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PRE-DEVONIAN STRATIGRAPHY AND STRUCTURE OF THE PRION BEACH-ROCKY BOAT INLET-OSMIRIDIUM BEACH COASTAL SECTION, SOUTHERN TASMANIA

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(with eight text-figures and three plates)

ABSTRACT

BERRY, R.F. & HARLEY, S., 1983 (31 viii): Pre-Devonian stratigraphy and structure of the Prion Neach-Rocky Boat Inlet-Osmiridium Beach coastal section, southern Tasmania. *Pap. Proc. R. Soc. Tasm.*, 117: 59-75, three plates. https://doi.org/10.26749/rstpp.117.59 ISSN 0080-4703. Department of Geology, University of Tasmania, Hobart, Australia.

The pre-Devonian stratigraphy of the Prion Beach to Surprise Bay area is composed of four stratigraphic units. The oldest is a (?) Precambrian, slightly metamorphosed, massive dolomite. This is in part the source area for three overlying units of the Denison Group (Late Cambrian to Early Ordovician). The Tyler Creek Beds are highly serpentinitic conglomerate, sandstone and siltstone. The Point Vivian Formation is a sequence of dolomitic siltstone and matrix rich polymictic conglomerates with a wide range of depositional features including channels, graded bedding and slump structures. It was probably deposited in a slope environment. The overlying Wierah Formation (Denison Group) is composed of quartz-rich pebbly sandstones and quartz arenites which formed in a high energy environment possibly above wave base. Two shear zones cut across this stratigraphy producing transposed layers and boudins. At least one of these shear zones was active during sedimentation and forms the western limit of the Point Vivian Formation in this area.

INTRODUCTION

The geology of the Rocky Boat Inlet (fig. 1) area has been studied briefly in reconnaissance surveys of southern Tasmania (Twelvetrees 1915; Banks 1959; Kennedy 1980). It is the southernmost exposure of Early Palaeozoic clastic sediment in Tasmania. Work on Gordon Subgroup sediments to the north and east (Burrett *et al.* 1981 and in press) suggests that the Ordovician sedimentary environment of this region was different from all other known localities. This study of the Early Palaeozoic clastic sediments was designed to determine if the different environment was of prolonged duration or a feature of the Ordovician. In addition the previous studies have shown that the structure of the area is complex, but the very good exposures along the coastal section were probably sufficient to determine the relationship between the lithological units. We have investigated these two aspects of the geology of the area.

Previous workers in the area interpreted the clastic sediments on Point Cecil as terrestrial conglomerates of the Denison Group and those on Point Vivian as Middle or Upper Cambrian turbidites. In addition a probable Precambrian dolomite was recorded from the western shore of Rocky Boat Inlet.

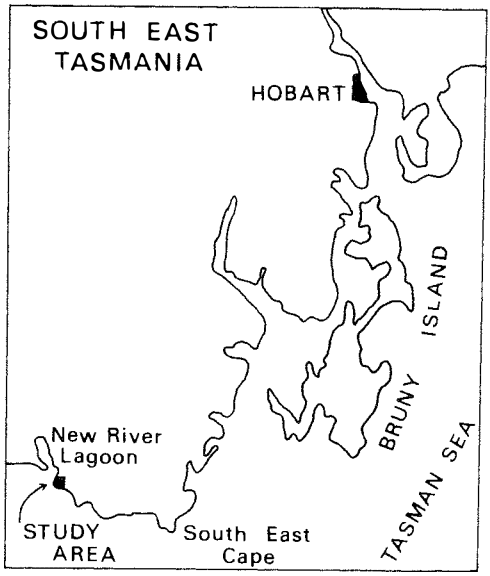

FIG. 1 - Location of Rocky Boat Inlet area, southern Tasmania.

This information was derived from a number of unpublished sources by Farmer (1979). It was confirmed in a general way by Kennedy (1980), who did not, however, find the Precambrian dolomite. As shown by our mapping this discrepancy was probably caused by the low accuracy of the 1:250 000 map which shows the dolomite closer to the head of Rocky Boat Inlet than its actual exposure.

The field work reported here was carried out in two sections. A preliminary investigation was made as part of a helicopter survey arranged by Dr C. Burrett. After this an expedition was carried out using foot access from Cockle Creek. Section thicknesses have not been measured directly but have been estimated and no exact stratigraphic logging of a specific section was carried out. The 90% exposure along the wave cut platform means that the mapping is reliable in these areas but very little data were available away from the coast and the map reliability drops off rapidly.

STRATIGRAPHY

The rocks of this area occur in four distinct stratigraphic units. Of these two are formal stratigraphic divisions. A massive grey, strongly recrystallized dolomite occurs on the western shore of Rocky Boat Inlet (fig. 2). Its age is problematical. It is unconformably overlain by the Wierah Formation on a probable karst topography. Pebbles of grey dolomite identical to this mass are widely distributed through the lower part of the Point Vivian Formation, but the boundary between these two rock types is a shear zone. White marble and grey dolomites similar to the massive grey dolomite unit are found as boulders in the Tyler Creek Beds. The grey dolomite may correlate with dolomites of probable Precambrian age found to the west (Farmer 1979).

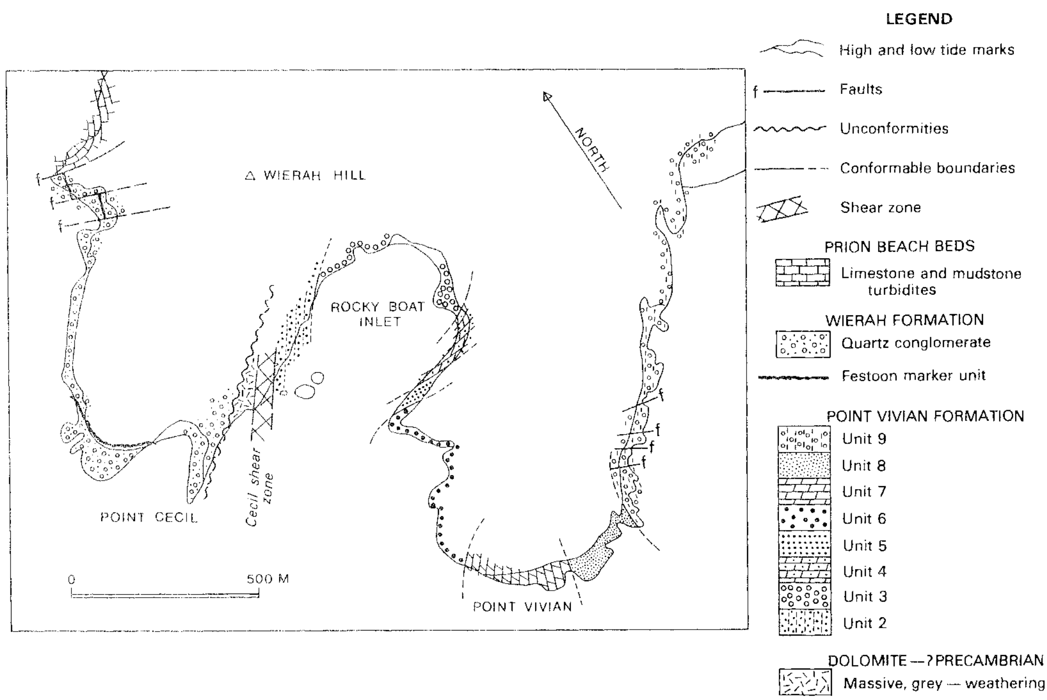

FIG. 2 - Outcrop map of pre-Devonian strata in the Rocky Boat Inlet area.

Tyler Creek Beds

The Tyler Creek Beds (new name) crop out for at least one km east of the Osmiridium Shear Zone (fig. 3). This unit is predominantly composed of pale green, calcareous siltstones and arenites which are 0.05 to 0.2 m thick. The arenites have load casts on the base and the siltstones are crossbedded. Less common are pale green, matrix-rich conglomerates which are graded, lenticular and intensely load casted. Clasts vary up to 200 mm and include grey dolomite and serpentinite. The 200 m thick section mapped does not show any systematic variation. It is closely similar to some of the rocks in the Osmiridium Shear Zone but no red-matrix conglomerates or pyritic rocks have been found. The only fossil found in these rocks was a sponge spicule (Banks 1959). The presence of serpentinite clasts supports a Middle or Upper Cambrian age by analogy with other areas of Tasmania (e.g. Rubenach 1974).

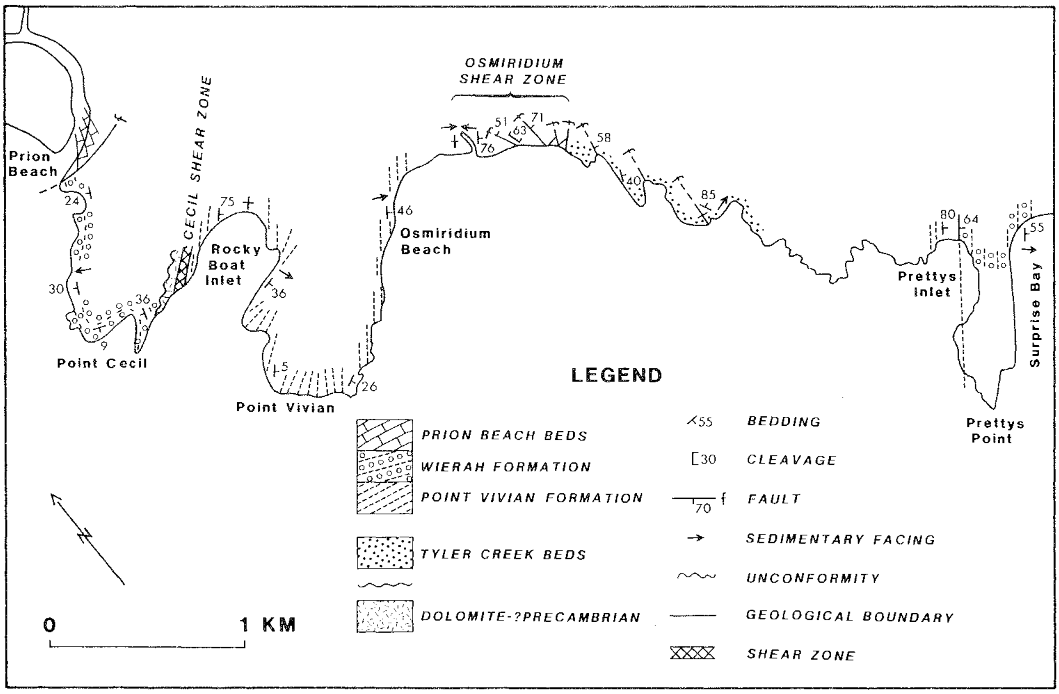

FIG. 3 - Outcrop map of pre-Devonian strata between Prion Beach and Surprise Bay, southern Tasmania.

The Tyler Creek beds are tentatively assumed to underly the Point Vivian Formation. The main evidence for this is the progression of sediment types from the Tyler Creek Beds through the Point Vivian Formation to the Wierah Formation. The conglomerates of the Tyler Creek Beds are polymictic with a very high component of serpentinite and serpentinitic gabbro. Serpentinite clasts are found throughout the Point Vivian Formation but are most common at the base. Quartzite and vein quartz boulders are most common towards the top and are the only clasts in the overlying Wierah Formation. In other parts of Tasmania serpentinitic boulders are an important component only in the Denison Group.

Point Vivian Formation

This outcrops on the coast between the west end of Osmiridium Beach (1:100 000 series Topographic Map 8210 co-ordinates 691784) and western Rocky Boat Inlet (8210 co-ordinates 681767). The formation includes conglomerates, sandstones, siltstones, dolomitic siltstones and dolomite that face and young westwards. Conglomerates and dolomitic rock types pass upwards into siltstones and interbedded siltstone-conglomerate. The Point Vivian Formation is bound to the east by the Osmiridium Shear Zone near Tyler Creek and on the west by the Cecil Shear Zone along western Rocky Boat Inlet. Generalized features of the sequence are presented in fig. 4.

Unit 1. Dolomite, conglomerate and siltstone.

The basal sequence of the Point Vivian Formation is a series of reworked dolomitic sedimentary rocks including grey-dolomite-clast-rich conglomerates often with a brown weathering dolomitic-siltstone matrix, and brown-weathering laminated and cross-laminated dolomitic siltstones. This unit is only exposed in the Cecil Shear Zone and the nature of its relationship to the massive grey dolomite is unclear. No estimate of thickness can be made because of the tight folding and shearing in this zone.

Unit 2. Conglomerate and dark siltstone.

Approximately 40 m of interbedded conglomerates and siltstones overly the dolomitic sedimentary rocks. The conglomerates occur as graded beds and channels up to 3 m thick. They are green and matrix-rich with medium to coarse clasts (2 mm-50 mm) of dolomite, red shale, chert, quartz and serpentinite set in a serpentinitic-chloritic matrix.

Lenses (<1 m) of argillaceous slate, dolomitic siltstone, and cross-laminated siltstone are commonly interlayered with lithic wacke. These siltstones and arenites contain cross bedding, flame structures, ripple marks and slump accentuated ripples.

Polymictic, matrix-supported conglomerates with very-coarse (to 150 mm), well-rounded clasts of dolomite, ferruginous chert, quartzite and quartz phyllite occur in the upper part of this unit.

The presence of medium-grained serpentinite and red shale clasts in the lower part of the unit provides an age constraint for the Point Vivian Formation. The ultramafic source of these clasts was probably emplaced by the late Middle Cambrian, by comparison with other such bodies in Tasmania (e.g. Rubenach 1974). Very coarse serpentinitic breccias and conglomerates occur adjacent to probable layered and altered ultramafics on Surprise Rivulet three km NE of Rocky Boat Inlet. These rocks are most probably the source for the serpentinite clasts observed in the lower part of the Point Vivian Formation. We conclude that the Point Vivian Formation at Rocky Boat Inlet is post-Middle Cambrian.

Unit 3. Coarse conglomerate.

A coarse, clast-supported conglomerate outcrops in the central part of Rocky Boat Inlet. Well-rounded clasts, up to 200 mm in diameter, of quartzite and dolomite occur. Bedding is poorly developed and defined by occasional thin (to 100 mm thick) sandstones lenses.

Unit 4. Laminated siltstone.

A sequence of well laminated, thinly-bedded and ripple-marked dolomitic siltstones and fine sandstones up to 10 m thick overlies Unit 3 on the east side of Rocky Boat Inlet. Asymmetric linear ripples, interference ripples, flames, coherent slump folds, parallel and wavy lamination are well developed in the dolomitic siltstones.

Thin (to 100 mm in thickness), clast-rich conglomerate sheets occur interbedded with the siltstones. These layers have sharp basal and upper contacts suggesting the operation of erosional processes (plate 1A).

Unit 5. Congomeratic sandstone.

Immediately overlying the Unit 4 siltstone is 10 m of poorly-sorted, conglomeratic sandstone. The sandstone is a lithic-quartz arenite containing dispersed, well-rounded pebbles, and cobbles (20 mm-100 mm in diameter) of quartzite, dolomite and chert.

Unit 6. Polymictic quartz and conglomerate. Approximately 60 m thickness of polymictic, matrix-poor conglomerate crops out around the east side of Rocky Boat Inlet and forms the high headlands on Point Vivian.

The conglomerate is white weathering with clasts of quartzite, quartz, chert and grey dolomite. Well-rounded clasts up to 150 mm in diameter are supported by finer clasts (5 mm-50 mm). A rough layering into discontinuous and lensoidal beds 1 m to 5 m in thickness is present. Occasional lenses and thin sheets (100 mm thick) of quartz sandstone define this layering.

Unit 7. Dolomitic siltstone. Thirty metres of well-laminated dolomitic siltstone overlies the Unit 6 conglomerates on Point Vivian. Intense slump folds are developed at the contact. In the lower part of the unit layering forms large scale gentle troughs and undulating megaripples (10-15 m wavelength and 5 m amplitude).

Slumping is developed as coherent S and Z folds, accentuated ripples or cross lamination. Individual siltstone layers sometimes act as decollement surfaces. Disrupted lamellae and sandstone dykes are developed in

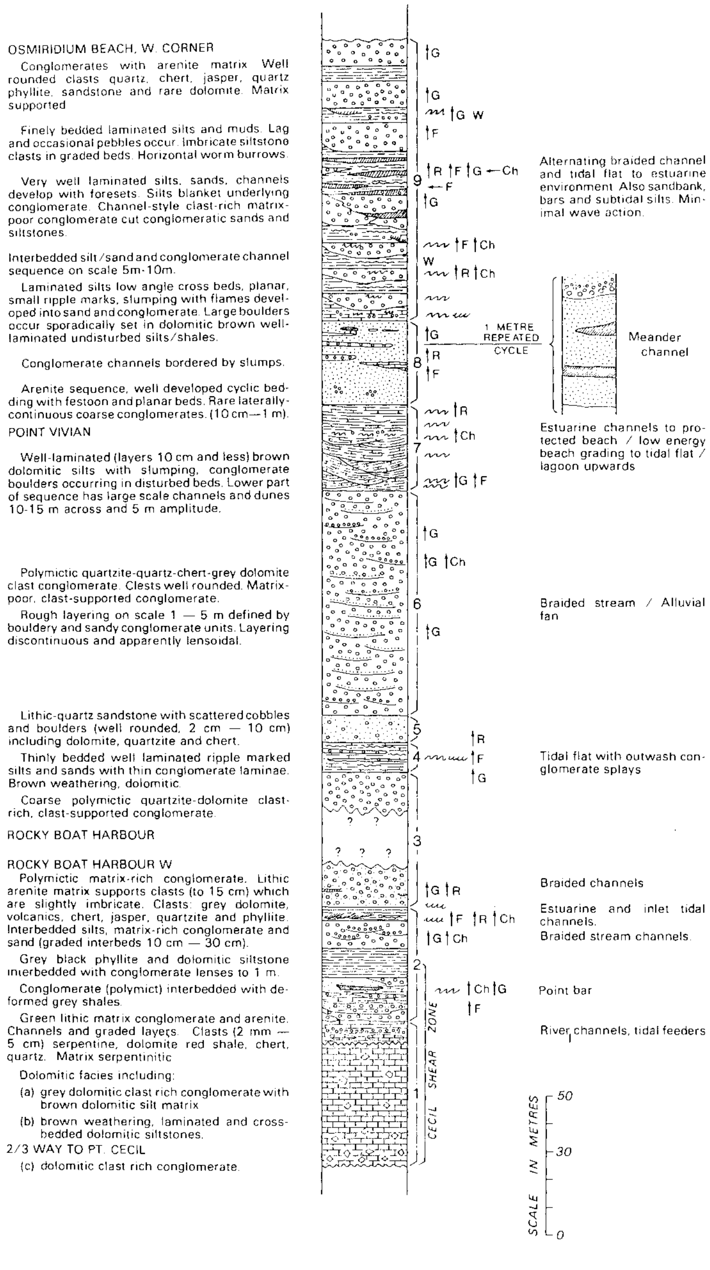

FIG. 4 - Stratigraphic log of the Point Vivian Formation. Legend as shown in figure 5.

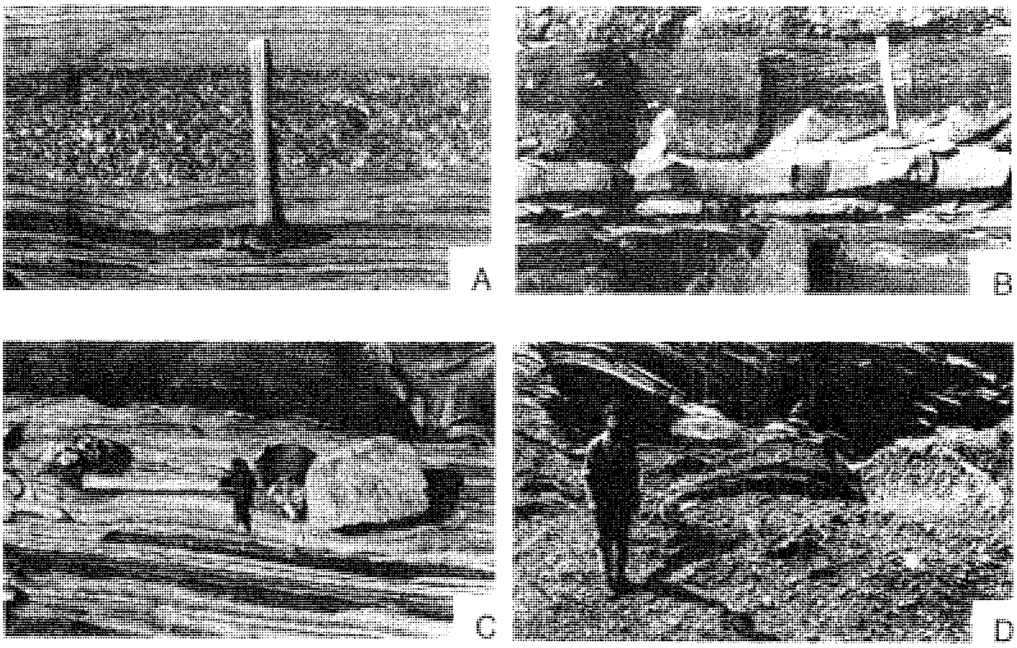

PLATE 1. - A - Thin, graded conglomerate bed in laminated, dolomitic siltstones with sharp upper and lower contacts. Slight channelling accentuated by compaction. B - Asymmetric flame structures extruded from dolomitic siltstone into graded and crossbedded conglomerate-sandstone layer. C - Isolated boulders and boulder clusters within dolomitic siltstones. Boulders partly truncate laminations with additional distortion of layers due to compaction. Note ripple-marked upper surface of dolomitic siltstones. D - Roll folds outlined by dolomitic siltstones within massive channel conglomerate.

some of the larger slump zones. Isolated pebbles, boulders (up to 300 mm diameter) and conglomeratic boulders (500 mm diameter) occur on slump surfaces or in only weakly deformed layers. Marginal deformation and incorporation of dolomitic siltstone indicates that some conglomeratic boulders were only partly consolidated when re-deposited.

Other features developed in the siltstones include small scale cross lamination, graded sandstone, siltstone layers (up to 100 m thickness), and small channels (up to 10 m wide).

Unit 8. Sandstone.

Approximately 30 m of brown-grey sandstone and very minor conglomerate outcrops just east of Point Vivian. This unit is made up of cyclically repeated 1 m thick, slightly-channelled sandstone beds (fig. 4). In each of these beds conglomeratic lag (up to 100 mm thickness) is succeeded by massive to poorly graded, quartz-lithic sandstones. Thin (to 200 mm thickness) cross-bedded sandstone lenses occur, displaying low angle ($<10^{o}$) trough and planar foresets. Ferruginous concretions (<10 mm diameter) are developed in these lenses.

Isolated boulders (to 200 mm diameter) are scattered through the siltstones, and intraformational clasts of dolomitic siltstone occur near the top of individual cycles.

Unit 9. Channel conglomerates and siltstone.

Interbedded channel-filling conglomerates, laminated siltstones, and cross-bedded siltstones and sandstones form the headland along the west end of Osmiridium Beach southwards to near Point Vivian. Five to ten metre thick conglomerate and siltstone-sandstone units are cyclically repeated.

(a) Siltstone. - Thinly bedded grey siltstones and brown weathering dolomitic siltstones occur in units up to 5 m thick. Bedding thicknesses in the laminated siltstones are 10-100 mm, with common erosional, truncated or ripple-soled bedding contacts. Common sedimentary structures include horizontal worm burrows, scour marks under conglomerates, planar lamination, low-angle cross lamination, asymmetric ripples with linear crest lines, and small scale (1-2 m width and 100 mm depth) channels with foresets. Ripple marks imply currents from the north, while foreset orientations indicate channelling from the south.

Flame structures are developed beneath several of the conglomerate beds (plate 1B). Accentuated ripples and tight slump folds are developed in zones up to 100 mm in thickness. Larger scale coherent slump folds and slightly overturned foresets, in sheets up to 300 mm thick, occur in some siltstone layers bounded by sandstones.

Sheet-like, thin (100-300 mm thick) conglomerate horizons showing sharp contacts with enclosing siltstones are present. Isolated large boulders (to 200 mm diameter) and clusters of boulders (plate 1C) are set in undeformed siltstones. Some scour effects with local sand buildups were found adjacent to such boulders.

Siltstones overlying conglomerate channels blanket these with sharp, erosional contacts.

(b) Sandstone. - Impure calcarenites and quartz sandstones form thin sheets and wedge-shaped layers 100 mm - 1 m thick within the siltstones. The sandstones are typified by low-angle planar cross-bedding and superposed shallow wedge-shaped troughs, or by graded bedding. The graded beds show conglomeratic lags, multiple grading, and massive bedding with imbricate siltstone clasts.

(c) Congomerate. - Matrix-poor pebble conglomerates occur as broad channel-like units 3-10 m in thickness and separated by the siltstone units. The polymictic conglomerates are mainly clast-supported, with up to 90% round to sub-rounded clasts including quartz, quartz-phyllite, chert, siltstone and some dolomite.

The conglomerate units have upper surfaces truncated by siltstone. Channel floors and sides are often slump folds. Syn-depositional faults occur in these areas and die out upwards towards disconformable siltstone-siltstone contacts above the conglomerates.

Within individual channels the conglomerates are usually massive, but grading into sandstone horizons occur in rare matrix-supported conglomerates. Some channels have been filled and subsequently scoured then refilled with further conglomerate. In such channels, roll-folds have developed in partly consolidated siltstone layers (<150 mm thickness) which have been extruded into the channels synchronous with conglomerate deposition (plate 1D).

Near the top of unit 9, at an unconformable contact with probable Tertiary and Quaternary sediments in the western corner of Osmiridium Beach, the conglomerates contain more matrix (20-25%) and include occasional poorly-sorted sandstone horizons. Solution zones containing carbonaceous soily deposits penetrate these conglomerates from the unconformity. These carbonaceous deposits are the cause of the previous erroneous assignment of a Tertiary age for these conglomerates (Twelvetrees 1915; Berry & Harley 1982).

The Point Vivian Formation also crops out in Prettys Inlet (fig. 3) where the sequence is conformably overlain by quartz sandstones and siltstones which correlate with the Wierah Formation. This eastern exposure is dominated by matrix-rich conglomerates with boulders and cobbles of quartzite, vein quartz, sandstone, dolomitic breccia and rare serpentinite. The conglomerates have boulders of quartzite up to 1 m in diameter. They are interbedded with sandstone with common horizontal burrows and, in one case, large numbers of silicified brachiopods. One 2 m thick bed of dolomite crops out 50 m below the contact with the Wierah Formation.

Provenance

Clast types in conglomerates of the Point Vivian Formation are of similar origin to clastic particles in the interbedded siltstones and sandstones. Siltstones are often calcareous, dolomitic, and contain clasts of dolomite, calcite and abundant quartz or quartzitic rock fragments.

In siltstones and calcareous sandstones, undulose and lamellar quartz grains of metamorphic origin are angular to subangular. Heavy mineral grains (ilmenite) occur, and subangular-subrounded rock fragments of polygonal granoblastic quartzite, recycled sparite, and siltstone-mudstone are common. Metamorphic muscovite, usually undulose or kinked, occurs in some siltstones.

A dolomite clast exhibits granoblastic polygonal recrystallised texture, and may have been weakly metamorphosed. This fragment appears to be identical with the massive grey dolomites on the western side of Rocky Boat Inlet.

The source area for most of the Point Vivian Formation is the Precambrian metamorphic basement which is exposed immediately west and northwest of New River. In the lower part of the formation, serpentinitic clasts, discussed above, indicate a Cambrian source area. This source area was possibly a minor high in the region of the Surprise Rivulet ultramafic body.

Depositional Environment

The most striking feature of the Point Vivian Formation, above the basal dolomitic facies, is the interbedding of contrasting conglomeratic and siltstone facies, often with sharp erosional contacts. In the lower part of the sequence conglomerate units are quite thick (to 50 m), while siltstones are less common. Higher in the sequence, towards Osmiridium Beach, conglomerate and siltstone occur in nearly equal abundance and the conglomerates form obvious channels. Any model for a depositional environment must account for these features as well as embracing more detailed sedimentological evidence from individual units.

The association of slumped beds, pebbly mudstone, turbidites, hemipelagite and channel deposits is characteristic of slope deposits (Stanley & Unrug 1972). The Point Vivian Formation contains sedimentary rocks with these characters.

The main evidence against of slope deposit is the widespread dolomitic siltstones. Dolomites are commonly found near basin margins which suggests the Point Vivian Formation may correlate with continental margin fans prograding over intertidal and low subtidal carbonates (e.g. Miall 1970) but this formation lacks all the other features of such shallow water sedimentation (e.g. mudcracks, evaporite casts, red beds, algal mats). The medium-grained, recrystallised texture of dolomite in the Point Vivian Formation suggests diagenetic dolomitisation which is not restricted to shallow water conditions (Zenger 1972). The environment of deposition of the Point Vivian Formation remains in doubt but it may be similar to the submarine fan environment of the Singing Creek Formation, Denison Ranges (Corbett 1970, 1975) which is of comparable age.

Wierah Formation

Unconformably overlying the massive dolomites of western Rocky Boat Inlet is a thick (>100 m) sequence of coarse conglomerates with rare layers of sandstone and chert. This unit outcrops from Point Cecil where it unconformably overlies massive dolomites (8210 co-ordinates 677766), to the entrance of New River Lagoon (8210, 67774), where it is in fault contact with the Prion Beach Beds of Middle and probably Upper Ordovician age (Burrett *et al.* 1981). The Wierah Formation (>100 m in thickness) consists almost wholly of thick plane-bedded conglomerates, with rare sandstone and siltstone layers 5 m thick with interlayered thinner bands of sandstone and conglomeratic sandstone (300 mm - 1 m thickness) (fig. 5). The conglomerates are characterised by well-rounded quartz phyllite clasts (to 200 mm diameter) and vein quartz pebble clasts (10-50 mm diameter), set in finer quartz clasts. Massive units alternate between phyllite clast-rich and vein quartz clast-rich types, most layers being bimictic.

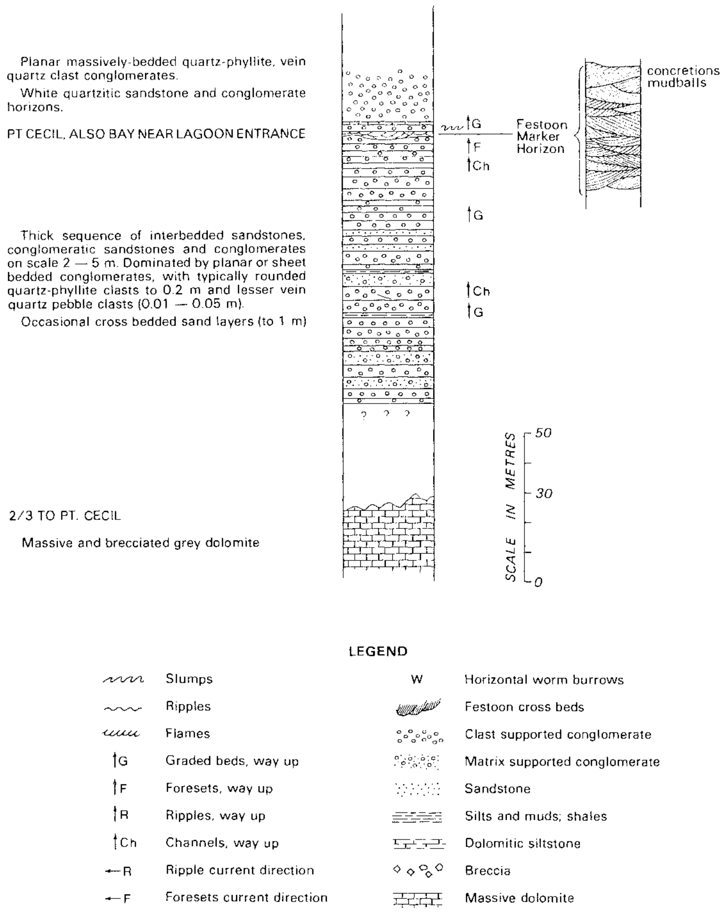

FIG. 5. - Stratigraphic log of the Wierah Formation.

Near the top of the sequence, at the western headland of Point Cecil and in a down-faulted block in a small bay near the entrance to New River Lagoon, are two marker horizons. The uppermost of these is a 500 mm - 1 m thick massive quartzitic sandstone with minor pebbly horizons.

Occurring about 3 m below the quartzitic horizon is a 1-2 m sandstone horizon (Festoon sandstone marker horizon, fig. 2) weathering brownish grey. This is a quartz sandstone with silica cement. The sandstone is characterised by low-angle trough cross-beds 100-200 mm thick, multiply scoured to form cosets. Fine, spherical, ferruginous concretionary mudballs 2-20 mm in diameter occur in the foreset beds and do not disturb the layering. Minor siltstones overlying this horizon contain horizontal worm burrows and ferruginous layers.

Four kilometres to the east at Prettys Point, cross-bedded and worm-burrowed quartz sandstones interbedded with quartz siltstones conformably overlie the Point Vivian Formation. We correlate these beds with the Wierah Formation on the basis of their stratigraphic position, and the absence of polymictic conglomerates and carbonates.

Provenance

The dominant clast type in the conglomerates and associated sands is quartz-phyllite, with vein quartz also common. The quartz-phyllite is typical of quartzitic metamorphics outcropping to the west and northwest in the Tasmanian Precambrian basement, which occurs as close as New River. Vein quartz may also be derived from this metamorphic source region. Comparative paucity of other clast types suggests that these conglomerates were derived from a close metamorphic source region with little input from more diverse areas.

Depositional Environment

The sheet-like layering of the conglomerates contrasts with the channel structures of the Point Vivian Formation. The massive pebbly sandstones implies deposition in the high flow regime or as debris flows. The low abundance of clay in the sands suggests the former environment although it may be the result of the very quartz-rich provenance of these rocks. The festoon crossbedded sandstones horizon implies moderate rates of deposition in the lower flow regime (Allen 1973). The presence of horizontal worm burrows is the principal evidence of a marine origin for these sediments. The high energy of deposition and good sorting suggests they may be deposited above wave base. The sediments of Prettys Point are apparently of lower energy and may have been deposited in deeper water.

STRUCTURE

Grey-weathering Metamorphosed Dolomite

The massive dolomite on the western shore of Rocky Boat Inlet (fig. 2) has not yielded any structural data. The outcrop is bounded on the east by an apparently conformable sequence of Point Vivian Formation. However this contact is a shear zone (referred to here as the Cecil Shear Zone) with intense transposition, tight folding (plate 2) and brecciation. The presence of clasts of dolomite identical to this unit throughout the lower half of the Point Vivian Formation does suggest a substantial erosional unconformity has been concealed by this shear zone. In addition the juxtaposition of presumably older Point Vivian Formation with the Wierah Formation suggests a reverse component of motion on this steeply dipping shear zone.

Denison Group

The vast majority of deformed Palaeozoic rocks in this area have simple deformation history. The poles to bedding (fig. 6) form a broad great circle which indicates fold axes plunging shallowly to 200^o. The folds of this orientation are asymmetrical with small areas of shallow westerly dips as on the western side of Point Cecil and structural terraces as on the western side of Point Vivian.

A very weak cleavage is locally developed parallel to this fold axis orientation and is probably parallel to the axial plane of these folds. However, no small scale folds of this generation were observed outside the shear zones. The cleavage is a spaced cleavage in limestones where it is best developed. It dips steeply both west and east, and strikes at 020^o.

The Tyler Creek Beds do not fit this distribution and appear to be rotated by faults similar to those in the Osmiridium Shear Zone. A second set of folds has distorted the bedding orientations produced by the early folding. These have only been recognised on Point Vivian and are with one exception limited to the structural terrace mentioned earlier. They are tightest on the southern end of Point Vivian where they form asymmetric upright open folds with steep north-dipping limbs and shallow south-dipping limbs. The axial surfaces of these folds strike 105^o and dip steeply south. A domain analysis of the structural terrace assuming deviations from a simple great circle distribution were due to this

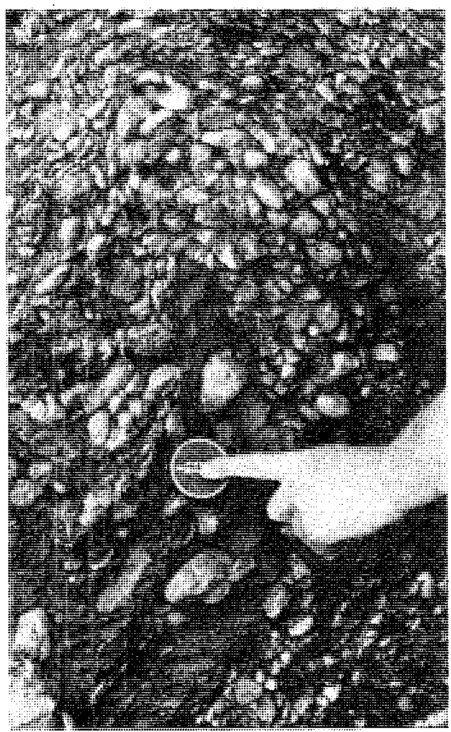

PLATE 2. - Tight fold in Unit 2 conglomerates of Cecil Shear Zone. Note bent and flattened quartzite pebbles in hinge zone.

phase of folding produced the interpretation of macroscopic D_2 fold closures shown in Fig. 7. The tightness of these closures varies from gentle for the northern anticline to open for the southern anticline. The boundaries of the structural terrace are shown as F_1 macroscopic folds.

There is a small deviation from a simple great circle distribution in the Wierah Formation and this indicates a steepening of the early phase fold axes at the southeastern end of Point Cecil. It is not clear if this is the result of F_2 folds or of proximity to the Cecil Shear Zone.

The Prion Beach Beds are complexly folded, possibly partly as a result of D_2 folds. A small area of intense folding of a similar orientation occurs at Surprise Bay and is closely related to strike-slip faults dipping 70° towards 340°. We interpret these as D_2 folds.

Minor faulting is very common in the Point Vivian Formation. One set of faults strikes 120° and dips shallowly both south and north. Slickensides on one of these faults indicates dip-slip motion and offset of recognisable beds implies the motion is in a reverse sense. These two fault orientation are probably a conjugate set and are compatible with σ_1 horizontal and trending 025°. These faults all occur in the steep east-dipping limbs of the D_1 folds and their orientation suggests that they were formed under the same stress/strain conditions as the D_2 folds. The absence of D_2 folds in these beds contrasts with the open buckles of the flat-lying beds nearby. This distinct zonation of D_2 struc-

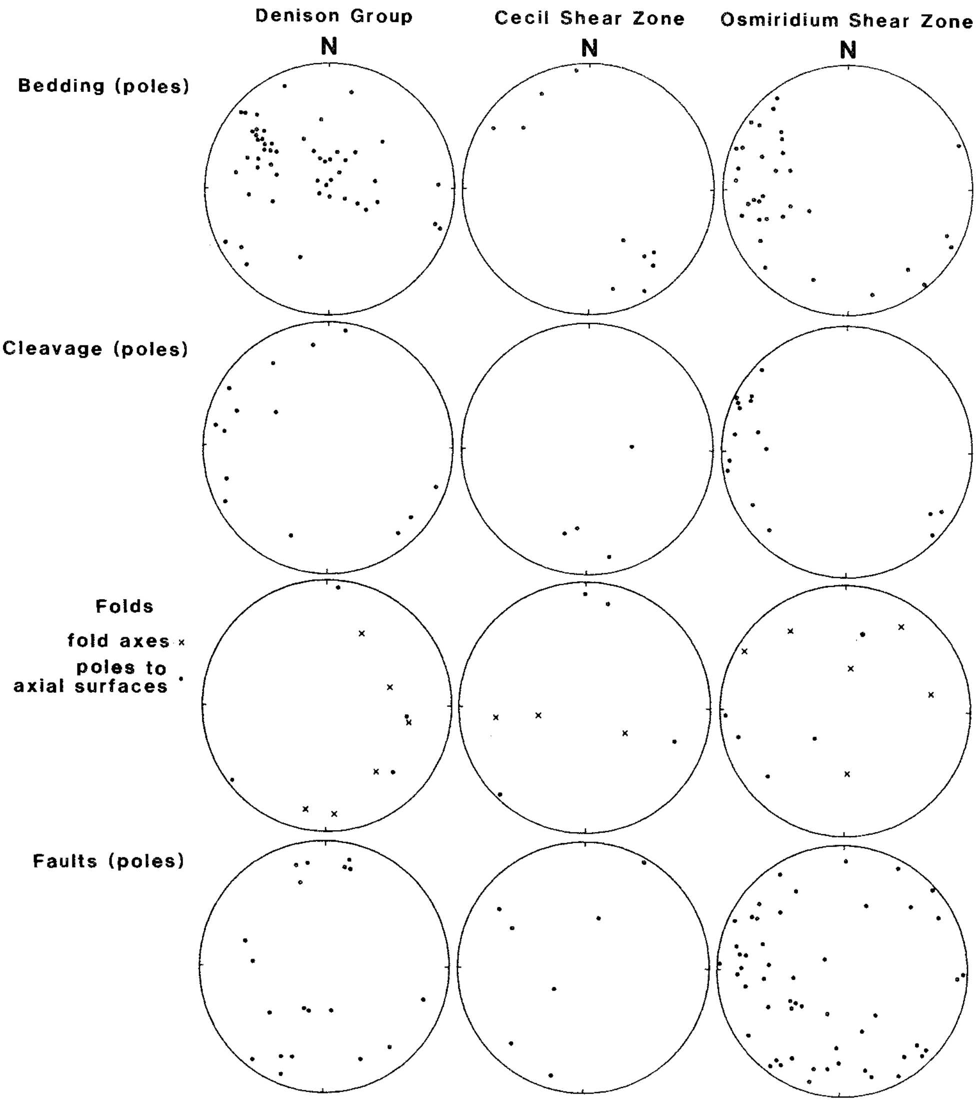

FIG. 6. - Lower-hemisphere equal-area stereographic projections of structural data from the Denison Group.

tures with folds forming on the D_1 structural terrace and thrust faults on the moderate to steeply dipping limbs, is the major evidence we have found for the relative ages of D_1 and D_2. The correlation of D_2 with the fault-related folds at Surprise Bay supports this interpretation since these folds post-date the S_1 cleavage.

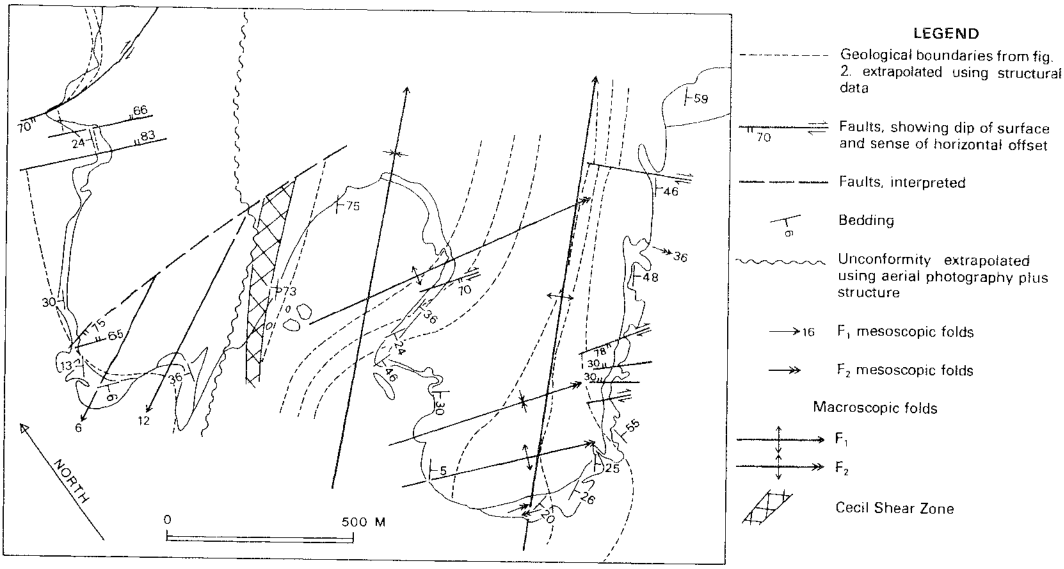

FIG. 7. - Interpretative structural map of the Rocky Boat Inlet area. Macroscopic folds shown are domain boundaries defined on bedding orientation as discussed in the text.

A second orientation of faults was recognised on the eastern side of Point Vivian. A series of small right-lateral offsets occurs on near-vertical faults which strike 105° and a conjugate set of left-lateral faults occurs with smaller displacement and a strike from 135 to 165°. These faults were formed in a stress environment where σ_1 was near-horizontal and had a trend of 130°. We have considered a possible correlation of these faults with the D_1 folds. However a similar fault which cuts Prettys Point a few kilometres to the east also probably offsets Permian sediments on Shoemaker Point so at least some of the motion of these faults is post-Permian.

The Wierah Formation is cut by a large number of conjugate normal faults. The orientation of these faults indicates σ_3 horizontal and trending 015° and σ_1 trending 280° and plunging moderately. These faults usually have a small net slip. The largest motions were found on two faults in the small bay near the outlet of the New River. They have an offset normal to bedding of 50 m. Finally, just to the north, the Prion Beach Beds are faulted against the Wierah Formation along a fault of nearly the same orientation. This fault appears to be a right-lateral, strike-slip and its orientation is similar to that of right-lateral faults in the Point Vivian Formation. South dipping faults in the Wierah Formation have a strike of 085° and the stress interpretation predicts a significant right-lateral component. It is likely that all these faults are the same age.

Shear Zones

The pre-Devonian sedimentary rocks of the study area are cut by two intensely sheared zones referred to here as the Cecil Shear Zone and the Osmiridium Shear Zone (fig. 3). In both cases these consist of a gradation from close coherent folds in recognisable sedimentary rocks through transposed sediments and finally to breccias. The cleavage developed in open and tight folds is very weak and only recognisable in suitably etched rocks. Clasts in the conglomerates are bent around some of these folds. In the Osmiridium Shear Zone compositional layers are often defined by a series of rotated blocks bounded on one side by curved faults and on the other by bedding (phacoids). The origin of the breccias is ambiguous since many of the sedimentary rocks which are included in these zones are polymictic conglomerates and there is a complete transition from coherently deformed sedimentary rocks to "tectonic" breccias. Local stratigraphic coherence can be recognised in the Cecil Shear Zone and in part of the Osmiridium Shear Zone but the high intensity of shearing is evident from the incorporation of an exotic block of pyritic limestone 30 m across in the clastic matrix of the latter. In combination all these features fit the definition of melange proposed by the 1979 Penrose Conference (Silver & Buetner 1980).

The boundaries of these shear zones are gradational. The Cecil Shear Zone appears to be entirely composed of Point Vivian Formation rocks and on the eastern side grades from tightly folded and sheared rocks through steeply dipping beds to the flat lying sedimentary rocks at the head of Rocky Boat Inlet. On the western side this shear zone has a sharp contact against the massive dolomites. There are clasts of this dolomite in the shear zone but these are at least partly cobbles and boulders from the basal part of the Point Vivian Formation. The shear zone is cut by many faults of variable orientation and often containing slickensided calcite veins. These faults are commonly sub-parallel to the limbs of tight folds.

The Osmiridium Shear Zone is predominantly composed of laminated siltstones, lenticular sandstones and matrix-rich conglomerates. Clasts in the conglomerates include serpentinised gabbro, chert, red limestone, white marble, dolomite, vein quartz, greywacke, quartzite, basalt and serpentinite. The matrix is either a red mudstone or a pale-green calcareous arkose. Clasts are up to 0.5 m in diameter. Major exotic blocks at the eastern edge of this zone include a layered and bioturbated pyritic limestone, pyritic dolomite shale, bedded pyritic shales and siltstones. The eastern margin is defined here as a fault against Tyler Creek Beds at the eastern end of Osmiridium Beach (fig. 3). The Tyler Creek Beds are closely similar in composition to the conglomerates and siltstones which make up the majority of the Osmiridium Shear Zone.

The bedding of the Osmiridium Shear Zone is steeply dipping to the east with variable strike but predominantly 350° to 040° (fig. 6). Locally a cleavage parallels the bedding, but it is not clear if this represents a sedimentary or a tectonic structure. The outstanding feature of this area is the intense faulting which occurs on all scales. An attempt to show a representative sample of these faults is made in fig. 6. There is a very wide range in orientations of faults in this zone and the only clear trend is a general dip towards the north and east. A significant proportion of the faults are parallel to the layering. A high proportion of faults in this unit contain fibrous calcite veins which indicate a wide range of slip vectors and in some cases two separate slip orientations on the same fault. No pattern has been recognised in the movement directions of these faults.

Other evidence is available for the history of strain in these rocks. Calcite-filled extension fractures are common throughout the conglomeratic units. The distribution of these fractures (fig. 8) strongly suggests a flattening plane which dips 70° towards 215°. Striated edges of dolomitic clasts in these conglomerates (plate 3) show two sets of striations, a near-horizontal set and a near-vertical set, supporting a two stage strain path for the Osmiridium Shear Zone.

The Cecil Shear Zone forms the western boundary of the Point Vivian Formation. To the east a thick sequence of sediments underlies the Wierah Formation but to the west the Wierah Formation sits unconformably on the ?Precambrian dolomite. The Cecil Shear Zone must have been an active fault during the Cambrian sedimentation. Such synsedimentary faults are well established in the Cambrian of Tasmania (e.g. Corbett 1970).

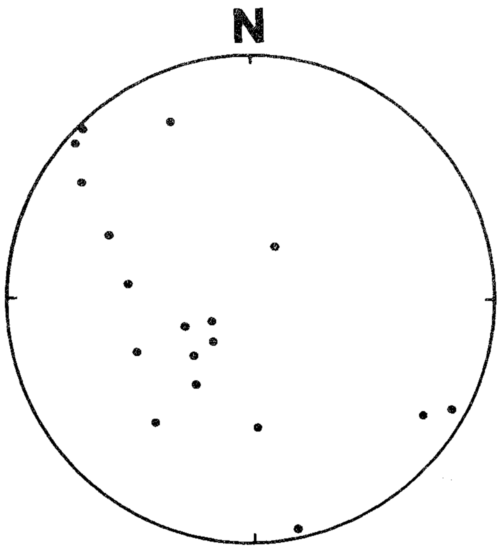

FIG. 8. - Lower-hemisphere equal-area stereographic projection of poles to extension fractures in the Osmiridium Shear Zone.

PLATE 3. - Dolomite cobble in Osmiridium Shear Zone showing two sets of tectonic striations (parallel and perpendicular to the pencil).

Summary and Correlations

Early Palaeozoic sediments of the Rocky Boat Inlet area have a simple structural history. Early open to gentle folds occur in all the sequences. A second generation of open folds strikes 105° and is correlated with minor faulting. Finally a set of strike slip faults in the Point Vivian Formation and normal faults in the Wierah Formation both imply σ_3 was near-horizontal and trending 020°. These fault sets both appear to be post-folding and in the former case is likely to be post-Permian.

On the western side of Rocky Boat Inlet and on Osmiridium Beach deformation is much stronger, forming distinct shear zones with a steeply dipping foliation. The Cecil Shear Zone contains tight folds of similar orientation to the early folds in the less deformed sequences. It has a relatively coherent appearance suggesting relatively small strains. The Osmiridium Shear Zone is dominated by brittle behaviour, contains blocks of exotic material and has had both dip-slip and strike-slip motions.

The correlation of fold structures affecting Lower Palaeozoic rocks over large distances in Tasmania has seldom been successful. The structures have orientations strongly controlled by the local basement orientation and especially in the northwest of the State this has produced a large number of fold orientations (Seymour 1980). However, in the southern areas there are some generally consistent observations despite substantial differences in detail.

Solomon (1962) recognised two generations of folds in the Queenstown area. He suggested the N-S trending phase was early and that WNW-ESE trending folds crosscut this sequence. Baillie & Williams (1975) confirmed the relative ages of these two deformations. Both deformations produced an axial plane cleavage but the early N-S cleavage was more extensively developed and the WNW striking cleavage was best developed near Queenstown. Cox (1981) correlated minor thrust faults in the Queenstown area with D_2 folds and suggested post-D_2 strike slip faults. Sharples (1979) identified doubly plunging N-S trending, open upright folds at Ida Bay.

The structure of the Rocky Boat Inlet is very similar to the folds in these areas. The early folds are dominant and strike NE. The second set is less important, closely associated with faulting, and strike ESE. This correlation supports the relatively poor dating evidence available in the region for the relative ages of the folds.

The Cecil Shear Zone and the Osmiridium Shear Zone are similar to well known structures further north. The Cecil Shear Zone is similar in appearance to the tightly-folded siliceous clastics underneath the Pioneer Beds east of the Lyell Mine where folds have been interpreted as slump folds (Solomon 1964, p.282). At Point Cecil the beds were folded while under substantial confining pressure since quartzite pebbles have been bent around the folds (plate 2). However there is little cleavage development even where interlimb angles are less than 20°. The Osmiridium Shear Zone is similar to the intensely deformed Cambrian sequence east of Penguin and at Adamsfield. However, not enough is known at this stage to support this correlation.

SUMMARY

Four major stratigraphic divisions have been proposed for the coastal exposure near Rocky Boat Inlet. A massive grey dolomite of probably Precambrian age has a very limited exposure on the western shore of Rocky Boat Inlet. The Tyler Creek Beds are pale green, graded sandstone and siltstone exposed on the coastal section east of Osmiridium Beach and form the predominant rock type in the Osmiridium Shear Zone. The Point Vivian Formation contains interbedded dolomitic siltstones, sandstones and polymictic conglomerates probably deposited on a steep slope. Deposition was post-Early Cambrian and pre-Devonian, with a probable age of Middle to Upper Cambrian. The Wierah Formation unconformably overlies the massive grey dolomite. This formation is composed of plane-bedded dimictic conglomerates with rare sandstones and siltstones. The age is poorly constrained, but this formation is certainly pre-Devonian and probably Upper Cambrian or Lower Ordovician based on lithological correlations with the Denison Ranges.

Two generations of folding, correlated with the Tabberabberan Orogeny of Devonian age, have been found in the area. The earliest phase produced upright folds with an axial surface striking NE. A second phase of folding was recognised on the southern end of Point Vivian. It has a steep axial surface striking 100° and is associated with minor thrusting. Late strike-slip faults post-date both fold phases.

There are two shear zones developed in the Denison Group. Both contain a range of structures from tightly folded coherent sedimentary rocks to incoherently sheared rocks. These zones are faulted on all scales and have a complex deformation history. The Cecil Shear Zone was active during Cambrian sedimentation. The Osmiridium Shear Zone has had at least two distinct episodes of faulting.

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