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GEOLOGICAL SURVEY BULLETIN 65

Stratigraphy, sedimentology and structural setting of the Cambrian Sticht Range Formation, western Tasmania

TASMANIA DEPARTMENT OF MINES

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Stratigraphy, sedimentology and structural setting of the Cambrian Sticht Range Formation, western Tasmania

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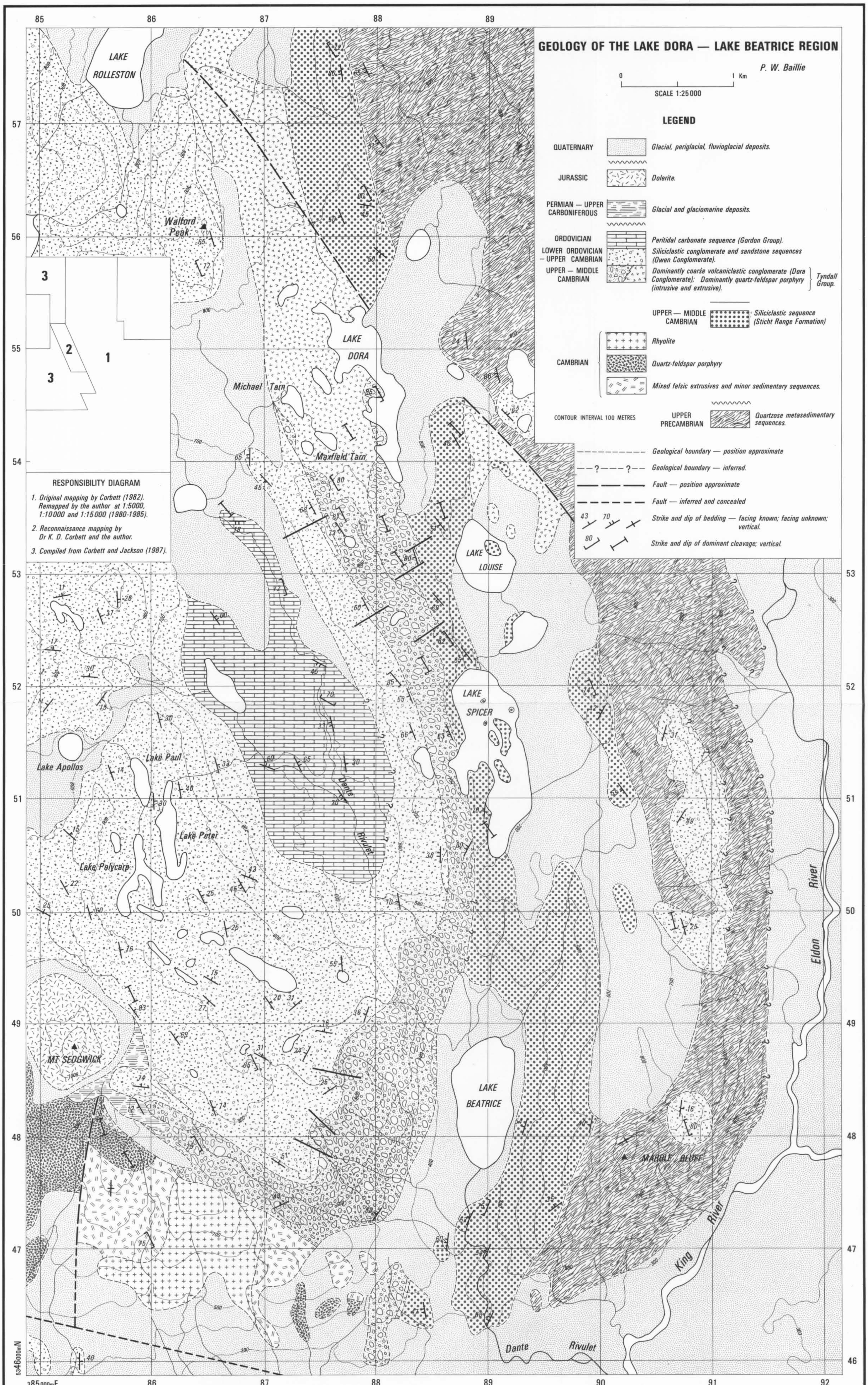

Figure 1.

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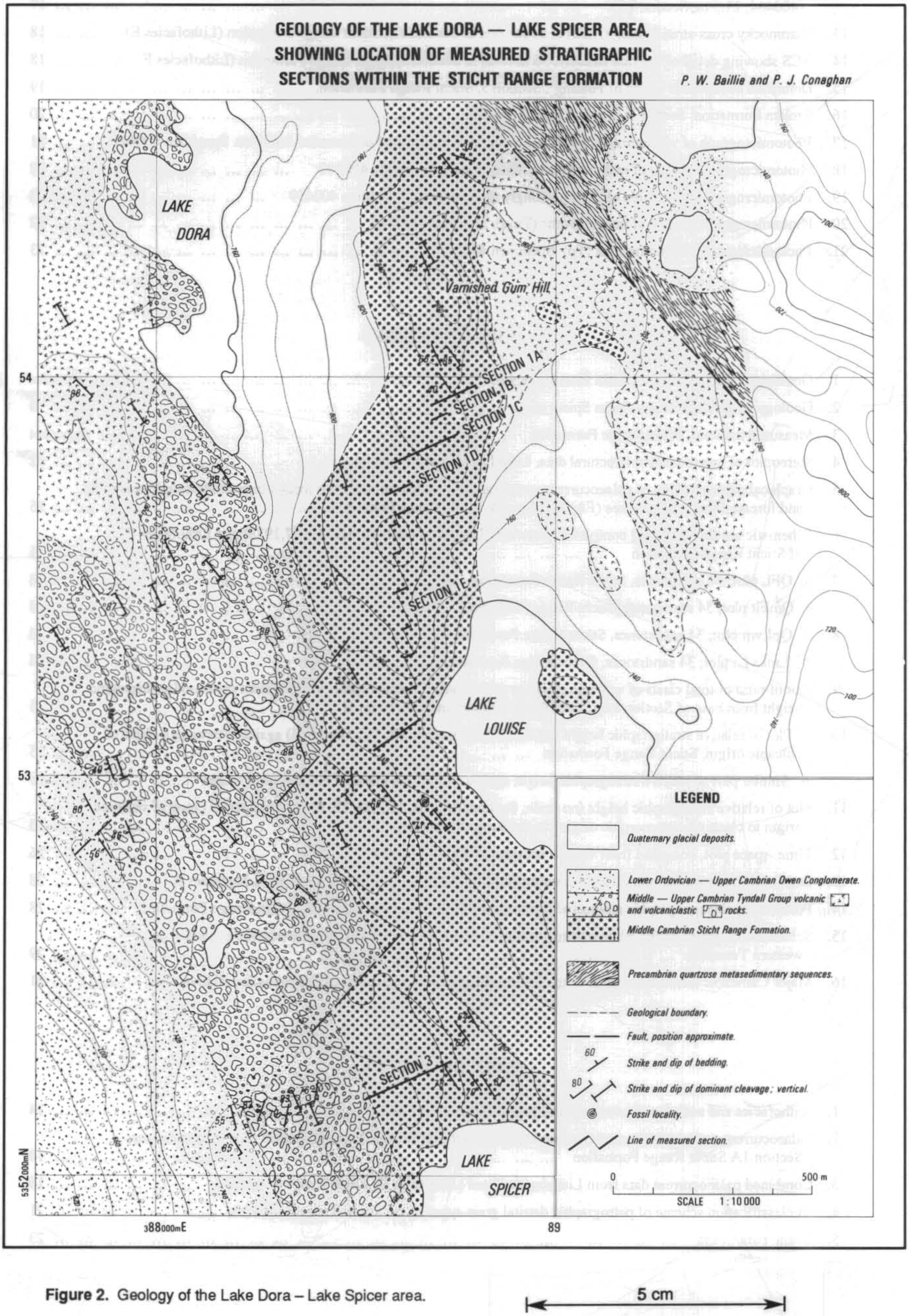

Figure 2. Geology of the Lake Dora – Lake Spicer area.

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INTRODUCTION

This report results from geological mapping at scales ranging between 1:5 000 and 1:15 840, together with stratigraphic and sedimentological analysis of an area of some 65 km^2 in western Tasmania (fig. 1). The location and scope of the project was determined by the lack of serious study of eastern sedimentary sequences of the Mt Read Volcanics, a more or less continuous belt of felsic volcanics, 10-15 km wide along the eastern margin of the Cambrian Dundas Basin. The fieldwork was carried out in conjunction with the mapping of the 1:50 000 Lyell Sheet by the Regional Mapping Branch, Geological Survey Division (Calver *et al.*, 1987).

The field area is located within the West Coast Range, a highland area of harsh climate and rugged relief largely comprising Upper Cambrian to Lower Ordovician siliciclastic Owen Conglomerate and correlates flanked by Cambrian volcanic rocks. Mountain peaks attain 800 to 1275 m altitude, and receive 2000 to 3200 mm of annual precipitation (Colhoun, 1985). The Lake Dora Plateau [CP880540], 720-800 m, flanks the central part of the West Coast Range and comprises, physiographically, a meridional plateau rimmed by a subdued southern extension of the Sticht Range to the east [CP895555], and the West Coast Range including the Tyndall Range [CP845575], Mt Geikie [CP827524], and Mt Sedgwick [CP853488] to the west.

The resistant lithology and the effects of multiple glaciations during the Pleistocene have produced a rugged area with thin (or commonly no) soils, and dominant vegetation of alpine moorland, buttongrass moorland and temperate rainforest. The vegetation type is strongly controlled by firing history (Kirkpatrick, 1977).

In the area of detailed study the combined effects of fires and glacial ice have produced an area of good outcrop, although the rocks are typically weathered to some degree. Access is easy and fairly rapid by foot from the main access track.

PREVIOUS LITERATURE

Although the published literature on the Mt Read Volcanics is voluminous (for summary and introduction refer to Corbett, 1981; Corbett *et al., in* Cooper and Grindley, 1982; Corbett, 1986), the sedimentary rocks in the Sticht Range–Lake Beatrice tract of country which overlie Precambrian basement and are overlain by volcanics have received little attention.

Banks (1956) briefly described the volcanic succession from near Lake Dora, but appears to have measured a section in which the Sticht Range Formation has been largely faulted out.

Solomon (1964) described the quartz sandstone/conglomerate succession underlying the volcanics near Lake Rolleston and the Anthony River (fig. 2) and concluded that the sedimentary rocks interfingered with volcanics in the Lake Spicer area. He noted the presence of 'convolute folds and local areas of intense brecciation (slumping?)' near the northern end of Lake Spicer.

In a major study of the Mt Read Volcanics, Corbett *et al.* (1974) figure the 'Sticht Range conglomerate-quartzite -slate sequence'. The succession of sedimentary rocks underlying pyroclastics in the Lake Selina–Lake Dora area was noted to rest unconformably on or against basement rocks of the Precambrian 'Tyennan Geanticline'.

Corbett (1979) described the sedimentary succession overlying Precambrian rocks in the Marble Bluff area and concluded that this interval (i.e. Sticht Range Formation) was a marginal marine facies developed near the eastern edge of the volcanic trough prior to the main volcanic episode.

In a subsequent work, Corbett (1982) used the term Sticht Range Beds and described in some detail the geology of the Lake Dora–Lake Spicer area. He also noted the disruption previously recognised by Solomon (1964), and postulated that the contact represented a Cambrian fault where Sticht Range sediments slumped into a volcanic rift structure. Corbett (*op. cit.*) described many of the Sticht Range sandstones as having a 'flysch-like' character, and recognised that some were of shallow-marine origin.

Specimens are referred to by six-digit Tasmania Department of Mines registrartion numbers.

TERMINOLOGY

In this report the word **terrain** is used in its geographic sense, that is a tract of land without any geological connotation; **terrane** is used in the tectonic sense to refer to a fault-bounded formation or series of formations.

Bedding terminology used in this report is essentially that of Conaghan (1980) and Harms *et al.* (1982). It should be noted however, that the term **flat-bedding** (horizontal stratification of Conaghan, *op. cit.*; planar lamination of Harms *et al., op. cit.*) is used to designate sets of laminae in sand-grade or coarser material within which the laminae are concordant or quasi-concordant to the plane of principal bedding (plate 11), or broadly undulose and hence were essentially horizontal or 'flat' at the time of deposition: the structure is attributed to aggradation during the lower part of the upper flow regime. **Parallel-lamination** is used to designate sets of laminae in very fine-grained sand, silt or clay-grade material, within which the laminae are parallel to the underlying set boundary: the structure is formed in suspension-load fallout as current flow wanes or ceases (Conaghan, 1980). The scale-hierarchy classification used here for sedimentary structures indicative of palaeocurrents is that of Miall (1974).

ACKNOWLEDGEMENTS

This work was carried out as part of a M.Sc. (Hons). project at Macquarie University (N.S.W.). Dr P. J. Conaghan supervised the project and shared in the collection of the field data during April 1984 and January–February 1985; he critically read several versions of the thesis and provided much useful advice, particularly with respect to sedimentological and petrographic aspects.

Drs G. R. Green, R. A. F. Cas and K. D. Corbett provided discussions and critical readings of various versions of this report.

Dr R. G. Richardson and R. S. Bottrill provided help with matters relating to computers.

REGIONAL STRATIGRAPHY

The area mapped as part of this project is shown as Figure 1; mapping was carried out at various scales, and together with the work of the author, consists of the published and unpublished work of Dr K. D. Corbett. The work includes part of the 1:50 000 Lyell sheet (Calver *et al.*, 1987).

Precambrian metasedimentary rocks

Basement rocks in the area consist of folded quartzose metasediments of the Tyennan region, a major source of sediment for many of the Palaeozoic successions of western Tasmania.

Precambrian rocks, from Skyline Knoll in the north [CP877574] to Marble Bluff [CP902480] in the south, are fairly uniform lithologically, and consist of interlayed metaquartzite, schistose quartzite and quartz-mica schist, with minor phyllite and dolomite. The rocks exhibit

5 cm

polyphase deformation; the earliest phase produced a cleavage sub-parallel to bedding, later phases are usually upright. In places the quartzites display original sedimentary cross-bedding, or bedding surfaces may show tectonically-steepened current ripples (plate 1).

The dominant cleavage (S_1), parallel to bedding and compositional layering is parallel to the axial surface of megascopic isoclinal folds. This surface is folded by later tight mesoscopic folds, in turn folded by more upright, commonly chevron, small-scale folds which produce a marked crenulation cleavage (S_3) in fine-grained rocks and closely-spaced joints or 'platy' cleavage in more massive quartzite.

In thin-section (400405, 400420, 400424) the rocks are seen to consist of recrystallised quartz with variable amounts of white mica responsible for the tectonic fabric of the rock. Accessory minerals include zircon, tourmaline and opaques.

The Tyennan complex has been thought to have been a 'geanticline' during the Cambrian, and as a stable block during Devonian deformation (Williams, 1978). Recent work (Leaman, 1986), based on gravity and magnetic surveys, suggests that the picture is more complex. Leaman concludes that parts of the Tyennan complex are of continental thickness, and that other parts are much thinner and have been disrupted and overthrust to the west.

Plate 1. Ripple marks in Precambrian metaquartzite, east of Lake Dora [CP887550].

Mt Read Volcanics (Cambrian)

The Mt Read Volcanics (Campana and King, *in* Banks, 1962*a*; Campana and King, 1963) consist of a thick pile of felsic to intermediate calc-alkaline extrusive and intrusive rocks with minor sediments with a total thickness in excess of 2.4 km. The type-section was designated as the Mt Read-Red Hills area, some 12 km north-west of the present study area. The belt is the host to four currently-producing base-metal mines (Mt Lyell, Rosebery, Que River, Hellyer) and a large number of smaller deposits. Although very complex in terms of stratigraphy, structure, alteration and tectonics, considerable advances have been made in recent years in understanding the nature and stratigraphy of the belt (Corbett, 1981; Corbett, 1986; Bamford and Green, 1986; Corbett and Lees, 1987).

In the study area, deformation and stratigraphy are relatively simple, and advances in understanding of the rock-record here may have wider application throughout the belt.

VOLCANIC ROCKS SOUTH OF MT SEDGWICK

Volcanic rocks are exposed on the southern slopes of Mt Sedgwick [CP852488]. The complex, described by Corbett (1982), was remapped by the author as part of the Lyell 1:50 000 sheet (Calver *et al.*, 1987). The complex can be sub-divided into several lithologically-distinct rock-associations or stratigraphic/igneous units.

Mixed felsic intrusives

A succession of mixed felsic extrusives and minor sedimentary rocks is exposed patchily east of the major southerly-flowing creek south of Mt Sedgwick [CP854479] and in the area west of Dante Rivulet [CP883468].

Rock types are generally fine-grained feldspar-phyric volcanic rocks which include vitric tuff with common prominent flattened pumice clasts, vitric-crystal tuff and lithic tuff, together with feldspar-quartz phyric rocks, minor agglomerate, epiclastic rocks, and possible lavas. In thin-section the rocks typically comprise recrystallised mosaics of quartz, feldspar, sericite, chlorite and carbonate minerals.

Mineralisation of vitric tuffs is developed near a fault zone south of Mt Sedgwick and consists of sphlalerite, galena and pyrite. The sulphides occur in epigenetic veinlets associated with rock alteration which occurred prior to deformation of the rocks (Dr G. R. Green, pers. comm, 1983).

Quartz-feldspar porphyry

A thick wedge of partly flow-banded quartz-feldspar porphyry occurs within and partly overlies the previously described association (Corbett, 1981). The major south-flowing creek south of Mt Sedgwick marks the site of a syn-volcanic fault, and is also the locus for the minor mineralisation previously described. The fault brings into juxtaposition quartz-feldspar porphyry and the mixed volcanic association described above. Immediately south of Mt Sedgwick the fault lies wholly within the quartz-feldspar porphyry body.

The porphyry is variable in colour, from pink or brown to green depending on degree of weathering and alteration, and is either massive or flow-banded. Flow-banding appears to be best-developed near the western margins of the body, just outside the area shown on Figure 1. The body is mainly intrusive, but may be in part extrusive.

In thin-section (101668–101671) the rock consists of phenocrysts of quartz from 1–7 mm in diameter together with generally altered feldspar phenocrysts 1–5 mm in diameter. The quartz is typically embayed or may be cracked and broken, is free of inclusions, and in unstrained examples shows sharp extinction: these features are typical of volcanic quartz. The feldspar varies in shape from euhedral to embayed. Albite twinning may be present, and the extinction angles indicate an albite composition, although it is probable that albitisation is a result of later alteration. The groundmass which is fine- to very fine-grained consists of an interlocking mass of feldspar, quartz, carbonate minerals, chlorite and white mica.

Rhyolite

A prominent knob, some 1.6 km southeast of Mt Sedgwick [CP864477], consists of broken or massive, fine-grained pink or white coloured rhyolite which in places is feldspar-phyric.

Corbett (1982) described a gradational contact between the rhyolite and the vitric pyroclastics to the west, and a possibly gradational contact with the rocks to the east. Mapping by the author (1980–1981) could not confirm any relationships and although no layering patterns have been determined because of the generally massive nature of the body, it is probable that the body represents the remains of an intrusive dome or plug.

STICHT RANGE FORMATION (MIDDLE CAMBRIAN)

The Sticht Range Formation is here defined as that succession of siliciclastic conglomerate, sandstone and minor siltstone lying above Precambrian rocks with angular unconformity, and below rocks of the Tyndall Group with apparent conformity (fig. 1). It is best exposed between Lake Spicer [CP887521] and Varnished Gum Hill [CP887542], but extends from Dante Rivulet in the south [CP890464] to the western slopes of the Sticht Range [~CP870600] in the north and from which the formation takes its name (previously 'Sticht Range Beds' of Corbett,1982). Maximum thickness of the formation is of the order of 1.2 km and evidence will be presented that the age of the formation is probably late Middle Cambrian.

The only previous study of the Sticht Range Formation is that of Corbett (1982) who noted the presence of volcanic detritus in some sandstone units and suggested that the succession was deposited either prior to the main Mt Read volcanic activity or during a significant hiatus in volcanism, and that the depositional environment included a variety of shallow-water and deeper marine (turbidite) environments. Corbett (*op. cit.*) described a complex contact between the Sticht Range Formation and the overlying Dora Conglomerate.

In this study, the formation was studied in detail between Lake Spicer and Varnished Gum Hill, and in lesser detail at Skyline Knoll [CP877575], west of Unconformity Ridge [CP899519] and in Dante Rivulet below Lake Beatrice [CP890470].

TYNDALL GROUP (MIDDLE-UPPER CAMBRIAN)

The Tyndall Group (Corbett *et al.*, 1974) consists of the Comstock Tuff, a distinctive succession of banded pink and green crystal lithic tuff and agglomerate, passing gradationally upwards into an interval of volcaniclastic conglomerate and sandstone with minor tuff known as the 'Jukes Formation'. A fossiliferous, marine, bioclastic limestone intersected by drill holes in the lower part of the Comstock Tuff contains trilobites of probable late Middle Cambrian age (Jago *et al.*, 1972).

The 'Jukes Conglomerate' (Wade and Solomon, 1958), as originally defined, comprised a locally-developed unit at the base of the Owen Conglomerate in the Mt Jukes region some 12 km south of Queenstown. Corbett *et al.* (1974) included the Jukes Formation in the newly-defined Tyndall Group and used the term for presumed correlates a long way away from Mt Jukes, and for rocks having different stratigraphic assocations to those in the type-area near Mt Jukes.

Corbett *et al.* (*op. cit.*) noted that the 'Dora Conglomerate' (Bradley, 1954) was roughly equivalent to the Jukes Formation, but erroneously concluded that volcanics in the Lake Dora area were of pre-Tyndall Group age, and therefore that the Dora Conglomerate was 'a poorly defined and essentially redundant term'.

Work reported herein and the published and unpublished work of Dr. K. D. Corbett has shown that the conglomerate occurring in the Lake Dora area forms a continuous belt southwards from Lake Dora to Lake Beatrice and thence westwards to a point west of Mt Sedgwick (fig. 1). The rocks are certainly Tyndall Group, both in their stratigraphic postion and lithological characteristics, and it is concluded that Dora Conglomerate is a preferable stratigraphic term to Jukes Formation when defining the Tyndall Group. This usage has been used on the Lyell 1:50 000 map (Calver *et al.*, 1987).

Plate 2. Outcrop of Dora Conglomerate showing well-rounded volcanic clasts, north of Lake Spicer [CP882522]. The prominent lineation in the large clast is possibly a pre-Devonian tectonic cleavage.

Dora Conglomerate

The Dora Conglomerate is here re-defined as that interval of poorly-sorted volcaniclastic conglomerate, with minor sandstone and tuff, lying above the Sticht Range Formation and below the Owen Conglomerate. It is best exposed west of Lake Spicer [CP885515], but extends from Lake Dora [CP880547] (from which it is named) to southwest of Mt Sedgwick [CP840482]. It appears to be contemporaneous with volcanics that occur north of Lake Dora.

The age of the formation is fairly well constrained in that west of Newton Peak, (CP830600, some 7 km north-west of Lake Dora) a correlate of the Dora Conglomerate is overlain by the Late Cambrian Newton Creek Sandstone, a marine unit at the base of the Owen Conglomerate correlate (Corbett, 1981).

Clasts in the Dora Conglomerate consist dominantly of quartz-feldspar porphyry (similar to that described from south of Mt Sedgwick), plus rhyolite and other fine-grained felsic rocks, together with sporadic clasts of Precambrian derivation. The clasts are usually well-rounded and range up to 0.6 m in diameter (plate 2). The rock generally shows a well-developed northwesterly-trending tectonic cleavage and the clasts are commonly flattened in that direction. The clasts are matrix-supported and the matrix is volcanogenic, being quartzose with chlorite and ?hematite.

In terms of its bedding characteristics, especially throughout its lower part, the conglomerate is typically very thickly-bedded in massive amalgamated units many metres in thickness which are internally either structureless or exhibit a crudely-defined flat-bedding. These bedding characteristics are suggestive of a possible mass-flow origin. Coarse- to very coarse-grained sandy lenses are developed, especially in the upper part of the formation, and usually display large-scale trough cross-bedding. In thin-section (400414, 400435) typical sandstones are coarse- to very coarse-grained, well-sorted, lithic arenite consisting of angular to well-rounded clasts of volcanic quartz, fine-grained altered felsic volcanic rock fragments, feldspar, opaques, carbonate minerals and clasts of Precambrian origin in a murky (?altered) volcanic-rich groundmass.

West of Mt Sedgwick the formation abruptly lenses to only a few metres in thickness and then disappears. In this area the contact between the base of the Dora Conglomerate and underlying quartz-feldspar porphyry is clearly erosional.

Volcanic rocks of the Lake Dora area

As noted by Corbett (1982), the Dora Conglomerate bifurcates around the southern end of a volcanics/porphyry complex at Lake Dora, with one arm wedging out against the

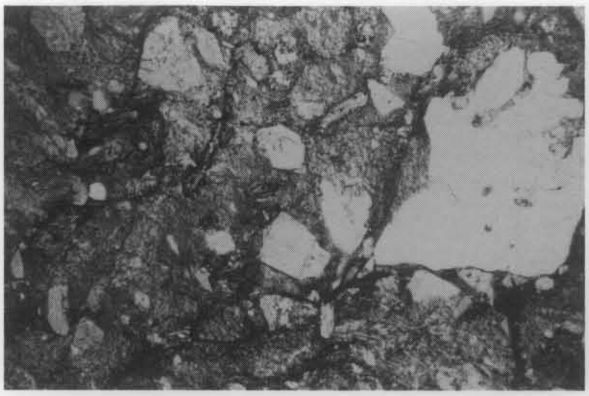

Plate 3. Photomicrograph of altered crystal-lithic tuff (400421) from volcanic succession west of Lake Dora. Ordinary light; field of view is 11.7 mm.

Plate 4. Masive quartz-feldspar porphyry (Tyndall Group) overlain by epiclastic Dora Conglomerate, west of Lake Dora [CP875537].

Sticht Range Formation to the east (fig. 1), and the other disappearing beneath Owen Conglomerate south of Michael Tarn [CP872544].

The volcanic complex consists dominantly of massive quartz-feldspar porphyry, but flow-banded, autobrecciated and other fragmental varieties occur. The rocks are generally well-cleaved and altered, making petrographic studies difficult.

Quartz-feldspar porphyry is generally mottled pink and green in colour, and in places is strongly chloritised. Although in outcrop the rock generally appears to be massive, in thin-section (400408, 400421) the rock may be fragmental and of extrusive origin (plate 3). Other rocks (400407, 400413), although usually strongly altered, show no evidence of fragmental textures and may have been shallow intrusions. Other rocks in the field display bedding and may be of epiclastic origin. In thin-section (400431, 400433) these rocks consist of volcanic quartz, generally altered fine-grained felsic volcanic rock fragments, and opaques in a murky, ?volcanic groundmass. Corbett (1982) provides full petrographic descriptions of many pyroclastic and igneous porphyritic rocks occurring in the complex.

Minor copper/silver/gold mineralisation is associated with the complex. Numerous adits, shafts and costeans were excavated in the period 1896-1899 by a number of small companies. A mineralised intrusive quartz-feldspar porphyry (400408) contains precleavage disseminated pyrite and minor chalcopyrite together with precleavage, post-sulphide, quartz-chlorite veins indicating that the age of the mineralisation is syn-volcanic (Cambrian) rather than associated with the the major Devonian deformation of the region (Dr G. R. Green, pers. comm., 1986).

The quartz-feldspar porphyry apparently intrudes the Sticht Range Formation immediately north of Lake Louise [CP890540] and one kilometre north of Lake Dora [CP880560].

An intrusive quartz-feldspar porphyry body occurs along the exposed part of the contact between the Sticht Range Formation and the Dora Conglomerate in a small creek west of Date Rivulet below Lake Beatrice [CP882465]; Corbett (1982) notes that the conglomerate is intruded by a massive quartz-feldspar porphyry immediately to the west of this area [CP879460], but the area is scrubby and of difficult access and stratigraphic relationships cannot be proved. It is considered probable that this latter porphyry body is related to the previously described porphyries of the Mt Sedgwick area which are clearly older than the Dora Conglomerate.

Relationship between Dora Conglomerate and volcanic complex

Interfingering relationships between the Dora Conglomerate and the volcanic complex rocks (plate 4) in the Lake Dora area indicate that the two units are contemporaneous. This is in agreement with the conclusions of Corbett (1982) and is how the units are depicted on the geological map of the area (fig. 1). Corbett (*op. cit.*) considered that the conglomerates represent an apron of epiclastic detritus derived largely from, and deposited around, the volcanic complex.

The generally massive and uniform nature of the Dora Conglomerate and the fact that it is matrix-supported suggest that the bulk of the formation may have been emplaced by debris-flow mechanisms.

Owen Conglomerate (Upper Cambrian-Lower Ordovician)

The Owen Conglomerate (Banks, 1962*b*) is one of the major stratigraphic units of western Tasmania, and it and correlates form the West Coast Range. The unit comprises a molasse-sequence of siliceous conglomerate and sandstone comprising a series of alluvial-fan, braidplain and shallow-marine deposits. Despite the physiographic prominence of the unit and the availability of excellent sections, no detailed sedimentological studies (with the exception of the work of Corbett (1970) in the non-contiguous Adamsfield 'Trough' 90 km to the southeast of Queenstown) of the Owen Conglomerate and its correlates have yet been undertaken.

In this study the Owen Conglomerate has been examined in a reconnaissance nature on the plateau between Mt Sedgwick and Lake Beatrice [CP865485], the low hills to the west of Lake Spicer and Lake Dora [CP877528], and the east-dipping outliers at Marble Bluff [CP908482], Unconformity Ridge [CP905515] (plate 5) and east of Lake Dora [CP893545].

At many localities the contact between the Owen Conglomerate and underlying Dora Conglomerate is exposed. The two formations are clearly structurally conformable, although locally-developed erosional channels indicate that the relationship may be, in part, paraconformable. The formations are clearly distinguished by the abrupt change from the volcaniclastic lithologies of the Dora Conglomerate to the siliclastic ones of the Owen Conglomerate. The Owen Conglomerate is composed predominantly of metasedimentary clasts of Precambrian origin: metaquartzite, quartz-mica schist, vein quartz, laminated quartzite; chert clasts of uncertain derivation may also be present. In places the rock is rich in hematite.

Several lithofacies can be recognised which reflect different depositional environments.

MASSIVE BOULDER CONGLOMERATE FACIES

This lithofacies forms the lower part of the formation immediately east of Mt Sedgwick. It is absent on the plateau above Lake Beatrice and the arm of Owen Conglomerate extending up to Michael Tarn.

It consists almost wholly of massive, grey-coloured, boulder conglomerate usually without any discernible internal fabric. Sandy lenses occur sparsely. Clasts are wholly siliceous, except near the base of the formation, and are derived from Precambrian metasedimentary rocks. Individual beds are commonly many metres thick (where bedding can be determined at all). The deposits are clast-supported, and given the large clast size, are moderately well- to well-sorted. This lithofacies belongs to type *Gm* of Miall (1977; *cf.* table 1 herein) and the deposits were probably transported by water on an alluvial-fan very close to the source area.

MIXED CONGLOMERATE/SANDSTONE FACIES

Lithologies in this lithofacies are variable and include boulder to granule conglomerate and commonly pebbly, coarse- to very coarse-grained, pink-coloured, quartz sandstone. Beds are usually less than 3 m in thickness and abrupt changes of lithology occur. Sedimentary structures include imbrication in the conglomerate, and solitary trough cross-stratification in the finer-grained beds. The tops of some sandstone beds exhibit ripples, commonly of the linguoid type. Clasts are siliceous and predominantly of metasedimentary origin, although some chert may be present. Rare bioturbation is present [e.g. CP869486].

The lithofacies contains facies *Gm, Gt, St, Sr* of Miall (1978; *cf.* table 1 herein) which indicate that deposition took place in longitudinal-bars and as micro-channel fills together with subaqueous sand dunes (*cf.* Miall, 1978, 1981). The presence of bioturbation indicates the limited development of marine conditions, indicating perhaps delta-type progradation into the sea.

The lithofacies forms the bulk of the east Sedgwick Plateau exposures and those west and east of Lake Spicer.

SANDSTONE FACIES

This facies is developed only in the east Sedgwick Plateau area [CP861486] and was also recognised by Corbett (1982) as a distinct lithofacies. The facies has a characteristic red appearance in the field and consists of well-sorted, red and paler-coloured, commonly bioturbated, medium- to coarse-grained quartz sandstone with minor siltstone. The sandstone commonly displays planar laminae and beds are usually 0.3–0.6 m in thickness. Trough cross-bedding is sporadically present in the sandstones. Thin, commonly one-clast-thick, layers of granules or pebbles are sprodically developed in the sandstones.

The presence of bioturbation, together with well-developed planar laminae and one-clast-thick pebble horizons suggests that this lithofacies represents a marine incursion possibly comprising beach deposits.

The prominent red colour may also indicate strongly oxidising conditions and subaerial exposure.

SUMMARY

The Owen Conglomerate in the study area consists of an overall fining-upwards mega-sequence; marine incursions evidently occurred at several different times in what was an otherwise terrestrial environment. The presence of Owen

Plate 5. Basal Owen Conglomerate, unconformably overlying Precambrian metaquartzite, Unconformity Ridge.

Conglomerate on Precambrian basement from Marble Bluff to east of Lake Dora (recognised as distinct from the Sticht Range Formation on basis of colour and sedimentary features; Plate 5) indicates either onlap onto basement subsequent to the filling of the main basin, or the preservation of remnants of feeder channels for the main basin to the west.

A limited number of palaeocurrent readings indicate an overall easterly source for sediment-bearing currents near Lake Spicer and at Unconformity Ridge. From the Owen Conglomerate ridge east of Lake Spicer, eight palaeocurrent readings, when restored on the regional fold axis, indicate a vector of 337°±140°. At Unconformity Ridge eighteen readings gave a value of 241°±96°. The high standard deviations are probably a factor of the small sample population and may also reflect inherent high dispersion. The data do, however, strongly indicate that the source of sediment for the Owen Conglomerate in the area was to the east.

Gordon Group (Ordovician)

The Owen Conglomerate is overlain conformably by the shallow-marine Gordon Group of Early to Late Ordovician age which is a dominantly peritidal limestone succession (Banks, 1962*b*; Banks and Burrett, 1980) common throughout western Tasmania.

In the study area, limestones of the Gordon Group crop out in Dante Rivulet above Lake Beatrice [CP870530]. The area was visited briefly by the author and Dr K. D. Corbett in 1986. Limestone outcrop is confined to the main creek where it occurs somewhat sporadically below Pleistocene fluvioglacial cover. Where observed it is dominantly fine-grained consisting of micrite with lesser dolosiltite.

Parmeener Supergroup (Upper Carboniferous-?Lower Permian)

Upper Carboniferous–?Lower Permian glacial and glacio-marine sediments of the Parmeener Supergroup occur immediately east of Mt Sedgwick [CP858489] where they rest on the Owen and Dora Conglomerates with pronounced landscape unconformity.

The succession is dominated by glacial deposits, which formed in pre-existing topographic depressions in the Owen and Dora conglomerates. Cobble and pebble conglomerate and pebbly sandstone are the main lithologies present, and occur in beds up to 2 m thick.

Jurassic dolerite

Dolerite is present on the summit of Mt Sedgwick [CP853488], and is near the western extremity of the

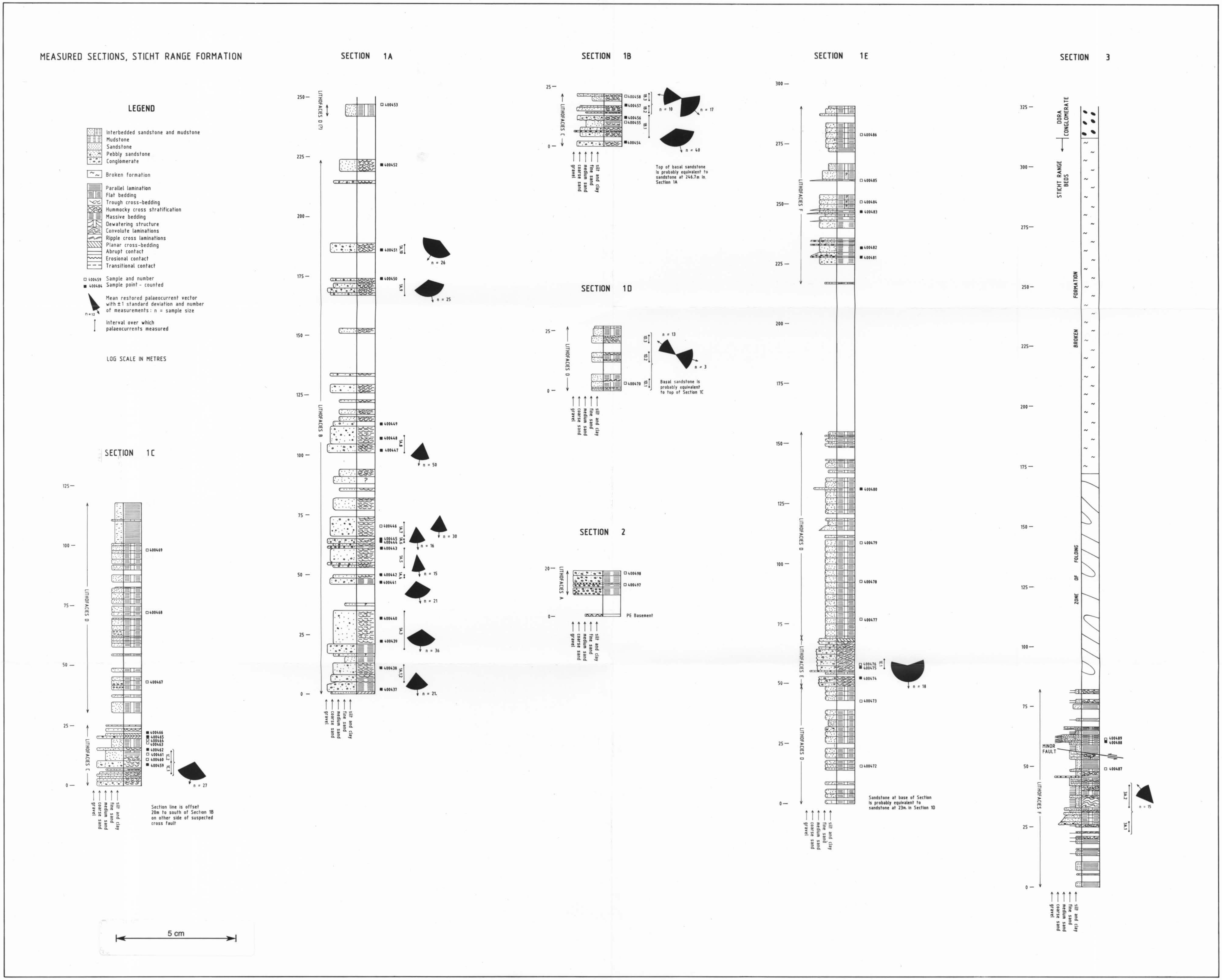

Figure 3.

GSB65

generally-concordant bodies of Jurassic dolerite which intruded the flat-lying Parmeener Supergroup rocks across much of Tasmania.

Quaternary deposits

A complex of Quaternary glacial and related deposits is present throughout the study area and at least two glacial stages can be recognised. Colhoun (1985) has summarised the Quaternary glacial history of the West Coast Range.

During the Margaret Glaciation (10 000–30 000 yr B.P.), a small ice-cap (91 km^2) accumulated east of The Bastion and Mount Geikie [CP825525], south of the Tyndall Range, and extended eastward across the ice-scoured Dora area toward the Eldon Valley [CP915535]. The ice-cap surface declined southward, and ice overrode Lake Beatrice [CP890485] and the valley head south of Mt Sedgwick. Ice thickness on the Dora Plateau was 200–250 m. (Colhoun, *op. cit.*).

Abundant evidence attesting to the former presence of ice is present in the Lake Dora–Lake Spicer areas in which the Sticht Range Formation was studied in the course of the project, and includes the presence of abundant erratics, roche moutonnees, and plucked and scoured and striated surfaces of various scales.

STRATIGRAPHY AND SEDIMENTOLOGY OF THE STICHT RANGE FORMATION

Introduction

The Sticht Range Formation comprises a west-facing quartzose conglomerate/ sandstone/mudstone succession at the base of the Mt Read Volcanics in the central West Coast Range region, and extending from Lake Beatrice to north of the Sticht Range. The formation was studied in detail between Varnished Gum Hill [CP887542] and Lake Spicer [CP888523], and in reconnaissance at Skyline Knoll [CP877573] and Dante Rivulet below Lake Beatrice [CP890643]. Approximately one kilometre of the formation was stratigraphically logged in detail at a scale of 1:100. The location of the section lines is shown on Figure 2, and all sections are graphically presented at a scale of 1:500 in the manner of Selley (1968*a*) as Figure 3.

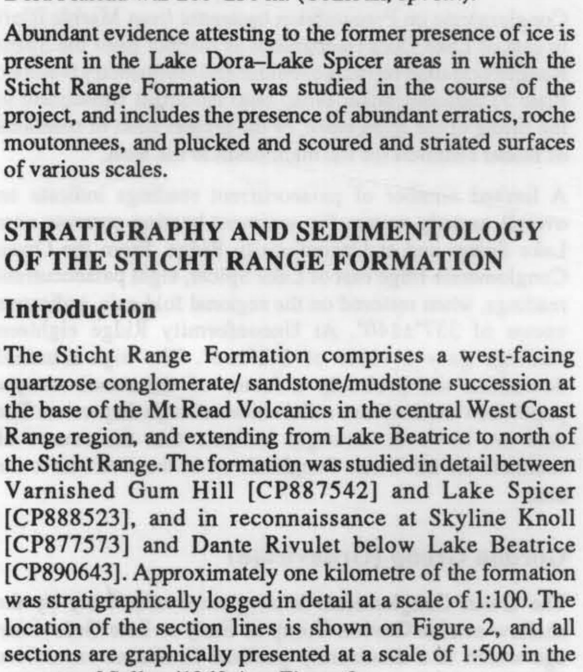

Figure 4. Stereoplot of representative structural data, Lake Dora – Lake Spicer area.

This section documents and analyses the stratigraphic and sedimentological data; petrographic studies of the sandstones are presented in the following section.

The geology of the area studied in detail is shown as Figure 2 and relevant structural data are plotted as Figure 4. The structural data defines a girdle which indicates that the regional fold-axis plunges 20° towards 325°; this fold-axis was used in all palaeocurrent restorations.

An integral part of the project was the determination of palaeocurrents for the Sticht Range Formation, and over 380 determinations were made. Cross-bedding, measured as dip and dip-azimuth together with the immediately adjacent attitude of principal bedding, was restored by computer using the method of Cooper and Marshall (1981). Palaeocurrents measured as cross-bed trough-axis lineations were restored by stereonet.

Six distinct lithofacies are present in the formation, each corresponding to a distinct dynamic geomorphic environment.

Lithofacies A (conglomerate)

The basal unit of the Sticht Range Formation consists of pebble to boulder conglomerate with minor coarse- to very coarse-grained sandstone. The clasts are entirely derived from the adjacent Precambrian quartzose metasedimentary rocks of the Tyennan region.

Despite intensive and careful searching the actual contact with underlying basement rocks was nowhere observed, and so although an angular unconformity is obviously present, the presence of a partly faulted contact cannot be wholly excluded.

The lithofacies is present at Skyline Knoll and to the east of Unconformity Ridge.

SKYLINE KNOLL

Immediately above Precambrian rocks at Skyline Knoll [CP877573] there occurs a development of the Sticht Range Formation which consists dominantly of cobble and boulder conglomerate with sporadic lenses of pebbly very coarse-grained sandstone. Clasts, which are entirely of Precambrian derivation, are angular to well-rounded and their form is related to lithology: metaquartzite or vein quartz clasts display higher sphericity than more schistose varieties.

The rocks vary from poorly-sorted to well-sorted, and at the outcrop scale bedding is very difficult to determine. In this area the conglomerates are all clast-supported.

UNCONFORMITY RIDGE

To the west of Precambrian rocks at Unconformity Ridge [CP900520] is a development of pebble and cobble conglomerate and subordinate very coarse, generally pebbly, sandstone (plate 6).

Corbett (1982) states that in this area the basal conglomerate rests directly and unconformably on Precambrian platy quartzite. Despite careful searching during the present study no actual contacts were observed; the smallest observed gap between the two formations was 3 m [CP900518].

A short section was measured near the contact at CP901520 and is shown as Section 2 on Figure 3. Rock types present included massive-bedded cobble conglomerate together with fine pebble or granule conglomerate. Clast lithologies present include metaquartzite, laminated quartzite, platey quartzite, quatz-mica schist and vein quartz; clasts are typically well-rounded and close-packed.

5 cm

Plate 6. Well-sorted cobble conglomerate in Sticht Range Formation (Lithofacies A), Unconformity Ridge [CP900518].

Plate 7. Poorly-sorted conglomerate or conglomeratic sandstone in Sticht Range Formation (Lithofacies A), Unconformity Ridge [CP900517].

Other conglomeratic units in the area are very poorly-sorted and are matrix-supported (plate 7). These rocks contain angular to well-rounded clasts, usually less than 0.4 m in diameter in a poorly-sorted sandy matrix.

DISCUSSION

The overall very coarse grain size, the close proximity of the lithofacies to, and its obvious origin from, Precambrian basement, strongly suggests that these rudites were deposited as a series of fans, perhaps close to a fault scarp. There is no direct evidence whether the apparent southerly-fining of the unit is an artefact of poor outcrop and/or sampling, or if the unit was derived from a northerly source.

It cannot be shown with certainty whether the conglomerate lithofacies was deposited in a terrestrial or a sub-marine environment; however, evidence will be subsequently presented that the two stratigraphically-following lithofacies represent a change from fluvial to shallow-marine conditions. If this is so then by implication lithofacies A was deposited within a series of alluvial-fans.

Using the classification of Miall (1978; *cf.* Table 1 herein) the predominant rock facies present is *Gm* (clast-supported gravel), together with subordinate *Gms* (matrix-supported gravel) and *St* (trough cross-stratified sand).

The clast-supported conglomerates are generally massive; laterally impersistent sandy lenses may occur. These rocks probably represent deposition from streamfloods (*cf.* Eriksson, 1978; Mack and Rasmussen, 1984; Steel, 1974).

The coarseness of the matrix-supported conglomerates, poor-sorting and overall lack of structures suggest emplacement by mass-flow (Eriksson, 1978; Miall 1978; Steel, 1974). As also noted by Eriksson (*op. cit.*) in the Archaean Moodies Group of southern Africa, the arenaceous matrix argues against a true debris-flow origin and the less specific term 'mass-flow' is preferred (for discussion and classification of sediment-flows on alluvial-fans see Shultz, 1984).

Lithofacies B (sandstone/conglomerate)

This lithofacies shows its best development in the Varnished Gum Hill area [CP886538] where nearly 250 m of section are present (Section 1A, fig. 2). No contacts with the underlying coarse conglomeratic facies were observed; the succession at Varnished Gum Hill is intruded by a body of quartz-feldspar porphyry and the stratigraphically-higher parts of the conglomerate lithofacies (Lithofacies A) at Skyline Knoll and Unconformity Ridge are obscured by Quarternary deposits.

A complete section could not be logged through this (and other) lithofacies because of obscuring scrub (i.e. downward extension of Section 1A), the presence of small gaps in the sections, the lateral impersistence of some units, and the presence of numerous small cross-faults. Some cross-faults are indicated on the geological map (fig. 2); the presence of these was largely determined by displacement of formation boundaries, but other intraformational faults are present, and the distribution of these could not be mapped in the time available.

DESCRIPTION

The lithofacies consists almost entirely of coarse to very coarse-grained, commonly pebbly sandstone, interbedded with granule or pebble conglomerate. Maximum observed clast size was 70 mm (cobble), but most were less than 20 mm (pebble). There appears to be an almost total absence of fine-grained rocks.

Plate 8. Fining-upwards succession from massive pebble conglomerate through massive very coarse-grained sandstone to trough cross-bedded sandstone (Lithofacies B), northern end of Varnished Gum Hill [CP886544].

Table 1
LITHOFACIES AND SEDIMENTARY STRUCTURES OF BRAIDED STREAM DEPOSITS (after Miall, 1978)

Facies code	Lithofacies	Sedimentary structures	Interpretation
Gms	massive, matrix supported gravel	none	debris flow deposits
Gm	massive or crudely bedded gravel	horizontal bedding, imbrication	longitudinal bars, lag deposits, sieve deposits
Gt	gravel, stratified	trough crossbeds	minor channel fills
Gp	gravel, stratified	planar crossbeds	linguoid bars or deltaic growths from older bar remnants
St	sand, medium to very coarse, may be pebbly	solitary (ϕ) or grouped (π) trough crossbeds	dunes (lower flow regime)
Sp	sand, medium to very coarse, may be pebbly	solitary (α) or grouped (o) planar crossbeds	linguoid, transverse bars, sand waves (lower flow regime)
Sr	sand, very fine to coarse	ripple marks of all types	ripples (lower flow regime)
Sh	sand, very fine to very coarse	horizontal lamination, parting or streaming lineation	planar bed flow (lower and upper flow regime)
Sl	sand, fine	low angle (<10°) crossbeds	scour fills, crevasse splays, antidunes
Se	erosional scours with intraclasts	crude crossbedding	scour fills
Ss	sand, fine to coarse, may be pebbly	broad shallow scours, including (η) cross-stratification	scour fills
Sse, She, Spe	sand	analogous to *Ss, Sh, Sp*	eolian deposits
Fl	sand, silt, mud	finer lamination, very small ripples	overbank or waning flood deposits
Fsc	silt, mud	laminated to massive	backswamp deposits
Fcf	mud	massive, with freshwater molluscs	backswamp pond deposits
Fm	mud, silt	massive, desiccation cracks	overbank or drape deposits
Fr	silt, mud	rootlets	seatearth
C	coal, carbonaceous mud	plants, mud films	swamp deposits
P	carbonate	pedogenic features	soil

Table 2
PALAEOCURRENT STATISTICAL DATA AS DETERMINED FROM FORESET-DIPS, TROUGH AXES AND FORESET-DIPS IN TROUGH-AXES; SECTION 1A STICHT RANGE FORMATION

Data-set	Number of Readings	Vector Mean Azimuth (°)	Standard Deviation (°)	Vector Length	Consistency Ratio (%)
Foreset-dips	214	179	48	155.4	72.6
Trough-axes	17	212	34	14.3	84.4
Foreset-dips in trough axes	9	209	32	7.8	86.7
All	240	182	48	174.2	72.6

Plate 9. Variable succession of trouth cross-bedded very coarse-grained sandstone and conglomerate, 187 m level, Section 1A, Sticht Range Formation (Lithofacies B).

The rocks are quartzose, and larger clasts are of Precambrian origin, but within the matrix of conglomerates, and in the sandstones, volcanic quartz and volcanic rock-fragment clasts also occur (documented in next section).

Coarser-grained varieties are generally either massive or display medium-scale trough cross-bedding; rare grading is present in some beds. Trough cross-beds are abundant in the sandstones (plate 9); no unequivocal planar-tabular cross-bedding was observed. The cross-beds are all rank 5 structures (*cf.* Miall, 1974) i.e. structures formed within dunes, sand-waves or bars. The thickness of individual cross-bed sets varies from 50–60 mm to one metre.

Contacts between individual beds are generally sharp, and although some contacts are clearly erosional (plate 9), many others probably are also. Bed thickness ranges from 0.1 to 2.5 m, but is generally within the range 0.5–1.5 m.

Within the lithofacies several poorly-defined fining-upwards cycles are present (fig. 3; plate 8). These commence with either massive or cross-bedded conglomerate or conglomeratic sandstone, and pass upwards through finer-grained, generally pebbly sandstone, and terminate in fine- or medium-grained sandstone.

The rocks are generally moderately well- to poorly-sorted and clast roundness is variable from angular to sub-rounded.

PALAEOCURRENT ANALYSIS

Restored palaeocurrents for Lithofacies B within Section 1A are shown on the log (fig. 3), and display a remarkable consistency throughout. A total of 240 restored vectors indicate a northerly source for the sediment-bearing currents: the Rayleigh probability that the pattern is random is 10^{-55}.

Palaeocurrent measurements were made as maximum foreset-dips in the majority of cases, although a few trough-axes were also able to be measured. Dott (1973) and Miall (1974) discuss problems of measurement in connection with trough cross-beds. In the Platte River, Nebraska, Smith (1972) showed that 42.6% of dip directions were within 10° of local current flow but that the divergence was symmetrical, with mean foreset-dip-azimuth closely corresponding to mean channel direction.

Palaeocurrent data from Section 1A, as measured separately from foreset-dips (FD), trough-axes (TA) and foreset-dips measured in trough-axes (FA), are compared in Table 2 and shown graphically in Figure 5. Vectors from trough-axes and foreset-dips measured in trough-axes correspond extremely well (212° and 209° respectively), but there is a 30° divergence from foreset-dip measurements (vector mean azimuth = 179°). Trough-axis and foreset-dips near trough-axes comprise relatively small samples, and their

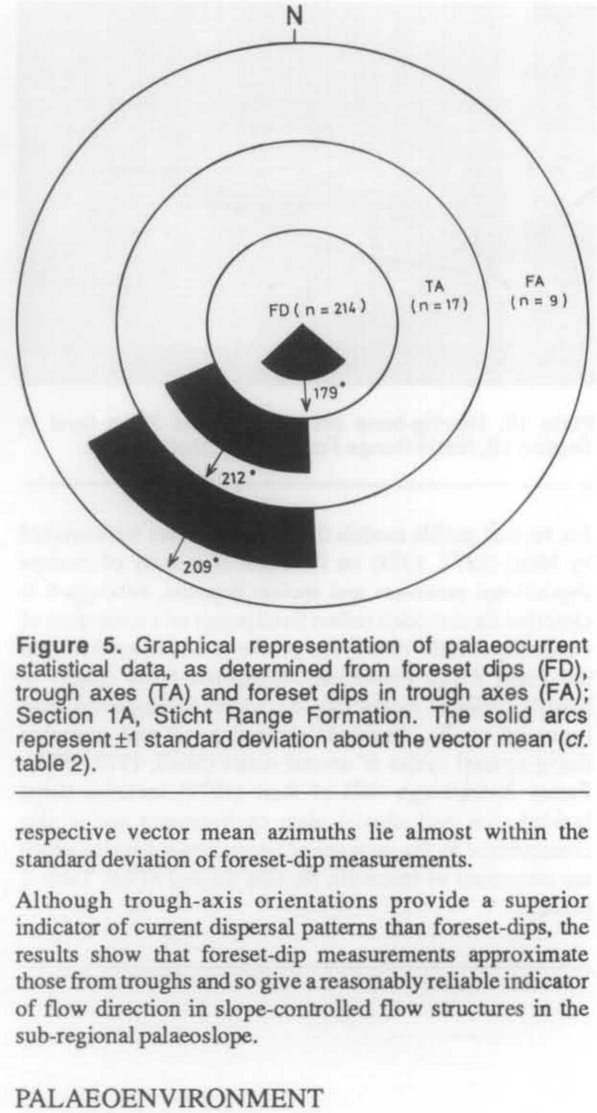

Figure 5. Graphical representation of palaeocurrent statistical data, as determined from foreset dips (FD), trough axes (TA) and foreset dips in trough axes (FA); Section 1A, Sticht Range Formation. The solid arcs represent ±1 standard deviation about the vector mean (*cf.* table 2).

respective vector mean azimuths lie almost within the standard deviation of foreset-dip measurements.

Although trough-axis orientations provide a superior indicator of current dispersal patterns than foreset-dips, the results show that foreset-dip measurements approximate those from troughs and so give a reasonably reliable indicator of flow direction in slope-controlled flow structures in the sub-regional palaeoslope.

PALAEOENVIRONMENT

The strongly unimodal palaeocurrent pattern, the relatively low textural-maturity, the lack of fine-grained sediments, and the evidence of rapid vertical accretion strongly suggest that the lithofacies was deposited in a fluvial environment. Furthermore, the age of the sediments (Cambrian: no land vegetation), the lack of fines, and the evidence of relatively rapid vertical accretion suggest that the fluvial environment was a low-sinuousity river system, perhaps a braidplain on the distal part of an alluvial-fan.

Section 1A is almost entirely composed of facies *St* (trough-crossbedded sand, in part pebbly) and *Gt* (gravel with trough cross-beds) of Miall (1978; table 1 herein). Deposition of these facies is interpreted to be from sand dunes, which range in relief from 1.5 to 8 m (Coleman, 1969), and as minor channel fills.

Visher (1965) emphasised use of the vertical-profile to interpret ancient depositional environments and produced a series of profile-categories based on vertical succession of grain size, sorting, lithology, sedimentary structures and geometry. Miall (1985) recognised limitations imposed by the use of vertical profile analysis and proposed a new method of analysis which subdivided fluvial deposits into local suites consisting of one or more of a set of eight basic three-dimensional architectural elements. This approach is empirical and descriptive but is limited to outcrop exposures of at least tens of metres across and with some degree of three-dimensional control. These rigid requirements are not present in the study area, and so the vertical-profile approach is necessarily followed here.

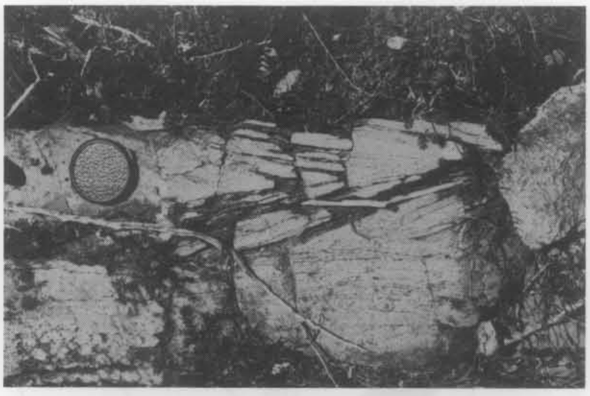

Plate 10. Herring-bone cross-bedding at 20 m level in Section 1B, Sticht Range Formation (Lithofacies C).

Six vertical profile models for 'braided' rivers were erected by Miall (1977, 1978) on the basis of a study of modern depositional processes and ancient deposits, although it is clear that these models reflect fixed points on a continuum of variability (Miall, 1985). The profile of Lithofacies B from the Sticht Range Formation corresponds fairly closely to Miall's 'Donjek' model (fig. 6), which encompasses most types of cyclic 'braided' river deposit and contains fining-upward cycles of several scales (Miall, 1977, 1978). Facies Assemblage GIII of Rust (1978) includes distal braided river and alluvial plain environments and is also characterised by the presence of fining-upward cycles which are comprised of facies *Gt, St, Gm, Sh* and *Fl* (*cf.* Table 1 herein).

5 cm

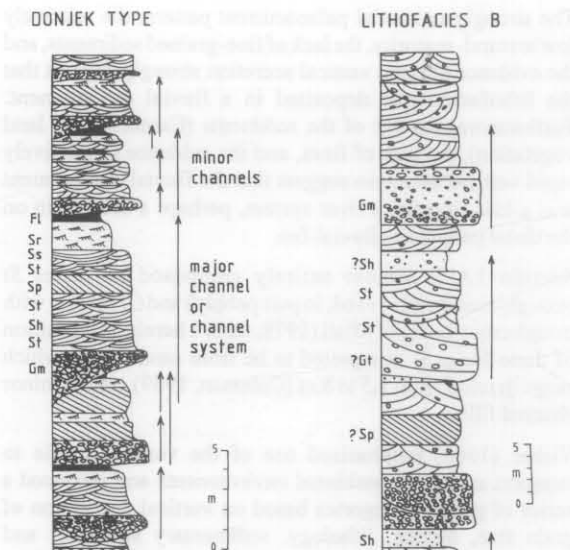

Figure 6. Schematic sections showing comparison between 'Donjek' model; of Miall (1977,1978) and Lithofacies B of Sticht Range Formation. Note differences in scale of the measured sections.

Lithofacies C (dominantly sandstone)

Whereas Lithofacies B is characterised by bed thicknesses in the range 0.5–1.5 m and by the presence of sandstone, conglomeratic sandstone and conglomerate, Lithofacies C is finer-grained overall and occurs in beds usually less than 1 m in thickness. Sandstones, and in particular the finer-grained sandstones, have a higher degree of textural maturity in this lithofacies than in Lithofacies B. Diversity of lithotypes and sedimentary structures is also greater than in Lithofacies B.

The lithofacies occurs in Section 1B, and from 0–25 m in Section 1C (fig. 3).

DESCRIPTION

The lithofacies consists of an interbedded succession of very fine- to very coarse-grained sandstone, pebbly sandstone and minor conglomerate. Medium-grained and coarser lithotypes generally display medium-scale trough cross-bedding; once again no unequivocal planar-tabular cross-bedding was observed. Finer-grained varieties may be flat-bedded. Herring-bone cross-bedding is present at some levels (plate 10).

Contacts between individual beds are usually sharp; some are clearly erosional. Bed thickness varies from less than 0.1 to 2 m, but is generally in the order of 0.2–0.8 m.

Grain size of conglomeratic rocks in this lithofacies is finer than in Lithofacies B. Maximum clast size is in the order of 10 mm (i.e. the coarsest rock type present is pebble conglomerate), but rocks this coarse are a relatively minor part of the lithofacies. The textural-maturity of sandstones within this lithofacies is greater than that of Lithofacies B. Although overgrowth cementation commonly makes it difficult to resolve the textural-maturity, finer-grained sandstones (e.g. 400458, 400461) are mature (terminology of Folk, 1951), whereas all the sandstones of Lithofacies B are submature.

PALAEOCURRENT ANALYSIS

Three sets of palaeocurrent data were collected from within the lithofacies. Two (1B.1 and 1C.1,2; fig. 3) show the northerly derivation of sediment-bearing currents as seen in the previous lithofacies; the second (1B.2,3) clearly displays a bimodal, almost bipolar, distribution nearly at right angles to the other sets. The bimodal distribution is manifested in the outcrop by the observed presence of herring-bone cross-bedding at this level.

DISCUSSION

The presence of herring-bone cross-bedding and bipolar current patterns are usually taken as indicators of reversing tidal currents (e.g. Selley, 1968*b*). They may also form under oscillation wave-generated flow conditions (Clifton *et al.*, 1971), or in fluvial environments where bars migrate toward each other across a channel (Miall, 1984*a*).

The textural-maturity together with bipolar palaeocurrent patterns make it probable that this lithofacies represents deposition in sub-littoral conditions, and hence the first marine influence present in the Sticht Range Formation.

Lithofacies D (dominantly flat-bedded sandstone)

The top part of Section 1A (240–250 m), the bulk of Section 1C (30–118 m), Section 1D, and parts of Section 1E (0–48.5 m; 66.5–155 m) consist dominantly of fine-grained, well-sorted, flat-bedded, quartz sandstone with minor parallel-laminated very fine sandstone (fig. 3).

Table 3
COMBINED PALAEOCURRENT DATA FROM LITHOFACIES C AND LITHOFACIES D, STICHT RANGE FORMATION (cf. fig. 3)

Data-set	Number of Readings	Vector Mean Azimuth (°)	Standard Deviation (°)	Vector Length	Consistency Ratio (%)	Log Rayleigh
1B.2, 3(a)	17	133	51	11.6	68.2	-3.44
1D(b)	3	118	37	2.6	86.9	-0.98
Grouped data	20	130	48	14.1	70.7	-4.34
1B.2, 3(b)	10	281	29	9.0	89.6	-3.49
1D(a)	13	319	23	12.0	92.6	-4.84
Grouped data	23	303	31	19.9	86.5	-7.47
Total data (both modes)	43	286	97	6.1	14.3	-0.38

Plate 11. Flat-bedded sandstone at 17 m level in Section 1E, Sticht Range Formation (Lithofacies D).

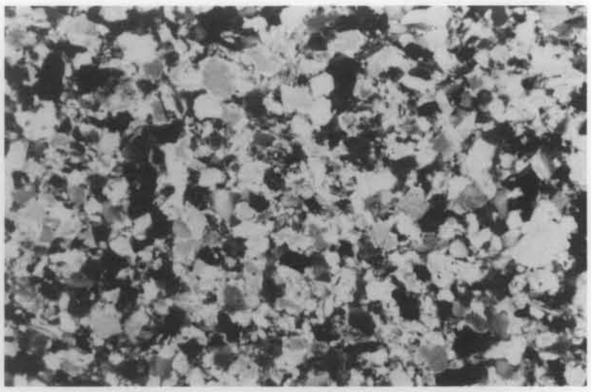

Plate 12. Photomicrograph of very well-sorted, micaceous quartz sandstone, Lithofacies D, Sticht Range Formation (400464; 21.5 m, Section 1C); crossed polars; field of view is 4.57 mm.

DESCRIPTION

The lithofacies consists of well- to very well-sorted, commonly flat- bedded, fine-grained quartzose sandstone (plate 11). Mica is present throughout the lithofacies (plate 12), and is commonly concentrated on bedding laminae. Primary current-lineation or parting-lineation is present, as also noted by Corbett (1982). Trough cross-bedding is common, and individual set thickness is generally less than 0.2 m, although all are rank 5 structures (*cf.* Miall, 1974). Sporadic single trains of ripples are present; these have amplitudes less than 25 mm and are rank 6 structures (*cf.* Miall, 1974). Dewatering structures are present in the lithofacies, although not encountered in the logged sections.

Sporadic, well-rounded pebbles occur throughout the lithofacies and these commonly occur in discrete layers that define bedding. Maximum observed clast size was 80 mm, but most are less than 25 mm.

Very fine-grained sandstone with flat-bedding is also present in the lithofacies (fig. 3). Gaps in the measured sections may indicate the presence of finer-grained lithologies.

PALAEOCURRENT ANALYSIS

Only limited palaeocurrent data are available for this lithofacies. Sixteen measurements were taken in Section 1D and show a weak bipolar distribution (fig. 3) that, significantly, corresponds very well with the distribution from sample 1B.2,3. Statistics from the individual data-sets, and combined, are shown as Table 3. As can be seen, a combined bipolar pattern is evident, but when all of the data (i.e. from both modes) are pooled together it is statistically meaningless.

DISCUSSION

Flat-bedding in fine-grained sandstone is generally taken as an indicator of high flow velocity and shallow water depth (Collinson and Thompson, 1982; Middleton and Southard, 1984). The concentration of mica, noted on bedding laminae, implies that some sorting has taken place, and this may be due to high-and low-velocity streaks in the viscous sublayer (Collinson and Thompson, 1982). The main environments for the formation of flat-bedding are in stream channels, beaches and other nearshore areas under strong shoaling waves, tidal inlets, and under high-speed turbidity currents (Clifton *et al.*, 1971; Elliott, 1978*a*; Howard and Reineck, 1981; Harms *et al.*, 1982).

Allen (1964) related the association of flat-bedded sandstone and parting-lineation to two geographic environments: on beaches in the zone of swash and backwash currents, and on submerged sand bars in channels where flow is persistently unidirectional (rivers) or unidirectional for relatively long periods (tidal channels).

A postulated nearshore or tidal-flat environment for this lithofacies of the Sticht Range Formation is in good agreement with the palaeocurrent data and the observed presence of single-clast-thick lag-pavements of very nearshore zone of a high-energy coast in California, Howard and Reineck (1981) showed that pebbles are locally abundant in an otherwise sandy domain and can make up distinct layers at the foreshore-shoreface boundary. The study also indicated that high-energy and low-energy areas do not differ greatly in their facies or overall vertical sequence of structures. Similar, more conglomeratic, deposits of Miocene age have been described from south-west Oregon (Leithold and Bougeois, 1984). Stingers of pebbles were interpreted as having formed on shoreward-migrating, low-amplitude bars on the lower shoreface generated on a storm-dominated coastline.

Lithofacies E (hummocky cross-stratified sandstone)

A distinctive and characteristic lithofacies occurs over the interval 48.5–66.5 m in Section 1E (fig. 3), and consists of a sequence of medium- to coarse-grained pebbly sandstone displaying hummocky cross-stratification (HCS) (plate 13).

DESCRIPTION

The lithofacies consists of moderately well-sorted, coarse- to fine-grained sandstone in which abrupt vertical changes of grain size occur. The rocks may contain abundant mica.

Bedding is wavy and lenticular, and bedding surfaces have irregular tops and bottoms. The characteristic hummocks or antiforms of Dott and Bourgeois (1982) are common and have 0.1–0.6 m of relief, and are one metre across.

HCS was first introduced by Harms *et al.* (1975), and described as:

(a) Sets have erosional lower bounding surfaces and commonly dip at less than 10°;

(b) Laminae above that surface are parallel to it or nearly so;

(c) Laminae can systematically thicken laterally in a set, so that their traces on a vertical surface are fan-like, and dip diminishes regularly upward;

(d) Dip directions of the laminae are scattered.

All these features are present within this lithofacies of the Sticht Range Formation; scattered dip directions were confirmed by measurement.

Eighteen 'palaeocurrent' (i.e. apparent maximum foreset-dip) measurements were made, which when restored are seen to have an overall southerly trend, but with a very large standard deviation and a Rayleigh probability (-0.09) indicating that the pattern is nearly random.

PALAEOENVIRONMENT

HCS is formed on the shoreface and shelf by waves, and characterises a wave-dominated facies often produced by storm waves acting below fair-weather wave base (Dott and Bourgeois, 1982; Walker, 1984). Greenwood and Sherman (1986), in a study of the surf zone of a storm-dominated coastline in the Canadian Great Lakes, concluded that HCS in the surf zone is produced by an actively growing bedform developed under the combined flow induced by *(i)* primary wave oscillation and *(ii)* a secondary current related to either an offshore-directed storm-surge on the shelf or a 'steady' (longshore) current.

As originally defined (Harms et al., 1975), HCS occurs mainly in coarse silt and fine sand; Lithofacies E is clearly much coarser than that. Lower Cretaceous storm deposits containing coarse detritus, and analogous modern deposits have been described from Texas (Hobday and Morton, (1984). Clearly, the grain size of the HCS deposit will be largely determined by the nature of the deposit present on the shore. The presence of coarse storm deposits in the Sticht Range Formation is consistent with the presence of coarse lag deposits, postulated to have formed on tidal-flats and described previously.

Lithofacies F (sandstone/siltstone/mudstone)

The top part of Section 1E (225–291 m), and the bottom portion of Section 3 (0–82 m) consists of interlayered sandstone of variable grain size, siltstone and mudstone (fig. 3). Gaps in the measured sections caused by lack of outcrop probably indicate a greater presence of finer-grained sediments in the lithofacies than that actually measured.

Because of overall paucity of outcrop and the presence of cross-faults in this part of the section, the top of Section 1E and the base of Section 3 are some 800 m apart (fig. 2) and separated by an unknown (but probably less than 150 m) stratigraphic interval.

On a bulldozed scrape at CP887529 (fig. 2) a single poorly-preserved trilobite cephalon and an equally poorly-preserved pygidium were found together with a single indeterminate inarticulate brachiopod. Although poorly-preserved, the trilobites are sufficiently diagostic to allow placement within the Family Asaphiscidae (Dr J. B. Jago; pers. comm., 1984), thus determining the age as either Middle or Late Cambrian. As the Dora Conglomerate which overlies the Sticht Range Formation is in turn overlain by the Upper Cambrian Newton Creek Sandstone (Corbett, 1981), it is probable that the fossils are Middle Cambrian in age.

Furthermore, as no known Tasmanian fossiliferous Cambrian rocks are older than middle Middle Cambrian (Jago, 1979; Jago, *in* Brown, 1986), the Sticht Range Formation is probably late Middle Cambrian in age.

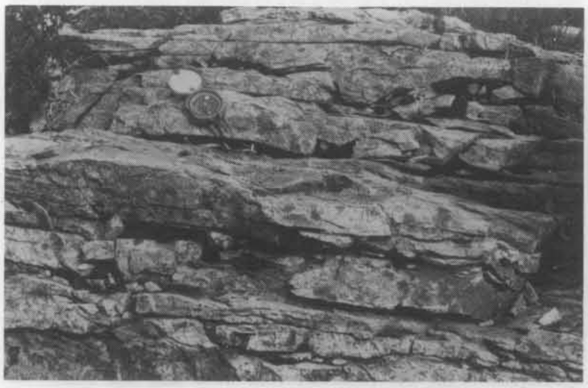

Plate 13. Hummocky cross-stratification (HCS) at 50 m level in Section 1E, Sticht Range Formation (Lithofacies E).

Plate 14. HCS showing detail of internal laminae, 36 m level in Section 3, Sticht Range Formation (Lithofacies F).

LITHOFACIES DESCRIPTION

This lithofacies contains the greatest diversity of rock-types and sedimentary structures in the Sticht Range Formation. It also contains the greatest development of fine-grained rocks.

The dominant lithotype within the lithofacies in Section 1E is well-sorted, fine- to medium-grained, flat-bedded, quartz sandstone similar to that previously described, although somewhat coarser-grained. Bed thickness is usually within the range 0.1–0.3 m.

Component interbeds within this lithofacies are of sandstone beds, 0.1–0.8 m in thickness but usually in the range 0.2–0.4 m, that are graded from very coarse and pebbly sand at the base to medium- or fine-grained sand at the top. The graded beds are generally massive and moderately well-sorted. Abundant detrital mica may be present (e.g. 400485), although clays in general are lacking. Tops and bottoms of these beds are sharp. Some water-escape structures are present, and a single example of flute casts was found.

The basal part of Section 3 consists of parallel-laminated dark grey siltstone; higher in the section sandy layers less than 50 mm thick appear and these usually have flat-, rather than parallel-laminae. Some sandy layers consist of trains of ripple cross laminations. Many of the laminae are contorted into convolute folds.

Above 25 m in Section 3 graded units appear, and these range in thickness from 0.1 to 0.5 m. Grain size varies from granule conglomerate or very coarse sand at the base, to medium- or fine-grained sand at the top. The base of these beds is usually erosional and rip-up clasts may be present. These graded beds are not classical turbidites, have no lateral persistence, and are generally moderately well-sorted. Hummocky cross-stratification is also sporadically present (plate 14).

Other beds within the lithofacies are also graded, but consist of 'normal' flat-bedded medium- or fine-grained sandstone less than one metre in thickness becoming siltier in the uppermost 100 mm of the bed.

Interbedded with the graded beds above 25 m in Section 3 is a complex succession of interlayered fine- to very fine-grained sandstone and mudstone in varying proportions. Sandstone layers are usually very thin and load-casts occur. Some sandstone beds show evidence of former thixotropy and have erosional bases onto the underlying strata. Trains of ripple cross-laminations may also be present.

Higher in the section, flow-rolls and convolute folding become common and dewatering structures may also occur. In this upper part of the section further evidence of rapid deposition and substrate instability is provided by the presence of intraformational faulting and evidence of former thixotropy.

PALAEOCURRENT ANALYSIS AND PALAEOENVIRONMENT

The presence of marine fossils in the section provides unequivocal evidence of a marine environment of deposition. In a probable correlate of the lithofacies in Dante Rivulet below Lake Beatrice, bioturbation also indicates the development of marine conditions.

Palaeocurrent data were collected from the trains of ripples and from cross-laminations (fig. 3) and indicate that the currents flowed to the northwest. The structures are small scale (rank 6 of Miall, 1974), asymmetric, and reflect essentially unidirectional bottom-current flow, potentially related to a range of water-movement phenomena that operate in the shallow-marine realm induced either by waves, tides, and storms or combinations of these. Such processes are independent of local topographic gradients, and so of little significance with respect to the regional palaeoslope. The fact that the mean palaeoflow direction is strongly polarised (L = 90.9%) and roughly orthogonal to the flow direction in the underlying fluvial facies (329° *vs* 272° in Section 1A) suggests that the Lithofacies F currents were either longshore or obliquely onshore.

This lithofacies is interpreted as having been deposited in deeper water than both Lithofacies D and Lithofacies E. Inasmuch as the terms 'shallow' and 'deep' water are qualitative and relative, the term 'deeper water' is used here to mean beyond storm wave-base and not the traditional 'deep water' turbidite environment of submarine fans and basin plains.

Deposits, similar to the storm deposits described by Elliott (1978*b*), and consisting of units with grading and/or wave- and current-ripples are present in Lithofacies F, and similar origins are inferred. Finer grained sediments in the lithofacies, including parallel-laminated siltstone and mudstone, were probably deposited by low-energy suspension. Periodic sand influxes, such as those occurring in trains of ripples, may represent distal or intermediate storm layers.

The graded sand units, as previously noted, are not classical turbidites, but probably were deposited by waning currents, possibly also related to storm activity. The complex alternation of lithologies and lack of lateral persistence suggests abrupt spatial perturbation or variation of the depositional process, such as might be expected to characterise storm-surge currents.

The presence of convolute bedding and water-escape structures within this lithofacies provides further evidence of rapid deposition (*cf.* Collinson and Thompson, 1982). Convolution involves plastic deformation of partially liquefied sediment soon after deposition, and water-escape structures indicate the conduits along which the water escaped.

Zone of disruption

The uppermost 230 m of the Sticht Range Formation in the Lake Spicer area, immediately underlying the Dora Conglomerate, consists of a zone of disrupted and folded beds, lithologically similar to those described from Lithofacies F, and broken formation consisting of similar lithologies (fig. 3). The zone has previously been described by Corbett (1982), and mentioned briefly and figured by Solomon (1964). Distinct zones of folded rocks and of broken formation are present.

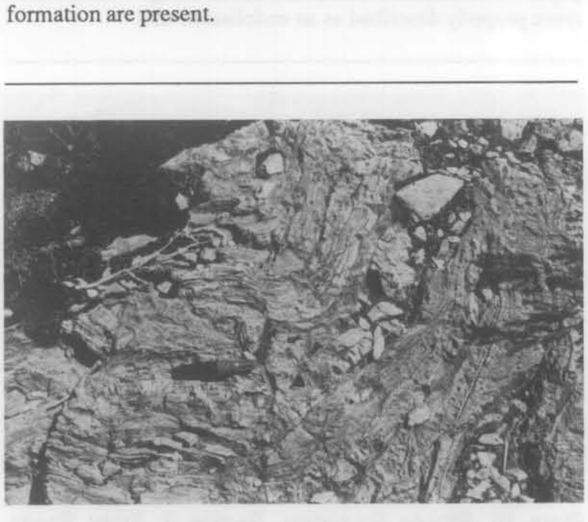

Plate 15. Deformed beds within 'Zone of Folding', Section 3, Sticht Range Formation.

5 cm

Corbett (1982) noted that the disrupted zone thins abruptly to the south of a small cross-fault near the northwest corner of Lake Spicer, and that an apparently conformable contact is present between a thick siltstone unit and the Dora Conglomerate south of the fault.

ZONE OF FOLDING

Immediately overlying relatively the undisturbed strata comprising interbedded sandstone and mudstone previously described, is 90 m (in terms of 'structural thickness'), of folded and disrupted sandstone/mudstone strata identical in lithology to those beneath (plate 15).

The folds vary from tight to open and are commonly box-like. There is little coherence in the sequence: individual folds are 'rootless' and are apparently jumbled against other detached folds. Time constraints of the project did not allow a detailed structural analysis of the zone but there is no apparent ordering of the fold axes. The folds are clearly cut by the regional northwesterly-trending Devonian cleavage.

BROKEN FORMATION

Above the zone of folding, deformation becomes more intense and disruption of the folds becomes such that the aspect is wholly that of a broken formation characterised by lack of internal continuity of contacts or strata, and by the inclusion of angular and broken clasts (usually less than 2 m, but rarely several metres in length) of Sticht Range Formation Lithofacies F rocks and rare volcanic inclusions, embedded in a fragmented, sheared matrix of fine-grained material (plate 16). The rocks do not show evidence of quartz-veining, and deformation within the zone becomes markedly more intense near the contact with the overlying Dora Conglomerate.

The rocks are very sheared, and the dominant cleavage is the regional northwesterly Devonian one; in places it is apparent that this cleavage is a crenulation, superimposed on an earlier cleavage of unknown age. The uniformity of composition of the deformed strata suggests that the primary cause of fragmentation and mixing is probably by 'soft-sediment' gravitational collapse or wholesale intraformational flow.

The term broken formation is used here as a general term to denote a body of rock characterised by the lack of internal continuity of strata and by the inclusion of fragments and blocks of all sizes embedded in a finer- grained fragmented matrix; the composition of the clasts is the same as the surrounding rocks. The classification of mélanges is discussed by Raymond (1984); within the context of that paper the occurrence within the Sticht Range Formation is more properly described as an endolistostrome.

Plate 16. Broken Formation, Section 3, Sticht Range Formation. Compass is aligned in dominant (Devonian) cleavage direction.

PETROGRAPHIC ANALYSIS

Introduction

This section presents petrographic data, dominantly from coarse- to very coarse-grained sandstones from the fluvial lithofacies of the Sticht Range Formation, and provides significant insights into the tectonic environment of the depositional area and tectonic setting of the formation.

Sandstone composition is influenced by the character of the source rocks, the nature of the sedimentary processes within the depositional basin, and the kind of dispersal paths that link provenance to basin (Dickinson and Suczek, 1979). The mineralogy of the major rock-forming constituents is not directly diagnostic of depositional environment but it does reflect the geology of the sediment source area (Miall, 1984*a*), and for non-marine rocks this means exposed upland regions. For ancient detrital successions, petrofacies studies help elucidate the tectonic setting of the source area, and so the first appearance, or a significant increase in the abundance of a particular mineral assemblage in a stratigraphic setting may indicate an important tectonic event (Miall, 1984*a*).

The Sticht Range formation is a quartzose succession in which the sandstones comprising the formation superficially have a mineralogically-uniform appearance; petrographic studies and the recognition of the component grains affords the sole means of determining provenance. It therefore follows that elucidation of the provenance and hence the tectonic setting of the formation will provide valuable information about the whole of the Mt Read Volcanics.

Methods

The sequence is comprised of components from both metamorphic and volcanic terrains. Finer-grained rocks are composed dominantly of monocrystalline quartz, together with minor detrital mica and lithic fragments. A relationship between increasing grainsize and a corresponding increase in the ratio of polycrystalline to monocrystalline varieties of quartz is well established (Conolly, 1965; Blatt, 1967).

For these reasons the present study will be mainly concerned with the coarser-grained sandstones: these obviously have a higher component of lithic clasts than the finer-grained rocks, but only by studying these coarser-grained varieties can a true indication of source-rock geology and tectonic setting be gained.

Sandstone samples were obtained at regular intervals through the measured sections (fig. 3). The samples were not collected systematically, but rather an attempt was made to collect from each lithotype, and also to provide regular representative sampling through the entire succession.

Modal-analyses were carried out on 34 samples of medium- to very coarse-grained sandstone. With the exception of three very coarse samples, a minimum of 600 points were counted in each thin-section and the counting was done with a Swift electronic point-counter. In most cases holes were excluded from the count, but where it was obvious that the hole was caused by the plucking out of weathered feldspar the hole was included as part of the feldspar count. In all cases the point distance chosen was equal to or slightly larger than the largest grain fraction in the count.

Criteria used for distinguishing the various grain-types are essentially those of Dickinson (1970) and Graham et al. (1976), but monocrystalline grains larger than 0.0625 mm (very fine sand and coarser) occurring within lithic fragments (usually metaquartzite), were counted as the specific lithic clast-type. Some workers (e.g. Dickinson, 1970; Ingersoll *et al.*, 1984) argue that the identification and recording of mineral crystals of sand size, whether within coarser-grained lithic fragments or not, reduces the effect of grainsize noted

5 cm

previously, thus allowing accurate determination of original detrital mode and occurrence. In this study it was felt that it was more meaningful in terms of source determination to count the clasts as rock-type rather than count their component minerals; sediments in the Sticht Range Formation had obviously not travelled far and there had been no significant recycling.

Problems of matrix determination are discussed by Dickinson (1970), and his terminology and identification criteria have been followed in the present study: with the exception of mica of obvious detrital origin all groundmass phyllosilicates have been included as matrix and a limit of about 0.03 mm. has been used as the cutoff between framework and matrix.

Grain-type categories

Prior to the present study the only systematic petrographic study within the Tasmanian fold province had been that of P. R. Williams (1983). That study was concerned with the sedimentology of the Late Proterozoic Clytie Cove Group, a flysch sequence derived from a metamorphic provenance.

Given the quartzose nature of the Sticht Range Formation, and the lack of previous studies, the grain-type classification system used in this study has been in part built up as the work has progressed, but in the main is adapted from those of Scholle (1979) and Conaghan (*in* McDonnell, 1983). In the present study there is little need to differentiate between the various types of microquartz, but there is some variety in the types of clast-lithology derived from metasedimentary terrains. The main types of grains recognised in this study are listed in Table 4.

Table 4
A CLASSIFICATION SCHEME OF PETROGRAPHIC DETRITAL GRAIN-TYPES IN THE STICHT RANGE FORMATION

Megaquartz:	**Volcanic:**
common (plutonic) quartz (Qc)	felsic (V)
volcanic (QV)	
vein (Qv)	
Microquartz:	**Metamorphic:**
metachert (Qcm)	metaquartzite (Tmq)
phyllite (Tp)	quartz-mica schist (Ts)
	ribbon quartz (Tq)
Feldspar (F)	undifferentiated (Tm)
Mica (Mm)	
Miscellaneous	
Iron oxides (Mfe)	
Chlorite (Mc)	
Heavy minerals (Mn)	

COMMON OR PLUTONIC QUARTZ (Qc)

Common or plutonic quartz (for review of usage of terminology see Blatt and Christie, 1963) is usually monocrystalline, may have a slightly undulose extinction and contain linear vacuole trains and (commonly aligned) inclusions of other minerals. Radiating inclusions of ?rutile occur in some grains.

Because of strain caused by the Devonian deformation of the region this type was often very difficult to distinguish from other varieties of monocrystalline quartz, in particular from small grains of strained volcanic quartz.

VOLCANIC QUARTZ (QV)

This type is usually easily recognised by the presence of embayments, sharp extinction, and a lack of inclusions. Curved fractures cracks are commonly present within larger grains and these cracks may be the site of curved lines of inclusion-blebs. Without other distinguishing characteristics grains with such inclusions may be difficult to separate from plutonic quartz.

Volcanic quartz may also be difficult to separate from plutonic quartz because of strain caused by the Devonian folding. As a result of this strain, volcanic quartz may exhibit slightly undulose extinction, and brittle fracture (essentially linear cracks) commonly occurs (plate 17). The deformation of volcanic quartz from a correlate of the Mt Read Volcanics located some 50 km north of the present study area has been studied by Seymour (1980) who concluded that the quartz deformed variously by brittle fracturing, pressure solution processes, and/or development of intra- granular deformation lamellae.

Difficulties in differentiating volcanic from plutonic quartz increase markedly as grainsize decreases; this is a further reason the present study was limited to coarser sand grades.

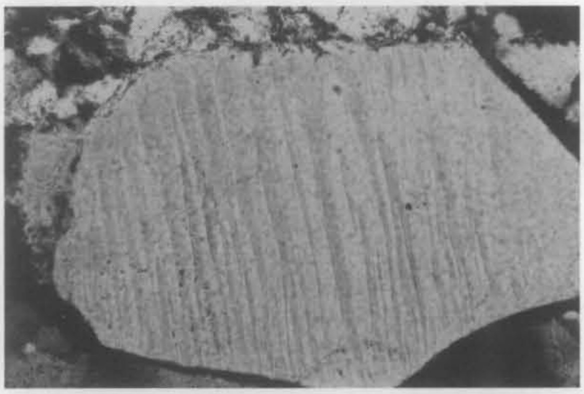

Plate 17. Photomicrograph of volcanic quartz (QV) showing development of deformation lamellae. Specimen 400442, crossed polars, length of grain is ~700 µm.

VEIN QUARTZ (Qvm, Qvp)

Vein quartz is usually cloudy, caused by the presence of numerous small vacuoles. Extinction is typically undulose, and often wavy and book-like inclusions of vermicular chlorite are present in some crystals. A distinction was made between polycrystalline (Qvp) and monocrystalline (Qvm) vein quartz: it follows that given the overall coarseness of the sandstones point-counted in this study polycrstalline grains were dominant.

All the vein quartz had undergone low-grade metamorphism, and some difficulties were experienced separating vein quartz, in particular finer-grained varieties, from other metamorphic-derived clast-types.

METACHERT (Qcm)

Metachert was a minor, although common, component in the thin-sections examined. The metachert comprises equant to sub-equant, usually polyhedral microcrystals of quartz with no visible relict texture (plate 18). As noted by Conaghan (table 5.2, in McDonnell, 1983) the texture is typically

5 cm

equigranular to semi-equigranular and hypidioblastic/ idioblastic with a strong tendency for the polyhedral quartz crystals to show triple-point relationships with neighbours.

The source of this grain-type is not known. Precambrian metasedimentary terrains consist of quartzite, quartz-mica schist, phyllite and related rocks, but no cherts are known. Chert (relatively unmetamorphosed) occurs in ?Lower Cambrian–?Upper Precambrian formations in northern Tasmania (eg. Barrington Chert), but metamorphosed formations containing chert are unknown. It is possible that the clasts are derived from replacement nodules in relatively unmetamorphosed carbonate-rock formations that occur within the Tyennan region, e.g. Jane Dolomite; or the clasts may be polycyclic and derived from a more distant source than Tasmania. Alternatively, the metachert is of siliceous volcanic origin (*cf.* Conaghan, in McDonnell, 1983, table 5.2).

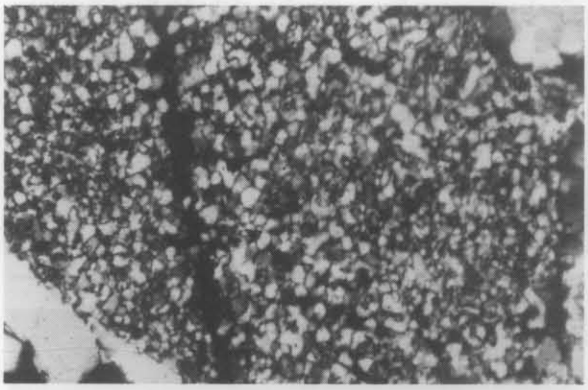

Plate 18. Photomicrograph of clast of metamorphosed chert (Qcm). Specimen 400440, crossed polars, field of view 712 µm..

FELDSPAR (F)

Feldspar is a common component in all Sticht Range Formation lithotypes. Much has weathered to clay and so all feldspar counts should be regarded as a minimum. Individual feldspar grains are generally untwinned and all appear to be K-feldspar. Relief is low, but the presence of cleavage traces and a cloudy appearance under plane light are usually diagnostic and allow for the ready indentification of the mineral; rare embayments, similar to those common in volcanic quartz, are present.

The Mount Read Volcanics in western Tasmania have undergone lower greenschist metamorphism producing a 'keratophyre' mineralogy, with quartz, albite, sericite, and chlorite together with clinopyroxene, K-felspar, hornblende, epidote and biotite (Solomon, 1964; Corbett, 1981). Because present feldspar composition may not reflect the felspar composition at the time of formation, feldspar type was not differentiated in the present study.

VOLCANIC ROCK-FRAGMENTS (V)

There are a number of similar felsitic volcanic clasts present in the rocks, all of which have clear volcanic origins, and all have been counted as one group. The rocks are generally altered and extremely fine-grained (approximately the same grainsize as chert) and consist of quartz with lesser amounts of sericite, chlorite and opaques (plate 19). The grains are usually cloudy or dusty, and commonly are light- or dark-coloured in plane-light and have a fuzzy appearance under cross-polars, superficially similar to chert. The presence of phenocrysts of volcanic quartz and/or (usually altered pseudomorphs after) feldspar gives the clue to the volcanic origin. The groundmass is usually microgranular, but 'lathwork' textures also occur. Source-rock-related veinlets of quartz commonly occur through the grains.

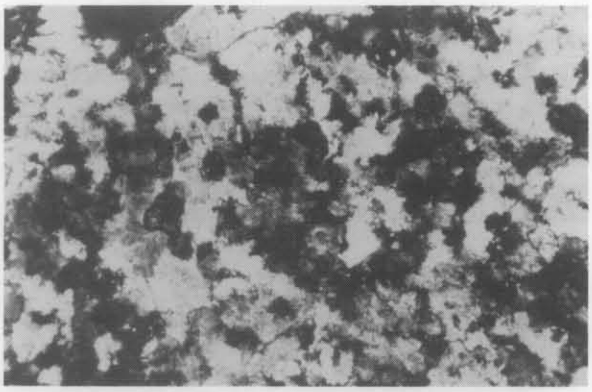

Plate 19. Photomicrograph of volcanic clast (V), strongly recrystallised. Specimen 400459, crossed polars, field of view is 1797 µm.

METAQUARTZITE (Tmq)

Included in this category are clasts derived from metaquartzite and comprising component clastic quartz grains set in a quartzose matrix (plate 20); the parent rock is recrystallised and the grains may have sutured boundaries. Although now strained, it is apparent that the original sorting in some of the source rocks was extremely good; the sorting in others less good.

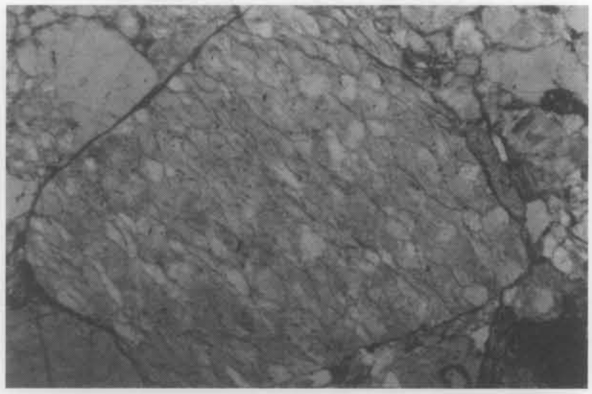

Plate 20. Photomicrograph of clast of metaquartzite (Tmq). Specimen 400444, crossed polars, grain is about 4mm across.

PHYLLITE (Tp)

Phyllite is a readily recognised lithic clast and typically consists of fine-grained interlayered quartz and mica, in some cases exhibiting a series of microfolds or crenulation cleavage (plate 21).

RIBBON-QUARTZ (Tq)

This is a variety of tectonite or mylonite consisting of ribbons or elongate 'rods' of quartz.

QUARTZ-MICA SCHIST (Ts)

There exists a continuum of metamorphic rock types from metaquartzite, through quartz-mica schist to phyllite.

5 cm

Plate 21. Photomicrograph of phyllite clast (Tp). Specimen 400447, crossed polars, field of view 712 μm.

Quarz-mica schist is a somewhat subjective intermediate variety between quartzite and phyllite and consists of elongate or platy quartz grains in a schistose matrix of white mica flakes.

In practice in this study if a clast had less than about 5% mica it was counted as a quartzite, if it contained greater than 5% mica it was counted as schist. While such a scheme might be unsatisfactory to a metamorphic petrologist, the aim of the present study is to determine the origin of a clast or group of clasts and so the somewhat arbitrary scheme used is considered satisfactory.

TECTONITE UNDIFFERENTIATED (Tm)

For reasons previously stated it was very often impossible to determine whether a particular grain was, say, metamorphosed vein quartz or metaquartzite. An undifferentiated tectonite category was introduced and in fact this became one of the (volumetrically) most important classes, particularly for smaller clasts where it became impossible to assign a more specific classification to the grain.

Many of the grains assigned to this class were bimodal; there exists a bimodality in the size distibution of unbroken quartz crystals. This feature commonly occurs in schists and gneisses during recrystallisation of a quartz aggregate where new grains are initiated at grain boundaries and the recrystallisation is subsequently terminated prior to development of an equigranular texture (Blatt, 1967).

MISCELLANEOUS GRAINS (M)

Miscellaneous detrital grains included in the modal-analyses include detrital mica (Mm), heavy minerals (Mn), detrital chlorite (Mc) and iron oxides (Mfe).

As noted earlier, mica is common in the finer-grained rocks that were deposited under shallow-marine conditions, and is a very significant component of the sediments too fine-grained to have been included in the modal-analyses.

Iron oxides in the rocks are probably present as a result of relatively recent weathering of pre-existing minerals such as phyllosilicates, and do not have any environmental significance.

In a few slides (e.g. 400454) grains of green tourmaline were observed, but not encountered under the crosshairs during the point-counting. Green tourmaline is derived from a metamorphic terrain and has been noted in other western Tasmanian Lower Palaeozoic sequences (e.g. Baillie and Williams, 1975).

Triangular diagrams

The most significant compositional variations among terrigenous sandstones can be shown as ternary plots on triangular diagrams. The three apices or poles, represent recalculated proportions of key categories of grain-types determined by modal-analysis. Five such sets of poles (QFL, QmFLt, QpLvLs, LmLvLs, QmPK) are useful in separating sandstone suites from different kinds of provenance terrains (Dickinson and Suczek, 1979; Dickinson *et al.*, 1983; Ingersoll, 1983; Ingersoll and Suczek, 1979). Four were used in the present study:

(*a*) For QFL diagrams, the poles are (1) total quartz grains, including quartzose polycrystalline rock fragments; (2) monocrystalline feldspar grains; (3) unstable polycrystalline lithic fragments of igneous, sedimentary or metamorphic origin.

(*b*) For QmFLt diagrams, the poles are (1) monocrystalline quartz grains; (2) monocrystalline feldspar grains; (3) total polycrystalline lithic fragments including quartzose varieties.

(*c*) For QpLvmLsm diagrams, the poles are (1) polycrystalline quartz grains; (2) volcanic and metavolcanic lithic fragments; (3) sedimentary and metasedimentary lithic fragments.

(*d*) For LmLvLs diagrams, the poles are lithic clasts of (1) metamorphic; (2) volcanic; (3) sedimentary origin.

The fifth diagram, the QmPK Plot (Dickinson & Suczek, 1979), was not used in the present study because K-feldspar and plagioclase were not differentiated, for reasons earlier stated.

Table 5

GRAIN PARAMETERS (modified from Graham et. al., 1976; and Ingersoll and Suczek, 1979)

(*a*) Q = Qm + Qp
where Q = total crystalline grains
Qm = monocrystalline grains
Qp = polycrystalline aphanitic quartz grains (including chert)
= Qc + QV + Qvm + Qvp + qcm + Tm + Tmq + Tq + Ts

(*b*) F = total feldspar grains

(*c*) L = unstable polycrystalline lithic fragments
= V + Tp

(*d*) Lt = L + Qp
= V + Tp +Qvp +qcm + Tm + Tmq + Tq + Ts

(*e*) Lv = total volcanic-hypabyssal aphanitic lithic grains
= QV + F + V

(*f*) Lm = metamorphic aphanitic lithic grains
= Qvp + Qvm + Tm + Tmq + Tp + Tq + Ts

(*g*) Lvm = volcanic-hypabyssal and metavolcanic aphanitic lithic grains
= V

(*h*) Lsm = sedimentary and metasedimentary aphanitic lithic grains
= Tm + Tp + Tq + Ts

(*i*) Qp = qcm + Qvp + Tm

Petrographic results

Point-count data were recalculated as indicated in Table 5 and plotted as the four triangular diagrams (fig. 7, 8).

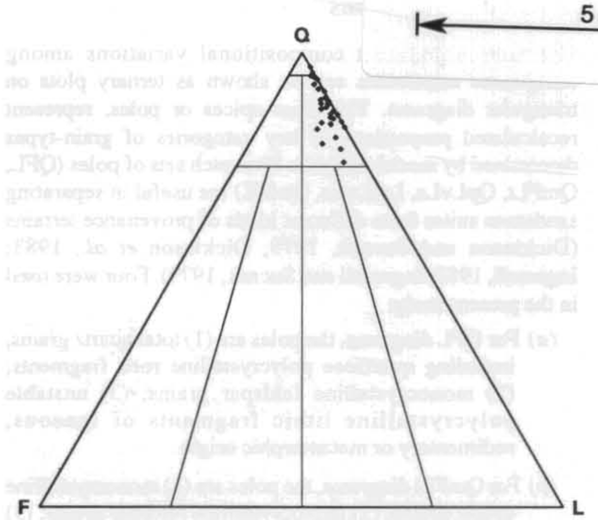

Figure 7a. QFL plot; 34 sandstones, Sticht Range Formation. Major fields are those of Folk (1980).

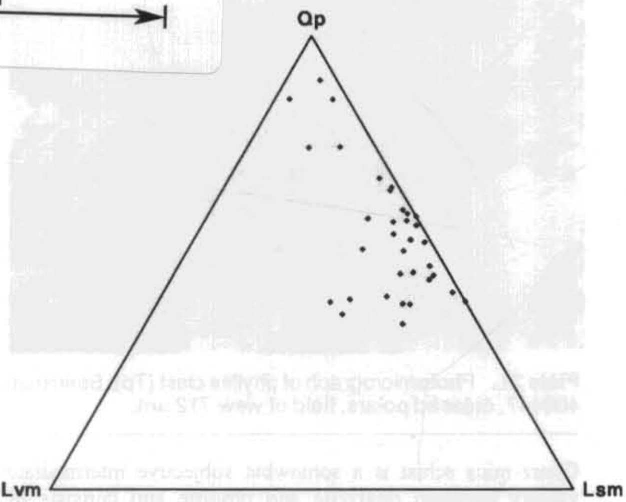

Figure 8a. QpLvmLsm plot; 34 sandstones, Sticht Range Formation.

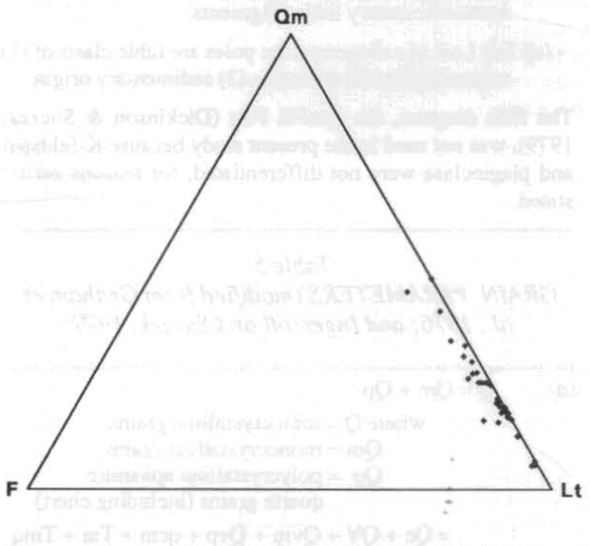

Figure 7b. QmFLt plot; 34 sandstones, Sticht Range Formation.

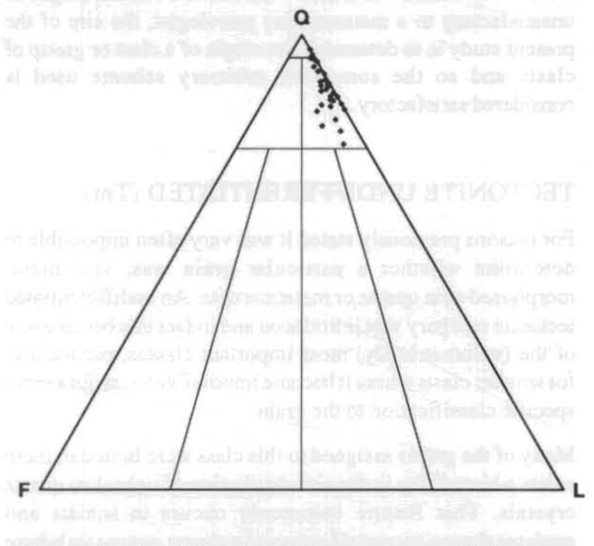

Figure 8b. LmLvLs plot; 34 sandstones, Sticht Range Formation.

Non-framework accessory detrital constituents, such as heavy minerals and iron oxides were disregarded.

The **QFL** plot (fig. *7a*) emphasises grain stability and illustrates the quartzose nature of the Sticht Range Formation. The plot indicates that most of the sandstones are sublitharenites (using the terminology of Folk, 1980), but does not clearly differentiate provenance, as the composition of the Sticht Range sandstones is made up of two dominant populations, both of which are quartzose.

The **QmFLt** plot (fig. 7*b*) indicates aspects of provenance, and demonstrates that the coarser sandstones of the Sticht Range Formation have been recycled from orogenic material, probably exposed by foreland uplift.

Dickinson and Suczek (1979), and Dickinson *et al.* (1983) illustrate QFL and QmFLT plots for framework modes of sandstone suites from different types of provenance terrains. These data indicate that the sediments of the Sticht Range Formation are derived from foreland uplift associated with a recycled orogen. Dickinson *et al.* (*op. cit.*) note that within recycled orogens, 'sediment sources are sedimentary strata and subordinate volcanic rocks, in part metamorphosed, exposed to erosion by the orogenic uplift of fold belts and thrust sheets'.

The **QpLvmLsm** plot (fig. 8*a*), introduced by Graham *et al.* (1976) and modified by Ingersoll and Suczek (1979), is another useful indicator of provenance, particularly for rapidly deposited sand-sized sediment derived from a single source. Using the interpreted tectonic settings proposed by Ingersoll and Suczek (1979), a rifted continental margin environment is indicated for the Sticht Range Formation.

The **LmLvLs** triangular plot (fig. 8*b*), introduced by Ingersoll and Suczek (1979), is a further useful provenance indicator and clearly indicates that the Sticht Range sandstones are derived from metamorphic and volcanic terrains. In this particular plot volcanic quartz was included within the Lv category. The pattern shown by the Sticht Range sandstones does not match any of the tectonic settings depicted by Ingersoll and Suczek (1979), but this is probably due to the differences between my and their approach to modal-analysis, i.e. by counting quartz within metasedimentary lithic clasts as the clast-type, and not the quartz-type. The diagram does, however, strongly indicate that two different source-rock types were supplying sediment into the system.

Overall, the results present a fairly uniform and coherent picture of the lithological nature of the source area which is in keeping with the known geological facts: deposition of the

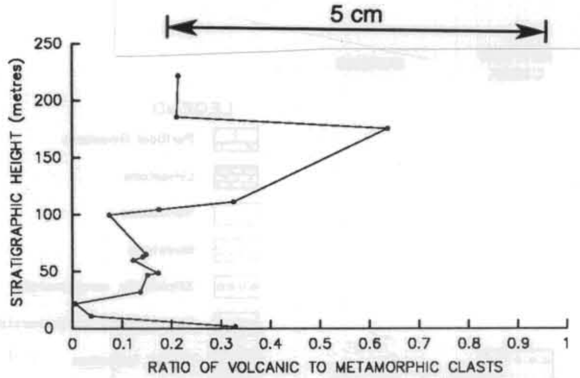

Figure 9. Plot of ratio of total clasts of volcanic origin to total clasts of metamorphic origin against measured stratigraphic height from base of Section 1A (Sticht Range Formation, Lithofacies B).

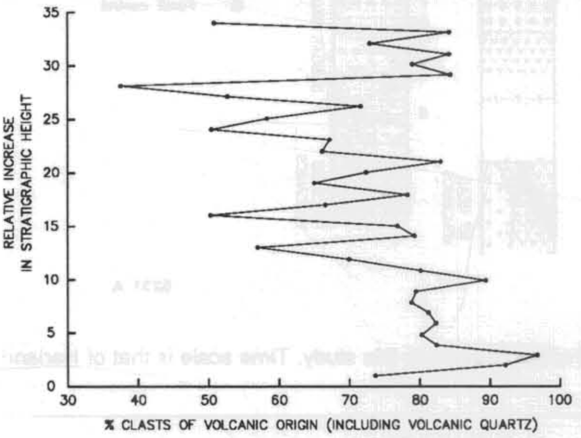

Figure 10a. Plot of relative stratigrtaphic height (no scale; Sections 1A, 1B, 1C, 1D, 1E, 3) against percentage clasts of volcanic origin, Sticht Range Formation.

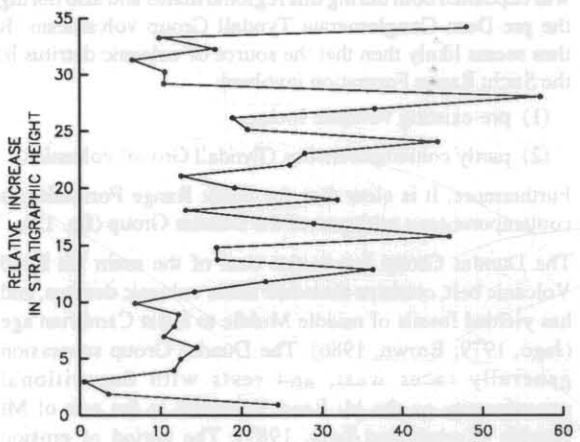

Figure 10b. Simlar plot of relative stratigraphic height against percentage clasts of metamorphic origin.

Sticht Range Formation sandstones occurred within a continental margin setting or an intracontinental rift where uplifted metasedimentary terrain and felsic volcanics were the only significant sources of sediment.

Upsequence changes

Having demonstrated that the rocks are derived from two distinct major source-rock types, it is clearly important to know if there is any systematic upsequence variation of detrital grain-types within the formation.

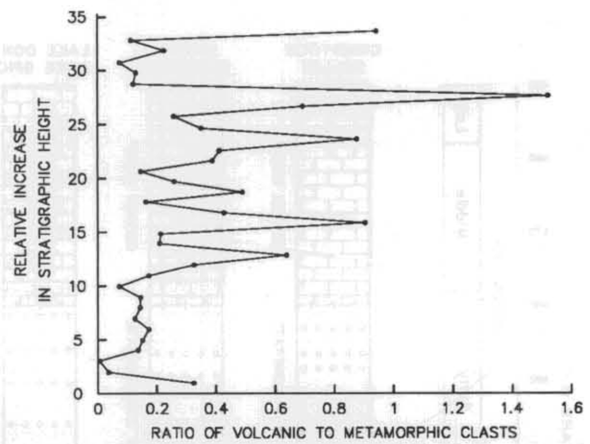

Figure 11. Plot of relative stratigraphic height (no scale; Sections 1A, 1B, 1C, 1D, 1E, 3) against ratio of clasts of volcanic origin to clasts of metamorphic origin, Sticht Range Formation.

Figure 9 is a plot of the ratio of clasts of volcanic to metamorphic origin against stratigraphic height for the samples point-counted from Lithofacies B (alluvial-fan or braidplain). The plot is far from conclusive, but does indicate the background ratio is in the order of 0.15–0.25 and that a pulse of increased volcanic clasts occurs from 100–175 m. As this 'pulse' is consistently defined by four points it is considered real and not an artefact caused by the sampling procedure.

The problems of measuring a continuous section through the entire Sticht Range Formation and complications caused by the common presence of cross-faults have previously been discussed. These faults make it impossible to plot various clast percentages against stratigraphic height for the entire formation. In an attempt to overcome this problem, and to demonstrate (but not to quantify) cyclicity if present, clast-type percentages were plotted against relative stratigraphic position. Figure 10*a* is a plot of the clasts of volcanic derivation (including volcanic quartz) against relative stratigraphic position; Figure 10*b* is a similar plot of the clasts of metamorphic derivation; Figure 11 is a similar plot, but of the volcanic/metamorphic ratio. For comparative purposes it should be noted that Figure 9 corresponds to the '4–15' interval of the y-axis on each of Figures 10*a*, 10*b*, 11.

The clearest trend is that in Figure 11 which shows progressive changes in the ratio of clasts of volcanic and metamorphic origin. Several 'pulses' (or an increase in the percentage of volcanic clasts) are apparent and are superimposed on a crude progressive increase in the background proportion of volcanic components. Three of the 'pulses' are defined by three or more points.

It is significant that the first three points on the 'pulse' in Figure 9 (100–175 m) correspond to a well-defined fining-upwards cycle recognised in Lithofacies B (fig. 3; Section 1A). Fining-upwards cycles are characteristic of distal facies of alluvial-fans, and the cycles may be related to tectonic events (e.g. Heward, 1978*a*; Heward, 1978*b*; Rust and Koster, 1984; Mack and Rasmussen, 1984). Alternatively, the pulses of volcanic debris influx may be related to eruptive pulses in the Tyndall Group volcanic belt: eruptive pulses have profound effects on the volume of sediment transported through volcanic terrains (Dr R. A. F. Cas, pers. comm., 1988).

DEPOSITIONAL HISTORY AND TECTONIC IMPLICATIONS

Regional setting of the Sticht Range Formation

Figure 12 is a time-space plot (using the time scale of Harland *et al.*, 1982) constructed for the 100 m.y. period commencing

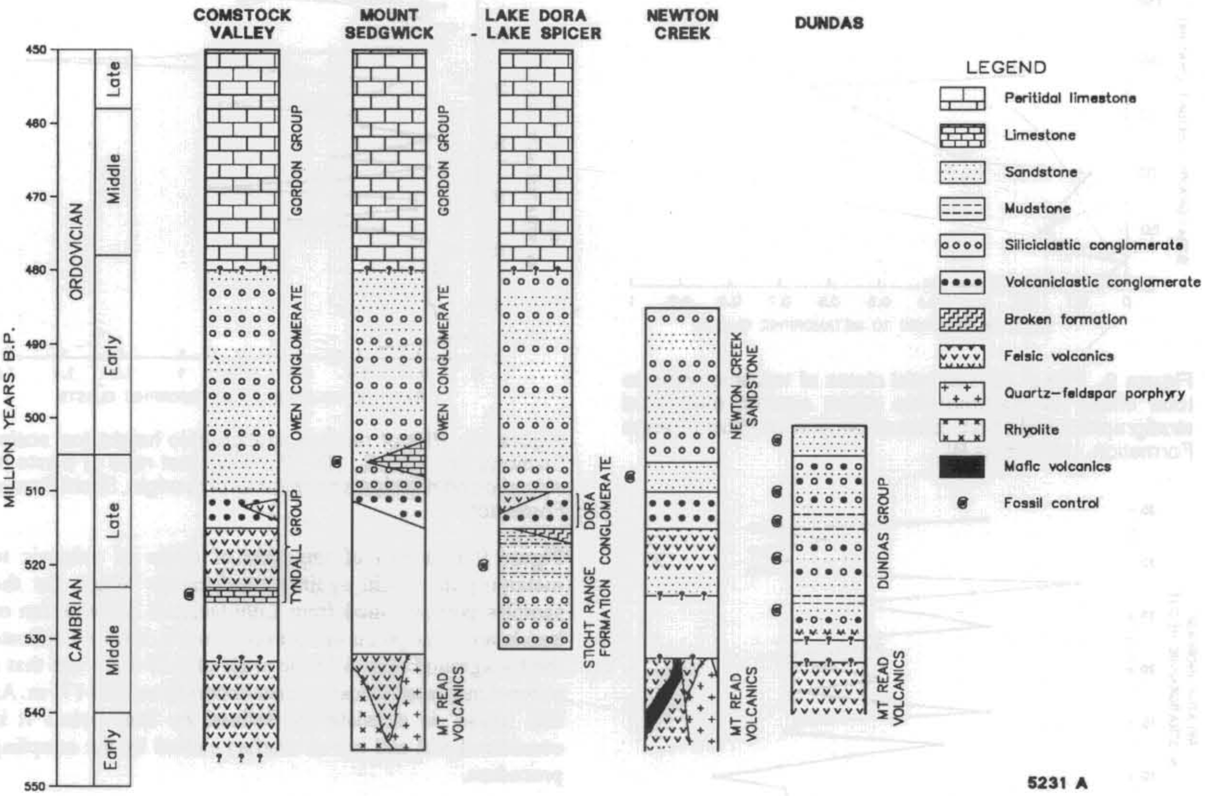

Figure 12. Time-space plot, compiled from various sources, of areas relevant to this study. Time scale is that of Harland *et.al.* (1982).

at 550 Ma, just before the Middle Cambrian, to 450 Ma or just after the Middle Ordovician and covering the region from the Comstock Valley, immediately north of Mt Lyell through the study area to Newton Peak and the Dundas area east of Zeehan.

The major problem in constructing the diagram is the assignment of an absolute age to sub-Tyndall Group volcanics in the Comstock Valley, Mt Sedgwick and Newton Creek areas. The rocks are unfossiliferous, and Rb-Sr total rock, U-Pb zircon and K-Ar dating of slates have shown that it is extremely difficult to obtain original crystallisation ages because of partial or complete resetting, contamination and isotopic loss (Adams *et al.*, 1985). Corbett (1981) considered that the bulk of the Mt Read volcanism occurred during the Middle and Late Cambrian and with a peak in the late Middle Cambrian and declining activity in early Late Cambrian times.

In the Comstock Valley, strongly altered and mineralised volcanics are overlain by fossiliferous limestone of latest Middle Cambrian age (Jago *et al.*, 1972), in turn overlain by the unmineralised Comstock Tuff. A time-break between the mineralised volcanics and the limestone is strongly implied and so the upper limit of emplacement of the volcanics probably occurred at about the middle of the Middle Cambrian.

In the Mt Sedgwick area a marked angular unconformity occurs between the abruptly westwards-thinning Dora Conglomerate and volcanics. The Comstock Tuff is absent, but it is likely that the volcanics are about the same age as those occurring a relatively short distance to the south in the Comstock Valley and Mt Lyell areas.

A similar lacuna (possibly an erosional hiatus) is also present in the Newton Creek area (Corbett, 1975), where an unconformity at the base of the Comstock Tuff correlate is indicated by an abrupt change in lithology and a difference in degree of alteration. It thus appears likely that the sub-Tyndall Group volcanics in this area are about the same age as those at Mt Sedgwick and the Comstock Valley.

It can be seen from Figure 12 that the Sticht Range Formation was deposited both during this regional hiatus and also during the pre-Dora Conglomerate Tyndall Group volcanicsm. It thus seems likely then that the source of volcanic detritus in the Sticht Range Formation involved:

(1) pre-existing volcanic rocks;

(2) partly contemporaneous (Tyndall Group) volcanics.

Furthermore, it is clear that the Sticht Range Formation is contemporaneous with part of the Dundas Group (fig. 12).

The Dundas Group lies to the west of the main Mt Read Volcanic belt, contains abundant felsic volcanic detritus, and has yielded fossils of middle Middle to latest Cambrian age (Jago, 1979; Brown, 1986). The Dundas Group succession generally faces west, and rests with depositional unconformity on the Mt Read Volcanics to the east of Mt Dundas (Corbett and Lees, 1987). The period of erosion which preceded depositon of the Dundas Group is probably analogous to the erosional interval which preceded Tyndall Group deposition in the Mt Lyell–Newton Creek region (Corbett and Lees, *op. cit.*).

The lower part of the Dundas Group consists of a basal interval of quartz and feldspar phyric tuffs and sedimentary rocks of submarine mass-flow origin (White Spur Formation of Corbett and Lees, *op. cit.*) overlain by a conglomerate-sandstone-mudstone succession ('Lower Dundas Group' of Brown, 1986) also largely of submarine mass-flow origin, but possibly shallowing upwards. The upper part of the Dundas Group also comprises a flysh-like succession of conglomerate, sandstone and mudstone, possibly containing shallow-water sediments near the top (Brown, 1986).

Figure 12 shows that there are strong similarities between the rock successions from the Comstock Valley, Mt Sedgwick, the Lake Dora– Lake Spicer area and Newton Creek, but that the succession at Dundas is somewhat different. It is noteworthy that the Dundas succession is separated from the others by the Henty Fault System (HFS), and that no Dundas Group rocks occur to the east of the HFS and no Tyndall Group rocks occur to the west of the HFS, although some rocks west of the HFS near the Hellyer mine look quite similar to typical Tyndall Group rocks (Dr G. R. Green, pers. comm., 1987).

The HFS cuts obliquely thorough the Mt Read belt and encloses a misfit wedge of sediments (of deep-water facies aspect), pillow lavas, gabbros and ultramafic rocks, which has been interpreted as the remnant of an inter-arc basin developed between two segments of a volcanic arc (Corbett and Lees, 1987). Lithological differences across and within the HFS, and the presence of unusual tholeiitic basalts and ultramafics suggest that the HFS may represent a suture between accreted terranes, consistent with the lithological and facies contrast between the Dundas Group rocks and those from the areas to the southeast of the HFS. Alternatively, it can be argued that the rocks of the Dundas area are merely deeper-water equivalents of the Sticht Range Formation and the Tyndall Group.

Environment of deposition and provenance of the Sticht Range Formation

The Sticht Range Formation is a grossly fining-upwards, transgressive, siliclastic mega-sequence composed of detritus derived from volcanic and metamorphic terrains. Corbett (1982) considered that the succession was at least partly marine, and that sedimentary structures indicated a variety of shallow-water and possibly deeper water (turbidite) environments. His study also showed that the Sticht Range sandstones had been derived partly from a volcanic source and partly from Precambrian metamorphic basement.

The present study has shown that the Sticht Range Formation consists of a variety of lithofacies, each corresponding to a different depositonal environment, but that overall the succession records a major transgression, commencing with a basal proximal alluvial-fan sequence (Lithofacies A), and passing upwards through distal alluvial-fan or braidplain deposits (Lithofacies B) and shallow-marine or tidal deposits (Lithofacies C, D) into deeper-water (shelf) deposits of sandstone/mudstone/siltstone in which there is abundant evidence of likely storm activity (Lithofacies E, F). An intraformational zone of disruption locally developed at the top of the succession is probably of sedimentary (?syntaphral) origin.

FLUVIAL DEPOSITS

Deposits of fluvial origin have been recognised both on the basis of their textural maturity and, more importantly, on the basis of palaeocurrent patterns. A total of 240 restored palaeocurrent vectors in the postulated alluvial-fan or braidplain lithofacies consistently indicate sediment- bearing currents which were derived from the north (fig. 5) and standard deviations for the various data-sets in the order of 30–60°. The data are in good agreement with work on current indicators in modern and ancient fluvial examples which demonstrate that directional variance increases with decreasing scale of the palaeocurrent indicators and that comparatively high consistency-ratios ('vector-strength') are characteristic of low-sinuousity fluvial systems (Allen, 1966; Miall, 1974).

Southward-directed palaeocurrents in the sandstones (Lithofacies B) are complemented by a northerly coarsening of the underlying coarser sediments (Lithofacies A) postulated to have been deposited in an alluvial-fan environment, although the apparent coarsening is not supported by any palaeocurrent data, and is also based on limited sampling.

Sediments in the inferred alluvial-fan facies are dominated by clast-supported conglomerate probably deposited by coalescing longitudinal gravel bars, whereas sporadic lenses of cross-bedded sandstone may have originated by dune migration in channels during low water (*cf.* Eriksson, 1978; Miall, 1985). Figure 13*a* is adapted from Miall (1985) and illustrates the depositional system envisaged for the alluvial-fan facies.

The finer-grained sediments of Lithofacies B, postulated to have been deposited on a distal alluvial-fan or braidplain are dominated by trough cross-bedded, commonly pebbly, sandstones commonly present in upward- fining cycles. There is no evidence for either point-bar or overbank sedimentation, and so vertical aggradation and mid-channel-bar and dune formation are likely to have been the dominant depositional processes (cf. Eriksson, 1978; Miall 1985; fig. 13*b*). The abundance of trough cross-bedding and the strongly unimodal palaeocurrent vectors (fig. 3, 5), together with the strong evidence of dominantly vertical aggradation are all in agreement with a low-sinuousity depositional environment (*cf.* Moody-Stuart, 1966; Eriksson, 1978).

Figure 14 is a block diagram illustrating the postulated palaeogeography during deposition of the lower part of the Sticht Range Formation and was constructed taking into account the known stratigraphic, sedimentological and petrographic data. The regional relationship of the Sticht Range Formation to the underlying basement rocks, together with the palaeocurrent data, suggest that the basin-fill pattern was by transverse alluvial-fans and longitudinal trunk streams. This type of sedimentation pattern occurs in tectonic settings which include graben, failed arms or aulacogens, fore-arc basins, retro-arc or foreland basins and peripheral or fore-deep basins (eg. Miall, 1981).

SHALLOW-MARINE DEPOSITS.

There is no discernably sharp stratigraphic boundary between rocks considered to have been deposited in a fluvial environment and those considered to have been deposited in a marginal marine or tidal environment: once again the most compelling evidence is from the palaeocurrent analysis where a bipolar sediment dispersal pattern is associated with an overall fining of average grainsize together with a corresponding decrease in bed-thickness (Lithofacies C; fig. 3).

Deltaic deposits might have formed at the interface between the fluvial system and the body of water into which the river system discharged. Given the strongly vertically-aggrading character of the fluvial Lithofacies B it is most probable that any river delta that might have formed was river- dominated and that rapid seaward progradation occurred. Braid deltas or fan-deltas form where braided rivers or alluvial-fans build or prograde into a standing body of water (Westcott and Ethridge, 1980; Galloway and Hobday, 1983; McPherson *et al.*, 1987). Fan-delta successions have a subaerial component that is an alluvial-fan facies comprising interbedded sheetflood, debris-flow, and braided-channel deposits, whereas braid deltas are gravel-rich deltas that form where a low-sinuosity fluvial system progrades into a standing body of water (McPherson *et al.*, 1987).

In pre-Devonian times braid deltas were probably the dominant type of river-dominated delta because of the absence of land vegetation. Lithofacies C, thus possibly represents braid delta deposits with deposition having occurred on sandy tidal-flats and distributary mouth bars.

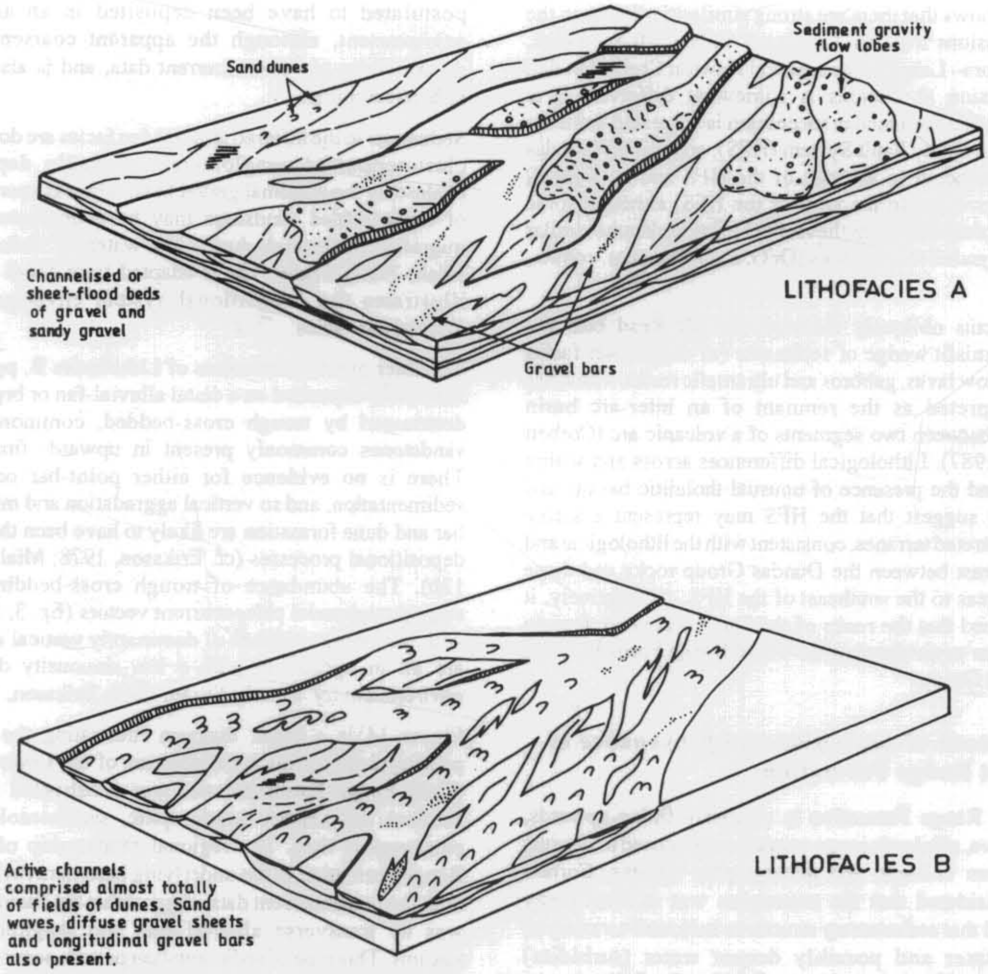

Figure 13. Postulated depositional model and foreset macroform elements for Lithofacies A and Lithofacies B, Sticht Range Formation (A: adapted from Miall, 1985, fig. 7; B: adapted from Miall, 1985, fig. 8).

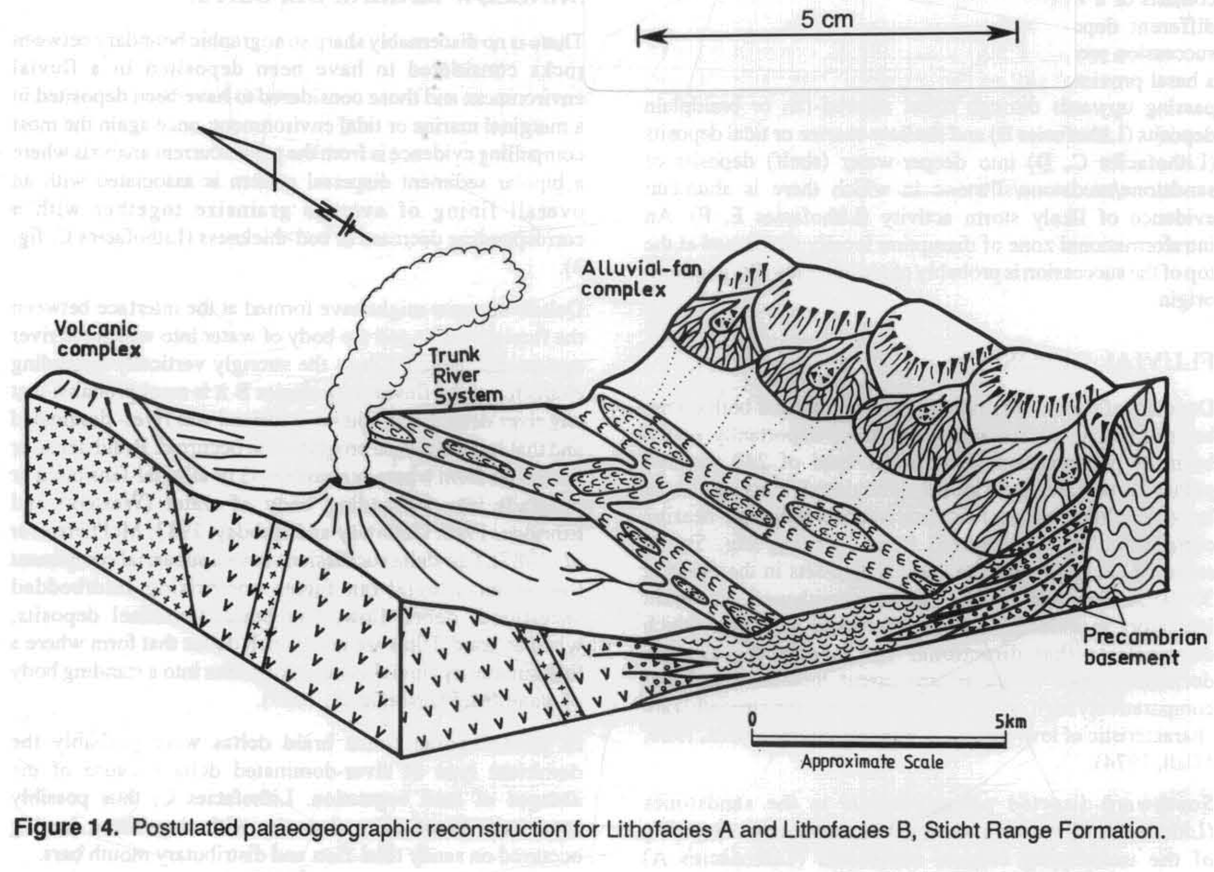

Figure 14. Postulated palaeogeographic reconstruction for Lithofacies A and Lithofacies B, Sticht Range Formation.

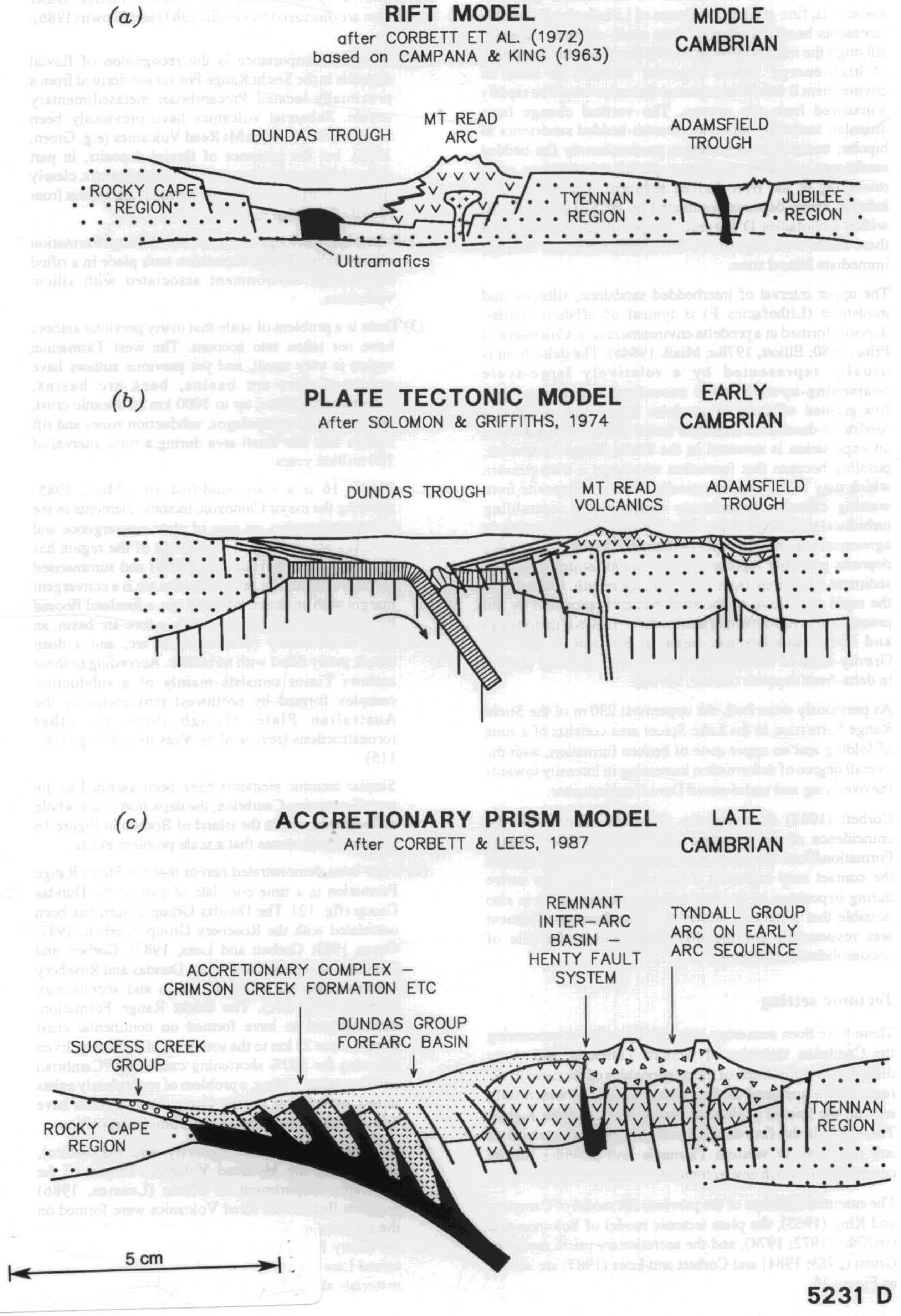

Figure 15. Schematic diagrams of (a) rift, (b) plate tectonic, and (c) accretionary models for Cambrian tectonic evolution of Western Tasmania.

The relatively thick successions of flat-bedded, generally micaceous, fine-grained sandstone of Lithofacies D possibly represents barrier washover sheet sands or beach deposits, although the mica content probably discounts the possibility of high-energy beach deposits because in such an environment it would be expected that mica would be rapidly winnowed from the system. The vertical change from unipolar, texturally less-mature cross-bedded sandstones to bipolar, texturally more-mature, predominantly flat-bedded sandstones probably represents partial or complete wave reworking of the river-derived sediment. The presence of inferred storm deposits dominated by HCS (Lithofacies E) within Lithofacies D suggests the possibility that some of these sands were deposited a little further offshore than the immediate littoral zone.

The upper interval of interbedded sandstone, siltstone and mudstone (Lithofacies F) is typical of offshore marine deposits formed in a prodelta environment (e.g. Coleman and Prior, 1980; Elliott, 1978*a*; Miall, 1984*b*). The delta-front is usually represented by a relatively large-scale coarsening-upward trend recording a passage from fine-grained offshore or prodelta facies upwards into a sandstone-dominated shoreline facies (Elliott, 1978*a*). Such an expectation is reversed in the Sticht Range Formation, possibly because that formation represents a transgression which may have been tectonically imposed. Deposits from waning currents (commonly superficially resembling turbidites) may occur in prodelta deposits (Elliott *op. cit.*), in agreement with similar deposits described herein. The coarser deposits probably represent flood- and/or storm-generated sediment incursions from a distributary mouth. Evidence of the rapid deposition of the sand bodies is provided by the presence of penecontemporaneous deformation (?thixotropy) and covolvute laminae seen in Section 3 (fig. 3). Gravity-induced bedding deformation is commonly present in delta-front deposits (Elliott, 1978*a*).

As previously described, the uppermost 230 m of the Sticht Range Formation in the Lake Spicer area consists of a zone of folding and an upper zone of broken formation, with the overall degree of deformation increasing in intensity towards the overlying and undeformed Dora Conglomerate.

Corbett (1982) described the disrupted zone, noted the coincidence of the disturbed zone with the Sticht Range Formation/Dora Conglomerate contact, and suggested that the contact may represent a fault zone which was active during deposition of the Sticht Range Formation. It is also possible that instability within the delta-front environment was responsible for the disruption within the pile of unconsolidated sediments.

Tectonic setting

There have been numerous previous hypotheses concerning the Cambrian tectonics of western Tasmania, and many different interpretations of the relationships of the rocks in the region have appeared in the literature, none of which fully explain the known geological characteristics of the region. This study is the first detailed sedimentological analysis of any rock unit in western Tasmania and provides further constraints to which any tectonic reconstruction must adhere.

The essential elements of the previous rift model of Campana and King (1963), the plate tectonic model of Solomon and Griffiths (1972; 1974), and the accretionary prism model of Green (1983; 1984) and Corbett and Lees (1987) are shown as Figure 15.

CONSTRAINTS ON A TECTONIC MODEL

As a result of the research presented herein, and other recent studies, certain new constraints arise which must be accomodated by any successful tectonic model. Other constraints are discussed by Green (1983) and Brown (1986).

(1) Of critical importance is the recognition of fluvial deposits in the Sticht Range Formation derived from a proximally-located Precambrian metasedimentary terrain. Subaerial volcanics have previously been recognised within the Mt Read Volcanics (e.g. Green, 1983), but the presence of fluvial deposits, in part derived from contemporaneous volcanic rocks, clearly indicates the presence of continental crust, at least from Middle Cambrian times.

(2) Petrographic evidence from the Sticht Range Formation clearly indicates that deposition took place in a rifted continental environment associated with silicic volcanism.

(3) There is a problem of scale that many previous authors have not taken into account. The west Tasmanian region is very small, and yet previous authors have crammed fore-arc basins, back-arc basins, accretionary prisms, up to 1000 km of oceanic crust, volcanic arcs, archipelagos, subduction zones and rift valleys into this small area during a time interval of 100 million years.

Figure 16 is a map (modified after Miall, 1985) showing the major Cainozoic tectonic elements in the Indonesian region, an area of plate convergence and complex arc-geology. The geology of the region has been discussed by Hamilton (1979) and summarised in Miall (1985). The Java - Sumatra arc is a convergent margin with an active volcanic arc, a foreland floored by continental crust to the north, a fore-arc basin, an outer accretionary (non-volcanic) arc, and a deep trench partly filled with turbidites. According to these authors Timor consists mainly of a subduction complex formed by northwest movements of the Australian Plate, though there are other reconstructions (reviewed by Veevers, 1984, p. 106–115)

Similar tectonic elements have been ascribed to the west Tasmanian Cambrian; the depiction of the whole of Tasmania within the island of Borneo in Figure 16 clearly demonstrates that a scale problem exists.

(4) It has been demonstrated herein that the Sticht Range Formation is a time correlate of part of the Dundas Group (fig. 12). The Dundas Group in turn has been correlated with the Rosebery Group (Corbett, 1981; Green 1983; Corbett and Lees, 1987). Corbett and Lees (*op. cit.*) postulate that the Dundas and Rosebery Groups represent a fore-arc basin and accretionary complex (fig. 15*c*). The Sticht Range Formation, demonstrated to have formed on continental crust occurs some 25 km to the southeast of Rosebery. Even allowing for 100% shortening caused by ?Cambrian and Devonian folding, a problem of scale clearly exists unless movements on the Henty Fault System have brought vastly disparate regions into juxtaposition.

(5) Geophysical evidence (gravity and magnetics), acquired for the Mt Read Volcanics Project of the Tasmania Department of Mines (Leaman, 1986) suggests that the Mt Read Volcanics were formed on the eastern shoulder of a deep continental rift, and that the Henty Fault System is a folded thrust of Middle to/and Late Cambrian age which has offset and raised materials along the east side of the rift.

DISCUSSION AND TECTONIC MODEL

Previous tectonic models for the Cambrian of western Tasmania fall into two groups:

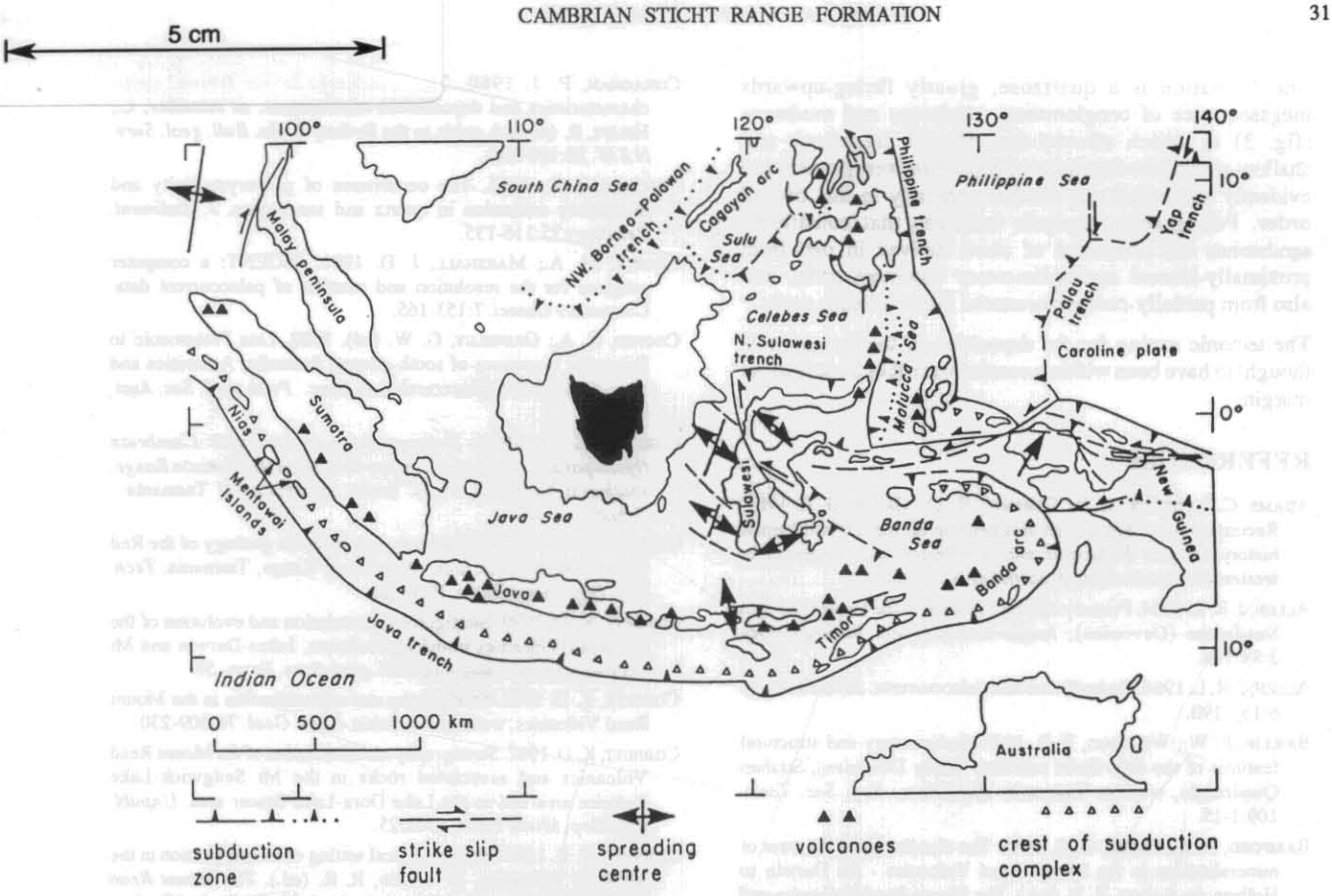

Figure 16. Major Cainozoic tectonic elements in the Indonesian region with overlay of Tasmania for relative scale (modified after Miall, 1984a, fig. 9.17).

(1) During (at least part of) Cambrian times western Tasmania **was** the site of a subduction zone (*cf.* fig. 15*b, c*).

(2) During (at least part of) Cambrian times western Tasmania **was not** the site of a subduction zone (*cf.* fig. 15*a*).

The subduction zone models have been proposed in an attempt to place the geology of the region into an actualistic model based on research into modern arc genesis, and largely because certain geological characteristics of the region are not readily explained by the more simple rift model.

Each of the major studies is a point on a continuing learning curve, in which additional constraints are placed on tectonic modelling which in turn must be considered by any future modelling. For example, the recent work of Brown (1986) resulted in new constraints, including the character of the early Dundas Trough Success Group sedimentation; the chemical nature of tholeiitic to andesitic volcanic rocks; the regional setting of high-magnesian andesite and chemical and petrological characteristics of the ultramafic rocks. The present study has resulted in still further constraints as previously discussed.

It has been shown that the basal part of the Sticht Range Formation consists of alluvial-fan and fluvial deposits derived in part from proximally-located continental basement rocks, and also from partially-contemporaneous 'Andean'-type volcanics. Given the small scale of the region it is likely that there was not room for oceanic crust to develop and that the Sticht Range Formation may have been deposited within a half-graben formed in a major rift in an extensional environment.

Recent geophysical work (Leaman, 1986) has shown that many of the Precambrian regions of western Tasmania are of variable thickness and are interpreted as parts of disrupted thrust sheets. Major faults, including the Great Lyell and Henty systems, are also interpreted as folded thrusts and the sense of movement on all Cambrian detachments appears to be west to east. Leaman (*op. cit.*) suggests that major Cambrian tectonism (dominantly thrusting) was followed by an increasingly stable regime until the Devonian.

There are, however, many similarities between the fault patterns of western Tasmania and strike-slip duplexes and imbricate thrust systems (Woodcock and Fischer, 1986; Mitra, 1986) and also with detachment faults developed in continental extensional terrains (Gibbs, 1984; Lister *et al.*, 1986). Clearly much detailed work is still needed, and one of the major problems will be to differentiate between structures developed during the Cambrian and those developed during the Devonian.

Detailed sedimentological analysis of major sedimentary units such as the Success Creek Group,the Crimson Creek Formation, the Rosebery Group and the Dundas Group would provide much useful information about the geological development of the region and help provide further constraints on tectonic modelling as has been demonstrated herein.

SUMMARY

The Sticht Range Formation, of probable late Middle Cambrian age, is separated from underlying Upper Proterozoic metasedimentary successions by an angular unconformity and occurs along the eastern margin of the Mt Read Volcanics in central-western Tasmania from the western slopes of the Sticht Range south to Lake Beatrice. The formation is best developed between Lake Spicer and Varnished Gum Hill (fig. 1) where it reaches a maximum thickness of about 1.2 km.

The formation is a quartzose, grossly fining-upwards megasequence of conglomerate, sandstone and mudstone (fig. 3) in which alluvial-fan, fluvial, nearshore and shallow-marine environments of deposition were present, and evidently succeeded one another vertically in that overall order. Petrographic analysis indicates that constituent sandstones are comprised of clasts derived in part from proximally-located metasedimentary basement rocks, and also from partially-contemporaneous felsic volcanic rocks.

The tectonic setting for the deposition of the formation is thought to have been within a continental rift or a continental margin.

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