MIDDLE-UPPER ORDOVICIAN CONODONTS AND STRATIGRAPHY OF THE GORDON LIMESTONE SUB-GROUP, TASMANIA

by

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Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

University of Tasmania
Hobart

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C Burnett

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ABSTRACT

The Gordon Subgroup attains a thickness of 2100m of carbonates and minor siltstones in its redefined type section in the Florentine Valley and ranges in age from Late Canadian-Llandoverian. Detailed studies of the conodonts from the Chazyan-Edenian parts of the subgroup, throughout the western half of Tasmania, reveal a faunal sequence very similar to that found in the North American Midcontinent faunal province.

Lithostratigraphic studies in the subgroup at Mole Creek in north-western Tasmania have led to the recognition of a conformable succession of seven mappable members within the 1300m. of the Chudleigh Limestone Formation. The Standard Hill Member is 120m. thick, conformably overlies the Moina Sandstone, is oncolitic with minor calcarenites and was probably deposited mainly in a low intertidal environment. This member is overlain by the Ugbrook Nodular Member which consists of 120m. of nodular agillaceous limestones, barren of macrofossils, and minor trilobite-bearing micrites. It is probably of the same age as a cross-bedded sandstone south of Standard Hill. The nodular limestone is interpreted as a lagoonal deposit formed behind a sand bar. The Sassafras Creek Member is a 135m. thick sequence of micrites and dolomicrites with a 3m. thick biocalcarenite bed at the base and a thin oncolitic bed at the top. The 470m. thick Dog's Head Member is a sequence of micrites and dolomicrites containing chert nodules and several beds of silicified macrofossils. The Mole Creek Member consists of 75m. of reddish siltstones containing an orthid/stictoporellid/*Pliomerina* fauna. The Overflow Creek Member consists of 45m. of mainly unfossiliferous dolomicrites and dolosiltites probably deposited on a tidal flat crossed by tidal channels. The subtidal Den Coralline Member consists of 45m. of highly fossiliferous

biomicrites and biocalcirudites overlain by 40m. of creamy textured, mainly macro-unfossiliferous, micrites. Brachiopodal/trilobitic siltstones overlie the creamy textured micrite and are the youngest beds of the Gordon Subgroup. These are overlain conformably by white unfossiliferous quartzites of the Eldon Group.

The Chudleigh Limestone was mainly deposited under peritidal conditions and only 20% of the sequence was deposited in a subtidal environment. Six major subtidal sequences may be identified. Four of these are in the Dog's Head Member, one is in the Mole Creek Member and one is in the Den Member and above. Very stable tectonic conditions and low amplitude eustatic oscillations are indicated for the Mole Creek area from the Chazyan-Edenian.

The conodont collections from Mole Creek and the Florentine Valley may be used to erect a local succession of assemblages. All assemblages contain *Panderodus gracilis* (Branson and Mehl), *Drepanoistodus suberectus* (Branson and Mehl) and *Belodina compressa* (Branson and Mehl).

Assemblage A is found in and just above the Standard Hill Member at Mole Creek and in and just above the Cashions Creek Formation in the Florentine Valley. It is also found in oncolitic and non-oncolitic limestones in many parts of the state.

The assemblage consists of *Phragmodus flexuosus* Moskalenko, *Belodina alabamensis* Sweet and Bergström, *Acontiodus* cf. *nevadensis* Ethington and Schumacher, *Belodella copenhagensis* (Ethington and Schumacher), *Panderodus serpaglii* sp. nov., *Appalachignathus?* Bergström *et al.*, and *Drepanoistodus forceps* (Lindström). Correlation to North American faunas 5 and 6 (Chazyan) and to the Kirenskiy Sub-formation of Siberia is suggested.

This assemblage is overlain at Mole Creek and in the Florentine

Valley by Assemblage B which contains the endemic species *Phragmodus tasmaniensis* sp. nov. and a probable member of the "Australian" fauna *Rhipidognathus? careyi* sp. nov. The assemblage is correlated with North American Fauna 7 by means of abundant specimens of *Chirognathus monodactylus* Branson and Mehl and by the earliest occurrence of *Plectodina aculeata* (Stauffer). Assemblage B is found at the base of the limestone sequences in the Vale of Belvoir and at Zeehan, in the Everlasting Hills and in the Lower Limestone Member of the Benjamin Limestone and the Ugbrook Member at Mole Creek.

Assemblage C contains *P. aculeata*, *Phragmodus undatus* Branson and Mehl and *Erismodus* sp. This and succeeding assemblages are found in most areas and correlation with Fauna 8 is suggested. Assemblage D contains the same species as Assemblage C but *Bryantodina? abrupta* (Branson and Mehl) and *Plectodina florentinensis* sp. nov. are added. Correlation with Fauna 9 is probable. Assemblage E is similar to D but *P. aculeata* is replaced by *P.* cf. *furcata* (Hinde) and correlation with Fauna 10 is suggested.

The highest assemblage (F) contains *O. robustus* (Branson, Mehl and Branson), *Oulodus* cf. *oregonia* Branson, Mehl and Branson and *P.* cf. *furcata* and correlation with the Edenian is suggested. Parts of this assemblage are found at Bubs Hill, Mole Creek, Picton River, Florentine Valley and Ida Bay and suggest that limestone deposition terminated at about the same time throughout the state. Limestone deposition at Flowery Gully terminated in the Whiterock and may have terminated in the Chazyan at Railton and in the Blackeriveran at Melrose.

Conodonts below Assemblage A have not been studied in detail though the presence of *Periodon aculeatus* Hadding and other conodonts studied by D.J. Kennedy suggests correlation to the Whiterock. Whiterock faunas are known at Railton at Flowery Gully and in the Florentine Valley. The lowest limestones in the Vale of Belvoir and near Zeehan are

Blackriveran in age and overlie intertidal siliciclastics and suggest that a westwards transgression occurred from the early Whiterock onwards.

The depositional area of the Gordon Subgroup may be compared to that of modern Shark Bay in Western Australia. Both may be considered as shallow water embayments into large peneplained continents and both contain thick sequences of carbonates dominated by intertidal limestones. As an embayment into continental crust no large scale relative movements are considered necessary to account for the differences between the Gordon Subgroup carbonates and the deep water graptolite-bearing lutites of eastern Tasmania and Victoria.

In a small embayment flanked by extensive carbonate mudflats hypersalinity would be expected and may account for the low conodont diversity. The very low conodont yields per kg. are ascribed to hypersalinity and other harsh and unstable environmental features and also to a high rate (32mm/1000 yrs.) of sedimentation.

The environmental preferences of most conodont species was for subtidal conditions and only *Panderodus serpaglii* sp. nov., *Rhipidognathus? careyi* sp. nov., *C. monodactyla*, *Erismodus* sp., and to a lesser extent *P. tasmaniensis* were well adapted to tidal flat conditions.

Mapping of the Conodont Alteration Index throughout the state necessitates the postulation of a high heat flow concentrated around the peripheries of the central Precambrian blocks during the Devonian.

CHAPTER I

INTRODUCTION

Gordon Subgroup

The Junee Group ranges in age from Franconian-Llandoverian and may be divided into a lower clastic sequence (the Denison Subgroup) and an upper, mainly carbonate sequence (the Gordon Subgroup).

The Gordon Subgroup is extensively developed in the western half of Tasmania. It ranges in age from Arenigian to Llandoverian and attains a maximum thickness of 2100 metres. The Gordon Limestone Subgroup has been redefined in the southern Florentine Valley by Corbett and Banks (1974, p.220) as "That sequence of marine limestone with lesser siltstone and sandstone lying conformably between the Florentine Valley Formation below and the Westfield Beds above." The Westfield Beds have since been included in the subgroup which was renamed the Gordon Subgroup (Corbett and Banks 1975). The general Lower Palaeozoic geology of Tasmania is summarised in Figure 1 (from Corbett 1970), and general accounts of the Lower Palaeozoic geology of Tasmania may be found in Banks (1963, 1965) and in Banks and Burrett *(in press)*.

Aims

The major aims of this study are to erect a conodont biostratigraphy for the Gordon Subgroup, based mainly on continuous sections west of Mole Creek (northwest Tasmania) and to correlate the subgroup throughout Tasmania.

The thesis will be argued that the Gordon Subgroup at Mole Creek may be divided into seven distinctive members which contain

conodonts characteristic of American "Midcontinent" conodont faunas five through to eleven. It will be shown that these faunas occur widely throughout Tasmania and provide a sound biostratigraphy for the Gordon Subgroup.

Only the Chazyan-Edenian part of the limestone sequences has been studied. The Middle Arenigian-Lower Chazyan sections below the *Maclurites-Girvanella* 'beds' of Banks and Johnson (1957) are being studied by Dr. David Kennedy (University of Waterloo, Canada).

Choice of Localities

At the beginning of this project no lithostratigraphic units (apart from the *Maclurites-Girvanella* lithotope) had been recognised within the Gordon Subgroup except in the Florentine Valley (Corbett 1963, 1970). Corbett and Banks (1974) have since published a description of the Ordovician sequence in the Florentine Valley, have outlined a preliminary biostratigraphy, and have defined several distinctive formations and members.

Mole Creek was chosen as the initial site of detailed biostratigraphic study by M.R. Banks and the writer because of the presumed lack of structural complication, the excellent outcrop, the fossiliferous nature of the limestone, the lack of thick bush and because the contacts between the overlying and underlying clastics could be mapped to within a few metres. The Florentine Valley outcrops, although lacking structural complexity and being fossiliferous, often have poor outcrop consisting of strike ridges with considerable stratigraphic gaps in between. Important outcrops are being continuously overgrown during forest regeneration.

FIGURE 1

Interpretative summary of the main elements of the Pre-Carboniferous rocks of Tasmania. From Corbett (1970).

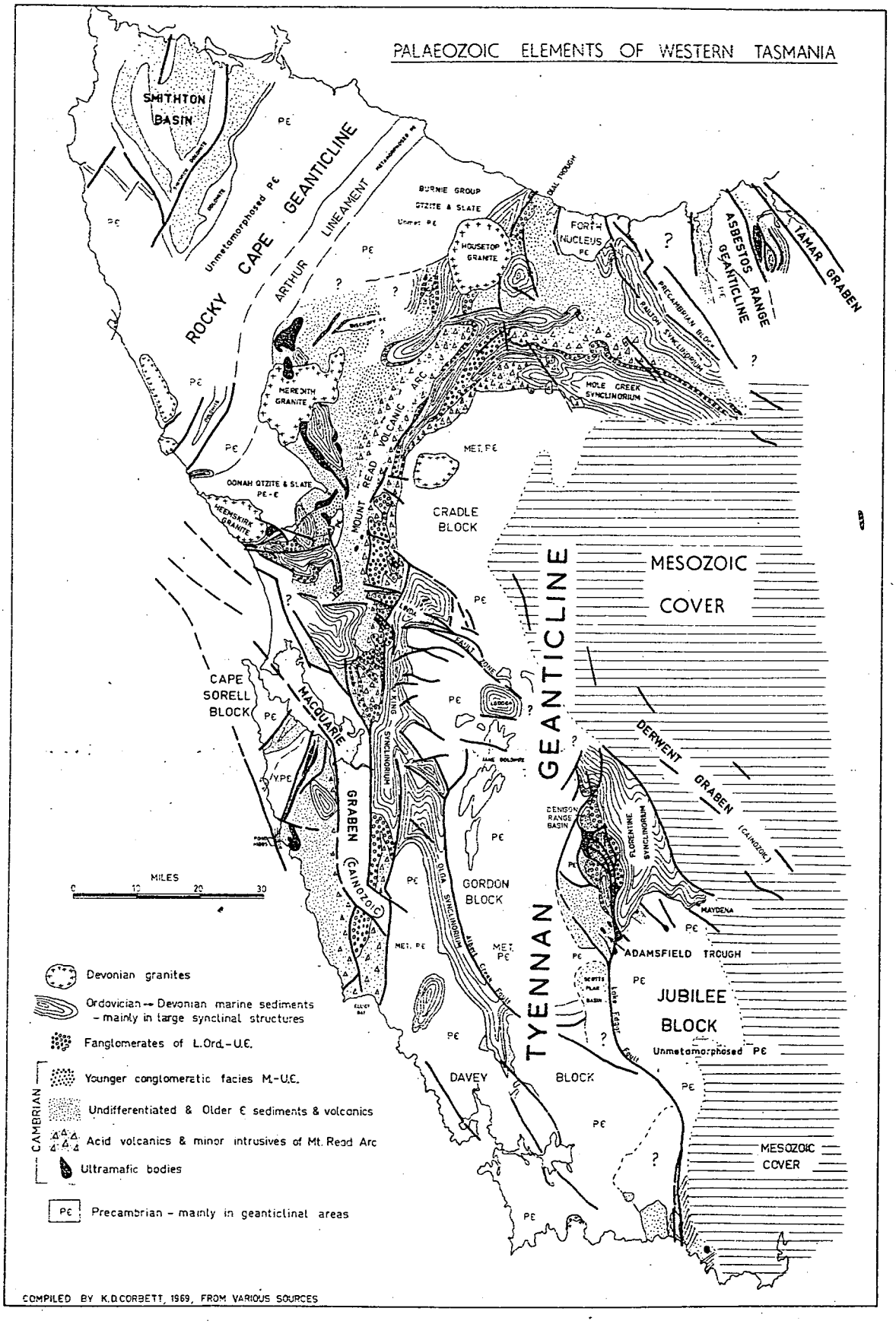
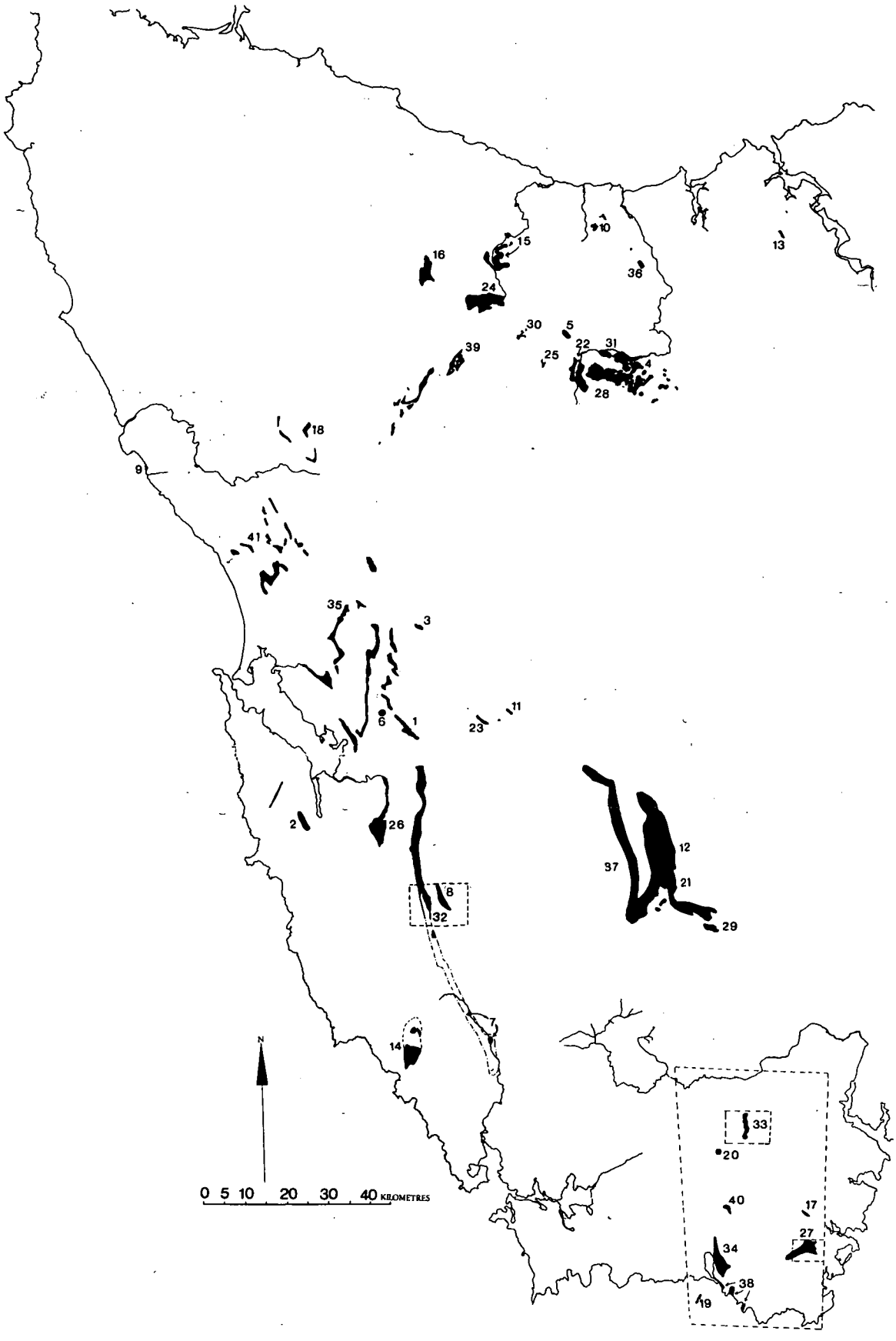

PALAEOZOIC ELEMENTS OF WESTERN TASMANIA
SMITHTON BASIN
ROCKY CAPE GEANTICLINE
ARTHUR LINEAMENT
Unmetamorphosed P€
BURNIE GROUP
QTZITE & SLATE
HOUSETOP GRANITE
FORTH NUCLEUS
ASBESTOS RANGE GEANTICLINE
TAMAR GRABEN
PRECAMBRIAN BLOCK
RALEIGH SYNCLINORIUM
HOLE CREEK SYNCLINORIUM
MEREDITH GRANITE
MOUNT READ VOLCANIC ARC
MET. P€
DONAH QTZITE & SLATE P€-€
HEEMSKIRK GRANITE
CRADLE BLOCK
MESOZOIC COVER
TYENNAN GEANTICLINE
CAPE SORELL BLOCK
MACQUARIE GRABEN (CAINOZOIC)
KING SYNCLINORIUM
FAULT ZONE
GORDON BLOCK
DENISON RANGE BASIN
FLORENTINE SYNCLINORIUM
DERWENT GRABEN (CAINOZOIC)
MAYDENA
ADAMSFIELD TROUGH
JUBILEE BLOCK
Unmetamorphosed P€
DAVEY BLOCK
MESOZOIC COVER
MILES
0 10 20 30
Devonian granites
Ordovician → Devonian marine sediments – mainly in large synclinal structures
Fanglomerates of L.Ord.–U.€.
CAMBRIAN
Younger conglomeratic facies M.–U.€.
Undifferentiated & Older € sediments & volcanics
Acid volcanics & minor intrusives of Mt. Read Arc
Ultramafic bodies
P€ Precambrian – mainly in geanticlinal areas
COMPILED BY K.D.CORBETT, 1969, FROM VARIOUS SOURCES

FIGURE 2 Distribution of main areas of Gordon Subgroup localities in Tasmania. Compiled from various sources.

1. Andrew River*, 2. Near Birch's inlet*, 3. Bubs Hill*, 4. Chudleigh*, 5. Claude Creek*, 6. Darwin Crater*, 7. Davey River (dashed line indicates probable extent of Gordon Subgroup under alluvial cover in Hardwood and Olga River Valleys), 8. Denison River*, 9. Near Duck Creek, 10. Eugenana-Melrose-Paloona Area*, 11. Everlasting Hills*, 12. Florentine Valley**, 13. Flowery Gully*, 14. Giblin River area, 15. Gunn's Plains*, 16. Hampshire, 17. Outcrop to West of Hastings Caves*, 18. Huskisson River area*, 19. Isle du Golfe, 20. Judd's Cavern, Picton Range*, 21. Junee*, 22. Liena*, 23. Loddon River, 24. Loongana*, 25. Lorinna*, 26. Lower Gordon River, 27. Lune River (Ida Bay)**, 28. Mayberry area*, 29. Maydena, 30. Moina*, 31. Mole Creek area**, 32. Olga River - Gordon River area*, 33. Picton River*, 34. Precipitous Bluff, 35. Queenstown*, 36. Railton*, 37. Rasselas Valley, 38. South Coast outcrops*, 39. Vale of Belvoir*, 40. Vanishing Falls*, 41. Zeehan*.

** Major section
* Sampled for conodonts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Previous Work

Although the Gordon Limestone has been studied for over one hundred years little detailed stratigraphical, sedimentological, or palaeontological work has been published.

Gould (1860, 1861) reported limestone in the Chudleigh (Fig. 2) and Don districts and considered limestones in the Gordon Plains and the Florentine Valley (Locality 12 in Fig. 2) to be identical with those in the north. In 1862 he collected fossils from the lower Gordon River (Locality 11 in Fig. 2) and considered these and limestones from Chudleigh, Don and the Florentine Valley to be Lower Silurian (i.e. Ordovician). This age assignment was confirmed by "the most competent Palaeontologist in the colonies" - McCoy (*in* Gould 1866). Thomas (1948 Table) clearly erred when he wrote that Gould had assigned the Gordon, Don and Chudleigh limestones to the Upper Silurian. The controversy (Carey 1947, Thomas 1948) surrounding the stratigraphic placement of the Gordon Limestone has been reviewed by Smith (1959, pp.72-74) and Corbett and Banks (1974, pp.211-212).

Johnston (1888, pp.39-40) tentatively suggested that the "ancient non-fossiliferous limestones at Chudleigh, Circular Marshes, Vale of Belvoir, Don, Mersey, Ilfracombe, and elsewhere" were Upper Cambrian and "probable equivalents of the Canadian Period." He placed these limestones into his Primordial Calciferous Group, leaving the Gordon River Group limestones in the Lower Silurian and more specifically correlating the latter group to the Bala and Caradoc of Britain.

The term Gordon Limestone was first used by Gould (1866), first defined by Banks (1962, p.171) and raised to the status of subgroup by Corbett and Banks (1974).

Techniques

Two hundred and fifty conodont samples were collected at approximately five metre intervals through the limestone at Mole Creek and another four hundred samples have been dissolved from Gordon Subgroup localities elsewhere in Tasmania (see Fig. 2). Unfortunately it soon became apparent that much of the Gordon Subgroup was barren of conodonts and extensive recollecting of potentially productive sub-tidal biomicrites and channel calcarenites, within mainly intertidal sequences, became necessary. Channel sampling would have yielded extremely small faunas as the intertidal/supratidal sequences would have diluted the moderately fossiliferous subtidal/low intertidal beds. When sampling new sections of Gordon Subgroup the most efficient method has been to recognise potentially productive lithologies and to concentrate collecting on these. A few high intertidal samples are collected as a control but these are invariably barren. This *modus operandi* has been particularly effective during reconnaissance surveys in the Vale of Belvoir, Everlasting Hills and Loongana areas (Localities 39, 11, & 15 in Fig. 2).

Many areas of Gordon Subgroup have not been sampled because of the jungle that covers large areas of the western half of Tasmania where there is very high rainfall. Mature temperate rainforest is relatively easy to move through but other terrains covered with thick bush can be traversed only with considerable difficulty. For this reason potentially interesting outcrops in southwestern Tasmania have not been sampled.

During the course of this study new Gordon Subgroup outcrops were found by bushwalkers along the Picton River and in the Cracroft area (Fig. 2) and a new outcrop was found by the writer and

I.A. McKendrick in the Everlasting Hills area (Fig. 2). It is very likely that more limestone outcrops are yet to be discovered in Tasmania.

Conodont abundances of productive samples average fifteen per kilogram and abundances of over one hundred per kilogram are very rare.

Limestones have been dissolved in acetic acid and all conodonts, scolecodonts, chitinozoa and problematica have been extracted.

A detailed local conodont zonation has not been possible because of the many unfillable gaps and correlations have therefore been made directly to the North American conodont faunal scheme (Sweet *et al.* 1971, Sweet and Bergström 1976)

Palaeontological work

During this century a few taxonomic studies have been carried out on small faunules from various, often poorly located, outcrops of the Gordon Subgroup. Hill and Edwards (1941), Hill (1942, 1955) worked on corals, Teichert and Glenister (1953) on cephalopods, Banks and Johnson (1957) on *Girvanella* and *Maclurites*, Ross (1961) on bryozoa and most recently Webby and Banks (1976) on some stromatoporoids. Kennedy (1971) studied a Lower Ordovician conodont fauna from samples from Flowery Gully (Locality 13 on Fig. 2).

Modern stratigraphic work

A general survey of Gordon Subgroup occurrences, mainly from an economic point of view, was compiled by Hughes (1957). General accounts of Gordon Subgroup stratigraphy and palaeontology by Banks (1957, 1962) form the basis of this work. The work of Corbett and Banks (1974) in the Florentine Valley is the only detailed stratigraphy of the Gordon Limestone published to date.

CHAPTER II

STRATIGRAPHY OF THE CHUDLEIGH LIMESTONE AT MOLE CREEK

Previous work

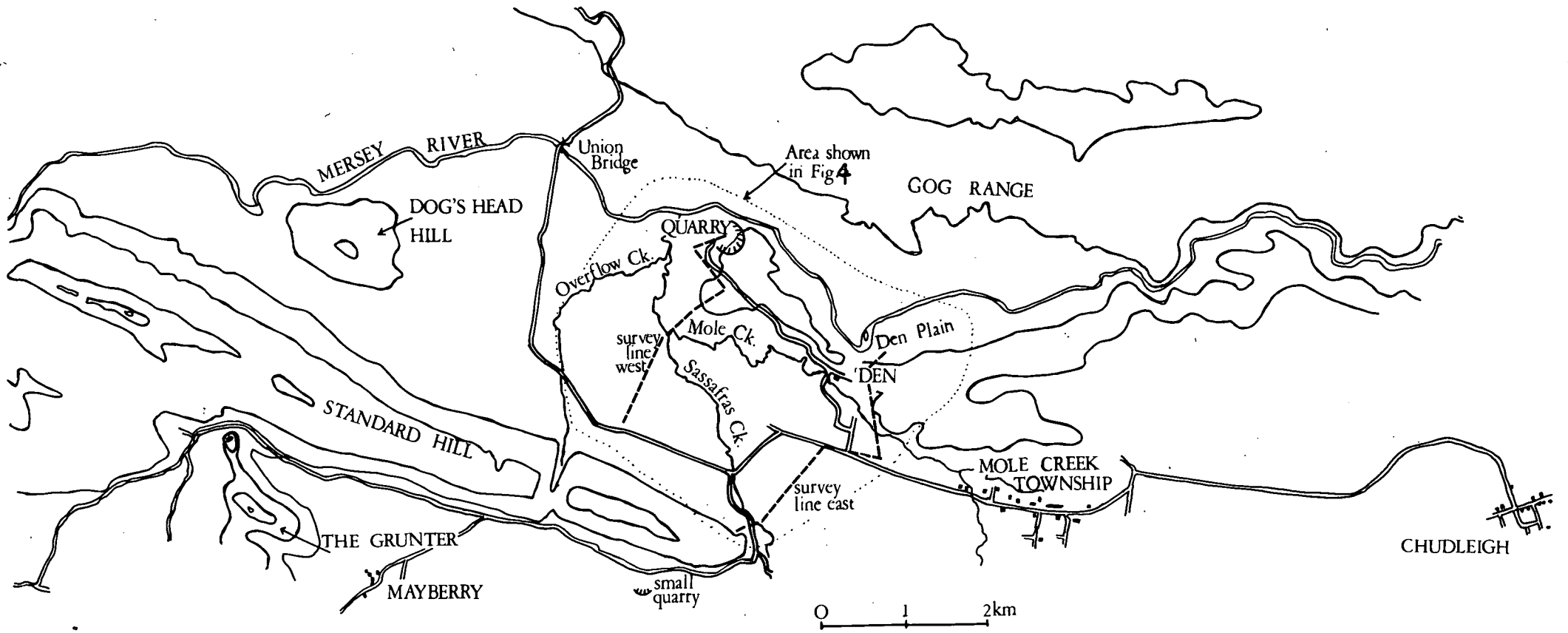
Limestone has been known in the Mole Creek (locality 31 on Fig. 2) - Chudleigh area (Locality 4 on Fig. 2) at least since Strzelecki (1845) mentioned it. Gould (1866) suggested that the limestone at Chudleigh was Lower Silurian (i.e. Ordovician). Johnston (1888) placed the Chudleigh Limestone in his Primordial Calciferous Group and thought it was Upper Cambrian (Canadian) mainly because of the apparent lack of fossils (see page 14) even though Gould (1866) had earlier found fossils in the limestone. Hill (1942, 1943) identified *Favistina cerioides*, *Plasmoporella* cf. *convexotabulata*, *Favosites marginatus* and *Falsicatenipora chillagoensis* at Liena and suggested a Late Ordovician age. General accounts of the limestone based on regional mapping by the Mines Department of Tasmania in the area are Hughes (1957), Jennings (1963) and Rowe (1963). Banks (1957, 1963) identified some elements of the fauna and gave an outline of the stratigraphy and Webby and Banks (1976) described and illustrated part of the stromatoporoid fauna from Mole Creek.

All grid references have been obtained from the Mersey 1:100.000 sheet 8114 edition 1, series R661.

An area to the north of Standard Hill (Fig. 3) was chosen for detailed study because of the lack of structural complexity, the lack of superficial covering, the good outcrop and ease of access. Two main sections were surveyed by M.R. Banks and the writer, one in the east starting at the eastern end of Standard Hill (grid ref. DP466989, see Fig. 3) and ending at Den Plains;

FIGURE 3

Locality map of the Mole Creek area. The axis of an anticline passes approximately along Standard Hill which is composed of sub-limestone Moina Sandstone. Ordovician limestone outcrops to the north and south of Standard Hill.


MERSEY RIVER
Union Bridge
Area shown in Fig 4
GOG RANGE
DOG'S HEAD HILL
QUARRY
Overflow Ck.
Mole Ck.
survey line west
Sassafras Ck.
Den Plain
'DEN
STANDARD HILL
MOLE CREEK TOWNSHIP
survey line east
THE GRUNTER
MAYBERRY
small quarry
CHUDLEIGH
0
1
2km

the other starting two kilometres to the west (at grid ref. DQ455002) and ending at the Mole Creek Quarry (Grid ref. DQ483010, see Fig. 4). Members recognised in these two sections were subsequently mapped elsewhere, some as far as Dog's Head Hill in the west (Grid ref. DQ417025, see Fig. 3) and some to the south of Standard Hill by B. Pierson. As these units have been mapped only for a few kilometres they are designated as members rather than as formations.

Samples were collected at approximately five metre stratigraphic intervals through thirteen hundred metres of limestone. All sampling points were labelled with red paint on the limestone outcrop. Sample localities are shown in Figure 5.

Most of the macrofossils mentioned herein have been named initially by M.R. Banks, mainly from preliminary field identifications.

Moina Sandstone

This formation was defined by Jennings (1963, p.56) and is overlain by the Gordon Subgroup. The contact between the limestone and the sandstone cannot be accurately located at the eastern end of Standard Hill though it can be placed to within three metres. Jennings (1963, p.57) showed that the contact between limestone and sandstone was gradational in the Mersey River south of Liena (see Fig. 2 for locality) and Gee (1966, pp. 36-37) found a gradational contact near Lorinna (see Fig. 2 for locality). The contact can be located to within five metres at The Grunter, south of Standard Hill (Grid ref. DQ463002, see Fig. 3). The sandstone was formerly called the Tubicolar Sandstone because of the large number of vertical, sub-vertical and horizontal worm burrows. Macrofossils are rare especially in the area mapped and much of the formation may be interpreted as high intertidal sands.

FIGURE 4

Geology of the region to the north of Standard Hill, showing extent of members recognised in the Chudleigh Limestone Formation. Areas labelled A - G are shown in detail in Figure 5.

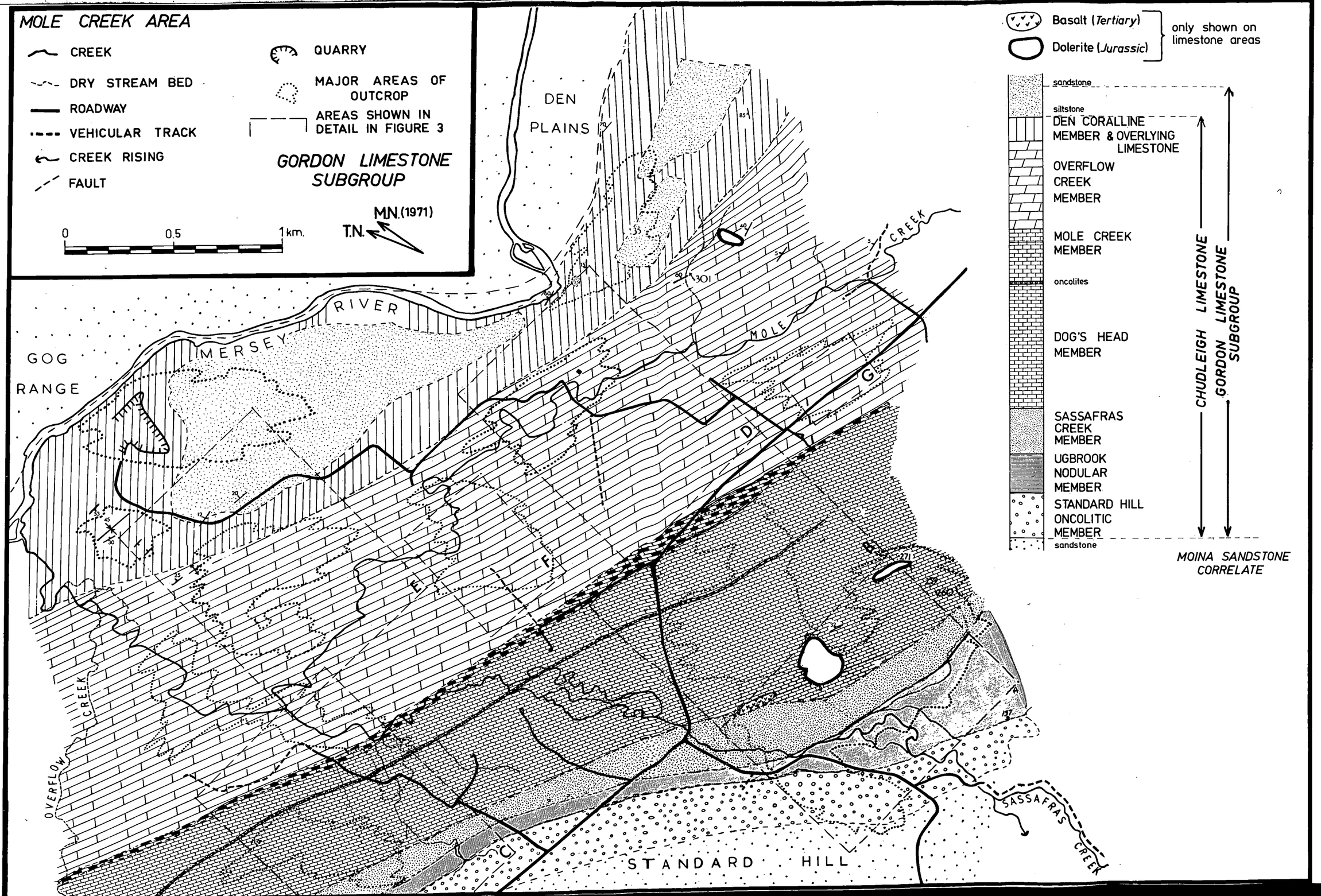
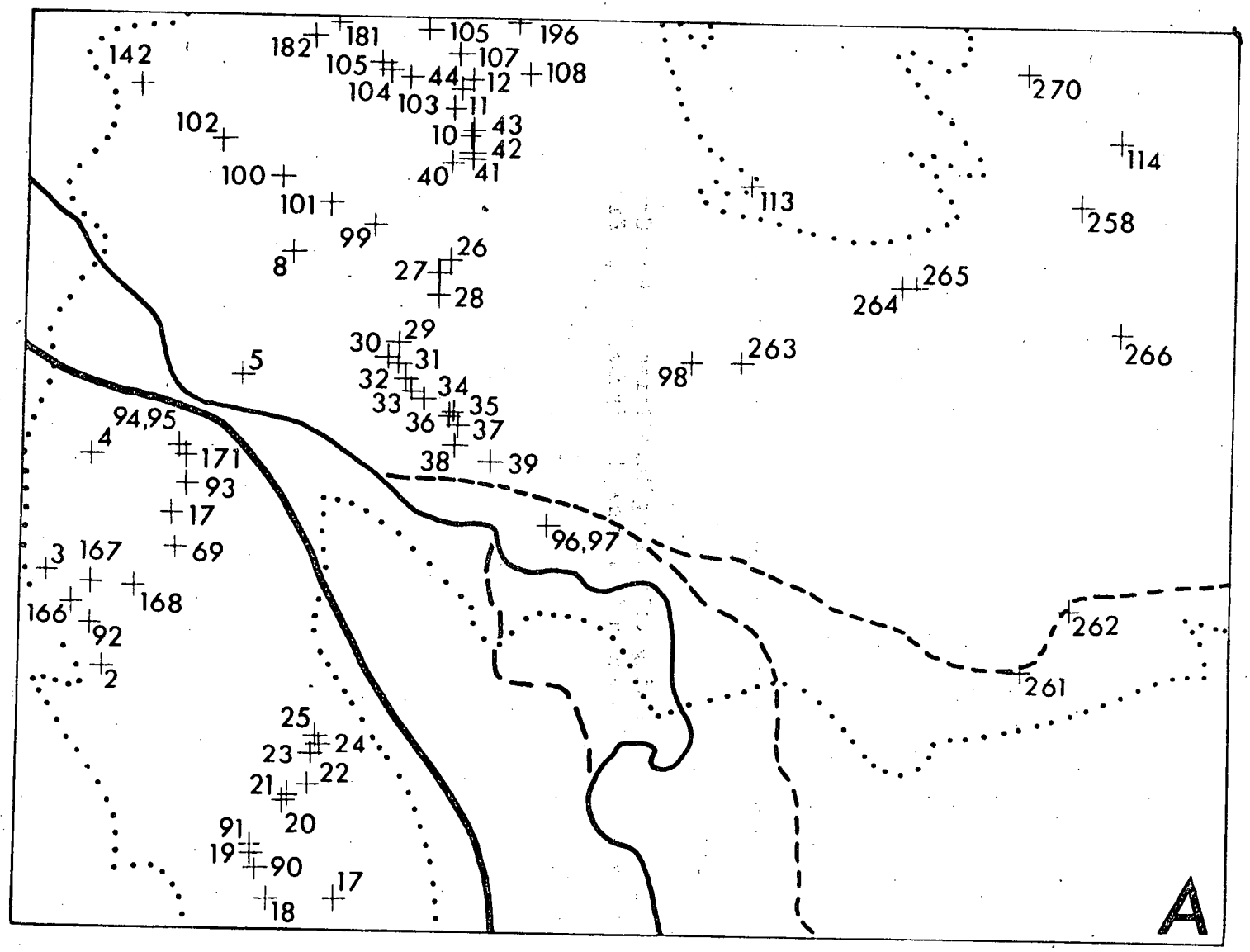

MOLE CREEK AREA
CREEK
DRY STREAM BED
ROADWAY
VEHICULAR TRACK
CREEK RISING
FAULT
QUARRY
MAJOR AREAS OF OUTCROP
AREAS SHOWN IN DETAIL IN FIGURE 3
GORDON LIMESTONE SUBGROUP
0
0.5
1 km.
M.N.(1971)
T.N.
Basalt (Tertiary)
Dolerite (Jurassic)
only shown on limestone areas
sandstone
siltstone
DEN CORALLINE MEMBER & OVERLYING LIMESTONE
OVERFLOW CREEK MEMBER
MOLE CREEK MEMBER
oncolites
DOG'S HEAD MEMBER
SASSAFRAS CREEK MEMBER
UGBROOK NODULAR MEMBER
STANDARD HILL ONCOLITIC MEMBER
sandstone
CHUDLEIGH LIMESTONE
GORDON LIMESTONE SUBGROUP
MOINA SANDSTONE CORRELATE
DEN PLAINS
GOG RANGE
LIMERSEY RIVER
MOLE CREEK
OVERFLOW CREEK
SASSAFRAS CREEK
STANDARD HILL
A
B
C
D
E
F
G

FIGURE 5

Maps showing collecting localities at Mole Creek.
A - G: areas shown in Figure 4. Symbols as in Figure 4.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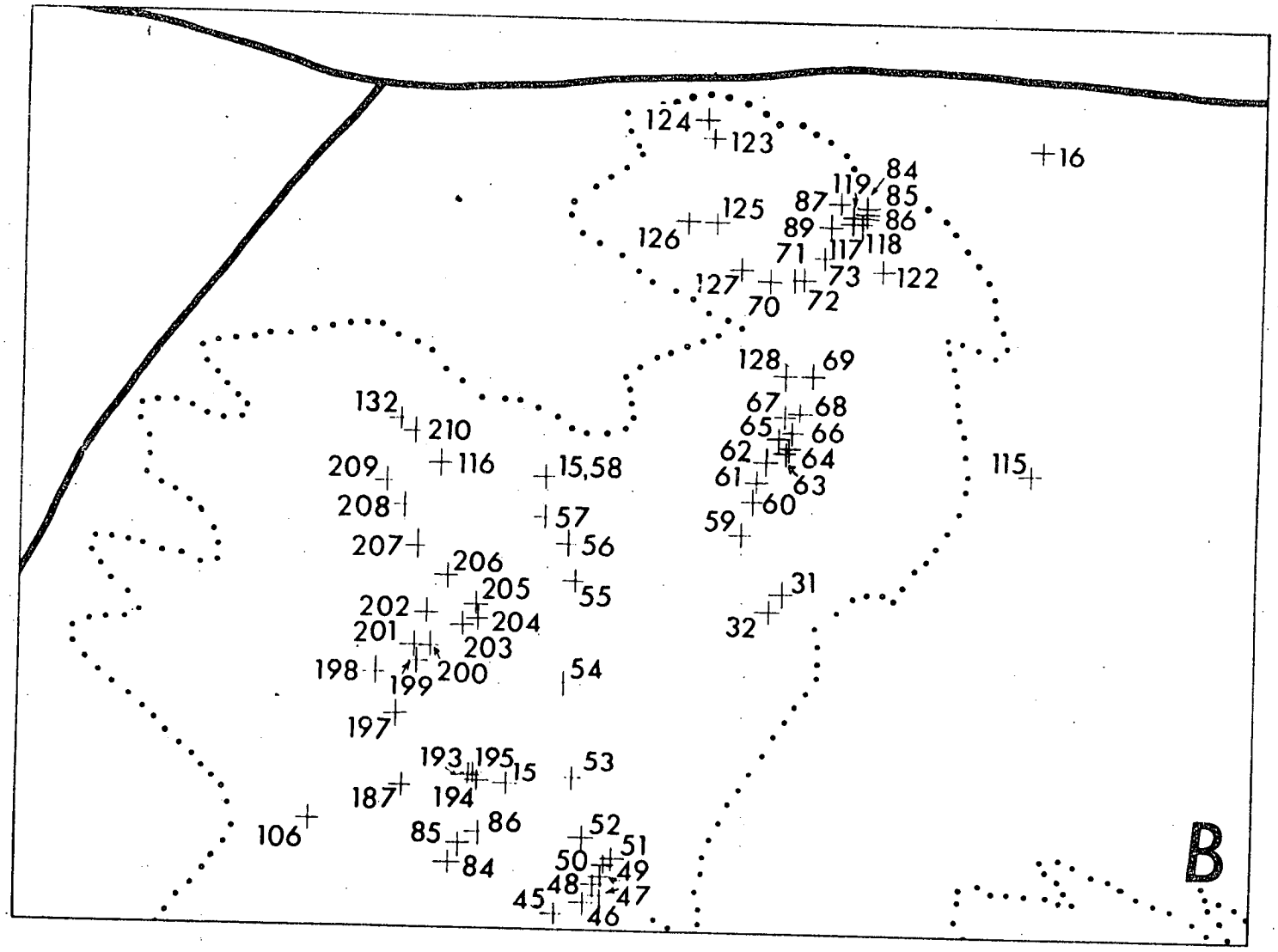
182
181
105
196
105
107
104
44
12
108
103
11
102
10
43
42
100
40
41
101
113
270
114
258
99
26
8
27
28
265
264
29
30
31
5
32
34
33
35
36
37
38
39
263
266
98
94,95
4
171
93
17
69
96,97
3
167
168
166
92
2
262
261
25
24
23
22
21
20
91
19
90
17
18
A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123
16
84
119
85
87
86
125
89
126
71
117
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73
122
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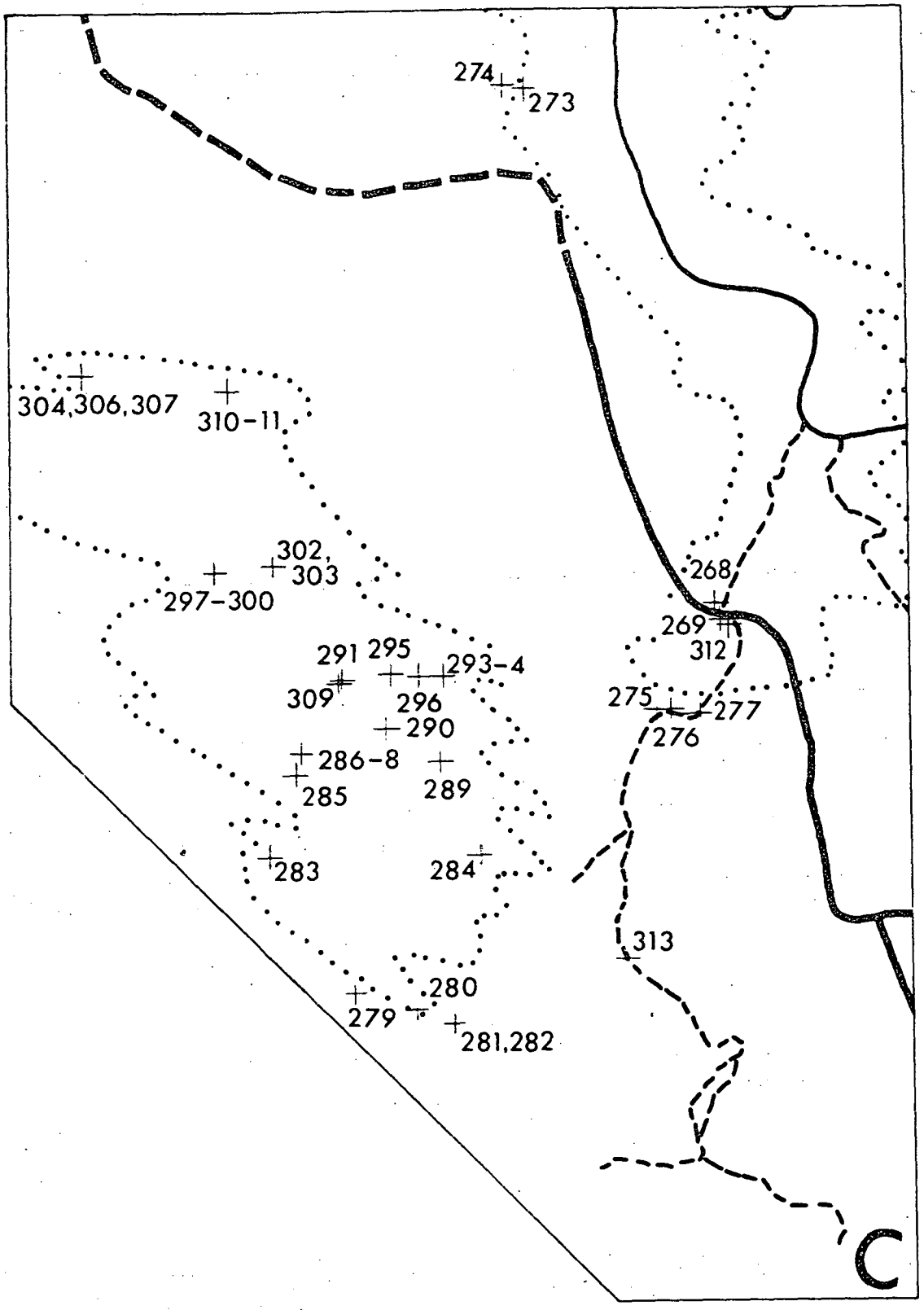
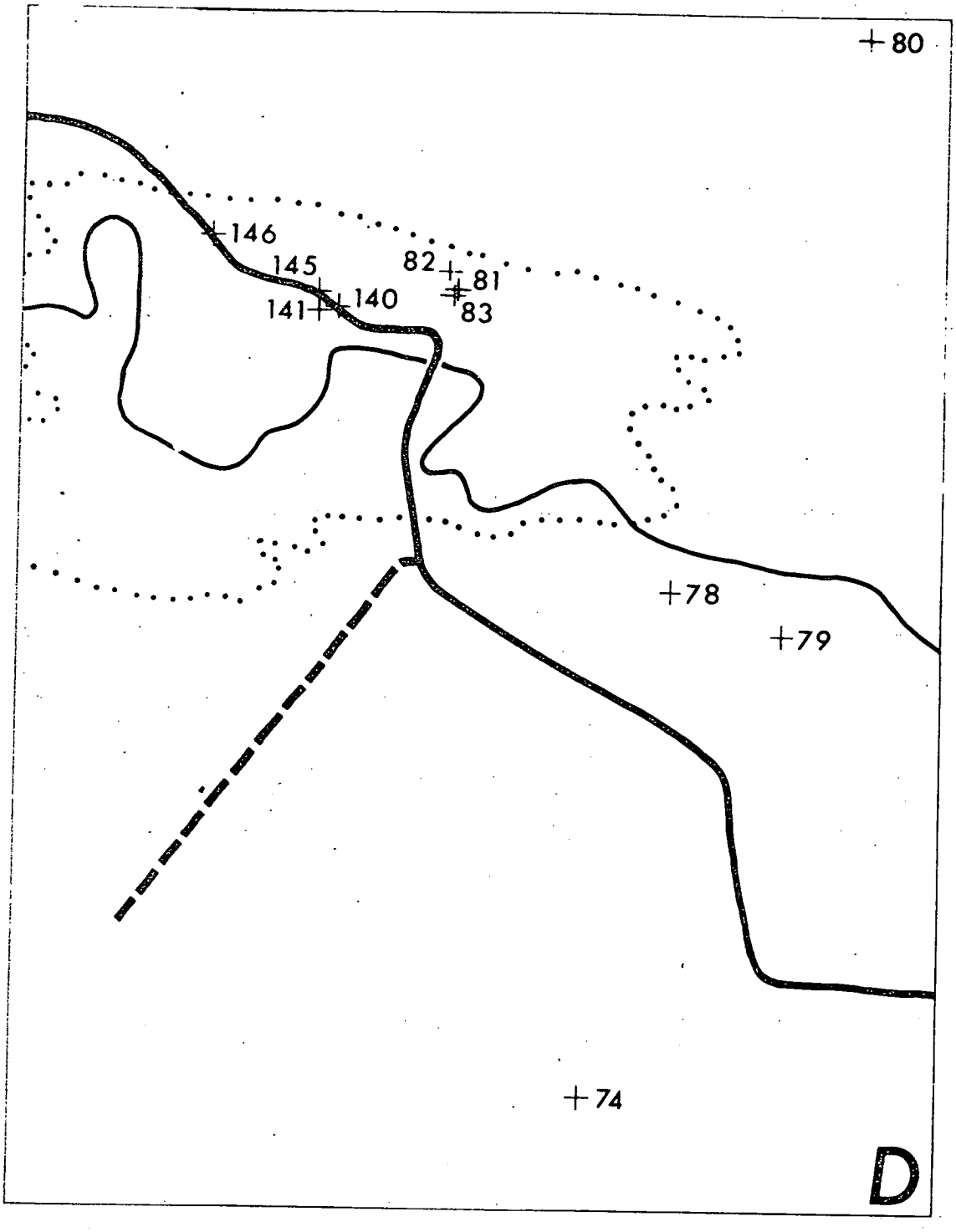
72
128
69
132
67
68
210
65
66
62
64
209
116
15,58
115
61
63
208
60
57
59
207
56
206
205
55
31
202
204
32
201
203
198
200
54
199
197
193
195
15
53
187
194
106
86
52
85
51
84
50
49
48
47
45
46
B


274
273
304,306,307
310-11
302,
303
297-300
291
295
293-4
309
296
290
286-8
285
289
283
284
268
269
312
275
277
276
313
280
279
281,282
C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146
145
82
81
141
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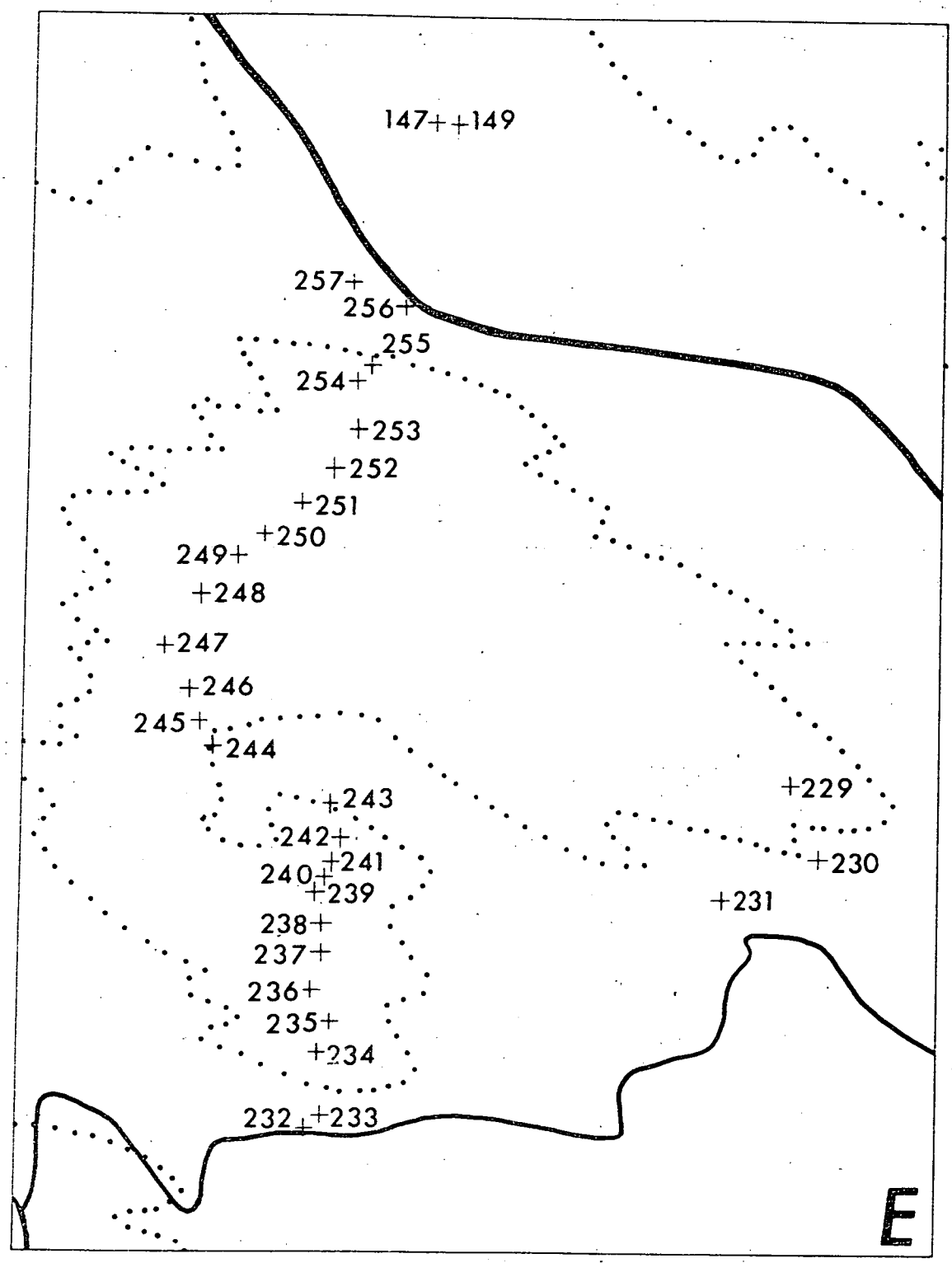
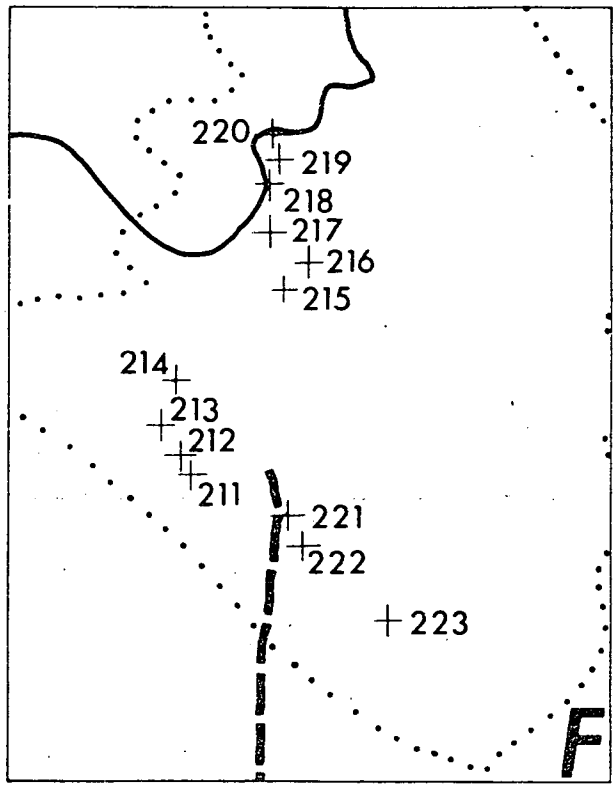
83
78
79
74
D


147++149
257+
256+
255
254+
+253
+252
+251
+250
249+
+248
+247
+246
245+
+244
+243
242+
+241
240+
+239
238+
237+
236+
235+
+234
232+
+233
+229
+230
+231
E


220
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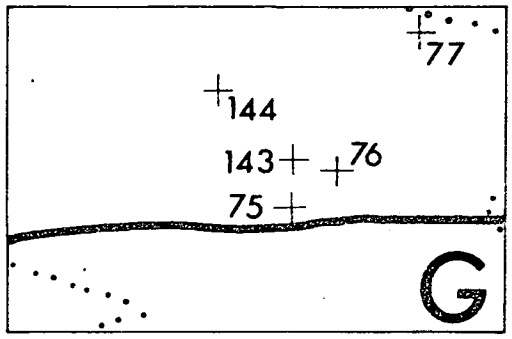
F


77
144
143
76
75
G

Chudleigh Limestone

Definition: That sequence of Ordovician limestones and minor siltstones, outcropping between Standard Hill (at grid ref. DQ 466989) and the Mersey River 2.5 km west of Mole Creek at grid ref. DQ 483010. The formation is thirteen hundred metres thick and overlies the Moina Sandstone and is overlain by fossiliferous siltstones of the uppermost part of the Gordon Subgroup. The lowest member consists of oncolitic limestone of Chazyan age and its topmost beds consist of creamy textured limestone, barren of macrofossils, of Edenian age.

Description: The term Chudleigh Limestone was first used by Johnston (1888, p.144) but has been rarely (if at all) used since. He used the term informally and his conception of the Chudleigh Limestone is not known. The Chudleigh Limestone consists of thirteen hundred metres of oncolitic, micritic, dolomicritic and minor calcarenitic limestones with minor beds of siltstone. It may be divided into seven named members plus one informal lithological unit forty metres thick at the top.

Standard Hill Member (nov.)

Definition: The Standard Hill Member is that 145 metres thick oncolitic limestone, with minor calcarenite beds, that outcrops on the northern side of Standard Hill at its eastern end between grid references DQ 466989 and DQ 467000. It is underlain by the Moina Sandstone and overlain by a nodular argillaceous micrite.

Occurrence: The Standard Hill Member was recognised as a distinctive rock unit by Banks and Johnson (1957) who referred to it as the *Maclurites-Girvanella* bed. This lithotope occurs widely throughout Tasmania. The Standard Hill Member is exposed at the eastern end of the northern side of Standard Hill. Further to the west the

member presumably exists under a cover of talus from the clastics of Standard Hill. To the south of Standard Hill the Standard Hill Member is only seen at and near to The Grunter (Grid ref. DQ 403002, see Fig. 3).

Description: The lowest outcropping limestone is two metres of non-oncolitic dolomitic micrite. This is overlain by one hundred and thirty eight metres of mainly oncolitic, stylolitic and dolomitic limestone containing at least three beds of dolomitic biocalcarenite each about a metre in thickness. The Standard Hill Member is lithologically and faunally indistinguishable from the Cashions Creek Limestone Formation in the Florentine Valley (Corbett and Banks 1974) which Weldon (1974, p.41) describes as "typically a dark-grey, grain supported, intraclastic calcarenite." Oolites are common in many beds in the Standard Hill Member and the writer has observed a green mineral in thin sections and in residues which is probably glauconite.

Fauna and Flora: The most important biological constituents of the Standard Hill Member are species of the chlorophyte genus *Girvanella* (Banks and Johnson 1957). *Maclurites florentinensis* is very abundant though its operculae are rather rare. *Maclurites* shells often form a point of attachment for *Stromatocerium*. Cephalopods similar to *Orthonybyoceras* are found and are common in the non-oncolitic calcarenites where they are associated with strophomenids and a gastropod similar to *Bucania*. The microfauna includes abundant scolecodonts and rare chitinozoa. Conodonts are rare except in the non-oncolitic beds or in occasional oncolite-free patches where they occur in reasonable abundance (up to thirty per kg).

Age: By comparing *Maclurites florentinensis* to *M. magnus* from the Marmor of New York, Banks and Johnson (1957) assigned a Chazyan age to this member. The conodont fauna confirms this dating. The

stratigraphic ranges of the conodont species are discussed in chapter five and the age assignment is not further justified here. The stratigraphic ranges of conodonts at Mole Creek are shown in Fig. 73.

Environment: Both Rao and Weldon consider that the major area of oncolitic formation was at the basinward margin of a tidal flat on a wave agitated, sandy substrate. Quartz and dolomite were derived from the tidal flat. The algal material for the oncolites was initially produced by the breaking-up of algal mats by dessication and by the grazing of *Maclurites*. Finks and Toomey (1972) have similarly postulated an algal diet for the *Maclurites* on or near the Chazyan reef mounds of New York State. An analogous modern situation has been reported from the Bahamas and the Gulf of Aqaba by Friedman *et al.* (1973) where "herds" of *Cerithium* graze on the edge of algal mats and prohibit the mats' seaward growth. Hypersalinity prohibits landward migration by the gastropods, thereby restricting the growth of algal mats to hypersaline conditions. Friedman *et al.* (1973) point out that oncolites "are a product of algal precipitation." Thus, although much oncolitic material is derived from the disintegration of algal mats, they continue to grow, under agitated conditions, by the *in situ* addition of algal material.

As in the Florentine Valley the oncolitic limestone includes one metre thick dolomitic, strongly stylolitic, crinoidal calcarenites containing cephalopods, strophomenids and gastropods (but not *Maclurites*). These beds are taken to represent occasional rises in sea level leading to subtidal environments in an otherwise intertidal regime (see Fig. 9).

The top of the Standard Hill Member is transitional to a nodular limestone sequence which is named the Ugbrook Nodular Member.

The contact is gradational and irregular (see Fig. 4) and cuts strongly across the general strike of the beds.

Ugbrook Nodular Member (nov.)

Definition: The Ugbrook Nodular Member is that sequence of nodular limestones and minor micrites outcropping between grid references DP467000 and DP471989. It overlies the oncolitic Standard Hill Formation and is in turn overlain by a three metre thick bed of crinoidal calcarenite. The member is 120 metres thick.

Occurrence: This member outcrops on the small hill at the eastern end of Standard Hill and is found in the road cutting at grid reference DP467000 and in outcrops to the east of Sassafras Creek at grid reference DP473985. It has not been recognised to the south of Standard Hill.

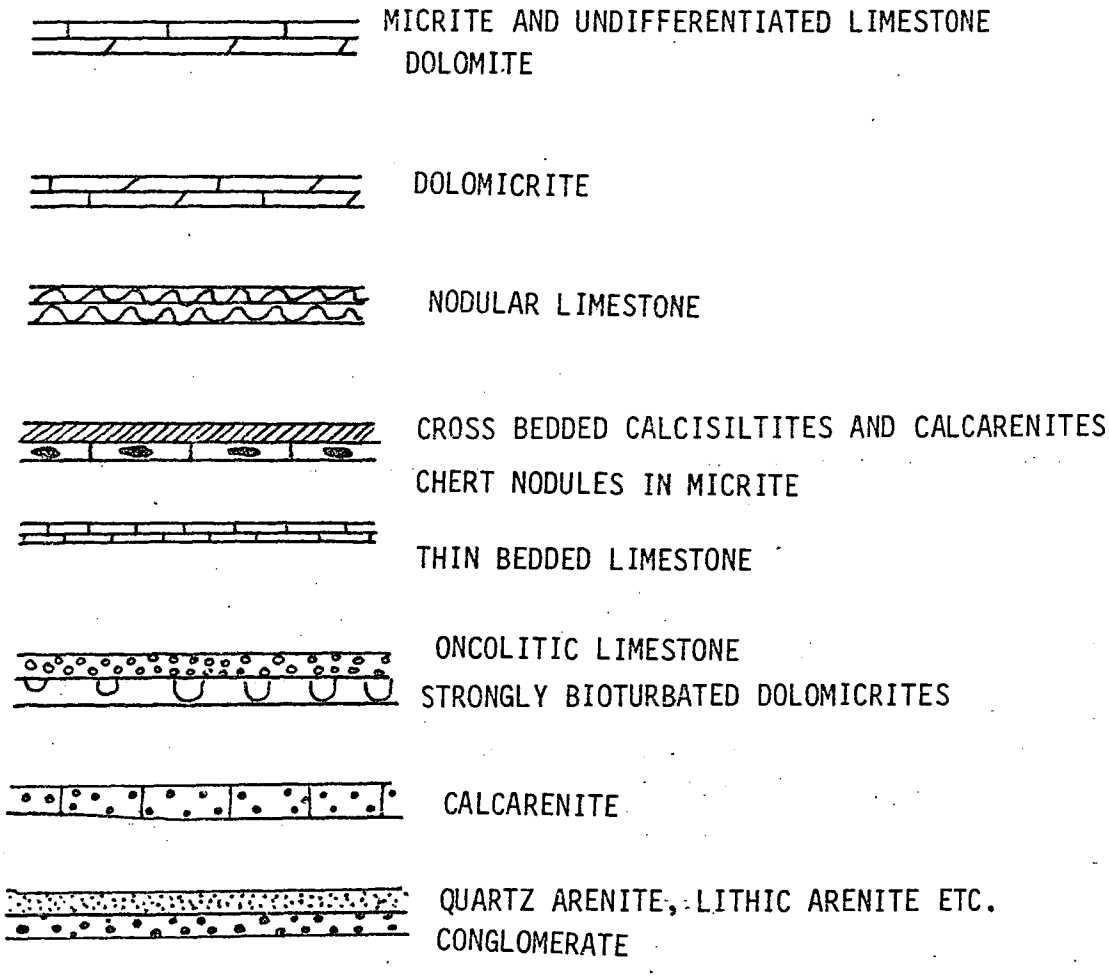
Description: The Standard Hill Member can be traced both vertically and laterally eastwards into a nodular argillaceous limestone. Nodules of micrite are found in beds between 80 and 200 millimetres thick. The nodules are surrounded by dark argillaceous material in irregular layers about 10 millimetres thick. Many of the argillaceous beds are bioturbated and are covered with 35 millimetre wide trains of unidentifiable shell debris. In its uppermost parts the nodular limestone is overlain by a micrite, some three metres thick, containing trilobites, which is immediately below a prominent bed of crinoidal calcarenite.

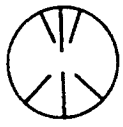
Fauna: Apart from unidentifiable trilobites and brachiopods near the top, the member is devoid of macrofossils. Scolecodonts are common and conodonts are very rare.

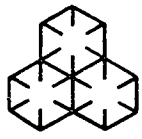
Environment: As this member is mainly unfossiliferous there is no faunal evidence to help with environmental interpretation. Certainly

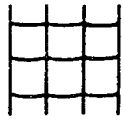
FIGURE 6

Stratigraphic columns measured at Mole Creek along section lines indicated on Figs. 3-4. Sample numbers shown to left of columns. Symbols are as follows: L = abundant *Lichenaria*.

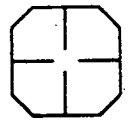



SIMPLE TETRACORALS

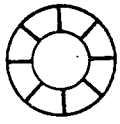

COMPOUND RUGOSA


TABULATE CORALS

LICHENARIA


TETRADIUM

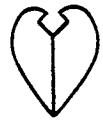
STROMATOPOROID


ISCHADITES

MACLURITES

TURRETED GASTROPODS

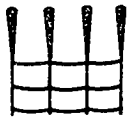
PLANISPIRAL GASTROPODS


PELECYPODS

ORTHOCONIC NAUTILOIDS

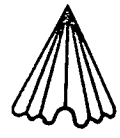
CYRTOCONIC NAUTILOIDS

COILED NAUTILOIDS


TREPOSTOMATA

CRYPTOSTOMATA

POLYZOAN GENERAL


RHYNCHONELLIDA

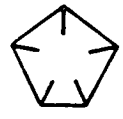
STROPHOMENIDA

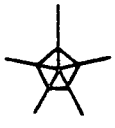
ORTHIDA

SPIRIFERIDA (OR BRACHIOPODA GENERAL)

TEREBRATULIDA

INARTICULATE BRACHIOPOD


PELMATOZOAN ECHINODERMS


ASTEROZOANS

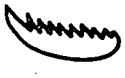
TRILOBITA

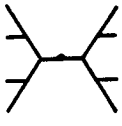
OSTRACODA

CONODONTS

FIBROUS CONODONTS

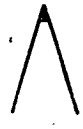
CHITINOZOA


SCOLECODONTS


MULTIRAMOUS GRAPTOLOIDS

TETRAGRAPTID

PENDENT TETRAGRAPTID


PENDENT DIDYMOGRAPTID

HORIZONTAL DIDYMOGRAPTID

BISERIAL GRAPTOLITE

MONOGRAPTINA

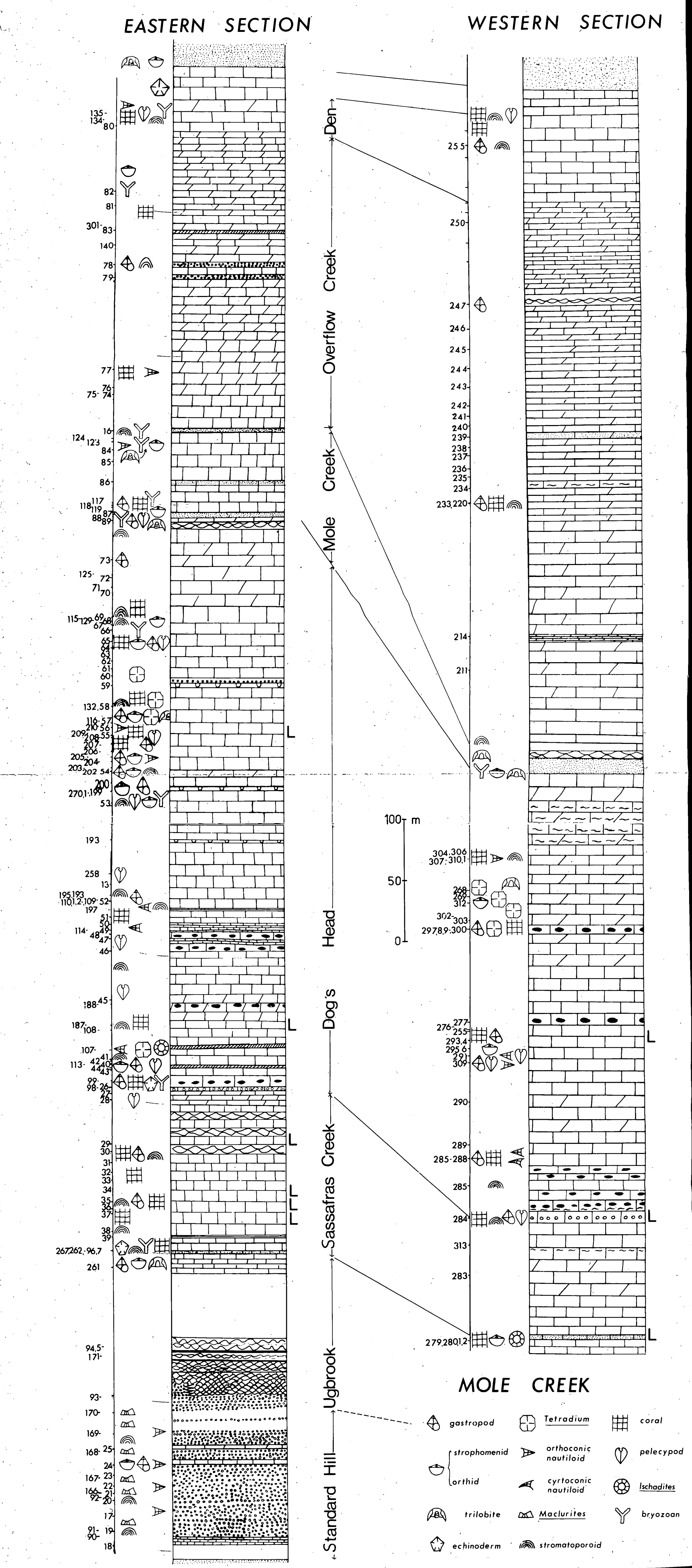
BURROW 90° TO BEDDING

U SHAPED BURROW

IRREGULAR BURROWS

MILACULUM

PORIFERA


EASTERN SECTION
WESTERN SECTION
Den
Creek
Overflow
Creek
Mole
Head
Dog's
Sassafras Creek
Ugbrook
Standard Hill
100 m
50
0
MOLE CREEK
gastropod
Tetradium
coral
strophomenid
orthid
orthoconic nautiloid
pelecypod
cyrtoconic nautiloid
Ischadites
trilobite
Maclurites
bryozoan
echinoderm
stromatoporoid

animals, perhaps worms, were present and produced the shell débris trains. Scolecodonts are very abundant in residues. The presence of trilobites near the top of the member with no intervening rocks and no obvious breaks between the fossiliferous micrite and the nodular limestone suggests a low intertidal environment (Fig.79).

Correlates of the Ugbrook Member South of Standard Hill

To the south of Standard Hill and approximately at the same stratigraphic position is a small quarry at grid reference DP455979 which contains dolomicrites, algal mats, stromatolites, birds-eye limestone and flat pebble conglomerates, (Fig.7e,f). These features suggest a high intertidal-supratidal environment. If the limestone in that quarry represents a facies change to the nodular limestone two kilometres to the north, then the nodular limestone may be postulated to have been deposited in deeper water, perhaps in a medium-high intertidal regime. The presence of so much clay material may be explained by postulating a lagoonal environment for the nodular rocks. In a lagoon, clay material brought down by streams would be trapped and the sandy fraction incorporated into an off-shore bar. Differential diagenetic compaction would have produced the nodular character.

Above the Standard Hill Member correlate near The Grunter, above Kubla Khan Cave (at Grid ref. DP397995), there is a poorly sorted sandstone, containing orthids and rare asaphinae, which is interpreted as the off-shore bar mentioned above. A conodont fauna from a trilobite bearing micrite which appears to be a lateral equivalent of the sandstone, is identical to that from the Ugbrook Member and suggests that the Ugbrook Member and the sandstone are the same age.

At The Grunter there is a gradual transition from an oolitic/oncolitic limestone upwards into a sandstone/siltstone sequence. Most of The Grunter is composed of oooncosparite, the lower parts of which have been strongly deformed with the oncolites having been shortened perpendicular to the cleavage by as much as sixty percent (Seymour 1975). The limestone conformably overlies a correlate of the Moina Sandstone Formation, which is quartzitic and contains many beds containing up to 60 percent by volume of pyritic spheroids the long axis of which average one millimetre in length. The limestone appears to be much more oolitic at The Grunter than to the north of Standard Hill.

Twenty metres from the summit of The Grunter the limestones are non-oncolitic calcarenites, micrites, and dolomicrites which contain thin (2 mm) beds of sandstone (see Fig. 7E) separated by, on average, 0.5 metres of limestone. The sandstone beds are undulating, of variable thickness and weather out from the adjacent limestone. The frequency of these sandstone beds increases towards the top of The Grunter. Towards the summit cross-bedded calcisiltites and sandstones increase in frequency. Palaeocurrent directions are from present day north. Several of the limestone beds, near to the summit, contain a profusion of vertical burrows suggesting an intertidal environment. Gravel beds are common towards the summit and the top of The Grunter is composed of resistant beds of sandstone with minor siltstone. Orthids are common in a few of the sandstone beds. No asaphids were found though they are present above the nearby Kubla Khan Cave in a lithological correlate. The hypostomes of the asaphid are common and are indistinguishable from that of *Basilicus*. No gradual transition between oncolitic limestone and sandstone is seen at Kubla Khan where the boundary appears to be relatively sharp.

The dull red sandstones and minor siltstones at the summit of The Grunter are well sorted and cross-bedded. They are tentatively interpreted as an offshore bar deposit, though a detailed study may reveal a different origin.

At The Grunter the transition from oncolitic limestone to brachiopod-rich sandstones takes place through 50 metres and thus, presumably, took place over a considerable time. Such a gradual transition points towards an *in situ* growth of a bar due to increased erosion of the source area and/or migration of a river system. If the offshore bar had migrated from an adjacent area, then the transition from the oncolitic limestone to the offshore bar would not be expected to be so gradual, nor to occupy such a stratigraphic thickness.

Sassafras Creek Member (nov.)

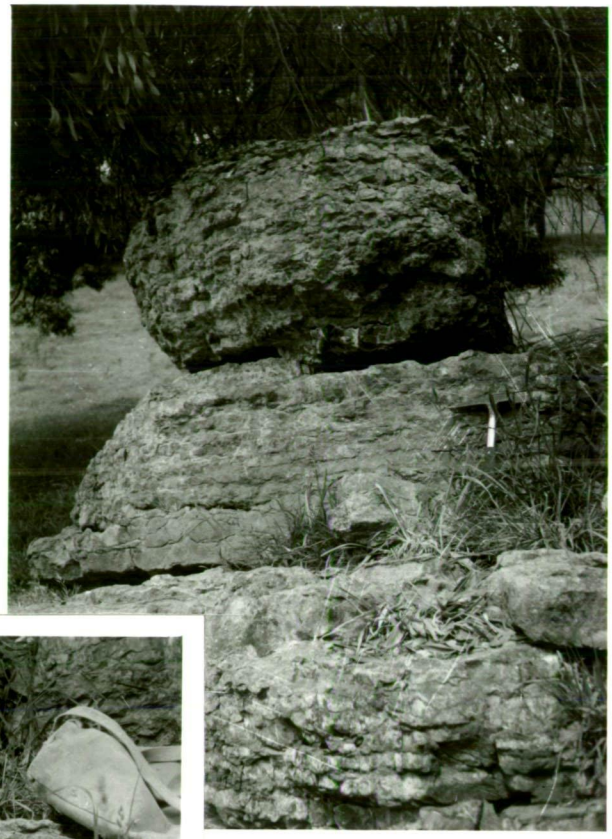
Definition: The Sassafras Creek Member is that 135m thick sequence of micrite and slightly dolomitic micrite, nodular in places that outcrops between Sassafras Creek (at grid ref. DP471989) and grid reference DP472993. The base consists of three metres of calcarenite and the top is marked by a thin oncolitic horizon succeeded by a gastropodal shell bed.

Occurrence: This member outcrops in both sections studied and also on Dog Head's Hill but has not been recognised elsewhere.

Description: The basal unit of the Sassafras Creek Member is a three metre thick bed of crinoidal biospararenite. On the main (eastern) section this forms the base of a cliff on the northern side of the Sassafras Creek flood plain. The calcarenite contains a patchy fauna of silicified stromatoporoids, brachiopods, gastropods and bryozoa. A calcarenite occurs near the base of the western

FIGURE 7A. Standard Hill Member Mole Creek, bedding plane, showing sections through *Maclurites* and oncolites. Lens cap is 50mm. in diameter.

FIGURES 7B,C. Ugbrook Nodular Member, Mole Creek facing north. 200m northeast of Sassafras Creek. Hammer is 340mm. long.



C

B

A

FIGURES 7E-F. Limestone with quartz rich ribs 30m. from summit of The Grunter, near Mole Creek. Stomatoporoid at lower left of F. Lens cap 50mm. in diameter.

FIGURE 7D. Basal bed of Sassafras Creek Member. Massive biocalcarenite bed 2m. thick (outcropping) behind figure. Looking north. 30m. north of Sassafras Creek.

FIGURE 7G. Large domal stromatolite in quarry south of Standard Hill, Mole Creek. Hammer is 350mm. long.

FIGURE 7H. Flat-pebble conglomerate interbedded with dismicrite. Quarry south of Standard Hill, Mole Creek. Lens cap 50mm. in diameter.

FIGURE 7I. Cherty limestone in probable correlate of Dog's Head Member south of Standard Hill at grid ref. DQ 192637. Hammer is 380mm. long.

FIGURE 7K. Small stromatolite in Overflow Creek Member near locality Mc 248 Mole Creek. Lens Cap is 50mm. in diameter.

FIGURE 7J. Steeply dipping Overflow Creek Member exposed south of Union Bridge, near Mole Creek. Darker outstanding beds are dolomitic. Lens cap is 50mm. in diameter.

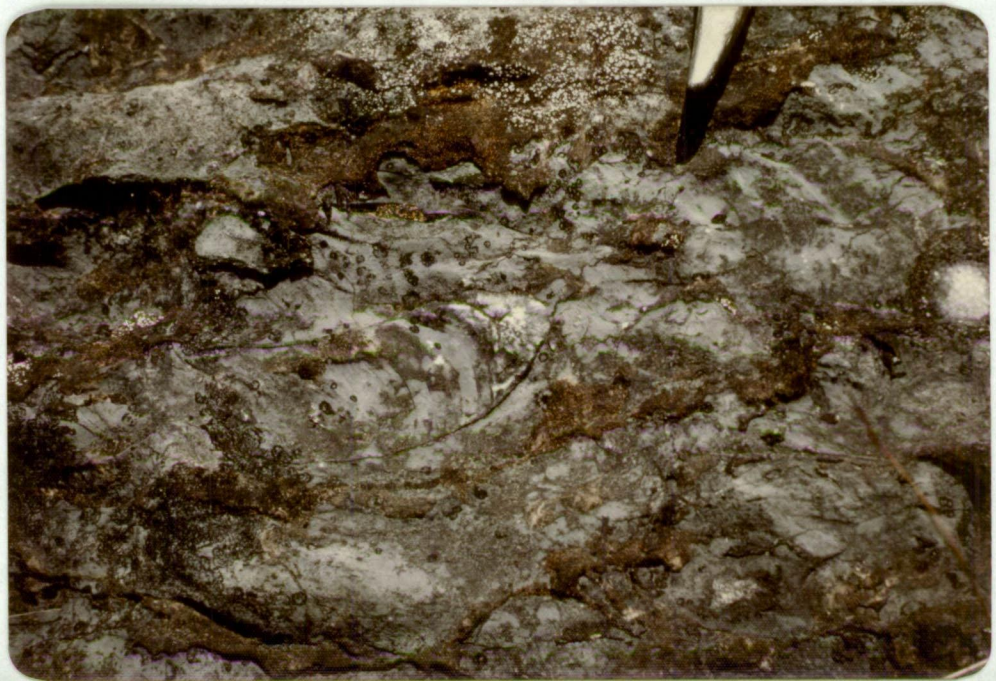


FIGURE 7L. Outcrop of Den Member showing massive bedding near the Den, Mole Creek. Camera pointed south east. Figure in foreground.
FIGURE 7M. Den Member, at the Den, Mole Creek showing large bivalved fossil. Hammer 350mm. long.
FIGURE 7N. Den Member, at the Den, Mole Creek. Cephalopod in centre and coral at right centre. Brown material is dolomite.
Cephalopod is 110mm. long.

Figure 7 (O)

Siltstone beds at top of Gordon Subgroup overlain by white quartzite of the Eldon Group at quarry, Mole Creek.

section which is just above a micrite with sowerbyellids. This calcarenite (which contains glauconite and *Ischadites*) is the base of the Sassafras Creek Member in the western section (Figs. 3 & 5).

In the eastern section the calcarenite is followed by 138 metres of dolomitic micrites containing a shell bed with gastropods, *Lichenaria* and stromatoporoids, though the upper part (30 metres) is unfossiliferous. Above this is a micrite unit (at 410 metres above the base of the Mole Creek Section) containing gastropods, crinoidal debris, halysitids and small pelecypods. In many places this unit contains large (up to 20 mm) diameter oncolites, which form beds up to 0.1 metres thick. Above this shell bed is two metres of bioturbated dolomicrites containing large chert nodules. The shell bed is taken as the top of the Sassafras Creek Member.

Fauna: Unidentified trochospiral gastropods and stromatoporoids occur in most of this member, though *Cystostroma* occurs near the base. *Lichenaria* is common throughout. Gastropods in the uppermost shell bed include *Helicotoma johnstoni*, *Loxoplocus (Loxoplocus)*, *Loxoplocus (Donaldiella)*, *Trochonema (Trochonema)* and indeterminate rotelliform gastropods (C. Tassel *pers. comm.*). Large colonies of *Tetradium* are associated with the gastropods.

Environment: The crinoidal calcarenite is interpreted as a tidal channel deposit cutting the intertidal limestones of the Ugbrook Nodular Member and the lower parts of the Sassafras Creek Member. The majority of the Sassafras Creek Member is unfossiliferous containing only the occasional stromatoporoid, gastropod and *Lichenaria*. This low diversity fauna is not associated with known stenobiontic faunal elements. The micrites contain an appreciable amount of dolomite though worm burrows are not abundant. Unfortunately

much of this member occurs in a cliff where bedding planes are not well exposed or on a wooded hill where the light is poor and lichen covers much of the rock surface. Thus a firm environmental interpretation must await detailed petrographic and geochemical work. However, in the more open western section bioturbated dolomicrites are found which together with the low diversity eurybiontic fauna, rarity of conodonts and abundance of scolecodonts, suggest a restricted and harsh and presumably mainly intertidal environment. The gastropodal/*Tetradium* rich/coralline/oncolitic shell bed at the top of the member suggests a deepening of the depositional basin and a low intertidal or high subtidal environment.

Dog's Head Member (nov.)

Definition: The Dog's Head Member is that 470m thick sequence of micrites and dolomicrites outcropping between grid references DP472993 and DP475997. Chert is common in the lower two thirds of the formation and worm burrows common in the upper third. The base is just below the first appearance of chert nodules and above a gastropodal and oncolitic horizon. The top is marked by the incoming of a reddish trilobite-rich siltstone.

Occurrence: This member is well exposed in both eastern and western sections and to the west at Dog's Head Hill (Fig. 8).

Description: Immediately above the gastropod/*Tetradium* bed at the top of the Sassafras Creek Member is a dolomitic bed containing abundant, small (40 mm diameter) stromatoporoids. The succeeding 480 metres of micrite and dolomicrite contains a large number of silicified shell beds and chert nodule beds. One three metre thick bed of oncolites can be traced (see map, Fig. 4) along strike for two kilometres, and is found in both sections and in inter-

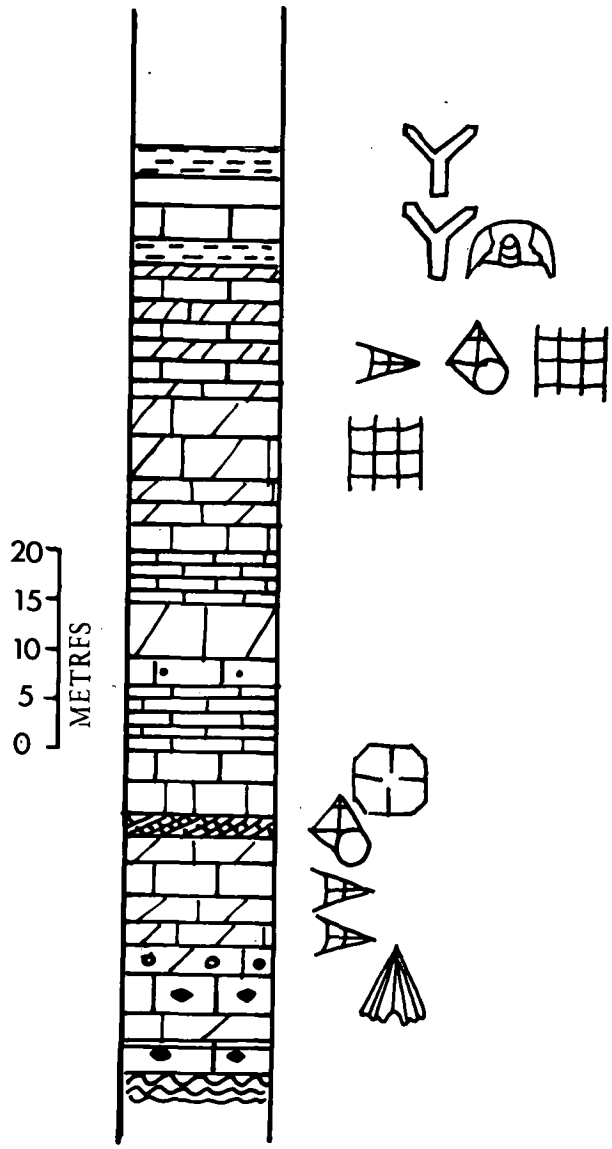


FIGURE 8

Stratigraphic column through Dog's Head Hill.
Symbols as in Figure 6.
Mole Creek Member at top overlying Dog's Head Member.

77/1/87

vening outcrops. Several sequences of very dolomitic bioturbated limestones are found between the fossiliferous micrites.

Fauna: The lowest fossiliferous beds contain *Labyrinthites* and *Ischadites* associated with rotelliform gastropods in the eastern section and *Foerstephyllum* in the western section. *Foerstephyllum* is found throughout the member in appropriate environments. Large colonies of *Cystostroma* are common in the lower half of the member. *Lichenaria* (sometimes *L. ramosa*), heliolitids, halysitids, and *Labechia* occur sporadically throughout the member. *Cryptophragmus* is found 320 metres above the base of the member. *Tetradium* is abundant and is represented by *T. cribriforme* and other species. *Palaeophyllum* enters at about 80 metres below the Mole Creek Member in both western and eastern sections. *Bajgolia* (or *?Eofletcheria*) is found in the upper third of the member associated with *Thamnobeatricea* and *Coccoseris*.

Trilobites are rare. *Pliomerina* occurs in one bed 300 metres above the base of the member. Cephalopods, brachiopods and pelecypods are abundant but have not, as yet, been studied.

Environment: The existence of a large number of shell beds containing a stenobiontic fauna suggests that many of these beds are subtidal. It is clear, however, that many of the beds do not contain biocoenoses as many of the corals are not in growth position. The presence of a diversity of forms, containing several growth stages contained within dark, slightly dolomitic micrites suggests that these assemblages have only been transported a short distance and do not represent beach accumulations on tidal flats.

Four shell bearing micrite sequences alternate with sequences characterised by bioturbated dolomicrites (see Fig. 6). Bedding

surfaces are often crowded with dolomitised horizontal to sub-horizontal worm burrows and/or gastropod grazing trails. Several beds show evidence of dessication and birds-eye limestone occurs rarely. Scolecodonts are very common in residues and are often quite large (several millimetres long) whereas conodonts are very rare. The four unfossiliferous bioturbated sequences are taken to have been deposited in high intertidal or even, in places, supratidal environments.

Between these high intertidal dolomicrite sequences and the subtidal sequences there are several thin (0.1m) or thick (3m) beds of oncolites which suggest agitated conditions in a low intertidal environment.

An interesting faunal gradation can be observed when moving from the intertidal into the subtidal sequences and back again (Figs. 6, 9). The shallowest assemblage consists of small pelecypods. At slightly deeper levels there is a stromatoporoid/ *Lichenaria* association, often including gastropods. A deeper assemblage contains *Tetradium* and the deepest contains cephalopods, orthids, strophomenids and trilobites. Thus four transgressions are each followed by a regression (Fig. 9). The last regressive sequence marks the top of the Dog's Head Member and is followed by the transgressive sequence of the Mole Creek Member.

Mole Creek Member (nov.)

Definition: The Mole Creek Member is that sequence of fossiliferous reddish siltstones, black shales, micrites and calcarenites outcropping between grid references DP475997 and DP476998. The top, in the eastern section, is an unfossiliferous siltstone 75 metres above the base of the member which is a fossiliferous reddish

siltstone 60 mm. thick. In the western section the member is 30 metres thick and the base is a fine fossiliferous sandstone and the top is a fossiliferous calcarenite.

Occurrence: The Mole Creek Member is exposed in both eastern and western sections and is also found at Dog's Head Hill (for locality see fig. 3, for section see fig. 8). A similar siltstone has been found to the south of Standard Hill by B. Pierson. The Mole Creek Member is lithologically and faunally very similar to the Lords Siltstone in the Florentine Valley (Corbett and Banks 1974).

Description: The base of the Mole Creek Member is a reddish siltstone containing trilobites, brachiopods and bryozoa. Along strike in Overflow Creek a correlate is a black foetid calcareous shale containing illaenid and other asaphid trilobites. Corals, stromatoporoids and gastropods are found in micrites between the two eastern section siltstones.

Fauna: The siltstone contains *Pliomerina*, illaenids, stictoporellids and orthids. The associated calcarenite (in the western section) also contains *Pliomerina*. *Eofletcheria*, and *Nyctopora* are found in micrites in the eastern section. Unidentified cephalopods, brachiopods, bryozoa and trilobites occur near the top of the member.

Environment: The environment is taken to be a fairly deep subtidal environment and possibly represents the deepest environment found at Mole Creek. In this model a fairly thin band of silts and sands would be deposited in subtidal environments well below wave base. Given a sufficient deepening of the depositional basin the siltstone would be found in the Mole Creek area. The silt would be winnowed out of the heavier carbonates and deposited basinward in patches or in belts parallel to the shoreline. An alternative model has been suggested by M.R. Banks (*in* Banks and Burrett *in press*).

He suggests that the siltstone deposition was due to basinal deepening and was possibly triggered by reheating at depth (Veevers 1976).

Overflow Creek Member (nov.)

Definition: The Overflow Creek Member is that 240 metres of mainly unfossiliferous dolomicrites and dolosiltites outcropping between the small hillock to the north of the road to Mole Creek (at grid ref. DP476998) and the small outcrop to the north of the gate to the Den (at grid ref. DQ462016).

Occurrence: The Overflow Creek Member is exposed in the eastern section but is poorly exposed and may be faulted in places. However, in the western section, from the junction of a dry creek with Sassafras Creek (at grid ref. DQ459008) to the top of the hill 700 metres to the south of the Mole Creek quarry (at grid ref. DQ462016), there is excellent exposure. The member is also well exposed on large bedding plane slabs in Overflow Creek (see figs. 3 & 4) and on the banks of the Mersey River at Union Bridge (grid ref. DQ444038, see fig. 3).

Description: The member consists of thickly bedded, bioturbated dolomicrites in its lower parts with very rare fossiliferous beds. The bulk of the member consists of thinly bedded (50mm thick) beds of micrite alternating with ten millimetre thick beds of dolomicrite or dolomite.

Many of the micrites contain gastropod fragments, are bioturbated and some are mud-cracked. Birds-eye limestone and stromatolites are present.

Basnayake (1975) has made a detailed study of the limestone and has recognised highly dessicated pelmicrites and dismicrites which

are cut by sometimes cross-bedded beds of pelsparites. Several of the cross-bedded units are found near the top of the member and these units can be traced for several kilometres along strike. Some of these cross-bedded units contain abundant but broken conodont elements.

The top of the unit is marked by a coralline, gastropodal micrite containing relatively little dolomite.

Fauna: *Palaeophyllum* and cephalopods are found near the base of the member and rare gastropods are found throughout the member. Stromatoporoids occur in or near the pelsparite beds. The uppermost beds contain *Eofletcheria*.

Environment: The environment is clearly intertidal mainly low intertidal with the occasional supratidal sequence. Basnayake's (1975) chemical work has shown high salinities based on high strontium, magnesium and sodium concentrations. The cross-bedded pelsparites are interpreted as channel deposits crossing tidal flats (Fig. 79).

Den Coralline Member and overlying limestone

Definition: The Den Coralline Member is that 93 metres of coralline calcirudites and sparsely fossiliferous micrites that outcrop between 120 metres north of the Den homestead and the valley slopes to the east of the bend in the Mersey River (at grid ref. DQ483010) overlooking the Den Plains. The Den Member has been loosely defined by Banks and Burrett *(in press)*.

Occurrence: The best exposures are probably near the Mole Creek quarry around a small syncline (grid ref. DQ463023) and through the quarry section. A similar coralline fauna is found to the south of Liena (Hill 1942) and probably represents the Den Member. Banks (1962, p.174) records the presence of a probable equivalent of

this member near Chudleigh. A highly coralline limestone is found at or near to the top of the limestone elsewhere in Tasmania at Gunns Plains, Ida Bay, Bubs Hill, Florentine Valley and at the Olga-Hardwood divide (see Fig. 2 for localities).

Description: The base of the Den Coralline Member is taken to be five metres of interbedded dolomicrites and micrites which overlie a coralline bed at the top of the Overflow Creek Member. Above this is a 55 metre thick sequence of micrites and coralline calcirudites, dolomitic in places, which pass upwards into 38 metres of sparsely fossiliferous micrites containing many thin (up to 30 mm thick) carbonaceous shales. The top of this sequence marks the top of the Den Coralline Member. Above the Den Member is 40 metres of light coloured (grey-white) unfossiliferous micrites containing thread-like calcite inclusions and resembling birds-eye limestone. This is overlain by siltstone, the base of which marks the top of the Chudleigh Limestone.

Fauna: *Favistina* and *Falaeophyllum* occur near the base of the member and *Catenipora* and *Plasmoporella* (and? *Grewingkia*) are found eight metres from the base. *Foerstephyllum* is found higher up the sequence and is followed by *Diploepora*, *Favistina*, *Favosites Aulacera*, *Falsicatenipora*, *Tryplasma*, *Streptelasma* and a host of, as yet unidentified, corals, stromatoporoids, pelecypods, bryozoans and cephalopods. A large bivalved organism (up to 80 mm long) is found at the quarry and at the Den and is possibly *Eodinobulus* or the pelecypod *Vlasta*. Webby and Banks (1976) have recently described some of the stromatoporoids from the syncline to the south west of the quarry.

Environment: The Den fauna is clearly subtidal and stenotopic. However, very few of the corals and stromatoporoids are in growth

position and the whole fauna could be a thanacoenotic introduction into an intertidal environment. Certainly the limestones are dolomitic but the alternation of beds containing distinctive faunas and the diversity and size range within species suggests that the fauna is essentially a biocoenosis inhabiting a shallow subtidal, limey, sea bottom (Fig. 79).

The environment of deposition of the 40 metres of creamy unfossiliferous micrite is enigmatic and must await detailed petrographic and geochemical study. The presence of an abundant conodont fauna probably indicates a subtidal environment.

Upper Ordovician Siltstones

Fifteen metres of buff coloured siltstones overlie the Chudleigh Limestone and contain an abundant fauna of brachiopods including *Orniella*, *Kjerulfina* and leptaenids. The only trilobites present are rare proetids. The top of the siltstone marks the top of the Gordon Limestone Subgroup and is overlain by an unfossiliferous quartzite of the Eldon Group.

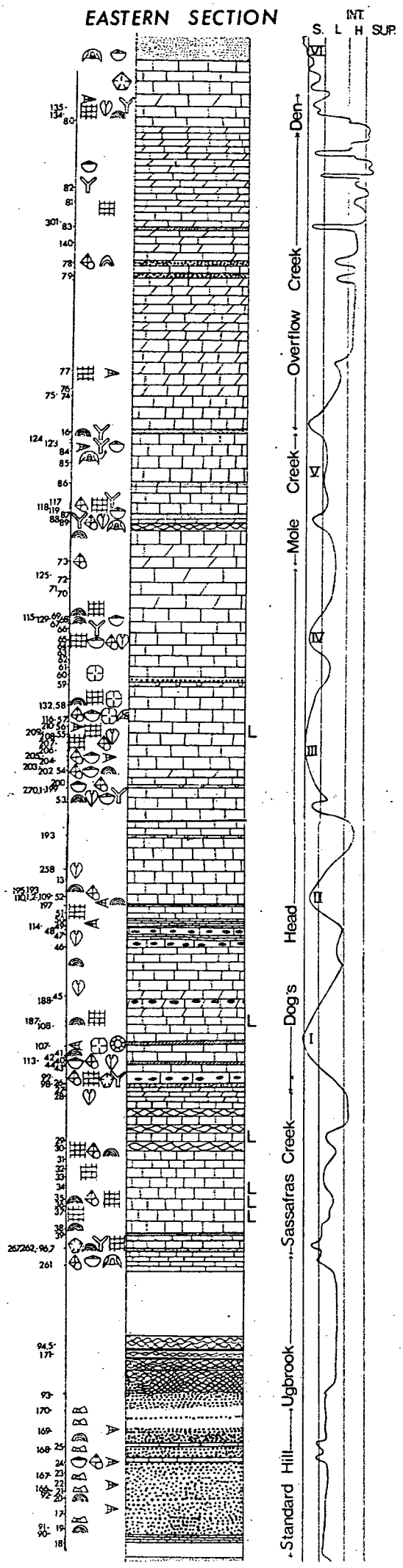
Summary of the Chudleigh Limestone

The sequence of members (Standard Hill, Ugbrook, Sassafras Creek, Dog's Head, Mole Creek, Overflow Creek and Den) is easily recognised and may be mapped to the west (to Dog's Head Hill) and with less facility to the south of Standard Hill.

Using simple faunal and lithological criteria, observable in the field, the Standard Hill Member is thought to be very low intertidal, the Ugbrook Nodular Member middle intertidal and lagoonal, the Sassafras Creek Member mainly middle intertidal and

FIGURE 9

Stratigraphic section through the Chudleigh Limestone at Mole Creek (Eastern Section) showing postulated changes in sea-level. Roman numerals I - VI are major subtidal sections. S = subtidal, INT = Intertidal, L = Low Intertidal, H = High Intertidal, SUP = Supratidal. L's to right of column are major zones of abundant *Lichenaria*. Fossil symbols as in Figure 6.


EASTERN SECTION
INT.
S. L H SUP.
Den
Creek
Overflow
Creek
Mole
Head
Dog's
Creek
Sassafras
Ugbrook
Standard Hill

subtidal near its top. The Dog's Head Creek Member is mainly subtidal (65% by thickness) and thirty five percent intertidal whereas the Mole Creek Member is subtidal and the Overflow Creek Member mainly intertidal-supratidal. The Den Coralline Member represents a return to subtidal conditions.

Of the 1300 metres of Chudleigh Limestone only twenty percent represents subtidal conditions. The majority is intertidal though exactly how much is supratidal remains to be worked out.

If the minor subtidal channel environments are ignored then there are six major subtidal transgressions, five of them concentrated in or just above or just below the Dog's Head Member (Fig. 9). The sixth is in the Den Coralline Member and marks the end of limestone deposition.

The general predominance of intertidal conditions explains the paucity of conodonts and other stenobiontic faunal elements.

Although conditions such as salinity and water depth have oscillated the fluctuations have been minor and of small amplitude. From the Chazyan to the Edenian conditions were, on the broad scale, extremely stable in the Mole Creek area.

CHAPTER III

GORDON SUBGROUP LOCALITIES

Introduction

The major purpose of this section is to outline the stratigraphy of those Gordon Subgroup localities that have been sampled for conodonts. A comprehensive review of each locality is not attempted as structural, economic and palaeontological data are available for several of the localities in Banks (1975, 1962), Hughes (1957), Banks and Burrett *(in press)* and in the various cited publications of the Mines Department of Tasmania and unpublished theses in the University of Tasmania. Much of the information in those publications and theses is not repeated here. However, for many of the localities this is the first geological or the first stratigraphic information available. Some of these data are of a reconnaissance nature only. Observations made by the writer are summarised along with such other published and unpublished information as is necessary to understand the biostratigraphic correlations made in Chapter Five. Localities that failed to yield conodonts have been very briefly summarised. Brief remarks are included on the general environment represented in each section.

Except for small faunules no attempt is made, in this chapter, to suggest correlations for the sampled sections.

Andrew River and the Darwin Crater (Localities 1 and 6 on Fig. 2)

Ten limestone samples were collected from the banks of the Andrew River 4.8 km east south east of the Darwin Crater at grid ref. 8013-940134. Access was by means of a helicopter landing on a bar in the river. The limestone is steeply dipping to the south west at 65° and is strongly

FIGURE 10B Channel calcarenite with dolomite blebs overlying intertidal micrites. Lower Limestone Member Florentine Valley. Conodonts are rare in the channel deposits and absent in the intertidal micrites.

FIGURE 10C Biocalcirudite in Upper Limestone Member containing corals and cephalopods. Conodonts are rare in this rock type.

FIGURE 10A
Strike ridge of Gordon Subgroup carbonate in the Florentine Valley Dolerite capped Mt. Field in background.

FIGURE 10E
Strongly deformed oncolites in oncosparite in Claude Creek. Lens cap is 50mm. in diameter.

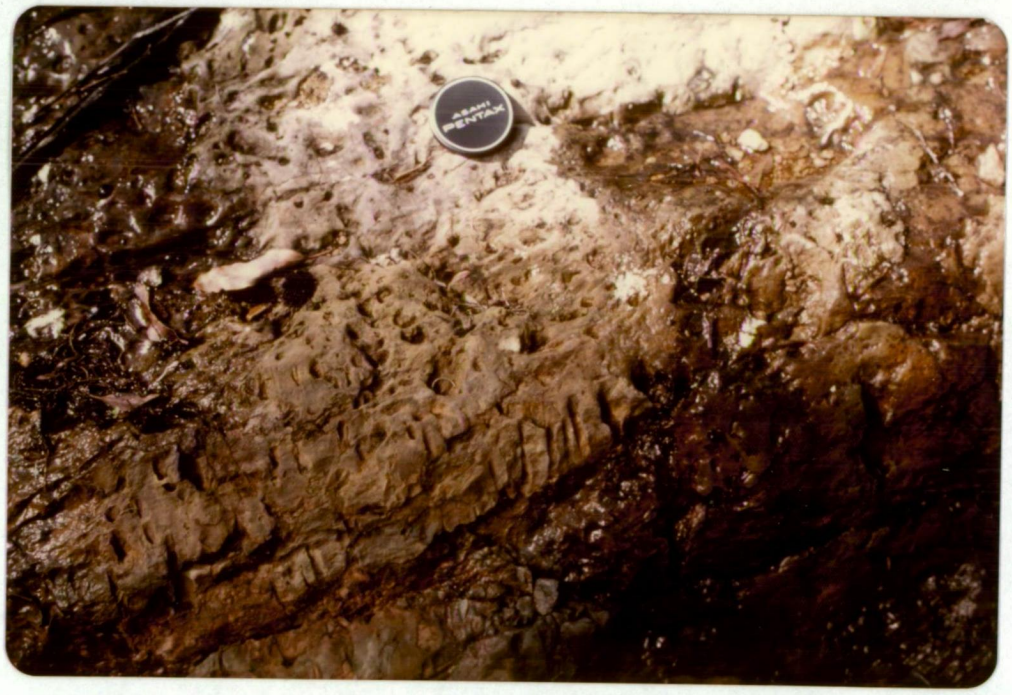


FIGURE 10D
Perpendicular to bedding worm tubes in dolomicrite in Claude Creek. Lens cap is 50mm. in diameter.

FIGURE 10G
Cleaved micrites with dolomite interbeds at base of limestone sequence near Grieve's Siding south of Zeehan. Hammer is 350mm. long. This sample contains conodonts belonging to C.A.I. 2.

FIGURE 10F
Valley formed in Gordon Subgroup carbonates near Grieve's Siding south of Zeehan facing west. Moina Sandstone correlate is foreground. Eldon Group siliciclastics in background.

FIGURE 10I
Flat pebble conglomerate in limestone quarry near Bubs Hill. Bedding plane view. Pen is 95mm. long.

FIGURE 10H
Flat pebble conglomerate and algal laminated limestone in quarry near Bubs Hill, side view.

FIGURE 10J
Perpendicular to bedding worm burrows ("tubicolar sandstone") in quartz arenite (Moina Sandstone correlate) beneath limestone near Grieve's Siding Zeehan (x 0.8)

FIGURE 10K
Ripple -marked Moina Sandstone correlate west of Grieve's Siding. Spots may be rain prints or gas escape holes. Hammer is 350mm. long.

FIGURE 10M
Channel calcarenite in intertidal limestones near base of Section Vale of Belvoir. Hammer is 330mm. long.

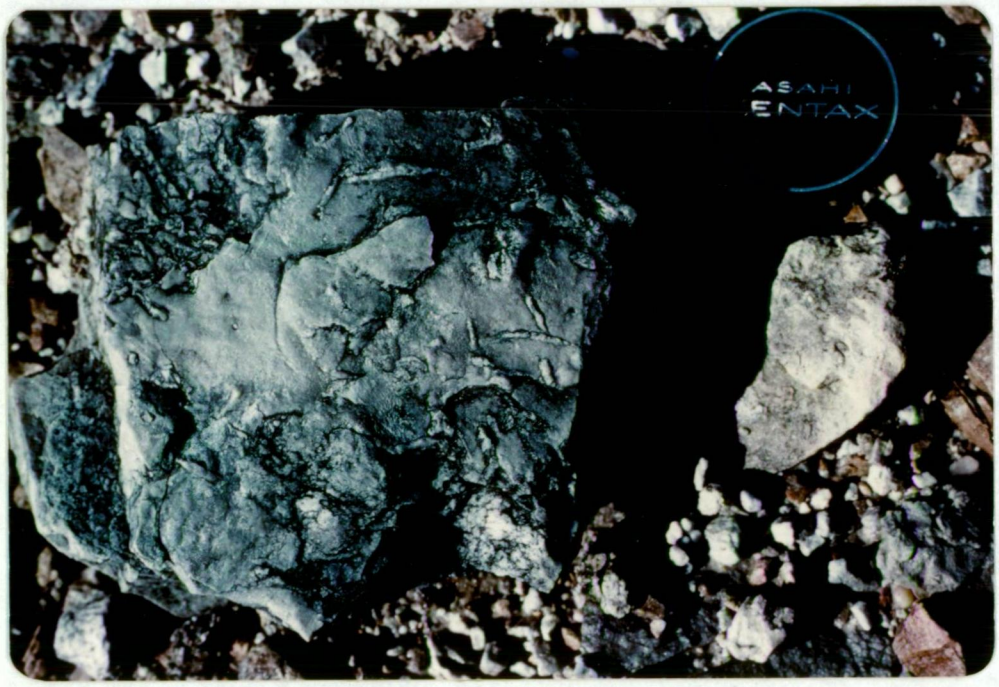


FIGURE 10L
Horizontal burrows in quartz arenite of the Moina Sandstone east of Grieve's Siding south of Zeehan. Lens cap is 50mm. in diameter.

FIGURE 10 O
Outcrop of nodular limestone in Picton River (Locality C). Large bedding plane is 1.5m. above water level.

FIGURE 10N
Silicified fossils in "reef" limestone along Picton River. Strophomenid in centre associated with corals. Lens cap is 50mm. in diameter.

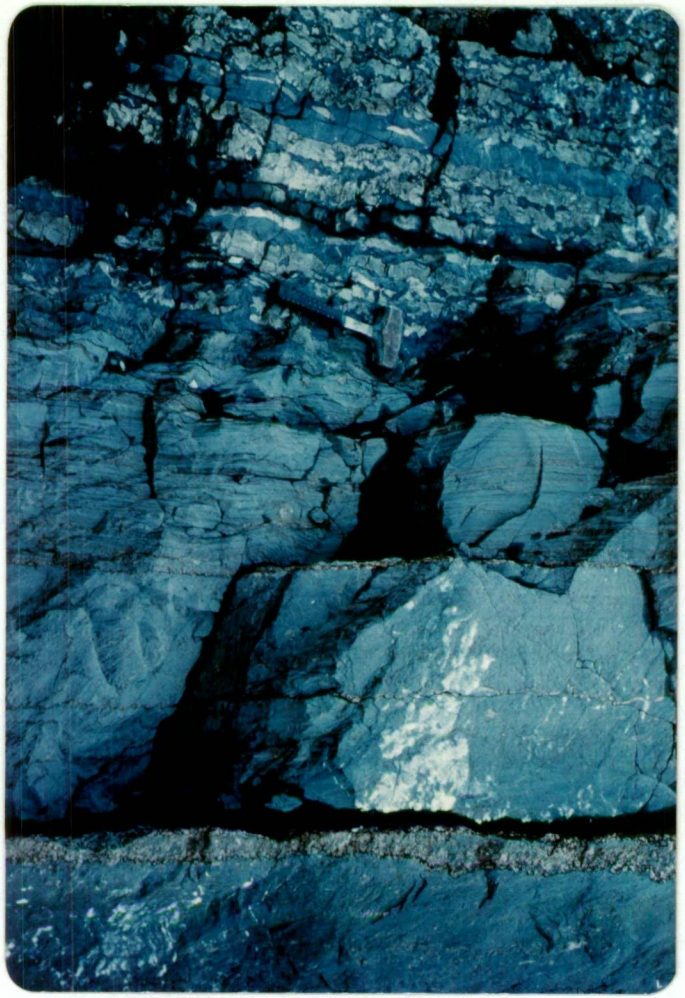


FIGURE 10P
Dolomitic beds overlying, algal laminated beds overlying dismicrites in Smelter's Quarry Queenstown. Hammer is 300mm. long.

FIGURE 10Q
Close-up of Figure 10P
Alternating dolomites/micrites overlying algal laminated beds.

FIGURE 10S
Large stromatoporoid and coral colonies in "reef" limestone along Picton River. Lens cap is 50mm. in diameter.

FIGURE 10R
Near vertical limestone in Smelters Quarry Queenstown. Face is 28m. high. Coralline horizon at right of quarry dolomitic beds at left.

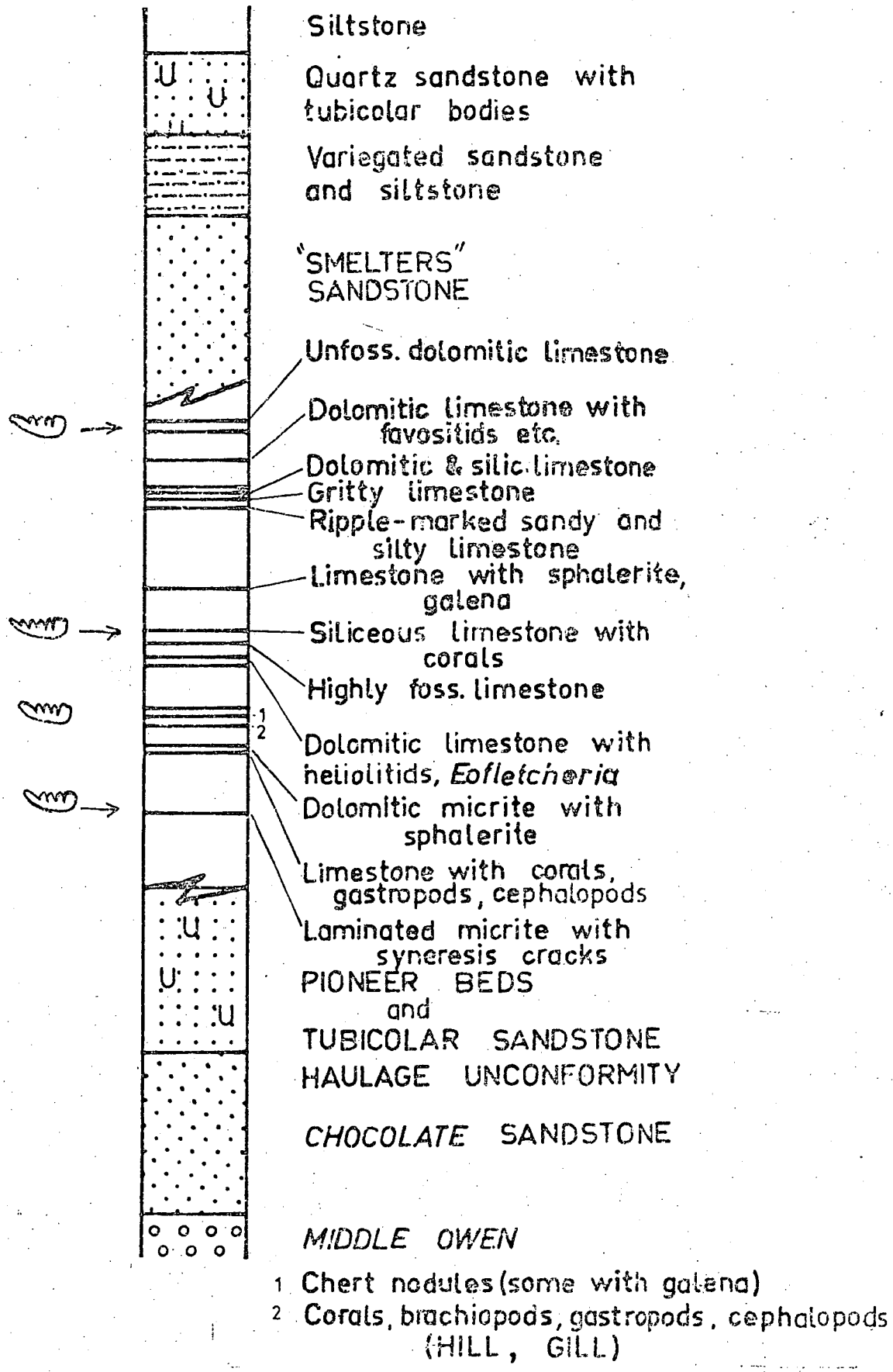


FIGURE 11

Stratigraphic section through Bubs Hill showing conodont-bearing horizons. Based on Banks and Burrett *in press*, from Reid 1964. Composite section includes data from Queenstown (Bradley 1954).

cleaved. The locality is probably a third of the way up the limestone section in this area. The dark micrite contains large blebs of dolomite up to 60 mm in diameter.

Two of the samples yielded a fauna consisting of *Phragmodus undatus* Branson and Mehl and *Belodina compressa* (Branson and Mehl) indicating an age range from Fauna eight to Fauna eleven. All of the specimens were deformed and fragile as is a collection from a drill hole from the Darwin Crater (grid ref. 8013, 8915) (Ford 1974). The specimens from the Darwin Crater (at a depth of 100 metres) are distorted, cleaved and unidentifiable.

Birch Inlet (Locality 2 on Fig. 2)

Three dolomicrites from the syncline to the southwest of Birch Inlet were processed but no conodonts were found.

Bubs Hill (Locality 3 on Fig. 2)

Approximately 400 m of Gordon Subgroup carbonates are present at Bubs Hill (grid ref. CP 986362).

The lower part of the limestone is faulted against the surrounding Precambrian rocks. The lowest part of the limestone is highly dolomitic, bioturbated and is unfossiliferous.

Beds of coralline micrite, dolomite and quartzite occur near the top of the carbonate sequence and the limestone is overlain disconformably by a correlate of the Crotty Quartzite (Reid, 1964).

The highest limestone beds, containing corals such as *Palaeophyllum* and *Favistina* and halysitids as well as bryozoa, brachiopods, gastropods and cephalopods, has yielded a conodont fauna consisting of *Plectodina* cf. *furcata* (Hinde), *Belodina compressa* (Branson and Mehl), *Drepanoistodus suberectus* (Branson and Mehl), *Panderodus gracilis* (Branson and Mehl), *Phragmodus undatus* Branson and Mehl, an eoligonidiniform element probably belonging to *O. robustus* (Branson, Mehl and Branson), and

Milaculum ethinelarki Müller. The lowest samples that yielded conodonts (2 on Fig. 10) contained *P. undatus* Branson and Mehl, *Drepanoistodus suberectus* (Branson and Mehl), *Belodina compressa* (Branson and Mehl), *Plectodina* cf. *furcata* (Hinde) and *P. gracilis* (Branson and Mehl).

Claude Creek (Locality 5 on Fig. 2)

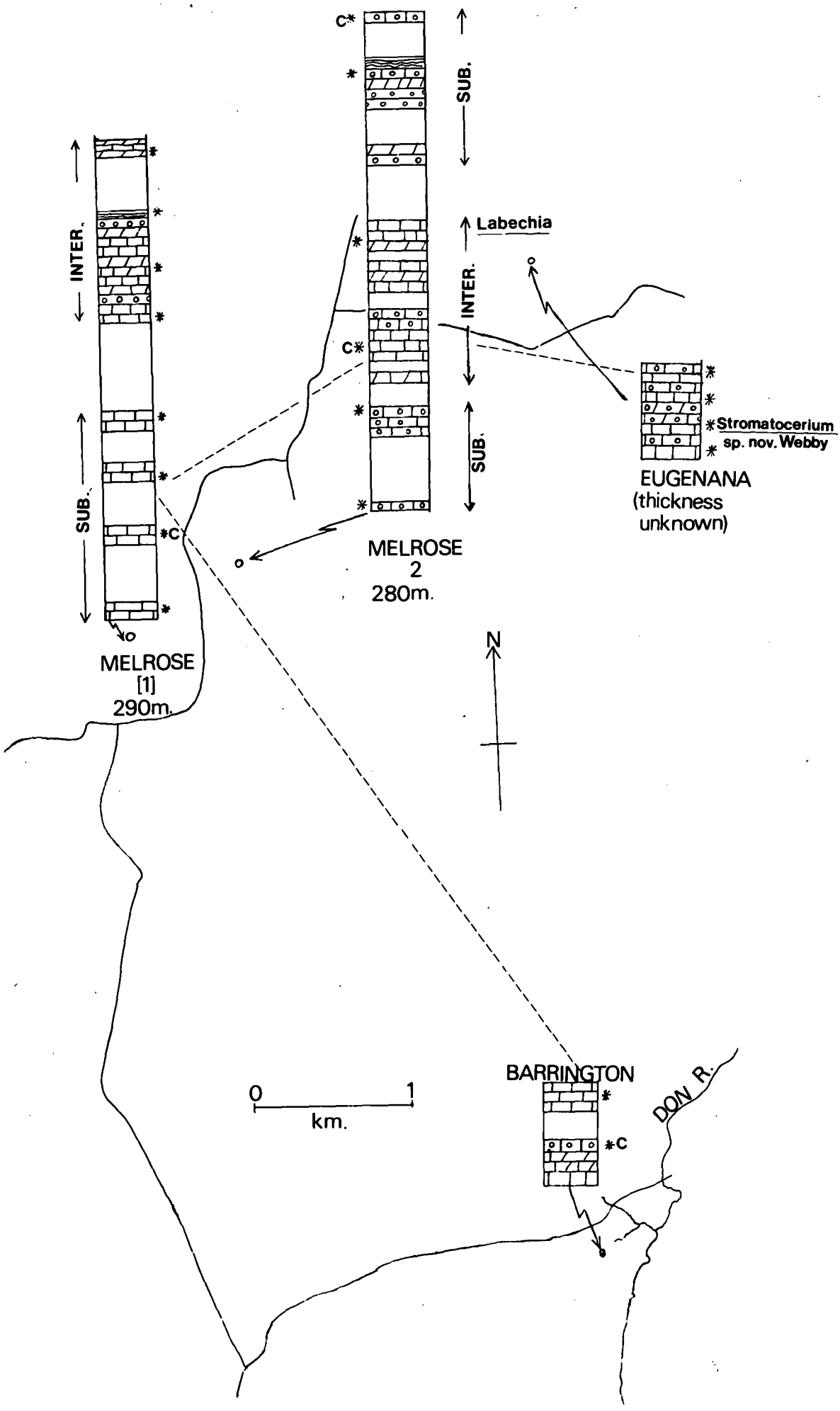
A small outcrop of limestone occurs at Claude Creek at grid ref. DQ311049 and contains deformed oncolites and *Maclurites* (Jennings 1958, Seymour 1975). The limestone is approximately 50m thick and has yielded a conodont fauna consisting of *Belodina alabamensis* Sweet and Bergström, *Panderodus serpaglii* sp. nov., *Phragmodus flexuosus* Moskalenko, *Acontiodus* cf. *nevadensis* Ethington and Schumacher and *Belodella copenhagenensis* (Ethington and Schumacher).

The Moina Sandstone, below the limestone, contains small and large scale cross-bedding, ripple marks and vertical and horizontal worm burrows. Most of the sedimentary features are similar to those from tidal flat deposits (various authors *in* Ginsburg 1975). Five metres above the base of the limestone there is a bed containing pyritised asaphids. The contact between the Moina Sandstone and the Gordon Subgroup is gradational and consists of about four metres of marl.

Because of structural complications the exact sequence within the limestone has not been determined. About 15% of the limestone consists of oncolitic beds which may be thick (up to 4 metres) or thin (10 mm). The remainder of the limestone is highly dolomitic and the shells (mainly gastropods) are completely replaced by dolomite. Algal laminated and vertically burrowed dolomicrites are common (Fig. 10 D). Many of the beds are lenticular and cross-bedded channels are common. Most of the sedimentary structures and the low faunal diversity suggests a tidal flat environment. Ten samples have been examined but only two have yielded conodonts, one from the base and one from near the top of the section which

FIGURE 12

Stratigraphic sections through the Gordon Subgroup in the Eugenana-Melrose-Paloona area based on data in Scanlon (1976). Asterisks indicate conodont collecting horizons. C = conodont-bearing samples; Sub = postulated subtidal environment; Inter = postulated intertidal environment; Dashed lines indicates probable correlation of sections within Faunas 5 and 6.


C*
SUB.
Labechia
INTER.
C*
SUB.
INTER.
SUB.
*C
MELROSE
2
280m.
MELROSE
[1]
290m.
*Stromatocerium
sp. nov. Webby
EUGENANA
(thickness
unknown)
N
0
1
km.
BARRINGTON
*C
DON R.

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contain identical faunas.

Eugenana-Melrose-Paloona area (Locality 10 on Fig. 2)

Several limestone outcrops are found in the Eugenana-Melrose-Paloona district (Burns 1964). The Ordovician rocks of the area have recently been studied by Scanlon (1976). Samples from the quarries at Eugenana (at grid ref. DQ418354) in the *Maclurites*-oncolitic assemblage failed to produce conodonts. Webby *(in litt.)* has identified *Stromatocerium* sp. nov. Webby from the Eugenana section. This species is found near the base of the section at Mole Creek.

At Melrose there are two limestone sections (Fig. 12). The first section (at grid ref. DQ397325) is 290m thick and consists of 100m. of biomicrite at the base overlain by intramicrite, oncointramicrite and algal biomicrite. The lower half of the section has been interpreted as deposited in a subtidal environment and the upper half in an intertidal regime (Scanlon 1976). A conodont fauna from 50 metres above the base includes *Belodella copenhagenensis* (Ethington and Schumacher), *Panderodus gracilis* (Branson and Mehl), *Phragmodus flexuosus* Moskalenko and *Panderodus serpaglii* sp. nov.

The second section (at grid ref. DQ399327) is 280m thick and is oncolitic at many levels. Scanlon (1976, fig. 46) showed that the environment oscillated between subtidal and intertidal. *Panderodus serpaglii* sp. nov. was found in a sample from 60m. above the base and *Plectodina aculeata* (Stauffer) was found in a biooncosparite at the top of the sequence.

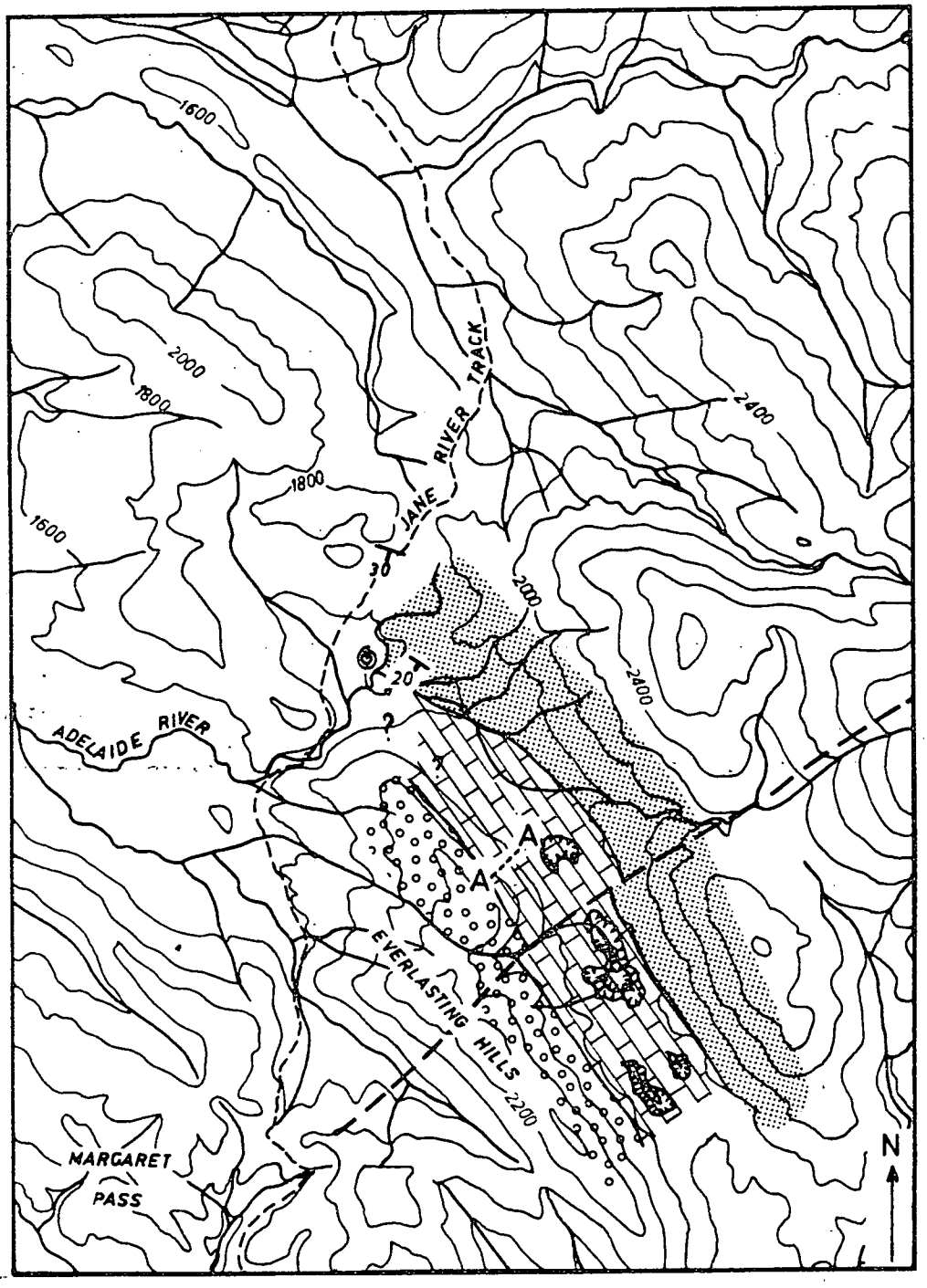
Only three out of twenty samples processed by Scanlon and the writer yielded conodonts and these are shown on Figure 12.

Maclurites occurs throughout the first section but is only found at the base of the second section.

A species of *Labechia* is found halfway through the second Melrose

FIGURE 13

Reconnaissance geological map of the Everlasting Hills area. No reliable mapping is available in this region outside of the area shown here. A-A section surveyed. Contour lines in feet above sea level.



LOWER (?) ORDOVICIAN SANDSTONE WITH GASTROPODS

GORDON LIMESTONE SUBGROUP

?SILURIAN SANDSTONES WITH BRACHIOPODS AND CRINOIDS

INFERRED FAULT

DIP

GASTROPOD LOCALITY

0 1 2 3 km.

section and is close to a species from the Sassafras Creek Member at Mole Creek.

The conodont fauna from the base of both Melrose sections suggests correlation with the Standard Hill Member. The discovery of *P. aculeata* and *Labechia* higher in the sequence suggests correlation with the Sassafras Creek Member.

Fifty-five m. of biosparite are found in a small outcrop near Lower Barrington (at grid ref. DQ423289) and one sample from halfway through the section has yielded *Phragmodus flexuosus* Moskalenko suggesting correlation with the Standard Hill Member of Mole Creek.

Everlasting Hills (Locality 11 on Fig. 2)

Limestone in the south Loddon River area (Locality 23 on Fig. 2) has been known for some time (Ward 1908, Wells 1955). The geological map of Tasmania (Williams, 1976b) shows the region between the South Loddon River and the Loddon Range (an area of over 100 square kilometres to be a fault bounded block containing a thin Ordovician sequence, overlain by extensive deposits of Siluro-Devonian clastics. Discussion about the area with Ian McKendrick revealed that he had found karstic features on aerial photographs within the supposed Siluro-Devonian outcrop. These dolines have the characteristic features of Gordon Limestone dolines rather than Precambrian dolomite dolines which are extensively developed to the south. A visit to the Everlasting Hills area (7 kilometres east of the Loddon River outcrop) revealed a very thick sequence of mainly unfossiliferous, often ferruginous, sandstones and siltstones, highly pyritic in places, dipping to the south along the Jane River Track (see Fig. 13). An outcrop of these clastics (at grid ref. DP196176 see Fig. 13) contained planispiral gastropods. The overall aspect of these clastics is Lower Ordovician rather than Siluro-Devonian.

The newly discovered limestone outcrop visited is two kilometres east of the Jane River Track (at grid ref. DP202157 see Fig. 13). The dolines are about two hundred metres in diameter and indicate that several hundred metres of limestone are present beneath the limestone outcrops examined on the northern flanks of Everlasting Hills (see Fig. 13).

The limestone is inferred to be mainly intertidal, being very dolomitic, generally unfossiliferous and bioturbated in places. Very few macrofossils have been observed through silicified brachiopods have been found in a metre thick channel calcarenite bed.

Specimens were collected from a fifty metre thick section above a cave at grid ref. DP199163 and a few of these yielded abundant conodonts including *Phragmodus tasmaniensis* sp. nov., *Chirognathus monodactylus* Branson and Mehl, *Belodina compressa* (Branson and Mehl), *Drepanoistodus suberectus* (Branson and Mehl), *Panderodus gracilis* (Branson and Mehl), *Plectodina aculeata* (Stauffer), *Erismodus gracilis* (Branson and Mehl) and *Rhipidognathus? careyi* sp. nov.

The fauna is very similar to that found in the Lower Limestone Member of the Benjamin Limestone and in the Ugbrook Nodular Member at Mole Creek. The presence of *Chirognathus monodactylus* suggests a Blackriveran age. Only the calcarenite yielded a diverse fauna; the dolomicrites of the intertidal/supratidal sequences yielded only fibrous conodonts.

Loose blocks of siltstone (containing abundant crinoid ossicles) and sandstone (containing abundant rhynchonellids and orthids) were found near to the topmost outcrop of limestone (Fig. 13) and, pending detailed examination are presumably Silurian although an Ordovician age cannot be excluded.

This reconnaissance survey has revealed a hitherto unknown

sequence of very interesting and palaeogeographically very important Lower Palaeozoic rocks that awaits further study.

Florentine Valley (Locality 12 on Fig. 2).

Introduction:

The Florentine Valley contains probably the most complete section of Gordon Limestone subgroup in the state. The oldest limestones in the synclinorium have yielded a conodont fauna belonging to the *Prioniodus evae* Zone of Lindström (1971) (Stait 1976). There are 500 metres of limestone below the Cashions Creek Limestone, the conodont fauna of which is being studied by Dr. D.J. Kennedy (Waterloo). Unfortunately the limestone outcrop is not as complete as in the Mole Creek area and therefore that area was chosen for detailed study (see p. 17).

The Florentine Valley has been mapped by Corbett (1963) and the stratigraphy and palaeontology outlined by Corbett and Banks (1974). Weldon (1974) studied the limestone sedimentology particularly in the Westfield Syncline area (see Fig. 14) and White (1974) studied the limestone just to the south in the Junee area (Locality 21 on Fig. 2).

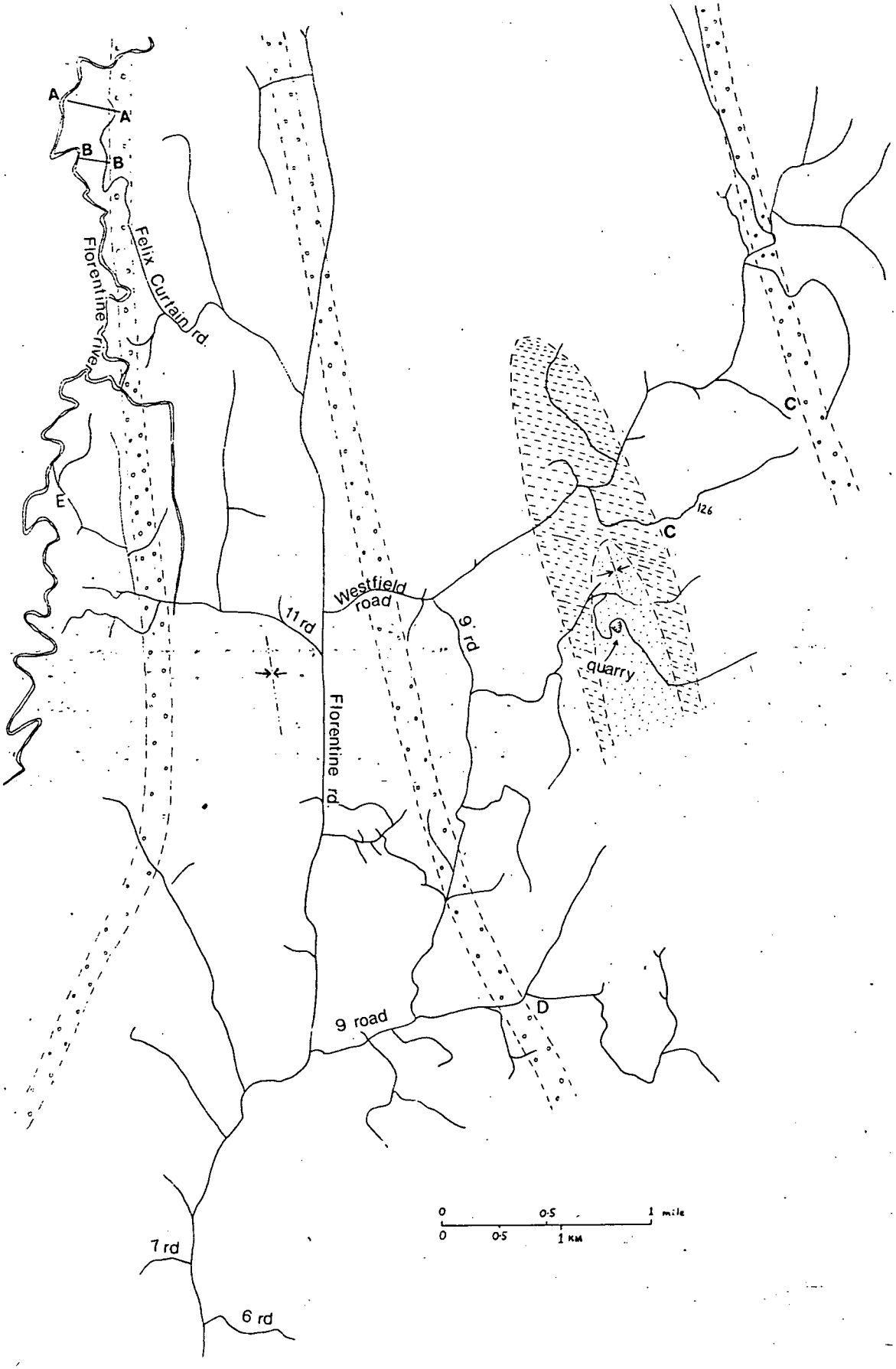
The stratigraphy of the limestone section is summarised in Figure 15.

Localities:

Three areas in the Florentine Valley synclinorium have yielded conodont faunas. Weldon (1974) measured and analysed a section through the Westfield Syncline (section C-C on Figure 14). He made 80 of his samples available to the writer but only 15 of these yielded conodonts. A section parallel to that of Weldon was measured, to the north, along the Westfield Road. This section is

FIGURE 14

Locality diagram of the Florentine Valley based on mapping by Corbett (1963, 1970). Circle symbol indicate outcrop and postulated outcrop of the Cashions Creek Limestone. Dots indicate Eldon Group sandstone and dashes outcrop of Westfield Siltstone. A-A: Northern section surveyed on the Felix Curtain Road, B-B: southern Felix Curtain Road section, C-C: Westfield Syncline section, D: Outcrop of the Lower Limestone Member of the Benjamin Limestone Formation along Nine Road.


A
A'
B
B'
Florentine river
Felix Curtain rd
E
11 rd
Westfield road
9 rd
Florentine rd
C
C'
126
quarry
D
9 road
7 rd
6 rd
0 0·5 1 mile
0 0·5 1 km

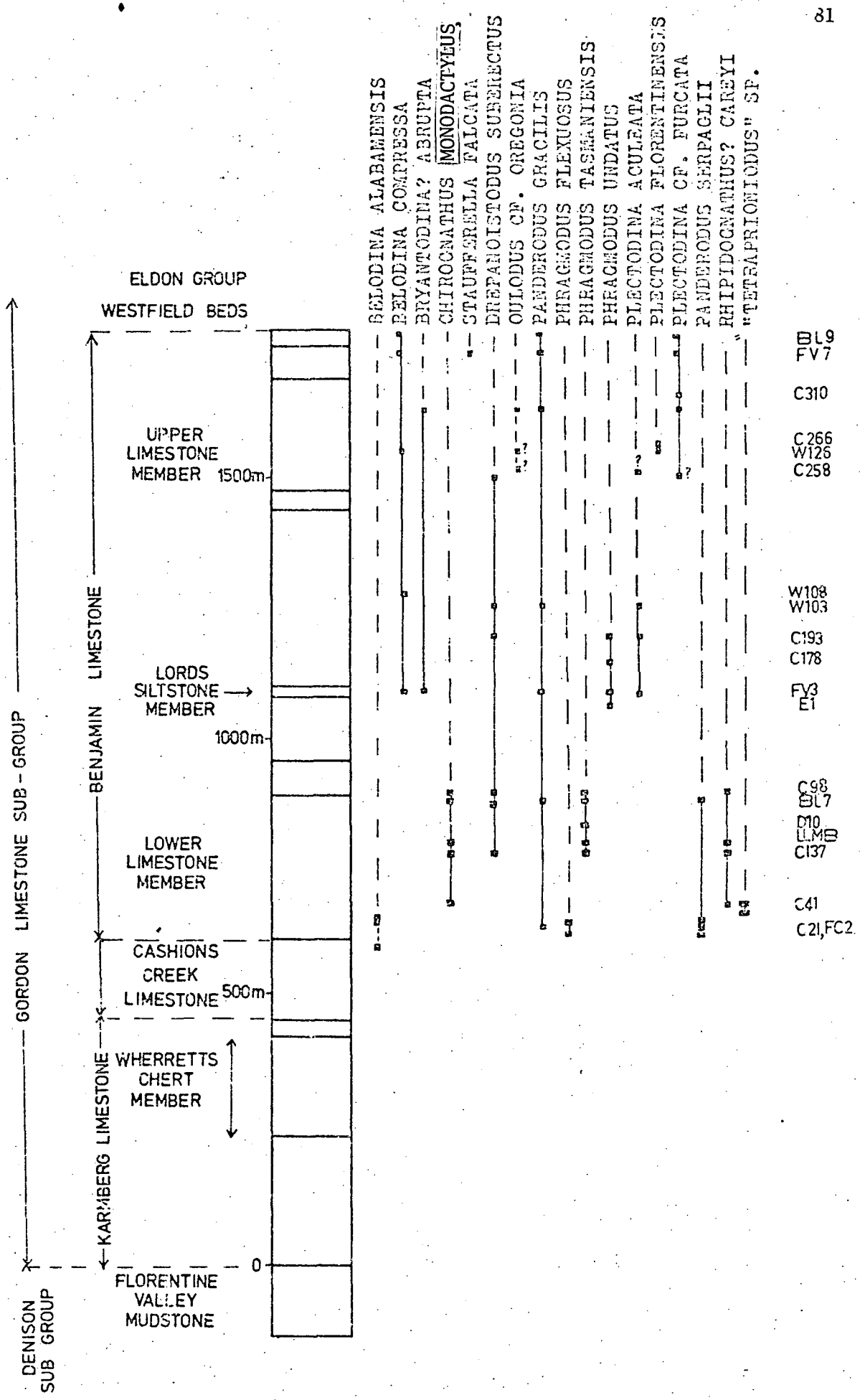


FIGURE 15

Summary of Gordon Limestone Subgroup succession in the Florentine Valley showing conodont-bearing horizons. From Corbett and Banks (1974). Dashed lines do not indicate range but are guides to the names above.

A:- Dessication features in dolomicrite. Near sample 13 on section of Figure 17. Lower Limestone Member.

B:- Dolomitised horizontal worm burrows near sample 12 on section of Figure 17. Lower Limestone Member.

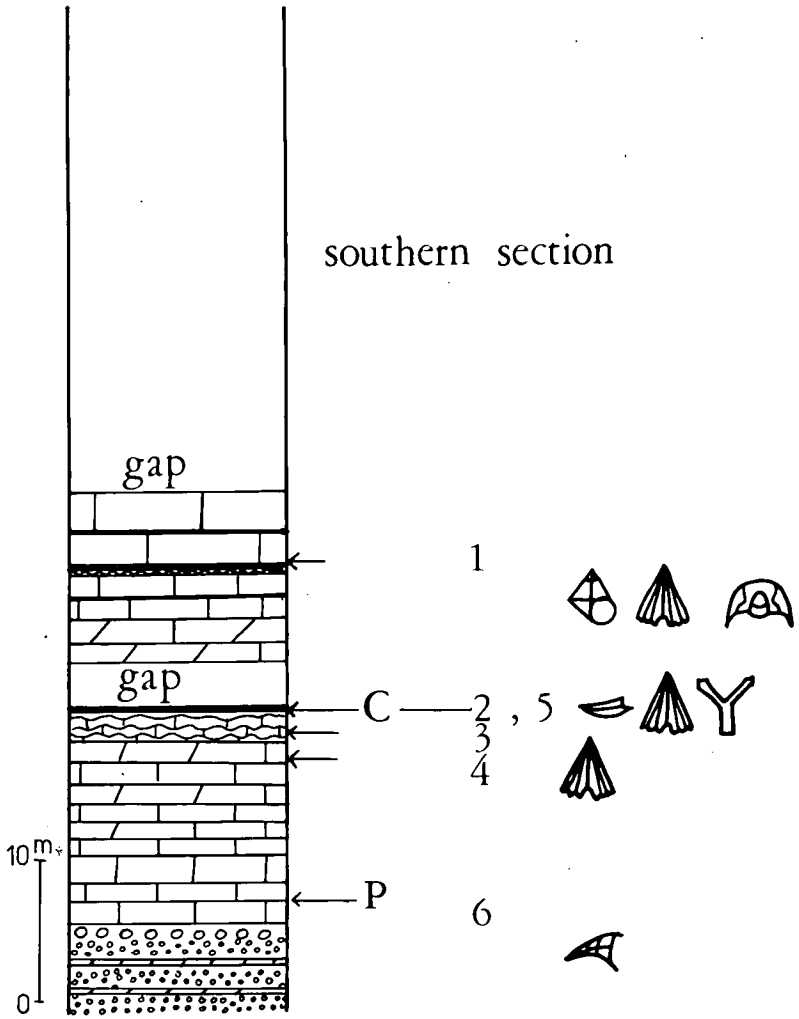
C:- Oncomicrudite showing characteristic cross sections through *Maclurites*. Near sample 8. Cashions Creek Limestone Formation.

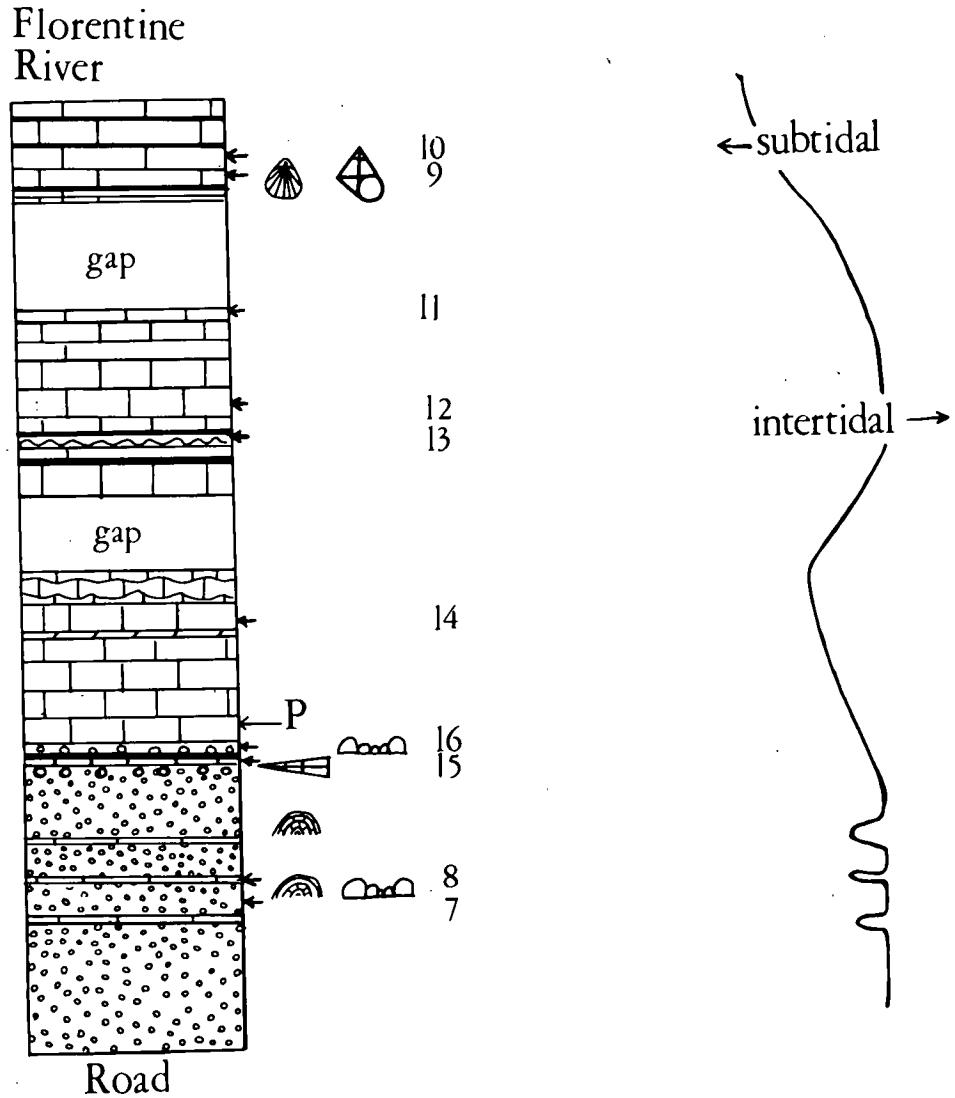
FIGURE 16

Limestone in the Felix Curtain Road area of the Florentine Valley. Hammer shaft just below head is 33mm. wide.

FIGURE 17

Succession of Gordon Limestone Sub-group west of Felix Curtain Road. See Figure 14 for localities. Symbols as in Figure 6. Numbers are conodont samples. Northern section is 45 metres thick, southern section is 26 metres thick. C = Productive conodont sample. P = position of flat pebble conglomerate.





FELIX CURTAIN ROAD
northern section

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not included in this thesis as the Westfield sections of the Benjamin Limestone are currently being studied in greater detail by C. Calver. Only calcarenites and samples containing a stenobiontic macrofauna were collected.

The distribution of the Cashions Creek Limestone Formation of Corbett and Banks (1974) is shown in Figure 14. Approximately thirty samples from this formation failed to yield conodonts. Only samples from the Felix Curtain Road area (sections A-A, B-B on Figure 14) contained useful conodonts. Two sections were measured and are summarised in Figure 17.

A few samples have been collected from the Lower Limestone Member from along Nine Road at grid ref. DN586754 at the point marked D on figure 14.

The locations of the productive samples and their included conodonts is summarised in Figure 15. The stratigraphic levels of the samples from the Felix Curtain Road section are extrapolated onto the composite section.

Flowery Gully (Locality 13 in Fig. 2).

Kennedy (1971) described the conodonts from one sample from Flowery Gully and suggested an Arenigian age for the base of the limestone. Graptolites from the siltstones, that overlie the limestone at Flowery Gully, have been identified as *Retiograptus* and *Pleurograptus* by M.R. Banks (Banks and Burrett *in press*) and therefore a Late Ordovician age for the upper part of the limestone seemed probable. Several samples from the top of the limestone, however, have yielded an abundant and diverse fauna including *Periodon aculeatus* Hadding and conodonts of Whiterockian age. This dating has since been confirmed in detail by Kennedy (*in* Banks and Burrett *in press*). Thus there is either a large stratigraphic gap between the limestone and the siltstones (as suggested by Noakes *et al.*, 1954) or the graptolite

identification is in error or the structure of the area is not as simple as envisaged by Kennedy (1971).

Rather surprisingly limestone deposition appears to have ceased in the Flowery Gully area before limestone deposition was initiated in most other areas in the state. Alternatively, the limestone was deposited and then eroded before the deposition of the overlying siltstones.

Gunns Plains (Locality 15 on Fig. 2)

Williams and Turner (1974) have estimated the thickness of the limestone at Gunns Plains as 900 metres. Two samples have been processed from the lowest outcropping limestones which are 150 m above the base of the limestone. The top of the limestone contains a coralline fauna (Banks 1962) and three samples were processed from this horizon.

The highest samples yielded a conodont fauna consisting of *Phragmodus undatus* Branson and Mehl, *Plectodina* cf. *furcata* (Hinde), *Panderodus gracilis* (Branson and Mehl), *Drepanoistodus suberectus* (Branson and Mehl) and *Belodina compressa* (Branson and Mehl). The lowest samples (from grid ref. DQ183276) yielded *Chirognathus monodactylus* Branson and Mehl, *Plectodina aculeata* (Stauffer) and *Panderodus gracilis* (Branson and Mehl). This sample is 200m. above the base of the limestone. No samples from the base of the section have yielded conodonts.

Locality near Hastings Caves (Locality 17 on Fig. 2)

A small outcrop of carbonate occurs in a creek two kilometres southwest of Hastings Caves at grid reference DM853962. Hastings Caves are developed in Precambrian dolomites and are four kilometres NNW from the Gordon Subgroup localities at Lune River (Ida Bay). The

discovery of what appeared to be fossils in the carbonate by I.B. Jennings suggested that this small outcrop could belong in the Gordon Subgroup. No conodonts were found in the limestone which lithologically is quite unlike Gordon Subgroup rocks.

Huskisson River area (Locality 18 on Fig. 2)

A thin (330 metres) sequence of Gordon Subgroup outcrops in the Huskisson River area (Blissett 1962, Groves 1966, Rubenach 1973) but none of the five brachiopod rich limestone samples collected from this area has yielded conodonts.

Isle du Golfe (Locality 19 on Fig. 2).

The new geological map of Tasmania (Williams 1976) shows the Isle du Golfe (at grid reference DM6175) as being entirely Gordon Subgroup. As it is almost impossible to land safely on this island by sea or air this mapping could not be verified. However examination of enlarged aerial photographs of the island did not reveal any karstic features.

Judd's Cavern - Picton Range (Locality 20 on Fig. 2)

Limestone at and near to Judd's Cavern (at grid ref. DN674105) contains oncolites and *Maclurites*. The conodont fauna consists of *Belodella copenhagenensis* Ethington and Schumacher), *Panderodus serpaglii* sp. nov., *Panderodus gracilis* (Branson and Mehl) and *Phragmodus flexuosus* Moskalenko.

Liena (Locality 22 on Fig. 2)

Limestone outcrops extensively around and to the south of the small township of Liena (Jennings 1963). This large area is yet to be studied but samples from the bridge four kilometres to the south

of Liena have been processed. This outcrop is close to (within six metres) of the base of the limestone. The outcrop near the bridge contains birds-eye limestone, bioturbated dolostones and algal laminated dolomicrites. The thin-bedded algal laminated dolomicrites are barren of conodonts but an overlying, metre thick micrite has yielded a few specimens of *Panderodus serpaglii* sp. nov. and *Phragmodus flexuosus* Moskalenko.

Loongana (Locality 24 on Fig. 2).

The structure, extent and economic importance of the Gordon Subgroup at Loongana has been summarised by Hughes (1957 pp. 138-140). The limestone occurs as a synclinal structure with minor parasitic folding. There are no overlying Siluro-Devonian clastics and the extent of post-Ordovician erosion of the Gordon Subgroup cannot be established. The limestone is estimated to be 650 metres thick.

Samples were collected (see Fig. 18) from near to the synclinal axis (at grid ref. 8015 157149) and along the road into Loongana (at grid ref. DQ 175159).

The base of the limestone contains only a few oncolites and very small *Maclurites* (up to 40mm in diameter).

A section along the road (Fig. 18) leading into Loongana displays the sequence summarised in Figure 19. Most of the section along the road from the house near the sharp bend sign-posted "Dangerous Bend" (at grid ref. DQ 176162) up to the bridge over Winter Brook (at grid. ref. DQ178150 - Fig. 18) is dolomitic, bioturbated and in its upper parts highly dolomitic (pure dolomites in places), and contains algal laminated dolomicrites. These are associated with chert nodules up to 30 millimetres in diameter which display planar faces which could

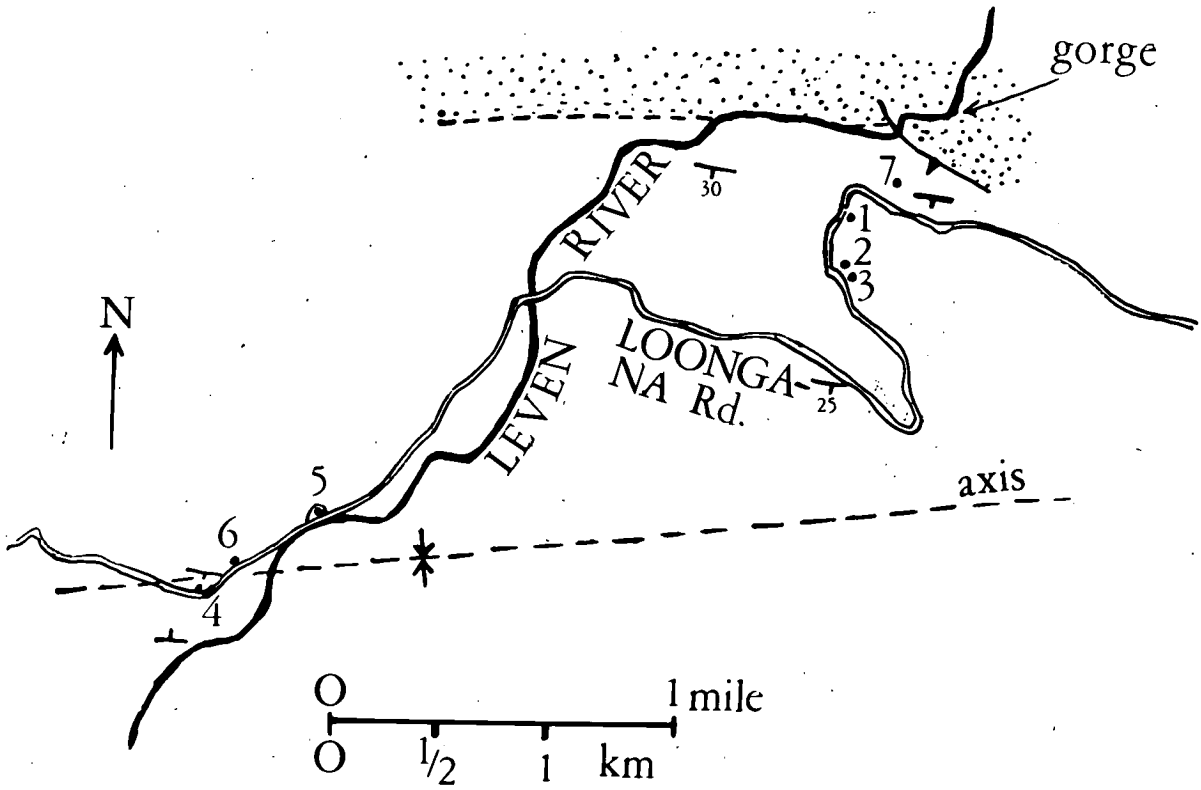

FIGURE 18

Locality map of the Loongana area.
Numbers refer to conodont samples.

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well be evaporite pseudomorphs. The lower part of the road section is inferred to be intertidal and the upper part supratidal. Only one shell bed occurs along the road (see Fig. 19) and this has been processed for conodonts.

The limestones collected and studied near to the synclinal axis are unfossiliferous dolomicrites which are occasionally bioturbated. Little variation could be seen in 120 metres of limestone studied.

conodont faunas:

The lowest oncolitic/intraclastic limestone contains *Phragmodus flexuosus* Moskalenko and *Panderodus serpaglii* sp. nov.

Sample no. 1 from near to the "Dangerous Bend" into Loongana has also yielded *Phragmodus flexuosus* Moskalenko associated with *Belodina compressa* (Branson and Mehl). Samples 2 through to 6 were barren.

Lorinna (Locality 25 on Fig. 2)

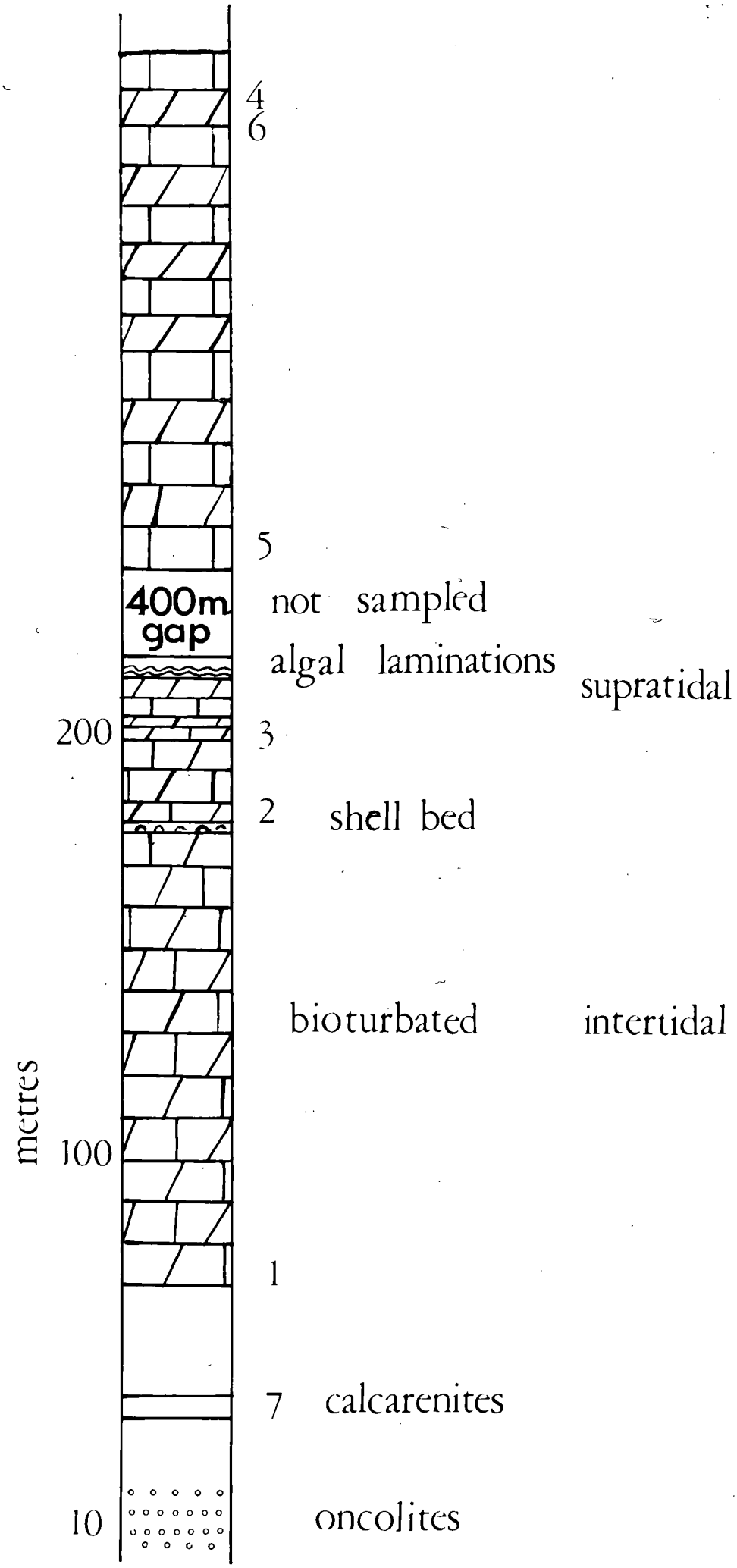
Thirty metres of "dense grey limestone" occurs 20 metres north of the bridge at Lorinna (Gee 1965). Samples collected by Gee (1965) have yielded a conodont fauna of *Phragmodus flexuosus* Moskalenko, *Panderodus serpaglii* sp. nov. and *Belodella copenhagenensis* (Ethington and Schumacher). Much of the limestone has now been flooded due to damming of the Iris River and resampling is impossible.

Lune River (Ida Bay) (Locality 27 on Fig. 2)

About 1000m of limestone are found at about three kilometres from Lune River. The area has been mapped by Everard (in Hughes 1957, p.52) and the geomorphology and hydrology discussed by Goede (1969). A large quarry is operative in the stratigraphically higher parts of the limestone at grid ref. DM 888874. Old abandoned quarries are also

FIGURE 19

Sketch section of the Gordon Subgroup at Loongana, showing position of conodont samples (to right of column). The 400m gap indicated is not a gap in outcrop but a gap in sampling. Reconnaissance survey only.


4
6
5
400m gap
not sampled
algal laminations
supratidal
200
3
2
shell bed
bioturbated
intertidal
metres
100
1
7
calcarenites
10
oncolites

77/1/86

present at grid ref. DM 874877. The limestone is overlain by the Upper Carboniferous or Lower Permian basal tilloid of the Parmeener Super-Group and the contact can be located to within a few metres. Blocks of sandstone containing strophomenids are found scattered through the quarry and these may be present in between the limestone and the tilloid. However, thick bush has not allowed the relationships to be worked out in detail. The base of the limestone is not exposed at the surface. Teichert and Glenister (1953, p.13) have described *Trocholitoceras idaense* and *Mysterioceras* from outcrops in Mystery Creek cave at grid reference DM 876878 and small samples of micrite have been collected from the bottom of this cave (Mystery Creek Cave). These samples are probably not far above the base of the limestone section and are probably about 20m. stratigraphically below the level at which M.R. Banks and others collected the cephalopods described by Teichert and Glenister (1953).

Specimens have been collected through a section along the road into the new quarry, through the new quarry and in the limestone of Marble Hill just above the quarry.

The section up to the floor of the main quarry is summarised in Figure 20. The section is mainly intertidal with minor subtidal beds that contain an abundant fauna of strophomenids and trilobites. A metre thick oncolitic bed occurs at 43 metres above the base. An oncolitic bed of similar thickness occurs on the South Coast Track (at grid ref. DM871874) and is probably a correlate.

The floor of the main quarry is composed of a dark micrite containing an abundant cephalopod-stromatoporoid-coral fauna. Subtidal and low intertidal micrites and dolomicrites comprise the working face (1976) of the quarry. Channel calcarenites are found within the intertidal sequences and have yielded conodonts. A coral/stromatoporoid

fauna is found near the top of the quarry. The highest limestone beds found (in dense vegetation) above the quarry comprise brachiopod-rich micrites.

The old quarry contains mainly intertidal dolomicrites with minor subtidal micrites containing large isotelids. In other beds there is a orthoconic cephalopod/stromatoporoid/*Foerstephyllum* community which is analogous to the subtidal *Actinoceras/Stromatocerium/Foerstephyllum* community recognised by Walker (1972) from the Blackriveran of New York State.

Conodont faunas:

The lowest conodont fauna was found at the bottom of the Mystery Creek Caves. This fauna consists of *Panderodus serpaglii* sp. nov. and *Belodina alabamensis* Sweet & Bergström.

The conodonts from the lowest productive samples on the road leading to the main quarry (10m. above the base of the section shown in Fig. 21) are *Plectodina aculeata* (Stauffer), *Belodina compressa* (Branson and Mehl), *Panderodus gracilis* and *Phragmodus undatus* Branson and Mehl. This fauna is found higher up the section (53m. above the base of the measured section) and also includes *Bryantodina abrupta* (Branson and Mehl). One hundred metres above the base of the quarry channel calcarenites contain *Plectodina* cf. *furcata* (Hinde), *Belodina compressa, Panderodus gracilis, Drepanoistodus suberectus* and *Phragmodus undatus*. This fauna is alo found 100 m stratigraphically above this point and about 30 m below the top of the limestone section.

Moina (Locality 30 on Fig. 2)

This area has been mapped by Jennings (1958), Gee (1965), Webb (1974) and Collins (1973). A thin sequence (100 metres) is found in drill cores and a sample from 15m. above the base of the limestone has yielded a conodont fauna consisting of *Phragmodus flexuosus* Moskalenko,

FIGURE 20

Outcrops of Gordon limestone Sub-group in part of South West Tasmania. Brickwork indicates known outcrops of limestone - actual outcrops could be far more extensive than shown.

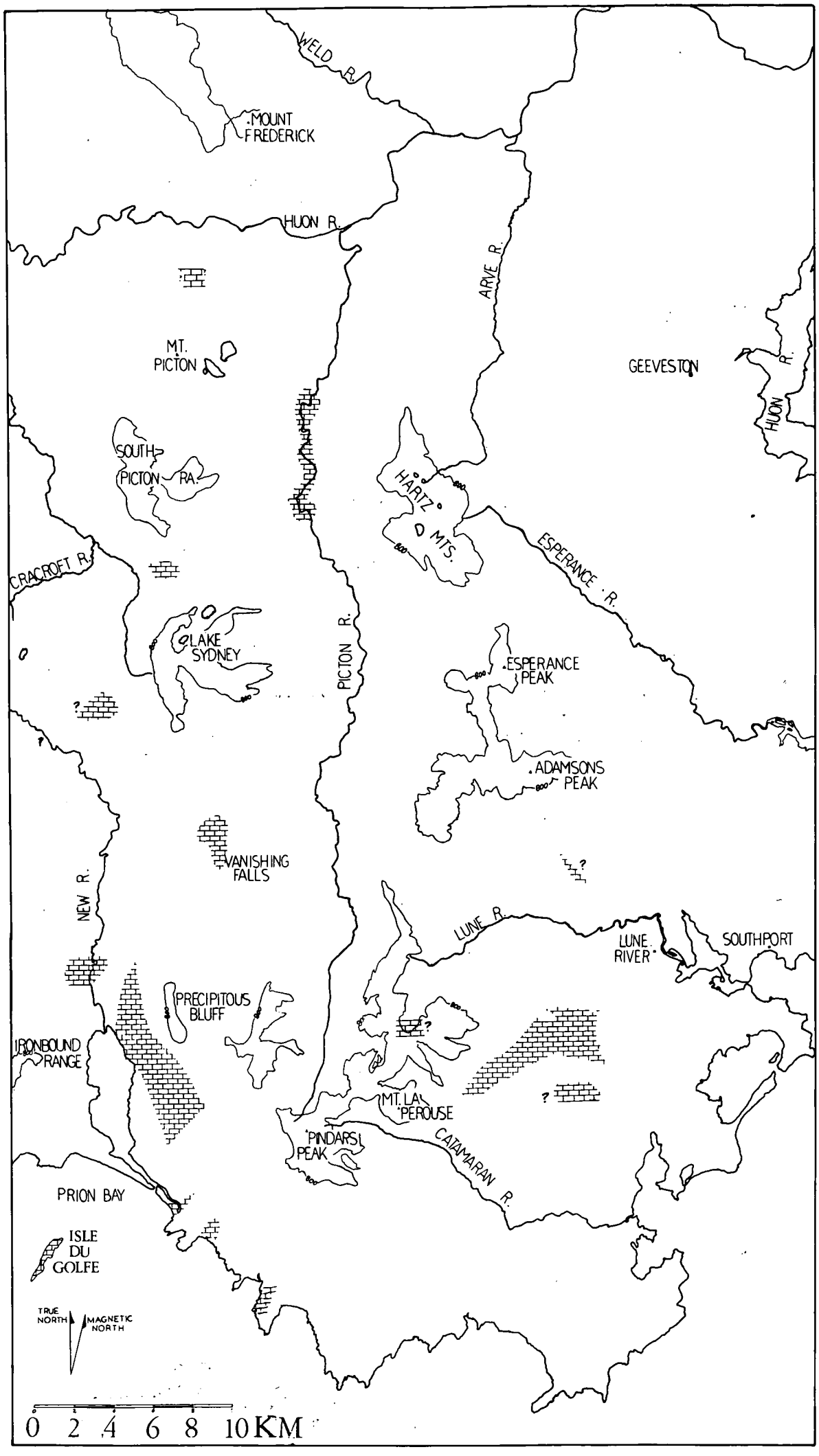
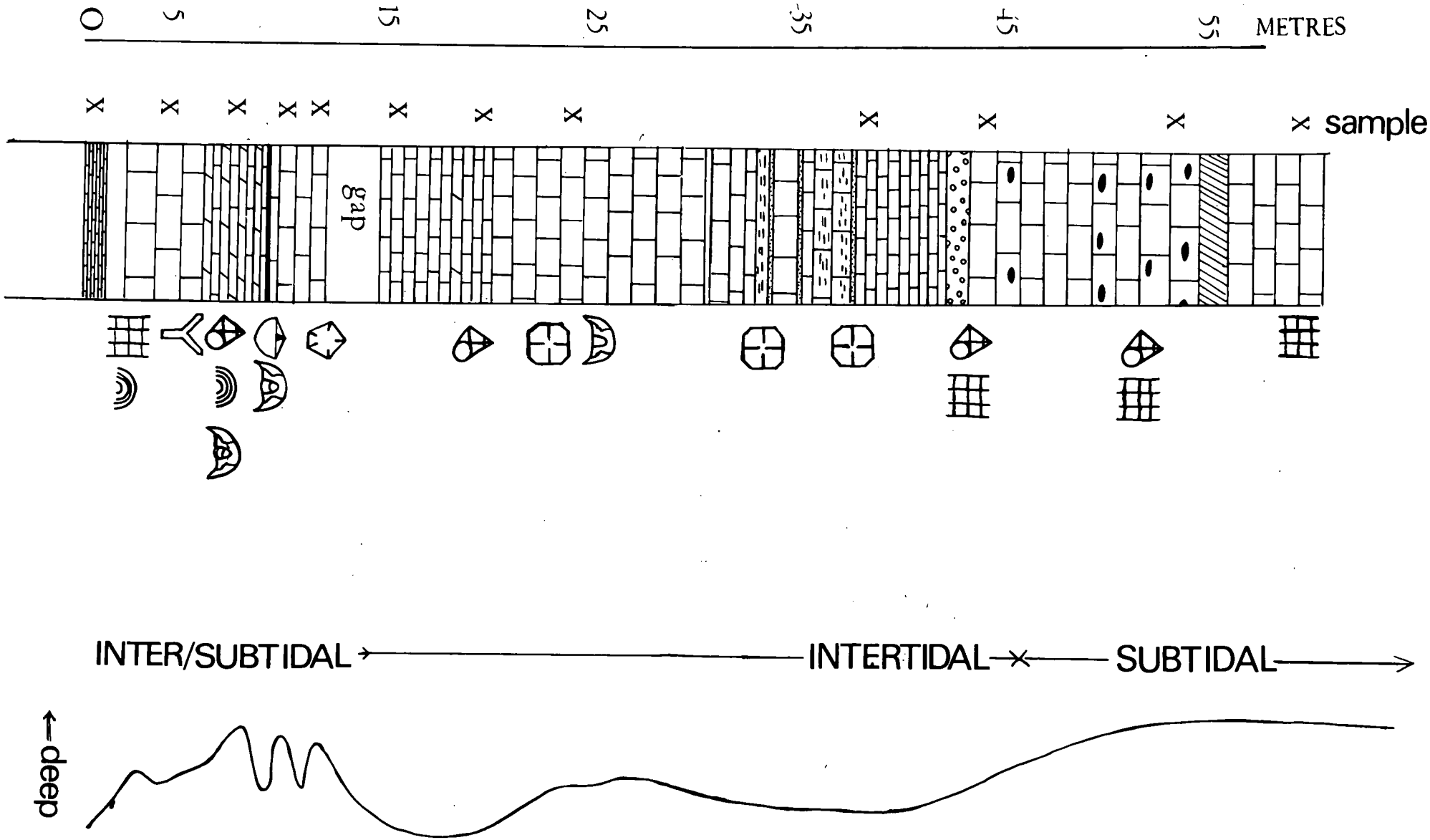

WELD R.
MOUNT FREDERICK
HUON R.
ARVE R.
MT. PICTON
GEEVESTON
HUON R.
SOUTH PICTON RA.
HARTZ MTS.
ESPERANCE R.
CRACROFT R.
LAKE SYDNEY
PICTON R.
ESPERANCE PEAK
ADAMSONS PEAK
VANISHING FALLS
NEW R.
LUNE R.
LUNE RIVER
SOUTHPORT
PRECIPITOUS BLUFF
IRONBOUND RANGE
MT. LA PEROUSE
PINDARS PEAK
CATAMARAN R.
PRION BAY
ISLE DU GOLFE
TRUE NORTH
MAGNETIC NORTH
0 2 4 6 8 10 KM

FIGURE 21

Section through the Gordon Limestone Sub-Group at Lune River (Ida Bay) quarries. The top of the section is the base of the main workings at the main productive quarry. Graph indicates probable relative water depth based on lithological and faunal evidence.

Symbols as in Figure 6. X's indicate conodont sample.


0
5
15
25
35
45
55
METRES
sample
gap
INTER/SUBTIDAL
INTERTIDAL
SUBTIDAL
deep

77/2/59

Belodella copenhagenensis (Ethington & Schumacher) and *Panderodus serpaglii* sp. nov.

Olga River-Gordon River area (Locality 32 on Fig. 2).

Investigations by the Hydro-Electricity Commission in this area have resulted in several drill cores many of which have been sampled for conodonts. Recently Rao and Naqvi *(in press)* have made a detailed geochemical and petrographic study of drill core limestones and sandstones from below the main limestone sequence. Roberts and Andric (1972, 1974) have outlined the geology of the area and Collins (1975) has sampled the limestone and assessed its economic potential. Collins has made 60 of his samples available to the writer, who has described the lithologies, identified the fossils and, from thickness information supplied by Collins, has constructed the stratigraphic column of Figure 22.

All of these samples were processed for conodonts but only three have yielded significant faunas.

The total thickness of Gordon Subgroup compiled from the data of Collins is approximately 1500 metres which is approximately the same as the limestone thickness given by Roberts and Andric (1974).

A sample from an outcrop of limestone near the junction of the Franklin River and the Gordon River (at grid ref. CN 965845) has been donated by Mr. R. Tarvydas. This sample contains silicified orthids and a conodont fauna consisting of *Phragmodus flexuosus* Moskalenko, *"Tetraprioniodus"* sp., *Panderodus serpaglii* sp. nov., *Appalachignathus?* Bergström *et al.*, and *Drepanoistodus forceps* (Lindström).

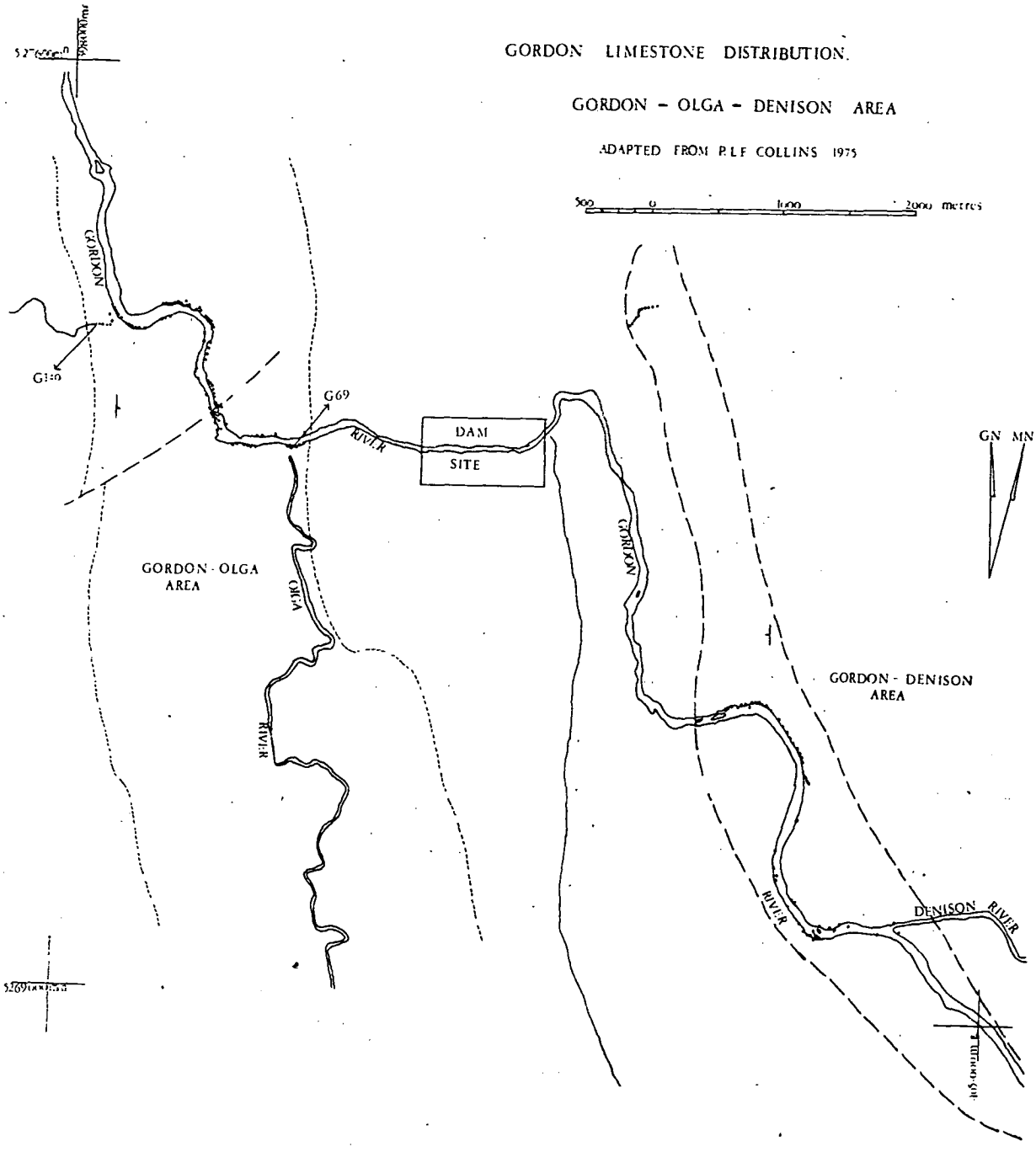


FIGURE 22

Map showing collecting localities of P.F. Collins along the Gordon River near the junction with the Olga River. Limestone occurs between faults (dashed lines) to east of dam site and between dotted lines to the west of the dam site.

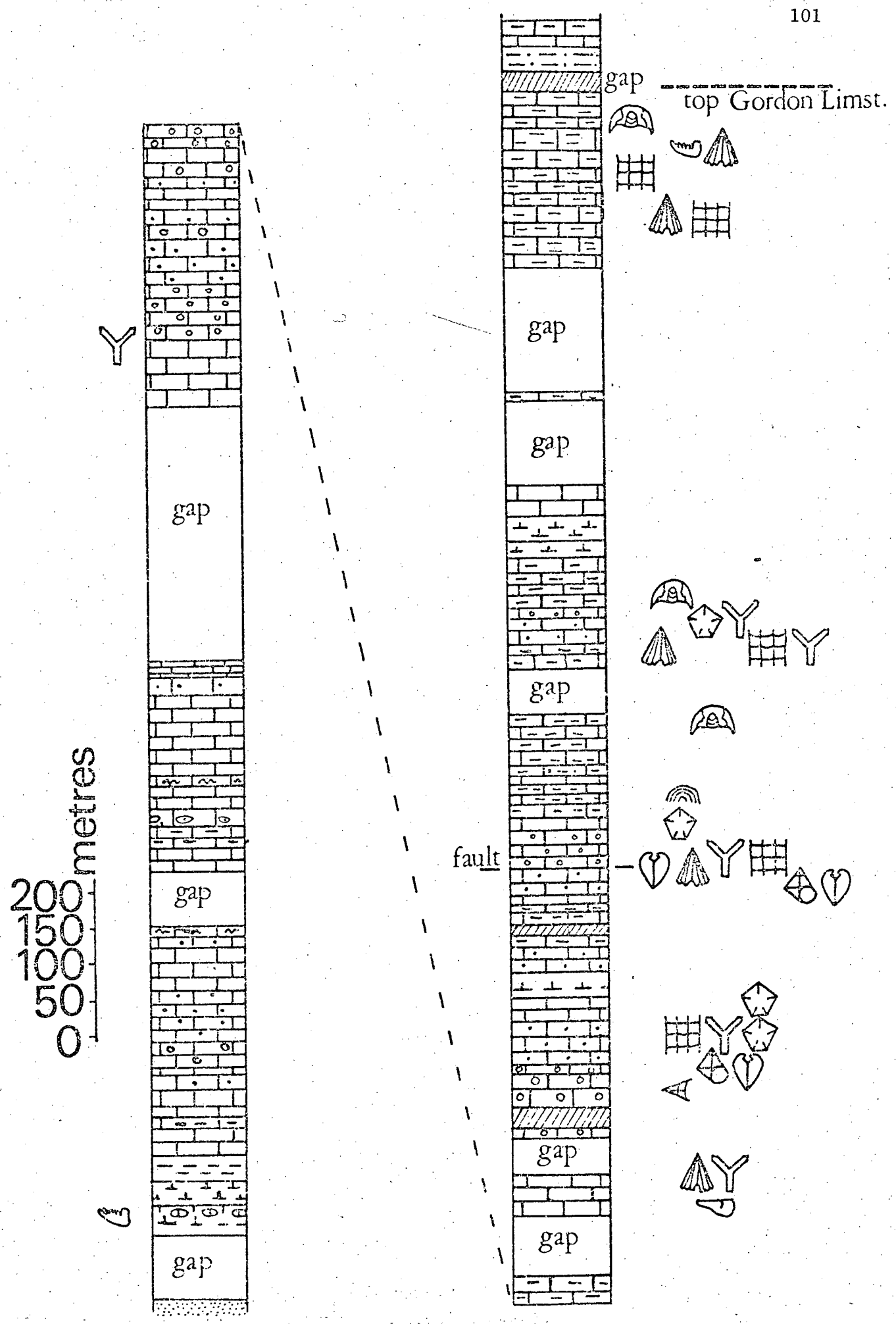


FIGURE 23

Stratigraphic section through the Gordon Limestone Sub-Group along the Gordon River based on samples collected by P.F. Collins. Symbols as in Figure 6.

Picton River (Locality 33 on Fig. 2)

The recently discovered limestone sequences along the Picton River occur as five main outcrops and probably represent a total limestone thickness of not more than 400 metres. The (presumed) lowest outcrops furthest upstream are shaley and do not contain conodonts but contain *Pliomerina* (Locality F on Figs. 24-25). This locality contains abundant specimens of the long ranging *Favistina*. As indicated in Figure 25 there is a possibility that locality F overlies locality C. The outcrop marked 'C' on Figure 24 contains a prolific fauna of stromatoporoids (up to 0.5m. across) and corals up to 0.8 metres in diameter associated with high and low spired gastropods, leptaenids, isotelids and bryozoa. Considerable expanses of biomicrite separate the colonial organisms and the outcrop cannot, therefore, be regarded as a reef. Above the 50 metres of coralline limestone is about 20 metres of buff coloured, argillaceous, nodular biomicrite containing an abundant silicified fauna of orthids, strophomenids, bryozoa, gastropods, pelecypods and cephalopods. A prolific conodont fauna occurs in the nodular member and includes *Belodina compressa* (Branson and Mehl), *Drepanoistodus suberectus* (Branson and Mehl), *Plectodina* cf. *furcata* (Hinde), *Phragmodus undatus* Branson and Mehl, *Panderodus gracilis* (Branson and Mehl), *O.* cf. *oregonia* (Branson, Mehl and Branson) and *O. robustus* (Branson, Mehl and Branson). This conodont fauna is unusually abundant for the Gordon Limestone Sub-group and the outcrops marked 'C' probably represent one of the deepest environments yet found in the Gordon Limestone Sub-group limestones.

Above the nodular limestone there is a considerable stratigraphic gap possibly representing at least 100 metres of limestone. The highest outcrops are dark, pyritic and contain an abundant brachiopod fauna. One fragment of a graptolite stipe was found at

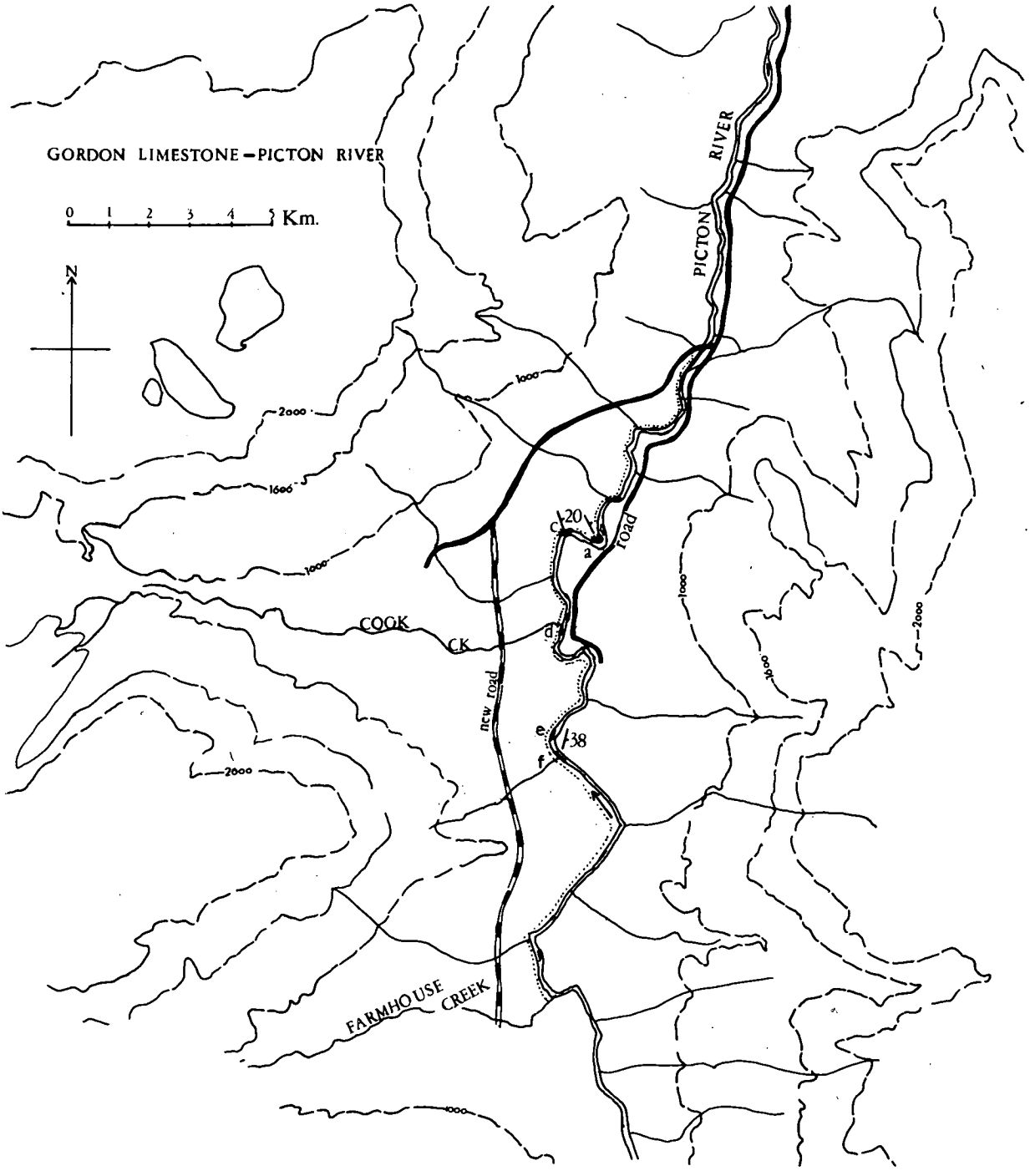


FIGURE 24

Map of the Picton River area showing as black areas outcrops along river. Geology away from river is uncertain as area is covered in dense bush, though tilloidal sediments belonging to the basal Parmeener Super-group (U-Carboniferous-Triassic) occur just to the north of Cook Creek. Localities a - f refer to horizons in Figure 24.

77/1/124

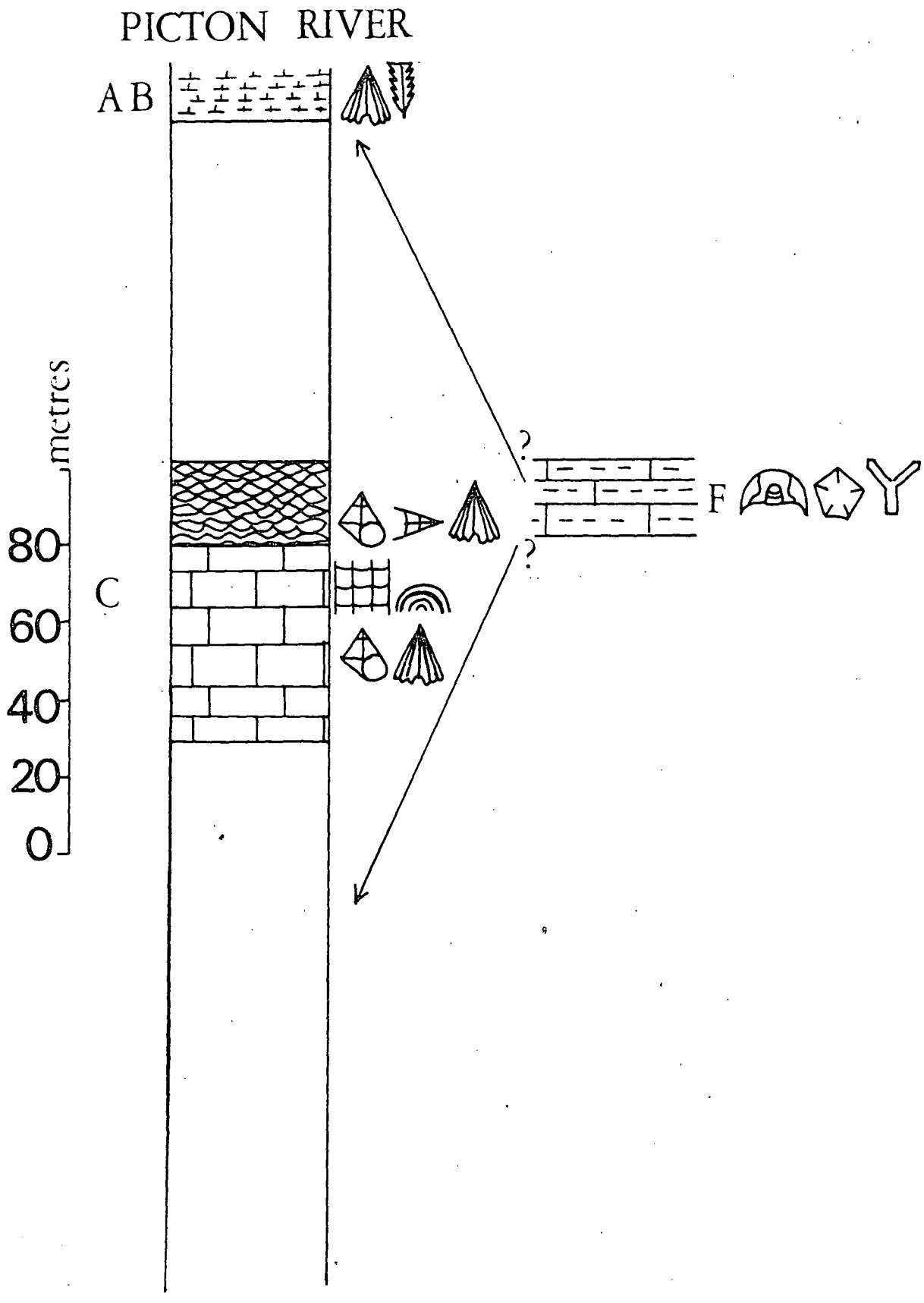


FIGURE 25

Stratigraphic section of Gordon Subgroup through Picton River area. Stratigraphic position of locality F is uncertain. Symbols as in Figure 6.

this locality but no conodonts were found in the residue. Intensive sampling failed to yield identifiable graptolites.

Queenstown (Locality 35 on Fig. 2)

Steeply dipping, almost vertical, strongly cleaved limestones are exposed in the Smelters Quarry at Queenstown. Twenty-three samples were collected but were barren of stratigraphically useful conodonts.

On the basis of *Tetradium* species diversity, correlation with the Lower Limestone Member of the Benjamin Limestone has been suggested (Banks and Burrett *in press*). Hill (1955) did not commit herself to an age assignment on the basis of the poorly preserved coral fauna. No evidence of facing is found in the quarry and the sequence shown in Fig. 26 could be inverted.

Railton (Locality 36 on Fig. 2)

The limestone sequence at Railton is approximately 800 metres thick. The lowest limestone sequence is exposed at Blenkhorn's Quarry where it overlies the Caroline Creek Sandstone Formation (grid ref. DQ517247). Species of *Nybyoceras* described by Teichert and Glenister (1953) are considered to belong in *Wutinoceras* and to be of Whiterock age by Flower (1968 p.8). No conodonts have been found in samples from Blenkhorn's Quarry and Flower's correlation is accepted in Figures 75 and 77.

At least eleven metres of steeply dipping siltstones, calcareous siltstones and silty limestones outcrop in the southern end of Blenkhorn's Quarry and contain an abundant, though often fragmentary, orthid/strophomenid/trilobite fauna.

Twenty samples were collected from the main productive (Goliath Cement) quarry only one of which yielded conodonts. The limestone

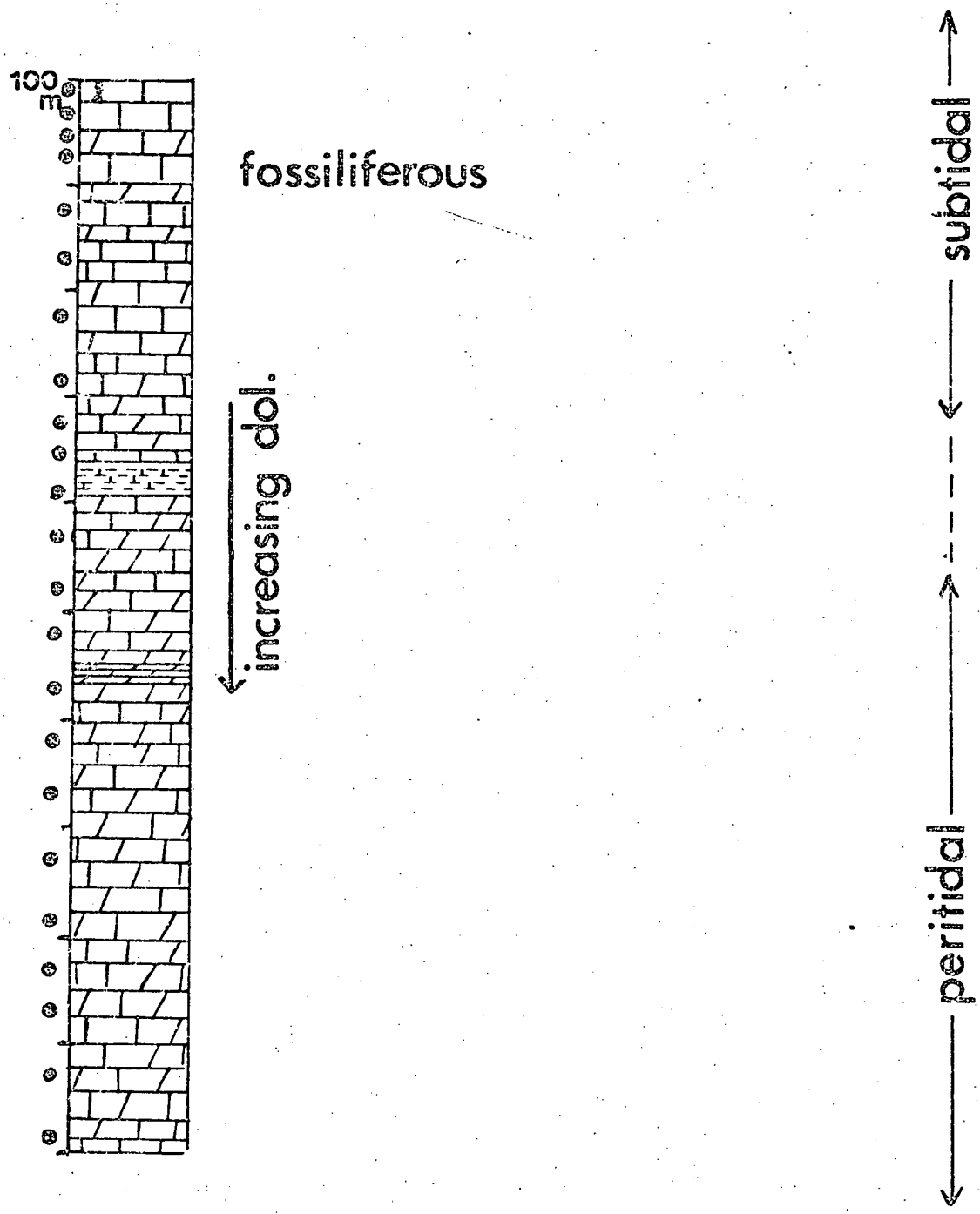


FIGURE 26

Stratigraphic sequence through the limestone in the Smelter's Quarry Queenstown. Dots indicate position of processed samples.

in the main quarry is cross-folded and cut by several small faults. The productive sample comes from the stratigraphically highest beds in the quarry and contains *Panderodus serpaglii* sp. nov., *?Belodina* sp. nov., and *Periodon aculeatus* (Hadding). (The last named species has not been figured in this thesis and is being studied by D.J. Kennedy).

This sample is stratigraphically above an oncolitic bed recorded by Banks (1962).

South Coast Outcrops (Localities numbered 38 on Fig. 2)

Of the south coast outcrops only samples from near Prion Bay (Fig. 19 - grid ref. DM681777) have yielded conodonts. This outcrop consists of calcareous siltstone containing trinucleids and brachiopods and includes a conodont fauna consisting of *Phragmodus undatus* Branson and Mehl, *Belodina compressa* (Branson and Mehl), *Panderodus gracilis* (Branson and Mehl).

Banks (1962, p.170) tentatively identified the trilobites at Prion Bay as *Ampyx* and a cryptolithid similar to *Eirelithus*. Webby (1970, p.881) suggested that these trilobites may be *Malongullia* and *Lloydolithus*, thereby implying correlation with the Malongulli Formation of New South Wales of Eastonian age. Recent work by M.R. Banks suggests that the trinucleid is a new genus related to *Guandacolithus*. M.R. Banks *(pers. comm.)* suggests a possible equivalence to the Lords Siltstone Formation in the Florentine Valley and the Mole Creek Member at Mole Creek. The siltstone also contains *Sowerbyella (Sowerbyella)* and sulcate orthids. The microfauna includes chitinozoa, sponge spicules and ostracods including *Sigmobolbina* and *Ceratopsis*. This faunal assemblage is remarkably similar to many Ordovician faunas in Britain such as the Middle Llandeilian of Wales (Spjeldnaes 1963; Bassett *et al.*, 1974) and a similar environment seems very likely.

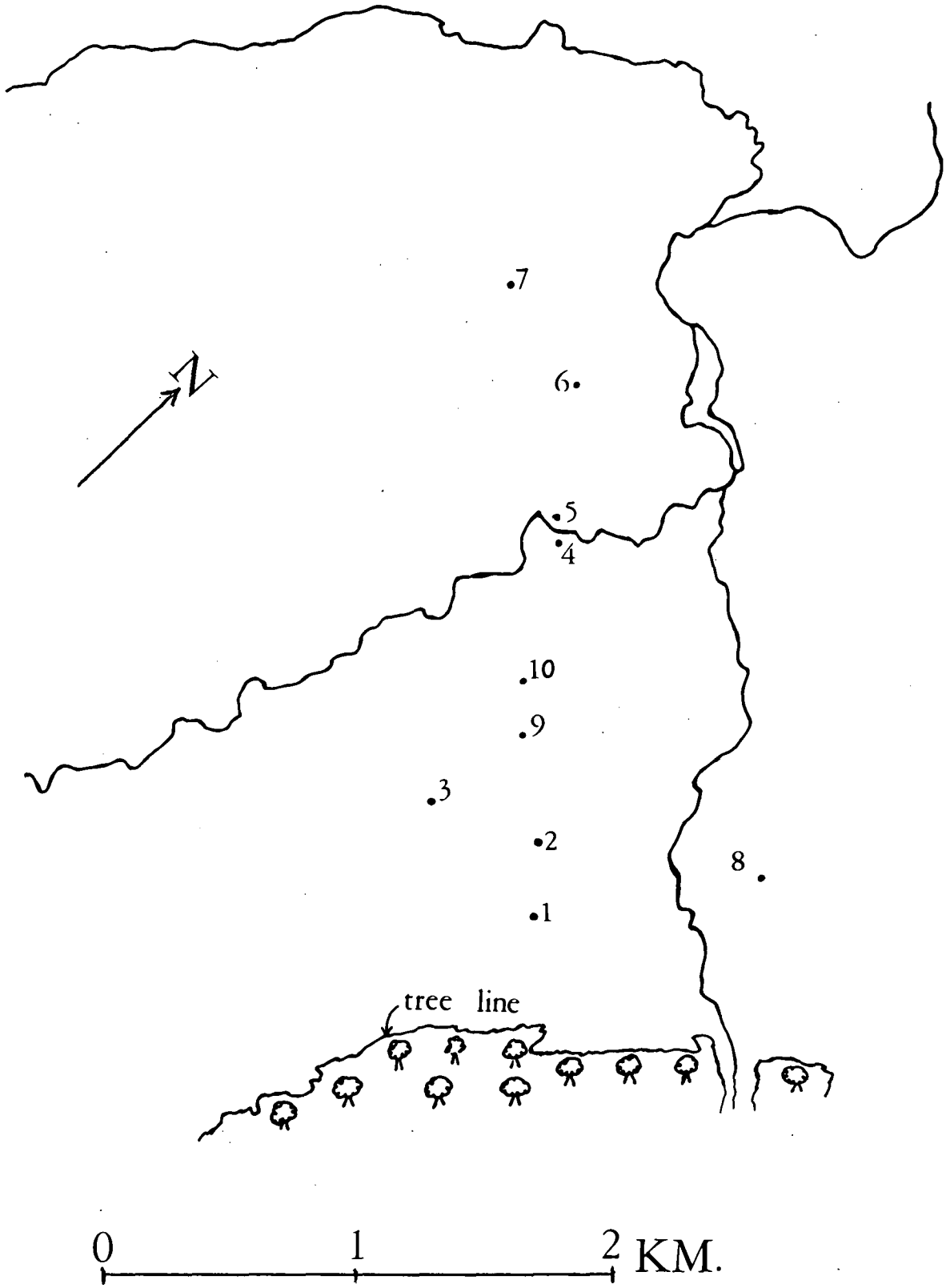
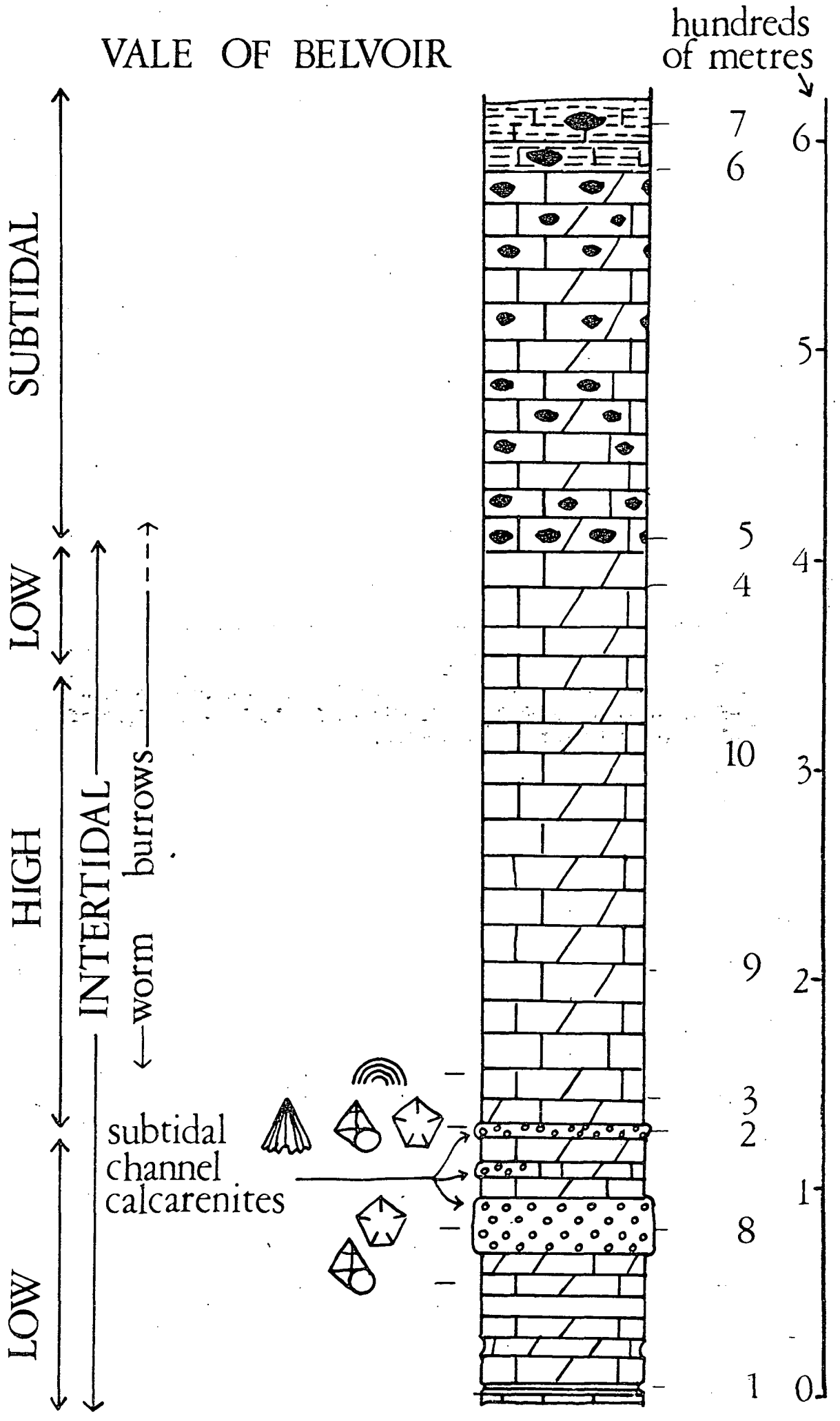


FIGURE 27

Map of the central part of the Vale of Belvoir traced from an aerial photograph showing sample localities.

FIGURE 28

Reconnaissance stratigraphic section through the central part of the Vale of Belvoir from grid ref. CQ 081004 to grid ref. CQ 065013. Symbols as in Figure 6. Numbers to right of column refer to samples collected.


VALE OF BELVOIR
hundreds of metres
SUBTIDAL
LOW
HIGH
LOW
INTERTIDAL
worm burrows
subtidal channel calcarenites
7
6
5
4
10
9
3
2
8
1
6
5
4
3
2
1
0

Vale of Belvoir (Locality 39 on Fig. 2)

Threader (1962) mapped the limestone in the Vale of Belvoir which covers about eight square kilometres. During a reconnaissance survey the limestone was estimated to be about 615 metres thick. The general structure is synclinal with a steeply dipping eastern limb and a flat western limb. The limestone is strongly cleaved and in places it is difficult to discern bedding. Ten samples were collected (see Figs. 27 & 28). The lowest limestone exposed is probably within 30 metres of the base of the limestone and overlies fine-grained conglomerates. Surprisingly few sand grade beds are found in this clastic sequence. Small outcrops of a polymictic breccia occur near grid ref. CQ 081004 between the conglomerate and the limestone but this is probably cemented Quaternary (or Tertiary) terrestrial deposits.

The lowest limestone sequence consists of about 100 metres of dolomicrites, the lowest bed of which is finely bedded (0.5 mm - 1 mm thick) and is one metre thick. The only macrofossils observed in the lower parts of this sequence were two bellerophontids and crinoid fragments. In the higher parts of this, mainly intertidal, sequence are channel calcarenites which are cross-bedded and contain silicified shell fragments (orthids and gastropods). The calcarenites are mainly composed of pelmatozoan fragments. Some of the thinnest calcarenite beds are clearly channel-like in form (see Fig. 10 M).

Above this channeled sequence is about 200 metres of dolomicrites which are intensively and spectacularly bioturbated by irregular, dolomitized and sub-horizontal worm burrows. The only macrofossil observed was one stromatoporoid near the base of the sequence.

The uppermost sequence consists of slightly dolomitic micrites and micrites containing a profusion of irregular, though elongate, chert nodules that are parallel or sub-parallel to the bedding. Nodule size

increases to the top of the cherty member where the largest nodules are 0.5 metres long. At least the last 20 metres of section consist of calcareous mudstones.

From this reconnaissance survey it appears likely that the lowest channeled member was deposited in a low intertidal environment with dominantly subtidal and high energy conditions prevailing in the channels. The succeeding burrowed member suggests a high intertidal environment and the third member was probably subtidal. However the unfossiliferous nature of the third member is puzzling and some other environment may be indicated by more detailed work.

Conodont fauna:

The lowest conodont sample (1 on Fig. 28) yielded rare *Chirognathus monodactyla* Branson and Mehl. Sample 8 (80m above the base) yielded *C. monodactylus* Branson & Mehl, *Panderodus gracilis* (Branson and Mehl), *Belodina compressa* (Branson and Mehl) and *Plectodina aculeata* (Stauffer).

Vanishing Falls (Locality 40 on Fig. 2)

Limestone has been collected from this nearly inaccessible area by Mr. B. Collin and Mr. A. Goede. Vanishing Falls (grid ref. DM704955) is a seventy metre waterfall over dolerite plunging into a sink hole in limestone. The limestone is variable but has a low dolomite content and contains silicified strophomenids. All samples have yielded an abundant conodont fauna consisting of *Belodina compressa* (Branson and Mehl), *Panderodus gracilis* (Branson and Mehl), *Plectodina* cf. *furcata* (Hinde), *Drepanoistodus suberectus* (Branson and Mehl). *Milaculum ethinclarki* Müller is also very abundant.

Zeehan (Locality 41 on Fig. 2)

The Gordon Subgroup correlate in the Zeehan area has been described and mapped by Pitt (1961) and Blissett (1962). Pitt (1961) estimates

the thickness as about 500m. in the vicinity of Zeehan township and it appears to thicken towards the south. At Grieve's Siding (see Fig. 29) the thickness is about 650m (Gill and Banks, 1950).

The limestone is strongly deformed and around Zeehan township is mineralized. The limestone is poorly exposed and the strongly acidic weathering in Western Tasmania has converted much of the limestone to a dark grey, decalcified residual clay deposit known as pug. Several samples of pug have not yielded conodonts.

A dendroid fauna has been described by Quilty (1971) from 100 metres above the base of the limestone (see Fig. 30). Quilty (1971, p.183) stated that "the age of the fauna is unknown but the general similarity of the forms described to known Lower Ordovician forms suggest that they are Lower Ordovician." Limestone samples from near the base of the sequence in the vicinity of Zeehan township have failed to produce conodonts. However 10 km. south of Zeehan just to the north of Grieve's Siding, Gill and Banks (1950) recorded *Rhinidictya* and *Polypora*. Banks (1957) added *Favosites* to these bryozoa thereby implying a surprisingly young age for the base of the limestone in this area. Sixty kilograms of limestone was collected from Gill and Banks' (1950) locality 58 (see Fig. 29). The limestone occurs as loose blocks scattered on spoil heaps from shallow mining operations. A wide variety of limestone types are present but the abundance of dolomite, bioturbation, mud cracks and the paucity of macrofossils other than gastropods is suggestive of an intertidal environment. Rare crinoidal/gastropodal biocalcarenites contain a relatively abundant conodont fauna. The limestones sampled are unlikely to have been derived from far above the base of the carbonate section. The underlying sandstones exhibit lenticular bedding, ripple marks, clay pellets and vertical worm tubes which also suggest an intertidal environment of deposition.

The conodont fauna consists of *Belodina alabamensis* Sweet and Bergström, *Panderodus gracilis* (Branson and Mehl), *Chirognathus monodactylus* Branson and Mehl, *Phragmodus tasmaniensis* sp. nov., *Belodina compressa* (Branson and Mehl), *Belodella copenhagenensis* (Ethington and Schumacher), *Panderodus serpaglii* sp. nov. and *Rhipidognathus? careyi* sp. nov. and a Blackriveran age is indicated.

Samples from the base of the bore hole (180m. stratigraphically below the surface) through the Oceana Mine (see Hill 1955 and Banks 1957 for details) contain *Plectodina aculeata* (Stauffer), *Belodina compressa* (Branson and Mehl), *Panderodus gracilis* (Branson and Mehl), *Drepanoistodus suberectus* (Branson and Mehl) and *Phragmodus undatus* Branson and Mehl suggesting an Early Trenton age. Twenty metres from the top of the core a similar fauna was found except that it contained *Plectodina* cf. *furcata* (Hinde) suggesting a Late Trenton or even Cincinnatian age for the top of the Oceana core. Hill (1950) suggested a Trentonian age for the top of the core based on her study of the corals. The approximate horizon of the Oceana mine is shown on Figure 30.

Above the Oceana horizon, the Smelter's Quarry has yielded a conodont fauna identical to that from the top of the Oceana core. The highest samples collected from the limestone (see Fig. 30) yielded a Late Trenton or Early Cincinnatian fauna again identical to that of the upper part of the Oceana core.

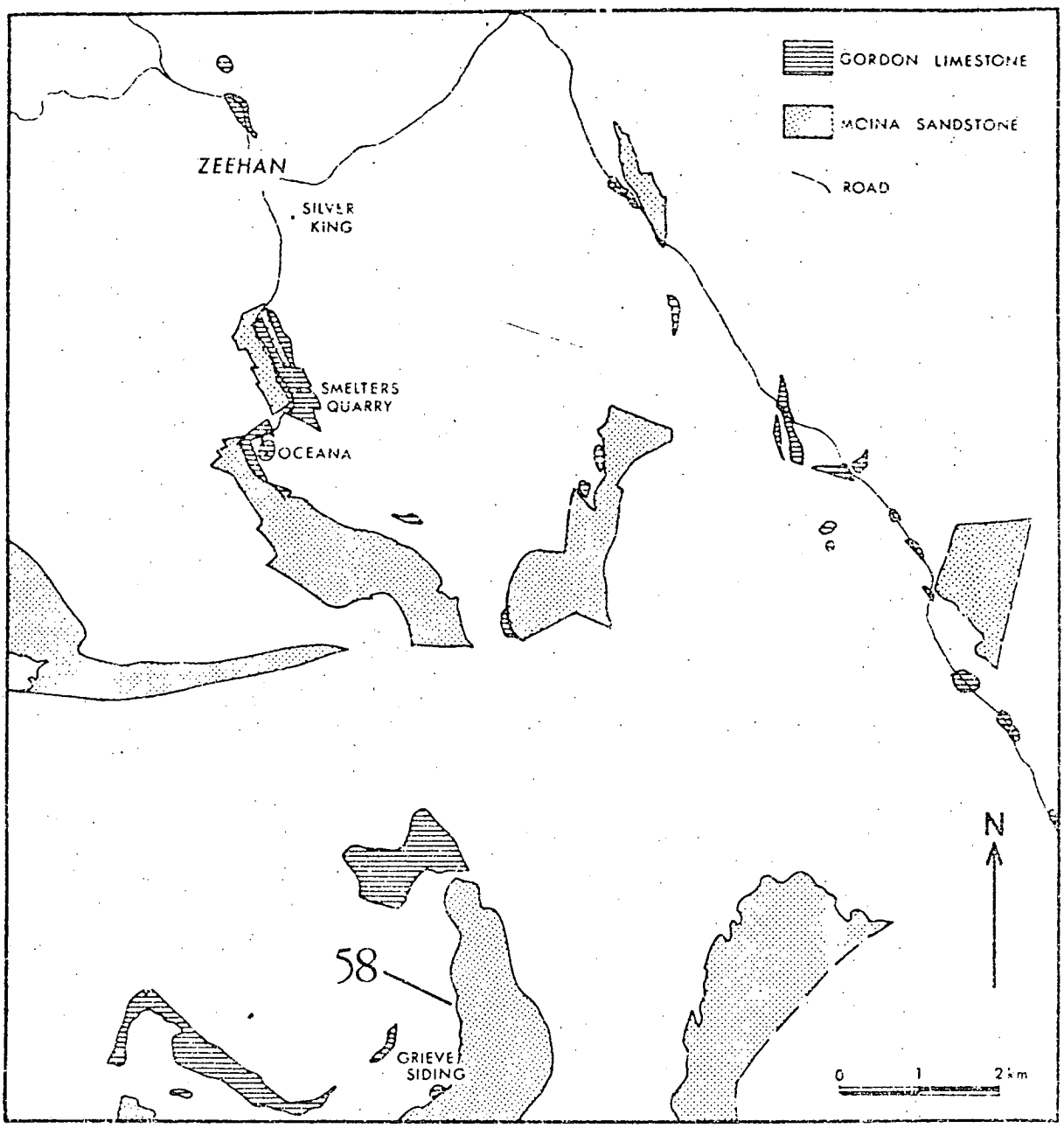


FIGURE 29

Locality map of the Zeehan area showing general distribution of Gordon Subgroup carbonates and Moina Sandstone (based on Blissett, 1962). Conodonts collected from locality 58 (marked) of Gill and Banks (1950).

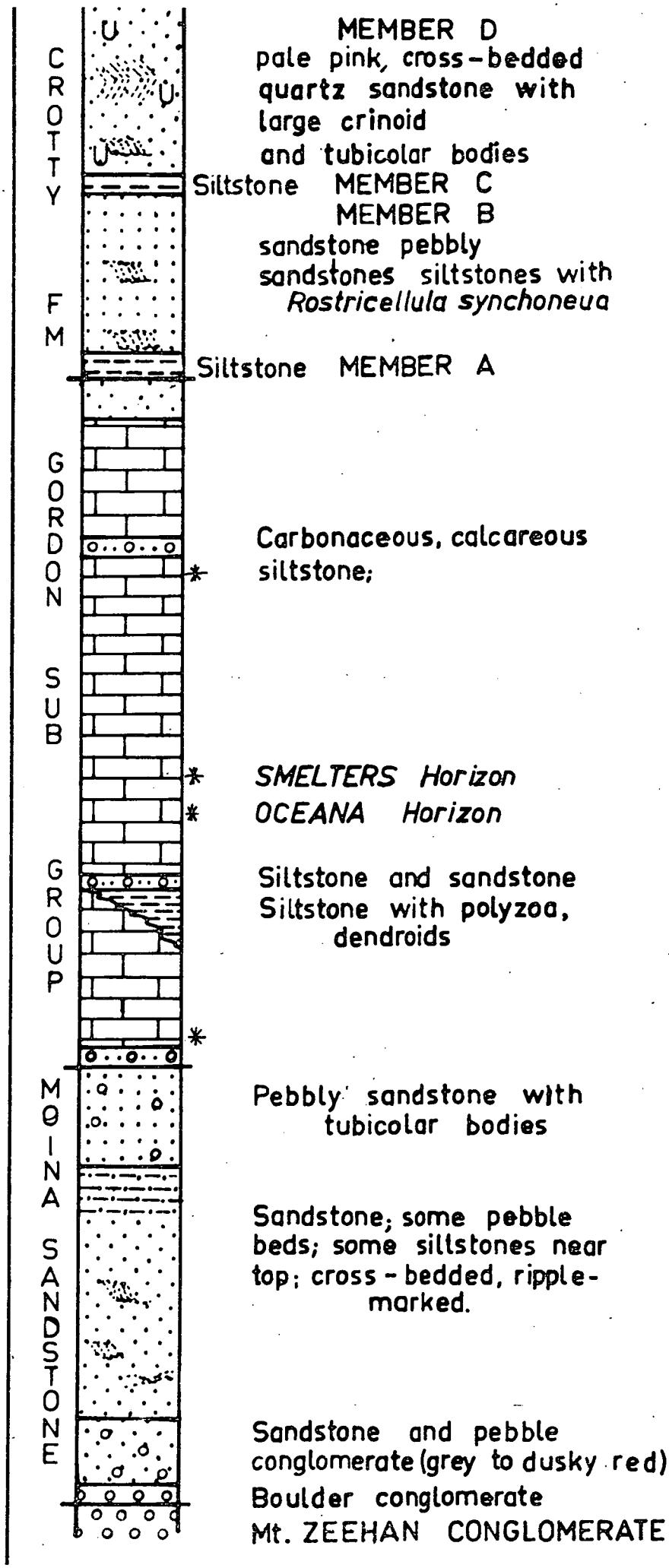


FIGURE 30

Stratigraphic section through Zeehan area from Banks and Burrett *(in press)* based on Pitt (1961) and others.

CHAPTER IV

TAXONOMY

Introduction:

The rarity of conodonts in most samples has precluded a detailed analysis of population and ontogenetic variation. No biometry was attempted. Fortunately sufficient elements were available, for a few species, to give some impression of variation (e.g. *Rhipidognathus? careyi* sp. nov.). Many of the fauna appears to belong in well known American species and the erection of a large number of new species on scanty populations has not been necessary. Only four species are new. Multielement taxonomy has been used wherever possible.* When large populations are available the Tasmanian material have similar element ratios as in North American multielement species. However, for the new multielement species *Phragmodus tasmaniensis*, *Plectodina florentinensis*, *Rhipidognathus? careyi*) the exact ratios and even the exact elemental composition is not clear. Although planned at the beginning of this work the small total fauna has precluded a detailed analysis of evolutionary changes. Preservation is often poor and details of basal cavities are often difficult to study in opaque specimens. However, in a few localities e.g. Lune River and the Florentine Valley preservation is good. In these localities basal cones are frequently preserved, having been either preferentially pyritized or silicified. All figured specimens are deposited in the palaeontological collection of the University of Tasmania, Geology Department and given UTG numbers.

* The recently introduced scheme for naming elements (Sweet and Schönlaub 1975) has not been used as that paper arrived after the present work was almost complete. However, the concept of referring to elements by a letter or letters rather than as trichonodelliform is obviously succinct and emphasises homologous relationships more efficiently than the method used herein.

Genus ACONTIODUS, Pander 1856

ACONTIODUS CF. NEVADENSIS Ethington and Schumacher, 1969

Figure 31, A,B

Synonymy:

Acontiodus nevadensis Ethington & Schumacher, 1969, pl. 67, figs. 21-22, text fig. 4c.

?*Acontiodus* n. sp. 2 LINDSTRÖM, 1960 Text figs. 6-11, 7-10.

Comments:

A scapula-shaped element that agrees in most details with *Acontiodus nevadensis* is found in sample MC 168 (160 m from the base of the Mole Creek section). However, only one lateral costa is present, not two as in the Nevada specimens, and this element might belong in a new species.

Genus APPALACHIGNATHUS Bergström *et al.* 1974

? APPALACHIGNATHUS sp.

Figures 32 A-F, 33 A-B

Synonymy:

?*Coleodus simplex* Branson and Mehl. WEBERS, 1966 p. 63, pl. 4, fig. 5

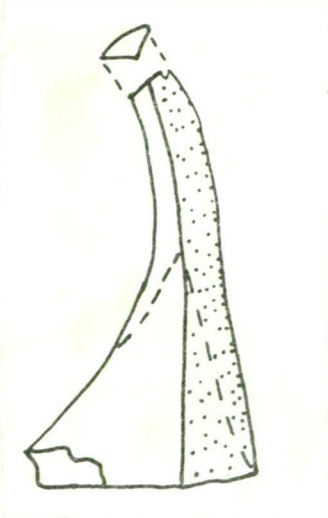
Coleodus n. sp. ETHINGTON & SCHUMACHER, 1969, p. 458, pl. 68, fig. 6.

New Genus B ETHINGTON & SCHUMACHER, 1969, p. 479, pl. 67, fig. 18, text-fig. 4H.

A.

FIGURE 31 *Acontiodus* cf. *nevadensis*

Spec. UTG 96968, x 180 (for details of sample number and locality see Appendix II).



B.

as A above, x 100.

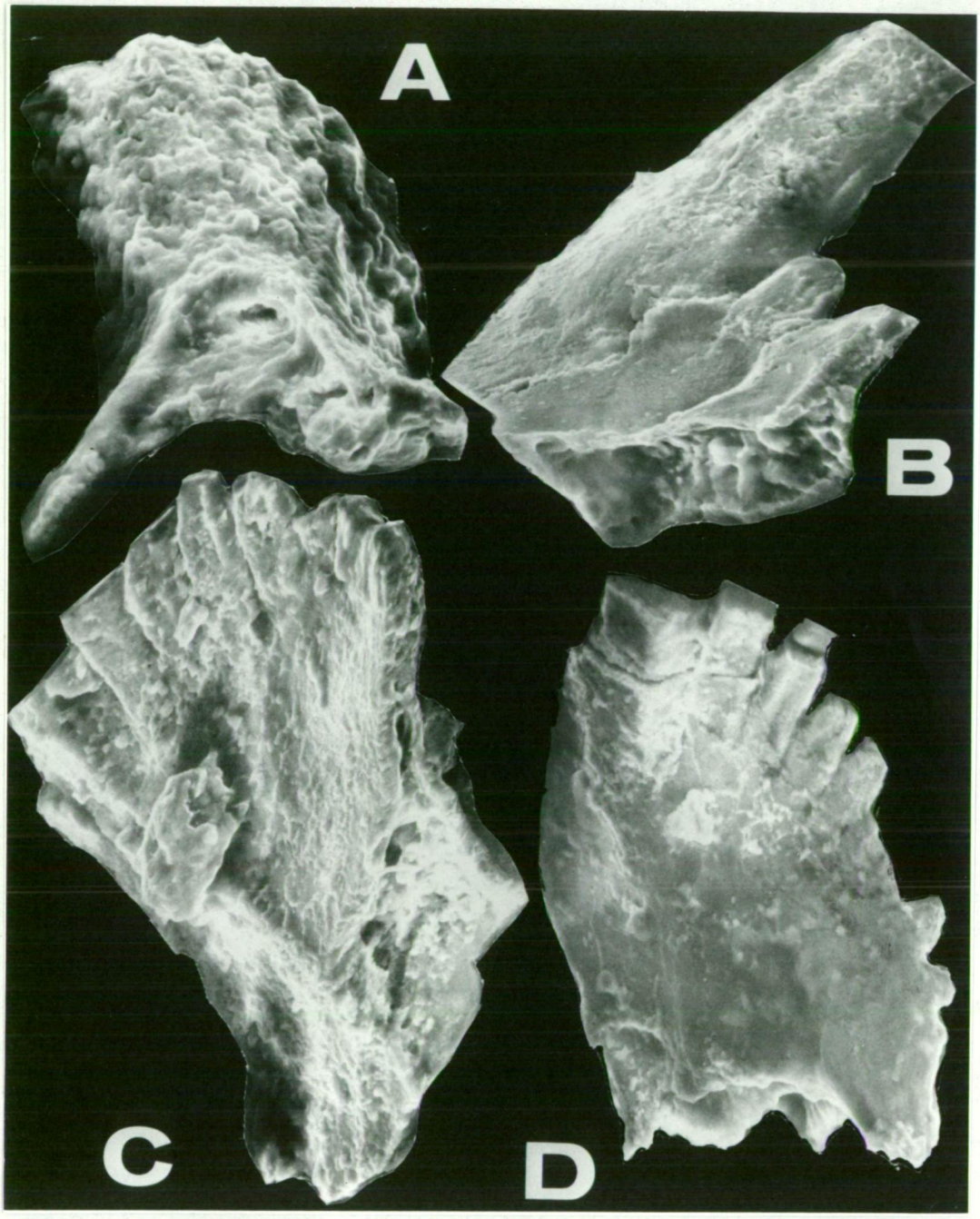
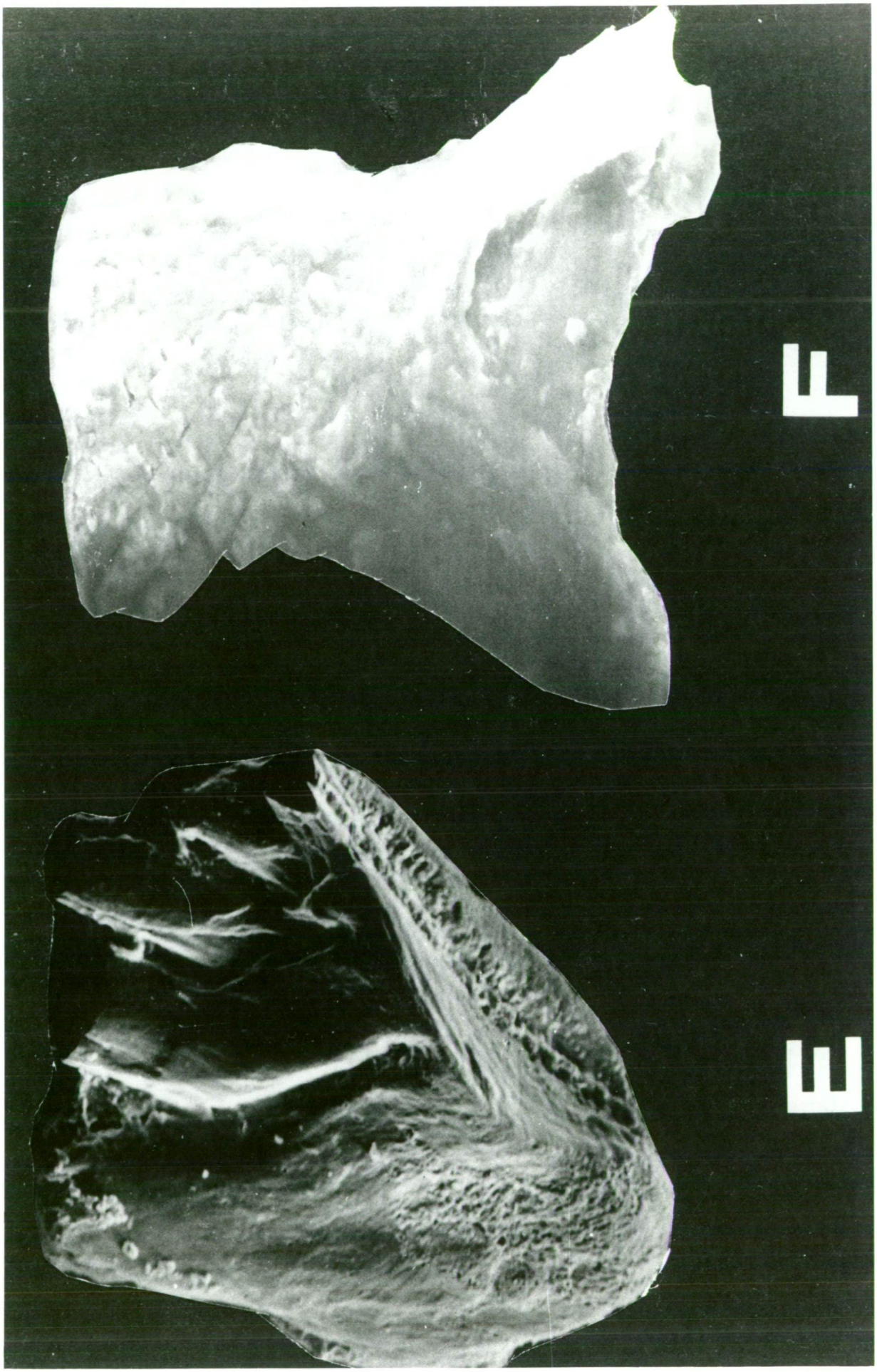


FIGURE 32 APPALACHIGNATHUS ?

A: rhipidognathiform element, spec. UTG 96958, x 180. B: spathognathiform element, spec. UTG 96958B, x 170. C: spathognathiform element, spec. UTG 96964, x 150. D: same element as C. E: spathognathiform element, spec. UTG 96970(B), x 100. F: rhipidognathiform element, spec. UTG 96958, x 185.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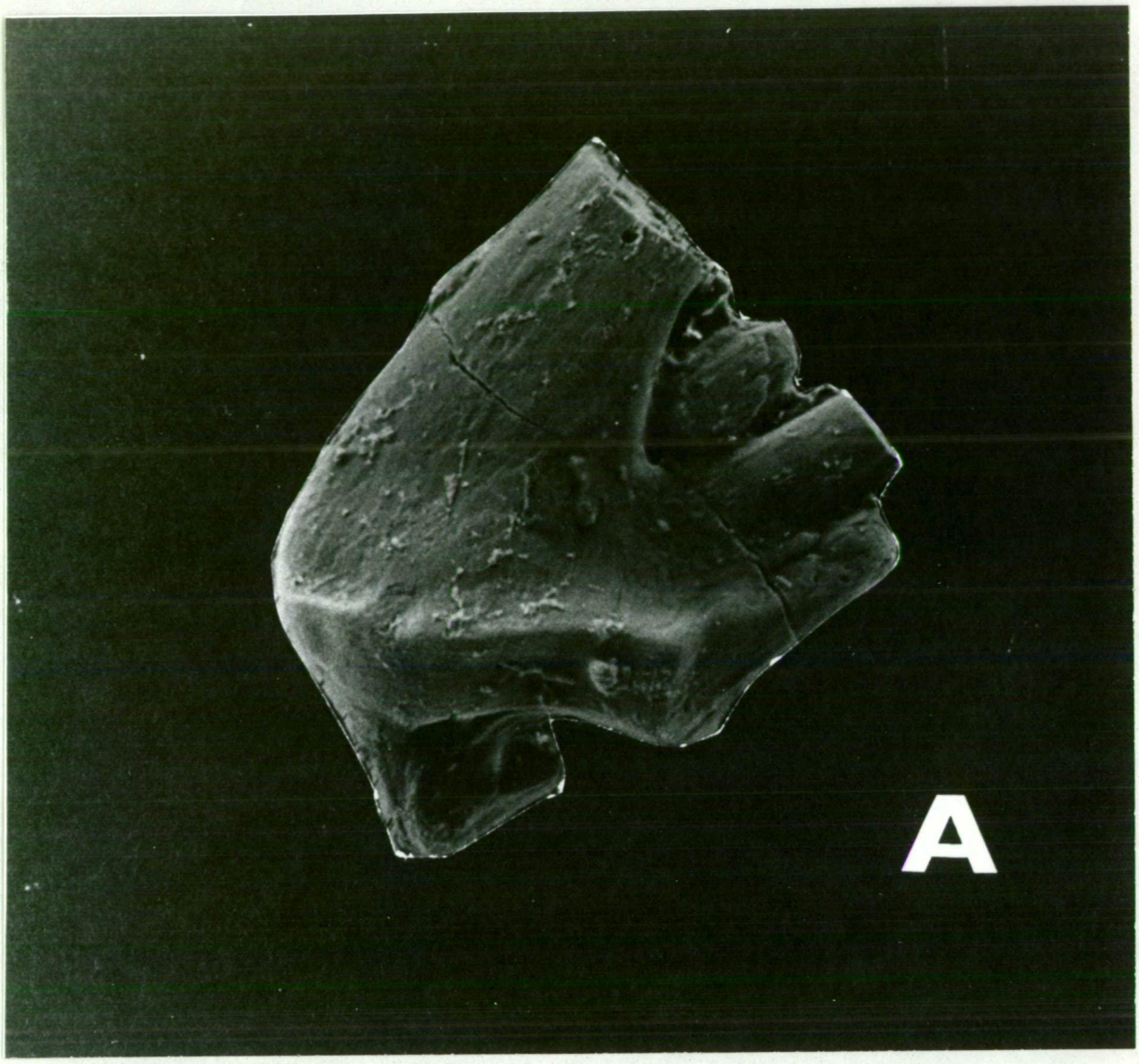


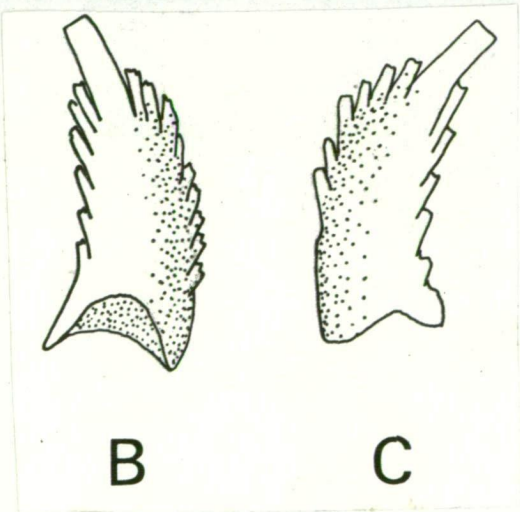


FIGURE 33 *?Appalachignathus*

A: spathognathiform element, spec. UTG 96970a, x 175.
B,C: rhipidognathiform element, spec. UTG 96958, x 90. Inner and outer surfaces respectively.

?Belodus sp. LEE 1975, pl. 1, fig. 1.

?Appalachignathus delicatulus Bergström *et al.*, H.Y. CHUN *in* REEDMAN, A.J. and SANG HO UM, 1976, pl. 6, fig. 1-2.

?Appalachignathus sp., REPETSKI AND ETHINGTON 1977, pl. 2, fig. 13.

Comments:

Rare specimens possibly referable to *Appalachignathus* are found in samples from near the base of the limestone sequences at Mole Creek and along the Gordon River (G 140 on Fig. 22). *?Appalachignathus* specimens are very rare, diminutive and fragmentary and the generic assignment is therefore tentative.

Genus BELODELLA

BELODELLA COPENHAGENENSIS (Ethington & Schumacher, 1969)

Figure 34 A, 35 A-F

Synonymy:

Oepikodus copenhagenensis ETHINGTON & SCHUMACHER 1969, p. 465, pl. 68, figs. 5, 9, Text Fig. 4L

Belodina n. sp. BERGSTRÖM, RIVA & KAY 1974, p. 1645, pl. 1, fig. 11.

"*Oepikodus copenhagenensis* Ethington and Schumacher, REPETSKI & ETHINGTON 1977, pl. 2, fig. 23.

Description:

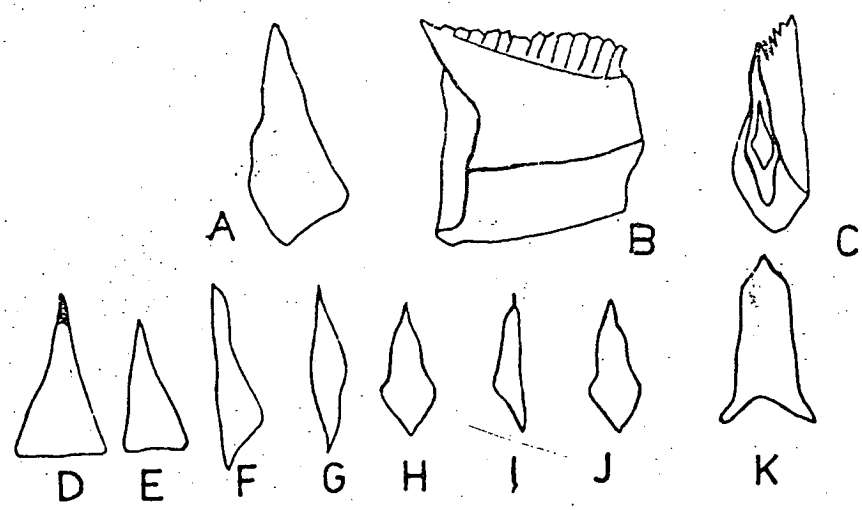
An asymmetric belodiniform element with eight-sixteen proclined denticles along the posterior margin. Denticles near the basal margin are upright and become progressively more proclined towards the cusp. Denticles are laterally compressed and fused for most of their length. Small denticles are present along the complete length of the posterior margin up to a small heel at the posterior margin of the base. Costae are present along the lateral faces but fade out towards the cusp apex. Positions of the costae are variable but are usually halfway between the midline and the anterior margin of the element. The element is slightly curved laterally (Fig.35F). Some of the specimens possess a small, slightly curved, smooth projection at the anterior margin of the basal cavity. Longitudinal striae are present along the anterior edges of the lateral faces but do not extend very far up the faces and intersect the anterior margin at a low angle (Fig.35F).

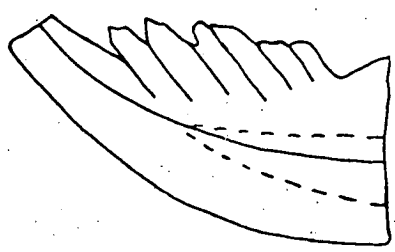
The element cross section is rhombic and variable. The anterior margin is keeled. The basal cavity is triangular in longitudinal section the apex of which reaches to the midline of the element in some specimens or the anterior margin in others. In either case the apex is just below the denticle immediately next to the cusp.

The belodelliform element is similar to several previously described species of *Belodella*. The unit is long, curved striated (at least in recrystallized specimens) and is laterally costate. The anterior margin supports a large number of small parallel denticles. The basal cavity is deep and is generally triangular and variable in basal view.

Comments:

Belodelliform and belodiniform elements occur together in the basal transgressive limestones of Chazyan age at Mole Creek, at Judd's Cavern and of Blackriveran age near Grieve's Siding south of Zeehan.





L

FIGURE 34 Drawings of *Belodella copenhagenensis* and related species.

A-C: spec. UTG 96984, x 100.
D-J: *B. erecta* (Rhodes and Dineley) from Serpaglii 1967 Tav. 11.
K : *Roundya* n. sp. from Sweet and Bergström 1962 fig. 5.
L : spec. UTG 96956, x 85.

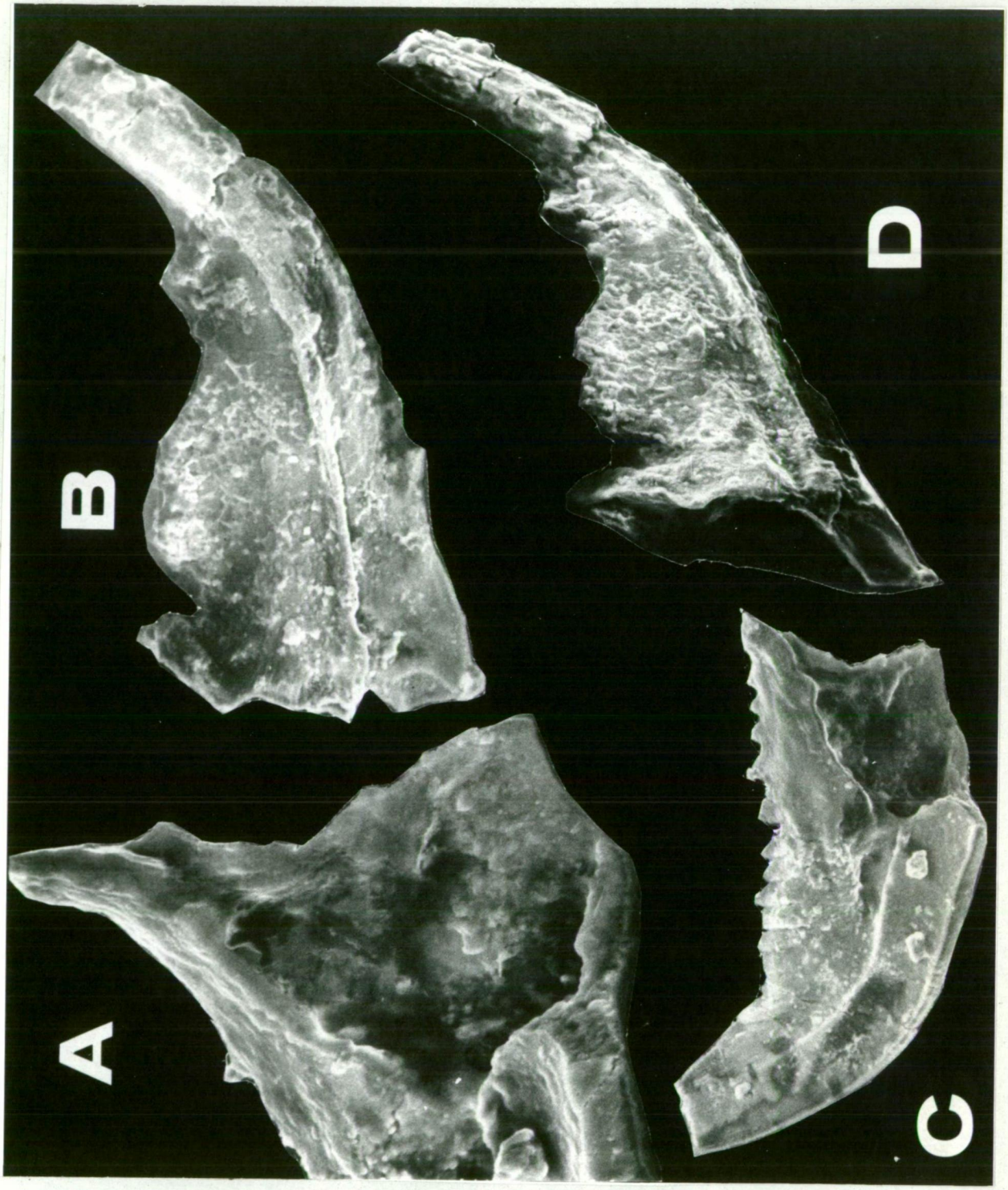
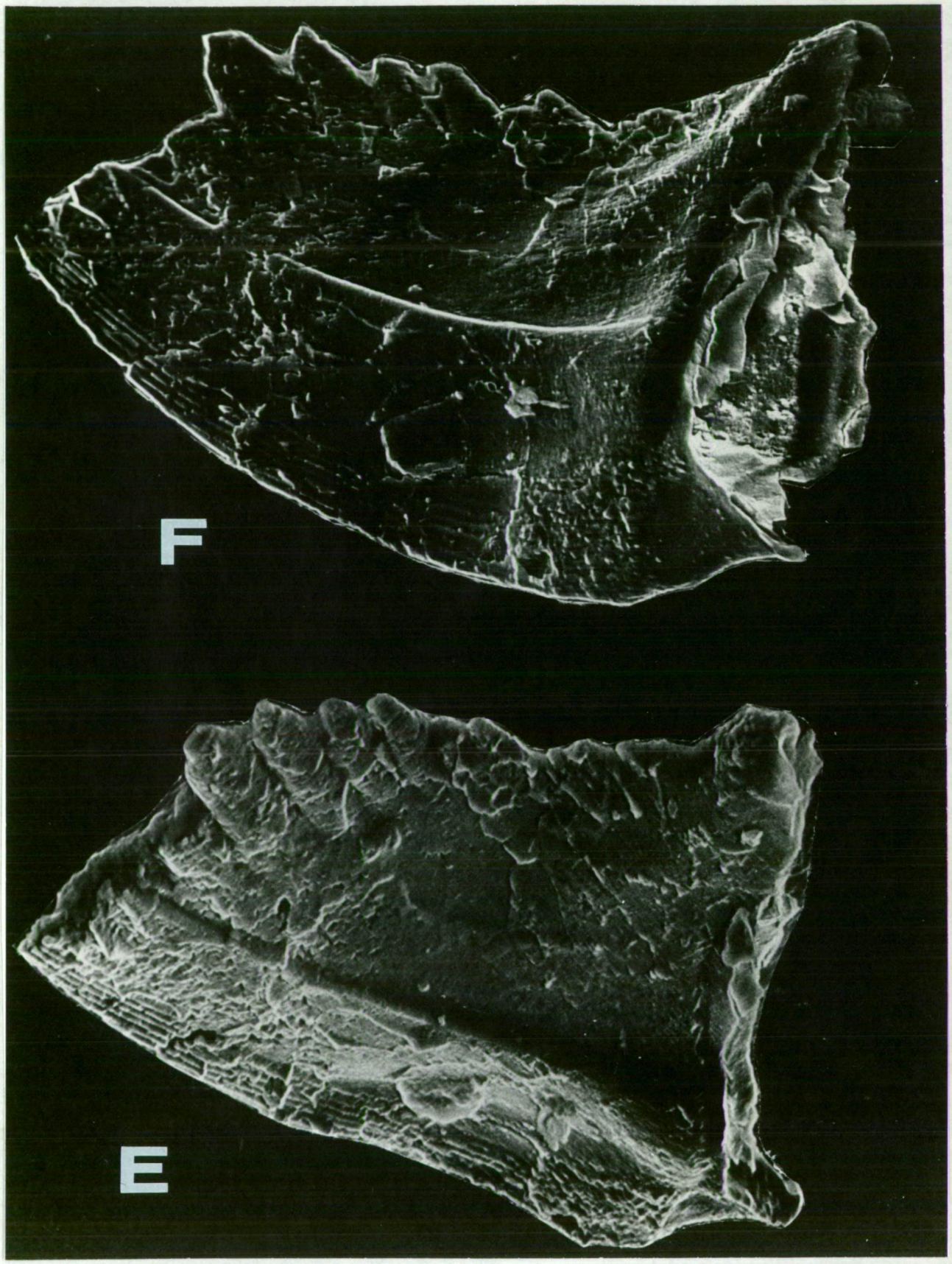


FIGURE 35 *Belodella copenhagenensis*

A,C: belodiniform element, A: basal view x 475, C: lateral view x 250, spec. UTG 96956.
B,D: belodelliform element, B: x 280, D: x 275, spec. UTG 96955.
E,F: belodiniform element, spec. UTG 96857.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E

Very rare specimens are also found in Blackriveran limestones throughout the state. As the elements are very similar in size, preservation, shape and size of basal cavities and in general form it appears reasonable to place them together into the same multi-element species.

The Tasmanian elements differ from *Belodina* n. sp. Bergström *et al.* in that (a) they have a smooth slightly curved process at the base of the anterior margin and (b) the lateral faces are striated near the anterior margin, though a suggestion of such striae is evident in Bergström *et al.'s* photograph of the specimen.

This specimen is very similar to *Oepikodus copenhagenensis* Ethington and Schumacher 1969. Ethington and Schumacher note that *O. copenhagenensis* has longitudinal striae (at high magnification - x200). They do not state whether these striae are confined to the anterior margin as they are in the Tasmanian specimen. Our specimen differs in that the keel is less prominent and that the basal process is more prominent than in *O. copenhagenensis*. *O. copenhagenensis* is found in the lower two thirds of the middle part of the Copenhagen Formation (Ethington and Schumacher 1969 Table 1).

Votaw (1972, p.60) assigns a form from the Pierre Limestone and basal Ridley (Blackriveran), that is similar to the Tasmanian form under consideration, to *Belodella niger* (Serpagli). Votaw (1972) would include within *B. niger*, Ethington and Schumacher's (1969) *O. copenhagenensis* from Nevada and Fåhraeus' (1970 p. 2064 and Fig. 3(0)) *Belodella* n. sp. *A* from Western Newfoundland. Fåhraeus (1970) includes Sweet and Bergström's (1962) *Roundya* n. sp. from Alabama in his *Belodella* n. sp. *A*. Votaw (1972 p. 60) bases his considerations on large collections made by Bergström in the Applachians. *Belodella niger* is based on an oistodiform element first described by Serpagli (1967 p. 79 plage 20) from the Ashgillian of the Carnic Alps. *Oistodus niger*

Serpagli is a variable element which seems to overlap morphologically with many other *"Oistodus"* species. *Belodella erecta* (Rhodes and Dineley) identified by Serpagli (1967, pl. 11) is certainly similar to the Roundya-like belodelliform element of *Belodella niger* (Serpagli) *sensu* Votaw 1972 (Text/fig. 6A) but differs in that the basal cavity extends to the main cusp (in *B. erecta*) but is much shallower in *B. niger*. Votaw (1972) includes Fårhaeus' (1970 p. 2064, fig. 3(o)) *Belodella sp.A* in his *B. erecta*. Fårhaeus includes Sweet and Bergström's (1962) *Roundya* n.sp. A transverse section of that species (see Fig.34) is very different from the range shown by Serpagli's specimens. However Serpagli's specimens are very similar in degree of lateral curvature and in cross section to Tasmanian belodelliform elements (see Fig. 34) which tend towards triangularity. The distinctive feature of Votaw's *Belodella niger* (Serpagli) seems not to be the *Roundya*-like element nor *Oistodus niger* but the element referred by Bergström *et al*.(1974, plate 1 Fig. 11) to *Belodina* n.sp. This element has a much more stratigraphically restricted range occurring only in strata of approximately Chazyan age. If this belodiniform element is, in fact, associated with *Oistodus niger* then it is surprising that it was not found by Serpagli (1967), Hamar (1966), Serpagli and Greco (1965) and Lindström (1959). Fårhaeus (1970) quotes Bergström as stating that "*Belodella* frequently occurs in beds older than the *Nemagraptus gracilis* Zone in the Middle Ordovician of the Appalachians." A similar element to the Tasmanian specimen was referred by Schopf 1966 (Plate 1 fig. 5) to *Belodina diminutiva*. However the specimen looks rather worn and may belong to *B. diminutiva*, *B. inclinata* or *Belodella niger sensu* Votaw. Moskalenko 1973 (Plate V fig. 8a, b) also refers a similar element to *B. diminutiva* (Branson and Mehl). Both Moskalenko's and Schopf's *B. diminutiva* are from Trentonian age limestones.

Assignment of the Tasmanian specimens to *Belodella niger* appears

unlikely because no associated oistodiforms have been found and they are therefore placed in *Belodella copenhagenensis*.

Genus BELODINA, Ethington 1959

BELODINA ALABAMENSIS Sweet & Bergström 1962

Figure 36A-F

Synonymy:

?*Belodus compressus* Branson & Mehl? FURNISH, BARRAGY & MILLER 1936 pl.2, Fig. 13.

Belodina alabamensis SWEET & BERGSTRÖM 1962, p.1223-1224, pl.170, figs. 10, 11.

Panderodus alabamensis (Sweet & Bergström) ETHINGTON & SCHUMACHER 1969 p.469, pl.69, fig.8.

Comments:

Many specimens clearly referable to *Belodina alabamensis* are found in samples from within and just above the Standard Hill Member at Mole Creek and correlates throughout the state. Ethington and Schumacher (1969) have removed their Nevada specimens from *Belodina* and placed them in *Panderodus* because (a)"were it not for the denticles ... this species would be a typical representative of *Panderodus* Ethington." (b) the denticles are not like those of belodinids and (c) a "heel" is not differentiated. Ethington's original definition of *Belodina* (Ethington 1959 p.271) states

> "Conodonts referred to this genus are complex dental units having an anteriorly directed horizontal cusp whose distal portion shows marked oral curvature. Lateral faces of the cusp may be smooth or carinate and are generally unequally developed so that the unit is longitudinally asymmetrical. The oral edge of the cusp bears a series of prominent laterally compressed denticles which may penetrate into the cusp. Anterior and posterior edges of the denticles are fused throughout the greater part of their length. The base of the cusp, arbitrarily considered to be posterior in position, is expanded orally to form a prominent "heel" posterior posterior to the first oral denticle. Two conical basal cavities extend anteriorly into the cusp from the base. The lower cavity is slender and penetrates more deeply into the

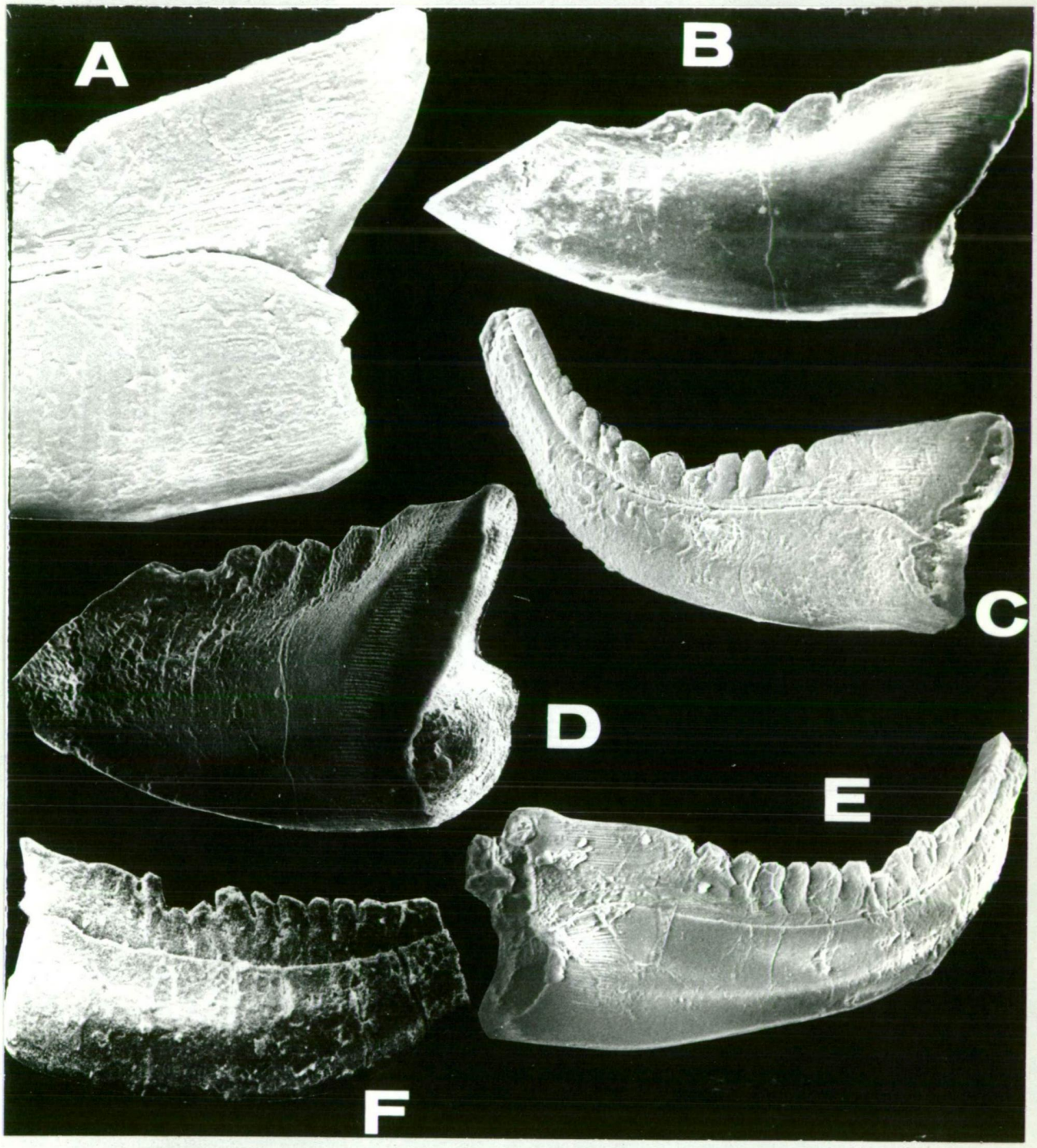


FIGURE 36 *Belodina alabamensis*

A,C: Spec. UTG 96968. A: x 400, C: x 220.
B,D: Spec. UTG 96951, x 180.
E : Spec. UTG 96967, x 200.
F : Spec. UTG 96521, x 300.

> cusp; it tapers distally to form a thread-like extension which curves orally parallel to the axis of the cusp. The upper cavity is laterally compressed and usually penetrates into the cusp as far as the base of the most posterior of the oral denticles."

Both the type specimens of *B. alabamensis* and the Tasmanian material possess an apparently bifurcate basal cavity and an obvious heel. Both are laterally asymmetric. Barnes and Poplawski (1973 p.770) have placed an element in *Belodina* although the "basal cavity is single." If this enlargement of the generic concept is accepted then the characteristic features of *Belodina* will be reduced to overall shape, denticulation and the possession of a heel.

Many of the Tasmanian specimens are strongly curved laterally (Fig. 36). There are about twice as many dextral as sinistral specimens. The number of denticles vary from 2-3 in small specimens to 11-12 in intermediate size specimens. A small number of larger forms possess a smaller number of denticles due to denticle fusion during ontogeny. *B. alabamensis* differs from *B. compressa* in having a large number of rectangular denticles, a strong laterally directed (but variable) curvature, a large number of striae running parallel to the cusp but restricted to the mid-portion of the heel and in having a tendency for the denticles to be reclined.

The smallest specimens of *B. alabamensis* are very similar to a posteriorly denticulated *Panderodus*. As noted by Sweet and Bergström (1962, p.1223) there is a transition from *Scandodus*-like elements to *Belodina alabamensis*. This appears to be the case in Tasmanian samples and the least *Belodina*-like elements could be referred to *Panderodus denticulatus* Schwab. Schwab (1969, p.524) notes that *P. denticulatus* is an Ordovician as well as a Silurian species, having been found by Ethington in the Galena Formation. The Tasmanian *"Panderodus denticulatus"* may be regarded as probable early growth stages of *B. alabamensis*. The Tasmanian specimens of *B. alabamensis* are very similar to *Paltodus sulcatus*

described by Fåhraeus (1966) the main difference being the possession of posterior denticulation in the *Belodina*.

BELODINA COMPRESSA (Branson and Mehl)

Figure 37 A-E

Synonymy:

Belodus compressus BRANSON and MEHL, Univ. Missouri Studies , p.114, pl.9, figs. 15, 15.

see Bergström and Sweet (1966) page 312-313 for synonymy from 1933-1966.

for synonymy 1966-1973 see Uyeno 1974, p.15.

Belodina compressa (Branson and Mehl) UYENO 1974 p.15, pl.1, figs. 10-13.

Belodina compressa (Branson and Mehl) SWEET *et al.* 1975, pl. 1, figs. 4-6.

Comments:

Elements of the well known form species *Belodina compressa* and *Eobelodina fornicala* (Stauffer) range through the section at Mole Creek, and are found in many sections throughout Tasmania. Although looked for, no evolutionary changes could be discerned in this long ranging species. The writer has accepted the view of Bergström and Sweet (1966 p.314) that *Belodina grandis* (Stauffer), *Belodina wykoffensis* (Stauffer), *B. dispansa* (Glenister) and *B. leithi* (Ethington and Furnish) are either extreme variants and/or early growth stages. Representative of all the above forms are present in Tasmanian collections.

? *Belodina* sp.

Figure 38

Comments:

A solitary specimen of a belodiniform element has been found in samples from the Goliath Quarry at Railton. The specimens are recrystallized and details of the basal cavity are obscured and therefore assignment to *Belodina* is tentative. The laterally compressed unit is reclined with a strongly serrated posterior margin. The serrations

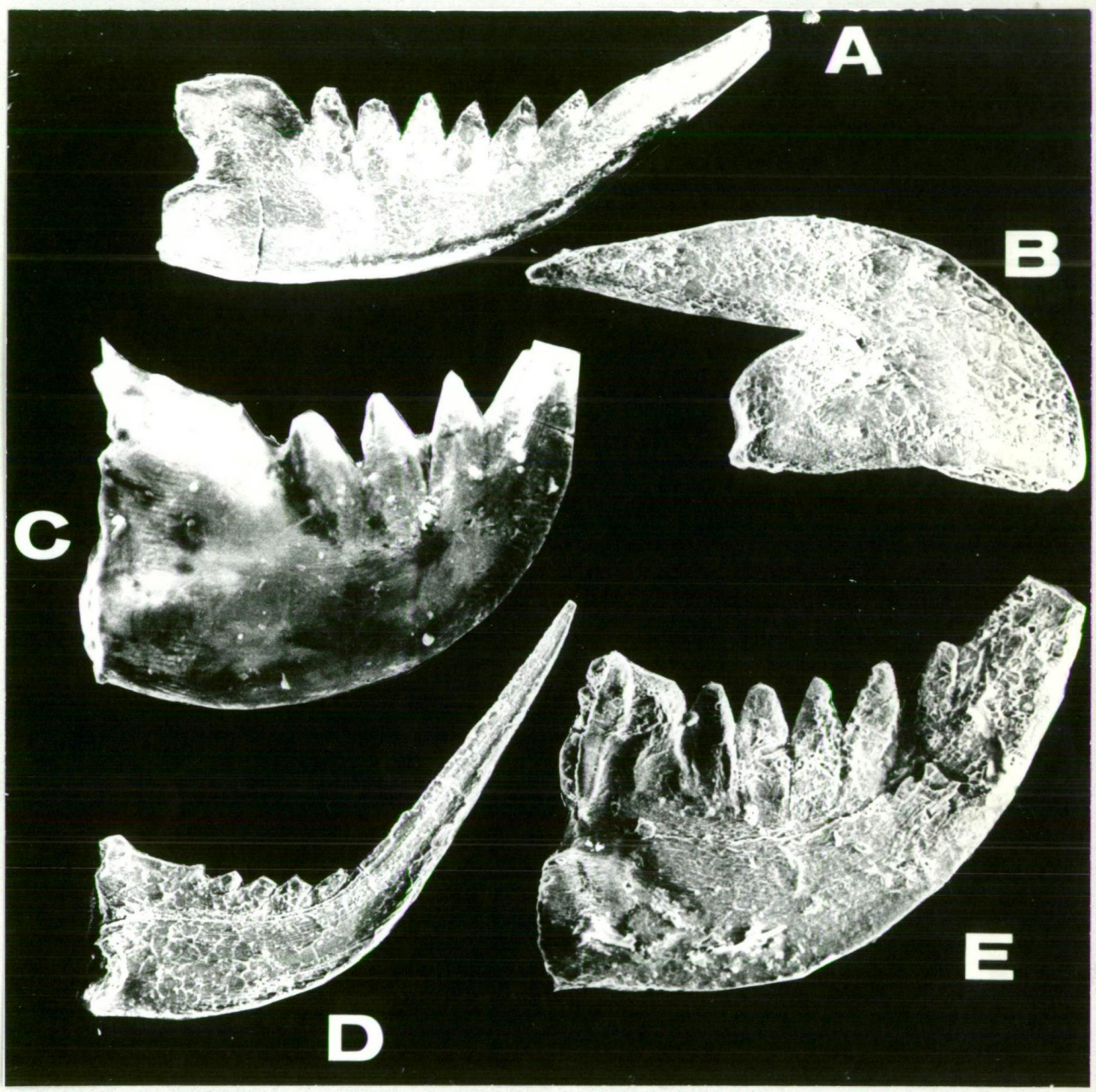


FIGURE 37 *Belodina compressa* (Branson and Mehl)

A: belodiniform element, spec. UTG 96907, x 100.
B: eobelodiniform element, spec. UTG 96908, x 150.
C: belodiniform element, spec. UTG 97037, x 100.
D: belodiniform element (= "*B. dispansa*"), spec. UTG 96911, x 125.
E: belodiniform element, spec. UTG 96909, x 100.

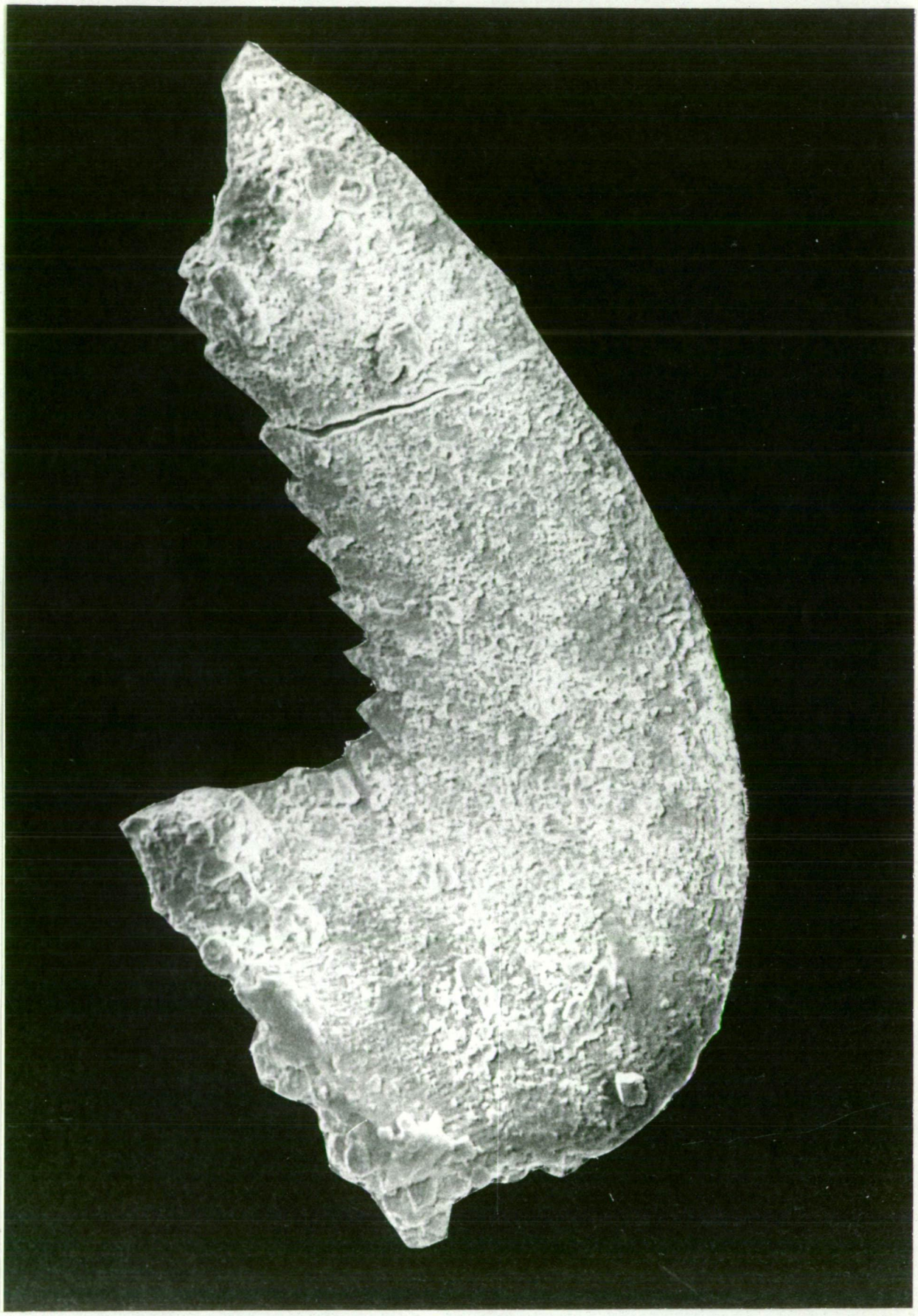


FIGURE 38 *? Belodina* sp.

Spec. UTG 97045, x 280.

appear to be the result of strongly inclined denticles that extend onto the oral edge. The anterior margin is rounded and smooth and there is no ornamentation, costation or striations on the lateral faces of the element. The specimen is different from all described species of *Acanthodus* and the possession of inclosed denticles and a rudimentary heel may suggest placement within *Belodina*. The specimens differ from *Oistodella* Bradshaw in that the Tasmanian specimens have a rounded posterior/basal margin and lack antero-lateral furrows.

Genus BRYANTODINA Stauffer 1935a

Only one species of *Bryantodina* has been found in this study - *Bryantodina? abrupta*. Assignment of this species to *Bryantodina* is doubtful (Bergström and Sweet 1966 pgs. 318 *et seq.*).

BRYANTODINA? ABRUPTA (Branson and Mehl 1933)

Figure 39

Synonymy:

Ozarkodina (?) abrupta BRANSON and MEHL 1933 Univ. Missouri Studies *8*, p.100, pl.6, fig.11.

Bryantodina, n. sp. BRANSON, 1944, Univ. Missouri Studies *19*, p.90, pl.13, figs. 34-36.

Bryantodina abrupta (Branson and Mehl), SCHOPF 1966, New York State Mus. Bull. 405, p.44, pl.4, figs. 13-14.

Rhipidognathus paucidentata Branson, Mehl and Branson, SCHOPF (1966), New York State Mus. Bull. 405, p.72, pl.2, fig.21.

Bryantodina? abrupta (Branson and Mehl). BERGSTRÖM and SWEET (1966). Bull. Amer. Paleontol. vol.50 (229) pgs.318-321, pl.30, figs.9-12. Text figs. 8A-D.

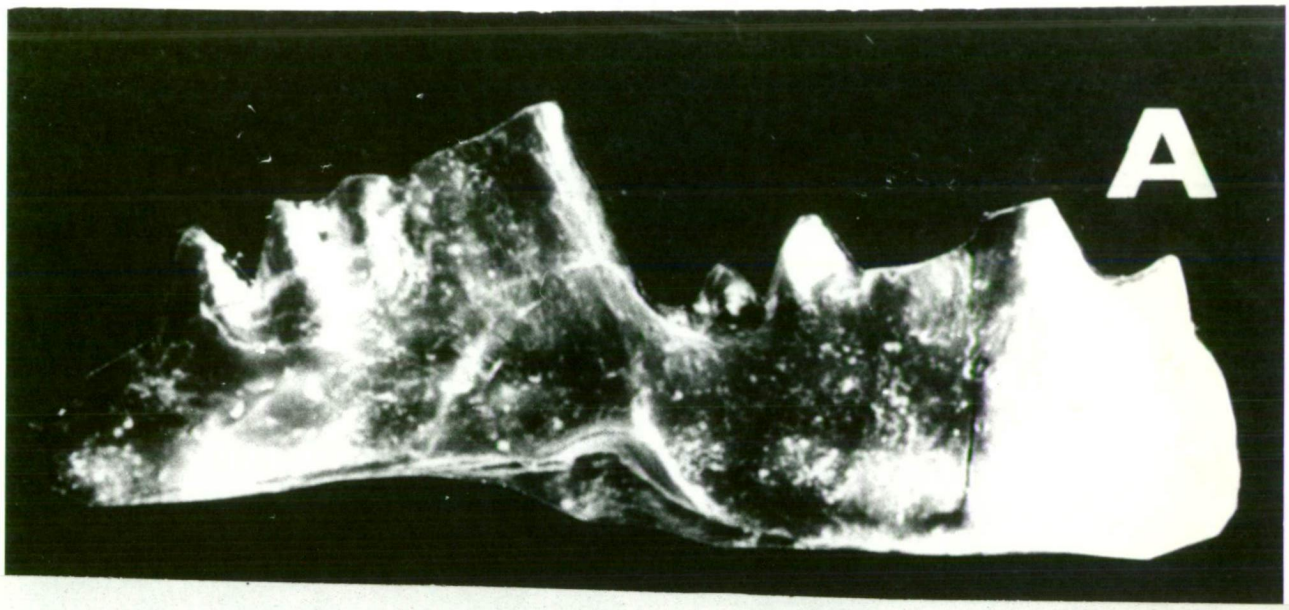


FIGURE 39 *Bryantodina? abrupta*

A: Spec. UTG 97030, x 150.

Bryantodina? abrupta (Branson and Mehl) SWEET ETHINGTON and BARNES (1971) Geol. Soc. Amer. Mem. 127, p.172-173, pl.2, fig.36.

Bryantodina? abrupta (Branson and Mehl) GLOBENSKY and JAUFFRED 1971, p.54, pl.2, fig.11.

Bryantodina? abrupta (Branson and Mehl) UYENO 1974, p.17, pl.1, figs. 20-22.

Comments:

Bergström and Sweet (1966, p.318-321) have discussed *Bryantodina? abrupta* at length. They consider that the multielement species also includes a prionodiniform element. Although *B. abrupta* is present in small numbers in several Tasmanian collections no prionodiniform elements have been found.

Genus CHIROGNATHUS, Branson and Mehl, 1933

CHIROGNATHUS MONODACTYLUS Branson and Mehl

Figure 40 A-E

Synonymy:

Chirognathus monodactyla BRANSON and MEHL, 1933, p.29, 31, pl.2, figs. 11, 13.

Chirognathus multidens BRANSON AND MEHL 1933 idem p.34, pl.2, fig.43.

Chirognathus admiranda STAUFFER 1935 p.135, pl.9, figs. 6, 16, 22.

Chirognathus alternatus STAUFFER 1935 p.135,158, pl.9, fig. 31.

Chirognathus delicatulus STAUFFER 1935 p.136, 158, pl.9, figs.1-3, 5, 7-13, 17-19, 21.

Chirognathus eucharis STAUFFER 1935 idem. p.136, 158, pl.9, figs. 23, 27, 28, 34.

Chirognathus duodactylus STAUFFER, 1935, idem. p.136, 158, pl.9, fig.29.

Chirognathus expatiatus STAUFFER, 1935, idem. p.137, 158, pl.9, fig.4.

Chirognathus idoneus STAUFFER, 1935, idem. p.137, 158, pl.9, fig.24.

Chirognathus hamatus STAUFFER, 1935, p.137, 158, pl.9, fig.33.

Chirognathus irregularis STAUFFER, 1935, p.137, 138, 159, pl.9, fig.32.

Chirognathus lanesboroensis STAUFFER, 1935, p.138, 158, pl.9, fig.14.

Chirognathus magnificus STAUFFER, 1935, p.138, 158, pl.9, fig.25.

Chirognathus radiatus STAUFFER, 1935, p.139, 158, pl.9, fig.15.

Chirognathus unguliformis STAUFFER, 1935, p.139, 158, pl.9, fig.41.

?*Chirognathus scalensis* STAUFFER, 1935, p.140, 158, pl.9, figs. 30,37,38.

Chirognathus monodactyla Stauffer, SWEET, 1955, p.239, pl.27, fig.20.

Chirognathus multidens Branson and Mehl, SWEET, 1955, p.235-236, pl.27, fig.15.

Chirognathus admiranda Stauffer, SWEET, 1955, p.235-236, pl.27, fig.15.

Chirognathus delicatulus Stauffer, SWEET, 1955, p.237, pl.27, figs.14-22.

Chirognathus eucharis Stauffer, SWEET, 1955, p.238, pl.27, fig.17.

Chirognathus idoneus Stauffer, SWEET, 1955, p.238-239, pl.27, figs.8, 16.

Chirognathus unguliformis Stauffer, SWEET, 1955, p.242, pl.27, fig.21.

Chirognathus delicatulus Stauffer, OBERG, 1966, p.136-137, pl.15, fig.6.

Chirognathus monodactyla Branson and Mehl, WEBERS, 1966, p.54, pl.5, fig.3.

Chirognathus delicatulus Stauffer, 1935, WEBERS, 1966, p.54-55, pl.15, figs.1-4.

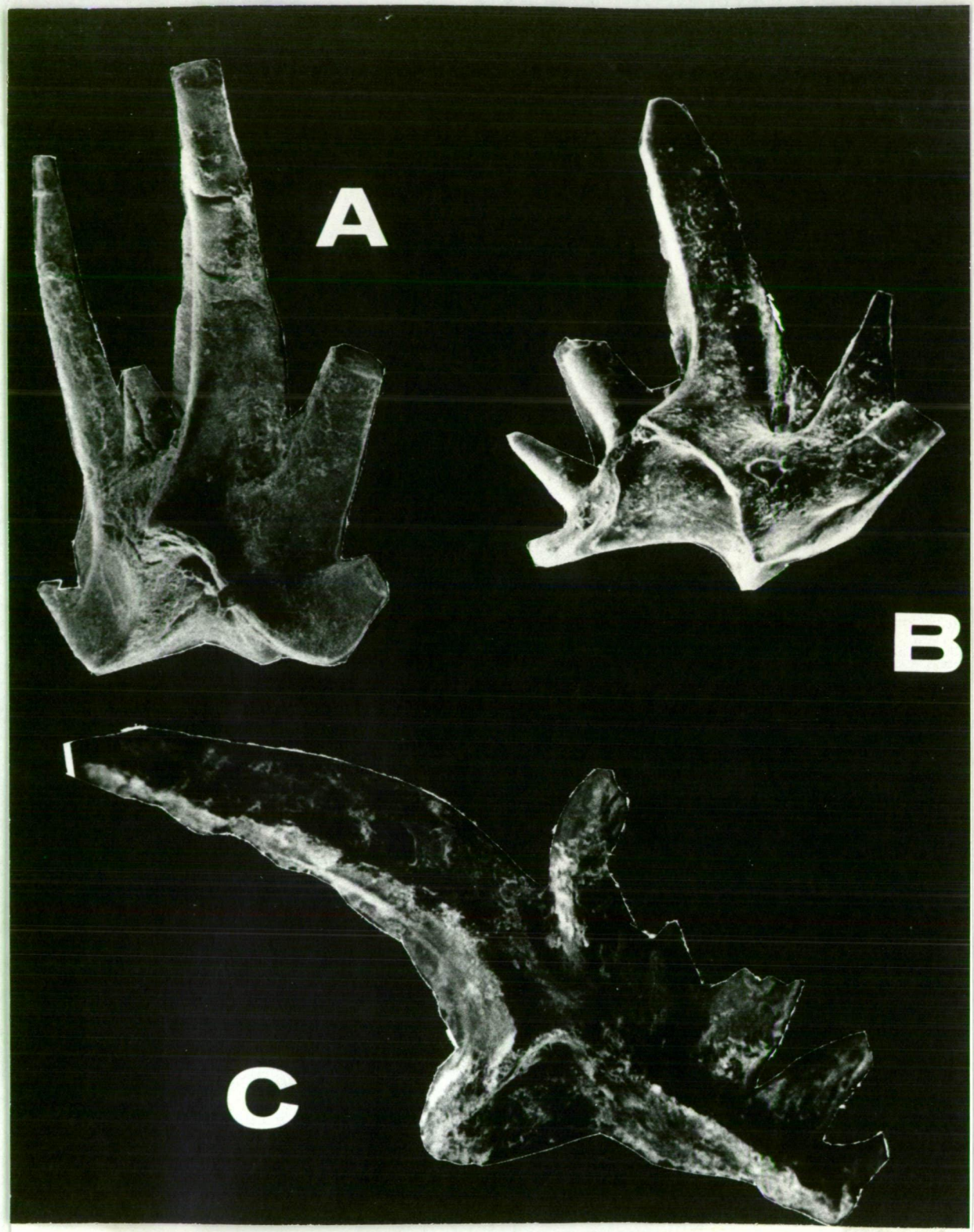
Chirognathus delicatula Stauffer, BARNES, SASS & MONROE, 1973, Figures 1-1, 1-3 to 1-7.

Comments:

Elements belonging to the multielement species *Chirognathus monodactylus* Branson and Mehl are common in the Ugbrook Nodular and Sassafras Creek Members at Mole Creek, in the Lower Limestone Member in the Florentine Valley and in the Everlasting Hills area.

FIGURE 40 *Chirognathus monodactylus*

A: Spec. UTG 96862, x 85.
B: Spec. UTG 96865, x 90.
C: Spec. UTG 96875, x 180.
D: Spec. UTG 97020, x 100.


A
B
C

D

Genus DREPANOISTODUS Lindström 1971

DREPANOISTODUS FORCEPS (Lindström 1955)

Figure 41

for synonymy see Ethington and Clark, 1965, and Lindström, 1971.

?*Oistodus forceps* Lindström, ETHINGTON & CLARK, 1965, p.194-5, pl.1, fig.18.

?*Oistodus forceps* Lindström, FÅHRAEUS, 1966, p.23, pl.III, figs.1a, 1b, Text fig.2H.

?*Oistodus* sp.D, HUNICKEN & GALLINO, 1970, pl.1, figs.6-8.

Comments:

The oistodiform element of *D. forceps* is found in small numbers in sample G140 from the base of the limestone section along the Gordon River near the Olga damsite. Lindström (1971, p.43) distinguishes *"Oistodus" forceps* from *"Oistodus" venustus* by the following "subtle characters"

(a) the anterior margin is straighter in *"O." forceps*

(b) there may be a slight undulation of the inner side of the basal margin in *"O." forceps*.

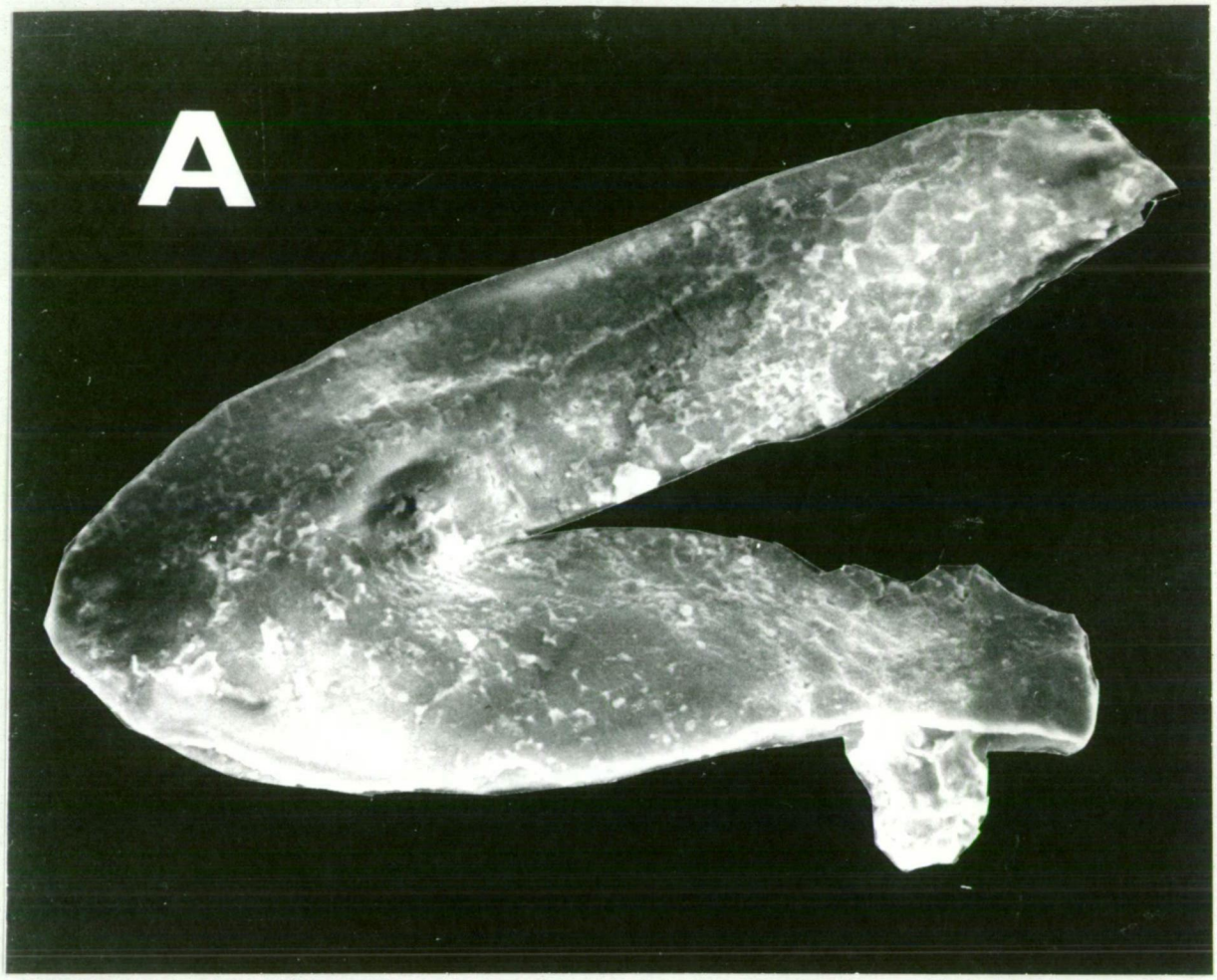


FIGURE 41 *Drepanoistodus forceps*

A: oistodiform element, spec. UTG 96961, x 225.

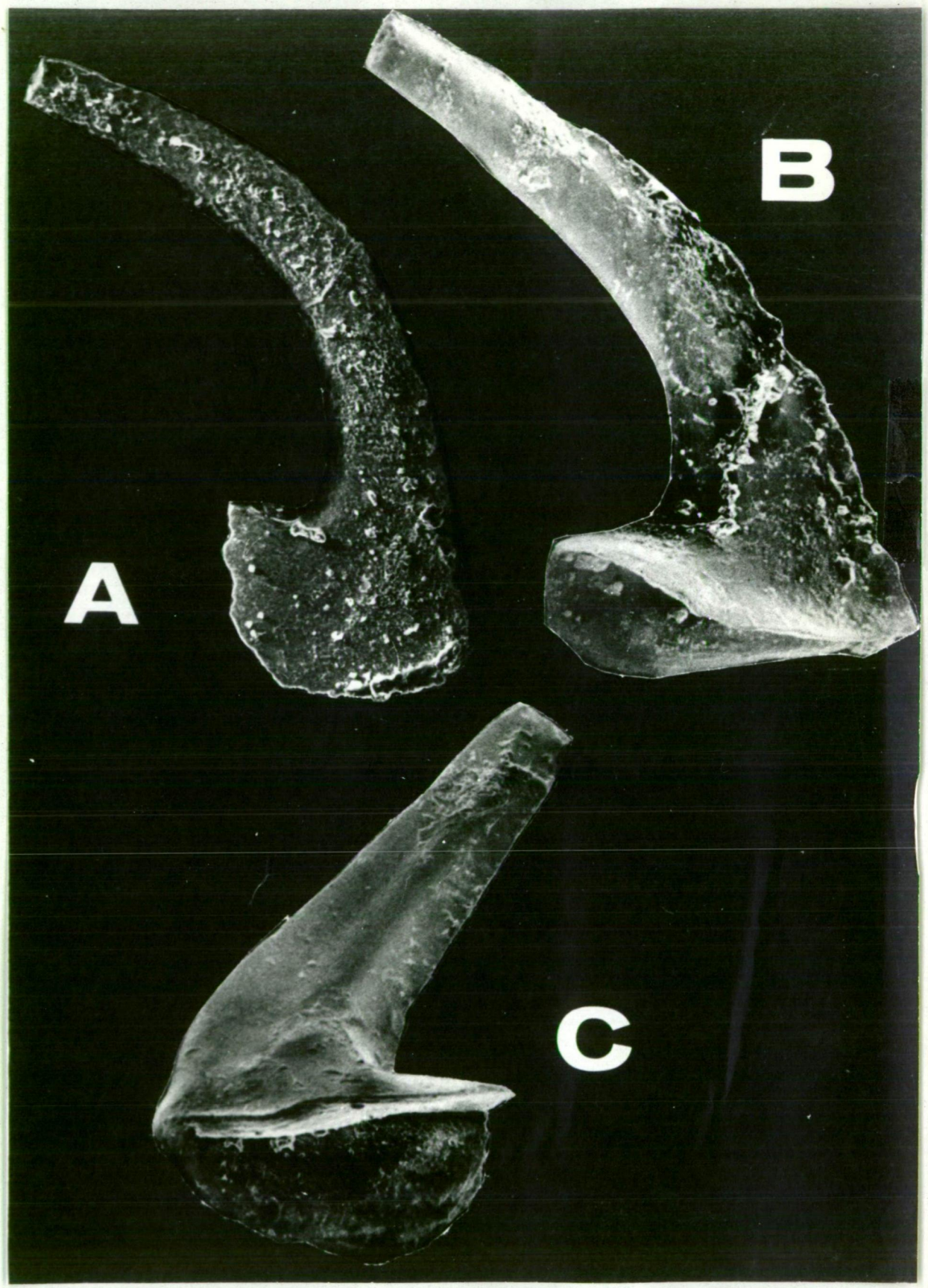


FIGURE 42 *Drepanoistodus suberectus*

A: drepanodiform element, spec. UTG 97008, x 120.
B: drepanodiform element, spec. UTG 96867, x 120.
C: oistodiform element, spec. UTG 96868, x 110.

These features are found in the Tasmanian specimens and these specimens are placed in *D. forceps*. Whether or not specimens such as those of Ethington and Clark (1965) from Alberta or those of Fåhraeus (1966) from Sweden belong in *D. forceps* as defined by Lindström (1971) remains to be seen.

DREPANOISTODUS SUBERECTUS (Branson and Mehl)

Figure 42 A-C

Drepanoistodus suberectus (Branson and Mehl) UYENO, 1974, p.14, pl.1, figs.5-9.

Comments:

Drepanoistodus suberectus is found in many samples from all levels of the Gordon Limestone Subgroup. No morphologic changes appear to have occurred over the interval Chazyan-Cincinnatian. *D. suberectus* includes drepanodiform, and oistodiform elements, *(D. homocurvatus, D. suberectus, O. excelsus* and *O. inclinatus)*.

Genus ERISMODUS, Branson & Mehl, 1933

ERISMODUS GRACILIS (Branson & Mehl)

Figure 43 A-I

for synonymy to 1966 see Andrews, 1967, p.894.

Ptiloconus sp. SCHOPF, 1966, pl.6, fig.4.

Ptiloconus gracilis (Branson & Mehl), WEBERS, 1966, p.70, pl.5, fig.8.

Ptiloconus compressus (Branson & Mehl), WEBERS, 1966, p.70, pl.5, fig.9.

Erismodus gracilis (Branson & Mehl), ANDREWS, p.894, pl.112, fig.19.

Ptiloconus gracilis (Branson and Mehl), BARNES, SASS & MONROE, 1973, figs. 3-1 to 3-12.

Comments:

Andrews (1967) has removed *Ptiloconus gracilis* from *Ptiloconus* to *Erismodus*. His arguments are accepted here and the Tasmanian specimens are placed in *Erismodus*. Specimens are generally rare but are locally common in intertidal limestones.

Erismodus spp.

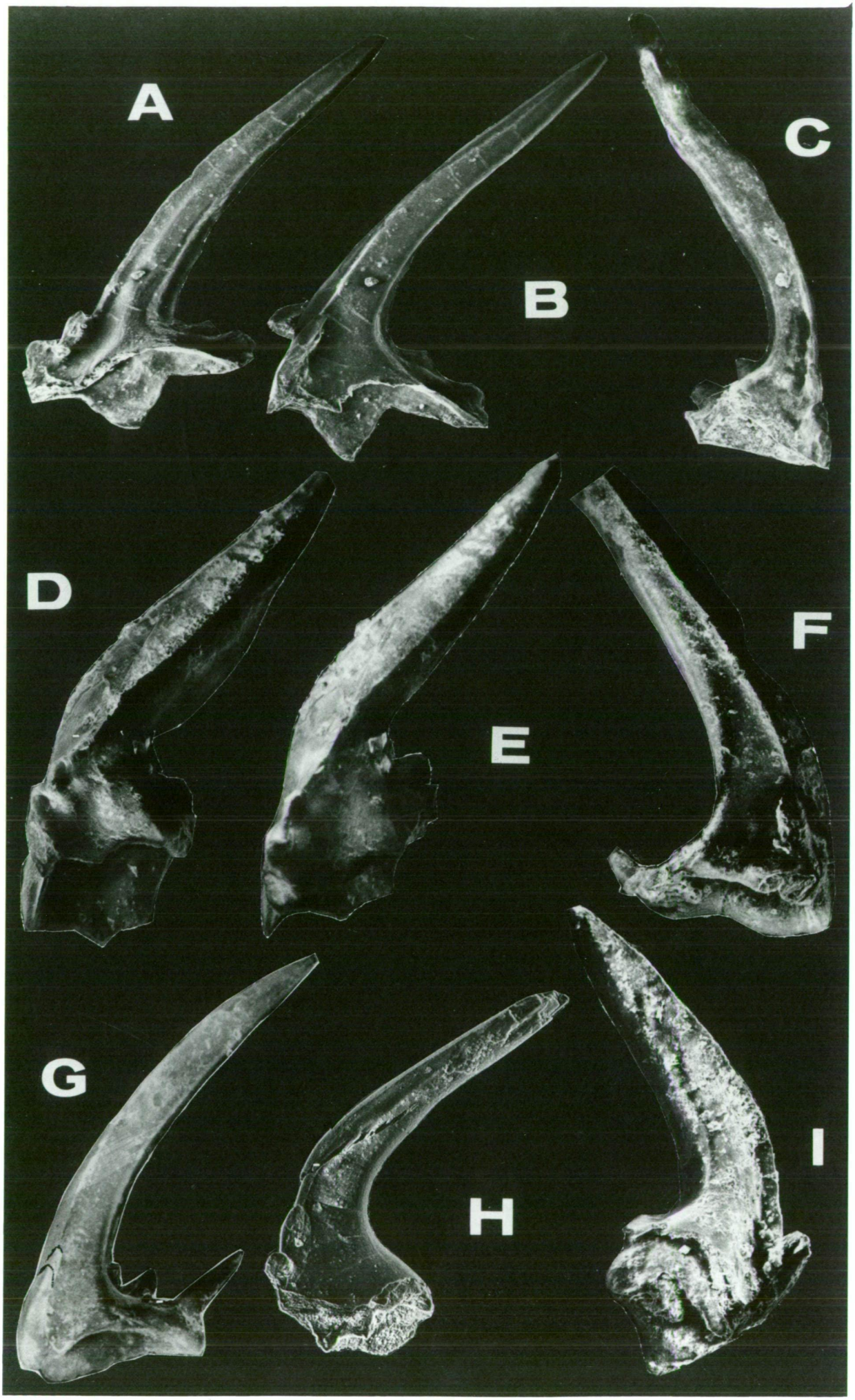
Figure 44 A,B

Comments:

Several specimens are found in Tasmanian collections that fall within *Erismodus*. However they are very rare in most samples and no large collections have been made to assess population and ontogenetic variability. The figured specimens are similar to *E. asymmetricus* and *E. symmetricus* but no definite assignment is possible until larger collections are made.

FIGURE 43 *Erismodus gracilis*

A,B: Spec. UTG 96521, A x 80, B x 90.
C : Spec. UTG 96914, x 50.
D,E: Spec. UTG 96879, both x 130.
F : Spec. UTG 96878, x 130.
G : Spec. UTG 96864, x 100.
H : Spec. UTG 96981, x 120.
I : Spec. UTG 96945, x 50.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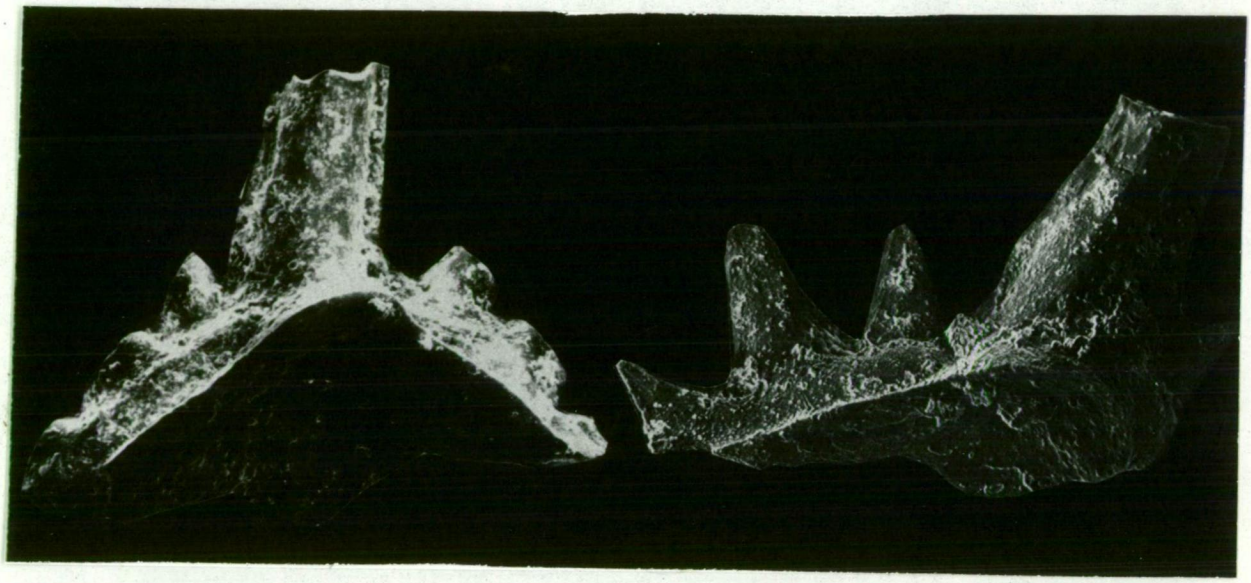


A B

FIGURE 44 *Erismodus* sp.

A: spec. UTG 96922, x 80. B: spec. UTG 96923, x 100.

Genus OULODUS Branson and Mehl, 1933

Sweet and Schönlaub (1975) have recently revised the genus *Oulodus*. They recognised 4 Ordovician species: *O. serratus*, *O. subundulatus*, *O. oregonia* and *O. robustus* each of which, they suggested, consisted of 6 morphological elements.

OULODUS CF. OREGONIA (Branson, Mehl and Branson, 1951)

Figure 45 A-B & E

Synonymy:

For synonymy see Sweet and Schönlaub (1975, p. 48).

Oulodus oregonia (Branson, Mehl and Branson, 1951) SWEET & SCHÖNLAUB 1975 p. 48, pl. 2, figs. 1-6.

Comments:

Rare specimens, close to *O. oregonia*, are found at several localities in Tasmania. However, insufficient material is available for definite specific determination.

OULODUS ROBUSTUS (Branson, Mehl and Branson, 1951)

Figure 45 C-D, F, H & I, Figure 46 A-C

Synonymy:

For synonymy see Sweet and Schönlaub (1975, pages 48-49)

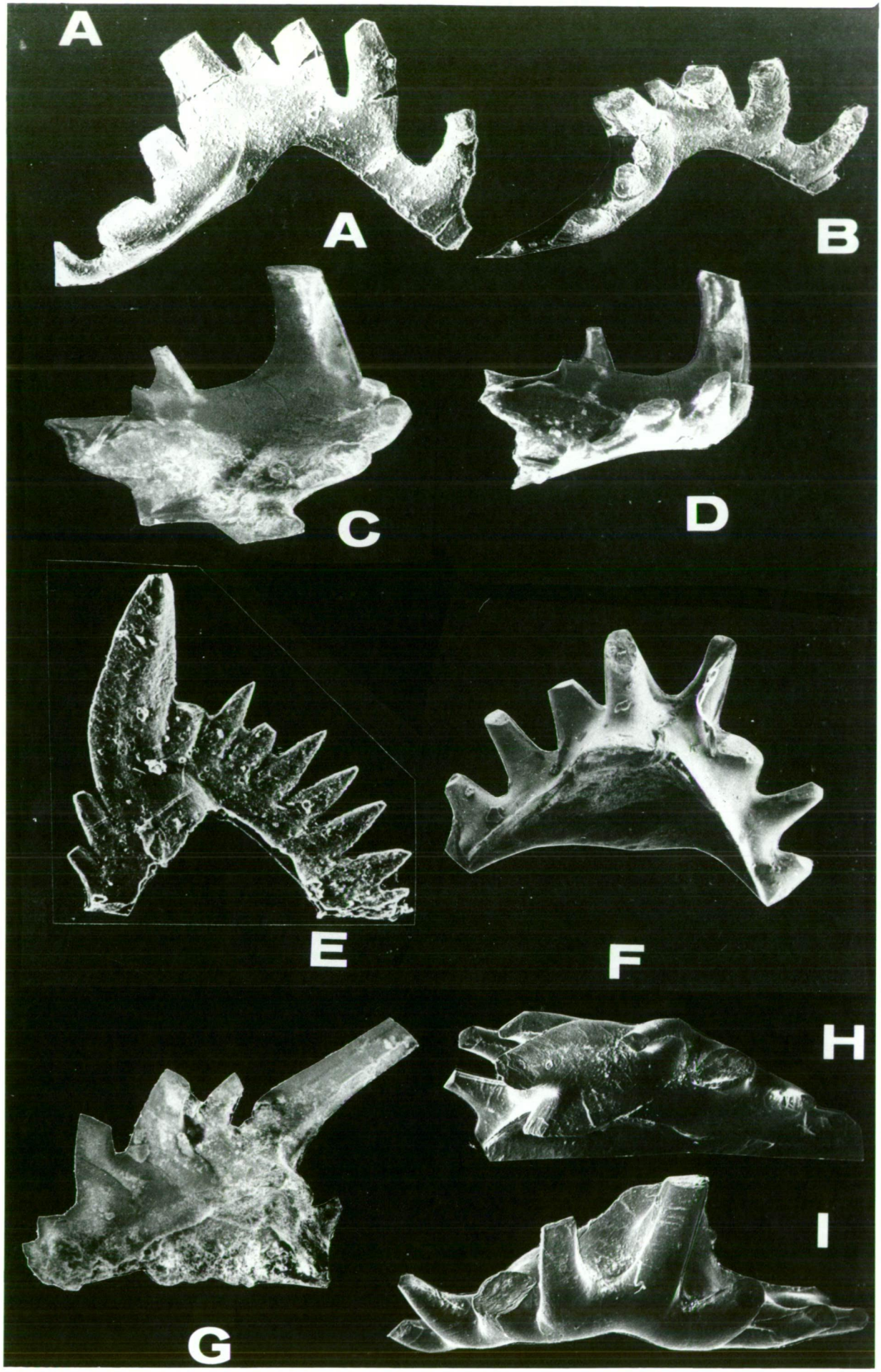
Oulodus robustus (Branson, Mehl and Branson, 1951) SWEET & SCHÖNLAUB 1975 pgs. 48-49, pl. 2, figs. 7-12.

Comments

Sweet and Schönlaub (1975) included some of the elements previously placed in *O. oregonia* by Kohut and Sweet (1968) and the elements of *Plectodina robusta* into the multielement species *O. robustus*. Specimens from the Picton River area are very close to the specimens illustrated from the Cincinnati region.

FIGURE 45 *Oulodus* cf. *oregonia* A, B & E
Oulodus robustus C, D, F, G, H & I

A: oulodiform element, spec. UTG 97046, x 120.
B: oulodiform element, spec. UTG 97046, x 100.
C: eoligonodiniform element, spec. UTG 96915, x 100.
D: eoligonodiniform element, spec. UTG 96915, x 85.
E: prioniodiniform element, spec. UTG 97003, x 100.
F: oulodiform element, spec. UTG 96887, x 100.
G,H,I: oulodiform element, spec. UTG 96982 (as F), x 120.


A
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7/8/246

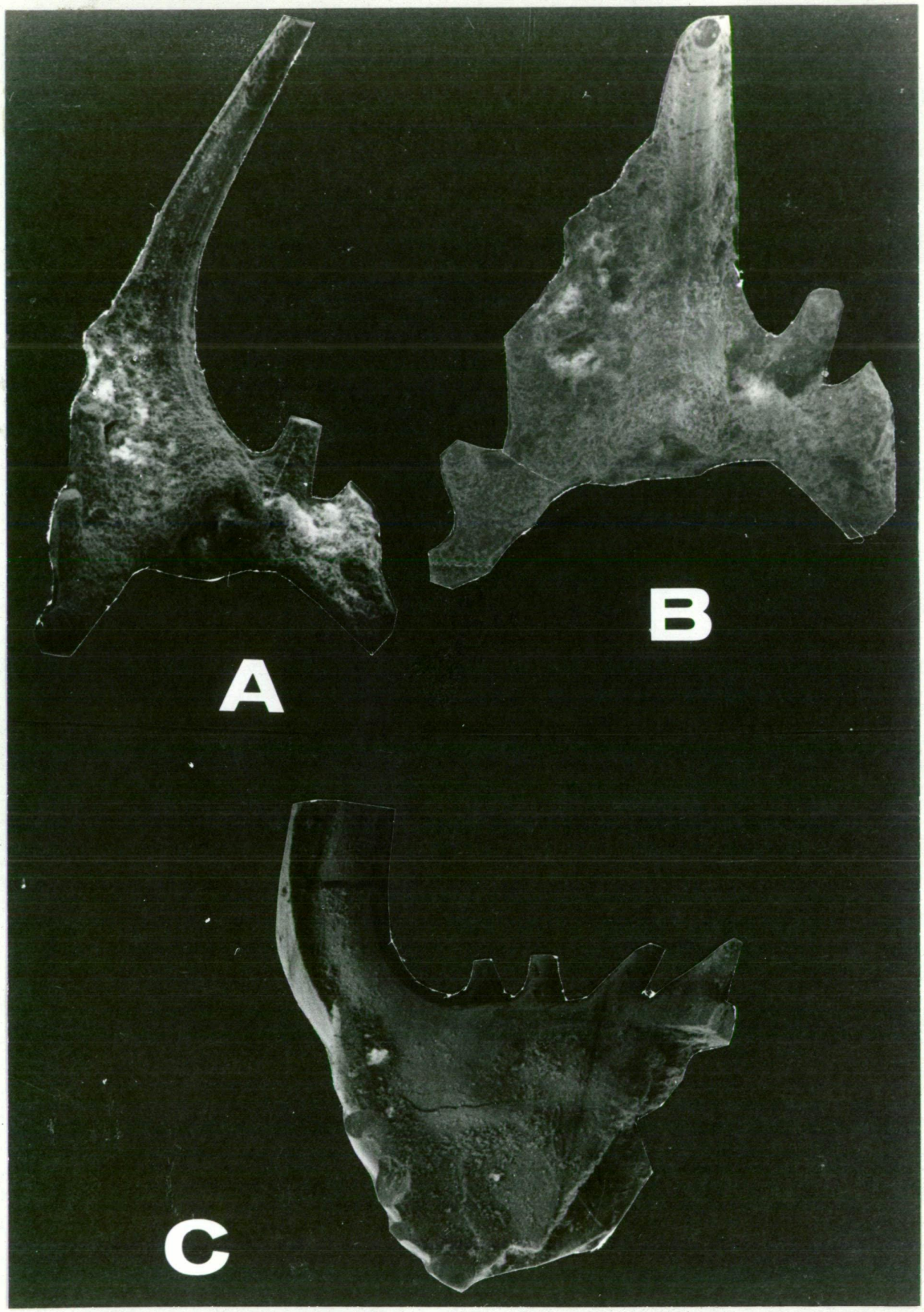


FIGURE 46 *Oulodus robustus*

A: trichonodelliform element, spec. UTG 96574, x 100.
B: as A.
C: eoligonodiniform element, spec. UTG 96725, x 120.

Genus PANDERODUS, Ethington 1959

PANDERODUS GRACILIS (Branson and Mehl)

Figure 47 A-D

Synonymy:

Paltodus gracilis Branson & Mehl, University Missouri Studies, 8, p.108, pl.8, figs. 20, 21.

for synonymy up to and including 1966 see Bergström and Sweet (1966, pp.355-357).

for synonymy 1966-1973 see Uyeno (1974, p.15).

Panderodus gracilis (Branson and Mehl). UYENO, 1974, p.15, pl.3, figs.7-14.

Panderodus gracilis (Branson and Mehl), SWEET *et al.*, 1975 pl. 1, figs. 7-8.

Comments:

In their discussion of the form species *P. gracilis*, Bergström and Sweet (1966, pp.357-359) include forms previously included in *P. elegans* (Stauffer) and *P. striatus*. Within the form species *P. compressus* they include forms usually referred to *P. cornutus* (Stauffer) and *P. feulneri* (Glenister). They suggest that the modified form species *P. gracilis* and *P. compressus* occur within the multi-element species *P. gracilis* in the ratio 2:1. This ratio is also found in Tasmanian samples where sufficiently large numbers of conodonts are present.

PANDERODUS SERPAGLII sp. nov.

Figures 48 A-D, 49 a-h

Synonymy:

Scolopodus cfr. *bassleri* (Furnish), IGO & KOIKE, 1967, p.23, pl.3, figs.7-8, Text fig. 6B.

?"*Panderodus*" sp. SERPAGLI, 1974, p.59, pl.24, figs.12-13; pl.30, figs.12-13.

Panderodus striatus (Stauffer), LEE, 1975, p.178, pl.1, fig.14.

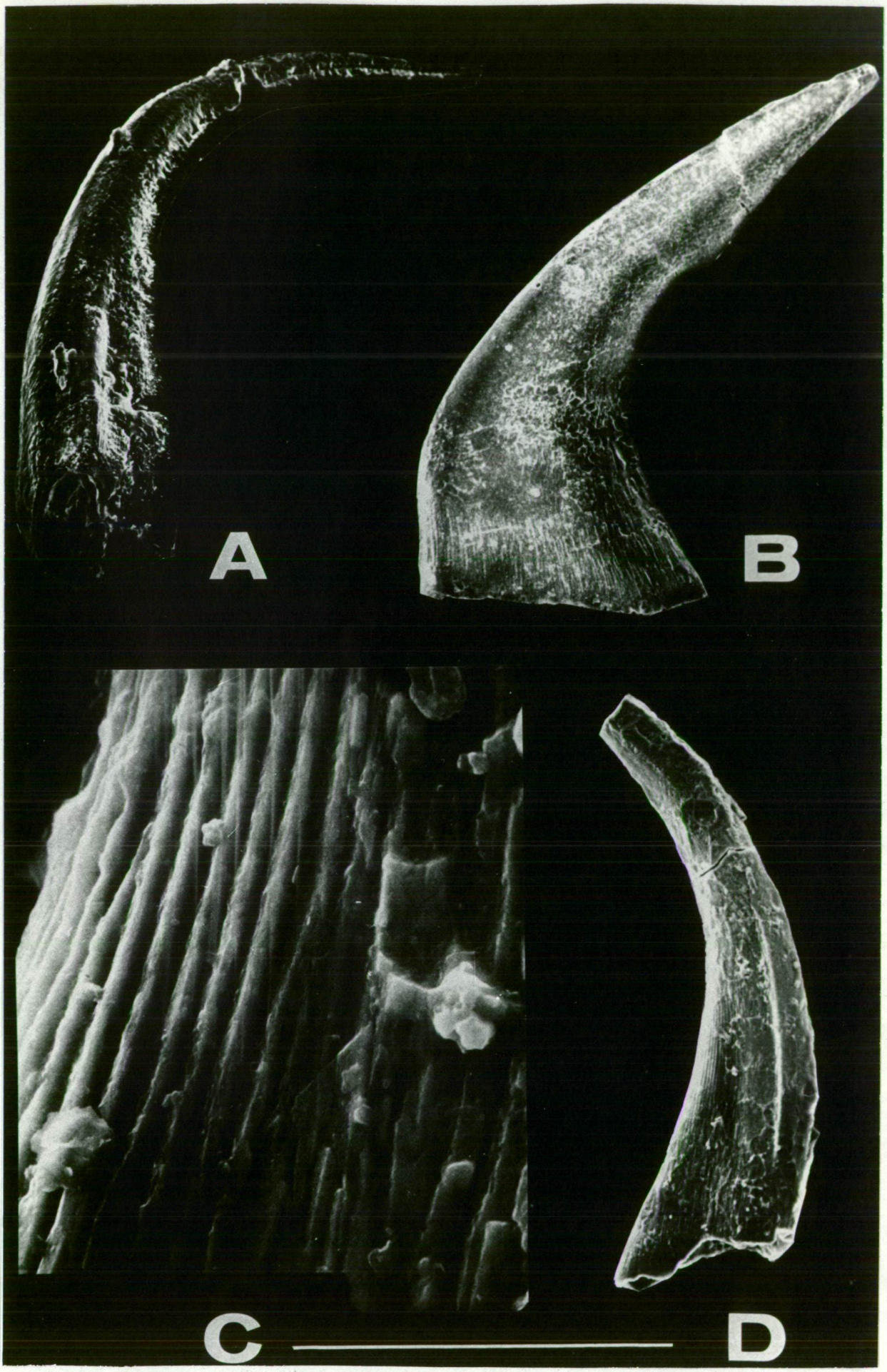


FIGURE 47 *Panderodus gracilis*

A: spec. UTG 96946, x 150.
B: spec. UTG 96910, x 100.
C,D: spec. UTG 96933; C, x 600; D, x 100.

Comments:

A strongly striated simple cone is common in the lower parts of the Gordon Limestone Sub-Group at Mole Creek and other parts of North-west Tasmania, in the lower Gordon River and in the Cashions Creek Limestone Formation and correlates in Southern Tasmania and in lower Blackriveran strata at Zeehan. The Tasmanian specimens are very similar to *Scolopodus* cfr. *bassleri* (Furnish) described by Igo and Koike (1967) from the Lower Setul Limestone of Malaysia. However Furnish (1938, p.331) does not mention any striations on his *Paltodus bassleri* specimens nor are they evident on his figure (ibid, pl.42, fig.1). The longitudinal sulci do not cut the aboral margin in *P. bassleri*.

Serpagli (1974) has described a similar form to the Tasmanian material under *Panderodus* sp. though there are differences including location of the lateral costae close to the sulci near the median line of the lateral faces. In the Tasmanian species the carinae are halfway between the sulci and the centre line of the anterior face. In the Argentinian specimen the costae converge distally towards the posterior margin. This is not observed in the Tasmanian nor in the Korean specimens placed in *Panderodus striatus* by Lee (1975). The Korean specimens bear little resemblance to *Paltodus striatus striatus* Stauffer 1935 or to any other specimens placed in this species by later authors. *P. striatus* was put into *P. gracilis* by Bergström and Sweet (1966). There can be little doubt that the well illustrated *P. striatus* of Lee (1975) is conspecific with the Tasmanian material.

Description:

Simple cones with a large base and slightly asymmetric erect cusp. The cusp has broad rounded posterior and anterior faces and the lateral faces possess unequally developed carinae along their anterior sides.

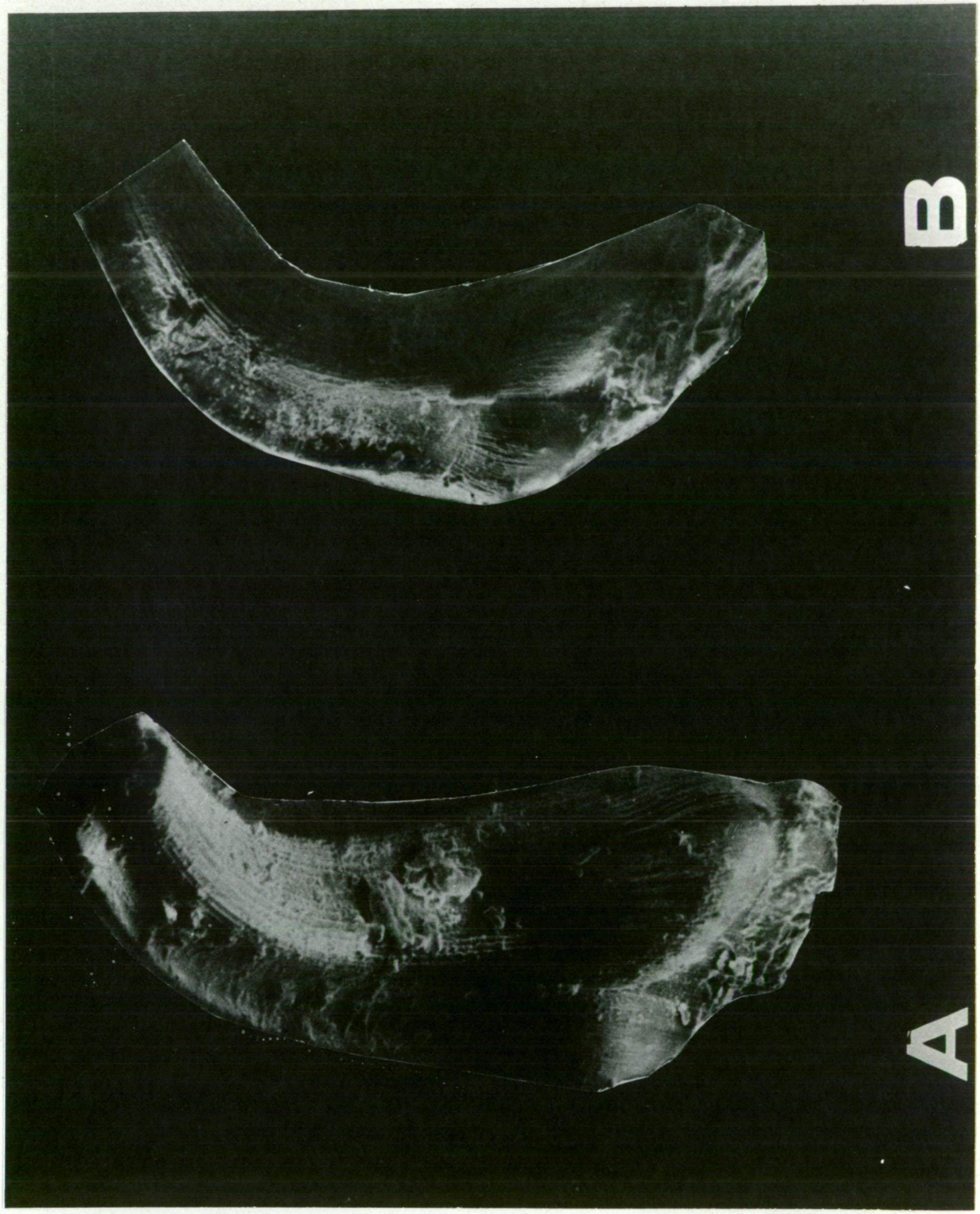


FIGURE 48 *Panderodus serpaglii* sp. nov.

A,B: Spec. UTG 96886, x 150.
C,D: Spec. UTG 96893, x 200.

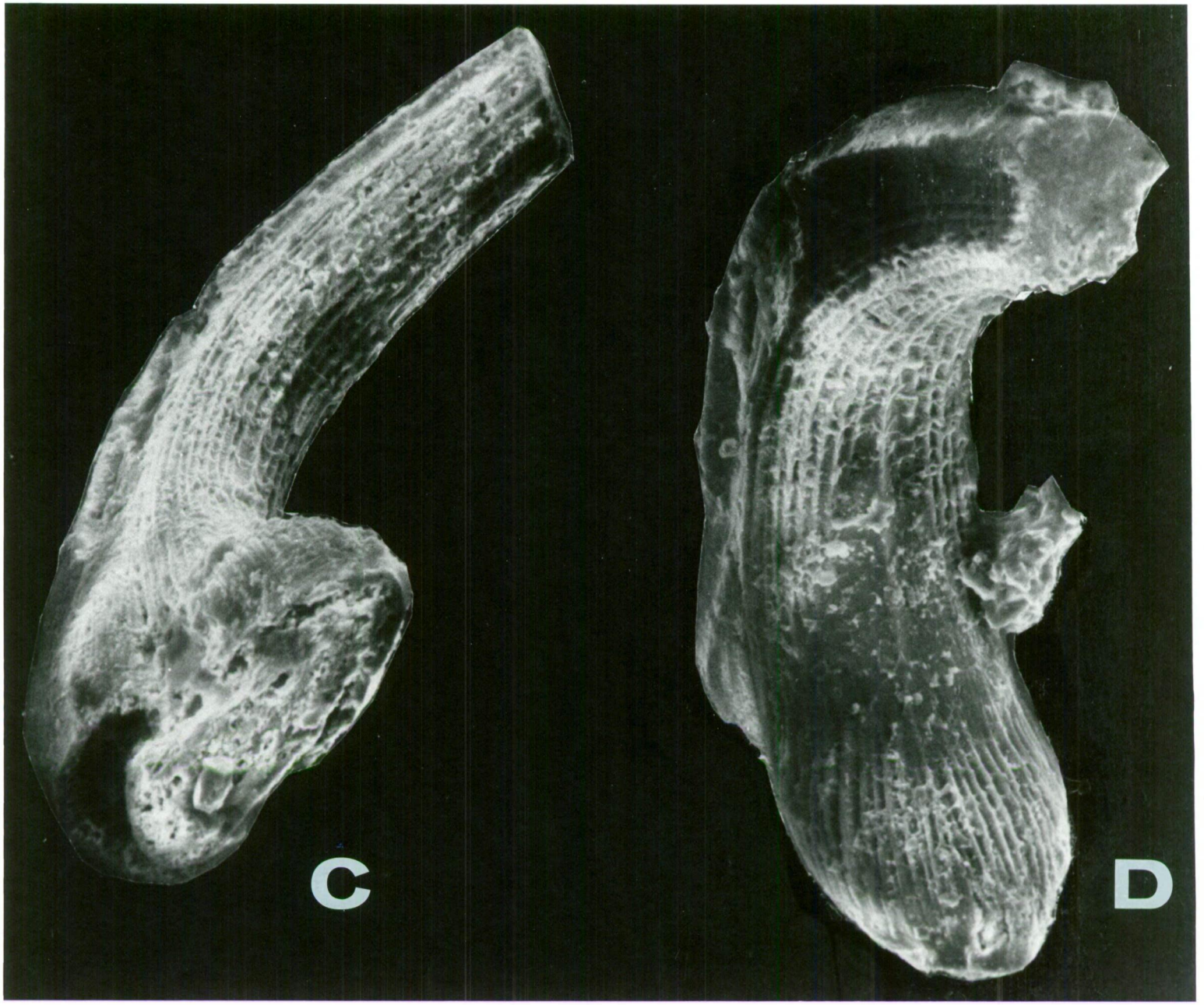
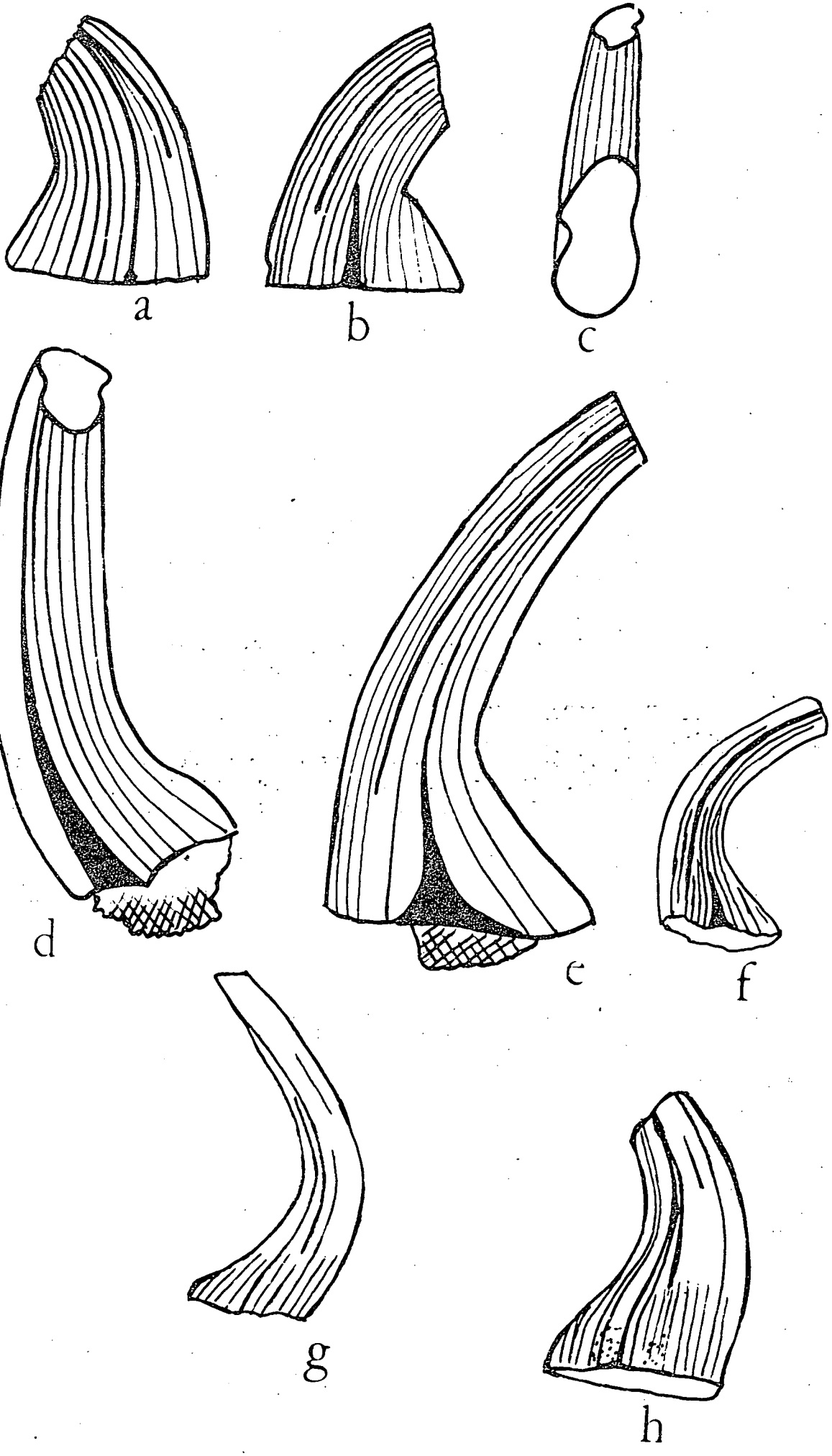

C
D

FIGURE 49 Drawings of elements thought to belong in *Panderodus serpaglii* sp. nov.

A-C: Spec. UTG 96889, x 60.
D-E: Spec. UTG 98554, x 85.
F : *Panderodus striatus* (Stauffer), traced from Lee 1975 pl. 1, fig. 14.
G : *Panderodus* sp., traced from Serpagli (1974) plate 24, fig. 12.
H : *Panderodus* sp., traced from Serpagli (1974) plate 24, fig. 13.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Carinae form lateral margins of the anterior faces and begin opposite the point of flexure extending up the cusp. Lateral faces of cusp are concave and are cut by wide and deep sulci that are widest along the basal margin and taper rapidly upwards becoming narrow opposite point of flexure. Anterior face of cusp possesses, in many specimens, a slight central ridge that fades out towards the base. Base and cusp "ornamented" by well developed striations that are easily observable under the optical microscope. The striations are parallel to the cusp axis and number between six and eight along the concave lateral faces. Striae are not present in a narrow zone along the aboral margin. The basal cavity is deep.

Comments:

If the synonymy of this element is correct then this species has been placed in both *Scolopodus* and *Panderodus*. Several species of *Scolopodus* (e.g. *S. asymmetricus* of Druce and Jones, 1971) are similar but all lack the well developed sulci cutting the aboral margin. This feature is typical of *Panderodus* species. General scolopodiform elements have been placed in *Protopanderodus* Lindström (1970a) who erected the genus to include "panderodids with a cusp higher than the base" which included many elements that had previously been brought to *Scolopodus* or *Acontiodus*. In *Protopanderodus* the "longitudinal striations of the cusp may be inconspicuous. The cross section of the cusp may be subcircular, comma-shaped or lanceolate or Acontiodus-like. Most species include symmetrical as well as asymmetrical elements but there are no oistodiform elements" (Lindström, 1970a, p.70). This is a very broad definition that has been slightly modified by Van Wamel (1974). The Tasmanian specimens are placed in *Panderodus* because of their overall similarity to other species in that genus.

Genus PHRAGMODUS, Branson and Mehl, 1933

Several workers (Sweet *et al.*, 1971; Votaw, 1971; Raring, 1972) have used multielement species of *Phragmodus* to zone the North American Middle Ordovician in a general way. Four important species have been recognized. These are in ascending order *P. flexuosus* Moskalenko, *P. inflexus*, *P. cognitus* and *P. undatus*. The last of these, *P. undatus* is easily recognized on the basis of its dichognathiform and oistodiform elements and is common in Tasmania. *P. flexuosus* Moskalenko is also common in Tasmanian limestones (Cashions Creek Limestone and correlates) but *P. cognitus* and *P. inflexus* have not been found.

PHRAGMODUS FLEXUOSUS Moskalenko, 1973

Figures 50 A-I, 51 A-P, 52 A-F

Synonymy:

?*Phragmodus undatus* (Branson and Mehl) ETHINGTON & SCHUMACHER, 1969, p.472, pl.67, fig.15.

Cyrtoniodus flexuosus (Branson and Mehl) ETHINGTON & SCHUMACHER, 1969, p.459, pl.67, fig.11.

Phragmodus sp. A. SWEET, ETHINGTON & BARNES 1971, pl.2, figs.3-6.

Phragmodus sp. MOSKALENKO, 1971, p.81, pl.13, fig.5.

Subcordylodus sinuatus Stuaffer, MOSKALENKO, 1971, p.88, pl.13, fig.4.

Phragmodus sp. nov. MOSKALENKO, 1972, Fig.1.

Phragmodus flexuosus MOSKALENKO, 1973, p.73-74, pl.11, figs. 4-6.

?*Subcordylodus sinuatus* MOSKALENKO, 1973, p.80-81, pl.12, figs.7-9.

Comments:

Phragmodus sp. nov. Sweet Ms. has been recognised by Votaw (1971) and Raring (1972) as being an important constituent of Chazyan faunas. Unfortunately the microfilms of the photographs in these theses available to the writer are not of sufficient quality to definitely identify the species. However from the descriptions given it seems very likely that *Phragmodus* sp. nov. Sweet Ms. does exist in Tasmania near to the base of the limestone at Mole Creek and elsewhere.

FIGURE 50 *Phragmodus flexuosus*

A-P: Elements of *P. flexuosus*, spec. UTG 96822, all x 120.
K-P: Dichognathiform element.

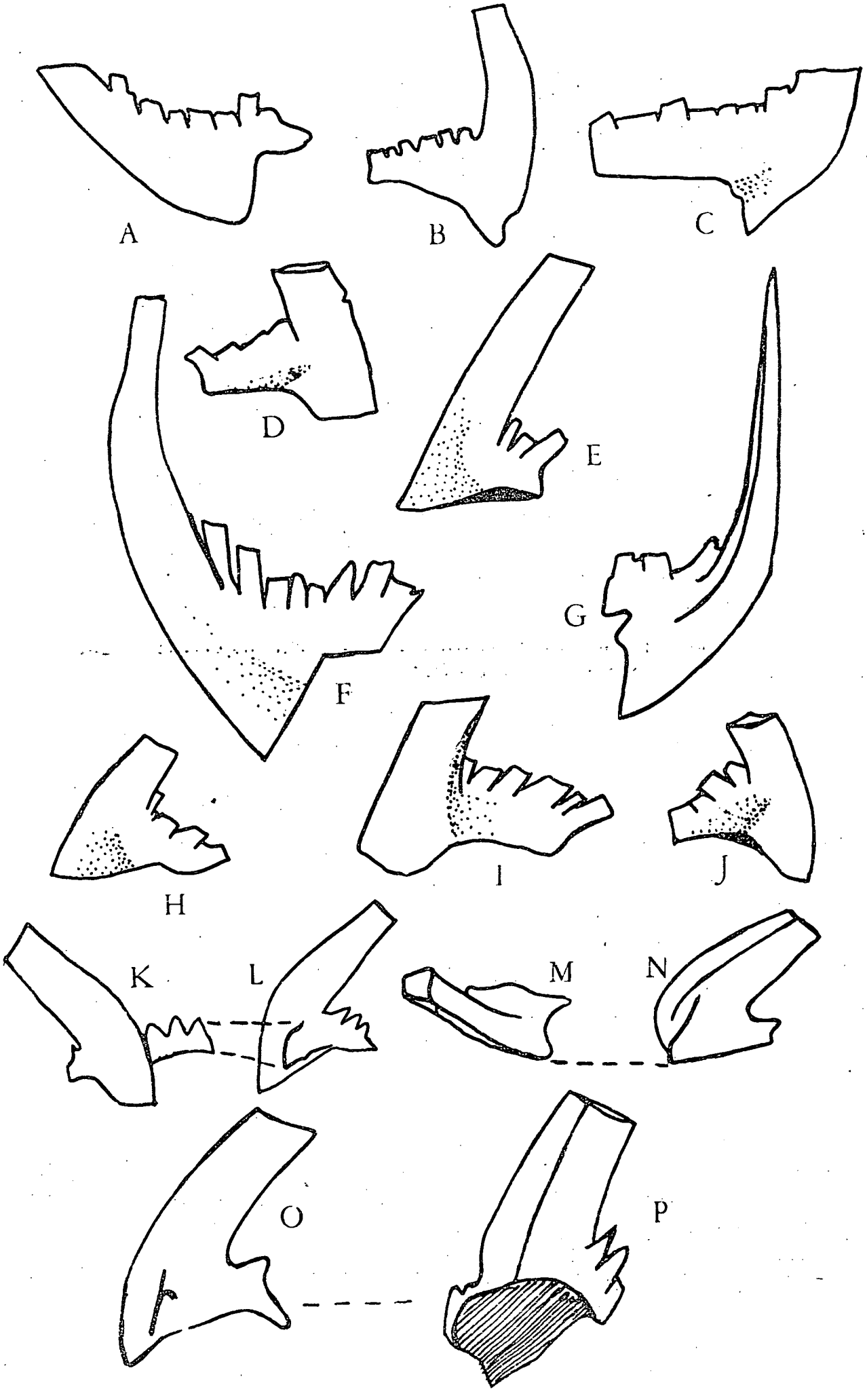
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FIGURE 51

Phragmodiform elements of *P. flexuosus*, spec. UTG 96823, all x 120.

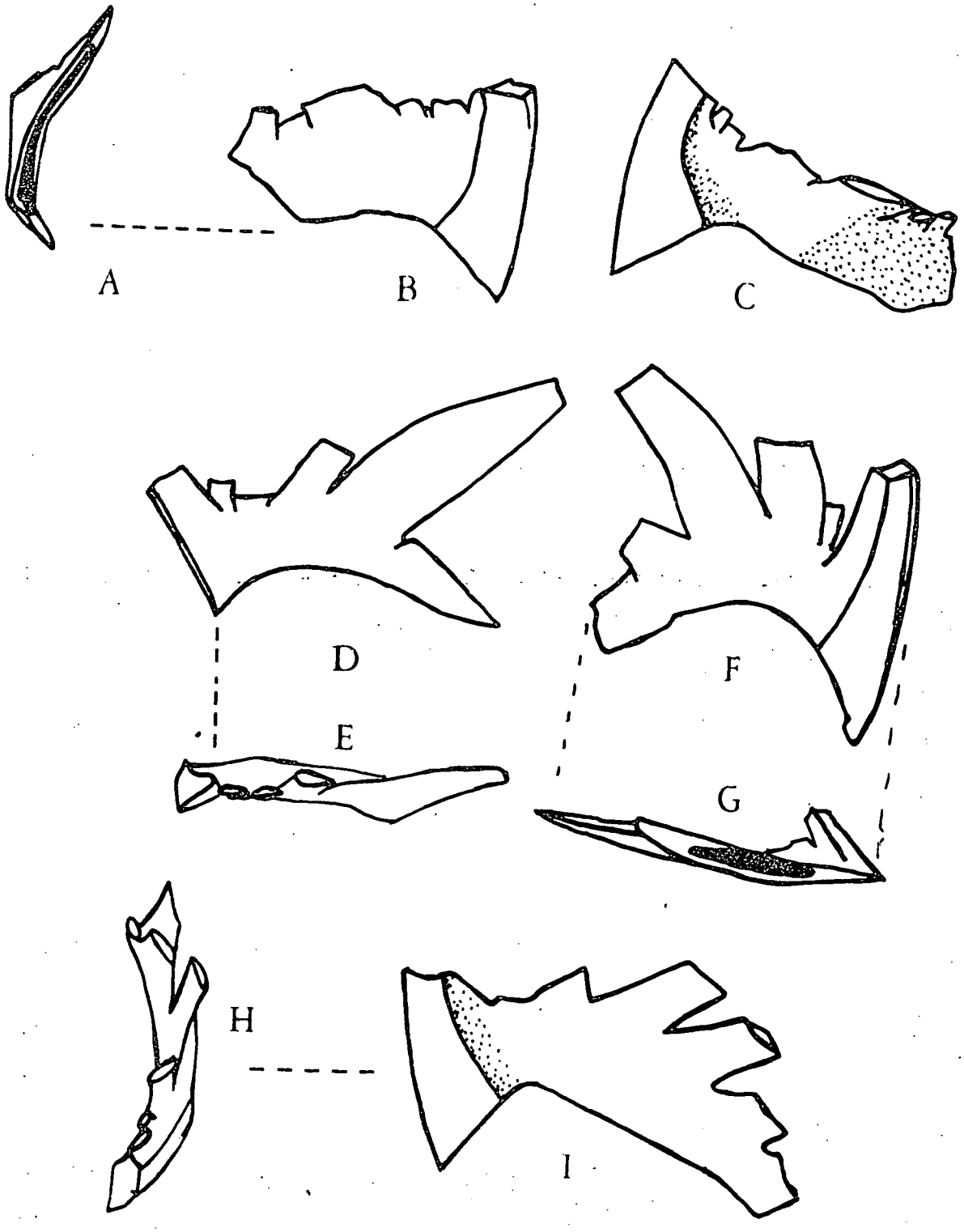
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FIGURE 52 *Phragmodus flexuosus*

A: phragmodiform element, spec. UTG 96983, x 150.
B: phragmodiform element, As A, x 200.
C: cordylodiform element, spec. UTG 96988, x 180.
D: cordylodiform element, spec. UTG 96992, x 150.
E: phragmodiform element, spec. UTG 96985, x 200.

A
B
C
D
E

76/4/87

Raring (1972, p.102) states that the phragmodiform element of *Phragmodus* sp. nov. Sweet Ms. is "distinguished by a large recurved cusp and a posterior process which is both twisted on its axis and deflected aborally." This is certainly true of the Tasmanian specimens (Fig.50A). The specimens of *P. flexuosus* illustrated in Moskalenko (1973) appear to be similar to the *Phragmodus* sp. nov. Sweet ms. in Raring (1972) and Votaw (1971) and the *Phragmodus* Sp. A in Sweet *et al.* (1971). The Tasmanian specimens differ from *P. flexuosus* Moskalenko in being apparently more flexed and in not being quite as elongate. There is no doubt, though, that the Tasmanian specimens (Figs. 48,50) are very similar to *P. flexuosus* from Siberia and *Phragmodus* sp. nov. Sweet from North America.

PHRAGMODUS TASMANIENSIS Burrett sp. nov.

Figures 53 A-C, 54 A-C

Diagnosis:

A species of *Phragmodus* consisting of phragmodiform, cyrtoniodiform and possibly dichognathiform elements. The phragmodiform element is short, slightly flexed, arched and usually carries between four and six denticles. Cyrtoniodiform element similar to that in *P. flexuosus* but may bear up to three small posterior denticles.

Description:

The phragmodiform element is short, strongly arched, very slightly flexed laterally and carries only a few denticles. The anterior cusp is asymmetric and variable in cross sectional shape. The outer margin is rounded but has a slight weakly developed central costa. The outer margin is rounded but has a sharp well defined costa running along

the anterior margin. The posterior process carries from four to six denticles with the main denticle being slightly twisted and directed strongly posteriorly forming an angle of about seventy degrees with the axis of the anterior cusp. Posterior process forms an angle of about fifty degrees with the axis of the anterior cusp. Major posterior denticle is broad at its base and is between 20-25% of the length of the element. It is biconvex with broadly rounded sides and sharp anterior and posterior edges. This denticle is flask shaped, narrows to about 50% of its height and then the sides are almost parallel for the rest of its height. Major posterior denticle separated from anterior cusp by one or two small denticles.

Basal cavity is deep with its apex probably being beneath the first posterior denticle. Actual depth of cavity is difficult to establish. Cavity continues under posterior process as a deep furrow taking up about 80% of the width of its base. The phragmodiform element may be distinguished from that of *P. flexuosus* in that it is short, relatively unflexed and carries few denticles.

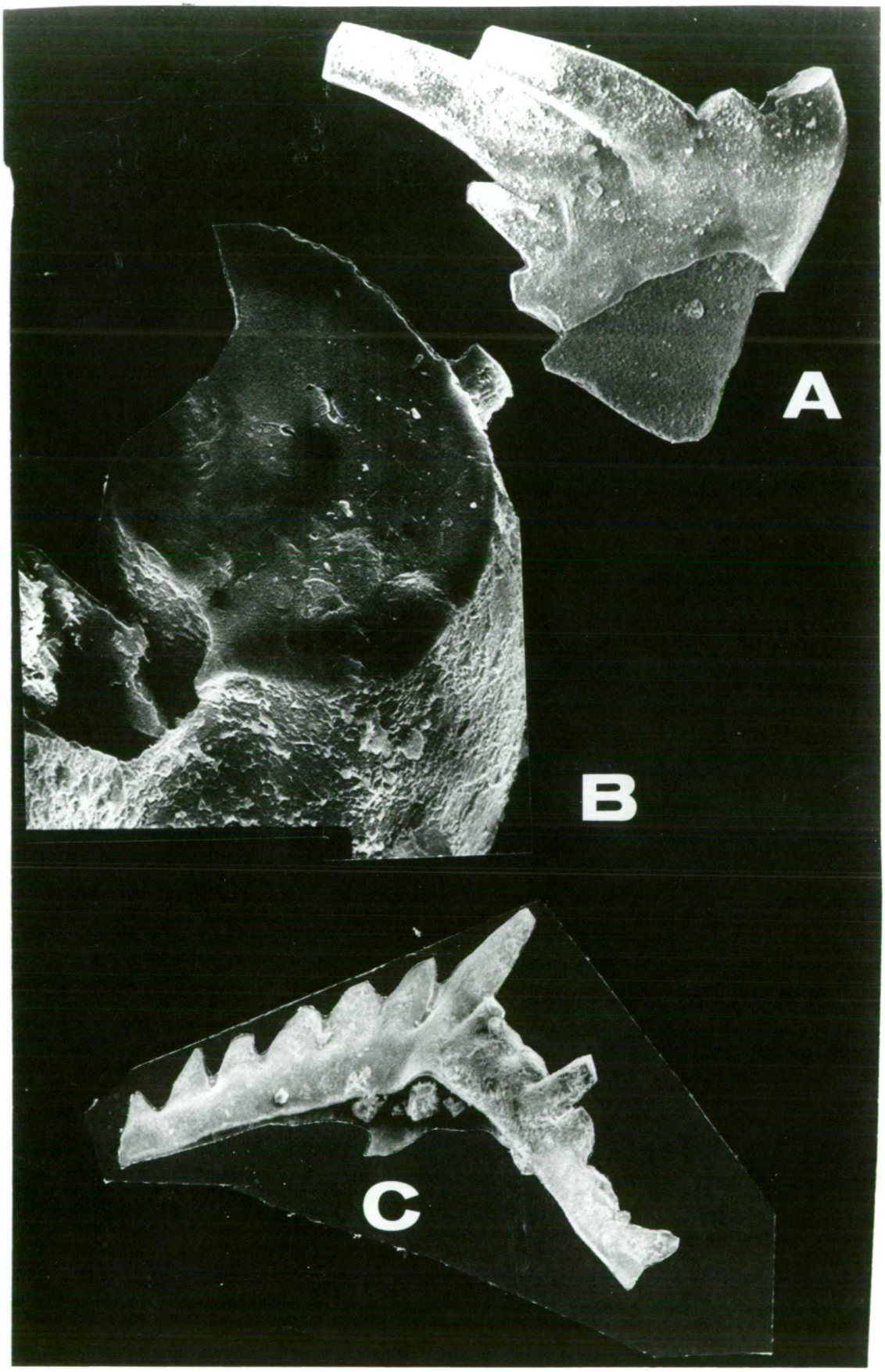
The cyrtoniodiform element is similar to that of *P. flexuosus*. A broad oistodus-like cusp that is deflected posterio-laterally and enlarges onto a broad base that is slightly elongated posteriorly The main cusp is elliptical in cross section being broadly rounded laterally with sharp edged anterior and posterior margins. The small posterior process carries from one to three small denticles. The first and second posterior denticles are about one-twentieth of the height of the main cusp. The first denticle abuts against the main cusp and is in contact with the main cusp and with the second denticle for most of its length. The third posterior denticle is about twice the height of the other denticles and is reclined forming an angle of

FIGURE 53 *Phragmodus tasmaniensis* sp. nov.

A: phragmodiform element with silicified basal cone, spec. UTG 96903, x 100 paratype

B: close-up of A showing cross section through main cusp, x 300.

C: dichognathiform element, spec. UTG 96855, x 100. paratype


A
B
C

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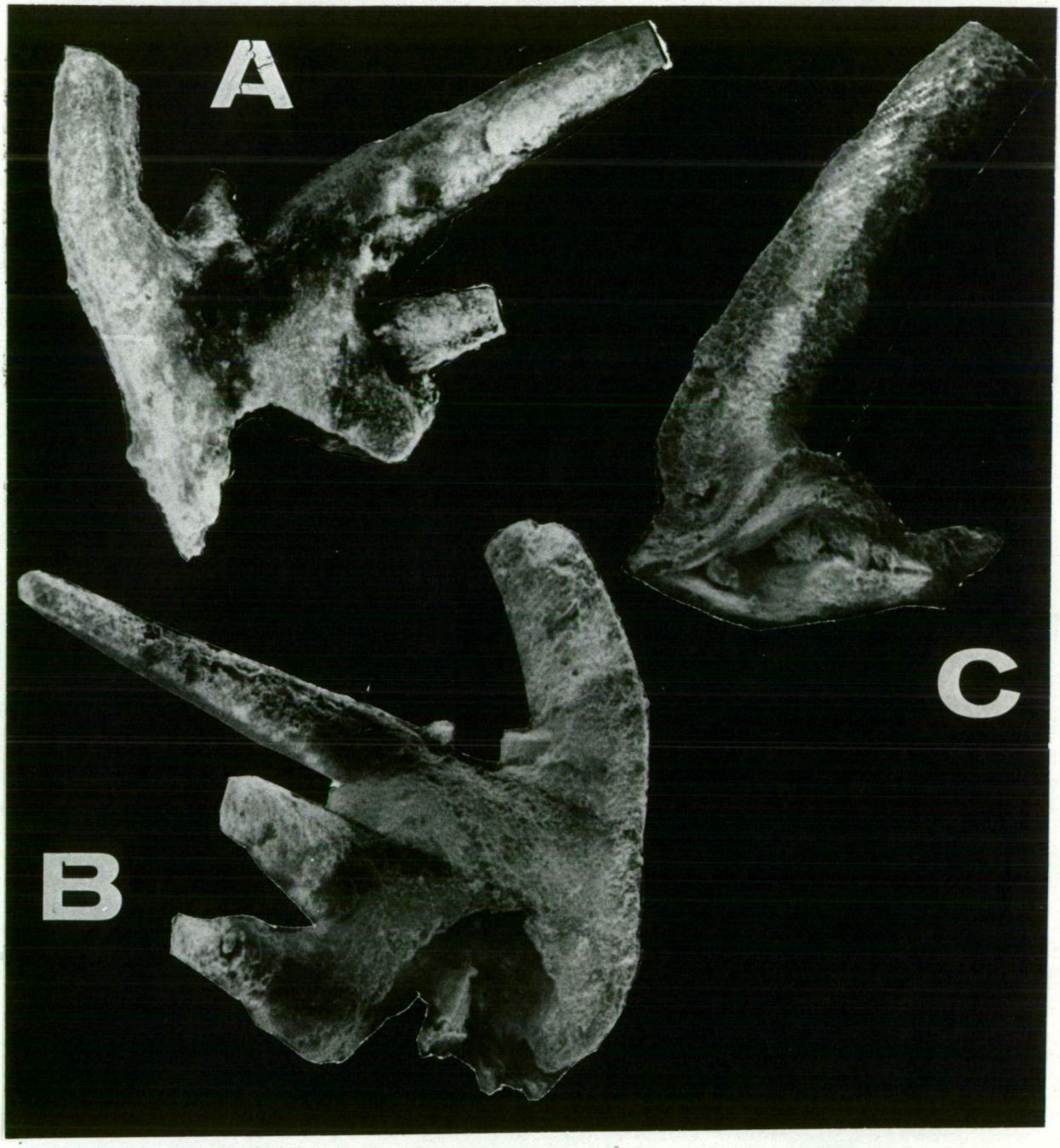


FIGURE 54 *Phragmodus tasmaniensis* sp. nov.

A: phragmodiform element, **paratype** spec. UTG 96858, x 95.
B: phragmodiform element, **paratype** spec. UTG 96859, x 125.
C: cyrtoniodiform element, **holotype** spec. UTG 96869, x 100.

about eighteen degrees with the main cusp. Basal cavity extends upwards for about 15% of the height of the element.

The dichognathiform element that consistently occurs with *P. tasmaniensis* sp. nov. may not belong in that species. *Rhipidognathus? careyi* sp. nov. also occurs in many samples with *P. tasmaniensis* and this dichognathiform element may belong in *R? careyi* or in some other species. As all *Phragmodus* species contain dichognathiform elements it is provisionally placed in *P. tasmaniensis*. The element is long, slightly arched with long slender denticles. The anterior process supports up to eight erect denticles. Only the proximal denticles are laterally confluent. The posterior process forms an angle of about 120° with the anterior process and supports up to seven denticles that are progressively more reclined distally. The anterior margin of the main cusp is continuous with the antero-lateral process that is only weakly developed in some specimens. The basal sheath flares more on the outer than the inner margin and confines a basal cavity that continues upwards to the base of the main cusp. The basal cavity continues as a narrowing groove almost to the ends of the processes.

PHRAGMODUS UNDATUS Branson and Mehl

Figure 55 A-F, 56 A-F

Synonymy:

for synonymy to 1966 see Bergström and Sweet (1966, pp. 369-370).

for synonymy 1966-1973 see Uyeno (1974).

P. undatus Branson and Mehl, PHILIP, 1966, figs. 5-7, 9.

P. undatus Branson and Mehl, SWEET ET AL., 1975, pl. 2, figs. 8, 12, 13.

Comments:

Typical representatives are common at many levels in the Gordon Subgroup from the Dog's Head Member and correlates to the top of the limestone sequences.

FIGURE 55 *Phragmodus undatus*

Phragmodiform elements.

A: spec. UTG 96996, x 150.
B: spec. UTG 96997, x 180.
C: spec. UTG 97041, x 100.
D: spec. UTG 97036, x 100.
E: spec. UTG 97001, x 100.
F: spec. UTG 97043, x 100.

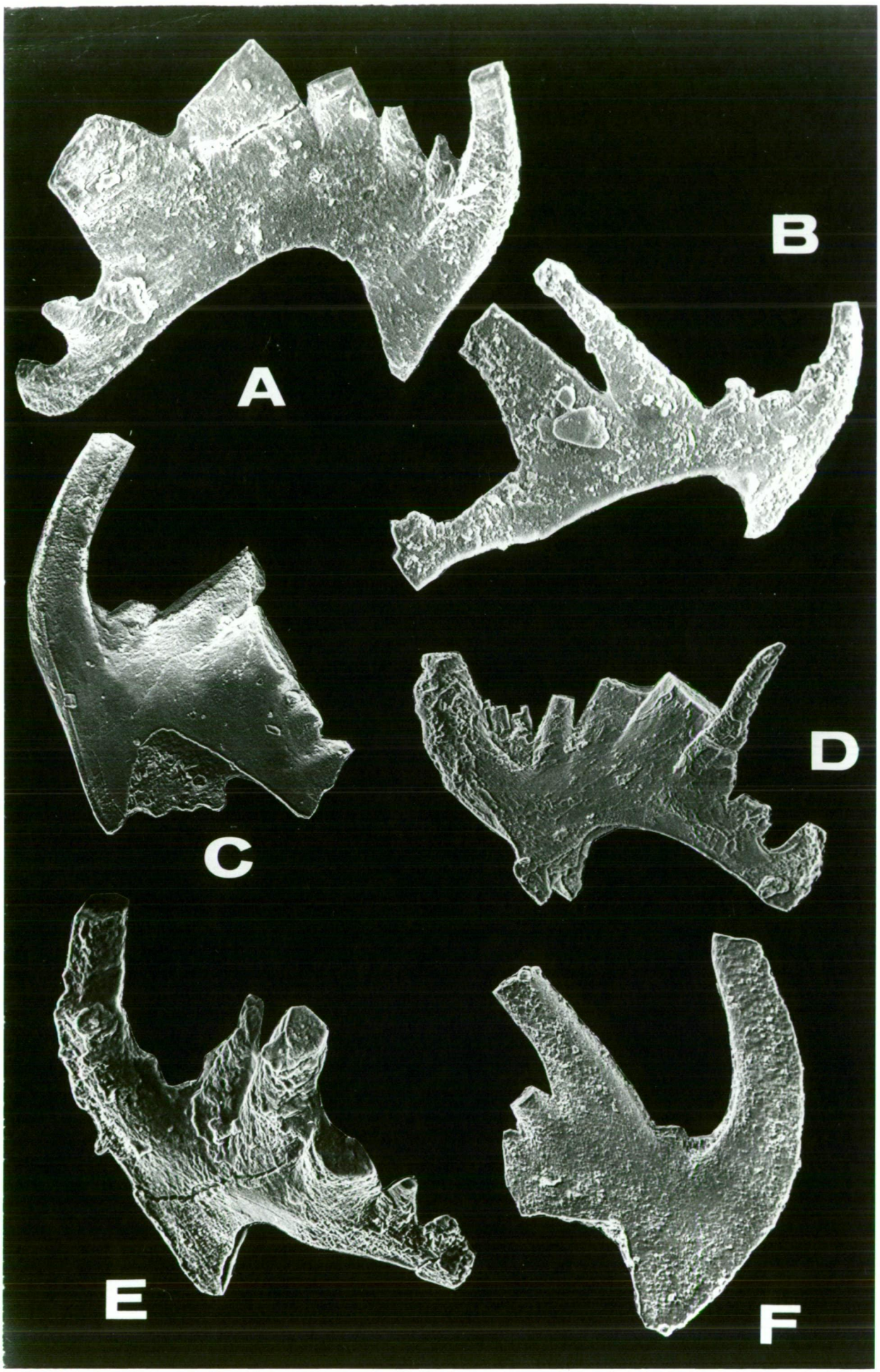
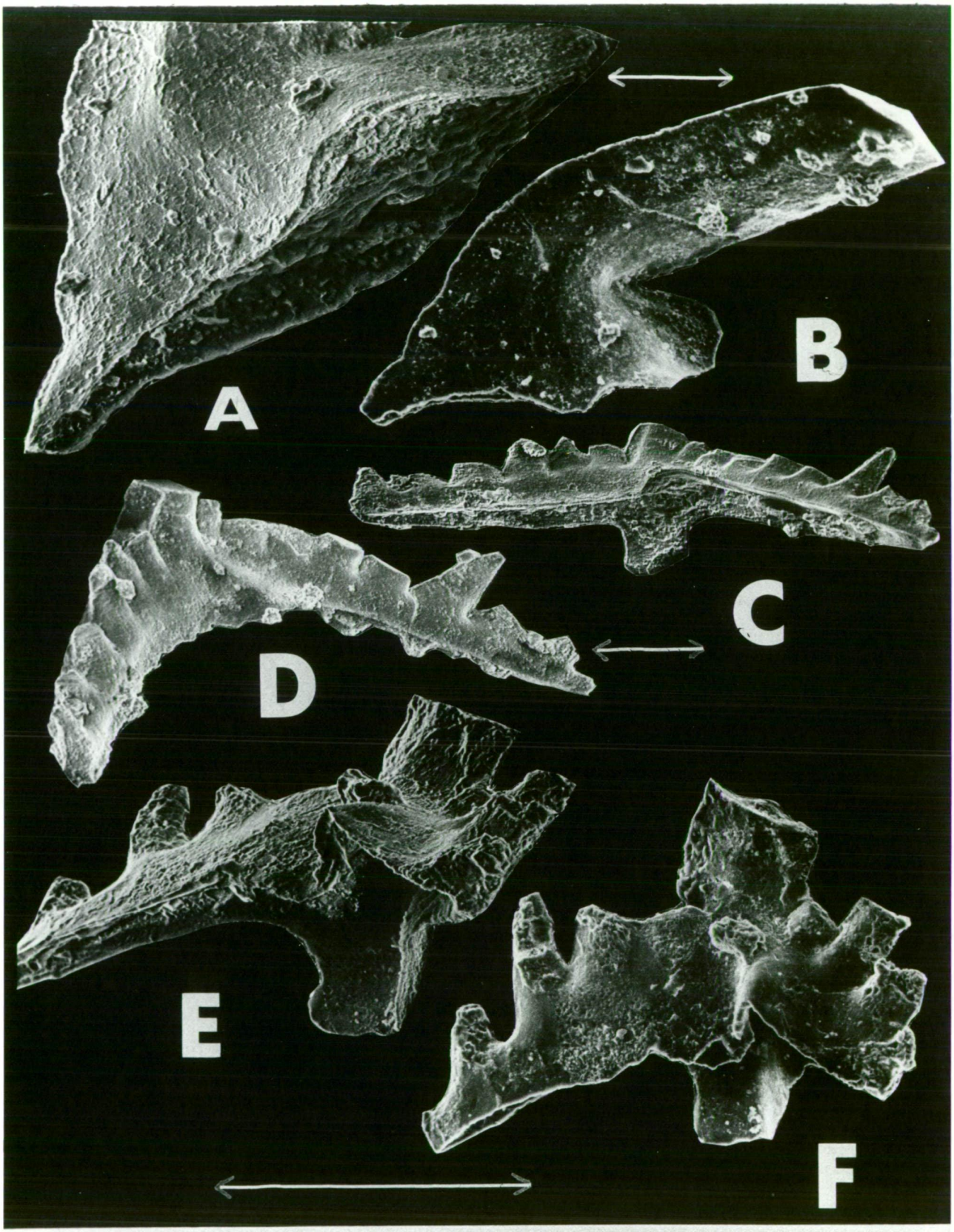

A
B
C
D
E
F

FIGURE 56 *Phragmodus undatus*

A: oistodiform element, spec. UTG 96921, x 250.
B: as A, x 125.
C,D: dichognathiform element, spec. UTG 97013, x 80.
E,F: spec. UTG 96921, x 100.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C
D
E
F

26/12/62

Genus PLECTODINA Stauffer 1935

Plectodina Stauffer (1935) is now defined as a multielement species based on the cordylodiform type of *Prioniodina aculeata* Stauffer 1930. An enormous number of trichonodelliform, cordylodiform, zygognathiform cyrtoniodiform, prioniodiniform, eoligonodiniform, dichognathiform and ozarkodiniform form species are now placed in a few species within this genus. Two species have been recognized in Tasmania - *P. aculeata*, *P. furcata*.

Bergström and Sweet (1966, p.380) differentiate *P. aculeata* from *P. furcata* by:

(a) process denticles tend to be laterally compressed and confluent in *P. furcata* whereas in *P. aculeata* they tend to be discrete and peglike in at least advanced growth stages.

(b) antero-lateral denticles in cordylodiform and posterior denticles in trichonodelliform elements develop only in large *P. furcata* whereas even juvenile stages bear such denticles in *P. aculeata*.

(c) *P. furcata* possesses prioniodiniform elements whereas they are apparently absent in *P. aculeata*.

Other elements have since been placed in *P. aculeata* and *P. furcata* by Sweet and Bergström (1972) and Uyeno (1974). In particular prioniodiniform elements are now included in *P. aculeata*.

PLECTODINA ACULEATA (Stauffer)

Figs. 57 A-F, 58

Synonymy:

Prioniodus aculeatus Stauffer, 1930, p.126, pl.10, fig.12.

synonymy up to 1966 is found in Bergström and Sweet (1966).

Plectodina aculeata (Stauffer), BERGSTRÖM and SWEET, 1966, pp.373-377, pl.32, figs.15-16; pl.33, figs.22-23; pl.34, figs.5, 6; Text fig. 9 A-F.

Cyrtoniodus flexuosus (Branson and Mehl), BERGSTRÖM and SWEET, 1966, pp.324-327, pl.32, fig.11 only.

Ozarkodina obliqua (Stauffer), BERGSTRÖM and SWEET, 1966, pp.348-351, pl.33, figs.6-9; pl.24, figs. 7, 8; text fig. 10 A-F.

Trichonodella recurva (Branson and Mehl), OBERG, 1966, p.143, pl.15, figs. 5, 26.

Trichonodella tenuis (Branson and Mehl), OBERG, 1966, p.144, pl.15, fig.9.

Zygognathus ? sp. cf. Z? abnormis Branson, Mehl and Branson, OBERG, 1966, p.145, pl.15, fig.24; pl.16, fig. 8, 15.

Zygognathus deformis (Stauffer), OBERG, 1966, p.145, pl.15, fig.18.

Zygognathus pyramidalis Branson, Mehl and Branson, OBERG, 1966, pl.15, fig.13.

Cyrtoniodus complicatus Stauffer, OBERG, 1966, v.40, p.137, pl.15, figs.4, 10.

Ozarkodina concinna Stauffer, OBERG, 1966, p.140, pl.15, fig.15.

Prioniodina delecta (Stauffer), OBERG, 1966, p.141, pl.15, fig.7; pl.16, fig.7.

Subcordylodus delicatus (Branson and Mehl), OBERG, 2966, p.141-142, pl.15, fig.21.

Subcordylodus plattinensis (Branson and Mehl), OBERG, 1966, p.142, pl.16, fig.12.

Trichonodella? sp. OBERG, 1966, p.144, pl.16, fig.18.

Trichonodella exacta Ethington, OBERG, 1966, p.143, pl.15, fig.11; pl.16, fig.9.

?Eoligonodina richmondensis Branson, Mehl and Branson, ANDREWS, 1967, pp.889-890, pl.113, fig.20.

Prioniodina? delecta (Stauffer), ANDREWS, 1967, p.898.

Eoligonodina prima (Branson and Mehl), ANDREWS, 1967, p.889, pl.113, figs.8, 22.

Subcordylodus delicatus (Branson and Mehl), ANDREWS, 1967, p.889, pl.113, figs. 12, 13, 23.

Trichonodella sp., ANDREWS, 1967, pp.899-900, pl.113, fig.19; pl.114, fig.17.

Zygognathus sp., ANDREWS, 1967, p.900, pl.113, fig.2; pl.114, fig.20.

?Cordylodus concinnus (Branson and Mehl), BARNES, 1967, p.236.

?Cordylodus delicatus Branson and Mehl, BARNES, 1967, p.236.

?Eoligonodina robusta Branson, Mehl and Branson, BARNES, 1967, p.236.

?Prioniodina robusta (Stauffer), BARNES, 1967, p.236.

Trichonodella sp., BARNES, 1967, p.236.

?Zygognathus cf. *Z. maysvillensis* Pulse and Sweet, BARNES, 1967, p.236.

Plectodina aculeata (Stauffer), SWEET and BERGSTRÖM, 1970, p.167.

Plectodina aculeata (Stauffer), SWEET, ETHINGTON and BARNES, 1971, pl.2, figs.12-14.

Plectodina aculeata (Stauffer), SWEET and BERGSTRÖM, 1972, p.36, fig.4F.

Plectodina aculeata (Stauffer), UYENO, 1974, no.248, pl.2, figs. 1-26.

Comments:

A relatively large number of elements that are very similar to American specimens have been found in Tasmania. They differ from illustrated North American forms in a few small details but the erection of a new species is probably not warranted.

FIGURE 57 *Plectodina aculeata*

A: zygognathiform element, spec. UTG 97007, x 100.
B: zygognathiform element (early growth stage), spec. UTG 97004, x 160.
C: cordylodiform/prioniodiniform element (early growth stage), spec. UTG 97005, x 180.
D: as B.
E,F: trichonodelliform element, spec. UTG 97012; E, x 250; F, x 100.

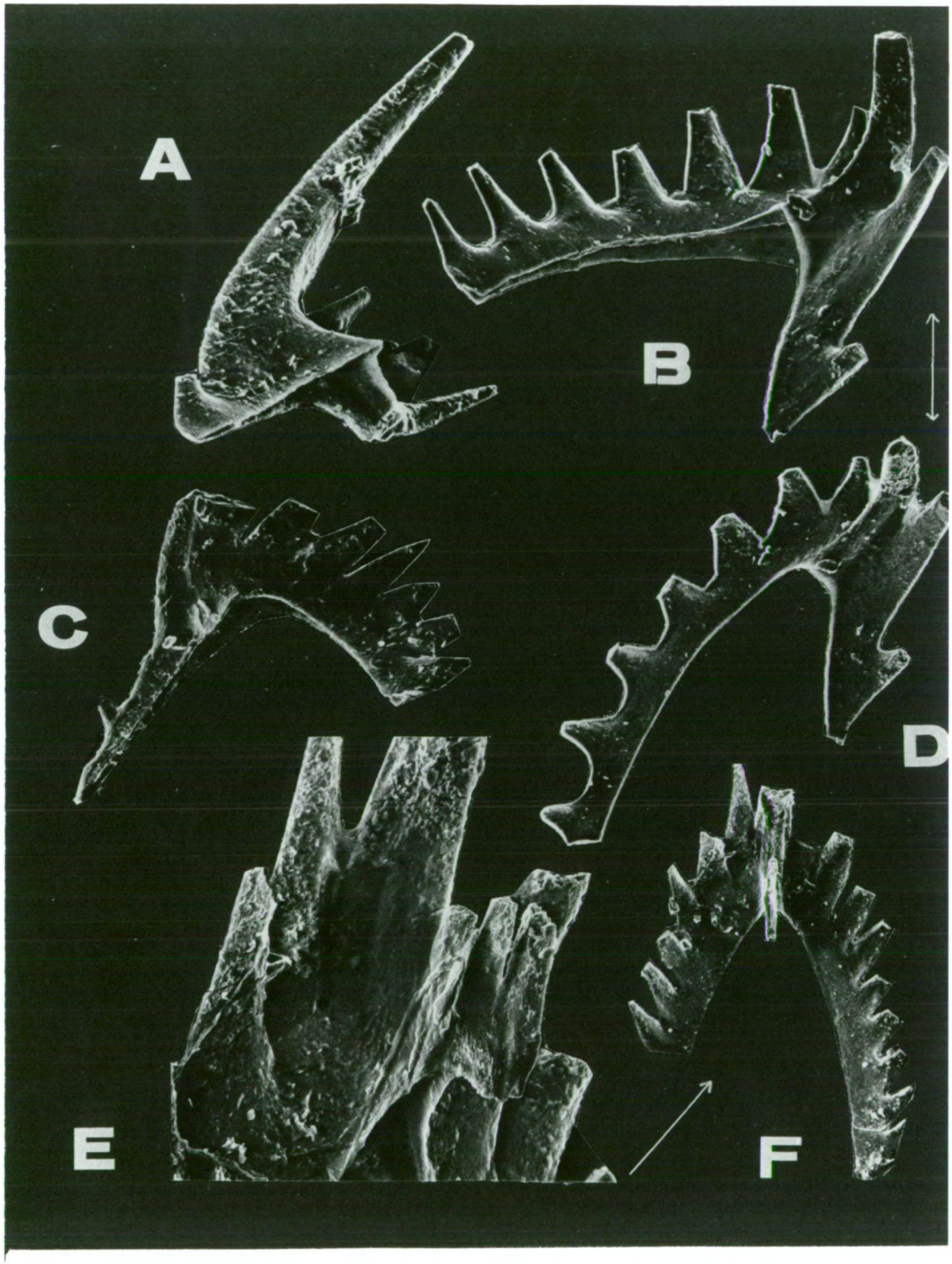
A
B
C
D
E
F

FIGURE 58 *Plectodina aculeata*

A,B: Zygognathiform element, stereopair spec. UTG 97006, x 135.

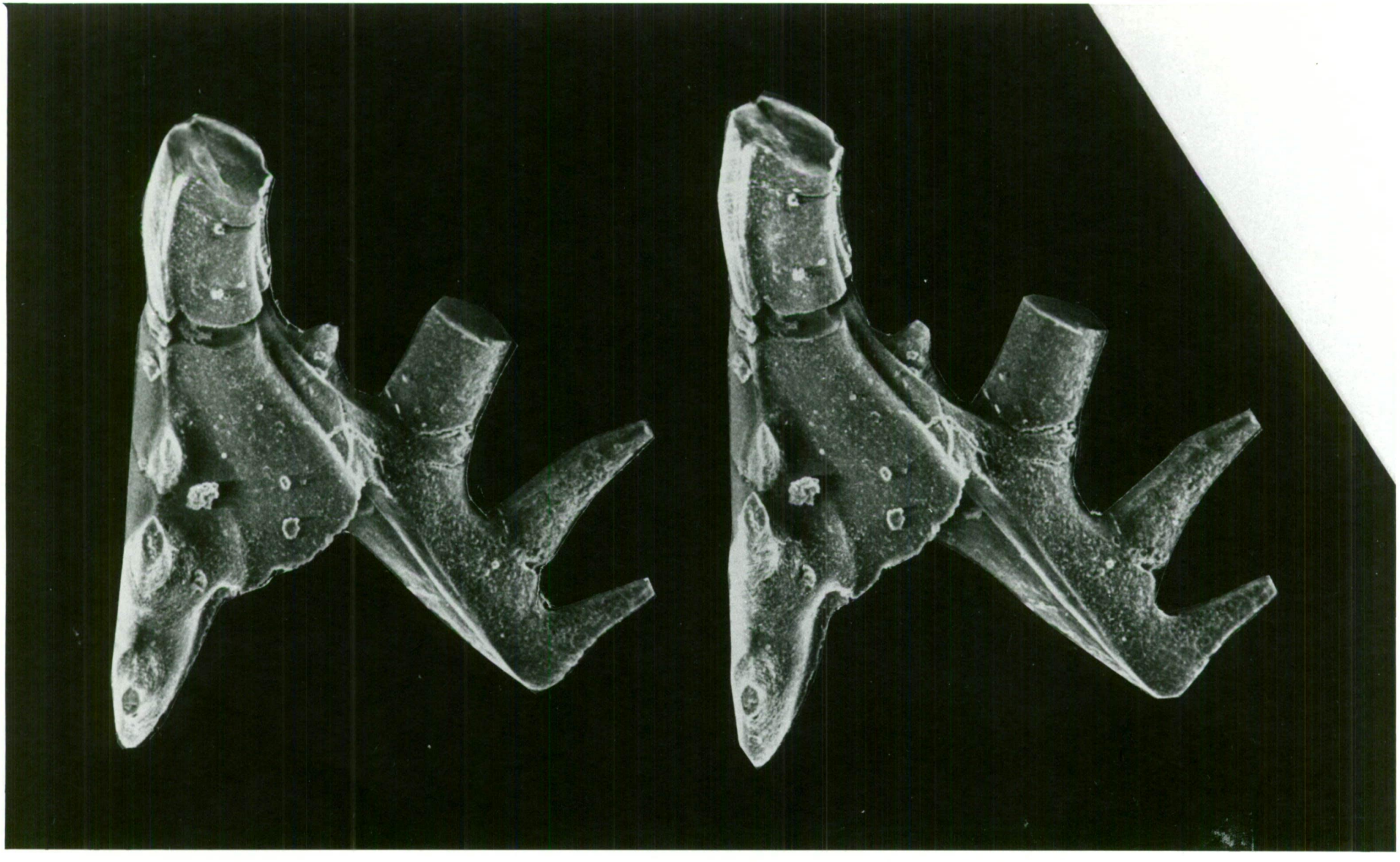

FIGURE 58 *Plectodina aculeata*

A,B: zygognathiform element stereopair x 135 from sample MC64, Mole Creek.

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PLECTODINA FLORENTINENSIS Burrett sp. nov.

Figure 59 A-D

Diagnosis:

A *Plectodina* consisting of at least trichonodelliform and zygognathiform/eoligonodiniform elements. The trichonodelliform element has two lateral processes that meet beneath the cusp at an angle of not less than 120° and generally the angle is larger.

Description:

The trichonodelliform element has two long lateral processes that meet beneath the main cusp at an angle of not less than 120° (in a vertical plane). The process denticles are short and round to sub-quadrate in cross section. The process denticles are between one-fifth and one-tenth of the height of the main cusp and are smallest proximally. The main cusp is long recurved and approximately circular in cross section. The anterior margin of the main cusp is rounded and forms a "step" along the lateral margins of the cusp. This step is confluent with the proximal process denticles. The posterior margin is rounded with a radius substantially less than that needed to draw the anterior margin of the cusp. The centre of the face is defined by a prominent carina that extends the full height of the cusp and continues onto the basal sheath. Well defined grooves, each flanked by two converging costæ extend from the postero-lateral face of the cusp onto the shoulders of the lateral processes extending as far as the third lateral denticles. The basal sheath flares slightly posteriorly and encloses a shallow basal cavity. The basal cavity narrows rapidly under the lateral processes and reaches to about the fourth lateral denticles. In mature specimens the basal sheath is elongated posteriorly into a narrow, smooth lappet.

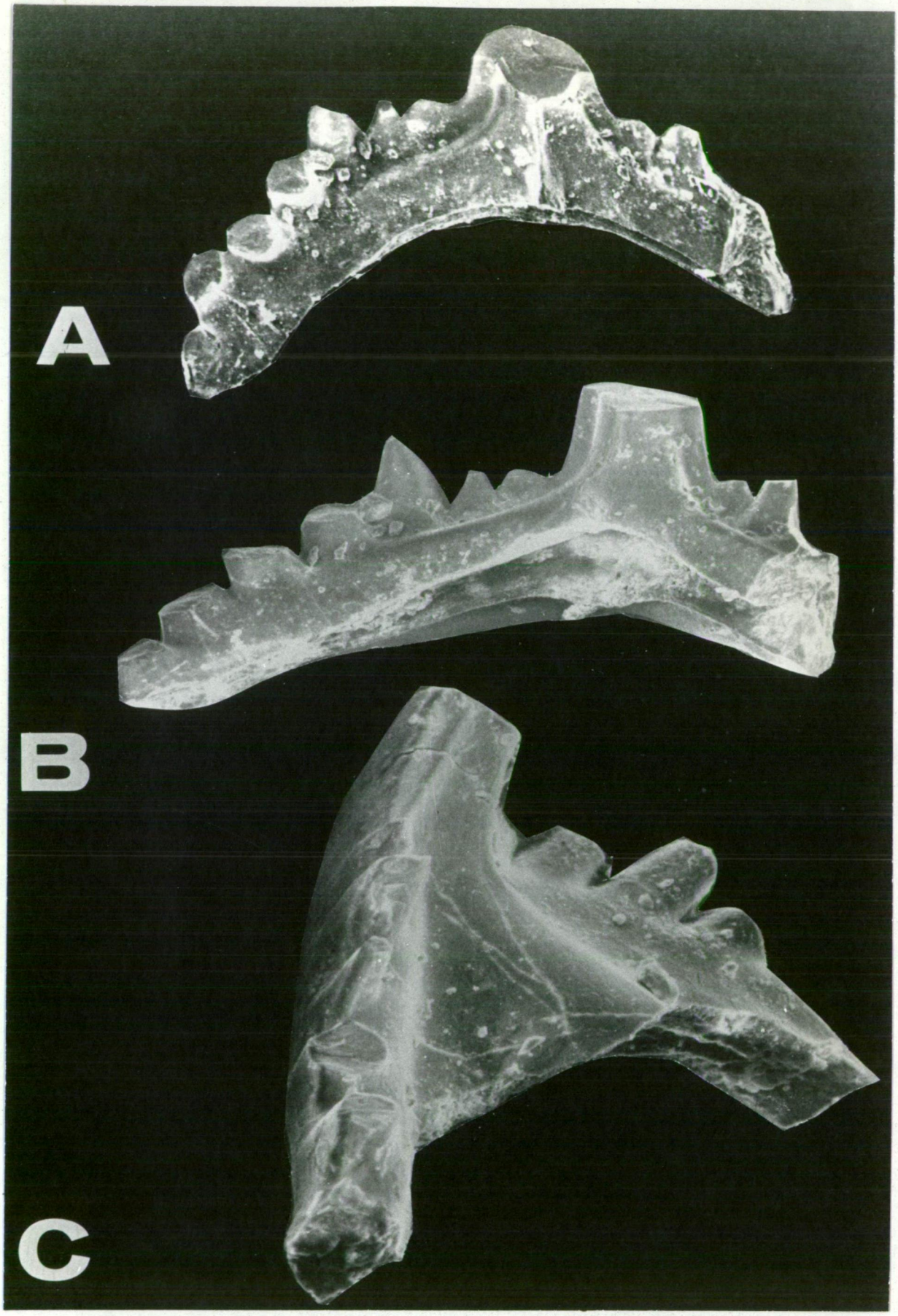
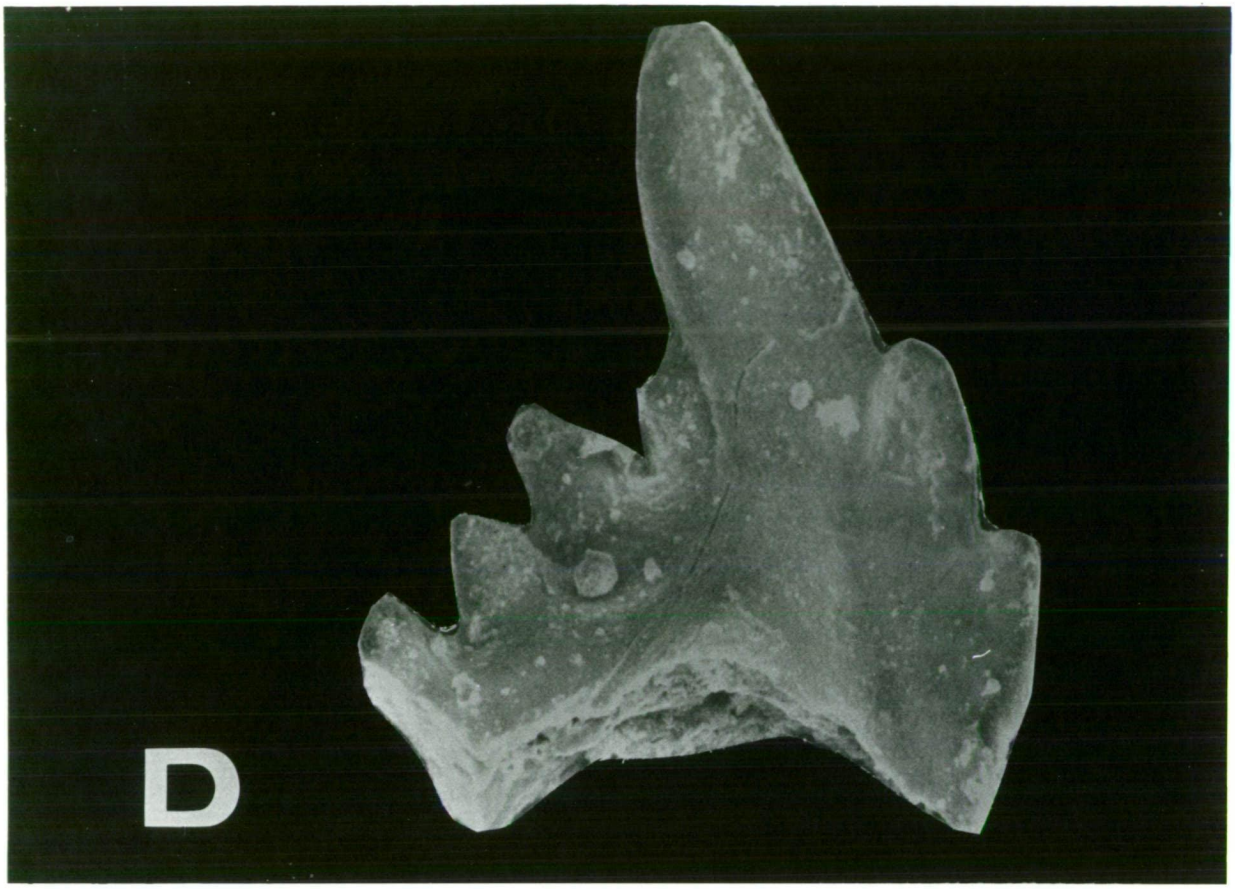


FIGURE 59 *Plectodina florentinensis*

A: trichonodelliform element, spec. UTG 96940 holotype, x 60.
B: same specimen, x 80.
C: zygognathiform element, spec. UTG 96941 paratype, x 180.
D: (next page) prioniodiniform element, spec. UTG 96944. paratype


D

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The zygognathiform (and eoligonodiniform) elements are robust and bear similar denticles to those in the trichonodelliform elements. The basal sheath flares strongly posteriorly enclosing a wide basal cavity that extends as a wide groove along the lateral processes. The slightly recurved cusp is round in cross section and, as in the trichonodelliform elements, has downwardly narrowing grooves each flanked by two costae running along the lateral faces of the cusp. The costae converge just proximally of the first lateral denticles.

Comments:

Only a few specimens have been found. They are associated with robust prioniodiniform elements but these may belong in another species. The similarities between the denticulation and costation of the two elements strongly suggest an intimate association. The trichonodelliform element is very distinctive though its costate, recurved cusp is similar to that of *P. robusta*.

PLECTODINA CF. FURCATA (Hinde)

Figures 60 A-D, 61 A-C, 62 A-C

Synonymy:

Prioniodus furcatus HINDE, 1879, p.358, pl.15, fig.13.

Eoligonodina richmondensis, BRANSON, MEHL and BRANSON, 1951, p.15, pl.4, figs.23-27.

Plectodina furcata (Hinde), BERGSTRÖM and SWEET, 1966, pp.377-382, pl.32, figs.17-19; pl.33, figs.1-4, 14-21; pl.34, figs.9-12; Text fig. 9M- (includes synonymy 1879-1966 inclusive).

?Cordylodus delicatus Branson and Mehl, WINDER, 1966, pl.10, fig.12.

?Cordylodus flexuosus (Branson and Mehl), WINDER, 1966, pl.10, fig.16.

Ozarkodina concinna Stauffer, WINDER, 1966, pl.10, fig.22.

Prioniodina delecta (Stauffer), WINDER, 1966, p.60, pl.10, fig.26.

Trichonodella exacta Ethington, WINDER, 1966, pl.10, fig.14.

Trichonodella flexa Rhodes, WINDER, 1966, pl.10, fig.15.

Zygognathus deformis (Stauffer), WINDER, 1966, pl.10, fig.13.

Plectodina furcata richmondensis (Branson, Mehl and Branson), KOHUT and SWEET, 1968, pp.1470-1471, pl.186, figs.7-8.

Plectodina furcata (Hinde), SWEET, ETHINGTON and BARNES, 1971, pl.1, figs.7-11.

Comments:

Many elements of forms similar to *P. furcata* have been found and are distinguished from *P. aculeata* mainly by the absence of posterior denticulation in the trichonodelliform elements. Kohut and Sweet (1968) note that the cordylodiform element (*P. richmondensis*) that they place in *P. furcata richmondensis* is similar, in its antero-lateral denticulation, to the cordylodiform elements of *P. aculeata*.

In their detailed discussion of *Plectodina furcata* Bergström and Sweet (1966) included cordylodiform, trichonodelliform, zygognathiform and prioniodiniform elements. The stratigraphically older *Plectodina aculeata* did not include prioniodiniform elements. Uyeno (1974, p.16) extended the *P. aculeata* to include elements referred to *Cyrtoniodus flexuosus* (Branson and Mehl) and *Ozarkodina? obliqua* (Stauffer) by Bergström and Sweet (1966). The ozarkodiniform elements figured by Uyeno (1974, plate 2, figs. 14-17, 20-21) are, as he states, very similar to *Ozarkodina polita*. As with *P. aculeata* the Tasmanian specimens are not identical in every respect with the figured elements from North America but the differences are not considered sufficiently large to justify the erection of a new species.

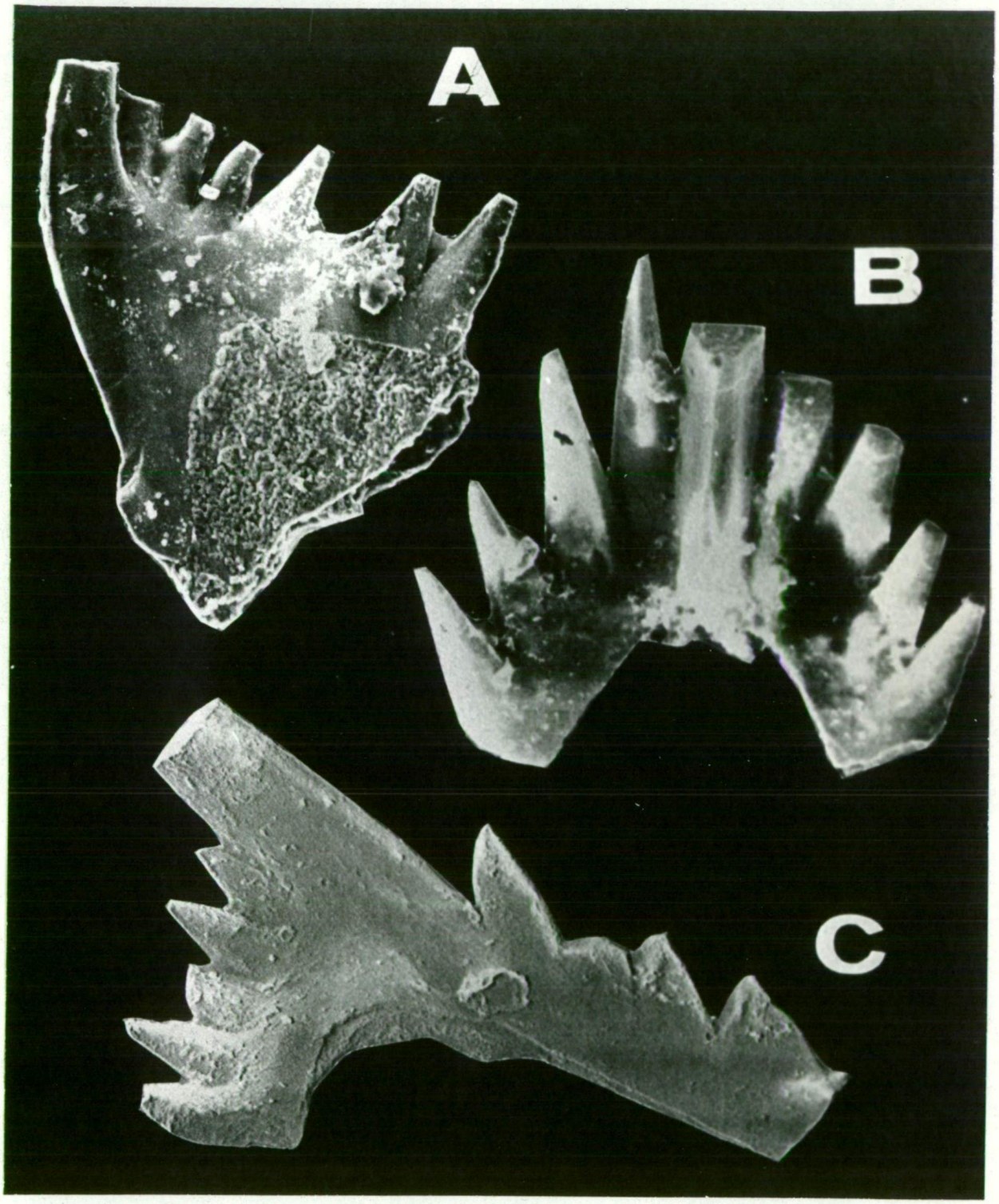
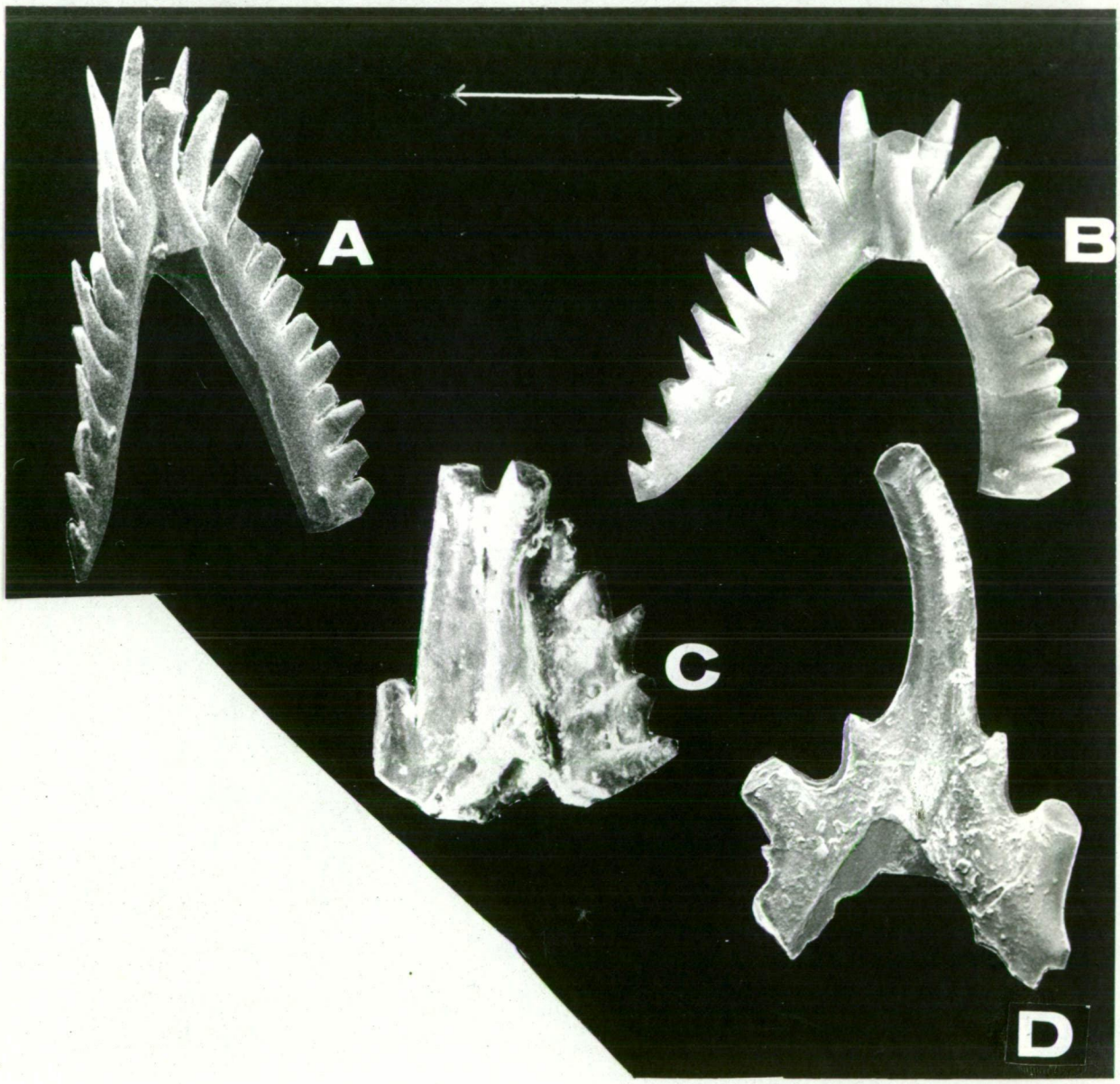


FIGURE 60 *Plectodina* cf. *furcata*

A: Cordylodiform element, spec. UTG 96926, x 150.
B: Trichonodelliform element, spec. UTG 96926B, x 100.
C: Prioniodiniform element, spec. UTG 97042.

FIGURE 61 *Plectodina* cf. *furcata*

A,B: trichonodelliform element, spec. UTG 97039, x 130.
C : zygognathiform element, spec. UTG 97034, x 120.
D : immature zygognathiform element, spec. UTG 96894, x 110



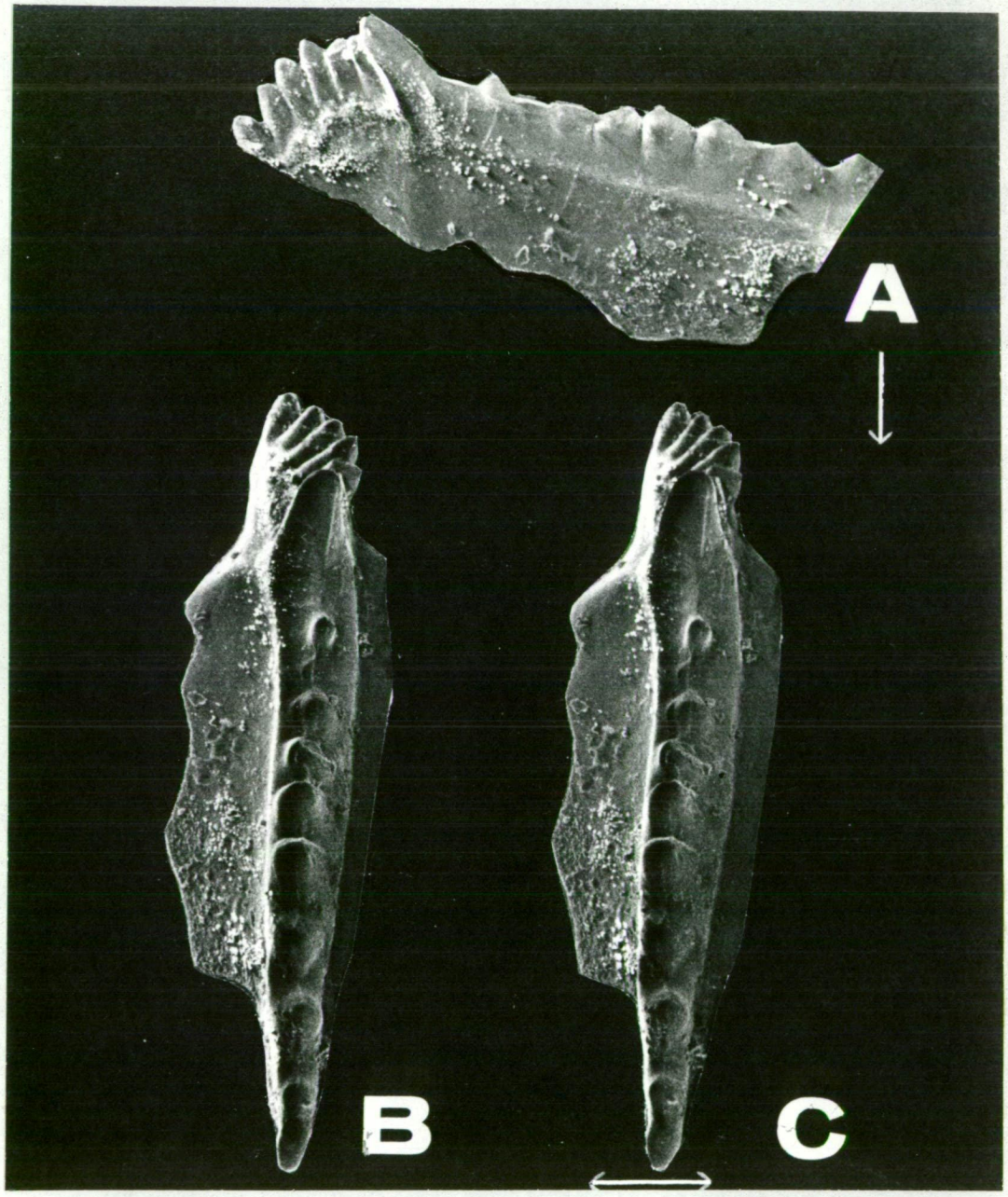


FIGURE 62 *Plectodina* cf. *furcata*

Mature ozarkodiniform element with basal cone preserved, spec. UTG 96549.

A: oblique lateral view.
B,C: stereopair. x 120

Genus RHIPIDOGNATHUS Branson, Mehl & Branson, 1951.

Rhipidognathus has been discussed by Bergström and Sweet (1966). Following Branson, Mehl and Branson (1951) they included trichonodelliform, ozarkodiniform and prioniodiniform elements within the genus. They note that in some species of *Rhipidognathus* "germ denticles" are formed whereas in others (e.g. *R. symmetrica discreta*) no such tendency is observed. They find that in known species "a short segment of the lower edge of the outer (anterior) side of all elements tends to develop into a distinct downwardly directed boss beneath the cusp; on the inner (or posterior) side, these elements develop a ridgelike swelling just above the margin of the base". Bergström and Sweet (1966) observe that elements of *R. symmetrica symmetrica* are separated by their extreme fragility, profuse process denticulation and overgrowth of juvenile denticles.

Prioniodiniform elements similar to those in subspecies of *R. symmetrica* are abundant in two samples from the Everlasting Hills and are present in samples from the Lower Limestone Member in the Florentine Valley. They are associated with trichonodelliform, cordylodiform and ozarkodiniform elements. These elements are placed in *Rhipidognathus* because

(a) there is a strong tendency for the development of germ denticles (as in *R. symmetrica symmetrica*).

(b) an anterior (or outer) downwardly directed boss is developed in most elements.

(c) the specimens are very fragile (as in *R. symmetrica symmetrica*).

(d) there is the development of a ridgelike swelling just above the margin of the base of the inner (or posterior) sides.

If this generic assignment is correct then the evolution of this genus is probably more complex than that tentatively put forward by Bergström and Sweet (1966). They note that species of *Rhipidognathus* are known from the Hermitage of Tennessee (of Kirkfieldian age). The Tasmanian material would place the origin of *Rhipidognathus* within or before the Blackriveran.

RHIPIDOGNATHUS? CAREYI Burrett, sp. nov.

Figure 63 A-E, 64 A-F, 65 A-G, 66 A-G, 67 A-D, 68 A-E

Diagnosis:

R? careyi consists of prioniodiniform, ozarkodiniform, cordylodiform, trichonodelliform, zygognathiform elements. Prioniodiniform elements have a distinct downwardly directed outer lateral boss and strongly reclined and slightly curved cusp. The anterior process is usually much higher and much longer than the posterior. The ozarkodiniform element is straight with the anterior process being distinctly higher and slightly longer than the posterior process. Some of the trichonodelliform elements have a downwardly directed anterior boss, a denticulate posterior process that is triangular in plan view and a cusp that has a pronounced posterior costa. Dichognathiform elements may also be present.

Description:

The prioniodiniform elements of *R. careyi* exhibit considerable ontogenetic variation (Fig.64). Morphologically they are similar to the prioniodiniform elements of *R. discreta* and *R. symmetrica* and, as in the latter species, the cusp and denticles grow by incorporating adjacent denticles. This is clearly seen in Figure 68 B and C where the first anterior denticle has been incorporated into the main cusp. The prioniodiniform element is slightly arched to straight. The anterior

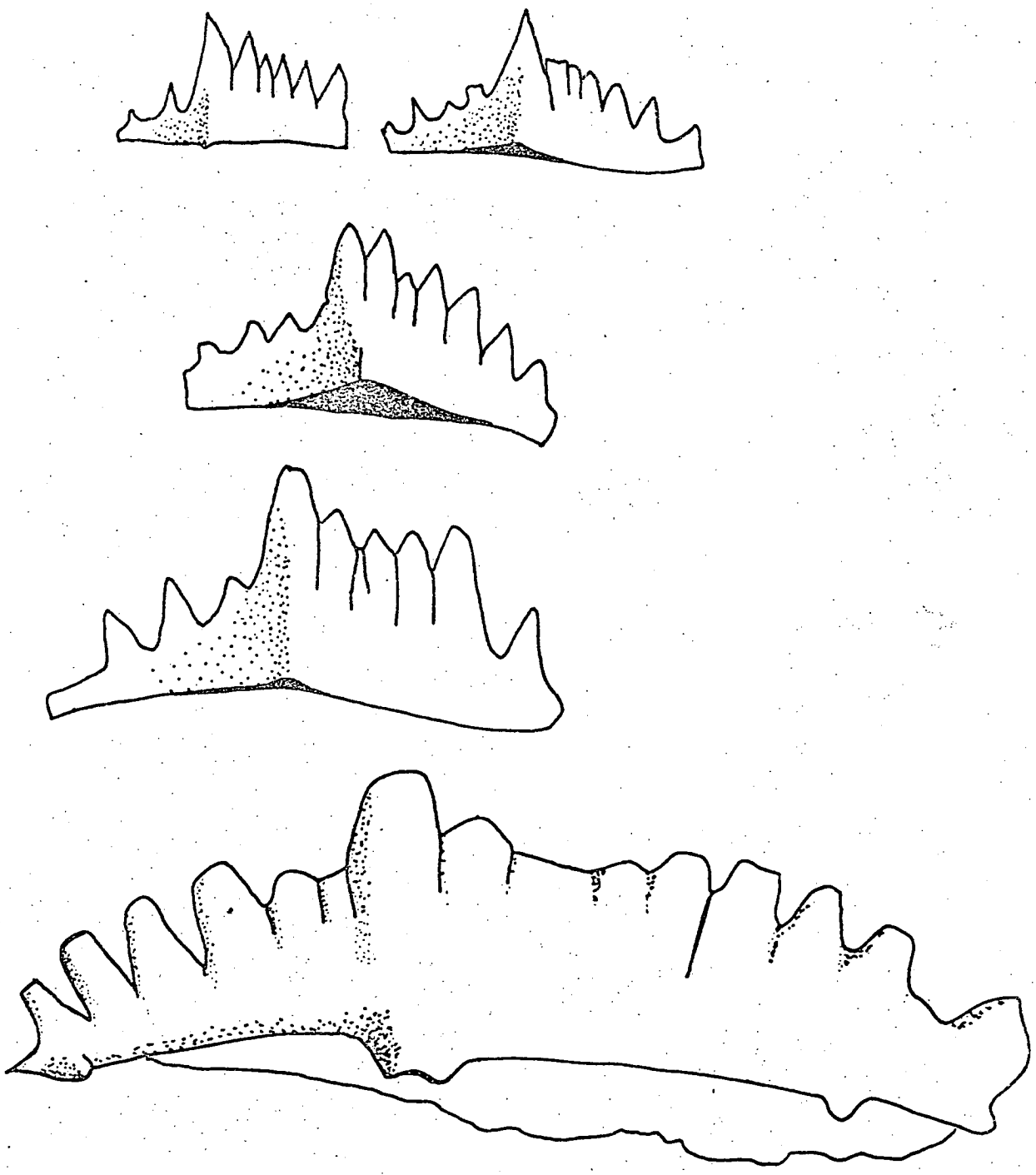


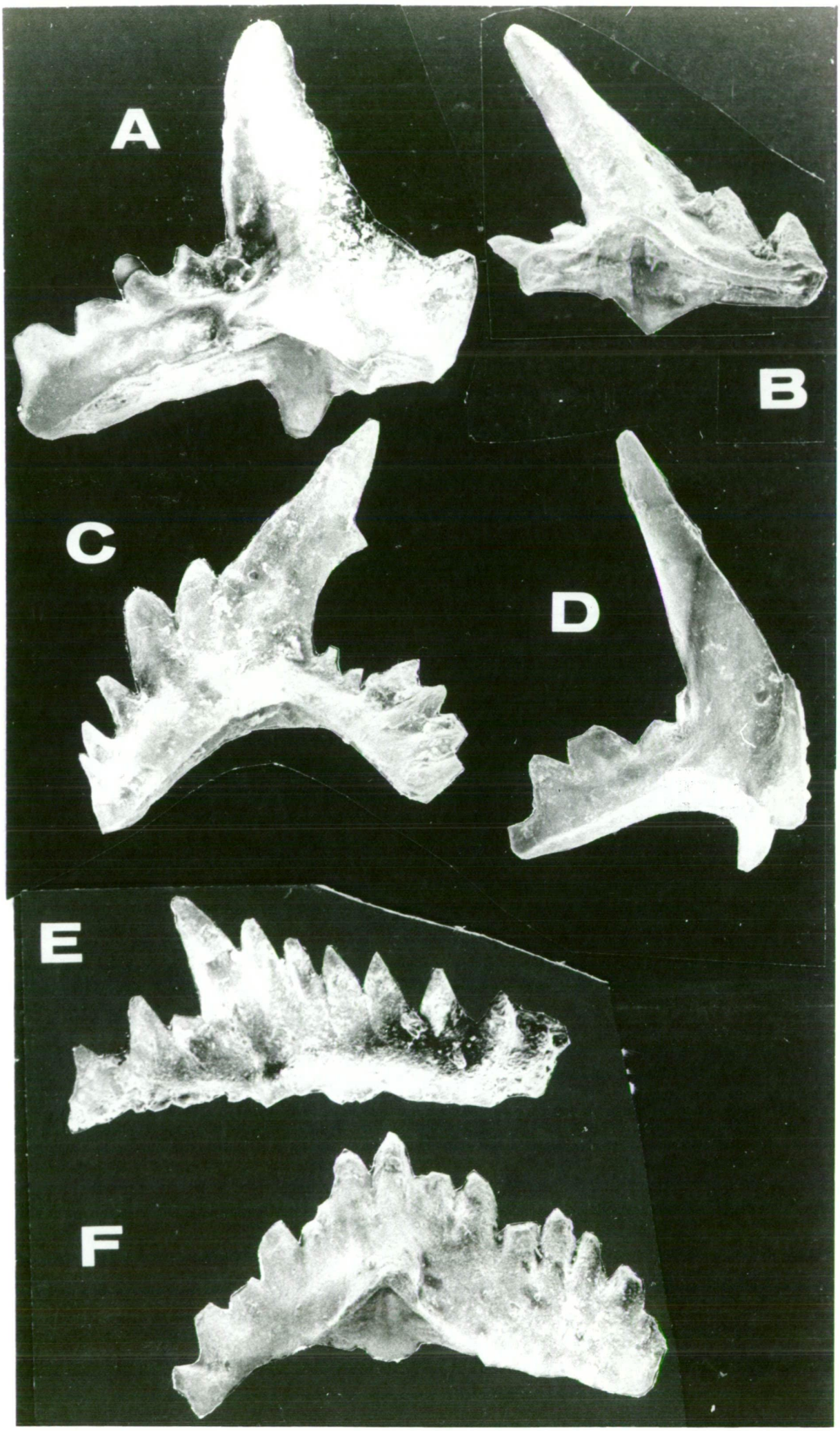
FIGURE 63 *Rhipidognathus? careyi* sp. nov.

Ozarkodiniform elements showing ontogenetic variation. Notice development of lateral processes in mature specimen. All x 80. Specimens UTG 96893 (a - e).

FIGURE 64

Prioniodiniform and ozarkodiniform (E - F) elements of *Rhipidognathus? careyi* sp. nov.

A: Spec. UTG 96853 paratype, x 100.
B: Spec. UTG 96860 paratype, x 130.
C: Spec. UTG 96850 paratype, x 80.
D: Spec. UTG 96857 paratype, x 130.
E: Spec. UTG 96856 holotype, x 150.
F: Spec. UTG 96851 paratype, x 60.


A
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C
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E
F

FIGURE 65 *Rhipidognathus? careyi* sp. nov.

A: eoligonodiniform element, paratype, UTG 96876, x 100.
B: prioniodiniform element, paratype, UTG 96822, x 150.
C: zygognathiform element, paratype, UTG 96877, x 130.
D: zygognathiform element, paratype, UTG 96872, x 130.
E,F: trichonodelliform element, paratype, UTG 96863, x 100.
G: trichonodelliform element, paratype, UTG 96874, x 100.

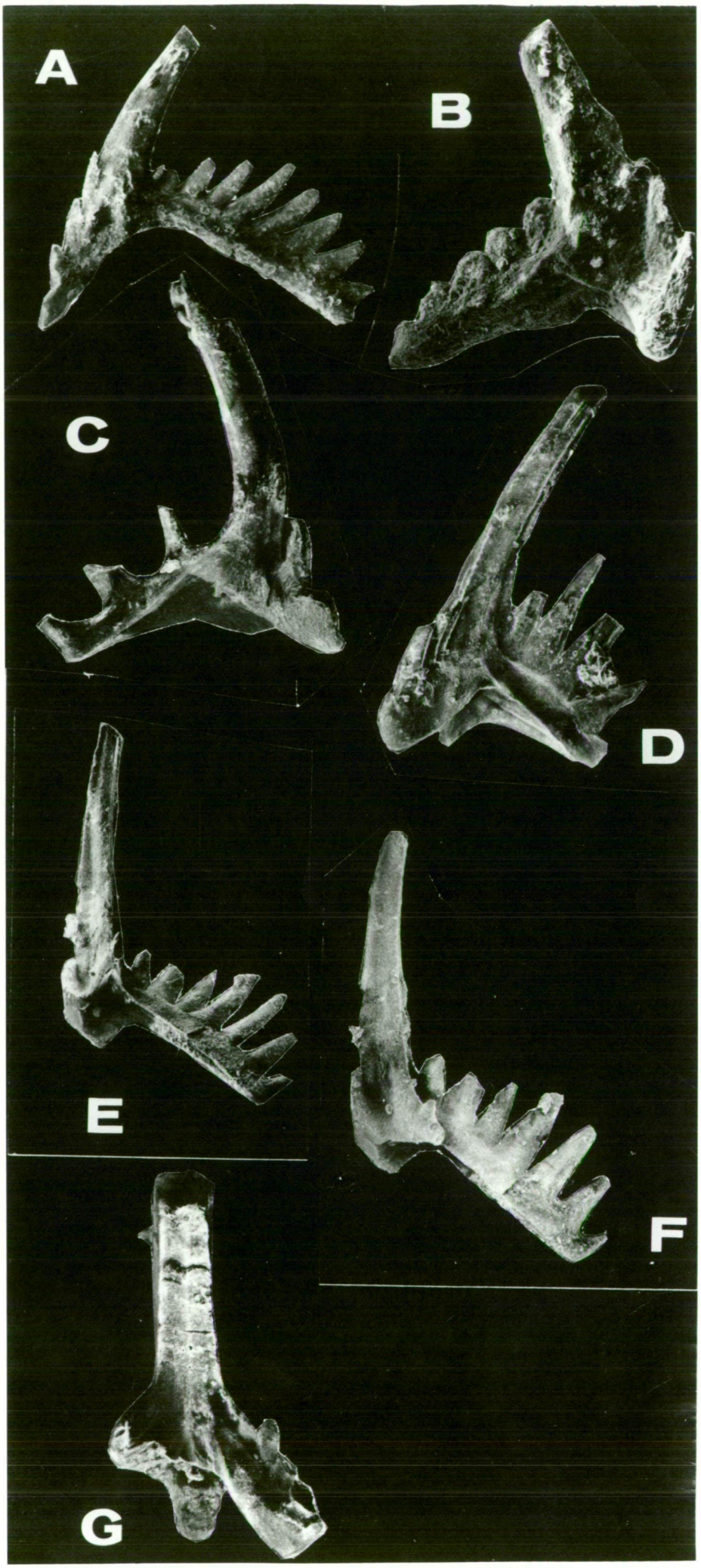
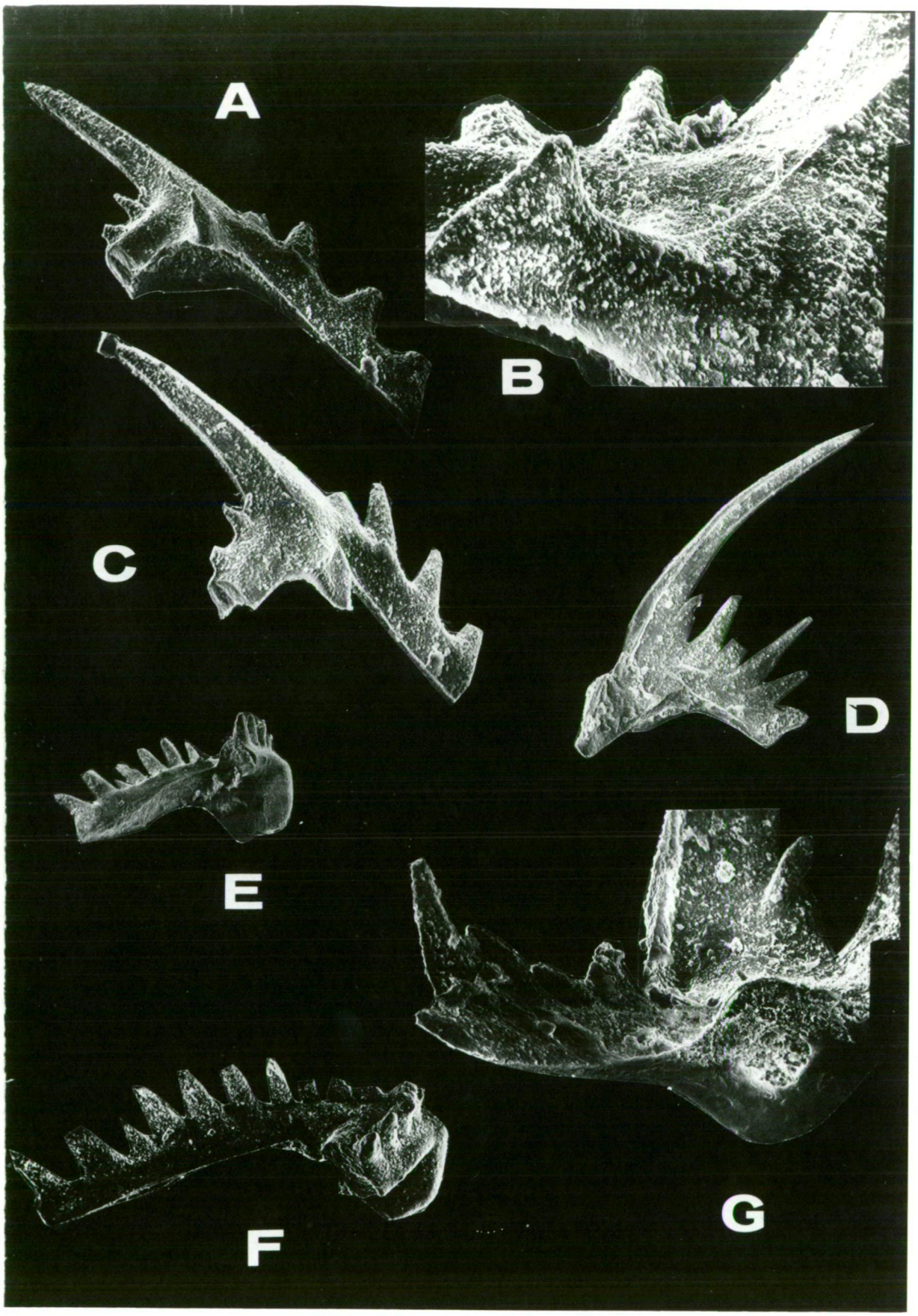

A
B
C
D
E
F
G

FIGURE 66 *Rhipidognathus? careyi* sp. nov.

A-C: prioniodiniform element, spec. UTG 96904, A & C: x 100;
B: detail of anterior process, x 300.
D,G: eoligonodiniform/zygognathiform element, spec. UTG 96905,
D: x 100; G: x 250.
E,F: broken trichonodelliform element, spec. UTG 96902, E: x 50;
F: x 100.


A
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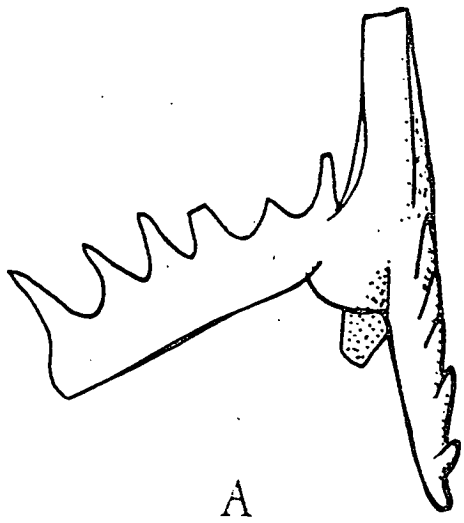
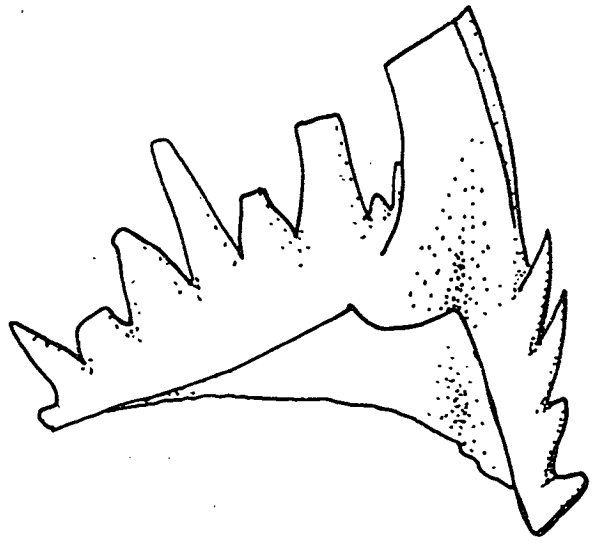
C
D
E
F
G

FIGURE 67 *Rhipidognathus? careyi* sp. nov.

A: eoligonodiniform/zygognathiform element, spec. UTG 96898, x 100.
B: eoligonodiniform/zygognathiform element, spec. UTG 96899, x 100.
C,D: trichonodelliform element, spec. UTG 96900, x 100. C: postero-lateral view, D: antero-basal view.

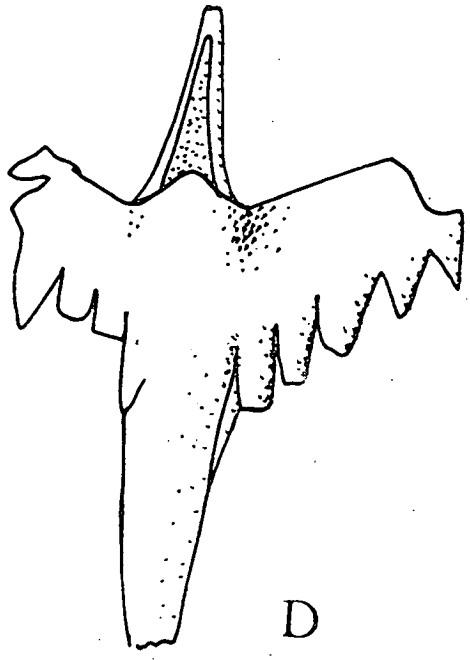


A



B

C



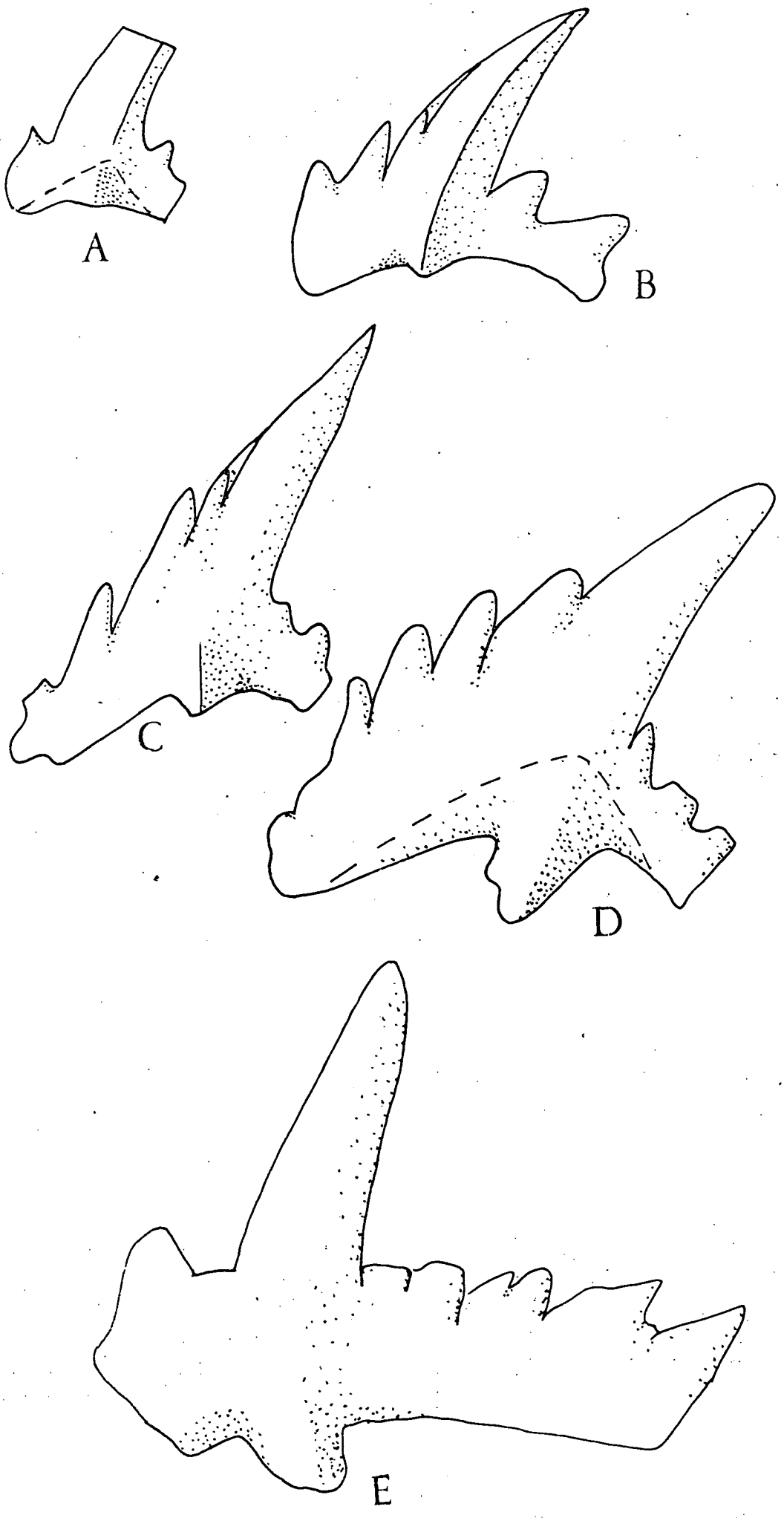
D

FIGURE 68

A-E: ontogenetic variation in prioniodiniform elements of *Rhipidognathus? careyi* sp. nov.

All specimens x 100.

A: UTG 96895, B: UTG 96901, C: UTG 96894, D: UTG 96896, E: UTG 96897.


A
B
C
D
E

process is usually longer than the posterior process. A dagger-shaped cusp is slightly bowed posteriorly, slightly bent inwards, and its posterior edge is more steeply inclined to the horizontal than the anterior. The angular difference varies between ten and twenty degrees. The cusp has a broadly rounded outer and inner margins that narrow to sharp anterior and posterior edges. In the earliest growth stages a pronounced groove exists posteriorly to the centre of the outer margin. This groove extends downwards to the level of the upper margins of the lateral processes. More advanced growth stages have a curved step-like feature running along the centre of the outer margin of the cusp down to the base of outer boss. The downstep part is posterior. The angle between the posterior margin of the cusp and the posterior process varies between 90-100 degrees. The relative length of the process varies during ontogeny. The posterior process carries a single denticle in the earliest growth stage which gradually increases to two and three in most growth stages though mature specimens may have five or six denticles. The posterior denticles are short, squat and, except in mature elements, are not laterally confluent. The anterior process carries one denticle in the earliest growth stages found, gradually increasing in number throughout most of growth. Mature specimens may have only a few anterior denticles. Most specimens have between four and five anterior denticles that are reclined, slender in early growth stages and are higher than the posterior denticles. The most proximal denticles are laterally confluent and are gradually incorporated into the adjacent proximal denticle. The outer boss is variably developed. It is only weakly developed in immature specimens and is strongly developed in mature specimens. However some fairly mature specimens lack a pronounced boss. The boss has a ridge developed in early growth stages which gradually dies out during ontogeny. The boss forms the

outer margin of the basal cavity. The inner margin of the basal cavity is formed by an enlargement of the base of the cusp. The basal cavity is shallow and extends upwards under three main cusp to just below the level of the top of the lateral processes. The basal cavity extends almost to the end of the lateral processes as a narrowing, shallowing groove.

The ozarkodiniform elements of *R? careyi* are distinctive and also exhibit considerable ontogenetic variation. They are straight, have an erect (or in mature forms slightly inclined) cusp, two processes of unequal length and in non-mature specimens bear sharp pointed laterally confluent denticles that are elliptical in cross section. In most growth stages the anterior process is slightly longer and distinctly higher than the posterior process. This difference in height is also very clear in *Ozarkodina joachimensis* Andrews but these American specimens have strongly isolate posterior denticles. The earliest growth stages found have two small, distinct, posterior denticles increasing to four in larger specimens and six in the largest. The anterior denticles are laterally confluent (except for the most distal denticles) and most elements carry six though the most mature specimens may have eight. The denticles become rounded during ontogeny and tend to fuse. In early and intermediate growth stages the basal cavity is a conical subapical pit that extends almost to the end of the processes as a narrow trench. The sheath flares most prominently on the outer lateral side and is developed into a prominent boss in mature specimens. Mature specimens develop small bosses on the processes. A wide flat basal filling is preserved in some of the mature specimens. A few mature specimens exhibit a very narrow, but well defined, ridge running along the centre of the boss and continuing to the cusp apex. In about half of the ozarkodiniform elements in intermediate and mature forms the

denticle immediately anterior to the cusp grows to almost the same size as the main cusp. In these forms the posterior element is slightly twisted laterally.

There are two types of trichonodelliform elements. In the first the elements are perfectly symmetrical and possess a very prominent median costa running along the posterior side of the main cusp. The main cusp has a broadly rounded anterior margin with sharp edges. The central posterior costa is about half as long as the main cusp is wide. The posterior process is short, averaging about one-quarter to one-fifth of the length of the lateral processes. The posterior process is triangular both in plan and lateral views and carries one or more peglike denticles about one-fifth the height of the lateral denticles and one-twentieth the height of the main cusp. The lateral denticles are round to elliptical in cross section and are between one-quarter and one-fifth (on average) the height of the main cusp. Lateral denticles are distinct and slender. The basal sheath is enlarged downwards into a triangular anterior boss. The basal cavity extends upwards into the main cusp and takes in most of the interior of the posterior process. The basal cavity extends as a wide but shallowing and narrowing groove under the lateral process.

The other trichonodelliform elements (Fig.65G) are slightly asymmetric, do not have a triangular denticulated posterior process and have only a slightly costate cusp. The main cusp is subquadrate in cross section and bears slight anterior and posterior costae. The anterior flaring of the basal sheath is more pronounced in this variant. In both trichonodelliform types the angle between the lateral processes is close to 90°. There is a gradual transition to zygognathiform elements (Fig.67 C-D).

The cordylodiform element is arched. Some of the elements are almost prioniodiform with the antero-lateral process being in the same plane as the posterior process. The main cusp is tall, slender, smooth, recurved and has an elliptical cross section. The posterior process carries a variable number (between 3 and 10) of tall, slender, slightly flexed, isolate denticles that are between a third and a quarter as high as the main cusp. These denticles may become fused in later growth stages. The antero-lateral process carries a smaller number of denticles (between 2 and 3) of reclined or laterally inclined denticles that are in partial contact with their neighbour for some of their length, one of which lies against the main cusp. The non-denticulate basal sheath is triangular in plan view. The basal cavity extends up into the main cusp to the level of the top of the lateral processes. The basal cavity narrows rapidly under the lateral processes where it continues as a narrowing groove almost to the ends of the processes.

Comments:

R? careyi has been found in five samples with the ratios shown in Table I. The similarity of the prioniodiniform elements to those in *R. symmetrica discreta* and *R. symmetrica symmetrica* and the presence of ozarkodiniform and trichonodelliform elements would suggest placement within *Rhipidognathus*. The presence of cordylodiform (or eoligonodiniform) elements in the Tasmanian assemblages may suggest that this element was lost during evolution.

TABLE I

Element	J R C 2	L.L.M.B.	C 98	C 137c
Prioniodiniform	21	2	9	2
Ozarkodiniform	23	6	8	3
Trichonodelliform				
A				
B		7	6	1
combined	26			
Zygognathiform)				
)				
)	12		6	
)				
Cordylodiform)				

Number of each element within *R? careyi* by sample. Sample JRC2 is from the Everlasting Hills and the other samples are from the Florentine Valley.

STAUFFERELLA Sweet *et al.* 1975

STAUFFERELLA FALCATA (Stauffer)

Figure 69 A-D

for synonymy see Sweet *et al.* 1975, p. 44.

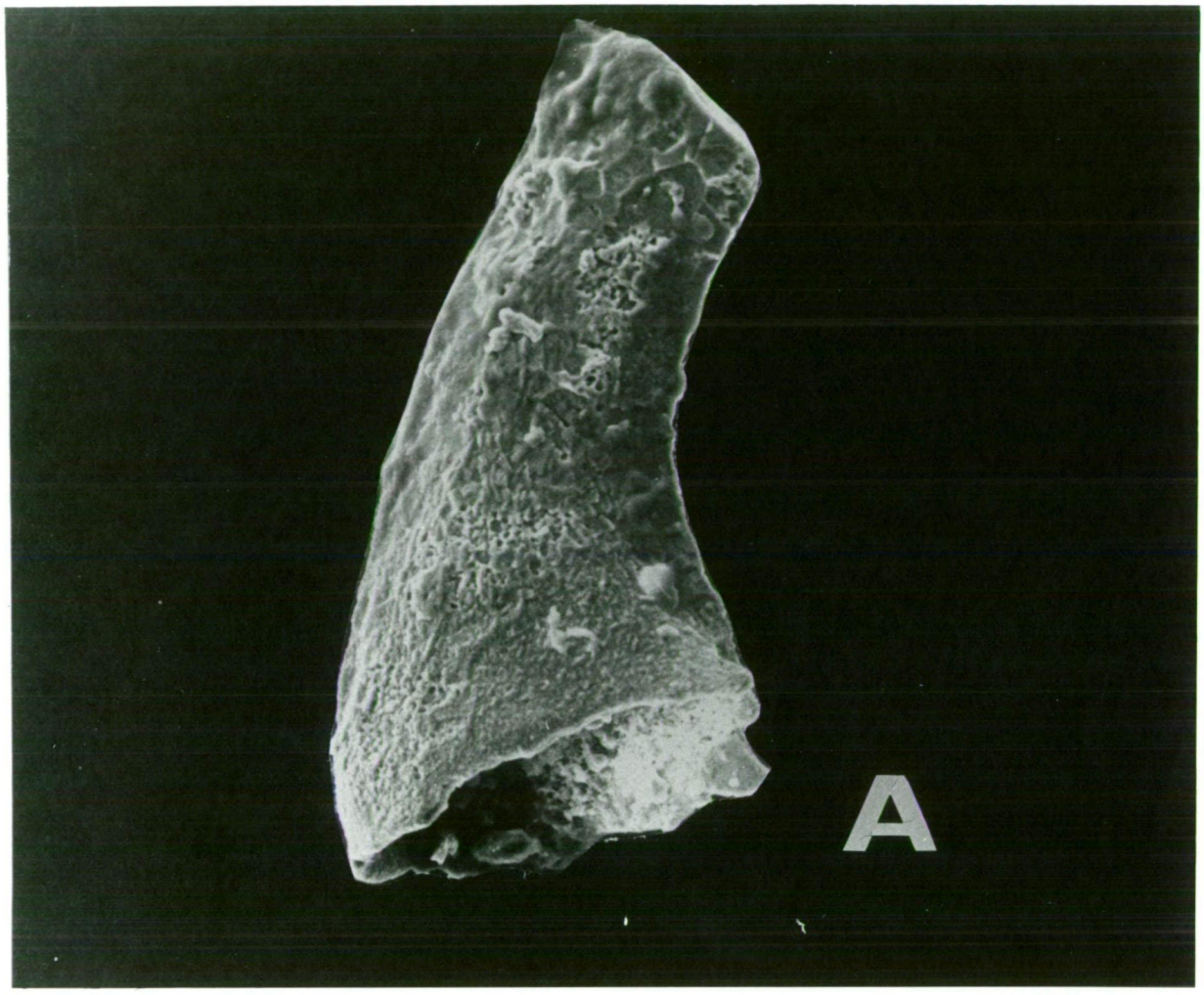
Stauffereila falcata (Stauffer, 1935a) SWEET ET AL. 1975, p.44-46, pl.1, figs.10-13.

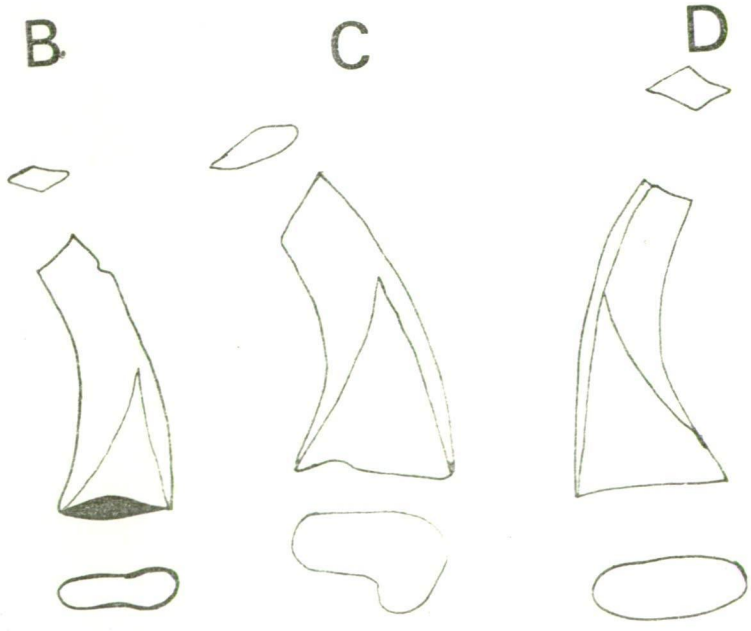
Comments:

Sweet *et al.* have revised and defined the multi-element species *S. falcata*. Very rare specimens are found near the top of the sequence in the Florentine Valley.

FIGURE 69 STAUFFERELLA FALCATA (Stauffer)

A: spec. UTG 96920a, x 180.
B-D: drawings of specimens 96920 b-d, x 100.


A


B
C
D

77/8/259

"TETRAPRIONIODUS" sp.

Figure 70 A-E

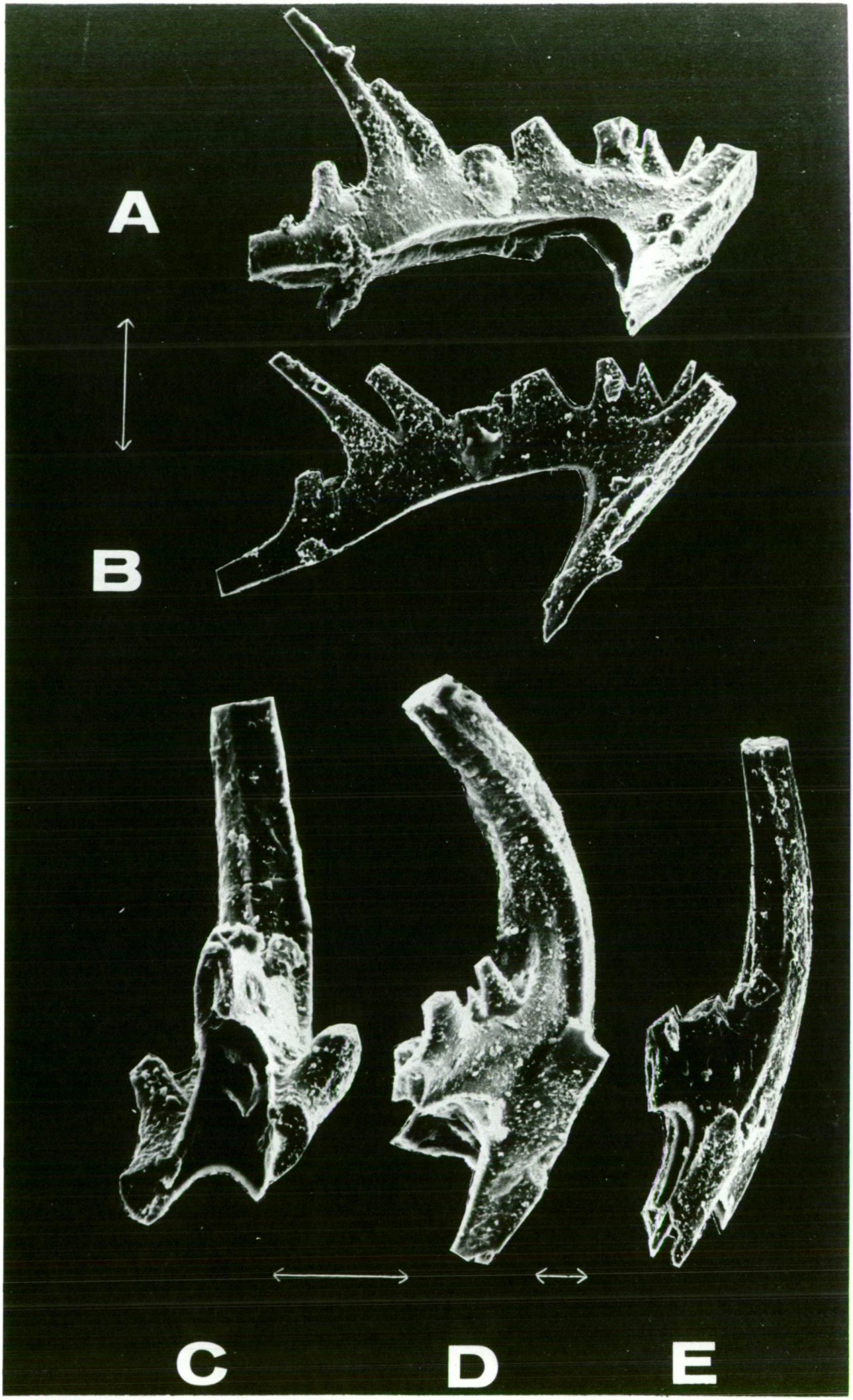
A ligonodiniform element is found in the Lower Limestone Member in the Felix Curtain Road area of the Florentine Valley. The asymmetric element has two relatively short lateral processes that carry a small number of denticles. In lateral view the posterior process forms an angle of 35° with the posteriorly directed lateral processes. The posterior process is twice as long as the lateral process and carries eight or more reclined denticles some of which are long, slender and elliptical in cross section. The proximal denticles of the posterior process are short and erect or proclined. The main cusp is slightly asymmetric and subquadrate in cross section. The slightly recurved main cusp has two lateral costae and subcentral anterior and posterior costae. The basal cavity is deep and extends under the posterior and lateral processes as shallowing, narrowing grooves.

Comments:

In the absence of other elements these specimens cannot be definitely placed in a species but there are similarities with elements described for example by Rhodes (1953), Viira (1974), Bergström and Sweet (1966), Webers (1966) and Viira (1974).

FIGURE 70 *"Tetraprioniodus"* sp.

A,B: spec. UTG 96721, x 150.
C,D,E: spec. UTG 96722, x 150.


A
B
C
D
E

76/12/10.

PROBLEMATICA

Genus MILACULUM Müller, 1973

MILACULUM ETHINCLARKI Müller, 1973

Figure 71 A-C

Synonymy:

Form B ETHINGTON and CLARK, 1965, p.204, pl.1, fig.20.

? Form A ETHINGTON and CLARK, 1965, p.204, pl.1, fig.17.

Form K WEBERS, 1966, p174, pl.15, fig.9.

Milaculum ethinclarki MÜLLER, 1973, pp.223-224, pl.34, figs. 5, 6, 8.

Milaculum sp. WINDER, 1976, p.654, pl.2, fig.12.

Comments:

As noted before (Burrett *in* Corbett and Banks, 1974, p.) phosphatic structures similar to Form B of Ethington and Clark (1965) from the Columbia Ice Fields in Alberta are found near the top of the Gordon Limestone Sub-group in the Florentine Valley. *Milaculum ethinclarki* is found in several locations near the top of the limestone part of the Gordon Limestone Sub-group (Ida Bay, Zeehan, Mole Creek, Bubs Hill) but is rare below that level.

An interesting feature of the Tasmanian specimens is that they exhibit abrasion of the apical nodes which, as is exhibited on most specimens, suggests that this is a primary feature related to the function of the element rather than *post mortem* erosion. The most likely function for the *Milaculum* element is as a crushing or grinding tooth.

A qualitative electron-probe analysis of *Milaculum* reveals a similar composition to that of conodonts.

Rare *Milaculum* from the Standard Hill Member at Mole Creek are indistinguishable from those of the Den Member at the top of the sequence. Apart from an apparently thicker wall, abraded apical nodes and a generally more robust structure the Tasmanian specimens are

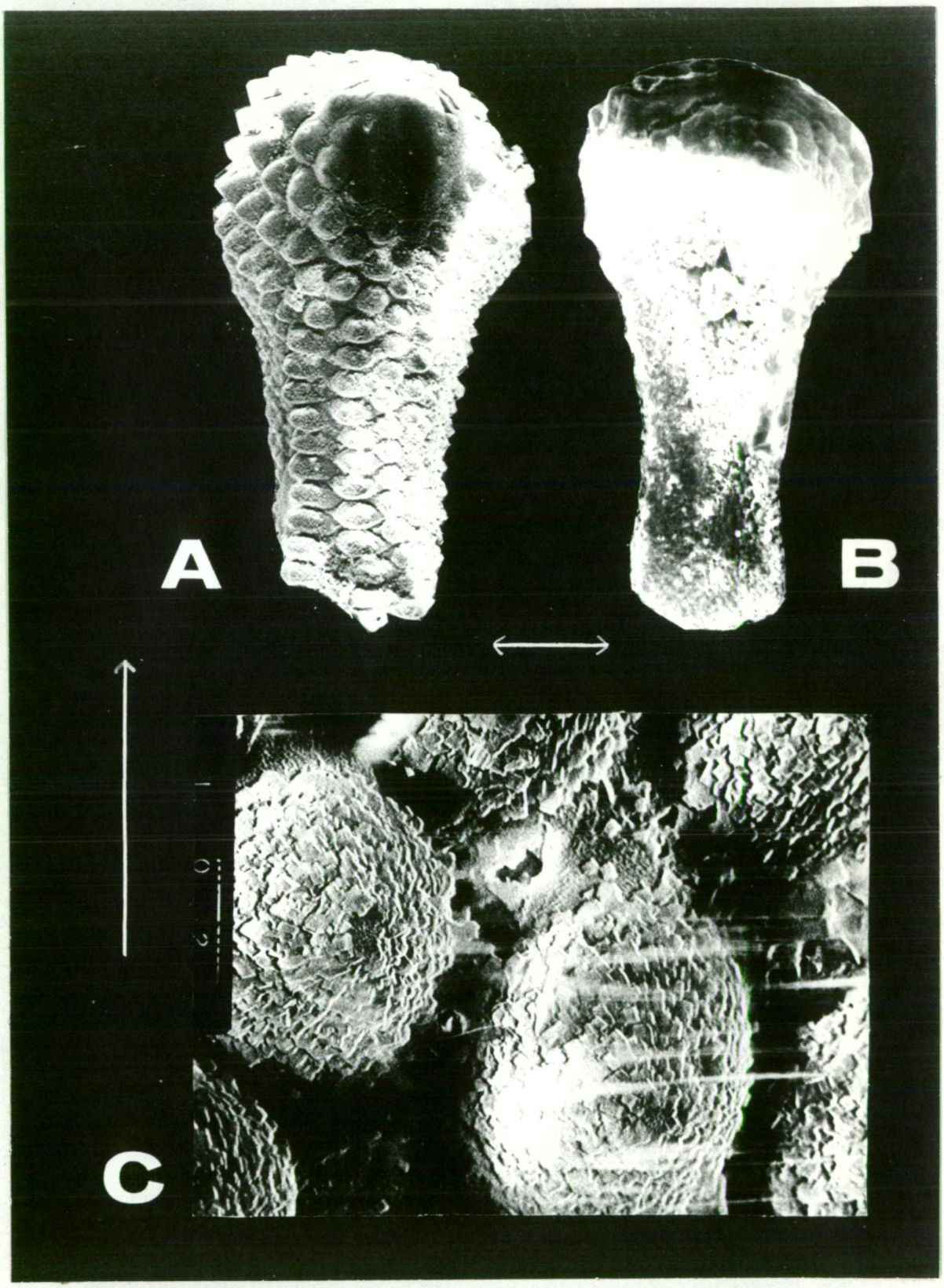


FIGURE 71 *Milaculum ethinclarki*

A-C: spec. UTG 97145, A,B: x 175, C: x 740.

indistinguishable from those in the Arenigian of Alberta (Ethington and Clark, 1965) suggesting the *M. ethinclarki* is of very limited biostratigraphic utility.

Nitecki *et al.* (1975) have recently figured a *Milaculum* from the Simpson of Oklahoma which is very different from the *Milaculum* found in Tasmania and also from the types in that there are very obvious costae traversing obliquely across the sub-apical parts of the specimen.

Genus PHOSPHANNULUS UNIVERSALIS Müller, Nogami & Lenz 1974

Figure 72 A

Synonymy:

Form B Weber's, 1966, p.72, pl.14, figs. 3, 6.

Phosphannulus universalis MÜLLER, NOGAMI & LENZ, 1974, pp.80-92, Text fig. 3, pl.18, figs.10-12; pl.19, figs.1-13; pl.20, figs.1-7; pl.21, figs.1-9.

Comments:

P. universalis is found at several levels in the Gordon Limestone Sub-group. Very well preserved *Phosphannulus* are found near the base of the section at Ida Bay (sample 3 on Figure 21) associated with well preserved conodont basal cones. These specimens exhibit the tube-like structures figured by Muller *et al.* (1974, Text Fig. 3A).

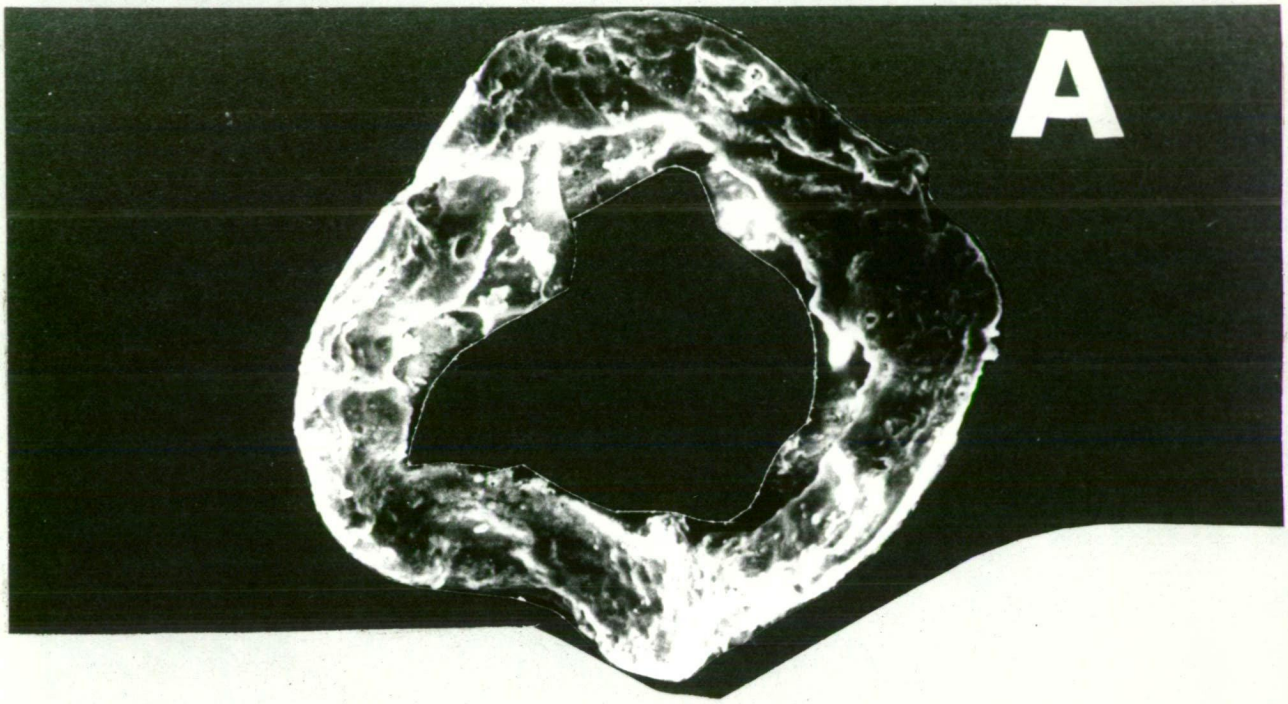


FIGURE 72 A *Phosphannulus universalis*

Spec. UTG 96793, x 100.

CHAPTER V

BIOSTRATIGRAPHY

Introduction

Most of the conodont species found in this study are conspecific with well known North American forms. Most species are typical of the North American Mid-Continent fauna (see pages 256-59) and correlation with the sequence of conodont faunas established by Ethington, Sweet and Barnes (1970) and Sweet and Bergström (1976) is easily effected. The general rarity of conodonts in the Gordon Subgroup has not allowed a detailed local zonation to be established. The total stratigraphic range of many species still needs to be refined by careful collecting in subtidal rock types along depositional strike from the sampled intertidal/supratidal sequences. In particular the range of the conodont fauna in the correlates of the Lower Limestone Member of the Florentine Valley and the Ugbrook and Sassafras Members of Mole Creek needs to be fully documented.

The extent to which several species extend into strata older than the Cashions Creek Formation must await the publication of Dr. D.J. Kennedy's results.

Age and Correlation of the Standard Hill Member and Cashions Creek Limestone Formation.

Despite intensive sampling very few conodonts have been obtained from the oncolitic Cashions Creek Limestone Formation from the Florentine Valley (see pages 78-85). The few that have been found are identical to those from the Standard Hill Member at Mole Creek.

TABLE II

Extra-Australian distribution of species found in the Standard Hill Member at Mole Creek.

STANDARD HILL MEMBER	COPENHAGEN LIMESTONE (NEVADA)	GANGGYE AREA AND MANDAL FORMATION (NORTH KOREA)	SAN JUAN LIMESTONE ZONES C - E (ARGENTINA)	PRATT FERRY FORMATION (ALABAMA)	SETUL LIMESTONE FORMATION (MALAYSIA)	VOLGINSKIY AND KIRENSIY FORMATIONS (SIBERIA)	CHAZY GROUP (NEW YORK)	COBB'S ARM LIMESTONE LOCALITY A (NEWFOUNDLAND)
Acontiodus nevadensis Ethington and Schumacher	✓	-	-	-	-	-	-	-
?Appalachignathus Bergström, Carnes, Ethington, Votaw, Wigley	✓	✓	-	-	-	-	✓	✓
Belodella copenhagenensis (Ethington and Schumacher)	✓	-	✓?	-	-	-	✓?	✓
Belodina alabamensis Sweet and Bergström	✓	-	-	✓	-	-	-	-
Belodina compressa (Branson and Mehl)	?✓	-	-	✓	-	-	✓	-
Panderodus gracilis (Branson and Mehl)	✓	✓	-	✓	-	-	-	✓?
Panderodus serpaglii sp. nov.	-	✓	✓	-	✓	-	-	-
Phragmodus flexuosus Moskalenko	?✓	-	-	-	-	✓	✓	-

The Standard Hill Member fauna includes *Acontiodus nevadensis* Ethington and Schumacher, *Phragmodus flexuosus* Moskalenko, *Belodina alabamensis* Sweet and Bergström, *Appalachignathus?* Bergström, Carnes, Ethington, Votaw and Wigley, *Belodina compressa* (Branson and Mehl) and *Panderodus serpaglii* sp. nov. *Belodella copenhagenensis* (Ethington and Schumacher) is found near the top of the Standard Hill Member (Fig.73). The distribution of some of these species in extra-Australian formations is tabulated in Table II. No attempt is made to document all North American occurrences as these are often numerous (e.g. *Appalachignathus* is found in at least fifteen North American localities (Bergström *et al.* 1974). Most North American occurrences have been compiled into the Mid-Continent faunal sequence (Sweet, Ethington and Barnes 1971, Sweet and Bergström 1976). Species such as *B. compressa* and *P. gracilis* are widely distributed geographically and are stratigraphically long ranging and a detailed analysis of their distribution would not aid in correlating the strata considered here

From Table II it is clear that the fauna of the Standard Hill Member is most closely related to the fauna from the Middle Member of the Copenhagen Formation of Nevada described by Ethington and Schumacher (1969). *B. alabamensis* is mainly found in the lower part of the Upper Member of the Copenhagen but does extend into the Middle Member. Conodonts were not found in the Lower Member of the Copenhagen Formation and therefore the conodont fauna could easily range down into older strata.

Age of the Copenhagen Formation (Nevada)

Cooper (1956) suggested correlation of the Lower and Middle Copenhagen with the Joachim and Rock Levee Formations of Missouri. Bergström (1971, p.124) has identified *Pygodus anserinus*, *Eoplacognathus*

elongatus and *Prioniodus variabilis* from the lower (but not the lowest) parts of the Middle Member. He placed this fauna "either in the very topmost part of the *Pygodus anserinus* Zone or the very lowermost parts of the *Amorphognathus traerensis* Zone." Ross (1976, p.78) agrees with this correlation though he extends the top of the Copenhagen up to the Edenian based on macrofossil studies (Ross, 1970, Ross and Shaw 1972). A Llandeilian age is indicated for the Middle Member by the platform conodonts (Table III).

Age of the Pratt Ferry Formation (Alabama)

Sweet and Bergström (1962) described *B. alabamensis* and *B. grandis (= compressa)* from the Pratt Ferry Formation. This formation has been placed in the zones of *P. serrus* and *P. anserinus* by Bergström (1971, p.117). The boundary between those two zones is 0.3 metres below the top of the Pratt Ferry Formation and would place most of the Pratt Ferry in the Llanvirnian and the top 0.3 metres in the Llandeilian. Although not stated in their paper (Sweet and Bergström 1962) the presence of *P. anserinus* in their sample containing *B. alabamensis* would place that sample in the top 0.3 metres of the formation.

Age of the Lower Volginskiy Sub-formation (Siberia)

Moskalenko (1973) erected *Phragmodus flexuosus* for conodonts from the Volginskiy and the lower part of the Kirenskiy sub-formation of the Krivolutskiy Formation. She correlated these with the Early Blackriveran. Later Moskalenko (1974) found *Polyplacognathus sweeti* Bergström in the higher part of the Krivolutskiy associated with species of *Chirognathus*, *Cardiodella*, *Curtognathus* and other conodont elements. *P. sweeti* is "an excellent guide for the" *Pygodus anserinus* zone (Bergström 1971, p.144). Hence the strata containing

P. flexuosus are slightly older than, or within, the *P. anserinus* Zone.

Age of the San Juan Limestone (Argentina)

Although originally thought to be Llanvirnian by Harrington and Leanza (1957), Hünicker and Gallino (1970) and Acenoloza (1976 pp.482-483), Cuerda has placed the San Juan Limestone in the Arenigian and Llanvirnian (Cuerda 1973) or solely within the Arenigian (Cuerda 1974).

From a thorough analysis of the conodonts Serpagli (1974) has shown that the San Juan Limestone ranges in age from the zone of *Prioniodus elegans* to the zone of *Paroistodus originalis*.

The conodont element of interest (*Panderodus serpaglii* sp. nov.) occurs in the top half of the limestone section examined and is found only with *"Belodella"* sp.A in the upper 50 metres of limestone (zone E) above the zone of *P. originalis*. Thus the age of zone E could be Late Arenigian or even, in part, Llanvirnian; the latter age being in better agreement with the macrofossil evidence.

Age of the Mandel Formation (North Korea)

Lee (1975) has found *Panderodus serpaglii* sp. nov. in the samples collected from the Mandel Formation of North Korea. Little data is given on the age of this formation though it is supposed to range from the Llanvirn to the Caradoc. The conodonts described by Lee (1975) do not appear to support definitely a Caradocian age for any part of the formation. The sample containing *P. serpaglii* contained *Cameroceras* cf. *mathieui* Grabau. This genus ranges from the Middle to the Upper Ordovician (Moore 1964, K174). Kobayashi (1966) suggested a Middle Ordovician age for the formation.

Age of the Setul Limestone (Malaysia)

Panderodus serpaglii sp. nov. has been reported as *Scolopodus cfr. bassleri* from the lowest beds of the Lower Setul Limestone in the Langkawi Islands, Malaysia (Igo and Koike 1967, 1968). A definite age assignment was not attempted though Igo and Koike (1967, p.4) did state that "The lowest conodont faunule in the Langkawi Islands is characterised by species recorded previously from either the Lower or Middle Ordovician of Europe and North America." Unlocated cephalopods and gastropods from the Lower Setul Limestone have been assigned a Llandeilian age by Kobayashi (1959).

Summary of Age of the Standard Hill Member and correlates

From Table III it appears highly likely that the lowest beds of the Standard Hill Member fall within the *Pygodus serrus* Zone and the uppermost beds within the *Pygodus anserinus* Zone. The restriction of *Phragmodus flexuosus* to faunas 5 and 6 in North America (Sweet, Ethington and Barnes 1971, Sweet and Bergström 1976) suggests that most of the Standard Hill Member is Chazyan. Given the thickness of the Standard Hill Member a Fauna 5 age is highly likely for the base of the Member and a Fauna 6 age for the upper parts. The extent to which elements of Fauna 5 are found in the pre-Standard Hill/pre-Cashions Creek clastics and limestones is not known. As is suggested by its range in Korea, Malaysia and Argentina, *Panderodus serpaglii* sp. nov. ranges into pre-Chazyan strata and has been found in the main quarries at Railton associated with probable pre-Chazyan taxa (see page 105).

An oistodiform element probably belonging to *Drepanoistodus forceps* is found at the base of the limestone in the Gordon-Olga Region associated with the same species found in the Standard Hill Member at Mole Creek. Lindström (1971) gives the range of *D. forceps* as Billengen to Lower Volkhov. However if Fåhraeus' (1966) identification is correct then

TABLE III

Summary of age ranges of formations containing species found in the Standard Hill Member at Mole Creek.

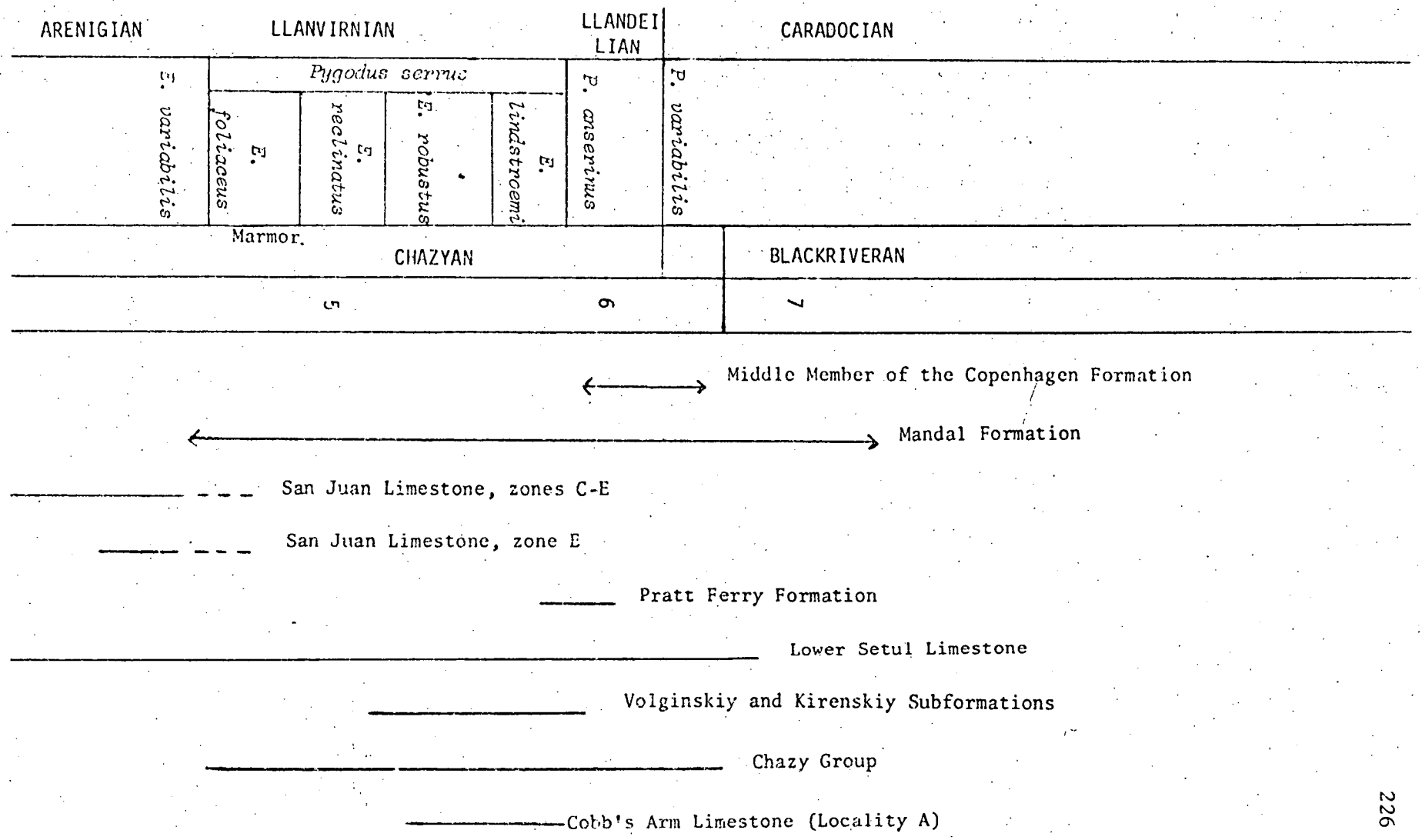
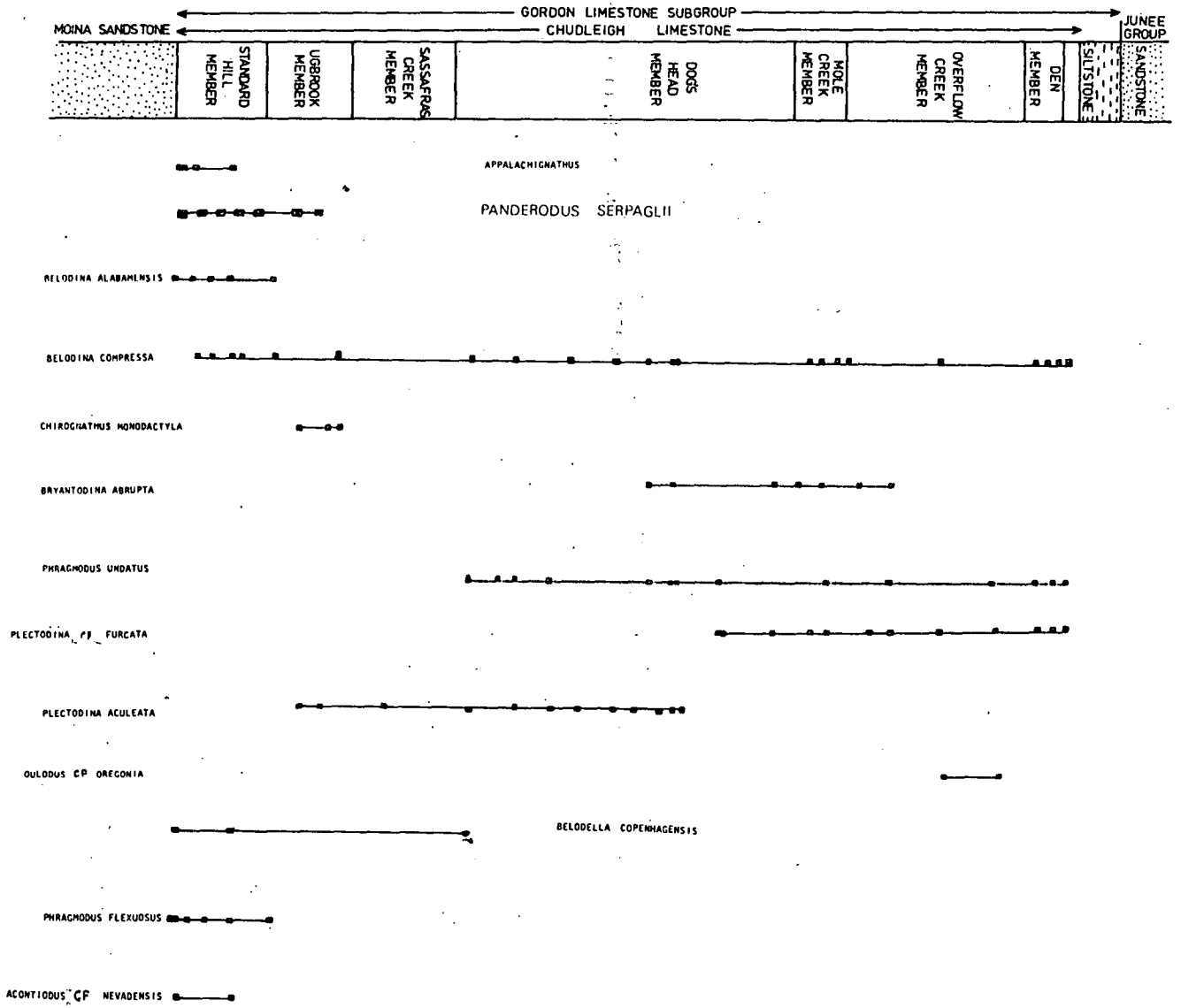


FIGURE 73

Ranges of stratigraphically significant conodonts through the Mole Creek Section. *Drepanoistodus suberectus* and *Panderodus gracilis* range through the whole section and are not included.


GORDON LIMESTONE SUBGROUP
MOINA SANDSTONE
CHUDLEIGH LIMESTONE
JUNEE GROUP
STANDARD HILL MEMBER
UGBROOK MEMBER
SASSAFRAS CREEK MEMBER
DOGS HEAD MEMBER
MOLE CREEK MEMBER
OVERFLOW CREEK MEMBER
DEN MEMBER
SILTSTONE
SANDSTONE
APPALACHIGNATHUS
PANDERODUS SERPAGLII
BELODINA ALABAMENSIS
BELODINA COMPRESSA
CHIROGNATHUS MONODACTYLA
BRYANTODINA ABRUPTA
PHRAGMODUS UNDATUS
PLECTODINA CF FURCATA
PLECTODINA ACULEATA
OULODUS CF OREGONIA
BELODELLA COPENHAGENSIS
PHRAGMODUS FLEXUOSUS
ACONTIODUS CF NEVADENSIS

D. forceps ranges up to the Lasnamagi (Upper Llanvirn).

Correlation of post-Standard Hill Member strata.

The Standard Hill Member at Mole Creek is overlain by the Ugbrook Nodular Member and contains *Plectodina aculeata* and *Chirognathus monodactylus* which indicate correlation to Fauna 7 of Sweet *et al.* 1971.

Although searched for, the characteristic species of Fauna 7 - *Phragmodus inflexus* has not been found at Mole Creek or anywhere else in Tasmania. It is unlikely that this species have been misidentified as its dichognathiform element is very distinctive.

A strongly endemic and distinctive fauna is associated with *Panderodus serpaglii* and *Chirognathus monodactylus* in the Lower Limestone Member of the Benjamin Limestone, in part of the Everlasting Hills sequence and in the basal limestone south of Zeehan. This fauna is dominated by *Rhipidognathus careyi* and *Phragmodus tasmaniensis* and correlation to Fauna 7 of North America is effected only by means of *C. monodactylus*.

The incoming of *Phragmodus undatus* is taken to mark the base of Fauna 8 (Sweet *et al.* 1971, p.175). This species occurs with *Plectodina aculeata*. The mutual occurrence of *P. aculeata* (including *O. obliqua*) and *P. undatus* is regarded as the distinctive quality of Fauna 8 (Sweet *et al.* 1971). Elements of Fauna 8 occur widely in Tasmania associated with *B. compressa* and *P. gracilis*. *Bryantodina? abrupta* is found near the top of Fauna 8 (Sweet, Ethington and Barnes 1971) but is also known in Fauna 7 assemblages in North America.

In most Tasmania sections *Plectodina* cf. *furcata* enters just above *Bryantodina? abrupta*. In North America the entry of *P. furcata* marks the base of Fauna 9. The base of Fauna 10 in North America is characterized by the incoming of *Amorphognathus superbus*. This is joined, a little later on, by *Rhipidognathus symmetricus*. Neither of these species are found in Tasmania and therefore the local placement of

TABLE IV

Composite local conodont assemblages and suggested correlations to northern hemisphere conodont zones.

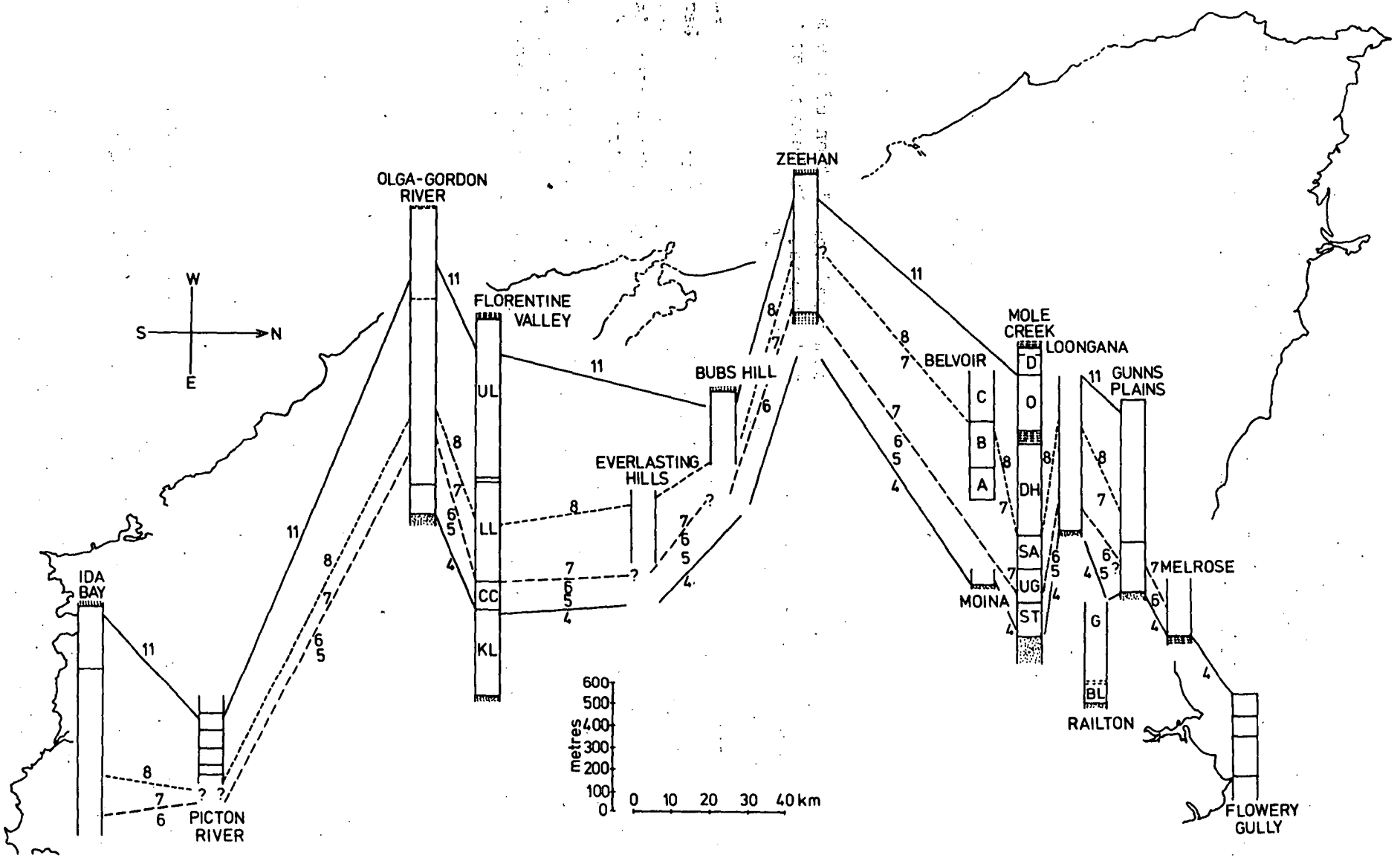
INFORMAL LOCAL ASSEMBLAGE	CONODONTS	LONG RANGING FORMS	NORTH AMERICAN CONODONT FAUNA
F.	*Oulodus robustus* *Oulodus* cf. *oregonia* *Plectodina* cf. *furcata* *Phragmodus undatus* *Staufferella falcata*	*Belodina compressa* *Panderodus gracilis* *Drepanoistodus suberectus*	11
E.	*Bryantodina abrupta* *Plectodina* cf. *furcata* *Phragmodus undatus*		10
D.	*Phragmodus undatus* *Bryantodina abrupta* *Plectodina florentinensis* *Plectodina* cf. *furcata*		9
C.	*Plectodina aculeata* *Bryantodina abrupta* *Phragmodus undatus*		8
B.	*Chirognathus monodactylus* *Panderodus serpaglii* *Phragmodus tasmaniensis* *Rhipidognathus ? careyi* *Plectodina aculeata* *"Tetraprioniodus" sp.* *Erismodus gracilis*		7
A.	*Phragmodus flexuosus* *Belodina alabamensis* *Panderodus serpaglii* *?Appalachignathus* *Drepanoistodus forceps* *Belodella copenhagenensis*		5-6
	?Belodina sp. *Periodon aculeatus** *Scolopodus* spp.* *Panderodus serpaglii*		WHITEROCK FAUNA

* not studied

FIGURE 74

Diagram showing position, thicknesses and correlation of the major Gordon Limestone Sub-group sections in Tasmania. Numbers refer to conodont faunas of Sweet, Ethington and Barnes 1971.

A: Lower Member in the Vale of Belvoir; B: Middle Member in the Vale of Belvoir; BL: Blenkhorn's Quarry horizon; C: Upper Member in the Vale of Belvoir; CC: Cashions Creek Limestone Formation; D: Den Member of the Chudleigh Limestone Formation; DH: Dog's Head Member; G: Goliath Quarry, Railton; K: Karmberg Limestone Formation; LL: Lower Limestone Member of the Benjamin Limestone Formation. O: Overflow Creek Member; SA: Sassafras Creek Member of the Chudleigh Limestone; ST: Standard Hill Member of the Chudleigh Limestone Formation; UG: Ugbrook Nodular Member of the Chudleigh Limestone Formation; UL: Upper Limestone Member of the Benjamin Limestone Formation.


W
S
N
E
IDA BAY
PICTON RIVER
OLGA-GORDON RIVER
FLORENTINE VALLEY
UL
LL
CC
KL
EVERLASTING HILLS
BUBS HILL
ZEEHAN
BELVOIR
C
B
A
MOINA
MOLE CREEK
LOONGANA
D
O
DH
SA
UG
ST
GUNNS PLAINS
G
BL
RAILTON
MELROSE
FLOWERY GULLY
metres
600
500
400
300
200
100
0
0 10 20 30 40 km

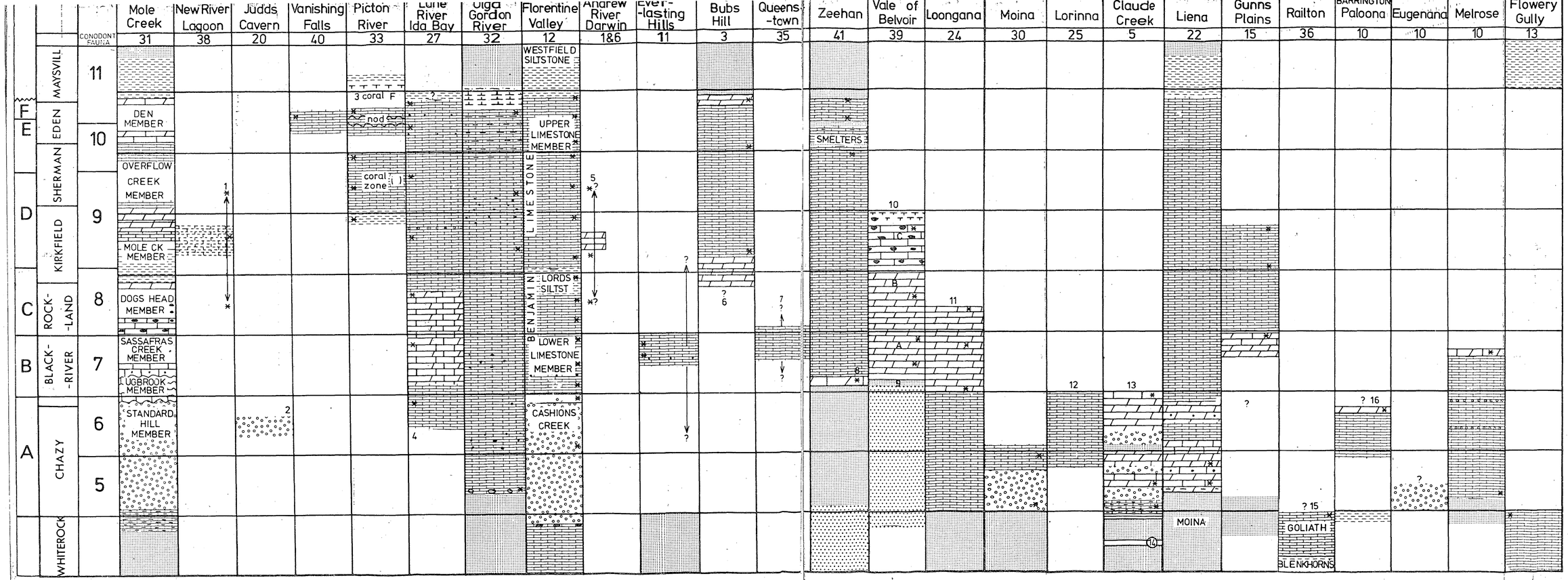
the base of Fauna 10 poses difficulties. The base of Fauna 11 is defined by the last occurrence of *Bryantodina? abrupta*. In the Gordon Subgroup *B. abrupta* is not found near the top of the Limestone. At Mole Creek *B. abrupta* is not found above 270 metres from the top of the limestone and in the Florentine Valley it is not found above 180 metres from the top of the limestone. This disappearance of *B? abrupta* is unlikely to have been ecologically controlled as, at least in the Florentine Valley, almost all environments are found above its level of disappearance and many of these environments contain conodonts.

In North America the base of Fauna 11 is defined by the incoming of *Belodina* sp.A, *Belodina inclinata*, *Panderodus angularis* and *Oulodus oregonia*. Only the last of these is found in Tasmania. In North America *Belodina compressa* disappears halfway through Fauna 11. In Tasmania *B. compressa* is found at many localities at the top of the Limestone associated principally with *Phragmodus undatus* and *Plectodina* cf. *furcata*. This gives an upper age limit to the Gordon Subgroup of Upper Edenian (Burrett *in* Corbett and Banks 1974). *Oulodus robustus* is found in the Picton River and probably in the highest limestones at Bubs Hill.

O. robustus ranges "from a few feet above the base of the Upper Ordovician Maysvillian stage to the top of the Richmondian stage" Sweet and Schönlaub (1975).

FIGURE 75

Suggested correlation of the various limestone sections discussed in Chapter III. Symbols as in Figure 6. Letters on left are local conodont assemblages. Numbers at head of columns refer to localities on Figure 2. Numbers on columns refer to notes below. 1:- The New River Lagoon calcareous shales could range between Faunas 8 and 10. 2:- This section might belong in Fauna 5. 3:- Stratigraphic relation of sections F to C not definitely known. 4:- Base not seen, top poorly defined. 5:- May range between Faunas 8 and 10. 6:- Base of Bubs Hill section not seen. 7:- Age of Queenstown section unknown, tentative range based on macrofossils. 8:- Base of section sampled at Grieve's Siding, top of section sampled near to the Smelter'sQuarry. 9:- Base of Vale of Belvoir limestone section not exposed. Underlying clastics are mainly fine grained conglomerates. 10:- Top of Vale of Belvoir section not present. Age of calcareous mudstones not known. 11:- Top of Loongana section not erosional - no overlying clastics. 12:- Top of Lorinna section erosional. 13:- Top of Claude Creek section erosional. 14:- Base of Gunns Plains section not exposed. 15:- Top of Railton section erosional. 16:- Top of Paloona, Eugenana and Melrose sections erosional - no overlying clastics.


CONODONT FAUNA
Mole Creek 31
New River Lagoon 38
Judds Cavern 20
Vanishing Falls 40
Picton River 33
Lune River Ida Bay 27
Olga Gordon River 32
Florentine Valley 12
Andrew River Darwin 1&6
Ever-lasting Hills 11
Bubs Hill 3
Queens-town 35
Zeehan 41
Vale of Belvoir 39
Loongana 24
Moina 30
Lorinna 25
Claude Creek 5
Liena 22
Gunns Plains 15
Railton 36
BARRINGTON Paloona 10
Eugenana 10
Melrose 10
Flowery Gully 13
F
E
D
C
B
A
MAYSVILL
EDEN
SHERMAN
KIRKFIELD
ROCK-LAND
BLACK-RIVER
CHAZY
WHITEROCK
11
10
9
8
7
6
5
DEN MEMBER
OVERFLOW CREEK MEMBER
MOLE CK MEMBER
DOGS HEAD MEMBER
SASSAFRAS CREEK MEMBER
UGBROOK MEMBER
STANDARD HILL MEMBER
3 coral F
nod
coral zone
WESTFIELD SILTSTONE
UPPER LIMESTONE MEMBER
BENJAMIN LIMESTONE
LORDS SILTST
LOWER LIMESTONE MEMBER
CASHIONS CREEK
SMELTERS
MOINA
GOLIATH
BLENKHORNS

CHAPTER VI

PALAEOECOLOGY OF THE GORDON SUBGROUP

Brief Outline of Environments within the Gordon Subgroup Carbonates.

From the stratigraphic data of chapter V it is clear that the oldest limestones occur in the eastern part of the outcrop area and are Late Canadian. Chazyan limestones are widespread and at Zeehan and in the Vale of Belvoir the oldest limestones are Blackriveran in age. These Blackriveran limestones overlie intertidal siliciclastics that in turn overlie probable terrestrial conglomerates. This suggests that terrestrial conglomerates were being deposited in the west at the same time as intertidal and subtidal limestones were being deposited towards the east. This also suggests that a westwards transgression took place from the Canadian onwards up to, and perhaps above, the Blackriveran (Fig.77). However the exact extent of land and sea during each segment of the Ordovician has not yet been worked out in detail and more information is clearly required from several critical areas before reliable palaeogeographic maps may be drawn.

If there has been no relative movement of Tasmania and Victoria then Tasmania has to be interpreted as a shallow water embayment along tectonic strike from the deep water lutites of Victoria. With land to the west, probably to the north and possibly to the south the size and setting of western Tasmania is comparable to Shark Bay in Western Australia (Logan *et al.*, 1970, 1974) (Fig.76). However, in general, lithofacies sequences are closer to those around the Persian Gulf rather than in Shark Bay (C.P. Rao *pers. comm.*).

Considerable advances have been made in the last few years in interpreting the environment of formation of ancient carbonate sequences

FIGURE 76

Diagram showing probable maximum area of Tasmania covered by warm shallow seas during the Upper Ordovician compared to modern-day Shark Bay, Western Australia. Dashed line is 120 fathom submarine contour. Dashed-dot line is eastern limit of Ordovician carbonate deposition in Tasmania.

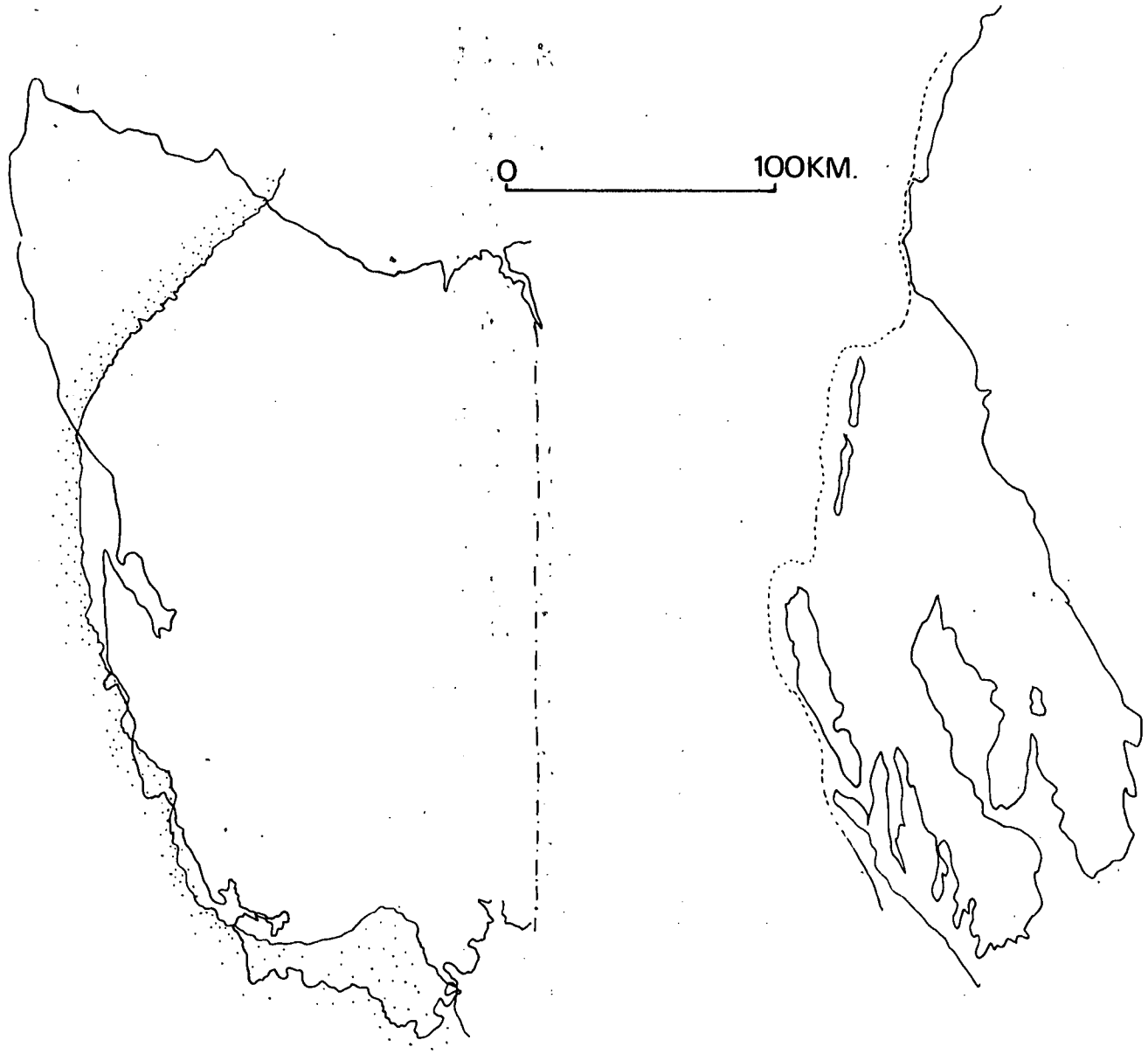
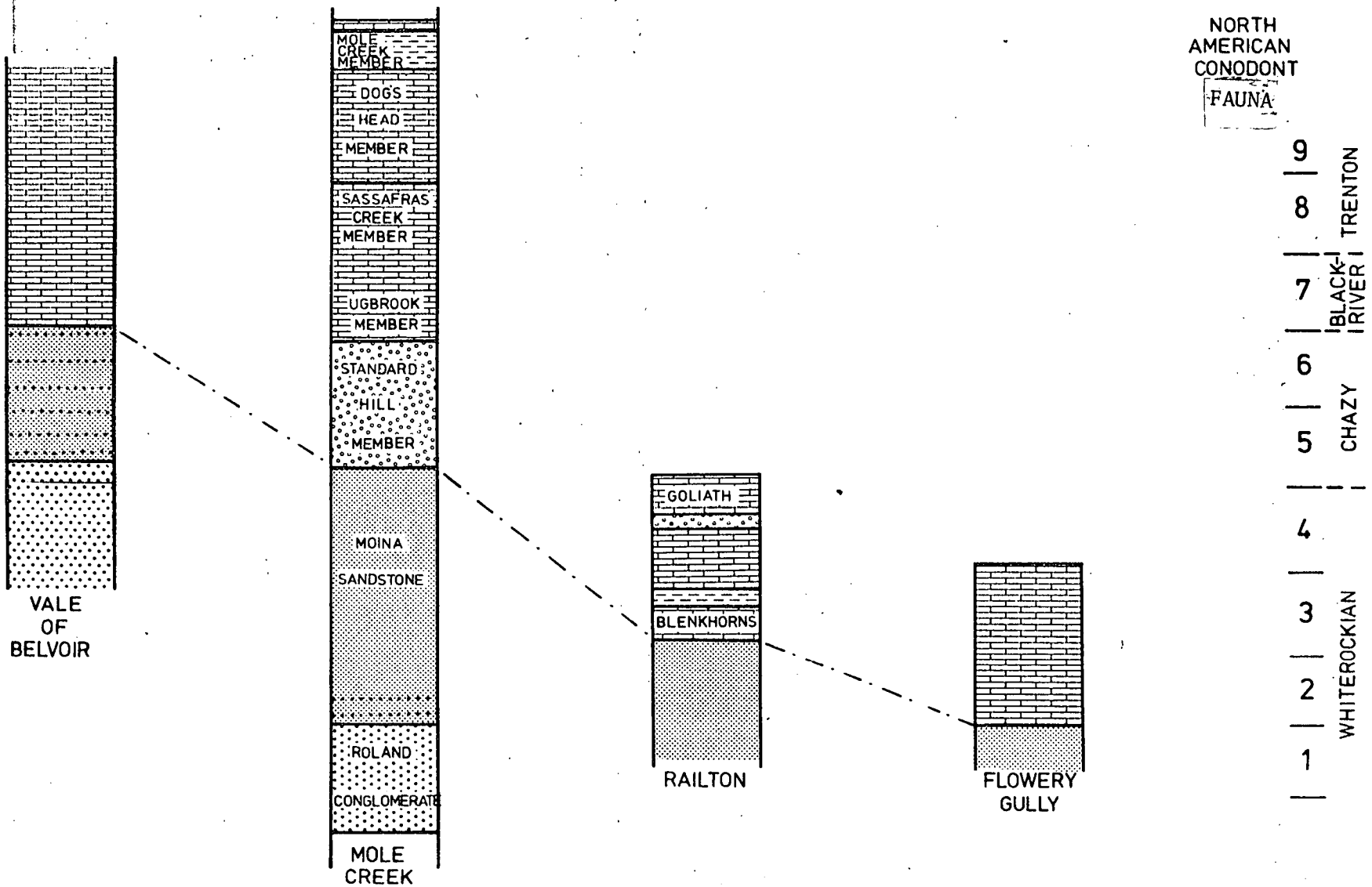

0
100KM.

FIGURE 77

Diagram showing the probable diachronous nature of the base of the Gordon Subgroup in northwestern Tasmania. Section is from east-north-east (on the right) to west-south-west.


VALE OF BELVOIR
MOLE CREEK MEMBER
DOGS HEAD MEMBER
SASSAFRAS CREEK MEMBER
UGBROOK MEMBER
STANDARD HILL MEMBER
MOINA SANDSTONE
ROLAND CONGLOMERATE
MOLE CREEK
GOLIATH
BLENKHORNS
RAILTON
FLOWERY GULLY
NORTH AMERICAN CONODONT FAUNA
9
8
7
6
5
4
3
2
1
TRENTON
BLACK RIVER
CHAZY
WHITEROCKIAN

by comparing them with modern limestone complexes. Criteria for recognizing intertidal and supratidal carbonates have become particularly widely utilized. Environments within the Gordon Subgroup have been reconstructed by using the lithic features discussed by the authors in Ginsburg (1975) and by such authors as Bathurst (1971), Bhatt (1976), Braun and Friedman (1969), Eriksson and Truswell (1974), Friedman *et al.*, (1973), Frost (1974), Gebelein (1969), Houlik (1973), Logan *et al.* (1970), Logan *et al.* (1974), Mukhererji and Young (1973), Purser (1973), Schenk (1967), Shinn *et al.* (1969), Waller (1972) and Warme *et al.* (1976). Important unpublished studies on the Ordovician carbonates of Tasmania have also been used (Weldon 1974, Whyte 1974 and Basnayake 1975) but only one paper has yet been published (Rao and Naqvi 1977). Many data have been accumulated by Dr. C. Prasada Rao and several of the environmental interpretations have been inspired by discussions with Rao and his students B. Weldon, R. Whyte, Kwajah Ali, S. Basnayake, A. Scanlon, and B. Pierson.

Criteria for recognizing particular environments are summarised in Table V and examples are illustrated in Figures 7, 10 & 16. As is quite common in geological studies no one lithic feature may unequivocally place a rock assemblage in a particular environment. However ,using the whole suite of characters in continuous carbonate sequences a model may be constructed that accounts satisfactorily for the majority of the data. Frequently several lines of evidence converge on one probable answer though individually each piece of evidence is inconclusive. Generally gross field characteristics have been used in environmental interpretations. Very detailed micropetrographic and geochemical studies on the Gordon Subgroup carbonates are in preparation by C.P. Rao and his students.

Models for the deposition of several members recognised at Mole Creek are summarised in Figure 79. Descriptions of the rock types

TABLE V

A summary of the major lithic and faunal criteria used to discriminate broad environments within the Gordon Subgroup carbonates. Compiled from many authors.

SUBTIDAL	INTERTIDAL		SUPRATIDAL
	LOW	HIGH	
		flat pebble conglomerates	
stromatolites rare	stromatolites present-common	stromatolites common	
algal mats rarely	algal mats rare	algal mats common	algal mats common
-	-	birds eye limestone (dismicrites)	dismicrites present
oncolites present	oncolites abundant		
	calcarenites in tidal channels		
		mud cracks	mud cracks common
dolomite rare-present	dolomite present	dolomite common	dolomite very common
scolecodonts rare & large	scolecodonts abundant	scolecodonts abundant	
		vertical worm burrows	
	horizontal worm burrows common		
high diversity	low diversity fauna	very low diversity	very little of any fauna
gastropods present	gastropods abundant	gastropods present to abundant	
high spired gastropods	low spired gastropods		
sponge spicules common	sponge spicules rare		
holothurian sclerites common	-	-	-
trilobites common	trilobites rare	-	-
articulate brachiopods common	articulate brachiopods rare		
chitinozoa abundant	chitinozoa present-rare		

	Tetradium	
corals abundant	corals other than *Tetradium*	
cephalopods often abundant	cephalopods present	
pelecypods common	pelecypods often common	pelecypods rare
bryozoa common	bryozoa present	

77/10/01

are given in Chapter II. Lateral ranges of some of the principal organic components are also indicated on the diagrams.

These diagrams are not meant to be definitive but indicate the major environments of deposition of certain members within the Gordon Subgroup at Mole Creek. The environments of formation of the members at Mole Creek are probably applicable to much of the carbonate sequence within the Gordon Subgroup elsewhere in Tasmania.

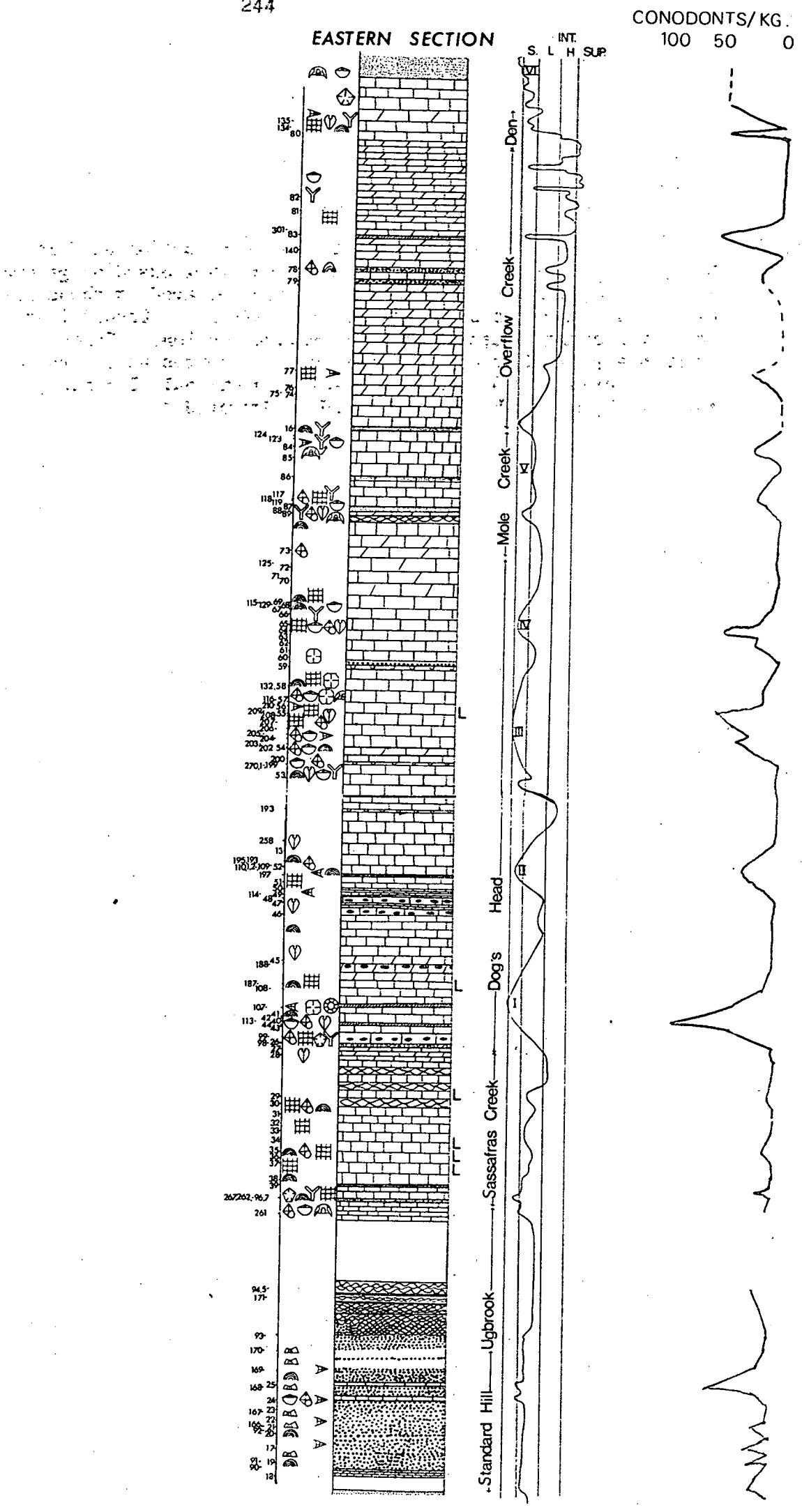
Palaeoecology

Most samples from the Gordon Subgroup carbonates contain a low diversity fauna. Certain notable localities yield high diversities but these are mainly near the top of the sequence (e.g. the Den Member at Mole Creek and the coralline horizons along the Picton River). Conodonts are generally rare and of low diversity. If the general palaeogeographic picture of the Tasmanian Ordovician as a small embayment into the Gondwanaland continental margin is correct then the paucity of stenohaline faunal elements is to be expected. By comparison with modern Shark Bay salinities, hypersalinity would be expected even in subtidal environments. Extremely high values would be expected in intertidal regimes.

The low conodont yields of this study are also probably caused by a high rate of sedimentation. Lindström (1963) calculated that the rate of sedimentation in Öland, Sweden was 1 mm per 1000 years and Jaanusson (1973) calculated an average rate of 4-5 mm per 1000 years for the Östergötland sequence. Using the data of Sweet and Bergström (1966) for the Lexington Limestone an average rate of 8 mm per 1000 years may be calculated. The estimated value of 32 mm/1000 years for the Mole Creek sequence is therefore high compared with certain conodont bearing platform carbonates of North America and Sweden. Thus the paucity of conodonts in Tasmanian limestones of this study could be completely

FIGURE 78

Stratigraphic column through the eastern section at Mole Creek showing postulated variation in sea level based on general sedimentological and macrofaunal evidence compared to abundance of conodont elements per kilogram of limestone. Dashed line indicates extrapolated curve from western section. Three fragmentary conodont elements are taken to represent one whole conodont element. S = subtidal; INT = Intertidal; L = Low Intertidal; H = High Intertidal; SUP = Supratidal.


EASTERN SECTION
CONODONTS/KG.
100 50 0
INT.
S. L H SUP.
Don
Creek
Overflow
Creek
Mole
Head
Dog's
Creek
Sassafras
Ugbrook
Standard Hill

explained by high rates of sedimentation. The general low diversity may be explained by high salinities or by other features of environmental instability.

From Mole Creek it is estimated that of the 1.3 km of limestone only twenty percent was laid down in subtidal conditions (see p.51.). Detailed studies by Weldon (1974) in the Florentine Valley have shown that of the Lower Limestone Member 55% was subtidal and 6% supratidal and of the Upper Limestone Member 20% was subtidal and 3% supratidal. Such high proportions of intertidal conditions in the two well studied sections also provide a good explanation for the general low conodont diversity.

When conodont abundances are plotted against changes in water depth, derived from sedimentological and macrofossil evidence, there appears to be a positive correlation (Fig. 78). This may, in part, be due to differences in rates of sedimentation with lower rates having been operative in subtidal regimes, though a primary control would most likely be ecological. Moskalenko (1976) has found a similar relationship along the Podkamennaya Tunguska of the West Siberian Platform and Bergström and Carnes (1976) have shown greatest conodont abundances in deeper subtidal environments.

Several attempts have been made to relate Ordovician conodont faunas to particular environments (e.g. Kohut and Sweet 1968, Seddon and Sweet 1971, Barnes, Rexroad and Miller 1973, Barnes and Fåhraeus 1975, Fåhraeus and Barnes 1975, Bergström and Carnes 1976, Moskalenko 1976, Le Fèvre, Barnes and Tixier 1976). Barnes *et al.*, 1973 related conodont distribution to broad tectonic regimes. Thus certain Whiterock/Chazy conodonts were placed into (a) shelf (b) miogeosyncline (c) continental margin and (d) eugeosyncline. Such a scheme is *a priori* unlikely to yield useful results because this is not an ecological classification of environments; it is tectonic. Tectonic regime may have little appreciable

FIGURE 79

Environments of lithic members at Mole Creek.

A:- One model for environmental distribution of members in the lowest parts of the section based on the assumption of contemporaneity of the Ugbrook and Standard Hill Members.

1 = Oncolitic Standard Hill Member formed in an intertidal environment.
2 = Ugbrook Nodular Member formed in lagoon behind bar.
3 = Offshore bar formed of siliciclastics exposed at the Grunter Hill south of Standard Hill.
4 = Dolomicrites of the Sassafras Creek Member.
5 = Calcarenite at base of Sassafras Creek Member formed at wave base.
6 = Tidal flat deposits found in small quarry to south of Standard Hill with flat pebble conglomerates, stromatolites and dismicrites.

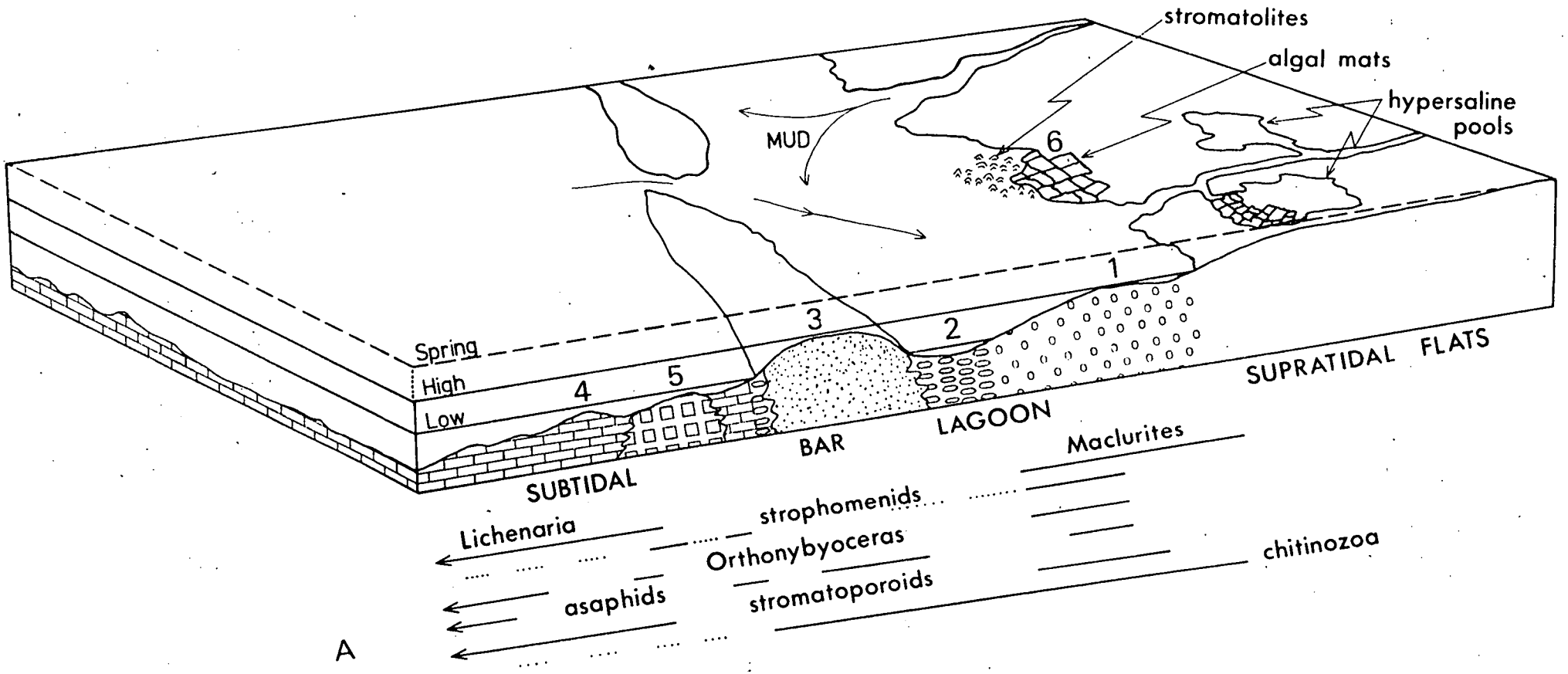
B, C:- Alternative environmental model for the lower members at Mole Creek.

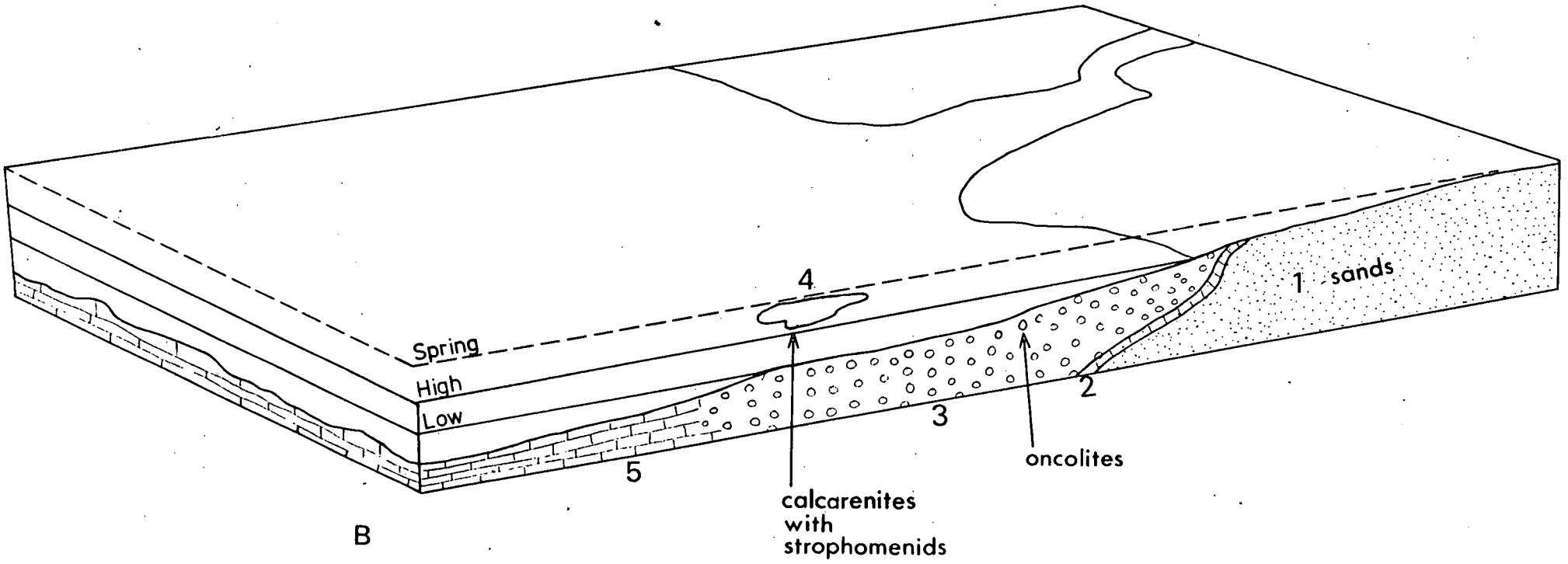
1 = Siliciclastics of the Moina Sandstone grading formed on tidal flats crossed by tidal channels.
2 = Marls and siltstones at boundary between Standard Hill Member and Moina Sandstone.
3 = Oncolites of Standard Hill Member formed in an intertidal environment with channel calcarenites supporting a strophomenid fauna (4).
5 = Subtidal micrites.
6 = Offshore bar of siliciclastics with lagoon behind with Ugbrook Nodular Member, (7).

D:- 1 = Siltstones and sandstones of the Mole Creek Member forming in a subtidal environment.
2 = Subtidal micrites of the Dog's Head Member.
3 = Calcarenites formed in the Mole Creek Member at wave base.
4 = Intertidal dolomicrites of the lower part of the Overflow Creek Member.

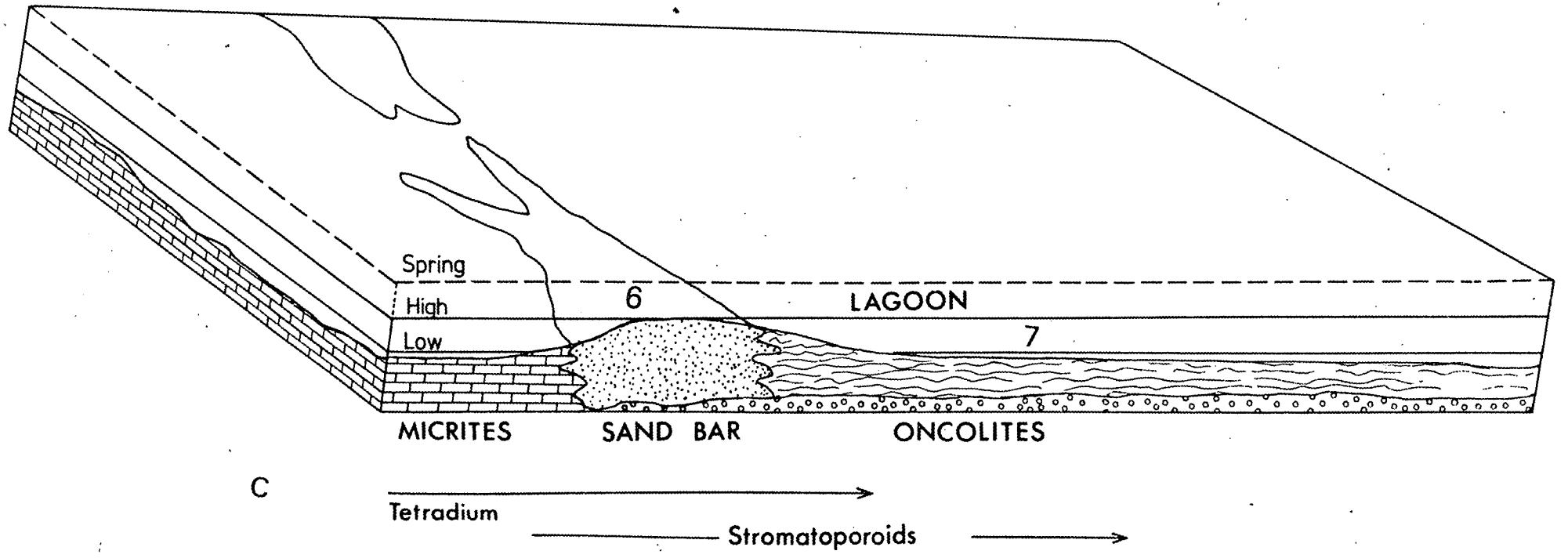
E:- Environments within the Overflow Creek and Den Members at Mole Creek.

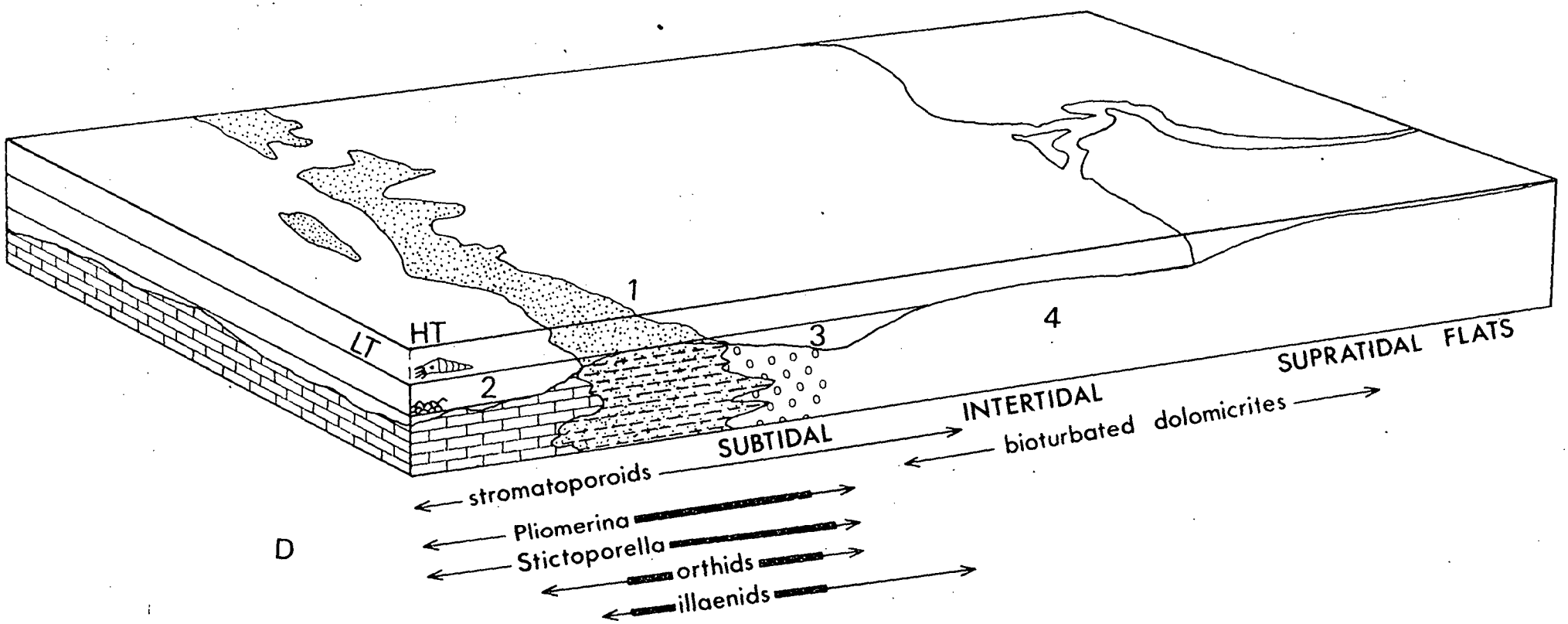
1 = Den Member with coral patches formed in a subtidal environment.
2 = Stromatolites formed in low intertidal environment.
3 = Channel calcarenites.
4 = Sabkha dolomicrites of the Overflow Creek Member.

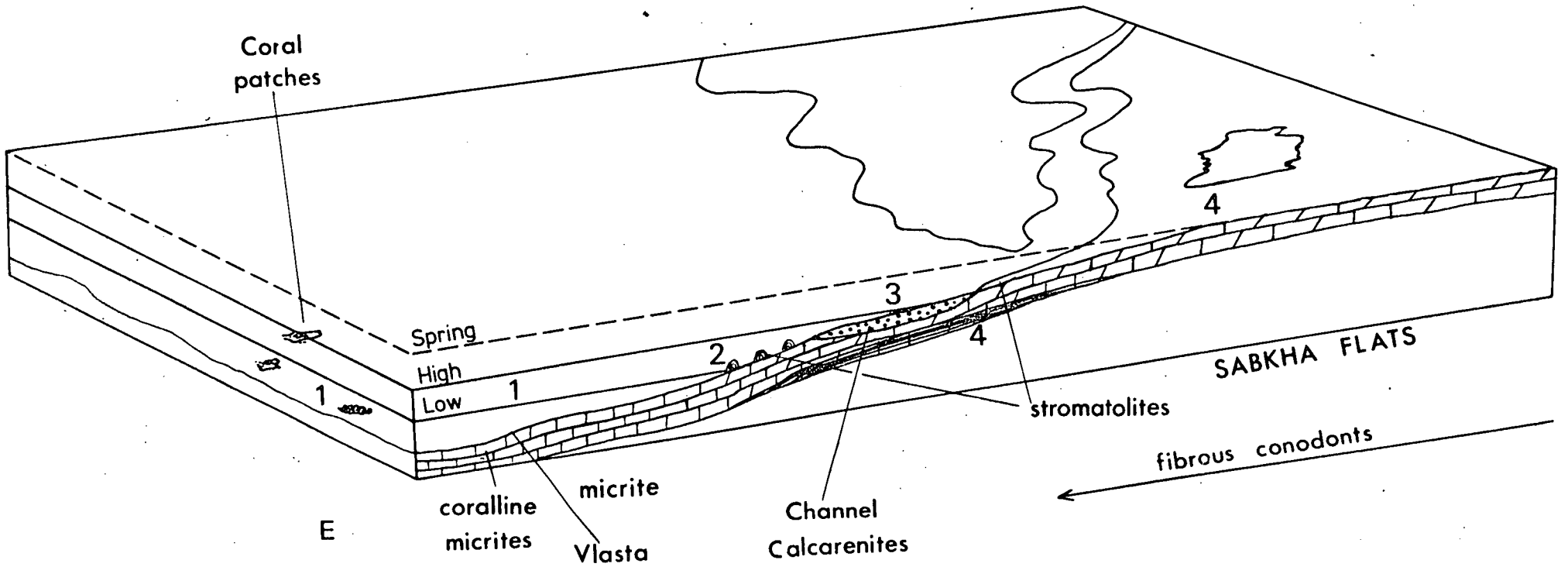

stromatolites
algal mats
hypersaline pools
MUD
6
1
2
3
4
5
Spring
High
Low
SUPRATIDAL FLATS
LAGOON
BAR
SUBTIDAL
Maclurites
strophomenids
Lichenaria
Orthonybyoceras
chitinozoa
asaphids
stromatoporoids
A


Spring
High
Low
4
1 sands
2
3
5
oncolites
calcarenites
with
strophomenids

B


Spring
High
Low
6
LAGOON
7
MICRITES
SAND BAR
ONCOLITES
C
Tetradium
Stromatoporoids


1
2
3
4
LT
HT
SUPRATIDAL FLATS
INTERTIDAL
SUBTIDAL
bioturbated dolomicrites
stromatoporoids
Pliomerina
Stictoporella
orthids
illaenids
D


Coral
patches
Spring
High
Low
1
1
2
3
4
4
SABKHA FLATS
stromatolites
fibrous conodonts
E
coralline
micrites
micrite
Vlasta
Channel
Calcarenites

effect on the *local ecological controls operating on a local conodont fauna.* A broad classification of tectonic units will tell us little about local salinity, temperature, water depth, environmental stability, bottom sediment, faunal associates, food supply etc. This is especially clear in Tasmania where the sediments are typical of "shelf" conditions, where the water depth was extremely shallow for most of the Ordovician and yet because of the thick sedimentary pile and the general tectonic situation, the label "miogeosyncline" would have to be applied. It is interesting that Barnes *et al.* 1973 (p.175) refer to the Tasman Shelf when referring to Tasmania. They also mention the conodont faunas of "limestone platforms" from within the Tasman Geosyncline listed by Packham (1967) and others illustrated by Philip (1966). The writer has found fibrous conodonts in New South Wales limestones (i.e. forms characteristic of the littoral shelf according to Barnes *et al.*, 1973 fig. 14) but were clearly deposited around volcanic island arcs and hence, on the Kay scheme, were eugeosynclinal.

Bergström and Carnes (1976) have also pointed out that many genera supposedly characteristic of eugeosynclinal terrains are, in fact, abundant in the very shallow water shelf carbonates of Sweden. Bergström and Carnes (1976) found that conodonts were abundant in certain shallow water Swedish carbonates that contain many stromatolites and that have been interpreted as mainly intertidal by Larsson (1973). However stromatolites by themselves are not good indices of intertidal conditions and subtidal stromatolites are now well known (Gebelein 1969, Frost 1974). Larsson (1973) does not figure or fully describe other typically intertidal sedimentary features from the section. However as Bergström and Carnes (1973) remark there can be little doubt that the Lunne sequence was laid down in very shallow water. Thus such genera as *Periodon* and *Eoplacognathus* are unlikely to be controlled,

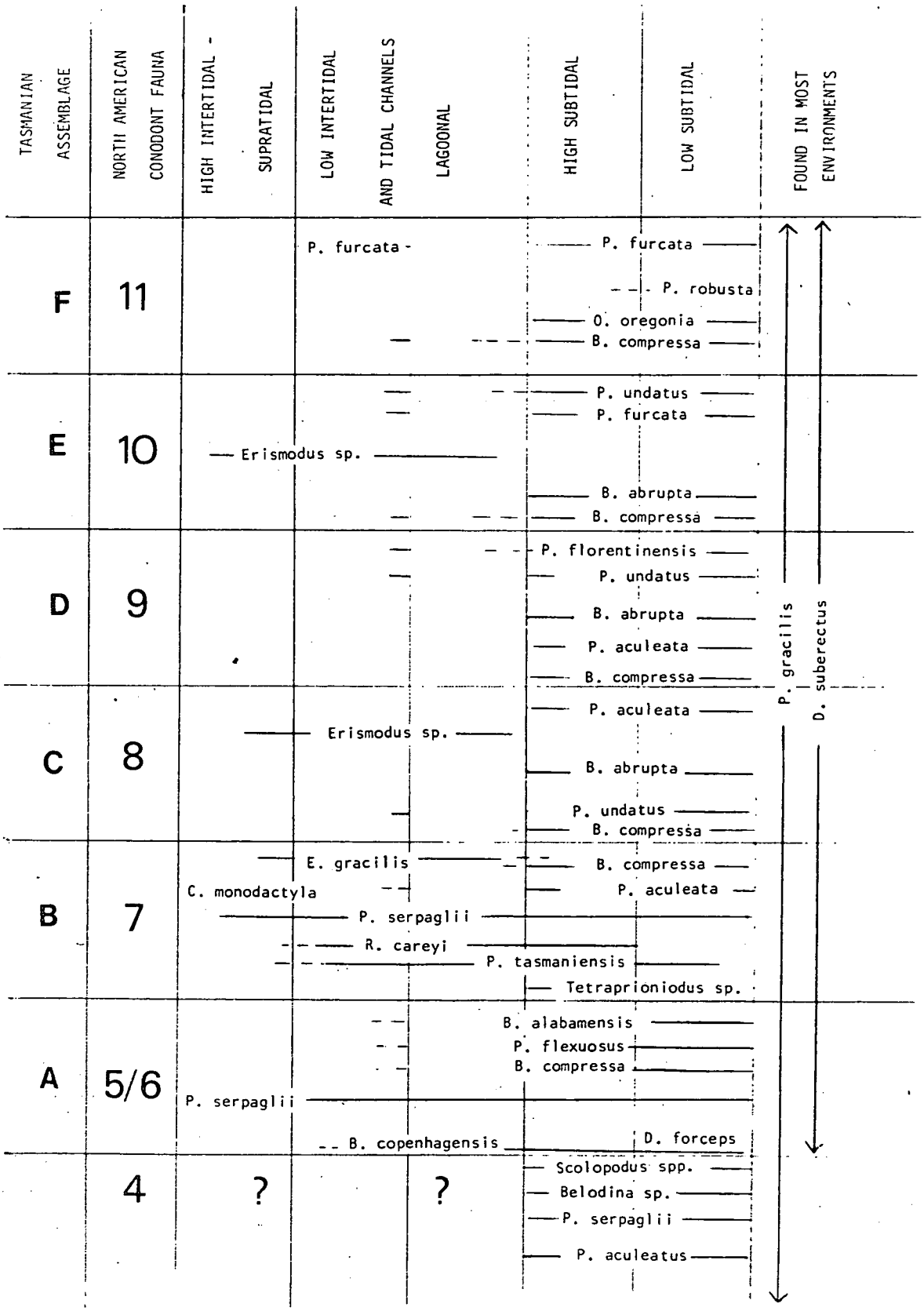
	INCREASING DEPTH →		
	LITTORAL		
CINCINNATIAN		BELODINA OULODUS PLECTODINA	PHRAGMODUS
TRENTONIAN BLACKRIVERAN	CHIROGNATHUS ERISMODUS	BELODINA BRYANTODINA PLECTODINA	PHRAGMODUS
CHAZYAN WHITEROCKIAN	genera not found in Tasmania		BELODELLA PHRAGMODUS
	← increasing PANDERODUS		} Pelagics
	← DREPANOISTOIDUS →		

TABLE VI

Slightly amended Table showing Barnes' and Fåhraeus' (1975) postulated segregation of conodonts into communities. Tasmanian genera only are included. Adapted from Barnes and Fåhraeus (1975, fig.1).

TABLE VII

Probable environmental distribution of conodonts recognised in this study.



in their gross distribution, by such factors as salinity or water depth but by temperature (Bergström 1971, 1973). These "European" genera are not found in Tasmania which presumably was covered by sea water of elevated, "Mid-Continent" temperatures.

Barnes and Fåhraeus (1975) produced a table indicating the lateral segregation of the main conodont communities in the Mid-continent Province. This Table is amended to include only the known Tasmanian forms in Table VI.

Using the environmental indicators discussed earlier (pgs. 240-242) the Tasmanian conodont species may be placed in the environments indicated. Generally there is agreement between the environmental preferences shown in Table VI (from Barnes and Fåhraeus 1975) and Table VII.

Panderodus gracilis and *Drepanoistodus suberectus* occur in most environments and the former species may be found in high intertidal limestones in very small numbers. Following Barnes and Fåhraeus (1975) these species are taken to be pelagic forms.

Very few species are found in supratidal and high intertidal environments. The main microfaunal constituents are fibrous conodonts, *P. serpaglii* and *R? careyi*. Rare specimens of *P. serpaglii* are found in tidal flat deposits in the Chazyan. *P. serpaglii* is also found in subtidal environments and a pelagic habitat is suggested.

Very robust specimens of *R? careyi* are occasionally found in high intertidal limestones in the Lower Limestone Member in the Florentine Valley and in the Everlasting Hills. They are associated with *C. monodactylus* and *E. gracilis*.

Kohut and Sweet (1968) have postulated a tidal flat environmental preference by *R. symmetrica symmetrica* and *R. rowlandensis* in the Cincinnatian suggesting that *Rhipidognathus* was one of the few conodont genera that preferred to live in such unstable and harsh environments.

Le Fèvre *et al.*, 1976 have also noted that *Rhipidognathus* appears to be euryhaline.

During the time span of faunas 8 through to 10 rare, often corroded, fibrous conodonts are the only elements found in high intertidal conditions.

Forms such as *B. copenhagenensis* and ?*Appalachignathus* are rare and are found in tidal channels within intertidal sequences (as at Mole Creek) or in subtidal limestones. In all cases they are diminutive and comprise a small proportion of the conodont fauna. This suggests that these species favoured deeper water and only rarely inhabited inshore environments.

Higher in the sequence forms such as *B. abrupta* and *P. undatus* are relatively common in subtidal environments and become rare inshore. *Plectodina florentinensis* has only been found in subtidal rock types. The highest faunas contain *P.* cf. *furcata* and *B. compressa* in shallow water with *O.* cf. *oregonia*, *O. robustus* and *S. falcata* occurring in relatively deep subtidal environments. *Milaculum ethinclarki* is abundant in certain subtidal limestones especially those near to the top of the limestone sequences in the Florentine Valley, Lune River (Ida Bay) and Bubs Hill. *M. ethinclarki* is only rarely found in intertidal limestones.

The ecologic controls recognised here and in the various recent papers on conodont palaeoecology cited above do not appear to affect the biostratigraphic scheme outlined earlier.

Biogeographic Connections of the Tasmanian Ordovician Conodont Fauna

The Chazyan-Cincinnatian conodonts of Tasmania belong mainly to well known North American species. Most of these are typical of the Mid-continent faunal province. The Mid-continent affinities of certain Australian faunas has been commented on before by several authors.

The only published illustrations of post-Whiterock Australian conodonts are those of Philip (1966). Packham (1967) listed several conodonts from limestone outcrops near Parkes in New South Wales. These publications have led several authors, Bergström (1971, 1973), Barnes *et al.*, (1972), Sweet and Bergström (1974), Barnes and Fåhraeus (1975) and Lindström (1976), to place Australia in the Midcontinent province (or *Phragmodus* fauna of Lindström 1976). Bergström (1971, 1973) has recognised an Australian fauna based on samples from Central Australia and also, according to Sweet and Bergström (1974, p.196), from Tasmania. This fauna has since been recorded and figured from the Appalachians by Raring 1972 who has (p. 92) listed the characters of the Australian fauna as "long slender denticles and generally the presence of two to three rather long processes." The new species *Rhipidognathus? careyi* probably belongs in the Australian fauna. No other representatives of this fauna have been found in Tasmania and it is not clear whether *R? careyi* is merely a homoeomorph of North American *Rhipidognathus* and adapted to a similar tidal flat environment or whether it is a member of a large collection of endemic Australian species of generic or supra-generic status. It would seem unlikely that all of the "Australian" fauna belong in *Rhipidognathus? careyi*.

Whiterockian fauna

Whiterockian faunal elements have not been studied in detail in this thesis and will be examined by Dr. D.J. Kennedy. They include the well known widely distributed species *Periodon aculeatus* as well as several species of *"Scolopodus"*. *Panderodus serpaglii* sp. nov. is first found associated with Whiterock elements. This species is found elsewhere in Argentina (Serpagli 1974), Malaysia (Igo and Koike 1947) and in North Korea (Lee 1975). Interestingly all of these

localities have been included within a Greater Gondwanaland by several authors.

Chazyan fauna

P. serpaglii is a common element associated with *Appalachignathus?*. This latter genus is widespread in North America but may also be found in South Korea (Chun *in* Reedman and Sang Ho Um 1976) or more probably in North Korea (as *?Belodus* sp. Lee 1975). *Belodella copenhagenensis* is widespread in North America, *Acontiodus* cf. *nevadensis* is found in Nevada and *Belodina alabamensis* is known in Nevada and Alabama. *Drepanoistodus forceps* is widespread being known from North America and Europe. *Belodina compressa* is well known in North American and Siberia and has previously been figured by Philip (1966) from Australia (though from much younger strata).

Blackriveran fauna

Faunas correlated with Fauna 7 contain three new species only one of which *(P. serpaglii)* has been previously illustrated. The "endemic" species are *Phragmodus tasmaniensis* and the "Australian" faunal element *Rhipidognathus? careyi*. The well known North American species *Plectodina aculeata*, *Chirognathus monodactylus* and *Erismodus gracilis* are associates.

Trentonian and Cincinnatian faunas

The well known North American species *Bryantodina? abrupta* and *Phragmodus undatus* are common in local assemblage C and these are joined by the endemic *Plectodina florentinensis* in assemblage D. *P.* cf. *furcata* is common in local assemblage D and is familiar in North American faunas as are *O. robustus*, *O. oregonia* and *S. falcata* from local assemblage F.

In general the Chazyan faunas have strongest affinities to North American forms with connections to Siberia, Malaysia, Korea, and Argentina. Blackriveran faunas contain endemic elements associated with well known North American forms. All Trentonian and Cincinnatian species are North American Midcontinent elements except for the endemic *P. florentinensis*.

CHAPTER VII

CONODONT METAMORPHISM

Introduction

It has been known for several years that the colour and preservation of palynomorphs are a function of thermal alteration (Correia 1969, Staplin 1969) and that a regional study may be of considerable economic importance (Cramer *et al.* 1974, Cramer and Diez 1975) but it is only recently that Epstein *et al.* (1977) have shown that conodont colour is similarly temperature dependent.

Epstein, Epstein and Harris (1977) have studied a large number of conodont samples from the Appalachians and have related the observed geographic pattern of colour variation to careful laboratory experiments. They correlate the colour changes with amount of fixed carbon in the conodont and in the surrounding sediments. The conodonts darken with increasing temperature because of the carbonization of the organic material in the interlamellar spaces, though they tend to clear at temperatures above 400°C.

The conodont colour chart of Epstein *et al.* (1977) is divided into five divisions. Colour Alteration Index (C.A.I.) one indicates temperatures of less than ninety degrees centigrade, C.A.I. two: sixty to one hundred and forty degrees, C.A.I. three: one hundred and ten degrees to two hundred degrees, C.A.I. four: one hundred and ninety degrees to three hundred degrees and the darkest C.A.I. five: more than three hundred degrees. Epstein *et al.* (1977, p.19) showed that pressure does not affect the conodont C.A.I. though they did find that water in combination with confining pressure and heat considerably retards carbonization. Therefore the conodont C.A.I. should in some,

or in all cases, be regarded as a minimum. Epstein *et al.* (1977, p.23) argue that tectonism does not affect C.A.I. values because of the experimental results that showed that pressure does not alter C.A.I. values and from observations on a large number of conodont samples from the Appalachians that bear little relationship to tectonic belts. They also show that time is of little importance for C.A.I. values in durations in excess of 50 million years.

Slightly metamorphosed conodonts (displaying a C.A.I. of 2) are found to the south of Zeehan near Grieve's Siding (see p.103) in a strongly cleaved limestone. However at the Smelter's Quarry, Zeehan the conodonts are darker (C.A.I. = 5) but the limestones are not so strongly cleaved. This suggests that cleavage formation and hence tectonic stress are not the most important factors in conodont metamorphism.

Results

Difficulties of comparing conodont colour between a large number of samples has probably resulted in some imprecision in C.A.I. values though the error is unlikely to have been significantly large. Within-sample variation is low and probably does not exceed five percent. As there is some C.A.I. variation between growth stages only medium-size conodonts have been measured and as there is a possibility of C.A.I. variation between genera only elements of *Panderodus*, *Phragmodus*, *Belodina*, and *Plectodina* have been studied.

The average C.A.I. values for each conodont sample from the base of the Gordon Subgroup are plotted in figure 80 and those from the top of the limestone are plotted in figure 81. The latter figure also includes C.A.I. values from three samples of Devonian limestone.

To obtain objective contouring of the data the raw figures were given as points on an otherwise blank sheet of paper to a group of ten people, nine of whom derived virtually identical contour patterns to those shown in figures 80-81.

FIGURE 80

Contoured C.A.I. values for samples from the base of Gordon Subgroup localities. Crosses indicate margins of Precambrian blocks. A = Forth Block, B = Badger Head Block, C = Cradle Mountain Block, D = Prince of Wales Range Block (from E. Williams 1976).
The C.A.I. value of 5.5 is plotted separately as many conodonts are strongly deformed and clearly well into the C.A.I. rank of 5.

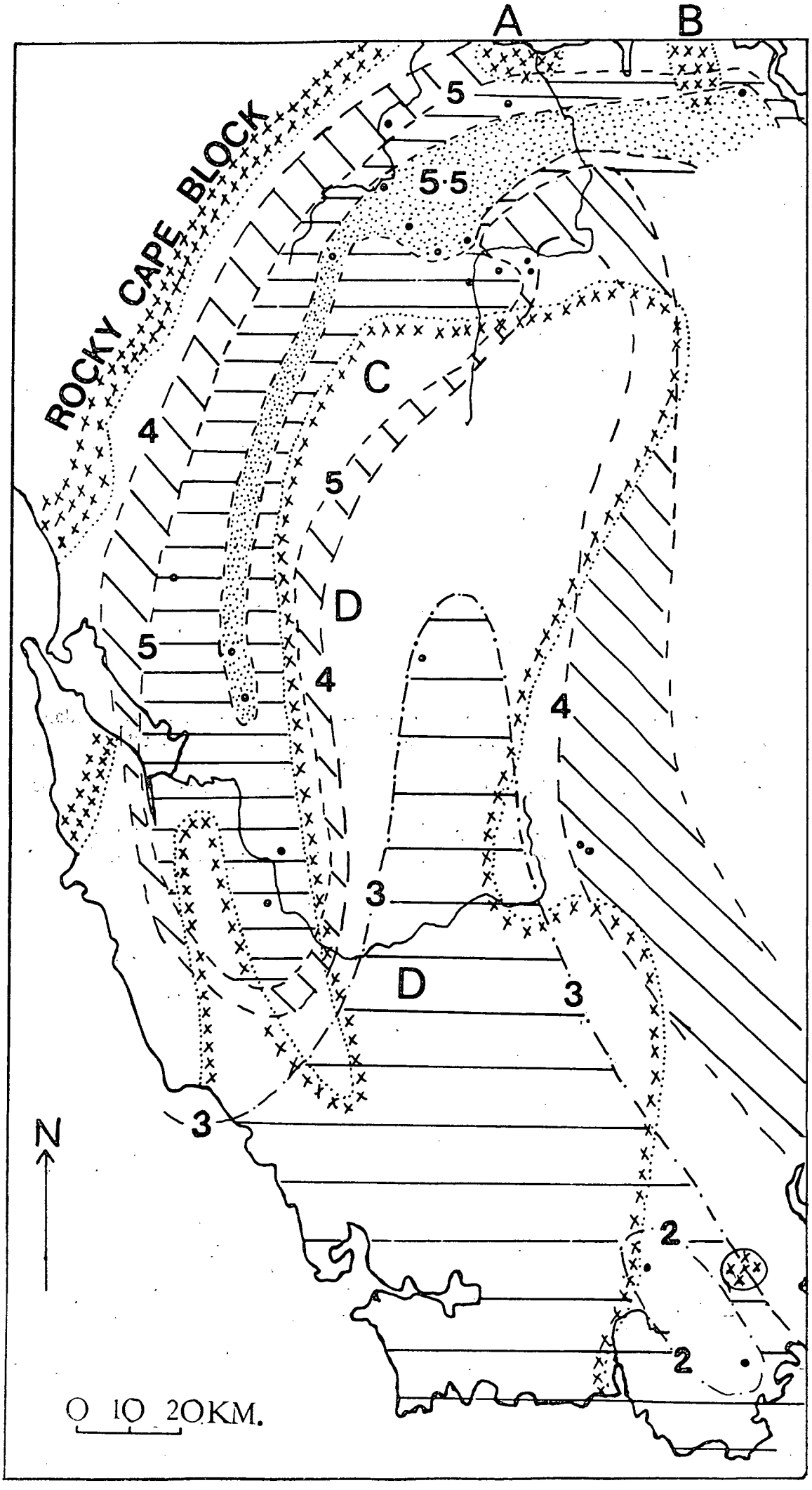
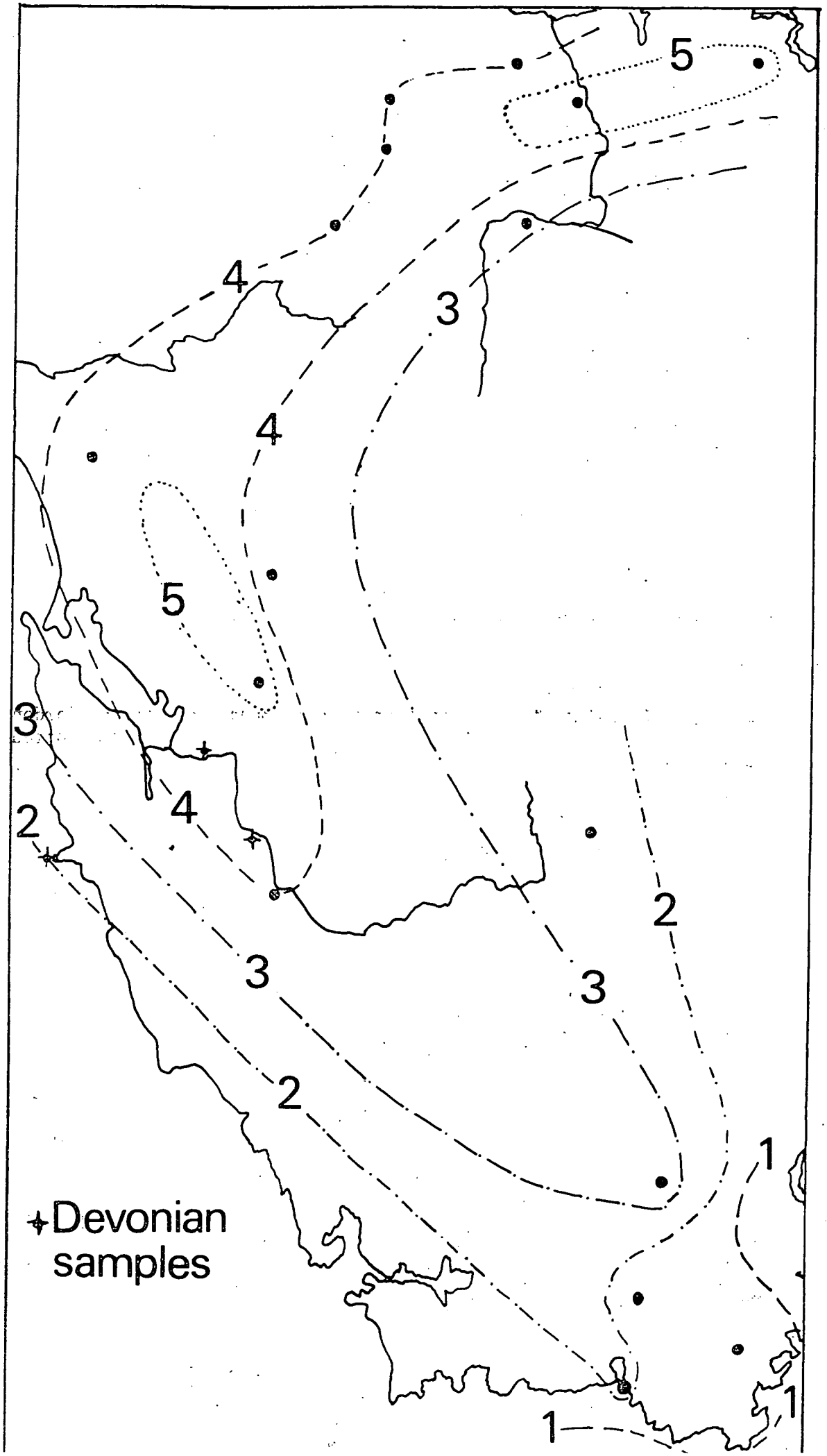

A
B
ROCKY CAPE BLOCK
5
5·5
C
4
5
D
5
4
4
3
D
3
3
N
2
2
0 10 20KM.

FIGURE 81

C.A.I. values for conodont samples from the top of the Gordon Subgroup. Three samples from Devonian Limestones are also plotted (as crossed dots).


5
4
3
4
5
3
2
4
2
3
3
2
1
Devonian samples
1
1

Interpretation

The raw data show an interesting pattern, the most obvious feature of which is the arcuate trend around the Precambrian blocks of central Tasmania. This parallels the major structural trends in the lower Palaeozoic synclinoria that fringe the Precambrian blocks (E. Williams 1976a). The Cambrian volcanics follow this trend the arcuate nature of which has tempted some workers to interpret the volcanics and associated sediments as an island arc. The position of the arc-generating subduction zone remains enigmatic (Corbett, Banks and Jago 1972, Solomon and Griffiths 1974) and many Tasmanian geologists believe that subduction is not necessary to explain the volcanic arc. These geologists prefer a rift valley model based on that of Campana and King (1963) (see E. Williams (1976a) for a review). Most, if not all, workers would agree that the Cambrian geothermal gradient was considerably raised along and adjacent to the zone which contains the darkest Ordovician and Devonian conodonts. Although conduction of heat in the Earth's crust is slow there is unlikely to be a causal relationship between the C.A.I. of Ordovician and Devonian conodonts and Cambrian heat flow. However the Cambrian crustal dilation presumably left a trough of thinned crust flanking the Precambrian blocks. If it is also assumed that this trough was not floored by Precambrian crust then highest heat flow would be expected along this trough in post-Cambrian times.

The zone of darkest conodont colour also coincides with a belt of maximum deformation in the Gordon Subgroup localities. The limestone at Flowery Gully, Eugenana, Loongana and in the Olga Synclinorium are strongly cleaved and folded whereas those in the Florentine Valley and at Lune River (Ida Bay) are less strongly folded and cleavage is generally poorly developed.

The plot of C.A.I. values therefore shows a positive geographic correlation with a trough basinward from a Cambrian volcanic arc (and associated hydrothermal deposits), with the fold trends superimposed on the Palaeozoic sediments and volcanics, and with degree of deformation of these strata.

There appears to be no correlation between C.A.I. values and the distribution of Tertiary basalts, Jurassic dolerite and Devonian granites, all of which are possible heat sources.

Carey (1976) postulated a higher than average heat flow regime during the Jurassic, mainly in order to account for the enormous volumes of dolerite intruded at that time. However, in Tasmania, the dolerite is generally distributed in the central and eastern parts of the state and away from the high C.A.I. values shown in figures 80 and 81 (see Spry and Banks 1962, fig. 43). Dolerite is closely associated with limestones at Vanishing Falls and Lune River (Ida Bay) though the conodonts show the lowest C.A.I. values in the state. A high heat flow during the Jurassic would be expected to have reset the K-Ar dates of the Tabberabberan granites but this does not appear to have happened, though the heat may have been confined to the dolerite masses.

The distribution of Tertiary basalts also appears to bear no relationship to the contoured C.A.I. values of Figures 80 and 81. The basalt tends to be concentrated in the central, eastern and north-western parts of the state (see Fig. 46 in Spry and Banks 1962) and seems to be related to the development of the Bass Strait aulacogen (Burke and Dewey 1973) rather than to any Palaeozoic structure.

If Epstein *et al.* (1977) are correct in their statement that "depth of burial and the attendant increase in temperature is the dominant factor" in altering conodont colour then we would expect that the arcuate trend observed in Figures 80 and 81 coincides with

the greatest thickness of Ordovician and post-Ordovician rocks. This is clearly not the case at Eugenana and Flowery Gully where the Ordovician limestone sequences are very thin (see Fig. 74) and the Devonian and later rocks are also relatively thin.

At Eugenana cave deposits of carbonaceous siltstone (The Eugenana Beds) have yielded an Upper Middle Devonian spore assemblage (Balme 1960). The Gordon Subgroup at Eugenana had been subjected to three phases of deformation, uplifted and eroded prior to the deposition of the cave deposits (Burns 1965). Exactly how much of the limestone was eroded cannot be known with certainty; however the thickness of post-Ordovician rocks is unlikely to have exceeded one kilometre.

Figure 82 shows a selection of modern geothermal gradients (observed and calculated) from various tectonic regimes. Geothermal gradients for the Gordon Subgroup localities are calculated assuming the most likely overburden thickness and fifty percent post-heating, shortening of the original limestone column. Such shortening may be excessive. Shortening by diagenetic stylolitization would have been completed before the heatflow regime considered here would have been operative (see Appendix C for a discussion of shortening in limestone columns).

It is clear that for the Eugenana/Melrose/Paloona area to have had a normal (and modern) geothermal gradient (Fig.82) (and assuming a post-Devonian overburden thickness of one kilometre) then the present (eroded) Ordovician sequence would have to have had about five kilometres of Ordovician to Devonian strata removed by pre Upper Middle Devonian erosion. This appears unlikely. Therefore the most reasonable conclusion is that high heat flows developed in the Eugenana area in post-Middle Ordovician times.

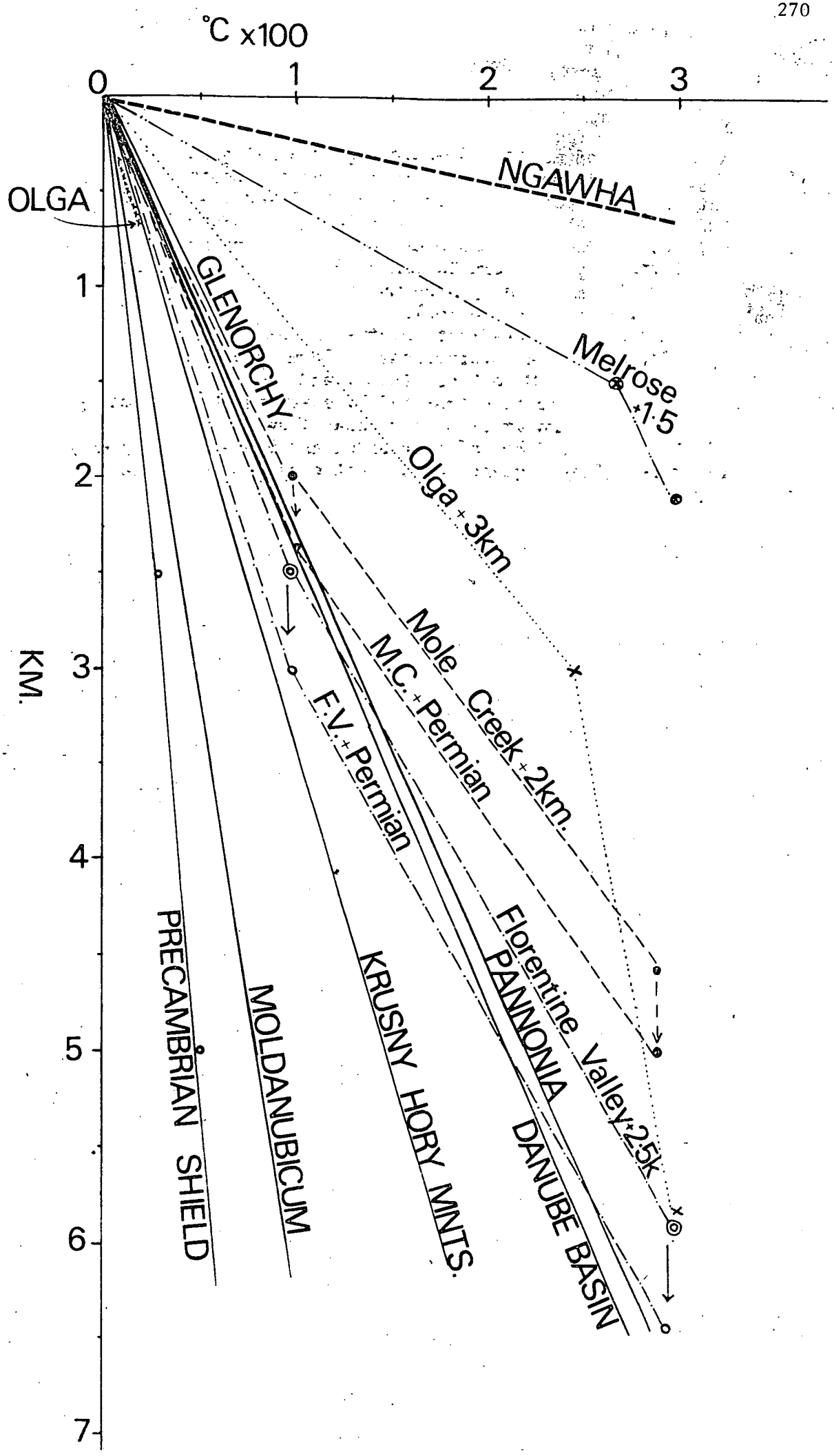
Similar arguments may be used for the Gordon Subgroup at Flowery Gully.

FIGURE 82

A selection of modern and ancient geothermal gradients. Modern gradients in upper case, inferred ancient geothermal gradients in lower case. Gradients from PRECAMBRIAN SHIELD, MOLDANUBICUM, KRUSNY HORY MNTS., DANUBE BASIN & PANNONIA from Cermak (1975). Data from the OLGA (western Tasmanian drill core) and Glenorchy (southern Tasmanian drillcore) from Wronski (1971). Data from NGAWHA (geothermal springs area in New Zealand from A. Davey *pers. comm.*).

Ancient geothermal gradients plotted assuming probably excessive Siluro-Devonian overburdens. Permian overburdens plotted separately for Mole Creek (M.C.) and the Florentine Valley (F.V.). Gradients calculated by assuming 50% shortening of stratigraphic column after maximum heat flow.

Only by assuming 3 km. of overburden and 50% shortening may the Florentine Valley sequence be brought close to modern geothermal gradients.


°C x100
0
1
2
3
NGAWHA
OLGA
GLENORCHY
Melrose +1·5
Olga +3km
Mole Creek +2km.
M.C. +Permian
F.V. +Permian
Florentine Valley +2·5k
PANNONIA
DANUBE BASIN
KRUSNY HORY MNTS.
MOLDANUBICUM
PRECAMBRIAN SHIELD
KM.
1
2
3
4
5
6
7

On the basis of rather weak field evidence Noakes *et al.*, (in Hughes 1957) postulated folding and erosion of the limestone prior to deposition of possibly Upper Ordovician argillites. The highest limestones at Flowery Gully have yielded a Whiterock conodont fauna. A considerable stratigraphic gap is therefore indicated between the limestone and the siltstones if the identification of Upper Ordovician graptolites in the siltstones is correct (Banks and Burrett *in press*). The possibility of an intra-Ordovician deformational event at Flowery Gully cannot be ruled out but on regional considerations appears unlikely. The total thickness of sedimentary and igneous rocks overlying the limestone at Flowery Gully is very unlikely to have exceeded three kilometres whereas at least six kilometres would be needed for a normal continental thermal gradient to have existed at Flowery Gully.

High heat flows are also indicated in the west coast region though much of the gradient may be due to burial by the thick sequence of Siluro-Devonian Eldon Group sediments (Banks 1963). Permian sediments may have provided further overburden but a high post-Ordovician heat flow still needs to be postulated for the west coast.

The heat flow that produced the excess conodont C.A.I. values at Eugenana, Flowery Gully and elsewhere is thought to be Devonian and most likely Middle Devonian because

(i) Lower Devonian conodonts which are unlikely to have been buried to any appreciable depth are metamorphosed.

(ii) A C.A.I. gradient exists between conodonts from the base of the limestone, at several localities, and the top of the limestone. If the heat flow was post-tectonic then the C.A.I. of conodonts from the top and bottom of gently dipping limestone sequences should be very similar.

(iii) The K-Ar ages of Upper Devonian granites have not been re-set by subsequent heat induced leaking of argon. However the K-Ar

ages of Upper Cambrian granites have been re-set to Ordovician ages (McDougall and Leggo 1965) presumably by Devonian heating.

If the distribution of the C.A.I. in Tasmania is compared with the major Precambrian blocks (Fig. 1 & 80) then a model for palaeoheat flow in Tasmania may be developed. Thick sequences of Eldon Group clastics could have helped to thicken the crust in the west of the trough but not in the northern part of the trough. Thus the highest heat flow is postulated in the northern part of the trough, followed by lower values in the west of the trough with values elsewhere being proportional to the observed C.A.I. values.

The variations in C.A.I. values elsewhere in the state may be related to crustal thickness, rather than to depth of burial. If that postulate is correct then the thickness of Precambrian crust increases (or at least increased during the Devonian) towards the south. Recent seismic studies by R.G. Richardson have not, for logistic reasons, extended into the southwestern parts of the state though gravity studies by Johnson (1972) and Symonds and Willcox (1976) do not contradict the hypothesis of crustal thickening to the south. Johnson's (1972) highest positive Bouguer anomalies occur in the southwest and south of the state which may suggest crustal thickening in those directions.

The C.A.I. values and their interpretation suggest that high temperatures occurred at fairly shallow depths principally in the north of the state. The geothermal gradient indicated for Melrose would suggest that anatexis was occurring at a depth of approximately eight kilometres during the Devonian. If the formula of Verhoogen *et al.*, (1970, p.643) is taken:

$$T_H = T_0 + \frac{H}{K}(q_o - \tfrac{1}{2}\varepsilon H)$$

where T_H = temperature at base of crust

T_0 = temperature at surface

H = thickness of crust

K = thermal conductivity (cal cm^{-1} sec^{-1} deg^{-1})

q_o = heat flow at surface (cal cm^{-3} sec^{-1})

ε = intensity of heat sources (cal cm^{-3} sec^{-1})

and simplified to:

$$T_H = T_0 + \frac{H}{K}(q_o)$$

by assuming that most of the heat is generated in the mantle then the surface palaeoheatflow may be calculated by:

$$q_o = \frac{K}{H}(T_H - T_0).$$

If the following values are assumed: $K = 5 \times 10^{-3}$, $H = 8 \times 10^{5}$, $T_H = 700$ and $T_0 = 20$ then $q_o = 4.2 \times 10^{-6}$ which is an exceedingly high q_o value (most q_o values range between one and two - Lee and Uyeda 1965) then a thickness of fifteen kilometres has to be assumed in order to bring the q_o value down to two. An overburden thickness of more than ten kilometres is most unlikely to have existed in post-Ordovician times and therefore the C.A.I. values obtained at Eugenana may only be interpreted by assuming unreasonably high surface heat flow during the Devonian. Very high heat flow in the Eugenana/Melrose/Paloona area is unlikely as no hydrothermal deposits are known in the region.

A decrease in the q_o value cannot be effected by altering the values of thermal conductivities of the rocks beneath and above the limestone. Thermal conductivities of various rock types at various temperatures have been calculated from data in Weast (1975). Reasonable q_o values i.e. values below 3 cal cm^{-3} sec^{-1}, may only be obtained by assuming that the eight kilometres of sediment is composed of marble, dolomitic limestone and/or shale. This is unrealistic as much of the

Rock	I temperature °C	II K cal $m^{-1}hr^{-1}deg^{-1}$	III K cal $cm^{-1}sec^{-1}deg$		IV q_o cal $cm^{-3}sec^{-1}$	
			thermal conductivity at temperature shown in left hand column (used in calculations)		surface heat flow	
granite	0	3.02	8.39	10^{-6}	7.131	10^{-9}
	50	2.81	7.81	10^{-6}	6.635	10^{-9}
	100	2.59	7.19	10^{-6}	6.115	10^{-9}
	200	2.34	6.50	10^{-6}	5.525	10^{-9}
	300	2.12	5.89	10^{-6}	5.006	10^{-9}
marble	118	1.44	4.00	10^{-6}	3.400	10^{-9}
	196	1.29	3.58	10^{-6}	3.046	10^{-9}
	245	1.19	3.31	10^{-6}	2.810	10^{-9}
	360	0.95	2.64	10^{-6}	2.243	10^{-9}
dolomitic limestone	130	1.41	3.92	10^{-6}	3.329	10^{-9}
	181	1.37	3.81	10^{-6}	3.235	10^{-9}
	268	1.29	3.58	10^{-6}	3.046	10^{-9}
	377	1.15	3.192	10^{-6}	2.715	10^{-9}
shale	0	1.65	4.58	10^{-6}	3.896	10^{-9}
	100	1.51	4.19	10^{-6}	3.565	10^{-9}
	120	1.33	3.69	10^{-6}	3.140	10^{-9}
	188	1.41	3.92	10^{-6}	3.329	10^{-9}
	304	1.26	3.50	10^{-6}	2.975	10^{-9}
sandstone (quartzitic)	0	4.9	1.36	10^{-5}	1.157	10^{-8}
	100	3.82	1.06	10^{-5}	9.019	10^{-9}
	200	3.24	9.00	10^{-6}	7.650	10^{-9}

TABLE VIII

Initial values of K (in cal $m^{-1}hr^{-1}deg^{-1}$) in column II have been obtained from Weast (1975), converted to $cal^{-1}sec^{-1}deg$ (column III) and by using the formula $q_o = \frac{K}{H}(T_H - T_O)$ the heat flow values at the surface (q_o) have been calculated (column IV).

sub-limestone material is volcanic and probably has the conductivity characteristics of granite. Much of the pre-limestone material is also probably of sandstone (with quartz cement) which from the conductivity values shown in Table VIII would elevate the surface heat flow. The post-limestone material is also unlikely to have had low thermal conductivities.

The alternatives to high surface heat flow are:

1) great thicknesses of Ordovician and Siluro-Devonian sediments have been eroded from the region or

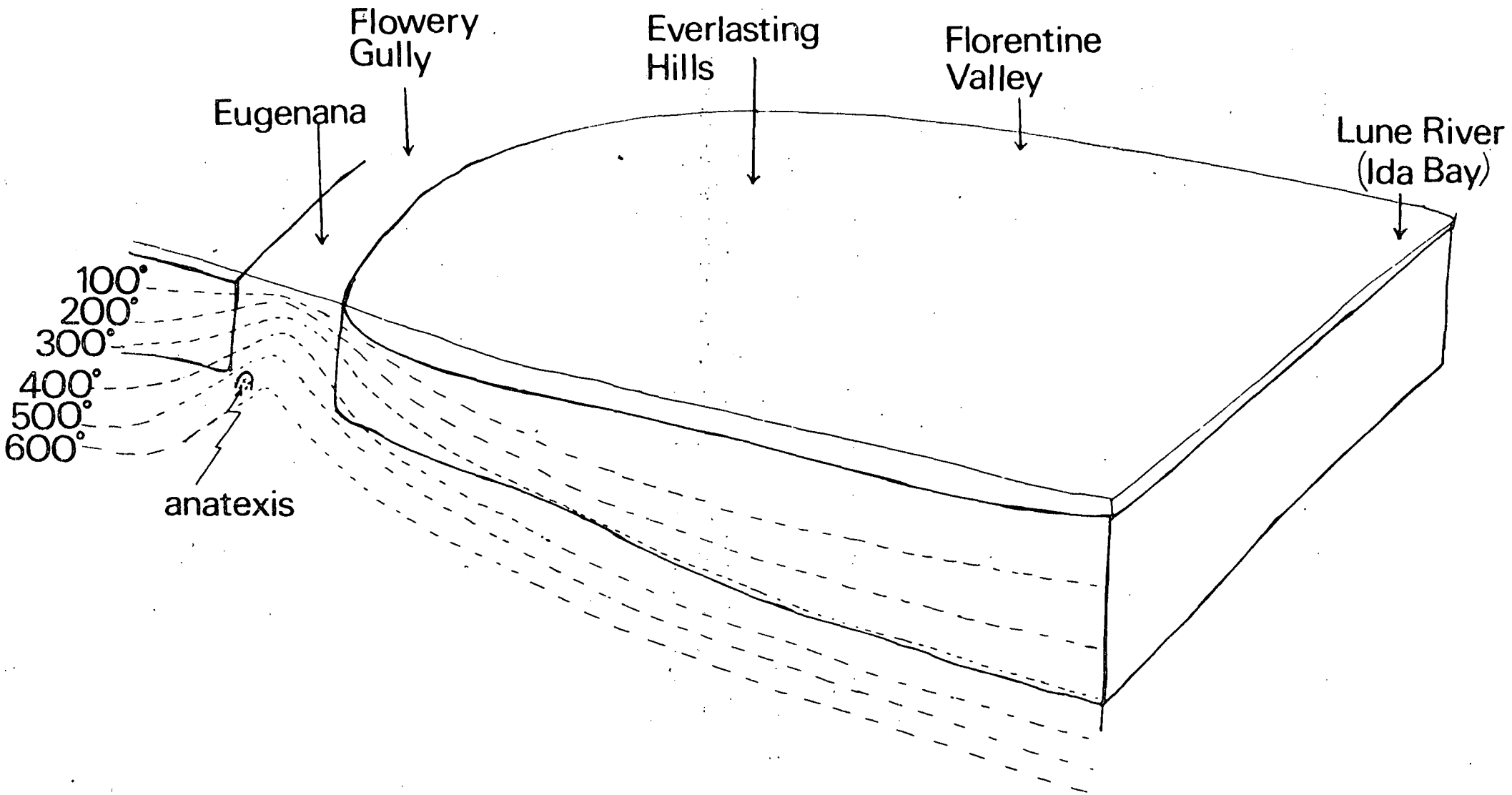
2) granites are present at shallow depths beneath Eugenana and Flowery Gully or

3) conodont geothermometry is in need of revision and in particular a pressure effect has to be postulated.

In the absence of compelling evidence suggesting extensive removal of Palaeozoic sediments and in the absence of experimental work suggesting that C.A.I. values can be altered by pressure, high heat flow is postulated for the whole of the state during the Devonian. Very high heat flows are suggested for the north of the state at all crustal levels. Lowest heat flows occurred in those areas of limestone floored by appreciable thicknesses of Precambrian crust. Lowest heat flow is indicated in the south and southwest of the state where Devonian crustal thicknesses are postulated to have been highest (Fig. 83).

FIGURE 83

Diagrammatic section through Tasmania showing the relative thickness of Precambrian crust and a postulated heat flow regime for the Devonian.


Flowery
Gully
Everlasting
Hills
Florentine
Valley
Eugenana
Lune River
(Ida Bay)
100°
200°
300°
400°
500°
600°
anatexis

SUMMARY AND CONCLUSIONS

Relatively detailed study of Gordon Subgroup carbonates near Mole Creek has allowed a lithostratigraphic sequence to be erected within the Chudleigh Limestone Formation. The Standard Hill Member consists of 145m. of oncolitic limestone and minor biocalcarenites deposited in a low intertidal environment and overlies the high intertidal Moina Sandstone. The Ugbrook Nodular Member consists of 120m. of macro-unfossiliferous nodular argillaceous limestones and minor micrites possibly deposited in a lagoonal environment. The Ugbrook Nodular Member is probably the same age as a presumed sand bar deposit laid down to the south of Standard Hill. The Sassafras Creek Member is a 135m. thick sequence of micrites and dolomicrites, slightly nodular in places with a 3m. thick bed of biocalcarenite at the base and a thin oncolitic bed at the top. Rare beds rich in macrofossils occur within the member. The 470m. thick Dog's Head Member is a sequence of micrites and dolomicrites containing chert nodules and several beds of silicified macrofossils. The Mole Creek Member consists of 75m. of reddish siltstones containing an orthid/stictoporellid/*Pliomerina* fauna. The Overflow Creek Member consists of 245m. of mainly unfossiliferous dolomicrites and dolosiltites probably deposited on a tidal flat crossed by tidal channels.

The Den Coralline Member consists of 45m.-60m. of highly fossiliferous biomicrites and beds of biocalcirudites overlain by 40m. of creamy textured mainly unfossiliferous micrites. Brachiopod-bearing siltstones overlie the Chudleigh Limestone and are the highest beds in the Gordon Subgroup. These siltstones are overlain by unfossiliferous white quartzites.

The Chudleigh Limestone is 1300m. thick and was mainly deposited

in peritidal conditions. From an analysis of the gross lithic and faunal characteristics of the limestone sequence only 20% of the carbonates were deposited under subtidal conditions. Six major subtidal periods may be identified. Four of these are in the Dog's Head Member, one in the Mole Creek Member and one in the Den Member and above.

From a study of conodont distributions at Mole Creek and in thirty other sections a composite local sequence of assemblages has been established.

Whiterockian forms have only been very briefly studied but include *Periodon aculeatus* Hadding, *?Belodina* sp., *Panderodus serpaglii* sp. nov. and several scolopodids. This fauna is found at Railton and a similar fauna has been collected at Flowery Gully.

Belodina compressa (Branson and Mehl), *Panderodus gracilis* (Branson and Mehl) and *Drepanoistodus suberectus* (Branson and Mehl) occur throughout the local assemblages A-F.

Assemblage A contains *Phragmodus flexuosus* Moskalenko, *Belodina alabamensis* Sweet and Bergström, *Panderodus serpaglii* sp. nov., *Appalachignathus?* Bergström *et al.*, *Drepanoistodus forceps* (Lindström) and *Belodella copenhagenensis* (Ethington and Schumacher). Assemblage A may be correlated with the *P. serrus* and *P. anserinus* zones, with the Chazy Group and with the Volginskiy and Kirenskiy Subformations.

Assemblage B contains *Chirognathus monodactylus* Branson and Mehl, *Panderodus serpaglii* sp. nov., *Plectodina aculeata* (Stauffer), *Erismodus gracilis* (Branson and Mehl), *"Tetraprioniodus"* sp. and the endemic species *Phragmodus tasmaniensis* sp.nov. and *Rhipidognathus? careyi* sp. nov. Correlation with Fauna 7 is suggested by *C. monodactylus*.

Assemblage C contains *P. aculeata*, *Bryantodina? abrupta* (Branson and Mehl) and *Phragmodus undatus* Branson and Mehl and may be correlated with Fauna 8.

Assemblage D contains *P. undatus*, *B? abrupta*, *Plectodina* cf. *furcata* (Hinde) and *Plectodina florentinensis* sp. nov. This assemblage is correlated with Fauna 9.

Assemblage E is the same as assemblage D except that it lacks *P. florentinensis*.

Assemblage F contains *Oulodus robustus* (Branson, Mehl and Branson), *Oulodus* cf. *oregonia* Branson, Mehl and Branson, *P.* cf. *furcata*, *P. undatus* and *Staufferella falcata* (Stauffer). Correlation with the Edenian part of Fauna 11 is suggested for assemblage F indicating correlation of assemblage E with much of Fauna 10.

These assemblages occur widely through the Gordon Subgroup carbonate though the new species *P. tasmaniensis*, *P. florentinensis* and *R. careyi* have a limited geographic distribution and have not been found in northwestern Tasmania. From a study of the vertical distribution of these assemblages in over thirty limestone sections spread through 23,000 sq. km a correlation chart for the Gordon Subgroup may be constructed (Fig.75). Assemblage A is found in the Standard Hill and Ugbrook Nodular Members at Mole Creek and in the Cashions Creek Formation and lower part of the Lower Limestone Member in the Florentine Valley. Assemblage A is also found in oncolitic limestones at Judd's Cavern, Moina and Claude Creek and in non-oncolitic limestones in the Olga-Gordon region near Lune River, at Loongana, near Liena and at Melrose. Assemblage B is found in the upper part of Ugbrook Nodular Member, in the Lower Limestone Member in the Florentine Valley in the Everlasting Hills, at Lune River, near Zeehan, in the Vale of Belvoir, near Loongana, at Gunn's Plains and at Melrose. Assemblage C is found in the Dog's Head Member at Mole Creek and in the upper part of Lower Limestone Member in the Florentine Valley, at Lune River, in the Vale of Belvoir and at Loongana. Assemblage D is found in the Mole Creek Member, and lower Overflow Creek Member, in

the Upper Limestone Member in the Florentine Valley, at Bubs Hill, in the Vale of Belvoir, at Gunns Plains and possibly in the Andrew Valley. Assemblage E is found in the Overflow Creek Member and lower parts of the Den Member at Mole Creek in the upper parts of the Upper Limestone Member in the Florentine Valley, in the Picton River at Ida Bay in the Olga-Gordon Region, at Bubs Hill and at Zeehan. Assemblage F is found in the Den Member and above at Mole Creek, in the Upper Limestone Member in the Florentine Valley, along the Picton River, at Lune River, at Bubs Hill and at Zeehan.

Despite the processing of large numbers of samples, limestone at Queenstown, and in the Huskisson River area did not yield conodonts.

From a study of the contained conodont assemblages it is evident that the base of the Gordon Subgroup is strongly diachronous. The underlying Denison Subgroup clastics are also almost certainly diachronous. It is highly probable that Denison Subgroup clastics were being deposited in terrestrial, supratidal, intertidal and partially subtidal conditions in the west whilst intertidal and subtidal carbonates were being deposited further east. The oldest limestones are in the east near Beaconsfield (Upper Canadian) and in and adjacent to the Florentine Valley (Upper Canadian). Slightly younger (Whiterockian) limestones are known at Flowery Gully and at Blenkhorn's Quarry at Railton. These would appear to be coeval with subtidal clastics near Melrose and intertidal sandstones near Mole Creek, Chudleigh, Moina, Claude Creek, Lorinna and Loongana. Slightly younger Whiterock limestones are known at the Goliath Quarry Railton and these are probably also contemporaneous with siliciclastics from Chudleigh westwards to Loongana. The Whiterock limestones are probably coeval with conglomerates in the Vale of Belvoir. Plotting of these relationships suggests an east-west trending Upper Whiterockian intertidal belt passing through or near Chudleigh, Mole Creek, Moina

and Loongana, with subtidal conditions occurring further north and north east.

Whiterockian limestones are not definitely known elsewhere in the state (apart from the Florentine Valley), though they may be present interbedded with quartz arenites near the junction of the Franklin and Gordon Rivers but these may be Chazyan. Chazyan limestones are widespread in the state and are often oncolitic. However at Zeehan and in the Vale of Belvoir the base of the limestone sections are Blackriveran suggesting that the underlying siliciclastics are Chazyan. Trenton limestones are found in many areas of the state though limestone deposition may have ceased at Melrose by the Blackriveran, at Railton by the Chazyan and at Flowery Gully by the Upper Whiterockian. Cincinnatian limestones are found at Zeehan, Bubs Hill, Ida Bay, Picton River, Vanishing Falls, Mole Creek, Liena, Olga River region and possibly at Gunns Plains. These limestones are often coralline and are near to the top of the limestone sequences. An influx of sands and muds, probably related to an uplift of the source areas, terminated limestone deposition in the Edenian.

During the Ordovician Tasmania may be regarded as a shallow water embayment into the margin of Gondwanaland. After uplift in the Upper Cambrian, molassic deposits belonging to Denison Subgroup were deposited around the flanks of Precambrian blocks. A gradual peneplanation during the Lower Ordovician allowed the incursion of warm seas. By the Chazyan large areas of Tasmania were flooded by waters in which extensive sheets of oncolites were being deposited probably in a low intertidal environment.

The general area covered by Ordovician carbonates in Tasmania is comparable to recent carbonate areas of Shark Bay, Western Australia. There is no necessity to postulate Ordovician or late transcurrent movements between Western Tasmania and either Victoria or Eastern

Tasmania or both. A transition from platform carbonates eastwards into deeper water sediments of the Mathinna Beds and northwards into the graptolitic shales of Tasmania is the simplest solution (Banks 1962) and explain most, if not all, of the geological and geophysical evidence.

An obvious feature of the Chazyan-Cincinnatian conodonts in Tasmania are their low diversity and general rarity. Over seven hundred limestone samples have been collected but only 40% yielded conodonts and only 25% yielded stratigraphically useful faunas. Low yields meant that channel sampling and random sampling were time consuming and economically wasteful. It is recommended that any future sampling should be carried out in conjunction with an appraisal of the depositional environments and that sampling be generally concentrated on likely rock-types deposited in subtidal and non-intertidal regimes. The paucity of conodonts is ascribed to (i) continuous basinal subsidence that allowed (or was caused by) a very fast rate of carbonate sedimentation and (ii) hypersalinity occurring not only in intertidal environments but also in shallow subtidal environments.

The mapping of Epstein *et al.'s* Conodont Alteration Index (C.A.I.) reveals an interesting pattern that appears to be related to crustal thickness and geological structures. The pattern cannot be explained by recourse to sediment overburden nor to a tectonic component in the C.A.I. The most reasonable explanation necessitates the postulation of an unexpectedly high heat flow regime during the Devonian.

The initial promise of the Gordon Subgroup for conodont studies has not been realised. Because of the many unfillable gaps in the ranges of each conodont species no detailed evolutionary changes could be mapped and only a preliminary local sequence of assemblages established. However sufficiently large conodont faunules have been

recovered to give a biostratigraphic framework for the Chazyan-Cincinnatian interval in Tasmania. This study also confirms that the composite zonation set-up by Sweet, Ethington and Barnes in 1971 and slightly modified later (Sweet and Bergström 1976) is easily applied in Tasmania and therefore potentially throughout Australia. Preliminary investigations by the writer of thick limestone sequences in New South Wales have revealed a similar conodont sequence that may be correlated with the graptolite zones of New South Wales and Victoria. As many of the Tasmanian macrofossils are also found in New South Wales a satisfying correlation scheme for the Middle-Upper Ordovician is promised for Australia. Unification of Dr. D.J. Kennedy's work on the pre-Chazy conodonts of Tasmania with that of the writer should provide a workable biostratigraphic zonation and provide information on changes in conodont faunas in the poorly known Whiterock-Chazy interval. Collecting of large (100 kg.) samples from the most likely rock types within the barren sequences found during this study should refine the preliminary range charts presented herein. Additional sampling of outcrops in the west and southwest of Tasmania should give us the basis for drawing palaeogeographic maps for each conodont faunal assemblage.

The macrofauna of the Gordon Subgroup is in the process of being studied and now that fairly reliable lithostratigraphic and micro-biostratigraphic schemes are available much important information will become available on modes of macrofaunal evolution and on the phylogenies and evolving ecologies of many shelly groups.

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REFERENCES

ACENOLOZA, F.G., 1976: The Ordovician System in Argentina and Bolivia in Bassett, M.G. (Ed.) *The Ordovician System*. Univ. Wales Press. Cardiff. 479-487.

ANDREWS, H.E., 1967: Middle Ordovician conodonts from the Joachim Dolomite of eastern Missouri. *J. Paleont.* 41: 881-901.

BAILLIE, P.W. & CLARKE, M.J., 1976: Preliminary comments on Early Palaeozoic (Late Ordovician-Early Silurian) rocks and fossils in the Huntly Quadrangle. *Tasmania Dept. Mines Unpub. Rep.* 1976/41.

BALME, B.E., 1960: Palynology of a sediment from Hallet's Quarry, Melrose Tasmania. *Palyn. Rep. Dep. Geol. Univ. W.A.*, 62.

BANKS, M.R., 1957: The stratigraphy of Tasmanian limestones. In Hughes, T.D. (Ed.) Limestones of Tasmania. *Tas. Geol. Surv. Min. Resources*. 10: 39-85.

_____ 1962: The Ordovician System. In Spry A., and Banks, M.R. (Eds.). The Geology of Tasmania. *Geol. Soc. Australia Jour.*, 9 (2): 147-176.

_____ 1965: Geology and Mineral Deposits. pp. 12-17. In Davies, T.L. (Ed.) *Atlas of Tasmania*. Mercury Press, Hobart.

BANKS, M.R. & BURRETT, C.F., *in press*. Ordovician of Tasmania. In Holland, C.H., (Ed.). *Lower Palaeozoic Rocks of Australasia and Antarctica*. Interscience. London.

BANKS, M.R. & JOHNSON, J.H., 1957: The occurrence of *Maclurites* and *Girvanella* in the Gordon Limestone (Ordovician) of Tasmania. *J. Paleont.* 31: 632-640.

BARNES, C.R., 1967(a): Stratigraphy and sedimentary environments of some Wilderness (Ordovician) limestones, Ottawa Valley, Ontario, Canada. *Canadian Jour. Earth Sci.*, 4: 209-244.

_____ 1967(b): A questionable natural conodont assemblage from Middle Ordovician Limestone, Ottawa, Canada. *J. Paleont.* 41: 1557-1560.

BARNES, C.R., 1974: Ordovician conodont biostratigraphy of the Canadian Arctic. In Aitken, J.D. and Glass, D.J. (Eds.) Symposium on Geology of the Canadian Arctic. *Geol. Assoc. Canada Can. Soc. Petrol. Geologists Spec. Vol.* 221-240.

BARNES, C.R., & FÅHRAEUS, L.E., 1975: Provinces, communities and the proposed nektobenthic habit of Ordovician conodontophorids. *Lethaia* 8: 133-149.

BARNES, C.R. & POPLAWSKI, M.L.S., 1973: Lower and Middle Ordovician conodonts from the Mystic Formation, Quebec, Canada. *J. Paleont.* 47: 760-790.

BARNES, C., SASS, D.B. & MONROE, E.A., 1973: Ultrastructure of some Ordovician conodonts. *Geol. Soc. America Spec. Pap.*, 141: 1-30.

BARNES, C.R., SASS, D.B., & POPLAWSKI, M.L.S., 1973: Conodont Ultrastructure : The family Panderodontidae. *Life Sci. Contrib. R. Ontario Mus.*, 90: 1-35.

BARNES, C.R., REXROAD, C.B., & MILLER, J.G., 1973: Lower Paleozoic Conodont Provincialism. *Geol. Soc. America Spec. Pap.*, 141: 157-190.

BARRETT, P.J., GRINDLEY, G.W., & WEBB, P.N., 1972: The Beacon Supergroup of East Antarctica. In Adie R.J. (Ed.) *Antarctic Geology and Geophysics*. Universitetsfortaget. Oslo. 319-332.

BASNAYAKE, S.B., 1975: Geochemistry and Petrography of Ordovician Gordon Limestone, Mole Creek area. *Unpublished thesis, University of Tasmania*, 127p.

BASSETT, D.A., INGHAM, J.K., & WRIGHT, A.D., 1974: *Ordovician System Symposium Field Excursion Guide*. Palaeontological Assoc. Birmingham. 1-66.

BATHURST, R., 1971: *Carbonate Sediments and their diagenesis*. Elsevier. Amsterdam. 1-620.

BERGSTRÖM, S.M., 1964: Remarks on some Ordovician conodont faunas from Wales. *Acta Univ. Lundensis Sec. II* 3: 1-66.

BERGSTRÖM, S.M., 1971; Conodont biostratigraphy of Middle and Upper Ordovician of Europe and Eastern North America. *Geol. Soc. America Memoir*, 127: 83-162.

_____ 1973: Ordovician Conodonts. In Hallam, A. (Ed.) *Atlas of Palaeobiogeography*. Elsevier. Amsterdam. 47-58.

_____ 1977: Early Palaeozoic conodont biostratigraphy in the Atlantic Borderlands. In Swain, F.M. (Ed.) Stratigraphic Micropaleontology of the Atlantic Basin and Borderlands. Elsevier. Amsterdam. 85-110.

BERGSTRÖM, S.M., & CARNES, J.B., 1976: Conodont biostratigraphy and paleoecology of the Holston Formation (Middle Ordovician) and associated strata in Eastern Tennessee. *Geol. Assoc. Canada Sp. Paper*. 15: 27-57.

BERGSTRÖM, S.M., CARNES, J.B., ETHINGTON, R.L., VOTAW, R., & WIGLEY, P.B., 1974: *Appalachignathus*, a new multielement conodont genus from the Middle Ordovician of North America. *J. Paleont*. 48(2): 227-235.

BERGSTRÖM, S.M., RIVA, J., & KAY, M., 1974: Significance of conodonts, graptolites, and shelly faunas from the Ordovician of Western and North Central Newfoundland. *Can. Jour. Earth Sci.*, 11: 1625-1650.

BERGSTRÖM, S.M., & SWEET, W.C., 1966: Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana. *Am. Paleontology Bull.*, 50 (220: 271-441.

BHATT, J.J., 1976: Geochemistry and petrology of the Main Limestone Series (Lower Carboniferous) South Wales, U.K. *Sed. Geol.*, 15: 55-86.

BLISSETT, A.H., 1962: Zeehan. *Geol. Survey Explanatory Report One Mile Geol. Map Series. Tasmania Dept. Mines*. 1-270.

BODOU, P., 1976: L'importance des joints stylolithiques dans la compaction des carbonates. *Bull. Centre Rech. Pau - SNPA.*, 10 (2): 627-644.

BOWEN, E.A. & MACLEAN, C.J., 1971: Palaeozoic Rocks of the Davey River South-West Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, 105: 21-28.

BRADLEY, J., 1954: The Geology of the West Coast Range of Tasmania. Part I, *Pap. roy. Soc. Tasm.*, 88: 193-243.

BRADSHAW, L.E., 1969: Conodonts from the Fort Pena Formation (Middle Ordovician) Marathon Basin Texas. *J. Palaeontol.* 43: 1137-1168.

BRANSON, E.B., 1944: The geology of Missouri. *Univ. Missouri Studies*, 19 (3): 1-535.

BRANSON, E.B., & MEHL, M.G., 1933(a): Conodonts from the Harding Sandstone of Colorado. *Univ. Missouri Studies* 8: 19-38.

_____ (b): Conodonts from the Joachim (Middle Ordovician) of Missouri. *Univ. Missouri Studies*, 8: 77-100.

_____ (c): Conodonts from the Plattin (Middle Ordovician) of Missouri. *Univ. Missouri Studies*, 8: 101-119.

_____ (d): Conodonts from the Maquoketa-Thebes (Upper Ordovician) of Missouri. *Univ. Missouri Studies*, 8: 122-131.

_____ (e): A study of Hinde's types of conodonts preserved in the British Museum. *Univ. Missouri Studies*, 8: 133-156.

BRANSON, E.B., MEHL, M.G., & BRANSON, C.C., 1951: Richmond conodonts of Kentucky and Indiana. *J. Paleont.* 25: 1-17.

BRAUN, M., & FRIEDMAN, G.M., 1969: Carbonate lithofacies and environments of the Tribes Hill Formation (Lower Ordovician) of the Mohawk Valley, New York. *Jour. Sed. Pet.*, 39 (1): 113-135.

BRÉTSKY, P.W., & LORENZ, D.M., 1970: Adaptive response to environmental stability : a unifying concept in paleoecology. *Proc. North American Paleont. Conv. 1969*, Part E: 522-550.

BURKE, K., & DEWEY, J., 1973: Plume generated triple junctions : key indicators in applying plate tectonics to old rocks. *Jour. Geology* 81: 406-433.

BURNS, K.L., 1963: Deep drilling near Latrobe. *Mines Dept. Tasmania Tech. Rep. 7* (1962): 29-36.

_____ 1964: Devonport. *Tasmania Dept. Mines. Geol. Survey Explanatory Report One Mile Geol. map series.* 1-270.

BURRETT, C.F., 1973: Ordovician Biogeography and Continental Drift. *Palaeogeog. Palaeoclimatol. palaeoecol.*, 13: 161-201.

CAREY, S.W., 1947: Report of the Government Geologist. *Rep. Dir. Mines for Tasmania for 1945*, 21-29.

_____ 1976: *The Expanding Earth* Elsevier, Amsterdam. 456p.

CAMPANA, B., & KING, D., 1963: Palaeozoic tectonism, sedimentation and mineralization in West Tasmania. *J. geol. Soc. Aust.*, 10: 1-53.

CERMAK, V., 1975: Temperature-depth profiles in Czechoslovakia and some adjacent areas derived from heat flow measurements, deep seismic sounding and other geophysical data. *Tectonophysics*, 26: 103-119.

COLLINS, P., 1973: Exploratory diamond drilling in the Moina area. *Tas. Dept. Mines., Tech. Rep.*, 18: 17-27.

_____ 1975: Economic potential of the Gordon Limestone in the lower Gordon River area. *Mines Dept. Tasmania. Unpublished report* 75: 1-40.

COOPER, G.A., 1956: Chazyan and related brachiopods. *Smithson. Misc. collns.*, 127: 1-1024.

COOPER, R.A., 1975: New Zealand and South-east Australia in the Early Paleozoic. *New Zealand Jour. Geol. Geophys.*, 18 (1): 1-20.

COOPER, R.A., & WRIGHT, A.J., 1972: Silurian rocks and fossils at Hailes Knob, North-west Nelson, New Zealand. *New Zealand Jour. Geol. Geophys.* 15 (3): 318-335.

CORBETT, K.D., 1963: Geology of the Florentine Valley area. *Unpublished thesis. Univ. of Tasmania.* 1-162.

_____ 1970: Sedimentology of an Upper Cambrian Flysch-Paralic sequence (Denison Group) on the Denison Range Tasmania. *Unpublished thesis, Univ. of Tasmania.*

_____ 1975: The Late Cambrian to Early Ordovician sequence on the Denison Range, southwest Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, 109: 111-120.

CORBETT, K.D., & BANKS, M.R., 1974: Ordovician stratigraphy of the Florentine Synclinorium, Southwest Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, 107: 207-238.

_____ 1975: Revised terminology of the Late Cambrian-Ordovician sequence of the Florentine-Denison Range area and the significance of the 'Junee Group'. *Pap. Proc. Roy. Soc. Tasm.*, 109: 121-126.

CORBETT, K.D., BANKS, M.R., & JAGO, J.B., 1972: Plate Tectonics and the Lower Palaeozoic of Tasmania. *Nature (Phys. Sci.)* 240: 9-11.

CORREIA, M., 1969: Contribution à la recherche de zones favorables à la genèse du pétrole par l'observation microscopique de la matiere organique figuree. *Inst. Francais Petrole Rev.* 24: 1417-1454.

CRAMER, F., & DIEZ, M., 1975: Palynology suggests hydrocarbon mobilization in Ordovician of Kasba Tadla Basin, Morocco. *Geol. Rundsch.*, 65(1): 288-290.

CRAMER, F., KRAMER, W., & ALLAM, B., 1974: Degree of Metamorphism of Palynomorphs suggests wet-gas potential in Bajocian and younger strata of Sidi Kacem Region Morocco. *Amer. Assoc. Petrol. Geol. Bull.*, 58: 526-527.

CRAWFORD, A.R., & CAMPBELL, K.S.W., 1973: Large Scale Horizontal Displacement within Australo-Antarctica in the Ordovician. *Nature*, 241 (105): 11-14.

CUERDA, A., 1973: Resena del Ordovicico Argentino. *Ameghiniana* 10: 272-312.

DRUCE, E.C., 1973: Upper Palaeozoic and Triassic Conodont distribution and the recognition of biofacies. *Geol. Soc. Amer. Spec. Pap.*, 141: 191-237.

DRUCE, E.C., & JONES, P.J., 1971: Cambro-Ordovician conodonts from the Burke River Structural belt, Queensland. *Bull. Bureau Min. Res. Geol. Geophys.*, 110: 1-89.

EPSTEIN, A., EPSTEIN, J., & HARRIS, L.D., 1977: Conodont Color Alteration - an index to conodont metamorphism. *U.S. Geol. Survey Prof. Paper.*, 995: 1-27.

ERIKSSON, K.A., & TRUSWELL, J.F., 1974: Tidal flat association from a Lower Proterozoic carbonate sequence in South Africa. *Sedimentology* 21: 293-309.

ETHINGTON, R., 1959: Conodonts of the Ordovician Galena Formation. *J. Paleont.* 33: 257-292.

ETHINGTON, R.L., & CLARK, D.L., 1965: Lower Ordovician conodonts and other microfossils from the Columbia Ice Fields Section, Alberta, Canada. *Brigham Young Univ. Geol. Studies*, 12: 185-205.

ETHINGTON, R.L., & FURNISH, W.M., 1959: Ordovician conodonts from northern Manitoba. *J. Paleont.*, 33: 540-546.

_____ 1960: Upper Ordovician conodonts from southern Manitoba. *J. Paleont.*, 34: 265-274.

ETHINGTON, R.L., & SCHUMACHER, D., 1969: Conodonts of the Copenhagen Formation (Middle Ordovician) in central Nevada. *J. Paleont.* , 43: 440-484.

FÅHRAEUS, L.E., 1966: Lower Viruan (Middle Ordovician) conodonts from the Gullhögen Quarry, southern central Sweden. *Sveriges Geol. Undersökuing Arsb. ser. c.* 610: 1-40.

FÅHRAEUS, L.E., 1973: Depositional environments and conodont-based correlation of the Long Point Formation (Middle Ordovician) Western Newfoundland. *Can. Jour. Earth Sci.*, 12: 1822-1833.

FÅHRAEUS, L.E., & BARNES, C.R., 1975: Conodonts as indicators of palaeogeographic regimes. *Nature*, 258: 515-518.

FÈVRE, LE. J., BARNES, C., & TIXIER, J., 1976: Paleoecology of Late Ordovician and Early Silurian conodontophorids, Hudson Bay Lowland *Geol. Assoc. Can. Spec. Pap.* 15: 69-88.

FINKS, R.M., & TOOMEY, D.F., 1972: Paleoecology of Chazy Reef Mounds. *In:* Guidebook for Field Trips in Vermont, N. England. *Intercollegiate Geol. Congress Guidebook No. 64:* 443-456.

FLOWER, R.H., 1968: The first great expansion of the Actinoceroids *New Mexico Bureau of Mines and Min. Res. Memoir* 19: 1-15.

_____ 1976: Ordovician cephalopod faunas and their role in correlation. *In:* Bassett, M.G. (Ed.) *The Ordovician System.* Univ. of Wales Press. Cardiff 523-544.

FORD, R.J., 1972: A possible impact crater associated with Darwin Glass. *Earth and Planet Sci. Lett.*, 16(2): 228-230.

FRIEDMAN, G.M., AMIEL, A.J., BRAUN, M., & MILLER, D.S., 1975: Generation of Carbonate Particles and laminites in Algal mats - Example from sea-marginal hypersaline Pool Gulf of Aqaba Red Sea. *Amer. Assoc. Petrol. Geol. Bull.*, 57 (3): 541-557.

FROST, J.G., 1974: Subtidal algal stromatolites from the Florida Backreef environment. *Jour. Sed. Petrol.*, 44 (2): 532-537.

FURNISH, W.M., 1938: Conodonts from the Prairie du Chien (Lower Ordovician) beds of the Upper Mississippi Valley. *J. Paleont.* 12: 318-340.

FURNISH, W.M., BARRAGY E.J., & MILLER, A.K., 1936: Ordovician fossils from upper part of type section of Deadwood Formation, South Dakota. *Am. Assoc. Petroleum Geologists Bull.*, 20: 1329-1341.

GEBELEIN, C.D., 1969: Distribution, morphology and accretion rate of recent algal stromatolites, Bermuda. *Jour. Sed. Pet.*, 39(1): 49-69.

GEE, C.E., 1965: The geology and mineral deposits of the Moina-Lorinna area. *Unpublished thesis University of Tasmania.*

GEE, R.D., & LEGGE, P.J., 1974: *Beaconsfield.* Geological Survey, Explanatory Report Geological Atlas. 1 Mile Series. Zone 7. Sheet No. 30. Tasmanian Dept. Mines, Hobart. 1-122.

GEE, R.D., MOORE, W.R., PIKE, G.P., CLARKE, J.M., 1969: The geology of the Lower Gordon River - particularly the Devonian sequence. *Tasmania Dept. Mines Geol. Surv. Rec.*, 8: 1-23.

GILL, E.D., & BANKS, M.R., 1950: Silurian and Devonian stratigraphy of the Zeehan area, Tasmania. *Pap. roy. Soc. Tasm.*, (1949): 259-271.

GINSBURG, R.N., (Ed.) 1975: *Tidal Deposits*. Springer Verlag Berlin. 1-428.

GLENISTER, A.T., 1957: The Conodonts of the Maquoketa Formation of Iowa. *J. Paleont.*, 31(4): 715-736.

GLOBENSKY, Y., & JAUFFRED, J.C., 1971: Upper Trenton Conodonts from the Grondines section of Quebec. *Canad. Jour. Earth Science*, 8: 1473-1479.

GOEDE, A., 1969: Underground Stream Capture at Ida Bay, Tasmania and the relevance of cold climatic conditions. *Australian Geographical Studies*, 7: 41-48.

GOULD, C., 1860: Examination of the district between Chudleigh and Launceston. *Tasm. Legislative Council Pap.* 16.

_____ 1861: Mersey Coalfield. *Tasm. House of Assembly Pap.* 135.

_____ 1866: On the position of the Gordon Limestone relatively to other Palaeozoic formations. *Pap. Proc. R. Soc. Tasm. (1866)*;27-31.

GREEN, D.H., 1959: Geology of the Beaconsfield district, including the Anderson's Creek Ultrabasic complex. *Rec. Queen Victoria Museum Launceston, New Series*. 10: 1-25.

GRIFFITHS, J.R., 1974: Revised Continental Fit of Australia and Antarctica. *Nature*, 249(5455): 336-338.

GROVES, D.I., 1966: The geology of the Heazlewood-Godkin area. *Tasmania Dept. Mines Tech. Rep.* 10: 27-40.

GULLINE, A.B., 1965: St. Clair. *Geological Survey Explanatory Rept. Mines Dept. Tasmania*, 1-39.

GUNN, B.M., & WARREN, G., 1962: Geology of Victoria land between the Mawson and Mulock Glaciers Antarctica. *Bull. New Zealand geol. Surv.*, 71: 157-172.

HAMAR, G., 1964: The Middle Ordovician of the Oslo Region, Norway 17. Conodonts from the lower Middle Ordovician of Ringerike. *Norsk geologisk Tidsskr.*, 44: 243-292.

HARRINGTON, H.J., & LEANZA, A.F., 1957: Ordovician Trilobites of Argentina. *Spec. Publ. Univ. of Kansas* 1: 1-276.

HILL, D., 1942: Some Tasmanian Palaeozoic Corals. *Pap. Proc. R. Soc. Tasm. (1941):* 3-15.

_____ 1943: A reinterpretation of the Australian Palaeozoic record based on rugose corals. *Proc. R. Soc. Queensland* 54: 53-70.

_____ 1955: Ordovician corals from Ida Bay, Queenstown and Zeehan. *Pap. Proc. R. Soc. Tasm.*, 89: 237-252.

HINDE, G.J., 1879: On conodonts from the Chazy and Cincinnati Group of the Cambro-Silurian and from the Hamilton and Genesee Shale divisions of the Devonian, in Canada and the U.S. *Quart. Jour. Geol. Soc. London* 35(3): 351-369.

HOULIK, C.W., 1973: Interpretation of carbonate-detrital silicate transitions in Carboniferous of Western Wyoming. *Amer. Assoc. Petrol. Geol. Bull.* 57(3): 498-509.

HUGHES, T.D., 1957: Limestones in Tasmania. *Tasmanian Dept. Mines Mineral Resources* 10: 1-291.

HÜNICKEN, M.A., & GALLINO E.J., 1970: Los conodontes de la formacion San Juan (Llanvirniano) *Rev. Fac. Ciencias Ex. Fis. Nat. Univ. Cordoba Ser. Geol.* 1: 5-12.

IGO, H., & KOIKE, T., 1967: Ordovician and Silurian conodonts from the Langkawi Islands, Malaya. *Geol. Paleontology of South East Asia* 3: 1-29.

_____ 1968: Ordovician and Silurian Conodonts from the Langkawi Islands, Malaya. Pt. II. *Geol. and Paleontology of S.E. Asia vol. IV*: 1-21.

JAANUSSON, V., 1972: Aspects of carbonate sedimentation in the Ordovician of Balto-Scandia. *Lethaia* 5: 217-237.

JENNINGS, I.B., 1958: The Round Mount district. *Bull. Geol. Surv. Tas.* 45.

JENNINGS, I.B., 1960: Geology and Site investigations in the vicinity of the Goliath Portland Cement Company's Works - Railton, Tasmania. *Mines Dept. Tasmania Tech. Rep.* 4(1959): 62-90.

_____ 1961: Notes on the Geology of portion of South-West Tasmania. *Tas. Dept. Mines. Geol. Surv. Rep.* 5: 1-25.

_____ 1963: Middlesex. *Tasmania Dept. Mines. Geol. Surv. Explan. Rep. One Mile Geol. Map Series.* 1-150.

JOHNSON, B.D., 1972: Crustal Structure studies in Tasmania. *Unpublished Ph.D. thesis. University of Tasmania.*

JOHNSTON, R.M., 1888: *Systematic Account of the Geology of Tasmania.* Gov't Printer. Hobart.

KENNEDY, D.J., 1971: Geology of Flowery Gully (Northern Tasmania) and conodonts from the Lowermost Gordon Limestone (Ordovician) *Unpublished Thesis, University of Tasmania.* 113pp.

_____ 1974: Lower Ordovician Conodonts from the Cabbage Tree Conglomerate, Northern Tasmania, Australia. *Geological Soc. America Abstracts with programs for 1974 North Central Section, Kent, Ohio.*, 520-521.

KENNETT, J.P., HOUTZ, R.E., ANDREWS, P.B., 1973: Deep sea drilling in the roaring 40s. *Geotimes.* July 1973: 14-17.

KOBAYASHI, T., 1959: On some Ordovician fossils from Northern Malaya and her adjacence. *J. Fac. Sci. Tokyo Univ.* 11: 387-407.

_____ 1966: Stratigraphy of the Chosen Group in Korea and South Manchuria Sect B. The Chosen Group of North Korea and Northeast China. *J. Fac. Sci. Univ. Tokyo Sect. II,* 16(2): 209-311.

KOHUT, J.J., & SWEET, W.C., 1968: The American Upper Ordovician standard X. Upper Maysville and Richmond conodonts from the Cincinnati region of Ohio, Kentucky and Indiana. *J. Paleont.* 42: 1456-1477.

LAIRD, M.G., COOPER, R.A., & JAGO, J.B., 1977: New data on the lower Palaeozoic sequence of N. Victoria land, Antarctica and its significance for Australian-Antarctic relations in the Palaeozoic. *Nature,* 265: 107-110.

LARSSON, K., 1973: The Lower Viruan in the autochthonous Ordovician sequence of Jämtland. *Sveriges Geologiska Undersökning Ser. C. Nr.* 683: 1-82.

LEE, H.Y., 1975: Conodonten aus dem Unteren und Mitteleren Ordovizium von Nord Korea. *Palaeontographica* A. 150(4-6) 161-186.

LEE, W.H.K. (ed.) 1965: *Terrestrial Heat Flow. Amer. Geophys. Union Publ.* no. 1288 Washington. 276pp.

LEE, W.H.K., & UYEDA, S., 1965: Review of heat flow data. *Geophys. Mono.*, 8: 87-190.

LINDNER, A.W., 1953: The geology of the coastline of Waratah Bay. *Proc. R. Soc. Vict.*, 64: 77-92.

LINDSTRÖM, M., 1955: Conodonts from the lowermost Ordovician strata of south-central Sweden. *Geol. Fören. Stockholm Förh.*, 76: 517-604.

_____ 1959: Conodonts from the Crug Limestone (Ordovician, Wales) *Micropaleontology* 5: 427-452.

_____ 1960: A Lower-Middle succession of conodont faunas. *XXI Internat. Geol. Congress Repts.* pt. 7: 88-96.

_____ 1963: Sedimentary folds and the development of limestone in an Early Ordovician sea. *Sedimentology*, 2: 243-275.

_____ 1969: Faunal provinces in the Ordovician of the North Atlantic areas. *Nature*, 225: 1158-1159.

_____ 1970a: A suprageneric taxonomy of the conodonts. *Lethaia* 3: 427-445.

_____ 1971: Lower Ordovician Conodonts of Europe. *Geol. Soc. America Memoir*, 127: 21-61.

_____ 1976: Conodont Palaeogeography of the Ordovician. In Bassett, M.G., *The Ordovician System.* Univ. of Wales Press Cardiff. 501-522.

LINDSTRÖM, M., RACHEBOUEF, P.R., & HENRY, J.L., 1974: Ordovician conodonts from the Postolonnec Formation (Crozon Peninsula, Massif Armoricain) and their stratigraphic significance. *Geologica et Palaeontologica* 8: 15-28.

LOGAN, B.W., DAVIES, G.R., READ, J.F., & CEBULSKI, D.E., 1970: Carbonate Sedimentation and environments Shark Bay, Western Australia. *Amer. Assoc. Petrol. Geol. Mem.* 13: 1-223.

LOGAN, B., READ, J., HAGAN, G., HOFFMAN, P., BROWN, R.G., WOODS, P.J., & GEBELEIN, C., 1974: Evolution and Diagenesis of Quaternary Carbonate Sequences Shark Bay Western Australia. *Amer. Assoc. Petrol. Geol. Mem.*, 22: 1-358.

LOVERING, T.S., 1962: The origin of jasperoid in limestone. *Econ. Geology*, 57: 861-889.

MCDOUGALL, I., & LEGGO, P.J., 1965: Isotopic age determinations on granitic rocks from Tasmania. *J. geol. Soc. Aust.* 12: 295-332.

MITCHUM, R.M., THOMPSON, S., VAIL, P.R., SANGREE, J.B., & BUBB, J.N., 1972: *Concepts of sequences and Evitatic Cycles.* Esso Production Research Co. Houston. 73pp.

MOORE, R.C. (Ed.) 1964: *Treatise on Invertebrate Paleontology. Part K. Mollusca 3. Cephalopoda.* Geol. Soc. America, Univ. of Kansas Press, 519p.

MOSKALENKO, T., 1970: *Konodonti Krivolutskogo Yarusa (Sredniy Ordovik) Sibirskoi Platformi.* Nauka, Moscow. 1-115.

_____ 1972: Ordovician conodonts of the Siberian Platform and their bearing on Multi-element Taxonomy. *Geologica et Palaeontologica* SB1, 47-56.

_____ 1973: Konodonti sredrego i verkhnego ordovika Sibirskoi Platformy. *Akad. Nauk SSSR (Siberiskoy Otdel). Trudy Inst. Geol. Geofiz*, 137: 1-143.

_____ 1974: On the age of the rocks of the Krivaya Luka horizon on the Siberian Platform. *Soviet Geology and Geophysics* (Translation) 15(4): 100-103.

_____ 1976: Environmental effects on the distribution of Ordovician conodonts on the West Siberian Platform. *Geol. Soc. Canada Spec. Pap.* 15: 59-67.

MUKHERERJI, K.K., & YOUNG, G.M., 1973: Diagenesis of the Black River (Middle Ordovician) Limestones in Southern Ontario, Canada. *Sed. Geol.*, 9: 21-51.

MÜLLER, K.J., 1973: *Milaculum* n.g., ein phosphatisches Mikrofossil aus dem Altpaläeozoikum. *Paläont. Z.*, 47(3-4): 217-228.

MÜLLER, K., NOGAMI, Y., & LENZ, H., 1974: Phosphatische Ringe als Mikrofossilien im Altpaläozoikum. *Palaeontographica A*, 146: 79-99.

NEHRING, M., 1969: Konodonty ordowickie z otworu Ketrzyn. *Kwart Geol.*, 13(1): 27-42.

NITECKI, M.H., GUTSCHICK, R.C., REPETSKI, J., 1975: Phosphatic Microfossils from the Ordovician of the United States. *Fieldiana Geology*, 35(1): 1-9.

NOAKES, L.C., BURTON, G.M., & RANDALL, M.A., 1954: The Flowery Gully limestone deposit, Tasmania. Records. *Bur. Min. Resources. Geol. & Geophys. Australia.* 1954-55: 1-56.

OBERG, R., 1966: Winnipeg conodonts from Manitoba. *J. Paleont.*, 40: 130-147.

PACKHAM, G.H., 1967: The occurrence of shelly Ordovician strata near Forbes, New South Wales. *Aust. Jour. Sci.*, 30: 106-107.

PARK, W.C., & SCHOT, E.H., 1968: Stylolites: their nature and origin. *Jour. Sed. Petrol.*, 38: 175-191.

PHILLIP, G.M., 1966: The occurrence and palaeogeographic significance of Ordovician strata in northern New South Wales. *Aust. Jour. Sci.*, 29: 112-113.

PIELOU, E.C., 1975: *Ecological Diversity*. 165pp. Wiley; New York.

PITT, R.P.B., 1961: The geology of the Zeehan area. *Unpublished Thesis, Univ. of Tasmania.*

POPE, E.C., 1967: The Shore reefs of Darwin. *Australian Natural History*, 15(9): 278-284.

PULSE, R.R., & SWEET, W.C., 1960: The American Upper Ordovician standard III Conodonts from the Fairview and McMillan Formations of Ohio, Kentucky and Indiana. *J. Paleont.*, 34: 239-264.

ROSS, R.J., 1975: Early Paleozoic trilobites, sedimentary facies, lithospheric plates, and ocean currents. *Fossils and Strata* 4: 307-329.

_____ 1976: Ordovician Sedimentation in the Western United States. *In* Bassett, M.G. (Ed.) *The Ordovician System.* Univ. of Wales Press Cardiff p.73-105.

ROSS, R., & SHAW, F., 1972: Distribution of the Middle Ordovician Copenhagen Formation and its trilobites in Nevada. *Prof. Pap. U.S. geol. Surv.*, 749: 1-33.

ROWE, S.M., 1963: Limestone deposit Mole Creek Area. *Mines Dept. Tasmania Tech. Rep.* 7 (1962): 59-62.

RUBENACH, M.J., 1973: The Tasmanian Ultramafic - Gabbro and ophiolite complexes. *Unpublished thesis, Univ. of Tasmania.*

SATTERFIELD, I.R., 1971: Conodonts and stratigraphy of the Girardeau Limestone (Ordovician) of Southeast Missouri and Southwest Illinois. *J. Paleont.*, 45(2): 265-273.

SCANLON, A.P., 1976: The Ordovician Geology of the Eugenana Area. *Unpublished Thesis, Univ. of Tasmania.* 135pp.

SCHENK, P.E., 1967: The Macumber Formation of the Maritime Provinces, Canada - A Mississippian analogue to recent strand-line carbonates of the Persian Gulf. *Jour. Sed. Petrol.*, 37: 365-376.

SCHLANGER, S.O., 1964: Petrology of the limestones of Guam. *U.S. Geol. Surv. Prof. Paper* 403-D: 1-52

SCHOPF, T.J.M., 1966: Conodonts of the Trenton Group (Ordovician) in New York, Southern Ontario and Quebec. *New York State Mus. & Sci. Serv. Bull.*, 405: 1-105.

SCHWAB, K.W., 1969: *Panderodus denticulatus*, a new conodont species from the Aymestry Limestone (Upper Silurian) of England. *J. Paleont.*, 43: 521-525.

SEDDON, G., & SWEET, W.C., 1971: An ecologic model for conodonts. *J. Paleont.*, 45: 869-880.

SERPAGLI, E., 1967: I conodonti dell'Ordoviciano superiore (Ashgilliano) delle Alpi Carnische. *Boll. Soc. Paleont. Italiana*, 6(1): 30-111.

_____ 1974: Lower Ordovician conodonts from Precordilleran Argentina (Province of San Juan). *Boll. Soc. Pal. Italiana*, 13(1-2): 17-98.

SERPAGLI, E., & GRECO, A., 1965: Osservazioni preliminari su alcuni Conodonti ordoviciani e siluriani delle Alpi Carnische italiane. *Boll. Soc. Paleont. Italiana* 3(2)(1964): 192-211.

SEYMOUR, D., 1975: Deformation Studies of Gordon Limestone and Moina Sandstone. *Unpublished thesis, Univ. Tasmania.* 108pp.

SHINN, E.A., HALLEY, R.B., HUDSON, J.H., & LIDZ, B.H., 1977: Limestone Compaction: An enigma. *Geology*, 5: 21-24.

SHINN, E.A., LLOYD, R.M., & GINSBURG, R.N., 1969: Anatomy of a modern carbonate tidal-flat Andros Island, Bahamas. *Jour. Sed. Pet.*, 39(3): 1202-1228.

SMITH, E.M., 1959: Tasmania. *Lexique Stratigraphique International, VI 5d. Int. géol. Congress.*

SOLOMON, M., & GRIFFITHS, J.R., 1974: Aspects of the Early History of the Southern Tasman Orogenic Zone. *In: The Tasman Geosyncline - a symposium in honour of Dorothy Hill.* Geological Society of Australia and Univ. Queensland, Brisbane. 19-46.

SPASOV, K.H., & TELER, L., 1963: Konodonti ot ordovikskite vapovutsi pri c. Muicha v Gorach Swietokizyskich, polsha. *Bulg. Acad. Nauk.* 5: 75-87.

SPJELDNAES, N., 1963: Some Silicified Ordovician fossils from South Wales. *Palaeontology*, 6(2): 254-263.

SPRY, A., & BANKS, M.R. (Eds.) 1962: The Geology of Tasmania. *Jour. geol. Soc. Aust.*, 9(2): 1-412.

STAIT, B., 1976: Palaeontology and Biostratigraphy of the Florentine Valley Formation. *Unpublished Thesis, University of Tasmania.* 168pp.

STAPLIN, F.L., 1969: Sedimentary organic matter, organic metamorphism and oil and gas occurrence. *Bull. Canad. Petrol. Geol.,* 17: 47-66.

STAUFFER, C.R., 1930: Conodonts from the Decorah Shale. *J. Paleont.,* 4: 121-128.

_____ 1935(a): Conodonts of the Glenwood Beds. *Geol. Soc. America Bull.,* 46: 125-168.

STONE, G.L., & FURNISH, W.M., 1959: Bighorn conodonts from Wyoming. *J. Paleont.,* 33(2): 211-228.

STRZELECKI, P.E., 1845: *Physical description of New South Wales and Van Diemen's Land* London.

SWEET, W.C., 1955: Conodonts from the Harding Formation (Middle Ordovician) of Colorado. *J. Paleont.,* 29: 226-262.

SWEET, W.C., & BERGSTRÖM, S., 1962: Conodonts from the Pratt Ferry Formation (Middle Ordovician) of Alabama. *J. Paleont.,* 36: 1214-1252.

_____ 1970: The Generic Concept in Conodont Taxonomy. *Proc. N. American Paleontological Convention pt. c.* 157-173.

_____ 1971: The American Upper Ordovician Standard XIII. A revised time-stratigraphic classification of North American Upper Middle and Upper Ordovician rocks. *Geol. Soc. Amer. Bull.,* 82: 613-628.

_____ 1972: Multielement taxonomy and Ordovician conodonts. *Geol. et Palaeontologica* S.B.1: 29-42.

_____ 1974: Provincialism exhibited by Ordovician conodont faunas in Ross, C.A. (Ed.) Palaeogeographic Provinces and Provinciality. *Soc. Econ. Paleontol. Min. Spec. Publ.,* 21: 189-202.

SWEET, W.C., & BERGSTRÖM, S.M., 1976: Conodont biostratigraphy of the Middle and Upper Ordovician of the United States midcontinent *In* Bassett, M.G. (Ed.) *The Ordovician System.* University of Wales Press. Cardiff.

SWEET, W.C., ETHINGTON, R.L. & BARNES, C.R., 1971: North American Middle and Upper Ordovician Conodont faunas. *In* Sweet, W.C. and Bergström, S.M. (Eds.) Symposium on Conodont Biostratigraphy. *Mem. Geol. Soc. Amer.*, 127: 163-193.

SWEET, W.C., & SCHOENLAUB, H.P., 1975: Conodonts of the genus *Oulodus* Branson and Mehl 1933. *Geol. Palaeontol.*, 9: 41-59.

SWEET, W.C., THOMPSON, T.L., & SATTERFIELD, I.R., 1975: Conodont stratigraphy of the Cape Limestone (Maysvillian) of Eastern Missouri. *Missouri Geol. Surv. Studies in Stratigraphy. Rept. Inv.*, 57(2): 1-59.

SWEET, W.C., TURCO, C.A., WARNER, E., WILCIE, L.C., 1959: The American Upper Ordovician Standard I. Eden conodonts from the Cincinnati region of Ohio and Kentucky. *J. Paleont.*, 33: 1029-1068.

SYMONDS, P.A., & WILLCOX, J.B., 1976: The gravity field of offshore Australia. *Bureau Min. Res. Aust. Jour. Austral. Geol. and Geophys.* 1(1976): 303-314.

TEICHERT, C., & GLENISTER, B.F., 1953: Ordovician and Silurian cephalopods from Tasmania, Australia. *Bull. Am. Paleontol.*, 34(144): 1-66.

THOMAS, G.A., 1948: A critical review of the Lower Palaeozoic Succession of Tasmania. *Proc. Roy. Soc. Vict.*, 59: 23-52.

THREADER, V., 1963: Limestone in the Vale of Belvoir. *Tasmanian Dept. Mines Tech. Rep.* 7(1962): 66-68.

UYENO, T.T., 1974: Conodonts of the Hull Formation, Ottawa Group (Middle Ordovician), of the Ottawa-Hull area Ontario and Quebec. *Geol. Surv. Canada Bull.*, 248: 1-31.

VEEVERS, J.J., 1976: Early Phanerozoic events on and alongside the Australasian-Antarctic Platform. *Jour. geol. Soc. Aust.*, 23(2): 183-206.

VERHOOGEN, J., TURNER, F., WEISS, L.E., & WAHRHAFTIG, C., 1970: *The Earth.* Holt Rinehart and Winston Inc. New York 1-742.

VIIRA, V., 1974: *Konodonti Ordovika Pribaltiki.* Inst. Geol. Akad. Nauk Estonskoi SSR. "Valgus" Tallin. 1-141.

VOTAW, R.B., 1971: Conodont Biostratigraphy of the Black River Group (Middle Ordovician) and equivalent rocks of the eastern Midcontinent, North America. *Unpublished Thesis, Ohio State University.* 170p.

WADE, M.L., & SOLOMON, M., 1958: Geology of the Mt. Lyell Mines, Tasmania. *Econ. Geology.* 53(4): 367-392.

WALKER, K., 1972: Stratigraphy and environmental sedimentology of Middle Ordovician Black River Group in the type area - New York State. *New York State Museum and Science Service Bull.* 419: 1-43.

WAMEL VAN, W.A., 1974: Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of North-western Öland, South-eastern Sweden. *Utrecht Micropal. Bull.*, 10: 1-126.

WARD, L.K.,1908: King River to King William Range. *Tasmania Parliamentary Paper*, 21: 31-39.

WARME, J.E., EKDALE, A.A., EKDALE, S.F., & PETERSON, C.H., 1976: Raw material of the fossil record. *In:* Scott, R.W. and West, R.R. (Eds.) *Structure and Classification of Paleocommunities.* Dowden, Hutchinson & Ross, Stroudsburg Penn.

WEAST, R.C. (Ed.) 1975: *Handbook of Chemistry and Physics.* Chemical Rubber Co. Press Cleveland. 1532pp.

WEBB, P.N., 1974: The Dolcoath Granite Contact. *Unpublished thesis, University of Tasmania.*

WEBBY, B.D., 1976: The Ordovician System in South-eastern Australia. *In* Bassett, M.G. (Ed.) *The Ordovician System.* University of Wales Press Cardiff, 417-446.

WEBBY, B.D., & BANKS, M.R., 1976: *Clathrodictyon* and *Ecclimadictyon* (Stromatoporsidea) from the Ordovician of Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, 110: 129-137.

WEBBY, B.D., MOORS, H.T., & MCLEAN, R.A., 1970: Malongullia and Encrinuraspis, New Ordovician trilobites from N.S.W., Australia. *J. Paleont.*, 44(5): 881-887.

WEBERS, G.F., 1966: The Middle and Upper Ordovician conodont faunas of Minnesota. *Minnesota Geol. Survey Spec. Pub.* SP 4: 1-123.

WELDON, B.D., 1974: Ordovician Gordon Limestone Sub-group Florentine Valley. *Unpublished thesis, Univ. of Tasmania.*

WHYTE, R.K., 1974: Stratigraphic structural and sedimentological investigations of Cambro-Ordovician rocks between Maydena and Frodsham's Gap. *Unpublished thesis, Univ. of Tasmania.*

WELLS, B., 1955: Geology of map square 3978. *Hydro-Electric Commission Tasmania. Unpub. Rep.*

WILLIAMS, A., 1973: Distribution of brachiopod assemblages in relation to Ordovician palaeogeography. *In:* Organisms and Continents Through Time. *Special Papers in Palaeontology,* 12: 241-269.

WILLIAMS, E., 1976(a): *Tasman Fold Belt System in Tasmania. Explanatory Notes for the 1:500,000 Structural Map of Pre-Carboniferous Rocks of Tasmania.* Tasmania Dept. of Mines, Hobart. 29pp.

WILLIAMS, E., 1976(b): *Geological Map of Tasmania 1:500,000.* Mines Dept. Hobart.

APPENDIX I

Metric coordinates of Mole Creek Samples.

MOLE CREEK SAMPLE NUMBER	METRIC COORDINATES EASTINGS	NORTHINGS
1	446658.47	5399089.91
2	446559.56	5398947.09
3	446533.83	5399038.20
4	446603.26	5399121.27
5	446776.71	5399141.55
6		
7		
8	446847.02	5399227.37
9		
10	447028.30	5399281.56
11	447030.52	5399327.29
12	447044.19	5399331.10
13	447138.41	5399483.93
14	447182.85	5399594.13
15	447245.35	5399722.83
16	447741.79	5399874.79
17	446711.45	5398695.63
18	446653.64	5398715.07
19	446648.59	5398756.15
20	446684.84	5398783.99
21	446689.32	5398791.35
22	446718.50	5398798.09
23	446730.09	5398823.82
24	446739.15	5398830.32
25	446737.22	5398839.44
26	446982.76	5399187.80
27	446968.25	5399177.57
28	446962.95	5399161.97

MOLE CREEK	METRIC COORDINATES	
SAMPLE NUMBER	EASTINGS	NORTHINGS
29	446941.27	5399139.78
30	446850.04	5399124.11
31	446877.50	5399120.77
32	446918.79	5399106.62
33	446922.66	5399088.38
34	446925.51	5399079.27
35	446932.95	5399068.39
36	446942.15	5399063.01
37	446951.36	5399056.72
38	446942.40	5399041.07
39	446970.01	5399024.94
40	447003.84	5399262.99
41	447026.70	5399262.34
42	447022.06	5399267.78
43	447030.07	5399287.06
44	446993.75	5399345.15
45	447151.70	5399361.59
46	447183.65	5399365.62
47	447194.54	5399372.14
48	447189.81	5399385.80
49	447197.06	5399391.36
50	447203.37	5399399.66
51	447208.90	5399395.16
52	447193.97	5399421.49
53	447198.02	5399467.25
54	447210.51	5399573.43

MOLE CREEK	METRIC COORDINATES	
SAMPLE NUMBER	EASTINGS	NORTHINGS
55	447244.48	5399639.63
56	447245.88	5399677.13
57	447236.53	5399695.30
58	447245.35	5399722.83
59	447391.67	5399638.58
60	447410.52	5399668.05
61	447419.54	5399679.12
62	447435.88	5399688.45
63	447457.80	5399690.53
64	447462.32	5399695.16
65	447455.80	5399705.14
66	447464.92	5399707.07
67	447464.82	5399716.21
68	447483.10	5399716.42
69	447491.94	5399742.12
70	447480.06	5399821.51
71	447496.31	5399759.54
72	447509.36	5399817.27
73	447529.27	5399834.87
74	447725.14	5400130.55
75	448388.31	5399694.84
76	448424.82	5399699.83
77	448552.09	5399760.71
78	448035.72	5400546.39
79	447949.64	5400480.49
80	448286.65	5400983.47

MOLE CREEK	METRIC COORDINATES	
SAMPLE NUMBER	EASTINGS	NORTHINGS
81	447839.10	5400872.29
82	447841.88	5400868.66
83	447835.34	5400881.39
84	447581.91	5399867.47
85	447577.38	5399863.76
86	447572.92	5399854.57
87	447554.35	5399879.04
88		
89	447545.43	5399859.74
90	446648.70	5398747.01
91	446649.40	5398765.30
92	446559.19	5398979.08
93	446684.37	5399062.79
94	446681.16	5399103.88
95	446681.16	5399103.88
96	447001.82	5398961.32
97	447001.82	5398961.32
98	447167.12	5399054.63
99	446929.20	5399234.71
100	446894.65	5399298.30
101	446866.74	5399261.42
102	446816.49	5399338.54
103	447019.69	5399315.28
104	446974.56	5399344.93
105	446970.73	5399359.51
106	446964.54	5399500.21
107	447039.42	5399348.42

MOLE CREEK	METRIC COORDINATES	
SAMPLE NUMBER	EASTINGS	NORTHINGS
108	447094.60	5399318.89
109	447115.35	5399501.95
110		
111		
112		
113	447248.91	5399175.32
114	447583.05	5399132.54
115	447656.03	5399622.43
116	447163.55	5399762.11
117	447545.44	5399858.82
118	447568.35	5399854.52
119	447559.10	5399863.55
120	447576.00	5399808.92
121	447576.00	5399808.92
122	447578.01	5399808.92
123	447469.34	5399958.50
124	447466.44	5399972.18
125	447453.68	5399889.76
126	447421.64	5399893.96
127	447463.40	5399839.60
128	447469.02	5399748.25
129		
130		
131	447411.55	5399578.48
132	447391.64	5399561.80
133		
134	448676.31	5400881.92
135	448593.84	5400899.25

MOLE CREEK	METRIC COORDINATES	
SAMPLE NUMBER	EASTINGS	NORTHINGS
136	447554.35	5399879.04
137		
138		
139		
140	447734.72	5400886.63
141	447722.81	5400889.23
142	446753.55	5399406.37
143	448406.33	5399717.90
144	448382.55	5399798.07
145	447725.34	5400907.54
146	447638.52	5400985.16
147	446522.55	5402164.32
148	446659.43	5402581.81
149	446531.79	5402155.28
150		
151	446652.08	5402028.69
152	446652.08	5402028.69
153	446652.08	5402028.69
154	446652.08	5402028.69
155	446652.08	5402028.69
156	446652.08	5402028.69
157	446682.03	5401809.65
158	446682.03	5401809.65
159	446682.03	5401809.65
160	446682.03	5401809.65
161	446682.03	5401809.65
162	446682.03	5401809.65
163		

MOLE CREEK	METRIC COORDINATES	
SAMPLE NUMBER	EASTINGS	NORTHINGS
164		
165		
166	446549.79	5399001.82
167	446572.43	5399020.36
168	446611.04	5399000.70
169	446659.15	5399030.50
170	446661.68	5399048.81
171	446685.87	5399091.14
172		
173		
174		
175		
176		
177		
178		
179		
180		
181	446938.17	5399408.50
182	446919.93	5399405.54
183	447057.20	5399391.58
184	447076.88	5399429.29
185	447093.24	5399437.70
186	447106.89	5399442.43
187	447055.90	5399504.92
188	446992.01	5399495.96
189	446992.01	5399495.96
190	446992.01	5399495.96
191	446992.01	5399495.96

MOLE CREEK	METRIC COORDINATES	
SAMPLE NUMBER	EASTINGS	NORTHINGS
192	446992.01	5399495.96
193	447110.76	5399503.72
194	447107.60	5400414.13
195	447115.35	5399501.95
196	447101.41	5399362.84
197	447070.74	5399565.42
198	447061.06	5399612.84
199	447100.38	5399611.47
200	447114.00	5399618.94
201	447102.10	5399620.63
202	447116.41	5399648.21
203	447136.75	5399628.34
204	447157.75	5399630.41
205	447163.04	5399646.92
206	447145.31	5399678.71
207	447124.94	5399701.33
208	447120.98	5399727.79
209	447114.23	5399757.88
210	447153.22	5399785.75
211	446785.72	5400741.34
212	446785.41	5400768.76
213	446780.63	5400786.99
214	446803.16	5400814.67
215	446903.18	5400861.52
216	446924.09	5400870.90
217	446911.89	5400898.19
218	446920.46	5400948.56

MOLE CREEK	METRIC COORDINATES	
SAMPLE NUMBER	EASTINGS	NORTHINGS
219	446934.01	5400962.43
220	446938.42	5400976.19
221	446845.76	5400687.18
222	446850.60	5400664.39
223	446897.24	5400582.65
224		
225		
226		
227		
228		
229	446622.25	5401443.32
230	446623.20	5401361.06
231	446519.00	5401359.86
232	446075.61	5401284.38
233	446090.16	5401290.94
234	446106.90	5401345.98
235	446127.62	5401372.73
236	446119.87	5401410.12
237	446146.98	5401437.86
238	446155.78	5401467.21
239	446159.95	5401501.99
240	446173.56	5401511.29
241	446184.42	5401520.56
242	446205.25	5401537.25
243	446204.81	5401575.64
244	446118.65	5401675.20
245	446117.53	5401693.47
246	446116.30	5401720.88

MOLE CREEK

SAMPLE NUMBER	METRIC COORDINATES EASTINGS	NORTHINGS
247	446106.58	5401771.04
248	446156.48	5401803.61
249	446197.33	5401828.76
250	446229.23	5401836.44
251	446272.79	5401864.36
252	446315.59	5401878.57
253	446342.69	5401906.30
254	446360.45	5401952.21
255	446378.62	5401961.56
256	446439.44	5401998.82
257	446386.82	5402043.92
258	447536.09	5399082.64
259	447696.48	5398649.37
260	447674.62	5398959.92
261	447422.27	5399441.49
262	447356.85	5398771.61
263	447204.69	5399045.92
264	447354.38	5399065.92
265	447365.38	5399063.31
266	447538.23	5398976.63
267		
268	445719.26	5400715.36
269	445719.36	5400706.22
270	447516.40	5399204.90
271		
272		
273	445773.38	5401255.31
274	445664.56	5401258.63

MOLE CREEK

SAMPLE NUMBERS	METRIC COORDINATES EASTINGS	NORTHINGS
275	445635.18	5400633.95
276	445648.99	5400625.88
277	445671.97	5400614.27
278		
279	454186.75	4673302.93
280	445345.14	5400418.54
281	445372.77	5400400.58
282	445372.77	5400400.58
283	445251.59	5400604.86
284	445439.59	5400552.18
285	445296.50	5400673.93
286	445300.91	5400687.70
287	445300.91	5400687.70
288	445300.91	5400687.70
289	445424.83	5400643.42
290	445387.74	5400688.70
291	445364.16	5400752.41
292		
293	445451.30	5400725.99
294	445451.30	5400725.99
295	445405.39	5400743.75
296	445432.97	5400730.35
297	445275.85	5400879.37
298	445275.85	5400879.37
299	445275.85	5400879.37
300	445275.85	5400879.37
301	448533.75	5400560.34
302	445330.80	5400870.86

MOLE CREEK

SAMPLE NUMBER	METRIC COORDINATES EASTINGS	NORTHINGS
303	445330.80	5400870.86
304	445209.25	5401107.13
305		
306	445209.25	5401107.13
307	445209.25	5401107.13
308		
309	445359.64	5400747.79
310	445333.27	5401053.71
311	445333.27	5401053.71
312	445725.92	5400692.59
313	445541.78	5400409.84

APPENDIX II

SPECIMEN CATALOGUE

96850 JRC2 Everlasting Hills, Central Tasmania, grid ref. DP202157. Prioniodiniform element of *Rhipidognathus? careyi* sp. nov. syntype. Figured. Fig. 64C.

96851 locality as 96850. Ozarkodiniform element of *Rhipidognathus? careyi* sp. nov. syntype. Figured. Fig. 64F.

96852 locality as 96850. *Chirognathus monodactylus* Branson and Mehl Figured. Fig. 40C.

96853 locality as 96850. *Rhipidognathus? careyi* sp. nov. syntype. Figured. Fig. 64A.

96854 locality as 96850. Unfigured ozarkodiniform element. Unknown species.

96855 locality as 96850. Ozarkodiniform element of *Phragmodus tasmaniensis* sp. nov. Figured syntype. Fig. 51C.

96856 locality as 96850. Ozarkodiniform element of *Rhipidognathus? careyi* Figured syntype. Fig. 64E.

96857 locality as 96850. Prioniodiniform element of *Rhipidognathus? careyi* Figured syntype. Fig. 64D.

96858 locality as 96850. Phragmodiform element of *Phragmodus tasmaniensis* sp. nov. Figured syntype Fig. 52B.

96860 locality as 96850. Prioniodiniform element of *Rhipidognathus? careyi* sp. nov. Figured syntype. Fig. 64B.

96861 locality as 96850. Ozarkodiniform element species unknown. unfigured.

96862 locality as 96850 *Chirognathus monodactylus* Branson and Mehl, Figured specimen. Fig. 40A.

96863 locality as 96850. Trichonodelliform element of *Rhipidognathus? careyi* sp. nov. figured syntype. Fig. 65 E,F.

96864 locality as 96850 *Erismodus gracilis* (Branson and Mehl). Figured spec. Fig. 44G.

96865 locality as 96850 *Chirognathus monodactylus* Branson and Mehl figured specimen. Fig. 40B.

96866 locality as 96850 *Chirognathus* sp. not figured.

96867 Sample JRC2 Everlasting Hills, Central Tasmania. *Drepanoistodus suberectus* (Branson and Mehl). Fig. 43B.

96868 " *Drepanoistodus suberectus* (Branson and Mehl) Fig. 43C.

96869 " *Phragmodus tasmaniensis* sp. nov. Figured syntype Fig. 52C.

96870 " trichonodelliform element of *Rhipidognathus? careyi* sp. nov.? unfigured.

96871 " trichonodelliform element of *R? careyi* sp. nov. unfigured.

96872 " zygognathiform element of *R? careyi* Fig. 66D. Figured syntype.

96873 " zygognathiform element of *R? careyi* sp. nov. unfigured.

96874 " " " " " " " "

96875 " *Chirognathus monodactylus* Branson and Mehl Fig. 40C.

96876 " *Rhipidognathus? careyi* sp. nov. eolignodiniform element. Figured syntype. Fig. 66A.

96877 " *Rhipidognathus? careyi* sp. nov. zygognathiform element. Fig. 66C. Figured syntype.

96878 " *Erismodus gracilis* (Branson and Mehl) Fig. 44F.

96879 " *Erismodus gracilis* (Branson and Mehl) Fig. 44 D-E.

96880 " cyrtoniodiform element of *Phragmodus tasmaniensis* sp. nov. unfigured.

96881 " eoligonodiniform element of *R? careyi* sp. nov. unfigured.

96882 " prioniodiniform element of *R? careyi* sp. nov. Figured syntype. Fig. 66B.

96883 sample FC 2 & 3 Felix Curtain Road, Florentine Valley. grid ref. DN 536814. Unidentified. Unfigured.

96884 sample FC 2 & 3 Felix Curtain Road, Florentine Valley. *Panderodus serpaglii* sp. nov. Unfigured.

96885 " Unidentified. Unfigured.

96886 Stratigraphically highest sample in Goliath Quarry, Railton. *Panderodus serpaglii* sp. nov. Fig. 62 A-B.

96887 sample Picton River C2 grid ref. DN743189 *Oulodus* cf. *oregonia* Fig. 45G.

96888 " prioniodiniform element species unidentified, unfigured.

96889 Olga/Gordon dam site. unfigured. unidentified at depth of 1861 (feet) grid ref. CN994743

96890 as 96889, Olga/Gordon dam site. unfigured. unidentified.

96891 as 96889, Olga/Gordon dam site *Erismodus gracilis* unfigured.

96892 Locality details lost. dichognathiform element. unfigured.

96893 (a-e) Lower Limestone Member sample B Florentine Valley. grid ref. DN586754. ontogenetic variation in ozarkodiniform element of *Rhipidognathus? careyi* sp. nov. Fig. 64.

96894 as 96850 Everlasting Hills. sample JRC2 Fig. 69C.

96895 " " " " Fig. 69A.

96896 " " " " Fig. 69D.

96897 JRC2 Everlasting Hills, C. Tasmania Fig. 69E

96898 sample C98 lower Limestone Member, Florentine Valley, grid ref. 8212 592798 collected Clive Calver 1977. Eoligonodiniform element of *R? careyi* Fig. 68A.

96899 " " Fig. 68B

96900 " " Trichonodelliform element of *R? careyi* Fig. 68 C-D.

96901 as 96850 sample JRC2 Everlasting Hills, Central Tasmania. Prioniodiniform element of *R? careyi* sp. nov. Fig. 69B.

96902 as 96893 Lower Limestone Member B, Florentine Valley. Broken trichonodelliform element of *R? careyi*. Fig. 67 E,F.

96903 " *Phragmodus tasmaniensis* sp. nov. Fig. 51 A-B.

96904 " Prioniodiniform element of *Rhipidognathus? careyi* sp. nov. Fig. 67 A-C.

96905 " Eoligonodiniform/zygognathiform element of *R? careyi*. Fig. 67 D-G.

96906 Sample MC135 Mole Creek grid ref. 448593-84/5400899-25. Unidentified, unfigured bryantodiniform element. Probably pathological specimen.

96907 " *Belodina compressa* (Branson and Mehl) Fig. 37A.

96908 " eoligonodiniform element of *B. compressa* Fig. 37B.

96909 " *Belodina compressa* Fig. 37E.

96910 " *Panderodus gracilis* (Branson and Mehl) Fig. 47B.

96911 " *Belodina compressa* Fig. 37D.

96912 sample MC210 Mole Creek grid ref. 447153-22/5399785-75 Unfigured prioniodiniform element of *R? careyi*

96913 as 96887 Picton C2. Picton River. Zygognathiform element, unfigured.

96914 as 96887 *Erismodus gracilis* (Branson and Mehl). Fig. 44C.

96915 " *Oulodus* cf. *oregonia* (Branson, Mehl and Branson) Fig.46C-D.

96916 " broken specimen not figured.

96917 MC248 Mole Creek grid ref. 446156.48 5401803.61 Unfigured, unidentified fibrous conodont.

96918 MC248 Mole Creek as 96917 unidentified zygognathiform element.

96919 " " " unidentified eoligonodiniform element.

96920 Grid ref. 4513 4980 Sample FV7a Coralline horizon near top of Upper Limestone Member, Florentine Valley. *Staufferella falcata* Fig. 41A.

96921 as 96917 *Erismodus sp.* unfigured.

96922 as 96917 *Erismodus sp.*

96923 as 96917 " "

96924 as 96917 unfigured eoligonodiniform element.

96925 MC 56 Mole Creek grid ref. 447245.88, 5399677.13
Phragmodus undatus unfigured.

96926 Sample no. 82744 "100' (30m) below Member C in Gordon Limestone, Austral Valley below Smelters 840.711E 838.51N" from Pitt. Same sample as Pojeta's paratype of *Fidera maryae*. cordylodiform element of *Plectodina* cf. *furcata* Fig. 58A.

96927 MC 56 Mole Creek, grid ref. 4425.88, 5399677.13
Protopanderodus sp? unfigured.

96928 MC56, Mole Creek, unfigured prioniodiniform element.

96929 " " unfigured trichonodelliform element.

96930 as 96920 sample FV7a in coralline member top of Upper Limestone Member Florentine Valley. Sample collected MRB.
Phragmodus undatus unfigured.

96931 Sample FV7a ozarkodiniform element of *Plectodina furcata*. unfigured.

96932 " *Panderodus gracilis*

96933 " *Panderodus gracilis* Fig. 47C-D

96934 " *Belodina compressa* unfigured.

96935 " *Belodina compressa* unfigured.

96936 " eoligonodiniform element of *Oulodus robustus?* unfigured.

96937 " *Erismodus gracilis* unfigured.

96938 " prioniodiform element unfigured.

96939 from sample 82744 near Smelters Zeehan see 96926
Phragmodus undatus oistodiform element. unfigured.

96940 Bed 126 of B. Weldon Upper Limestone Member, Florentine Valley. grid ref. 4496 5072 *Plectodina florentinensis* sp. nov. Fig. syntype. Fig. 57A,B.

96941 locality as for 96940 *Plectodina florentinensis* sp. nov. Fig. syntype, Fig. 57C.

96942 " " ?prioniodiniform element of *P. florentinensis* sp. nov. unfigured.

96943 " " trichonodelliform element. unfigured unidentified.

96944 " " ?prioniodiniform element of *P. florentinensis*. Fig. 57D.

96945 " " *Erismodus gracilis* Fig. 44I.

96946 MC 54 Mole Creek grid ref. 447210.51, 5399573.43. *Panderodus gracilis* Fig. 47A.

96947 " unidentified unfigured.

96948 " unidentified unfigured.

94949 " unidentified unfigured.

96950 " cordylodiform element of *P. aculeata* unfigured.

96951 as 96920 FV7a Florentine Valley near top of Upper Limestone Member in coralline member grid ref. *Belodina compressa* unfigured.

96952 as 96920 FV7a *Panderodus gracilis*

96953 " " *Milaculum ethinclarki* Müller *problematica* Fig. 71B.

96954 " " " " " " Fig. 71A.

96955 G140 base of limestone section in Gordon River near Olga junction. collected by P. Collins. grid ref. CN982751 *Belodella copenhagensis* Fig. 35 B & D.

96956 G140 *Belodella copenhagensis* (Ethington & Schumacher). Fig. 35 A & C.

96957 " *Belodella copenhagensis* (Ethington & Schumacher). Unfigured.

96958 " ?*Appalachignathus* Bergström *et al.*, Fig. 32A & F, and Fig. 33B.

96959 A & B " *Phragmodus flexuosus* Moskalenko, unfigured.

96960 G140 not figured *Phragmodus flexuosus* Moskalenko unfigured

96961 " *Drepanoistodus forceps* (Lindström) Fig. 42A.

96962 " *Panderodus serpaglii* sp. nov. unfigured.

96963 " dichognathiform element of *P. flexuosus* Moskalenko unfigured.

96964 " *Belodella copenhagensis* (Ethington & Schumacher) unfigured.

96965 " *?Appalachignathus* Bergström *et al.* Fig. 32 C-D.

96966 G69 top of limestone section in Gordon River near Olga junction at grid ref. CN996734 collected P. Collins. prioniodiniform element of *P. furcata?*

96967 MC168. Mole Ck. grid ref. 446611.04 5399000.70. Calcarenite near top of Standard Hill Member, Mole Crek.
Belodina alabamensis Sweet and Bergström Fig. 36E.

96968 MC168 " " " " Fig. 36C

96969 " *Acontiodus* cf. *nevadensis* Ethington and Schumacher Fig. 31A-B.

96970 A & B " (A) *?Appalachignathus* Bergström *et al.* Fig. 33A.
(B) ? " " " Fig. 32E.

96971 Stratigraphically highest sample from Goliath Quarry Railton at grid ref DQ509238 - 2 specimens of *Periodon aculeatus* Hadding. unfigured.

96972 " " *Panderodus serpaglii* unfigured.

96973 " " *Panderodus serpaglii* sp. nov. unfigured.

96974 " " oistodiform element. unfigured.

96975 Loongana 1. grid ref DQ 176162. *Phragmodus flexuosus* Moskalenko unfigured.

96976 as 96887 Picton C2 from Picton River in nodular member, trichonodelliform element. unfigured.

96977 from sample 82743/4 see 96926 for details.
unfigured oulodiform element.

96978 as 96887 Picton C2 Nodular member *Plectodina robusta* Fig. 61C.

96979 " " prioniodiniform element of *P.* cf. *furcata* unfigured.

96980 " " broken bryantodiniform element unfigured.

96981 " " *Erismodus gracilis* Fig. 44H.

96982 " " *Oulodus* cf. *oregonia* Fig. 46F, H & I.

96983 MC133 Mole Creek from near base of limestone section at The Grunter - 3m stratigraphically above base. grid ref. DQ 403002. *Phragmodus flexuosus* Moskalenko Fig. 50 A-B.

96984 " " *Phragmodus flexuosus* Moskalenko unfigured.

96985 " " *Phragmodus flexuosus* Moskalenko Fig. 50E.

96986 " " *Belodina compressa* unfigured.

96987 " " *Panderodus* sp. broken. unfigured.

96988 " " *Phragmodus flexuosus* Moskalenko Fig. 50C.

96989 " " " " " unfigured.

96990 " " " " " "

96991 " " oistodiform element sp. unident. "

96992 " " *Phragmodus flexuosus* Moskalenko Fig. 50D.

96993 " " oistodiform element of *P. flexuosus* unfigured.

96994 " " " " " "

96995 grid ref. DP472984 MC137 Mole Creek *Chirognathus monodactylus* Fig. 40E.

96996 MC74 Mole Creek grid ref. 447725.14 5400130.55 *Phragmodus undatus* unfigured.

96997 MC74 Mole Creek *Phragmodus undatus* Fig. 53B.

96998 " *Phragmodus undatus* Branson and Mehl, unfigured.

96999 " " " " " "

97000 " " " " " "

97001 " " " " " Fig. 53E.

97002 " " " " " unfigured.

97003 as 96996 MC74 Mole Creek. Fig. 46E.

97004 MC64 Mole Creek. grid ref. 447462.32 5399695.16 *Plectodina aculeata* Fig. 55B, D.

97005 " " " " Fig. 55C.

97006 " stereopair *Plectodina aculeata* Fig. 56C,D.

97007 " " " " Fig. 55A.

97008 as 96966 Gordon River sample G69.
Drepanoistodus suberectus Fig. 43A.

97009 " unfigured spec. unident.

97010 " " " "

97011 " " " " problematica.

97012 MC64 as 97003 *Plectodina aculeata* Fig. 55E,F.

97013 MC40 Mole Creek grid ref. 447003.84 5399262.99
dichognathiform element of *Phragmodus undatus* Fig. 54C-D.

97014 MC40 as 97013 *Plectodina aculeata* unfigured.

97015 as 96995 MC137 Ugbrook Nodular Member grid ref.
unfigured fibrous conodont.

97016 MC137 ?trichonodelliform element of *P. aculeata* x150

97017 MC137 *Drepanoistodus suberectus* unfigured.

97018 " ozarkodiniform element of *P. aculeata* unfigured.

97019 " " " " "

97020 " *Chirognathus monodactylus* Fig. 40D.

97021 MC137 prioniodiniform element of *R. careyi?* unfigured.

97022 MC137 prioniodiniform element of *P. aculeata*. unfigured.

97023 MC137 *Plectodina aculeata* unfigured.

97024 " *Erismodus* sp. unfigured.

97025 " ozarkodiniform element unidentified, unfigured.

97026 MC57 Mole Creek grid ref. 447236.53 5399695.30
Erismodus sp. Fig. 45C.

97027 as 97026 prioniodiniform element.

97028 as 97026 *Erismodus* sp. Fig. 45D.

97029 as 90503 grid ref.

prioniodiniform element unfigured

97030 as 90503 grid ref.

Bryantodina? abrupta Fig. 39

97031 as 82743 and

prioniodiniform element of *P.* cf. *furcata* unfigured.

97032 " " trichonodelliform element of *P.* cf. *furcata* unfigured.

97033 " " ozarkodiniform element of *P.* cf. *furcata* unfigured.

97034 " " zygognathiform element Fig. 59C.

97035 " " " " unfigured. Fig. 53C.

97036 " " oulodiform element of *O. oregonia?* unfigured.

97037 " " *Belodina compressa* Fig. 37C.

97038 " " " " unfigured

97039 " " *Phragmodus undatus* unfigured

97040 " " " " with basal cone unfigured.

97041 " " " " Branson and Mehl. Fig. 53C.

97042 " " prioniodiniform element of *P. furcata* Fig. 58C.

97043 as 82744 oulodiform element of *O. oregonia?* unfigured.

97044 " " *P. undatus* Fig. 53D.

97045 as 96971 stratigraphically highest sample from Goliath Quarry Railton *?Belodina* sp. Fig. 38.

97046 MC 76 Mole Creek grid ref 448424.82 5399699.83 Fig. 46A-B

97047 IBI Ida Bay ozarkodiniform element of *P. aculeata.* grid ref. EM891883

97048 MC55 Mole Creek. grid ref. 447244.48 5399639.63

?Protopanderodus. unfigured.

97049 Junction of Gordon/Franklin rivers. grid ref. CN 964838

sample collected by R. Tarvydas *Panderodus serpaglii* sp. nov. unfigured.

97050 As 97049 *Panderodus gracilis* unfigured.

97051	As 97049	*?Phragmodus flexuosus*	unfigured.
97052	"	ozarkodiniform element	unfigured.
97052	"	*P. serpaglii* sp. nov.	unfigured.

APPENDIX III Quantitative distribution of conodonts by sample at Mole Creek

1. *Acontiodus* cf. *nevadensis* Ethington & Schumacher
2. *Appalachignathus?* Bergström, Carnes, Ethington, Votaw & Wigley *
3. *Belodella copenhagenensis* (Ethington & Schumacher) *
4. *Belodina alabamensis* Sweet and Bergström
5. *Belodina compressa* (Branson and Mehl) *
6. *?Belodina* sp. nov.
7. *Bryantodina? abrupta* (Branson and Mehl)
8. *Chirognathus monodactylus* Branson and Mehl *
9. *Staufferella falcata* (Stauffer)
10. *Drepanoistodus forceps* (Lindström) *
11. *Drepanoistodus suberectus* (Branson and Mehl)
12. *Erismodus gracilis* (Branson and Mehl) *
13. *Erismodus* spp
14. *Oulodus* cf. *oregonia* Branson, Mehl & Branson *
15. *Panderodus gracilis* (Branson and Mehl) *
16. *Phragmodus flexuosus* Moskalenko *
17. *Phragmodus tasmaniensis* Burrett sp. nov. *
18. *Phragmodus undatus* Branson and Mehl *
19. *Plectodina aculeata* (Stauffer) *
20. *Plectodina florentinensis* Burrett sp. nov. *
21. *Plectodina* cf. *furcata* (Hinde) *
22. *Oulodus robustus* (Branson, Mehl and Branson) *
23. *Panderodus serpaglii* Burrett sp. nov.
24. *Rhipidognathus? careyi* Burrett sp. nov. *
25. *"Tetraprioniodus"* sp.

non-conodonts

26. *Milaculum ethinclarki* Müller
27. *Phosphannulus universalis* Müller, Nogami & Lenz.

* denotes multielement species

SAMPLE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	CONO-DONT TOTAL	SAMPLE WT. KG	CONO-DONTS PER KG.
MOLE CK.																														
17																												0	.475	0
18	4	3	5	5											3													20	.955	20
19		4	4	2												6												16	1.022	16
20																												0	1.300	0
21		1	3	4												2												10	1.035	10
22			4	2											6	9												21	1.075	21
23			2												1													3	1.550	4
24																												0	1.854	0
25																1												1	1.105	1
26																												0	1.280	0
27															1													1	.784	1
28																												0	.945	0
29															2													2	.530	4
30																												0	.987	0
31																												0	.546	0
32																												0	.440	0
33																												0	.527	0
34																												0	.458	0
35															1				3									4	.893	5
36																												0	.530	0
37																												0	.424	0
38																												0	.735	0
39											4				4				10									18	1.030	18
40			4		54						43				55			85	102									343	3.715	92
41																												0	.461	0

SAMPLE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	CONO-DONT TOTAL	SAMPLE WT. KG	CONO-DONTS PER KG.
42																												0	.306	0
43											2				5			5	8									20	.405	45
45																												0	.894	0
46																												0	.890	0
47																												0	.831	0
48																												0	.815	0
49																												0	.860	0
50																			1									1	.606	2
51											1								1									2	.690	2
52					5						3				10				7									25	.800	30
53																												0	.942	0
54					1						2				1			2	3									9	.459	20
55					3						2				3			12	18									38	.932	40
56					10						5				3			10	29									57	1.140	50
57					3										2			6	5									16	1.601	10
58					2																							2	.660	4
59					1										1													2	.994	2
60																												0	.830	0
61																												0	.759	0
62							2											1			1							4	.886	5
63					2		1								1						5							9	1.101	8
64					1										1						4							6	1.054	6
65					5						2				8			1			7							23	.590	40
66					1						2				3			1			3							10	.987	10
67											1				2						2							5	1.092	5
68															1													1	1.035	1

SAMPLE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	CONO-DONT TOTAL	SAMPLE WT. KG	CONO-DONTS PER KG.
69																												0	1.631	0
70																												0	.981	0
71																												0	1.982	0
72																												0	.459	0
73																												0	2.123	0
74																												0	1.854	0
75																												0	.876	0
76											1				1													2	1.081	2
77						2					5			8	3			2			3							23	1.157	20
78						2					1				4			1			3							11	1.143	10
79						4									3						3							10	1.590	7
80																												0	1.675	0
81																												0	1.012	0
82																												0	2.24	0
83					57						38				41			40			34							210	4.204	50
84					4										6			3			9							22	1.120	20
85					1										5													6	1.034	6
86					1										3			2			1							7	9.892	1
87															2			1			2							5	1.054	5
88					4																1							5	1.022	5
89																												0	2.037	0
90					5										2	18							12					37	5.248	6
91				1											1													2	0.758	3
92																												0	0.959	0
93																							1					1	1.222	1
94								2							2				2									6	1.552	4

SAMPLE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	CONO-DONT TOTAL	SAMPLE WT. KG.	CONO-DONTS PER KG.
95																												0	1.854	0
96																												0	1.632	0
97															6				2									8	4.040	2
98																												0	3.368	0
99															4				8									12	1.076	12
100																														
101																														
102																														
103																														
104																														
105																														
106																														
107					4										8			13	1									26	.680	39
108															1				1									2	1.052	2
112											6				2			4	13									25	1.154	24
113					2						5				14			21	30									72	1.512	48
114																												0	1.183	0
117															4			2			2							8	1.102	7
119															4													4	.980	4
129					1		1								3													5	1.687	3
133	1			12											63	95							122					293	4.890	60
134																														
135					18						2				9			20	3									52	1.096	52
137					2			18			2				4				25									51	2.552	20
138								2							12				16									30	2.692	11

SAMPLE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	CONO-DONT TOTAL	SAMPLE WT. KG	CONO-DONTS PER KG.
150																												0	4.650	0
166				1											8	2							5					16	4.163	4
167															2	2							10					14	4.710	3
168	1	5	7	31											82	41							54					221	4.450	50
169																												0	2.731	0
170																												0	2.670	0
171					3										3													6	3.380	2
187					2													4										6	3.210	2
188															5			6										11	3.700	3
199																												0	3.420	0
200															1													1	5.310	1
203																												0	15.970	0
204							5			8					30			19	10									72	3.685	20
206					18			9							25			10	18									90	3.651	25
207					12			15							21			14	1									63	2.441	26
208					11			8							18			14	27									78	1.930	40
209																														
210					16										12				24									52	1.360	40
215																												0	2.610	0
216																												0	3.450	0
217																												0	3.010	0
218																												0	2.730	0
219																												0	3.260	0
220																												0	4.110	0
221																												0	3.040	0

SAMPLE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	CONO-DONT TOTAL	SAMPLE WT. KG	CONO-DONTS PER KG.
233					6										4			9			7							26	4.000	6
236																												0	2.340	0
237																													3.855	
238																												0	3.460	0
239																												0	4.680	0
240																												0	4.280	0
241																														
242																												0	3.290	0
248					16						2			3	15			31			42							109	3.200	34
249																												0	4.800	0
255					20								2		8			17			14							61	4.000	15
262					1										6													7	3.550	2
267																												0	4.430	0
268																												0	.570	
270																												0	.982	0
301					40						22				16			21			52							151	3.775	40
																												TOTAL 2579		

APPENDIX IV

CHANGES IN THICKNESS OF LIMESTONE COLUMNS BY PRESSURE SOLUTION AND TECTONIC PRESSURE

A column of limestone may be shortened normal to bedding by (i) diagenetic stylolitization (ii) tectonic stylolitization (iii) pressure solution without the formation of stylolites (Shinn *et al.*, 1977) (iv) cleavage formation after or contemporaneous with folding. The Tasmanian limestones have undergone a complicated history that probably includes all four factors which have only been analysed in detail in a few places.

Bodou (1976) has suggested a simple method of analysing stratiform stylolites which he claims gives an estimate of the original thickness of a limestone column *"at the time of deposition."* This would appear to be overly optimistic. It is known that stylolites may form under thin overburdens (90 metres in Guam limestones, Schlanger 1964, p.14) and in many ancient limestones stylolites are thought to be early diagenetic features (Park and Schot 1968, pp. 187-188). If stylolitization is initiated after only one hundred metres of limestone have been deposited then a complicated history for any limestone column may be envisaged (Fig. 84). After a few million years at a high rate of sedimentation sufficient thickness of limestone has been deposited so that stylolitization is initiated. As sedimentation continues pressure solution increasingly removes more of the sediment pile. The dissolved calcite is removed and helps to lithify the limestone column (Bathurst 1971). If the rate of sedimentation decreases then a stage may be reached where pressure solution is removing as much thickness from the base of the pile as sedimentation is adding to the top (point D in Fig.84). Short periods might even be attained where the rate of pressure solution exceeds the rate of sedimentation and the limestone column would then be reduced in thickness. As pressure solution increases the rate of thickness increase gradually declines. However this decline does not

continue, as the process of stylolitization must stop when the pressure at the base of the column is sufficiently high that calcite solution is inhibited. Lovering (1962) notes that the solubility of calcite decreases ten-fold from 50°C to 200°C whereas silica solubility increases fifteen-fold.

This increase in silica solution would further tend to fill pores or silicify fossils further down the column thereby inhibiting further stylolitization. Increasing thickness of the limestone column would lead to increased pressure solution to begin with but at a certain (unknown) level the pore spaces would be closed-up by overburden pressure thereby decreasing porosity and permeability and further inhibiting stylolitization.

Thus the non-stylolitizing basal parts of the column would be an upwardly expanding zone (C" on Figs.84 & 85). When limestone deposition ceases a clastic succession would gradually compact the limestone by pressure solution until a steady state is reached (point E on Fig.84) during the Devonian. The heat flow considered in this argument would then have reached its maximum prior to Mid-Devonian deformation.

Not all limestone sections in Tasmania have been deformed and major sections at Lune River (Ida Bay) and probably in the Florentine Valley have not gone beyond point F on Figure 84. Depending then on the angle between cleavage and bedding the limestone column would be either lengthened or shortened. Tectonic stylolites, usually parallel to cleavage (Seymour 1975), would act, along with cleavage, to reduce the limestone outcrop normal to the cleavage plane.

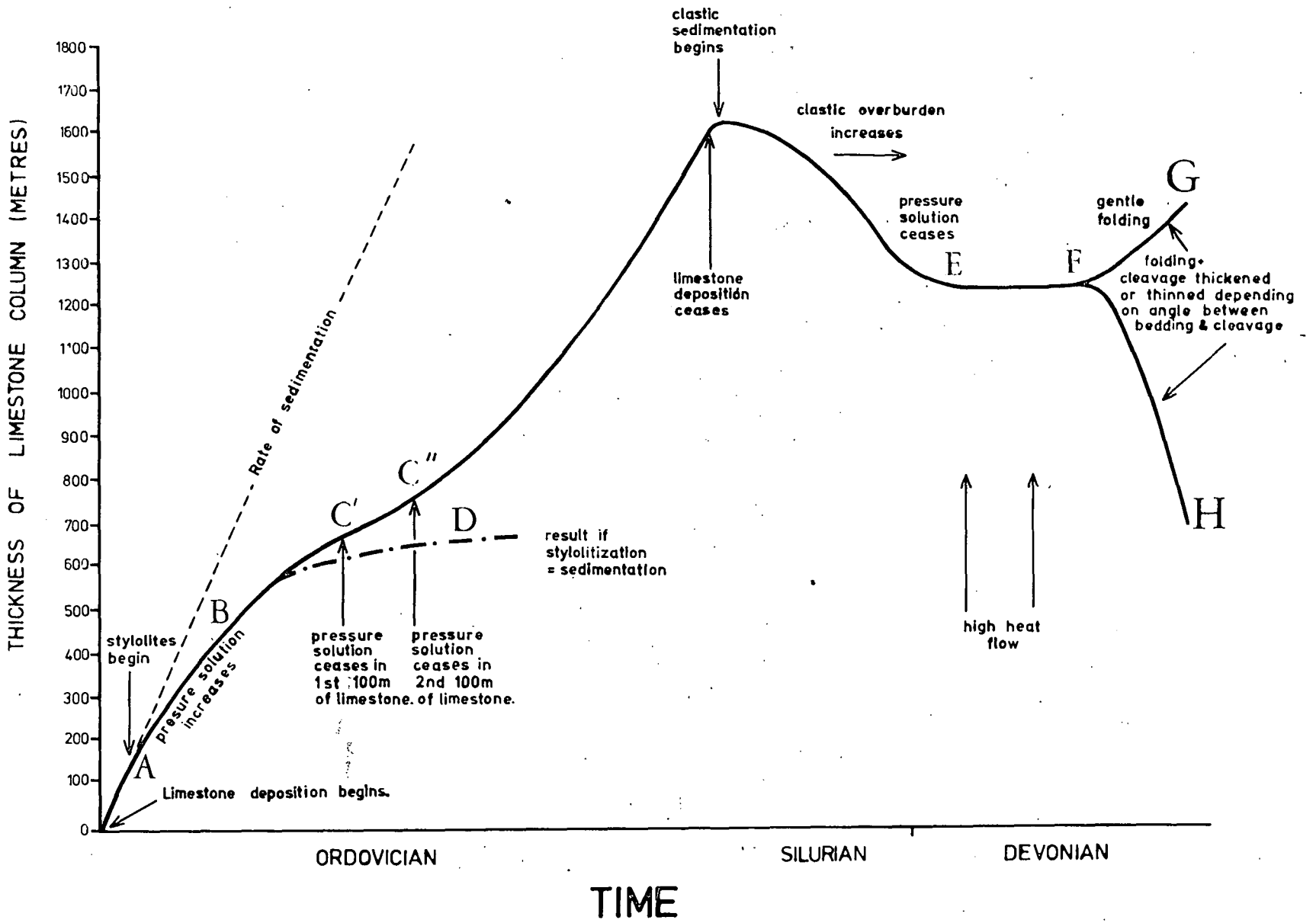
The above discussion of some of the major factors that modify the thickness of a limestone column indicates that contrary to Bodou (1976) no simple analysis of stylolites can restore the original thickness of a limestone pile. From Figure 84 we may also ask if the

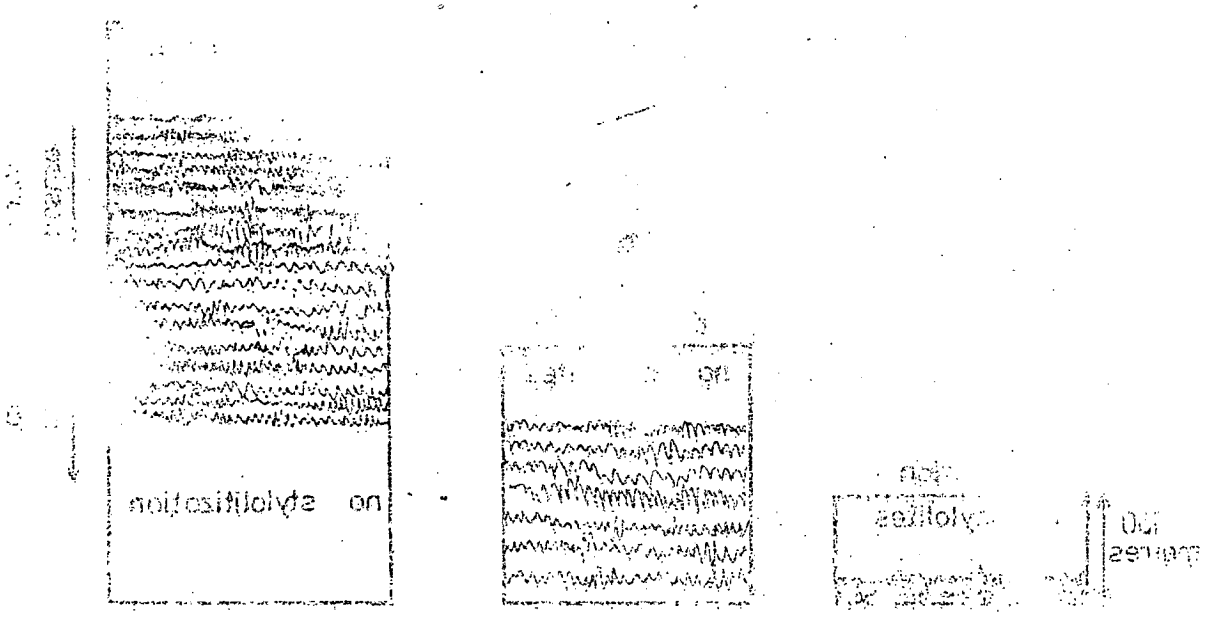
original thickness *"at the time of deposition"* (Bodou 1976) has any meaning. The only relevant question that we have to ask in this chapter is: *what was the thickness of the limestone columns prior to deformation by cleavage and tectonic stylolitization?* By strain analysis the amount of shortening or thickening may be calculated but the amount of shortening caused by non-seismograph type tectonic stylolitization cannot, at the moment, be analysed.

Strain analysis at The Grunter (to the south of Standard Hill near Mole Creek at grid ref. DP 397795) by D. Seymour (1975) has shown that during tectonic deformation extension has occurred in the direction of stratigraphic thickness rather than compression. Seymour (1975) worked on oncolites and oolites from the limestone near to the base of the sequence. In other parts of the Mole Creek synclinorium, analysis of cleavage/bedding relationships shows that the sedimentary pile has increased in stratigraphic thickness during Tabberrabberan deformation. To the north of Standard Hill at Mole Creek (at grid ref. DQ 466989) the deformation of oncolites in the lowest part of the limestone sequence is not so intense as at The Grunter but still indicates that at least the lowest part of the limestone sequence has increased in thickness. Thus the estimated 50% shortening of the original sedimentary pile may be unrealistic and makes the interpretation of the C.A.I. values even more difficult.

FIGURE 84

Diagram illustrating the major processes operative on the thickness of a carbonate pile overlain by clastics. Modelled on the Gordon Limestone Sub-group carbonates. Thicknesses hypothetical but similar to several Gordon Limestone Sub-group carbonate sections. Rate of sedimentation is assumed to be constant. A = initiation of stylolitization B = point where pressure solution considerably reduces rate of limestone thickness increase. C' = point where pressure solution ceases in first 100m. of limestone. C" = point where pressure solution ceases in 2nd 100m. of limestone. D = limestone thickness where pressure solution = rate of sedimentation. E = point where pressure solution ceases. F = thickness of limestone after high heat flow and prior to deformation. G = area of gentle folding where cleavage plane is at high angle to bedding. H = area of isoclinal folding where cleavage planes are at a low angle to bedding.


THICKNESS OF LIMESTONE COLUMN (METRES)
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Rate of sedimentation
clastic sedimentation begins
clastic overburden increases
pressure solution ceases
gentle folding
G
E
F
folding+ cleavage thickened or thinned depending on angle between bedding & cleavage
limestone deposition ceases
C''
C'
D
B
A
H
result if stylolitization = sedimentation
stylolites begin
pressure solution increases
pressure solution ceases in 1st 100m of limestone.
pressure solution ceases in 2nd 100m of limestone.
high heat flow
Limestone deposition begins.
ORDOVICIAN
SILURIAN
DEVONIAN
TIME



...ral line graphs showing extent of
... stages A, B and C.

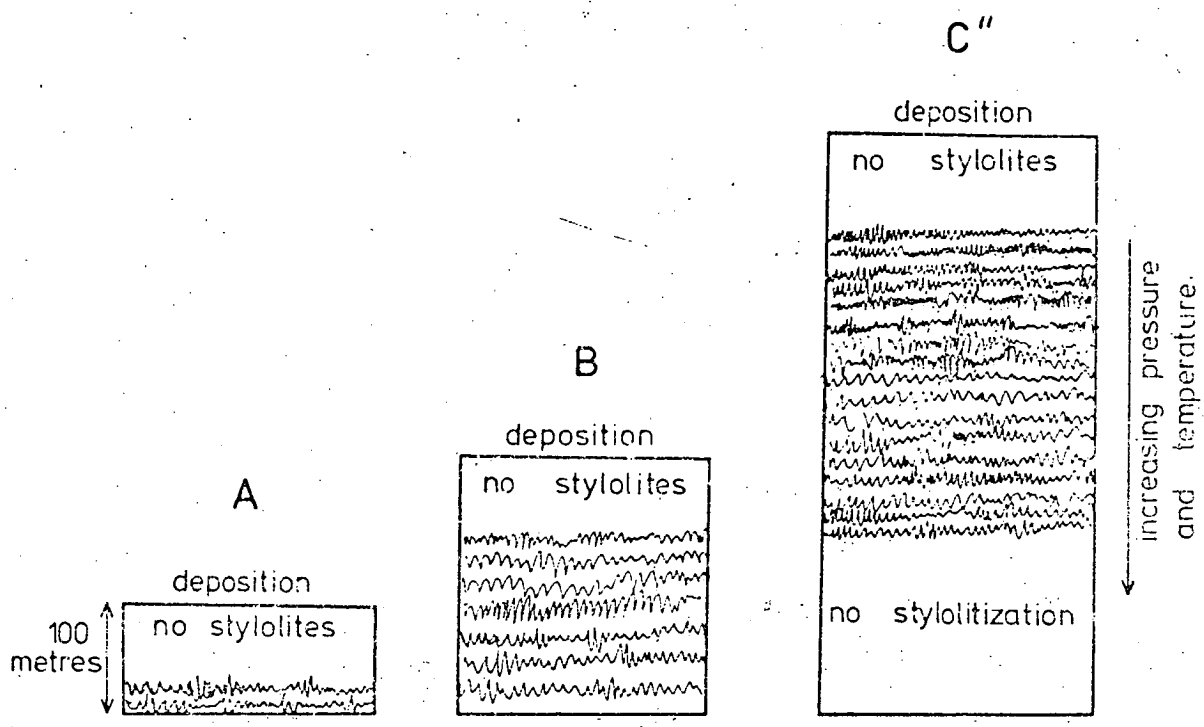


FIGURE 85

Hypothetical limestone columns showing extent of stylolites and stylolitization at the stages A, B and C" of Figure 84.