products. The mica flakes exhibit a variably preserved bedding-parallel (or subparallel) alignment.

Particularly large (0.1 mm) grains of green chlorite and intergrown chlorite-muscovite are present in both metamudstone and metasiltstone. These grains usually have a porphyroblastic style though in particularly chlorite-rich ≈25%) rocks at DN333621 there are also lepidoblastic grains parallel to the main cleavage. The porphyroblastic grains are sometimes kinked and they deflect the main cleavage. Therefore, they predate the cleavage. Their crystallographic cleavage exhibits preferred orientation parallel (or subparallel) to bedding. Chlorite-muscovite aggregates displaying similar porphyroblastic style and fabric relationships are found in weakly metamorphosed and deformed pelitic and psammitic rocks throughout the world (Gregg, 1986). They may result from prekinematic metamorphic overgrowth of detrital muscovite by chlorite or by early kinematic bedding-parallel mimetic replacement of clay minerals by chlorite followed by partial prograde metamorphism to muscovite.

Outcrops of Ꝑws near the foot of Junction Range are slightly more lustrous and phyllitic in hand specimen than the rocks further east but display similar features in thin section. The outcrops comprise predominantly grey, micaceous metasiltstone with 2-10 mm thick bands of metamudstone and slightly micaceous chert. The main cleavage is at a moderate angle to bedding and is defined by very close spaced, anastomosing, opaque-rich seams. These seams are deflected around sparse chlorite-muscovite porphyroblasts whose crystallographic cleavage lies parallel or subparallel to bedding. Silt-sized grains of quartz and muscovite predate the main cleavage and appear to be of detrital origin.

In some metamudstone bands the main cleavage crenulates a penetrative bedding-parallel fabric defined by alignment of very fine-grained, metamorphic mica. This crenulating relationship was not observed in the rocks to the east where the seamed and penetrative fabrics are parallel.

Three outcrops designated as Ꝑwsh occur around DN325616. They comprise dark red or, less commonly, green or lustrous cream metamudstone and metasiltstone of slaty appearance. Pink, poorly sorted, fine-grained, cleaved sandstone with thin, dark red, slaty bands is also present. Rubble of metaquartzarenite, possibly reflecting sub-outcrop, occurs near the Ꝑws exposures but no stratigraphic relationships were determined.

Cleavage in the slaty rocks of Ꝑwsh is defined by penetrative alignment of very fine-grained metamorphic mica though very fine-grained opaque material (?hematite) shows a tendency to form anastomosing seams. Silt-sized quartz grains are generally aligned with the cleavage but relatively coarse muscovite flakes of probably detrital origin are commonly oblique. These muscovite flakes deflect the cleavage and some are bent. No chlorite or chlorite-muscovite porphyroblasts were identified.

JUBILEE REGION

C. R. Calver

INTRODUCTION

Most of the eastern third of the Pedder Quadrangle is occupied by Precambrian rocks with a generally lower grade of regional metamorphism than is prevalent in the Tyennan region. These rocks are part of a larger area, extending south and east of the map sheet, of low–grade (and in places, unmetamorphosed) Precambrian rocks known as the Jubilee region (Turner, 1989*a*).

The relative age of Tyennan and Jubilee regions is uncertain. Low metamorphic grade has long been thought to be an indication of a younger age for the Jubilee region (Spry, 1962). An unconformity between Jubilee and Tyennan rocks is inferred by Godfrey (1970) and Williams (1976) but has not been proved. Instead, regional comparisons suggest that Tyennan and Jubilee region Precambrian rocks may overlap in age.

Metamorphic grades in both regions are variable and probably overlap. A structural comparison (Duncan, 1976) shows a similar number of cleavage-forming events in limited areas of both regions. The regions are also similar in lithologic character, both consisting of thick sedimentary sequences dominated by orthoquartzite, pelite and carbonate.

Due to the remoteness of the area and a perceived lack of economic mineral deposits, previous work was fragmentary and infrequent (Lewis, 1924; Hall, 1968). Regional mapping on Pedder and Huntley map sheets (Brown *et al.*, 1983) is the first detailed geological work to be undertaken in the Jubilee region. In contrast to the Tyennan region, the simpler structural style has allowed much of the stratigraphic succession to be worked out. On Pedder, three distinct Precambrian successions were mapped (fig. 3): the Mt Anne Group and the Pandani Group, which are in faulted juxtaposition and are of uncertain age relationship; and the Weld River Group, younger than both the above. The Mt Anne and Pandani Groups are defined below, while the Weld River Group is defined by Calver (1989*c*). The south-eastern corner of Huntley Quadrangle is occupied by a fourth distinct Precambrian sequence, the Clark Group (Carey and Banks, 1954; Calver, in. prep.) which extends southwards into the Pedder map sheet. The Clark Group is now considered to pre-date the Weld River Group as it is lithologically similar to the older (Mt Anne and Pandani) Groups.

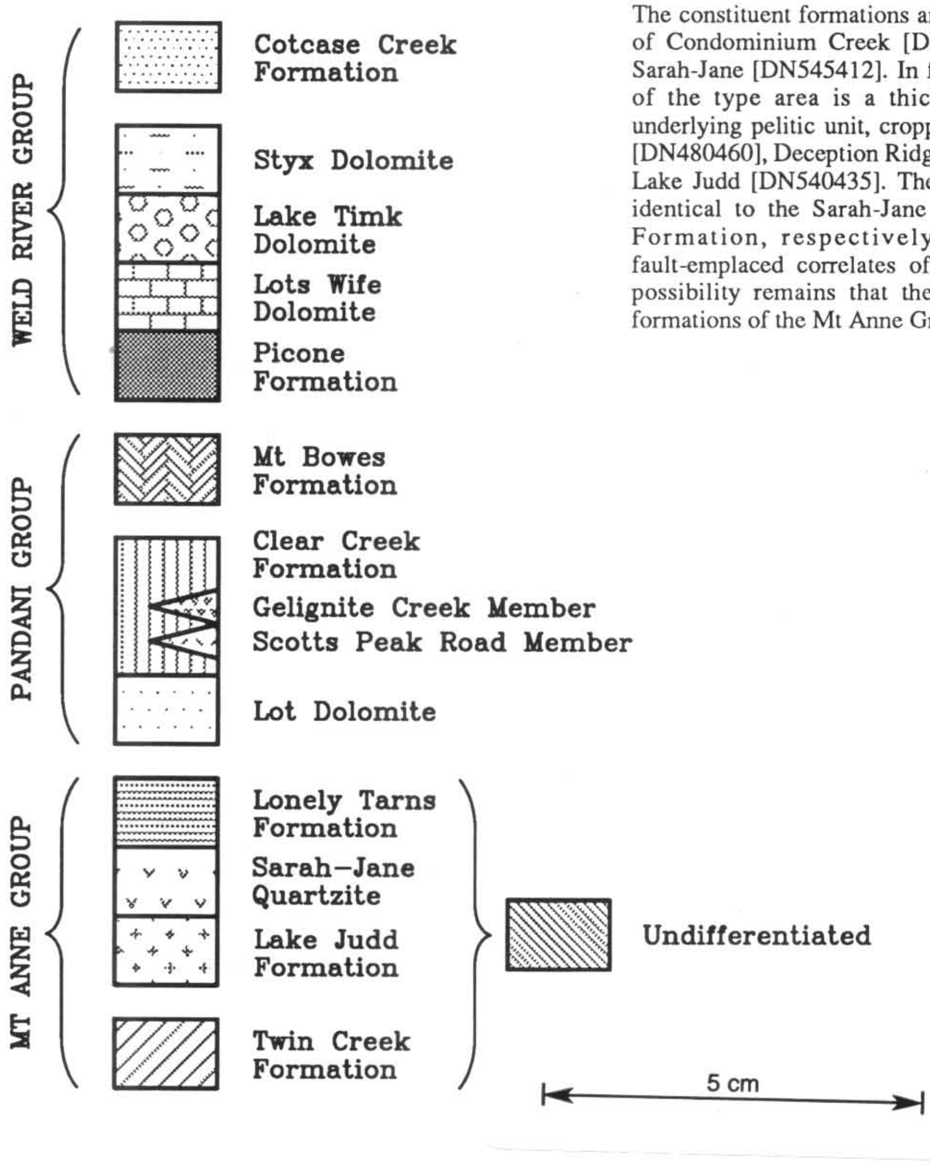
A major meridional strike-slip fault, the Lake Edgar Fault, separates the Jubilee region from the middle Cambrian Island Road Formation and Tyennan rocks to the west. To the north, Jubilee sequences are unconformably overlain by a ?Cambrian lithicwacke sequence and the Cambro-Ordovician Wurawina Supergroup.

MT ANNE GROUP

Introduction

The Mt Anne Group, here defined, consists of (from the base) the Twin Creeks Formation (map symbol Ᵽep, including Ᵽed, Ᵽeb and Ᵽeo), the Lake Judd Formation (Ᵽes), the Sarah-Jane Quartzite (Ᵽeq), and the Lonely Tarns Formation (Ᵽes), defined below. The Mt Anne Group is named after the highest peak in the area, situated at DN530451. It is characterised by predominant orthoquartzite, quartz siltstone, and pelite with minor dolomite, and crops out in the south-eastern part of the quadrangle (fig. 3). The sequence may extend further south and east into little-known areas beyond the limits of the quadrangle. No top or base to the sequence is known. To the north, the Mt Anne Group is faulted against the Pandani Group. Metamorphic grade is of lower greenschist facies and pelites are generally fine-grained phyllite or slate. The sequence has undergone polyphase deformation but bedding mostly dips steeply and youngs northwards, except for west-facing limbs of first-order folds near Mt Sarah-Jane [DN550410] and south of Twin Creeks [DN483414].

The constituent formations are defined in the area south of Condominium Creek [DN500440] and around Mt Sarah-Jane [DN545412]. In faulted contact to the north of the type area is a thick quartzite unit with an underlying pelitic unit, cropping out around Celtic Hill [DN480460], Deception Ridge [DN500450] and north of Lake Judd [DN540435]. These rocks are lithologically identical to the Sarah-Jane Quartzite and Lake Judd Formation, respectively; and are regarded as fault-emplaced correlates of these units, although the possibility remains that they are additional, younger formations of the Mt Anne Group.



Legend for Figure 3.

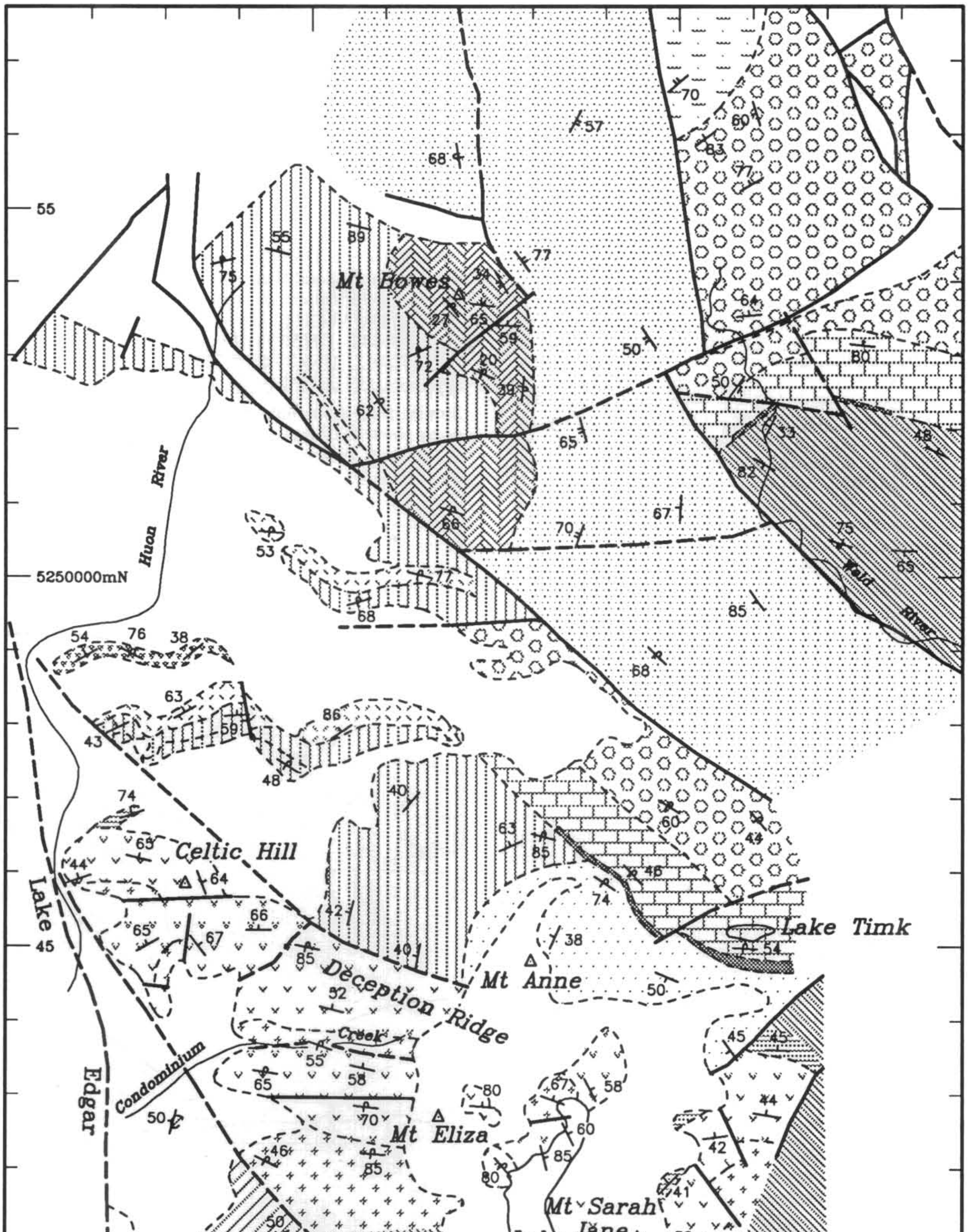


Figure 3. Simplified geological map of eastern Pedder quadrangle (Jubilee region), showing stratigraphic nomenclature.

5 cm

Twin Creeks Formation (Ꝑep, Ꝑed, Ꝑeb, Ꝑeo)

The Twin Creeks Formation is here defined as the unit dominantly consisting of phyllite, with subordinate dolomite and quartz siltstone and rare orthoquartzite (Ꝑep) with impersistent mappable units (unnamed) of dolomite (Ꝑed), black phyllite (Ꝑeb) and orthoquartzite (Ꝑeo), cropping out along the Scotts Peak Road between DN483413 and DN480390, and to the east. No base is known, and the unit extends southwards into unmapped areas beyond the limits of the map sheet. The formation is considered to be faulted against the Lake Judd Formation by an inferred major fault not shown on the 1:50 000 map (but see fig. 3). It is included with the Mt Anne Group on the basis of lithologic similarity and is probably older than the Lake Judd Formation as it occupies a southerly position in a predominantly north-facing structural regime. The formation is named after the creek crossed by the Scotts Peak Road at DN483414. It is a minimum of very approximately one kilometre in thickness.

Ꝑep is predominantly phyllite, usually pale grey-green, less commonly purplish grey. Commonly interlayered with the phyllite on the Scotts Peak Road, but only rarely seen in natural exposures, is a soft, earthy, fine-grained rock type that probably represents deeply leached, originally calcareous or dolomitic, mudstone or siltstone. This rock type commonly lacks cleavage; where present, cleavage consists of anastomosing thin phyllitic seams spaced a few mm apart. Also common is quartz siltstone, occurring as thin beds or laminae. The siltstone layers are usually planar, and often graded. Grading takes place through an upward increase in matrix proportion, together with a slight gradation in grain size of the silt. Siltstone-filled clastic dykes, a few mm wide and 10–20 mm long, are commonly developed beneath siltstone layers. Trough cross-lamination, with sets 20–50 mm thick, is rarely present in siltstone.

The phyllites in thin section consist of very fine-grained quartz and aligned layer silicates that define the primary foliation, with a small amount of clastic quartz silt. Layer silicates appear to be purely sericite in most slides but fine-grained chlorite may be abundant and occurs rarely as microporphyroblasts. Pelitic intraclasts are present in some slides.

Ꝑed consists dominantly of pale green to white, fine-grained cleaved dolomite. Weathered outcrop surfaces are yellow-brown to red. The rock is frequently massive, with bedding sporadically developed as planar lamination defined by slight textural variations. Some laminae, slightly coarser-grained than the enclosing rock, appear to be graded. Small-scale cross-bedding was observed at one locality. The primary cleavage usually appears slaty or sometimes as thin phyllitic seams spaced 1–2 mm apart.

A thin section of this rock type consists of about 80% clear xenotopic dolomite grains of 30–40 micron size. Quartz silt, phyllosilicates and opaques comprise the rest of the rock, with the layer silicates being concentrated along diffuse tectonic seams.

Ꝑeb consists dominantly of black graphitic phyllite, interbedded with pyritic quartz siltstone and minor fine-grained dolomitic rocks.

Ꝑeo consists of orthoquartzite that crops out on several narrow, impersistent strike ridges within the Twin Creek Formation. The most prominent of these is the ridge at DN486412 where orthoquartzite, about 100 m thick, dips steeply and faces south-east. The rock is a white or pink, quartz-cemented, fine- to medium-grained supermature orthoquartzite. Cross-bedding is present but is not as abundant as in the otherwise similar Sarah-Jane Quartzite.

The configuration of nearby (possibly stratigraphically equivalent, but discontinuous) orthoquartzite outcrops suggests that the SE-facing section may be the common limb of a coupled isoclinal NE-verging early fold (see later section).

The base of an orthoquartzite unit is exposed in a road cutting at DN481409. The contact with the underlying phyllite is abrupt, with some load cast development.

Lake Judd Formation (Ꝑes)

The Lake Judd Formation is defined here as the unit consisting of phyllite and slate with abundant thin beds and laminae of quartz siltstone, minor fine-grained quartzite and rare dolomite, cropping out between DN498416 and DN508425, where it is conformably overlain by the Sarah-Jane Quartzite. The upper part and top of the formation are again exposed west of Lake Judd [DN533431], south of Deception Ridge [DN488442–DN503441] and near Celtic Hill [DN470462, DN477452]. The formation is very approximately one kilometre thick.

Similar rock units, also indicated as Ꝑes on the map, occur above the Sarah-Jane Quartzite (The Lonely Tarns Formation) and as impersistent horizons within the Sarah-Jane Quartzite.

The quartz siltstone is pale grey to grey-green, less commonly reddish grey; while pelite tends to be more deeply pigmented, and is usually pale green, in places reddish or black. Siltstone, together with minor very fine-grained ripple-marked quartzite beds, becomes predominant near the top of the formation. Variation in pelite lithology from phyllite to slate may reflect slight changes in regional metamorphic grade, but no simple

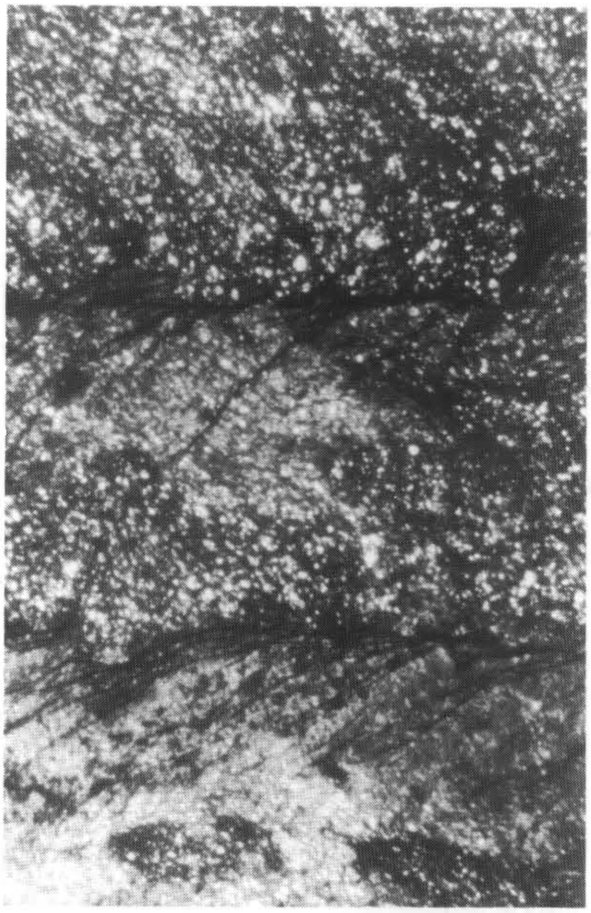


Plate 3. Thin section 002405 (Lake Judd Formation) showing thin, graded siltstone-pelite couplets, a slaty cleavage, S_1 (NW-SE) and a crenulation, S_2, in pelite laminae (NE-SW). Field of view 4 × 2 mm.

5 cm

zonal pattern is evident. Typically, quartz siltstone and pelite are interlaminated, with siltstone laminae occurring as planar, continuous, graded layers 0.2–10 mm in thickness (plate 3). The thicker layers usually show internal lamination which may be an expression of very small-scale recurrent grading or low-angle cross-lamination. The primary cleavage, nearly everywhere inclined to bedding, is usually sharply refracted at the bases of graded siltstone layers.

Load structures are common at the bases of the siltstone layers. Discoidal pelitic intraclasts, a few millimetres in length, are present in some siltstone or fine quartzite beds.

Small tabular clastic dykes of siltstone, originating in particular siltstone layers and extending downwards into underlying layers, are abundant at many localities (plate C4). They are 0.2–1.5 mm thick and up to 20 mm long (bedding-normal direction). Originally probably mostly subperpendicular to bedding, they now tend to lie at an acute angle to bedding, and in places are ptygmatically folded, as a result of strain accompanying development of the primary cleavage. Less commonly, the dykes may be in part parallel to bedding. Many dykes are composed of silt that is distinctly coarser and better-sorted than the material composing the laminae. They are probably injection dykes rather than mudcrack infillings as they are, in places, extremely numerous and closely-spaced, and they may intersect bedding at variable angles in any one layer.

Dolomitic siltstone is predominant in the top 20–30 m of the Lake Judd Formation at DN475448, and graded laminae are commonly developed in this rock type also.

In thin section the quartz siltstones consist mainly of subangular clastic quartz silt, with minor detrital muscovite, opaques, zircon and rare tourmaline. Denser minerals (notably zircon and opaques) are often markedly concentrated along the bases of siltstone layers. Silt at the bases of graded layers may be either in closed-framework or matrix-supported, and the proportion of pelitic matrix increases rapidly upwards, with transition into the overlying pelite. The pelite layers consist of fine-grained layer silicates oriented in the primary cleavage direction, with a sprinkling of detrital muscovite and fine quartz.

Sarah-Jane Quartzite (Ꝑeq)

The Sarah-Jane Quartzite is defined here as the orthoquartzite unit cropping out between DN508425, where it conformably overlies the Lake Judd Formation, and DN504438, where it is apparently overlain (contact not observed) by the Lonely Tarns Formation. This section, west of Mt Eliza, is faulted but essentially complete. Continuity of outcrop along strike to the east is interrupted by younger cover and by Lake Judd, but the orthoquartzite in the Lake Judd [DN530425]–Mt Sarah-Jane [DN550400] area is regarded as the same formation. The top of the formation is well-exposed at DN548416 and at DN565437; there is a conformable transition into the overlying Lonely Tarns Formation. The best-exposed complete section through the Sarah-Jane Quartzite occurs in this area [DN565425–DN565437]. The formation is named after Mt Sarah-Jane [DN545412]. Orthoquartzites cropping out on Celtic Hill [DN480460], Deception Ridge [DN500450] and north of Lake Judd [DN540435] are lithologically identical and similar in thickness to the Sarah-Jane Quartzite, and are regarded as correlates. The formation is about 1000 m thick in the (faulted) type area west of Mt Eliza, at least 900 m thick on the western shore of Lake Judd and about 800 m thick east of Mt Sarah-Jane. The correlate at Celtic Hill is about 650 m thick but here the top may be faulted out. The orthoquartzite is highly resistant and forms major strike ridges, exemplified by Celtic Hill and Deception Ridge.

The orthoquartzite is white or pink, and is of 0.1–2 mm, usually 0.25–1 mm, grain size. The rock is supermature, consisting almost wholly of well-sorted quartz grains that are silica-cemented and well-rounded, especially in

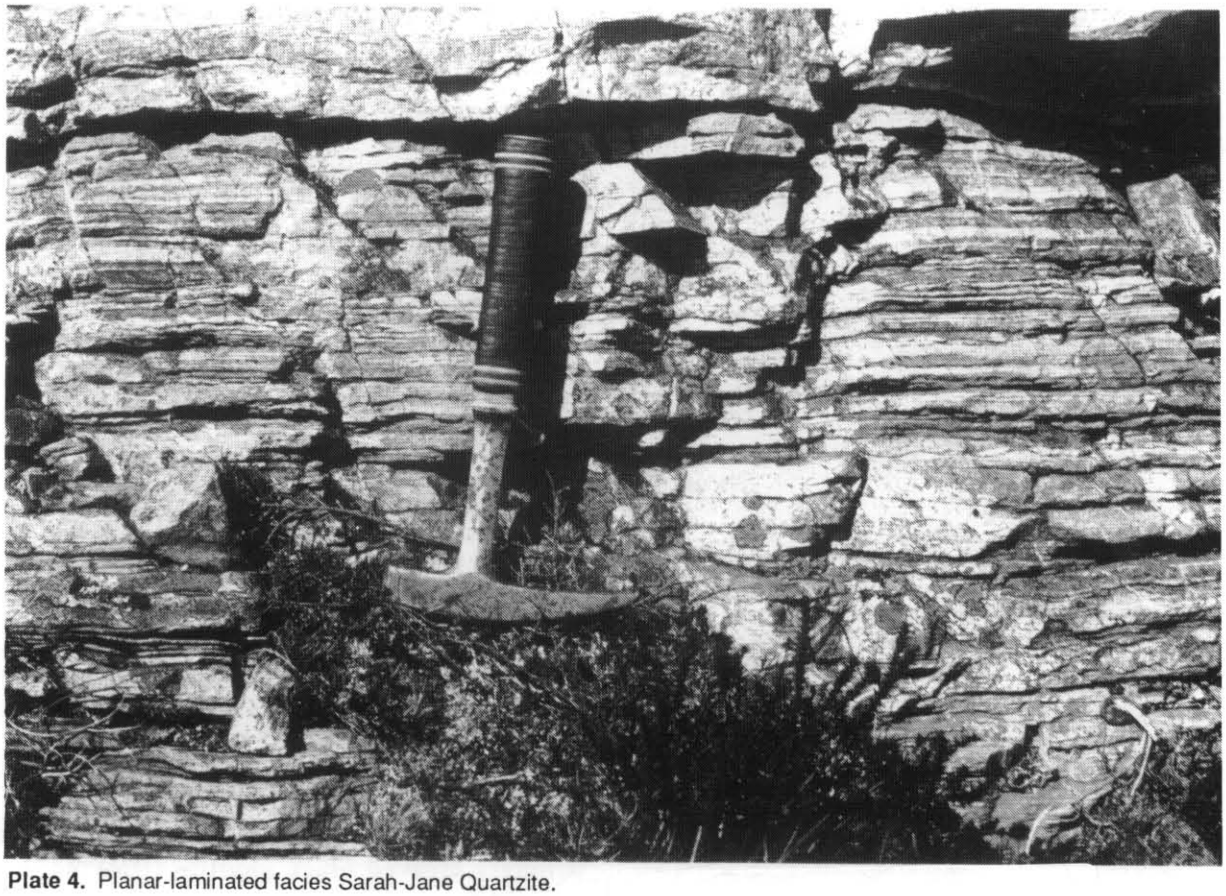


Plate 4. Planar-laminated facies Sarah-Jane Quartzite.

5 cm

the coarser grades. Most of the formation is cross-bedded, but massive and laminated facies are also present. Fresh outcrops sometimes show greenish pelite or quartz siltstone interbeds that are only rarely preserved in the more deeply-eroded outcrops on ridgetops. The orthoquartzite usually lacks cleavage and is mostly unstrained.

Bed thickness in the cross-bedded facies is 30–300 mm, usually about 100 mm. Cross-bedding is generally tabular and planar although rare troughs or festoons occur. A sample (n = 71) of angles of inclination of cross-stratification from the Celtic Hill section (see below) shows an average of 26°, and a maximum of 41° (angles less than 10° being excluded from the sample).

The laminated facies (plate 4) is distinctive but relatively uncommon, occurring as units several metres or a few tens of metres thick at DN472453, DN510432, DN558431, DN567443, and at the top of the formation at DN548416. This facies is characterised by thin planar bedding or lamination and a relatively fine (dominantly 0.125–0.25 mm) grain size. Upper surfaces of beds are frequently ripple-marked; the ripples are symmetrical, with crests more pointed than troughs, typically with wavelengths approximately 30–40 mm and amplitudes of about 5 mm. Some ripples have wavelengths of only 15 mm. Rare layers containing convolute laminae are associated with this facies.

The orthoquartzite also occurs as massive, structureless layers 1–20 m thick. This rock type is relatively fine-grained (≈ 0.2–0.3 mm), is wholly quartz-cemented and extremely tough. The thicker units of this type tend to crop out as narrow, prominent strike ridges, and some of these are indicated on the map near Celtic Hill and in the Mt Sarah-Jane area [DN550398–DN566426]. In the latter area, a pair of massive units appears to persist along strike across different fault blocks for a distance of several kilometres.

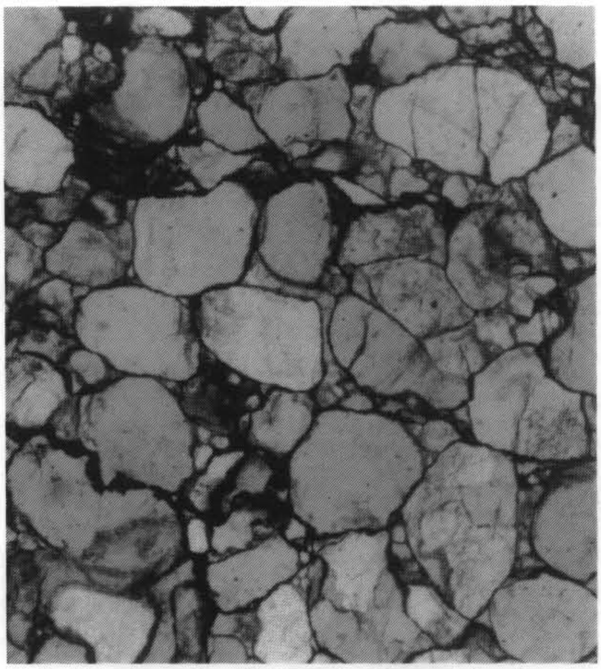


Plate 5. Thin section 001807 of orthoquartzite showing well-rounded quartz grains and incipient seamed cleavage. Field of view 2 × 1.8 mm |← 5 cm →|

In thin-section, orthoquartzites consist almost entirely of rounded quartz grains with porosity almost wholly occluded by syntaxial quartz overgrowths (plate 5). Quartz grains are nearly all monocrystalline, and in unstrained specimens, most grains have straight extinction. Microlites of zircon, rutile and muscovite are present in a few grains. A few polycrystalline grains are present, including highly strained metaquartzite. Chert grains are rare. Accessory minerals are tourmaline, zircon and rare detrital muscovite. Interstitial fine opaques and authigenic phyllosilicates may be present. Opaques, probably hematite, impart the common pink to purplish-grey colour, and may be distributed either around original grain boundaries or at the outer edges of syntaxial overgrowths. A weak cleavage may be developed as thin, sutured, strongly anastomosing seams accompanied by a slight flattening of grains due to pressure solution (plate 5).

A thin section of the massive orthoquartzite type shows a mosaic wholly of interlocking quartz grains meeting along irregular boundaries with no original grain boundaries discernible.

A few impersistent layers of pelite and quartz siltstone within the Sarah-Jane Quartzite are indicated on the map (Ꝑes). These are 30 m or less in thickness, and are lithologically very similar to the Lake Judd and Lonely Tarns Formations. In road cuttings at 463467 are exposed several bedding planes in siltstone with well-developed asymmetrical ripple marks of 10–15 mm wavelength. Ripple marks are also present at DN552405. Fine-grained impure dolomite occurs at DN552405, and leached dolomitic(?) rocks occur at DN492432.

Systematic palaeocurrent directions were measured in five small areas approximately equally spaced through the Sarah-Jane Quartzite correlate at Celtic Hill (fig. 4, a–e). This section is structurally simple, consistently dipping at 60–70° to the north. No attempt is made at palinspastic reorientation; the north point in the rose diagrams is in the dip direction of bedding at each station. All determinations are from cross-bedding.

The lower part of the formation is characterised by a strongly unimodal pattern. The upper two stations show the mode in a quite different direction to the lower horizons, and a weak second mode, about 180° away, is present.

Palaeocurrents from a single location [DN507427] in the type section of the Sarah-Jane Quartzite near Mt Eliza display a well-developed bipolar pattern (fig. 4f).

Systematic palaeocurrent analysis of this kind offers a potential tool for the correlation of the various fault-juxtaposed quartzite blocks in this area, here considered (but not proved) to be one and the same formation.

Lonely Tarns Formation (Ꝑes)

The Lonely Tarns Formation is defined here as the unit of phyllite, slate and quartz siltstone, which conformably overlies the Sarah-Jane Quartzite at DN548417, near Mt Sarah-Jane. No top to the formation is known. The formation is also exposed at DN552428, DN564438 and DN504439 and a probable correlate is exposed in road cuttings north of Celtic Hill. The Lonely Tarns is the name given to the string of small highland tarns extending from Mt Sarah-Jane as far north as, and including, Lake Picone.

The Lonely Tarns Formation is lithologically indistinguishable from the Lake Judd Formation, consisting dominantly of thinly interlayered, greenish-coloured (in places, black) pelite and quartz siltstone. North of Celtic Hill, flute casts are exposed at the base of a fine-grained sandstone bed at DN469471. Further north, road-cuts expose leached, earthy, originally dolomitic(?) fine grained rocks with a prominent seamed cleavage [DN471473], and then strongly cleaved black phyllite [DN474474–DN476476).

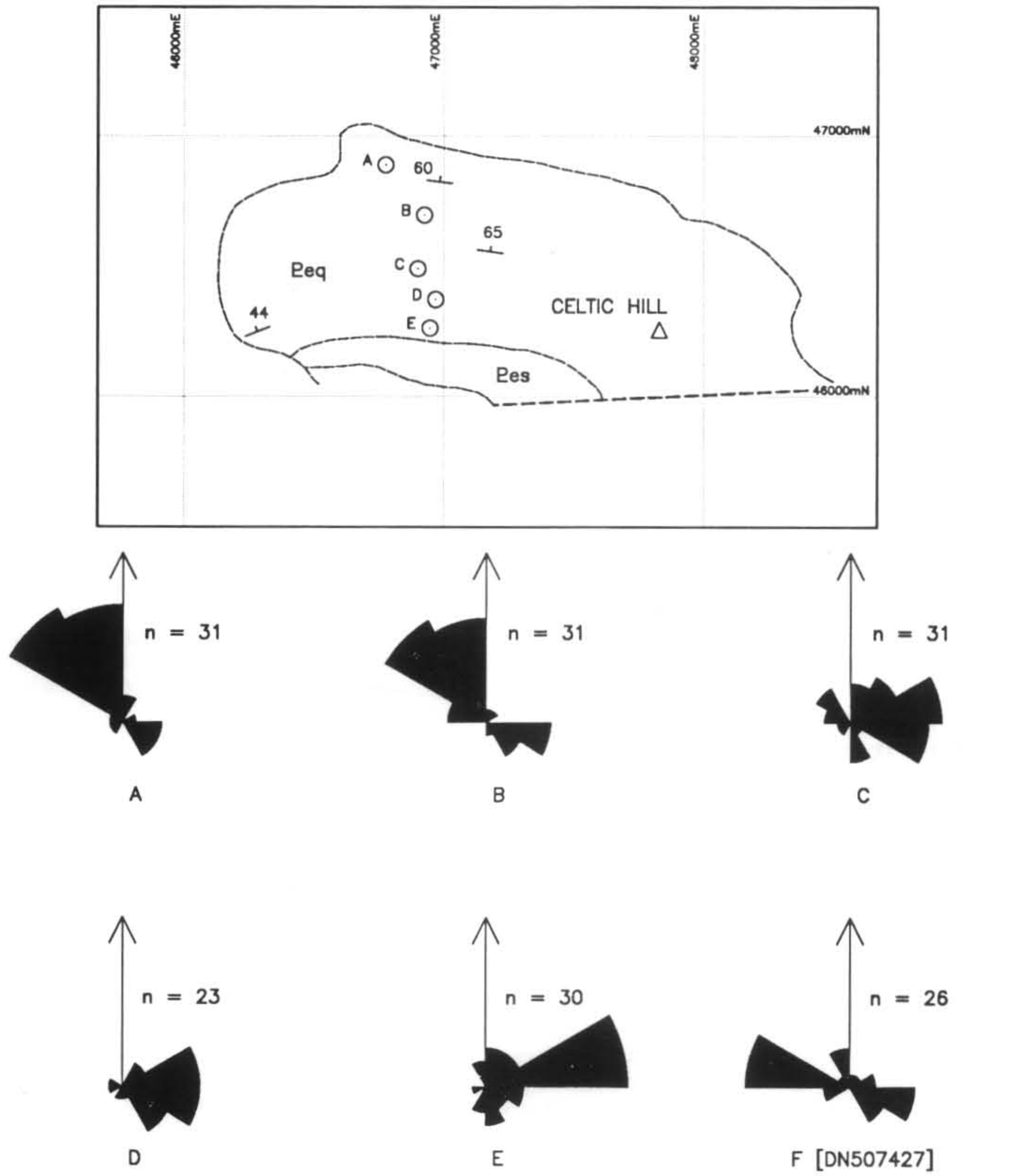


Figure 4. Palaeocurrents, Sarah-Jane Quartzite.

5 cm

Rocks east of Weld River [DN563525] (Ɛes′)

In a separate area east of the Weld River there crops out a thick sequence of interlaminated quartz siltstone and mudstone, lithologically similar to the Lake Judd Formation. Siltstone and mudstone are of sub-equal abundance. Clastic dykes and grading of the silt layers are common phenomena (plate 7). Rarely, the siltstone layers are dolomitic. Within this sequence at DN562522 is an interval about 100 m thick of impure dark grey fine-grained dolomite with shaly interbeds (indicated as Ɛes′c). At DN573512 occurs a 5 m thick unit of thinly bedded to thinly laminated, red and grey chert.

Unlike the well-cleaved pelitic rocks of the Mt Anne Group, the mudstone in this sequence is characterised by a very weak development of cleavage. The primary cleavage in thin section appears as a weak bedding-parallel alignment of fine-grained to cryptocrystalline phyllosilicates (see Structural Geology chapter). An incipient crenulation is locally developed. Chlorite is present as a cement in some siltstone layers.

The sequence is paraconformably overlain by the Weld River Group in the Weld River at DN564533. Recent mapping on Styx Quadrangle (to the east of Pedder) shows that the sequence overlies, probably conformably, the thick orthoquartzite unit that forms the Jubilee Range (Calver, 1989*a*). Ɛes′ would therefore be a correlate of the Lonely Tarns Formation, if the sequence on Jubilee Range is ultimately shown to be a correlate of

Plate 6. Thin section 002459 (Mt Anne Group correlate east of Weld River) showing folded clastic dykes. Field of view 12.5 × 9.3 mm.

the Mt Anne Group. The distinctly lower tectonometamorphic grade here is part of a regional north-eastward decrease in grades across the Jubilee Region (see later section).

Rocks in the Snake River area [DN564420–DN567427]

East of the high plateau between Mt Sarah-Jane and Lots Wife [DN560447] lies a poorly-known area tentatively indicated on the map as a correlate of the Mt Anne Group (?Ꝑeu), due merely to its proximity to the mapped area. A short traverse within this area was undertaken to examine outcrop in an old landslip scar between DN566417 and DN568424. The lower part of the landslip exposes red cleaved mudstone with minor quartz sandstone beds. The quartz sandstone in thin section is submature, with several percent chert and metamorphic rock fragments. Northwards, green and black slates crop out, then near the top of the landslide and on the crest of the ridge to the north, dolomitic mudstones and siltstones are exposed. A single bed of pure dolomite crops out near the top of the landslide. This rock has a well-preserved primary grainstone texture, and is composed of dark grey micritic intraclasts, some with a pronounced discoidal shape, cemented by sparry dolomite.

This sequence is rather different from the Mt Anne Group and must be regarded as of uncertain affiliation.

Depositional environments

The Twin Creek, Lake Judd and Lonely Tarns Formations are all dominated by pelite, and thin, graded siltstone layers are characteristic. A marine, low-energy shelf environment, below the influence of wave and tidal action, is considered likely. The graded silt layers were deposited from suspension clouds, as indicated by their persistence and basal concentrations of heavy minerals. The suspension clouds were presumably created by periodic storms in nearshore environments and swept offshore by storm-surge ebb currents (*cf.* Reading, 1978, p. 252). Dumping of silt onto uncompacted muds produced density instability, causing development of load structures and clastic dykes. The graded units lack the thickness and characteristic sedimentary structures of classical turbidites, and features associated with tidal mudflat deposition (flaser, lenticular bedding) are also lacking. Only at a few horizons in the Twin Creeks Formation and in the topmost part of the Lake Judd Formation, is there evidence for persistent sea-floor current action in the form of small-scale cross-bedding and ripple-marked bedding planes.

The Sarah-Jane Quartzite is similar to other thick, abundantly cross-bedded quartzarenite deposits of late Precambrian to Cambrian craton margins (see Walker, 1984). These deposits are generally considered to be products of a shallow-marine, tide-dominated shelf environment with net sedimentation rate keeping pace with subsidence (Walker, 1984). Abundant medium-scale planar-tabular cross-bedding, medium to coarse sand grain size, and high textural and mineralogical maturity are typical of these deposits (e.g. Swett *et al.*, 1971). The high maturity is considered to be a result of prolonged abrasion by tidal currents, which allow the necessary very great transport distances by back-and-forth reworking within the depositional area. Most fine-grained material is winnowed and transported offshore. Bipolar palaeocurrent directions, locally developed in the Sarah-Jane Quartzite, are diagnostic of tidal deposits, although unimodal patterns are actually more common in ancient tidal deposits (Levell, 1980).

Wind action has been shown to be far more effective than aqueous transport in abrading quartz sand (Kuenen, 1960), and aeolian abrasion is invoked by some writers (Boulter, 1978) to explain the high rounding and sphericity of quartz grains in some Precambrian quartzarenites. However, Balazs and Klein (1972) have shown, in a study of a modern intertidal sand body, that texturally supermature rounding of quartz can be produced by tidal bedload transport alone.

The laminated facies in the Sarah-Jane Quartzite has a close parallel in the laminated facies of Anderton, 1976) which is similarly a minor constituent of a late Precambrian tide-deposited quartzarenite. Anderton interprets this facies as predominantly upper phase plane bed origin, being rapidly deposited by decelerating currents probably related to periodic storms. The rippled tops of beds in this facies, present also in the Sarah-Jane Quartzite, may have been deposited by the waning phases of the storm surge current and may be partly the result of tidal reworking (Anderton, 1976). Dewatering structures (convolute lamination), restricted to this facies in the Sarah-Jane Quartzite, lend support to the concept of rapid deposition of this facies.

The Mt Anne Group was therefore laid down on a constantly subsiding shelf, with orthoquartzites reflecting an essentially proximal, shallow, mostly tide-dominated setting and the pelite-siltstone units representing a distal shelf environment below fair weather wave base.

Correlation

Elsewhere in the Jubilee region, thick quartzite units crop out on the Jubilee Range (east of Pedder map sheet) and on Schnells Ridge (to the south), and may represent correlates of the Mt Anne Group, but these areas are still poorly known. The Schnells Ridge quartzite is lithologically very similar to the Sarah-Jane Quartzite but is considerably thicker and more strongly deformed (Duncan, 1976).

Quartzites in nearby parts of the Tyennan region, described in a previous section are lithologically similar to, but mostly more intensely deformed than, the Sarah-Jane Quartzite. Unlike the Mt Anne Group, some of the associated phyllites contain sedimentary structures related to tidal mudflat or deltaic environments (Boulter, 1978).

PANDANI GROUP

Introduction

The Pandani Group, here defined, consists of (from the base) the Lot Formation (Ꝑsd), the Huon River Formation (Ꝑsm), and the Mt Bowes Formation (Ꝑss). Within the Huon River Formation, which comprises the bulk of the sequence, the Scotts Peak Road Member (Ꝑsr) and the Gelignite Creek Member (Ꝑsq) are differentiated. The Pandani Group is named after Pandani Shelf [DN533459], a topographic feature developed on the north-east ridge of Mt Anne. The sequence consists predominantly of pelite and carbonate (mostly dolomite) with minor intervals of quartzarenite. The Pandani Group like the Mt Anne Group dips steeply and faces predominantly north. The oldest beds crop out around Lots Wife [DN560440], the youngest on Mt Bowes [DN520550]. No top or base to the sequence is known. The Pandani Group is faulted against the Mt Anne Group to the south; at DN542463 it is unconformably overlain by the Weld River Group; and at DN490566 and DN510559 it is unconformably overlain by a ?Cambrian conglomerate-lithicwacke sequence (Ꞓals). Major faults transect the sequence at DN510500 and DN500526, and correlation is effected by the distinctive Scotts Peak Road Member which is present in all three of the resultant major fault blocks.

Exposure is generally poor, and conformity and continuity of the sequence are inferred from the relative constancy of bedding attitude and facing, with due allowance for folding. However, at the top of the Clear Creek Formation near Mt Bowes is a massive red mudstone unit (Ᵽse) whose conformity with the enclosing sequence is uncertain. Inclusion of Ᵽse with the Huon River Formation is therefore tentative, based on juxtaposition and lithologic similarity. Likewise, conformity of the Mt Bowes Formation with the Huon River Formation is not wholly clear; and this unit is included in the Pandani Group by virtue also of juxtaposition and lithologic similarity with the Gelignite Creek Member.

Two deformational events have produced an early slaty cleavage and a later crenulation, and a weak second crenulation is developed in a few places. The early cleavage is relatively intense to the south of the Sandfly Creek Valley [DN500500]; the rocks here are of lower greenschist facies, and the pelites are predominantly slates with some fine-grained phyllites. To the north, however, the early cleavage is very weakly developed and the rocks appear only very slightly metamorphosed.

Lot Formation (Ᵽsd)

The Lot Formation is defined here as the unit consisting predominantly of medium-to thick- bedded fine-grained carbonate with lesser interbedded slate and phyllite, cropping out east and north of Mt Lot [DN545442] (for which the formation is named) and overlain by the Huon River Formation at DN531467. No base is known; to the south-east the Lot Formation is faulted against the Mt Anne Group. The formation is a minimum of very approximately one kilometre in thickness.

Pelitic lithologies may locally exceed carbonate, and comprise a mappable unit (Ᵽsdm) near the top of the formation. Two impersistent, thin (<4 m) horizons of orthoquartzite (Ᵽsdq) are also indicated on the map.

The carbonate is predominantly dolomite with minor limestone. It is dark grey, less commonly pale grey, yellow, pinkish or greenish in colour, and is typically slightly impure, displaying a thin porous leached rind on weathered surfaces. Carbonate beds are usually internally uniform, but in places display thin internal planar bedding or lamination, or rarely, small-scale trough cross-lamination. Lamination may be an expression of variations in terrigenous content, or of limestone-dolomite alternation. A 0.3-m bed of oolitic limestone crops out at DN534451.

Stromatolites were observed at two horizons within the Lot Formation. Overlying the oolitic limestone bed at DN534451 is a metre-thick bed containing close-linked hemispheroidal stromatolites (nomenclature after Logan *et al.*, 1964) each about 0.25 m wide, with amplitudes about 0.2 m (dimensions measured on exposure surface approximately normal to both bedding and cleavage). At DN538463, space-linked hemispheroids, with amplitudes ≈0.15 m and widths ≈0.3 m, occur in several beds. The domes in plan view are ovoid, with an axial ratio of about 0.7:1; with the long axis parallel to the primary cleavage. Internally, the domes contain wavy, convex-up laminae.

The early cleavage is expressed in the carbonate layers as thin slightly wavy gently anastomosing phyllitic seams (tectonic stylolites) spaced more or less regularly in any one bed, 1–30 mm apart. The seams are prominent on weathered outcrop surfaces. The cleavage is strongly refracted at bedding interfaces with less competent pelitic layers in which the same surface is expressed as a slaty cleavage. Many relatively pure carbonate beds contain thin quartz veins, usually oriented subperpendicular to bedding; less commonly forming a random 'boxwork' structure.

Carbonate and pelite beds are usually intergradational. Pelites are black, red or pale green slates and fine-grained phyllites, and frequently contain planar laminae of dolomite, dolomitic siltstone or quartz siltstone. These sometimes display grading and basal load structures.

Thin (≈ 4 m) units of orthoquartzite crop out prominently at DN543457 and at DN542463, and are indicated on the map (Ᵽsdq). Both layers appear to be laterally impersistent, extending along strike no further than 200 m. The rock type is typical white or pink-tinged supermature orthoquartzite of 0.3–1.5 mm grain size. Both units are thin-bedded or massive and lack cross-bedding.

Thin sections of typical carbonates show a fine-grained xenotopic dolomite (15–20 μm grain size) with faint primary planar lamination defined by slight grain size and colour variations. Finer laminae are darker (more carbonaceous); coarser laminae contain a few percent detrital quartz silt. There are irregular patches, 2–3 mm wide, of very fine-grained (5–7 μm) xenotopic clear calcite, possibly remnants of the original limestone precursor. Euhedral albite microporphyroblasts, 50–150 μm in size, occur within the limestone patches. Early bedding-parallel microstylolites are weakly developed. The primary cleavage is represented by tectonic stylolites (seams) inclined to bedding and spaced a few millimetres apart. Within the microlithons and oriented normal to the tectonic seams and roughly parallel to bedding are numerous microscopic extension veinlets, 0.1–0.2 mm wide, filled with fibrous quartz and carbonate. These veinlets are variably developed, and represent up to about 30% extension. The limestone patches in one sample are fringed by pressure-shadow overgrowths of fibrous calcite. The albite micro-porphyroblasts are older than the tectonic fabric.

Other samples show a well-developed primary lamination in which many laminae are partially or wholly calcite. The calcite in all slides has the same appearance (microspar of 5–7 μm grain size) and is clearly being replaced by the coarser, pinkish-brown dolomite that comprises the bulk of the rock.

The widespread occurrence of the limestone patches, and the uniformity of the relatively coarse, xenotopic dolomite which clearly replaces calcite in some slides, suggest that calcite was the primary carbonate mineral. This dolomite fabric suggests deep-burial dolomitisation and contrasts with many other dolomites from higher in the Pandani Group and from the Weld River Group, which appear to be of early diagenetic origin.

The paragenesis in these rocks appears to be:

(i) dolomitisation,

(ii) bedding-parallel microstylolites,

(iii) albite microporphyroblasts,

(iv) thin dolomite-spar-filled veins in some samples

(v) cleavage (tectonic stylolites) and associated extensional features,

(vi) thin coarse calcite-spar-filled veins in some samples and

(vii) slight deformation causing deformed twin lamellae in the calcite veins.

The oolitic limestone (plate 7) consists of extremely well-preserved, tectonically deformed ooids 0.4–0.5 mm in diameter in a clear, fine-grained matrix identical in appearance to the calcite in other slides described above. The ooids are conspicuous, being coloured dark brown; and have a fine concentric layering and a fainter, coarser radial structure. The latter appears to be a product of recrystallisation, as the relatively broad radial zones are optically continuous. A few isolated large (1 mm) dolomite euhedra pre-date the deformation.

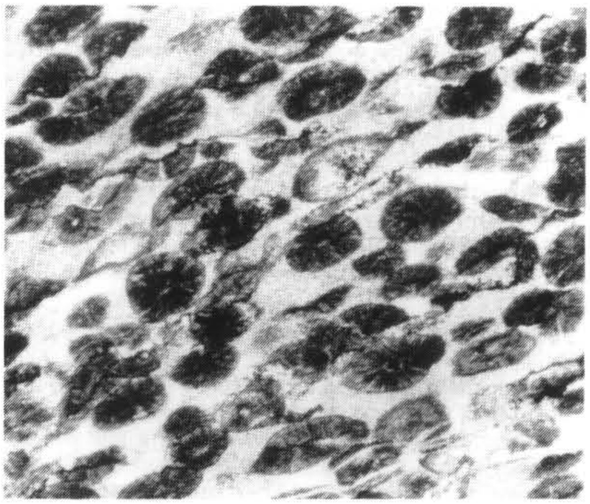


Plate 7. Thin section 001871 (Lot Formation): Deformed oolitic limestone. Field of view 3.8 × 3.3 mm.

5 cm

Huon River Formation (Ꝑsm, Ꝑsr, Ꝑsq, Ꝑse)

The Huon River Formation is defined here as the unit consisting of pelite with lesser siltstone and dolomite and minor quartzarenite, cropping out between the northern slopes of Mt Anne [DN531467] where it overlies, probably conformably, the Lot Formation; and Mt Bowes, where it is overlain, probably conformably, by the Mt Bowes Formation (Ꝑss). The name is derived from the Huon River whose upper catchment area is largely underlain by rocks of this formation. Within the formation, a quartzarenite and conglomerate unit (the Gelignite Creek Member, Ꝑsq) and an interlaminated pelite-siltstone unit (the Scotts Peak Road Member, Ꝑsr) are recognised. Several unnamed, impersistent dolomite (Ꝑsmd) and orthoquartzite (Ꝑsmq) units have been differentiated, and also a red mudstone (Ꝑse) at the top of the formation.

The sequence is broken into three major fault blocks. The presence in all three fault blocks of correlates of the Scotts Peak Road Member, allows the total thickness of the Huon River Formation (≈ 3 km) to be estimated.

As previously mentioned, there is a change in tectonometamorphic grade at about the latitude of Sandfly Creek [DN500500]. South of here, pelitic rocks are slates or low-grade phyllites with the primary cleavage inclined at a steep angle to bedding; to the north, the primary cleavage is reduced to a weak bedding-parallel fabric and the rocks appear to be unmetamorphosed mudstones. On the map, letter symbols for these unmetamorphosed parts of the Huon River Formation are suffixed with an apostrophe (Ꝑsm′, Ꝑsr′, etc.). The nature of the transition is unknown as it coincides with a broad zone of no outcrop; however, a major fault probably transects this zone. The northern area, where bedding is overturned and dips south-west, is probably the overturned limb of a major early fold; while the southern area, where bedding is upright and predominantly dips north-west, appears to represent the axial part of such a structure.

The predominantly siliciclastic Huon River Formation succeeds the predominantly carbonate Lot Formation around DN533647, but the contact is not exposed and the lower part of the Huon River Formation is poorly known. The sequence is very variable; probably the commonest lithology in the area encompassing the northern slopes of Mt Anne [DN533467–DN500475] is a red slate, sometimes massive but usually layered, with laminae or thin beds of quartz siltstone or rarely, fine-grained quartzite. Almost as common are black pyritic phyllite and greenish-grey phyllite which appear to contain fewer, and thinner, psammitic layers. The quartz siltstone layers are usually planar, sometimes cross-laminated, and sometimes graded. Many are associated with clastic dykes.

Commonly interbedded with the pelites and siltstones on all scales are grey to pink, fine-grained dolomite, and impure dolomitic rocks which are usually deeply leached to produce a soft, early yellow-brown rock. Impure dolomites commonly have a seamed, anastomosing cleavage while pure dolomites lack cleavage. At DN527466, beds of thinly laminated pure grey dolomite occur within dolomitic mudstone; in one bed the laminae are gently domed, suggesting a stromatolitic origin. Within an interval predominantly of red slate at DN531468, possible small stromatolites overlie a bed of flat-pebble dolomite breccia.

On an isolated knoll at DN493471 crops out an unusually pure, white, massive, very fine-grained dolomite. A close-spaced boxwork of randomly-oriented quartz veins, each 0.5 mm to several centimetres wide, pervades the rock and weathers out in positive relief.

Road cuttings near Sandfly Creek [DN486496–DN408482] provide good exposure through part of the Huon River Formation. The two dolomitic units indicated at DN478485 and DN480483 have been deeply leached to produce an earthy 'pug' in which sedimentary structures are still preserved, and in some beds, the anastomosing seamed cleavage typical of impure carbonates. Planar lamination, cross-bedding and an oolite bed are evident in the upper unit which immediately underlies the Scotts Peak Road Member. Between the dolomitic units at DN479484, road cuttings expose white, siliceous cherty mudstone interbedded with slate. Overlying the Scotts Peak Road Member, at DN480489 and DN486495, are white to pale green weathered slate with planar siltstone laminae.

The upper part of the Huon River Formation (overlying the Scotts Peak Road Member) is well-exposed in road cuttings between DN490566 and DN486534. This area is occupied by the relatively weakly tectonised mudstone phase (Ꝑsm′) of the Huon River Formation. The road cuttings are dominated by red mudstone and soft red-brown fine-grained beds that again probably represent deeply-weathered dolomitic rocks. The red mudstone contains minor siltstone layers and occasional beds of fine-grained intraclastic breccia, which in places resembles coarse-grained lithic sandstone. Chert nodules are present at a few horizons.

Thin sections from Ꝑsm′ show pelites composed of extremely fine-grained to cryptocrystalline sericitic layer silicates with a bedding-parallel fabric readily discernible as an extinction direction under low magnification. A close-spaced crenulation (S_2) is present.

Away from the road, in areas of natural outcrop, the leached rocks are less in evidence and outcrop of 'solid' dolomite appears more abundant. the dolomite units (Ꝑsmd′) are well-bedded or laminated, and in thin section are seen to be very fine-grained (5–20 μm). Fine-grained quartz partially replaces some layers. The rocks appear to be unstrained apart from a locally developed seamed cleavage (S_2). Two thin sections contain pseudomorphs, with hexagonal and rhombic outlines, 1–1.5 mm in diameter, composed of fine-grained quartz and dolomite but originally possibly celestite or gypsum. Another section is dolomicrite, quite uniform apart from minor stylolitic stringers containing numerous small (0.5 mm) columnar subhedral crystals of authigenic quartz. Dolomicrites are generally considered to be of early diagenetic origin (e.g. Morrow, 1983, p. 100).

The dolomite unit at DN494556, like that at DN493471, is massive, white, and probably quite pure.

Intraclastic breccias are developed in a few places in Ꝑsmd′. These appear to be of sedimentary origin except for an occurrence at DN491549 which may be an evaporite collapse breccia or a karst filling. This occurrence is a bed consisting of angular dolomite fragments up to 30 mm long, in closed-framework with a fine-grained dolomite matrix rich in quartz silt. The fragments are fine-grained laminated dolomite with varying proportions of quartz silt, sericite and carbonaceous material. Development of bedding-parallel microstylolites and secondary dolomite veins in the fragments pre-dates formation of the breccia.

Orthoquartzite (Ꝑsmq) crops out intermittently along two horizons in the middle part of the Huon River Formation. On the lower horizon, stratigraphically 200–300 m below the Scotts Peak Road Member, orthoquartzite occurs between DN470484 and DN496481. The upper horizon immediately underlying the Scotts Peak Road Member, is more persistent and orthoquartzite appears intermittently at this level in all three major fault blocks. The orthoquartzite is significantly more resistant to erosion than the surrounding sequence and invariably crops out along the crests of low ridges and hills. Neither unit exceeds 6 m in thickness. The rock is a typical white medium-grained orthoquartzite, usually thinly-bedded, in places ripple-marked, but only rarely cross-bedded. The substantially thicker quartzarenites of the Gelignite Creek Member (Ꝑsq) and the Mt Bowes Formation (Ꝑss) are of noticeably lower mineralogical and textural maturity.

A massive red mudstone (Ꝑse) occurs at the top of the Huon River Formation. Sparse bedding readings within Ꝑse do not suggest conformity with the adjoining parts of the Huon River Formation or the Mt Bowes Formation, but the occurrence of similar lithologies in both Formations suggests that Ꝑse belongs to the Pandani Group, and it is tentatively included in the Huon River Formation. The rock type is a rather tough, uniform, cleaved, slightly silty, massive red mudstone. Reduction spots are common. At DN509544–DN512542 the rock is slightly dolomitic, and in places sparse voids distributed along particular horizons probably represent weathered carbonate nodules. There are rare, thin beds of fine-grained quartzite.

Scotts Peak Road Member (Ꝑsr)

The Scotts Peak Road Member is here defined as the unit of variegated (usually reddish) interlaminated slate and siltstone, conformably enclosed by weathered pale greenish-grey to yellow-brown slate and dolomitic siltstone of the Huon River Formation on the Scotts Peak Road between DN478486 and DN479487. It is about 200 m thick and extends along strike to west and east. Probable correlates in two fault blocks to the north [DN500510, DN500530] belong to the weakly cleaved mudstone phase (Ꝑsr′).

In the type area, the rock is a hard slate, coloured yellow-brown, olive-grey, reddish, or black; with usually about 20–30% consisting of reddish siltstone laminae. The siltstone laminae are planar; rarely, they are lenticular or truncated at a low angle by overlying layers. They are usually graded, but unlike other graded

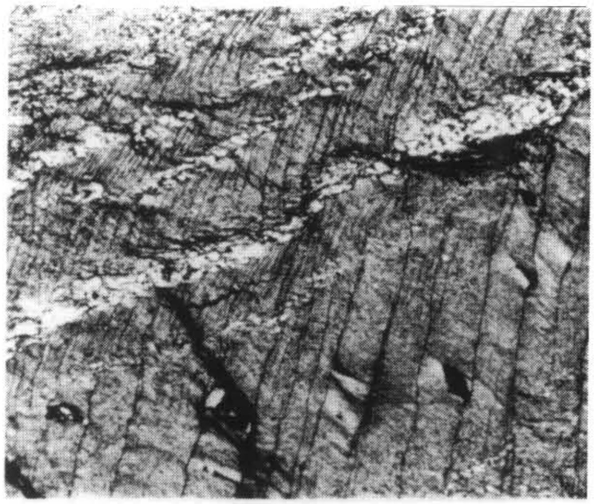


Plate 8. Thin section 001830 (Scotts Peak Road Member): Slate with thin graded siltstone laminae, a crenulation cleavage (S_2) and deformed pseudomorphs of iron oxide after pyrite. Field of view 3.2 × 2 mm.

5 cm

siltstones in the Clear Creek Formation, these show no internal lamination and clastic dykes are absent. Features indicative of synsedimentary disruption (slump folds, sedimentary boudinage, intraclastic breccia) are not uncommon. The siltstones predominantly consist of quartz, up to 30% granular iron oxide, and minor detrital muscovite. The proportion of matrix increases upwards through graded layers. Pelite layers are fine-grained slates lacking detrital quartz, with primary cleavage steeply inclined to bedding and a strong crenulation (plate 8). Some slate laminae contain abundant deformed pseudomorphs of iron oxide after cubic pyrite (plate 8) suggesting thorough diagenetic oxidation of a sediment originally rich in reduced iron.

The mudstone phase (Ꝑsr′) is similar in every respect except that the primary cleavage is expressed as a weak bedding-parallel fabric described above. Thin sections show chlorite as an authigenic cement in some siltstone layers.

Gelignite Creek Member (Ꝑsq)

The Gelignite Creek Member is here defined as the unit of sublithic quartzarenite and conglomerate that crops out along the crest of the unnamed sinuous ridge that extends west from the Scotts Peak Road [DN485495] almost to the Huon River [DN460495]. The outcrop is surrounded by broad areas of surficial Quaternary cover, but the unit appears to conformably overlie rocks similar to the Scotts Peak Road Member at DN478494 (N.J.T.), and gentle major folds are in harmony with those in the Huon River Formation to the south of Sandfly Creek. The Gelignite Creek Member is at least 200 m thick at the fault–truncated western end of the ridge but appears to become thinner eastwards. The road cutting at DN486496 appears to be the eastern limit of the unit, where a few metres of pink quartzarenite are conformably underlain by weathered slate and dolomitic rocks of the Clear Creek Formation. The top of the unit is everywhere obscured by Quaternary cover. The unit appears to be absent from the same stratigraphic level elsewhere, and is therefore probably a stratigraphically impersistent, single lenticular deposit. The member is named after a nearby creek [DN492512].

The Gelignite Creek Member is composed of white to pink medium–bedded, medium-to coarse-grained quartzarenite with lesser closed-framework quartzitic pebble conglomerate. Cross-bedding is uncommon.

Clasts in the conglomerate include quartzite, chert, mudstone, and weathered ?dolomitic mudstone. The quartzarenite is moderately to well-sorted, with sub-rounded to well-rounded quartz grains, a few percent chert and fine quartzite grains, and minor tourmaline and zircon. Some chert grains show evidence of derivation from carbonate rocks (oolite 'ghosts', rhomb-shaped pseudomorphs).

Since the nature of the sequence overlying the Gelignite Creek Member is unknown, a possibility remains that the unit belongs not to the Pandani Group but is a correlate of the Annakananda Formation, the basal clastic unit of the Weld River Group. The presence of the conglomerate and the relative immaturity of the quartzarenite are unlike any other known pre-Weld River Group units except for the Mt Bowes Formation which is similarly uncertain in its stratigraphic assignation. By comparison with the Annakananda Formation, the Gelignite Creek Member is considerably more quartz-rich and poorer in clastic dolomite but otherwise its provenance appears similar.

Mt Bowes Formation (Ᵽss)

The Mt Bowes Formation is defined here as the unit consisting of quartzarenite interbedded with lesser siltstone and red mudstone, and minor conglomerate, on the southern ridge of Mt Bowes [DN517548] between DN523535 and DN529540. This section is about 500 m thick. At the former locality a conglomerate (Ᵽssc) probably marks the lowest part of the formation; the base is not exposed but bedding appears to be broadly conformable with the underlying Clear-Creek Formation (predominantly dipping south-west and overturned). The top of the formation is not exposed; the contact with the Weld River Group to the east is a fault.

The formation is erosionally resistant and crops out on Mt Bowes and on the crests of hills to the south. Around DN515520, upright folds have an enveloping surface that dips gently south-west and is overturned.

The conglomerate (Ᵽssc) consists of at least 40 m of thick-bedded to massive, closed-framework pebble-cobble conglomerate with minor interbeds of red mudstone and quartzarenite (Ᵽssc). Clasts are well-rounded and consist mainly of white to red very fine-grained quartzite and yellow chert. Minor pebble and granule conglomerate persists into the lower parts of the overlying, predominantly quartzarenite sequence, notably at DN516549 and around DN527535.

The formation consists of medium- to fine-grained, white to red quartzarenite interbedded with red mudstone and quartz siltstone. Quartzarenite is predominant but thick (up to 50 m) intervals of mudstone occur. Quartzarenite layers range from laminae to very thick beds and are nearly always planar and internally structureless. Cross-bedding and ripple-marked bedding planes are only rarely preserved. Cross-bed sets are trough-shaped and 50–200 mm thick. The quartzarenite is moderately to well-sorted, with angular to well-rounded quartz grains, a few per cent chert and fine quartzite fragments and accessory tourmaline and zircon. Usually, the rock is cemented with syntaxial quartz overgrowths.

The siltstone and mudstone are usually fissile, nearly always red, rarely grey-green in colour. Commonly, red rocks are mottled with patches of white, or vice versa; a pattern that is unrelated to primary textural variations and probably reflects diagenetic redistribution of the ferruginous pigmentation.

In several places, particular mudstone beds feature numerous tabular clastic dykes that intrude stratigraphically downward from overlying quartzarenite layers. The dykes are 5–10 mm thick and 50–100 mm deep, sometimes tapering downwards, and usually slightly buckled as if by compaction. In plan view the dykes form a polygonal pattern, with polygons 100–150 mm wide (plate 9). These structures probably originated as desiccation cracks.

Plate 9. Bedding-plane view of desiccation cracks, Mt Bowes Formation. Photo by K. D. Corbett.

5 cm

Depositional environments

Most Pandani Group sedimentation appears to have taken place in a marine environment sufficiently deep to escape the effects of tidal and wave-driven currents. Terrigenous or carbonate muds were deposited, often simultaneously, from suspension in a low-energy probably distal shelf environment. Graded siltstone laminae may be storm-laid deposits as suggested for identical structures in the Mt Anne Group. However, at many levels throughout the Lot Formation and lower Huon River Formation are features suggestive of persistent current action in shallow water: stromatolites, oolites, and ripple-marked, cross-bedded orthoquartzite layers. Such features appear to be lacking from the upper part of the Clear Creek Formation (above the Scotts Peak Road Member) but possible evaporite pseudomorphs and early diagenetic dolomites here suggest shallow, occasionally hypersaline conditions.

The two thick arenaceous units, the Gelignite Creek Member and the Mt Bowes Formation, record a significantly different environment. Both units are notably less mature, compositionally and texturally, than the minor orthoquartzites (Ᵽsdg, Ᵽsmg) of the Lot and lower Huon River Formations, and the thick orthoquartzites of the Mt Anne Group. They have therefore presumably escaped the extensive tidal reworking thought to be responsible for the supermaturity of those rocks. The redbeds and desiccation cracks in the Mt Bowes Formation suggest a terrestrial environment.

Correlation

The Pandani Group is broadly similar in lithologic character to the Clark Group. Both are thick sequences dominated by pelite, siltstone and carbonate, in places stromatolitic and evaporitic. The Clark Group is of similar very low tectonomorphic grade to the northern

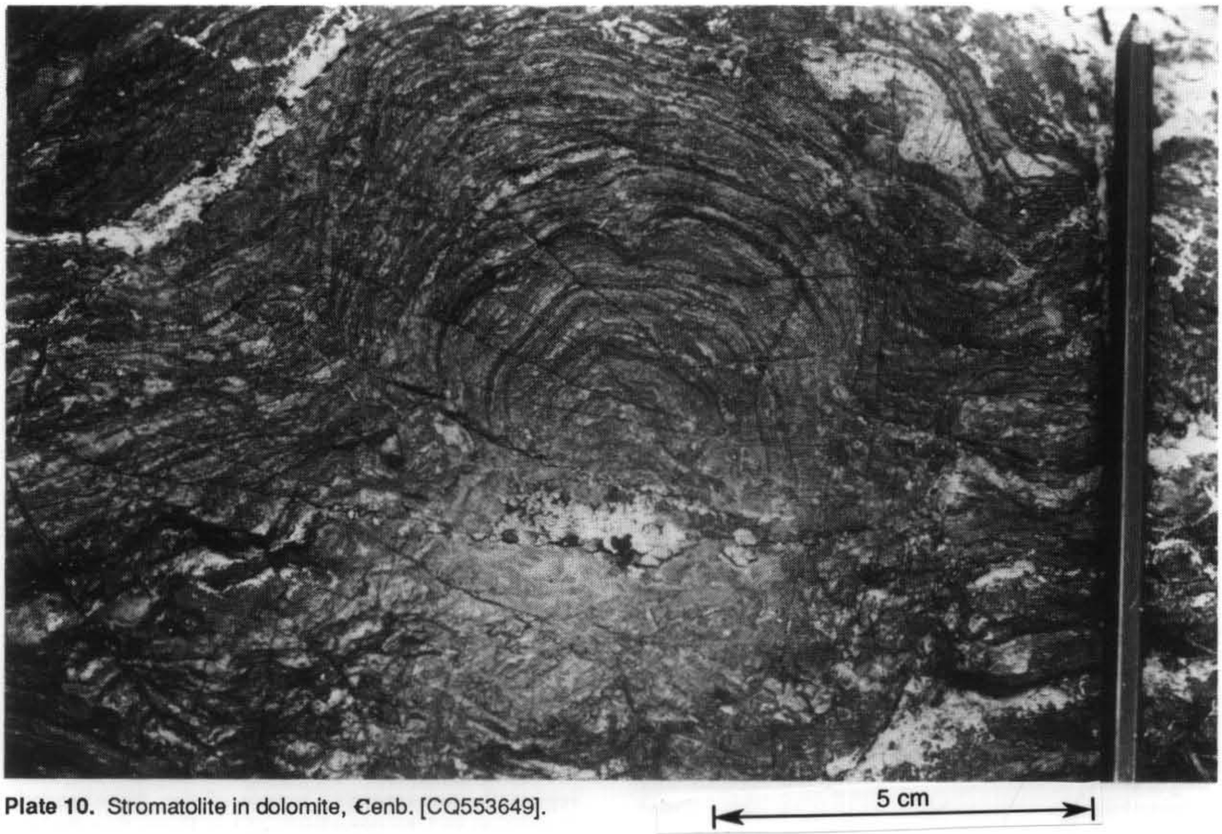


Plate 10. Stromatolite in dolomite, €enb. [CQ553649].

part of the Pandani Group. However, there is no closer stratigraphic correspondence; and no equivalent of the Needles Quartzite in the Pandani Group.

CLARK GROUP AND CORRELATE

Introduction

The Clark Group (Carey and Banks, 1954, p.249) is a Precambrian sequence that occupies the south-eastern corner of the Huntley map sheet (immediately north of Pedder). This sequence, of unmetamorphosed quartzite, argillaceous dolomite, mudstone and siltstone, is briefly described by Spry (1962) and Calver (1989*a*). The Needles Quartzite (€ens), a unit low in the Clark Group, crops out in a small area in the north-eastern corner of the Pedder Quadrangle [DN580668]. In a larger area north of Mt Mueller [DN560650–DN540640] there is a west-facing sequence of unmetamorphosed mudstone, siltstone and dolomite which are lithologically similar to the Clark Group, and although there appears to be no stratigraphic correspondence between the units mapped in this sequence and the subdivisions of the Clark Group, it is considered a probable correlate of the Clark Group. The sequence may represent the faulted western limb of the Needles Anticline, a major NW-plunging fold developed in the Clark Group on Huntley Quadrangle.

Bedding attitude and facing are constant except for minor folds and indicate a conformable west-facing sequence which is divided into four units. No formal nomenclature is applied. No top or base to the sequence is known. It is faulted against a ?Cambrian lithicwacke sequence (€als)to the east, and unconformably overlain by Denison Group to the north and Parmeener Supergroup to the south.

These rocks are shown on Pedder and Huntley maps as Eocambrian or Early Cambrian in age due to their unmetamorphosed character. The term 'Eocambrian' has been applied in Tasmania (Williams, 1976) to a cratonic shallow-water sedimentary sequence (the Success Creek Group and correlates), that unconformably overlies more deformed Precambrian rocks, and the subsequent unfossiliferous 'geosynclinal' sequences of turbiditic siliciclastics and volcanics (Crimson Creek Group and correlates: Brown, 1989). No rocks of proved Early Cambrian age are known in Tasmania. On Pedder Quadrangle, the Weld River Group is considered a correlate of the Success Creek Group (see below). On lithologic grounds, the Clark Group is unlikely to be a correlate of, or to be younger than, the Weld River Group. Rather, the Clark Group resembles lithologically the older Precambrian sequences (Pandani Group and Mt Anne Group). The occurrence of unmetamorphosed parts of these sequences described above, demonstrates that low metamorphic grade cannot be used as an indication of an Eocambrian or Cambrian age; and the Clark Group and its correlate on Pedder Quadrangle are therefore here regarded as pre-Eocambrian (*sensu* Williams, 1976).

€ena

This, the oldest unit, consists of quartz siltstone and red and green mudstone, with minor fine-grained orthoquartzite and rare dolomite. The siltstone is thin-bedded, slightly micaceous and has partings and interbeds of mudstone. The siltstone is resistant and in places there is transition to fine-grained quartzite. Ripplemarks (wavelengths 20–30 mm) and low-angle cross-lamination are common. Mud-flake intraclasts are present. Quartz siltstone is the predominant lithology but a few outcrops of massive mudstone were observed. Within the area mapped as €ena, at DN558660 there is an outcrop of pale grey, massive, fine-grained dolomite; and at DN556653 an outcrop of black micaceous shale with a bed of dark grey dolomite which resembles the following unit (€enb).

A thin section of the quartz siltstone shows a rock composed of well-sorted angular quartz silt and minor detrital muscovite, in a matrix of chlorite which is probably an authigenic cement.

€enb

At DN553649 €ena is conformably overlain by €enb, which consists predominantly of black micaceous shale with minor thin siltstone laminae and minor dark grey fine-grained dolomite. The dolomite is somewhat impure, and has a brown weathering crust. At DN553651, a 0.3 m-thick dolomite bed contains several small columnar stromatolites (plate 10). These are of the laterally-linked hemispheroidal type (Logan *et al.*, 1964); the flanks of the structures are perpendicular to bedding or slightly oversteepened.

€enr

The base of this unit was not observed. €enr consists of thin-bedded red mudstone and dolomitic mudstone. Dolomitic beds are marked by the development of a thick brown soft weathering crust on outcrop surfaces. There appears to be a transitional contact with the overlying dolomite unit (€enl) as dolomite and red dolomitic mudstone are interbedded near the top of this interval.

€enl

This unit consists predominantly of white or pale grey, fine-grained dolomite. Commonly, the dolomite contains a minor proportion of argillaceous material and outcrop surfaces have a thin brownish weathering rind. Slight compositional variations impart a thin bedding or lamination to most outcrops. One outcrop of laminated dolomite [DN542644] contains a few laminae that are distorted into cuspate shapes that resemble convolute lamination produced by dewatering.

Microscopically, the dolomite textures are variable. Primary textures are sometimes well-preserved and closely resemble grainstones of the Weld River Group. One sample is a fine-grained catagraphic grainstone with minor laminoid birdseye structures; another is a catagraphic packstone. A third slide is coarsely recrystallised with no vestige of the original fabric.

WELD RIVER GROUP

Introduction

The Weld River Group consists of (from the base) the Annakananda Formation (€ewtc), the Gomorrah Dolomite (€ewtf), the Devils Eye Dolomite (€ewtg), the Styx Dolomite (€ewtd) and the Cotcase Creek Formation (€ewc). The sequence is briefly described, and stratigraphic names are defined, by Calver (1989*c*). Dolomite is the overwhelmingly predominant rock type, and the sequence occupies most of the catchment of the upper Weld River [DN550580]. The oldest unit (the Annakananda Formation) unconformably overlies the Pandani Group. No top to the sequence is known; the youngest parts of the Cotcase Creek Formation are unconformably overlain by the Cambro-Ordovician Denison Group and faulted against Cambrian(?) Ragged Basin Complex. There is no known stratigraphic transition between the Cotcase Creek Formation and the other, probably older formations of the Weld River Group; only faulted contacts are known. However the intimate juxtaposition and broad lithologic similarity of the Cotcase Creek Formation with the older units suggests they be unified under a lithostratigraphic name of group rank.

The Annakananda Formation, Gomorrah Dolomite, and Devils Eye Dolomite crop out in conformable sequence on Mt Anne's north-east ridge [DN550470] where they are overturned and face north-east. The same sequence, with the addition of the Styx Dolomite, occupies the eastern half of the upper Weld Valley and faces north. Here, the Annakananda Formation paraconformably overlies a possible Mt Anne Group correlate (Ᵽes′). The top of the Styx Dolomite is unknown. The Cotcase Creek Formation occurs as three juxtaposed fault blocks occupying the western upper Weld catchment [DN540580–DN570490].

Dolomites of the Weld River Group, unlike those of the Pandani and Clark Groups, are characteristically pure, except for some secondary silicification, and are nearly always white to pale grey in colour. Karst topography is developed over much of the area.

Metamorphic rank is of sub-greenschist facies. The dolomites are essentially unstrained. Mixtites and rare mudstones have a weak cleavage close to bedding, and in some places, a crenulation.

Annakananda Formation (€ewtc)

The Annakananda Formation, the relatively thin siliciclastic unit at the base of the Weld River Group, unconformably overlies the Pandani Group in the Lake Timk-north-east ridge area. The type section, at DN543463 on the north-east ridge, consists of a few metres of sandstone, in places cross-bedded and ripple-marked, followed by very approximately 10 m of massive pebble-cobble conglomerate, succeeded by 10 m of yellow brown fine dolomitic sandstone which grades up into the overlying grey, massive Gomorrah Dolomite. The surface of unconformity is not exposed; the unconformable relationship is inferred from the regionally transgressive nature of the Annakananda Formation and the prevalence of Lot Formation-derived conglomerate in the Annakananda Formation. The unconformity and overlying Weld River Group are here overturned, and dip steeply south-west.

At DN547457, along strike to the south-east, the Annakananda Formation consists of about 30 m of interbedded conglomerate and laminated sandstone separated from the Lot Formation by a half metre thick layer of slickensided quartz. At DN558452, south of Lake Timk, the unit is thicker (more than 100 m?) and is considerably deformed. Dolomitic clasts are flattened (axial ratios typically approximately 5:1), while the more competent quartzite and chert clasts remain equant.

The conglomerate is typically massive, closed-framework, of pebble- to cobble-grade, and mostly reddish in colour. Clasts are rounded, and appear to be mostly or entirely derived from the underlying Lot Formation. Clasts of dark grey, red or yellow fine-grained dolomite and impure (argillaceous or silty) dolomite are predominant. About 5–10% are orthoquartzite; less significant are phyllite, quartz siltstone and chert. Siltstone and chert clasts show patchy replacement by dolomite; and some cherts have distinct rhombic 'ghosts', probably pseudomorphs after dolomite, suggesting an earlier phase of carbonate silicification. These diagenetic changes pre-date formation of the conglomerate. The matrix is composed of sand-sized lithic fragments (fine-grained dolomite and chert) and quartz. Quartz grains are frequently well-rounded, suggesting derivation from orthoquartzite. Detrital muscovite and rare K-feldspar are also present.

The associated sandstones are thick-bedded to thinly laminated, rarely with poorly-defined cross-bedding. They are red, yellow or grey, moderately-sorted lithic sandstones with a similar composition to the matrix of the conglomerate described above. Laminated black, red and white dolomitic siltstones are interbedded with the sandstones at several localities.

The Annakananda Formation correlate in the Weld River area [DN563533] is predominantly mudstone (€ewctm), and paraconformably overlies siltstone and mudstone (Pes′:possible Mt Anne Group correlate). The section exposed on the Weld River begins with a 300 mm bed of closed-framework pebble conglomerate, which is succeeded by about 10 m of thinly-bedded red mudstone, with sparse, very thin planar laminae of lithic sandstone. Some laminae are only one or two grains thick. Similar mudstone crops out in the eastern tributary (around DN576534). Some bedding-parallel shearing of the unit is evident in this area.

Gomorrah Dolomite (€ewtf)

The Gomorrah Dolomite consists predominantly of massive, fine-grained dolomite and conformably overlies the Annakananda Formation on the north-east ridge of Mt Anne. The formation is about 800 m thick, and is overturned. The base of the formation is exposed in the precipitous southern wall of the sinkhole at DN543463, where pale brown dolomitic sandstone of the Picone Formation is transitionally overlain (stratigraphically) by thick-bedded to massive, pale grey Gomorrah Dolomite. The formation includes rare units of sandstone, mudstone and minor chert (€ewtfs).

The Gomorrah Dolomite is nearly everywhere a white to pale grey dolomite that is fine-grained, massive and rather uniform. Outcrops often bear a network of etched, fine random fractures and joints, and sometimes sheet veins or breccia veins, either of carbonate or of quartz. Bedding is preserved rather rarely: on perhaps only 10% of outcrops can bedding be identified. It is typically expressed as a finely corrugated outcrop surface that reflects differential erosion of planar, thin beds or laminae. The layering results from variations in grain size, with coarser (0.1–0.2 mm) layers weathering more prominently. Layers of differing colours (yellow brown to grey), reflecting slight compositional variations, are developed on the north shore of Lake Timk. Rarely, the dolomite contains up to 30% rounded quartz sand grains. In thin section, a typical laminated dolomite has a xenotopic, recrystallised fabric with grain sizes varying from 0.02–0.2 mm in adjacent, well-defined laminae. Much of the rock, particularly the finer layers, has abundant, indistinct, clots of more opaque material about 0.2 mm in diameter which may be remnants of original peloids.

A number of large ellipsoidal structures of uncertain origin protrude from several well-exposed bedding planes on the north shore of Lake Timk (plate 11). Bedding here is considered to be overturned; the structures, which otherwise superficially resemble stromatolites, protrude downward stratigraphically. They are 150–400 mm in diameter and up to one metre long, with long axes perpendicular to bedding. They are composed of yellow-brown dolomite and appear to be appreciably more resistant to erosion than the enclosing grey thinly-bedded dolomites. The structures have fine concentric internal laminae that conform to their outward shape, being parallel to the margins and strongly convex-downward (stratigraphically) in the axial regions. Two of the structures contain conformable pale green mudstone layers that thicken in the axial region. The structures are rather sparsely distributed on particular bedding planes. Surrounding bedding is slightly deformed as if by slight compaction about these bodies. Very similar structures are described by Walkden and Davies (1983), and attributed to the effects of near-surface, localised intrastratal solution, accompanied by subsidence of overlying unconsolidated sediment into the solution pits.

Plate 11. Enigmatic ellipsoidal structures, Gomorrah Dolomite, Lake Timk. Bedding is approximately parallel to surface of outcrop.

5 cm

Two small areas of terrigenous sandstone and pelite (€ewtfs) are known. Neither appears to be laterally persistent. The first crops out along 150 m of stream bed immediately west of Lake Timk. This is a tightly-folded sequence of fine-grained lithic sandstone, mudstone and chert, which appears to be structurally discordant with the surrounding dolomite (see Structural Geology section). The lithic sandstone and mudstone, grey to green in colour, are thinly interbedded and interlaminated, and many sandstone layers are graded. The sandstone contains about 50% quartz, the remainder being mudstone, dolomitic mudstone and dolomite grains, in a chloritic matrix. There is a slaty cleavage parallel to bedding. Also cropping out in this sequence are laminated black carbonaceous shale, and purplish-grey fine-grained slate containing thin beds of turquoise-coloured chert. Upstream, there is outcrop of interbedded dolomite and red mudstone that appears to be conformable with the enclosing dolomite sequence, and possibly represents the upward transition to dolomite.

The second pelitic outcrop is not shown on the map, but occurs in an eastern tributary of the Weld River at DN577543. Here, about 5 m of red mudstone is conformable with the enclosing dolomite sequence. The mudstone contains a few per cent of lithic sandstone as very thin, planar laminae, in places weakly graded. This lithology is identical to the nearby Annakananda Formation correlate (€ewtcm).

Lake Timk Formation (€ewtm)

Laminated pebbly dolomitic mudstone (€ewtm) underlies dolomite and overlies basal conglomerate (Annakananda Formation) south of Lake Timk. This unit, the Lake Timk Formation, is up to 300 m thick and appears to thin rapidly westwards. It is not clear whether the wedge-like shape of the formation is due to lateral facies change or faulting. The upper and lower boundaries are not exposed. The predominant rock type is a black to grey-green dolomitic mudstone, with perhaps 10% consisting of thin laminae of lighter-coloured dolomitic quartz-rich siltstone. The mudstone is usually pyritic. The siltstone contains about 30% grains of very fine-grained to cryptocrystalline dolomite. Some siltstone laminae display tiny basal load structures and are weakly graded. In several places, there are sparse floating granules and pebbles (lonestones) of dolomite and (less commonly) quartzite. Disruption of laminae by the lonestones was not observed. This unit is texturally akin to some of the mixtites of the Cotcase Creek Formation described below.

Devils Eye Dolomite (€ewtg)

The Devils Eye Dolomite consists of pale grey dolomite, distinctive by virtue of its well-bedded appearance and the common occurrence of well-preserved primary grainstone textures. It overlies, probably conformably, the Gomorrah Dolomite on the north-east ridge of Mt Anne [DN550468] and, in a separate area of outcrop in the upper Weld Valley, is overlain, probably conformably, by the Styx Dolomite around DN554578.

The formation appears to be at least 2.5 km thick. On the north-east ridge, the lower 1.3 km of the formation is present; the top is faulted out. In the Weld Valley, a major fault transects the formation; the thicker, apparently unfaulted northern block contains about 2.5 km of Lake Timk Dolomite.

Like the underlying Gomorrah Dolomite, this formation is composed almost entirely of clean, pale grey dolomite, but is distinguished by the presence of numerous beds in which arenaceous or rudaceous grainstone textures are preserved. In some outcrops, grainstone is pervasive, but usually there is considerable interlayered fine-grained, uniform dolomite. Bedding on weathered outcrops is usually enhanced by selective partial silicification of the grainstone layers. Bedding is thus readily discernible in most places, unlike the predominantly massive dolomites of the rest of the Weld River Group.

The grainstone beds are usually gently lenticular and are frequently cross-bedded, with sets 50–100 mm, rarely 200 mm in thickness (plate 12). Herringbone cross-bedding is common. Locally developed at the bases of some beds, and filling shallow scours, are thin lenses of flat-pebble breccia composed of platy intraclasts up to 30 mm long, oriented subparallel to bedding. Commonly, the spaces between the flat pebbles are partially filled by interstitial sand- and silt-sized grains, so that remaining pore space (now occluded by clear sparry dolomite or quartz cement) occurs only immediately beneath the larger intraclasts. This geopetal fabric, usually termed shelter porosity, is often sufficiently clear in outcrop to be used as facing evidence.

The partial silicification that affects most grainstone outcrops is thought to be not of replacement origin, but a late-stage cement present only in the largest interstices (see below). Deeply-leached outcrops of flat-pebble breccia may thus display a 'negative' of the original sedimentary texture, due to differential solution of the carbonate.

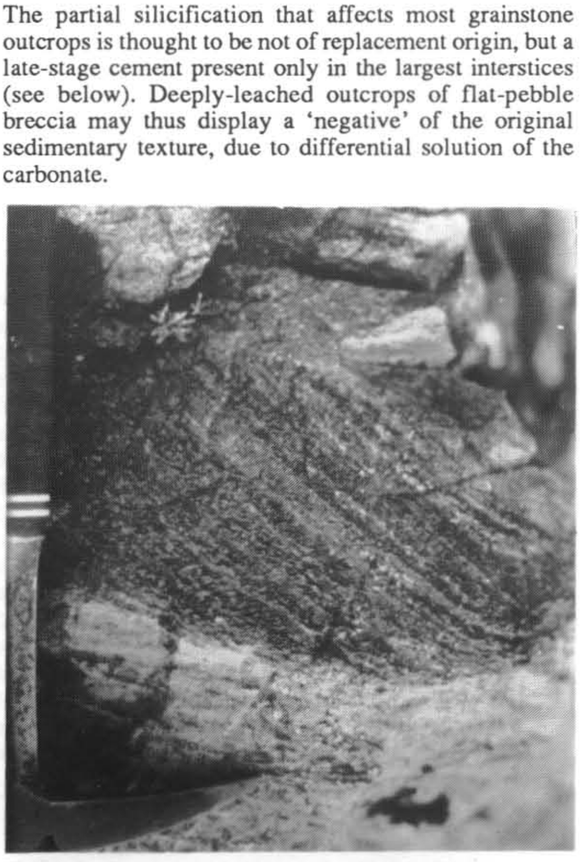


Plate 12. Cross-bedded layer of partly silicified grainstone overlying micritic dolomite, Devils Eye Dolomite.

5 cm

Arenaceous grainstone beds are easily identified when partially silicified, as weathered outcrop surfaces clearly show the granular texture and primary sedimentary structures such as cross-bedding (plate 12). Unsilicified grainstones are less easily identified; commonly the grains (e.g. oolites) are visible as lighter-coloured, slightly more deeply-etched bodies in a darker matrix.

Dolomite conglomerate is exposed along the fault-line scarp that terminates the north-east ridge section [DN553484]. The lower contact of the conglomerate was not observed. The conglomerate is presumably a conformable unit within the Devils Eye Dolomite. It is a massive, closed-framework rock composed of well-rounded pebbles and cobbles of Weld River Group-type dolomites and rare quartzite. About 40% of dolomite clasts are grainstones, the rest are fine-grained and uniform or laminated, or coarsely recrystallised. Significantly, the clasts are not silicified but otherwise have textures and cements that are identical to the enclosing sequence and which pre-date the formation of the conglomerate.

The top 100 m or so of the Devils Eye Dolomite, where exposed in the Weld River [DN555578], contains a few per cent scattered well-rounded quartz sand grains. Quartz sand persists into the lower part of the overlying Styx Dolomite.

Grainstone petrography

A preliminary petrographic examination of the grainstones of the Devils Eye Dolomite, using about twenty thin sections, shows that primary depositional textures and early diagenetic phases are usually well-preserved, allowing a general paragenetic sequence to be established.

Essentially three types of particle comprise the grains (allochems) in the grainstones: catagraphs, ooids, and intraclasts. Volumetrically the most significant are catagraphs – spheroidal to irregular grains, 50–500 μm in diameter, with sparry interiors and micritic rims (plate 13). These structures are thought to be of microbial origin (Hofmann, 1987). In the Devils Eye Dolomite samples, the catagraph walls are usually clearly defined, only 1–10 μm thick, and are the substrate for a secondary cement that has grown centrifugally and centripetally to fill intergranular and intragranular porosity. This texture resembles many diagenetically modified Phanerozoic limestones in which micritised envelopes around grains are preserved as a stable residue (with sufficient mechanical strength to maintain their original shape) while the grain interiors undergo dissolution and reprecipitation (aragonite to calcite transformation) (Bathurst, 1971, p. 333). In the Devils Eye Dolomite grainstones, many catagraphs have thicker, less well-defined walls, and interiors of partially opaque microspar. There is, indeed, a spectrum of types ranging from thin-walled cement-filled grains to wholly micritic grains that should probably be termed peloids.

The ooids are larger than the catagraphs, ranging from 0.3 to 1.5 mm in diameter. There is a wide variety of types (plates 14–16). Small ooids with thin cortices are indistinguishable from catagraphs. Many ooids, both large and small, have undergone dissolution and internal cementation as described above, leaving only a thin micritic wall of ovoid to spherical shape, filled with cement (plates 15, 17). Rarely, the micrite envelope has been broken by overburden pressure in the time after dissolution of grain interiors and prior to cementation (plate 15). Some ooids have an ill-defined micritic core that dropped to the bottom of the cavity during this phase ('half-moon' ooids of Carozzi, 1963) (plate 14). Most ooids have a substantial micritic cortex (30–100% of ooid radius in thickness) with faint concentric

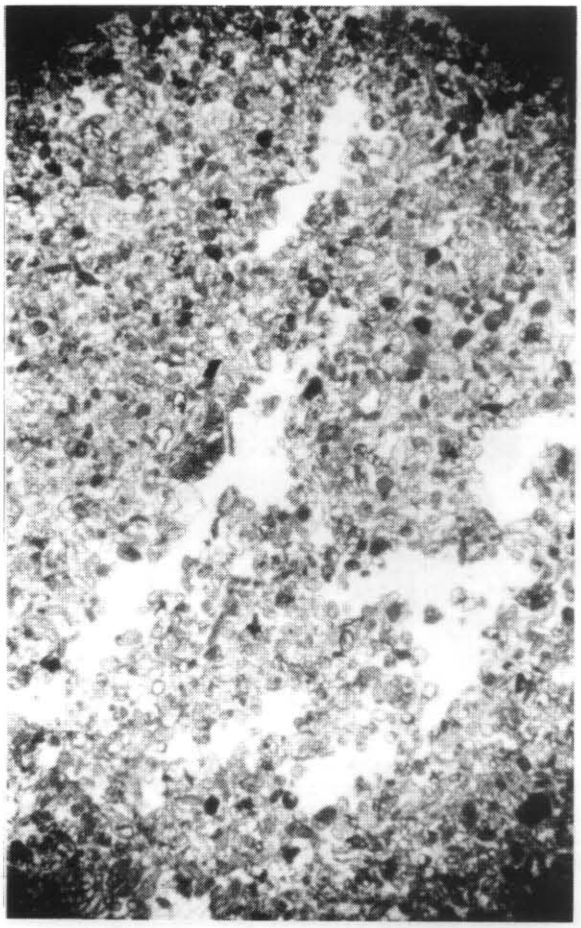


Plate 13. Thin section 002455 (Devils Eye Dolomite): Catagraphic grainstone. Large cement-filled birdseye vugs are approximately parallel to bedding. Field of view 6 × 10 mm.

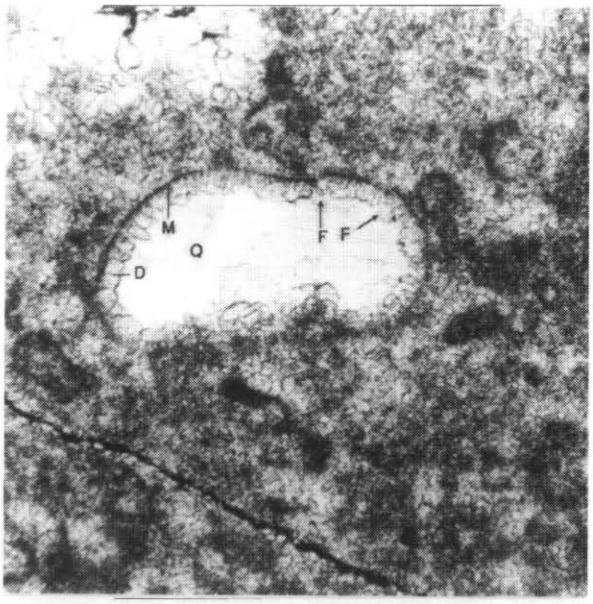


Plate 15. Thin section 002512 (Weld River Group correlate, south of Tim Shea, Huntley Quadrangle): Cement-filled oolimold with thin, micritic outer wall (M): centripetal sparry dolomite cement with euhedral terminations (D); quartz cement (Q); slightly offset fractures in outer wall (F). Field of view 1.5 × 1.5 mm.

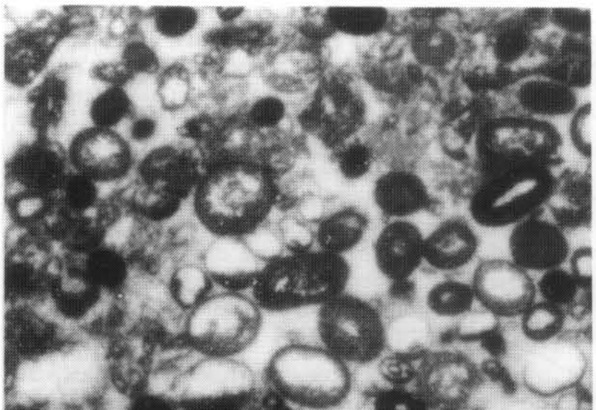


Plate 14. Thin section S281 (Devils Eye Dolomite correlate, Styx quadrangle): Oolitic grainstone showing variable ooid structure. Note geopetal fillings in ooids just left of centre. Field of view 6.3 × 6.4 mm.

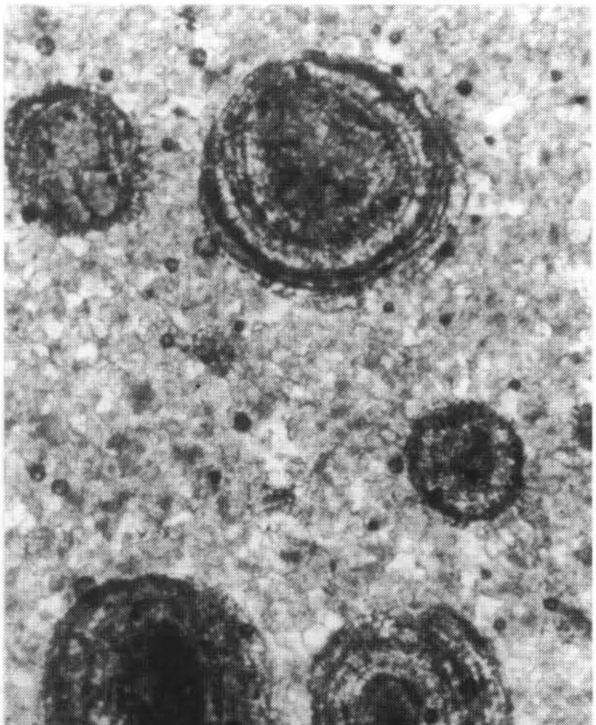


Plate 16. Thin section 002474 (Devils Eye Dolomite). Oolitic grainstone with large ferruginous ooids in a matrix of brownish xenotopic replacement dolomite. Other parts of slide show ghost outlines of non-ferruginous ooids in closed-framework with tangential contacts. Field of view 2.5 × 4 mm.

5 cm

layering (plate 14). No radial-fibrous ooid cortices are present. In some cases, individual layers within the cortex have been replaced by clear sparry dolomite. Generally the core is clear spar and often appears to be composed of a single catagraph or aggregate of catagraphs. Composite bodies, of two or three ooids bound together by a common outer cortex, are present in a few slides. Rarely, some of the ooids have lamellae enhanced by a dusting of fine-grained iron oxide, giving them a brownish colouration in hand specimen (plate 16).

Intraclasts are common, as irregular, subequant grapestone lumps in arenaceous grainstones or as larger (up to 30 mm) platy flakes in flat-pebble breccias. They are mostly composed of catagraphic, sparsely oolitic grainstone or packstone. Even the largest intraclasts have tangential contacts and generally appear to lack modification by compaction, suggesting they were wholly lithified when deposited.

The grainstones are moderately to well-sorted, and there is thus a spectrum of grain size-determined types ranging from fine-grained catagraphic rocks through oolitic types to the coarsest intraclastic breccias. The most fine-grained are catagraphic packstones and grainstones that lack ooids (002455, 002457). These rocks commonly have multiple wavy micritic laminae that may be of cryptalgal origin. They have irregular to laminoid birdseye structures (plate 13) resembling those of Shinn (1983) from modern subtidal hardgrounds. Sparsely oolitic catagraphic grainstone is the commonest type (002447, 002450, 002452, 002473). Many of the larger, rounder catagraphs are difficult to distinguish from small ooids. Of slightly coarser average grain size is abundantly oolitic catagraphic grainstone (002431, 002487) which contains a variety of ooid types, including aggregates of catagraphs bound by one or two thin oolitic coats. Section 002431 contains crescent-shaped structures that may be collapsed micritic envelopes of ooids. Pure oolite appears to be rare. 002474 consists wholly of large (1.5 mm) close-packed ooids. Most are coarsely recrystallised but many have well-preserved concentric lamellae (plate 16). Intraclastic oolitic grainstones are exemplified by 002456, 002451, and 002486. Section 002486 appears to be partially derived from reworking of an oolite similar to 002474. Both samples were collected near the top of the Devils Eye Dolomite. The coarsest grainstones are intrasparites composed of subequant (002453, 002454) to platy (002448) intraclasts (flat-pebble breccia).

The primary depositional components are bound by three generations of cement, all of which are developed in most slides. The earliest is an isopachous fringe, 50–100 μm in thickness, of fibrous to columnar dolomite, usually light brown in colour. Typically, this is markedly thinner, or even absent, from intragranular cavities suggesting either that micritic envelopes acted as a barrier to migrating fluids or that dissolution of the grain interiors took place mostly after this cement was deposited. In some slides, there is a suggestion that this early cement preceded compaction, as many would-be grain-to-grain contacts appear to be held apart by the thin isopachous cement rinds on juxtaposed grains.

The second cement generation is a clear, subequant sparry dolomite which usually fills most pore space and increases in grain size towards the centres of interstices. The boundary between first and second generation is usually rather diffuse, sometimes with a degree of crystallographic continuity between the two.

The third generation, absent in many slides, consists of equant megaquartz which fills the remaining pore space in the centres of large interstices. This is the quartz cement, referred to previously, that is conspicuous on

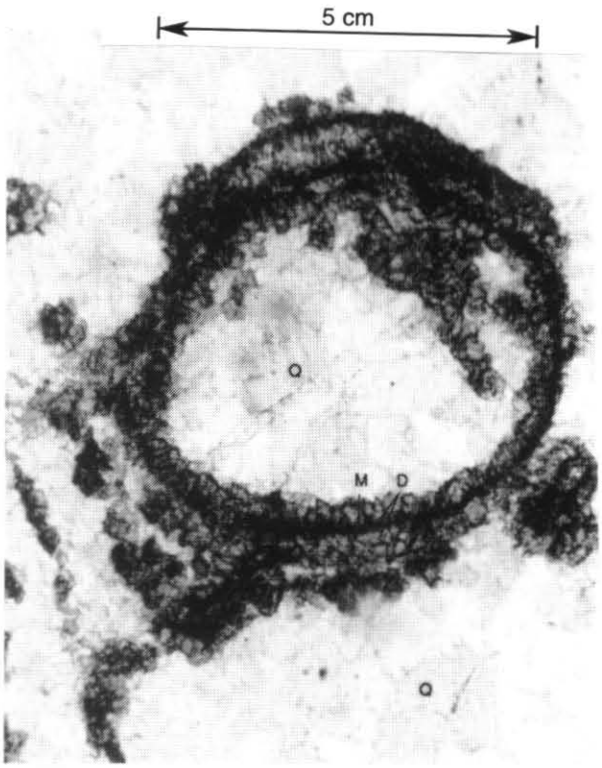


Plate 17. Thin section 002431 (Devils Eye Dolomite) Silicified grainstone. Micritic envelope (M) of original grain, probably an ooid, is the substrate for an early, isopachous dolomite cement (D) and a later generation, volumetrically predominant, of quartz (Q). Field of view 2.5 × 3 mm.

weathered outcrop surfaces. The second-generation sparry dolomite projects into the remaining (quartz-filled) pore space with rhombohedral terminations. Small pores may be filled by a single quartz crystal which accommodates itself to the shape of the pore; larger pore spaces are filled with a mosaic of equant quartz crystals which increase in size away from the substrate.

Section 002447 and 002431 are unusual in that the earliest cement is a fringe of clear, subequant to rhombohedral dolomite followed directly by quartz. Section 002431 consists largely of micritic envelopes encrusted by a thin (20–30 micron) dolomite fringe, floating in a groundmass of quartz cement that comprises the bulk of the rock (plate 17). This suggests that quartz cementation was early, since the tenuous carbonate fabric could not be expected to survive compaction. A later replacement origin for the quartz seems unlikely, as the dolomite-quartz boundaries are sharp, euhedral, and not corroded; and the quartz has the fabric of a pore-filling cement.

A later pervasive chalcedonic replacement, that cuts across bedding, is present is some outcrops. This is probably related to Tertiary weathering.

In 002474, 002477 and 002486, early fabrics are largely obscured by coarse recrystallisation. These rocks consist predominantly of coarse (0.5 mm) sucrosic, subhedral dolomite that in thin section has a distinct pinkish-brown colour and strong pseudopleochroism.

The well-preserved primary textures of many Proterozoic dolomites has led to suggestions that they are primary dolomites (Tucker, 1982), their formation being facilitated by a different seawater chemistry than at present. However, a more strictly uniformitarian scheme involving early replacement of calcite is now more widely accepted, mainly due to the kinetic problems involved in directly precipitating dolomite (Ricketts, 1983; Tucker, 1983). Fine grain size of the replacement dolomite and preservation of fine detail is considered to be indicative of very early diagenetic, even syndepositional, replacement (Tucker, 1983).

The dynamics of early dolomitisation of limestones remain uncertain (Hardie, 1987). Neither of the two presently widely-invoked mechanisms (the mixing-zone model and the sabkha model) seems applicable to the Devils Eye Dolomite as no evidence has yet been found of emergence or evaporitic conditions. Perhaps a different Proterozoic seawater chemistry favoured early dolomitisation of the primary metastable carbonates rather than conversion to low-Mg calcite as in most Phanerozoic carbonates (Tucker, 1983). A prolonged convective circulation of seawater through the sediment pile would be necessary to bring this about at normal surface temperatures (Hardie, 1987).

Primary depositional minerals in Phanerozoic and modern warm-water carbonates are aragonite and high-Mg calcite (James and Choquette, 1983). These are metastable in the diagenetic environment and are usually replaced during early diagenesis by low-Mg calcite. The work of Tucker and others, summarised by Tucker (1983), shows that early dolomite replacement appears to be similar to calcite replacement of metastable grains: fabric-destructive where aragonite is replaced, and fabric-retentive where the crystallographically and chemically similar high-Mg calcite is the precursor mineral. 'Fabric destruction' involves dissolution of aragonite and precipitation of the replacing mineral in the resultant voids.

These factors suggest that, of the primary depositional components in the Devils Eye Dolomite, the preserved, micrite-textured components (ooid cortices, micrite envelopes, small peloids) were originally high-Mg calcite, whilst cement-replaced components (catagraph interiors, many ooid cores) were originally aragonite. Ooids of similar mixed primary mineralogy have been described from the Phanerozoic (Wilkinson *et al.*, 1984).

The first-generation isopachous columnar cement in the Devils Eye Dolomite grainstones was probably originally precipitated as high-Mg calcite. This is the most common early cement in the modern shallow-marine environment (Bathurst, 1979). Early dolomite cements are known (Kaldi and Gidman, 1982) but these are of equant, rhombohedral habit. Crystallographic constraints prohibit dolomite precipitation in a fibrous form (Ricketts, 1982). It is likely, therefore, that the first-generation cement in the Lake Timk samples is a partially mimetic replacement of dolomite after fibrous high-Mg calcite. The common pale brown colouration may represent clouding by submicroscopic inclusions of the precursor mineral.

The early clear, rhombohedral cement in 002447 and 002431 resembles that of Kaldi and Gidman (1982) and may be a direct dolomite precipitate, perhaps a 'correlate' of the second-generation cement in other slides.

The second-generation cement of clear, subhedral dolomite spar is probably a direct precipitate, although in some instances the irregular grain boundaries suggest slight recrystallisation. Dolomitisation of the earlier components probably preceded or accompanied this generation of cement, as the indistinct boundaries between generations, and the occasional instances of crystallographic continuity, suggest.

The third-generation quartz cement, it is argued above, was deposited relatively early in diagenesis, prior to appreciable overburden accumulation. Early siliceous cements are known from the Proterozoic (Simonson, 1985); their presence being attributed to seawater saturated in silica due to the presumed absence of silica-secreting organisms.

In summary, the catagraphs, ooids and intraclasts that comprise the grainstones of the Devils Eye Dolomite were at first probably composed of aragonite and high-Mg calcite. Early in diagenesis these components were cemented by a first-generation isopachous cement of high-Mg calcite. Aragonite was then dissolved leaving considerable intragranular porosity, as demonstrated by fallen ooid cores and cracked micritic envelopes. Up to this stage the paragenesis is similar to Phanerozoic shallow-marine warm-water carbonates. Then there is a departure from the usual Phanerozoic pattern with the remaining high-Mg calcite components being dolomitised with a large degree of fabric retention, and intragranular and remaining intergranular pore space being filled by clear equant dolomite followed by quartz. These final stages of cementation appear to precede the development of appreciable overburden stress.

Departures from this pattern include a few rocks that lack the first generation cement and contain more quartz, and rocks that have undergone a later stage of coarse recrystallisation.

Styx Dolomite (€ewtd)

The Styx Dolomite consists of massive, white to pale grey, fine-grained dolomite. It overlies, probably conformably, the Devils Eye Dolomite in the Weld River at DN554578. The formation is well-exposed upstream as far as DN548581, this section representing a thickness of about 600 m, but is poorly known elsewhere. The top of the unit is not exposed: to the west, the Styx Dolomite is faulted against the Cotcase Creek Formation. The Styx Dolomite may be partly equivalent to the Cotcase Creek Formation but appears to lack the mixtite units characteristic of the latter.

The predominant rock type is that typical of massive dolomite elsewhere in the Weld River Group (Gomorrah Dolomite, Cotcase Creek Formation). Most outcrops in the lower 300 m of section in the Weld River contain several per cent rounded quartz sand grains, which tend to be scattered through the rock without being concentrated into beds or laminae. Oolitic coatings were observed on some quartz grains. Near the top of the river section, at DN549581 and DN548581, are two small outcrops of red mudstone with thin planar sandstone laminae.

Cotcase Creek Formation (€ewc)

The Cotcase Creek Formation consists predominantly of massive dolomite, with lesser mixtite, minor mudstone, rare sandstone, and rare chert. The formation occupies a broad meridional belt west of the Weld River [DN540590–DN580500]. No top or base to the sequence is known. Although poorly delineated stratigraphically, the sequence is included by virtue of lithologic similarity and proximity, in the Weld River Group. The Cotcase Creek Formation is probably wholly younger than the Devils Eye Dolomite but may be partially equivalent to the Styx Dolomite, which although predominantly massive, lacks mixtite.

Several units of predominantly mixtite (€ewcx) and mudstone (€ewcm), and areas of variable lithology that include labile sandstone (€ewcs) and quartz sandstone (€ewcq) were differentiated. Stratigraphic order of the sequence is uncertain due to faulting, the paucity of facing evidence, and the apparent impersistence of many of the mapped units. Overall, there is a preponderance of westward facings, supported by juxtaposed west-facing Ragged Basin Complex and Denison Group near Frodshams Pass, and by fault-juxtaposed west-facing older rocks (Ꝑes', €ewt) to the east. The sandstone-bearing units (€ewcs, €ewcq) therefore probably occur at or near the top of the sequence. A few eastward facings in the Cotcase Creek Formation suggest isoclinal folding, but no such hinges were detected in the field. Generally, the formation is poorly known due to paucity of outcrop and difficulty of access.

Dolomite (€ewc)

Dolomite of the Cotcase Creek Formation is typically massive, fine-grained, white to pale grey rock, lithologically identical to the Gomorrah and Styx Dolomites described above. Likewise bedding, not commonly visible, appears as a relief-pattern on weathered surfaces reflecting laminae with slight textural differences.

Bedded grainstones similar to those of the Devils Eye Dolomite (€ewtg) are present but rare. A typical occurrence is at DN561504, where about a metre of cross-bedded grainstone, partially quartz-cemented, occurs within massive dolomite. Rarely, flat-pebble breccias are associated with laminated fine-grained dolomite.

Locally the dolomite may contain a few percent or more well-rounded quartz sand grains. At DN575505, DN553509 and DN547496 there are thin beds containing up to 50% quartz sand.

A distinctive unit of dolomite-derived conglomerate and coarse sandstone crops out at DN545515, and along strike at DN548520, adjoining a thick unit of mixtite to the west. Pebble-conglomerate at the former locality is closed-framework, consisting of well-rounded clasts of various dolomite types, predominantly pale grey and fine-grained, and rare clasts of greenish and black mudstone, in a fine-grained quartz-sand-bearing dolomite matrix. Associated granule conglomerate and coarse sandstone are of similar composition, the sandstone containing up to 20% well-rounded quartz sand. Thin sections of granule conglomerate and sandstone show about 30% of clasts are fine-grained (micritic) dolomite, and about 30% are variably recrystallised dolomite of 10 μm (microspar) to 500 μm (sucrosic) grain size, many with possible remnant oolitic fabrics. Several percent consist of oolitic dolomite clasts described fully below. Well-rounded quartz grains are abundant, and there are rare fragments of catagraphic grainstone, peloidal grainstone, terrigenous mudstone, fine-grained quartzwacke, and chert.

The oolitic dolomite clasts are particularly noteworthy. The ooids are very small (70–250 μm in diameter) but with a very narrow size range in any one clast. A few isolated, large ooids are scattered through the matrix. Virtually all the ooids have a radial-fibrous cortex of pale brown dolomite. Larger ooids tend to have relatively thin cortices and large cores that have been replaced by dolomite spar or quartz. Most oolitic clasts have suffered varying degrees of recrystallisation, but even some of the most coarsely recrystallised clasts retain vestiges of the distinctive brown ooid cortices. The extremely finely-preserved fabric in some of the ooids suggests a high-magnesium calcite precursor (Sandberg, 1975; Tucker, 1983), while spar-replaced cores may have been originally aragonite.

That these oolitic clasts are of local (intrabasinal) derivation is strongly suggested by their relative abundance, the grapestone-like appearance of many clasts and the occurrence of free, un-abraded ooids in the matrix.

Identical oolitic clasts occur in a similar conglomerate at DN518567, within an area mapped as €ewc (see below); and a single oolitic clast occurs within a mixtite sample from DN576485. Possibly in situ radial-fibrous oolitic dolomite is common in the Cotcase Creek Formation but remains undetected due to the microscopic nature of the texture and the paucity of samples.

At a few localities the dolomite contains appreciable muddy terrigenous impurities. At DN547520, near a transition to mixtite, dark grey muddy dolomite, with thin planar quartz siltstone laminae, crops out. Also associated with mixtite at DN535544 is outcrop of dark grey fine-grained dolomite interbedded with fissile dolomitic mudstone. Bedding-perpendicular dolomite veins cut the dolomite beds but not the mudstone layers. At DN549530, laminated pale grey dolomite contains thin beds of chert and laminae of dark grey muddy dolomite.

Mixtite (€ewcx)

Several mixtite units, ranging in thickness from a few metres to over 400 m, were mapped within the Cotcase Creek Formation. Few mixtite units could be followed along strike for any distance due in part to poor outcrop and in part to faulting, or possibly in some cases, stratigraphic impersistence.

The rock is wholly massive and typically consists of rather sparse (5–30%) clasts, predominantly white to pale grey dolomite, in an abundant, dark grey-brown to black matrix of impure sandy dolomite. On deeply-weathered outcrop surfaces, the dolomite clasts tend to be leached out, leaving voids. Clasts are mostly angular, rarely rounded, and usually pebbles or cobbles are the largest size although boulder-sized clasts are locally present. A small proportion (perhaps 5%) of the clasts are non-dolomitic rock types: orthoquartzite, quartz siltstone, mudstone and chert. Usually the matrix has a weak cleavage, and inequant clasts may have a weak parallel preferred alignment with the cleavage.

Thin sections show a variety of dolomite clast types. Recrystallised pale brown sucrosic dolomite, and very fine-grained micritic dolomite, are most abundant. Some micritic dolomite clasts have vuggy porosity filled with drusy cement. A few clasts are peloidal grainstone. One clast is intrasparite in which two generations of cement – an early, pale brown, fibrous rind and a later equant drusy spar – may be clearly discerned. Another clast consists of ooids, 0.5 mm in diameter, with thin outer cortices of pale brown radial-fibrous dolomite, and abundant intragranular and intergranular cement of clear euhedral dolomite followed by quartz. Significantly, boundaries of the clasts are sharply delineated and abruptly transect these dolomite cements, indicating that diagenesis was essentially completed prior to incorporation into the mixtite. Many dolomite clasts contain sparse detrital quartz silt and sand.

Mudstone clasts are extremely fine-grained, consisting of aligned cryptocrystalline phyllosilicates. Also discernible in thin-sections are rare quartzwacke fragments, and in 002462 there is an altered volcanic rock fragment with a fine-grained trachytic or basaltic texture.

The matrix consists of very approximately 30% sand grains, of which about half are quartz and half are fine-grained dolomite fragments. Many quartz grains are well-rounded, and are therefore probably derived from supermature quartzarenites. 002457 contains a detrital plagioclase fragment. The finest fraction consists predominantly of very fine-grained xenotopic dolomite with ill-defined detrital carbonate silt grains, quartz silt, and minor opaques. Terrigenous mud or clay appears to be rare or absent, although secondary dolomitisation of such material cannot be ruled out.

Many local variations in mixtite composition were noted. Two mixtite units near the Weld River [DN564514] have a relatively high proportion (≈ 50%) of sand-grade material and are thus relatively rich in

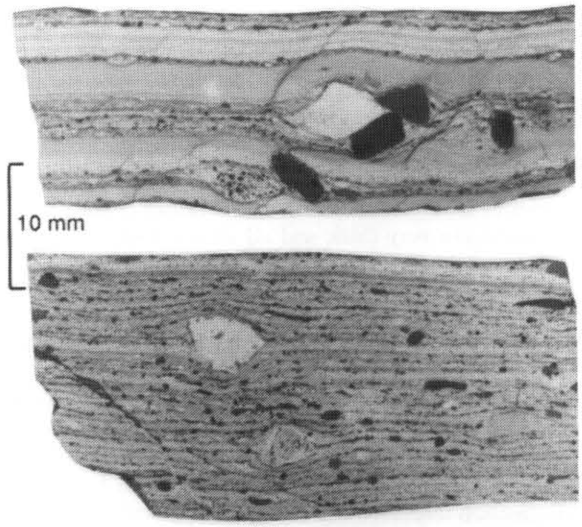


Plate 18. Etched slabs of pebbly laminated dolomite, Cotcase Creek Formation. Note possible till clast in upper slab.

quartz, although the megaclast fraction is still almost entirely dolomite. The more northerly unit has relatively sparse (a few percent) megaclasts. The southerly unit, about 200 m thick, is well-exposed in a creek section [DN562513]. At the lower (northern) contact, massive dolomite (Єewc) is overlain by a few metres of black dolomitic quartzwacke (i.e. megaclast-free mixtite) followed by boulder mixtite with abundant (30%) megaclasts. Then follows sparse (5% megaclast) mixtite, which appears to make up the bulk of the unit, with more megaclast-rich rock reappearing near the top (southern) contact.

A thin (≈20 m) mixtite unit at DN536543 contains megaclasts of only granule size. Another thin mixtite at DN547529 contains sparse megaclasts of up to small pebble size, but near the western (top?) contact they are more abundant and up to cobble grade.

The mixtite unit at DN550518, 150–200 m thick, includes two thin (a few metres) mudstone units. The mudstone is predominantly grey to black, with graded laminae of dolomitic fine sandstone and siltstone; tough cherty red mudstone is also present. A westward (upward) transition from mudstone to mixtite is exposed at DN550518, with several sharp-based beds of mixtite appearing in the upper part of the mudstone unit.

An interval about 50 m thick at DN541516 is notably richer in siliciclastic material than the enclosing mixtite. Quartzite constitutes a higher proportion of the rudite fraction, and the matrix appears to be a reddish or grey quartz-rich sandy mudstone.

A mixtite-dolomite transition is exposed at DN544516. Mixtite grades up into about one metre of laminated dark grey dolomite, with graded laminae indicating (anomalously) east-facing; in turn overlain (to the east) by pure massive dolomite (Єewc).

The most unusual mixtite variants crop out in the south, between DN576487 and DN557488. Both mixtite units indicated on the map in this area consist predominantly of relatively dolomite-rich mixtite and laminated pebbly dolomite interlayered on a scale of metres to tens of metres. The mixtite is composed of megaclasts of almost entirely dolomite in a matrix of grey, slightly impure fine-grained dolomite with a brownish weathering crust. The laminated pebbly dolomite consists of relatively sparse (a few percent) granules, small pebbles and rare cobbles floating in a thinly planar-laminated dolomite siltstone. Detrital quartz sand and silt comprise several percent of the rock. Lamination is defined by grain size variation, with thin layers rich in fine sand and silt alternating with thicker, more fine-grained layers. The laminae are distorted by differential compaction about the megaclasts. Some small pebbles appear to be clumped together in loose aggregates that resemble till clasts (plate 18). The more northerly mixtite unit includes, as well as the above lithologies, minor intervals of laminated black mudstone, and at DN564489, several metres of boulder mixtite with a black mudstone matrix. The boulders are rounded dolomite up to 0.6 m in diameter, the largest clasts recorded from the mixtites.

Mudstone (Єewcm)

Apart from the very minor, unmapped occurrences of mudstone within Єewc and Єewcx described above, there are substantial mappable units composed dominantly of mudstone, with minor chert, siltstone and sandstone. A thick (300 m) mudstone unit at DN540520 is flanked to east and west by mixtite. This unit consists of grey-green argillite and black pyritic, dolomitic mudstone, the latter with local thin siltstone laminae. There is also minor quartz siltstone with carbonaceous partings.

About 50–100 m of mudstone and chert crop out at DN547501 and are underlain and overlain by massive dolomite. The predominant lithology is a massive red mudstone, in places dolomitic; with lesser laminated grey mudstone and chert. This sequence is gently folded about hinges that plunge steeply south-west.

The mixtite unit at DN546544 is bounded to the east by about 100 m of mudstone not indicated on the map. This unit is predominantly medium to dark grey laminated mudstone, locally with thin lenses of siltstone and rare thin beds of fine-grained quartzite.

Єewcs

A traverse [DN520569–DN515562] within the area mapped as Єewcs encountered predominantly massive, fine-grained dolomite with a number of other lithologies interbedded on a finer-than-mappable scale. The dolomite locally contains a few percent rounded quartz sand grains. Rarely, the dolomite is laminated. At DN518567 there is a thin bed of oolite consisting almost wholly of large (2 mm) well-preserved ooids with concentric lamellar structure. Micritic intraclasts, some forming ooid nuclei, constitute a few percent of the rock. The ooids, but not the intraclasts, have been finely recrystallised to a mosaic of 50 mm grain size. The grains are cemented by a fringe of euhedral clear dolomite followed by quartz. Twenty metres to the west, well-sorted dolomite-granule conglomerate crops out that is indistinguishable to that described above in Єewc, even containing similar fragments of radial-fibrous oolitic dolomite. In thin-section the large (1 mm) well-rounded quartz sand grains in this rock appear to be undergoing progressive replacement by coarse sparry dolomite. Wholly-replaced grains closely resemble cement-filled oolimoulds.

At DN519568 there is outcrop of mixtite consisting of sparse angular granules and small pebbles of dolomite in a black, foliated matrix of dolomitic mudstone rich in quartz sand (20–30%).

Around DN517566 massive dolomite is interbedded with coarse- to fine-grained lithic sandstone and quartz-rich dolomitic siltstone. The lithic sandstone in thin section consists of sedimentary rock fragments (shale, sandstone, chert, dolomite) and about 30% well-rounded quartz grains.

Discussion

Weld River Group sedimentation began with deposition of the conglomeratic Annakananda Formation upon the surface of unconformity. The conglomerate in the North-east Ridge–Lake Timk area is derived entirely from local basement. A high-energy, perhaps terrestrial, environment is indicated. The thickening of the conglomerate south of Lake Timk is accompanied by the appearance of overlying pebbly mudstone of the Lake Timk Formation very similar to parts of the Cotcase Creek Formation thought to be of either gravity-flow or glacial origin (see below). A general proximal(?) thickening of these clastic rocks to the south-east seems evident. By contrast, on the Weld River to the north, a thin Annakananda Formation correlate of predominantly mudstone passing up directly into massive dolomite suggests a quieter, distal environment.

The rest of the Weld River Group constitutes a very great thickness (at least 5 km, assuming superposition of the Cotcase Creek Formation on the other units) of predominantly (≈90%) dolomite. Some of this large apparent thickness, however, may be due to repetition by undetected faulting, particularly in the poorly-known Weld Valley area.

Generally, carbonate sedimentation requires a warm, shallow marine environment free of terrigenous influx (Wilson, 1975). The depositional environments of the massive, fine-grained dolomites (Lots Wife, Styx and Cotcase Creek Formations) remain otherwise enigmatic, although the apparent lack of sedimentary structures suggests depths below the influence of tidal and wave action. The grainstones of the Devils Eye Dolomite indicate a shallow and constantly agitated tidal shelf environment. The good sorting of the grainstones, the possible algal origin of the catagraphs, the common ooids, and the frequent herringbone cross-bedding support such a conclusion. Competence and persistence of currents at the sea floor varied from relatively low (packstones, fine grainstones) to high (pure oolites). As in modern carbonate environments, current agitation facilitated early sea-floor cementation and local reworking of intraclasts into flat-pebble breccias and grapestone aggregates. Lamination of possible algal origin occurs but, rather surprisingly, no columnar stromatolites were found. No cyclicity characteristic of peritidal carbonates (Wilson, 1975) or evidence for subaerial exposure were observed, although a more systematic sampling program may reveal these.

The dolomites in the Cotcase Creek Formation contain rare oolitic grainstone layers, possibly including some pure oolite composed of radial-fibrous ooids. The latter were not found in situ, but are common as reworked clasts. The smallness of these ooids, and their radial-fibrous fabric, suggest a relatively low-energy environment (Davies *et al*., 1978). The oolites, diagnostic of tropical or subtropical water, (Wilson, 1975), are significant in view of the possible glacigene origin of the mixtites. Presumably they represent, as in the Devils Eye Dolomite, periods of persistent tidal action.

Primary ooid mineralogies in both the Cotcase Creek Formation and Devils Eye Dolomite probably included both aragonite and calcite (*cf.* Sandberg, 1983).

Diagenesis of the dolomites has been discussed previously. Dolomitisation was apparently pervasive, as no associated limestones have been found. The frequently extremely well-preserved primary textures, and the sharply-bounded dolomite cement fabrics in the clasts within the various intraformational conglomerates and mixtites, show that dolomitisation and cementation occurred early in diagenesis.

Mixtites such as those of the Cotcase Creek Formation may be either tillites or mudflow deposits. Conclusive proof of either mechanism may be elusive. Harland *et al.* (1966), Schermerhorn (1974) and Flint (1975) evaluate criteria for distinguishing mixtites of glacial and mudflow origin.

If of glacial origin, the Cotcase Creek Formation mixtites are either submarine basal tillites or aquatillites, as some are very thick and all are enclosed by marine strata (Schermerhorn, 1974, p. 685). Faceting and striation of clasts was not observed, but would be difficult to demonstrate in these rocks as they are thoroughly lithified and the clasts tend to be less resistant to weathering than the matrix. Aquatillites, and commonly tillites, are characterised by a laterally extensive, sheet-like form, while mudflows are lenticular to elongate in shape. The inferred lateral impersistence of some mixtites and of the Lake Timk Formation therefore argues against a glacial origin. The apparently abrupt upper and lower contacts of the mixtite units, and the lack of any glacial imprint (e.g. lonestones) in the associated mudstones and dolomites, also militate against a glacial origin. Possible candidates for transitional pebbly glaciomarine rocks are present, however, in the pebbly mudstone of the Lake Timk Formation (€ewtm) and the laminated pebbly dolomite beds at DN576487–557488 described previously. The presence of what appear to be till clasts in the latter locality is suggestive of at least a local glacial imprint.

The alternation of mixtites of possible glacial origin with warm-water carbonates presents a palaeoclimatological paradox that has been documented from many late Precambrian sequences worldwide (e.g. Williams, 1975). Though scarcely credible in uniformitarian terms, there is strong evidence to suggest that more or less abrupt changes, from one climatological extreme to the other, did occur at this time (e.g. Williams, 1975; Fairchild and Hambrey, 1984).

If mudflows, the mixtites were apparently thoroughly homogenised during emplacement, as they are structureless and lack any remnant of contorted bedding or soft-sediment deformation structures. Grading of clast sizes, due to settling during transport, may be an explanation for the variations in grain size seen in the unit at DN562513 described above. The occurrence of mixtite with maximum grades of only granule or small pebble size, also could be attributed to proximal settling of larger clasts. The wholly intrabasinal provenance of the mixtites (with the possible exception of the orthoquartzite and a single volcanic fragment) is in accord with a mudflow origin. The thicker mixtites could be composite mudflows, and compositional variations within thick units have been noted above.

Schermerhorn (1974), a proponent of a general debris-flow origin for Precambrian mixtites, visualised an unstable platform setting where, periodically, epeirogenic movements caused differentiation of relief. In the ensuing erosive phase, coarse debris (mixtite) was deposited in the deeper parts of the basin. In the Cotcase Creek Formation, laminated mudstone is closely associated with mixtite and may represent periods of normal sedimentation within these deepened parts of the basin.

No all-embracing mechanism of formation can be proved for the mixtites of the Cotcase Creek Formation on presently available evidence. It is quite possible that, like certain other Late Precambrian sequences (e.g. Tucker, 1986), both debris flows and tillites are present in different parts of the sequence.

Correlation

Within the Jubilee Region, possible correlates of the Weld River Group occur on the southern slopes of Tim Shea, in a small area north of Mt Mueller (see previous section) and at Blakes Opening. The Weld River Group appears to be the youngest Precambrian sequence in the region, with the possible exception of the Clark Group and its correlate north of Mt Mueller. The Clark Group, however, as previously mentioned, has a lithologic resemblance, and probably a similar age, to the older Precambrian sequences. The Weld River Group is presumably succeeded stratigraphically by a ?Cambrian lithicwacke-conglomerate sequence (**€**als) which contains Weld River Group-derived detritus and which unconformably overlies the Pandani Group on the Scotts Peak Road [DN490565] and north of Mt Bowes [DN510559].

A broadly similar stratigraphy occurs in late Precambrian to Cambrian successions exposed in north-western Tasmania. In the Smithton Basin, a thick carbonate unit (the Black River Dolomite) with a thin basal siliciclastic unit (the Forest Conglomerate) unconformably overlies older Precambrian rocks, and is overlain by siliciclastics and basic volcanics correlated with the Crimson Creek Formation (Brown, 1989). Similarly, in the Pieman River area, the Success Creek Group, of shallow-water siliciclastics and carbonates, unconformably overlies older Precambrian rocks and is followed by the Crimson Creek Formation (Brown, 1986). The Pieman River sequence and the Smithton Basin sequence are considered to be correlates (Williams, 1976) and the term 'Eocambrian' has been applied to these sequences (Williams, 1976).

It has therefore been suggested (Calver, 1989b) that the Weld River Group is a correlate of the Success Creek Group and Black River Dolomite on the basis of general lithologic similarity and similar stratigraphic setting. These sequences are of Vendian age on acritarch evidence (Cooper and Grindley, 1982) and the Black River Dolomite post-dates the Cooee Dolerite (≈725 m.y.).

The Jane Dolomite, of central-western Tasmania, is another possible correlate, being a relatively unmetamorphosed massive dolomite-dominated unit unconformably overlying older metamorphic Precambrian rocks (Spry and Zimmerman, 1959).

Mixtites are recorded from the Success Creek Group (Brown, 1986), the top of the Black River Dolomite (Griffin and Preiss, 1976), the Jane Dolomite (Spry and Zimmerman, 1959) and from a similar stratigraphic setting on King Island (the Cottons Breccia: Jago, 1974; Williams, 1976). If mixtites of glacial origin are present, they are probably related to the Late Adelaidean (750–670 m.y.) glaciations widespread on mainland Australia (Dunn *et al.* 1971).

Precambrian to Middle Cambrian (?) (€a, etc.)

N. J. Turner

This category includes the extensive unit **€**aw and its widespread lithological correlates together with the less extensive units of **€**als and **€**alc. The stratigraphic relationships of these three units are interpretive and uncertain.

€aw

SETTING

€aw comprises a suite of lithologies including wacke, mudstone, chert, fine-grained mafic igneous rocks and volcaniclastics. The proportions of the constituent lithologies vary such that **€**aw may be subdivided into successions dominated by greywacke (**€**awf), other successions in which red mudstone, chert and volcanics are predominant (**€**awb) and successions containing common or predominant chert (**€**awc, **€**awcc). The rocks in the principal outcrop area of **€**aw which extends along Ragged Range and across Ragged Basin to around Island Road are referred to as the Ragged Basin Complex.

Deep weathering is a feature of **€**aw. It particularly affects the wacke, which contains a high proportion of labile material, and the mafic igneous rocks. Soils and talus are widely developed and virtually all contacts between the various lithologies and successions within **€**aw and between **€**aw and other units were mapped on the basis of float. Analysis of the contact relationships is further complicated by disruption of the rocks in **€**aw at both the outcrop and regional scale.

Particularly notable features of the disruption in **€**aw include an anastomosing, lenticular cleavage (scaly cleavage) which is associated with shearing, lack of continuity of lithological units at both regional and outcrop scales, pinch and swell structure (boudinage) in competent beds and local occurrences of block-in-matrix fabric. Overall, **€**aw is a stratigraphic unit with locally broken internal stratal continuity and thus may be termed a broken formation in the sense of Raymond (1984).

In several zones the degree of disruption in **€**aw appears to be greater because the zones contain exotic lenses consisting of sheared, serpentinised ultramafic rocks with minor foliated amphibolite, relatively rare chromite-bearing actinolitic andesite, gabbro and sheared talcose ultramafic. The longest of these zones extends from Adamsfield, in Huntley quadrangle, south along the west flank of Sawback Range [DN460666] into the upper reaches of the Florentine River then south and south-east to the Serpentine Creek area [DN490536]. A second zone containing exotic lenses extends between DN463552, DN476567 and DN435396, around the upper reaches of the Boyd River. A narrow third zone occurs along the eastern edge of **€**mm'c and is well exposed on the Gordon River Road at DN461589.

The narrow zone along the eastern edge of **€**mm'c is clearly related to fault movement and there is major fault movement associated with the Adamsfield – Serpentine Creek zone. The upper Boyd River zone is bounded by major faults. The presence of exotic lenses in the various zones indicates that the constituent rocks may be termed mélange (Raymond, 1984). Since there is a clear association with faulting it appears that the mélange is tectonic. However, the presence outside the zones of very irregular lithological distributions at outcrop scale (Turner, *in* Brown *et al.*, 1989) and of probable intra-formational breccia, resedimented chert and olistoliths imply early instability and thus the overall fabric of **€**aw and the mélange zones is probably polygenetic.

AGE

An age of Middle Cambrian(?) has been assigned to **€**aw in the Pedder map legend but the age is very poorly constrained. It is based on a possible relationship between **€**aw and siltstone in **€**als around DN351558. The siltstone contains hydroids and dendroids of suggested Middle or Late Cambrian age (Quilty, 1971) and its host sequence displays bedding orientation which is concordant with bedding orientation in rocks to the north-east which include undifferentiated **€**aw. If **€**als and **€**aw are conformable then the fossils also provide a control on the age of **€**aw. However, the true contact relations are obscured by poor outcrop. Since the part of €aw which is closest to the unexposed contact is a strongly sheared mélange, the contact is probably a fault and the concordant bedding orientations in €als and the rocks to the north-east may thus be fortuitous.

Lithological comparisons suggest that the fossiliferous rocks in €als should be grouped with the unit €m, which is of known Middle Cambrian age, rather than with €aw. The sandy rocks in the fossiliferous assemblage are unlike the labile-rich greywacke in €aw but are similar to the siliceous lithicwacke in €m and contain the same type of low grade metasedimentary detritus. On balance, the view favoured here and in Turner (1988) is that these rocks should be grouped with €m and that the boundary with €aw is faulted. On the basis of regional considerations including relationships in Huntley Quadrangle €aw is probably older than €m though it appears to have supplied little of the detritus in €m (Turner, 1989).

LITHOLOGIES

Chert, chert breccia

Chert: Chert is interbanded with the greywacke, mudstone and volcanics in layers which range in thickness from a few centimetres to greater than 20 m. In the successions designated €awc these layers are common and they are particularly abundant on the crest of Ragged Range [DN438645] where they dominate a succession that has an apparent thickness of some 500 m.

The chert layers are generally bedded at a scale of 20–300 mm thickness and there are commonly scattered, relatively thin interbeds of massive or shaly mudstone between the chert beds. Colour bands at a scale of 1–20 mm occur conformably within the chert beds though in weathered outcrops this banding is commonly obscured by bleaching. A second type of banding may be present and is due to translucent quartz in thin (1–2 mm) discordant veinlets which form parallel swarms in patches of otherwise opaque chert. A platy or flaggy parting is usually present and is generally parallel to the conformable colour banding though a few examples of slightly oblique orientations were observed.

In thin section the chert commonly displays an even-grained, granoblastic-type texture made up of recrystallised quartz grains 0.01–0.02 mm across. These grains usually exhibit progressive, wavy extinction suggestive of a fibrous (?relict) structure. Finer grained variants of chert are also present in which recrystallisation is far less advanced. Tiny muscovite flakes comprise less than 1% (volume estimate) of the chert and are oriented parallel to bedding. Opaque minerals may be abundant and include both (?)carbonaceous matter and iron minerals. These opaque minerals probably cause the wide range of colours in the chert. The colour range includes black and dark grey, pale grey and pale green, brown, red and pink though most exposures are weathered and have been bleached to white and pale grey. No biogenic structures were recognised in either outcrops or thin-sections of the chert.

Chert breccia: Chert breccia which does not appear to be associated with faults and which is probably of intraformational origin comprises a small proportion of €aw but occurs widely. Most occurrences were found in association with the thicker chert layers on Ragged Range (e.g. DN435644) but there are small occurrences of similar breccia at DN458555, DN381655 and elsewhere.

The breccia consists entirely of completely angular chert fragments ranging in size from a few millimetres across up to, usually, a few centimetres but sometimes up to 0.4 m across. The texture is massive with little evidence of shearing and cataclasis. On Ragged Range the breccia occurs in concordant intervals of up to several metres thickness and may show internal stratification due to variation in fragment size. Unlike the outcrops on Ragged Range, the exposure at DN458555 has not been bleached by weathering and as a result colour banding in the fragments is distinct. The colour banding is undeformed within the fragments and displays preferred orientation parallel to the strike of the surrounding rocks. There are relatively intact blocks of colour banded chert up to 60 mm across into which brecciation extends both concordantly and along highly discordant, small fractures. The apparent absence of shearing in the breccia and the various bedding-parallel features support an intraformational origin.

Red to brown mudstone

Shaly mudstone and siltstone of red to brown colour is a common and widespread rock type in €aw and occurs as layers ranging in thickness from less than one metre to greater than 20 m. Unlike the thin grey-green to khaki mudstone which is consistently interlayered with the greywacke, the red to brown mudstone is sporadic in occurrence and is particularly abundant in successions designated €awb.

Colours of the mudstone are similar in weathered and fresh outcrops and range from reddish through reddish-brown to chocolate brown and, rarely, purple. The mudstone layers consist mainly of unbedded or thinly (few millimetres) laminated mudstone and include minor siltstone. Commonly there are intervals within the thicker layers in which there are interbeds of red to brown chert of 20-60 m thickness. There is also a relationship between the occurrence of igneous rocks and the occurrence of mudstone. Igneous rocks are generally accompanied by occurrences of red to brown mudstone though the reverse does not always hold. In some mudstone layers there are black, earthy patches and bands which contain fractures on which manganiferous dendrites are developed.

A penetrative grain is commonly evident in the shaly mudstone and is mainly subparallel to bedding though examples of low angle, oblique intersections were observed. A spaced, anastomosing (scaly) cleavage with slickensides on its surfaces is also commonly present. In some more massive layers there is a parting parallel to bedding which tends to be flaggy.

Wacke

Wacke is the most abundant rock in €aw. It forms a large part of the successions designated €awc and most of the successions designated €awf. The variation in original thickness of wacke layers is difficult to determine because the contacts between wacke and other lithologies are commonly movement surfaces rather than bedding surfaces. Bed thickness appears to have ranged from less than 0.1 m up to several metres. Deep weathering has affected much of the wacke and fresh material is scarce. Relatively fresh rocks occur at DN475590 on the Gordon River Road, at several places on the western slopes of Ragged Range (e.g. DN447631) also at DN461573, DN426592 and other localities.

In its weathered form the wacke is a yellow to orange, very soft rock containing subordinate detrital quartz in ochrous and limonitic materials which display relict sandy texture. When fresh the wacke is a hard, dark green rock. Most of the wacke is characterised by coarse flakes of muscovite up to about 3 mm across but a minor type occurring around DN424582 and DN472608 contains only a little, relatively fine-grained muscovite.

Sorting of the wacke is very poor and its average grain size is usually medium or fine. Though a little coarse sand is usually present there are few rocks of coarse average grain size and there appears to be no rudite. Grading is generally difficult to discern in wacke beds. A few clear examples of grading occur near DN417659.

A distinctive suite of detrital minerals comprises the silt and sand grains in the greywacke. These grains are very angular. Monocrystalline and minor polycrystalline quartz comprise 40-50% (volume estimate) of the wacke whilst poikiloblastic and clear, polysynthetically twinned (albite) and untwinned feldspar makes up 5–10%. Coarse to fine monocrystalline flakes of biotite and chlorite make up another 5–10% and similar flakes of muscovite comprise about 3%. Accessory grains of pink garnet are consistently present in the wacke as are opaque minerals. Zircon and sphene may also be present. Carbonate is a highly variable constituent which comprises about 25% of the wacke at DN475590 on the Gordon River Road. It is common at DN447631 on Ragged Range but absent at DN461573. The carbonate grains are monocrystalline and, uncommonly, polycrystalline and appear to be clastic. However, veinlets at the Gordon River Road locality indicate that carbonate was a late, mobile phase in the rocks thus allowing the possibility of a replacement origin for carbonate grains.

Rock fragments comprise less than 1% of the wacke but are consistently present. They are mostly fine grained, schistose, metasedimentary lithologies consisting of quartz, green-tinted muscovite, chlorite and biotite. These lithologies together with the garnet, biotite, muscovite, chlorite and feldspar grains imply a predominantly metamorphic provenance of upper greenschist or amphibolite facies for the greywacke. Since the Late Precambrian metamorphic rocks in Pedder quadrangle are of lower grade and contain only very rare, poorly crystallised biotite and garnet, another terrane must have been the provenance of the greywacke in €aw. Chert fragments are present in the wacke (e.g. DN461573). The chert does not display schistosity and probably represents resedimented material derived from €aw.

Many, but not all, mica flakes in the wacke exhibit planar preferred orientation as do many elongate quartz and feldspar grains. This fabric is thought to be essentially detrital though there appears to have been tectonic enhancement (e.g. DN461573) which caused zonal development of subparallel cleavage defined by anastomosing seams of very fine-grained opaque material. It also caused the development of incipient beards on some grains. At DN461573 this fabric is cut by variably oriented microshears with which cataclasis is associated. These shears appear to be equivalent to the scaly cleavage that is widely evident in outcrop.

Mafic volcanic rocks

N. J. Turner

General features

Fine-grained, mafic igneous rocks occur commonly but sporadically throughout €aw. They appear to be most abundant in successions designated €awb. Deep weathering and soil or talus tends to obscure the relative proportion of igneous material in many areas but successions (€awb?) on Ragged Range and to the south-west around Island Road are possibly similar to €awb because they exhibit similar, anomalously high aeromagnetic response (Aero Services, 1966).

In their weathered form the igneous rocks comprise distinctive bright orange to orange-yellow, ochrous and limonitic clay with relict granular texture. The clay is permeated by close spaced, irregular, variably-oriented, black-coated fractures. Quartz and mica are absent. Near DN444578 there is a transition from this material into relatively fresh rock. The fresh igneous rocks in €aw are dark green in colour. Both fresh and weathered material may display the anastomosing, lenticular cleavage that is evident in the greywacke and red to brown mudstone.

The igneous rocks appear to be generally conformable with the other rock types and individual layers range upward in thickness from about 0.5 m. No upper limit of thickness was determined but maximum outcrop width is in the range 50–100 m. The general association of igneous material with a specific sedimentary rock type (red to brown mudstone) indicates that the igneous rocks are extrusive though no characteristic extrusive features such a pillowed lava were recognised in the consistently poor outcrops. Possibly some of the slightly coarser grained variants represent shallow dolerite sills.

Basalt

All the mafic rocks outside the mélange zones may be basaltic since all the fresh material examined is of that composition. Such a conclusion must be tentative because so many mafic rocks are too weathered to be certain of their original composition. The basaltic rocks consist of phenocrysts or glomerophenocrysts up to about 3 mm across in a fine-grained groundmass. The phenocrysts may consist entirely of augite, entirely of plagioclase or of both minerals. Subhedral feldspar laths with maximum lengths varying from about 0.3–0.5 mm make up most of the groundmass with interstitial clinopyroxene and black, opaque mineral. The proportion of opaque mineral ranges from less than 5% (volume estimate) to about 20% and probably both magnetite and ilmenite are present. Alteration is ubiquitous but variable. Feldspar grains are turbid and variable amounts of chlorite and serpentine are present. Prehnite, ?pumpellyite, quartz and calcite may be present in veinlets and patches. Seams of microcataclasite are virtually ubiquitous and appear to correspond to the lenticular or scaly cleavage that is evident in outcrop. The microbreccia seams clearly post-date the chlorite alteration in some cases and do not usually appear to have a distinctive alteration assemblage associated with them.

Basalt, in places strongly sheared, crops out on the Weld River at DN559543. A thin section shows a holocrystalline rock mostly of plagioclase with an estimated 20% clinopyroxene, 3% opaques and minor chlorite- and carbonate-filled amygdules and veins (C.R.C.).

The only chemical analysis obtained from a basalt in €aw (table 1) was of a fairly extensively altered type at DN396578 on Island Road. Phenocrysts in the rock consist of augite which poikilitically encloses turbid plagioclase laths but in some glomerophenocrysts there are also serpentinised grains of unknown initial composition. The augite may show alteration at grain margins to hornblende which is commonly further altered to chlorite. Turbid feldspar laths comprise most of the groundmass and surround interstitial chlorite. Relatively large, anhedral, often skeletal grains of black, opaque mineral (?ilmenite) comprise less than 5% (volume estimate) of the total rock. Veinlets which have been open fissures and veinlets related to shears are present and contain chlorite and pumpellyite with minor prehnite, calcite and quartz. Various ratios of alkalis, silica and the stable components TiO_2, Zr, Y and Nb (Floyd and Winchester, 1978) in the altered basalt indicate a subalkaline composition.

Table 1
ANALYSIS OF A BASALT (OR FINE-GRAINED DOLERITE) FROM Єawf AT DN595589 ON ISLAND ROAD

SiO_2	49.19	Na_2O	3.11	Zr	43
Al_2O_3	14.61	P_2O_5	0.11	Nb	<3
Fe_2O_3	2.18	SO_3	0.08	Ni	105
FeO	8.25	CO_2	0.12	Ba	310
TiO_2	0.86	H_2O	0.15	Cr	210
MnO	0.20	H_2O^+	3.67	V	390
CaO	8.86	Sr	230	Co	44
MgO	7.76	Rb	15		
K_2O	0.53	Y	17		

Rocks found only in the mélange zones

Tuff and tuffaceous wacke

Mafic (?basaltic) tuff and volcanic wacke were only recognised in the mélange zones. However, their wider distribution may be obscured since it is probable that deeply weathered tuff is indistinguishable from other deeply weathered mafic igneous rocks. Fresh tuff is dark green in hand specimen and consists of fine (0.5–1 mm) and sometimes, coarse (3–4 mm) ash. No thickness estimate of tuff layers was possible but outcrops are small and presumably the layers are thin.

Ejecta in the tuff comprise very angular to rounded fragments of devitrified glass, chilled lava and crystal fragments. The devitrified glass is bright medium green in colour and consists of finely fibrous chlorite. It is commonly amygdular and may contain crystallites. Scattered shards and complete bubbles of devitrified glass occur in some tuff. Lava fragments may be glass-rich or very fine-grained holocrystalline. They commonly contain flow textured feldspar laths and may be amygdular or contain phenocrysts of augite or plagioclase. Crystal fragments in the tuff are minor and consist of augite and plagioclase. The tuff may contain veinlets in which there is chlorite, plagioclase, prehnite or calcite. Seams of microbreccia are usually present.

Tuffaceous wacke is very poorly sorted and consists of lithic fragments similar to those in the tuff but contains a much higher proportion of mineral grains, particularly plagioclase. There are also common fragments of green fibrous chlorite (?after glass) and minor amounts of clinopyroxene and pumpellyite. Fragments of shale and recrystallised chert are also common as are grains of opaque mineral. The matrix is fine grained and chloritic. Microbreccia seams may be present and transect a fabric due to parallel alignment of elongate grains.

Carbonate (Єad)

Two occurrences of fine-grained, medium-grey carbonate occur in the upper Boyd River mélange zone near DN463563 and small sinkholes occur in the near vicinity. The general absence of carbonate from other parts of Єaw may suggest that these rocks are of exotic derivation. The thickest interval of carbonate observed in outcrop was 5 m and it was bounded by lithologies normal to Єaw.

Bedding in the carbonate is mostly flaggy but thin (10 mm) banding is present in intervals. The rock is patchily recrystallised but no cleavage or shearing was recognised though irregularly oriented stylolites are present. The rock consists almost entirely of carbonate with a little dusty, opaque material and a few blebs of recrystallised quartz.

Andesite

Altered andesite occurs within the Adamsfield – Serpentine Creek mélange zone at DN480554. It probably also occurs in the upper Boyd River mélange at DN446574 and DN449574. Outcrop is poor in all localities with the andesitic material occurring in fairly small patches of rubble spatially associated with serpentine and lithologies of Єaw.

The andesite at DN480554 is altered but unfoliated. It comprises abundant laths of actinolitic amphibole which may be further altered to talc. There are relatively large chloritised phenocrysts and there is minor chlorite in the groundmass where partly chloritic, but largely indeterminate, devitrified glass is interstitial to the amphibole laths. Anhedral to subhedral grains of chromite are present in the andesite.

At DN446574 the probable andesite is altered and also foliated. It consists of aligned, extremely fine-grained actinolitic amphibole containing abundant rounded, spheroidal and irregularly-shaped bodies which probably represent amygdules. The amygdules consist of finely granular to well crystallised, radiating talc. Subhedral opaque grains are present but chromite was not specifically identified.

Rubble of unfoliated diorite consisting of relict clinopyroxene, ortho-amphibole, coarse poikilitic feldspar and minor quartz is spatially associated with the andesite at DN480554 and a similar rock occurs at DN480546.

Serpentine (Єrs)

Relatively large lenses of serpentinised ultramafic rocks occur on Sawback Range and in the upper reaches of the Florentine River (Brown, this volume). The lens on Sawback Range extends north to Adamsfield in Huntley Quadrangle and is about 7 km long whereas the Florentine River lens is about 2 km long. Both bodies are within the Adamsfield-Serpentine Creek mélange zone.

There are many small lenses of greenish serpentinite intermixed with Єaw lithologies within both the Adamsfield-Serpentine Creek mélange zone and the upper Boyd River mélange zone. Though some of these small bodies are partly massive and some (e.g. DN450569) display the distinctive 'birdseye' texture that is evident at DN479591 on the Gordon River Road, most are very strongly sheared. They consist of serpentine, chlorite, talc, subhedral opaque minerals and very fine-grained opaque minerals. They may be extensively veined and replaced by carbonate.

Gabbro (Єrg)

An isolated outcrop of massive, coarse-grained (5 mm), mafic rock occurs at DN475568. The rock consists of large subhedral to euhedral crystals of altered (?sericitised) plagioclase with subordinate unaltered, interstitial clinopyroxene. Opaque minerals are common and there are patches of secondary, fine-grained actinolite with minor chlorite.

Talcose rocks (Єrt)

Small lenses of talcose rocks are intermixed with lithologies of Єaw in the upper Boyd River mélange zone and at DN463590. The rocks are fine grained and grey in colour. They display intense scaly cleavage and the lenses are interpreted as structurally emplaced bodies.

In thin section the rocks consist mainly of fine-grained talc. There are minor, relatively coarse-grained, opaque minerals which include chromite. There are also abundant, fine-grained opaque minerals which outline a diffuse granular pattern similar to the pattern of dusty magnetite associated with serpentinised olivine. The rocks are thought to be altered, serpentinised dunite.

Foliated amphibolite (€rsa)

Amphibolite occurs widely in the mélange zones and is usually closely associated with serpentinite though contact relationships are rarely visible. A sharp, possibly faulted contact with serpentinite is exposed at DN470591 on the Gordon River Road. Amphibolite occurs within serpentinite at DN456660 in the Sawback Range serpentinite body and is interlayered with serpentinite and isoclinally folded at DN477558.

The amphibolite ranges from fine-grained (1 mm) to very fine-grained (<0.1mm). It usually displays a well developed foliation and a lineation is also generally evident. Compositional banding of 1–3 mm thickness may occur parallel to the foliation.

Some amphibolite is virtually monomineralic, consisting almost entirely of green to bluish green pleochroic hornblende. However, most amphibolite consists of hornblende with variable, up to 50% by volume, felsic minerals. These latter comprise quartz and turbid, altered feldspar. Opaque minerals are common and chlorite may be present. Quartz, turbid feldspar and epidote may be present in late veins and turbid feldspar or quartz and epidote may be present in augen-like structures. Berry (1990) recorded diopside in amphibolite at DN479591 on the Gordon River Road and identified the hornblende as a Mg-rich variety. Opaque minerals in the amphibolite usually occur as very fine-grained, irregularly shaped lenticules subparallel to the foliation.

The intensity of the foliation in amphibolite is variable. Usually the hornblende grains are strongly aligned giving a schistose fabric but in uncommon examples they display little alignment and the foliation is defined by scattered chlorite lenticules. In coarser grained, strongly foliated amphibolite such as occurs adjacent to the serpentine contact at DN479591, there are relatively large, aligned hornblende porphyroclasts with 'beards' which are surrounded by very fine-grained hornblende and felsic minerals. In banded amphibolite there are layers with hornblende porphyroclasts and interlayers of very fine-grained, fairly uniformly comminuted hornblende and felsic minerals. An example of a hornblende phyllite was found in Recent alluvium beside the Clear Hill Road at DN423656. Amphibolite which occurs away from the serpentine contact at DN479591 is also uniformly very fine grained. It has a hard, platy character and is finely banded.

Late structure in the amphibolite includes cross-cutting seams of microbreccia, microkinks and veinlets.

The amphibolite is interpreted as metamorphic mylonite produced early in the emplacement history of the ultramafic rocks. Along with the ultramafic rocks, it was disrupted during subsequent mélange formation.

Serpentine Creek area

In the mélange which crops out along the Scotts Peak Road near Serpentine Creek there is a considerable range of lithologies. Included are chert and poorly sorted, coarsely muscovitic sandstone similar to rocks in €aw along with finely muscovitic, poorly sorted sandstone which more closely resembles sandstone in €mml.

At DN473540 there is poorly sorted conglomerate with well rounded cobbles and pebbles of chert and deeply weathered ?amphibolite. Adjacent to the serpentinite at DN484544 there is deeply weathered, fine-grained, clayey material containing rounded igneous fragments.

€asc, €as

In several places on Ragged Range there are small occurrences of an unusual rock (€asc) in which angular fragments of chert and, less commonly, pelite up to 50 mm across are supported in a matrix of quartzarenite (e.g. DN440636, DN448634, DN444624). The quartzarenite consists of very well sorted, well rounded, medium-grained, monocrystalline quartz and very minor polycrystalline quartz. No source of this type of mature, siliceous detritus exists within €aw. Similar detritus forms the sandstone on Wings Lookout in Huntley quadrangle (Brown *et al.*, 1989) and the quartzarenite (orthoquartzite) in the relatively unmetamorphosed (Ꝑe, Ꝑs) and metamorphosed (Ꝑt) Late Precambrian sequences.

The packing of the quartz grains in €asc is notably loose compared with quartzarenite in Ꝑt with 10-20% (volume estimate) of the rock comprising quartz cement which forms optically continuous overgrowths on the detrital grains. Both the grains and their overgrowths display undulose extinction but there appears to have been little, if any, dynamometamorphic dissolution or recrystallisation of quartz and no cleavage is evident. Several per cent (volume estimate) of very fine-grained, disseminated ferruginous material may impart pink or reddish colours to the quartzarenite.

Structures in the quartzarenite include bedding-parallel preferred orientation of the larger chert and pelite fragments. At DN448634 there is also a bedding-parallel variation in the proportion of chert and pelite fragments in a quartzarenite layer. This variation is expressed as a thin lower portion of the layer with common fragments which passes upward into quartzarenite with sparse fragments then no fragments. The relatively large size and very angular nature of the chert and minor pelite fragments suggests that they are 'rip-up' clasts. Clearly the sandy detritus in the quartzarenite was derived from outside the basin of deposition of €aw but how it travelled into the basin is uncertain. The total absence of matrix in the quartzarenite indicates that it was not transported by turbid flow in the same way that other sandstone in €aw was probably transported.

A lens of white quartzarenite and pebbly quartzarenite is exposed in a cutting on the Scotts Peak Road at DN498579. The rock is similar to the €asc occurrences on Ragged Range except that the chert fragments are very small and possibly not of the same origin. Again the quartzarenite appears to be exotic when compared with the sequence of lithicwacke, mudstone and chert (€alc) in which it occurs. The lens is interpreted as an olistolith because its basal contact transects bedding in the enclosing sequence at a very low angle.

Isolated weathered occurrences of quartzarenite (?€as) are present in the now inundated area north-east of Mt Cullen around DN340650. The relationships of these occurrences to other rock types are unknown. The rocks resemble €asc in that the quartzarenite is relatively undeformed, showing little evidence of cleavage or recrystallisation. It contains lenticular voids which display preferred orientation parallel to the general structural trend and which resemble voids remaining after pelite fragments at DN448634 on Ragged Range have been removed by weathering. The quartzarenite has experienced considerably greater compaction than €asc with the result that the quartz grains are tightly packed, usually with dissolution at grain-grain boundaries, and there is little pore space containing authigenic quartz.

CORRELATES OF Ꞓaw

Rock assemblages correlated with Ꞓaw occur west of Mt Mueller around DN520630 and in a larger tract to the south-east of Mt Mueller. They also occupy three separate areas along the eastern edge of Lake Pedder though only banded chert outcrops in two of these areas. The various assemblages are correlated with Ꞓaw because they comprise similar lithologies including greywacke which contains similar detritus to greywacke in Ꞓaw. The correlated assemblages also display a high degree of disruption and contain the same distinctive, anastomosing lenticular, or scaly, cleavage that is present in Ꞓaw. Chert in the areas east of Lake Pedder, particularly near Harlequin Hill, exhibits stronger fracturing and more common minor folds than most chert units in Ꞓaw.

Coarsely micaceous, labile-rich greywacke occurs in the most northern of the three correlates of Ꞓaw that lie east of Lake Pedder. There are also red to brown mudstone, khaki mudstone and chert but neither basalt nor tuff were recognised.

Ultramafic rocks are associated with the poorly outcropping Ꞓaw correlate south-east of Mt Mueller and at least part of the correlate [near DN585585] is mélange. Elsewhere in the correlate [DN586606] there is a small occurrence of carbonate with block-in-matrix fabric. The matrix consists of very fine-grained, black, impure carbonate in which there is an intense, lenticular cleavage. It encloses scattered rounded to subrounded fragments of fine-grained, dark grey, recrystallised carbonate which are aligned with the cleavage. Other small exposures of carbonate nearby are intensely fractured rather than cleaved.

There may also be mélange in the correlate of Ꞓaw west of Mt Mueller since an unusual, probably exotic quartzose amphibolite occurs near DN520629. In the southern part of the correlate there is the most extensive known development of tuff in Ꞓaw and its correlates. Traces of malachite occur in a red-brown mudstone nearby [DN517630].

Ꞓals

N. J. Turner
C. R. Calver

SCOTTS PEAK ROAD AREA

N. J. Turner

Setting

In the legend of Pedder map Ꞓals is shown as possibly the oldest subdivision of the group of rocks designated Ꞓa. It was assigned this position because it apparently rests on Precambrian rocks and appears to concordantly underlie other rocks belonging to Ꞓa on the Scotts Peak Road. The inferred age of the entire Ꞓa grouping is in turn dependent on a single fossil locality in one of the lithological units in Ꞓals on the Scotts Peak Road. These relationships must be regarded as very uncertain in view of the lack of established boundary relationships and the possibility of mélange style deformation. An alternative interpretation (Turner, 1989) groups the fossiliferous rocks in Ꞓals with the Middle Cambrian rocks designated Ꞓm and assigns older ages to Ꞓaw and Ꞓalc.

On the Scotts Peak Road north-west of Mt Bowes there is a passage northwards from rocks which are assigned to the Precambrian category Ꝑs, through five distinct lithological units which are grouped as Ꞓals, into rocks which are assigned to Ꞓaw. Boundaries between the various units are poorly exposed and stratigraphic assignment of the small units in Ꞓals is uncertain. The overall sequence is contiguous with the Adamsfield – Serpentine Creek mélange zone and parts of the sequence display structure typical of the mélange zone. Thus, it may be that some of the lithological units have been structurally juxtaposed such that the sequence does not necessarily represent a stratigraphic succession.

Lithological units

In the Scotts Peak Road section the Precambrian rocks south of Ꞓals consist predominantly of thinly bedded, red, maroon, khaki and orange, shaly siltstone and mudstone (Ꝑsm′) which may be partly after very impure dolomite. There are thin carbonate units (Ꝑsm′d) which are clastic, consisting of pebbly, slightly siliceous dolarenite. There are also occasional sedimentary breccia layers and graded sandstone layers consisting of chert detritus.

The first of the lithological units included in Ꞓals outcrops south of the sign saying 'Cambrian Dolomite'. It consists of lithic, cobbly and pebbly conglomerate containing rounded clasts of red, indurated siltstone and chert in a matrix of red shale similar to shale in Ꝑsm′.

At the 'Cambrian Dolomite' sign is another lithological unit which consists of dolomite and pebbly dolomite containing clasts of quartz, dolomite and siltstone.

Between the 'Cambrian Dolomite' sign and a quarry some 200 m to the north there is a more extensive unit consisting of quartzose wacke, siltstone and mudstone which contains an occurrence of hydroids and dendroids of Middle to ?Upper Cambrian age (Quilty, 1971). The wacke consists of angular, monocrystalline quartz and relatively fine-grained muscovite with abundant muscovite-quartz phyllite and polycrystalline quartz. There are clasts of opaque-rich (?carbonaceous) pelite as well as accessory amounts of plagioclase, chlorite, tourmaline, biotite and zircon.

Along the ridge which extends south-west from the road section there are occurrences of similar wacke which are apparently associated with pebble and cobble conglomerate. Carbonate is common in some wacke, partly occurring in fractures. Detritus in the conglomerate includes quartz, quartzarenite and mafic igneous material, including chromite-bearing andesite, which all occur as well rounded clasts, with angular chert clasts.

In the road section the wacke, siltstone, mudstone unit displays a strongly developed, scaly, coarsely anastomosing cleavage with slickensides commonly developed on the cleavage surfaces. The cleavage is particularly prominent in pelitic rocks in the quarry and bedding throughout the unit is disrupted due to displacement on the cleavage. This fabric is typical of the mélange zones and its presence may imply that the rocks have undergone substantial displacement. It is noted that the mélange 'zones', as previously discussed, are delineated on the basis that exotic lenses of serpentine and other rocks are present. However, the scaly cleavage typical of the zones is more widespread and may be a more accurate indicator of the extent of movement.

Just north of the quarry, in the eastern road cutting, there is a small exposure consisting of blocks of poorly sorted, pebbly conglomerate and wacke in a matrix of strongly foliated, dark grey carbonate. Detritus in the conglomerate and wacke comprises angular to rounded fragments of distinctively pink dolomite, chromite-bearing serpentinite, chromite, talc and rare quartz. These clasts rest in a matrix of carbonate which is partly detrital and which contains a few oolites. Carbonate has locally replaced serpentinite in the clasts and there is a little chloritic alteration. The strongly foliated carbonate matrix in which the blocks of conglomerate and wacke are contained is very fine grained and rich in opaque (?carbonaceous) material. Tension fractures are developed perpendicular to the cleavage in the matrix and contain fine-grained quartz aligned with the cleavage.

North of the serpentinitic rocks, along the western verge of the road, is the fifth of the small lithological units comprising €als. It consists of massive dolomite in which bedding is defined by thin (10 mm) bands containing angular chert fragments.

The boundary between the northern unit of €als and the adjacent €awu is not exposed. Shearing is intense in €awu which consists of red-brown and orange shale, coarsely muscovitic wacke, chert and basalt. The shearing in both €awu and the deformed parts of €als is parallel indicating their involvement in the same movement episode. The extent of relative movement is unknown.

MT BOWES AREA

C. R. Calver

One outcrop area lies just north of Mt Bowes [DN510560]. This sequence dips and faces north and probably unconformably overlies the Precambrian Pandani Group to the south and is faulted against the Weld River Group to the north.

The southernmost outcrops are conglomerate (€alsc) which appears to be a basal facies, although the contact with the Precambrian rocks was not observed. The conglomerate is closed-framework, of pebble grade with clasts of slate, mudstone, dolomitic mudstone and siltstone, and less commonly of orthoquartzite, and dolomites typical of the Weld River Group. Most of the clasts are identical to rock types in the Pandani Group which crops out extensively to the immediate south. A slaty cleavage and crenulation (morphologically identical to S_1 and S_2 in the northern part of the Pandani Group) are present in pelitic clasts and clearly pre-date the conglomerate.

The conglomerate is interbedded with minor lithic sandstone and is probably overlain conformably (no contact exposed) by fine-grained dark grey lithic/quartzwacke sandstone, siltstone, and black mudstone (€als). The sandstone is tough, often massive and uniform, in places with faint planar lamination or with interbeds of black mudstone. Grading was noted in some thin sandstone beds. Thin sections show abundant angular quartz, minor sericitised feldspar, detrital muscovite and biotite, with the lithic component consisting of fine-grained quartzite and quartz-mica schist. Massive chert crops out at DN513561. Narrow saddle dolomite-filled veins with minor chalcopyrite were observed at DN515563.

MT MUELLER AREA

C. R. Calver

In the outcrop area north of Mt Mueller, in the north-eastern corner of the map sheet, the sequence is folded but predominantly dips steeply and faces north-east or east. It is in faulted contact with the Clark Group and its correlate to the north and west.

Here, the predominant rock type is a tough, rather uniform greenish-grey fine-grained quartz-rich lithicwacke. The lithicwacke is massive in places but in most outcrops it is interbedded with dark grey to black, slightly micaceous shale, often with planar laminae of siltstone. Individual sandstone beds, 60 mm–2 m thick, in some cases are weakly graded, and in rare instances exhibit sole marks (longitudinal scours, poorly-developed flute casts), planar-laminated tops, and low-angle cross-lamination. A weak, anastomosing foliation in shale layers is subparallel to bedding. In a few outcrops, sandstone layers appear to be disrupted, resulting in isolated boudin-like pods or blocks of sandstone surrounded by weakly foliated shale. Coarse-grained lithicwacke is a minor component of the sequence and there are rare occurrences of conglomerate of granule to pebble grade [DN586664, DN582653, DN580653]. Conglomerates are closed-framework, with rounded clasts of pale grey dolomite (≈50%), volcanic rock fragments, quartzite and shale.

Thin sections of lithicwackes show abundant subangular quartz, minor detrital muscovite, plagioclase and authigenic chlorite. Lithic grains are fine-grained metaquartzite, quartz-mica schist, dolomite, chert, slate, and rare volcanic rock fragments. Conglomerates contain abundant dolomite clasts exhibiting a suite of textures identical to typical Weld River Group lithologies, including oolitic-catagraphic grainstone. Also present are volcanic rock fragments that consist of a fine-grained mesh of sodic plagioclase in an altered chloritic groundmass, chert, quartzite, and phyllite.

Two small inliers, surrounded by Parmeener Supergroup, are anomalous and their relationships are uncertain. At DN570655 fine-grained massive white quartzite with a joint set trending at 145°, is indicated as €as. At DN573653 the rock type is a massive, dark grey very fine-grained quartzite with irregular patches of coarsely crystalline dolomite, soft ferruginous weathered residue, and thin quartz veins. Boulders of chert occur at DN588664.

Relationships of rocks mapped as €als in the Mt Mueller area are problematical. The rocks are unfossiliferous. Compositionally, they resemble €als near Mt Bowes but contain volcaniclastic detritus.

€alc

SETTING

Rocks designated €alc occur east of the Adamsfield – Serpentine Creek mélange zone around DN445593 in the upper Florentine River and on the nearby part of the Gordon River Road. They also occur around DN450581 on the Scotts Peak Road where they are apparently interlayered with rocks assigned to €aw. It is not clear that the two occurrences are of the same stratigraphic unit.

€alc is characterised by the presence of beds of poorly sorted, granule, pebble and rarely cobble conglomerate with abundant chert detritus. Wacke in €alc may also be rich in chert detritus.

There does not appear to be any conglomerate in €aw west of the Adamsfield – Serpentine Creek mélange zone nor is any of the wacke notably rich in chert detritus. Thus €alc may represent a different stratigraphic level from €aw.

LITHOLOGIES

On Scotts Peak Road €alc comprises mainly relatively massive, fine-grained sandstone and siltstone in which bedding is usually undisrupted. Weathering is generally advanced and colours range from orange to greenish grey. There are scattered, graded layers of coarse-grained, poorly sorted sandstone 30–200 mm thick and occasional layers of poorly sorted conglomerate up to about 500 mm thick. Detritus in the coarser grained rocks includes chert, pelitic rocks and rocks of igneous derivation. The latter may comprise a distinctive bright green mineral, sometimes in a white groundmass or they may consist of flow-textured felsic porphyry with feldspar laths up to 5 mm long in a fine-grained, white groundmass. Similar felsic porphyry occurs in €awu in weathered outcrop at DN494573. There also are occasional fragments of possible ultramafic rock and rare fragments comprising quartz-lined amygdules up to 15 mm across in a fine-grained white groundmass. A 2 m thick lens of white quartzarenite (€asc) occurs near the base of €alc and is interpreted as an olistolith.

In the Florentine Valley section there are wacke, chert and mudstone (red-brown, khaki) similar to lithologies in €aw. There are also thin (<1 m) beds of poorly sorted, granule and pebble conglomerate containing abundant chert detritus as well as beds of moderately sorted sandstone containing abundant angular detritus of chert and monocrystalline quartz with common slate and accessory grains of feldspar, biotite, garnet, mafic volcanic and secondary chlorite. Carbonate is sporadically present and there are occasional grains of very well rounded, monocrystalline quartz.

Middle Cambrian (€m)

N. J. Turner

INTRODUCTION AND SETTING

Rocks assigned to the category €m comprise mainly associations of turbiditic sandstone, siltstone and mudstone (€mm') which may contain common but subordinate fine-grained, siliceous conglomerate (€mm'c). North of Sentinel Range, at south Marsden Range and at Harlequin Hill there are associations in which coarser-grained, siliceous conglomerate is common (€ml') whilst on the western slopes of Harlequin Hill there is poorly exposed, coarse-grained conglomerate which is characterised by its high content of relatively soft lithic clasts. Late Middle Cambrian fossils are present in €mm'.

The rocks extending SSE from the shore of Lake Gordon at DN366618 to around Mt Wedge thence south along Marsden Range are referred to as the Island Road Formation. Similar, isolated rocks on Harlequin Hill are correlated with the Island Road Formation. The small, fault-bounded body of rocks extending from DN431609 across the Gordon River Road to DN470572 is called the Boyd River Formation and is also regarded as a probable correlate of the Island Road Formation.

At DN378554 on the Gordon River Road, north of Sentinel Range, there is an exposed unconformity which was initially interpreted as the base of the Island Road Formation resting on the Proterozoic Wedge River Beds. However, the material above the unconformity shown as €ml'p on Pedder map, is not strongly lithified and may not be part of the formation. There are no other localities in which a contact between the Island Road Formation and older rocks is exposed but there is abundant lithic detritus in the formation which is very similar to rocks in the strongly deformed and metamorphosed Proterozoic sequence which underlies the western part of Pedder quadrangle. Thus, an unconformable relationship is clearly indicated. The proximal nature of €ml'p and €ml' is consistent with the palaeoposition of the provenance area being much the same as the present relative position of the Proterozoic metamorphic rocks.

All contacts between the Island Road Formation and the Ragged Basin Complex are thought to be faults. Rare, unfoliated chert clasts in the Island Road Formation provide the only indication that the Ragged Basin Complex may have formed part of the provenance of the formation. Rare chert occurs in the Boyd River Formation which also contains rare ultramafic detritus.

Faulting and poor outcrop obscure the relative stratigraphic order of the lithological association which make up the Island Road Formation and its correlates though fragmentary evidence exists. North of Sentinel Range €mm' rests conformably on €ml' whilst at Marsden Range it rests with apparently transitional conformity on €m'c. At south Marsden Range €mm'c rests with apparent conformity on €ml'. The variation in the apparent succession between Marsden Range and north of Sentinel Range may mark a lateral facies change which has been obscured by faulting. On Harlequin Hill €ml' is underlain with apparent conformity by €ml'p. Thus, the overall sequence appears to be €ml'p (base), €ml, €mm'c and €mm' (top) with the distribution of the associations reflecting faulting and probable lateral facies changes.

SANDSTONE AND FINE TO COARSE SILICEOUS CONGLOMERATE (€ml')

North of Sentinel Range €ml' is an interbedded sequence of fine- to coarse-grained, commonly pebbly sandstone and granule, pebble, uncommon cobble and rare boulder conglomerate. The rocks are moderately sorted though there are scattered graded sandstone beds. Bedding throughout is generally planar and scouring appears to be uncommon. Granules and coarser clasts display a depositional alignment which may be subparallel or oblique to bedding.

The clasts comprise lithologies typical of the metamorphosed Proterozoic rocks, namely foliated quartzarenite, vein quartz and muscovite-quartz phyllite with uncommon quartz-muscovite phyllite and opaque-rich (?carbonaceous) muscovite phyllite. Cleavages in the clasts are disoriented and of similar morphology to dominant cleavages in the Proterozoic rocks. Clasts containing kinked cleavages occur at DN370560.

Polymerid trilobites of non-specific age (J. Jago, pers. comm.) occurs in fine-grained, white sandstone in the southern cutting of the Gordon River Road at DN378556. The presence of trilobites indicates marine deposition and the lithological association is interpreted as a fairly proximal, marine fan deposit.

At the southern end of Marsden Range and on Harlequin Hill there are similar well-bedded sequences containing fine-grained to coarse-grained conglomerate. Detritus in these rocks also appears to be derived from the metamorphosed Proterozoic rocks, in particular the siliceous varieties.

COARSE CONGLOMERATE WITH ABUNDANT LABILE CLASTS (€ml'p)

At DN452413, just west of the crest of Harlequin Hill, there is a change in conglomerate type marked by lag of weathered, friable and limonitic conglomerate containing rounded clasts of quartz and quartzite together with muscovite phyllite. No outcrop occurs on the western slope of Harlequin Hill but there is widespread lag of rounded fragments of Proterozoic quartzite.

Godfrey (1970) excavated inspection pits across the western slope and encountered conglomerate with a much higher proportion of relatively soft clasts than is usually present in €ml'. Along with sub-rounded to sub-angular fragments of foliated quartzite which are up to 600 mm across there are sub-rounded, tabular cobbles comprising red-maroon, banded siltstone with less common light green, banded argillite and micaceous foliated quartzite. The matrix of the conglomerate consists of coarse sand and granules with a large proportion comprising siltstone and other fine-grained rocks. The fabric of the conglomerate is random except for small 'pockets' of granule grade material. On weathering the conglomerate becomes yellow and limonitic. Conglomerate extends west of Harlequin Hill below Lake Pedder to near the old Huon River Crossing.

SANDSTONE WITH FINE-GRAINED CONGLOMERATE (€mm′c)

MARSDEN RANGE

A well-bedded unit comprising predominantly sandstone and siltstone with common interbeds of fine-grained conglomerate overlies the coarser-grained facies, **€ml′**, with apparent conformity at the southern end of Marsden Range. Similar rocks underlie the central part of the range but are separated from those to the south by an inferred fault.

Sandstone in **€mm′s** is light grey to greenish-grey in colour. Coarse-grained sandstone is moderately sorted in that the silt and clay fractions are very minor or absent whereas finer grained sandstone is poorly sorted and usually displays distinct graded bedding. Granules and small pebbles are prevalent in coarse-grained sandstone and there are beds of granule and pebble conglomerate which are common but subordinate to the sandstone beds. Elongate granules and pebbles usually display a depositional alignment sub-parallel to bedding. Bed thicknesses of all lithologies rarely exceeds 0.5 m.

Coarse detritus in **€mm′c** comprises angular to well-rounded fragments of vein quartz and foliated quartzite whilst finer lithic detritus comprises angular to moderately-rounded vein quartz, foliated quartzite, muscovite-quartz phyllite, quartz-muscovite phyllite and opaque-rich (?carbonaceous) muscovite phyllite. In medium- and fine-grained sandstone angular monocrystalline quartz and muscovite are major constituents.

Polymerid trilobites of non-specific age (J. Jago, per comm.) are present in fine-grained sandstone at DN424507 in Maria Creek and at a nearby locality.

UPPER BOYD RIVER

The Boyd River Formation is surrounded by rocks of the Ragged Basin Complex. Its eastern boundary is a movement zone which is well-exposed on the Gordon River Road. In the Ragged Basin Complex the movement zone is expressed as a serpentine-bearing mélange about 20 m wide in which the shear cleavage dips steeply west. There is a narrower zone of intense deformation in the Boyd River Formation. Other boundaries of the Boyd River Formation were mostly mapped on the basis of float. They appear to be faults which mainly dip shallowly to the east.

Lithologies in the Boyd River Formation include poorly sorted turbiditic sandstone and siltstone together with subordinate moderately sorted, very coarse-grained sandstone, granule conglomerate and pebble conglomerate. There are a few occurrences of poorly-sorted conglomerate with muddy matrix in which clasts are of cobble size. In a few sandstone beds there is reverse grading in the lower part of the bed and normal grading in the upper part. In general, bed thicknesses rarely exceed 0.5–1 m.

Detritus in the formation is generally similar to detritus in **€mm′c** on Marsden Range, that is, lithic detritus of probable Proterozoic provenance is abundant. Coarse clasts tend to be rounded whilst finer grains tend to be angular. There are some lithologies represented which were not found on Marsden Range. In particular, unfoliated dolomite is common in conglomerate in the creek section around DN468589 where sparse fragments of serpentinite, chert and chloritised mafic volcanic are also present. Rounded cavities in conglomerate elsewhere in the formation probably result from leaching of carbonate clasts.

Polymerid trilobites and brachiopods of non-specific, possibly Middle Cambrian, age (J. Jago, pers. comm.) occur in reddish shale at DN457589. The shale is interbedded with turbiditic sandstone in the western cutting of a track a little north west of the position indicated by the fossil symbol on Pedder map.

SANDSTONE, SILTSTONE AND MUDSTONE (€mm′)

The lithological association designated **€mm′** is the most widespread of the associations in the Island Road Formation. It is characterised by the predominance of turbiditic sandstone and siltstone. The association conformably overlies the conglomeratic association, **€ml′**, north of Sentinel Range and appears to conformably and transitionally overlie the sandy and pebbly association, **€mm′c** on Marsden Range.

Sandstone and siltstone with mudstone are the greatly predominant lithologies in **€mm′** though there are minor, local occurrences of granule and pebble conglomerate. There is an unusual occurrence of poorly sorted, boulder conglomerate containing dolomite clasts and deformed Proterozoic detritus near DN371575. No carbonate or volcanic rocks appear to be present in **€mm′**.

Medium- and coarse-grained, graded beds of poorly sorted sandstone occur throughout **€mm′** but their relative abundance varies locally. There are intervals consisting mostly of graded sandstone beds with interbedded siltstone and mudstone and other intervals which consist mainly of thin (a few centimetres) interbeds of fine-grained sandstone, siltstone and subordinate mudstone with scattered, thicker, coarser grained graded sandstone beds. In general, graded sandstone beds are less than 0.3 m thick though they may exceed 0.5 m. They may display sole marks, massive basal sections, plane-laminated intermediate sections and cross-bedded upper sections. However, in most areas the beds appear to be either massive, plane laminated, or a combination of both.

Sandstone is usually greenish-grey, medium-grey or olive in colour and it weathers to an orange, clay rich material. Finer grained lithologies may be dark in colour or khaki. Grain size in the graded sandstone beds usually ranges from coarse- or medium-grained sand to fine-grained sand or silt although some beds may grade from very coarse-grained sand or granules to silt. Individual sand grains are angular but granules and pebbles tend to be better rounded.

Detritus in the sandstone mainly comprises monocrystalline quartz and metasedimentary rocks similar to those in the Proterozoic terrane in the western part of Pedder quadrangle.

In fine-grained sandstone and coarse-grained siltstone there are few lithic clasts and monocrystalline quartz and muscovite are major constituents. Carbonate is of very variable proportion and may comprise over 50% (by volume) of the rock. Accessory chlorite and tourmaline may be present and opaque minerals are consistently present. In coarser-grained sandstone there are abundant lithic lasts comprising mainly deformed vein quartz, quartzite, muscovite-quartz phyllite, minor quartz-muscovite phyllite and minor opaque-rich (?carbonaceous) muscovite phyllite. Carbonate is again variable in proportion and may be abundant. Rare fragments of unfoliated chert may be present and possibly represent a provenance other than the metamorphosed Proterozoic rocks.

Fossils occur widely in **€mm′** but only the assemblage at DN369571, which is a few metres below the high water level of Lake Gordon, provides a specific age. It contains agnostid trilobites including *Tasagnostus*, *Peronopsis* and *Nepea* (Jago **et al.**, 1989) which indicate the late Middle Cambrian *Lejopyge laevigata* 1 Zone. At the other localities, which are shown on Pedder map, there are polymerid trilobites and brachiopods of non-specific age (J. Jago, pers. comm).

Wurawina Supergroup

N. J. Turner

SETTING

The Wurawina Supergroup in Pedder quadrangle is a succession ranging from well-sorted siliceous sandstone and conglomerate up through less siliceous sandstone and siltstone (Denison Group) to shallow water limestone (Gordon Group). An angular unconformity marks the base of the succession which transgresses across many of the older lithological groups. The age of the oldest part of the succession is probably close to the Cambro-Ordovician boundary though there are rocks of middle Late Cambrian age in the adjacent Huntley quadrangle which are lower in the succession and are not represented in Pedder quadrangle.

Folding in Devonian times produced a northerly plunging syncline in the Wurawina Supergroup and the western limb of the syncline was subsequently down-faulted. As a result of the combination of folding and faulting there are exposures of the lower part of the supergroup (Denison Group) along Ragged Range in the down-faulted western limb of the syncline, from Sawback Range to Junction Hill in the western limb, and from Junction Hill north-eastwards in the eastern limb. In combination these areas of exposure show that there is considerable lateral variation in the lower sandy and conglomeratic part of the Wurawina Supergroup. The lowermost unit on Ragged Range (Odl), lenses out against basement, and is absent from the other areas of exposure further east. The coarse-grained units Odc and Ods which overlie Odl on Ragged Range also lens out against basement. Though these units are present on Sawback Range and on Junction Hill they also appear to be discontinuous, apparently lensing out against basement south of Ibsens Peak. North-east and north-west of Junction Hill Ods and Odc are indistinguishable at the scale of the Pedder map and an undifferentiated, coarse-grained unit (Odsc) is shown. In the structurally confused area around DN530650 on the eastern limb the rocks (Odhs) comprise essentially sandstone much like Odh but with sparse pebbly beds. No mappable subdivisions appear to be present.

DENISON GROUP

N. J. Turner

RAGGED RANGE (DOWN-FAULTED WESTERN LIMB)

Odl

An unconformity at which Odl overlies rocks of the Ragged Basin Complex is exposed at DN434666 on Ragged Range. Above the unconformity there is a breccia interval 0.5 m thick consisting of angular chert fragments up to 0.5 m across. There is a rapid transition from the breccia to white, small-pebble conglomerate in which bed thickness is about 150 mm. Chert is common as angular clasts in the lowermost 2 m or so of the conglomerate but rapidly becomes minor though it is still present some 6 m above the unconformity. The predominant clasts are angular to moderately rounded foliated quartzite and vein quartz of metamorphosed Proterozoic provenance.

Most of Odl comprises white weathering, thinly bedded (10–80 mm), medium-grained, quartz sandstone containing sparse beds with angular to poorly rounded, small pebbles. Worm casts are abundant in some beds.

Odc

On Ragged Range the boundary between Odc and the underlying Odl is very sharp and is marked by changes to coarser grain size and to pink colouration. Odc is about 40 m thick and comprises massive, well-sorted, siliceous conglomerate containing well rounded clasts of predominantly foliated quartzite and vein quartz which range in size up to small boulders. There are sparse thin interbeds of granule conglomerate. Near DN444654 where Odc lenses out the coarse-grained conglomerate is relatively thinly (200 mm) bedded and interbanded with pebbly and granuly conglomerate and sandstone.

Ods

Ods consists of coarse-grained, well sorted, quartz sandstone which is commonly pebbly and interbedded with granule and small pebble conglomerate. Cross-bedding may be prominent in the sandstone.

The rocks in Ods are mostly white though at DN446650 where the unit is close to lensing out against basement, the rocks are pink to red. These latter rocks are sandy and pebbly and contain common chert detritus. Their grain size places them in the Ods category but their colour may indicate that they are a lateral facies variant of Odc.

Odh

Uniform, white weathering, well sorted, medium- to coarse-grained, quartz sandstone comprises Odh on Ragged Range. It commonly has a flaggy bedding parting.

Thin pebbly conglomerate with rounded clasts of quartzite and quartz together with angular chert clasts comprises the lowermost metre or so of the unit where it overlies basement. Where it overlies Ods the boundary is fairly sharp.

Worm casts are abundant in the sandstone at DN447652 and small brachiopods are present in the uppermost part of the unit at DN467624 on the Adamsfield track.

Odf

Just east of Ragged Range Odf comprises medium-grained sandstone consisting of angular monocrystalline quartz grains, patches of very fine-grained muscovite (? after clay) and up to 10% by volume of glauconite. Commonly the sandstone is deeply weathered to an oxidised orange-brown, clayey material or to a leached, friable, siliceous material.

The sandstone often displays a wavy bedding lamination defined by wispy muddy lenticules and sometimes cross-bedding is apparent. Worm casts are common and small brachiopods are present in float of glauconitic sandstone and siltstone around DN445668.

SAWBACK RANGE – JUNCTION HILL (WESTERN LIMB)

The lithological subdivisions on Sawback Range are similar to those on Ragged Range though the lowermost unit (Odl) is absent. Along part of the range the two units Ods and Odh have not been mapped separately and the interval containing them is designated Odhs.

In Huntley quadrangle the western boundary of the Denison Group on Sawback Range is interpreted as a fault. In Pedder quadrangle this boundary is either covered by talus or crops out poorly. It may, or may not be a fault. Given the similarity between the stratigraphic section on Sawback Range and the section on Junction Hill, which apparently rests unconformably on basement, there seems little reason to believe that faulting has caused substantial attenuation of the Sawback Range section. The absence of Odl on Sawback Range may be due to lensing out against basement south of Adamsfield.

The conglomeratic unit, Odc, which forms the apparent base of the Sawback Range section appears to lens out south of Ibsens Peak. The overlying sandy and pebbly unit, Ods, also lenses out south of Ibsens Peak, whilst the next unit, Odh, appears to lap onto basement. Each of the two lower units (Odc, Ods) is again present on Junction Hill though to the north-west of Junction Hill they are indistinguishable at the scale of Pedder map and are shown as an undifferentiated unit, Odsc. On Junction Hill Odc is white rather than pink.

Outcrop of Odf is very poor along the eastern side of Sawback Range and the unit is obscured by extensive Quaternary cover near the Florentine River. It reappears north of Junction Hill. A thin interval of white, well sorted, coarse-grained, quartz sandstone (Odfs) occurs in Odf at DN477621 and may be continuous from the northern edge of the quadrangle near DN471666. The sandstone beds display prominent, planar to gently curved, cross-lamination. Small brachiopods occur in Odf at DN488592 and DN496594.

NORTH-EAST OF JUNCTION HILL (EASTERN LIMB)

Odh, Odhs, Odsc

Strata extending along the ridge north-east of Junction Hill comprise mainly well bedded, white, quartz sandstone (Odh). There is a thin, basal unit (Odsc) consisting of quartzose interbedded pebble and small cobble conglomerate, pebble and granule conglomerate, pebbly or granuly sandstone and sandstone. The occurrence of conglomeratic rocks at DN508604 on the lower western side of the ridge is thought to be a 'window' of the basal unit emerging on the dip slope.

Further to the north-east in the structurally confused region around DN530650 the rocks are designated Odhs. The predominant lithology is quartz sandstone which is flaggy to relatively thickly bedded and may display cross-lamination. There are occasional, thin, pebbly conglomerate beds and the sandstone may be granuly or pebbly. Most outcrops in the region are white though fresh sandstone in river sections may be greyish and there is pink, pebbly sandstone at DN524647. No coarse- grained unit similar to Odsc or to Ods was delineated.

Odf

The lowermost parts of Odf which outcrop around DN496594 and DN504606 consist of greyish-white sandstone and interbedded, orange weathering, argillaceous siltstone. These rocks are overlain by orange and brown weathering, fine-grained sandstone and siltstone, grey and khaki sandstone and siltstone and grey mudstone. Textures in the siltstone and fine-grained sandstone are commonly inhomogeneous, having a lenticular or nodular form.

Well bedded, quartzose sandstone occurs near DN504617 and contains interbeds of richly glauconitic sandstone. Exposures of sandstone bedding planes in cuttings beside the Gordon River Road display randomly oriented grooves 30–70 mm long by 5–10 mm wide filled with glauconitic sandstone.

Interbeds of chert occur in argillaceous siltstone and mudstone in the upper part of the formation around DN507630 and more widely around DN518659. The interbeds are 50–150 mm thick and the chert is grey to white in colour.

GORDON GROUP

N. J. Turner

KARMBERG LIMESTONE CORRELATE (Ogk)

Carbonate rocks overlie Odf with the stratigraphically lowest exposures occurring in Salvation Creek around DN508647. These rocks extend westwards to near the Florentine River and comprise massive, fine-grained, grey carbonate containing irregular to lenticular patches of light grey chert. The lenticular chert patches define a roughly planar fabric which is parallel to another roughly planar, anastomosing fabric defined by stylolitic seams. The compound fabric is thought to be parallel to bedding. Cleavage is locally developed in the carbonate and is a spaced, subplanar to anastomosing parting with weak, parallel segregation of black (?carbonaceous) material.

CASHIONS CREEK LIMESTONE CORRELATE (Ogo)

A single outcrop of grey carbonate containing abundant *Girvanella* occurs at DN498658. It displays a generally planar fabric of anastomosing stylolitic seams which is parallel to a planar fabric defined by a preferred orientation of the fossils. The compound fabric is thought to be parallel to bedding.

BENJAMIN LIMESTONE CORRELATE (Ogb)

Overlying the Cashions Creek Limestone correlate is a well bedded (20–100 mm) to massive carbonate. It is generally dark grey and very fine-grained though some beds are of coarser (1 mm) grain size. Stylolitic seams define an anastomosing fabric which is subparallel to bedding. Cleavage is locally present and is also expressed as an anastomosing fabric of stylolitic seams.

Lower Parmeener Supergroup

C. R. Calver

INTRODUCTION

The Lower Parmeener Supergroup, an essentially flat–lying glaciomarine sequence of late Carboniferous to late Permian age, occurs on Pedder Quadrangle as three isolated highland outliers at Mt Mueller, Mt Anne and Mt Wedge. The sequence overlies older, folded rocks with landscape unconformity and is overlain by Jurassic dolerite. The Mt Mueller outlier is the most stratigraphically complete and areally extensive occurrence, and here the same stratigraphic subdivision of the sequence can be recognised as on Huntley Quadrangle. Detailed descriptions of nearby correlative sequences can be found in Jago (1972) and Farmer *et al.* (1985).

CONGLOMERATE (Pglt)

This unit consists predominantly of dark grey-brown to black, massive, open-framework conglomerate, with minor pebbly mudstone and laminated mudstone. The unit is roughly 200 m thick at Mt Mueller, and ranges from 0 to 100 m thick at Mt Anne. The conglomerate is texturally a mixtite and contains 10–30% angular to mostly sub-rounded clasts of granule to cobble size, less commonly to boulder size, in a dark, structureless mudstone matrix. Clast lithologies include quartzite, phyllite, felsic quartz porphyry, dolomite and schist, with Wurawina Supergroup rocks (fossiliferous limestone and quartz siltstone) also present at Mt Mueller. In places, relatively clast-poor rock – weakly fissile, poorly-sorted pebbly mudstone – occurs as distinct layers up to a few metres in thickness. There are also rare, thin sandstone beds. In creek sections north of Mt Mueller, several intervals each 2–4 m thick, of laminite were recorded. These units consist of mudstone with thin planar laminae of siltstone or sandstone. The laminae lack the regularity of varves. Sparse dropstones occur in one interval, with laminae distorted about them by differential compaction. At DN555646, conglomerate is overlain by 0.5 m of impure fine-grained limestone followed by 2.5 m of laminite, with penecontemporaneous slumping affecting the top 0.5 m.

In the Mt Anne area, Pglt is relatively thin and passes up directly into the Bundella Mudstone correlate (Pglb) with no intervening Woody Island Siltstone correlate (Pglw) as on Mt Mueller. This implies that Pglt is a diachronous basal facies and that basement was relatively high in the Mt Anne area: perhaps 200–250 m higher than at Mt Mueller. On Mt Wedge, Pglt is the only Lower Parmeener unit present and is approximately 80 m thick.

Local basement relief is reflected in variations in the thickness of Pglt in the Mt Anne area. A basement high is inferred north of Mt Anne, where Pglt is absent and pebbly fossiliferous mudstone (Pglb) directly overlies Precambrian rocks. Pglt is relatively thin at Mt Sarah-Jane but becomes much thicker around Lots Wife. Nearby, a small basement high occurs at DN554442, and cliff exposures of conglomerate immediately to the north appear to display a gentle primary depositional dip away from this feature.

Pglt is a lithologic correlate of the Truro Tillite of south-eastern Tasmania (Farmer *et al*., 1985), which is thought to be late Carboniferous in age. At Mt Anne, the unit is probably younger as it directly underlies the Tamarian (early Permian) Bundella Mudstone correlate (Pglb). On the nearby Maydena Range, the top of the tillite is Lower Permian on fossil evidence (Jago, 1972).

PEBBLY MUDSTONE (Pglw)

This unit consists of dark grey, sparsely pebbly (less than 1%), poorly sorted massive mudstone. The unit is roughly 120 m thick at Mt Mueller, and appears to be absent at Mt Anne. The rock has a hackly, cuboidal fracture, or in places a weak shaly fissility. Clasts are predominantly fine-grained grey dolomite. These are rare developments of open-framework conglomerate. Glendonites are characteristic of this unit, but are rare. At DN557644, a bed of weathered mudstone contains abundant small (1–2 mm) spherical voids that were probably originally pyrite framboids. An unusual, small outcrop of quartzarenite occurs near the top of the formation at DN580628. Pglw is unfossiliferous except for small siliceous cylindrical tests in one sample (W77). These are probably simple agglutinating foraminifera, and are similar to those recorded from younger parts of the Lower Parmeener Supergroup (Forsyth, 1984, p.22; Calver, 1987, p.29).

Pglw is a lithologic correlate of the Woody Island Siltstone (Farmer *et al*., 1985).

FOSSILIFEROUS PEBBLY MUDSTONE (Pglb)

Pglb consists of massive to poorly bedded, poorly sorted dark grey mudstone and minor poorly sorted sandstone. The presence of marine fossils distinguishes this unit from the one below. Pglb is up to 100 m thick in the Mt Anne area but appears to be considerably thinner (≈40 m) at Mt Mueller. Dropstones are generally somewhat sparse but in a few places they are concentrated into open-framework conglomerate horizons. At Mt Mueller, dropstones are predominantly fine-grained grey to white dolomite similar to Precambrian Weld River Group lithologies. In the Mt Anne area, dolomite clasts are predominant at some horizons, while quartzite, phyllite and schist are commonest at others.

Fossils are rare to abundant, in a few places comprising greater than 50% of the rock volume. A ramose bryozoan is dominant at many horizons, and fenestellids, spiriferids, productids, and *Eurydesma* are also locally abundant. An outcrop near the base of the formation west of Mt Mueller [DN538628] consists of several metres of pebbly, richly fossiliferous, calcareous mudstone and bioclastic limestone. Here, dropstones (entirely of dolomite) comprise up to 30% of some beds; bioclastic debris up to 70% of others. *Eurydesma* is particularly common. A similar unit in the Maydena Range is correlated by Jago (1972) with the Darlington Limestone.

Fossil collections from DN548413, DN547420, and DN538628 are characteristic of the Bundella Mudstone (M. J. Clarke, pers. comm.), which is Tamarian (early Permian) in age (Farmer *et al.* 1985).

SANDSTONE (Plf)

Plf is a flaggy, fine- to medium-grained quartz sandstone, usually displaying cross-bedding or small-scale trough cross-lamination. The rock is slightly feldspathic and slightly micaceous. Comminuted carbonaceous debris is often present on partings. The unit is thin (about 6 m) and was identified only on the western ridge of Mt Mueller. Elsewhere it may be obscured by surficial deposits. At DN542630, five foreset dip directions all indicate palaeocurrents from the north-west quadrant.

At DN549636, an isolated, prominent outcrop of siliceous conglomerate occurs at the approximate stratigraphic level of Plf. About 3 m of conglomerate are exposed. It consists of 30% pebbles and cobbles of quartzite and phyllite (but no dolomite) in a matrix of coarse quartz sandstone. Although texturally dissimilar to the outcrops described above, this unit is tentatively assigned to Plf on the basis of composition and lack of marine fossils.

Plf is a correlate of the Faulkner Group, or Lower Freshwater Sequence.

FOSSILIFEROUS SANDSTONE, SILTSTONE AND MUDSTONE (Pga)

Pga consists of thick-bedded, poorly sorted grey-brown sandstone, siltstone and mudstone. Dropstones are generally sparse but locally concentrated into conglomeratic bands. Dropstone lithologies are varied and include dolomite, phyllite and quartzite. Most outcrops are fossiliferous, some abundantly so. Fenestellids are usually dominant, and in profusion impart a bedding-parallel fissility to the rock. Spiriferids, productids, crinoid ossicles, gastropods, ostracods and *Eurydesma* were also recorded. This unit is about 70 m thick at Mt Mueller and is overlain by Jurassic dolerite. Much of the unit is contact metamorphosed by the dolerite intrusion.

Fossils collected from this unit in the Fossil Lake area [DN572637] indicate a correlation with the Deep Bay Formation of south-east Tasmania (M. J. Clarke, pers. comm.) of Early and Middle Lymingtonian age (Farmer *et al*., 1985).

Quaternary deposits

C. R. Calver
P. W. Sansom

INTRODUCTION

Quaternary deposits on Pedder quadrangle include Pleistocene till of probably at least two distinct ages, fluvioglacial outwash gravels, scree and talus of probably largely Pleistocene age, and recent alluvium and swamp and marsh deposits. Most deposits shown on the map are undifferentiated due to lack of exposure: their presence is inferred from geomorphology and lack of basement outcrop. The most extensive undifferentiated areas, on broad valley floors around the Wedge, Huon and Florentine rivers, are probably underlain by alluvium and fluvioglacial outwash (see below).

TILL (Qpt)

Most of the till indicated on the map is formed into well–defined moraines associated with glacially-eroded landforms (highland cirques and glacial valleys). However, at several widespread localities at lower altitudes there are till deposits that are not of moraine-like form and are not associated with obvious glacially-eroded features (on the Scotts Peak Road at DN483413, DN478427 and DN472472; in Condominium Creek at DN498440; on the Mueller Road at DN550600, and at DN493413). Most of these localities are exposed by road or stream cuttings, and susceptible lithologies (notably Jurassic dolerite) have clearly undergone prolonged in situ chemical weathering. The Scotts Peak Road exposures consist of an abundant clayey matrix, light grey to brown in colour, containing boulders mostly of dolerite, and pebbles and cobbles mostly of Precambrian quartzite and phyllite. The dolerite boulders, which are up to 1.5 m in diameter, have weathered rinds approximately 0.02–0.2 m thick. At DN493413 and around DN485427, large, rounded dolerite boulders have probably been exhumed from similar deeply weathered till.

Other till developments are lateral and terminal moraines at moderate to high elevations (about 400 m) in the Mt Anne, Mt Mueller and Frankland Range areas. The moraines are morphologically well-defined; sharp-crested, and not dissected.

In the Mt Anne area, the largest moraines flank the two relatively large glacial valleys presently occupied by Lake Judd and Lake Timk. Only the western side of Lake Judd features a lateral moraine. Quaternary deposits on the eastern side may include lodgement tills but lack the morphology of moraine. Lake Judd is partially dammed at its southern end by a low recessional moraine, and other recessional moraines, not indicated on the map, are evident as low, tree-covered ridges running across the flat marshy outwash plain south of the lake.

The high slopes facing onto the north-western shoreline of Lake Judd are essentially devoid of talus, suggesting that at least this northern part of the valley was ice-filled during the last glaciation. There are two almost-submerged roches moutonées at DN527421 and nearby shoreline outcrops appear glacially streamlined. These outcrops, of interbedded quartzitic siltstone and slate, have developed about 100 mm of relief by post-glacial differential erosion. An arcuate, semi-submerged bouldery ridge at the northern end of the lake [DN534431] appears to be the last recessional moraine left by a greatly diminished body of ice.

The precipitous eastern face of Mt Anne is the headwall of the cirque that fed the other large valley glacier that extended east and north-east almost to the Weld River. The middle reaches of this valley are overdeepened and partly filled by Lake Timk. A large (20 m) erratic of Parmeener Supergroup conglomerate was observed east of Lake Timk [DN566457]. The lower parts of this boulder, apparently recently exposed, are glacially smoothened and striated while the upper parts have been considerably roughened by post–glacial weathering. Another large conglomerate erratic, 50 m in length, occurs on the north-east ridge of Mt Anne at DN542462.

The Lonely Tarns occupy a series of small highland cirques on the plateau between Mt Lot and Mt Sarah-Jane. Most of the cirques are partly bounded by moraine ridges, and the two southern tarns are dammed by moraine. The Lake Picone cirque was evidently the source of a valley glacier as suggested by the large lateral moraine well downstream beside Whitewater Creek. The cirque at DN553427 also produced ice that moved down off the shelf by way of the small glacial valley that breaches the cliffs at DN559428. On the floor of this valley there are several low, rounded, ice-moulded hillocks of quartzite bedrock, 20–50 m in length. A metre of surface relief caused by post-glacial differential weathering suggests these features pre-date the last glaciation (*cf.* Colhoun, 1985, p.47). The high quartzite cliff [DN557425] delimiting the eastern edge of the high country may itself be the headwall of a large cirque, and nearby ridges at DN567414 and DN574416 are possibly moraines but this has not been confirmed by ground traverses.

At several high-altitude localities there are small cirque-like features, developed on drift or talus, that are thought to be nivation (snow-eroded) cirques. These are bowl-like depressions 100–200 m wide, not overdeepened and not associated with much transport or deposition. One near Mt Eliza, [DN522433], has a north-westerly aspect. Some of these nivation cirques are indicated on the map.

At Mt Mueller, a large lateral moraine lies beside the upper reaches of the Styx River. A more limited body of ice overlay a cirque partly floored by bedrock at Fossil Lake, itself dammed by a small moraine. On the eastern threshold, striae were observed on Permian mudstone bedrock.

The third area of significant highland glaciation is the Frankland Range in the south-west of the map sheet. Glacial deposits here have not been differentiated on the map. Many small sharp-crested lateral moraines are present on the northern slopes of the range, where they flank the lower reaches of short glacial valleys sourced in deep north-facing rock-basin cirques.

Well-preserved, undissected moraines at high elevations in the Frankland Range, Mt Mueller and Mt Anne areas are, by comparison with the relatively well-known West Coast Range glacial history, of last glacial age (≈30 000–10 000 yr b.p.) (Colhoun, 1985; Kiernan, 1983). On the other hand, the deeply-weathered nature of the tills on the Scotts Peak Road and the Mueller Road is an indication that they belong to an older glaciation, possibly the early Pleistocene Linda glaciation (>130 000 yr b.p.) (Kiernan, 1983). The large lateral moraines at intermediate elevations, such as those east of Lake Timk, west of Lake Judd and south of Whitewater Creek, are of uncertain age.

FLUVIOGLACIAL SAND AND GRAVEL (Qpf)

Fluvioglacial deposits have only been differentiated on the Scotts Peak Road around DN480420, but in view of the widespread nature of the earlier glaciation and the then much greater sediment flux into the valleys than is presently occurring, they are probably far more widespread. They may underlie much of the flat-lying valley floors adjoining the Florentine and upper Huon rivers shown on the map as undifferentiated Quaternary (Qu).

On the Scotts Peak Road, the gravels are at least one metre thick and consist of poorly-rounded pebbles, cobbles and small boulders of quartzite, phyllite and dolerite, with minor lenses of sand. The presence of such coarse grades in an area of low relief suggests the gravels are of fluvioglacial origin.

Fluvioglacial gravels comprise several laterally coalescing, gently-sloping fans that extend northward from the foot of the Frankland Range across the plain now mostly covered by the new Lake Pedder (Davies, 1967).

SCREE AND TALUS (Qqs)

Scree and talus deposits are abundantly developed on the flanks of highland areas. These are bouldery slope deposits of strictly local provenance, and have been differentiated according to parent rock type as indicated in the map legend. On Mt Anne and Mt Mueller, dolerite blockfields are extensive at high elevations. Much of the high-level dolerite talus mapped in these areas could be glacially-transported material which, without good exposure, would be indistinguishable from bouldery slope deposits unless moraine topography is preserved. A narrow belt of Qqsd occupying a slight depression on the plateau north of Mt Eliza [DN526438] was probably transported by ice or nivation processes.

At lower elevations, some talus deposits appear to merge into proximal alluvial fans. For example, an exposure of rounded quartzite cobble- and boulder-gravels at DN494519 may be an alluvial fan deposit, as is also suggested by the morphology of the surrounding area, mapped as Qqss.

A predominantly Pleistocene age is suggested by the presence of only sporadic or relatively thin developments of talus and scree in cirques. Slope transport mechanisms (solifluction, etc.) were presumably more active during the Pleistocene than at present. The talus and scree deposits appear to be presently stabilised.

ALLUVIUM, SWAMP AND MARSH DEPOSITS (Qha)

Small areas of these deposits were delimited on the basis of topography along short depositional tracts of streams that in some instances may be a result of local glacial over-deepening (e.g. DN570438, DN550455).

Recent alluvial gravel and sand are undoubtedly widespread in the vicinity of modern streams in areas shown as undifferentiated Quaternary.

IGNEOUS ROCKS

Precambrian

METADOLERITE DYKES (Ꝑtm)

J. McClenaghan
M.P. McClenaghan

Metadolerite dykes can be seen intruding the light green-grey phyllite (Ꝑtl) at DN208627, DN253613 and DN248603, and intruding the chlorite-actinolite-epidote-albite schist (Ꝑts) at DN256652. The dykes consist of a dull, green-grey, poorly foliated and generally weathered rock. They trend NNW-SSE, their foliation and trend being parallel with the cleavage in the adjacent phyllite. Thicknesses range from about 2 to 14 m.

The amphibolite dyke at the Serpentine Lookout [DN208627] has a foliation defined by fibrous actinolite and by chlorite. In places this foliation is seen to be a later crenulation cleavage. Porphyroblasts of actinolite and aggregates of chlorite after actinolite deflect the cleavage.

Porphyroblasts of albite overgrow the foliation.

Cambrian

ULTRAMAFIC ROCKS (₠rpx; ₠rpd; ₠rs)

A. V. Brown

The small area (≈1.5 km^2) of ultramafic rocks along the northern part of the map sheet, to the south of DN460666, consists of partially serpentinised, massive, coarse-grained orthopyroxenite (₠rpx); partially serpentinised massive to layered dunite and orthopyroxene-bearing dunite (₠rpd); and a zone of sheared serpentinite (₠rs), along the western margin of the peridotite.

Field evidence, substantiated by chemical data, indicates that the massive orthopyroxenite originally overlay the interlayered dunite and orthopyroxene-bearing dunite sequence. The present boundary between the two bodies show evidence of cataclasis and high temperature plastic flow of the dunite and orthopyroxene-bearing dunite sequence into the massive orthopyroxenite.

The rocks in this area are part of the Adamsfield Ultramafic Complex, the northern continuation of which is covered by the Huntley 1:50 000 map sheet. Early work on the ultramafic rocks in this area can be found in Nye (1929) and Carey and Banks (1954). The following petrological descriptions are based on Brown (1972) and Varne and Brown (1978), the latter of which incorporated data obtained during mapping of the ultramafic rocks in this area. Data on the bulk rock chemistry can be found in Brown (1972) and Varne and Brown (1978) and electron microprobe analyses of mineral components in Varne and Brown (1978) and Brown (1986). An extensive description of the northern extension of the body, onto the Huntley 1:50 000 Map sheet, can be found in Brown *et al.*, (1989).

Massive orthopyroxenite (₠rpx)

Typical massive orthopyroxenite consists of interlocking subhedral to anhedral grains of enstatite. In hand specimen, the enstatite is a light olive green when fresh to bronze-green when weathered, and ranges in size from fine-grained (1 mm) and equidimensional to coarse-grained (up to 150 × 30 mm) and irregular in shape. The coarser grained crystals have an irregular interlocking intergrowth.

In thin section, the orthopyroxene grains exhibit undulose extinction (up to 50°), kink bands and bent cleavage traces, as well as cataclastic deformation of the grains. In some samples, small elongate amphibole grains are observed within enstatite crystals, where they occur along the boundaries of different areas of undulose extinction. In most samples, minor (1–2%) anhedral olivine and euhedral to subhedral chromian spinel grains occur.

Electron probe analyses of constituent mineral grains gave a composition of En_{92-94} for enstatite, which usually had less than detection limit (0.2 mass%), and always less than 0.5 mass%, CaO and Al_2O_3 contents. The composition of olivine is Fo_{88}. Chrome spinel grains contain between 65 and 70 mass% Cr_2O_3, giving a Cr/(Cr+Al) ratio of 0.90–0.94.

Serpentinised dunite with interlayered orthopyroxene-bearing dunite (€rpd)

The colour of dunite in hand specimens depends upon the degree of serpentinisation; the freshest samples being a yellowish green and the serpentinised samples being dark green. In the interlayered part of the sequence the orthopyroxene grains define a mineral foliation and are a buff-brown colour.

In thin section, dunite samples consists of flattened, elongated olivine crystals, up to 5 mm long, irregular in cross section, but typically wedge-shaped, and consisting of sub-grains (up to 0.5 mm in diameter) surrounded by a mantle of intergrown lizardite, chrysotile and magnetite. These sub-grains exhibit very fine optical deformation lamellae, parallel to (100) and sweeping extinction (up to 45°). Orthopyroxene bearing dunite have a porphyroclastic texture with the enstatite grains exhibiting undulose extinction and pull apart textures (along the 010 and 100 planes). In most samples, not only are the olivine and enstatite crystals flattened and deformed but the larger grains of the accessory chromian spinel also exhibits pull apart structures. As the degree of serpentinisation increases, lizardite forms typical serpentine group mineral mesh-structured arrangements with smaller and smaller olivine sub-grain cores.

Chemically, both olivine and orthopyroxene grains have a very uniform composition, olivine being Fo_{92-93}, and enstatite being En_{92-94}. The CaO and Al_2O_3 contents of enstatite are below detection limits. Chrome spinel grains have a Cr/(Cr+Al) ratio of 0.89–0.96.

These ultramafic rocks are considered to have been formed as cumulate bodies at high temperatures (≈1250°C) and low pressures (≈5 Kb) in the forsterite + protoenstatite + spinel + liquid stability field from a quartz normative liquid, rich in magnesium and chromium, low in titanium, calcium and aluminium, and with a low hydrous content. The extrusive product of such a magma would be equivalent to the high-magnesian lavas (boninite) found in the Dundas Trough of western Tasmania (Brown, 1986; Brown and Jenner, 1989).

Serpentinite (€rs)

Between the western side of the partially serpentinised primary ultramafic rocks, and the western bounding fault, is a zone of sheared serpentinite. All measured foliations within the serpentinite are vertical with a strike parallel to sub-parallel to the bounding fault. The foliation is considered to have been formed during deformation and re-intrusion of the ultramafic rocks, through the Cambro-Ordovician sedimentary rock cover, during Devonian times.

Lamprophyre

N. J. Turner

A lamprophyre dyke is well exposed in the cuttings beside the Gordon River Road near DN475590. The dyke is about 400 mm wide, subplanar and dips 75° towards 240°. It cuts across bedding and cleavage in the host rocks (€awc). The dyke rock is massive and uncleaved. Its age is unknown.

The lamprophyre is fine grained with mafic phenocrysts up to about 1 mm across. About 10% by volume of the rock comprises phenocrysts of brown biotite and there are subordinate phenocrysts of clinopyroxene (?diopside) and sparse phenocrysts of quartz. There is minor secondary chlorite but, in general, the biotite grains are fresh. Small grains of opaque oxide are abundant. The groundmass is predominantly felsic with many grains displaying an extinction mode suggestive of fibrous character. An apparent absence of twinning in the felsic grains suggests that they are orthoclase and that the lamprophyre is a minette.

Jurassic dolerite (Jdl)

C. R. Calver

The three highest peaks on Pedder map sheet are capped by outlying erosional remnants of the same resistant Jurassic dolerite that underlies much of eastern and central Tasmania. The outliers on Mt Wedge, Mt Mueller and Mt Anne are probably remnants of a single widespread sheet-like intrusion that once covered much or all of the map sheet. No roof to the intrusion is preserved except near Mt Eliza.

On Mt Wedge, the dolerite intrudes the basal conglomerate unit of the Lower Parmeener Supergroup, while on Mt Mueller, the dolerite intrudes at a level high in the Upper Glacio-Marine sequence. The much larger Mt Anne outlier is geometrically more complex. The intrusion here is in places at least 400 m thick. On the escarpment surrounding the northern part of Lake Judd the dolerite intrudes Precambrian rocks. The base of the intrusion gently rises away from this central area and overlies Bundella Mudstone equivalent (Pglb) in the Lonely Tarns area and north of Mt Anne. The basal contact is irregular on outcrop scale. Lots Wife, a sheer blade-like dolerite peak, is an erosional remnant of the sheet and not a dyke as its form might suggest, as here the basal contact remains subhorizontal and dips gently east.

An area (≈0.2 km^2) of Precambrian quartzite lies atop the plateau just east of Mt Eliza, surrounded by dolerite and 400 m above the base of the intrusion. This quartzite body has a roughly horizontal basal contact upon dolerite except for a steeper section along the north-western boundary. Bedding within it is roughly conformable with bedding in the quartzite below the intrusion. It appears to be remnant of the roof of the intrusion. The dolerite, as elsewhere in Tasmania, is essentially uniform apart from chilled margins and subtle variations associated with differentiation. Minor pegmatitic veins and schlieren were observed in the high country between Mt Anne and Mt Eliza. A thin section from the top of Mt Anne is a normal mesostasis-poor coarse-grained (1–2 mm) dolerite with subophitically intergrown labradorite, augite and pigeonite, and minor opaques. The chilled margin at the top contact [DN523432] contains orthopyroxene microphenocrysts, 0.5 mm in size, and smaller (0.1 mm) plagioclase laths in an abundant dark, cryptocrystalline groundmass.

Contact metamorphism due to dolerite, indicated on the map, is noticeable in susceptible lithologies many metres below the base of the intrusion. Baked mudstone and mud-rich sandstone and conglomerate of the Parmeener Supergroup are lighter-coloured and noticeably indurated with respect to their unaffected counterparts. Contact-metamorphosed Precambrian phyllite and siltstone are hornfelsed in places, and commonly spotted. In thin sections the spots, 0.2–1 mm in diameter, are merely light-coloured segregations of fine-grained quartz and sericite in a similar but more turbid matrix rich in small clots of brownish opaques. Quartzite above the top contact near Mt Eliza appears unaffected.

At several localities [DN544633, DN555446, DN542463] contact metamorphosed rock is more distant from dolerite outcrop but close to the level of nearby intrusion. Here, metamorphism attests to the former presence of superincumbent dolerite now removed by erosion.

Recent mapping suggests the small area of dolerite shown at DN589657 is not *in situ*.

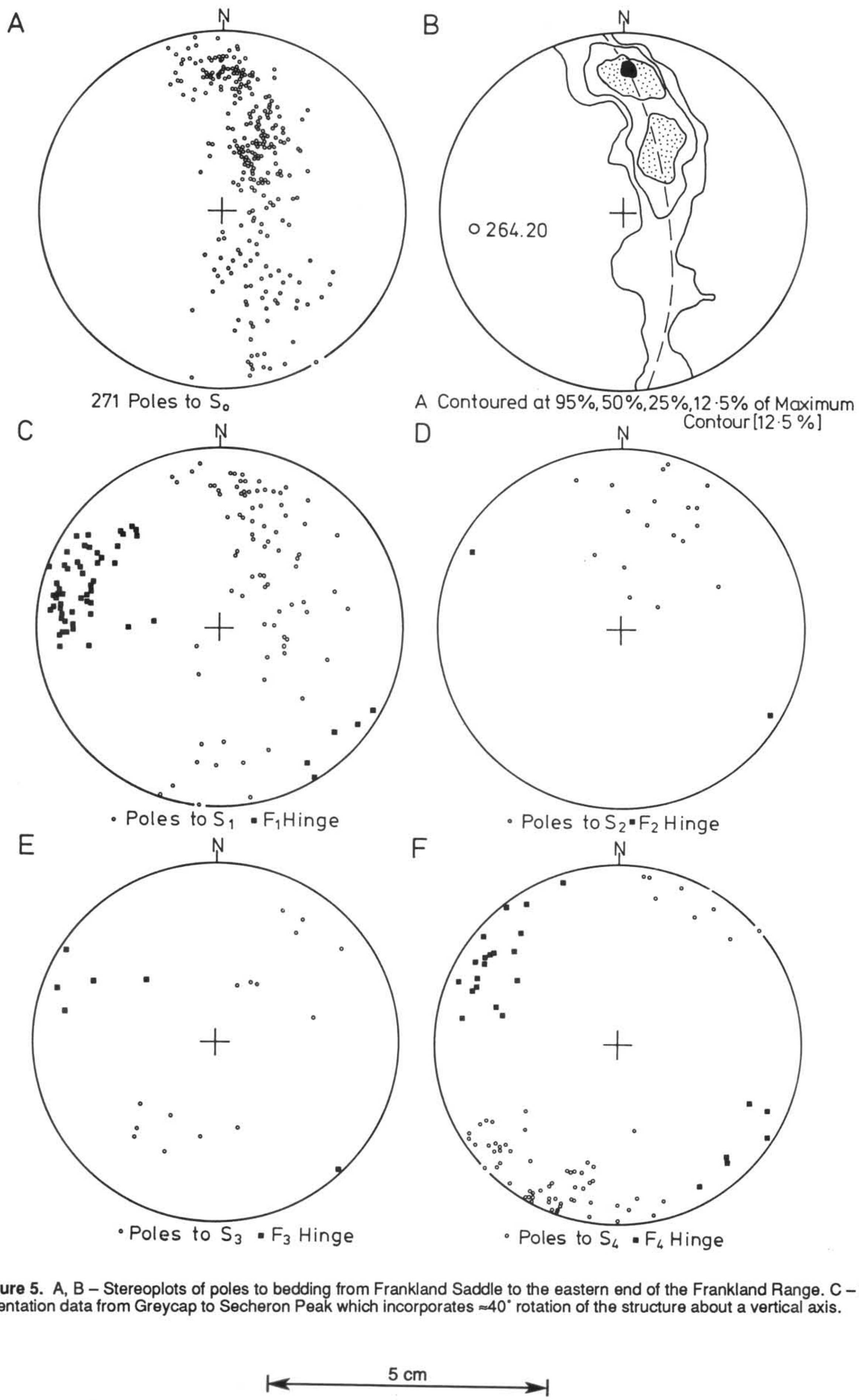


Figure 5. A, B – Stereoplots of poles to bedding from Frankland Saddle to the eastern end of the Frankland Range. C – F Orientation data from Greycap to Secheron Peak which incorporates ≈40° rotation of the structure about a vertical axis.

STRUCTURAL GEOLOGY

Precambrian

TYENNAN REGION

FRANKLAND RANGE

C. A. Boulter

Overprinting of structural events demonstrates up to four discrete deformation phases in single exposures and, in areas of several tens of square metres, cleavage-forming events can be demonstrated. The quartzite dominated ridge of the main Frankland Range has a geometry, at the macroscopic scale, that is almost exclusively the product of D_1 and D_4. Local macroscopic D_2 and D_3 folds are generally restricted to regions of schistose micaceous quartzite and flaggy quartzite. D_5 only generates mesoscopic to microscopic structures and is rarely found in lithologies other than phyllite.

From Greycap to Terminal Peak the geometry relates to D_1 structures in isolation except for a near uniform rotation during D_4 (fig. 5–6). Contributions to the total geometry, from the west/south-west limb of the major D_4 synform, are minimal. There are two style groups to the first generation folds separated by a zone, a few metres wide, of highly strained quartzite interpreted to be a syn-D_1 metamorphic slide (fig. 6). Above the slide, S_1 is parallel to bedding except in the immediate region of large fold closures, and boudinaged layers are common. Below the slides, S_1 is usually at an angle to bedding and isoclinal macroscopic D_1 folds are rare. The major D_1 fold above Terminal Peak on the profile (fig. 6) is a multiple hinge type enclosing two disharmonic near isoclinal folds. S_1 is well developed on both sides of the slide and is fanned by around 15° on either side of the fold axial surfaces. Features attributable to D_2 and D_3 are very sparse in this area. The fourth cleavage is also fanned about the major upright D_4 synform. Between the eastern end of the Frankland Range and Greycap the structural trend, defined by statistical fold axes, changes from 20° → 264° to 20° → 310°. The readings of S_1/F_1 to S_4/F_4 (fig. 5c–f) were taken in a region that extends through most of this change in trend hence distributions for individual elements (e.g. S_4, F_4 hinge lines, etc.) have broad strike/bearing ranges of around 40°. The bedding readings (fig. 5a–b) were chosen from an approximately rectilinear section of the range (Frankland Saddle to Terminal Peak) to illustrate the regular nature of the fold geometry particularly the cylindrical distribution. That this section of ridge is mainly in the area of tight, rather than isoclinal, D_1 folds is clearly shown by the contoured version of the stereographic projection (fig. 5b). Scatter of poles along the girdle is slightly influenced by the D_4 synform, but evidence taken from the whole Frankland Range shows

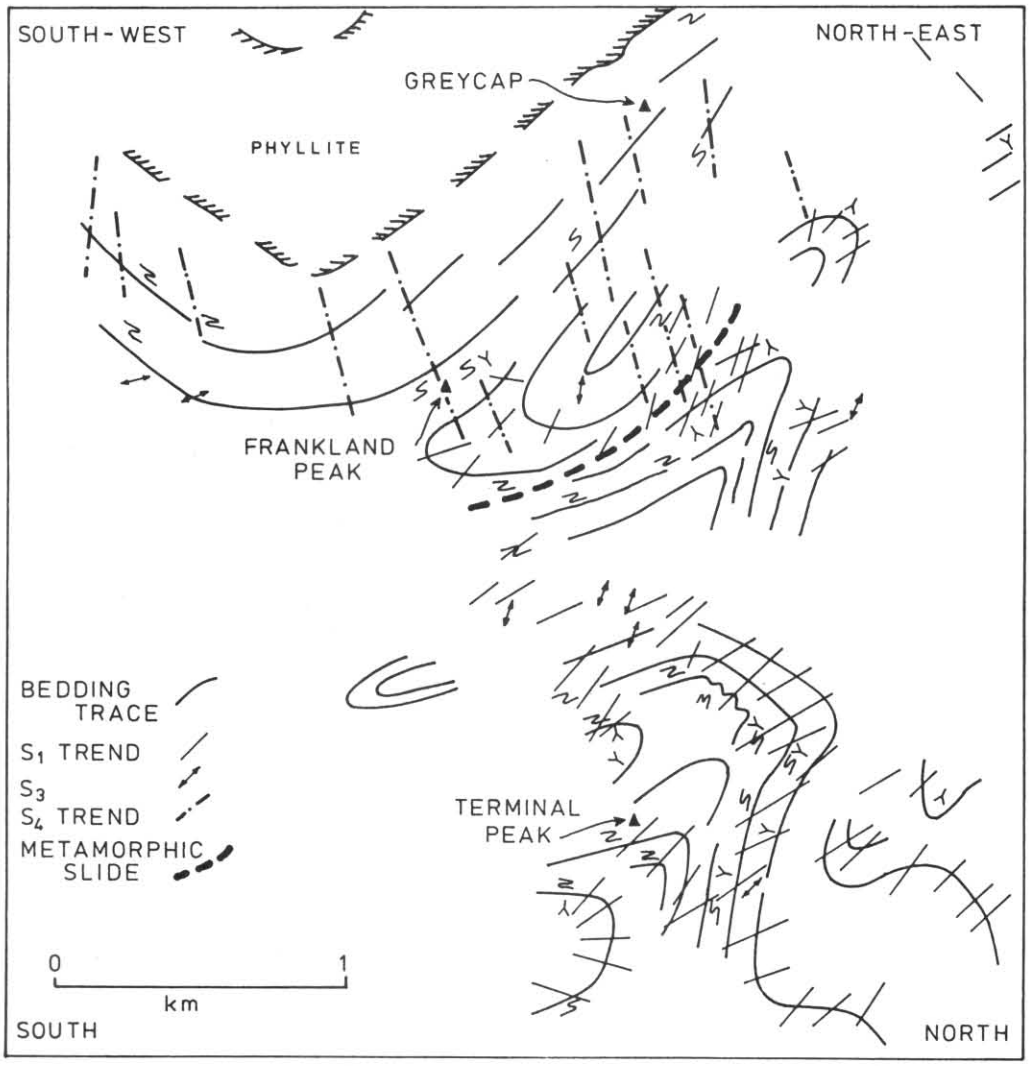


Figure 6. Detailed down-plunge profile from Grey Cap to the eastern end of the Frankland Range. The change in trend of the range required three profiles (top 20 → 310, centre 16 → 244, bottom 20 → 264) to be keyed together, S_1 S_4 are highlighted and cleavage fans are well displayed. The metamorphic slide separates zones with different F_1 characteristics.

5 cm

5 cm

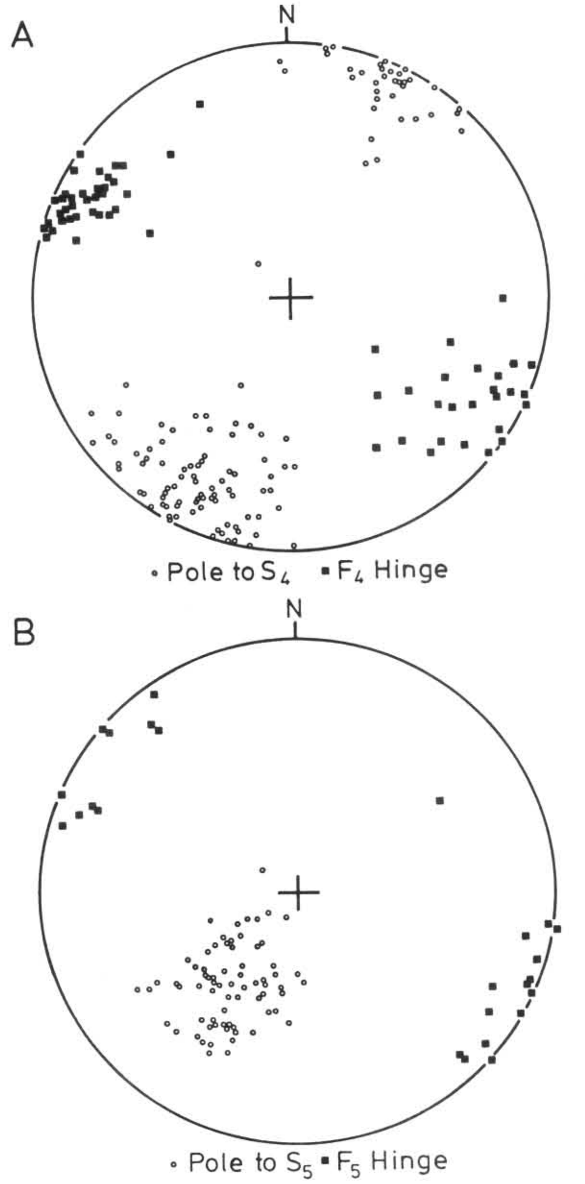


Figure 7. Stereoplots of D_4 and D_5 structures from Redtop Peak to Cleft Peak region.

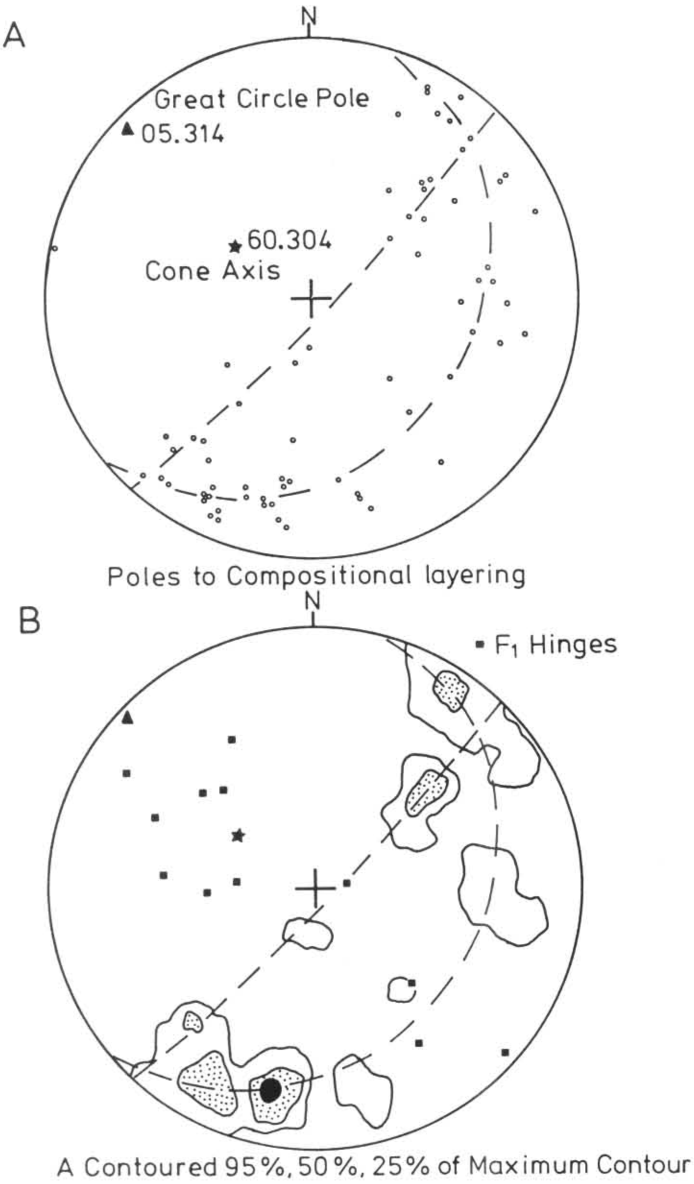


Figure 8. Stereoplots of poles to bedding and F_1 hinge lines from the region between Cupola Peak–Redtop Peak and Lake Pedder.

these to be approximately coaxial at the regional scale. Contrasts between D_4 and D_5 geometry are best shown in the large outcrop of phyllite between the Frankland Range and Remote Peak. Again the two phases are approximately coaxial but S_4 is upright to steeply inclined and S_5 is moderately to gently inclined (fig. 7). Cleavage refraction across lithological boundaries ensures orientation overlap of these two fabrics. Two weakly developed pairs of conjugate kink bands post-date D_5 and pre-date the regional rotation of the structures defining the trend of the mountain range.

In the foothills of the Frankland Range towards Lake Pedder, the zones of interlayered quartzite, flaggy quartzite, schistose micaceous quartzite and phyllite, show more variable geometry. North and South of the Bell Basin, layering dips uniformly 75° towards 085°. On Starfish Hill bedding readings show a very broad scatter (fig. 9a) though an approximate girdle can be proposed. Much of this scatter can be attributed to the numbers of mesoscopic F_1, F_2, and F_3, folds. In particular F_1 hinge lines are widely dispersed possibly a combination of initial variation after heterogeneous stretching in D_1 and of refolding. The flaggy quartzite unit is less affected by minor folding and its geometry (fig. 9b) is fairly regular and probably reflects the overall macroscopic fold. This structure is D_3 in age based on overprinting and orientation grounds. In its present orientation, after major rotation in D_4, the fold is moderately inclined though its pre-D_{P4} attitude would be defined by restoring the long fold limb through Bell Basin to horizontal. On the low ground between the Cupola/Redtop Peak and Lake Pedder is a zone of lithologies similar to those on Starfish Hill. A plot of all bedding readings shows a complex distribution that could be interpreted in terms of a cylindrical fold with a gentle plunge (05° $\rightarrow$ 314°) and a cone with an axis oriented 60° $\rightarrow$ 304° (fig. 8). However, the macroscopic significance of this is suspect when the map shows fairly simple rectilinear outcrop patterns. Also a down plunge profile only shows a broad open fold which on the map evidence must be sub-horizontal. It appears that the bedding pole pattern must result from interference of non-coaxial minor folds and F_1, F_2, F_3 and F_4 are fairly common in the region. The incongruous relation between major and minor folds is probably the product of several factors including variable stretching in the x directions of each deformation event.

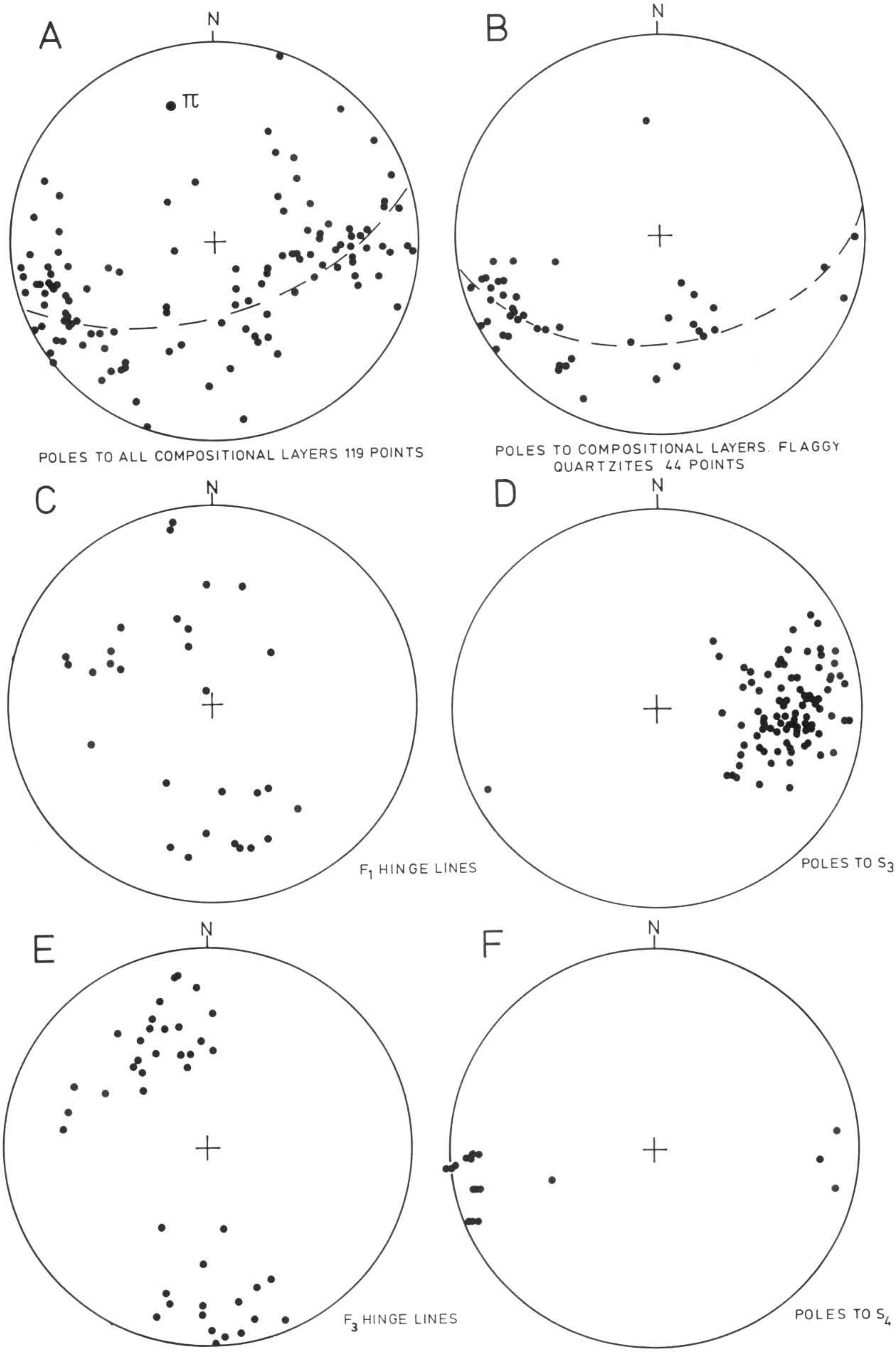


Figure 9. Stereoplots of orientation data from Starfish Hill

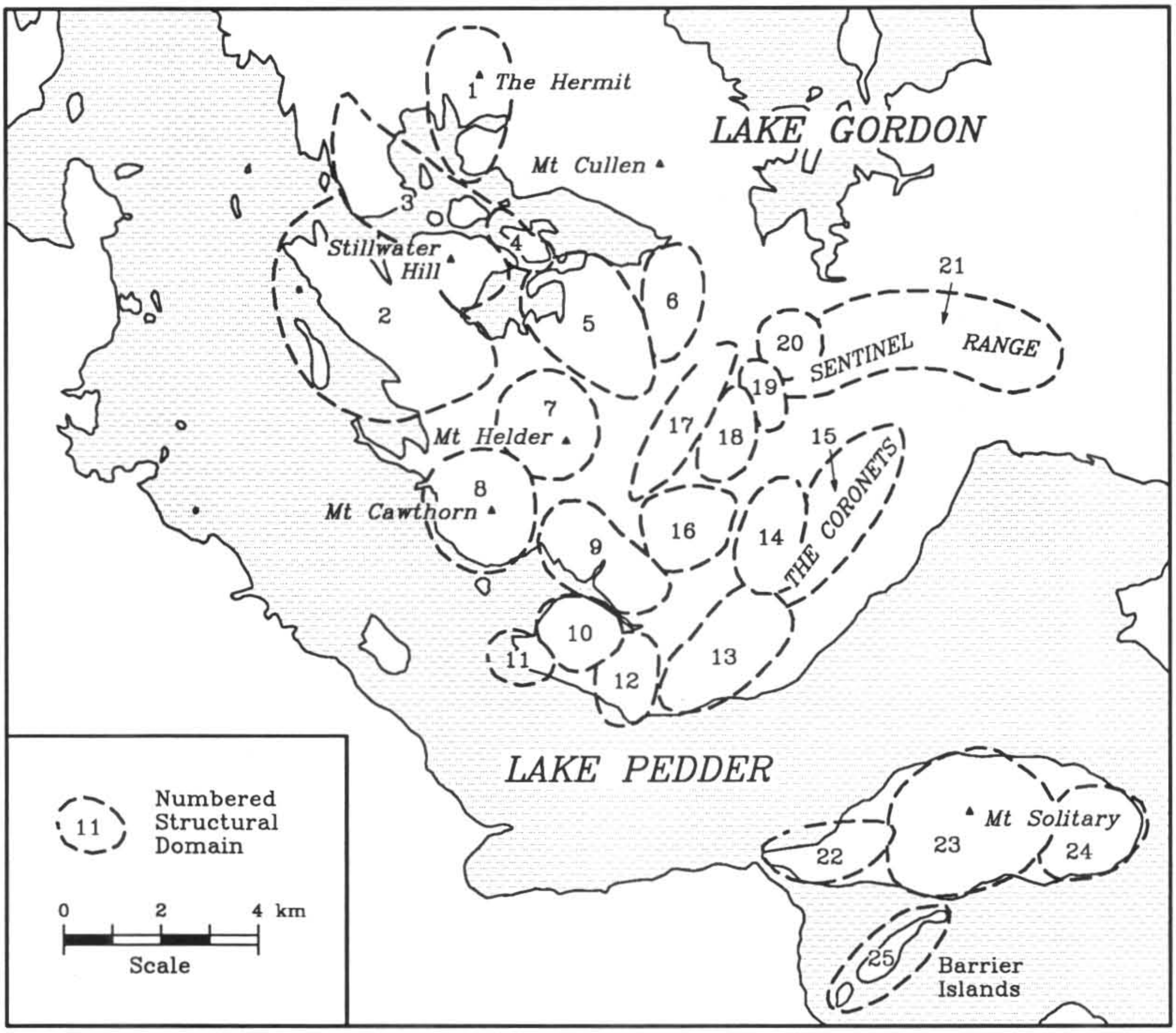


Figure 10. Structural domains in the Lake Pedder area.

MT SOLITARY AND BARRIER ISLANDS

M. P. McClenaghan

Mt Solitary and Barrier Islands consist dominantly of massive white and slightly pink coarse-grained quartzite (Ꝑtqc). Current bedding is well developed providing abundant way-up evidence. A schistose micaceous quartzite (Ꝑtqs) is very poorly exposed in the lower parts of the northern slopes of Mt Solitary.

In western Mt Solitary (domain 22, fig. 10) the beds young north and strike east with steep dips to the north and south (fig. 11). Cleavage of undetermined order is approximately horizontal. The axial plane of open minor folding of the bedding has a similar attitude (fig. 12). Passing east to the central part of Mt Solitary domain 23 (fig. 10) minor folding is more common with axial planes dipping at moderate angles to the north-west (fig. 13). The folding is open with sharp curvature at the hinge lines and with gently curved limbs. This has produced a distinct grouping of the poles to beds younging to the north-west and to those younging to the north-east (fig. 14). The cleavage is of undetermined order and has dominantly the same attitude as the axial planes to the folds, however, two readings have a low dip and appear to group with the almost horizontal cleavage in the previous domain (fig 15). A crenulation cleavage is present in the schistose micaceous quartzite (Ꝑtqs) which dips south at moderate angles. The different attitude of this cleavage from that in the quartzite suggests that it is a not the same one. In the eastern part of Mt Solitary the rocks display similar structures (fig. 16–18). On the Barrier Islands to the south (domain 25, fig. 10) the overall younging of the bedding is to the south-east. The poles to bedding appear to plot on a small circle indicating non-cylindrical folding (fig. 10). Minor folds have axial planes dipping steeply to the south-east and the north-west and their hinges plunge at steep to moderate angles to the north and south-west (fig. 20). The wide spread of plunge angles suggests that these folds are folding previously folded beds. Cleavage of undetermined order is present with an approximately similar attitude to the axial planes of the folds (fig. 21) and in some areas is clearly related to the folding.

In Figure 22 a bedding strike trend line diagram of the area is presented. Clearly Mt Solitary and the Barrier Islands form limbs of a north-east trending synformal anticline. The steep dip of the beds on both limbs of this structure indicates that its axial plane is also steep. This suggests that the minor folds with moderately dipping axial planes are produced by a later fold phase. The difference in attitude of the cleavage in the western part of Mt Solitary and the rest of Mt Solitary (see fig. 12, 15), suggests that the later folding may be split into two phases. The cleavage in the schistose micaceous quartzite (Ꝑtqs) on the north flanks of Mt Solitary was probably produced by a further phase of deformation.

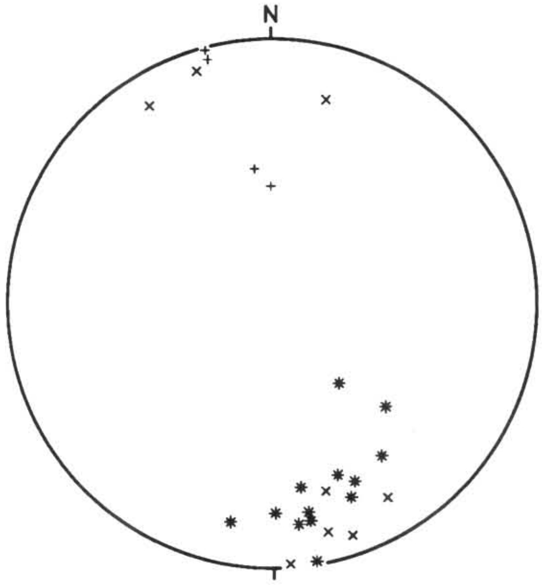


Figure 11. Stereoplot of poles to bedding, domain 22.

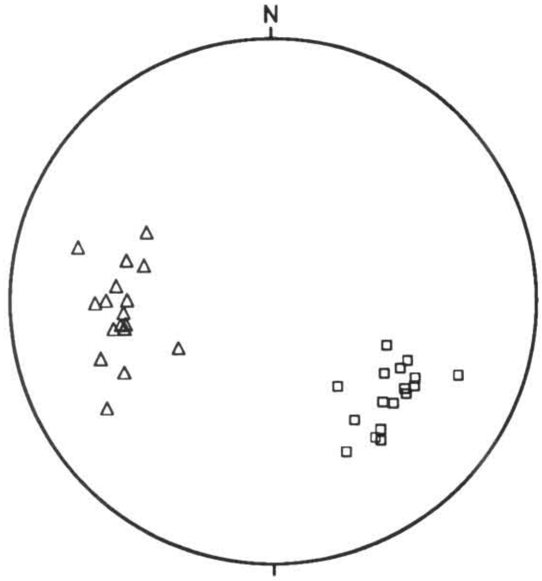


Figure 13. Stereoplot of structural elements, domain 23.

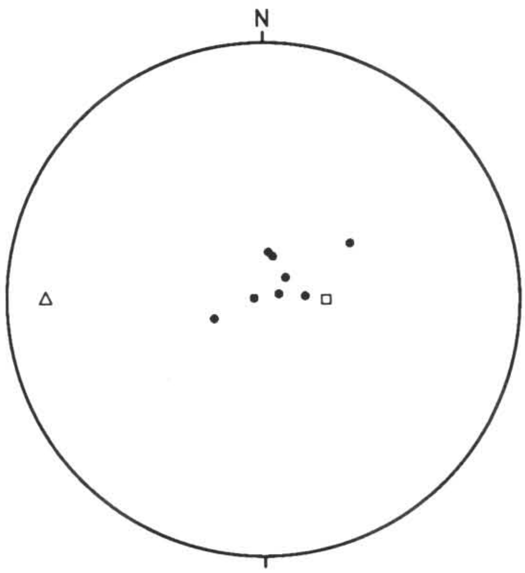


Figure 12. Stereoplot of structural elements, domain 22.

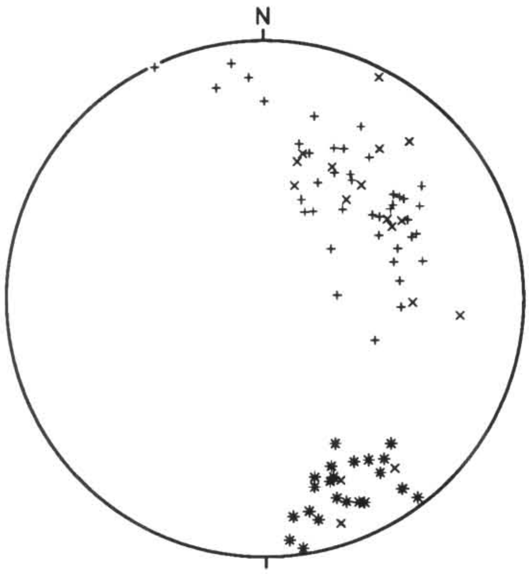


Figure 14. Stereoplot of poles to bedding, domain 23.

Symbols used in Figures 11–21

- × pole to bedding, way-up unknown
- * pole to bedding, right way up
- ◆ pole to cleavage of undetermined order
- ○ pole to crenulation cleavage
- △ hinge of fold in bedding
- □ pole to axial plane in fold in bedding

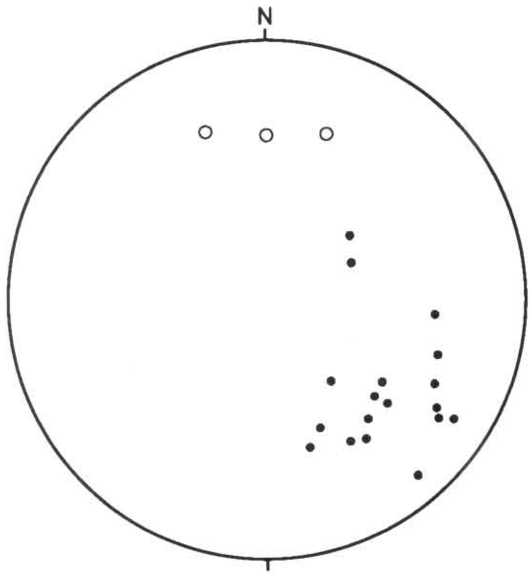
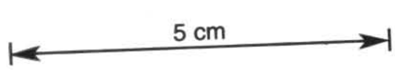


Figure 15. Stereoplot of structural elements, domain 23.



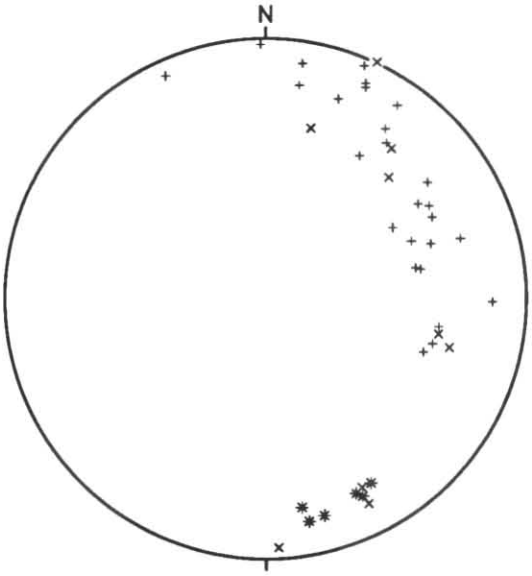


Figure 16. Stereoplot of poles to bedding, domain 24.

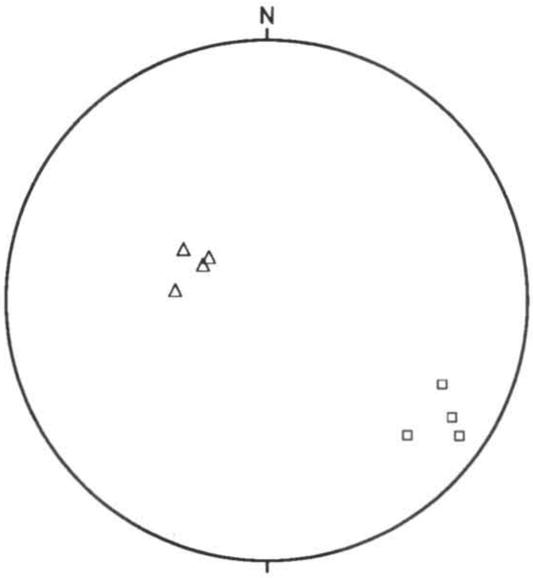


Figure 17. Stereoplot of structural elements, domain 24.

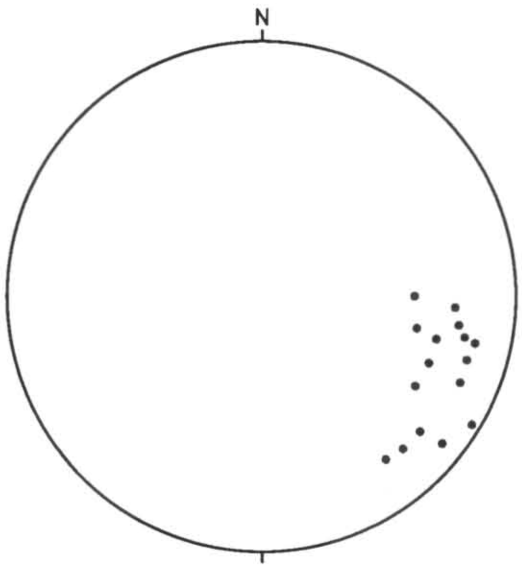


Figure 18. Stereoplot of structural elements, domain 24.

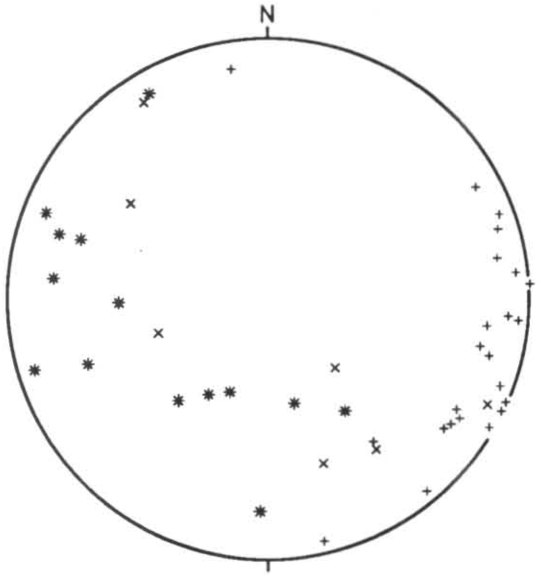


Figure 19. Stereoplot of poles to bedding, domain 25.

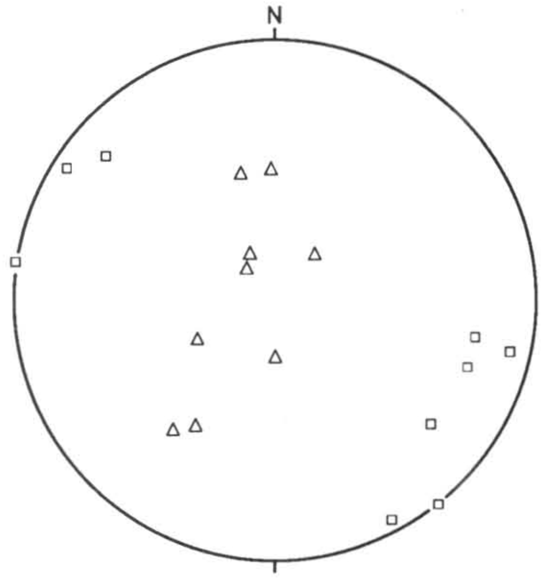


Figure 20. Stereoplot of structural elements, domain 25.

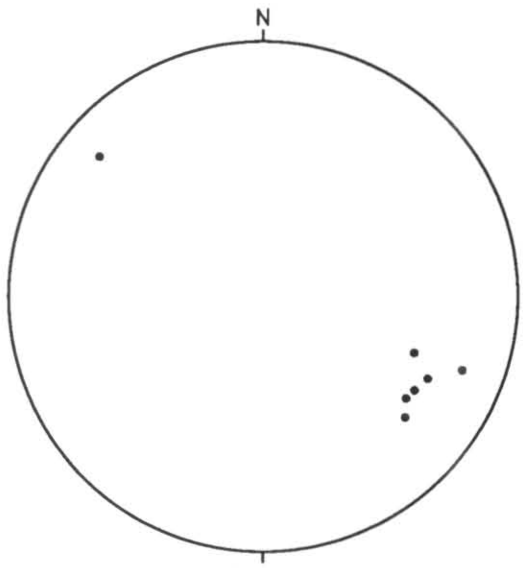
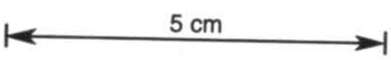


Figure 21. Stereoplot of structural elements, domain 25.



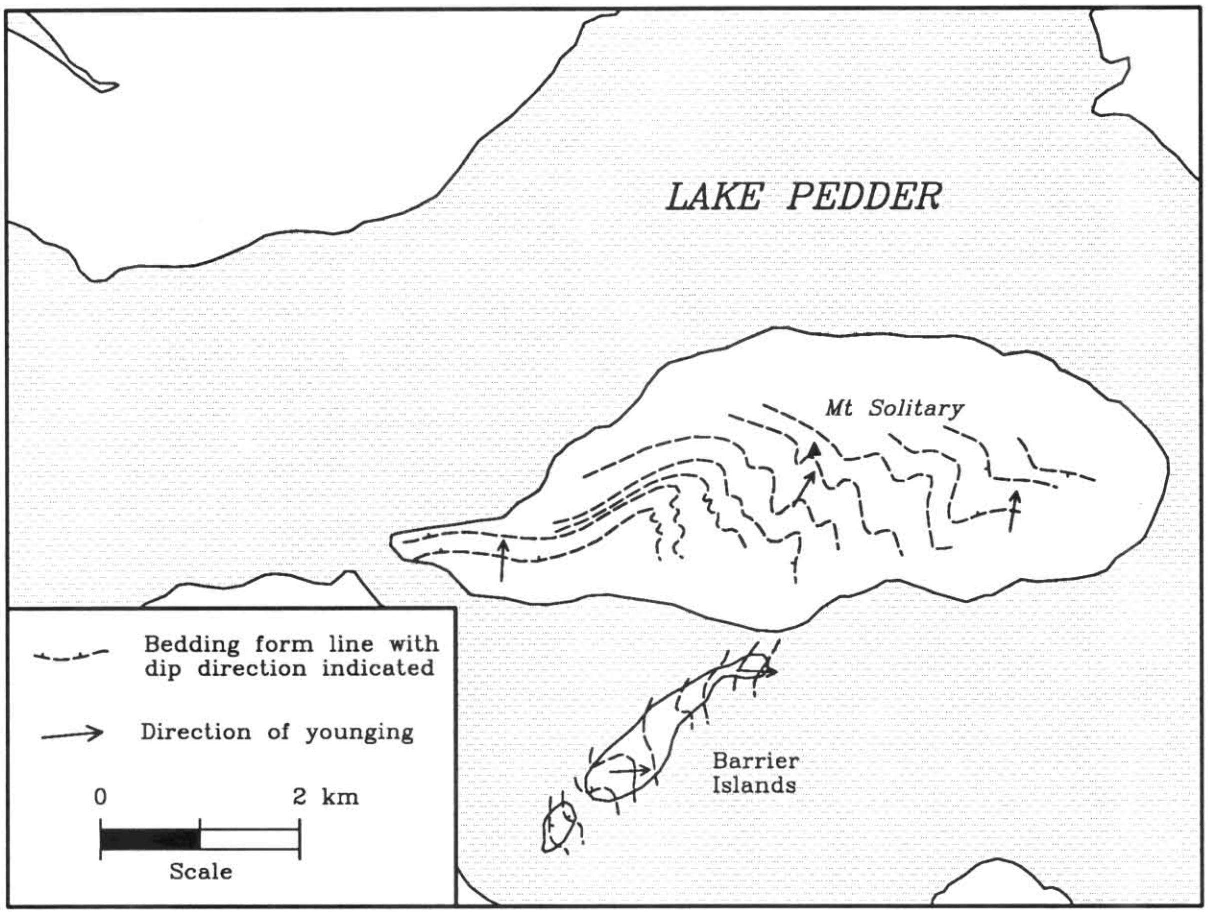


Figure 22. Bedding form line diagram of the Mt Solitary–Barrier Islands area.

STRATHGORDON AREA

J. McClenaghan
M. P. McClenaghan

In the Strathgordon area the structures can be related to three major phases of deformation (D_1–D_3) which are co-axial and co-planar. Some minor cross folds are possibly related to a fourth deformation phase. Minor structures are abundant in all lithologies and locally structural sequences can be established. However, correlation of structures in the quartzite with those in the phyllites is difficult and generally speculative.

Structures in the major quartzites

The least deformed quartzites of the area occur in the Twelvetrees Range east of Strathgordon where bedding can be established. Although there are examples of current bedding and ripple marks, tectonic modification makes their way-up interpretation unreliable. The bedding has been modified by an early variable fracturing which has no folding associated with it and is not regarded as a cleavage. Both the bedding and the fracturing have been folded into a series of open to tight and isoclinal folds with wavelengths about 3 m and amplitudes often up to 5–6 m. The hinges of these mesoscopic folds trend 155° to 175°, frequently around 165° with plunges at low angles, generally 0° to 15°, but up to 40°, to the north and south (fig. 23). Their axial planes are vertical to steeply inclined to the east. These are the earliest folds (F_1) and no earlier recumbent structures are present. A penetrative cleavage is developed axial planar to the folds (S_1). In the massive banded quartzite this cleavage has a preferred development along the bedding and fracture planes. In many places though, in particular along the eastern part of the Twelvetrees Range, the cleavage becomes dominant and bedding is often obliterated. In many fold closures the cleavage shows fanning.

Where the cleavage intersects bedding it gives rise to a fine lineation which trends 160–176°, plunging at 0–27° to the north and south. This lineation is often seen at an angle on the surface of sedimentary ripples. However, there are sometimes other linear structures which are broad and often plicate in profile. These can in places, be seen to be tectonic mullions forming where the cleavage penetrates massive quartzite bands as more widely spaced fractures; they have a similar orientation to that of the fine lineation. Not all mullion-like structures can be easily explained tectonically and it is likely that there has been tectonic modification of sedimentary ripples. Where the cleavage intersects the platy laminae of the current bedding it gives the appearance of two cleavages.

On the south-western slope of the Twelvetrees Range the mesoscopic F_1 folds culminate in a large antiform [DN241618] which has a hinge trending 165°, plunging at 10°N, and with an axial plane inclined at 80° ENE. To the east of this antiform hinges of mesoscopic folds outcrop but their vergence is indiscernible.

In the eastern part of the Twelvetrees Range on the ridge [DN251624] immediately to the west of the Holley Road the S_1 cleavage is folded on a minor scale with hinges trending about 160°, plunging at low angles to the north and south and with the vergence of the folds to the west. Similar later folds are seen along the access road to Trappes Hill where the hinges trend 002–007°, plunging at 3–8°N and verging westwards. The S_1 cleavage is also folded by minor conjugate kink folds (fig. 23).

Although the limbs of the mesoscopic F_1 folds on the Twelvetrees Range are at high angles and the axial

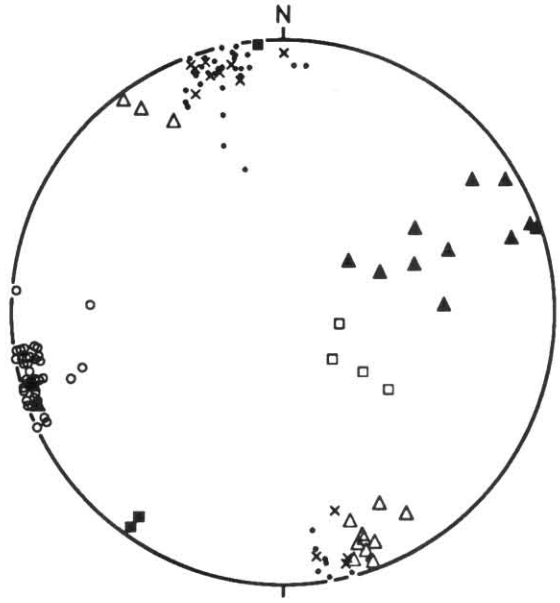


Figure 23. Minor folds and lineations in the quartzite, Twelvetrees Range.

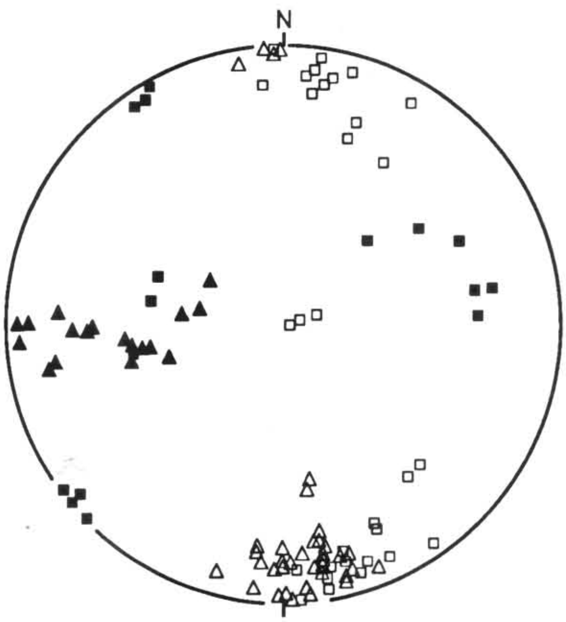


Figure 24. Minor folds in the quartzite, White Spur.

5 cm

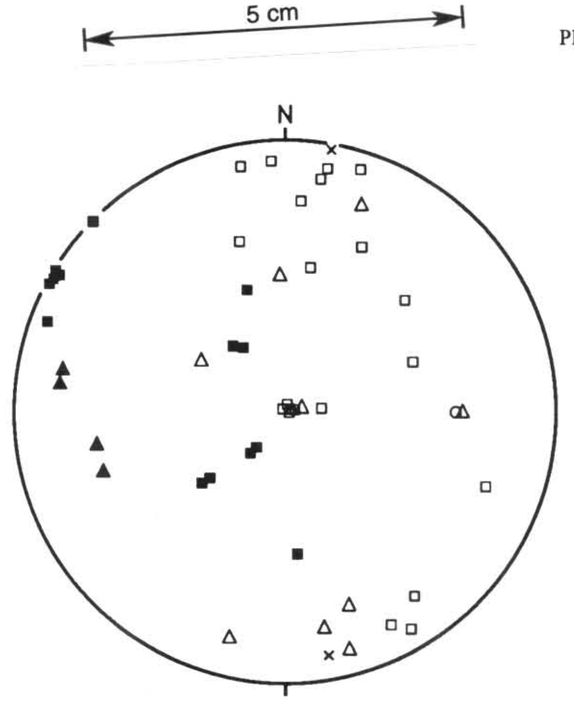
planar S_1 cleavage is steep the enveloping surface of the folds is at a low angle. This is demonstrated by the approximately horizontal boundary of the overlying quartzite on the green-grey phyllites at the southern end of the Twelvetrees Range. At the eastern side of the range the quartzite dips very steeply and crops out southwards as a narrow unit separating the green-grey phyllites (Ptl) and the mixed grey phyllites (Ptp).

On White Spur [DN206638], west of the Twelvetrees Range, the banding of the quartzite is finer and there are zones of micaceous schistose quartzite. The banding possibly represents bedding but there are no sedimentary structures and this cannot be proved. An early cleavage parallels the banding and is folded into minor folds which are generally tight and intrafolial. These are regarded as F_2 structures. However, if the early cleavage surface is the same as the parting in the Twelvetrees Quartzite these folds would be the same as those designated as F_1 in the Twelvetrees Range. The folds have hinges trending 165–186° and plunging at 5°N to 22°S with axial planes variable due to later refolding but predominantly inclined at 65–85°E (fig. 24). A penetrative cleavage (S_2) is developed axial planar to these folds and becomes dominant in the zones of more micaceous quartzite. A fine lineation is developed on the banding surfaces where S_2 intersects and has the same approximate trend and plunge as the F_2 hinges. In the lower part of the access road to White Spur and on the top of the ridge the early folds are refolded by a series of open, conjugate flexures and kinks (F_3). These have hinges predominantly trending 135° to 212°, plunging 30°S to 32°N. This variation in plunge is sometimes seen in a single fold hinge suggesting later folding (F_4). Another set of transverse kink folds have hinges trending 070°–080° and plunging at 80° to 88°E; these are possibly later F_4 folds (fig. 24).

Structures in the phyllites

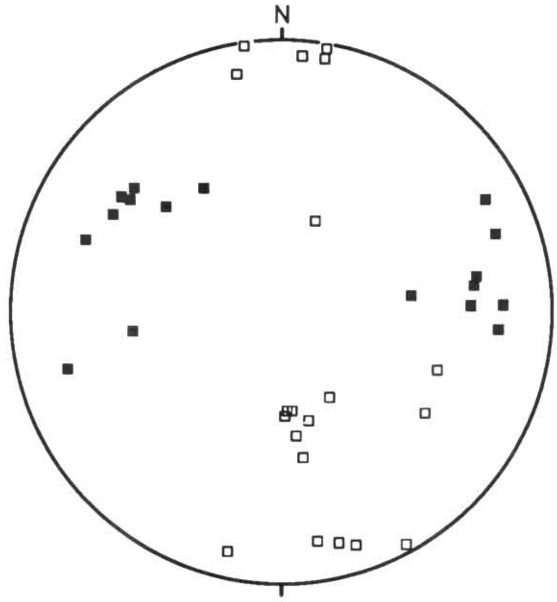
In the sequence of mixed grey phyllites (Ptp) west of White Spur D_1 to D_3 structures are seen. The dominant structures are a S_2 crenulation cleavage and minor F_2 folds, with occasional minor F_3 kink folds. In the good exposures along the Gordon River Road and access road 8-10 (particularly at DN195653, DN186642 and DN194642) there are numerous minor, tight, isoclinal folds with hinges trending 165° to 200° and plunging at low angles to the north and south (fig. 25). The dominant cleavage is axial planar to these folds and is a crenulation cleavage striking N–NNW to S–SSE and dipping at 60–80°E. These folds are considered to be F_2 as they fold an early cleavage (S_1) and a fine compositional banding. Earlier folds associated with the S_1 cleavage are not seen. A fine lineation is developed on S_2 surfaces where the S_1 cleavage intersects; this trends N-S, plunging at low angles to the north. There is some minor folding (F_3) of the S_2 crenulation cleavage with local development of a S_3 cleavage. At DN195653 minor, conjugate, F_3 kink folds have hinges trending 025–069° and plunging 34°–49°NE (fig. 25). On the White Spur access road at DN204643 minor F_3 kinks refold minor F_2 closures. These F_3 kink folds have axes trending approximately E-W and plunging at 80°E (fig. 25), being similar in style and attitude to those described in the adjacent White Spur quartzite and designated as possibly F_4.

In the mixed grey phyllites east of the Twelvetrees Range the same D_1 to D_3 structures are seen with a dominant S_2 crenulation cleavage. Along the Holley River Road at DN253651 there are minor, tight, intrafolial F_2 folds and two sets of minor, open F_3 folds. One set of F_3 folds has hinges in the direction of the general cleavage with low plunges to the SE. The other set has hinges transverse to the general strike with steep plunges (fig. 25). Similar minor F_3 kink folds are seen in exposures along the Gordon River Road. At DN256608 one set of F_3 folds has hinges trending 050–067°, plunging at 90° with vertical axial planes. Another set of



△ F2 fold hinges
▲ poles to axial planes of F2 folds
□ F3 fold hinges
■ poles to axial planes of F3 folds
× lineation, S_1/S_2 intersection
○ lineation, S_2/S_3 intersection

Figure 25. Minor folds and lineations in the mixed grey phyllites (Ꝑtp).



□ F3 fold hinges
■ poles to axial planes of F3 folds

Figure 26. Minor F_3 folds in the light green-grey phyllite.

F_3 folds has hinges trending 165–190°, plunging 7–23°N and axial planes inclined at 14–30°NE (fig. 25).

The light green-grey phyllites (Ꝑtl) of Strathgordon show D_1 to D_3 structures with the dominant structures being S_2 and S_3 crenulation cleavages and F_3 minor folds. These structures are particularly well seen at DN227650 where four surfaces can be defined. Here the dominant structures are F minor folds with hinges trending 150–178° and plunging 45–60°S (fig. 26). These fold a crenulation cleavage (S_2) which contains remnants of a S_1 cleavage. A fine compositional layering, probably of sedimentary origin, has been transposed parallel with the S_1 and S_3 cleavages. In the quartz-rich layers the S_2 cleavage is preserved with a S_3 cleavage developed as widely spaced partings. In the more micaceous phyllite the S_3 cleavage becomes dominant.

In the Trappes Hill area [DN244604] a similar S_3 crenulation cleavage is patchily developed and is seen crenulating the earlier S_2 crenulation cleavage. Minor F_3 kink folds, folding the S_2 cleavage, have hinges trending 331–010° and plunging between 5°N and 10°S (fig. 26).

Major structure and discussion

The sequence of mixed grey phyllites west of White Spur forms the core of a southward plunging, asymmetric synform. To the north, on the adjacent Huntley Sheet, the flanking quartzites are seen to form a fold closure. Minor structures suggest this is a D_2 structure (J. and M. P. McClenaghan in Brown *et al.*, 1989). The mixed grey phyllites to the east of the Twelvetrees Range closely resemble those to the west of White Spur and possibly belong to the same unit. If this is the case, then the major quartzites of White Spur, Four O'Clock Ridge and Twelvetrees Range also form a single unit. An antiformal culmination must, therefore, occur between White Spur and the eastern side of the Twelvetrees Range. The large antiform on the western flanks of the Twelvetrees Range would be part of this antiformal culmination.

When attempting a regional correlation of structures it can be seen that there are two generations of folds in each lithology. In the phyllites the earliest set fold a cleavage, whereas in the massive quartzite the earliest set fold a rough fracture cleavage. No earlier folds are seen associated with these surfaces. It is not known whether these early folds are of the same age but it seems likely that in the quartzite lithology the earliest structures are preserved and the phyllites are exhibiting the later structures. Trend does not provide reliable evidence in correlation as there is a general parallelism of first and second generation structures. Style of folding is influenced by lithology. Only some late kink folds have a distinctive style and trend. The nature of the surface being folded and its relation to porphyroblastic mineral growth provide the most reliable correlation evidence.

HERMIT HILL – CORONETS – SENTINELS

M. P. McClenaghan

The Hermit Hill area (domain 1, fig. 10) consists of massive white quartzite (Ꝑtq) interbedded with light to dark-grey phyllite (Ꝑtp). The quartzite shows bedding banding with current bedding visible at a few points. Cleavage is strongly developed and in some cases can be seen to be a crenulation cleavage. Sedimentary features are completely obliterated by a strongly developed crenulation cleavage in the phyllite. Poles to bedding planes in the quartzite define a girdle consistent with the north-west plunging minor folds in the bedding (fig. 27). Cleavage developed axial planar to these folds is generally a crenulation cleavage and thus at least S_2, however, some cleavages of undetermined order, have poles plotting in the same girdle as the bedding poles (fig. 28). This indicates that these readings are from an earlier cleavage or cleavages, which have a low angle with bedding and have been folded with it. At one point folding of a crenulation cleavage occurs which therefore must be at least S_3. The axial planes of these folds have the same attitude as the axial planes of the folds in bedding (fig. 29). It is unclear whether the folding is all S_3 with S_1 and S_2 being folded with the bedding or whether approximately co-axial F_2 and F_3 folding has taken place and the minor folds are both F_2 and F_3.

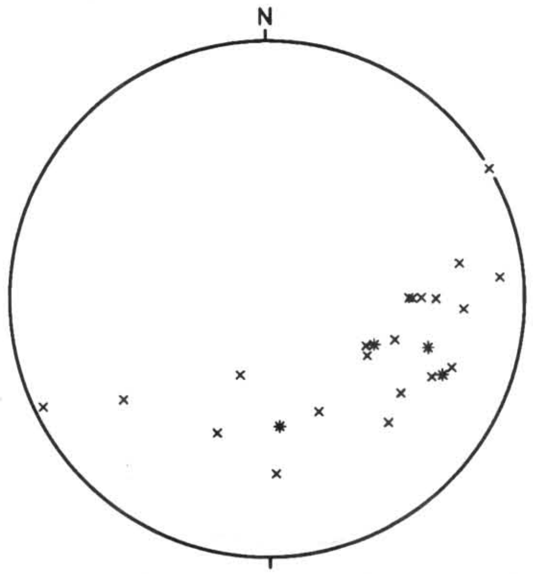


Figure 27. Stereoplot of poles to bedding, domain 1.

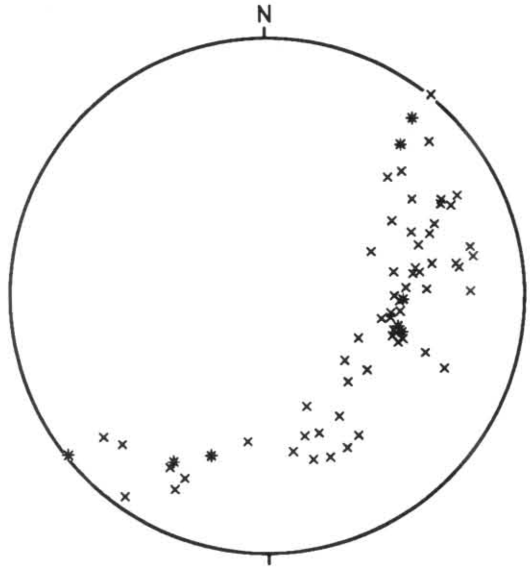


Figure 30. Stereoplot of poles to bedding, domain 3.

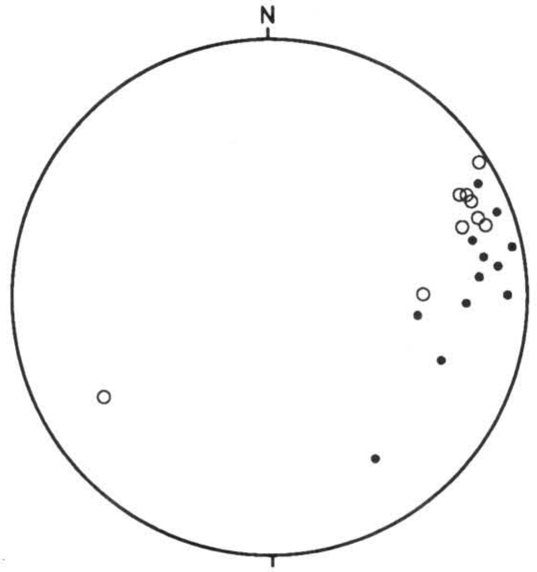


Figure 28. Stereoplot of structural elements, domain 1.

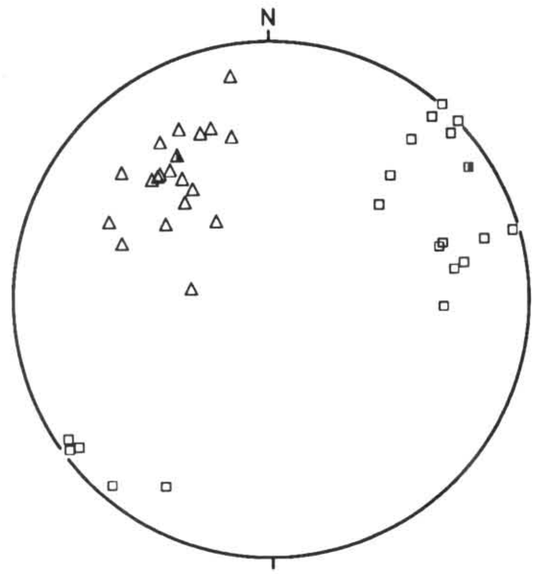


Figure 31. Stereoplot of structural elements, domain 3.

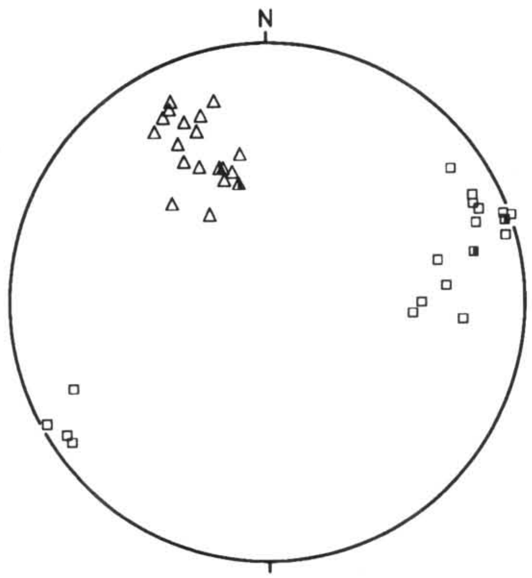


Figure 29. Stereoplot of structural elements, domain 1.

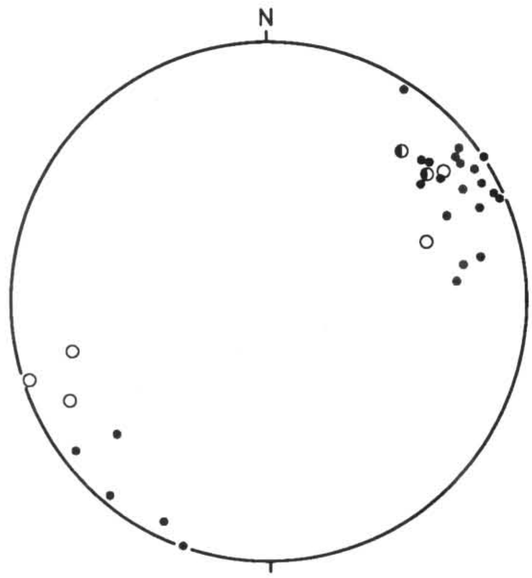
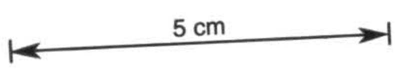


Figure 32. Stereoplot of structural elements, domain 3.



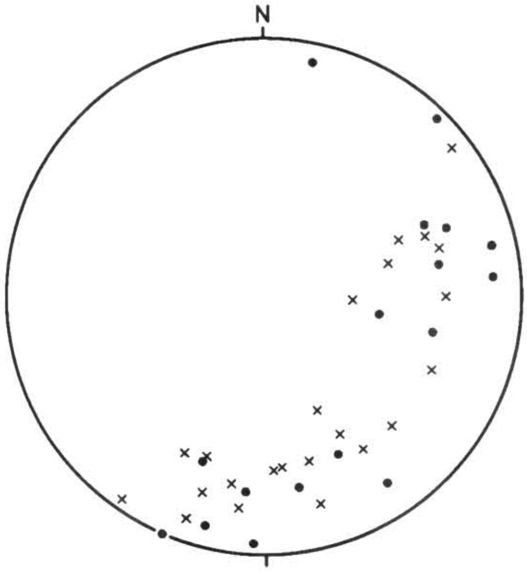


Figure 33. Stereoplot of poles to bedding, domain 4.

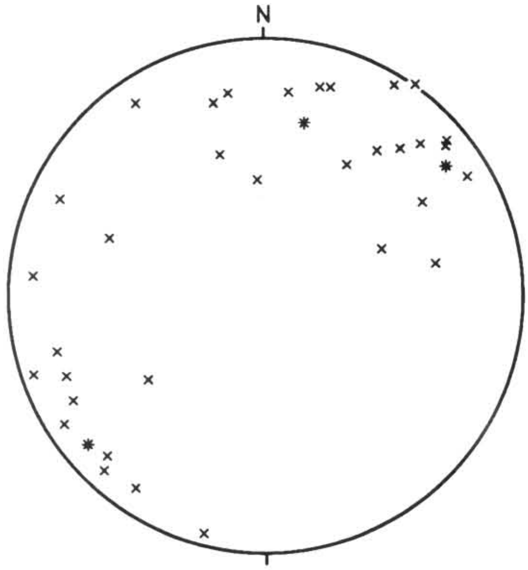


Figure 35. Stereoplot of poles to bedding, domain 2.

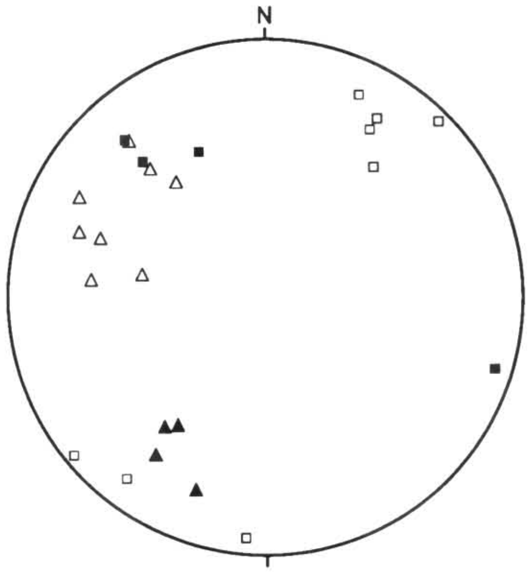


Figure 34. Stereoplot of structural elements, domain 4.

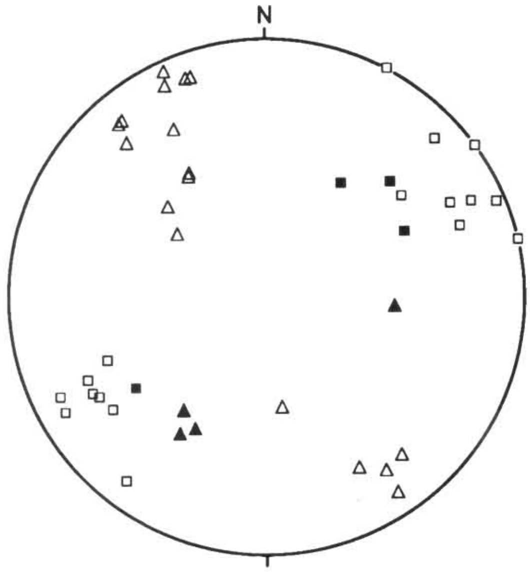
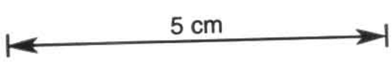


Figure 36. Stereoplot of structural elements, domain 2.

Symbols used in Figures 27–37

- × pole to bedding, way-up unknown
- ✱ pole to bedding, right way up
- ◆ pole to cleavage of undetermined order
- ○ pole to crenulation cleavage
- ◐ pole to cleavage crenulating a crenulation cleavage
- △ hinge of fold in bedding
- ▲ hinge to possible late fold in bedding
- ◭ hinge of fold in a crenulation cleavage
- □ pole to axial plane in fold in bedding
- ■ axial plane to possible late fold in bedding
- ◧ pole to axial plane in fold in a crenulation cleavage



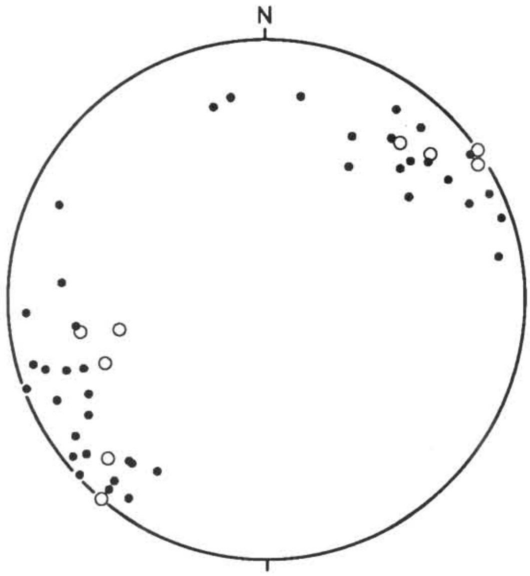


Figure 37. Stereoplot of structural elements, domain 2.

The Stillwater Hill area (domains 2, 3 and 4, fig. 1) shows lithological structural continuity with the Hermit Hill area. The dominant rock type is massive white quartzite (Ᵽtq) with interbedded light-grey phyllite (Ᵽtp) and light green-grey phyllite (Ᵽt). In the quartzite bedding is shown by a coarse banding, and current bedding can be seen at a few points. Sedimentary structures are not apparent in the phyllites due to the strongly developed cleavage. Poles to bedding in the quartzite of domain 3 and 4 plot in a girdle consistent with folding plunging at a moderate angle to the north-west (fig. 30). Minor folds in bedding plunge at moderate angles to the north-west and have axial planes dipping steeply north-east and south-west (fig. 31). Cleavage is strongly developed in the quartzite generally at a slight angle to bedding. In the phyllite at DN286557 the dominant cleavage is a crenulation cleavage and thus is at least S_2. In the same area a later crenulation cleavage (S_3) (fig. 32) is developed in patches associated with minor folds of the S_2 crenulation cleavage. In the eastern part of the area (domain 4, fig. 10) poles to cleavage readings in the quartzite fall in the same zone as the bedding readings (fig. 33) and thus have been folded with the bedding and belong to an early deformation event. In this domain minor folds occur at DN293550 with a different attitude to the others in the area (fig. 34). There is no direct evidence as to the order of these folds but it is possible that they represent a later fold phase (F_4).

In the domain 2 (fig. 10) west of Stillwater Hill the poles to bedding in the quartzite (fig. 35) show a wide spread and minor folds in bedding plunge to the north-west and south-east (fig. 36). Cleavage in the phyllite and at some points in the quartzite can be seen to be a crenulation cleavage. There is a broad spread in cleavage attitude in the domain (fig. 37) with a general north-west trend similar to the trend in the other domains of the area.

In the area immediately to the south-east of Stillwater Hill (domain 5, fig. 10) the ridge consists of massive white banded quartzite with current bedding visible at many places. The lower ground consists of light-grey phyllite (Ᵽtp) which is generally very quartz rich and in which sedimentary features are masked by cleavage. The poles to bedding form a girdle consistent with folding plunging steeply to the west (fig. 38). Many minor folds in bedding are present which plunge steeply west or south-west. Some of the folds can be seen to refold earlier folds. The poles to the axial planes of the folds mostly fall in the same zone as the bedding poles which suggests that they have been folded by a later event. A small group of folds have axial planes dipping steeply south-east (fig. 39). Poles to cleavage display a similar pattern with most falling in a similar zone to the bedding and the axial planes of the folds, but a small group have a north-east strike and steep dip, mostly to the south-east (fig. 40). At one locality a cleavage of this attitude was measured that was crenulating a crenulation cleavage and thus is at least S_3. It thus seems likely that the second group of folds are produced by a later deformation event than the others. This group of folds has a similar attitude to the minor group of folds in the previous area which were suggested to belong to a D_4 phase.

To the east of the Stillwater Hill area the ridge south of McPartlan Pass consist largely of massive white quartzite (Ᵽtq) with minor lenses of phyllite (fig. 10, domain 6). The quartzite is flanked by light-grey phyllite (Ᵽtp) on the sides of the ridge. The quartzite is strongly cleaved though bedding is commonly apparent and current bedding can be distinguished at some points. A crenulation cleavage is present in the phyllitic rocks.

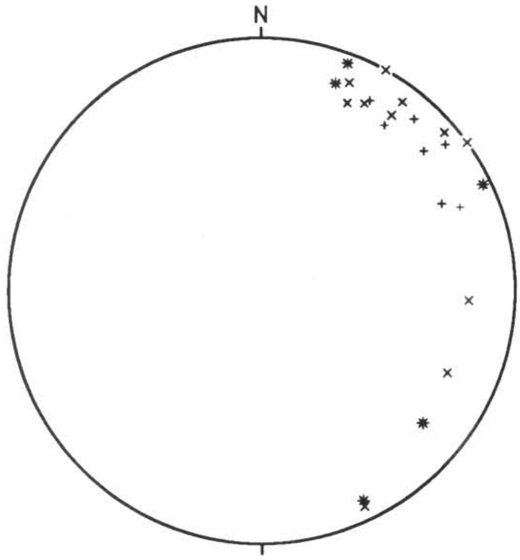


Figure 38. Stereoplot of poles to bedding, domain 5.

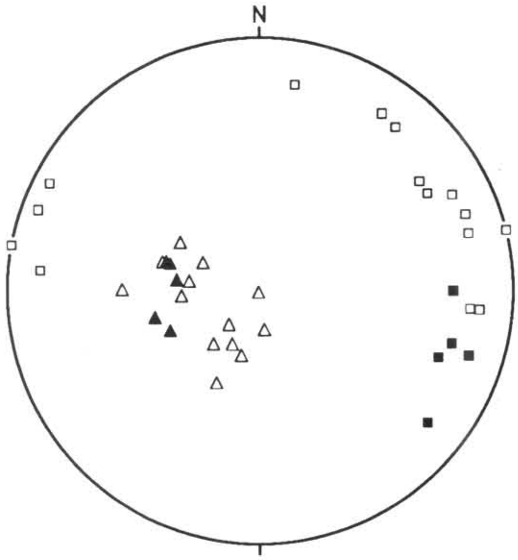


Figure 39. Stereoplot of structural elements, domain 5.

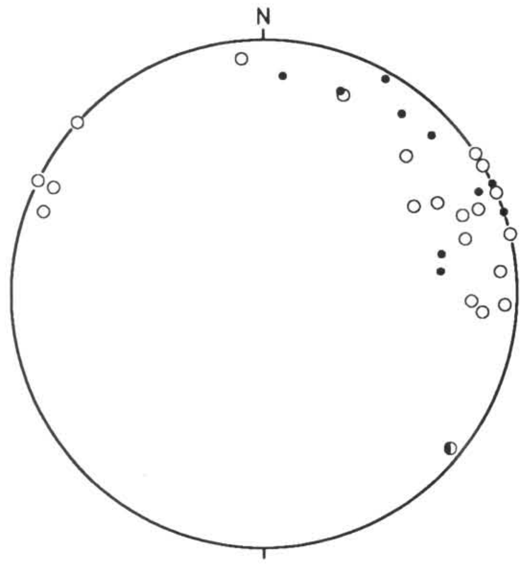


Figure 40. Stereoplot of structural elements, domain 5.

5 cm

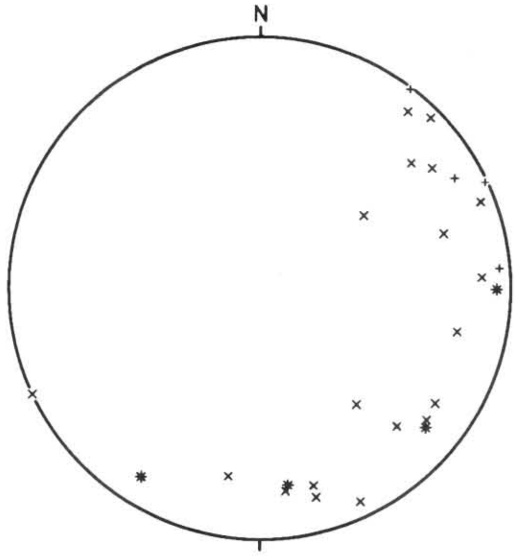


Figure 41. Stereoplot of poles to bedding, domain 6.

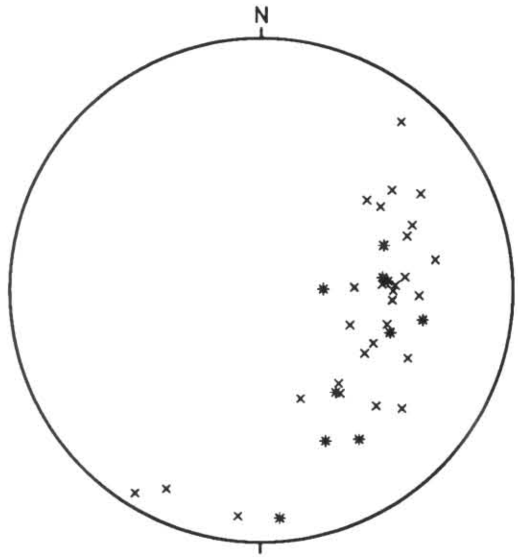


Figure 44. Stereoplot of poles to bedding, domain 7.

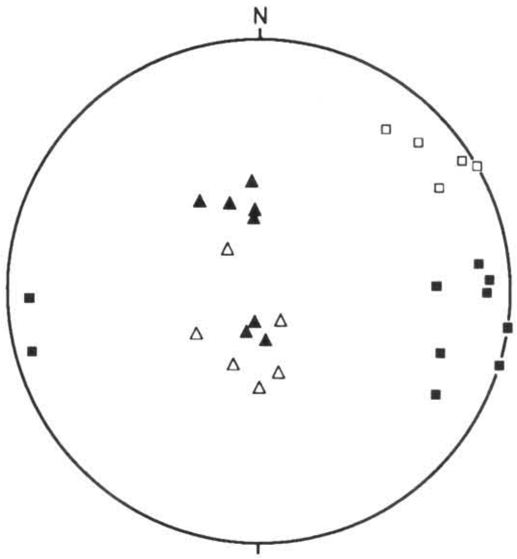


Figure 42. Stereoplot of structural elements, domain 6.

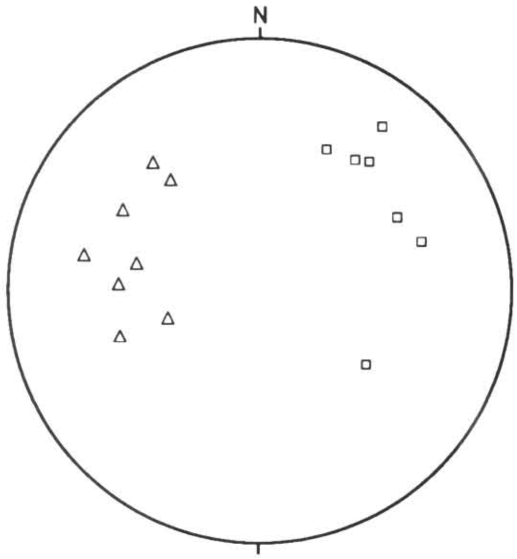


Figure 45. Stereoplot of structural elements, domain 7.

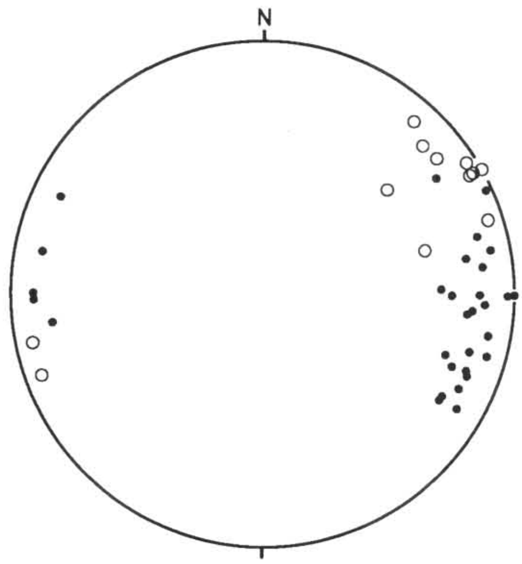


Figure 43. Stereoplot of structural elements, domain 6.

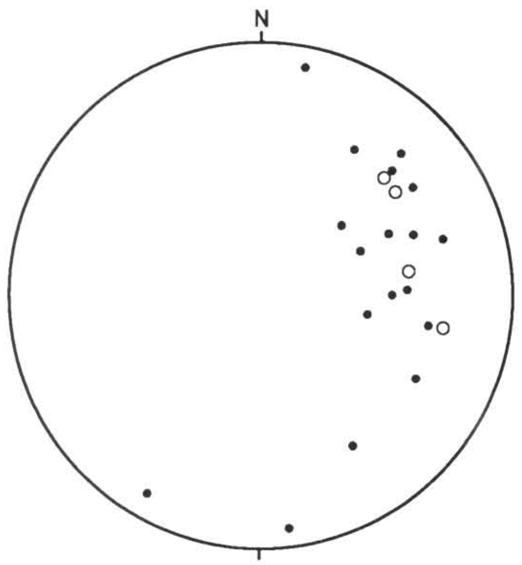
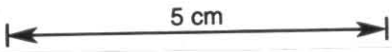


Figure 46. Stereoplot of structural elements, domain 7.

Symbols used in Figures 38–46

× pole to bedding, way-up unknown
✱ pole to bedding, right way up
◆ pole to cleavage of undetermined order
○ pole to crenulation cleavage
△ hinge of fold in bedding
▲ hinge to possible late fold in bedding
□ pole to axial plane in fold in bedding
■ axial plane to possible late fold in bedding



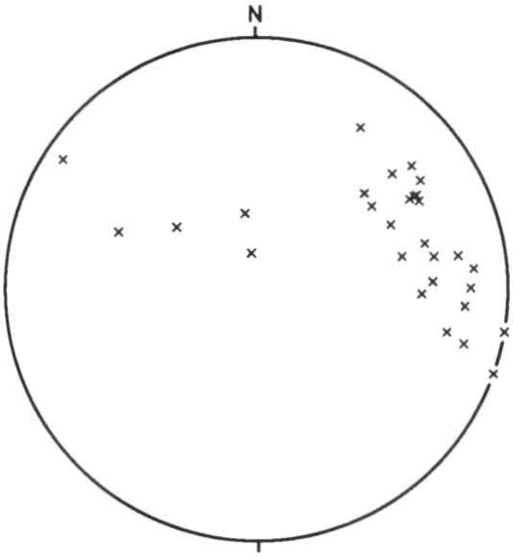


Figure 47. Stereoplot of poles to bedding, domain 8.

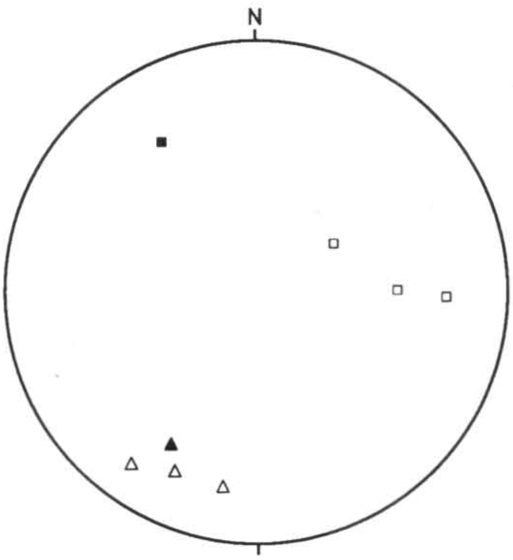


Figure 48. Stereoplot of structural elements, domain 8.

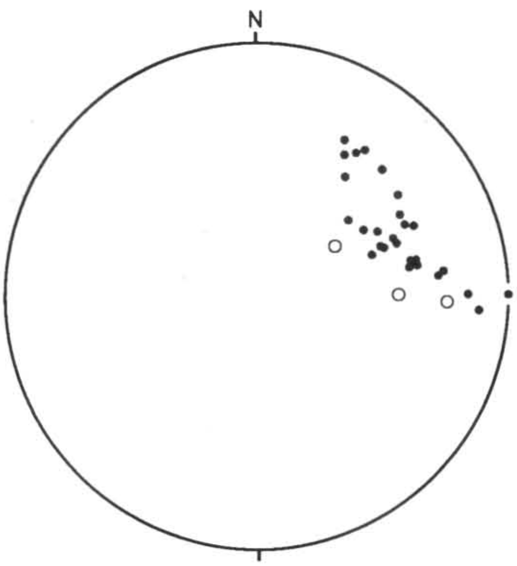


Figure 49. Stereoplot of structural elements, domain 8.

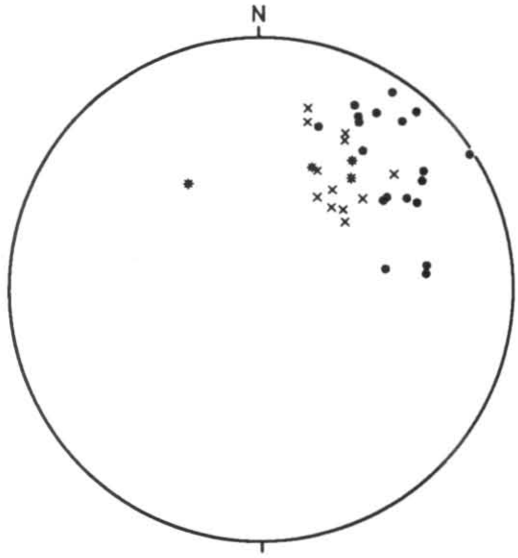


Figure 50. Stereoplot of structural elements, domain 9.

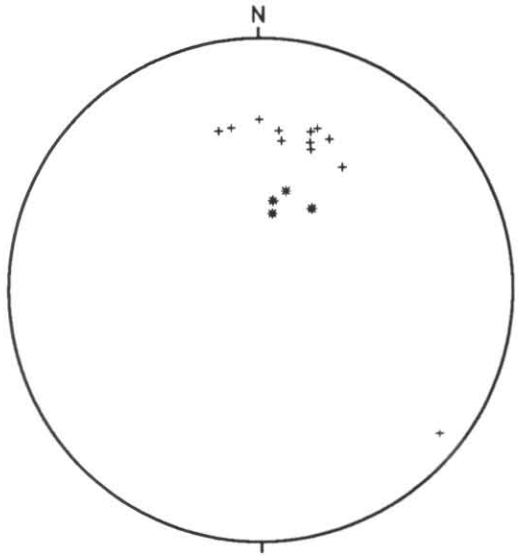


Figure 51. Stereoplot of poles to bedding, domain 10.

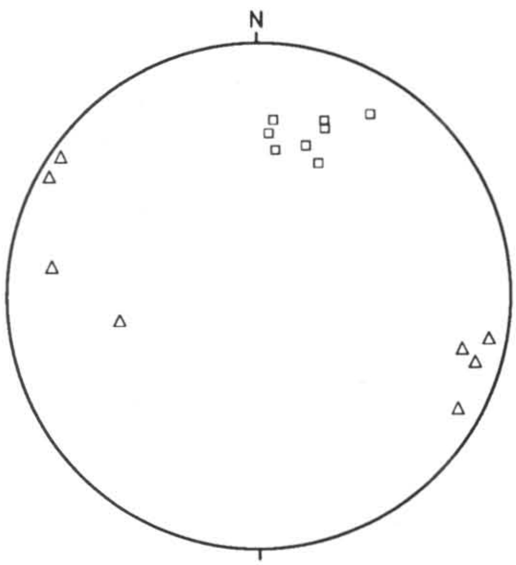


Figure 52. Stereoplot of structural elements, domain 10.

5 cm

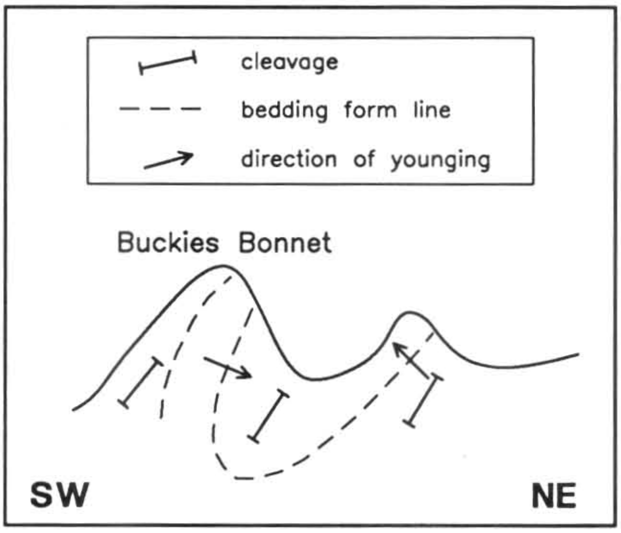
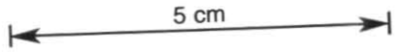


Figure 53. Sketch section of syncline east of Bonnet Bay.



Symbols used in Figures 47–62

- × pole to bedding, way up unknown
- ✱ pole to bedding, right way up
- + pole to bedding, overturned
- ◆ pole to cleavage of undetermined order
- ○ pole to crenulation cleavage
- ◐ pole to cleavage crenulating a crenulation cleavage
- △ hinge of fold in bedding
- ▲ hinge to possible late fold in bedding
- ◭ hinge of fold in a crenulation cleavage
- □ pole to axial plane in fold in bedding
- ■ pole to axial plane to possible late fold in bedding
- ◧ pole to axial plane in fold in a crenulation cleavage

The girdle of poles to bedding in the quartzite indicate that the dominant fold direction is steeply to the north-west (fig. 41). The crenulation cleavage developed in the phyllite strikes consistently in the same direction (fig. 43) suggesting it may be connected to that fold phase. The cleavage in the quartzite (fig. 43) is associated with minor folds of bedding plunging steeply to the north-west and south (fig. 42). There is a greater spread of strike direction for this cleavage than for the crenulation cleavage (fig. 43) suggesting that it has been refolded and that it is an earlier cleavage than the crenulation cleavage.

In the Mt Helder area (fig. 10, domain 7) which lies to the south-east of the Stillwater Hill, bedding is generally visible in massive white quartzite (Ꝑtq) and current bedding can also often be distinguished. Poles to bedding define a girdle consistent with folding plunging at moderate angles to the north-west (fig. 44). Minor folds in bedding plunge west and north-west and have poles to their axial planes lying along part of the girdle of bedding poles (fig. 45). Cleavage is strongly developed and at several points is a crenulation cleavage and is related to the folding of the bedding. Poles to cleavage lie on the same zone as the poles to bedding (fig. 46) which together with the spread in the axial planes of the folds suggests that the folds and cleavage have been folded by a later deformation. It seems probable that the cleavage throughout the area is the same one and is the same as the crenulation cleavage. The folding of the crenulation cleavage and associated folds must be at least F_3.

The Mt Cawthorn area (domain 8, fig. 10) lies to the south-west of the Mt Helder area and consist of a continuation of the same massive white quartzite (Ꝑtq), however, in this area cleavage is more strongly developed and bedding is less prominent. Current bedding cannot be distinguished. Poles to bedding lie on a poorly defined girdle (fig. 47) suggesting folding gently plunging to the SSW. Minor folds in bedding plunge in this direction and have a crenulation cleavage axial planar (fig. 48). This cleavage is generally close to parallel to bedding and it seems probable it is the same one throughout the area. The spread in the strike of the cleavage (fig. 49) suggests that it has undergone refolding. At DN282503 folding of the cleavage can be

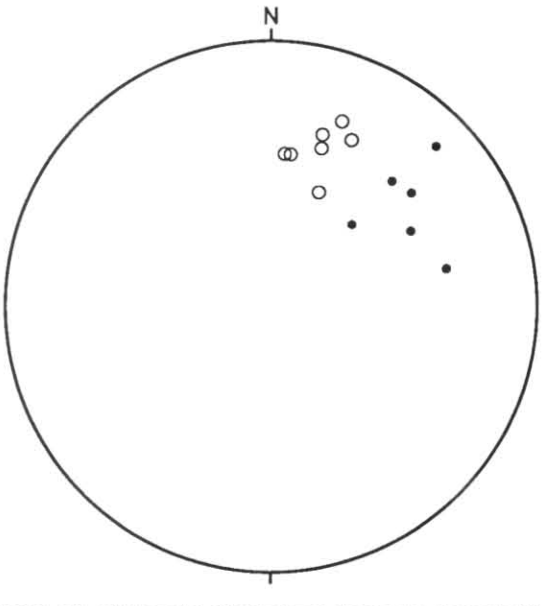


Figure 54. Stereoplot of structural elements, domain 10.

seen with a fold having an axial plane trending north-east. This deformation phase is at least D_3.

In domain 9 (fig. 10) east of Bonnet Bay the bedding banding in the massive white quartzite (Ꝑtq) can be distinguished from a strongly developed cleavage of similar attitude. Current bedding is visible at a number of points and indicates that the beds young south-west. Both cleavage and bedding strike north-west (fig. 50) and have an approximately constant difference in attitude with the cleavage dipping more steeply south-west than bedding. No indication was found as to the order of the cleavage.

South-east of Bonnet Bay domain 10 (fig. 10) consist of massive white quartzite (Ꝑtq) with well developed bedding banding. Current bedding is commonly well developed. The strike of bedding is slightly north of west with moderate dips to the south-south-west (fig. 52). Minor tight folding of bedding is common with axial planes having a similar attitude to bedding (fig.

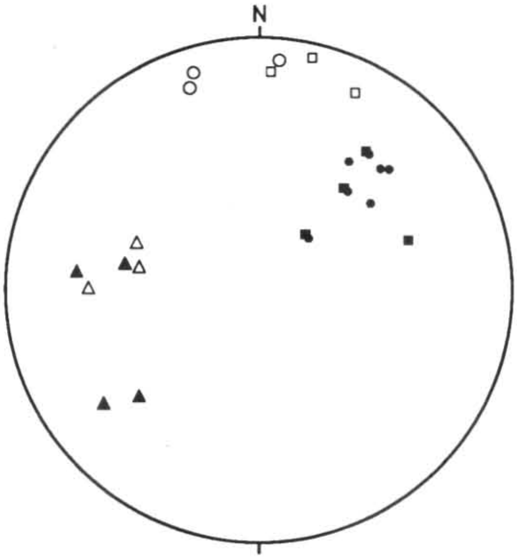


Figure 55. Stereoplot of structural elements, domain 11.

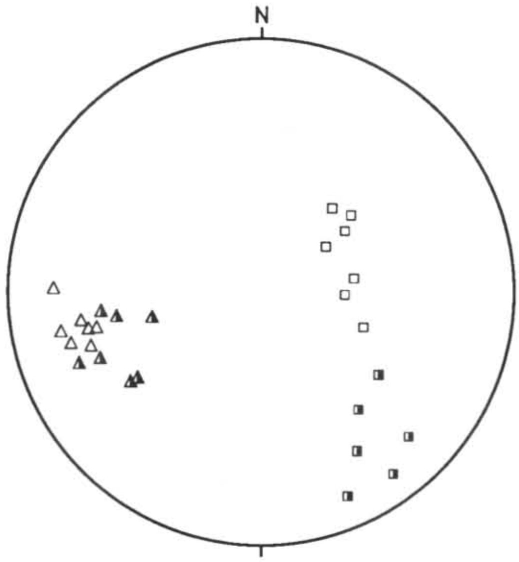


Figure 56. Stereoplot of structural elements, domain 12.

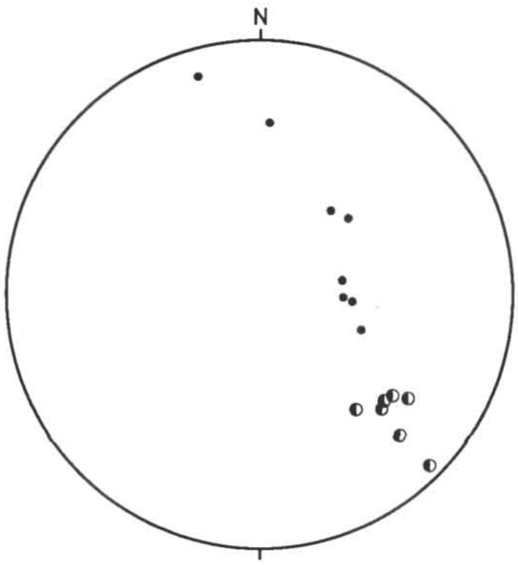


Figure 57. Stereoplot of structural elements, domain 12.

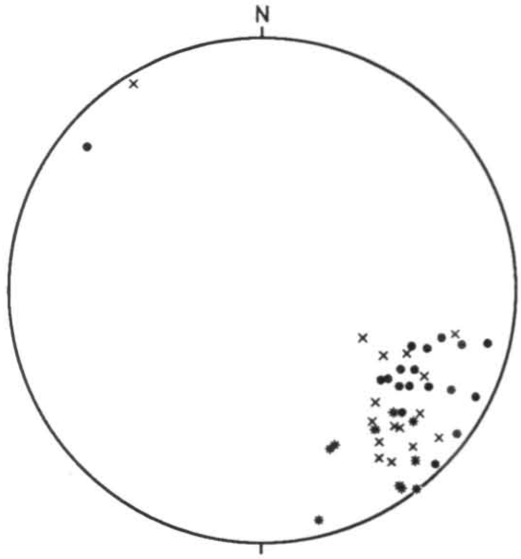


Figure 58. Stereoplot of structural elements, domain 13.

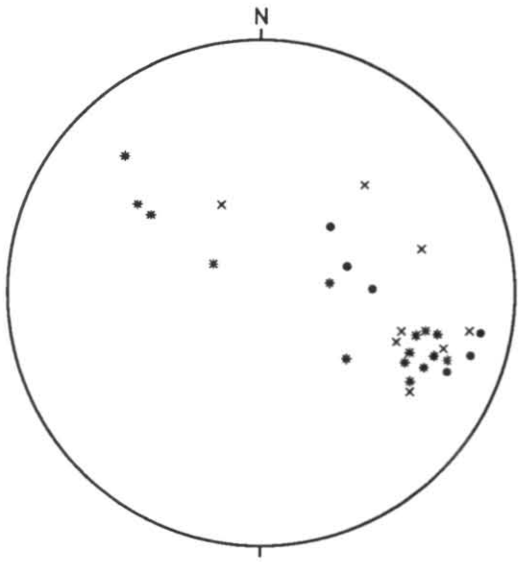


Figure 59. Stereoplot of structural elements, domain 14.

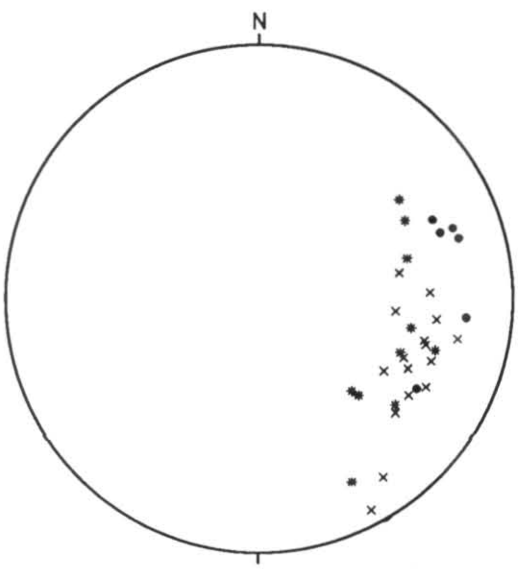


Figure 60. Stereoplot of structural elements, domain 15.

5 cm

52). Vergence of the folds is to the south-south-west and together with the way up evidence provided by the current bedding indicates that the rocks of this domain form the southern overturned limb of a large syncline which has its northern limb in domain 9 (fig. 53). Cleavage is strongly developed with at least two cleavages present dipping at a moderate angle to the south-west. Cleavage at some points is clearly related to the minor folding, however, cleavage is also present crossing the folds and therefore later (fig. 54) which has a slightly different attitude. No morphological difference was found between the cleavages.

The low ridge on the southern shore of Bonnet Bay constitutes domain 11 (fig. 10) and consists of light green-grey phyllite (Ptl) and white quartzite (Ptq). Quartz rock bands in the phyllite probably represent bedding. Two generations of tight folding of this banding are present shown by refolding (fig. 55). The early folds are associated with a north-east striking crenulation cleavage that dips at moderate angles to the south-west. A later crenulation cleavage is also present in patches associated with the minor cross folds (fig. 55). The latest cleavage is at least S_3. It is not clear how these two cleavages relate to these in the previous domain.

Domain 12 lies immediately to the east of the last domain (fig. 10) and consists of massive white quartzite (Ptq) with well developed current bedding. Tight folding of the bedding is present with axial planes dipping west and south-west associated with a cleavage. Cross folding is present with axial planes dipping north-west and also associated with a cleavage (fig. 56–57). The similarity of attitude of the earlier cleavage in this domain to the cleavages in the previous two domains suggest that it may include readings from both of them. If this is the case and since the later cleavage in domain 11 was at least S_3 it is possible that the latest cleavage in this domain is S_4.

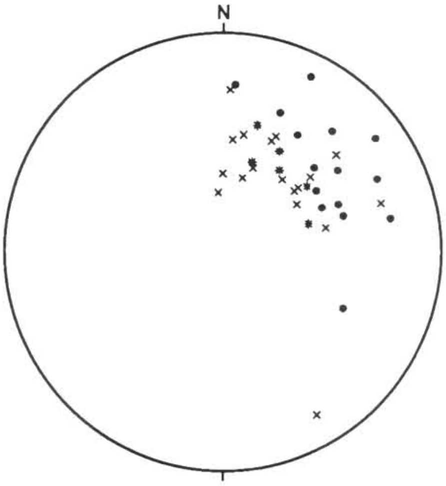


Figure 61. Stereoplot of structural elements, domain 16.

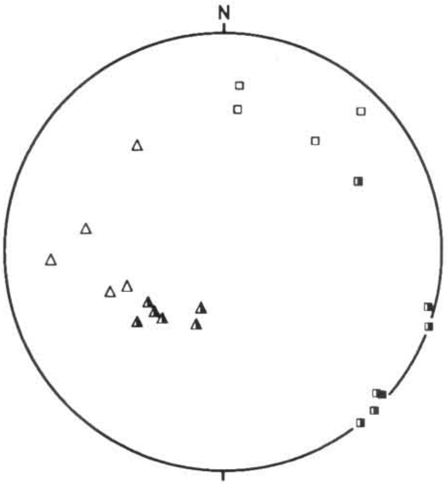


Figure 62. Stereoplot of structural elements, domain 16.

5 cm

The Coronets Range is composed of massive white quartzite (Ptq) with well developed current bedding allowing identification of way up in many outcrops.

The south-west part of the range constitutes domain 13 (fig. 10). The quartzite beds are right way up and dip at steep to moderate angles to the north-west. Cleavage has a similar attitude to bedding (fig. 58). No evidence as to the order of the cleavage was found, however, it has a similar attitude to the latest cleavage in domain 12 immediately to the west which suggests that they may be the same one.

In the central and western part of the Coronets Range (fig. 10, domain 14) the bedding generally has the same attitude and younging direction as in the previous domain, however, in the north of the domain a large fold plunging steeping south-west is defined by a sharp swing in the bedding (fig. 59). Some of the cleavage has a similar attitude to the cleavage in the previous domain i.e. dipping steeply to the north-west, while other readings are of a cleavage dipping at moderate angles to the south-west (fig. 59). It seems probable that these represent different cleavages though no morphological difference was recognised between them.

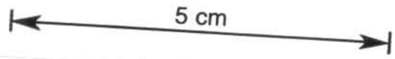
Domain 15 consists of the north and eastern part of the Coronets Range (fig 10). Bedding dips and youngs to the north-west at moderate to steep angles. As for the previous domain, cleavage in the quartzite falls into two groups, a south-west dipping cleavage and a north-west dipping one (fig. 60). In the narrow strip of phyllite (Ptl) in the domain [DN355483], a crenulation cleavage is present with the same attitude as the south-west dipping cleavage in the quartzite which suggest it may be the same one and that cleavage in the quartzite is at least S_2.

West of the Coronets Range domain 16 (fig. 10) consists of massive white quartzite (Ptq) with current bedding. Bedding dips generally south-west at moderate angles and is right way up. A single cleavage is present dipping in the same direction more steeply (fig. 61). Minor tight folds in the bedding are present with axial planes having a similar attitude to the cleavage. Minor later kink style cross folding is present with axial planes dipping steeply north west (fig. 62).

Domain 17 lies to the north-west (fig. 10) and has the same rock type. Bedding generally dips at moderate to steep angles to the north-west and is right way up (fig. 63). It is crossed by cleavage which dips at moderate to steep angles to the west (fig. 64).

Adjoining the previous two domains, domain 18 lies on the south-west continuation of the Sentinels Range (fig. 10). The area consists dominantly of massive white and slightly pink quartzite (Ptq) showing abundant current bedding. Poles to bedding plot on a well defined girdle (fig. 65) consistent with folding plunging north at a moderate angle. The strike of the bedding shows that the domain consists of one large fold. Cleavage readings dip west at moderate to steep angles and have a wide spread (fig. 66). The structure youngs to the north.

Throughout the Sentinels Range the quartzite (Ptqc) is extremely massive generally with slight pink colouration and has well developed current bedding. The quartzite youngs to the north and north-west. Cleavage is not well developed due to the common coarse grain size. Bedding poles plot on girdle consistent with folding plunging steeply to the north and north-west (fig. 67–69). In the eastern part of the range (domain 21, fig. 10) many of the beds have a steep southerly dip but are younging north (fig. 69). In domain 19 (fig. 10) at the western end of the range some of the cleavage in the



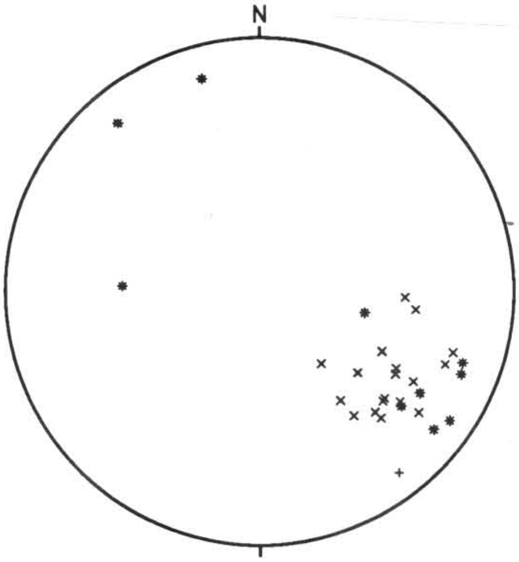


Figure 63. Stereoplot of poles to bedding, domain 17.

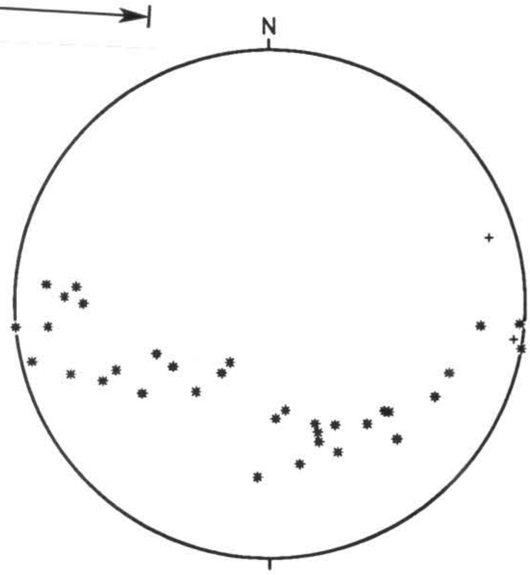


Figure 65. Stereoplot of poles to bedding, domain 18.

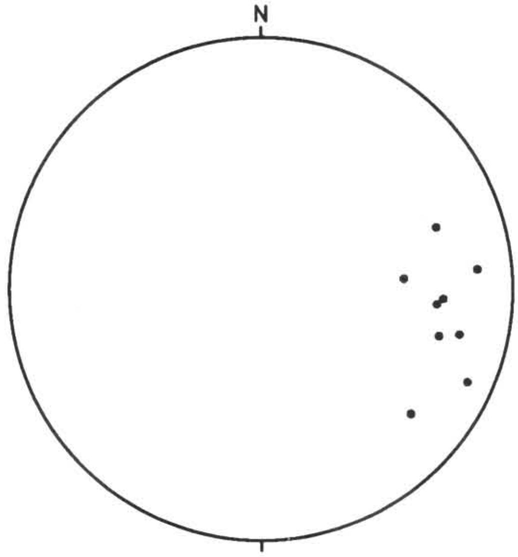


Figure 64. Stereoplot of structural elements, domain 17.

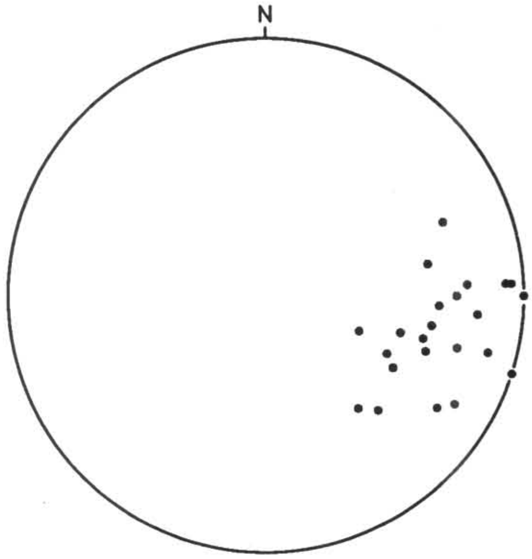


Figure 66. Stereoplot of structural elements, domain 18.

quartzite is a crenulation cleavage and thus at least S_2, elsewhere, no evidence was found as to the order of the cleavage. Cleavage shows considerable variation in attitude (fig. 70–72) but has a general north strike with a steep dip to the west. Minor folding of the bedding is abundant in the eastern part of the range (fig. 10, domain 21) with steep axial planes dipping slightly north of west. Due to the variable development of the cleavage it can be seen to be associated with only some of the folding (fig. 73). The wide spread of hinge directions suggests that the folding was imposed on previously folded beds.

The abundant preservation of bedding of known way up, in the area south of Stillwater Hill and including the Coronet and Sentinels Ranges, allows observations to be made about the major structure. Generalised bedding trend lines have been drawn for this area with the way up and dip of the beds indicated (fig. 74). Different interpretations of the fault pattern are possible and the one presented in this diagram differs slightly from the one on the Pedder map sheet. The faults are necessary since the bedding structures in different parts of the area have sharp discontinuities. The fault postulated to strike along Swampy Creek west of the Coronets Range is required to explain the abrupt termination of the NW-trending syncline lying to the south-east of Bonnet Bay. The north end of this fault has been drawn in the diagram to go to the south-east of a small spur of quartzite on the north end of the Coronets Range at DN365512. This is because the beds on this spur young northwards rather than to the north-west as for the adjoining part of the range. The beds on this spur may have structural continuity with those of the Sentinels Range. Another NE-trending fault is postulated to lie on the western side of the Sentinels Range and emerge in Bonnet Bay. It is possible that an E-trending splay fault at DN335503 may join this fault with the one lying along the Swampy Creek. This fault would separate the rocks of domain 16 and 18 (fig. 10). The attitude of cleavage and bedding in these two domains is quite different. This interpretation differs from the Pedder map sheet. The alternative to this fault is to assume an east trending anticline separating domain 16 and 18. A further north-east trending fault is postulated passing south of Mt Cawthorn and Mt Helder and extending from Bonnet Bay towards Wedge Inlet (fig. 74). This fault is also in addition to those on the Pedder sheet. It has been postulated because of the difficulty in joining the structures from the Stillwater Rivulet area to Mt Cawthorn with those from Bonnet Bay to the Sentinels.

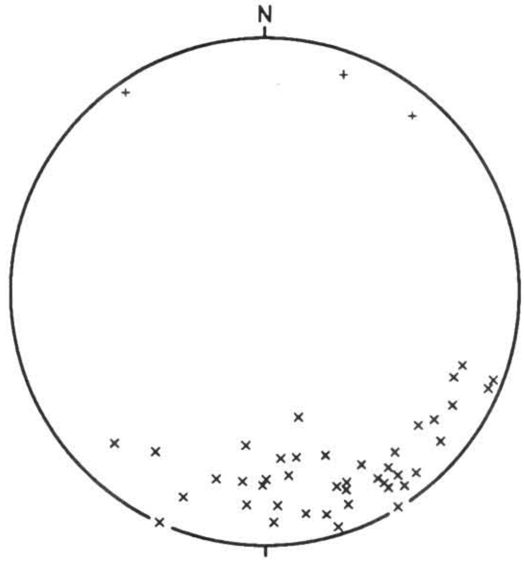


Figure 67. Stereoplot of poles to bedding, domain 19.

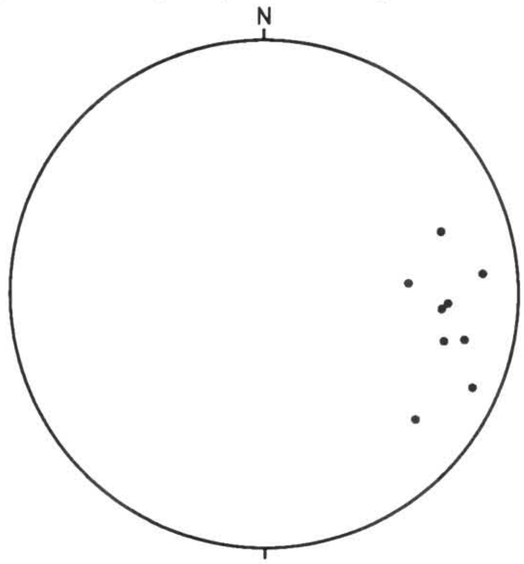


Figure 68. Stereoplot of poles to bedding, domain 20.

Symbols used in Figures 63–73

- × pole to bedding, way up unknown
- ✱ pole to bedding, right way up
- + pole to bedding, overturned
- ◆ pole to cleavage of undetermined order
- ○ pole to crenulation cleavage
- ◐ pole to cleavage crenulating a crenulation cleavage
- △ hinge of fold in bedding
- ▲ hinge to possible late fold in bedding
- ◭ hinge of fold in a crenulation cleavage
- □ pole to axial plane in fold in bedding
- ■ pole to axial plane to possible late fold in bedding
- ◧ pole to axial plane in fold in a crenulation cleavage

The major difference in trend of the structures in the Coronets Range to the structures in the rocks to the north-west points to a major late movement. This movement also involved the faulting since the faults mark the major changes in structural trend. The movement must have been after the major structures in the Bonnet Bay area otherwise structures with the trends of that area would also be present in the Coronets Range. The cleavage associated with the latest deformation in several of the domains has a north-east trend which is a similar trend to that of the faults. This trend is quite different from the north-west trend of the earlier structures which in some areas can be seen to be D_1-D_3. This suggests that this latest event is D_4.

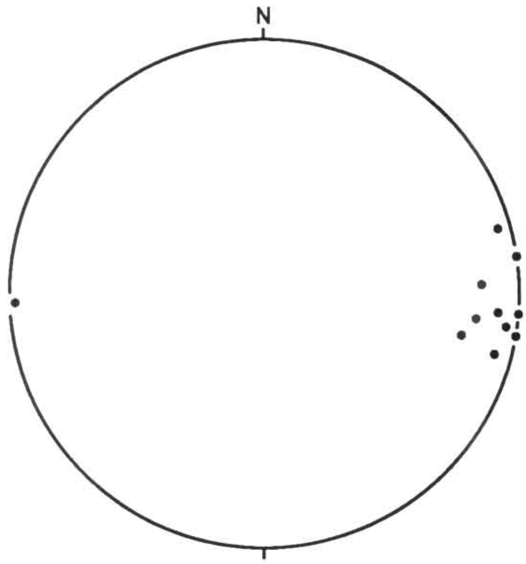


Figure 69. Stereoplot of poles to bedding, domain 21.

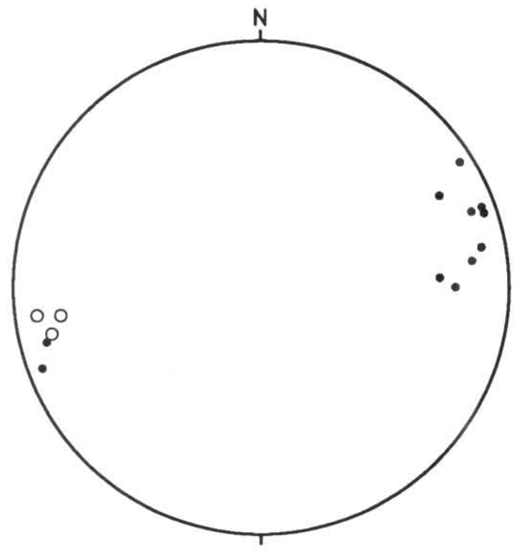


Figure 70. Stereoplot of structural elements, domain 19.

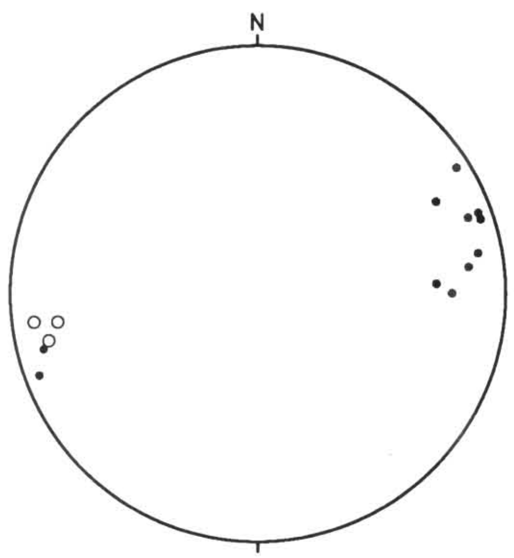


Figure 71. Stereoplot of structural elements, domain 20.

5 cm

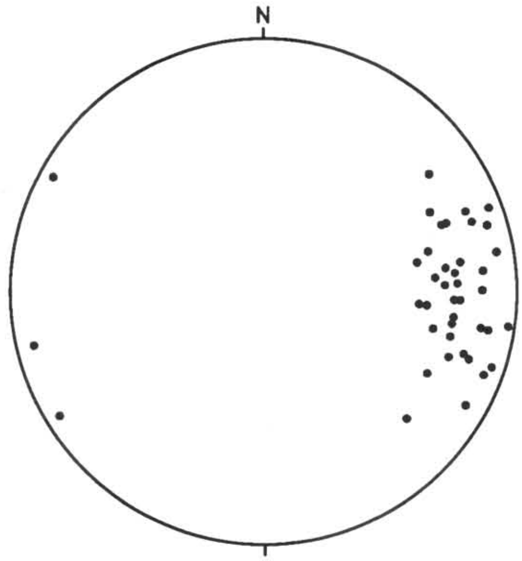


Figure 72. Stereoplot of structural elements, domain 21.

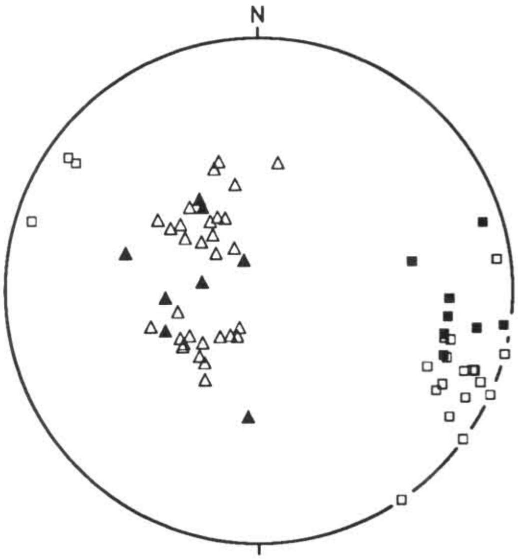


Figure 73. Stereoplot of structural elements, domain 21.

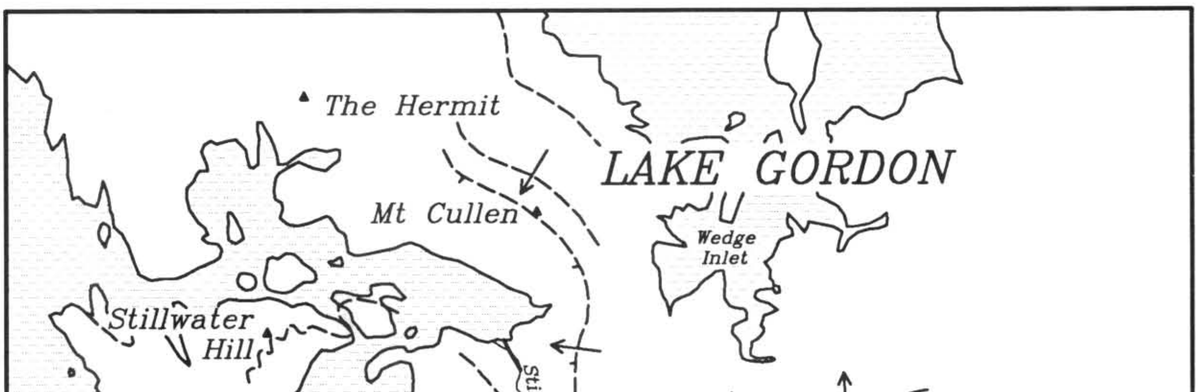
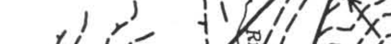


Figure 74. Bedding form line diagram of the Stillwater Hill, Coronet and Sentinel Ranges area.



MT CULLEN – JUNCTION RANGE

N. J. Turner

Cleavages

Several cleavages are commonly present in the phyllite and metasandstone around Mt Cullen and Junction Range. The appearance or morphology of each cleavage is strongly influenced by rock type and the clarity with which cleavage may be seen is influenced by the nature of outcrop. Cleavage is clearest in weather-etched outcrops such as occur along the ridge extending north from DN308580 near Hermit Valley, and in similar outcrops scattered around Mt Cullen.

In quartz-rich phyllite the dominant cleavage corresponds to a metamorphic lamination comprising relatively quartz-rich laminae, ranging from about one to (rarely) 20 mm thickness, and mica-rich laminae of about 0.5-1 mm thickness. In the micaceous laminae the mica grains are relatively coarse and there is abundant, very fine-grained opaque material (?carbonaceous). The mica grains are aligned parallel to the laminae. In the relatively quartz-rich laminae there is subordinate green-tinted mica and the grain size of both quartz and mica is very fine. A penetrative grain alignment may be present in these laminae and there may be weak metamorphic segregation of quartz and mica parallel to the alignment. The grain alignment is crenulated and is transected by the main cleavage, thus the two fabrics are regarded as S_1 and S_2 respectively.

A late structural surface is present in most outcrops of quartz-rich phyllite and two trends (?S_3, S_4) are evident (fig. 75). Crenulation tends to be developed in zones, commonly corresponding to the hinge zones of small folds, and is widely spaced (about 2–10 mm). There is little associated metamorphic differentiation but fine-grained opaque material may be concentrated in the limbs of crenulations, thus imparting cleavage.

In mica-rich phyllite there is little metamorphic differentiation. Commonly, no cleavage earlier than the dominant foliation can be discerned in outcrop and the same applies in many thin sections. However, where quartz-rich and mica-rich phyllite are interbanded (e.g. DN327581, DN316581, DN325569, DN308578) it can be seen that the dominant foliation in the mica-rich phyllite is equivalent to S_2 in the quartz-rich phyllite. Cleavage associated with late crenulation tends to be better developed in micaceous phyllite than in more quartzose rocks but is still wide-spaced and zonal.

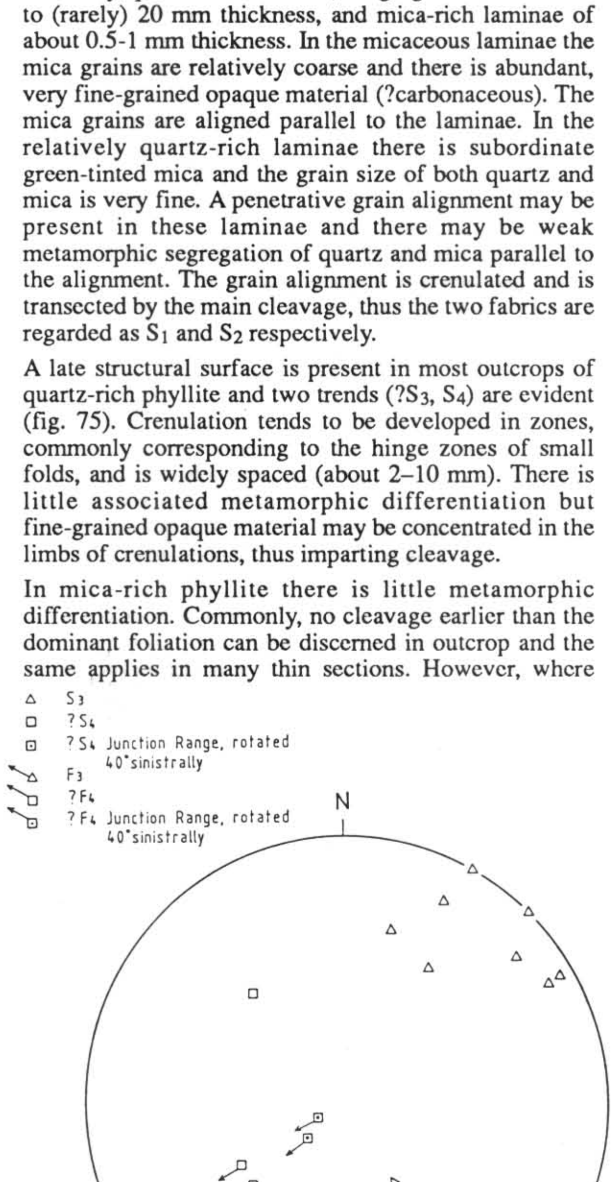


Figure 75. Late crenulation and associated folds in the Mt Cullen and Junction Range sub-areas. Crenulation - triangles, cross-trending crenulation - squares, Junction Range cross-trending fold axial surfaces rotated 40° - dots in squares. Folds: arrows with tails as above.

5 cm

Two cleavages with distinct morphologies may be present in metasandstone (e.g. DN309576, DN329563, DN313589). The later, generally dominant cleavage is spaced at intervals from about one millimetre to, rarely, 20 mm. It is subparallel to anastomosing and corresponds to very thin mica films. An earlier cleavage is defined by penetrative, preferred dimensional orientation of both clastic grains and metamorphic matrix grains. It is usually only easily discerned in weather-etched outcrops or in thin section. Of eight paired measurements of the two cleavages, the average angle between was 17° and the range of angles was 5–28°. It seems that the angular separation is commonly small since in many outcrops it is difficult to measure the individual orientations. The two cleavages are regarded as S_1 and S_2 and are considered to be equivalent to the S_1 and S_2 surfaces in phyllite. The late crenulation in pelitic rocks is rarely expressed in metasandstone.

In the dolomite bands at the eastern end of McPartlans Pass canal there is a strong, spaced (2–20 mm) cleavage corresponding to thin (1 mm), anastomosing seams of silvery-grey, relatively coarse-grained mica which is rich in dusty, opaque material (?carbonaceous). These seams are mostly gently curving but, in part, they are sutured and resemble stylolites. The cleavage is subparallel to the dolomite/phyllite layers and to the dominant cleavage in the micaceous phyllite. It transects an earlier structural surface defined by a swarm of subparallel veinlets which are thin (≈1 mm) and closely spaced in some intervals but thicker (5–10 mm) and more widely-spaced (10–20 mm) in other intervals. The thin veinlets comprise quartz and subordinate green tinted mica which have a strong dimensional alignment across the veins. Where the veinlets are thicker they contain carbonate. Though the dolomite enclosing the veinlets has recrystallised, giving a texture in which there are irregularly shaped patches of varying grain size, no dimensional alignment of patches or carbonate grains is apparent. Thus, there appears to be no surface in the dolomite that is morphologically similar to S_1 in the quartz-rich phyllite and metasandstone. However, the main cleavage is both morphologically similar to S_2 in the other rocks and is subparallel. Thus, it is regarded as equivalent.

Folds

No regional fold profiles were established either on Junction Range or around Mt Cullen. However, outcrop-scale folds in metasandstone may be overturned to the north-east and probably generally verge in that direction. The common attitude of bedding in the metasandstone (fig. 76) is consistent with a regional pattern of north-east vergence. The folds have dihedral angles of 35–60° and their apices are thick relative to their limbs. Plunges are shallow to moderate and of variable direction (fig. 77–78). The folds appear to be related to S_1 with S_2 superimposed on them in an orientation oblique to the axial surface (e.g. DN325580, DN319577, DN307585).

Short wavelength, low amplitude folds associated with late crenulation are developed in phyllite and have S_2 as their form surface. Their axial surfaces may have similar orientation to the early folds in the metasandstone but a few cross-trending structures were observed, e.g.

5 cm

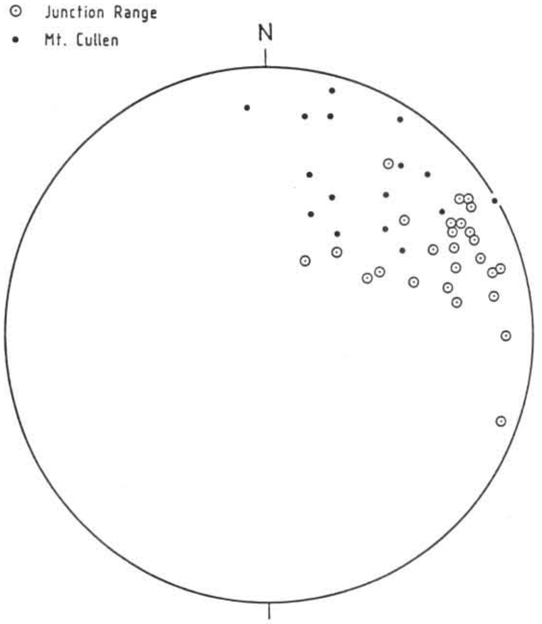


Figure 76. Bedding. Junction Range sub-area - dots; Mt Cullen subarea - circled dots.

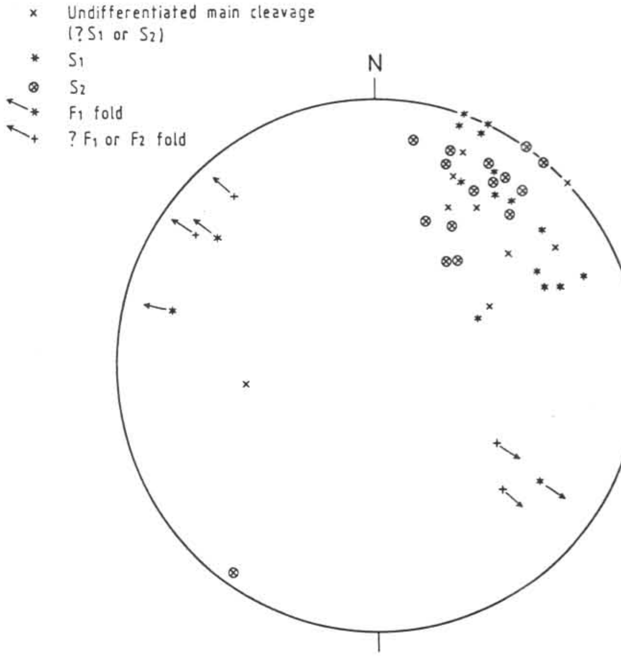


Figure 78. Early cleavages and folds in the Mt Cullen sub-area excluding measurements in and near McPartlans Pass canal. Symbols as for Figure 77.

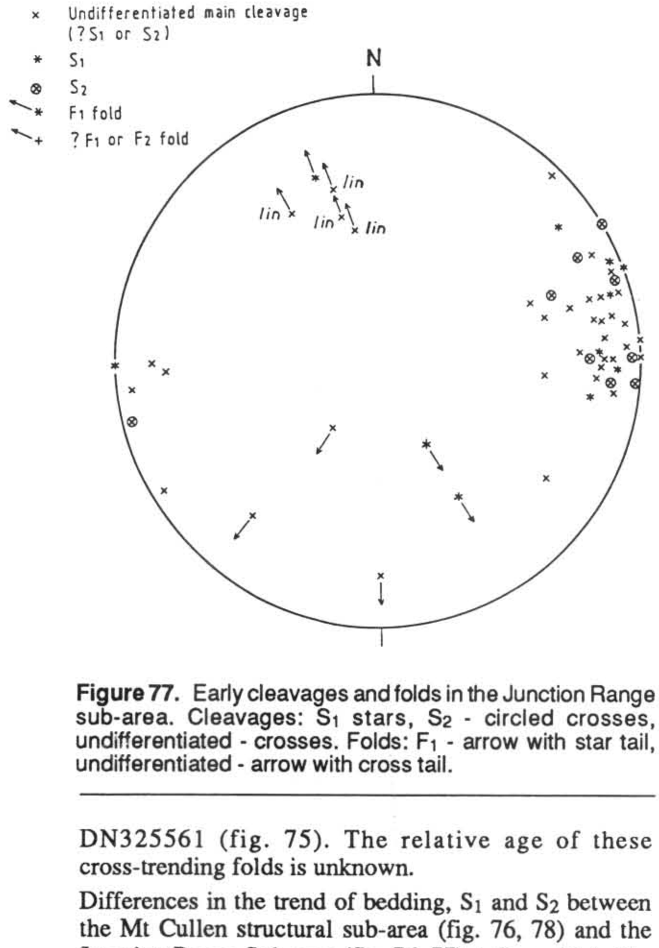


Figure 77. Early cleavages and folds in the Junction Range sub-area. Cleavages: S_1 stars, S_2 - circled crosses, undifferentiated - crosses. Folds: F_1 - arrow with star tail, undifferentiated - arrow with cross tail.

DN325561 (fig. 75). The relative age of these cross-trending folds is unknown.

Differences in the trend of bedding, S_1 and S_2 between the Mt Cullen structural sub-area (fig. 76, 78) and the Junction Range Sub-area (fig. 76–77) define a kink-like fold whose faulted hinge trends approximately north-east through DN305577 and DN321590. There is an apparent rotation of 40° (vertical axis) between the two sub-areas which may also be reflected in the late cross-trending folds since rotation by 40° aligns measurements of these structures (fig. 75) made in each sub-area.

WEDGE RIVER BEDS (Ꝑwc)

N. J. Turner

Cleavage in the conglomeratic Wedge River beds is very strongly developed and exhibits marked deflection around aligned usually discoidal, sometimes boudinaged, sedimentary clasts. The dominant cleavage is defined by close-spaced (about 1–2 mm), very thin (<1 mm), anastomosing films of mica. An earlier cleavage is evident in thin section but is not usually discernible in outcrop. This early cleavage is defined by penetrative alignment of metamorphic quartz and muscovite grains in the very fine-grained matrix between the sand grade and coarser clasts. In a single thin section the earlier and later fabrics may range from subparallel to strongly oblique. They are regarded as S_1 and S_2 respectively.

Changes in direction of sedimentary facing in cuttings along the Gordon River Road (fig. 79) indicate the presence of tight folds and tight closures are exposed at DN373546. The main cleavage around this locality dips more shallowly than bedding irrespective of the sedimentary facing thus indicating that the cleavage is later than the folds. The folds are probably F_1 structures. Further NE near DN375550 the bedding - main cleavage relationships changes, possibly indicating the presence of F_2 folds.

Late, low amplitude, short wavelength folds of NW–N trend occur in scattered outcrops of the Wedge River beds and the adjacent phyllite (Ꝑwp). A wide-spaced crenulation is commonly associated with these folds and minor metamorphic differentiation of mica and ?carbonaceous material may give rise to crenulation cleavage in places. The prominent, N plunging fold which affects the main cleavage and the Ꝑwc-Ꝑwp boundary around DN365547 probably belongs to the same late phase as the outcrop-scale folds.

In the Wedge River beds and Ꝑwp the main cleavage (S_2) has a generally similar orientation to bedding whilst the late phase folds and cleavage are cross-cutting. However, on Sentinel Range where the trend of bedding

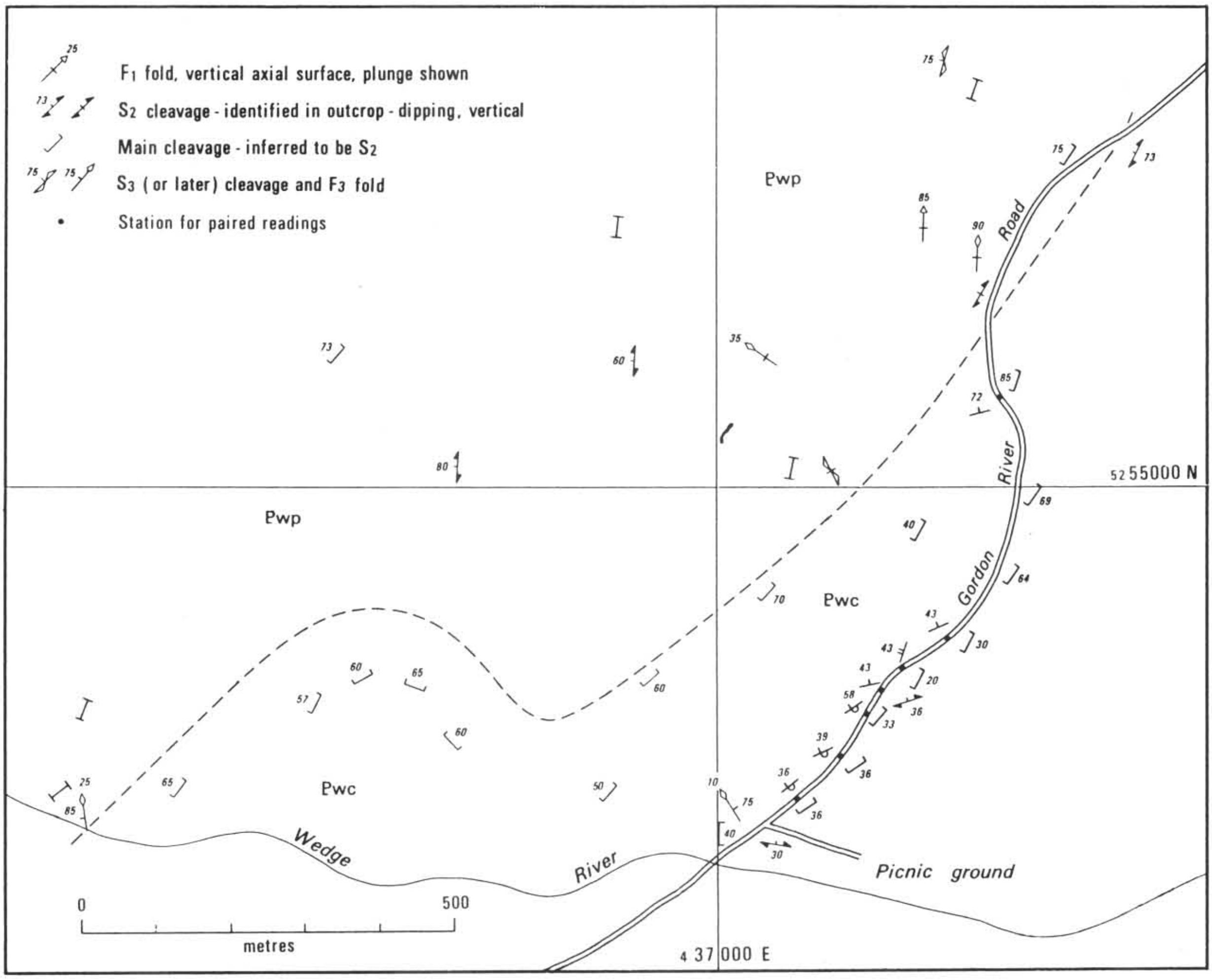


Figure 79. Structural measurements in the Wedge River Beds (Ꝑwc) and adjacent phyllite (Ꝑwp).

is much the same as in the Wedge River beds, the S_2 surface has a NW-N cross-cutting trend (M. P. McClenaghan, this work) similar to the trend of late folds and cleavage in the Wedge River beds and Ꝑwp. An earlier interpretation (Williams, 1976) assigned the predominantly NW-trending, cross-cutting structure on Sentinel Range to D_3 and identified D_1 and D_2 as isoclinal, nearly coplanar phases.

JUBILEE REGION

C. R. Calver

INTRODUCTION

Precambrian rocks of the Jubilee region on Pedder Quadrangle are generally less deformed than those of the Tyennan region. Also, metamorphic grade is generally lower, ranging from rocks that appear essentially unmetamorphosed up to lower greenschist facies.

Deformation is polyphase but sequences nearly everywhere face north, north-west or north-east. Mesoscopic (outcrop-scale) folding is not commonly observed, typically being limited to the axial regions of major folds. Cleavages, therefore, have been generally used to characterise and order deformational events, particularly cleavages in pelitic rock types. The more competent lithologies (orthoquartzite, dolomite) remain unstrained or are only weakly cleaved.

Regional correlation of deformation events has been hindered by lack of continuity of outcrop and faulting. The ordering and correlation of tectonic elements (cleavages, folds) proposed below are largely internally consistent but must be regarded as tentative, being based on local overprinting of cleavages and an assumption that regional orientations are relatively constant or vary systematically. Relative ages of cleavages and minor folds are shown on the 1:50 000 map, while locations and postulated relative ages of major folds are shown in Figure 80. No correlation of phases between stratigraphic Groups is necessarily implied, although it is probable that D_1 in the Mt Anne, Pandani and Weld River Groups is one and the same deformational phase.

MT ANNE GROUP

Occupying the south-eastern corner of the map sheet, the Mt Anne Group is of lower greenschist metamorphic facies and has undergone at least three cleavage-forming deformation events, followed by at least two conjugate kink sets, and extensive faulting. The faulting, besides causing problems of stratigraphic correlation discussed earlier, has also led to uncertainties in structural correlation.

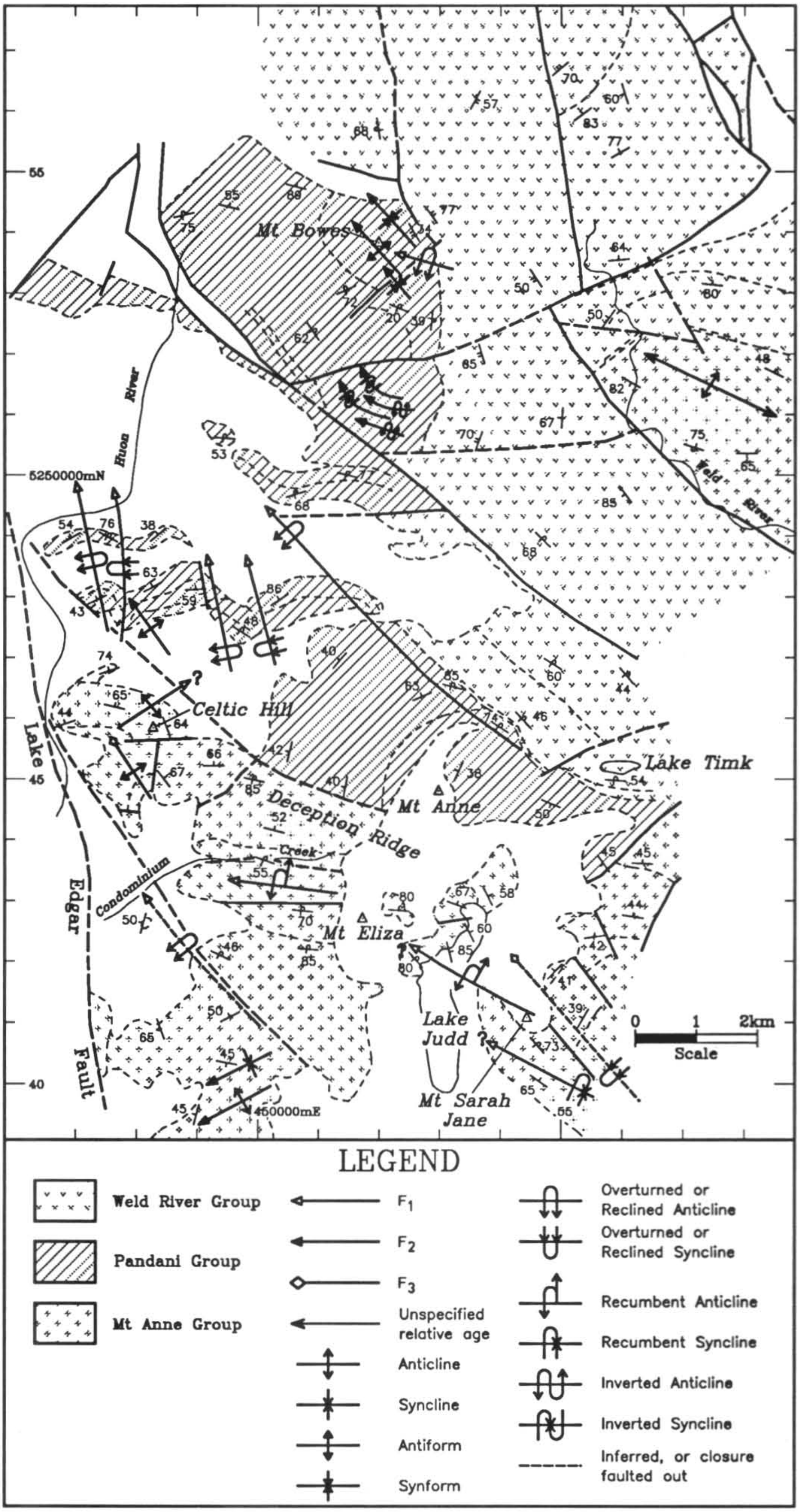


Figure 80. Major folds, Jubilee region. No correlation of fold ages is necessarily implied between Groups.

5 cm

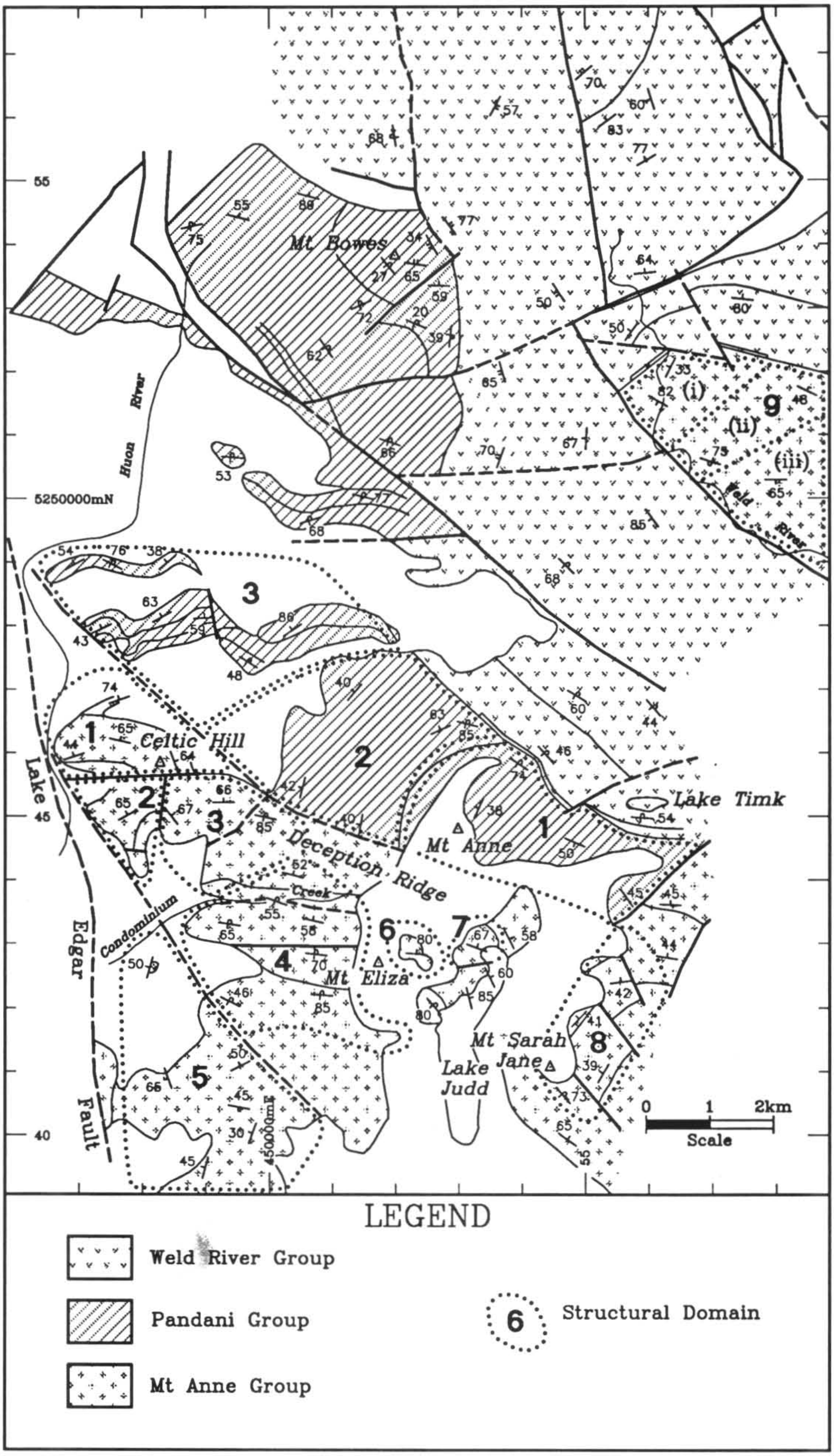


Figure 81. Structural domains, Jubilee region.

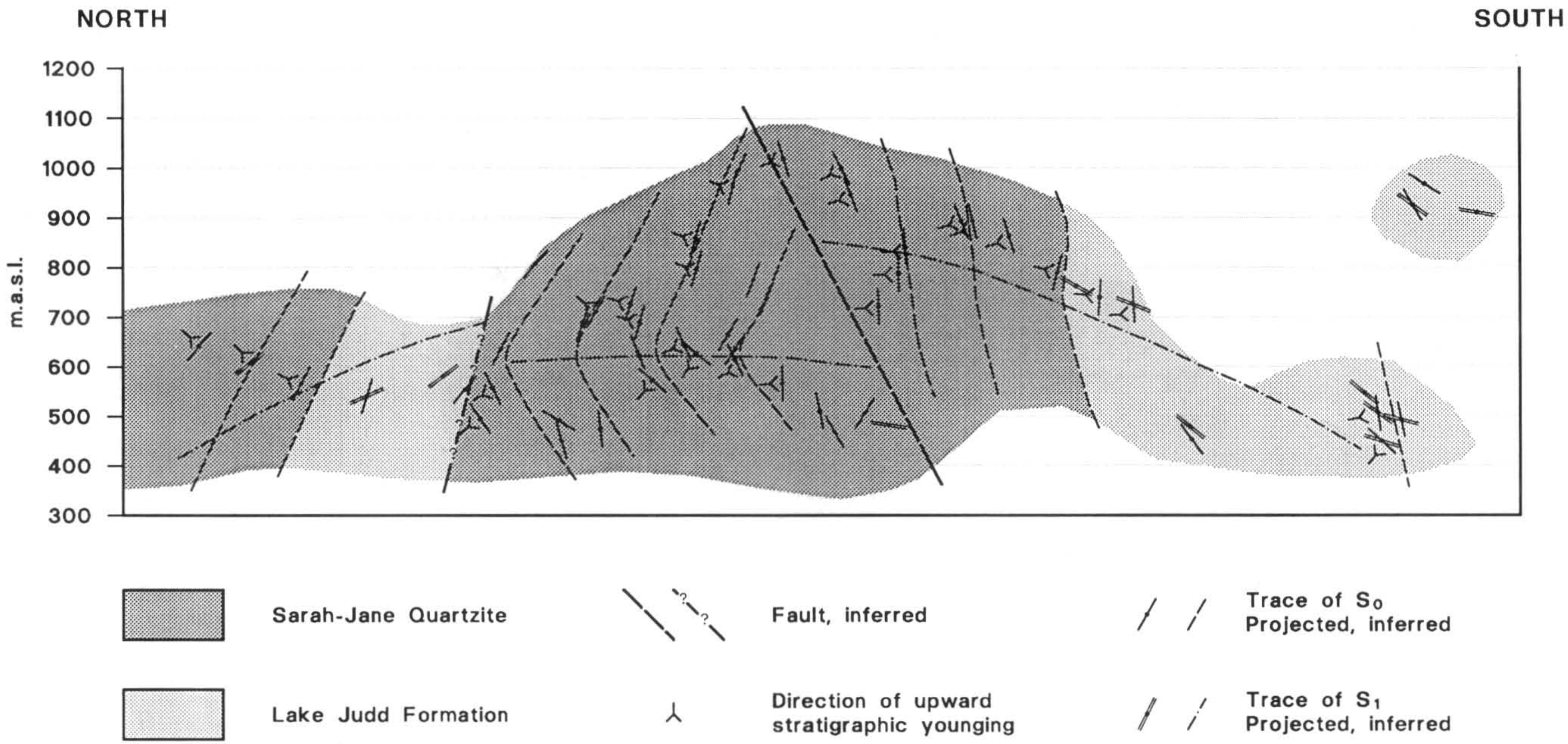
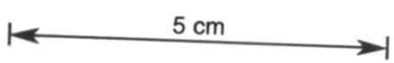


Figure 82. Structural profile, Mt Eliza – Condominium Creek (domain 4). Projection plane: view to 107°, elevation 0°, V:H = 1:1.



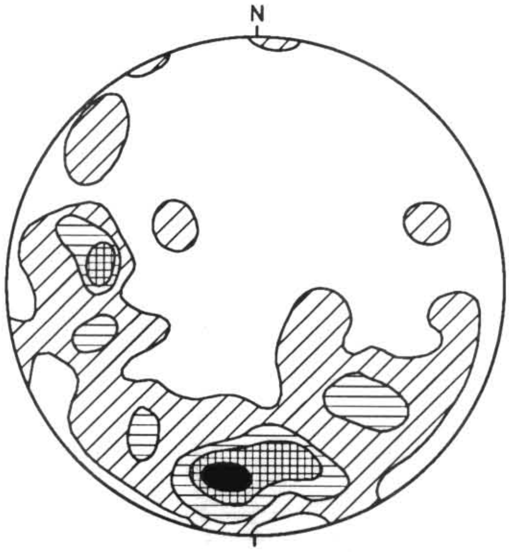


Figure 83. Stereoplot of poles to bedding, Mt Anne Group domain 1. $n = 93$. Contours 1, 3, 5, 7% per 1% area.

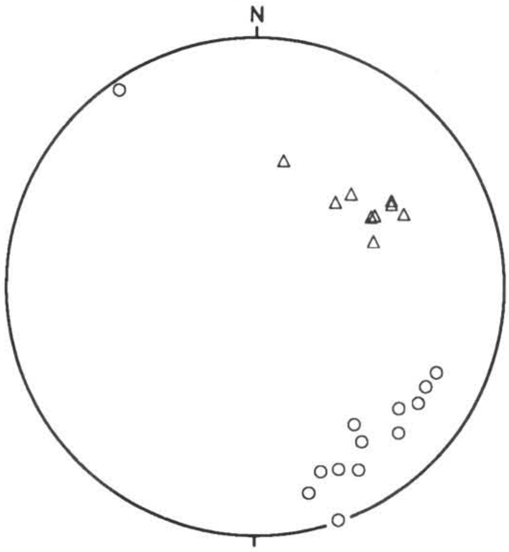


Figure 84. Stereoplot of poles to S_1 cleavage, and probable F_1 fold hinges, Mt Anne Group domain 1.

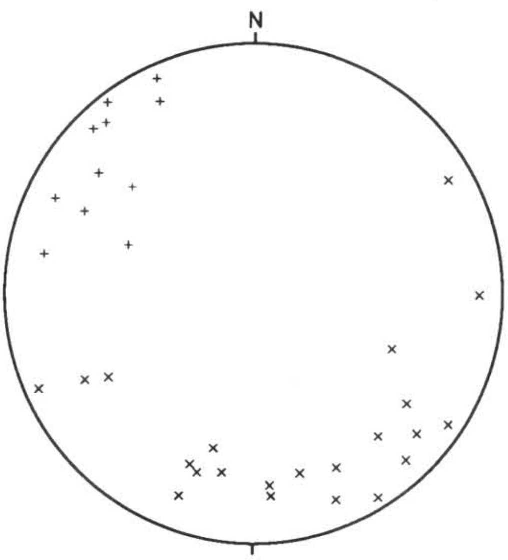
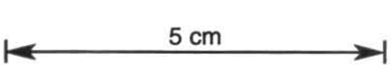


Figure 85. Stereoplot of poles to bedding, Mt Anne Group domain 2.



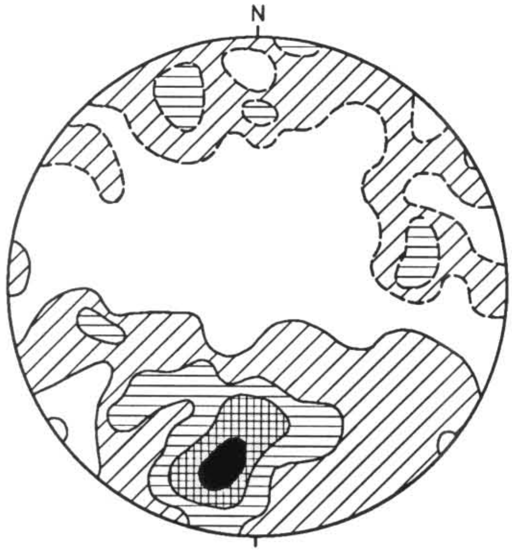


Figure 86. Stereoplot of poles to bedding, Mt Anne Group domain 3. $n = 129$. Contours 1, 4, 8, 12%. Broken contours enclose poles to overturned bedding.

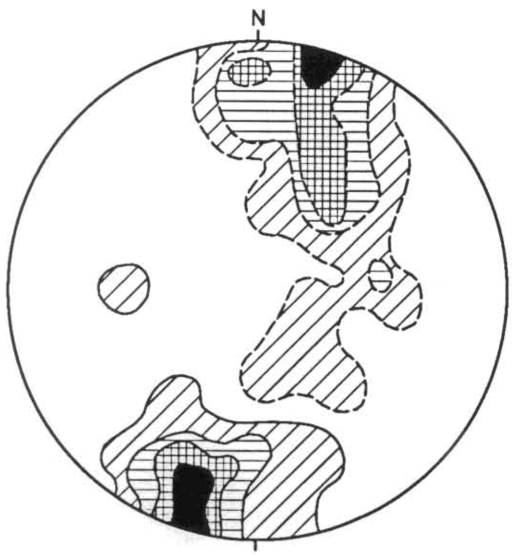


Figure 87. Stereoplot of poles to bedding, Mt Anne Group domain 4. $n = 103$. Contours 1, 3, 5, 7%. Broken contours enclose poles to overturned bedding.

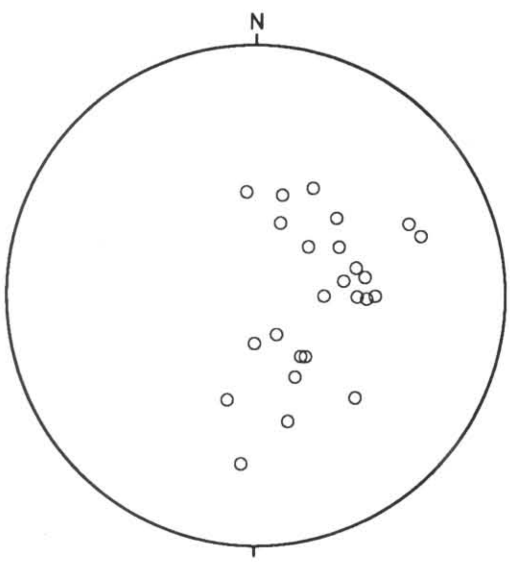


Figure 88. Stereoplot of poles to S_1 cleavage, Mt Anne Group domain 4.

First deformation phase (D_1)

The attitude of the earliest foliation, a slaty cleavage in pelites, is regionally variable in the Mt Anne Group. This can only partly be attributed to folding by known later events (D_2,D_3).

In a central domain west of Mt Eliza (domain 4, fig. 81) S_1 dips moderately to gently north or south, and lies approximately in the axial plane of a major open north-facing recumbent anticline in the Sarah-Jane Quartzite (see structural profile, fig. 82; stereoplots, fig. 87–88) The variation in attitude of S_1 is in accord with an expected fanning of cleavage in the relatively incompetent pelite layers in which S_1 is developed. Folds of similar style and orientation (open, recumbent or gently reclined, with subhorizontal or gently west-dipping axial surfaces) occur in the quartzite south of Mt Sarah-Jane (fig. 80) and on Deception Ridge (domain 3, fig. 86), and are tentatively attributed to D_1.

To the south-west, the Twin Creeks Formation (domain 5, fig. 89–90) comprises a separate fault block in which bedding and S_1 are frequently subparallel and mostly dip steeply west. The eastern part of this fault block, where bedding dips north and becomes steeply inclined to S_1, is probably near the closure of a large NW-plunging F_1 anticline overturned to the north-east (fig. 80). The east-facing quartzite outcrop at DN486412 may represent the thickened common limb of a parasitic N-verging coupled F_1 fold.

To the north, around Celtic Hill and the Druids (domains 1–3, fig. 83–86) the sequence is complexly faulted but is predominantly steeply dipping and north-facing, with S_1 subparallel (domains 2 and 3) or close to (domain 1) bedding. At Celtic Hill, an upright NE-plunging major fold is developed in the Sarah-Jane Quartzite with tight parasitic minor folds present in the axial region along the inner arc of the quartzite formation. The minor folds have wavelengths of a few metres, interlimb angles of 70–80°, and upright to N-dipping axial surfaces. The axial surfaces are subparallel to S_1 in local pelitic units (fig. 84–85) and the folds are therefore tentatively assigned to F_1; however, they are unlike F_1 elsewhere in style and attitude.

Plate 19. Thin section 001856 (Lake Judd Formation): interbedded quartz sandstone and slaty pelite. S_2 is the predominant cleavage, steeply inclined to bedding, of close-spaced weakly anastomosing seams; S_1 is a slaty fabric, barely perceptible only in broader microlithons in pelite layers, oriented close to bedding. Field of view 2 × 2.5 mm.

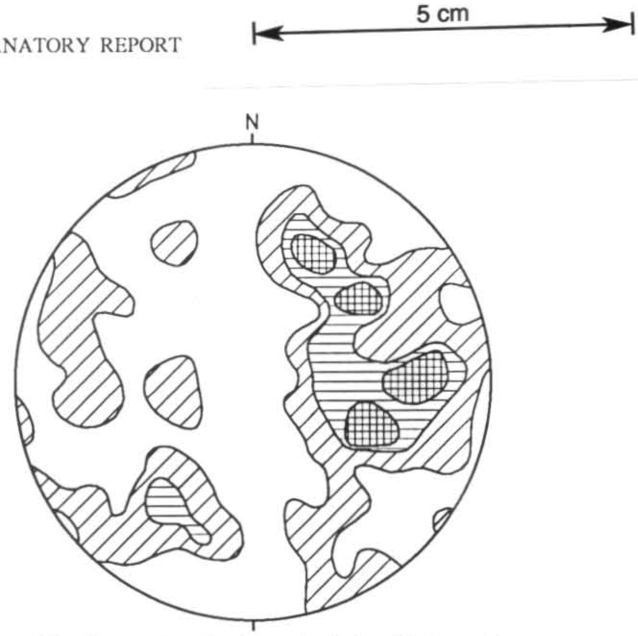


Figure 89. Stereoplot of poles to bedding, Mt Anne Group domain 5. $n = 93$. Contours 1, 3, 5% per 1% area.

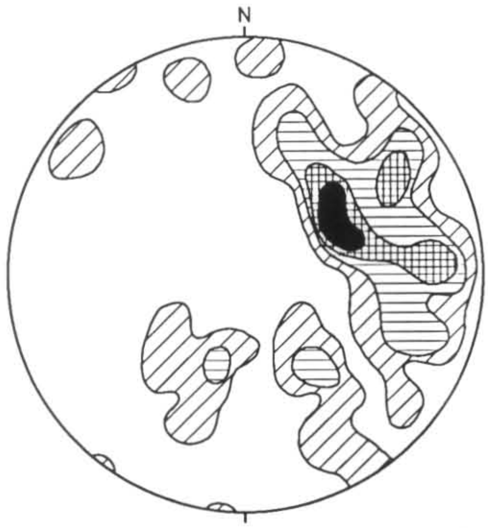


Figure 90. Stereoplot of poles to S_1 cleavage, Mt Anne Group domain 5. $n = 90$. Contours 1, 3, 5, 8%.

In eastern areas (Lake Judd–Mt Sarah-Jane, domains 7 and 8) S_1 is relatively weakly developed (see below) and is predominantly close to or subparallel to bedding.

Thin-sections of slate and phyllite show S_1 as a continuous fabric of aligned fine-grained layer silicates. In the Twin Creeks Formation some phyllite samples show a perfect planar fabric of optically continuous layer silicates in pure mica (phengite) layers. In the more common slates and slaty phyllites, however, S_1 consists merely of a strong preferred alignment of almost merging platy phyllosilicate crystals 30–50 μm long, resolvable under high power and best seen in over-thinned parts of the slide. Graded siltstone layers typically display a sharp refraction of S_1 at their bases (plate 3). There is no general parallelism between S_1 and clastic dykes: commonly, the dykes are ptygmatically folded, or rotated from an original probably bedding-perpendicular orientation, by shortening perpendicular to S_1. Minor fibrous quartz has grown within pressure shadows cast by small pyrite crystals and some detrital muscovite grains.

In some northern and eastern areas (domains 2, 3, 8 and parts of 7), slates have a relatively weakly developed S_1 fabric of smaller (10–20 μm), apparently less strongly aligned layer silicate grains. In these areas, a later cleavage may be locally sufficiently intense to appear slaty in outcrop but may be distinguished as a close-spaced crenulation in thin-section (plate 19).

In orthoquartzite, S_1 is locally developed as a 'rough' cleavage of discontinuous anastomosing seams (plate 5). Generally, however, quartzite is essentially unstrained and unrecrystallised, with detrital grains lacking pronounced undulose extinction.

In fine-grained dolomite of the Twin Creeks Formation, and in leached, probably originally dolomitic rocks exposed in road-cuts at DN471473 and south of DN482410, S_1 is a differentiated layering defined by weakly anastomosing dark-coloured phyllitic seams 1–5 mm apart. Highly strained trough cross-lamination in leached ?dolomitic siltstone is exposed in a road-cut at DN487396.

In summary, D_1 produced overturned to recumbent major folds in Sub-areas 4 and 5, transported from the south or south-west and with a slaty axial planar fabric. Other areas, where bedding and cleavage dip steeply and are frequently subparallel, appear to represent rotated and fault-dismembered parts of the limbs of these early folds.

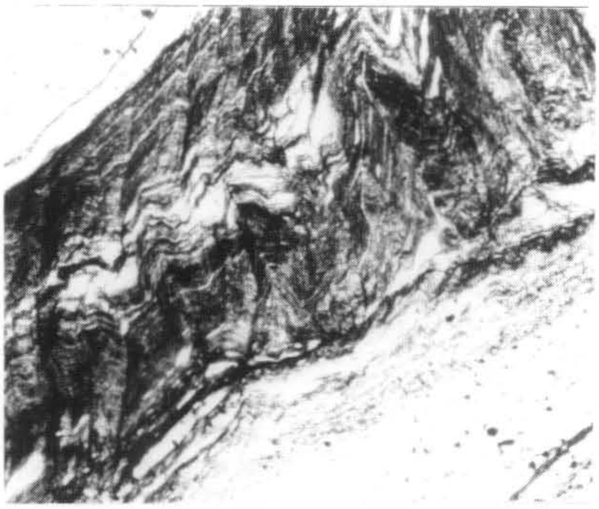


Plate 20. Thin section 001893 (Twin Creek Formation). Phyllite. S_1 is a slaty cleavage with lepidoblastic fabric parallel to compositional layering; S_2 is defined by limbs of tight crenulations (micro-folds). Field of view 3.5 × 3 mm.

Later phases (D_2, D_3)

Later cleavages are crenulations in slates and phyllites. Crenulations are usually discernible in outcrop as spaced (0.1–1 mm) planar to wavy thin differentiated seams, or, in some phyllites, as the axial surfaces of microfolds (plate 20).

In some areas where S_1 is relatively weakly developed (see above), notably south of the Druids and east of Mt Sarah-Jane, S_2 or S_3 may be sufficiently intense to appear slaty in outcrop but in thin-section consist of very close-spaced, planar to slightly anastomosing seams, only 5–10 μm thick and about 10 μm apart but somewhat variable in density across the slide (plate 19).

Usually only one crenulation is present in outcrop. Where quartz siltstone and pelite are interlayered (as in the Lake Judd Formation) the crenulation is often only developed in the pelite layers whereas S_1 may be developed in both (plate 3).

The orientation data fall into two broad groups (fig. 91–92) which, together with consistent overprinting relationships at several localities (notably DN478427, DN482410, DN477452) are taken to represent crenulations of two generations. Unlike S_1, the orientations are broadly consistent regionally. The spread of cleavages allotted to S_3 (fig. 92) suggests a greater number of generations but this cannot be proved with present data.

D_2: S_2 orientations are predominantly N-dipping (fig. 91) but vary systematically across the region, due at least in part, to later gentle folding (F_3).

Around DN495403, S_2 lies in the axial plane of open, major (wavelength ≈1 km) and minor upright F_2 folds that plunge W-SW (fig. 80).

North-west of Lake Judd, a north-facing sequence of quartz siltstone and slate is folded into open, reclined, east-plunging folds with a pervasive east-dipping axial planar cleavage (domain 7, fig. 94). This cleavage crenulates S_1 and probably pre-dates a patchy, spaced south-west-dipping crenulation orientationally similar to S_3 in other areas. It is, however, orientationally dissimilar to S_2 elsewhere (fig. 91).

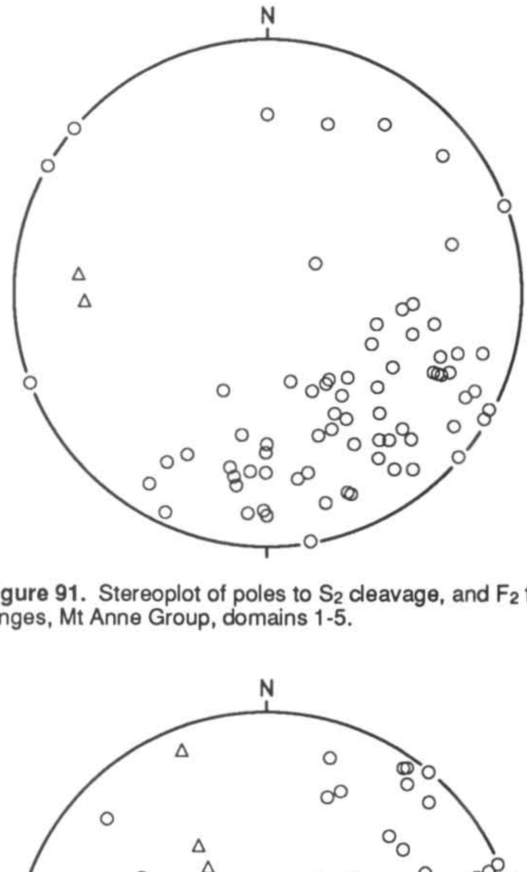


Figure 91. Stereoplot of poles to S_2 cleavage, and F_2 fold hinges, Mt Anne Group, domains 1-5.

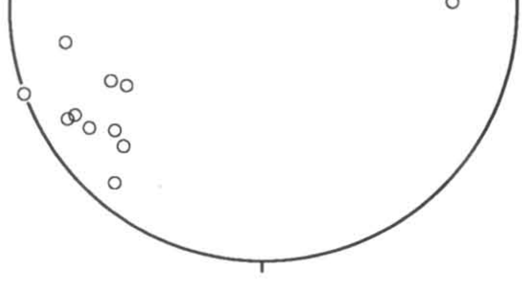


Figure 92. Stereoplot of poles to S_3 cleavage, and F_3 fold hinges, Mt Anne Group, domain 1-5.

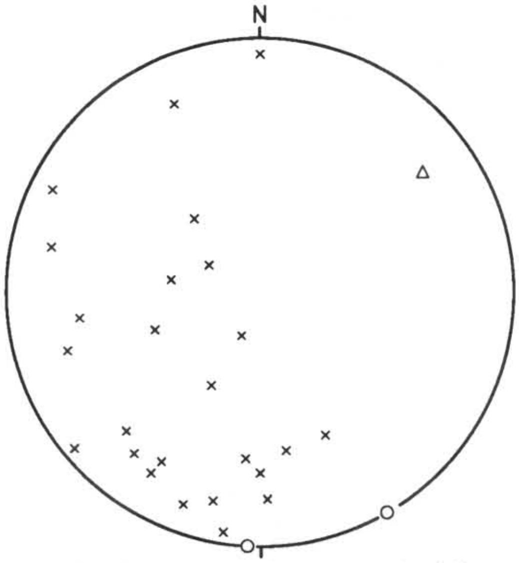


Figure 93. Stereoplot of poles to bedding and undifferentiated cleavage, and undifferentiated fold hinge, Mt Anne Group domain 6.

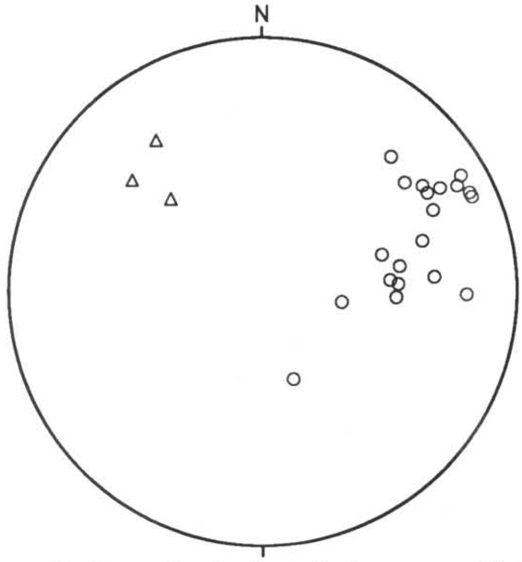


Figure 96. Stereoplot of poles to S_3 cleavage, and F_3 fold hinges, Mt Anne Group domain 8.

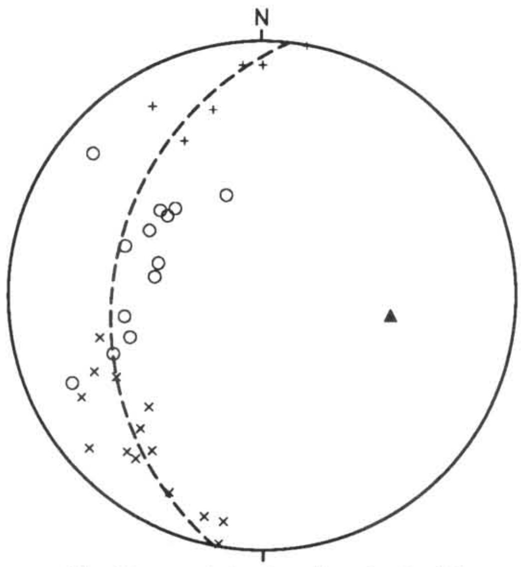


Figure 94. Stereoplot of poles to bedding and undifferentiated cleavage, and undifferentiated inferred major fold hinge, Mt Anne Group domain 7.

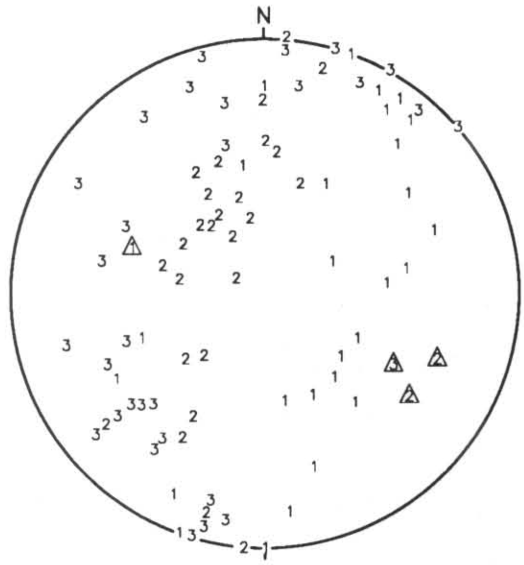


Figure 97. Stereoplot of poles to bedding, Mt Anne Group correlate of Weld River area (domain 9), differentiated according to sub-area.

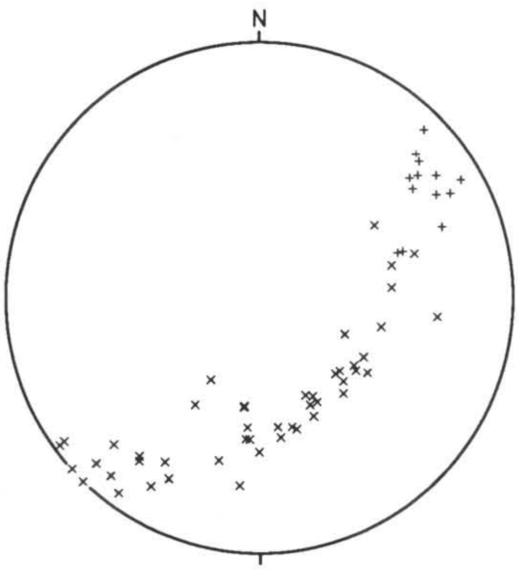


Figure 95. Stereoplot of poles to bedding, Mt Anne Group domain 8.

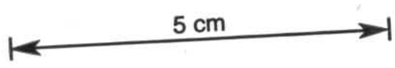
Symbols used in Figures 83–104.

× pole to bedding

\+ pole to bedding, overturned

○ pole to cleavage

△ hinge of fold in bedding



D_3: Near the Druids (domain 2) S_3 lies approximately in the axial plane of a major, open NW-plunging upright anticline that affects all earlier surfaces. Minor west-verging folds of similar attitude occur in the adjacent fault block to the east, around DN483451.

South-west of Mt Eliza (domains 4 and 5), S_2 is folded into a gentle NW-plunging antiform (N-dipping limb around DN495420; W-dipping limb around DN482405) that may be F_3.

East of Mt Sarah-Jane, the major NW-plunging syncline affecting the quartzite is F_3 (domain 8, fig. 95–96). The closure is faulted out by a fault trending parallel to the axial surface; on either side of the fault, minor parasitic folds with wavelengths of several metres are developed in the quartzite. Parasitic folds are absent away from the immediate axial region except possibly at DN559437. S_3 is locally developed as a 'rough' cleavage in quartzite and is strongly developed in pelite near the major fold axis (the southern part of domain 8). In the Lonely Tarns Formation at DN548416, S_3 appears slaty in outcrop but is recognised as a crenulation in thin section. Away from the axial region, for example at DN563438, S_3 becomes a weakly developed, patchy crenulation in pelite. At DN559437, minor folds in quartzite and red and green mudstone are consistent in attitude and vergence with regional D_3 structures.

Upright folds in quartzite north of Lake Judd [DN540435], with wavelengths approx. 100 m, have axial planes inclined steeply SW and may therefore be F_3.

In a road-cut exposure at DN471473, north of Celtic Hill, a differentiated surface (S_1) in leached dolomitic rocks is crenulated and tightly folded on a small (100 mm wavelength) scale by F_3 and S_1 is locally transposed into the S_3 direction. S_3 becomes more intense further north-east along the road, until at DN476475, weathered black phyllite has a pervasive, slaty-looking S_3 and S_1 is only preserved in the more competent silty layers.

Faulting

A major north-west-trending fault, not shown on the 1:50,000 map, probably separates the Twin Creeks Formation (domain 5) from the rest of the Mt Anne Group (fig. 81). The existence of this fault is suggested by the truncation of the quartzite ridges south of Celtic Hill [DN470450] and south of Condominium Creek [DN485435], and by the presence of otherwise anomalous outcrops at DN473444, DN478427 and DN510402. Another, SW-trending fault, not shown on the 1:50 000 map, is inferred west of Deception Ridge (domain 3, fig. 81) to account for pelitic rocks (Lake Judd Formation correlate?) cropping out around DN490451, and the truncation of the quartzite spur at DN487447.

Rocks East of the Weld River (domain 9)

This sequence of interlaminated mudstone and quartz siltstone, a possible correlate of the Mt Anne Group on lithologic grounds, has been subjected to at least two phases of deformation but is only very weakly cleaved.

The gross structure of this area consists of a first-order E-W trending anticline with a northern limb dipping gently north or north-west and a steeply dipping southern limb, in places overturned (e.g. around DN577510). To the north, these rocks are overlain by north-dipping Weld River Group; to the south-west they are faulted against the Weld River Group.

The anticline is overturned in the opposite direction to major F_1 folds in the Mt Anne and Pandani Groups, and is probably post-D_1.

Thin sections show a weak slaty cleavage, here called S_1, parallel to bedding in the mudstone layers, defined by a preferred orientation of tiny (5–10 μm) platy phyllosilicate grains, and appearing merely as an extinction direction under crossed polars and low magnification. S_1 is not developed in the siltstone layers. Clastic dykes of siltstone are thickened and ptygmatically folded where they transect mudstone layers, suggesting considerable shortening orthogonal to bedding within mudstone layers. Bending of the S_1 foliation and variations in cleavage intensity around the ptygmatic folds suggests that this shortening, and the bedding-parallel fabric in general, are largely of tectonic origin rather than purely of sedimentary/ compactional origin.

Locally, an incipient crenulation is developed, which parallels the axial surfaces of minor upright folds on the southern limb of the major anticline. The attitude and vergence of the minor folds suggests they may be parasitic on the major structure. They plunge west in the western part of the area but are subhorizontal to gently east-plunging in the east (fig. 97). Whether this change in attitude is original and due to pre-existing structure, or to later refolding, is unknown.

The second cleavage is weakly developed and impersistent, inclined to bedding and present in both siltstone and mudstone layers. It is best developed within tiny flame structures which have evidently been accentuated by slight cleavage-perpendicular shortening.

PANDANI GROUP

Like the Mt Anne Group, the Pandani Group has been subject to at least three cleavage-forming tectonic events but the macrostructure is simpler and the sequence appears less faulted. Two cleavages are nearly everywhere developed, are usually readily differentiated in the field, and are relatively constant in orientation across the region.

First deformation phase (D_1)

The gross structure of the whole of the Pandani Group can be described in terms of a first-order F_1 anticline, overturned to the north-east and plunging steeply NW (fig. 80), broken by faults into three major blocks. The axial planar slaty cleavage dips moderately to steeply W to SW. The southern fault block (= domains 1, 2 and 3 on fig. 81) contains the axial region and part of the adjoining upright limb of this fold; S_1 is pervasive, strongly developed and inclined to bedding. The two northern fault blocks constitute the overturned limb and bedding here predominantly dips SW and is overturned; and S_1 is a relatively weakly developed bedding-parallel fabric. There are thus two distinct domains within the Pandani Group defined by the intensity of S_1, with slates and phyllites characteristic of the southern domain and rather weakly-cleaved mudstones constituting the northern domain. The transition is not exposed: it underlies a broad zone covered by superficial Quaternary deposits on the plains around Sandfly Creek and the Huon River.

In the southern domain, second-order (wavelengths 1–2 km) F_1 folds verge toward the first-order hinge (fig. 80). A coupled, reclined F_1 fold, also with dextral vergence and with a short limb 30 m or so in length, is exposed in a road cutting at DN478484.

Near Mt Anne, in the axial region of the first-order anticline, the Lot Formation is locally folded on outcrop scale. The folds are best exposed in cliffs that form the headwall of the large cirque immediately east of Mt Anne [DN535455]. Here, the folds have a wavelength of 50–100 m, are overturned to the north-east, are moderately tight (typical interlimb angle 60°) and have slight dextral vergence. The axial planar cleavage is alternately convergent and divergent in more competent carbonate, and less competent phyllite, layers.

In the northern domain, the Mt Bowes Formation near Mt Bowes is affected by both reclined and upright major folds (fig. 80) which are probably F_1 and F_2 respectively by analogy with older Pandani Group rocks. The formation is predominantly overturned and dips as shallowly as 20° (overturned) near the summit of Mt Bowes. At DN524545, right-way-up north-dipping beds comprise the upper limb of a west-plunging reclined major fold whose closure and overturned limb are exposed 200–400 m north-east and along the escarpment to the south.

In the southern, more strongly deformed domain, S_1 is a penetrative slaty cleavage in pelites and is usually present as a spaced, seamed cleavage in carbonates. As in the Mt Anne Group, some phyllites have a microfabric of perfectly aligned, optically continuous layer silicates whereas the more common slaty pelites have a microfabric of closely appressed, strongly aligned but apparently separate phyllosilicate grains 10–30 µm long. Some slates, particularly in the Scotts Peak Road Member, contain pseudomorphs of iron oxide after cubic pyrite that have been strongly deformed by shortening orthogonal to S_1 (plate 6). Some other pelites contain larger (2 mm) undeformed pyrite grains with well-developed pressure-shadow fibrous quartz overgrowths. Commonly, thin sections show sparse, large bedding-parallel flakes of detrital muscovite that have been little deformed but are substrates for pressure-shadow fibrous quartz overgrowths that typically greatly exceed the volume of the original detrital grain.

Carbonates in the southern domain, and particularly in the Lot Formation, are characterised by a well-spaced, seamed S_1 cleavage. The wavy, weakly anastomosing seams of insoluble phyllitic material are prominent on weathered outcrop surfaces. Relatively pure carbonate beds tend to have more widely spaced (30–40 mm apart), thicker seams, whereas more argillaceous and/or carbonaceous beds have more closely spaced (a few mm), thinner seams. S_1 is a slaty cleavage in the interbedded pelite layers. Cleavage is refracted by up to 50° at carbonate-slate lithologic boundaries, reflecting the poorer competence of the latter.

In thin-section the cleavage seams in carbonates are sharply defined. The intervening microlithons lack cleavage but in some samples are crossed by numerous microscopic extension veinlets oriented normal to the cleavage direction. The veinlets are 0.1–0.2 mm wide, filled with fibrous quartz and dolomite, and represent up to about 30% extension. They are subparallel to bedding in the axial parts of minor F_1 folds, indicating maximum extension perpendicular to the fold axis.

Remnant limestone patches in dolomite, and rare pure limestone beds, are characterised by a microfabric of clear, very fine-grained (5–7 µm) microspar which resembles textures formed by primary recrystallisation (annealing) of originally coarser, deformed sparry calcite (e.g. see Bathurst, 1971, p. 477). In oolitic limestone (plate 8) deformation has proceeded both by pressure solution along S_1 cleavage seams and by homogeneous strain producing elliptical ooid outlines. A few isolated large (1 mm) dolomite euhedra in the oolitic limestone pre-date S_1. One contains the ghost outline of an undeformed (circular) ooid, indicating that the dolomite has a greater competence than the enclosing calcite microspar. By contrast, fine-grained impure dolomite in other slides appears less competent than calcite microspar as the limestone patches are typically fringed by pressure-shadows of fibrous calcite.

Many carbonate beds in the Pandani Group lack cleavage and appear essentially undeformed.

Mudstones of the northern domain are characterised by a weak S_1, oriented subparallel to bedding. This cleavage is not usually discernible except in thin section. The microfabric consists of a preferred orientation of very fine-grained to cryptocrystalline layer silicates, resolvable in a few slides into grains 5–10 µm long, and readily discernible as an extinction direction under crossed polars.

S_1 has not been recognised in northern domain carbonates. Bedding-parallel solution seams are developed, but could be of sedimentary overburden origin.

Later phases (D_2, D_3)

The second deformation phase is widely manifested as a steeply N-NE-dipping crenulation cleavage. F_2 folds are uncommon. In the southern domain, NW-plunging minor folds affecting bedding and S_1, with S_2 as axial planar foliation, are present at DN502459 and in road cuttings at DN477486 and DN479488. A major open, upright fold, probably F_2, is indicated on fig. 80. These folds are approximately coaxial with F_1 (fig. 98–104).

In the northern domain, which encompasses the overturned limb of the first-order F_1 anticline, upright folds affecting the Mt Bowes Formation are probably F_2. Around DN515520 there are inverted, upright F_2 folds of moderate tightness (interlimb angles ≈60°), with wavelengths approximately 200 m. The axial surfaces, initially trending westwards swing around to a northerly orientation as indicated on the map. The cause of this change of trend is unknown. A structural profile indicates an enveloping surface with a gentle S-SW dip. Larger, upright gentle major folds further north near Mt Bowes are similarly probably F_2 (fig. 80).

In the southern domain, the second cleavage is expressed as a spaced (0.2–1 mm), seamed crenulation in slate and phyllite, and usually is not developed in siltstone or quartzite (plate 6). Nor is a second cleavage visible in carbonate rock types, except rarely as a crenulation within the S_1 phyllitic cleavage seams, as at DN478485 on the Scotts Peak Road.

In the northern domain, S_2 is widely developed in mudstone as a microscopic crenulation cleavage that appears as a weak slaty cleavage, inclined to bedding, in outcrop. In thin section, the cleavage fabric consists of weakly anastomosing, closely-spaced thin opaque films, which have a non-uniform, bunched distribution and which tend to coalesce into thicker, more widely-spaced seams in some siltstone layers. The difference between this S_2 morphology and that in the slate and phyllite of the southern domain is presumably due to the finer grain size and weaker grain alignment of the pre-existing S_1 fabric in the northern domain. This S_2 fabric is similar to the crenulation cleavages developed on relatively weak S_1 in the Mt Anne Group (plate 19).

S_2 is locally developed in carbonates in the northern domain, as spaced (2–10 mm), discontinuous, planar to anastomosing seams.

Post-D_2 tectonism has produced a rare second crenulation cleavage and locally, major gentle folds. Correlation of these features is uncertain as they are widely separated and not clearly orientationally similar. A crenulation overprinting S_2 at DN507483 dips steeply NE, whereas one at DN492515 dips steeply W. A gentle major fold in the area surrounding the upper reaches of the Huon River [DN485550] brings the predominantly SW-dipping, overturned beds of the Serpentinite Creek catchment into NW-dipping, right-way-up attitudes along the Scotts Peak Road [DN490565–DN483550]. A west-dipping weak cleavage at DN490566 (indicated,

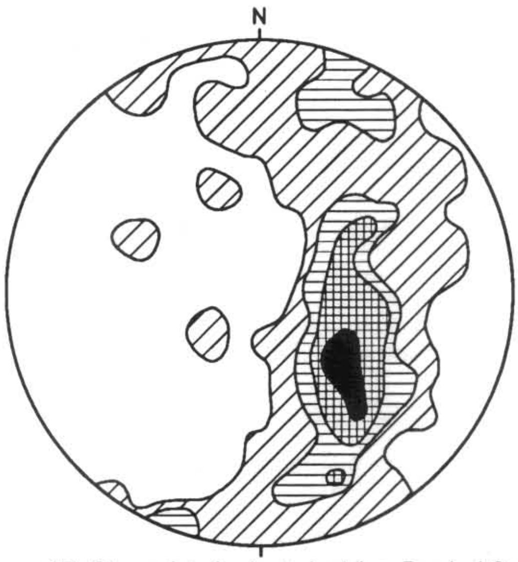


Figure 98. Stereoplot of poles to bedding, Pandani Group domain 1. $n = 108$. Contours 1, 3, 5, 8% per 1% area.

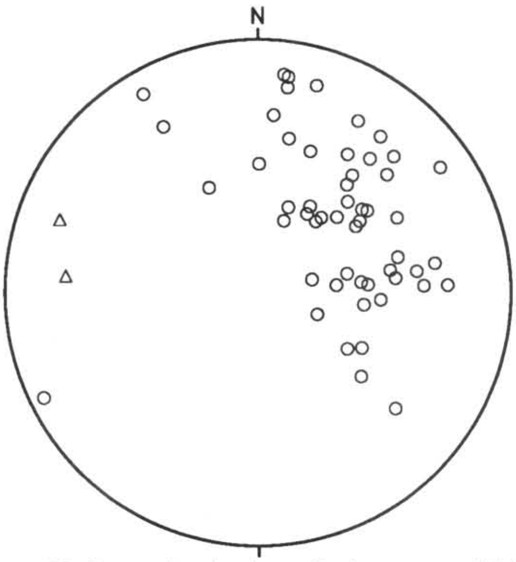


Figure 99. Stereoplot of poles to S_1 cleavage, and F_1 fold hinges, Pandani Group domain 1.

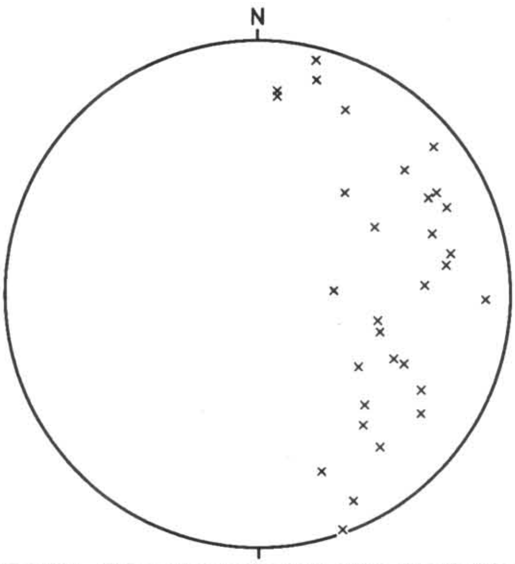
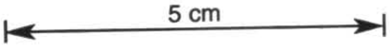


Figure 100. Stereoplot of poles to bedding, Pandani Group domain 2.



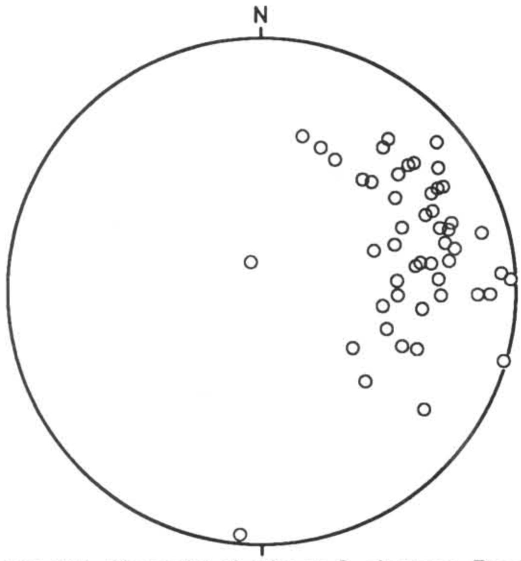


Figure 101. Stereoplot of poles to S_1 cleavage, Pandani Group domain 2.

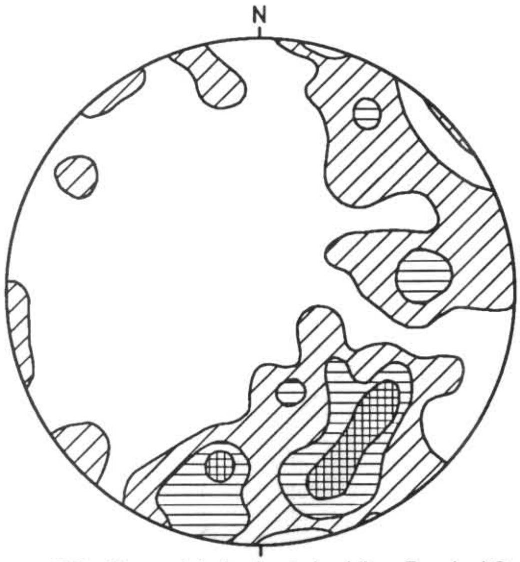


Figure 102. Stereoplot of poles to bedding, Pandani Group domain 3. $n = 86$. Contours 1, 3, 5%.

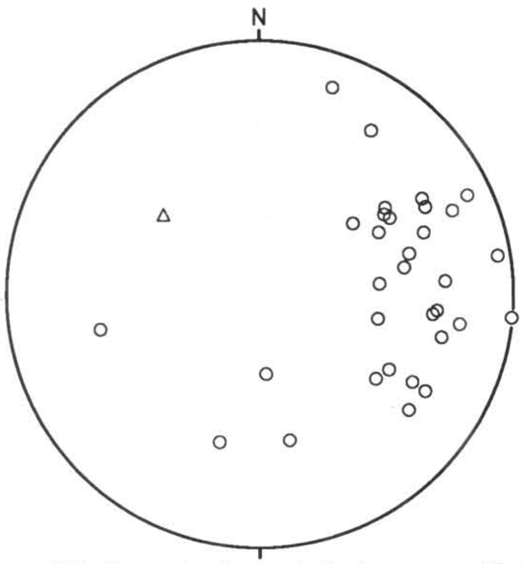


Figure 103. Stereoplot of poles to S_1 cleavage, and F_1 fold hinge, Pandani Group domain 3.

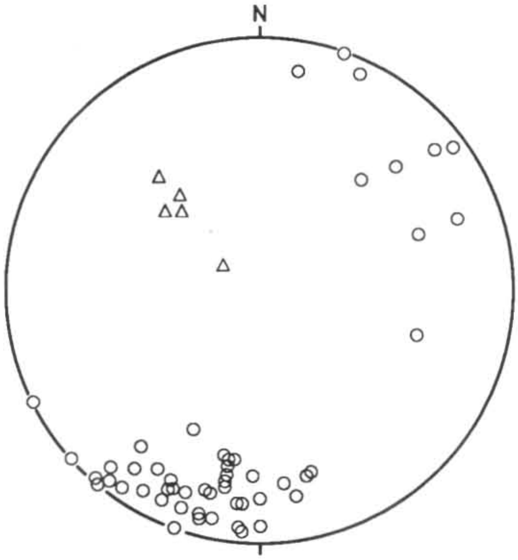


Figure 104. Stereoplot of poles to S_2 cleavage, and F_2 fold hinges, Pandani Group domains 1-3.

probably wrongly, as S_2 on the map) lies approximately in the axial plane of this structure. Around DN517520, subhorizontal upright F_2 folds in the Mt Bowes Formation (see above) have west-trending axes that swing around to a northerly trend as indicated on the map. This change in trend could be due in part to fault drag.

CLARK GROUP CORRELATE

This west-dipping sequence north of Mt Mueller has undergone a similarly slight degree of deformation and metamorphism as the northern part of the Pandani Group, the Weld River Group, the possible Mt Anne Group correlate east of the Weld River, and the Clark Group itself on the adjacent Huntley Quadrangle. Mudstone and shale have a weak to moderate slaty cleavage parallel to bedding. Carbonate rock types appear to be unstrained. Minor south-plunging folds with sinistral vergence at DN553649 have a locally-developed axial planar cleavage, and post-date the slaty cleavage.

WELD RIVER GROUP

The Weld River Group consists predominantly of relatively pure dolomite that, although considered to have been subjected to a similar tectonic history to the older rocks, has behaved competently and is nearly everywhere unstrained and uncleaved. Regional gentle folds or warps are present, however; and in the Cotcase Creek Formation, rare facing reversals suggest isoclinal folding but no closures were mapped. Mixtites are commonly cleaved, and the rare fine-grained siliciclastic rocks are cleaved and in places mesoscopically folded.

The Weld River Group lies unconformably upon Pandani Group in the Mt Anne–Lake Timk area and, in a separate area in the Weld Valley, rests para- conformably upon possible Mt Anne Group correlate. The unconformable nature of the base of the Weld River Group is indicated by its regionally transgressive nature, and the presence of a basal conglomerate (Annakananda Formation) derived from underlying sequences.

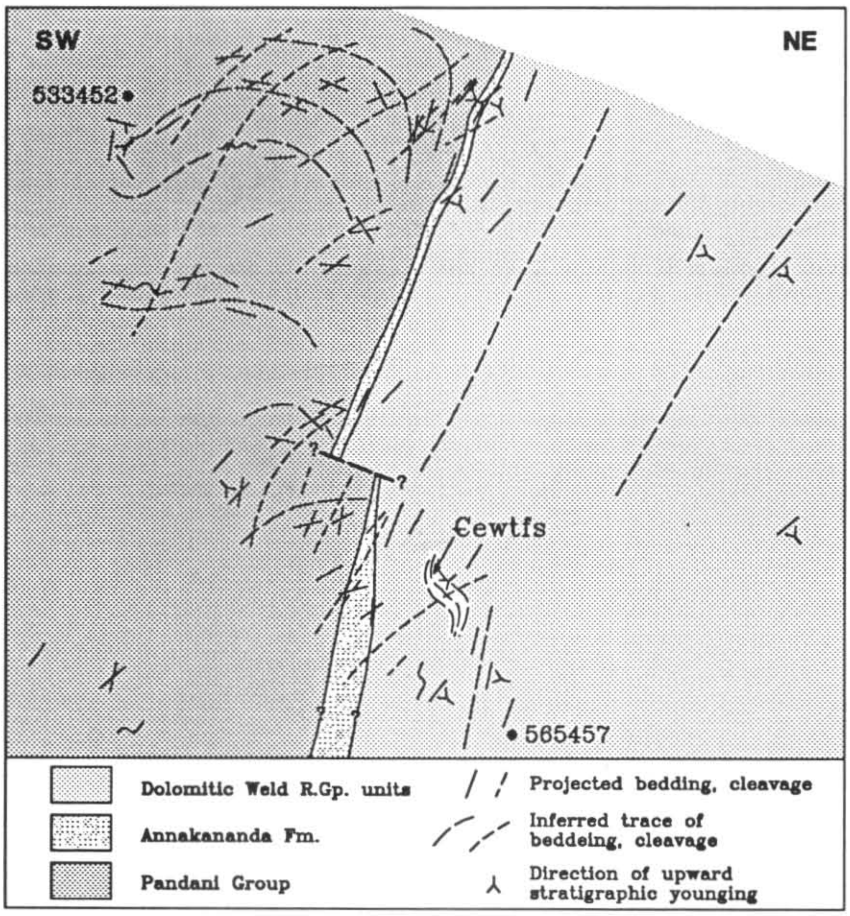


Figure 105. Structural profile, north-east ridge of Mt Anne to Lake Timk. Projection plane : view to 290°, elevation 40°.

5 cm

North-east of Mt Anne, the angular discordance is not great (≈20–30°) and the Weld River Group is structurally simple, the sequence dipping SW, overturned, and comprising part of the overturned limb of the first-order F_1 anticline whose axial region lies within the adjacent Pandani Group (fig. 80; structural profile, fig. 105). The Weld River Group thus appears to pre-date D_1 of the Pandani Group, and this is also borne out by observations on cleavage.

South of Lake Timk (in the lower part of fig. 105) the fold closure within the Pandani Group appears to have been faulted out, presumably by movement along the unconformity.

South of Lake Timk the Annakananda Formation carries a strong S_1 cleavage and the constituent clasts are variably flattened. Competent clast lithologies (quartzite, coarse-grained dolomite) remain undeformed, whereas the more abundant siltstone, fine-grained dolomite and especially pelite clasts are flattened into discoidal shapes in S_1. These clasts contain a concordant slaty S_1 and a weak crenulation. In the matrix, discontinuous, anastomosing seams in S_1 enwrap the more competent clasts. Bedding dips steeply south and is overturned; S_1 dips moderately south (fig. 105). In the overlying laminated dolomitic mudstone unit (Ꞓewtm), parasitic minor F_1 folds are developed with subhorizontal hingelines [DN562454].

Nearby, within the SW-dipping Gomorrah Dolomite, there is an isolated outcrop west of Lake Timk of a sequence of sandstone and slate (Ꞓewtfs) about 50–100 m thick. Here bedding is right way up, dips moderately north-west and is apparently discordant with the enclosing, overturned Gomorrah Dolomite. This sequence contains a well-developed slaty cleavage axial planar to tight, NW-plunging minor folds with dextral vergence (not indicated on the map), probably S_1 and F_1 respectively. The gross attitude of bedding and folds is in accord with the whole exposure occupying the short limb of a second-order NW-plunging parasitic F_1 Z-fold (fig. 105). The apparent lack of lateral continuity of this unit may be due to poor outcrop or undetected faulting.

On the north-east ridge of Mt Anne [DN537467–DN547457] the Annakananda Formation is only weakly cleaved: the two cleavages are best developed in slate clasts which contain a slaty cleavage and a crenulation. Sandstones of the Annakananda Formation, being more compositionally mature, generally lack cleavage.

The base of the Weld River Group is disconformable where exposed in the Weld River [DN563533]. The basal conglomerate of the Annakananda Formation here contains mudstone clasts with a conformable, incipient slaty cleavage subparallel to bedding that is very similar in style and attitude to S_1 in the underlying mudstones. The overlying Gomorrah Dolomite (Ꞓewtf) and Devils Eye Dolomite (Ꞓewtg) are structurally simple and undeformed, dipping north and right-way-up.

Nowhere in the Annakananda Formation is there any indication of a cleavage in the constituent clasts that pre-dates the formation of the conglomerate. The first and second cleavages in the north-east ridge–Lake Timk area probably correlate directly with those in the underlying Pandani Group.

The Cotcase Creek Formation is structurally less well known and probably more complex. The formation, a roughly north-striking sequence occupying the western Weld Valley, probably predominantly faces west for reasons outlined previously (p. 39). Rarely, a few opposed facings (e.g. at DN544516 *versus* DN550519) imply isoclinal folding but no closures were observed. A weak cleavage is locally developed in mixtite and mudstone units, generally subparallel to bedding but in places steeply inclined (e.g. DN575485). No correlation is attempted between these sparse and widespread observations.

FAULTING

Most of the faults in the Jubilee region are probably pre-late Cambrian in age since the Cambro-Ordovician Wurawina Supergroup to the north remains relatively undisrupted. There appear to be two sets of major faults: an earlier, variable but predominantly E-W set and a later, NW-trending set. The earlier set, with trends often roughly parallel to bedding, in several instances causes older rocks to structurally overlie younger ones (e.g. DN500440, DN520500, DN570550) and may therefore reflect an early phase of thrusting.

The later set includes five NW-trending faults with displacements of at least several kilometres: at DN490420 (not shown on the map but see fig. 3), DN510450, DN520510, DN560520 (which may be continuous with the fault at DN515563), and DN585565 (known also from recent mapping on Styx map sheet). Exposure of one of these faults at DN557480 indicates a subvertical attitude but sense of movement is unknown. Westward, these faults appear to merge with the Lake Edgar Fault system which constitutes the western boundary of the Jubilee region. This pattern suggests a genetic association of the NW-trending set with the Lake Edgar Fault. Large-scale sinistral strike-slip movement on the latter is post-middle Cambrian in age since rocks of that age (Ꞓmu) are affected.

West-side-up movement of about 5 m on the Lake Edgar Fault during late Pleistocene to Holocene times is indicated by a fault scarp developed in gravels of probably Pleistocene age on the flats near Harlequin Hill [DN468415–DN469435).

METAMORPHISM

Variation in the grain size of secondary phyllosilicate (sericite), described above, suggests a northward decline in metamorphic grade in the Pandani Group and also possibly the Mt Anne Group. This observation is supported by the occurrence of rare porphyroblastic rocks in the southern parts of both sequences.

A sample from the Twin Creeks Formation (001894) contains minor lenticular chlorite microporphyroblasts 0.5 mm long aligned in S_1, and more equant, wholly altered, indeterminate porphyroblasts. Similar rare chlorite occurs in the southern part of the Pandani Group (001829, 001848). A spotted green phyllite from the southern part of the Pandani Group (002411) contains abundant wholly altered blocky porphyroblasts 0.2–0.4 mm in size, originally possibly andalusite. S_1 wraps around these porphyroblasts which, however, have a preferred orientation oblique to S_1. Some carbonate samples from the Lot Formation contain small euhedral albite crystals (50–150 μm in size) probably of metamorphic origin. The porphyroblasts in all these instances appear to pre-date the first cleavage, suggesting that peak metamorphic conditions occurred before the first deformation.

DISCUSSION

D_1 folds in the Mt Anne Group, the Pandani Group and the southern part of the Weld River Group are predominantly overturned to the north-east and have an axial planar surface that is a penetrative slaty fabric in pelitic lithologies. There is apparent continuity of S_1 across the unconformity between the Pandani and Weld River Groups (fig. 105). D_1 in all three sequences, therefore, appears to be one and the same event. As noted previously the conglomerate-lithicwacke sequence (Ꞓals) north of Mt Bowes contains Pandani Group-derived detritus with disoriented cleavage. The

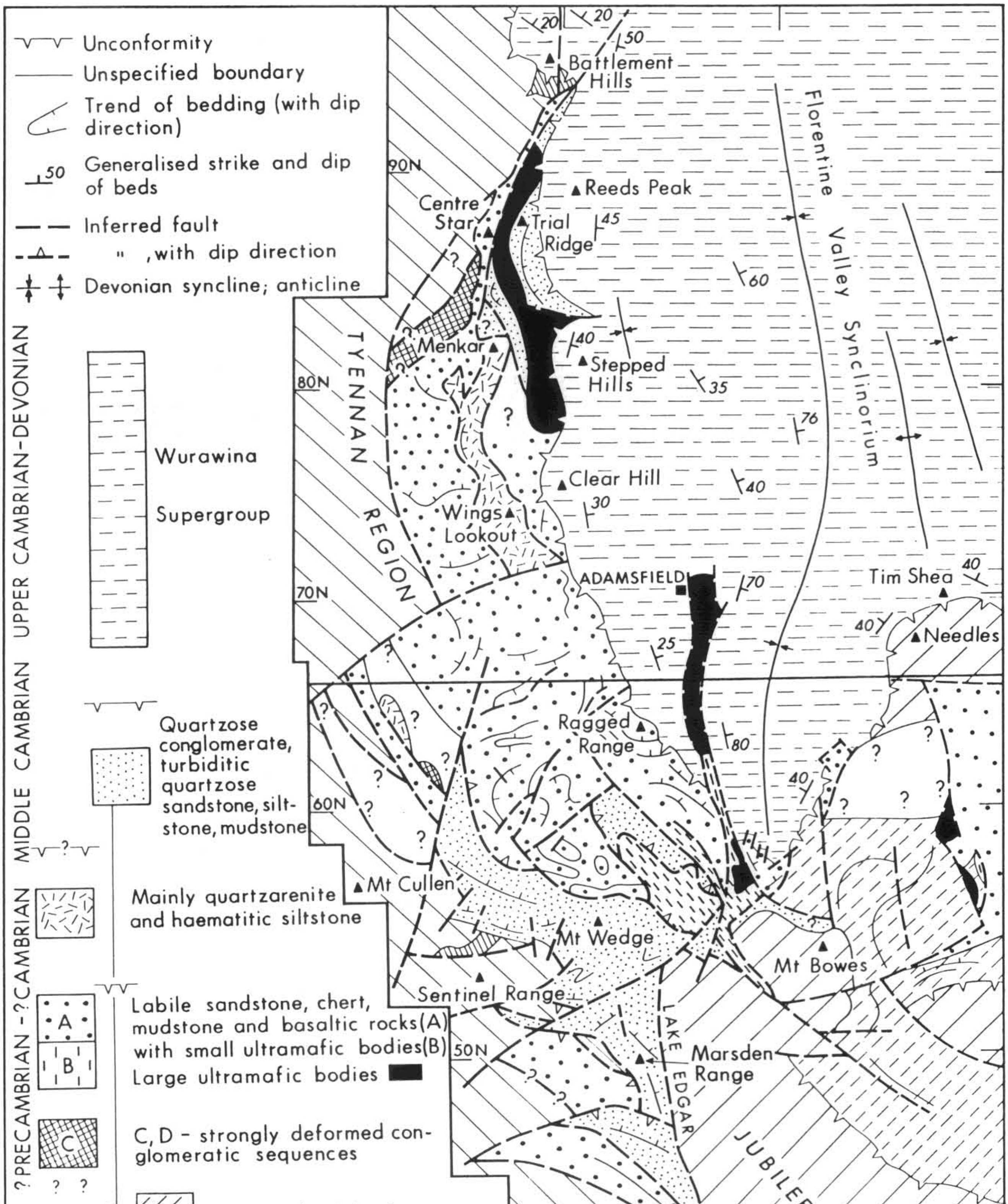


Figure 106. Interpretive map of the pre-Carboniferous geology of the central and eastern parts of Pedder and Huntley quadrangles from Turner (1989). Blank areas with question marks mostly represent areas where younger deposits totally obscure the older rocks, though small patches of outcrop of uncertain affiliation occur in the area north of Mt. Cullen. Faults with their approximate dip direction shown are shallowly dipping (<20°), as determined from fault traces on the topography.

probable minimum middle or late Cambrian age of these rocks places an upper age limit on D_1.

Correlation of later deformational events is less certain. Where Mt Anne Group and Pandani Group adjoin along their faulted mutual contact, in particular near Lake Picone [DN557437] and on the Scotts Peak Road [DN480480], there is close orientational similarity between S_3 of the Mt Anne Group and S_2 of the Pandani Group. Both cleavages are crenulations that trend roughly NW-SE, axial planar to upright, open folds that are approximately coaxial with F_1.

Correlation of these events with structural histories elsewhere in Tasmania is problematic. On broad lithostratigraphic grounds the Weld River Group can be correlated with the Success Creek Group and its equivalent, the Forest Conglomerate-Black River Dolomite of the Smithton Basin (Calver, 1989*b*). These sequences unconformably overlie rocks deformed in the Penguin Orogeny (Williams, 1976). If this correlation is valid, then there is no cleavage or fold phase in the Mt Anne or Pandani Groups that can be ascribed to the Penguin Orogeny, as the earliest phase (D_1) affects the Weld River Group as well. This accords with the conclusion of Adams *et. al.* (1985) that the Penguin Orogeny was restricted to north-west Tasmania, based on preliminary isotopic dating. D_1 therefore appears to be younger than the Penguin Orogeny (700–750 Ma) and may represent the early Cambrian event shown by isotopic dating in the eastern part of the Tyennan region (Adams *et al.*, 1985, Råheim and Compston, 1977).

However, Turner (1989) argues that there is no firm basis for more than one major Precambrian tectonometamorphic event in Tasmania (*cf.* Spry, 1962), and proposes an enlarged Penguin Orogeny which affected not only the Rocky Cape region but also, more or less synchronously, other Precambrian regions (Tyennan and Jubilee) as well. The relatively less metamorphosed areas, such as the Jubilee region, may merely represent the shallower parts of the same orogenic pile. Significant in this context is the similar north-easterly tectonic transport direction apparent from the early (D_1) fold asymmetry in both the Tyennan and Jubilee regions on Pedder Quadrangle.

Further isotopic dating will probably be needed to resolve this apparent mismatch between tectonic and lithostratigraphic histories in the Jubilee region relative to other parts of Tasmania.

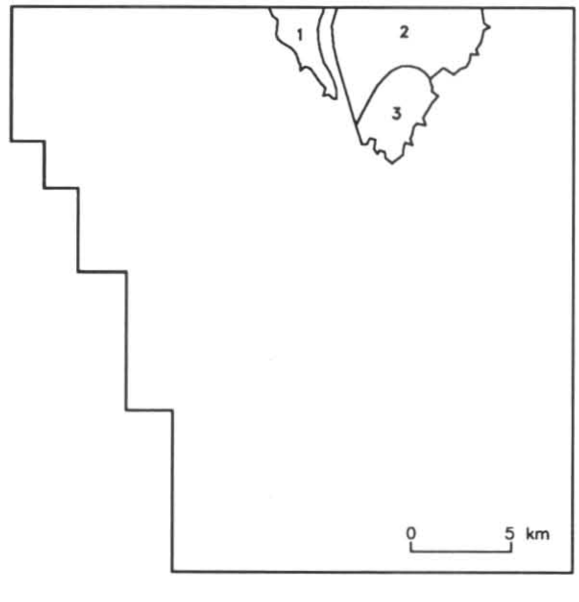


Figure 107. Distribution of the Wurawina Supergroup as shown in Figure 106 with locations of structural sub-areas

5 cm

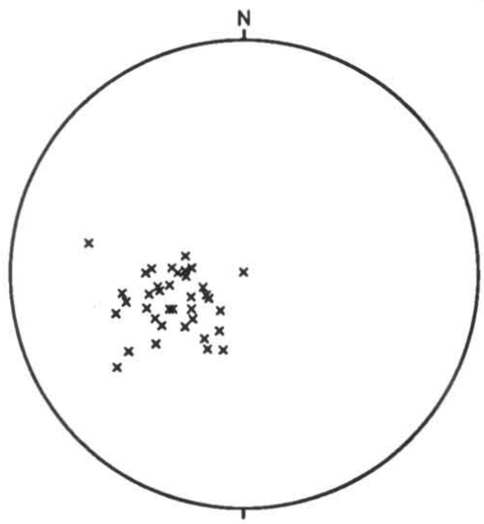


Figure 108. Equal area plot of bedding orientations in Sub-area 1 of the Wurawina Supergroup. A Simple pattern in the down faulted western limb of the Devonian syncline fold on Ragged Range is shown.

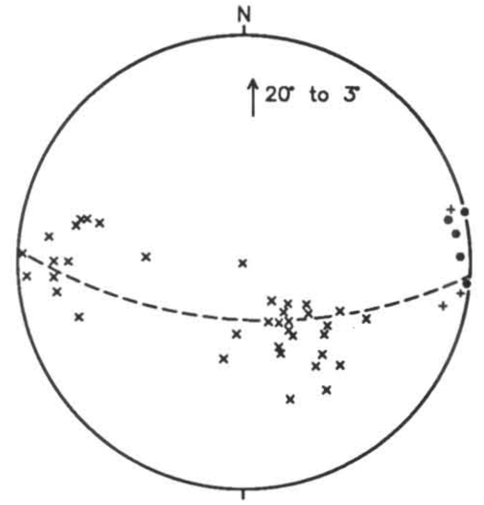


Figure 109. Equal area plot of bedding orientation in Sub-area 2 of the Wurawina Supergroup. This sub-area represents a section across the Devonian syncline showing the steeply dipping to overturned western limb on Sawback Range and the moderately dipping eastern limb east of the Florentine River. Cleavage in the carbonate rocks (Ogk, Ogb) is consistent with being in the axial surface of the fold.

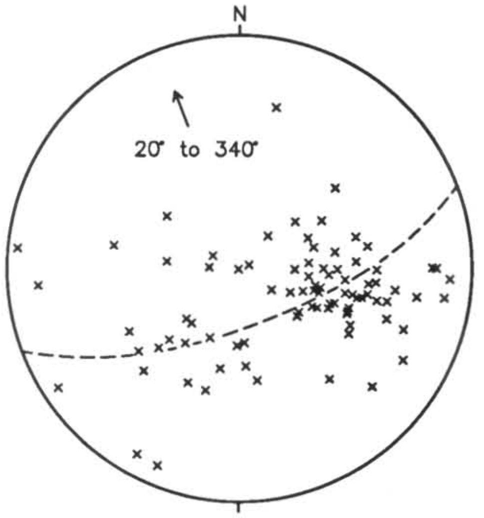


Figure 110. Equal area plot of bedding in Sub-area 3 of the Wurawina Supergroup. This sub-area includes the closure of the Devonian syncline at Junction Hill. The pattern is diffuse but reflects a NNW trend in folding at the closure.

Palaeozoic

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Structural data for the rock associations designated €a, €m and O are summarised in Figures 106–133.

FOLDING

The major problem in assessing the ages of folds and faults in these associations is to distinguish structures related to Devonian and later deformation from those related to early Palaeozoic and older deformation. The very considerable effect of Devonian deformation is clearly evident within the Wurawina Supergroup (fig. 106–110), which was folded into a large, northerly trending syncline with related subvertical cleavage of northerly to NNW trend developed in carbonate lithologies. The middle Cambrian rocks (fig. 106, 111–117) do not contain folds of regular wavelength and orientation, nor is there strong cleavage development. Of the various structures, only a weak crenulation cleavage in parts of the Island Road and Boyd River Formations exhibits a generally northerly trend similar to fold and cleavage trends in the Wurawina Supergroup. This crenulation cleavage is interpreted as a Devonian structure. North of Mt Wedge, the scaly cleavage in the Ragged basin Complex (fig. 131) has a domain of northerly trend but in the adjacent block to the east, and generally its trend is north-west.

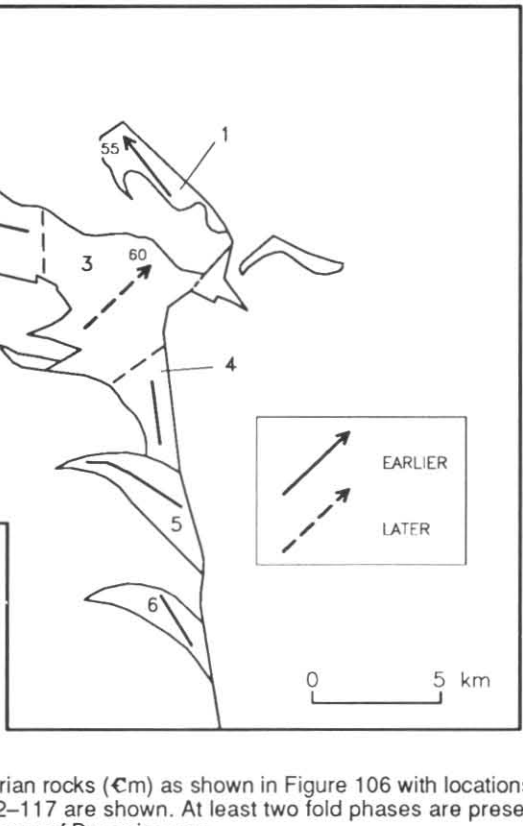
In the Ragged Basin Complex (fig. 106, 118–133), open, moderate to long wavelength folds of north-easterly trend are transected by the basal Wurawina Supergroup unconformity at Ragged Range. Because of the similarity of their trends, these folds and folds in Middle Cambrian rocks in the Mt Wedge–Marsden Range area are considered to have the same age, that is, they are post-late middle Cambrian and pre-mid late Cambrian. Lack of continuity of the Mt Wedge–Marsden Range zone of folds across the shallowly-dipping, faulted contact with the upper Boyd River mélange zone east of Mt Wedge indicates that the faulting has caused substantial dislocation of the pre–existing fold system.

ESE-trending slaty cleavage and minor folds in the Island Road Formation north-west of Mt Wedge, together with the general east to south-east trend of beds in the central and southern part of the district, probably reflect another (?earlier) folding event during the interval late-middle to mid-late Cambrian.

FAULTING

At least two groups of major faults displace the middle Cambrian and older rocks. One group affects the Wurawina Supergroup whilst the other group is older. Unfortunately, the relative age of many faults is not directly known. However, it is clear that major faulting of the middle Cambrian and older rocks predated the Wurawina Supergroup because its basal unconformity transgresses fault-bounded blocks of many older lithologies (fig. 106). There is also a general absence from the Wurawina Supergroup of major faults in the number and with the patterns of trend, dip and apparent displacement that feature in the older rocks.

The faults which form the boundaries between the blocks of middle Cambrian and older rocks also transect folds of inferred late middle Cambrian to middle late Cambrian age. Therefore, they are thought to have formed late in this period. A series of shallow east to north-east dipping boundary faults are inferred in the central part of the district, but there are also steeply dipping faults. No senses of movement are known. South of Mt Wedge there are a number of inferred, shallowly-dipping faults. The inferred fault west of Marsden Range (fig. 106) thrusts Precambrian rocks over middle Cambrian strata. However, the overall rock distribution south of Mt Wedge is difficult to reconcile with a system of thrusts, and other types of fault may be present.



5 cm

Figure 111. Distribution of the Middle Cambrian rocks (€m) as shown in Figure 106 with locations of structural sub-areas. Structural trends as indicated by Figures 112–117 are shown. At least two fold phases are present which are probably of Cambrian age together with crenulation cleavage of Devonian age.

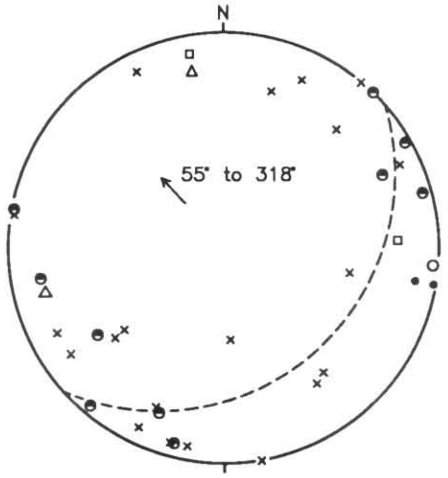


Figure 112. Equal area plot of bedding, cleavages and minor folds in Sub-area 1 (Boyd River Formation) of Ꞓm. The pattern of bedding and slaty cleavage is diffuse but suggest a dominantly NW-SE trend with a very approximate plunge of 35° to 318°. Late crenulation cleavage has a northerly trend and is interpreted as a Devonian structure (c.f. fig. 109).

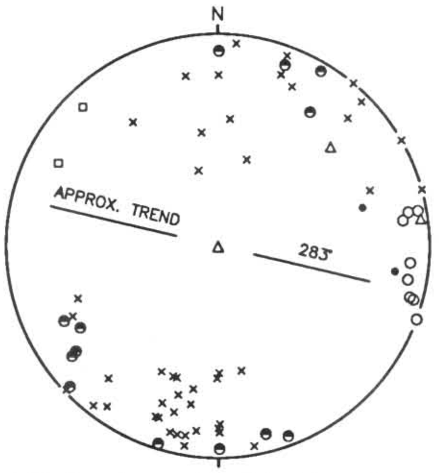


Figure 113. Equal area plot of bedding, cleavages and minor folds in Sub-area 2 of Ꞓm, a part of the Island Road Formation. The pattern of bedding and slaty cleavage is again diffuse but clearly indicates a predominant ESE trend. Late crenulation cleavage of generally northerly trend is interpreted as a Devonian structure.

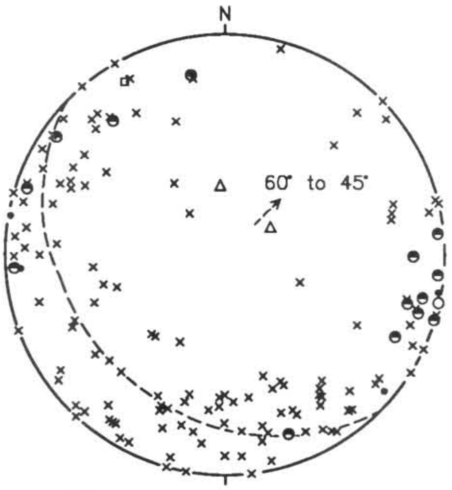


Figure 114. Equal area plot of bedding, cleavage and minor folds in Sub-area 3 of Ꞓm, a part of the Island Road Formation. The overall pattern of bedding is approximately cylindroidal or possibly conical. A generally NE trend of folding is indicated which is thought to reflect refolding of the trends apparent in other sub-areas. Slaty cleavage has an overall NNE trend and late crenulation cleavage appears to be poorly developed.

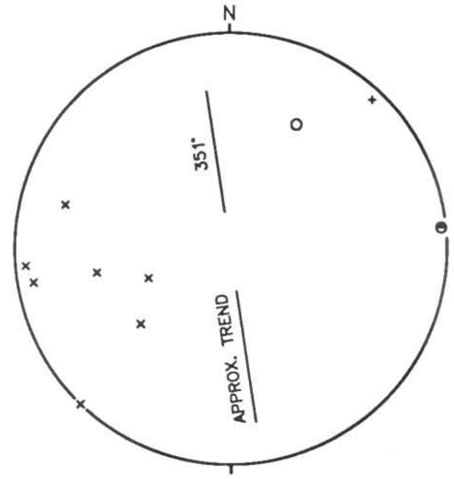


Figure 115. Equal area plot of bedding and cleavage in sub-area 4 of Ꞓm, a part of the Island Road Formation. A simple but diffuse SSE trend of bedding is indicated. A single measurement of wide-spaced (3 mm) crenulation cleavage is of different orientation to crenulation cleavage in other sub-areas.

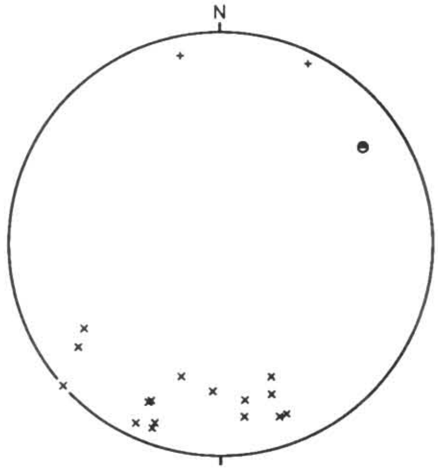


Figure 116.

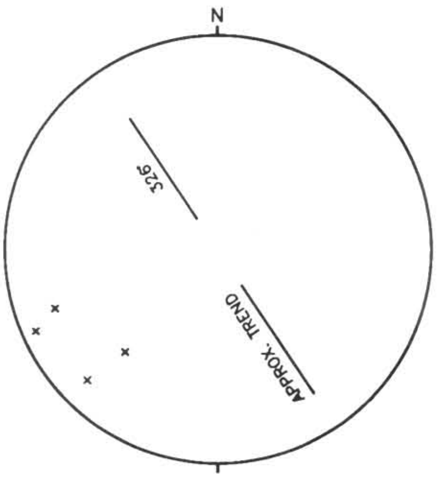


Figure 117.

Figures 116–117. Equal area plots of bedding and cleavage in Sub-area 5 (part of the Island Road Formation) and Sub-area 6 (correlate of the Island Road Formation) of Ꞓm. Simple but diffuse patterns indicate bedding trends of ENE-SE and SE respectively.

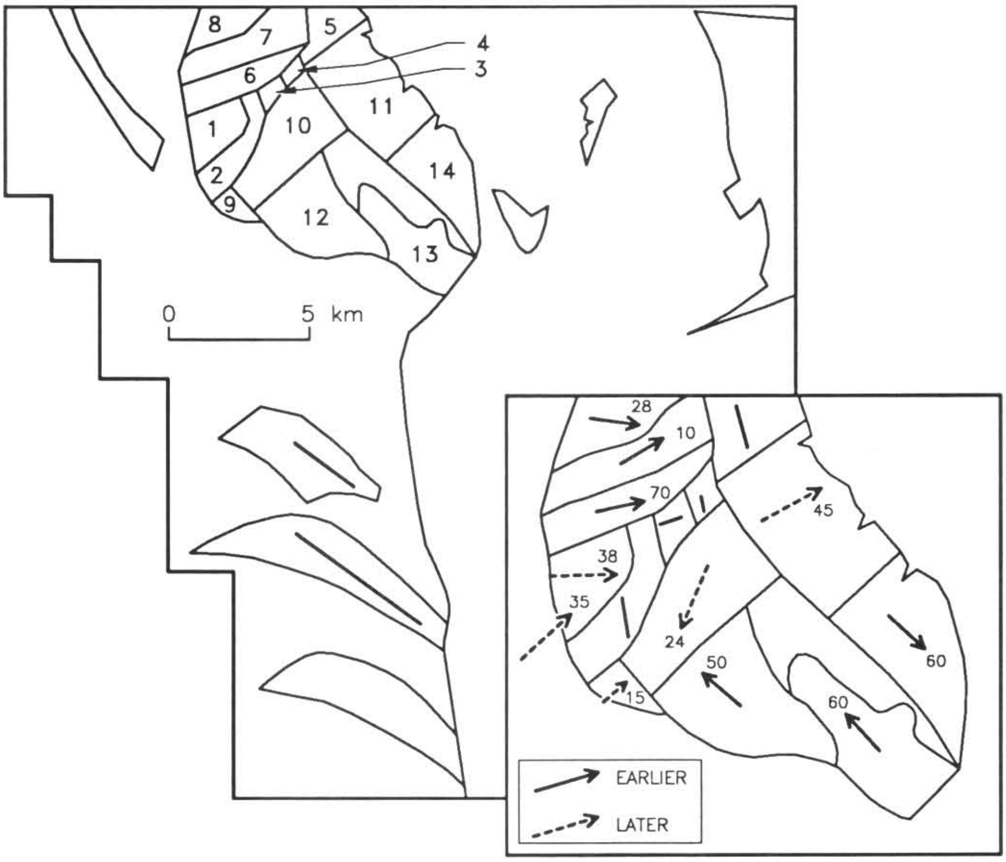


Figure 118. Distribution of the possibly Middle Cambrian or older rocks (Ꞓa) as shown in Figure 106 with locations of structural sub-areas in Ꞓaw in the Ragged Range–Island Road area (Ragged Basin Complex). The inset shows the structural trends in the various sub-areas as indicated by Figures 119–133. At least two fold phases are present but the pattern of folding appears to be disrupted by faulting. The two phases are probably equivalent to the two phases in Ꞓm (fig. 111).

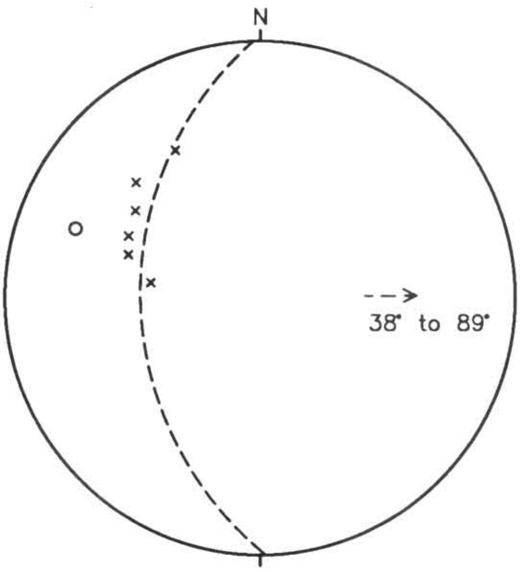


Figure 119. Equal area plot of bedding along the ridge extending through DN382616 in structural Sub-area 1 of Ꞓaw. A fold plunging 38° towards 89° is indicated. The fold is an open structure which is interpreted as part of a regional closure zone related to a second, or later, folding episode. A single measurement of crenulation cleavage at DN381622 appears to be unrelated to the fold.

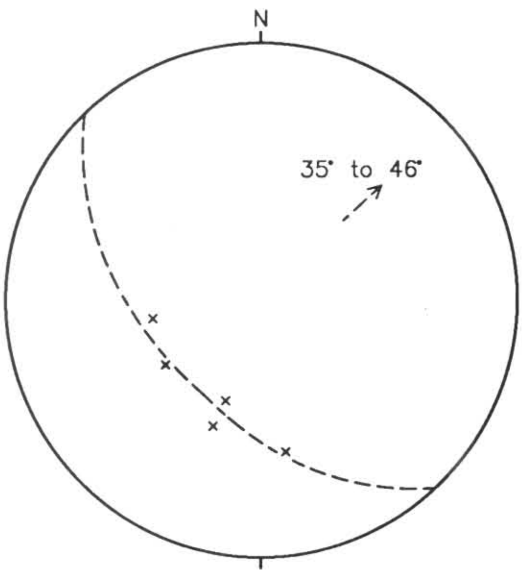
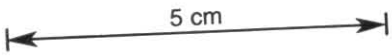


Figure 120. Equal area plot of bedding in a small area around DN382603 in structural Sub-area 1 of Ꞓaw. A fold plunging 35° towards 46° is indicated. The fold is an open structure. Locally at the closure there is parasitic folding which terminates downwards at a decollement. The folding in the area is thought to be of the same phase as the folding illustrated in Figure 119.



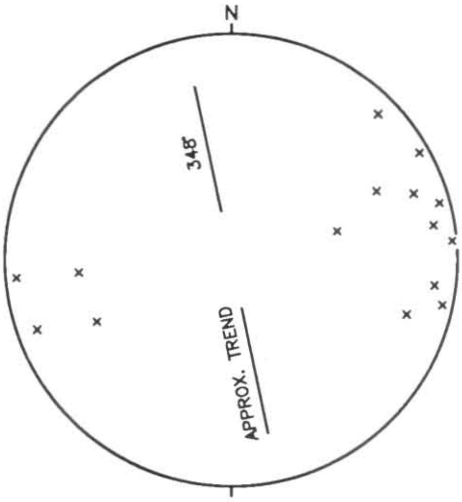


Figure 121. Equal area plot of bedding in structural Sub-area 2 of Ꞓaw. This sub-area includes the southern part of the fold illustrated in Figure 119. However, the limb is relatively steep and does not fall on the girdle defined in Figure 119. Its attitude is consistent with the moderately tight folds which occur around DN384607 and with bedding orientations measured elsewhere in structural Sub-area 2. Folds of approximate trend 348° are indicated but the plunge is undefined. These folds are regarded as earlier structures then those in Sub-area 1.

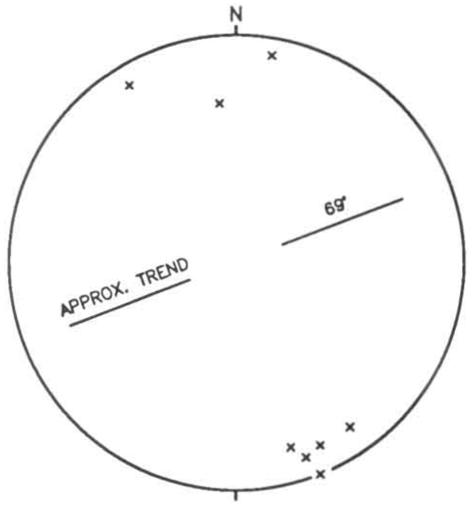


Figure 122.

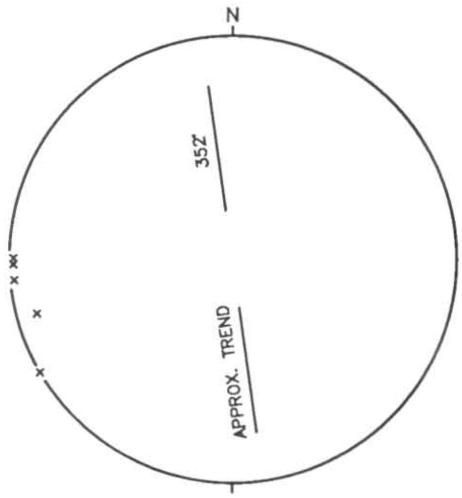


Figure 123.

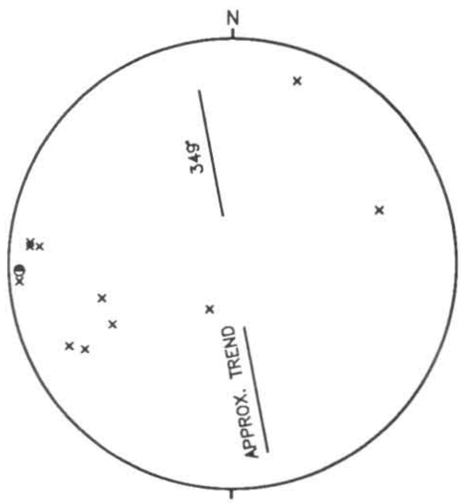
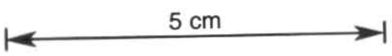


Figure 124.

Symbols used in Figures 108–133.

- × POLE TO BEDDING, WAY UP UNKNOWN
- ✱ POLE TO BEDDING, RIGHT WAY UP
- + POLE TO BEDDING, OVERTURNED
- • POLE TO CLEAVAGE (unspecified)
- o POLE TO CRENULATION CLEAVAGE
- ◐ POLE TO CLEAVAGE CRENULATING A CRENULATION CLEAVAGE
- ● POLE TO SLATY CLEAVAGE
- ◉ POLE TO SCALY CLEAVAGE
- △ HINGE OF FOLD IN BEDDING
- ▲ HINGE OF FOLD IN CRENULATION CLEAVAGE
- ▲ HINGE OF FOLD IN BEDDING, LATER CROSS FOLD
- ▽ CLOSE SPACED FRACTURE IN CHERT
- □ POLE TO AXIAL PLANE OF FOLD IN BEDDING
- ■ POLE TO AXIAL PLANE OF FOLD IN CRENULATION CLEAVAGE
- ▣ POLE TO AXIAL PLANE OF FOLD IN BEDDING, LATER CROSS FOLD



Figures 122–124. Equal area plots of bedding in structural Sub-areas 3, 4 and 5 of Ꞓaw. Approximate folding trends of 69° 342° and 349° respectively are indicated. No plunges are defined. Trends in Sub-areas 4 and 5 are essentially the same and are very similar to the trend in Sub-area 2. The markedly different trend in Sub-area 3 is attributed to refolding associated with the phase of folding developed in structural Sub-area 1. A single measurement of slaty cleavage in structural Sub-area 5 may be associated with the earlier episode of folding.

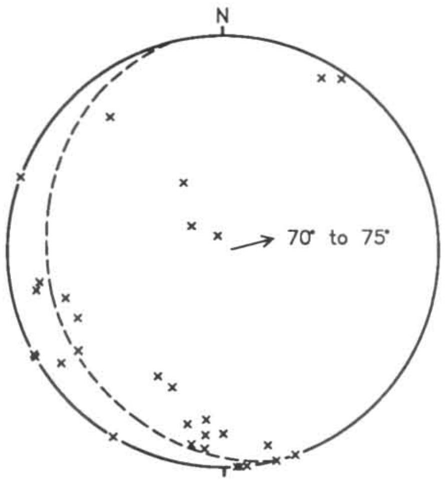


Figure 125.

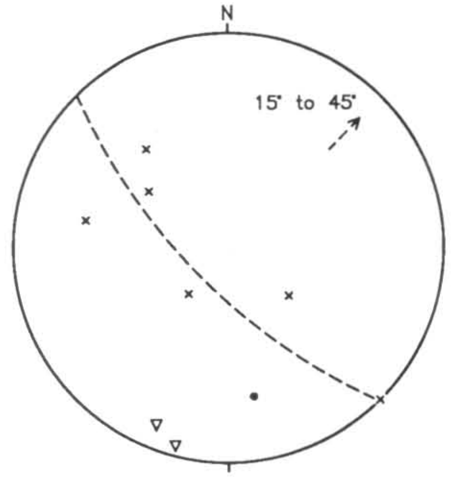


Figure 128.

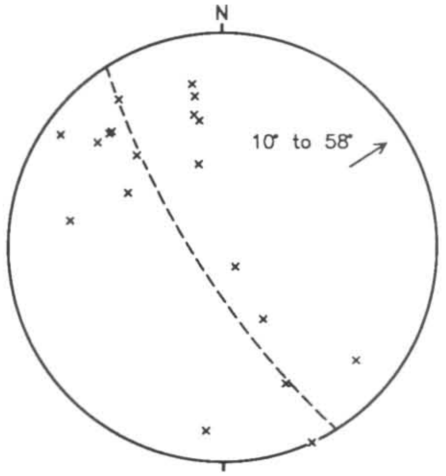


Figure 126.

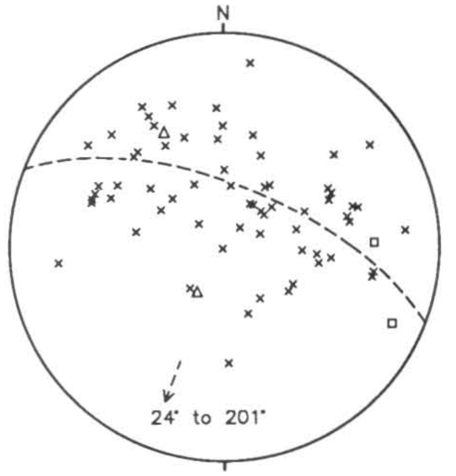


Figure 129.

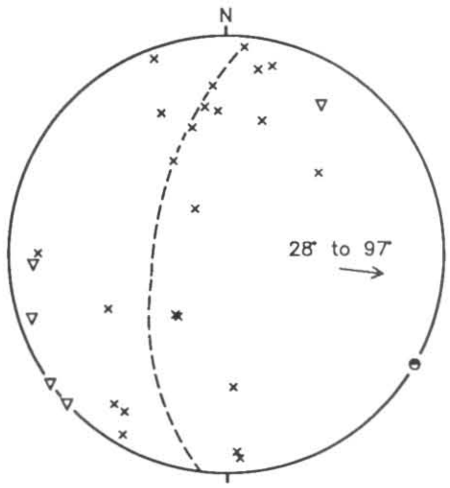


Figure 127.

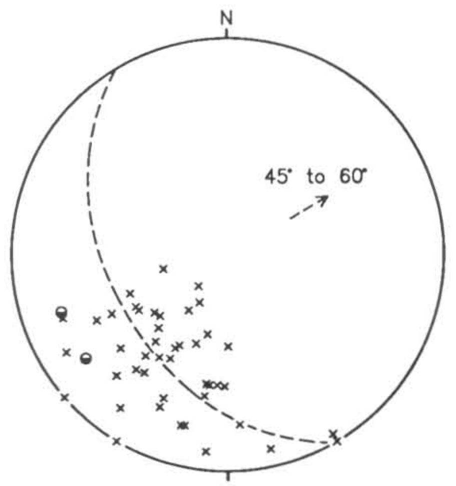
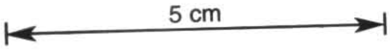


Figure 130.

Figures 125–127. Equal area plots of bedding in structural Sub-areas 6, 7 and 8 of Ꞓaw. The plot for Sub-area 6 (fig. 125) is dominated by measurements made in the chert unit (Ꞓawcc) which outcrops around DN385637. This chert unit is tightly to isoclinally folded with a steep plunge of about 70° towards 75°. Its margins appear to be faulted. The rocks in structural Sub-areas 6 and 7 are predominantly south dipping but there are diffuse girdles indicating plunges of 10° towards 58° and 28° towards 107° in the respective sub-areas. The folds appear to be moderately tight. Folds in all three sub-areas are thought to represent the earlier phase of folding, having been rotated into NE-E trends around the regional closure represented in Sub-area 1. The close spaced fractures in chert in Sub-area 8 appear to be unrelated to the folds.

Figures 128–130. Equal area plots of bedding in structural Sub-areas 9, 10 and 11 of Ꞓaw. Each plot displays diffuse patterns indicating girdles with approximate plunges of 15° to 45°, 24° to 201° and 45° to 60° respectively. The folds are open and are grouped with the folds in Sub-area 1, that is, as part of the later episode of folding. In Sub-areas 9 and 10 the half wavelength is relatively short (<1 km) but in Sub-area 11 it is longer (about 2 km). Close spaced fractures in chert in sub-area 9 appear to be unrelated to the folding and a single measurement of cleavage is of uncertain relationship. The pair of minor folds in Sub-area 10 were measured in the same outcrop (near DN407620). Scaly cleavage of NW trend in sub-area 11 appears to be unrelated to the later folding.



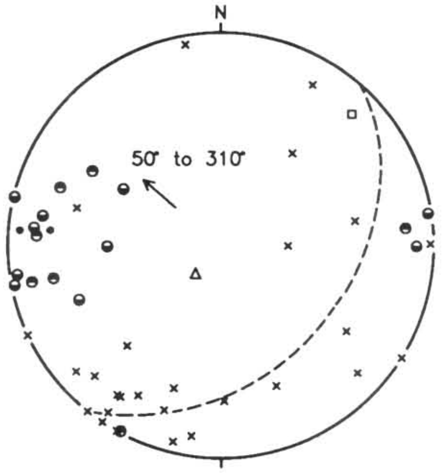


Figure 131.

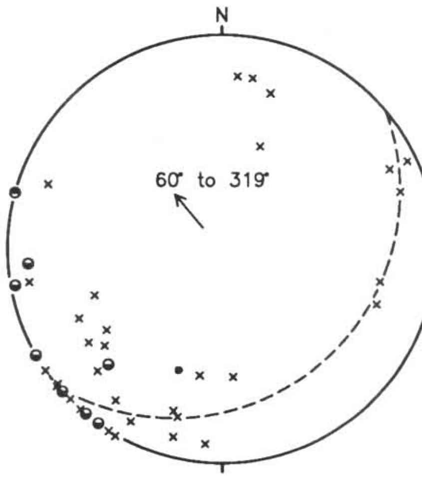


Figure 132.

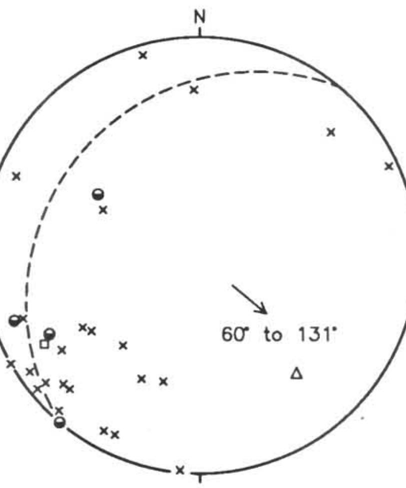


Figure 133.

Figures 131–133. Equal area plots of bedding and cleavage in structural Sub-areas 12, 13 and 14 of €aw. Beds in each sub-area have predominantly vertical to steep north-easterly dips but scattered measurements of different orientation suggest poorly defined girdles indicating plunges of 40° to 310°, 30° to 319° and 30° to 131° in the respective sub-areas. The girdles in the three sub-areas are thought to reflect the earlier phase of folding. Scaly cleavage in Sub-areas 13 and 14 is roughly consistent with being in the axial surface of the folds but in Sub-area 12 it cross cuts the folds and is therefore regarded as later. Slaty cleavage in Sub-area 12 is of similar orientation to the scaly cleavage but their relationship is unknown.

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APPENDIX A

Economic Geology

R. S. Bottrill

METALLIC MINERALS

Introduction

Very little mineral production or exploration has been conducted in this quadrangle and most has been in relation to the ultramafic bodies present in the area.

Platinum-group elements ('osmiridium')

The Adamsfield mineral field, although mainly in the Huntley quadrangle, extends into the Pedder quadrangle. Tasmanian 'osmiridium' is actually a mixture of alloys, usually dominated by iridosmine, with subordinate osmiridium, rutheniridosmine and other minerals (Cabris and Harris, 1975 and Ford, 1981). Nye (1929) described leases for 'osmiridium' on Williams Creek [DN457654], Sawback Creek [DN554657] and a tributary to Sawback Creek [DN455654]. The Adamsfield geology and mineral deposits have been described by Nye (1929), Brown *et al.* (1989) and Bottrill, 1989. The claims worked shallow alluvial gravels, with minor sands and clays, 0.3–1 m thick, underlying peaty soil and overlying serpentinite or clays. The Adamsfield osmiridium deposits worked residual and alluvial material derived from the Adamsfield Ultramafic Complex.

Osmiridium has been reported from the Serpentine River area, but Reid (1921) discredited this.

Other mineralisation

Twelvetrees (1908) reported that traces of gold had been found on the western side of Mt Mueller, and traces of gold and tin in the Styx basin. The source of these metals is unknown, but could well be the basal Parmeener sequences around Mt Mueller. The lodes in the Humboldt and Mt Mueller mines may also contribute a little gold (Bottrill, 1989).

Twelvetrees (1908 and 1919) noted several small deposits of iron ore in buttongrass swamps of the Florentine Valley and in the headwaters of the Styx and Weld rivers, south of Mt. Mueller. These deposits had been prospected by trenches and adits but appear to have been merely concretionary 'bog iron ore' deposits, formed in lake beds rather than gossans.

Flood (1972*b*) reported anomalous copper, nickel and zinc associated with gabbroic rocks in the Florentine River headwaters, while BHP (1984) detected weak gold and arsenic anomalies associated with ultrabasics south of Mt. Mueller. Neither anomaly was followed up.

The Precambrian ironstones in the Holley Road area are too small for consideration as iron ore deposits but Green (1985) noted that they are similar to the iron formations associated with polymetallic sulphide deposits.

INDUSTRIAL MINERALS

Asbestos

Flood (1972*a*) investigated an asbestos occurrence where the Gordon River Road intersects the Adamsfield Ultramafic Belt, near DN480592. Here an 'orbicular serpentinite' contains about 1% short fibre (<1.5mm) chrysotile asbestos over an interval of about 30 m. Milling tests were conducted by Woodsreef Mines Core Laboratories on several samples, with dissappointing results.

Flood (1972*b*) identified several other scattered, small asbestos occurrences in the ultramafics, particularly about DN460655 and DN480555. Both areas contain small amounts of short cross-fibre chrysotile asbestos in serpentinised peridotites, mostly in amounts <0.5% over a few metres. The former locality also contains some ribbon fibre (4% fibre over 0.4 m) and some slip/slant fibre.

Flood (1972*b*) concluded that the area contained insufficient asbestos to be of economic interest, and that which was present is of low grade and quality.

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