



The Ironbound Group of southern Tasmania; new data bearing on the Cambro-Ordovician relationship between Tasmania and northern Victoria Land, Antarctica

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Abstract

In the Ironbound Range of Southern Tasmania a probable Cambrian to latest Cambrian proximal fan sequence (Ironbound Group) apparently overlies, with a landscape unconformity, low-grade, polydeformed Precambrian metaquartzite, metaconglomerate, and pelite beds. The Ironbound Group consists of three formations: the basal Havelock Bluff Formation and the overlying flysch of the Lousy Bay and Purrar Point Formations. The Purrar Point Formation was deposited in a submarine fan channel within the Lousy Bay Formation. These rocks are overlain, apparently conformably, by siliciclastic rocks correlated with the latest Cambrian-Ordovician Denison Group.

Tectonic considerations suggest that the Ironbound Group is contemporaneous with the Mariner Group of northern Victoria Land. Palaeocurrent indicators in the Ironbound Group indicate a continental source to the southeast which would separate the two contemporaneous depocentres; this continental mass could be the South Tasman Rise.

INTRODUCTION

The recent series of West German, Italian and New Zealand expeditions to northern Victoria Land and the extensive studies carried out under the auspices of the 1981/82 International Northern Victoria Land Project (USA-NZ-Australia) have led to numerous attempts to interpret the Cambro-Ordovician geology of this Southwest Pacific sector of Gondwana in terms of plate tectonics (*cf.* Weaver *et al.*, 1984; Burrett and Findlay, 1984; Gibson and Wright, 1985; Findlay, 1987a; Borg and Stump, 1987; Kleinschmidt and Tessensohn, 1987). Although it is well established that Tasmania formed part of the Pacific margin of Gondwana between Devonian and Cretaceous times, when it was probably located off the present northern to northeastern coast of

northern Victoria Land (Grindley and Davey, 1982), Tasmania's pre-Devonian situation with respect to Antarctica is less well understood.

Past interpretations (Laird *et al.*, 1977; Jago, 1981; Laird, 1981; Burrett and Findlay, 1984; Baillie, 1985) have suggested that Tasmania lay adjacent to northern Victoria Land in Cambrian and Ordovician times (fig. 1). If this is the case, any tectonic interpretation for the Cambro-Ordovician rocks of northern Victoria Land must take into account tectonic interpretations for the Cambro-Ordovician sequences in Tasmania; the converse also applies. It is therefore necessary to closely assess the possible correlations between the pre-Devonian sequences of southern Tasmania and northern Victoria Land.

The present study was intended to investigate the rocks in the Ironbound Range, which are shown as 'comparatively unmetamorphosed Precambrian' on the first edition of the 1:500 000 *Geology of Tasmania* map produced by the then Tasmania Department of Mines in 1976. These supposedly Precambrian rocks had been correlated by Burrett and Findlay (1984) with the Antarctic Millen Range schist described previously by Findlay and Field (1983). The present study has demonstrated that Burrett and Findlay's correlation is not correct but does support the previously unrealised possible existence of a continental land mass between Tasmania and northern Victoria Land during the Mid to Late Cambrian.

The study region (fig. 2) comprises the heavily bush-clad southern flanks of the Ironbound Range in southwest Tasmania, and extends to New River Lagoon. Initial work in the Ironbound Range identified as Precambrian (Hall, 1966; see also Farmer, 1979) beds of unmetamorphosed breccia, conglomerate, sandstone and siltstone, here named the Ironbound Group and now found to rest unconformably on

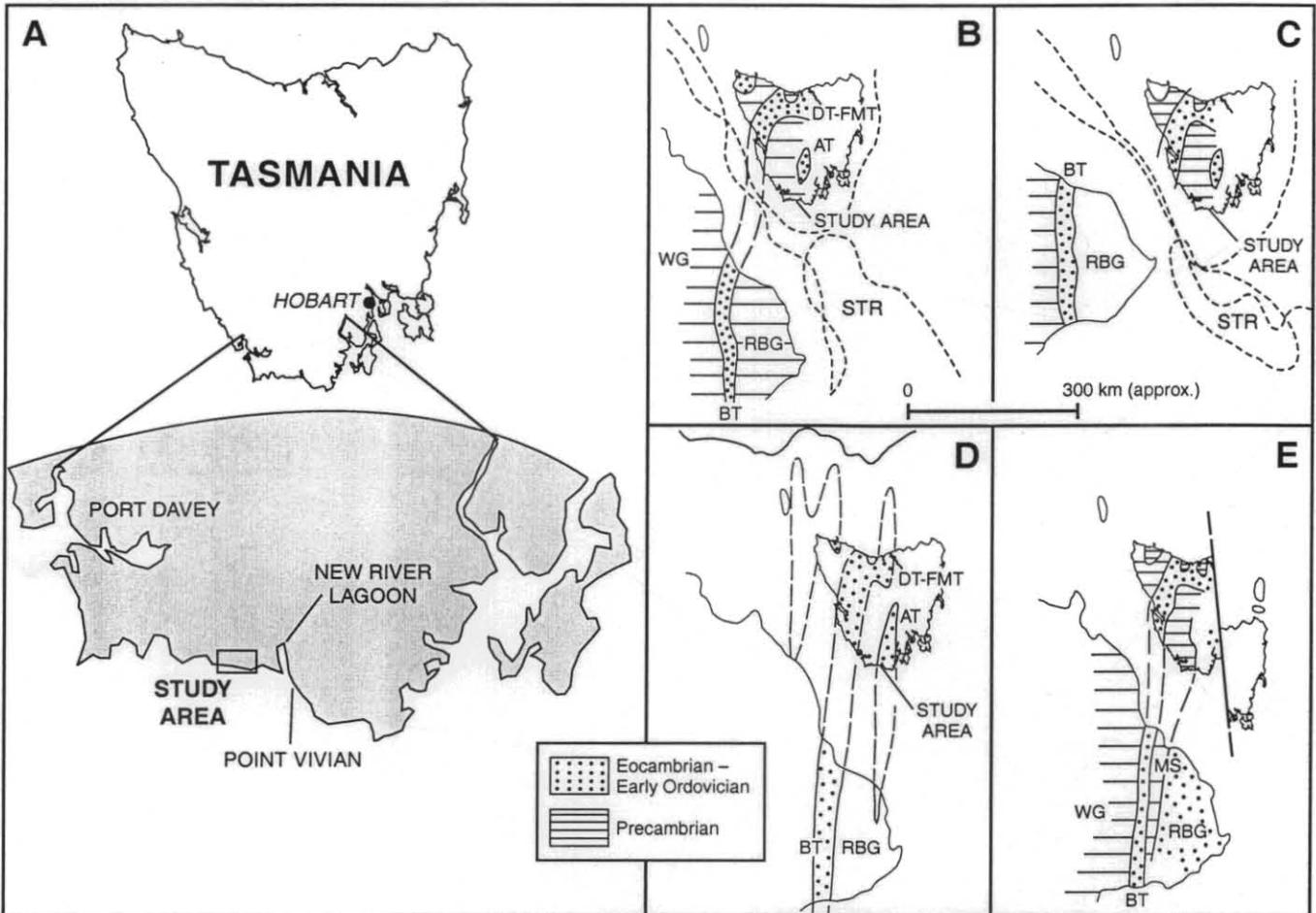


Figure 1

Location map of study area (a) and plate tectonic reconstructions of Tasmania and northern Victoria Land, Antarctica, during Cambrian-Devonian times (b, c, d, e).

From: (b) Laird et al. (1977); (c) Jago (1981); (d) Laird (1981); (e) Burrett and Findlay (1984).

Names for rock units/depositcentres as from these authors: DT-FMT = Dundas Trough-Fossey Mountains Trough; BT = Bowers Trough; WG = Wilson Group; RGB = Robertson Bay Group; AT = Adamsfield Trough; MS = Millen Range schist; STR = South Tasman Rise. Arrow shows study area. Close hatched lines show continental margin as drawn in originals. Broken lines show correlation of units proposed by authors. Age assignments are as given by original authors.

metamorphosed Precambrian rocks. As will be discussed later, the Ironbound Group is probably of Cambrian age (see also Jennings, 1961).

Early work east of the study region (Twelvetrees, 1915; Blake, 1938) described a small area near Point Vivian (fig. 1) underlain by a Cambro-Ordovician sequence. Twelvetrees (1915) reported serpentinite within this sequence and Banks (1959; 1962) reported trace fossils and spicules of *Protospongia* from the sedimentary rocks. The Point Vivian region was revisited by Berry and Harley (1983), who described the stratigraphy and structure of the area. Bischoff (1983) extended this work to produce a detailed description of the sedimentology of these Cambro-Ordovician rocks.

For the purposes of this study the coastline between New River Lagoon and Havelock Bluff (fig. 2) and the summit ridge of the Ironbound Range were mapped. As the sequences in the Ironbound Range are separated from those in the Point Vivian region by a major fault zone striking south through New River Lagoon (Berry

and Harley, 1983; Bischoff, 1983) a lithostratigraphic nomenclature unique to this study area was developed.

The oldest rocks in the region are polydeformed schistose quartzite beds, lesser conglomeratic beds, and thin pelitic units. These are mapped as Precambrian metamorphic rocks in the 1:500 000 scale *Geology of Tasmania* and are of lowest greenschist facies grade of metamorphism. They are overlain unconformably by the probable Cambrian rocks described below as the Ironbound Group.

The Ironbound Group consists of three formations:

1. Havelock Bluff Formation;
2. Lousy Bay Formation; and
3. Purrar Point Formation, which forms a lense within the Lousy Bay Formation.

These rocks are overlain with an apparent conformity by a coarse, probably Late Cambrian to Ordovician

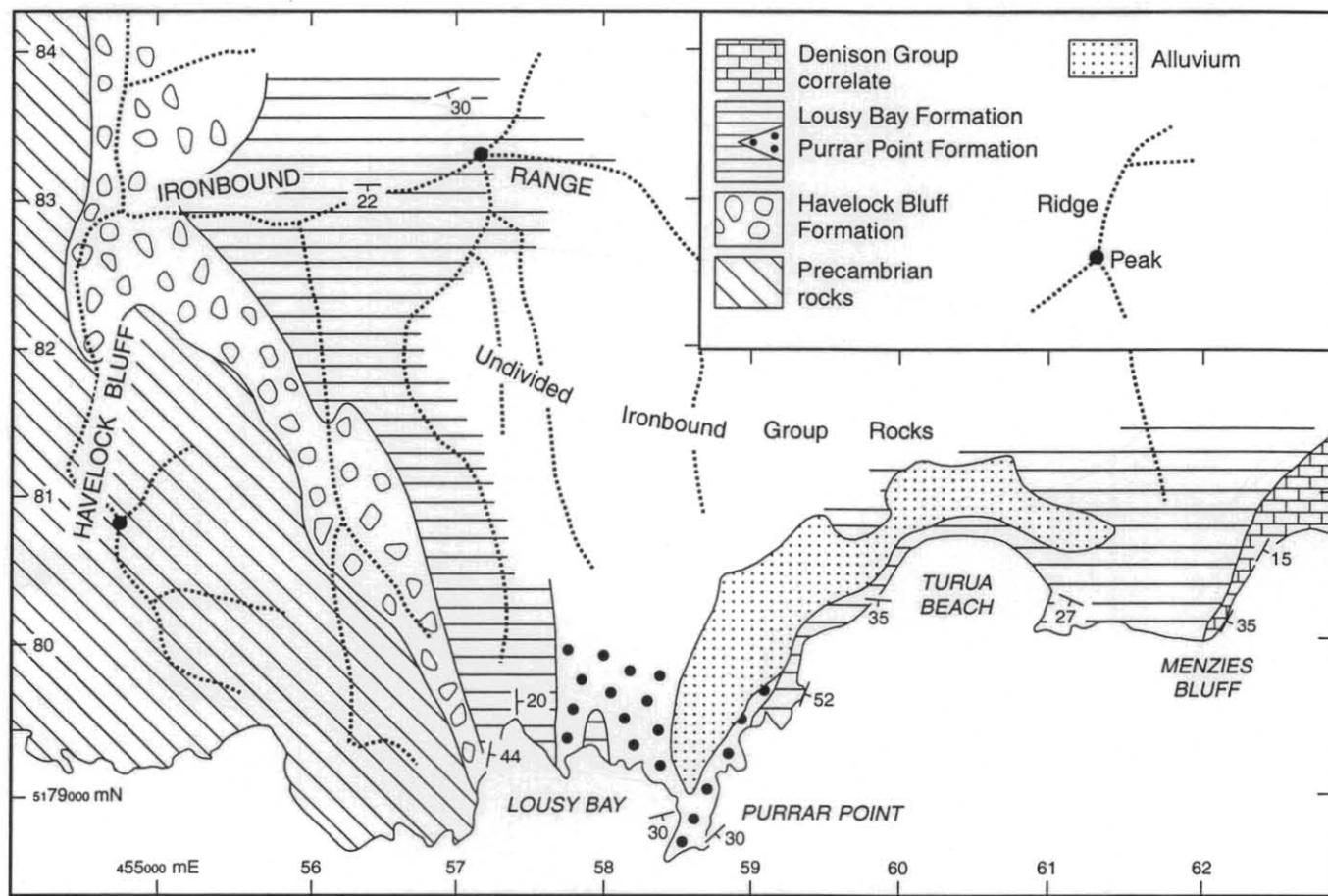


Figure 2 5 cm

Geological sketch map of study area showing rock distribution and simplified structural geology.

siliciclastic sequence assigned on lithological grounds to the Denison Group of the Wurawina Supergroup.

Three post-lithification deformations have been recognised in the Ironbound Group:

- D1. early thrusting of uncertain extent;
- D2. upright folding about north-trending axes;
- D3. upright warps about E-W axes.

Serpentinite-filled faults are known at one locality and may be related either to the thrusting, or may be younger structures.

No fossils are known in the Ironbound Group. The age range of the Group is thought to be between Middle Cambrian and latest Cambrian as:

1. the presence of serpentinite detritus throughout is supportive of a Middle or Late Cambrian age by analogy with other areas of Tasmania (see Rubenach, 1974);
2. the Ironbound Group is overlain by a siliciclastic sequence typical of dated Late Cambrian to Ordovician siliciclastic sequences common throughout western Tasmania;
3. clasts of felsic volcanic rocks occur sporadically within the sedimentary rocks and such volcanic

rocks of Middle to Late Cambrian age are well known in western Tasmania;

4. Banks (1959) reported a Cambrian sponge spicule in the Tyler Creek Beds east of New River Lagoon, and the Tyler Creek Beds lithologically resemble rocks of the Ironbound Group;

LITHOSTRATIGRAPHY AND SEDIMENTOLOGY

Ironbound Group

Havelock Bluff Formation

This formation, which consists of a basal breccia overlain by pink granule conglomerate with quartzite beds, is exposed between the eastern seaward end of Havelock Bluff and grid reference DM544826. According to the possible width of the sequence in the summit ridge of the Ironbound Range, the formation is no thicker than 300 metres.

The basal breccia overlies the metamorphosed Precambrian rocks with a landscape unconformity and grades up into the granule conglomerate/quartzite series.

The basal breccia, although apparently massive, contains lenses of coarse to granule-sized quartz sandstone, as well as lenses of coarser quartzitic

pebbles in the otherwise more fine-grained quartz-pebble conglomerate beds. The dominant clasts are schistose quartzite, which are typical of the underlying polydeformed Precambrian metamorphic rocks. Metaquartzitic cobble and boulder conglomerate beds are also present low in the sequence, while large blocks occur at the base of the sequence (Plate 1). Other clasts include rare phyllite and one 300×30 mm piece of hematite-magnetite, the source of which is not known.

The basal breccia fines upwards, through clast and matrix-supported quartz-pebble conglomerate beds with a red, quartzitic matrix, to a unit dominated by pink-weathering quartzitic beds. The lower part of this sequence is formed by units containing granule-sized clasts in a medium to coarse-grained quartzitic matrix. The coarser clasts are subangular with a low sphericity and are clast supported. The upper part of the unit consists of medium to coarse-grained pink quartzite. There is no obvious grading, cross bedding, ripples, or internal lamination, and there are no siltstone intervals. The beds exposed at grid reference 454 400 mE, 5 182 600 mN thin upwards from 450 mm to 15 mm thick over a four metre interval.

Sedimentological interpretation

The basal breccia is interpreted as a locally-derived breccia formed along a coastline of Precambrian metamorphic rocks. The fining-upwards nature is indicative of reduction in the palaeorelief and reworking of the locally-derived detritus to ultimately form the pink quartzite series of the upper part of the formation. Unlike the overlying units, the formation contains only locally-derived material.

Lousy Bay Formation

The Lousy Bay Formation succeeds, apparently conformably, the Havelock Bluff Formation and is exposed in the northern and western part of the summit ridge of the Ironbound Range as well as at Lousy Bay and along Turua Beach (fig. 2). A minimum thickness of 600 m is exposed in the summit ridge of the Ironbound Range. The contact between the Lousy Bay and Havelock Bluff Formations is not exposed, and the two formations contrast markedly in sedimentology and petrology.

The lower part of the formation, as seen in the ridge of the Ironbound Range, consists predominantly of medium-grained quartz-rich lithic sandstone interbedded with thinly laminated, fine and coarse-grained sandstone (Plate 2a). Although the sandstone beds appear to be massive in many of the coastal exposures, some of the weathered sandstone beds in the summit ridge of the Ironbound Range display size grading and convolute, parallel, and ripple laminations, and low angle cross bedding with a truncated top (Plate 2b). Sorting of clasts according to size is poor; all beds are polymict. Sandstone dykes and sills are rare, although some massive sandstone beds contain trains of elongate, angular to rounded clasts of siltstone floating in sandstone, suggestive of the

liquefaction and amalgamation of sandstone beds formerly separated by siltstone. Bouma intervals ABCD, AEF, and ACDEF have been recognised in some beds, these features being consistent with a turbiditic origin.

Beds of disorganised conglomerate (Plate 2c) are common in the lower part of the formation in Lousy Bay, but appear to be very sparse and thin in the Ironbound Range summit ridge and are unknown along Turua Beach. These conglomerates are ill sorted and commonly matrix-supported. Although pebbles are dominant, the size of the clasts ranges from infrequent sub-angular cobbles to granules. The clast content includes sub-spherical to non-spherical serpentinite; red, grey, and white quartzite; vein quartz; rare quartz porphyry; flow-banded rhyolite; basalt; and grey siltstone and fine sandstone, rare grey dolomite, black and red chert, and purple fine sandstone.

The conglomerate beds are commonly massive, such as that exposed in Lousy Bay at grid reference 457 300 mE, 5 179 500 mN. Some are crudely stratified, and one bed fines upwards. The massive conglomerate at 457 300 mE, 5 179 500 mN is overlain by sandstone beds which contain dish structures and fining-upwards, 150–200 mm thick, granule to fine-pebble conglomerate of identical composition to the underlying massive conglomerate.

The sequence becomes dominated by packets of sandstone interbedded with packets of siltstone some 300 m above the base. This part of the sequence consists of interbedded siltstone and sandstone in the approximate ratio of 50:50 (fig. 3). Six coarsening-up cycles are evident within this part of the formation in the summit ridge of the Ironbound Range. The sandstone beds range in grain size from fine sand to granule. Some sandstone beds display characteristics of deposition by turbidity currents, whereas others display features indicative of grain flow. Sand volcanoes, clastic dykes and clastic sills are also present. Evidence for welding and amalgamation of sandstone beds is common (see below).

Common sedimentary structures in the pelite-dominated intervals include:

- parallel bedding often containing thin, plane parallel laminae of fine-grained to medium-grained sandstone;
- trains of isolated ripples which are formed of medium-grained sandstone and which may have amplitudes as great as 70 mm and wavelengths as long as 150 mm;
- 40 mm thick coarse-grained to medium-grained graded sandstone beds; and
- clastic dykes of sandstone.

Plate 1

Havelock Bluff Formation, showing the basal breccia.



5 cm



Plate 2

- (a) *Lousy Bay Formation; apparently massive sandstone with fine sandstone/siltstone partings. East end, Lousy Bay.*
- (b) *Lousy Bay Formation; graded bedded sandstone with convolute lamination, plane parallel lamination, ripple lamination, and siltstone at top overlain by pelitic unit. Ironbound Range summit ridge.*
- (c) *Lousy Bay Formation; disorganised conglomerate. West end of Lousy Bay.*

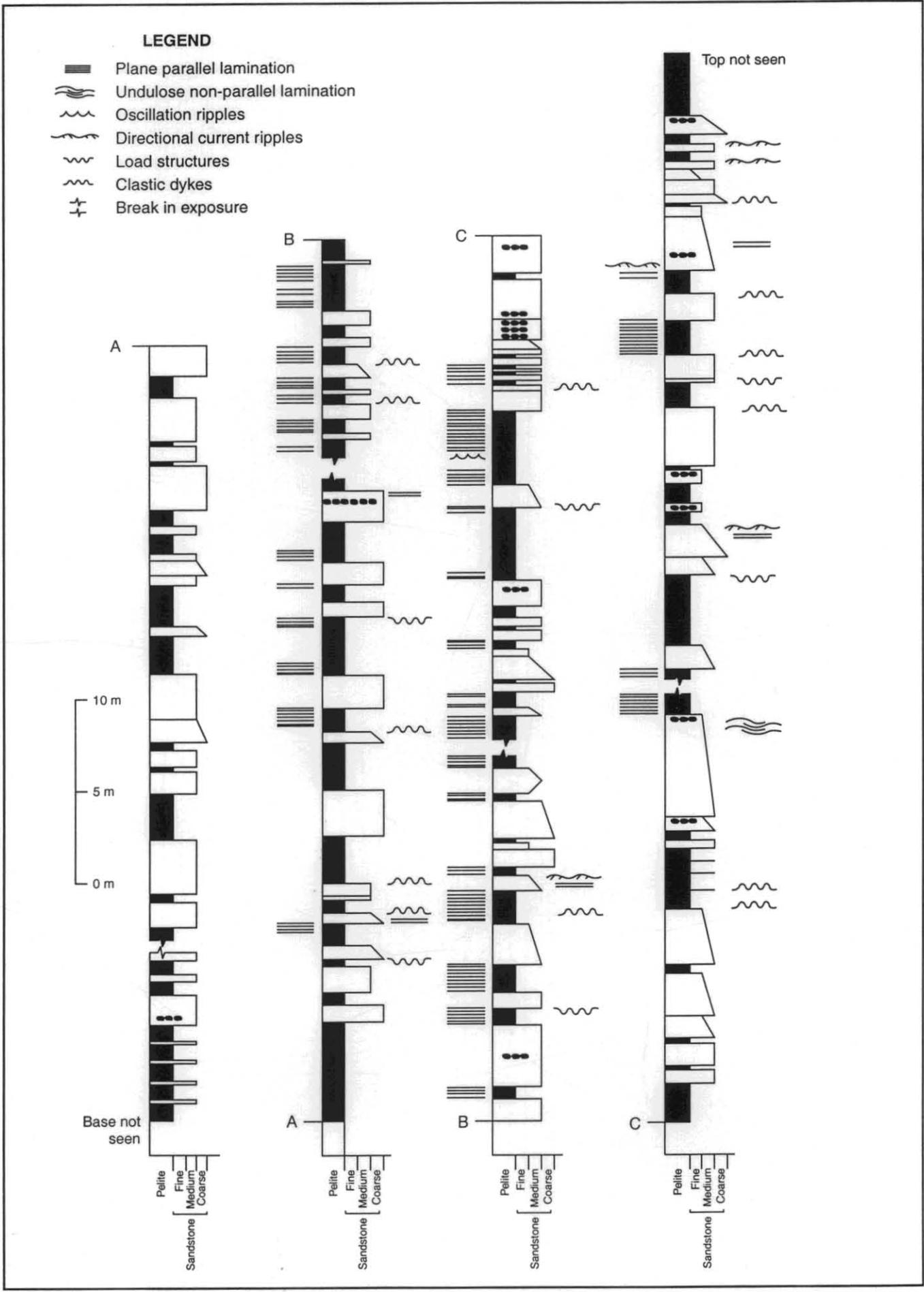


Figure 3

Measured section within the Lousy Bay Formation at Turua Beach.

In many cases, 50–100 mm thick beds of siltstone can be followed laterally into increasingly disorganised trains of siltstone clasts within massive sandstone beds.

The sandstone is invariably polymict and some beds contain quartz grains, considerable white mica, grains of quartzite and mica schist, and bleached brown biotite. In contrast others also contain clasts of mafic lava (with vesicles), serpentinite, much chlorite, possible diorite, green biotite, grains of microcrystalline quartz, myrmekite, perthite, plagioclase, strained to sutured quartz, basalt, tourmaline, felsic volcanic rock, possible fuchsite, clasts of ribbon quartz (mylonite), quartz sandstone, and possible gabbro or dolerite.

The uppermost part of the Lousy Bay Formation is exposed at Menzies Bluff, where the typically grey-green flysch sequence grades rapidly into interbedded red siltstone and sandstone. These red beds form a coarsening-up sequence (fig. 4) which is replaced, apparently conformably but abruptly, by coarse, white, vein quartz and quartz-cobble conglomerate and quartzite of the overlying Denison Group correlate. Some sandstone beds within the red beds grade up from a generally coarse but polymodal base, whereas others are massive or crudely stratified. One massive sandstone contains evidence for bioturbation.

The red siltstone beds of this sequence are commonly featureless, although some horizons contain fine-grained to coarse-grained sandstone layers as fine plane-parallel laminations. Also present are sparse trains of low-amplitude long-wavelength isolated and connected ripples.

Sedimentological interpretation

Although inferred to overlie the Havelock Bluff Formation conformably, the Lousy Bay Formation represents a marked change in the sedimentological environment. The sandstone beds appear typical of a proximal fan sequence (e.g. Mutti and Ricci Lucchi, 1978) in which the lenses of disorganised conglomerate are interpreted as debris flows. Palaeocurrent indicators (fig. 5) in the sandstone units from the lower part of the formation indicate a source to the southwest to west, although transport from the east is indicated in the siltstone beds at Turua Beach. These latter units may indicate the general water flow, whereas the palaeocurrent directions from the sandstone beds would give the overall source region for the sediments.

The Lousy Bay Formation represents an increasing diversity of the rock types being eroded. The clast content of the lithicwacke sandstone beds would be characteristic of a west Tasmanian source to the north, were it not for the palaeocurrent indicators within the sandstone beds and also within the Purrar Point Formation; this is discussed more fully later.

Ripples within the red siltstone beds at Menzies Bluff also indicate transport from an eastern to southeastern

source, in marked contrast to the overlying beds of the Denison Group correlate in which a southerly transport direction is exhibited (fig. 5). These red beds are thought to indicate a shallowing of water depth, in relation to the onset of regional Late Cambrian uplift which saw the production of the voluminous siliciclastic rocks of the Wurawina Supergroup (see Burrett and Martin, 1989).

Purarr Point Formation

The Purrar Point Formation does not occur in the summit ridge of the Ironbound Range but is well exposed along the coast between Purrar Point and grid reference 457 800 mE, 5 179 300 mN, where a minimum thickness is of the order of 100–150 metres. The formation consists of two parts, one dominated by coarse sandstone and conglomerate beds and the other by laminated siltstone beds. The coarse sandstone and conglomerate beds are best exposed between 455 800 mE, 5 179 600 mN and 457 800 mE, 5 159 300 mN, where the upper and lower parts of the sequence are dominated by sandstone beds with relatively minor conglomeratic horizons, in contrast to the middle part which is dominated by conglomeratic beds.

The sandstone beds are commonly never thicker than two metres and are lenticular across distances of 100–150 metres. They are generally medium to coarse-grained. Their sedimentary structures include plane-parallel lamination, tabular cross bedding, trough cross bedding, and small scours with granule to fine-pebble lag deposits. Isolated pebbles and cobbles, and small clusters of the same (Plate 3), are also common in the sandstone beds. Small scours have formed around such clasts and occur on the opposite side of an elongate raised ridge of sandstone tailing away from the coarse clasts. This constitutes a current lineation which remains remarkably uniform throughout the unit and, corresponding with palaeocurrent directions derived from shallow foresets and asymmetric ripples, confirms a southeastern provenance (fig. 5).

The upper, sandstone-dominated, part of the sequence is formed of 60–80 m of sandstone horizons which thin upwards from one metre to 200 mm. These beds grade up and laterally into the unit dominated by laminated siltstone beds.

The clasts in the sandstone beds are dominantly rounded to angular, weakly strained to sutured quartz; rounded quartzite; angular to rounded microcrystalline quartz (chert?); brown devitrified glass; rare white mica; ribboned quartzite; rare mica schist; rare plagioclase; rare biotite; rare clinozoisite; non-schistose quartzite; possible myrmekite; rare tourmaline; and secondary calcite. The volcanoclastic content is much reduced in comparison to the Lousy Bay Formation.

The middle part of the sandstone and conglomeratic sequence is dominated by coarse, commonly lensoidal,

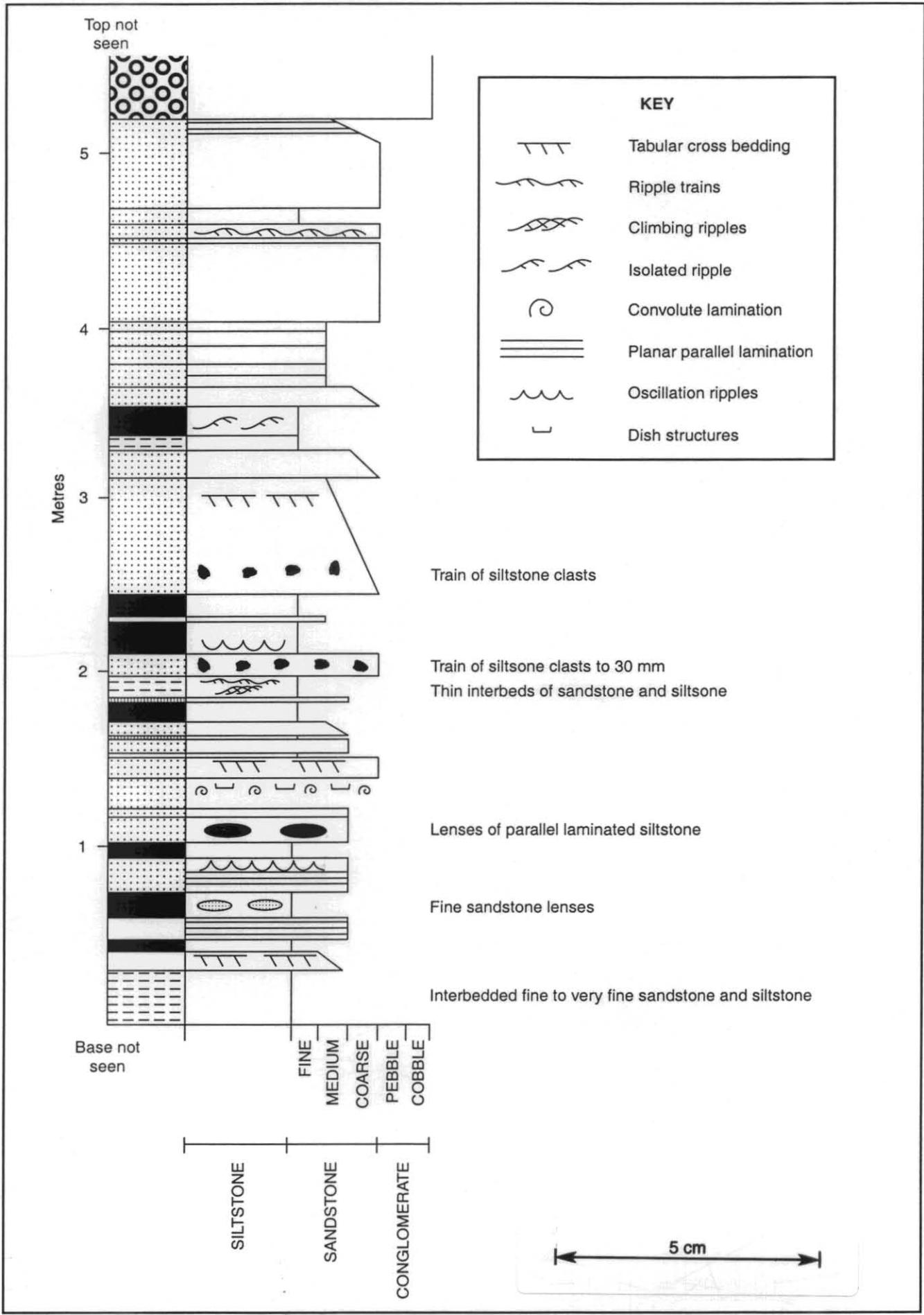


Figure 4

Measured section of red bed sequence, Lousy Bay Formation at Menzies Bluff.

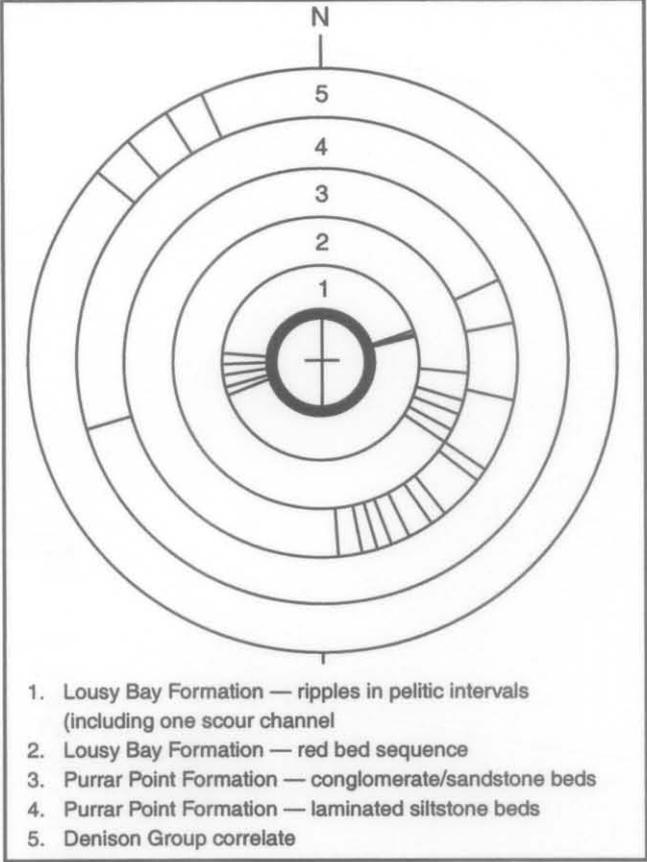


Figure 5

Measured palaeocurrent directions

polymict, stratified to poorly-stratified conglomerate units interbedded with lensoidal coarse to very coarse-grained sandstone beds.

Within this sequence are six notably disorganised conglomerate beds, each about one metre thick. These are typically non-stratified, ill sorted, clast-supported polymodal and polymict, with a clast assemblage similar to that described above. These units form distinct, regular planar beds (Plate 4) within the otherwise less regular, commonly lensoidal, conglomeratic layers of the series. Only one of the six beds is slightly lensoid; the upper two coarsen upwards, and only the fifth bed shows any imbrication of clasts.

The conglomerate beds are commonly clast-supported and poorly sorted to non-sorted. Clast content comprises serpentinite, serpentinite-bearing conglomerate, rounded to subangular white quartzite, dolomite, pink quartzite, laminated siltstone clasts, purple-weathering siliceous conglomerate, and pebbles and cobbles of fine-pebble conglomerate with well-rounded quartzite clasts.

The laminated siltstone beds (Plate 5) are best exposed along the eastern side of Purrar Point. They contain medium to coarse-grained sandstone beds about 25 to 40 mm thick, interbedded with thin grey siltstone alternating with thin fine-grained to medium-grained sandstone.

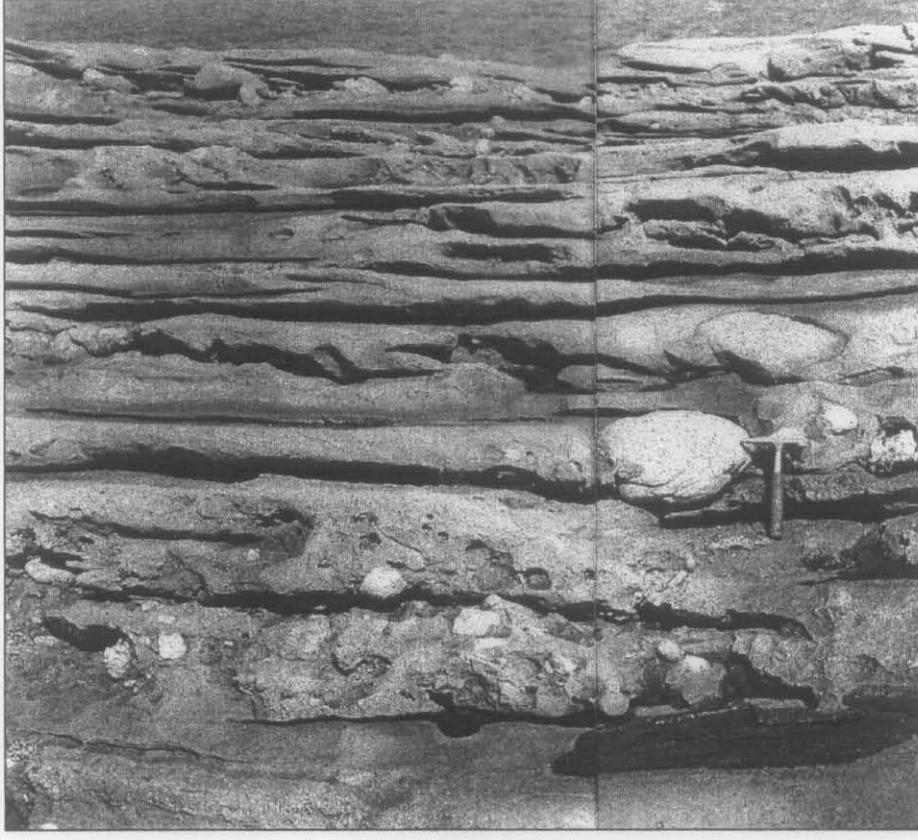


Plate 3

Sandstone beds in the Purrar Point Formation at Purrar Point containing isolated cobbles and pockets of pebbles.

This unit forms a lateral transitional facies between the Lousy Bay and Purrar Point Formations, although in places the transition is interrupted by faulting and affected by complex folding.

The thin siltstone-sandstone alternations commonly form a non-parallel undulatory lamination. In some cases siltstone drapes trains of ripples, sometimes isolated, of fine sandstone; in other examples fine sandstone forms discontinuous elongate lenses within the siltstone.

Near grid reference 459 000 mE, 5 179 400 mN, where the laminated siltstone unit grades into the Lousy Bay Formation, the gradation contains a thin interbed of disrupted laminated siltstone and sandstone, followed by a laterally discontinuous incursion of a disorganised siliceous pebble-cobble conglomerate containing dominantly rounded to subangular, poorly spherical clasts of pink quartzite. These

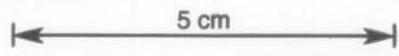




Plate 4

Disorganised conglomerate in Purrar Point Formation at Purrar Point.

clasts are identical to pink quartzite beds which are known elsewhere within the Tasmanian Precambrian sequence, and to the quartzite beds in the Havelock Bluff Formation. The presence of pebbles of pink quartzite in these beds, and elsewhere in the Purrar Point Formation, suggests that the Purrar Point Formation was being deposited whilst the basal units of the Phanerozoic sequence, or the Precambrian sequence, were exposed elsewhere.

Sedimentological interpretation

Along the coastline, the Purrar Point Formation forms a wedge within the flyschoid Lousy Bay Formation but it is absent in the summit ridge of the Ironbound Range. Palaeocurrent data (fig. 5) indicate a southeasterly source. The sedimentological setting and the nature of the formation are consistent with its interpretation as a submarine channel within the more proximal part of a submarine fan. The coarse disorganised conglomerate sheets are interpreted as debris flows within the channel, which also contains coarse sand and pebbly lag deposits. The laminated siltstone beds could well represent overbank deposits of silt invaded periodically by minor currents carrying coarser detritus.

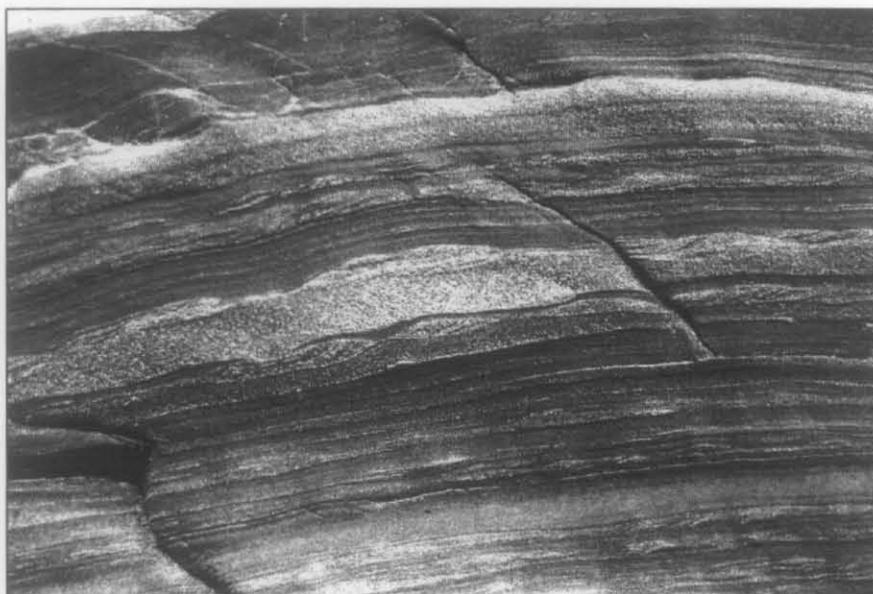


Plate 5

Laminated siltstone unit, Purrar Point Formation.

DISCUSSION

Correlation with Eocambrian to Early Ordovician sequences elsewhere in southernmost Tasmania

Age of the Ironbound Group

It is well established (Burrett and Martin, 1989 for reviews) that in Middle to Late Cambrian times sedimentation in western Tasmania was dominated by the production of polymict turbiditic sequences showing lateral variation and containing mass-flow deposits similar in style to those forming the Purrar Point Formation. Some of these beds are fossiliferous,

while many contain detrital serpentinite and volcanic clasts.

The presence of such fine to coarse serpentinite detritus is the principal control on the maximum age for the Ironbound Group, as serpentinite detritus appears in the Cambrian sedimentary record during Middle Cambrian times (Rubenach, 1974). The minimum age is given by the presence of siliciclastic rocks characteristic of the widespread Wurawina Supergroup, which were produced in response to the latest Cambrian to Early Ordovician exposure of the Precambrian units of western Tasmania. Additional supporting information comes from the presence of non-schistose volcanic felsic and mafic detritus and intrusive mafic detritus characteristic of the Middle to Late Cambrian mafic to felsic volcanic arc sequences within western Tasmania.

The petrology of the Ironbound Group reflects the major tectonomagmatic events documented in Middle to Late Cambrian times in Tasmania, and which terminated with exposure of the Tasmanian Precambrian sequences in latest Cambrian and Ordovician times.

A similar age has been applied to the Tyler Creek Beds and Point Vivian Formation east of the New River Lagoon Fault Zone. These rocks occur within a series of fault-bound packets (Berry and Harley, 1983; Bischoff, 1983) and strongly resemble the Ironbound Group in terms of their lithology and sedimentology. Banks (1959) described a Cambrian sponge spicule from the Tyler Creek Beds; a Late Cambrian to Ordovician fauna within the Wierah Formation, which overlies the Point Vivian Formation, defines the minimum age (Bischoff, 1983).

Lithologically the Tyler Creek Beds appear to be identical to the lower part of the Lousy Bay Formation, and the Purrar Point Formation appears to be identical to the Point Vivian Formation. A major problem influencing a direct correlation is the presence of an angular unconformity between locally highly sheared and transposed rocks of the Tyler Creek Beds and the locally overlying Point Vivian Formation (Bischoff, 1983). This unconformity has been photographed but was not accessible to Bischoff, and has not been mapped regionally. Consequently it is difficult to interpret, particularly as there is evidence for thrusting within the Ironbound Group. The supposed unconformity could be a thrust, or could indicate that strong local shearing and disruption of bedding was occurring during sedimentation of the Ironbound Group, Tyler Creek Beds, and Point Vivian Formation.

Although the Ironbound Group is consistent sedimentologically and petrologically with similar Middle to Late Cambrian beds elsewhere in western Tasmania, the palaeocurrent indicators point to a southeastern and not a northern provenance. The Tasmanian continental crust extends 650 km to the south in the form of the rifted South Tasman Rise (see Willcox *et al.*, 1989), and it is reasonable to suppose that these rocks could well be composed of units similar to the Precambrian to early Palaeozoic sequences in Tasmania and that these could have formed the source for the Ironbound Group.

Relationship to Antarctica

Northern Victoria Land is formed of three terranes; the high-grade unfossiliferous Wilson terrane (high-grade metamorphic rocks, migmatite, granite) in the west, the central Bowers terrane, and the eastern Robertson Bay terrane (see Bradshaw, 1989; Laird, 1989; GANOVEX team, 1987; and Findlay, 1991 for reviews). There is no known equivalent of the Wilson terrane in Tasmania and therefore the possible Antarctic correlates of the Ironbound Group would lie either in the Bowers or Robertson Bay terranes.

The Bowers terrane rocks range in age from Middle Cambrian to Late Cambrian (see Tessensohn, 1984; GANOVEX team, 1987; Laird, 1989; Findlay, 1991 for reviews). The oldest unit is the Sledgers Group, which consists of the early to late Middle Cambrian (Cooper *et al.*, 1983) Molar Formation which interfingers with a series of volcanic and intrusive rocks (Glasgow and

Solidarity Formations), including predominantly high-Mg low-Ti andesites (Weaver *et al.*, 1984; Wodzicki and Robert, 1987) of boninitic affinities. Overlying these are the Mariner Group rocks, consisting of at least 2.5 km of fossiliferous late Middle Cambrian to Upper Cambrian sandstone, calcareous mudstone, and disorganised conglomerate horizons, with red beds and limestone forming a mainly regressive sequence with marginal marine sediments at the top. The Sledgers and Mariner Groups are truncated by a very extensive erosion surface and are overlain with a folded unconformity (see Findlay, 1990 for review) by shallow marine to fluvial siliciclastic rocks of the Leap Year Group. Although the age of this unit is unknown, it has been assigned a latest Cambrian to earliest Ordovician age (Cooper *et al.*, 1983; but see Findlay, 1990). In northern Victoria Land this unit indicates the same style and age of sedimentological change as is represented by the Late Cambrian to Ordovician siliciclastic rocks of the Denison Group, and, in the New River Lagoon region, the Wierah Formation.

The Robertson Bay terrane (*cf.* Field and Findlay, 1983; Findlay, 1987b) is formed of a quartz-flysch sequence (Robertson Bay Group) with an eastern to southeastern provenance (Wright, 1981; Field and Findlay, 1983). These rocks, of ?Cambrian to lowermost Ordovician age (Burrett and Findlay, 1984; Wright *et al.*, 1984; Adams and Kreuzer, 1984), were deposited in a middle to outer fan to basin plain setting (Wright, 1981; Field and Findlay, 1983).

The boundary zone between the Robertson Bay Group and the Bowers Supergroup is formed of the Millen Schist, which consists of a tectonic amalgam of units within these two sequences (Findlay and Field, 1983; Bradshaw *et al.*, 1985; Findlay, 1987b). This schist terrane, distinct structurally and metamorphically from the adjacent Robertson Bay Group and Bowers Supergroup, was thought to extend into the Ironbound Range region by Burrett and Findlay (1984). This study has shown that the previously supposed relatively unmetamorphosed Precambrian rocks of the Ironbound Range are probably the Middle to Upper Cambrian Ironbound Group. They cannot correlate with the Millen Range schist on structural and metamorphic grounds, and do not contain obvious lithological equivalents of the units seen in this schist belt (Findlay and Field, 1983; Findlay, 1987b; Wright and Brodie, 1987). Therefore the correlation of Burrett and Findlay (1984), in which the Millen Range schist strikes into the Ironbound Range, is discarded.

This study also discounts part of Laird's (1981) correlation between Tasmania and northern Victoria Land, in which he intimated that in the general area of the Ironbound Range a sequence of Cambrian rocks trended south into the Robertson Bay terrane (Laird, 1981; fig. 5).

At first sight such a correlation with the Ironbound Group might appear attractive. However, the two units

are distinct in clast content, and the Ironbound Group is a proximal fan sequence whereas the Robertson Bay Group is a mid fan/basin plain sequence (Wright, 1981; Field and Findlay, 1983). Although it might be argued that the Ironbound Group forms the proximal part of the Robertson Bay Group fan, the palaeocurrent directions in both units are principally northwest directed. That is, were a correlation made between the two groups, the proximal part of the fan would appear the more distant from the source area. Unless Tasmania in Cambrian times had a remarkably convoluted drift history relative to northern Victoria Land, the palaeocurrent data from both groups must preclude the interpretation that the Ironbound Group is the proximal part of the Robertson Bay Group.

The sedimentological style of the Ironbound Group resembles that of the Molar Formation and parts of the Mariner Group (see Andrews and Laird, 1976; Laird, 1989; Cooper *et al.*, 1993). The age range of the Ironbound Group appears, at first sight, to be broad enough to allow a correlation with either unit, and the composition of the clasts within the Ironbound Group appears to resemble closely that described for the Molar Formation (Laird, 1989 for review).

The timing of tectonic events in Tasmania and northern Victoria Land provides a useful guide for comparing the age of sedimentation of the Ironbound Group with that of the Molar Formation and Mariner Groups. The Molar Formation is contemporaneous with boninitic island-arc volcanism in northern Victoria Land, and the Mariner Group followed after volcanism had ceased. The Ironbound Group was deposited after the exposure of ultramafic rocks, which in western Tasmania has been attributed to obduction of sea floor (Berry and Crawford, 1988) or boninitic island-arc magma chambers (Brown, 1986; Findlay *et al.*, 1991). This obduction event occurred after intrusion of the ultramafic rocks by tonalite dykes dated at around 520 Ma (Brown, 1986).

If the late Middle Cambrian cessation of island-arc volcanism in northern Victoria Land was held to be contemporaneous with the obduction and exposure of the ultramafic rocks of Tasmania, then the sedimentary records of the Mariner and Ironbound Groups indicate that they must be closely equivalent in time. Deposition of both units preceded a major tectonic event at 510–500 Ma (Adams and Kreuzer, 1984; Adams *et al.*, 1985; Wright and Dallmeyer, 1991; Turner *et al.*, 1992) which produced tight folding in northern Victoria Land and isotopic resetting and blueschist facies metamorphism and subsequent uplift in western Tasmania. In the case of the Ironbound Range area, the indicator for this event is the sudden influx of siliciclastic sediments from the north, which correlates in time (Bischoff, 1983) with the uplift and exposure of the highly silicic Tasmanian Precambrian rocks.

A direct link between the Ironbound Group and Mariner Group depocentres is less easy because of the geographic intervention of the South Tasman Rise in

any simple reconstruction aligning the two. Wyborn (1981) and Borg and Stump (1987) have argued that the geochemistry of the Robertson Bay Group rocks and the Devonian Admiralty Intrusives, which intrude the Robertson Bay Group, indicate an increasing northeasterly continental involvement in the source of these rocks. Such a source could be the same as that which provided the detritus for the Ironbound and Mariner Groups, and again could be represented in part by the South Tasman Rise (see Willcox *et al.*, 1989). If indeed there were a such common source for the Ironbound and Mariner Groups, then published models for the common evolution of Tasmania and northern Victoria Land need re-addressing, and the simple linear correlations of volcanic belts, such as proposed by Laird *et al.* (1977) and re-affirmed by Findlay *et al.* (1991), may not hold. Despite this reservation, the idea of a common, non-Tasmanian source for the Ironbound and Mariner Groups is in keeping with the concept expressed in Harrington (1974) and Findlay (1987a) of a Middle to Late Cambrian volcanic archipelago, similar to that represented by the present Indonesian-Papua New Guinean system, in Late Cambrian/Ordovician collision with the Pacific seaboard of the then Gondwana supercontinent.

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