Middle-Upper Ordovician shallow platform to deep basin transect, southern Tasmania, Australia

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There is a profound change in sedimentary environment and in fauna going from the Middle-Upper Ordovician of Ida Bay to Surprise Bay over a present distance of only 25 km. The transition is from peritidal carbonates at Ida Bay, to subtidal carbonates at Precipitous Bluff to deep subtidal calcareous shales at Pt. Cecil to deep water micrites, graptolitic shales and carbonate turbidites at Surprise Bay. The blind (*Nanshanaspis, Bulbaspis*) or large eyed (*Telephina*) trilobites at Surprise Bay suggest sub-photic or twilight depositional conditions and a phosphatic, ironstone hardground enriched in metals and with imploded nautiloids suggests a zone of nutrient-rich upwelling currents at about 300 ± 50 m water depth. Macrofauna from Ida Bay is mainly endemic and is associated with Midcontinent province type or endemic conodonts. The shelf edge sections at Precipitous Bluff and Pt. Cecil contain more widespread macrofossils and Midcontinent conodonts whereas the macrofauna from the deep-water deposits is widespread or cosmopolitan and is associated with North Atlantic province conodonts.

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The Ordovician in Tasmania is chronostratigraphically the most complete sequence in Australia (Banks 1962; Banks & Burrett 1980; Webby *et al.* 1981) and its regional palaeogeographic setting has been reviewed by Webby (1976, 1978). The fossiliferous sequence in the Florentine Valley (Figs. 1, 2) ranges from the Lower Tremadoc through to the Lower Silurian in a conformable succession 2300 m thick (Corbett & Banks 1974). Other important sections occur in southern, northwestern and western Tasmania (Figs. 1, 2). Most sections exhibit a conformable fining-up sequence from siliciclastic conglomerates (often fanglomerates) to quartz arenites (intertidal–high subtidal) to siltstone (mainly subtidal) to limestone (mainly peritidal) up to siliciclastics (subtidal–peritidal).

The tripartite lithostratigraphy is probably best classified at the group level and we recommend that the Denison (dominantly siliciclastic) and Gordon (dominantly carbonate) Limestone Subgroups (of Corbett & Banks 1974 *not* Corbett & Banks 1975) be given the same status as the Eldon Group (dominantly siliciclastic). The Tiger Range Group of Baillie (1979) applied to the siliciclastics overlying the Gordon Group in the Florentine Valley may best be regarded as a subgroup of the Eldon (Fig. 2).

Based on conodont studies it is clear that the base of the Gordon Group is strongly diachronous; being oldest in the east (Middle Arenig in the Florentine Valley), Chazyan at Mole Creek and Blackriveran in the northwest at Queenstown and the Vale of Belvoir (Figs. 1, 2).

The Florentine Valley Formation contains a sequence of trilobite, brachiopod and graptolite faunas ranging from the Lower Tremadoc to the Middle Arenig (Quilty 1971; Laurie 1980; Stait & Laurie 1980; Jell & Stait in prep; Rickards & Stait in prep).

The overlying Gordon Group contains sequences of nautiloids, conodonts, brachiopods, trilobites, stromatoporoids, corals, gastropods, pelecypods, rostroconchs and bryozoa all of which have been the subject of recent intensive

In Bruton, D. L. (ed.), 1984. *Aspects of the Ordovician System.* 149–157. Palaeontological Contributions from the University of Oslo, No. 295, Universitetsforlaget.

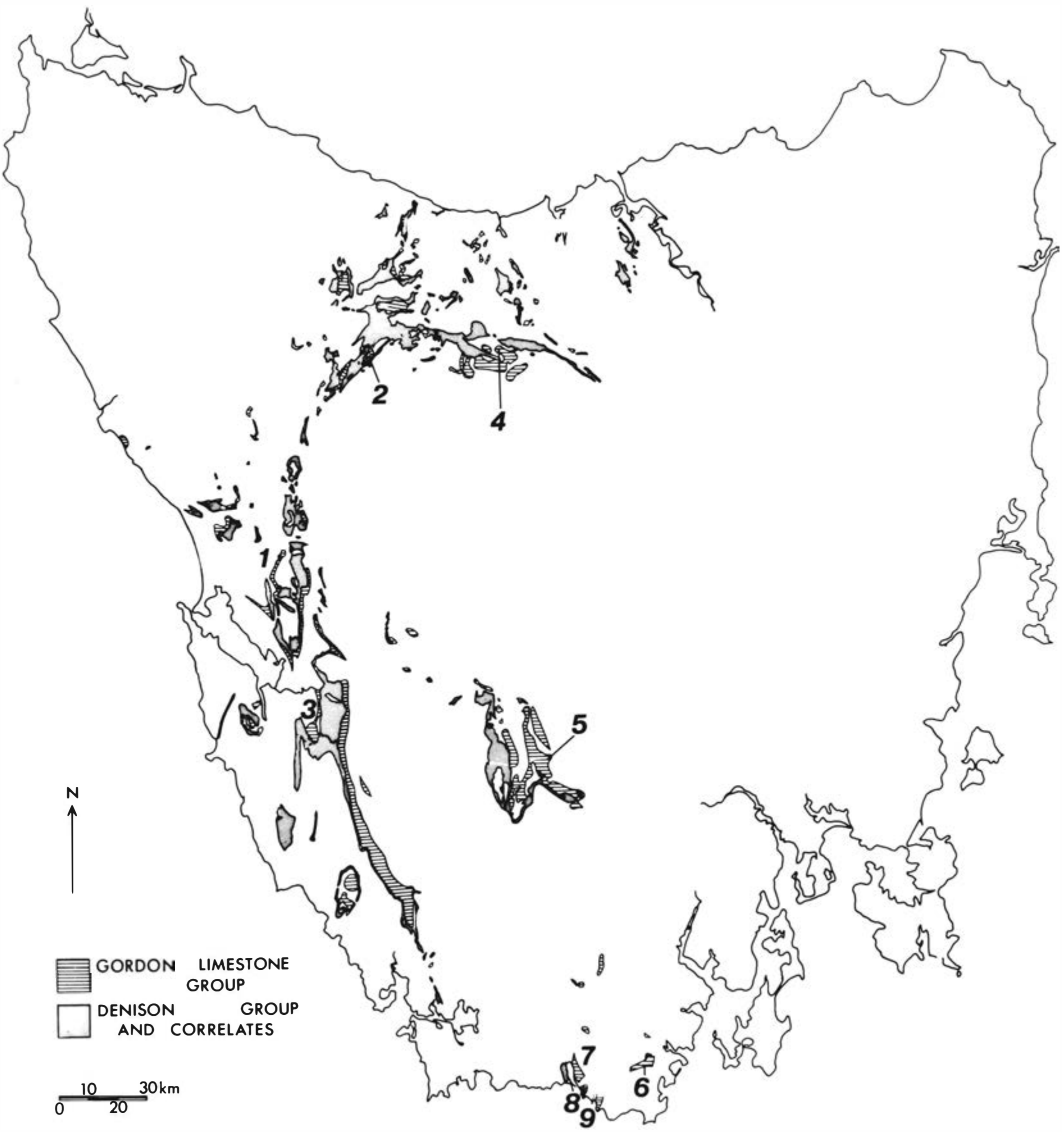

Fig. 1. Locality map of Tasmania showing major sections mentioned in text. 1: Queenstown, 2: Vale of Belvoir, 3: Lower Gordon River, 4: Mole Creek, 5: Florentine Valley, 6: Ida Bay, 7: Precipitous Bluff, 8: Point Cecil, 9: Surprise Bay.

studies. These faunas range in age from Middle Arenig through to Edenian or Maysvillian (Banks & Burrett 1980). The overlying Westfield Beds (the basal formation of the Eldon Group in the Florentine Valley) contains an *Hirnantia* fauna (Laurie 1982) occurring below, with and above a graptolite fauna of the *G. persculptus* or lower *A. acuminatus* zones of the Llandovery (Baillie *et al.* 1978).

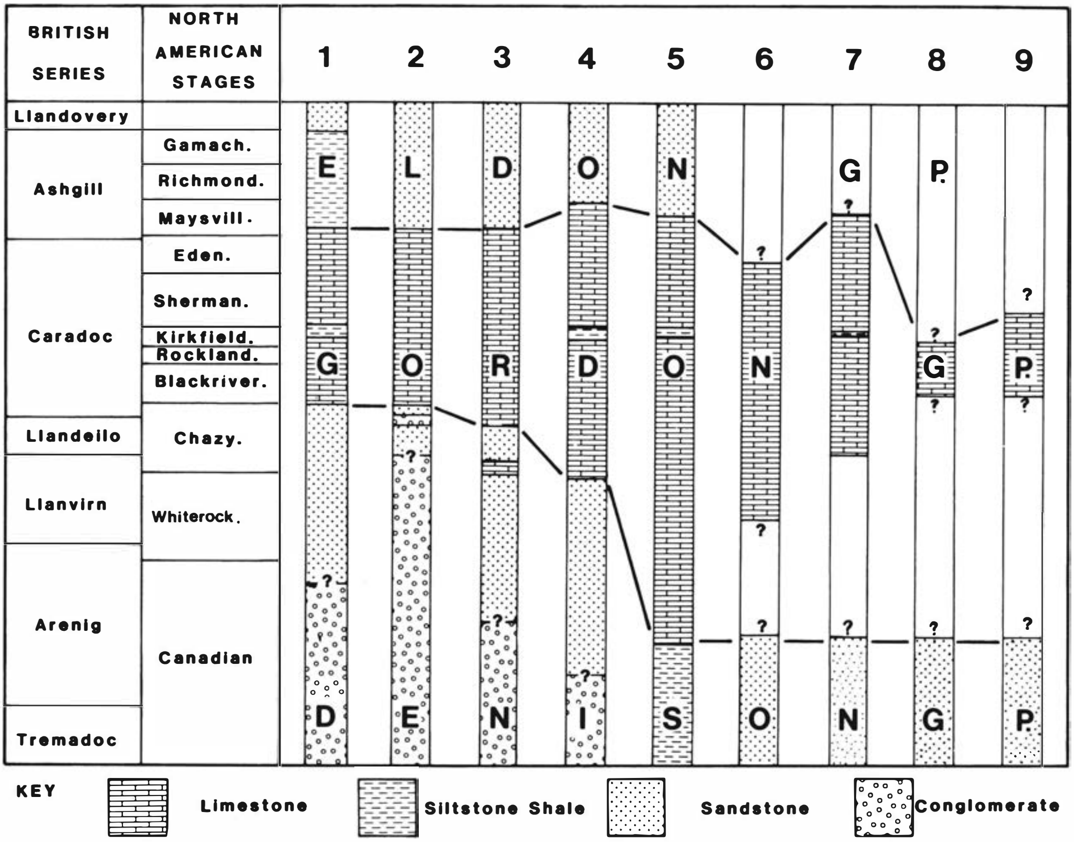

Fig. 2. Simplified stratigraphic columns showing diachronous base of the Gordon Group. Numbers refer to locations marked on Fig. 1.

Ordovician sequences in southern Tasmania

Ida Bay. – Although the limestone section at Ida Bay (Figs. 1, 2) is thrust faulted and incomplete being overlain unconformably by Upper Carboniferous or Lower Permian tillites, it is typical of the mainly peritidal Gordon Group sequences studied elsewhere in Tasmania. Ten lithofacies have been recognised (Fig. 5) ranging from supratidal/or high intertidal to high subtidal. The stratigraphic succession of the lithofacies shown in Fig. 3, indicates that most of the depth changes involve cycles of deposition followed by erosional transgressions in an overall environment of a wide, prograding tidal flat.

Precipitous Bluff and Pt. Cecil. – In contrast to the dominantly peritidal sequences at Ida Bay, the Gordon Group at Precipitous Bluff was deposited in much more open and deeper waters. Burrett *et al.* (1981) have named two conformable lithostratigraphic units. The lower New River Beds consist of 130 m of bryozoan/algal/coralline biosparenites deposited in a high energy subtidal environment. Corals and *Calathium* are sufficiently abundant on many horizons that the designation reef is appropriate. However, thick bush precludes a detailed examination of these beds away from a narrow walking track. The New River Beds are overlain by 230 m of siltstones, calcareous shales and minor biosparites and biomicrites containing a bryozoan/brachiopod/trilobite fauna (the Precipitous Bluff Beds) deposited in a deep subtidal environment.

The Prion Beach Beds at Pt. Cecil, 5 km

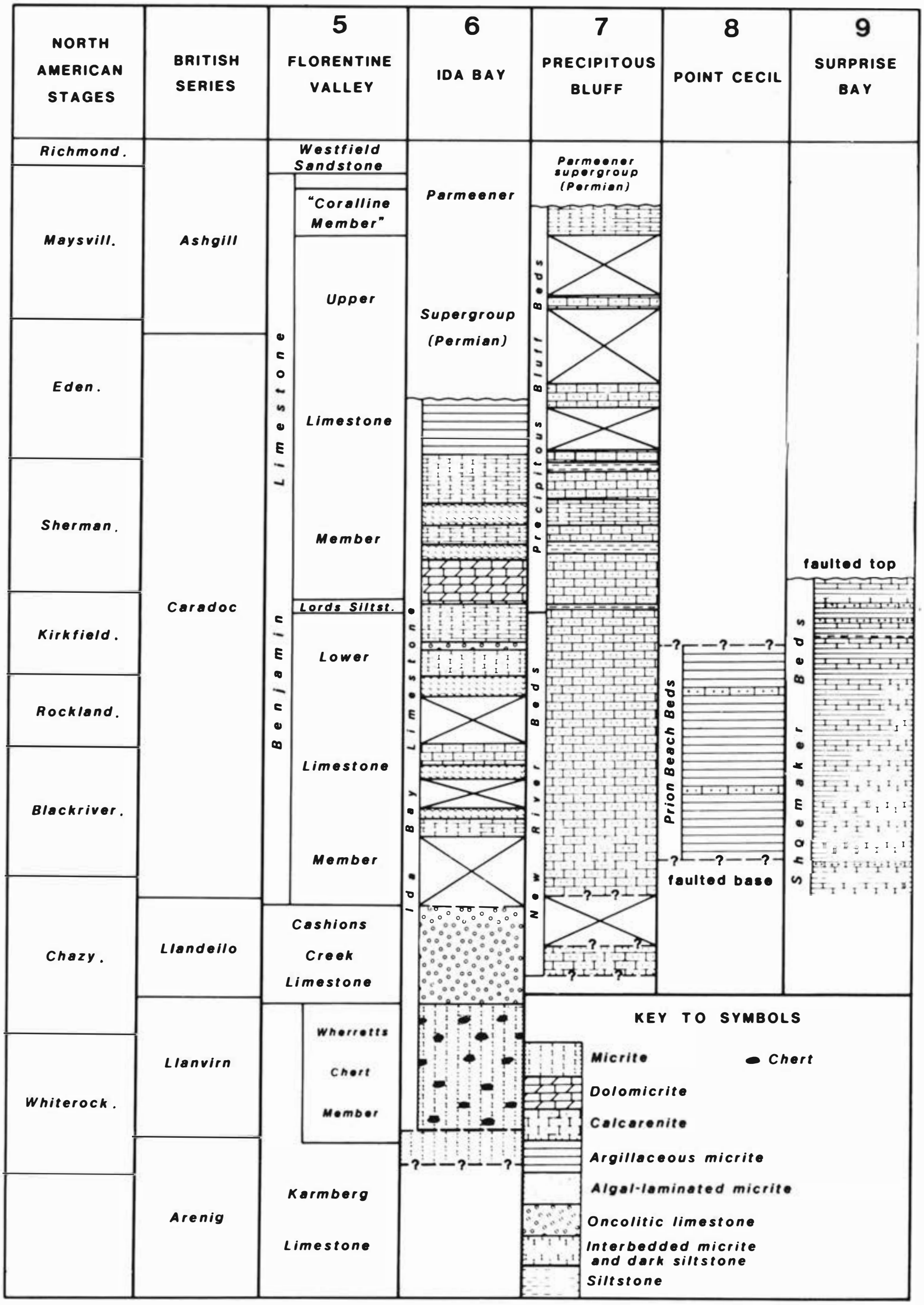

Fig. 3. Simplified stratigraphic columns showing range of carbonate lithologies in southern Tasmanian sections of the Gordon Group. Siltstone (dashed) symbol on Surprise Bay column indicates position of phosphatic hardground. Numbers refer to locations on Fig. 1.

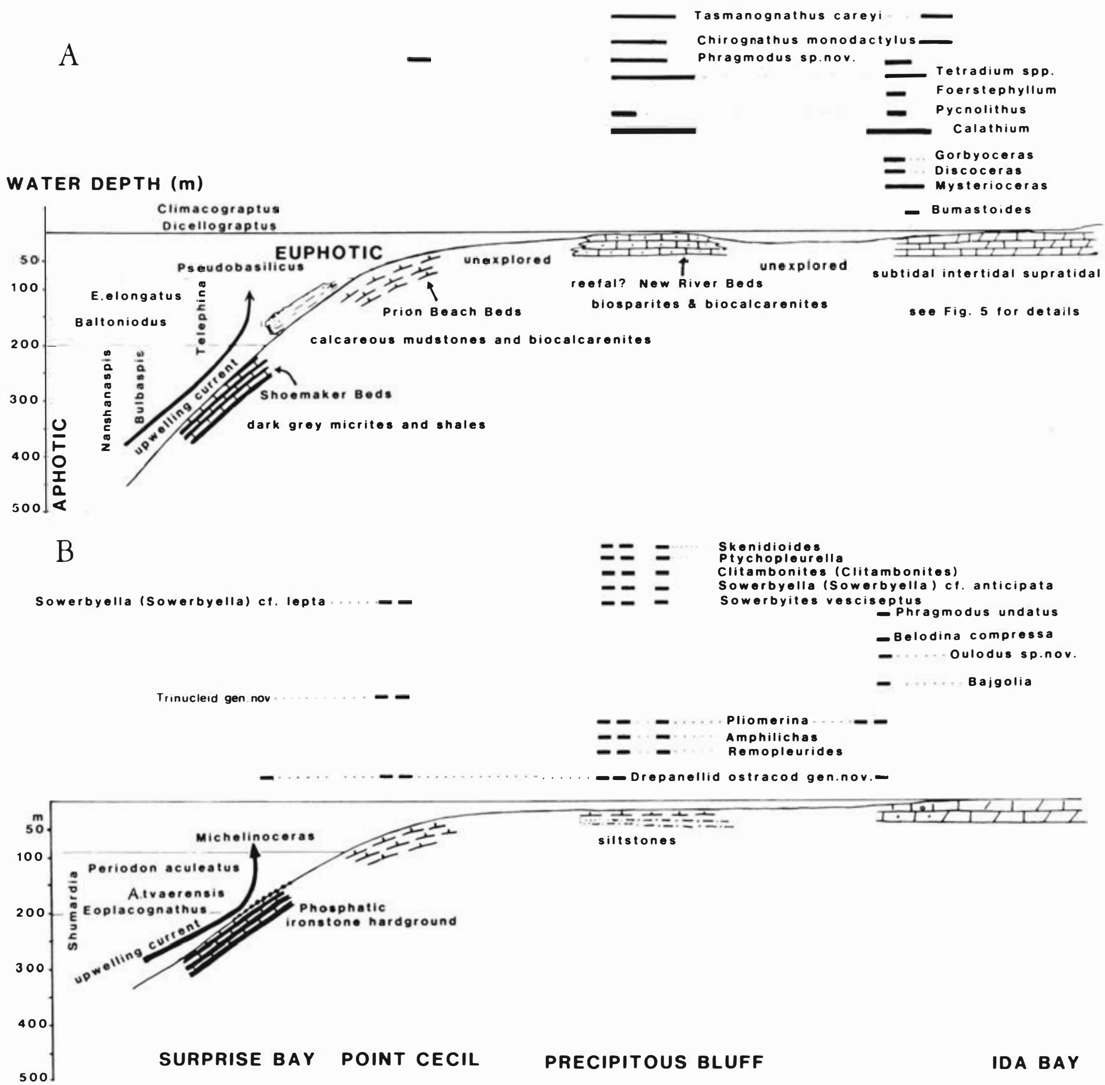

Fig. 4. Generalised environmental model showing transect from Ida Bay to Surprise Bay. Present distance is 25 km. A: Diagrammatic reconstruction for Blackriveran, B: reconstruction for Rocklandian/Kirkfieldian time.

south of Precipitous Bluff, are argillaceous micrites with minor biosparites containing a raphiophorid, a new genus of cryptolithid (Banks 1962, p. 170) and brachiopods (Fig. 4).

Surprise Bay. – The Shoemaker Beds at Surprise Bay are distinctly different from any of the other Ordovician limestones in Tasmania (Burrett *et al.* 1983). They consist of thinly bedded dark grey micrites interbedded with shales, a few lensoidal bodies of biocalcarenite and at least two phosphatic ironstone beds (Figs. 3, 4). About 5% of the micrite beds contain trilobite "swarms". The lower 100 m of section contain *Nanshanaspis murrayi*, *Bulbaspis* sp., *Telephina (Telephia) twelvetreesi*, *Pseudobasilicus* sp. and *Nileus* sp. The upper

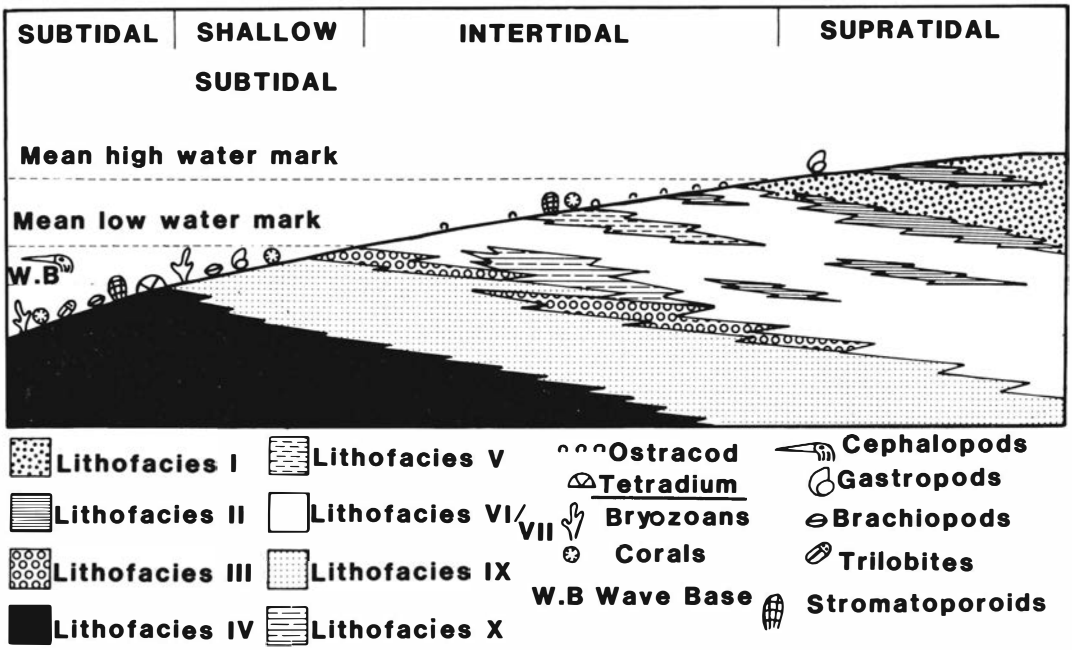

Fig. 5. Environmental distribution of the lithofacies recignised at Ida Bay. Lithofacies I: dimicrites with abundant, irregular spar birdseyes. Fossils rare except Hormotoma-*supratidal or upper intertidal. Lithofacies II: pelmicrites and rarely micrites with abundant laminae (probably algal) of dark bituminous material, abundant dolomite and minor aeolian quartz grains. Well developed mudcracks and rare gastropods. Protected, dessicating environment – peritidal. Lithofacies III: oncolitic limestones between subtidal and intertidal horizons. Oncolites decrease in size towards the subtidal going from 30–40 mm diameter in a dolomitic microspar down to 5–8 mm in a poorly washed intrabiospelsparite matrix. Wave agitated, low intertidal or upper subtidal environment. Lithofacies IV: Biomicrites with dolomitised worm burrows and diverse biota of corals, bryozoa, gastropods, nautiloids, calcareous algae, crinoids and stromatoporoids.* Tetradium *dominated band may represent "wave baffle community" of Walker (1972). Lithofacies V: horizontally burrowed intrapelsparites with minor oosparites. Fauna dominated by large stromatoporoids,* Foerstephyllum *and* Hecatoceras. *This may be analogous to the coeval* Stromatocerium/Foerstephyllum/Antinoceras *community of Walker (1972). Low intertidal, subject to intermittent wave action and crossed by tidal channels. Lithofacies VI: micrites and biomicrites with thin, irregular, dolomitic layers, interbedded with intraclastic breccias and graded calcarenites resting on scoured surfaces. Vertical burrows, probable evaporite pseudomorphs, rare birdseyes and mudcracks are present. Ostracods abundant. Dessicated upper-intertidal environment. Lithofacies VII: is similar to VI but lacks dessication features and contains greater abundance of unbroken fossils. Lower intertidal environment. Lithofacies VIII: is volumetrically minor, rests above Lithofacies II and below I. Micrites with tabular, 1–2 mm diameter birdseyes and abundant vertical worm burrows. Upper intertidal/ lower supratidal environment. Lithofacies IX: intrasparites and intrabiosparites with micrite intraclasts several centimetres long. Brachiopods, trilobites, gastropods, bryozoa,* Solenopora, *solitary corals and crinoid debris. Energetic subtidal environment. Lithofacies X: biosparites and biomicrites with silt layers. Micrite beds are sparsely fossiliferous but may contain worm burrows. Most fossils are confined to graded, densely packed coquinae in a spar matrix. Silt bands consist of angular quartz in an argillaceous and/or bituminous groundmass. The silt bands are thought to represent changes in terrigenous input from the source area. Low intertidal environment.*

100 m contains abundant specimens of *Shumardia forbesi.* Of these trilobites *Nanshanaspis, Bulbaspis* and *Shumardia* are blind and *Telephina* has extremely large eyes. By analogy with modern marine isopods (Menzies *et al.* 1973; Taylor & Forester 1979) it is probable that the blind forms inhabited depths below the photic zone. The very large eyes of *Telephina* are most reasonably considered adaptations to the disphotic (twilight) zone (i.e. about 150–200 m

in the tropics). In the early–Middle Ordovician, *Nileus* is characteristic of the Nileid Community of Fortey (1975) which is thought to have inhabited the upper slope of the North American Block (Shaw & Fortey 1977).

Several 0.5–1 m thick, graded, lensoidal biocalcarenites with minor cross-bedding at their tops, are probably carbonate turbidites and are similar to modern examples described by Van Tassell (1980).

The lowest of these turbidites contains a North Atlantic Province conodont fauna (*Periodon aculeatus, Protopanderodus varicostatus, Eoplacognathus* and *Baltoniodus gerdae*) whereas higher calcarenites yield *Amorphognatus tvaerensis* and *Protopanderodus liripipus.* None of these genera or coprovincial forms are found in Gordon Group sections of Middle-Ordovician age which are dominated by either Midcontinent Province species or endemic species morphologically similar to Midcontinent genera and species.

A 4 cm thick phosphatic, ironstone bed marks a lithological and biological change in the Shoemaker Beds. Below this bed there is generally no sessile benthos except to within 10 m of the bed where sponges are present. Above the ironstone, bryozoans and articulate brachiopods occur and nautiloids and gastropods are common within the ironstone. The overlying micrites are much lighter than those below which, with the faunal evidence, suggests a transition into a more oxygenated zone. By analogy with modern basins this transition may have occurred at about 250 m water depth (Rhoads & Morse 1971). The ironstone consists of pyrite and collophane with a nodular, oxidised (limonitised), bored crust suggesting that it was a submarine hardground. The ironstone is considerably enriched in Cu, Zn, Pb and Ba (but not Mn, Os and Ir) relative to the bulk of the Shoemaker Beds suggesting that the bed formed in a zone of nutrient rich, plankton rich (and hence trace element rich, Berry 1981) upwelling near a basin margin.

The large numbers of *Michelinoceras* sp. in the hardground perhaps fed on the profuse plankton in this upwelling zone. Most of the *Michelinoceras* specimens are completely broken but a few have their distal camerae crushed in. One specimen is proximally embedded in the ironstone but the crushed distal camerae do not contain any of the overlying shale indicating that the crushing is more likely due to implosion than to overburden pressure or predation. Using the formula of Westermann (1973) which relates septal thickness and curvature to implosion depth, a depositional depth of 300 ± 50 m is suggested.

Nodular phosphates are currently forming at similar depths in areas of upwelling along the East Australian shelf margin (Kress & Veeh 1980) and similar sulphide/ironstone beds have been reported from basinal carbonates of the Ordovician of the Appalachians (Read 1980).

The hardground thus forms a useful, absolute palaeodepth datum within the Shoemaker Beds of 300 ± 50 m. The change to oxygenated conditions above this level may have been caused by a basinal uplift, or by a shift in the zone of upwelling or by a downward expansion of the oxygen-rich zone in the manner suggested by Fischer & Arthur (1977).

Conclusions

During the Blackriveran-Kirkfieldian in southern Tasmania there is a transition from tidal flats, to outer platform reefs, to platform marginal calcareous shales to deep pelagic carbonates. This transition fits the general model of Wilson (1975). Similar transects have recently been documented from the Upper Cambrian of Nevada (Cook & Taylor 1976), from the Lower Ordovician of Spitzbergen (Fortey 1975; Fortey & Barnes 1977), and the Middle Ordovician of Texas (Bergström 1978; King 1977), Virginia (Read 1980), and the Mackenzie Mountains (Ludvigsen 1978). Tasmania appears to have been a mini-platform compared with the North American, Siberian and Australian blocks and the profound sedimentological contrasts occur over a relatively short distance (< 25 km) compared with several hundred on the major platforms. The faunal contrasts are also profound. The peritidal sections supported a strongly endemic macrofauna with a Midcontinent province type conodont fauna. A similar fauna but with elements found elsewhere in Australia occurs in the platform margin whilst the deep water facies contain a totally different macrofauna with cosmopolitan or "Chinese" affinities and a North Atlantic Province conodont fauna. Only one faunal element (a new drepanellid ostracod genus) is found across the whole transect but this is stratigraphically long-ranging and it remains impossible to correlate directly between Surprise Bay and the rest of Tasmania. However, it seems possible that the shallowing exhibited in the top part of the Shoemaker Beds at Surprise Bay and the deepening exhibited at Precipitous Bluff (and indeed in the Florentine Valley) happened isochronously at about the Kirkfieldian suggesting a substantial decrease in depositional slope over a wide area of southern and central Tasmania. Using Read's (1982) terminology this is a transition from a rimmed shelf to a ramp which caused or coincided with a profound change in lithology and fauna across the whole of the Tasmanian platform.

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