STRATIGRAPHY AND CONODONT BIOZONATION OF THE LOWER DEVONIAN LIMESTONES , WARATAH BAY , VICTORIA.

(28 Text-figures, 10 Tables, 9 Plates)

A thesis submitted for the degree of Bachelor of Arts (Honours) in the School of Earth Sciences,

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A B S T R A C T

The stratigraphical relationship of a number of limestone sequences belonging to two formations at Waratah Bay, Victoria, has been determined on lithological and micro-faunal evidence. Two new members have been defined for the WARATAH LIMESTONE. The older, Lower Grinder Member, includes those sequences developed at Point Grinder (lower part), the Black Stack (new name), Robin Rocks and the uppermost part of the Bell Point section. The younger, Mushroom Rock Member, embraces Point Grinder (upper part), Kiln, Bird Rock, Gair Rock and Mushroom Rock sequences.

The BELL POINT LIMESTONE, above the unconformity, has been re-defined, so that the uppermost part of the Bell Point section is now assigned to the Lower Grinder Member of the WARATAH FORMATION. The dark grey limestone sequences at the Bluff (Walkerville) and Point Grinder (uppermost part) are relegated to the BELL POINT FORMATION.

Detailed description of the various carbonate sequences, together with field maps showing section traverses, are included under Appendix A ; Section Profiles are in pocket.

An early to middle Siegenian age is attributed to the Waratah Bay limestones on the presence of three diagnostic forms, Spathognothodus sulcatus (PHILIP), S. remscheidensis ZIEGLER and S. exiguus philipi KLAPPER. A conodont biozonation is proposed for part of the Lower Devonian with reference to KLAPPER'S (1969) work on the conodont sequence at Royal Creek, Canada, in association with LENZ'S brachiopod stages.

The Waratah Bay faunas permit the establishment of two zones and one sub-zone as follows :

1. Zone with Spathognathodus victoriensis n.sp. and Ozarkodina grinderi n.sp., lying below the S. sulcatus zone ;

2. Zone with S. sulcatus, associated with S. remscheidensis in the lower part (sub-zone).

Of the 210 samples treated from Waratah Bay, 75 yielded conodonts, representing 13 genera and 40 species. Of these, 32 species are identifiable and 8 species are indeterminate. Six new species with short ranges within the Lower Devonian are described from Waratah Bay and figured on Plates 1 to 9. They are : Belodella australensis n. sp., Ligonodina waratahensis n. sp., Ozarkodina bischoffi n. sp., Ozarkodina grinderi n. sp., Spathognathodus victoriensis n. sp., and Trichonodella australis n. sp.

A preliminary interpretation of the palaeo-environment, based on limited petrographic evidence together with conodont frequency, indicates that extremely variable conditions analogous to modern shore-line environments, were partly operative during deposition of the Waratah Bay limestones.

TABLE OF CONTENTS

PAGE

A. INTRODUCTION

I. Scope of Thesis 1
(a) The Problems 1
(b) The Aims 1

II. Geographical Setting
(a) General 2
(b) Location of Sections 4

III. Geological Setting 7

IV. Previous Investigations 9

V. Methods of Study
(a) Field Work 12
(b) Laboratory Work 13
Collection and Processing Data ... 15
(c) Photography 16

VI. Storage of Material 16

VII. Acknowledgements 16

B. STRATIGRAPHY

(a) The Sections
1. Point Grinder 18
2. Bell Point 24
3. Walkerville
Black Stack & Robin Rocks 37
Kiln - Bluff 39
Bird Rock 42

(b) Stratigraphic Nomenclature 51
Definitions of New Members 51
Bell Point Formation revised 58
Liptrap Formation 61
Summary 62

TABLE OF CONTENTS (continued)

		PAGE
C.	CORRELATION OF THE WARATAH BAY LIMESTONES	71
D.	CONODONT BIOZONATION	72
E.	PALAEO-ECOLOGICAL CONSIDERATIONS	82
F.	SYSTEMATIC PALAEONTOLOGY	86
	EXPLANATION OF PLATES 1-9	127
	REFERENCES	139
	APPENDIX A	150
	SECTION PROFILES	in pocket.

LIST OF ILLUSTRATIONS

FIGURES	PAGE
1. Locality Maps - Waratah Bay	3
2. Geological Map of part of Waratah Bay	8
3. Field Map of Point Grinder	21
4. Basal "agglomeratic" horizon of Lower Grinder Member, with chert wedge, resting unconformably on Cambrian Greenstones, Point Grinder.	22
5. Lithological units of Lower Grinder Mbr, Point Grinder.	23
6. Lower Grinder Mbr, with unconformity on Cambrian Bm.	23
7. Field Map of Bell Point.	31

TABLE OF CONTENTS (continued)

FIGURES PAGE

8. Gair Rock, Bell Point, showing unconformity. 32

9. Mushroom Rock, Bell Point. 32

10. Gair Rock, Bell Point, showing infillings of old solution channels in the Waratah Limestone . 33

11. Lower part of Bell Point Limestone, Bell Point. 34

12. Gair Rock, Bell Point, showing location of fish "bone beds" just above the unconformity. 34

13. "Biostromal" limestone, Bell Point north. 35

14. Stromatoporoid beds, north of Bell Point. 35

15. Upper Bell Point Section, looking north to Digger Is. 36

16. Location of Bird Rock, Robin Rocks & Black Stack. 36

17. Field Map of the Walkerville area. 44

18. Field Map showing the relationship between Kiln and Bluff limestone sequences, Walkerville. 45

19. The Black Stack, southern end of South Walkerville. 46

20. Robin Rocks, South Walkerville. 46

21. Basal "agglomeratic" horizon with unconformity on Pre-Devonian Basement, Black Stack, South Walkerville. 47

22. Kiln and Bluff limestone sequences, Walkerville. 47

23. Relationship between Kiln & Bluff sequences, Walkerville. 48

24. Kiln sequence ("southern slice"), South Walkerville. 48

25. Unconformity between Kiln & Bluff sequences. 49

26. Unconformity between Kiln & Bluff sequences. 49

27. Walkerville Fault Zone, the Bluff, Walkerville. 50

28. Bird Rock, Walkerville. 50

TABLE OF CONTENTS (continued)

TABLES	PAGE
1. Distribution of Conodonts, Black Stack Section.	64
2. Distribution of Conodonts, Upper Bell Point Section.	65
3. Distribution of Conodonts, Point Grinder Section.	66
4. Distribution of Conodonts, Mushroom Rock Section.	67
5. Distribution of Conodonts, Gair Rock / Lower Bell Point.	68
6. Distribution of Conodonts, Bluff / Kiln Sections.	69
7. Correlation of the Waratah Bay limestone sequences.	70
8. Conodont Zonation within the Lower Devonian.	80
9. Waratah Bay stratigraphy - comparison with previous authors.	81
10. Petrographic evidence & the Palaeo-environment.	85
PHOTOGRAPHIC PLATES 1-9 of Waratah Bay Conodonts.	128

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A. INTRODUCTION

I. SCOPE OF THE THESIS:

(a) The problems :

Palaeozoic rocks are exposed at a number of locations along some nine miles of coast-line between Walkerville and Cape Liptrap, on the western shores of Waratah Bay, Victoria. Complex tectonics have obscured the original relationships of the various formations and good exposures are limited to coastal cliffs and tidal platforms. Three isolated occurrences of limestone crop out at Point Grinder, Bell Point and Walkerville (Fig. 2). Until now, their stratigraphical relationships and precise age have been uncertain.

A broad correlation of the various carbonate sequences has been attempted by a number of authors on the basis of lithology and macrofossil content, but the evidence does not allow an unequivocal correlation to be made.

Two different limestones, separated by an angular unconformity, have been recognised in the Bell Point area. The coral, brachiopod and mollusc faunas described from these formations indicate an age somewhere in the Lower Devonian, but further refinement has not been possible.

(b) The aims:

(1) A correct determination of the stratigraphical relationship of all the isolated limestone occurrences at Waratah Bay by means of conodonts.

(2) A precise determination of the age of major stratigraphic units by means of conodonts.

(3) An attempt to improve the conodont biozonation for this particular time span within the Lower Devonian.

(4) A preliminary interpretation of the depositional environment, with comments on the genesis of the Waratah Bay limestones.

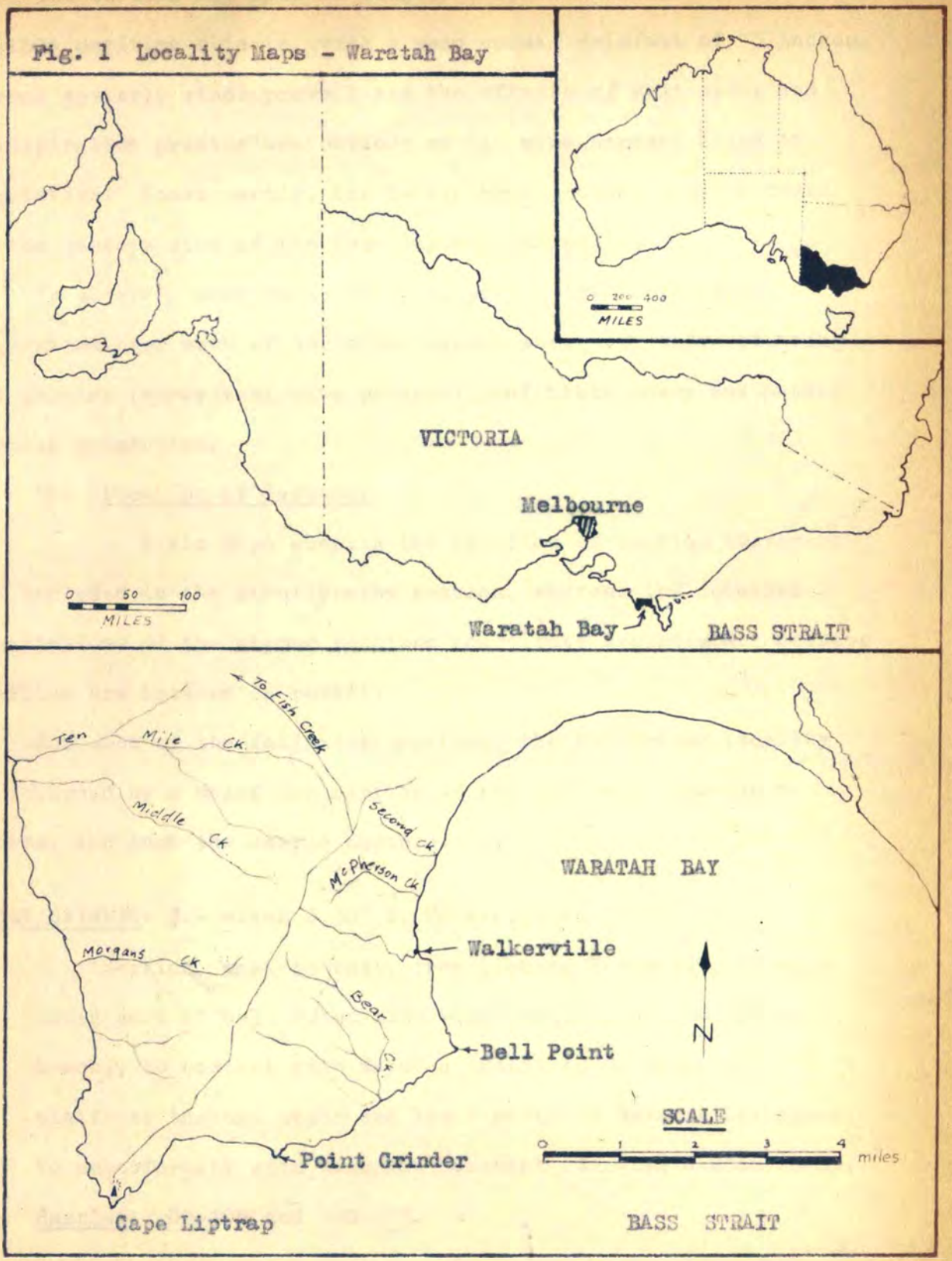
II. GEOGRAPHICAL SETTING:

(a) General:

Waratah Bay is that broad expanse of the Southern Ocean between the Cape Liptrap peninsula and Wilsons Promontory on the mid-coast of Victoria (Fig. 1). Walkerville, a small sea-side resort on the west coast of Waratah Bay, is 16 miles by road from the nearest railhead at Fish Creek, and 116 miles east of Melbourne.

The Cape Liptrap peninsula is an undulating plateau, some 30 square miles in area, bounded by rocky cliffs which rise abruptly from wave-cut platforms to heights of 30 m or more. The watershed is formed by a ridge of low relief running several miles N.N.E. from Cape Liptrap. A number of small streams drain into the sea on each side, the largest of these to the west. LINDNER (1953), who described the geomorphology of the area in some detail, believes that the nature and distribution of the Tertiary sediments on the eastern side (from Point Grinder to Walkerville), provide evidence for the prior existence of a coastal plain, following the emergence of a marine platform in late Tertiary time. He points out that the East Gippsland coastline was uplifted in Pliocene times.

Fig. 1 Locality Maps - Waratah Bay



The Waratah Bay area is subject to a relatively cooler, but equable maritime climate, with a mean annual rainfall of 43 inches. Strong westerly winds prevail and the effects of salt spray and transpiration pruning are obvious on the more exposed belts of vegetation. Consequently, the better agricultural land is found on the eastern side of the Cape Liptrap peninsula.

In general, poor sandy soils support a low heath-type vegetation over much of the area, except where extensive clearing and pasture improvement have produced profitable sheep and cattle grazing properties.

(b) Location of Sections:

Field Maps showing the location of section traverses are included in the stratigraphy section, whereas the detailed descriptions of the mapped sections constitute Appendix A. Section Profiles are located in pocket.

For each of the following sections, the collecting locality is followed by a brief description of the traverse from top to bottom, and then the sample numbers.

POINT GRINDER: 3.4 miles S 30° W, Walkerville.

Section, west to east, from Liptrap Formation, through lower part of Bell Point Limestone (scattered outcrops on beach), to contact with Waratah Limestone on wave-cut platform; through upper and lower parts of Waratah Limestone, to unconformity with Cambrian basement (Waratah Greenstones).

Samples: 80-105 and 300-317.

BELL POINT: 1.4 miles S 25° E, Walkerville.

Upper Bell Point - Section, north to south, from contact with Digger Island Formation, through lower part of Waratah Limestone, to a prominent sand gap on the fore-shore.

Samples: 54-74, 335 and X.

Lower Bell Point - Section, north to south, from sand gap (above), through Bell Point Limestone, along fore-shore, with long offsetto cliff, midway between Gair and Mushroom Rocks; thence due east to unconformity with Waratah Limestone on rocky fore-shore.

Samples: 21-53 and Y.

Gair Rock - Section, west to east, from unconformity with Bell Point Limestone, through upper part of Waratah Limestone, across wave-cut platform to low tide mark.

Samples: 0-20.

Mushroom Rock - Section, west to east, from unconformity with Bell Point Limestone, through upper part of Waratah Limestone, across wave-cut platform to low tide mark.

Samples: 320-334 and G.B.1.

WALKERVILLE SECTIONS:

Bluff - 120 m N, Walkerville.

Section, north to south, through Bell Point Limestone, from Walkerville Fault zone, along fore-shore to unconformity with Waratah Limestone of Kiln section.

Samples: 140-143, 163-169, 366-370.

Kiln - 20-100 m N, Walkerville.

Northern Slice - On beach, 80 m N, old lime kilns.

Section, north to south, from unconformity with Bell Point Limestone of the Bluff, through upper part of Waratah Limestone, along fore-shore to low tide mark.

Samples: 144-148.

Middle Slice (?) - Outcrop on beach, 40 m N, old lime kilns.

Short section, through upper part of Waratah Limestone.

Samples: 344-346.

Southern Slice - Cliff section adjacent to old lime kilns.

Section through upper part of Waratah Limestone, from cliff-top (erosion surface) to beach.

Samples: 149-152, 336-343.

Black Stack - Rocky fore-shore at southern end of South Walkerville surfing beach.

Section, north to south, from low tide mark, through lower part of Waratah Limestone, over rock stack of low relief (partly tidal), to unconformity with Pre-Devonian dolomitic basement at shore level.

Samples: 114-120, 352-365.

Robin Rocks - Brown rock stack (4.6 m high), on rocky fore-shore, 20 m E, Black Stack.

Short section, through lower part of Waratah Limestone, from erosion surface at top of stack, downwards to unconformity with Pre-Devonian dolomitic basement at shore level.

Samples: 110-113.

Bird Rock: Three separate, large rock stacks on tidal platform, 40-60 m south-east of Robin Rocks.

Basal Sequence - Exposed on large rock stack nearest shore.

Short section through a Pre-Devonian Basement.

Samples: 0500-502.

Inner Bird Rock - Section, north to south, through Waratah Limestone, from just below erosion surface to low tide mark.

Samples: 347-351.

Middle Bird Rock - Section, north to south, from low tide mark, through Waratah Limestone, on wave-cut platform, along western edge of large rock stack, to low tide mark.

Samples: 130-137.

Outer Bird Rock - Inaccessible, not sampled.

III. GEOLOGICAL SETTING:

A belt of Cambrian diabasic rocks, cropping out along the Waratah Bay coastline, has been referred to as the Waratah Axis. Parallel to it and some five miles to the west, a belt of Upper Ordovician slates and sandstones trends northwards to become the Waratah-Boolarra Anticlinorium. Between these structural axes lies an exotic belt of folded and faulted Lower Palaeozoic sediments of varied lithology. Important among these are two carbonate formations with isolated exposures limited to coastal cliffs and tidal platforms between Point Grinder and Walkerville. The limestones

Fig. 2

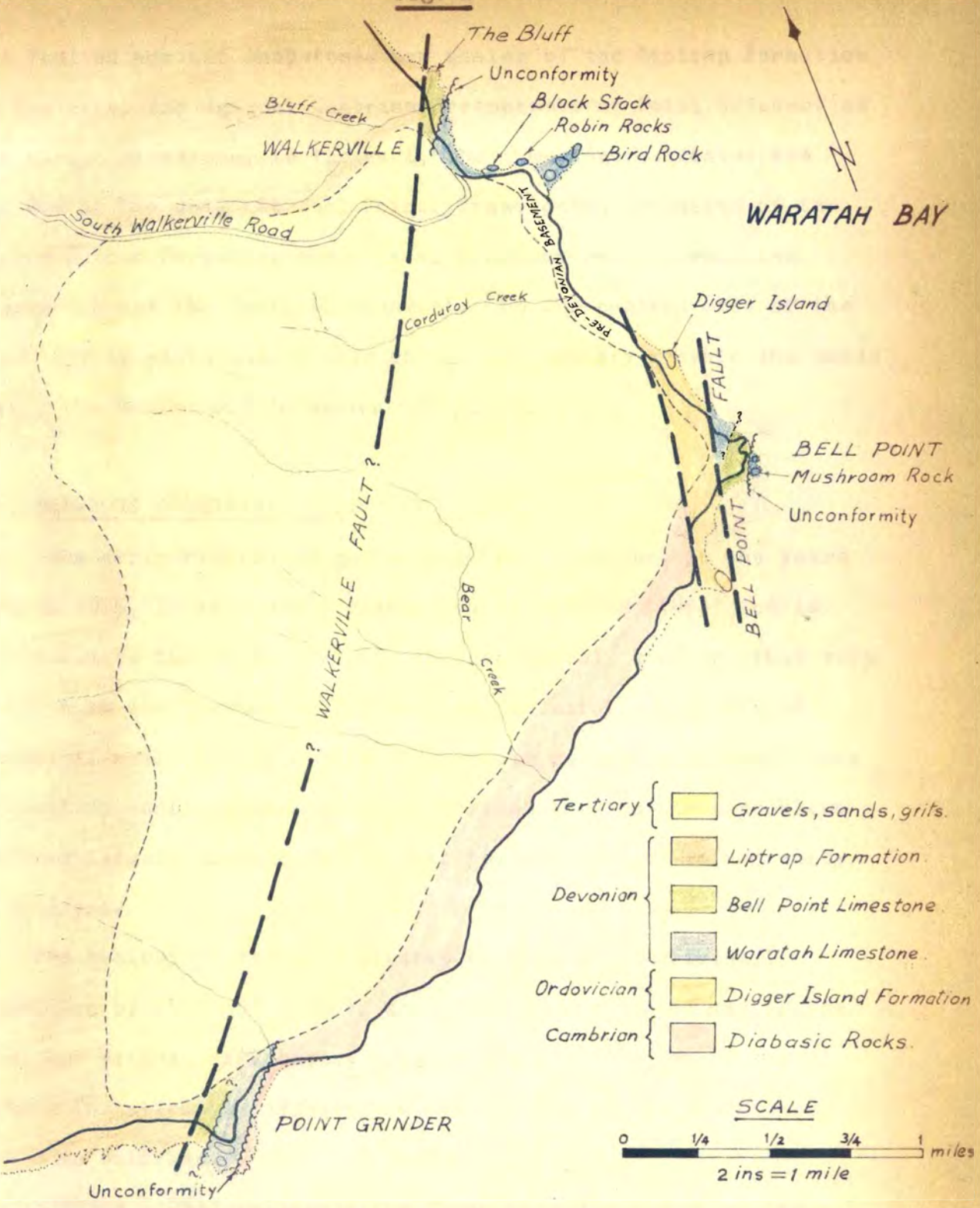


Fig. 2 Simplified geological map of part of Waratah Bay, modified after Ferguson (1928), Lindner (1953) & Talent (1959).

from Talent (1959)

are faulted against sandstones and shales of the Liptrap Formation on the west, and against Cambrian Greenstones at Point Grinder, on the east. Elsewhere, to the east, the limestone sequences are bounded by the sea. At Bell Point, Tremadocian sediments of the Digger Island Formation wedge in as a narrow belt between the limestones and the Cambrian Basement. On the eastern side of the Cape Liptrap peninsula, a thin mantle of Tertiary gravels and sands covers the Palaeozoic formations (Fig. 2).

IV. PREVIOUS INVESTIGATIONS:

The early history of geological investigation, in the years 1876 to 1925, is adequately summarized by LINDNER (1953) and is peripheral to the present work. It does reveal, however, that very little work was carried out on the complex stratigraphical and structural relationships of the Palaeozoic sediments exposed along the western coast of Waratah Bay. Serious work on these problems has been largely limited to the last two decades and is currently in progress.

The geology of the Cape Liptrap peninsula was originally undertaken by FERGUSON (1928), who produced a detailed map of the area, but without explanatory notes. The distribution of the various formations is illustrated and the age of the limestones listed as Silurian.

LINDNER (1953) published the first detailed report on the overall geology of the area, including a rough map based on the work of FERGUSON (op. cit.). LINDNER recognized three Palaeozoic

sequences which he named Digger Island, Liptrap and Bell Point Formations, respectively. Of significance here, was his referral of all carbonate units to a single formation, the Bell Point Limestone, to which he ascribed a Devonian age.

TEICHERT (1954) made a brief reconnaissance of the limestones in the Walkerville area and subdivided the Bell Point Limestone into three distinct lithologies, which he named the Bluff, Kiln and Bird Rock Members, respectively.

Corals, collected by LINDNER, SINGLETON and TEICHERT, from Waratah Bay, together with those of the National Museum, Melbourne, were described by HILL (1954). These she placed within the range Lower Devonian to Couvinian, and pointed to their close affinity with the Lilydale and Loyola faunas (HILL, 1939).

TALENT (1955, 1959, 1965) has made significant contributions to the understanding of the Palaeozoic complex at Waratah Bay. He recognized the "abrupt facies change" referred to by LINDNER (op. cit., p.82) as a major unconformity separating the dark grey Bell Point Limestone from the underlying pale grey Waratah Limestone, which he named. He carried out palaeontological studies which revealed two mutually exclusive brachiopod-mollusc faunas above and below the unconformity, corresponding well with the marked difference in lithology. Although he reserved TEICHERT'S subdivision of the Waratah Limestone into three members, he pointed out that the Kiln and Bird Rock Members were most likely contemporaneous, and that the succession at Walkerville was not as complicated tectonically as TEICHERT had suggested. TALENT felt

that the Waratah Limestone reached its maximum extent in the Bluff Member at Walkerville, and that its absence from Point Grinder and Bell Point was due to loss by erosion. The Bell Point Limestone proposed earlier by LINDNER was later restricted by TALENT to include only those dark grey limestones above the unconformity at Bell Point. TALENT regarded the Waratah Limestone as late Siegenian to early Emsian, largely on the basis of stromatoporoids and corals, and to a lesser extent on brachiopods and molluscs. He noted a strong resemblance between this fauna and those of the Coopers Creek Formation. On the other hand, he felt that the brachiopod faunas of the Bell Point Limestone were comparable with those of the Buchan Caves Limestone, which he regarded as Eifelian.

PEDDER (1965) revised the taxonomy of certain corals referred to the genus Mictophyllum by HILL (op. cit.). Three of these disphyllid corals were collected from the Bell Point Limestone, immediately north of Bell Point. PEDDER ascribes a Siegenian age for these revised corals (Chalcidophyllum spp.), and points out that Mictophyllum is more likely a Givetian and Frasnian genus.

PHILIP and PEDDER (1967 b, 1967 d), on the basis of corals (the Lyrielasma chapmani fauna) and one conodont species (Eognathodus sulcatus), regard the Waratah Limestone at Mushroom Rock as Siegenian in age, correlating with the Coopers Creek and Lilydale Limestones. They also suggest correlation of the Kiln Member with the Coopers Creek Limestone, but on the basis of a different assemblage of corals. Similarly, limestones in the

vicinity ? of Bird Rock yielded a coral fauna which partly suggests a correlation with the Coopers Creek and Lilydale Limestones, although species of apparently younger age (Lochkovian) were also present. PHILIP (1965) had previously dated the Tyers fauna as upper Gedinnian or early Siegenian on conodonts from the Coopers Creek Formation.

V. METHODS OF STUDY

(a) Field Work:

Intensive field work involving the detailed sampling and associated stratigraphy of some nine sections was carried out in January, 1970. A second trip was made one year later (January, 1971) in order to resample those beds which had yielded conodonts, in an effort to increase the comparatively sparce faunas, and to carefully re-examine those sections in which long intervals were apparently barren. In the latter case, alternative horizons, which appeared to be lithologically more suitable, were sampled. Since sample numbers had been painted on the rock surface previously, the work of resampling was greatly facilitated.

True thicknesses of beds were either measured directly by tape, or calculated trigonometrically. In general, sequences of fairly uniform lithology were sampled at regular intervals, 1-2 m apart; but where there were marked changes in lithology or thickness of beds, additional samples were taken. Samples were marked on location with texta colours and bagged. Sample numbers ranged from 0 to 370, except for a basal sequence at Inner Bird Rock, where

samples 0500 to 502 were collected. Since a number of sections are only exposed at low tide, maximum use of time with respect to outgoing and incoming tides was an important consideration. This meant that part of a section may have been worked from top to bottom or vice versa. The sample numbers reflect such reversals in that they are not always sequential.

(b) Laboratory Work:

The larger field samples, weighing from 1-5 kg, were reduced in size to about 3 cm^3 by means of a jaw-crushing machine. This size provided increased surface area for more rapid dissolution, with minimal damage to conodonts by breakage.

Initially, only 1 kg of each sample was treated in order to establish those samples which yielded conodonts. In this way, samples which gave no returns were considered barren and further treatment abandoned.

The limestone was digested using a 50% solution of monocloracetic acid. Several acid changes together with frequent washing and residue collection were necessary over about 3 days until complete dissolution was effected. Extended washing techniques (as advocated by LINDSTROM, 1964) were preferable to wet sieving methods because the fine denticles of many conodonts have a tendency to get caught in the 100 to 120 mesh-per-inch screens resulting in unnecessary damage. Since many conodonts are rare in the Waratah Bay material, the slower but safer method of continuous washing was employed. Furthermore, many small particles, useful for environmental interpretations, are usually lost by fine sieving methods.

After washing, the residues were dried and then separated into heavy and light fractions using the heavy liquid, bromoform (diluted with alcohol to a specific gravity of 2.74). Conodonts, which have a specific gravity of 2.8 to 3.1, sink readily in the bromoform, along with a variety of impregnated organic remains and heavy minerals. These constitute the heavy fraction which is easily recovered by filtering and washing in alcohol to remove excess bromoform. The light fraction is handled in exactly the same way; both residues are dried separately on open filter papers using gentle heat, stored and labelled until needed.

The Waratah Bay conodonts were removed from the heavy residue under a binocular microscope, using needle and picking tray. All specimens from a given sample were thus transferred directly to the one microslide for later determination.

In some cases, large quantities of dolomite and/or heavy minerals were present in the heavy fraction, so that further separation with an electromagnetic separator was necessary before normal hand picking could proceed. This was particularly so in the case of the Bell Point Limestone and samples from the Black Stack, which contained an abundance of iron compounds, in addition to silt.

WARATAH BAY

COLLECTION AND PROCESSING DATA

Average weight of field samples	2 kg
Total number of samples collected	225
Number of lithological samples collected	15
Number of samples treated for conodonts	210
Number of samples yielding conodonts	75
Total weight of limestone processed	322 kg
Total number of identifiable conodonts	2,120
Total number of compound conodont fragments	784
Average abundance of conodonts (excluding fragments)	6.6/kg
Total number of conodont genera represented	13
Number of known conodont species	26
Number of new conodont species	6
Number of unnamed conodont species	7

(c) Photography:

The field photographs (Text-figures) illustrating the location and stratigraphy of various outcrops at Waratah Bay were taken with a Praktica IV single-lens-reflex camera using Kodak 35 mm Panatomic X film.

The specimen plates were prepared from photographs taken with a Leica MD 35 mm camera attached to the Leitz Aristophot.

The conodonts were coated with white ammonium chloride sublimate and photographed on a background of ruby-red glass.

VI. STORAGE OF MATERIAL:

All figured specimens, lithological thin sections, together with the rest and residue of specially selected samples, are registered in the Palaeontological Collection of the Macquarie University (MU), North Ryde, N.S.W.

Catalogue Numbers: MU 401-MU 496

VII. ACKNOWLEDGEMENTS:

I am indebted to Dr. G. BISCHOFF (Macquarie University), who supervised the project and kindly helped in the preparation of the photographic plates. My thanks are also due to Dr. J. TALENT (Macquarie University), who first pointed to the need for additional research on the Waratah Bay area and made available a number of reports pertaining to it. His counsel during the early stages of field work was invaluable. Maps used herein are based on his unpublished maps.

Other members of staff within the University contributed as follows: Professors A.H. VOISEY and A.J. ROSE (Heads of the School of Earth Sciences) made available the various facilities of the School; Dr. P.J. CONAGHAN gave valuable advice in connection with the lithological thin sections; Dr. R. MEYER (Director of the Centre for the Advancement of Teaching) kindly offered the photographic facilities of his department; and Mr. K. KENDALL gave advice on certain aspects of the cartography. To these people I extend my sincere thanks.

B. STRATIGRAPHY

(a) The Sections:

1. Point Grinder: (See Figs. 3 to 6)

Two limestone formations reaching a combined thickness of 184 m are represented at Point Grinder. To the east, the Waratah Limestone (133.6 m thick) unconformably on sheared and contorted diabasic rocks of the Cambrian Basement. However, in one place, thin beds of Pre-Devonian cherts wedge in between the limestones and the basement (Fig. 4). To the west of the Point Grinder headland the Bell Point Limestone is poorly exposed.

The lower part of the Waratah Limestone (Figs. 5,6) commences with a thin bed of agglomeratic material, composed of up to 90% chert fragments in a tuffaceous matrix. Above this, are thin beds of pale grey calcareous argillite which weather to a buff colour. These softer, less competent beds of argillite are overlain by dark grey to black silty shales, sufficiently hardened by silicification to form prominent projections on the wave-cut platform. These are followed in turn by about 2 m of interbedded limestones and shales, medium grey in colour.

At this stratigraphic level there is a marked change in the lithology of the Waratah Limestone, for there follows a thick sequence (110 m) of light grey limestones, which weather to a pale yellowish-grey colour. The beds are normally quite thick, often with a massive appearance, but several horizons are thinly bedded, with intercalations of argillaceous material.

Accelerated weathering and erosion of these horizons have produced narrow surge channels and crevasses in platform and cliff outcrops. In general, the Waratah Limestone at Point Grinder is a monotonous sequence of calcarenites, becoming richly fossiliferous in the upper part, where stromatoporoids, rugose and tabulate corals are locally abundant. Towards the top, a large sink-hole and several sea caves are developed in thick beds of coarse crinoidal limestone. In the uppermost beds, irregular lumps and lenses of dark grey silty ? material, occur more or less normal to the bedding planes. These are apparently infillings of old solution channels in the Waratah Limestone, filled during deposition of the overlying Bell Point Limestone, although the unconformity which must separate these two formations is not directly exposed. A similar relationship can be observed on the western face of Gair Rock at Bell Point.

Beyond this, to the west, scattered outcrops of dark grey limestone, of the Bell Point Formation, extend along a sandy beach until they are faulted against the sandstones and shales of the Liptrap Formation. These beds of dark grey limestone, shattered and veined by calcite, with local increase in dip, indicate the presence of a major fault. Previous workers have interpreted this as a continuation of the Walkerville Fault (Fig. 2) although it is not well defined; and have apparently been unaware of the intervention of the Bell Point Limestone (approximately 50 m thick) within this rather wide interval.

Composition of Fauna - The following conodonts were obtained from the Waratah Limestone at Point Grinder :

Ligonodina waratahensis n. sp.

Ozarkodina bischoffi n. sp.

Ozarkodina denckmanni

Ozarkodina grinderi n. sp.

Ozarkodina typica australis

Paltodus acostatus

Spathognathodus remscheidensis

Spathognathodus sulcatus

Spathognathodus victoriensis n. sp.

Trichonodella australis n. sp.

Fig. 3 ROUGH FIELD MAP OF POINT GRINDER

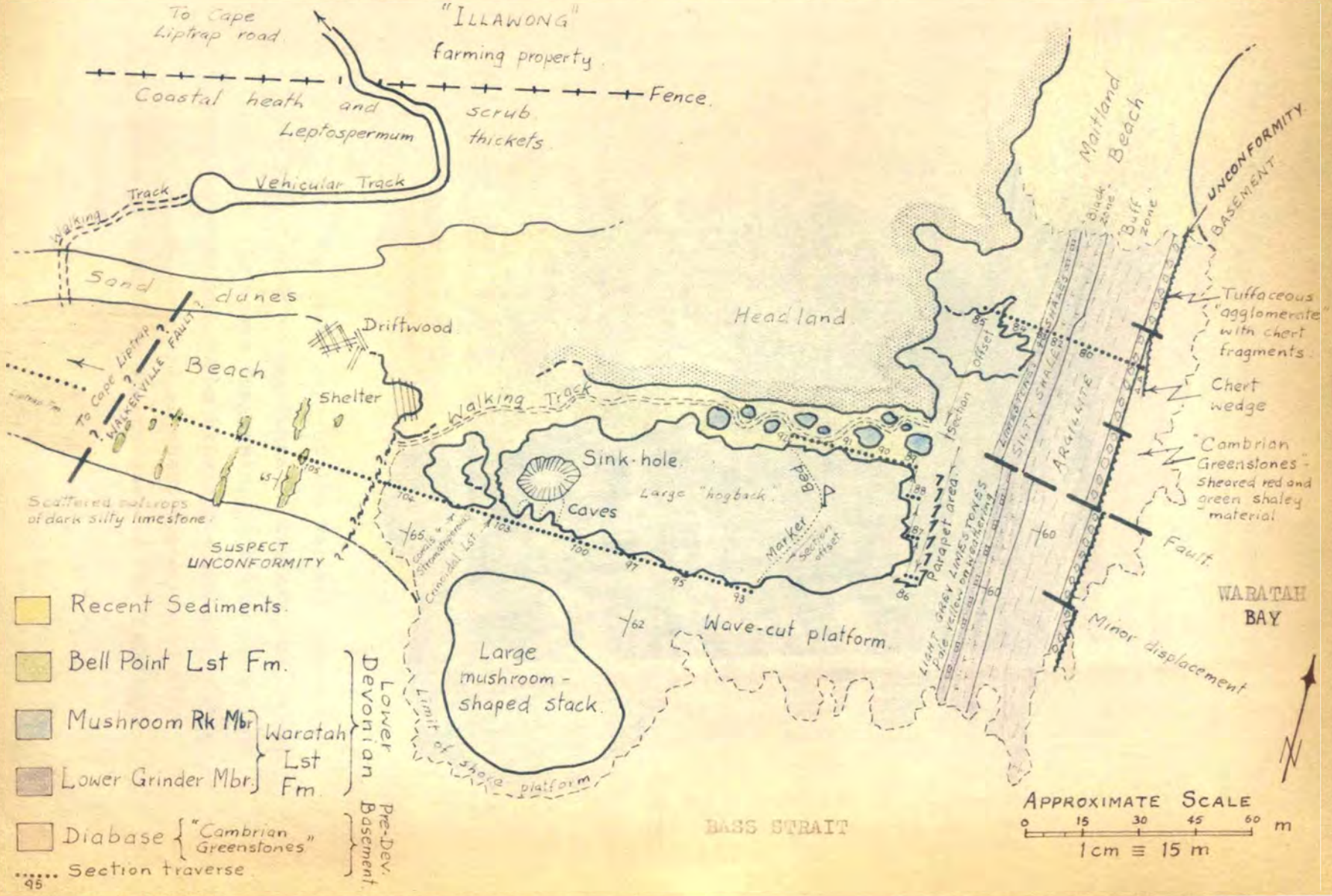


Fig. 3

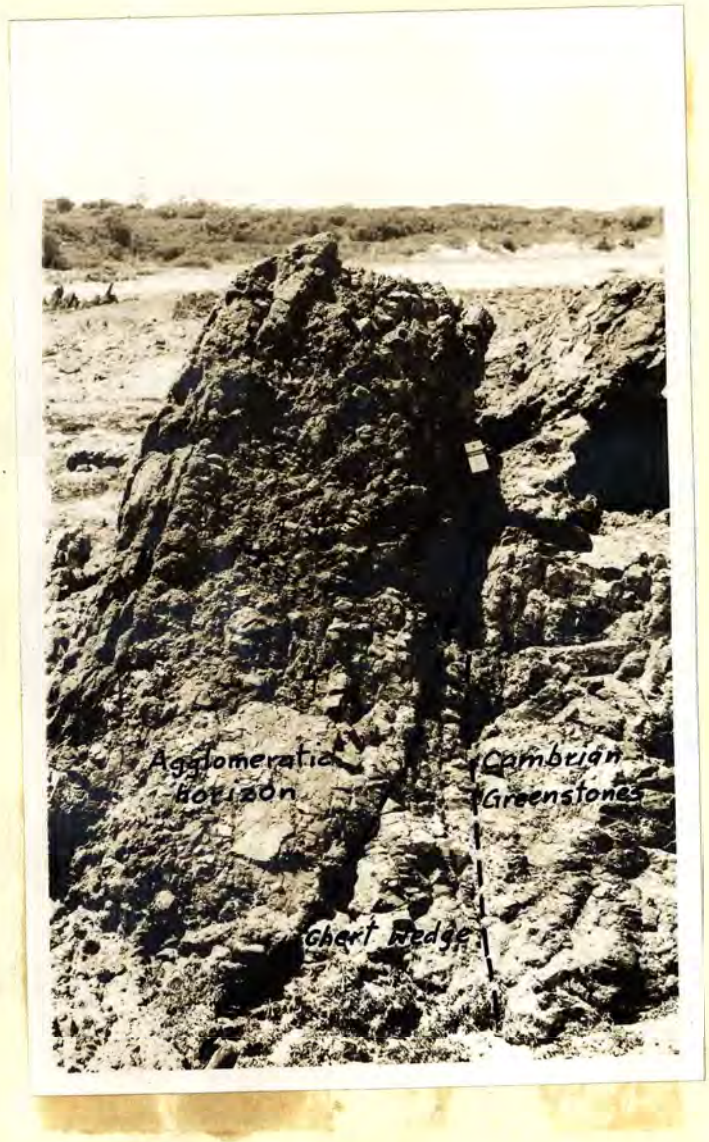


Fig. 4 - The Lower part of the Waratah Limestone commences with an agglomeratic horizon consisting of up to 90% chert fragments, probably derived as reworked material from older Pre-Devonian rocks, such as the thin bed of chert which can be seen wedging in against Greenstones of the Cambrian basement.

Fig. 5 - Point Grinder, eastern side, looking north along the wave-cut platform with Maitland Beach in the background. The various lithological units within the Lower Grinder Member can be seen, together with its upper and lower boundaries.

Fig. 6 - Point Grinder (as above), showing the Lower Grinder Member of the Waratah Limestone resting unconformably on diabasic rocks of the Cambrian basement.

2. Bell Point: (See Figs. 7 to 15):

At Bell Point, the limestones are covered by sea to the east and faulted against the Digger Island Formation to the west. The beds dip rather steeply to the west and north-west at angles ranging from 35-65° and strike roughly north-south. The exposed thickness totals some 246 m.

Two distinctly different limestones can be recognized at Bell Point. A light grey sequence, weathering to pale yellow, represents the upper part of the Waratah Limestone, characteristic of Gair and Mushroom Rocks. Both sections extend from the edge of the tidal platform shorewards to a prominent unconformity, which separates the Waratah Limestone from the overlying Bell Point Limestone (Figs. 8, 9). Immediately below the unconformity, and for a distance of some 10 m (true thickness), irregular patches of dark grey, calcareous siltstones of the transgressive Bell Point Formation are present as infillings in old solution channels of the Waratah Limestone (Fig. 10).

The uniformly thick-bedded limestones of Gair and Mushroom Rocks are relatively silt-free, fine to medium-grained calcarenites. Macrofossils are not obvious, but some corals, stromatoporoids and abundant crinoid columnals occur throughout the sections, particularly towards the top.

The Bell Point Limestone commences with a thin sequence of black, calcareous siltstones, followed by richly fossiliferous dark grey, argillaceous limestones, alternating with very thin

beds of dark silty shales (Fig. 11). Some of the more silty layers abound with fish remains, incorporating an array of head-shields, plates, scales, spines and teeth, in a type of "bone-bed" accumulation (Fig. 12). These have not been recorded by previous workers in the Waratah Bay area. The limestones are locally rich in corals, ostracodes and molluscs, particularly the gastropod Waratahella, which is so prevalent in some horizons that it forms plasters on bedding plane surfaces. Such horizons provide useful marker beds in the transposition of section traverses.

North of Gair Rock, dark grey, argillaceous limestones containing corals, brachiopods, ostracodes and the stromatoporoid Amphipora, are overlain by a rather thick sequence of medium to dark grey, "biostromal" limestones. In some cases, a mixed bag of fossils may constitute up to 90% of the rock, including stromatoporoids (3-40 cm in diameter), rugose corals (5-15 cm in length), brachiopods, molluscs and indeterminate shell fragments (Fig. 13). In other cases, whole beds may be composed of a single species of stromatoporoid (Fig. 14).

Immediately north of Bell Point, beyond the rocky headland, a small beach extends northwards for several hundred meters, until it terminates against outcrops of the Digger Island Formation (Fig. 15). Within this interval lies a belt (70 m) of dark grey, silty limestone, partly silicified, belonging to the lower part of the Waratah Limestone (cf. lower part of Point Grinder Section). Macrofossils are less numerous than in the Bell Point Limestone, but stromatoporoids, rugose corals and

brachiopods are locally abundant.

In the upper part of the section (66 m), the limestones are in contact with a sequence of pale grey, dolomitic siltstones, along a sharp lithological boundary. They have a stratigraphic thickness of 42 m, are thinly bedded, frequently veined by calcite, and badly eroded. The siltstones are overlain by some 20-30 m of medium grey limestone, which is also thinly bedded, somewhat shattered and meshed by calcite veins. Tectonic disturbance of these strata, as evidenced by shattering, calcite veining and local reversals of dip, increases with proximity to the Bell Point Fault running adjacent to the Digger Island Formation.

The Digger Island Formation is a sequence of yellow-brown, calcareous shales and decalcified mudstones, interbedded with grey-green, fine-grained, dense limestones, with a total thickness of 90 to 100 m. According to LINDNER (1953), it occurs as a faulted-in slice separating the Cambrian Greenstones to the west from the Bell Point sequences to the east. He assigned an early Ordovician age to these sediments on the basis of trilobites and brachiopods. Some nodular limestone bands sampled by the writer failed to yield any conodonts.

Composition of fauna - The following conodonts were obtained from the various limestone sequences at Bell Point:

Waratah Limestone - Upper Part:

Gair Rock Section -

Belodella australensis n. sp.

Belodella resima

Belodella sp. cf. B. devonica

Belodella triangularis

Hindeodella priscilla

Icriodus cf. woschmidti

Icriodus sp. a

Lonchodina murrindalensis

Neoprioniodus bicurvatus

Neoprioniodus excavatus

Ozarkodina bischoffi n. sp.

Ozarkodina denckmanni

Ozarkodina grinderi n. sp.

Ozarkodina typica australis

Ozarkodina typica typica

Paltodus acostatus

Paltodus unicostatus

Paltodus valgus

Plectospathodus alternatus

Plectospathodus extensus

Plectospathodus lacertosus

Spathognathodus inclinatus inclinatus

Spathognathodus remscheidensis

Spathognathodus sulcatus

Trichonodella excavatus

Trichonodella symmetrica

Trichonodella symmetrica pinnula

Trichonodella sp. a

Gen. indet. sp. a

Mushroom Rock Section -

Belodella australensis n. sp.

Belodella resima

Belodella sp. cf. B. devonica

Belodella triangularis

Belodella sp. a

Hindeodella priscilla

Icriodus sp. a

Ligonodina waratahensis n. sp.

Neoprioniodus bicurvatus

Neoprioniodus excavatus

Ozarkodina denckmanni

Ozarkodina media

Ozarkodina typica typica

Paltodus acostatus

Paltodus valgus

Plectospathodus alternatus

Plecrospathodus extensus

Plectospathodus lacertosus

Spathognathodus exiguus philipi

Spathognathodus inclinatus inclinatus

Spathognathodus remscheidensis

Spathognathodus sulcatus

Spathognathodus victoriensis n. sp.

Trichonodella excavatus

Trichonodella sp. cf. inconstans

Trichonodella symmetrica pinnula

Fish remains and otoliths were present in some samples from Gair and Mushroom Rocks.

Waratah Limestone - Lower Part:

Bell Point - North, to Digger Is. Fm.

Lignonodina waratahensis n. sp.

Ozarkodina bischoffi n. sp.

Ozarkodina denckmanni

Ozarkodina grinderi n. sp.

Spathognathodus sulcatus

Spathognathodus victoriensis n. sp.

Trichonodella symmetrica

Trichonodella sp. a

Fish remains - present in one sample.

Bell Point Limestone:

Bell Point - South:

Ozarkodina denckmanni

Ozarkodina sp. a

Plectospathodus alternatus

Plectospathodus extensus

Plectospathodus lacertosus

Spathognathodus remscheidensis

Spathognathodus sulcatus

Trichonodella excavatus

Ostracodes, forams, otoliths and fish remains were abundant in some samples.

Fig. 7 - BELL POINT

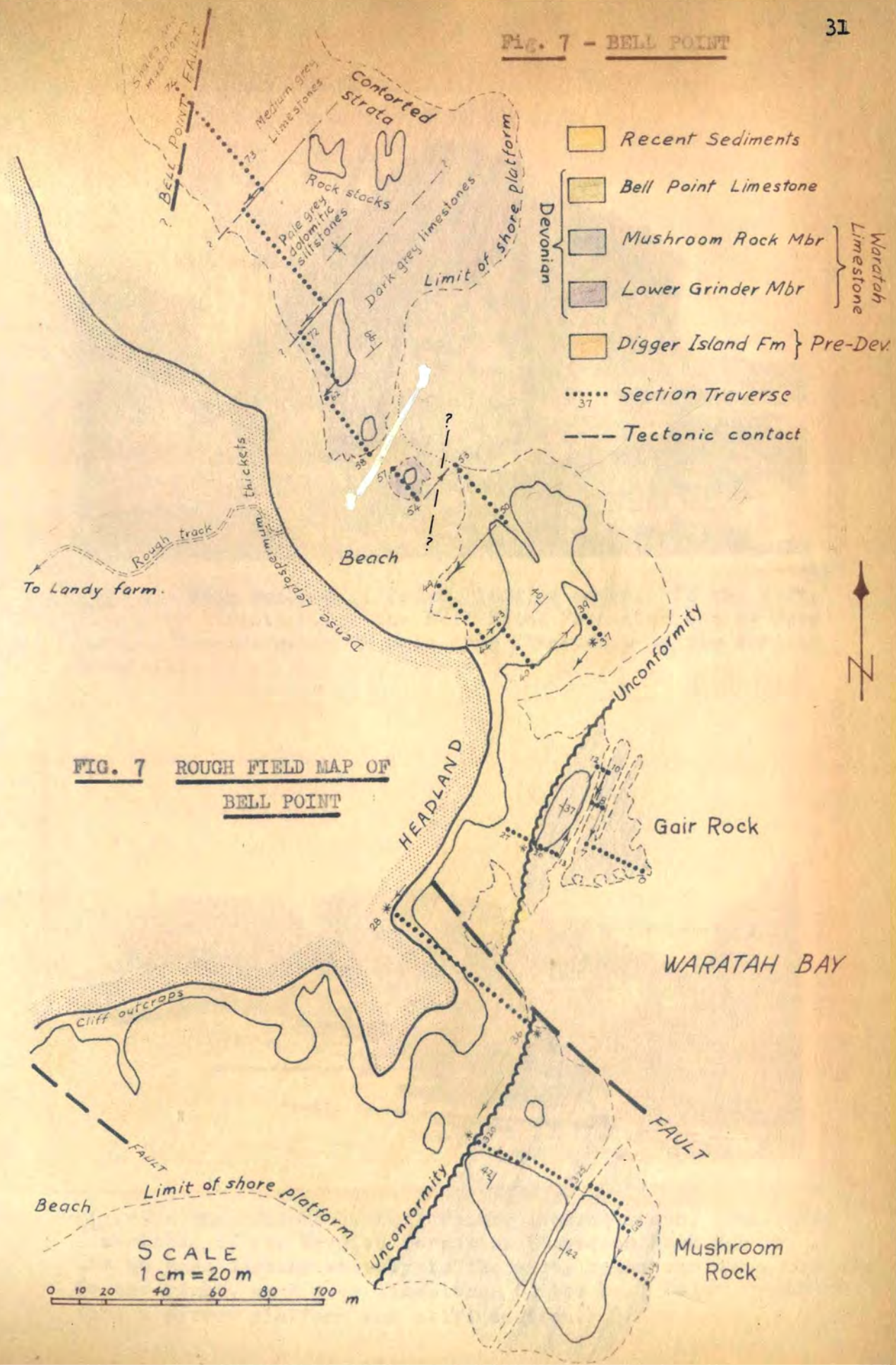


FIG. 7 ROUGH FIELD MAP OF BELL POINT

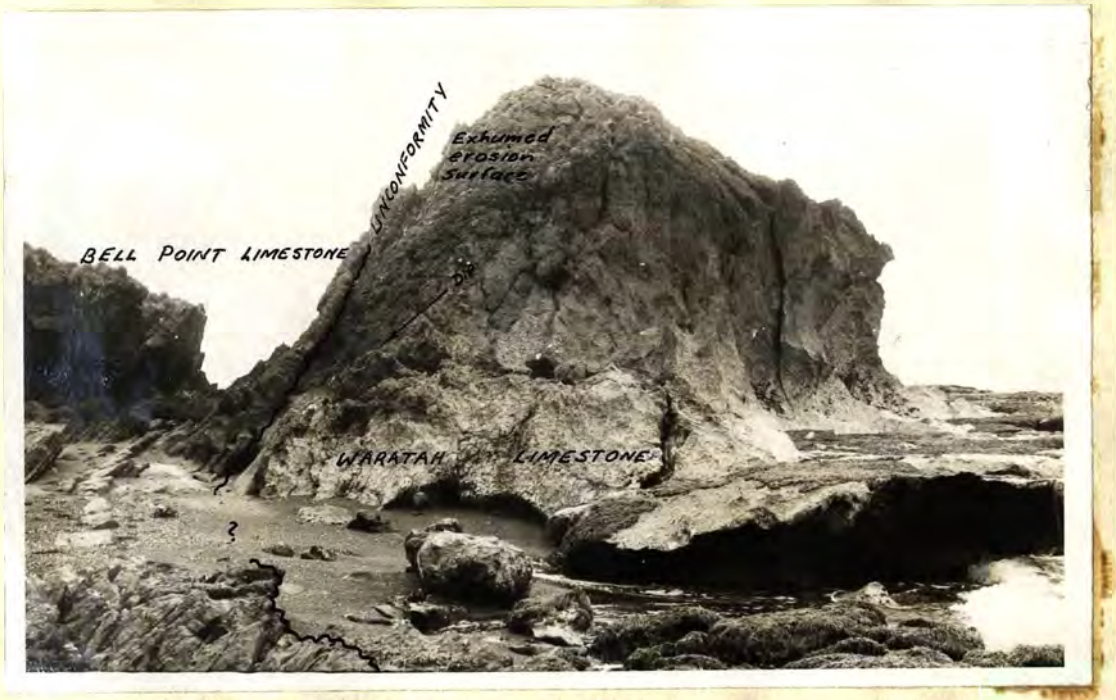


Fig. 8 - Gair Rock, Bell Point, looking north. To the left, dark grey limestones of the Bell Point Formation can be seen resting unconformably on pale grey limestones of the Waratah Formation.

Fig. 9 - Mushroom Rock, Bell Point, looking south. Pale grey limestones of the Waratah Formation (Mushroom Rock Member) can be seen dipping steeply to the west, below the unconformity. To the right, dark grey limestones of the Bell Point Formation form a narrow platform and cliff section.

Fig. 10 - The western side of Gair Rock, Bell Point, looking north. Immediately below the unconformity, irregular patches of dark grey, calcareous siltstones of the transgressive Bell Point Formation, are present as infillings in old solution channels of the Waratah Limestone.

Fig. 11 - Bell Point, looking south, with part of Mushroom Rock in the left background. In the foreground, the Bell Point Limestone commences with thinly bedded, calcareous siltstones, followed by richly fossiliferous beds of dark grey, argillaceous limestones.

Fig. 12 - View north along the tidal platform to Gair Rock. Abundant fish remains were discovered in thin beds of dark calcareous siltstone, immediately above the unconformity, just south of the fault between Gair and Mushroom Rocks.

Fig. 13 - Close-up of richly fossiliferous limestone (almost biostromal) at Bell Point, north of Gair Rock. Large macrofossils present include bivalve molluscs, rugose corals, brachiopods and indeterminate shell fragments of smaller size.

Fig. 14 - Some beds of dark grey limestone are composed almost entirely of a single species of stromatoporoid. Weathering of the limestone (Lower Grinder Member) north of Bell Point has produced these characteristic stromatoporoid "heads".

Fig. 15 - Bell Point, north, looking towards Digger Island, with Bird Rock in the far background. The dark grey limestones in the foreground are here assigned to the Lower Grinder Member on the basis of conodonts. These limestones are faulted against Tremadocian sediments of the Digger Island Formation.

Fig. 16 - View south-east from Walkerville showing the location of Bird Rock, Robin Rocks and the Black Stack.

3. Walkerville: (See Figs. 16, 17, 18)

Black Stack and Robin Rocks: (Figs. 19, 20)

Both of these sections belong to the lower part of the Waratah Limestone and rest unconforambly on a Pre-Devonian beasement composed of pale grey, dolomitic material, which can be traced the short distance along-shore from one outcrop to the other. Each section commences with a pale grey-green, agglomeratic argillite, containing angular fragments of dark grey chert, together with subrounded pebbles of varying size (Fig. 21).

At Robin Rocks, only 4 m of the overlying limestone remains and this is heavily leached and impregnated with iron compounds. Macrofossils are abundant in thin beds and include a mixed shelly fauna together with tabulate and rugose corals, crinoid columnals and some stromatoporoids. The beds strike approximately east-west and dip to the north at 27-33°.

A somewhat thicker section (about 15 m) is present at the Black Stack. Here, the overlying limestones are more argillaceous in the lower part, but remain fairly silty throughout. Thin beds of dark grey limestone alternate with very thin layers of black, calcareous siltstone, with rugose and tabulate corals, stromatoporoids and ostracodes abundant in some beds, particularly in the lower part. The beds strike roughly east-west and dip to the north at 43°, a steeper angle than that at Robin Rocks.

Composition of Fauna - The Black Stack sequence (Lower part of the Waratah Limestone) yielded the following:

Conodonts: Ligonodina waratahensis n. sp.

Neoprioniodus bicurvatus

Oistodus sp. a

Ozarkodina bischoffi n. sp.

Ozarkodina denckmanni

Ozarkodina grinderi n. sp.

Ozarkodina typica australis

Plectospathodus lacertosus

Spathognathodus exiguus philipi

Spathognathodus remscheidensis

Spathognathodus victoriensis n. sp.

Spathognathodus sp. a

Trichonodella australis n. sp.

Trichonodella symmetrica

Trichonodella sp. a

Ostracods - normal to abundant in 60% of samples.

Fish Remains - rare to normal in 14% of samples, but abundant in lowermost sample.

Otoliths - abundant in lowermost sample.

Scolecodonts - very rare, in one sample only.

Kiln Section: (Fig. 22)

The Kiln sequence belongs to the upper part of the Waratah Limestone. Lithologically, it consists of light grey, medium-grained limestone, which weathers to a pale greyish-brown colour.

The sequence has been disrupted by at least one, possibly two, reverse faults, so that a continuous section is not possible. Good exposures occur to the south and north, but the interval between has been largely removed by quarrying, or partly covered by the dumping of quarry waste. Only one small outcrop, on the beach at the base of the cliff below the old quarry, is representative of the middle part of the sequence, but its precise stratigraphic position is rather uncertain (Fig. 23).

TEICHERT (1954) proposed that this belt of limestones be known as the "Kiln Member". He claimed that it was divided into three fault blocks by two steep reversed faults, accompanied by conspicuous zones of black clayey rocks. The present investigation has shown that at least one of these black clayey zones has been derived by seepage from waste material dumped from the old quarry above. Furthermore, a narrow wedge of TEICHERT'S "Bluff Member" intrudes the Kiln sequence as a faulted-in slice, just below the unconformity which separates Kiln and Bluff sequences. Previous workers have not recognized this unconformity, believing the limestones of the Kiln and Bluff sequences to be separated by a high-angle thrust fault. Such a fault is indeed present, but it occurs entirely within the Bluff sequence, a few metres north of the unconformity (Fig. 18). These faults are probably

associated with the more extensive Walkerville Fault a short distance to the west, and run more or less parallel to it.

The lower part of the Kiln section ("southern slice"), adjacent to the old lime kilns, commences with a thin band of coarse bioclastic material, passing upwards into pale grey, medium to coarse-grained limestone, with locally abundant corals and stromatoporoids. The exposed thickness of this southern portion is only 15.4 m, since the section is covered by sandy beach at the base, and terminates as an erosion surface at the top of the cliff. (Fig. 24).

The upper part of the Kiln section ("northern slice"), commences on the beach some 80 m north of the old lime kilns. Here, scattered outcrops of the limestone are exposed only at very low tides. These outcrops are separated from the uppermost 40 m of the Kiln section by a narrow wedge of dark grey, Amphipora -rich limestone of the Bluff sequence; faulted-in between whitish-grey limestones of the Kiln sequence. The limestones are exceedingly shattered and meshed by calcite veins, the beds dipping steeply 60-65° to the north-west. In some beds, coarsely crystalline fragments of calcite may constitute up to 70% of the rock. The unconformity separating the distinctly different limestones of the Kiln and Bluff sequences can be observed in at least two places on the fore-shore (Figs. 25, 26). Both units are paraconformable with no evidence of tectonic thrusting along the contact.

Composition of Fauna - The following conodonts were recovered from the "Southern Slice" of the Kiln sequence (Upper part of Waratah Limestone):

Ligonodina waratahensis n. sp.
Neoprioniodus bicurvatus
Ozarkodina bischoffi n. sp.
Ozarkodina grinderi n. sp.
Ozarkodina typica australis
Plectospathodus alternatus
Plectospathodus extensus
Spathognathodus sulcatus
Spathognathodus victoriensis n. sp.
Trichonodella australis n. sp.
Trichonodella symmetrica

Bluff Section: (Fig. 22)

This sequence has an exposed thickness of 63.4 m and rests unconformably on Waratah Limestone of the Kiln sequence. The limestones are similar to those of the Bell Point Formation to which they are assigned. The sequence begins above the unconformity with thin beds of calcareous siltstones, silty to dolomitic in parts, somewhat leached and impregnated with iron compounds to give an orange-brown colour. Angular fragments of dark grey limestone with scattered shell remains are present,

together with Amphipora and a few rugose corals. The sequence passes upwards into dark grey limestones, intensely shattered and meshed by calcite veins with proximity to the fault, which runs along-strike a few metres north of the unconformity. It can easily be traced as a narrow belt of dark grey clayey material extending across the fore-shore.

Dark grey limestones, thickly bedded and interspersed with very thin beds of calcareous shale, are found teeming with the stromatoporoid Amphipora, throughout most of the section, often to the exclusion of other macrofossils. At the top, the sequence is faulted against sandstones and shales of the Liptrap Formation. Here, the Walkerville Fault is prominently displayed in both cliff and shore as a zone of mashed rock material some 8-10 m wide (Fig. 27).

Composition of Fauna - Only one sample from the Bluff sequence yielded conodonts, and this was collected adjacent to the Walkerville Fault. The following species were present:

Belodella resima

Belodella triangularis

Paltodus acostatus

Spathognathodus sp. indet.

Spathognathodus sulcatus

Abundant otoliths and a few fish remains were also present.

Bird Rock: (Fig. 28)

The precise stratigraphic position of the limestone sequence at Bird Rock is problematical, since neither top nor

bottom is exposed. Lithologically, the limestones correspond to those of the upper part of the Waratah Limestone, but very few macrofossils have been found and unfortunately no conodonts. The sequence attains its maximum thickness at Middle Bird Rock, where 68 m of limestone is exposed. The limestones are light grey, medium to coarse-grained calcarenites, thickly bedded, silty in parts and somewhat dolomitic. At Inner and Middle Bird Rocks, the beds strike approximately east-west and dip 32° N. At Outer Bird Rock, the strike is north-south and the dip 25° E.

Composition of Fauna - All samples from Bird Rock were barren of conodonts.

FIG. 17 WALKERVILLE

Fig. 17 ROUGH FIELD MAP OF THE WALKERVILLE AREA

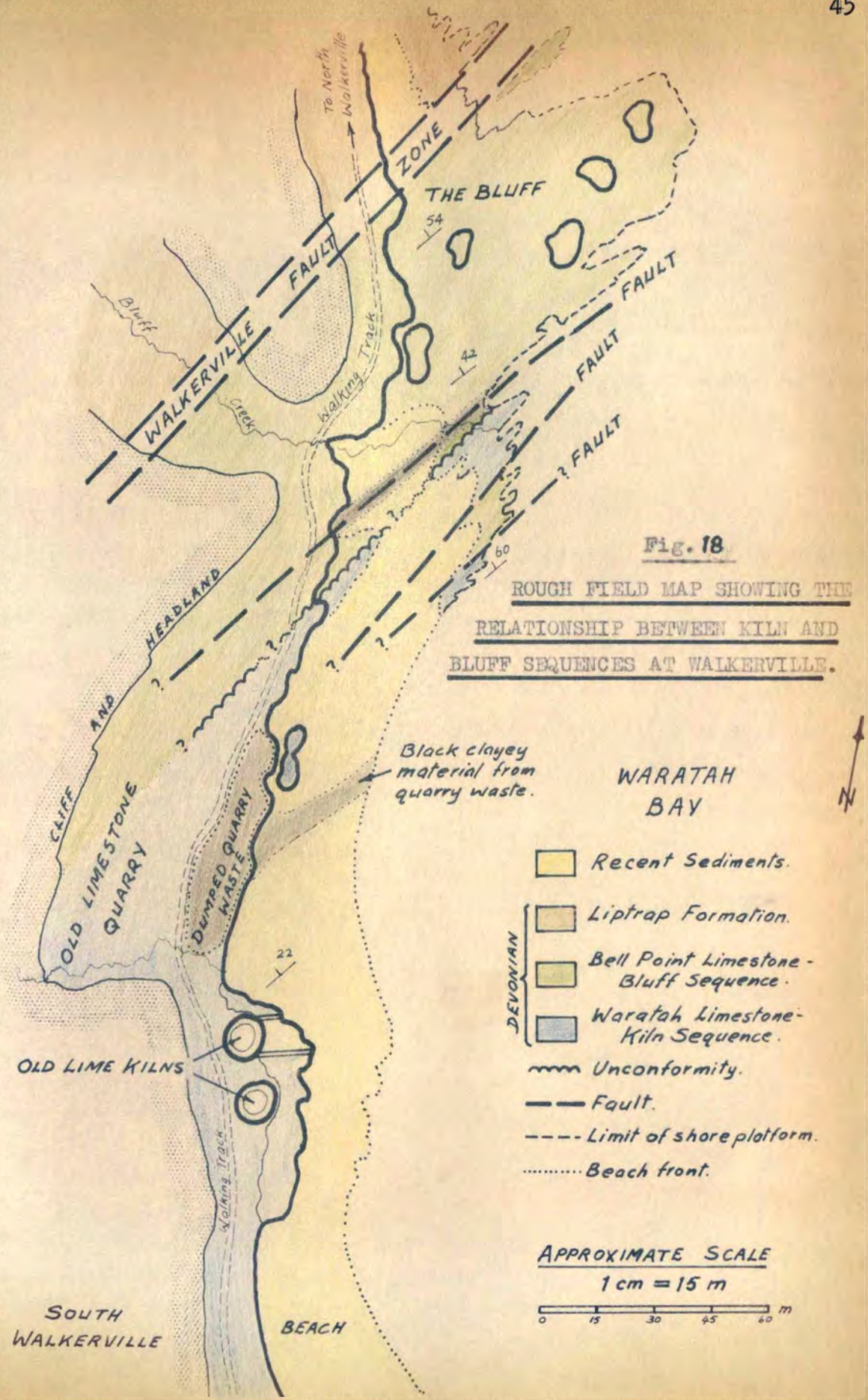


Fig. 18

ROUGH FIELD MAP SHOWING THE RELATIONSHIP BETWEEN KILN AND BLUFF SEQUENCES AT WALKERVILLE.

Fig. 19 - The Black Stack, South Walkerville, looking east across Waratah Bay towards Wilsons Promontory on the horizon. This limestone sequence (Lower Grinder Member) rests unconformably on a Pre-Devonian dolomitic basement.

Fig. 20 - Robin Rocks, South Walkerville, looking south-east across Waratah Bay. This limestone sequence (Lower Grinder Mbr) rests unconformably on the same Pre-Devonian basement as that of the Black Stack above.

Fig. 21 - Black Stack, South Walkerville, showing the basal agglomeratic horizon developed immediately above the unconformity. Angular chert fragments and subrounded pebbles of various sizes are embedded in a pale grey-green argillite.

Fig. 22 - View north from South Walkerville beach showing the location of Kiln and Bluff limestone sequences.

Fig. 23 - View north from the old lime kilns at South Walkerville, showing the relationship between Kiln and Bluff sequences, with the Liptrap Formation in the background.

Fig. 24 - The Kiln sequence ("southern slice") at South Walkerville, adjacent to the old lime kilns on the foreshore.

Fig. 25 - The unconformity separating the distinctly different limestones of the Kiln and Bluff sequences can be observed here in a low cliff at the back of the Walkerville Beach.

Fig. 26 - The same unconformity (as above) is exposed further down the beach, but only at very low tide.

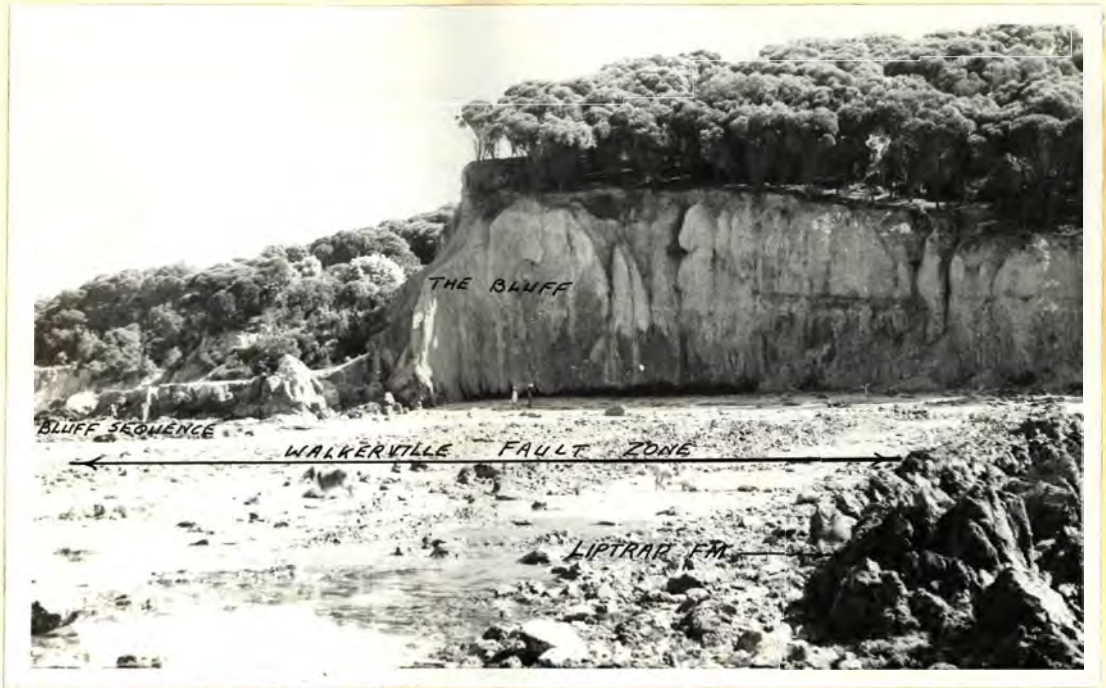


Fig. 27 - The Bluff, North Walkerville, where mashed rocks of the Walkerville Fault zone are prominently displayed in both cliff and shore platform. To the left, limestones of the Bluff sequence are faulted in against sandstones and shales of the Liptrap Formation, to the right.

Fig. 28 - Bird Rock, Walkerville, looking east towards Middle and Outer Bird Rocks. A third stack, Inner Bird Rock (not shown), is further to the right.

(b) Stratigraphic Nomenclature:

Two limestone formations, differing significantly in lithology and faunal composition, have been recognized at Waratah Bay. The present work retains the formational names assigned to them by TALENT (1959, 1965), but varies in some of the units ascribed to them, largely on the basis of conodont faunas and to a lesser extent on field evidence, some of which is new. It is proposed to divide the Waratah Limestone into two new members, the Lower Grinder Member and the Mushroom Rock Member.

Definition of New Member

(See Figs. 3-6)

Lower Grinder Member - This member represents the lower part of the Waratah Limestone and takes its name from the basal sequence at Point Grinder.

Location of Type Section - The wave-cut platform on the eastern side of the Point Grinder headland, 9 miles south of Walkerville.

Lower Boundary - Represented by the unconformity with Cambrian diabasic rocks, along the eastern margin of the shore platform.

Upper Boundary - Represented by the following lithological change: thinly bedded, light to medium grey limestones with black, silty intercalations of the uppermost horizon, are replaced by a monotonous sequence of light grey, thickly bedded

limestones, which weather to a pale yellowish-grey colour, of the overlying member.

Stratigraphic Thickness - The type section is completely exposed at low tide and has a true thickness of 23.5 m. The beds strike north-south and dip 60°W. The member extends laterally some 150 m, from Maitland Beach on the north, to the limit of the shore platform on the south.

Description - The section commences at the bottom with narrow beds of dark grey cherts, 6.1 m thick, wedging in against Cambrian Greenstones of the basement. The chert beds dip steeply to the east and are tectonically shattered.

These are overlain by an "agglomeratic" horizon some 2.3 m thick. Angular chert fragments up to 10 cm in diameter are incorporated in a fine-grained, olive-brown matrix of tuffaceous material, and decrease in size and angularity towards the top.

This horizon is followed by thin beds of pale grey, calcareous argillite, 4.6 m thick. The beds are 5-10 cm thick, are easily eroded, and weather to a buff colour. A small brachiopod was collected from the lowermost bed.

The argillite is overlain by a unit of dark grey to black, silty shale, 8.5 m thick. The thin beds of shale are siliceous and hard, with sufficient competence to withstand wave action, so that they form prominent rock stacks, which jut out above the level of the surrounding platform. They are moderately calcareous and alternate with thin beds of light to medium grey limestone, in beds 2-20 cm thick.

The uppermost horizon of the Lower Grinder Member is 2.1 m thick and consists of light to medium grey, fine-grained limestone, in layers 12-20 cm thick, separated by thin bands of dark grey to black silty argillite, 4-5 cm thick. The sequence then passes conformably into "cleaner" limestones of the Mushroom Rock Member.

Conodont Fauna - The conodonts recovered from the type section at Point Grinder are as follows :

Ligonodina waratahensis n. sp.

Ozarkodina bischoffi n. sp.

Ozarkodina denckmanni

Ozarkodina grinderi n. sp.

Ozarkodina typica australis

Paltodus acostatus

Spathognathodus remscheidensis

Spathognathodus victoriensis n. sp.

Trichonodella australis n. sp.

Stratigraphic Range - The age of the Lower Grinder Member as indicated by conodonts is ? Upper Gedinnian to Lower Siegenian.

Other Occurrences - At Walkerville, the Lower Grinder Member is represented by those dolomitic to impure limestone sequences developed on a Pre-Devonian basement, at Robin Rocks (4.0 m thick) and the Black Stack (15.0 m thick). The Lower Grinder Member

attains its greatest thickness (approximately 120 m) north of Bell Point, where a belt of limestones and calcareous siltstones, extends from a prominent gap in the section, along-shore to its contact with the Digger Island Formation. Although the basal sequence cannot be observed, the conodont fauna provides indisputable evidence of its true stratigraphic position. Previous investigators have regarded this sequence as a continuation of the Bell Point Limestone.

Definition of New Member

(See Figs. 7-10)

Mushroom Rock Member - This members represents the upper part of the Waratah Limestone and takes its name from Mushroom Rock.

Location of Type Section - Mushroom Rock is a prominent rock stack resting on the shore platform at the southern end of Bell Point, about 1½ miles S.S.E. of Walkerville.

Lower Boundary - Only the uppermost part of the member is exposed at Mushroom Rock, the rest of the sequence being covered by the sea; so that the lower boundary is the eastern margin of the shore platform.

Upper Boundary - This is represented by the unconformity which separates the Waratah Limestone from the Bell Point Limestone at Bell Point. This can be observed a few metres west of Mushroom Rock itself, but is best developed on the western face of Gair Rock about 120 m to the north.

Stratigraphic Thickness - The exposed thickness at Mushroom Rock is 50.2 m, but the total thickness is much greater. The beds strike almost due north and dip 35-37° W. The member extends laterally some 100 m at its widest part, and is bounded on all sides by the sea.

Description - The limestones are light grey, fine to medium-grained, somewhat porous, thickly bedded, relatively silt-free, and most characteristic of all, weather to a pale yellowish-grey colour.

Immediately below the unconformity, and for a distance of some 10 m (true thickness), irregular patches of dark grey, calcareous siltstones of the transgressive Bell Point Formation are present as infillings in old solution channels of the Mushroom Rock Member. These infillings are well displayed at Gair Rock and to a lesser extent in the uppermost beds of the member at Point Grinder. Macrofossils are not obvious due to etching of the limestone by salt spray, but some corals, stromatoporoids and abundant crinoid columnals occur towards the top of the section.

Conodont Fauna - The conodonts recovered from the type section at Mushroom Rock are among the best developed at Waratah Bay.

Belodella australensis n. sp.

Belodella resima

Belodella sp. cf. B. devonica

Belodella triangularis

Belodella sp. a

Hindeodella priscilla

Icriodus sp. a

Ligonodina waratahensis n. sp.

Neoprioniodus bicurvatus

Neoprioniodus excavatus

Ozarkodina denckmanni

Ozarkodina media

Ozarkodina typica typica

Paltodus acostatus

Paltodus valgus

Plectospathodus alternatus

Plectospathodus extensus

Plectospathodus lacertosus

Spathognathodus exiguus philipi

Spathognathodus inclinatus inclinatus

Spathognathodus remscheidensis

Spathognathodus sulcatus

Spathognathodus victoriensis n. sp.

Trichonodella excavatus

Trichonodella sp. cf. *inconstans*

Trichonodella symmetrica pinnula

In addition to conodonts, fish remains and otoliths were present in some samples.

Stratigraphic Range - The Mushroom Rock Member exhibits a typically younger fauna than that of the Lower Grinder Member. The age as indicated by conodonts is Lower to ? Middle Siegenian.

Other Occurrences - In general, the Mushroom Rock Member refers to those limestone sequences which lie above the Lower Grinder Member but below the unconformity which separates the two formations at Bell Point. What appears to be the same unconformity was observed by the writer on the fore-shore at Walkerville, some 80 m north of the old lime kilns (Figs. 25, 26). Previous workers have interpreted this as a tectonic contact, but there is little or no evidence to suggest faulting. The whitish-grey limestones of the Kiln sequence (northern "slice") are unconformably overlain by dark grey to black silty limestones of the Bluff section. These Amphipora-rich limestones are here assigned to the Bell Point Limestone.

At Point Grinder, the Mushroom Rock Member reaches its maximum thickness of 110 m and can be seen to rest conformably on rocks of the Lower Grinder Member. Although the unconformity at the top of the sequence is not exposed, because of beach sand cover, infillings of old solution channels, similar to those at Gair and Mushroom Rocks, can be observed in the top-most horizon. In addition, dark grey limestones, similar to those of the Bell Point Formation, are found overlying the pale grey limestones of the Mushroom Rock Member at Point Grinder.

Consequently, the Mushroom Rock Member embraces those carbonate sequences developed at Gair Rock, Kiln and the upper part of Point Grinder. Bird Rock is somewhat problematical, since neither top nor bottom of the sequence is exposed, and all samples treated failed to yield conodonts. However, the Bird Rock limestones may be tentatively assigned to the Mushroom Rock Member on lithological grounds.

Bell Point Formation - Revised.

(See Figs. 7-13)

The Bell Point Limestone, originally proposed by LINDNER (1953), was restricted by TALENT (1959, 1965) to include only those dark grey limestones developed above the unconformity at Bell Point. The present work necessitates further restriction and amplification of this formation.

Location of Type Section - Bell Point, 1½ miles S.S.E. of Walkerville.

Lower Boundary - The unconformity exposed on the shore platform adjacent to Gair and Mushroom Rocks at Bell Point.

Upper Boundary - A prominent gap in the section occurs about 120 m north of Gair Rock. Here, an isolated outcrop, surrounded by beach sand, is exposed at low tide (see Fig. 7). This outcrop is the uppermost part of the Bell Point Limestone, since the belt of limestones which follow yield a conodont fauna typical of the older Lower Grinder Member of the Waratah Formation.

Stratigraphic Thickness - The type section is completely exposed, except at the top where it makes tectonic contact with the Lower Grinder Member, although this contact cannot be observed directly. A long offset north of Gair Rock is necessary in order to follow the sequence, and certain beds, teeming with the gastropod Waratahella, make useful marker horizons. The beds strike roughly north-south and dip to the west/north-west at 37-40°. The maximum thickness of the Bell Point Limestone is 76.5 m. A shorter section can be followed to the south and west of Mushroom Rock, but the strata are disturbed in proximity to the Bell Point Fault and are rather poorly exposed.

Description - The type section has been described in detail on pages 13-24 of Appendix A. In general, the section commences at the bottom with a thin sequence of black, calcareous siltstones, followed by richly fossiliferous dark grey, argillaceous limestones, alternating with very thin beds of dark, silty shales. North of Gair Rock, dark grey limestones containing corals, brachiopods, ostracods and the stromatoporoid Amphipora, are overlain by a rather thick sequence of medium to dark grey, biostromal limestones, in which macrofossils may constitute up to 90% of the rock.

Conodont Fauna - The conodonts recovered from the type section at Bell Point have a much younger element than those of the Waratah Limestone. They are as follows:

Ozarkodina denckmanni

Ozarkodina sp. a

Plectospathodus alternatus

Plectospathodus extensus

Plectospathodus lacertosus

Spathognathodus remscheidensis

Spathognathodus sulcatus

Trichonodella excavatus

In addition, ostracods, forams, otoliths and fish remains were abundant in some samples.

Stratigraphic Range - The age of the Bell Point Limestone as indicated by conodonts is Middle to Upper Siegenian.

Other Occurrences - The dark grey limestones of the Bluff sequence rest unconformably on pale grey limestones of the Kiln sequence (Mushroom Rock Member), and thereby occupy a corresponding stratigraphic position to the Bell Point Limestone. They are lithologically similar and both sequences contain Amphipora, although much less so in the case of the Bell Point section. Consequently, the Bluff sequence is here assigned to the Bell Point Formation, and the limited conodont fauna recovered from the Bluff in no way negates this proposal.

The scattered outcrops of dark grey limestone in the uppermost part of the Point Grinder section did not yield conodonts, but they too are found overlying the Mushroom Rock Member and like the Bluff sequence, are faulted against sandstones and shales of the Liptrap Formation. For these reasons, the dark

grey limestones of the uppermost part of the Point Grinder sequence are here assigned to the Bell Point Formation.

Liptrap Formation

More than 1500 m of detrital sediments (sandstones, shales and conglomeratic horizons) have been relegated to the Liptrap Formation by LINDNER (1953). These occur adjacent to the limestones at Waratah Bay and are separated from them by the Walkerville Fault. Both LINDNER and TALENT (1965) have pointed to the difficulty of determining the stratigraphical relationship of these sediments with respect to the carbonates, largely because macrofossils are rare or badly preserved. TALENT suggested that the Liptrap Formation may have coincided with the break in deposition between the Waratah and Bell Point Limestones, but the present work indicates that the hiatus involved was far too limited to accumulate such a tremendous thickness of Liptrap sediments. Relatively short-ranging conodonts such as Spathognathodus sulcatus and S. remscheidensis continue through the unconformity.(TABLE).

Since both LINDNER and TALENT agree that the limited coral fauna does have a Devonian aspect, the writer feels that the Liptrap Formation was deposited later than the Bell Point Limestone, or more questionably, as a contemporaneous lateral facies. In any case, correlation of the Liptrap Formation is still problematical, and lies outside the scope of the present work.

Significant departures from the previously known stratigraphy of Waratah Bay may be summarized as follows: -

1. Subdivision of the Waratah Limestone into two members, the lower horizon to be known as the Lower Grinder Member and the upper one as the Mushroom Rock Member.

2. Further restriction of the Bell Point Limestone at Bell Point, by excluding the northern-most (uppermost) part of the section, and assigning it to the Lower Grinder Member, on micro-faunal evidence.

3. Relegation of the Robin Rocks and Black Stack (new name) sequences to the Lower Grinder Member, thereby excluding them from Teichert's Bird Rock Member.

4. Extension of the Bell Point Limestone to include the Bluff sequence.

5. Recognition of the unconformity separating Teichert's Kiln and Bluff "Members" at Walkerville, casting doubt on the assumption that the northern part of the section is a faulted-in slice, though nearby faults are obvious.

6. Recognition of the Bell Point Limestone forming the uppermost part of the section at Point Grinder, and that the continuation of the ? Walkerville Fault must lie to the west of this interval; rather than the fault zone separating the Mushroom Rock Member from the Liptrap Formation, at Point Grinder.

7. TEICHERT'S Bluff and Bird Rock "Members" are here regarded as correlates of the Mushroom Rock Member of the Waratah Limestone, and his Bluff "Member" is better placed with the Bell Point Limestone, on stratigraphic and faunal evidence.

8. The Liptrap Formation, previously regarded as intermediate in age between Waratah and Bell Point Limestone deposition, is here considered to be younger (or ? contemporaneous with) than the Bell Point Limestone on the basis of short-ranging conodonts.

The stratigraphy of the Waratah Bay sediments, as revealed by the present work, is compared with that of previous authors in TABLE 9.

TABLE 1 DISTRIBUTION OF CONODONTS - BLACK STACK SECTION, WARATAH BAY, VICTORIA.

* SECTION SAMPLE NUMBER	Trichonodella sp. a	Ozarkodina typica australis	Ozarkodina denckmanni	Spathognathodus sp. a	Oistodus sp. a	Trichonodella symmetrica	Spathognathodus victoriensis n. sp.	Spathognathodus exiguus philipi	Ozarkodina grinderi n. sp.	Ligonodina waratahensis n. sp.	Ozarkodina bischoffi n. sp.	Spathognathodus remscheidensis	Plectospathodus lacertosus	Neoprioniodus bicurvatus	Trichonodella australis n. sp.	Hindeodella sp. indet.	Roundya sp. indet.	Indet. conodont fragments	Ostracods	Fish remains	"Otoliths"	Scolecodonts	
TOP OF EXPOSED OUTCROP - REST OF SECTION COVERED BY SEA																							
365																							
364									2	4	3	1	1	1	1			20	c				
363								2	1						2	1			c				
362							1		1		1				2			12	r			r	
361																		4	c				
360							1											2	a				
120							2	4	6	7	6	1	2		3			70	a				
359																			a				
358																			c	c			
357								1										3	c				
119							2	5	10	6	1	1			4		1	54	a	r			
356								4	1	5						1		15					
118						1	4			1		1						20					
355			2	1	1		2	17	9	5	3							61					
117		1					7	4	4	5	1	3	2	1	2	3		40	r	r			
354										1									a				
115							2	2	4	9		1						33					
353							2	1	2	2								16					
114	2	3					14	7	3	39	1	3	1			4		117		a	a		
352			1				1		4	2								22					

UNCONFORMITY ON PRE-DEVONIAN BASEMENT.

(r = rare, c = common, a = abundant)

* For sample intervals - see Appendix A.

TABLE 2 DISTRIBUTION OF CONODONTS - UPPER BELL POINT SECTION

* SECTION SAMPLE NUMBER	Neoprioniodus sp. indet.	Spathognathodus sulcatus	Ozarkodina grinderi n. sp.	Ozarkodina denckmanni	Trichonodella symmetrica	Trichonodella sp. a	Ozarkodina bischoffi n. sp.	Spathognathodus victoriensis n. sp.	Trichonodella australis n. sp.	Ligonodina waratahensis n. sp.	Indet. conodont fragments	Ostracods	Fish remains			
BELL POINT FAULT																TOP OF SECTION
73							1	2	1	2	12		c			
72													c			
71		13	1	3	2	1	3	4		7	20					
70								3		2	5					
69		4					1	5		2	11					
68												c				
67																
66																
65																
64		1	1					1			9					
63																
62		1														
61																
60																
59																
58																
57																
56																
55																
54	1	1					1	1	2	1	21					

(r = rare, c = common, a = abundant)

? TECTONIC CONTACT - Gap with sand cover. BASE OF OUTCROP.

* For sample intervals - see Appendix A.

TABLE 3 DISTRIBUTION OF CONODONTS - POINT GRINDER SECTION

* SECTION SAMPLE NUMBER	Ozarkodina bischoffi n. sp.	Ozarkodina denckmanni	Paltodus acostatus	Ozarkodina typica australis	Spathognathodus victoriensis n. sp.	Spathognathodus remscheidensis	Ligonodina waratahensis n. sp.	Ozarkodina grinderi n. sp.	Trichonodella australis n. sp.	Spathognathodus sulcatus	Indet. conodont fragments	Ostracods	Fish remains	"Otoliths"		
WALKERVILLE FAULT											TOP OF SECTION					
300																
105																
? UNCONFORMITY																
301																
302																
104																
303																
103																
304																
102																
305																
101																
306							1	2	2	1	2					
100																
99																
307																
98																
97																
96																
95																
94																
93												c				
92																
91																
90																
89																
88																
87																
308																
309																
310																
311																
312																
86					6	2	2	5	4		30					
313																
314												c				
85c																
85b																
85a							1									
84																
83	2	1	1	1	7		1	1	2		10					
317							3	1	1		6					
316			1		1			1								
82	1	1			5	1	2		2		15					
81	2				5			1	4		9					
80																
315							1				2					

UNCONFORMITY ON CAMBRIAN BASEMENT

(c = common)

* For sample intervals - see Appendix A.

TABLE 4 DISTRIBUTION OF CONODONTS – MUSHROOM ROCK SECTION, WARATAH BAY, VICTORIA.

* SECTION SAMPLE NUMBER	Trichonodella sp. cf. T. inconstans	Plectospathodus alternatus	Spathognathodus victoriensis n. sp.	Spathognathodus exiguus philipi	Ozarkodina media	Plectospathodus lacertosus	Trichonodella symmetrica pinnula	Neoprioniodus bicurvatus	Spathognathodus inclinatus inclinatus	Trichonodella excavatus	Paltodus valgus	Plectospathodus extensus	Ligonodina waratahensis n. sp.	Belodella resima	Belodella sp. cf. B. devonica	Ozarkodina denckmanni	Neoprioniodus excavatus	Belodella australensis n. sp.	Ozarkodina typica typica	Paltodus acostatus	Belodella sp. a	Spathognathodus remscheidensis	Belodella triangularis	Icriodus sp. a	Spathognathodus sulcatus	Hindeodella prisoilla	Indet. conodont fragments	Ostracods	Fish remains	"Otoliths"
UNCONFORMITY																	TOP OF MUSHROOM ROCK SECTION													
320														2	1	1								1	1	1				
321																										3				
322																					1	1	1			2				
323																										3				
324																		1	1	1	1	3			2	1	3				
325																	1	1	2						9	1	7				
326																1				3					2		3		c		
327														2	1	2		3	1			4	2				3			r	
328									1	1	6	1	1	4	3	3		8		3		3	5		8	1	5				
329								1	1		5		1	4		1		7		3		4	3		2	2	7		r		
330					1	2	1	2	2	4	19			36	12	4		40		20		12	42		8	4	46		c	c	
331							1	1			18	1		15		5	1	22	1	3		2	17		3	2	3				
GB1			2	1				2																		13				
332		1						1			1			4		2		2					2		4		2		c	r	
333		2			2	1		2	1	3	11			29		2		43	2	9		5	29		10	2	28				
334	1				1			1	1	1				20		2	1	20	2			1	18		12	1	10				
BASE OF OUTCROP																														

Ostracods, Fish remains, "Otoliths" { r = rare (< 5); c = common (6-20); a = abundant (> 20)

* For sample intervals – see Appendix A.

TABLE 5 DISTRIBUTION OF CONODONTS - GAIR ROCK AND LOWER BELL POINT SECTIONS, WARATAH BAY, VICTORIA.

* SECTION SAMPLE NUMBER	Ozarkodina grinderi n. sp.	Ozarkodina bischoffi n.sp.	Spathognathodus inclinatus inclinatus	Plectospathodus extensus	Ozarkodina typica australis	Plectospathodus alternatus	Neoprioniodus bicurvatus	Ozarkodina denckmanni	Spathognathodus sulcatus	Spathognathodus remscheidensis	Hindeodella priscilla	Belodella australensis n. sp.	Belodella triangularis	Belodella sp. cf. B. devonica	Paltodus valgus	Paltodus acostatus	Paltodus unicostatus	Trichonodella sp. a	Gen. indet. sp. a	Paltodus sp. a	Neoprioniodus excavatus	Lonchodina murrindalensis	Trichonodella symmetrica	Belodella resima	Ozarkodina typica typica	Trichonodella excavatus	Trichonodella symmetrica pinnula	Plectospathodus lacertosus	Icriodus sp. a	Icriodus sp. cf. I. woschmidti	Ozarkodina sp. a	Indet. conodont fragments	Ostracods	Fish remains	"Otoliths"
TOP OF LOWER BELL POINT SECTION																	(Gap with sand cover - suspect tectonic contact)																		
53																																		
52																																a		
51																																a		
50				2				3	34											1		1				1	27					
49b									3																		4					
49a									3																		3					
48																															c	
47																																
46																															c	
45																																
44									1																		1		r			
43																																
42																																
41				1					3																		2		c			
40																																
39																																

TABLE 6 DISTRIBUTION OF CONODONTS - BLUFF & KILN SECTIONS, WALKERVILLE.

* SECTION SAMPLE NUMBER	Ozarkodina typica australis	Ozarkodina grinderi n. sp.	Neoprioniodus bicurvatus	Plectospathodus alternatus	Spathognathodus sulcatus	Trichonodella symmetrica	Plectospathodus extensus	Hindeodella sp. indet.	Ligonodina waratahensis n. sp.	Spathognathodus victoriensis n. sp.	Trichonodella australis n. sp.	Ozarkodina bischoffi n. sp.	Belodella triangularis	Belodella resima	Paltodus acostatus	Spathognathodus sp. indet.	Trichonodella sp. indet.	Ozarkodina sp. indet.	Indet. conodont fragments	Ostracods	Fish remains	"Otoliths"
WALKERVILLE FAULT																TOP OF BLUFF SECTION						
163					5								1	1	22	3	2	1	8		c	a
366																						
367																						
159a																						
159b																						
160																						
164																						
165																						
368																						
161																						
162																						
369																						
166																						
167																						
168																						
169																						
140																						
141																						
142																						
370																						
143																						
UNCONFORMITY																TOP OF KILN SECTION						
144																						
145																						
146																						
147																						
148																						
346																						
345																						
344																						
343																						
152										1	1	1							1			
342																						
341									1	1												
151																						
340								1	2	4		1										
339					2	2	1		5	3		1					1	1	17			
150					1		1		1	7		1							12			
338		1	3	1	4	1			9	20	3	8					3		70			
337		3	1						8	13	2								15			
149	4	1							5	2									12			
336									1										3			
BASE OF OUTCROP																						

(r = rare, c = common, a = abundant)

* For sample intervals - see Appendix A.

28																																			
29																																			
30																																	c	a	c
31						1				1																						3	c	a	c
32																																			
33																																			
34																																			
35																																			
36																																	c	a	c

UNCONFORMITY ———————— TOP OF GAIR ROCK SECTION ————————

20																																			r
19								1	4	6	1	1	4	1	4	1										1				1		6			
18																																			
17									4						1																	3			
16																																2			
15																																			
14							1	2		5	1		1								1						1					5			c
13					1	1		1	5	3	1				1										2							7			
12									2	1			1												1							4			
11				2	1			1	9	6	2	1	1	1						1	1				1							5			
10									1																										
9					1			4	2	5	1		1																			1			
8							1	6	5	9	3	7	4	2	2	6								3		1						3			
7				2	1	1	2	2	25	30	2		1		2	1				1					6			2	1			55			
6			3	1		1		2	8	3	1	7	3		1	5					1		1	3		1	1					19			
5			1		1	1	1	2	8	8	1	3	1	1	3	8	4			1				3	1		1					4			
4			1	2	2	1	3	3	7	8	2	15	10	5		12	5				2	1	1	12								24			
2		2	1	1			5	4	6	2	2	8	10	2	9	7	2	1	3	1	2			2								20		c	
1			2	1	1		1	2	8	6	2	1	1		2		2							1								3			
0	1	1	1	2	1	2	1	3	8	9	4	12	7	6	9	13								12								6			

BASE OF OUTCROP

* For sample intervals - see Appendix A.

Ostracods, Fish remains & "Otoliths":
- r = rare (< 5)
- c = common (6-20)
- a = abundant (> 20)

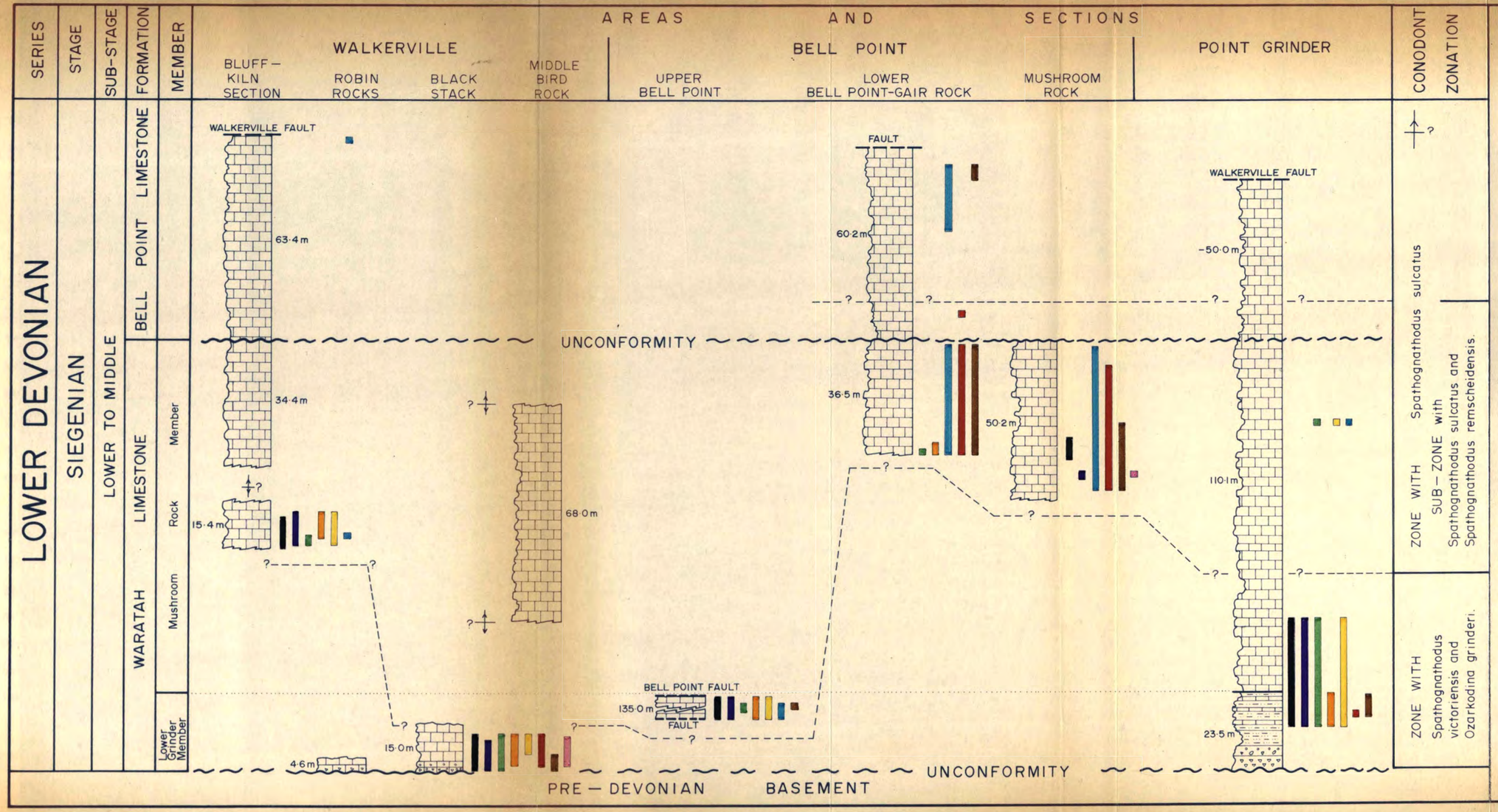


TABLE 7

CORRELATION OF LOWER DEVONIAN LIMESTONE SECTIONS AND RANGE OF IMPORTANT CONODONT SPECIES, WARATAH BAY, VICTORIA.

VERTICAL SCALE

1:1000

(1mm = 1m)

(except Upper Bell Point Section)

CONODONT LEGEND

- Ligonodina waratahensis n.sp.
- Spathognathodus victoriensis n.sp.
- Ozarkodina grinderi n.sp.
- Ozarkodina bischoffi n.sp.
- Trichonodella australis n.sp.
- Spathognathodus sulcatus
- Spathognathodus remscheidensis
- Ozarkodina denckmanni
- Spathognathodus exiguus philipi
- Approximate time boundary

ARGENT, 1971

C. CORRELATION OF THE WARATAH BAY LIMESTONES (TABLE 7):

Apart from the lithological and stratigraphical field evidence (discussed under section B. Stratigraphy), correlation of the various carbonate sequences at Waratah Bay can be made on the range of the more important conodont species.

Those sections resting unconformably on a Pre-Devonian basement, such as the lower part of Point Grinder and the Black Stack (including Robin Rocks), represent the oldest units at Waratah Bay. These limestones are characterized by the presence of *Spathognathodus victoriensis* n. sp. and lie below the range of *Spathognathodus sulcatus*. Together with the uppermost part of the Bell Point section, these units constitute the Lower Grinder Member of the Waratah Formation. However, the upper Bell Point Section is younger because of the presence of *Spathognathodus sulcatus*, but is older than the limestones of Gair and Mushroom Rocks, where *Spathognathodus remscheidensis* occurs together with *Spathognathodus sulcatus*.

Kiln, Mushroom Rock, Gair Rock and upper Point Grinder sequences are likely time-equivalents on the basis of those species which reach their uppermost limit within these sections, namely, *Spathognathodus victoriensis* n. sp., *Ozarkodina grinderi* n. sp., *Ozarkodina bischoffi* n. sp. and *Trichonodella australis* n. sp. For these sequences, the upper boundary is delineated by the unconformity with the overlying Bell Point Limestone, whilst the lower boundary is marked by the lowest limit of the *Spathognathodus sulcatus* zone.

Above the unconformity, the Bell Point Limestone shows a marked decrease in numbers of species and individuals. Never-the-less

the Bluff and lower Bell Point sections can be correlated on the presence of Spathognathodus sulcatus and the absence of other diagnostic forms. None of the new species, characteristic of the older Waratah Limestone,are found in the Bell Point Limestone.

D. CONODONT BIOZONATION : (TABLE 8)

An early to middle Siegenian age is attributed to the Waratah Bay limestones on the presence of three diagnostic forms, Spathognathodus sulcatus (PHILIP), S. remscheidensis ZIEGLER and S. exiguus philipi KLAPPER. S. remscheidensis ranges from Gedinnian to top of the lower Siegenian. S. sulcatus is limited to the range, middle to upper Siegenian and S. exiguus philipi is probably a middle Sieginian form, although it may extend further as a transitional form.

Of further significance at Waratah Bay is the arrival of new species with short ranges restricted to the ? lower Siegenian in this case. These are Spathognathodus victoriensis n. sp., Ozarkodina bischoffi n. sp., O. grinderi n. sp. and Trichonodella australis n. sp.

Other well known lower Devonian forms such as Neoprioniodus excavatus (BRANSON & MEHL), N. bicurvatus(BRANSON & MEHL), Ozarkodina media WALLISER, O. denckmanni ZIEGLER, Plectospathodus extensus RHODES, P. alternatus WALLISER and Trichonodella symmetrica (BRANSON & MEHL), are also present in the Waratah Bay collection.

KLAPPER (1969) has established a conodont zonation for the Lower Devonian on material collected from Royal Creek, Yukon Territory, Devon Island, Canada and Eureka County, Central Nevada, U.S.A. He recognized some six conodont zones, five of which correspond with

LENZ'S brachiopod stages, so that some orthochronological control was possible.

Based on the distribution of conodonts in the Waratah Bay limestone sequences, a conodont zonation is here suggested for part of the Lower Devonian (Siegenian Stage) and correlated with KLAPPER'S zonation (TABLE 8).

(a) Zone with Spathognathodus victoriensis and Ozarkodina grinderi :

Correlation with the orthochronology :

The upper boundary of this zone lies in the lower portion of the Siegenian. From the present material, it is impossible to determine the stratigraphical position of the lower boundary.

Correlation with the existing conodont zonation (KLAPPER, 1969) :

The upper boundary of the zone with S. victoriensis and O. grinderi coincides with the lower boundary of KLAPPER'S Zone with Icriodus latericrescens subsp. B and Spathognathodus sulcatus. The lower boundary cannot be correlated.

Key Fossils : Spathognathodus victoriensis n. sp., Ozarkodina grinderi n. sp.

Other Important Conodonts : Spathognathodus exiguus philipi, Ozarkodina bischoffi n. sp., Trichonodella australis n. sp.

Lower Boundary : Not observed, but herewith defined as the first appearance of Ozarkodina grinderi n. sp.

Upper Boundary : Coinciding with the first appearance of Spathognathodus sulcatus.

Occurrence :

1. Black Stack (southern end South Walkerville beach);

Sample Numbers : 114-120 & 352-364 ; Waratah Limestone, Lower Grinder Member.

2. Point Grinder (eastern side) ; lower part of section ; Sample Numbers : 80-86 & 313-315 ; Waratah Limestone, Lower Grinder Member and lower part of Mushroom Rock Member.

Composite Microfauna : The following fossils were determined :

Ligonodina waratahensis n. sp.

Neoprioniodus bicurvatus

Oistodus sp. a

Ozarkodina bischoffi n. sp.

Ozarkodina denckmanni

Ozarkodina grinderi n. sp.

Ozarkodina typica australis

Plectospathodus lacertosus

Spathognathodus exiguus philipi

Spathognathodus remscheidensis

Spathognathodus victoriensis n. sp.

Spathognathodus sp. a

Trichonodella australis n. sp.

Trichonodella symmetrica

Trichonodella sp. a

Paltodus acostatus

Ostracods & Fish Remains (not identified).

(b) Zone with Spathognathodus sulcatus :

Correlation with the orthochronology : This zone correlates with the middle and upper portion of the Siegenian according to KLAPPER (op. cit.). The upper boundary may coincide with the Siegenian / Emsian boundary.

Correlation with the existing conodont zonation : The zone with Spathognathodus sulcatus encompasses both the Zone with Icriodus latericrescens n. subsp. B and Spathognathodus sulcatus and the Zone with Spathognathodus sulcatus sensu KLAPPER, 1969.

Key Fossils : Spathognathodus sulcatus.

Lower Boundary : First appearance of Spathognathodus sulcatus.

Upper Boundary : Upper limit of range of Spathognathodus sulcatus and before the first appearance of the genus Polygnathus.

Occurrence :

1. Gair Rock (southern part of Bell Point) ; Sample Numbers : 0-19 ; upper part of Waratah Limestone, Mushroom Rock Member.

2. Lower Bell Point (southern part of Bell Point) ; Sample Numbers : 41-50 ; lower part of Bell Point Limestone.

3. Upper Bell Point (northern part of Bell Point) ; Sample Numbers : 54-71 ; lower part of Waratah Limestone, Lower Grinder Mbr.

4. Mushroom Rock (southern part of Bell Point) ; Sample Numbers : 320-334 ; upper part of Waratah Limestone , Mushroom Rock Mbr.

5. Kiln (southern "slice", adjacent to old lime kilns, South Walkerville) ; Sample Numbers : 150, 338-339 ; Waratah Limestone, Mushroom Rock Member.

6. Bluff (between north and south Walkerville) ; Sample Numbers : 163 ; Bell Point Limestone.

7. Point Grinder (upper part of section - southern side from east to west) ; Sample Numbers : 306 ; upper part of Waratah Limestone, Mushroom Rock Member.

Composite Microfauna : The following fossils were determined :

Belodella australensis n. sp.

Belodella resima

Belodella sp. cf. B. devonica

Belodella triangularis

Belodella sp. a

Hindeodella priscilla

Icriodus sp. cf. I. woschmidti

Icriodus sp.a

Ligonodina waratahensis n. sp.

Lonchodina murrindalensis

Neoprioniodus bicurvatus

Neoprioniodus excavatus

Ozarkodina bischoffi n. sp.

Ozarkodina denckmanni

Ozarkodina grinderi n. sp.

Ozarkodina media

Ozarkodina typica australis

Ozarkodina typica typica

Ozarkodina sp. a

Paltodus acostatus

Paltodus unicostatus

Paltodus valgus

Paltodus sp. a

Plectospathodus alternatus

Plectospathodus extensus

Plectospathodus lacertosus

Spathognathodus exiguus philipi

Spathognathodus inclinatus inclinatus

Spathognathodus remscheidensis

Spathognathodus sulcatus

Spathognathodus victoriensis n. sp.

Trichonodella australis n. sp.

Trichonodella excavatus

Trichonodella sp. cf. T. inconstans

Trichonodella symmetrica

Trichonodella symmetrica pinnula

Trichonodella sp. a

Gen. indet. sp. a

Ostracods and Fish Remains (not identified).

(c) Sub-zone with Spathognathodus remscheidensis and Spathognathodus sulcatus :

Correlation with the orthochronology : This sub-zone corresponds approximately to the middle part of the Siegenian Stage.

Correlation with the existing conodont zonation : The sub-zone lies within the lower part of the Spathognathodus sulcatus range. The lower boundary coincides with the lower boundary of KLAPPER'S Zone with Icriodus latericrescens n. subsp. B and Spathognathodus sulcatus. The upper boundary of this sub-zone cannot be correlated with KLAPPER'S sub-division.

Key Fossils : Spathognathodus remscheidensis together with

Spathognathodus sulcatus.

Other Important Conodonts : Restricted to the lower part : Ozarkodina grinderi n. sp., Ozarkodina bischoffi n. sp.

Lower Boundary : The first appearance of Spathognathodus sulcatus.

Upper Boundary : The upper limit of the range of Spathognathodus remscheidensis.

Occurrence :

1. Gair Rock (southern part of Bell Point) ; Sample Numbers : 0-19 ; upper part of Waratah Limestone, Mushroom Rock Member.

2. Lower Bell Point (southern part of Bell Point) ; Sample Numbers : 31-36 ; lower part of Bell Point Limestone.

3. Mushroom Rock (southern part of Bell Point); Sample Numbers : 322-334 ; upper part of Waratah Limestone, Mushroom Rock Member.

Composite Microfauna : The following fossils were determined :

Belodella australensis n. sp.

Belodella resima

Belodella sp. cf. B. devonica

Belodella triangularis

Belodella sp. a

Hindeodella priscilla

Icriodus sp. cf. I. woschmidti

Icriodus sp. a

Ligonodina waratahensis n. sp.

Lonchodina murrindalensis

Neoprioniodus bicurvatus

Neoprioniodus excavatus

Ozarkodina bischoffi n. sp.

Ozarkodina denckmanni

Ozarkodina grinderi n. sp.

Ozarkodina media

Ozarkodina typica australis

Ozarkodina typica typica

Paltodus acostatus

Paltodus unicostatus

Paltodus valgus

Paltodus sp. a

Plectospathodus alternatus

Plectospathodus extensus

Plectospathodus lacertosus

Spathognathodus exiguus philipi

Spathognathodus inclinatus inclinatus

Spathognathodus remscheidensis

Spathognathodus sulcatus

Spathognathodus victoriensis n. sp.

Trichonodella excavatus

Trichonodella sp. cf. T. inconstans

Trichonodella symmetrica

Trichonodella symmetrica pinnula

Trichonodella sp. a

Gen. indet. sp. a

Ostracods and Fish Remains (not identified)

STAGES	KLAPPER 1969 ROYAL CREEK , DEVON ISLAND , NEVADA		ARGENT 1971 WARATAH BAY , VICTORIA	
EMSIAN	Eurekaspirifer pinyonensis	Polygnathus foveolatus		
	Sieberella cf. weberi, Nymphorhynchia pseudolivonica	Polygnathus lenzi		
	Acrospirifer kobehana		? ?	
SIEGENIAN	Gypidula sp. 1 Davidsoniatrypa Trematospira	Spathognathodus sulcatus	ZONE WITH Spathognathodus sulcatus	
	Spinoplasia	Icriodus latericresens subsp. B Spathognathodus sulcatus		? SUBZONE WITH Spathognathodus remscheidensis & S. sulcatus
	Spirigina Quadrithyris	Icriodus pesavis Spathognathodus johnsoni	ZONE WITH Spath. victoriensis & Ozarkodina grinderi ?	
GEDINNIAN	UNNAMED	ZONE		
	Gypidula pelagica	Icriodus woschmidti		

TABLE 8
CONODONT ZONATION
WITHIN THE LOWER DEVONIAN

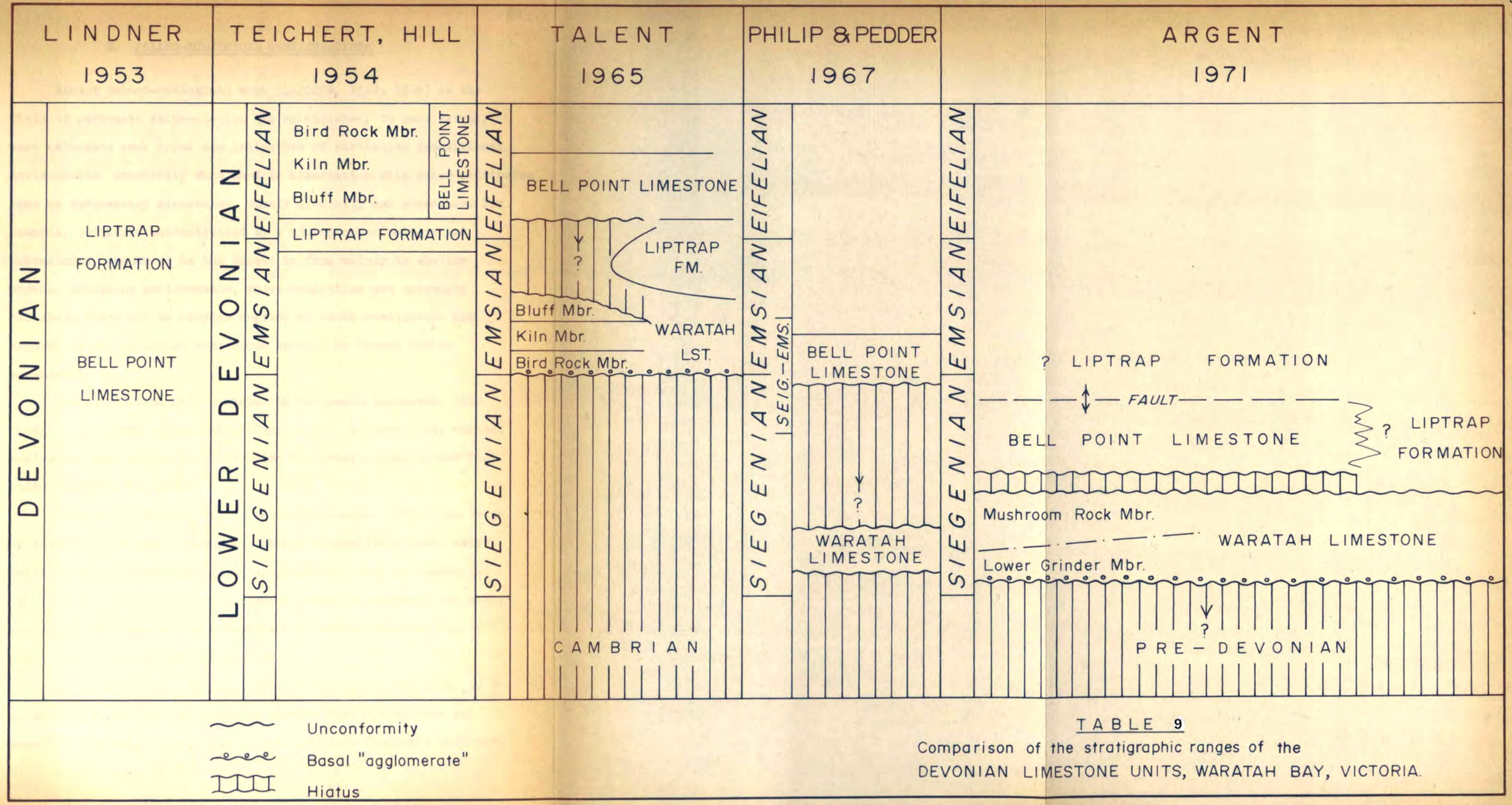


TABLE 9

Comparison of the stratigraphic ranges of the DEVONIAN LIMESTONE UNITS, WARATAH BAY, VICTORIA.

E. PALAEO-ECOLOGICAL CONSIDERATIONS

Recent palaeo-ecological work (LAPORTE, 1968; 1969) in the field of carbonate sedimentation has established, to some extent, that carbonate rock types are indicative of particular depositional environments, especially when used in association with other attributes such as sedimentary structures, fossil diversity and abundance. For example, sediments characterized by a dominance of pellets and intraclasts, are known in the Recent to form mainly in shallow marine, shoreline environments, where conditions are extremely variable. There may be varying degrees of local restriction and hypersalinity, producing conditions hostile to normal marine organisms.

Recent pelleted and intraclastic carbonate sediments, like those of the Great Bahama Bank (PURDY, 1963), do have their ancient analogues, such as the Lower Devonian Helderberg Group in New York State (LAPORTE, op. cit.).

Because the Waratah Bay limestone sequences show a wide range of conodont frequency, some very thick sections (Bird Rock, upper parts of Point Grinder and Kiln) yielding little or no faunas, it was felt that the relationship between conodont abundance and palaeo-ecological environment, as determined by petrographic studies, might shed some light on the problem.

Some preliminary petrographic work was undertaken then, in an attempt to assess the relationship between lithofacies type and conodont frequency. Since only 13 thin sections (together with hand

specimens) were prepared, any conclusions reached must remain fairly tentative. The samples were chosen as being representative of the various limestone units at Waratah Bay, and the relevant data is summarized in TABLE 10. The petrographic terminology employed is that of FOLK (1959; 1962).

The Mushroom Rock Member of the Waratah Limestone consists, for the most part, of pelleted and intraclastic limestones, and a low energy, shallow marine, possibly shoreline environment is postulated. The general paucity of conodonts in these sections (Bird Rock and the upper parts of Kiln and Point Grinder) is indicative of such a hostile environment. However, Mushroom Rock (Sample 330) and nearby Gair Rock are somewhat anomolous in this regard, since both sections have yielded abundant and diverse conodont faunas.

By contrast, those carbonates (biosparites, biomicrites, biomicrudites, etc) containing a high percentage of shelly marine biotas are known to form under more open marine conditions of variable energy level. The abundance of conodonts in the lower part of the Kiln section (Sample 149) and the comparatively high yield from the Black Stack (Sample 119) substantiates this relationship between lithofacies type and conodont frequency. In the case of the Black Stack (Lower Grinder Member of the Waratah Limestone), the biomicrudite contains 25 % macrofossils and provides the highest yield of conodonts, some 18 specimens per kg. Although low energy, shallow marine conditions probably prevailed during Black Stack deposition, there is no evidence for an extremely variable, semi-restricted, hypersaline, supratidal shoreline environment; conditions which ordinarily limit the distribution and abundance of conodonts.

Similarly, the micrites and biolithites of the Bell Point Limestone could be reasonably expected to have a high conodont frequency, but in comparison with the Waratah Limestone, there is an overall deficiency of conodonts, both in numbers of species and individuals. This anomoly might be explained by the tremendous influx of terrigenous material during deposition of the Bell Point Formation, for some of the limestones are extremely silty and thin beds of calcareous shales and siltstones pervade the section, particularly in the lower part; ostracods, fish remains and molluscs are abundant in some horizons, but rarely conodonts.

It is interesting to note that the basal sequence at Bird Rock (Samples 501 & 502) is partly dolomitized and that this took place probably before reworking of the contributing sediment. Since dolomite is virtually absent from the Devonian limestone formations, dolomitization of the basement rocks in this area pobably took place in Pre-Devonian times, before deposition of the younger limestones. This evidence supports the current opinion that the Black Stack and Robin Rocks sections rest paraconformably on a Pre-Devonian dolomitic basement.

SUMMARY OF SOME PETROGRAPHIC DATA, OF LIMITED USE IN DETERMINING THE DEPOSITIONAL ENVIRONMENT OF THE LIMESTONES AT WARATAH BAY, VICTORIA.

FOSSILS	ADDITIONAL REMARKS	ENVIRONMENTAL INTERPRETATIONS	RELATIVE ABUNDANCE OF CONODONTS: SAMPLES Total processed	SAMPLES Total weight	Total yield	Average abundance
Ostracods (5 %)	Accessory amounts of disseminated quartz silt present ; authigenic pyrite rare.	Low energy, marine, ? shallow.				
Ostracods, calcispheres ; brachiopods including tiny chitinous ? inarticulate brachiopods ; molluscs. (2 %)	Accessory quantities of disseminated quartz silt present, together with accessory amounts of authigenic pyrite.	Low energy, marine, ? shallow.				
Stromatoporoids - Amphipora, ostracods. (20 %)	No terrigenous material present.	Low to moderate energy, shallow marine, semi-restricted, barrier-protected partly.	50	56 kg	138	2.3 / kg
Indeterminate.	Sample adjacent to fault zone ; essentially a fault breccia ; depositional textures and fabrics obliterated.	Not possible.				
Echinoderm/crinoid debris and rare molluscs. (4 %)	Some intraclasts present. Terrigenous components and authigenic pyrite essentially absent,	Low energy, shallow marine, possibly shoreline environment.				
Echinoderm/crinoid fragments very abundant, plus bryozoans, ? corals, ? stomatoporoids, molluscs & brach's (60 %)	Intraclasts of micrite & pellet Lst common; sediment shows moderate sorting, but most grains, particularly larger ones - well rounded. Micrite envelopes common on skeletal grains.	Moderate to high energy, shallow marine, possibly a shoreline environment.				
Echinoderm/crinoid frag's, ostracods, brachiopods, rare molluscs, ? calcispheres. Fossils more abundant. (7 %)	Micrite envelopes on some fossil grains ; spar-cemented, pellet-filled organic burrows present. Terrigenous grains and authigenic pyrite essentially absent.	Low energy, shallow marine, possibly shoreline environment.				
Echinoderm/crinoid frag's, brachiopods, molluscs, ? stromatoporoids, ostracods common. (5 %)	Some intraclasts; micrite envelopes common on fossil grains; spar-filled burrows with re-crystallized internal sediments common; terrigenous grains rare ; pyrite absent.	Moderately low energy, shallow marine, possibly shoreline environment.	89	171 kg	1,626	9.5 / kg
Echinoderm/crinoid fragments, together with brachiopods and molluscs, (4 %)	Micrite envelopes common on fossil grains. Intraclasts grade into finer grains, possibly faecal pellets. Rare spar-filled burrows. Terrigenous silt & authigenic pyrite extremely rare.	Moderately high energy, shallow marine, possibly shoreline environment.				
Fragments of echinoderms/crinoids, brachiopods and molluscs ; ? ostracods. (3 %)	Rock somewhat re-crystallized through tectonic fracturing ; terrigenous grains and authigenic pyrite essentially absent.	Low energy, shallow marine, possibly shoreline environment.				
Fragments of tabulate corals, molluscs, brachiopods, echinoderms/crinoids, plus ostracods. (25 %)	Some intraclasts & silt-sized faecal pellets present ; accessory amounts of quartz silt & authigenic pyrite also present, sometimes infilling organic ? burrows.	Low energy, shallow marine.	27	48 kg	869	18.0 / kg
No fossils present.	Rare ooids present (exhibiting radiating structure around micritic nuclei). Intraclasts of ferroan calcite , and the spar cement is calcite.	Shallow marine, possibly shoreline.				
Fragments of echinoderms/crinoids, brachiopods, ? trilobite. (5 %) ? Girvanella.	Limeclasts (? intraclasts, possibly extraclasts) dolomitized probably before reworking of the contributing sediment. Fabric evidence suggests 2 other generations dolomite present.	Moderate to high energy, shallow marine.				
		Grand totals for the above figures	166	275 kg	2,633	9.5 / kg

TABLE 10

SAMPLE NUMBER	STRATIGRAPHIC POSITION	FORMATION MEMBER	LITHOLOGY
50	Upper part. LOWER BELL POINT	BELL POINT LIMESTONE	Micrite
29	Lower part.		Micrite
168	Lower part. BLUFF SECTION		Biolithite
300	Uppermost. POINT GRINDER		Crystalline Limestone
148	Upper part. KILN SECTION	WARATAH LIMESTONE — MUSHROOM ROCK MEMBER	Pelsparite - Pelmicrite
149	Lower part.		Biosparite
330	Lower part. MUSHROOM ROCK		Pelsparite - Pelmicrite
93	Upper part. POINT GRINDER		Pelsparite - Pelmicrite
86	Lower part.		Intrasparite
135	Middle part. MIDDLE BIRD ROCK		Pelsparite - Pelmicrite
119	Middle part. BLACK STACK	LOWER GRINDER MEMBER	Biomicrudite
502	BIRD ROCK BASAL SEQUENCE	? PRE-DEVONIAN BASEMENT	Intrasparite
501			Intrasparite

F. SYSTEMATIC PALAEONTOLOGY

Genus Belodella ETHINGTON 1959

GENOTYPUS : Belodus devonicus STAUFFER 1940.

Belodella australensis n. sp.

Pl. 1, fig. 1, Pl. 2, figs. 1-3

DERIVATION OF NAME : After its occurrence in Australia.

HOLOTYPUS : Pl. 1, fig. 1 ; MU 401.

LOCUS TYPICUS : Bell Point, Mushroom Rock.

STRATUM TYPICUM ; Mushroom Rock section, Sample No. 330.

PARATYPOIDES : Pl. 2, figs. 1-3 ; MU 413, MU 414, MU 415.

OTHER OCCURRENCES : WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 324, 325, 327, 328, 329, 331, 332, 333, 334.

Gair Rock - No. 0, 1, 2, 4, 5, 6, 8, 11, 19.

DEFINITION : A species of Belodella with a deep basal cavity which is narrowly triangular in cross-section. The distal process is moderately to strongly curved posteriorly. Denticles on the posterior edge are numerous and fused. The junctions of the narrow anterior and wide equidimensional lateral faces are marked by sharp ridges.

DESCRIPTION : The unit is narrowly triangular in lateral view; the distal process is gently to strongly curved posteriorly. The basal cavity is very deep and narrowly triangular in cross-section. The junctions of the relatively narrow anterior face and the equi-dimensional lateral faces are marked by sharp ridges, which can be slightly curved towards the posterior. These ridges become less

prominent distally and terminate near the tip. The posterior edge bears numerous closely-spaced, needle-like denticles, which are very slightly inclined towards the tip of the cusp. The denticles are longest in the median part of the unit and decrease in length as they approach the tip and the aboral edge.

REMARKS : A variation in the relative width of the anterior face can be observed in the specimens from Waratah Bay. As transitional forms occur between specimens with a very narrow anterior face and those with a wider one, it is not possible at this stage to distinguish two different species or even sub-species.

Belodella australensis n. sp. differs from B. resima in that the distal process only curves posteriorly and does not also deflect laterally.

Belodella resima (PHILIP)

Pl. 1, figs. 9-10

1965 Belodus resimus n. sp. - PHILIP, pp. 98-99, pl. 8, figs. 15-17, 19 ; text-fig. 2e-f.

1966 Belodella resima (PHILIP) - PHILIP, p. 444, pl. 1, figs. 20-21.

The main characteristic of B. resima is its posteriorly curved distal process, which is distinctly deflected in the lateral plane. Since this feature, which distinguishes B. resima from other similar forms, is not given in the original diagnosis, a revised definition is given here.

DIAGNOSIS : A species of Belodella with a posteriorly curved and laterally deflected distal process ; deep basal cavity narrowly triangular in cross-section ; junctions of anterior and lateral faces marked by sharp ridges ; denticles along the posterior edge, numerous and fused.

FIGURED SPECIMENS : MU 409, MU 410.

MATERIAL : 151 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Bluff - No.163

WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 327, 328, 329, 330, 331, 332, 333, 334.

Gair Rock - No. 0, 1, 2, 4, 5, 6, 9.

Belodella sp. cf. B. devonica (STAUFFER)

Pl. 1, figs. 11-12

cf. 1940 Belodus devonicus n. sp. - STAUFFER, P.420, pl. 59, figs. 47-48.

cf. 1959 Belodella devonica (STAUFFER) - ETHINGTON, pp. 271-272

DESCRIPTION : The deep basal cavity is tear-shaped at the aboral edge, but plano-convex in cross-section for the remainder of the unit. The distal process is moderately to strongly curved posteriorly. A sharp ridge runs down the antero-lateral margin of the cup, extending to the aboral edge and forms the junction of the flat lateral face with the anterior margin of the unit. The lower part of the sharp posterior edge bears numerous small and partly fused denticles.

REMARKS : The apecimens from Waratah Bay differ from B. devonica largely because of their plano-convex shape in cross section.

FIGURED SPECIMENS : MU 411, MU 412

MATERIAL : 33 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 327, 328, 330.

Gair Rock - No. 0, 2, 4, 5, 8, 11, 19.

Belodella triangularis (STAUFFER)

Pl. 1, figs. 3-8

1940 Belodus triangularis n.sp. - STAUFFER

p. 420, pl. 59, fig. 49

1959 Belodella triangularis (STAUFFER) -

ETHINGTON, pp. 271-272.

This species is characterized by a solid distal process strongly curved or hooked posteriorly by a deep basal cavity, which forms, in cross-section, a wide unequal-sided triangle. The sharp posterior edge bears numerous parallel denticles, which are fused except for their tips.

FIGURED SPECIMENS : MU 403, MU 404, MU 405, MU 406, MU 407, MU 408.

MATERIAL : 166 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Bluff - No. 163.

WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 322, 327, 328, 329, 330, 331, 332, 333, 334.

Gair Rock - No. 0, 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 14, 19.

Belodella sp. a

Pl. 1, fig. 2.

The conodont is curved posteriorly in its apical portion and expands rapidly towards the aboral margin. The basal cavity is very deep and asymmetrically biconvex in cross-section : one side is strongly convex forming a crestlike feature running almost parallel and close to the anterior margin ; the other side is only very slightly convex and forms the sharp ridge of the anterior margin. Up to 10 very short, distinct denticles occur on the lowermost portion of the posterior edge.

REMARKS : Belodella sp. a could represent a transitional form between the genera Paltodus and Belodella.

FIGURED SPECIMEN : MU 402.

MATERIAL : 1 specimen.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member : Mushroom Rock - No. 324.

Genus Hindeodella BASSLER 1925

Genotypus : Hindeodella subtilis BASSLER 1925

Hindeodella priscilla STAUFFER

Pl. 3, fig. 1-2.

1938 Hindeodella priscilla n. sp. - STAUFFER, p. 429 pl. 50, fig. 6.

1938 Hindeodella lambtonensis n. sp. - STAUFFER, p. 428, pl. 50, fig. 2, 5, 8, 13, 14, 17, 20, 25, 28, 31.

1938 Hindeodella milleri n. sp. - STAUFFER, p. 428, pl. 50, fig. 3a, 3b, 4, 9-11.

1940 Hindeodella moweri n. sp. - STAUFFER, p. 424, pl. 58, fig. 2, 10-11.

(Synonomy list according to BISCHOFF & ZIEGLER 1957).

The specimens from Waratah Bay lie within the known range of variation for this species.

FIGURED SPECIMENS : MU 427, MU 428.

MATERIAL : 38 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroon Rock Member :

Mushroom Rock - No. 320, 324, 325, 328, 329, 330, 331, 333, 334.

Gair Rock - No. 0, 1, 2, 4, 5, 6, 7, 8, 9, 11, 13, 14, 19.

Genus Icriodus BRANSON & MEHL 1938

Genotypus : Icriodus expansus BRANSON & MEHL 1938.

Icriodus sp. cf. I. woschmidti ZIEGLER

Pl. 2, fig, 12.

1960 Icriodus woschmidti n. sp. - ZIEGLER, pp 185-186, pl. 15, figs. 16-18, 20-22.

1964 Icriodus woschmidti ZIEGLER - WALLISER, pp. 38-39, pl. 9, fig. 22, pl. 11, figs. 14-22.

Only one specimen has been found in the Waratah Limestone. It is damaged at the posterior end but coincides otherwise with the descriptions and figures given by ZIEGLER (1960) and WALLISER (1964). Although the lateral process is missing, a sharp ridge running down the inner side of the main cusp suggests that the lateral ornamented process must have formed an angle of approximately 120° with the main axis of the unit.

FIGURED SPECIMEN : MU 495.

MATERIAL : 1 specimen.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Gair Rock - No. 19.

Icriodus sp. a

Pl.2, fig.13.

A juvenile Icriodus with a tear-shaped aboral outline which is widest posteriorly. Of the six developing nodes on the oral crest, the four towards the posterior end show a tendency to sub-divide.

REMARKS : Further classification is not possible because of the juvenile nature of the specimen.

FIGURED SPECIMEN : MU 496.

MATERIAL : 2 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Gair Rock - No. 7.

Mushroom Rock - No. 322.

Genus Ligonodina ULRICH & BASSLER 1928.

Genotypus : Ligondina pectinata ULRICH & BASSLER 1926.

Ligondina waratahensis n. sp.

Pl. 9, figs. 1-4.

DERIVATION OF NAME : After its occurrence at Waratah Bay.

HOLOTYPUS : Pl. 9, fig. 1 ; MU 483.

LOCUS TYPICUS : Point Grinder.

STRATUM TYPICUM : WARATAH LIMESTONE : Lower Grinder Member :

Point Grinder section - Sample No. 83.

PARATYPOIDES : Pl. 9, figs. 2-4 ; MU 484, MU 485, MU 486.

OTHER OCCURRENCES : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114, 115, 117, 118, 119, 120 ; 352, 353, 354, 355, 356, 364.

Lower Point Grinder - No. 82, 83 ; 315, 317.

Upper Bell Point - No. 69, 70, 71, 73.

WARATAH LIMESTONE : Mushroom Rock Member :

Upper Point Grinder - No. 85a, 86, 306.

Lower Kiln Section - No. 149, 150 ; 336, 337, 338, 339, 340, 341.

Mushroom Rock - No. 328, 329.

DIAGNOSIS : A Ligondina (BASSLER) with two large discrete denticles on the posterior process ; with a short lateral bar and an extremely wide basal cavity with an inner and outer projecting lip, beneath the very long, curved main cusp.

DESCRIPTION : The main cusp is very long, in some cases almost as long as the length of the conodont. It is moderately curved to the posterior and slightly to the inner side. In cross section it is sub-circular to ovate. A distinctly sharp ridge runs along the entire length of the main cusp and extends onto, and forms, the oral edge of the lateral process.

The lateral process is very short, about half the size of the posterior one. It is slightly flexed downwards and curved inwards ; the angle between the lateral faces of the anterior and posterior processes varies from 90° to 150°. The oral edge of the anterior process bears 2 to 3 discrete denticles of sub-circular cross-section which are slightly curved to the posterior and moderately inclined towards the main cusp.

The posterior process bears on its distal half, two long, discrete denticles of sub-circular cross-section, which are slightly inclined posteriorly and may be slightly curved inwards. On the proximal half of the posterior process a small, needle-like denticle may be found.

The basal cavity beneath the main cusp is very wide, asymmetrical and extremely deep, with a downward projecting, U-shaped lip on the outer side, restricted to the area beneath the main cusp and an almond-shaped lip on the inner side which extends onto the posterior bar. The basal cavity continues as a wide, deep, tapering groove to the extremities of the unit.

REMARKS : The numerous specimens of Ligonodina waratahensis n. sp. found in the Waratah Bay sequences, show remarkable stability in their characteristic features.

The two large denticles on the posterior process and the large basal cavity with its characteristic lips distinguish L. waratahensis n. sp. from other species of Ligonodina.

Genus Lonchodina BASSLER 1925.

Genotypus : Lonchodina typicalis BASSLER 1925

Lonchodina murrindalensis PHILIP 1966

Pl. 3, fig. 6.

1966 Lonchodina murrindalensis n. sp. - PHILIP

p. 446, fig. 9-14 ; text fig. 4.

The only specimen recovered from Waratah Bay fully agrees with the original diagnosis and description of the species.

The form is slightly arched and strongly twisted laterally. In oral view, the short anterior process forms an angle of approximately 100° with the posterior process, which is only slightly longer. The anterior process bears three discrete denticles, the posterior one five, and slightly smaller. The aboral surface is excavated beneath the cusp and posterior process.

FIGURED SPECIMEN : MU 432.

MATERIAL : 1 specimen.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member : Gair Rock - No. 4.

Genus Neoprioniodus RHODES & MULLER 1956

Genotypus : Prioniodus conjunctus GUNNEL 1933.

Neoprioniodus bicurvatus (BRANSON & MEHL 1933)

Pl. 3, figs. 3-5.

1933 Prioniodus bicurvatus n.sp. - BRANSON & MEHL, p. 44, pl. 3, fig, 9-12.

1956 Prioniodina tropa (STAUFFER) - ZIEGLER, p. 104, pl. 16, fig. 29, pl. 7, fig. 29.

1960 Prioniodina bicurvata pronoides WALLISER - ZIEGLER, p. 193, pl. 15, fig. 8-9.

1960 Prioniodina n. sp. - ZIEGLER, p. 193, pl. 15, fig. 23.

1960 Prioniodina bicurvata pronoides n. subsp. - WALLISER, p. 33, pl. 8, fig. 8-10.

1962 Neoprioniodus n. sp. - ETHINGTON & FURNISH, p. 1275, pl. 173, fig. 3.

1964 Neoprioniodus bicurvatus (BRANSON & MEHL) - WALLISER, p. 46-47, pl. 9, fig. 13 ; pl. 29, fig. 27-33 ; text-fig. 5d.

The long posterior bar is slightly arched and gently curved laterally. It bears numerous, discrete denticles, which are steeply inclined towards the anterior. The main cusp is relatively large, directed forward and slightly curved inwards. It is sub-ovate in cross-section with a flattened outer side. The anterior edge of the main cusp projects downwards to form a sharply pointed process with the antero-aboral margin. The anterior edge of this process may be smooth, or bear a few very small denticles, which are directed steeply upwards. A well defined basal cavity is present beneath the main cusp and continues in the form of a narrow groove along the aboral edge of the posterior bar.

Following WALLISER (1964), forms in which larger and smaller denticles may alternate on the posterior bar, are here included.

FIGURED SPECIMENS : MU 429, MU 430, MU 431.

MATERIAL : 31 specimens.

OCCURRENCE : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 117, 364.

MUSHROOM ROCK MEMBER : Mushroom Rock -

Mushroom Rock - No. 334, 333, 332, G.B.1, 331, 329

Gair Rock - No. 0, 1, 2, 4, 5, 7, 8, 14.

Kiln - No. 337, 338.

Neoprioniodus excavatus (BRANSON & MEHL 1933)

Pl. 3, fig. 7.

1933 Prioniodus excavatus n. sp. - BRANSON & MEHL - p.45 pl. 3, fig. 7-8.

1957 Prioniodina bicurvata (BRANSON & MEHL) - WALLISER, p. 46, pl. 2, fig, 18-19.

1962 Prioniodina bicurvata (BRANSON & MEHL) - ETHINGTON & FURNISH, p. 1283, pl. 173, fig. 17.

1962 Prioniodina bicurvata (BRANSON & MEHL) - WALLISER, p. 283, fig. 1 (17).

1964 Neoprioniodus excavatus (BRANSON & MEHL) - WALLISER, p. 49-50, pl. 8, fig. 4 ; pl. 29, fig. 26 ; text fig. 5c.

1966 Neoprioniodus bicurvatus (BRANSON & MEHL) - PHILIP, p. 446, pl. 3, fig. 13 ; non fig. 12, 14-16 (= N. bicurvatus)

The posterior bar is slightly arched and gently curved inwards. It bears closely spaced, but discrete denticles, which are vertical to the oral edge, or only slightly inclined towards the anterior. The main cusp is relatively strong, curved inwards and flattened on the outside. A very short anterior bar is present. It curves inwards and bears only a few discrete denticles. The aboral margin of the anterior bar is convex in lateral view. The basal cavity, beneath the main cusp, is wide and extends as a wide groove along both posterior and anterior aboral edges.

REMARKS : N. excavatus differs from N. bicurvatus in the nature of its convex antero-aboral margin, which forms a sharply pointed process in N. bicurvatus.

FIGURED SPECIMEN : MU 433.

MATERIAL : 10 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 334, 331, 325.

Gair Rock - No. 2, 4, 6, 11, 14.

Genus Oistodus PANDER 1856

Genotypus : Oistodus lanceolatus PANDER 1856.

Oistodus sp. a

Pl.2, fig. 6.

The only specimen from Waratah Bay has a reclined cusp, the anterior edge of which forms an angle of approximately 60° with the aboral margin. In cross section, the cusp is distinctly concave-convex (convex to the outside). The anterior and posterior edges are sharp.

The basal cavity if of moderate depth, almond-shaped in outline with a stronger inflation on the inner side. The oral edge of the base, which forms an angle of about 50° with the posterior edge of the cusp, is sharp and lamellar-like. It does not show any denticulation.

REMARKS : This specimen was recovered from beds in close proximity to the basal unconformity and since the genus Oistodus is restricted to the Ordovician, the specimen is regarded as being reworked from Ordovician strata.

FIGURED SPECIMEN : MU 417.

MATERIAL : 1 specimen.

OCCURRENCE : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 355.

Genus Ozarkodina BRANSON & MEHL 1933

Genotypus : Ozarkodina typica BRANSON & MEHL 1933

Ozarkodina bischoffi n. sp.

Pl. 7, figs. 1-5.

1965 Ozarkodina (?) sp. B. - PHILIP pp. 107-108, Pl. 9, fig. 5.

1970 Ozarkodina typica australis n. subsp. PEDDER, JACKSON & PHILIP, p. 215, Pl. 39, fig. 1, non-figs. 2-4, 11-15.

1969 Ozarkodina typica australis PHILIP & JACKSON - FLOOD Pl. 1. fig. 4.

DERIVATION OF NAME : In honour of Dr. G. Bischoff, Macquarie University.

HOLOTYPUS : Pl. 7, fig. 1 ; MU 464.

LOCUS TYPICUS : Outcrop at southern end of South Walkerville beach.

STRATUM TYPICUM : WARATAH LIMESTONE : Lower Grinder Member . Black stack section, Sample No. 117.

PARATYPOIDES : Pl. 7, figs. 2-5.

MU 465, MU 466, MU467, MU 468.

OTHER OCCURRENCES : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114, 117, 119, 120 ; 355, 362, 364.

Upper Bell Point - No. 54, 69, 71, 73.

Lower Point Grinder - No. 81, 82, 83.

WARATAH LIMESTONE : Mushroom Rock Member :

Lower Kiln Section - No. 150, 152; 338, 339, 340.

Gair Rock - No. 0, 2.

DIAGNOSIS : An arched and curved Ozarkodina with an extremely strong main cusp and, on the bars, broad, triangular-shaped denticles fused only at the base. The very wide basal cavity is inflated particularly to the inner side forming a distinct inner lobe.

DESCRIPTION : The conodont is slightly to moderately curved in oral view and arched in lateral view ; the aboral edges of the anterior and posterior bars form an angle of 120° to 135°. The anterior bar is relatively high, particularly as it approaches the main cusp. It bears from 3 to 5 laterally compressed, triangular-shaped, broad denticles which are fused only at the base. The denticles are either erect of slightly inclined towards the broad and long main cusp, which is laterally compressed, with sharp anterior and posterior edges.

The posterior bar is somewhat shorter and lower than the anterior bar and ends abruptly posteriorly. It bears from 2 to 3 denticles, which are similar in shape, but distinctly shorter than those on the anterior bar. The main cusp and the denticles on both the anterior and posterior bars are slightly to moderately curved to the inside.

The asymmetrical basal cavity is widest beneath the posterior portion of the main cusp and extends as far as the medial part of the posterior bar from where it continues as a tapering groove to the end of the unit. Anteriorly it rapidly narrows into a groove which terminates not far from the anterior end. The basal cavity develops a very distinct inner lobe in the area of the main cusp which is clearly visible in oral view. The outer portion of the basal cavity is directed downwards to form a semi-circular lip, the crest of which is displaced posteriorly with respect to that of the inner side, thus lying behind the main cusp. In oral view no outer lobe is apparent.

REMARKS : Ozarkodina ortuformis also has a wide basal cavity restricted to the area of the main cusp, but lacks the outer lobe typical of Ozarkodina bischoffi n. sp., which also differs in the particulars of denticulation.

O. bischoffi n. sp is related to O. grinderi n. sp., but the latter lacks an outer lobe. No transitional forms between these two have been found at Waratah Bay, so two distinct species have been erected on the material available at present.

Ozarkodina denckmanni ZIEGLER 1956

Pl. 8, figs. 4-5.

1956 Ozarkodina denckmanni n. sp. - ZIEGLER.
p. 103, pl. 6, figs. 30-31 ; pl. 7, figs. 1-2.

1964 Ozarkodina typica denckmanni ZIEGLER - WALLISER
p. 61, pl. 9, fig. 14 ; pl. 26, figs. 3-11.

1969 Ozarkodina denckmanni ZIEGLER - KLAPPER
pp. 10-11, pl. 2, figs. 40-41.

The specimens from Waratah Bay lie within the range of variation for the species as described by WALLISER, 1964.

Some specimens are a little more strongly arched than the holotype. The slim, laterally compressed denticles are fused together except for the tips, which are free. On the anterior bar, they are slightly inclined and in some specimens, also slightly curved towards the main cusp. The denticles increase uniformly in size towards the centre of the unit, so that the oral edge, built by their free tips, forms a straight or slightly convex line, which in some specimens includes the broad and somewhat triangular cusp, without a break. The denticles on the posterior bar are generally smaller and decrease

in size towards the posterior end.

The basal cavity under the main cusp is relatively wide. Apical lips are strongly developed, the inner one projecting laterally to a greater extent than the outer lip, which, in some specimens, projects straight down.

FIGURED SPECIMENS : MU 476, MU 477.

MATERIAL : 66 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Lower Bell Point - No. 50.

WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 352, 355.

Lower Point Grinder - No. 82, 83.

Upper Bell Point - No. 71.

WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 326, 327, 328, 329, 330, 331, 332, 333, 334.

Gair Rock - No. 0, 1, 2, 4, 6, 7, 8, 9, 11, 13, 14, 19.

Ozarkodina grinderi n. sp.

Pl. 7, figs.6-9 ; Pl. 8, figs.1-3.

DERIVATION OF NAME : After its occurrence at Point Grinder.

HOLOTYPUS : Pl. 7, fig. 6 ; MU 469.

LOCUS TYPICUS : Point Grinder.

STRATUM TYPICUM : WARATAH LIMESTONE : Mushroom Rock Member (lower part):

Point Grinder - Sample No. 86.

PARATYPOIDES : Pl. 7, figs. 7-9 ; pl. 8, figs. 1-3.

MU 470, MU 471, MU 472, MU 473, MU 474, MU 475.

OTHER OCCURRENCES : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114, 115, 117, 119, 120 ; 352, 353, 355 356, 362, 363, 364.

Lower Point Grinder - No. 81, 83 ; 316, 317.

Upper Bell Point - No. 64, 71.

Upper Point Grinder - No. 306.

Gair Rock - No. 0.

WARATAH LIMESTONE : Mushroom Rock Member :

Lower Kiln Section - No. 149 ; 337, 338.

DIAGNOSIS : Ozarkodina BRANSON & MEHL with a very strong main cusp; with high and partly or almost completely fused denticles on the anterior bar, and few small denticles on the short posterior bar ; with a widely flaring, asymmetrical, heart-shaped basal cavity tapering from beneath the main cusp to the posterior end; both the inner and outer lobes of the basal cavity are strongly developed.

DESCRIPTION : The unit is curved in oral view, convex to the outside. In lateral view it is more or less arched, the angle between the aboral edges of the posterior and anterior bars varying between 160° and 110°, even within specimens of the same fauna. The main cusp is extremely strong. From the tip, which can be recurved to the anterior, it widens rapidly towards the base, particularly on its anterior side. In cross-section it is tear-shaped, rounded posteriorly, with the sharp edge along the anterior margin. The anterior bar is very high, particularly as it approaches the main cusp. It bears, in adult forms, from 4 to 7 strong laterally compressed denticles, which increase in size towards the main cusp. Anteriorly the denticles sit vertically on the bar, but are

increasingly inclined and slightly curved as they approach the main cusp. They are fused, except for their free tips ; the last denticle can be completely included in the anterior basal part of the cusp.

The posterior bar is flexed downwards ; its aboral edge forms an angle of 90° with the posterior edge of the main cusp. It is distinctly shorter than the anterior bar, and in some specimens it is less than half the length of the anterior bar. In lateral view it tapers uniformly to the posterior end and usually bears 2 to 3 small, laterally compressed and widely spaced denticles along the sharp oral edge. In some specimens these denticles are barely visible, or may be completely lacking.

The basal cavity is asymmetrically heart-shaped, extremely wide beneath the main cusp and tapers towards the posterior end. In some specimens its maximum width can equal half the length of the conodont. The basal cavity extends in the form of a wide tapering groove towards the anterior end. In oral view the basal cavity builds a wide almond-shaped inner lobe which almost extends to the posterior end, whereas the outer lobe of the basal cavity is U-shaped and is restricted to the area of the main cusp. The oral surface of the inner and outer lobes is entirely smooth.

REMARKS : In very young specimens the anterior bar is not longer than the posterior bar and bears only 1 to 2 denticles. However the main cusp is already strongly developed and the basal cavity exhibits, in oral view, the typical lobes on both the inner and outer sides.

Ozarkodina grinderi n. sp. shows some relationship to the

Silurian species O. ortus WALLISER, in that it also has a very wide basal cavity with inner and outer lobes. However the denticles on the anterior bar of O. ortus are discrete and the denticles on the posterior bar are larger.

Ozarkodina grinderi n. sp. differs from the Silurian species O. ortuformis WALLISER by the restriction of the wide basal cavity to the area beneath the main cusp. It might be possible that O. grinderi n. sp. is derived from O. ortuformis but since no Gedinnian specimens are available for comparison and no transitional forms between O. ortuformis and O. grinderi n. sp. have been found in the Waratah Bay sequences, it would be premature to establish O. grinderi n. sp. as a new subspecies of O. ortuformis.

Ozarkodina media WALLISER

Pl. 8, fig. 6.

1953 Ozarkodina sp. - RHODES, pl.23, fig. 244.

1957 Ozarkodina media n. sp. - WALLISER, p. 40, pl. 1, figs.21-25.

1964 Ozarkodina media WALLISER - WALLISER, pp. 58-59, pl. 8, fig. 5 ; pl. 26, figs. 19-34.

The four specimens from Waratah Bay fit the original description of Ozarkodina media.

FIGURED SPECIMEN : MU 478.

MATERIAL : 4 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 330, 333, 334.

Ozarkodina typica australis PHILIP

Pl. 8, figs. 7-8.

1965 Ozarkodina sp. A - PHILIP, p.107, pl. 9, figs. 26-27.

1966 Ozarkodina sp. cf. O. jaegeri WALLISER - PHILIP, p. 447, pl. 4, figs. 31-32.

1970 Ozarkodina typica australis n. subsp. - PHILIP & JACKSON, p. 215, pl. 39, figs. 2-4, 11-15 ; non fig. 1.

The specimens from Waratah Bay show the same intraspecific variations as those figured by PHILIP & JACKSON, 1970 (as above). However, the specimen shown on Pl. 39, fig. 1, PHILIP & JACKSON, 1970, has discrete denticles and a completely different appearance to O. typica australis. It is here included with O. bischoffi n. sp.

O. typica australis is somewhat similar in outline to Ozarkodina denckmanni , in lateral view, but can be distinguished from it by its more solid construction and fewer denticles, which are less compressed laterally.

FIGURED SPECIMENS : MU 479, MU 480.

MATERIAL : 18 specimens.

OCCURRENCE : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114, 117.

Lower Point Grinder - No. 83.

WARATAH LIMESTONE : Mushroom Rock Member :

Lower Kiln Section - No. 149.

Gair Rock - No. 0, 1, 4, 5, 7, 9, 11, 13.

Ozarkodina typica typica BRANSON & MEHL.

Pl. 8, fig. 10.

1933 Ozarkodina typica n.sp. BRANSON & MEHL
p. 33, pl. 3, figs. 43-45.

1964 Ozarkodina typica typica BRANSON & MEHL - WALLISER
pp. 61-62, pl. 9, fig. 21 ; pl. 25, figs. 20-21 ;
pl. 26, figs, 1-2.

The specimens from Waratah Bay correspond with the revised description given by Walliser, 1964.

FIGURED SPECIMEN : MU 482.

MATERIAL : 20 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 324, 325, 327, 331, 333, 334.

Gair Rock - No. 5, 7, 11, 12, 13.

Ozarkodina sp. a

Pl. 8, fig. 9.

The unit is arched and gently curved inwards posteriorly. The anterior bar is of moderate height and bears five relatively strong, discrete denticles of ovate cross-section, which are inclined towards the main cusp.

The main cusp is strong, subcircular in cross-section, and gently curved towards the posterior.

The low posterior bar is approximately $1\frac{1}{4}$ times the length of the anterior one and bears seven comparatively small, discrete and erect denticles, ovate in cross-section.

The basal cavity is situated beneath the main cusp and the

anterior portion of the posterior bar. It is tear-shaped in outline and extends as tapering grooves to each end of the conodont.

FIGURED SPECIMEN : MU 481.

MATERIAL : 1 specimen.

OCCURRENCE : BELL POINT LIMESTONE : Lower Bell Point - Section No.5C

Genus Paltodus PANDER 1856

Genotypus : Paltodus subaequalis PANDER 1856.

Paltodus acostatus BRANSON & BRANSON

Pl. 2, fig. 4-5.

1947 Paltodus acostatus n. sp. BRANSON & BRANSON p.554, pl. 8, figs. 1-5, 23-24.

The cusp is slightly to moderately curved posteriorly. The anterior edge is relatively wide and gently rounded. The posterior edge is very narrowly rounded. The lateral faces show a distinct groove, which fades distally. The basal cavity is deep.

REMARKS : P. acostatus differs from P. unicostatus by the lack of the longitudinal carina along one face.

FIGURED SPECIMEN : MU 416.

MATERIAL : 119 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Bluff Section - No. 163

WARATAH LIMESTONE : Lower Grinder Member :

Lower Point Grinder - No. 83 ; 316.

WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 324, 326, 328, 329, 330, 331, 333.

Gair Rock - No. 0, 2, 4, 5, 6, 7, 8, 19.

Paltodus unicostatus BRANSON & MEHL.

Pl. 2, figs. 5, 7-8.

1933 Paltodus unicostatus n. sp. - BRANSON & MEHL
p. 42, pl. 3, fig. 3.

This species is very similar to Paltodus acostatus, but possesses a sharp carina running along the anterior edge of one lateral face.

FIGURED SPECIMENS : MU 418, MU 419.

MATERIAL : 13 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Gair Rock - No. 1, 2, 4, 5.

Paltodus valgus PHILIP

Pl. 2, figs. 9-11.

1965 Paltodus valgus n. sp. - PHILIP
p. 109, pl. 8, figs. 7-8, 12 ; text - fig. 2b.

The material from Waratah Bay fully agrees with the original description and the figures given by PHILIP, 1965.

FIGURED SPECIMENS : MU 420, MU 421, MU 422.

MATERIAL : 94 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 328, 329, 330, 331, 332, 333.

Gair Rock - No. 0, 1, 2, 5, 6, 7, 8, 13, 17, 19.

Paltodus sp. a

Pl.2, fig.14.

The cusp is gently curved posteriorly. The anterior margin is rounded ; the posterior one relatively sharp. One lateral face is very gently convex ; the other is strongly convex. The basal cavity is very deep.

FIGURED SPECIMEN : MU 423.

MATERIAL : 4 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member : Gair Rock - No. 2, 5, 7, 11.

Genus Plectospathodus BRANSON & MEHL 1933

Genotypus : Plectospathodus flexuosus BRANSON & MEHL 1933.

Plectospathodus alternatus WALLISER

Pl. 3, figs. 8-9.

1960 sp. indef. a - WALLISER, p. 35, pl. 7, fig. 14.

1964 Plectospathodus alternatus n.sp. - WALLISER, p. 64, pl. 9, fig. 17 ; pl. 30, figs. 23-25.

The long posterior bar is relatively straight, with alternating denticulation. Discrete denticles are inclined towards the posterior. Between the larger denticles, 3 to 5 much smaller denticles are present in the Waratah Bay material. Two large, laterally compressed denticles occur at the posterior end. They are strongly inclined posteriorly and are of similar size to the main cusp.

The anterior bar is inclined downwards at a shallow angle to the posterior bar. It bears small, discrete denticles, which are

slightly inclined towards the main cusp.

The basal cavity, below the main cusp, is very small. A narrow, indistinct groove extends from the basal cavity onto the aboral edge of the posterior bar.

FIGURED SPECIMENS : MU 434, MU 435.

MATERIAL : 12 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Lower Bell Point - No. 31.

WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 332, 333.

Gair Rock - No. 0, 4, 5, 6, 7, 13.

Lower Kiln Section - No. 338.

Plectospathodus extensus RHODES

Pl. 3, fig. 10.

1953 Plectospathodus extensus n. sp. - RHODES, p. 323, pl. 23, fig. 236-240.

The unit is slightly arched in lateral view and gently curved in oral view. The anterior bar is almost as long as the posterior bar. The discrete denticles are relatively strong, ovate, with sharp anterior and posterior edges. The denticles on the anterior bar are erect, becoming slightly inclined as they approach the main cusp. The denticles on the posterior bar are slightly inclined proximally, becoming increasingly more inclined distally. One or two denticles at or near the posterior end of the unit are so strongly developed that they approximate, or even exceed the size of the main cusp. The basal cavity beneath the main cusp is

relatively large; the inner lip is well developed and flares somewhat towards the posterior.

REMARKS : In some specimens from Waratah Bay, one or two smaller denticles are inserted between the larger ones. According to WALLISER (1964), these forms should therefore be included under P. alternatus. However, the general form of the unit, gently arched and curved inwards, together with the relatively long anterior bar, is more typical of P. extensus. These forms also agree with those described from the Lower Devonian of Germany by BISCHOFF and SANNENMANN (1958).

FIGURED SPECIMEN : MU 436.

MATERIAL : 17 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Bell Point - No. 50.

WARATAH LIMESTONE : Mushroom Rock Member :

Gair Rock - No. 0, 1, 2, 4, 6, 7, 11.

Plectospathodus lacertosus PHILIP

Pl. 3, figs. 11-13.

1966 Plectospathodus extensus lacertosus n. subsp. - PHILIP, p. 448, pl. 1, fig. 25-28 ; text fig. 5.

The material from Waratah Bay generally agrees with the diagnosis and description given by PHILIP.

The posterior bar can be flexed downwards up to an angle of some 60° to the anterior one. The anterior bar is gently arched, curves inwards slightly and bears up to ten discrete, stout denticles, sub-circular in cross-section and slightly inclined and/or curved

towards the anterior. The anterior bar is one-and-a-half times as long as the posterior bar, which is higher, somewhat arched and curved inwards. It bears four to six relatively large, discrete denticles, which are ovate in cross-section. These denticles increase in size posteriorly, except for the last one or two, which are smaller. There is a tendency for the main cusp to be offset towards the inner side in adult forms. The basal cavity beneath the main cusp is relatively large in juvenile specimens, becoming quite small and shallow in adult forms, which exhibit a narrow groove extending from the hasal cavity along the aboral edge of both anterior and posterior bars.

REMARKS : Comparisons of P. lacertosus with P. extensus from Waratah Bay, together with numerous specimens of P. extensus from Europe, show that there is no relationship between them. Whereas P. lacertosus has a short and high posterior bar, flexed downwards at an angle of 30-60° to the long, low anterior bar, P. extensus displays a long posterior bar, which is about the same height as the anterior one, and is not flexed downwards, though the entire unit is gently arched in lateral view. P. lacertosus is therefore interpreted as a separate species.

FIGURED SPECIMENS : MU 437, MU 438, MU 439.

MATERIAL : 11 specimens.

OCCURRENCE : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114, 117, 120.

WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 333, 330.

Gair Rock - No. 7.

Genus Spathognathodus BRANSON & MEHL 1941.

Genotypus : Ctenognathodus murchisoni PANDER 1856

Spathognathodus exiguus philipi KLAPPER

Pl. 5, figs. 1-4.

1969 Spathognathodus exiguus philipi n. subsp. - KLAPPER, pp. 16-18, pl. 4, figs 30-38.

REMARKS : Sp. exiguus philipi is distinguished from the nominate sub-species by a basal cavity restricted to the median part of the conodont.

FIGURED SPECIMENS : MU445, MU 446, MU 447, MU 448.

MATERIAL : 48 specimens.

OCCURRENCE : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114, 115, 117, 119, 120 ; 353, 355, 356, 357, 363.

WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. GB 1.

Spathognathodus inclinatus inclinatus (RHODES)

Pl. 6, fig. 7.

1953 Prioniodella inclinata n. sp. - RHODES, p. 324, pl. 23, figs. 233-235.

1957 Spathognathodus inclinatus (RHODES) - WALLISER p. 47, pl. 1, figs. 16-20.

1964 Spathognathodus inclinatus inclinatus (RHODES) - WALLISER, pp. 76-77, pl 8, fig. 6 ; pl. 19, figs. 6-21.

The few specimens from Waratah Bay lie within the known range of variation of the species.

FIGURED SPECIMENS : MU 462.

MATERIAL : 15 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroon Rock Member :

Mushroom Rock - No. 328, 329, 330, 333, 334.

Gair Rock - No. 0, 1, 2, 4, 5, 6.

Spathognathodus remscheidensis ZIEGLER

Pl. 5, figs. 10-11 ; Pl. 6, fig. 6.

1960 Spathognothodus remscheidensis n. sp. - ZEIGLER, pp. 194-196, pl. 13, figs. 1, 2, 4, 5, 7, 8, 10, 14.

1960 Spathognathodus cf. canadensis WALLISER - ZEIGLER, p. 196 ; pl. 13, fig. 3, 9, 11.

1960 Spathognathodus cf. frankenwaldensis BISCHOFF &SANNEMANN - ZIEGLER, p. 196 , pl. 3, fig. 13.

1960 Spathognathodus ex. aff. wurmi BISCHOFF & SANNEMANN - ZIEGLER, p. 196, pl. 13, fig. 15.

1960 Spathognathodus canadensis n. sp. - WALLISER, p. 34, pl. 8, fig. 1-3.

1964 Spathognathodus steinhornensis remscheidensis ZIEGLER - WALLISER, p. 87, pl. 9, fig. 24 ; pl. 20, figs 26-28 ; pl. 21, figs. 1-2.

1969 Spathognathodus remscheidensis ZIEGLER - KLAPPER, pp. 21-22, pl. 4, figs. 1-6 (non-figs. 7-12).

The species is characterized by irregular denticulation; one denticle above the basal cavity and one or two denticles at the anterior end are larger. The denticles near the posterior end of the blade are slightly inclined posteriorly in many specimens from Waratah Bay. The oval-shaped basal cavity is wide, relatively short

and restricted to the anterior portion of the posterior half of the unit.

REMARKS : Spathognathodus remscheidensis is distinguished from S. exiguus philipi by the more posterior location of the basal cavity and by the character of the denticulation on the anterior portion of the blade. In S. exiguus philipi, the anterior third of the blade bears several very high denticles, the posterior-most of which is usually the highest one. Its posterior edge forms a sharp angle with the distinctly smaller denticles that follow posteriorly. In S. remscheidensis only one or two larger denticles occur near anterior end of the blade.

FIGURED SPECIMENS : MU 452, MU 453, MU 454.

MATERIAL : 151 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Lower Bell Point - No. 31.

WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114, 115, 117, 118, 119, 120 ; 364.

Lower Point Grinder - No. 82.

WARATAH LIMESTONE : Mushroom Rock Member :

Upper Point Grinder - No. 86.

Mushroom Rock - No. 322, 324, 327, 328, 329, 330, 331, 333, 334.

Gair Rock - No. 0, 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 19.

Spathognathodus sulcatus (PHILIP)

Pl. 5, figs 8-9 ; Pl. 6, figs. 1-5.

1965 Eognothodus sulcatus sp. nov. - PHILIP, p. 100, pl. 10, figs. 17, 18, 20, 21, 24, 25 ; text fig. 1.

1966 Spathognathodus bipennatus nevadensis n. sp. CLARK & ETHINGTON, p. 687, pl. 84, figs. 1, 6, 8, 10, 11.

1969 Spathognathodus sulcatus (PHILIP) - KLAPPER, pp. 22-23, pl. 2, figs. 35-37, 42-47 ; pl. 3, figs. 1-21.

The numerous specimens from the Waratah Bay sequence all agree with detailed description by Klapper 1969. Klapper's observation regarding the occurrence of forms with a wide, heart-shaped basal cavity in the lower part of the sequence, the distribution of species with a narrower basal cavity in higher parts of the sequence can be supported. The adult forms that have been recovered from the Mushroom Rock member of the Waratah Limestone possess the wide basal cavity, at least in the adult forms, whereas adult specimens from the younger Bell Point Limestone exhibit a narrower and more restricted basal cavity. Because of gaps in recording due to barren samples and the hiatus between the Waratah Limestone and the Bell Point Limestone, there is not a basis for a well-founded division of the species into two subspecies.

FIGURED SPECIMENS : MU 455, MU 456, MU 457, MU 458, MU459, MU 460, MU 461.

MATERIAL : 240 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Lower Bell Point - No. 41, 44, 49a, 49b, 50.

WARATAH LIMESTONE : Lower Grinder Member : Upper Bell Point - No. 62, 64, 69, 71.

WARATAH LIMESTONE : Mushroom Rock Member :

Upper Point Grinder - No. 306.

Lower Kiln Section - No. 150 ; 338, 339.

Mushroom Rock - No. 320, 324, 325, 326, 328, 329, 330, 331, 332, 333, 334.

Gair Rock - No. 0, 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 19.

Spathognathodus victoriensis n. sp.

Pl. 4, figs. 1-5.

1967 Spathognathodus steinhornensis steinhornensis ZIEGLER - PHILIP & PEDDER, P. 797, text figs. 6-7, (non-fig. 5).

NAME : After its occurrence in the State of VICTORIA.

HOLOTYPE : Pl. 4, fig. 1. (Ca No) MU440

LOCUS TYPICUS : Outcrop at southern end of South Walkerville beach.

STRATUM TYPICUM : Waratah Limestone : Lower Grinder Member :

Black Stack section - Sample No. 115.

PARATYPOIDES : Pl. 4, figs. 2-5 ; MU 441, MU 442, MU 443, MU 444.

MATERIAL : 131 specimens.

OTHER OCCURRENCES : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114, 115, 117, 118, 119, 120 ; 353, 355, 360, 362.

Lower Point Grinder - No. 81, 82, 83 ; 316.

Upper Bell Point - No. 54, 64, 69, 70, 71, 73.

WARATAH LIMESTONE : Mushroom Rock Member :

Upper Point Grinder - No. 86

Mushroom Rock - No. GB 1.

Lower Kiln Section - No. 149, 150, 152 ; 337, 338, 339, 340, 341.

DIAGNOSIS : A Spathognathodus with a wide asymmetrical basal cavity and a coarse denticulation consisting of 8 to about 14 laterally compressed and partly fused denticles with widely triangular free tips. The oral edge of the blade formed by the tips of the denticles is slightly sigmoidal and meets the aboral margin at the posterior end.

DESCRIPTION : The blade is straight or only very slightly curved in oral view. The aboral margin is gently concave in lateral view. The denticulation consists of 8 (in juvenile) to 14 (in adult forms) coarse, laterally compressed and partly fused denticles with widely triangular free tips. The denticle at the anterior end is usually the largest one. From there they decrease in size towards the posterior except for one above the central portion of the basal cavity which is larger than the adjacent denticles, so that the oral edge of the unit formed by the tips of the denticles describes a slightly sigmoidal curve, meeting the aboral margin at the posterior end.

The basal cavity is asymmetrically heart-shaped, widest in the mid-region of the conodont and tapering to the posterior end. At the outer side it is only slightly expanded with a gently convex outline, but it is very strongly inflated in its inner anterior portion. A distinct tapering groove extends from the basal cavity to the anterior end.

REMARKS : Spathognathodus victoriensis n. sp. is similar to S. johnsoni KLAPPER in the character of the blade. It differs from the latter one with respect to the basal cavity which does not form a long inner lobe as in S. johnsoni.

S. victoriensis n. sp. is distinguished from S. steinhornensis by the relatively straight blade, by the differently shaped basal cavity and by the lack of side nodes even in adult specimens.

S. victoriensis n. sp. differs from S. linearis PHILIP mainly in the posterior end of the blade, which is pointed and does not end abruptly as in S. linearis.

Spathognathodus sp. a

Pl. 6, fig. 8.

FIGURED SPECIMEN : MU 463.

MATERIAL : 1 specimen.

OCCURRENCE : WARATAH LIMESTONE : Lower Grinder Member : Black Stack - No. 355.

The blade is very slightly curved in oral view. The aboral margin is moderately concave in lateral view. The oral edge of the blade bears 12 coarse, laterally compressed and partly fused denticles with triangular free tips. One denticle in the mid-region of the blade is markedly larger than the other denticles which decrease in size both towards the anterior and posterior, so that the oral edge of the conodont formed by the tips of the denticles describes a strongly convex curve.

The asymmetrical, relatively wide but flat basal cavity is located in the posterior half of the conodont and seems to extend to the tip of the posterior end, which is broken. A tapering groove runs from the basal cavity to the anterior end.

Genus Trichonodella BRANSON & MEHL 1948

Genotypus : Trichognathus prima BRANSON & MEHL 1933

Trichonodella australis n.sp.

Pl. 9, fig. 8.

DERIVATION OF NAME : After its occurrence in Australia.

HOLOTYPE : Pl. 9, fig. 8. (Cat. No.) MU 490

LOCUS TYPICUS : Outcrop at southern end of South Walkerville beach.

STRATUM TYPICUM : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack Section Sa. No. 119.

MATERIAL : 38 specimens.

OTHER OCCURRENCES : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 117, 120 ; 362, 363, 364.

Lower Point Grinder - No. 81, 82, 83 ; 317.

Upper Bell Point - No. 54, 73.

WARATAH LIMESTONE : Mushroom Rock Member :

Upper Point Grinder - No. 86 ; 306.

Lower Kiln Section - No. 152 ; 337, 338.

DIAGNOSIS : A robust species of Trichionodella with a very strong cusp and short but high lateral processes that each bear two small and one large discrete denticles. Aboral edges form an angle of about 90°. Basal cavity very wide and subcircular in outline.

DESCRIPTION : The main cusp is very strong, sub-circular in cross section and gently curved posteriorly. A low, narrow,

longitudinal ridge occurs on the lateral faces of the cusp and runs over the oral edges of the lateral processes.

The lateral processes are relatively short and high. They are slightly deflected posteriorly. Their aboral edges form an angle of about 90°. The oral edges bear three distinct denticles of ovate cross section. The middle one is large, the other two denticles are very small.

The deep and very large basal cavity beneath the main cusp is almost circular in outline with a semicircular anterior lip projecting downwards and a very wide semicircular posterior liplike expansion projecting posteriorly and only slightly downwards. A wide and relatively deep groove extends from the basal cavity to the ends of the lateral processes.

Trichonodella excavatus (BRANSON & MEHL)

Pl. 9, fig. 7.

1933 Trichognathus excavata n. sp. BRANSON & MEHL, p. 51, pl. 3, figs. 35, 36.

1957 Trichonodella excavata (BRANSON & MEHL) - WALLISER, p. 48, pl. 3, figs. 3, 4, 6-8 ; text fig. 2.

1964 Trichonodella excavata (BRANSON & MEHL) - WALLISER, pp. 89-90, pl. 8, fig. 2 ; pl. 31, figs. 26, 27.

The specimens from Waratah Bay agree with the description and figures given by WALLISER 1957 and 1964.

FIGURED SPECIMEN : MU 489.

MATERIAL : 13 specimens.

OCCURRENCE : BELL POINT LIMESTONE : Lower Bell Point - No. 50.

WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 328, 330, 333, 334.

Gair Rock - No. 6, 8, 19.

Trichonodella symmetrica (BRANSON & MEHL 1933)

Pl. 9, fig. 10-11.

1933 Trichognathus symmetrica n. sp.- BRANSON & MEHL. p. 50, pl. 3, figs. 33, 34.

1953 Trichonodella symmetrica (BRANSON & MEHL) - RHODES, pl. 23, fig, 246, (non fig. 232).

1964 Trichonodella symmetrica (BRANSON & MEHL) - WALLISER, p. 90, pl. 9, fig. 11 ; pl. 31, figs. 28-30.

The specimens from Waratah Bay lie within the known range of variation of the species.

FIGURED SPECIMENS : MU 492, MU 493.

MATERIAL : 8 specimens.

OCCURRENCE : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 118.

Upper Bell Point - No. 71.

WARATAH LIMESTONE : Mushroom Rock Member :

Lower Kiln Section - No. 338, 339.

Gair Rock - No. 4, 6.

Trichonodella symmetrica pinnula PHILIP 1966

Pl. 9, fig. 12.

1966 Trichonodella symmetrica pinnula n. subsp. - PHILIP p. 452-454, pl. 4, fig. 1-6 ; text fig. 9.

1960 Trichonodella n. sp. aff. symmetrica (BRANSON & MEHL) - ZIEGLER, p. 197-198, pl. 15, fig. 1-2.

This subspecies is characterized by its slender cusp, which, in lateral view, widens markedly towards the base forming a smooth, blade-like posterior projection. Also typical, is the small triangular basal cavity, located at the junction of the aboral edges of the two lateral bars with the main cusp. Narrow grooves extend from the basal cavity onto the aboral edges of these three elements.

The oral edges of the denticulate lateral bars extend distally as thin lamellae onto the anterior edge of the main cusp and so delimit a distinct groove, which narrows uniformly to terminate above mid-length.

FIGURED SPECIMEN : MU 494.

MATERIAL : 5 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Mushroom Rock - No. 330, 331.

Gair Rock - No. 5, 6, 14.

Trichonodella sp. cf. T. inconstans WALLISER

Pl. 9, fig. 9.

cf. 1957 Trichonodella inconstans n. sp. - WALLISER pp. 50-51, pl. 3, figs. 16-17 ; text fig. 3.

1960 Trichonodella inconstans WALLISER - ZIEGLER, p. 197, pl. 14, figs. 14, 17.

The unit is strongly arched and curved posteriorly. The aboral edges of the very long lateral processes from an angle of about 90°. The oral edges bear 11 or 12 closely set but distinct denticles of circular cross section that increase in size towards the distal portion of the lateral processes. The main cusp has a circular cross section and seems to be about twice as large as the biggest of the denticles. A basal cavity is not visible. The aboral edges of the processes are sharp.

REMARKS : T. sp. cf. inconstans differs from T. inconstans mainly in the lack of the basal cavity and in the greater number of denticles on the lateral processes.

FIGURED SPECIMEN : MU 491.

MATERIAL : 1 specimen.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member : Mushroom Rock - No. 334.

Trichonodella sp. a

Pl. 9, figs. 5-6.

The conodont is slightly arched and very gently curved posteriorly. The main cusp is relatively large, strongly compressed and slightly

curved to the posterior. The high lateral processes bear three denticles of flat-ovate cross section which are only fused at their bases. They decrease in size distally and are gently curved posteriorly. The large sub-triangular basal cavity beneath the main cusp is strongly inflated posteriorly. A relatively wide and deep groove extends from the basal cavity to the distal ends of the lateral processes.

FIGURED SPECIMENS : MU 487, MU 488.

MATERIAL : 4 specimens.

OCCURRENCE : WARATAH LIMESTONE : Lower Grinder Member :

Black Stack - No. 114.

Upper Bell Point - No. 71.

WARATAH LIMESTONE : Mushroom Rock Member :

Gair Rock - No. 2.

Gen. indet., n.sp. a

Pl. 2, figs.15-17.

The three specimens are hollow aborally. The oral surface is smooth except in one specimen, where the crests of the three diverging projections show a single view of very faint nodes.

The specimens might represent juvenile forms of the genera Pelekysgnathus or Icriodus.

FIGURED SPECIMENS : MU 424, MU 425, MU 426.

MATERIAL : 3 specimens.

OCCURRENCE : WARATAH LIMESTONE : Mushroom Rock Member :

Gair Rock - No. 2.

EXPLANATION OF PLATES

All conodonts figured are assumed to be adult specimens.

Juvenile specimens are noted as such in the plate explanations.

The name of the species is followed by the stratigraphic unit (Formation or Member) in which it was found ; then the appropriate Section and Sample Number is given.

The Catalogue Number of each figured specimen carries the prefix MU (Macquarie University).

PLATE 1

PLATE 1

All figures are X 85.

Fig. 1 — Belodella australensis n. sp. Mushroom Rock Member, Mushroom Rock 330 ; Holotype MU 401 :
1a- inner lateral view; 1b - outer lateral view.

Fig. 2 — Belodella sp. a . Mushroom Rock Member, Mushroom Rock 333;
2a - outer lateral view of MU 402.
2b - inner lateral view of MU 402.

Fig. 3-8 — Belodella triangularis (STAUFFER).
Mushroom Rock Member, Mushroom Rock 333 ;
3a - outer lateral view of MU 403.
3b - inner lateral view of MU 403.
4 - inner lateral view of MU 404.
5a - outer lateral view of MU 405.
5b - inner lateral view of MU 405.
6 - inner lateral view of MU 406.
7 - inner lateral view of MU 407.
8 - inner lateral view of MU 408.

Fig. 9-10 — Belodella resima (PHILIP) .
Mushroom Rock Member, Mushroom Rock 333 ;
9 - inner lateral view of MU 409.
10a - inner lateral view of MU 410.
10b - outer lateral view of MU 410.
10c - outer lateral view of MU 410.

Fig. 11-12 — Belodella sp. cf. B. devonica(STAUFFER).
Mushroom Rock Member, Gair Rock O.
11a - inner lateral view of MU 411.
11b - outer lateral view of MU 411.
12a - inner lateral view of MU 412.
12b - outer lateral view of MU 412.

PLATE . 1

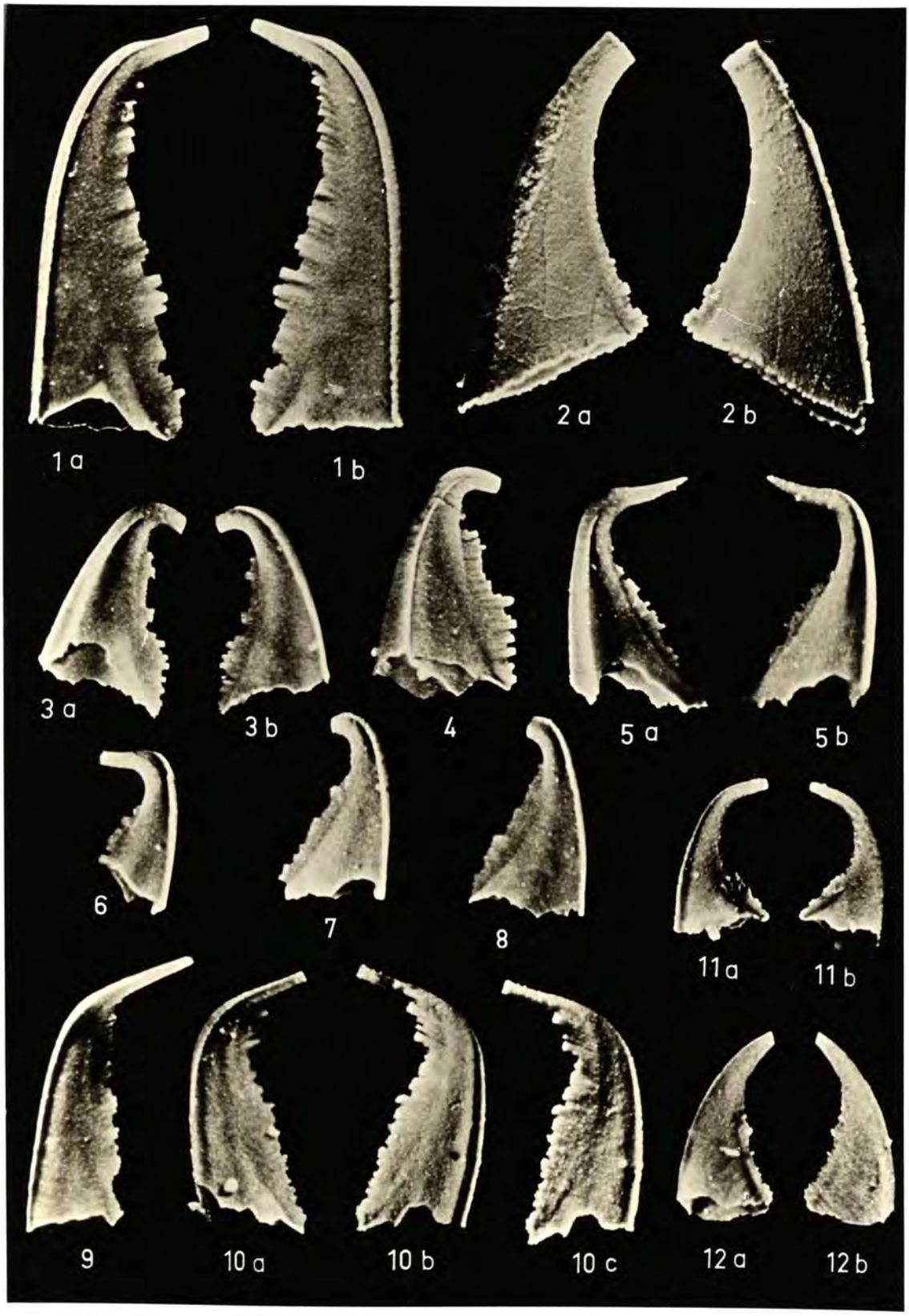


PLATE 2

Fig. 1-3 *Belodella australensis* n. sp.
Mushroom Rock Member, Mushroom Rock 330.
1 - lateral view of MU 413.
2 - lateral view of MU 414.
3 - lateral view of MU 415.

Fig. 4-5 *Paltodus acostatus* BRANSON & BRANSON.
Mushroom Rock Member, Gair Rock 2.
4a, 4b - lateral views of MU 416.
5 - posterior view of MU 416.

Fig. 6 *Oistodus* sp. a
Lower Grinder Member, Black Stack 355.
Inner lateral view of MU 417.

Fig. 7-8 *Paltodus unicostatus* BRANSON & MAHIN.
Mushroom Rock Member, Gair Rock 1.
7 - lateral view of MU 418.
8a, 8b - lateral views of MU 419.

Fig. 9-11 *Paltodus valgus* PHILIP.
Mushroom Rock Member, Gair Rock 2.
9a, 9b - lateral views of MU 420.
10 - lateral view of MU 421.
11 - lateral view of MU 422.

Fig. 12 *Icriodus* sp. cf. *I. woschmidti* ZIMMER.
12a - oral view of MU 495. Mushroom Rock Member,
12b - aboral view of MU 495. Gair Rock 19.

Fig. 13 *Icriodus* sp. a . Mushroom Rock Member, Gair Rock 7.
Oral-oblique view of juvenile specimen MU 496.

PLATE 2

All figures are X 85.

Fig. 1-3 Belodella australensis n. sp.
Mushroom Rock Member, Mushroom Rock 330.
1 - lateral view of MU 413.
2 - lateral view of MU 414.
3 - lateral view of MU 415.

Fig. 4-5 Paltodus acostatus BRANSON & BRANSON.
Mushroom Rock Member, Gair Rock 2.
4a, 4b - lateral views of MU 416.
5 - posterior view of MU 416.

Fig. 6 Oistodus sp. a
Lower Grinder Member, Black Stack 355.
Inner lateral view of MU 417.

Fig. 7-8 Paltodus unicostatus BRANSON & MEHL.
Mushroom Rock Member, Gair Rock 1.
7 - lateral view of MU 418.
8a, 8b - lateral views of MU 419.

Fig. 9-11 Paltodus valgus PHILIP.
Mushroom Rock Member, Gair Rock 2.
9a, 9b - lateral views of MU 420.
10 - lateral view of MU 421.
11 - lateral view of MU 422.

Fig. 12 Icriodus sp. cf. I. woschmidti ZIEGLER.
12a - oral view of MU 495. Mushroom Rock Member,
12b - aboral view of MU 495. Gair Rock 19.

Fig. 13 Icriodus sp. a . Mushroom Rock Member, Gair Rock 7.
Oral-oblique view of juvenile specimen MU 496.

PLATE 2 (continued)

PLATE 2 (continued)

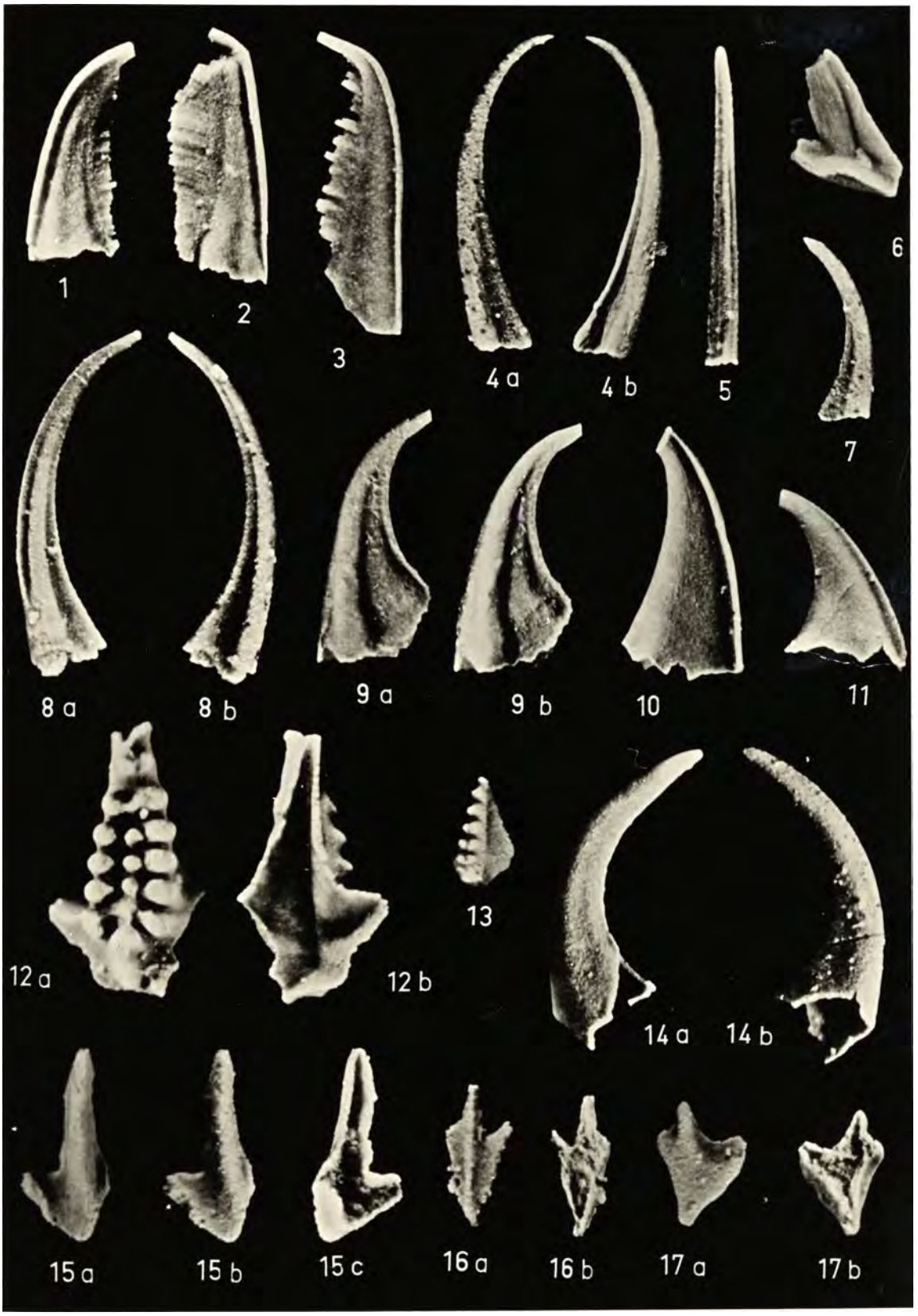
Fig. 14 Paltodus sp. a.
Mushroom Rock Member, Gair Rock 2.
14a, 14b - lateral views of MU 423.

Fig. 15-17 Gen. indet. sp. a.
15a, 15b - oral views of MU 424.
15c - aboral view of MU 424.

16a - oral view of MU 425.
16b - aboral view of MU 425.

17a - oral view of MU 426.
17b - aboral view of MU 426.

PLATE 2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17 b

PLATE 3

PLATE 3

All figures are X 85.

Fig. 1-2 Hindeodella priscilla STAUFFER.
Mushroom Rock Member, Waratah Limestone.
1a, 1b - inner lateral views of MU 427 (Gair Rock 2).
2 - inner lateral view of MU 428 (Gair Rock 1).

Fig. 3-5 Neoprioniodus bicurvatus (BRANSON & MEHL).
Mushroom Rock Member, Waratah Limestone.
3 - inner lateral view of MU 429. (Mushroom Rock 330).
4a, 4b - outer lateral views of MU 430.
5a, 5b - inner lateral views of MU 431. (Gair Rock 4).

Fig. 6 Lonchodina murrindalensis PHILIP.
Mushroom Rock Member, Gair Rock 4.
6a, 6b, 6c - lateral views of MU 432.

Fig. 7 Neoprioniodus excavatus (BRANSON & MEHL).
Mushroom Rock Member, Gair Rock 2.
7a, 7b - lateral views of MU 433.

Fig. 8-9 Plectospathodus alternatus WALLISER.
8 - inner lateral view of MU 434. Mushroom Rock Member.
9 - inner lateral view of MU 435. (Gair Rock 0)

Fig. 10 Plectospathodus extensus RHODES.
Mushroom Rock Member, Gair Rock 0.
10a, 10b - inner lateral views of MU 436.

Fig. 11-13 Plectospathodus lacertosus PHILIP.
11 - inner lateral view of MU 437 (Bell Point 50).
12 - inner lateral view of MU 438 (Mushroom Rock 331).
13 - inner lateral view of MU 439 (Mushroom Rock 331).

PLATE 3

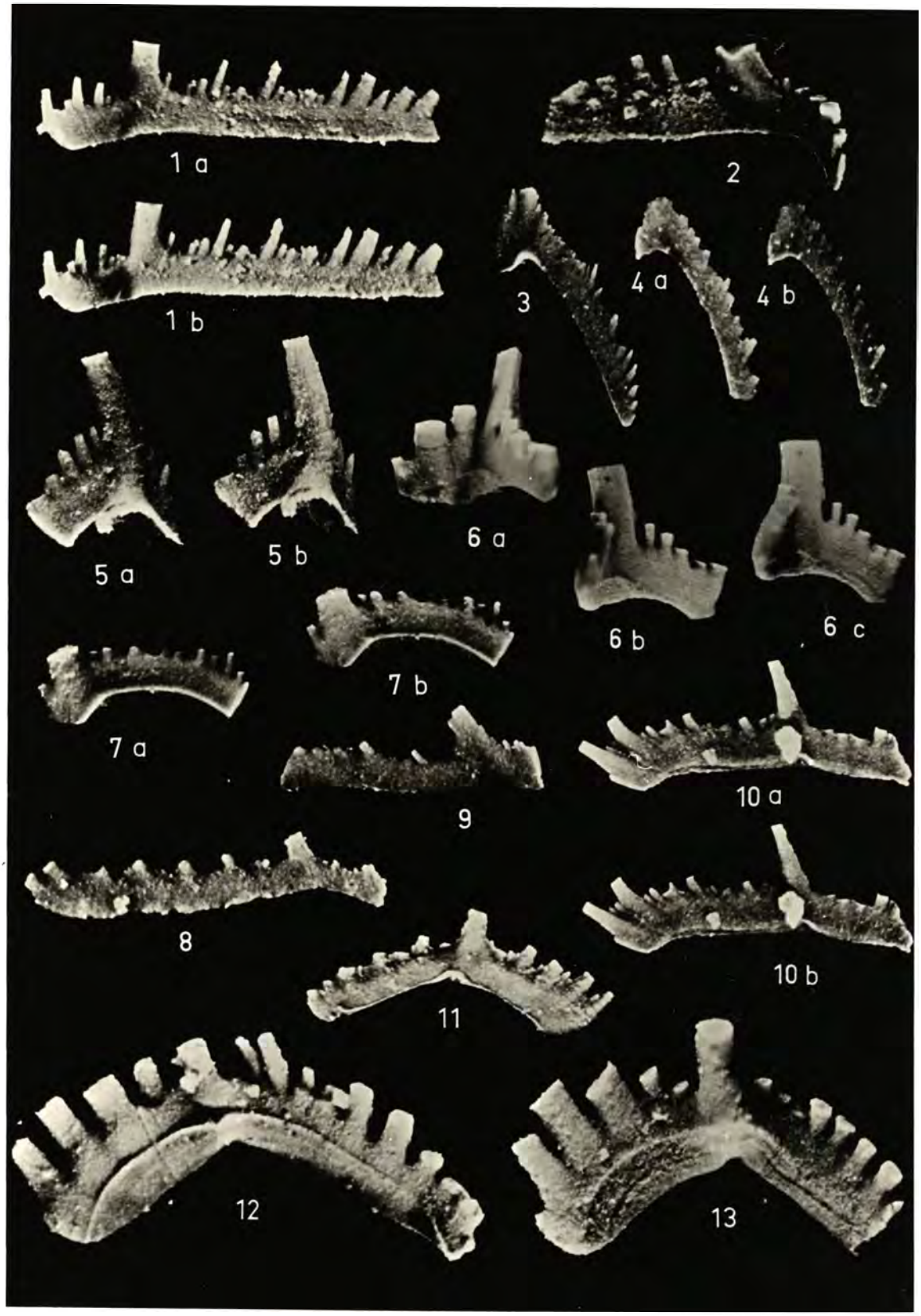


PLATE 4

PLATE 4

All figures are X 85.

Fig. 1 Spathognathodus victoriensis n. sp. Holotype MU 440.
Lower Grinder Member, Black Stack 115.
1a - oblique, outer lateral view.
1b - inner lateral view.
1c, 1d - oral views.

Fig. 2 Spathognathodus victoriensis n. sp. Paratype MU 441.
Lower Grinder Member, lower part of Point Grinder 83.
2a - inner lateral view.
2b, 2c - oral views.

Fig. 3 Spathognathodus victoriensis n. sp. Paratype MU 442.
Mushroom Rock Member, Mushroom Rock GB 1.
3 - outer lateral view.

Fig. 4 Spathognathodus victoriensis n. sp. Paratype MU 443.
Mushroom Rock Member, Mushroom Rock GB 1.
4 - outer lateral view.

Fig. 5 Spathognathodus victoriensis n. sp. Paratype MU 444.
Lower Grinder Member, lower part of Point Grinder 83.
5a, 5b - outer lateral views.

PLATE 4

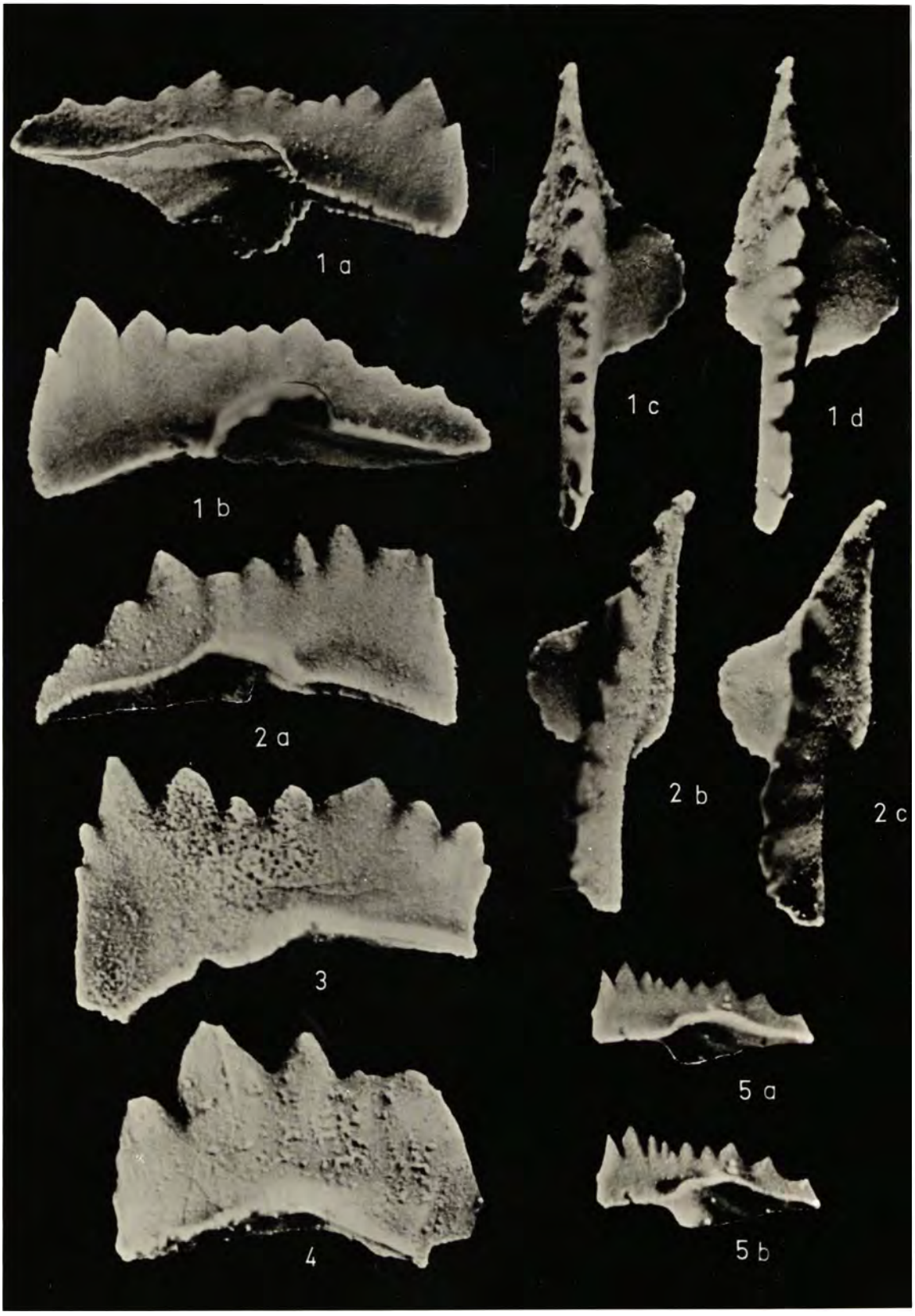


PLATE 5

PLATE 5

All figures are X 85.

Fig. 1-4 Spathognathodus exiguus philipi KLAPPER.
Mushroom Rock Member, Mushroom Rock GB 1.
1 - lateral view of MU 445.
Lower Grinder Member, Black Stack 115.
2 - lateral view of MU 446.
3 - lateral view of MU 447.
4 - lateral view of MU 448.

Fig. 5-7 Spathognathodus remscheidensis ZIEGLER.
Mushroom Rock Member, Gair Rock 1.
5a - oblique lateral view of MU 449.
5b - lateral view of MU 449.
5c - oblique oral view of MU 449.
6a, 6b - lateral views of MU 450.
6c - oral view of MU 450.
Lower Grinder Member, Black Stack 364.
7a - lateral view of MU 451.
7b - oral view of MU 451.

Fig. 8-9 Spathognathodus sulcatus (PHILIP).
Upper part of Bell Point Limestone, Bell Point 50.
8a, 8b - lateral views of MU 455.
8c - oral view of MU 455.
9a, 9b - lateral views of MU 456.
9c - oral view of MU 456.

Fig. 10-11 Spathognathodus remscheidensis ZIEGLER.
Mushroom Rock Member, Gair Rock 2.
10 - lateral view of MU 452.
11 - lateral view of MU 453.

PLATE 5

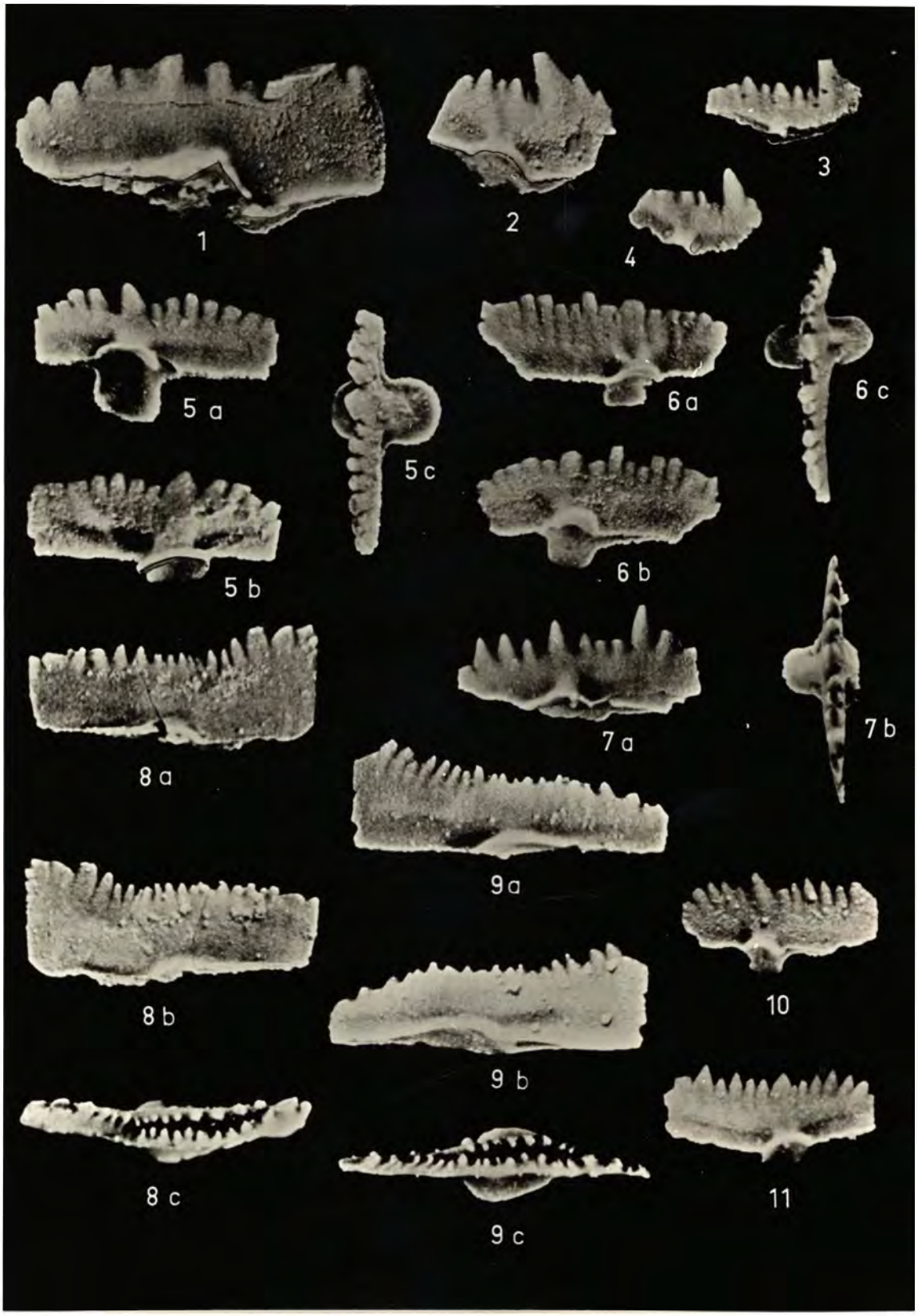


PLATE 6

PLATE 6

All figures are X 85.

Fig. 1-5 Spathognathodus sulcatus (PHILIP).

Mushroom Rock Member, Waratah Limestone.

1a - aboral view of MU 457. (Gair Rock 7).

1b - oblique oral view of MU 457.

2a - aboral view of MU 458. (Gair Rock 2).

2b - oral view of MU 458.

3 - lateral view of MU 459. (Gair Rock 6).

Upper part of Bell Point Limestone, Bell Point 50.

4a - lateral view of MU 460.

4b - lateral view of MU 460.

4c - oral view of MU 460.

Mushroom Rock Member, Waratah Limestone.

5a - lateral view of MU 461. (Gair Rock 13).

5b - oral view of MU 461.

Fig. 6 Spathognathodus remscheidensis ZIEGLER.

Lower Grinder Member, Black Stack 117.

Lateral view of MU 454.

Fig. 7 Spathognathodus inclinatus inclinatus (RHODES).

Mushroom Rock Member, Gair Rock 4.

Lateral view of MU 462.

Fig. 8 Spathognathodus sp. a.

Lower Grinder Member, Black Stack 355.

Lateral view of MU 463.

PLATE 6

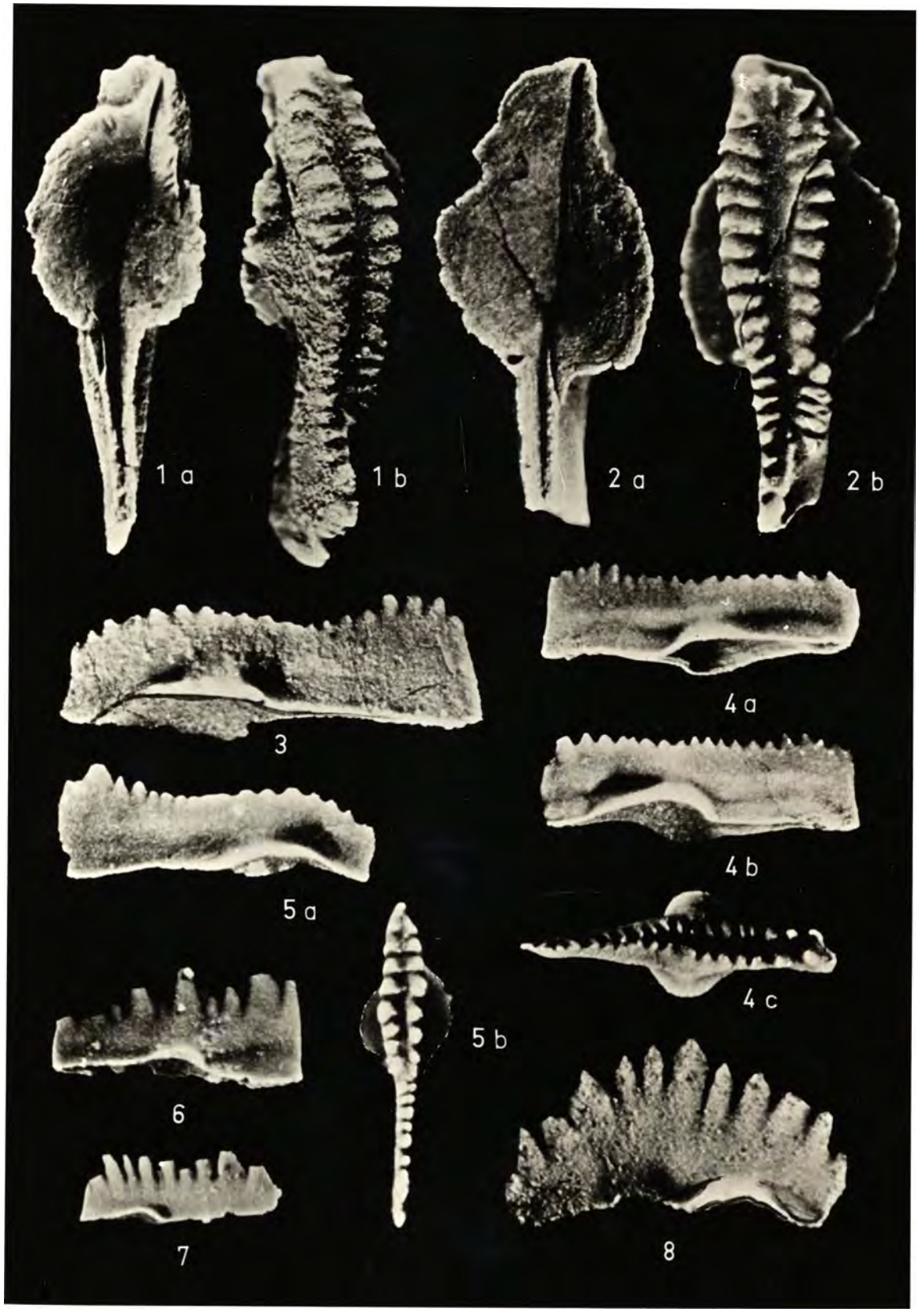


PLATE 7

PLATE 7

All figures are X 85.

Fig. 1-5 Ozarkodina bischoffi n. sp.

Lower Grinder Member, Waratah Limestone.

1a - inner lateral view of Holotype MU 464 (Black Stack 117).

1b - outer lateral view of Holotype MU 464.

2 - inner lateral view of Paratype MU 465 (Black Stack 355).

3 - outer lateral view of juvenile MU 466 (Bell Point 71).

4 - inner lateral view of Paratype MU 467 (Bell Point 71).

5 - outer lateral view of Paratype MU 468 (Black Stack 364).

Fig. 6-9 Ozarkodina grinderi n. sp.

Mushroom Rock Member, Point Grinder 86 (lower part).

6a - inner lateral view of Holotype MU 469.

6b - outer lateral view of Holotype MU 469.

Mushroom Rock Member, Gair Rock O.

7 - outer lateral view of juvenile Paratype MU 470.

Mushroom Rock Member, Point Grinder 86 (lower part).

8a - inner lateral view of Paratype MU 471.

8b - outer lateral view of Paratype MU 471.

Lower Grinder Member, Black Stack 119.

9 - inner lateral view of Paratype MU 472.

PLATE 7

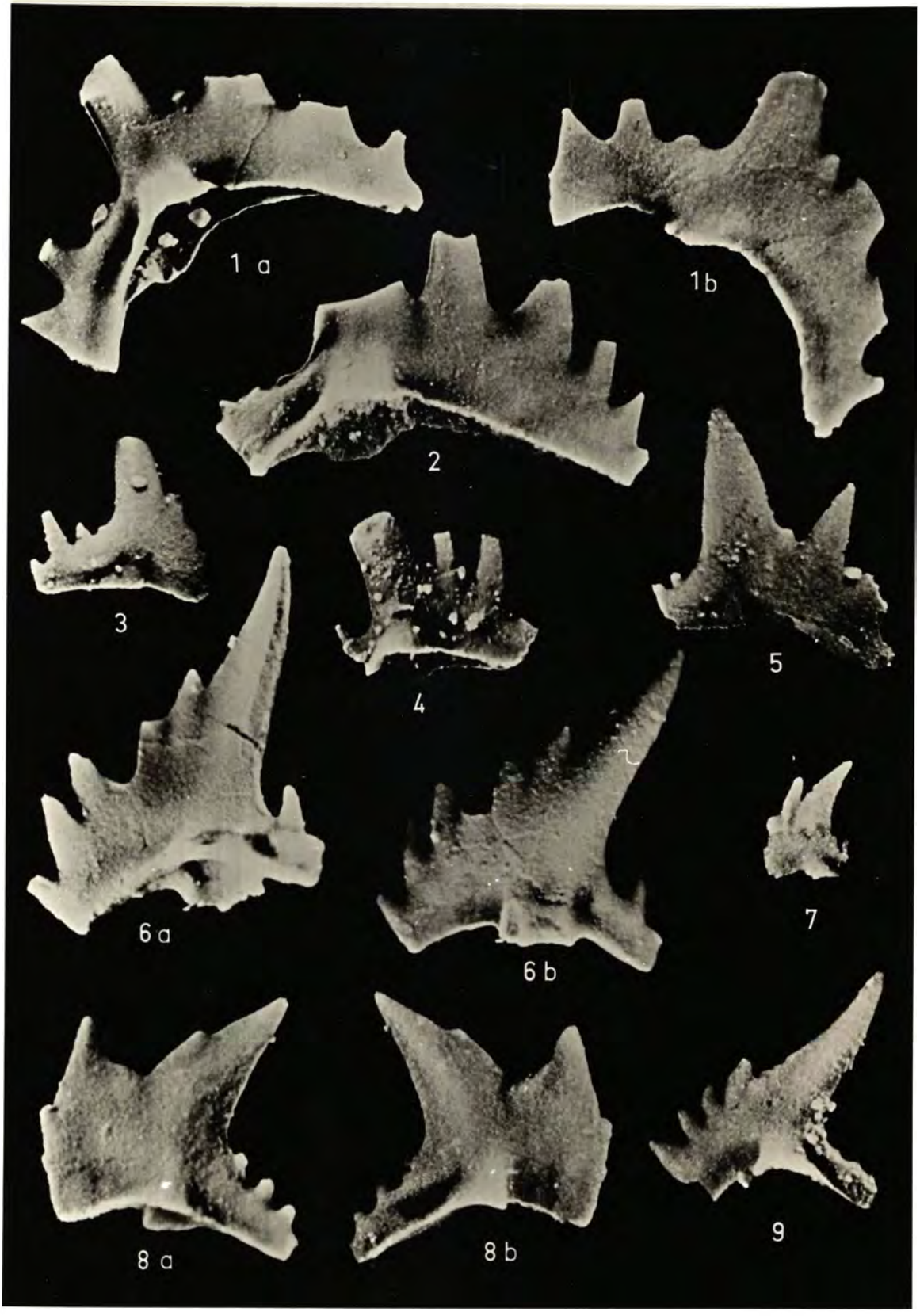


PLATE 8

PLATE 8

All figures are X 85.

Fig. 1-3 Ozarkodina grinderi n. sp.
Lower Grinder Member, Black Stack 119.
1 - inner lateral view of Paratype MU 473.
2 - inner lateral view of Paratype MU 474.
3 - outer lateral view of Paratype MU 475.

Fig. 4-5 Ozarkodina denckmanni ZIEGLER.
Upper part Bell Point Limestone, Bell Point 50.
4 - outer lateral view of MU 476.
Mushroom Rock Member, Gair Rock 2.
5 - lateral view of MU 477.

Fig. 6 Ozarkodina media WALLISER.
Mushroom Rock Member, Mushroom Rock 330.
6a, 6b - lateral views of MU 478.

Fig. 7-8 Ozarkodina typica australis PHILIP.
Lower Grinder Member, Black Stack 114.
7a, 7b - inner lateral views of MU 479.
Mushroom Rock Member, Gair Rock 1.
8 - lateral view of MU 480.

Fig. 9 Ozarkodina sp. a.
Upper part Bell Point Limestone, Bell Point 50.
9a, 9b - inner lateral views of MU 481.

Fig. 10 Ozarkodina typica typica BRANSON & MEHL.
Mushroom Rock Member, Gair Rock 7.
Lateral view of MU 482.

PLATE 8

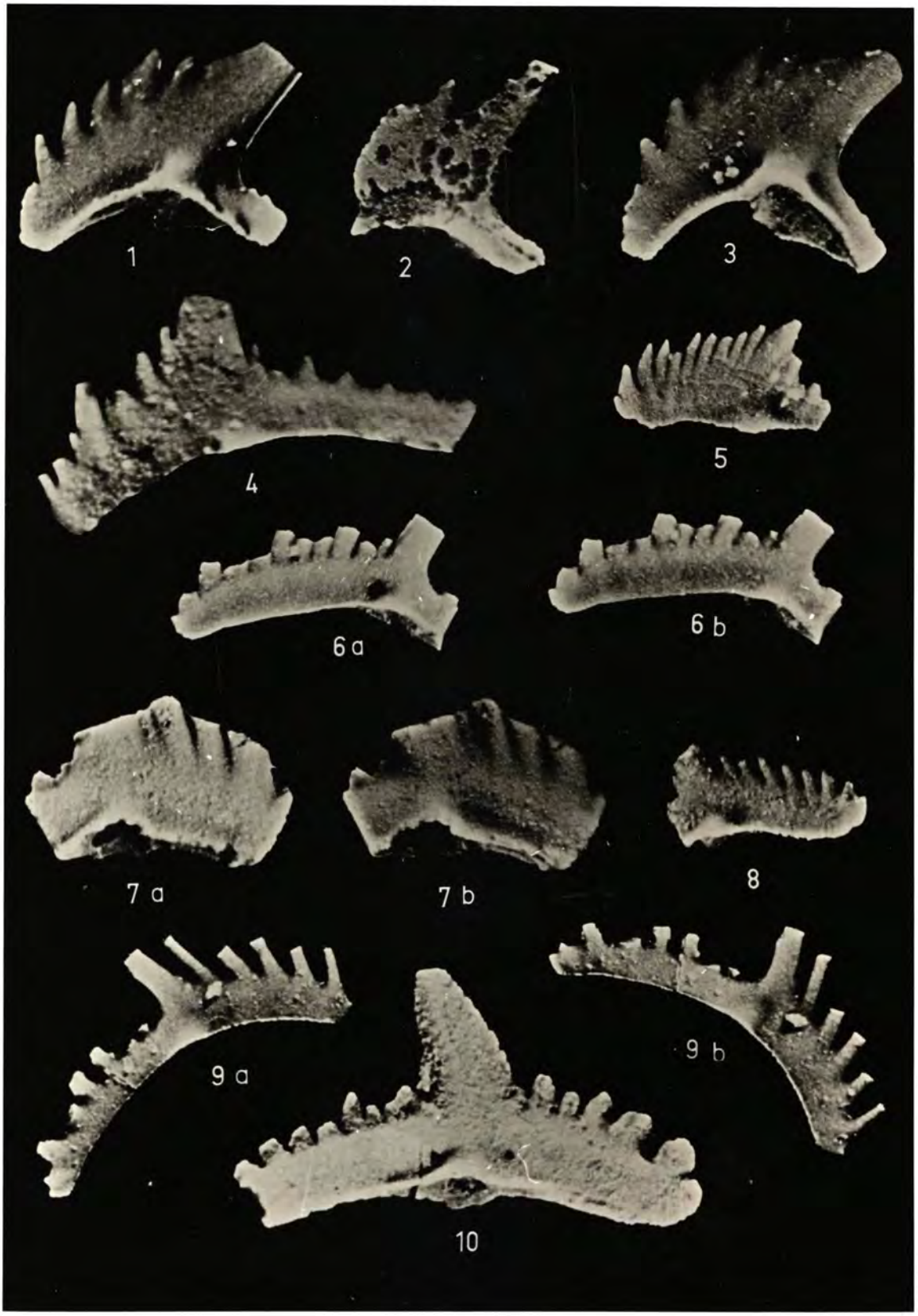


PLATE 9

Fig. 1–4 *Diconodina wertebomaia* n. sp.

Lower Grinder Member, Point Grinder 83.

1a – outer lateral view of Holotype MU 483.

1b – inner lateral view of Holotype MU 483.

Lower Grinder Member, Point Grinder 82.

2 – inner lateral view of Paratype MU 484.

Lower Grinder Member, Mask Stack 119.

3 – outer lateral view of Paratype MU 485.

Mushroom Rock Member, Kiln 140 (lower part).

4a – outer lateral view of Paratype MU 486.

4b – inner lateral view of Paratype MU 486.

Fig. 5–6 *Trichonodella* sp. c.

Lower Grinder Member, Mesa Point 71 (upper part).

5 – posterior view of MU 487.

Mushroom Rock Member, Mesa Rock 2.

6 – posterior view of MU 488.

Fig. 7 *Trichonodella excavatus* (BRANSON & MEHL).

Mushroom Rock Member, Mushroom Rock 230.

Posterior view of MU 489.

Fig. 8 *Trichonodella australis* n. sp.

Lower Grinder Member, Mask Stack 119.

8a – posterior view of Holotype MU 490.

8b – anterior view of Holotype MU 490.

Fig. 9 *Trichonodella* sp. cf. *T. inconstans* WALTHER.

Mushroom Rock Member, Mushroom Rock 234.

Posterior view of MU 491.

Fig. 10–11 *Trichonodella symmetrica* (BRANSON & MEHL).

Mushroom Rock Member, Dair Rock 2.

10 – posterior view of MU 492.

PLATE 9

All figures are X 85.

Fig. 1-4 Ligonodina waratahensis n. sp.
Lower Grinder Member, Point Grinder 83.
1a - outer lateral view of Holotype MU 483.
1b - inner lateral view of Holotype MU 483.
Lower Grinder Member, Point Grinder 82.
2 - inner lateral view of Paratype MU 484.
Lower Grinder Member, Black Stack 119.
3 - outer lateral view of Paratype MU 485.
Mushroom Rock Member, Kiln 149 (lower part).
4a - outer lateral view of Paratype MU 486.
4b - inner lateral view of Paratype MU 486.

Fig. 5-6 Trichonodella sp. a.
Lower Grinder Member, Bell Point 71 (upper part).
5 - posterior view of MU 487.
Mushroom Rock Member, Gair Rock 2.
6 - posterior view of MU 488.

Fig. 7 Trichonodella excavatus (BRANSON & MEHL).
Mushroom Rock Member, Mushroom Rock 330.
Posterior view of MU 489.

Fig. 8 Trichonodella australis n. sp.
Lower Grinder Member, Black Stack 119.
8a - posterior view of Holotype MU 490.
8b - anterior view of Holotype MU 490.

Fig. 9 Trichonodella sp. cf. T. inconstans WALLISER.
Mushroom Rock Member, Mushroom Rock 334.
Posterior view of MU 491.

Fig. 10 Trichonodella symmetrica (BRANSON & MEHL).
Mushroom Rock Member, Gair Rock 2.
10 - posterior view of MU 492.

PLATE 9 (continued)

PLATE 9 (continued)

Fig. 11 Trichonodella symmetrica (BRANSON & MEHL).

Lower Grinder Member, Bell Point 71 (upper part).

Anterior view of MU 493.

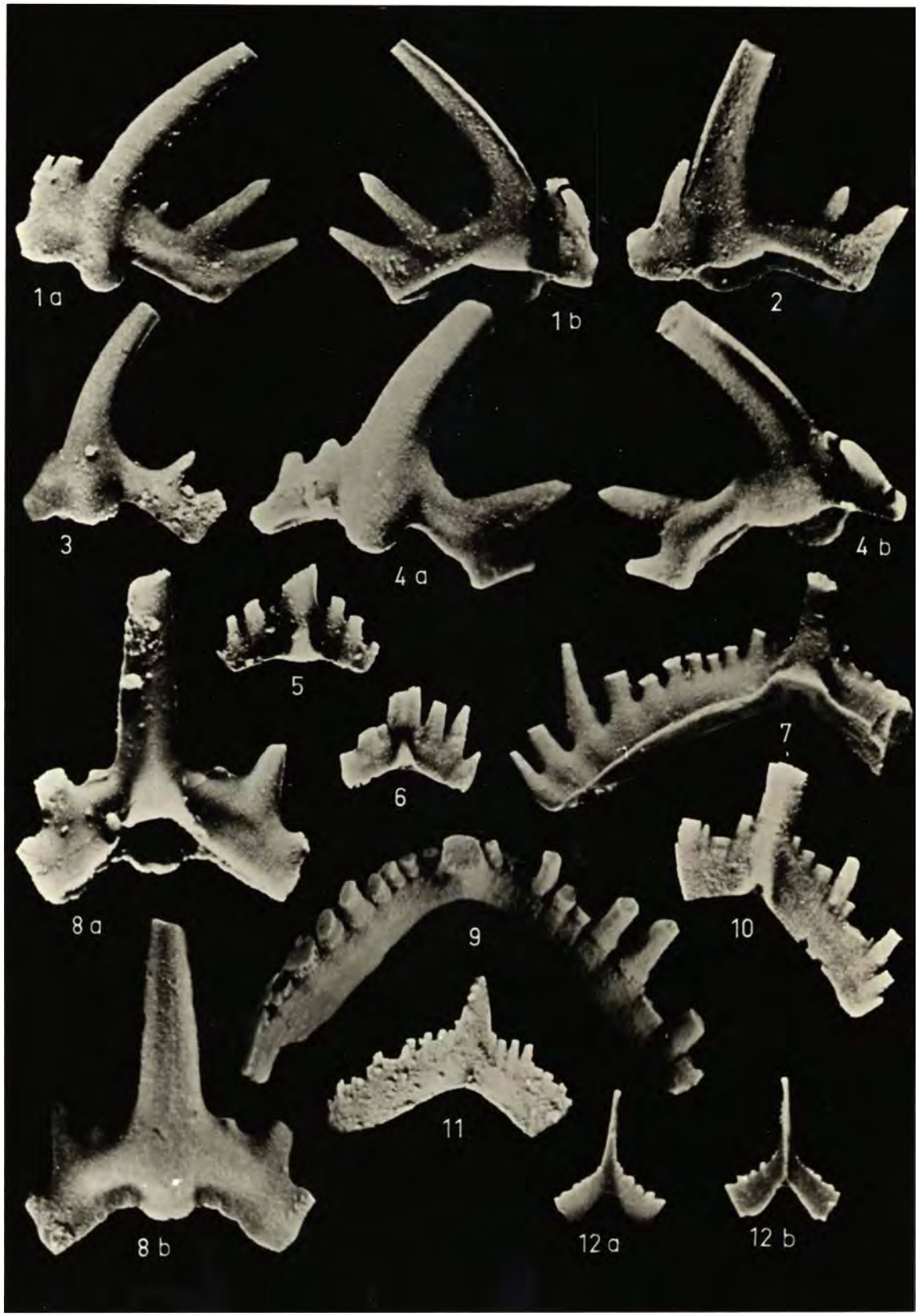
Fig. 12 Trichonodella symmetrica pinnula PHILIP.

Mushroom Rock 330, Mushroom Rock Member.

12a - anterior view of MU 494.

12b - posterior view of MU 494.

PLATE 9



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APPENDIX A

TABLE OF CONTENTS

PAGE

1. Detailed descriptions of measured sections :

Point Grinder 1

Bell Point

Mushroom Rock 25

Gair Rock 27

Walkerville Area

Bluff 31

Kiln 34

Black Stack 36

Robin Rocks 39

Bird Rock 40

2. Field maps showing section traverses and other salient features :

Point Grinder 8

Bell Point 30

Walkerville Area 45

POINT GRINDER

Access to Point Grinder was gained by following the vehicular track through the "Illawong" farming property situated on the eastern side of the Cape Liptrap (lighthouse) road.

The section begins on the beach some 80 m west of Point Grinder, where the scattered outcrops of dark grey limestone are replaced by siltstones of the Liptrap Formation . (See Section Profile--in pocket.)

TOP OF SECTION

Sample Number	True Thickness	Description
		BELL POINT LIMESTONE:
	35.0 m	Limestone--dark grey, extensively veined by calcite, extremely weathered, scattered outcrops on beach, exposed at low tide only. These limestones may be grouped with the Bell Point Limesone Formation on the basis of stratigraphic position and similar lithology.
105 300	15.4 m	Limestone--as before.
==========?		Supposed continuation of Walkerville Fault may occur within the unit above, but not observed directly.

Point Grinder (continued)

UUUUUUUUUUUU ?		Suspect UNCONFORMITY?
		WARATAH LIMESTONE : Mushroom Rock Member:
301 302 104	10.7 m	Limestone--medium grey, fine-grained, many calcite veins, evidence of much fracture. Lower 4 m with many lumps and lenses of black siltstone or sandy shale--these lenses up to 23 cm in length. Composite sample over the lower 8 m.
	1.4 m	Crinoidal limestone -- light grey, pale yellowish-brown on weathering, very coarse (calcirudite). Crinoid stems up to 1 cm in diameter. Scattered lenses of dark argillaceous material, up to 5 cm in length, occur in the uppermost 60 cm.
303 103	4.6 m	Crinoidal limestone - as before, but with rugose corals and flattened stromatoporoids. Composite sample of 4 pieces.
304	1.0 m	Limestone - fine to medium grained, whitish-grey but weathering to a pale yellowish-brown colour, in beds 60 to 90 cm thick, a somewhat massive appearance. Stromatoporoids and rugose corals present.

Point Grinder (continued)

102 305 4.8 m Limestone - as before. Stromatoporoids up to 15 cm in diameter. Sample from uppermost 15 cm.

101 306 4.8 m Limestone - as before. Dip = 62-65 °
Sample from topmost 15 cm - 3 pieces.

100 4.9 m Limestone - as before.
Sample from uppermost 20 cm.

99 307 6.1 m Limestone - as before.
Samples from uppermost 25 cm.

98 4.9 m Limestone - as before.
Sample from uppermost 15 cm.

97 96 4.6 m Limestone - as before.
Sample 97 from uppermost 20 cm.
Sample 96 from lowermost 20 cm.

4.8 m Limestone - as before. No sample taken.

95 7.9 m Limestone - as before, but somewhat more massive in appearance. Sample from 60 cm below top of unit.

94 2.7 m Limestone - as before, but evidence of some slight shearing along a narrow zone. Sample taken from above the shear zone in the uppermost 15 cm.

93 3.7 m Limestone - as before, but thickly bedded - up to 1 m. Sample from uppermost 15 cm - 3 pieces.

Point Grinder (continued)

92 2.7 m Limestone - as before. Dip = 62-65 °
Sample from uppermost 15 cm.

91 5.5 m Limestone - as before, but in beds 60 to 90 cm thick, alternating with several thin beds, 10 to 15 cm thick. Some evidence of cyclic sedimentation.
Sample from uppermost 15 cm.

90 4.4 m Limestone - as before. Sample from 85 cm below top.

89 5.7 m Limestone - as before, but thickly bedded (up to 1 m thick), massive appearance, with several thinner beds towards the top. Sample from uppermost 60 cm - 4 pieces.

88 1.8 m Limestone - in two massive beds, each 90 cm thick, whitish-grey in colour. Sample from lowermost 20 cm- 4 pieces.

0.4 m Limestone - medium grey colour with a buff tint in thin chips, weathering to a pale yellowish-brown colour. Thinly bedded in layers (6 or 7) 5-12 cm thick.

2.7 m Limestone - as before, but in thicker beds - to 90 cm.

87 4.2 m Limestone - light grey, yellow ochre colour in thin
308
309 chips, containing tiny shell fragments, gastropods
310
311 and ostracodes. Samples taken at regular intervals across a narrow, upraised "parapet" on wave-cut platform at base of sea-cliff facing east.

Point Grinder (continued)

86 312 313	1.8 m	Limestone of "parapet" area - as above - thinly bedded towards the top, in beds 4 to 17 cm thick. Sample 86 from top of unit yielded conodonts.
""""""""""""""""""""""		Section offset.
314 85c	4.2 m	Limestone - light grey, fine grained, porcellaneous appearance, thickly bedded, somewhat massive, in beds up to 60 cm thick. Samples from top of unit.
85b	7.2 m	Limestone - as before. Sample from bottom of unit.
85a	4.3 m	Limestone - as before, but somewhat coarser and medium grey in colour. Sample taken from bottom of unit yielded conodonts.
84	4.2 m	Limestone - as before, but in thicker beds - up to 1 m. Sample taken from bottom of unit.
	2.6 m	Limestone - medium grey in colour, with occasional beds of argillite - very thin (1-2 cm thick).
		LOWER GRINDER MEMBER
83 317	2.1 m	Limestone - light grey, fine grained, in layers 12 to 20 cm thick, separated by thin bands of dark grey to black silty argillite, 4 to 5 cm thick. Sample 83 from the uppermost 15 cm, whilst Sample 317 was composite. Both yielded conodonts.

Point Grinder (continued)

"The black zone"

316
82
81 8.5 m Silty Shale - dark grey to black, hard - indurated, perhaps siliceous, moderately calcareous, alternating with beds of limestone, light to medium grey, 2 to 20 cm thick, with one bed in the lower half 45 cm thick. Sample 316 from the upper part, Sample 82 from mid-way, and Sample 81 from the lower part. In addition, two lithological samples were taken for thin sections. All samples yielded conodonts, provided they were limestones - the silty shales were not treated.

"The Buff zone"

80 4.6 m Argillite - pale grey, slightly to moderately calcareous, somewhat silty, perhaps silicified, thinly bedded (5-10 cm thick), weathers to buff colour.

1.7 m "Agglomerate"- fine grained, olive brown, ? tuffaceous matrix, irregular fragments decreasing in size towards the top of the unit. Small chert pebbles, up to 2 cm in diameter, become less numerous towards the top where their average diameter is about 2 mm.

0.6 m "Agglomerate"- as before, but with chert fragments up to 10 cm in diameter. The average diameter is about 3 cm.

Point Grinder (continued)

6.1 m Chert - dark grey, wedging in against the "Cambrian Greenstones" of the basement. Chert beds dipping steeply to the east, and tectonically shattered.

BOTTOM OF SECTION

UUUUUUUUUUUUUUU UNCONFORMITY - Lower Grinder Member faulted against diabasic rocks of Pre-Devonian age, along the eastern margin of the shore platform at Point Grinder.

.....

Thickness of Bell Point Limestone ..... 50.4 m.

Thickness of Mushroom Rock Member .....110.1 m.

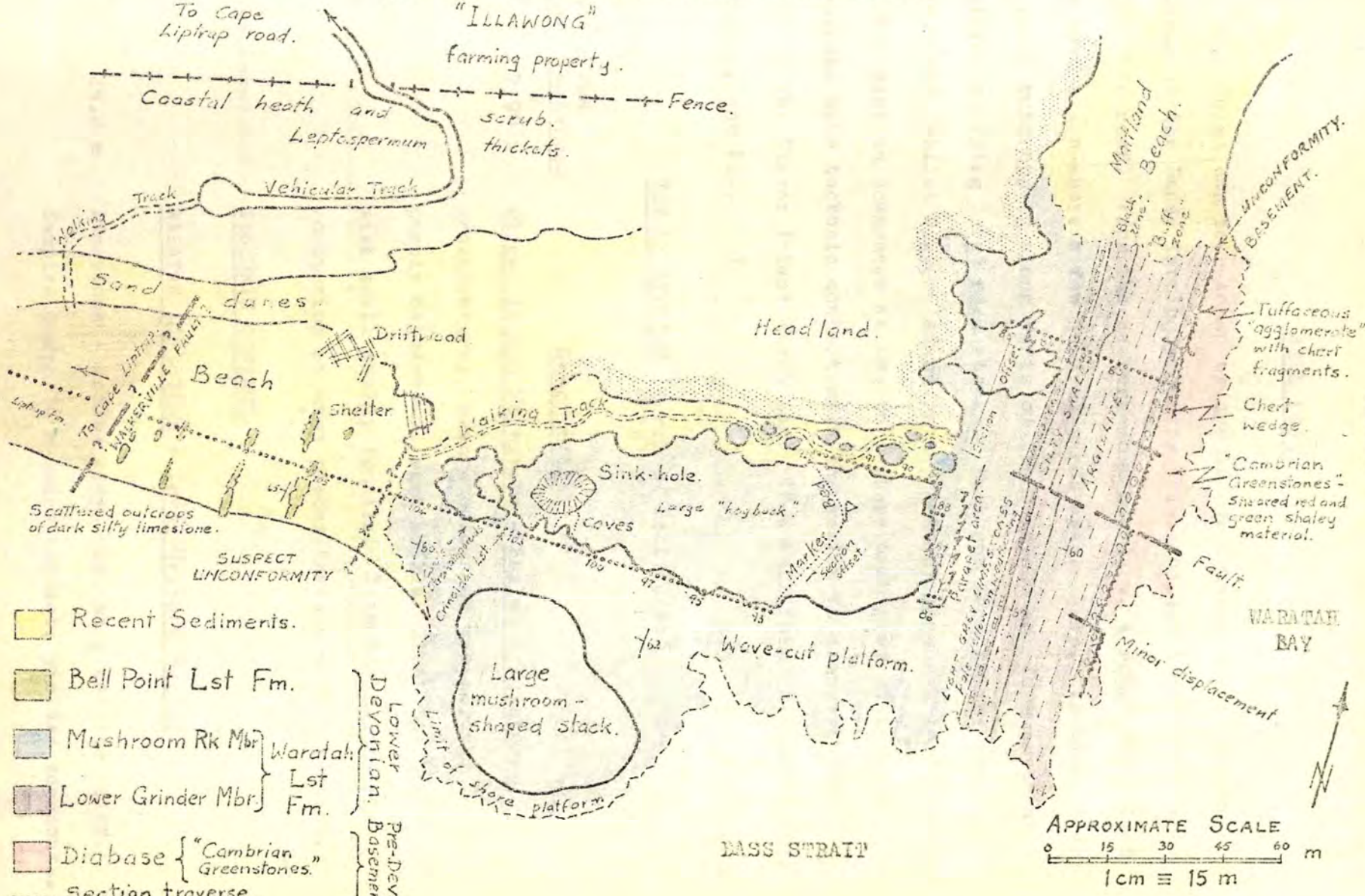
Thickness of Lower Grinder Member ..... 23.5 m.

Total thickness of Point Grinder Section .....184.0 m.

.....

A field map of Point Grinder showing the section traverse and other salient features is included overleaf.

Fig. 3 ROUGH FIELD MAP OF POINT GRINDER



BELL POINT

Bell Point can be reached by car if one travels over the open paddocks of the Landy farming property which adjoins the South Walkerville road. From the eastern-most boundary, a rough track leads down to the sea-shore a few hundred yards away. Here, the limestones are found outcropping along parts of the headland and form wave-cut platforms carrying large rock stacks. Mushroom Rock to the south is aptly named, whilst Digger Island is a prominent landmark to the north.

The section commences at the top, where dark grey siliceous limestones make tectonic contact with the yellow to orange-brown shales of the Digger Island Formation. (See Bell Point Section Profile - in pocket, and Fig. 7).

TOP OF SECTION (north of Bell Point)

Sample Number	True Thickness	Description
74	? 90 m	Digger Island Formation - Shales & Mudstones, greenish-grey, orange colour on weathering, partly calcareous; some nodular limestone bands with small shelly fossils. Lithological sample consisting of many pieces taken 9 m from contact.
==========		TECTONIC CONTACT
		WARATAH LIMESTONE : Lower Grinder Member.
73 335	24.2 m	Limestone - medium grey, with many calcite veins. Samples taken 16 m below contact, yielded conodonts.

Bell Point (continued)

X	41.5 m	Siltstones - dolomitic, light grey, with calcite veining. Lithological Sample X from about mid-way.
==========		TECTONIC CONTACT
	8.1 m	Limestone - dark grey, in beds up to 20 cm thick, alternating with thin layers (2-5 cm thick) of harder, impregnated (?siliceous) material. Beds showing reverse dip, indicating small synclinal fold and tectonically disturbed strata. Dip = 66°.
	0.4 m	Limestone - as before, but with band of stromatoporoids.
72	5.2 m	Limestone - as before, but without stromatoporoids.
72	4.3 m	Limestone - as before. Sample from uppermost 15 cm, consisting of two pieces, yielded conodonts.
70	1.8 m	Limestone - as before. Sample from uppermost 15 cm, yielded conodonts.
69	3.2 m	Limestone - as before. Sample from uppermost 15 cm, consisting of two pieces, yielded conodonts.
68	3.1 m	Limestone - as before.
67	1.5 m	Limestone - as before. Sample from uppermost 18 cm.

Bell Point (continued)

0.7 m Limestone - medium to dark grey, fine-grained; biostromal development of stromatoporoids; which weather to a pale grey-brown, producing an irregular, nodular-like surface.

66 1.6 m Limestone - medium to dark grey, fine-grained, slightly fossiliferous - a few stromatoporoids, corals and brachiopods. Sample from upper 15 cm.

65 1.4 m Limestone - as before. Sample from upper-most 13 cm.

0.5 m Limestone - medium to dark grey, fine-grained; biostromal development of stromatoporoids, which weather to a pale grey-brown, producing an irregular, nodular-like surface.

0.9 m Limestone - medium to dark grey, fine-grained, slightly fossiliferous - a few stromatoporoids, corals and brachiopods.

64 0.9 m Limestone - as before. Sample 64 taken in the interval 20-30 cm below top, yielded conodonts.

5.2 m Limestone - as before, but with abundant (95 %) stromatoporoids up to 45 cm in diameter; with occasional lenses of dark grey limestone bearing coral fragments in the matrix, and some irregular patches of dark grey argillaceous limestone.

Bell Point (continued)

63	2.2 m	Limestone - dark grey, fine-grained. Sample 63 taken 30 cm below top of unit.
	1.1 m	Limestone - medium grey, fine-grained, weathering to light grey-brown, pitted and mottled surface, some patches of dark grey encrusting material; abundant stromatoporoids (biostrome) with little or no matrix.
62	0.9 m	Limestone - dark grey, banded appearance due to alternating beds of fine and coarser grained limestone, in bands 5 mm to 5 cm thick. The coarser grained bands softer. Bands show regular parallel bedding. Sample from lower half, 2 pieces, yielded conodonts.
	1.1 m	Limestone - as before.
61	1.6 m	Limestone - as before. Sample from uppermost 8 cm.
60	3.7 m	Limestone - as before. Sample from uppermost 15 cm.
59	2.2 m	Limestone - as before. Sample from uppermost 15 cm.

Bell Point (continued)

58	2.1 m	Limestone - dark grey, fine-grained, thinly bedded; alternation of hard and soft beds, with scattered stromatoporoids in the softer beds. Sample from uppermost 5 cm.
---	---	---
Gap	3-6 m	No outcrop - section covered by beach sand.
---	---	---
""""""""""""""""""""""""		Section offset - 30 m north-east.
		BELL POINT LIMESTONE:
57	2.9 m	Limestone - dark grey to black, fine-grained, thinly bedded; soft beds, 10-13 cm thick, separated by harder bands, 6 mm to 5 cm thick - these bands impregnated with iron compounds, and normally parallel to bedding planes, were previously argillaceous and black. Scattered stromatoporoids in the softer layers. Sample 57 from the uppermost 15 cm.
56	1.6 m	Limestone - as before. Sample from uppermost 15 cm.
55	5.9 m	Limestone - as before. Sample from softer beds.
54	2.3 m	Limestone - as before, with scattered stromatoporoids up to 18 cm in diameter; irregular patches of

Bell Point (continued)

argillaceous limestone and calcareous shale. Sample 54 yielded conodonts.

Gap 0.9 m No outcrop - section covered by beach sand. Suspect tectonic contact.

"""""""""""""""""""""" Section offset - 30 m north-east.

57 2.9 m Limestone - dark grey to black, fine-grained, thinly bedded; soft beds, 10-13 cm thick, separated by harder bands, 6 mm to 5cm thick - these bands impregnated with iron compounds, and normally parallel to bedding planes, were previously argillaceous and black. Scattered stromatoporoids in the softer layers. Sample 57 from the uppermost 15 cm.

56 1.6 m Limestone - as before. Sample from uppermost 15 cm.

55 5.9 m Limestone - as before. Sample from softer beds.

54 2.3 m Limestone - as before, with scattered stromatoporoids up to 18 cm in diameter; irregular patches of argillaceous limestone and calcareous shale. Sample 54 yielded conodonts.

Bell Point (continued)

BELL POINT LIMESTONE

Gap 0.9 m No outcrop - section covered by beach sand.

1.5 m Limestone - medium to dark grey, fine-grained; with scattered fossil remains - shell fragments.

53 0.5 m Limestone - as before. Composite sample - 3 pieces.

1.2 m Limestone - biostromal : with abundant large stromatoporoids, 10-12 cm in diameter, which appear to be in situ (autochthonous), embedded in a dark grey calcareous matrix, together with irregular patches of black calcareous shale.

0.3 m Limestone - medium grey, fine-grained, with scattered rugose corals (up to 12 cm in length), plus occasional gastropods (Waratahella) up to 5 cm in diameter.

52 0.3 m Limestone - as before. Sample from uppermost 15 cm.

0.9 m Limestone - dark grey, fine-grained, moderately argillaceous, with irregular layers and lenses of very argillaceous limestone or calcareous shale. Branched corals scattered throughout the unit.

Bell Point (continued)

0.05 m Shale - black, slightly calcareous, with ostracodes.

51 0.8 m Limestone - dark grey, fine to medium grained, somewhat argillaceous in the upper half; interspersed with lenses of very argillaceous limestone to calcareous shale. Many stromatoporoids, 3-23 cm in diameter, and large rugose corals up to 15 cm long, present on the bedding plane in middle of unit. Sample 51 from the uppermost 15 cm.

0.8 m Limestone - dark grey, fine-grained, with a thin bed (15 cm thick) of argillaceous limestone in middle. Some corals + "maggoty" surface (suggests Amphipora.)

2.3 m Limestone - medium to dark grey, thinly bedded, in layers 8-20 cm thick, with occasional rugose corals.

0.2 m Shale - black, badly weathered.

50 0.3 m Limestone - medium to dark grey, in 5 thin beds, with small gastropods, particularly in the upper half. Sample 50 yielded conodonts.

0.6 m Limestone - medium to dark grey, fine-grained, with abundant, large rugose corals (up to 25 cm in length) and stromatoporoids (3-37 cm in diameter). Fossils constitute about 90% of the rock. Enriched with brachiopods in shaley patches. "The Biostrome."

Bell Point (continued)

49b	0.8 m	Limestone - medium to dark grey, with many stromatoporoids and scattered corals - denser in some patches. Sample taken at top of unit.
	1.1 m	Limestone - dark grey, fine-grained, with scattered brachiopods, rugose corals and rare stromatoporoids; beds meshed with many calcite veins (2 mm thick).
49a	0.4 m	Limestone - dark grey, fine-grained, with scattered brachiopods, branched corals and stromatoporoids in the uppermost 13 cm. Composite sample - 2 pieces.
48	0.9 m	Limestone - medium to dark grey, medium-grained : barren of macrofossils. Sample from uppermost 10 cm.
	0.1 m	Shale - dark grey to black.
	0.3 m	Limestone - medium to dark grey, medium-grained, with scattered brachiopods in the lowermost 5 cm.
	0.1 m	Shale - dark grey to black.
	0.3 m	Limestone - medium to dark grey, argillaceous, with many rugose and branched corals, some brachiopods and scattered stromatoporoids, up to 5 cm in diameter.
	0.1 m	Shale - dark grey to black, with many rugose corals.
	0.2 m	Limestone - dark grey, medium-grained, argillaceous.

Bell Point (continued)

47 0.3 m Limestone - grey-brown, argillaceous, grading to dark grey, fine-grained limestone towards the top. Large Waratahella (up to 5 cm in diameter) present.

0.1 m Shale - dark grey to black.

1.1 m Limestone - medium grey, medium to fine grained, argillaceous, thinly bedded, in layers 10-20 cm thick, increasing in thickness towards the top. One layer (8 cm thick) rich in rugose corals.

46 0.2 m Limestone - dark grey, fine-grained, yielding microscopic fish remains.

2.4 m Limestone - medium grey, fine-grained, thinly bedded, argillaceous; alternating with very thin layers of calcareous claystone. Beds show evidence of cyclic sedimentation, with layers of argillaceous limestone repeatedly capped by thin bands of non-argillaceous limestone, some 5 cm thick. Some beds with rugose corals and occasional brachiopods.

45 1.8 m Limestone - medium grained, grey-brown, argillaceous in upper half, in beds 8-20 cm thick, with "maggoty" surface indicating Amphipora. A thin bed (3 cm thick) at the top composed mainly of large rugose corals. The lowermost 60 cm consisting of medium to dark grey limestone, very argillaceous and with scattered

Bell Point (continued)

brachiopods and rugose corals. Sample 45 from the uppermost 5 cm consisted of 2 pieces.

44 0.9 m Limestone - medium grey, fine-grained, well bedded, in layers 3-15 cm thick, with irregular patches and lenses of dark grey argillaceous limestone throughout. Sample 44 at top, yielded conodonts and fish remains.

"""""""""""""""""""""""" Section offset - 9.0 m to the east.

43 1.8 m Limestone - medium to dark grey, grey-brown tint on weathering, thickly bedded. Amphipora present.

42 2.6 m Limestone - as before.

41 4.6 m Limestone - as before, but in beds ranging from 8-90 cm thick, and somewhat argillaceous. Dip = 39°. Sample 41 yielded conodonts and fish remains.

40 2.1 m Limestone - medium grey, fine to medium grained, grey-brown tint on weathering; very thickly bedded.

0.5 m Shale - slightly silty, medium grey, becoming calcareous towards the top, where the uppermost 15 cm grades into an argillaceous limestone. This unit resistant to weathering due to impregnation by iron and manganese, plus silicification in some layers.

39 1.2 m Limestone - medium grey, in 7 beds, 15-25 cm thick, alternating with extremely thin beds of shale. The unit weathers to a yellowish-grey.

Bell Point (continued)

Gap	0.5 m	No outcrop - sea channel (? shales)
	0.2 m	Limestone - medium grey, fine to medium grained.
	0.1 m	Shale - black, soft, somewhat silty.
	0.9 m	Limestone - medium to dark grey, medium grained. thickly bedded, with many Waratahella (2 cm in diameter), especially in the uppermost part.
	0.2 m	Shale - medium to dark grey; tectonically squeezed and crumpled.
	0.5 m	Limestone - medium to dark grey, several beds alternating with thin layers of black silty shale. Upper bedding plane with a "plaster" of Waratahella.
38	1.0 m	Limestone - medium grey, in approximately 9 beds, alternating with very thin layers of black silty shale, altered by silicification. Limestone with a honey-comb appearance and brown tint on weathering. Sample 38 with microscopic fish remains.
	0.1 m	Limestone - dark grey, argillaceous, honey-comb appearance on weathering.
37	0.3 m	Limestone - medium grey, in 3 beds separated by

Bell Point (continued)

thin layers of argillaceous limestone, 1-5 cm thick. Honey-comb appearance on weathered surface.

2.5 cm Shale - dark grey to black, slightly silty.

0.3 m Limestone - dark grey, 3 beds alternating with thin layers of black shale; lowermost 5 cm with 80% Waratahella.

"""""""""""""""""""""""" Section offset - 72 m south, immediately beyond the fault between Gair Rock and Mushroom Rock, using a guide horizon.

1.4 m Limestone -black, silty; pitted surface; clay increasing towards bottom of bed. Abundant Waratahella (4 cm in diameter).

0.2 m Limestone - medium grey, with scattered shell fragments of small gastropods and brachiopods.

5.0 cm Shale - black, silty.

0.2 m Limestone - as before, with occasional rugose corals.

0.1 m Shale - black, silty, calcareous; weathering to grey.

28 0.2 m Limestone - medium grey, with fragments of rugose corals, brachiopods and abundant Waratahella on the uppermost bedding plane. Sample 28 - two pieces.

Bell Point (continued)

0.5 m Limestone - medium grey, in thin beds, 9-19 cm thick, alternating with very thin layers of black, calcareous shales, 1-2 cm thick.

2.2 m Limestone - dark grey to black, in thin beds, 5-10 cm thick; argillaceous in parts, alternating with thin beds of black, silty, calcareous shales, 1-50 cm thick, with many calcite veins parallel to bedding planes. Beds teeming with Waratahella (2-3 cm in diameter), which weather out to produce a pitted surface.

29 2.6 m Limestone - as before, alternating with shales (as before), and teeming with Waratahella (as before). Sample 29, from uppermost bed, yielded ostracodes and abundant fish remains.

30 3.2 m Limestone - as before, alternating with shales (as before), but with scattered Waratahella and in the lower part, a few coral remains. Sample 30, two pieces, from the uppermost bed, yielded abundant fish remains, some ostracodes and rare conodont fragments.

Y 0.6 m Shale - black, slightly silty, calcareous, in a few thin beds, 2-3 cm thick, with Waratahella more abundant in some beds. Lithological sample Y shows small scale slickensiding.

Bell Point (continued)

31 0.6 m Limestone - medium to dark grey, fine-grained, in three beds, the middle one very argillaceous; scattered Waratahella in uppermost bed. Sample 31 from lowermost bed yielded ostracodes, fish remains and rare conodonts.

32 1.9 m Shale - dark grey to black, silty calcareous; in thin beds, 2-25 cm thick; some relatively hard beds with abundant ostracodes, scattered brachiopods and shell remains of unknown affinities; softer beds badly eroded. Sample 32 (composite) from uppermost bed yielded numerous fish remains in addition to ostracodes.

33 0.5 m Limestone - dark grey, fine-grained, silty, very
26 hard and sharply etched, giving a honey-combed appearance; barren of macrofossils.

34 0.3 m Siltstone - medium grey, slightly calcareous, fairly soft; with abundant fish remains (head-shields, plates, scales, teeth) and ostracodes, in a "bone-bed" layer, 5-8 cm thick; occasional large Waratahella. Composite sample - several pieces.

0.1 m Limestone - as before, but very argillaceous.

Bell Point (continued)

1.4 m Shale - dark grey to black, very silty, some beds calcareous and hard, others carbonaceous and soft. Scattered shell fragments in uppermost bed and large Waratahella in lower part of unit.

35 25 24 23 22 3.6 m Siltstone - medium to dark grey, calcareous, very hard, thickly bedded. Abundant fish remains - "bone beds" with armoured head-shields; numerous ostracodes; scattered Waratahella in some layers. Composite sample - several pieces.

36 1.2 m Siltstone - medium grey, fine-grained to sandy in the lower part, very calcareous in the upper part, which yields ostracodes. The lowermost bed transgressing the pale grey Waratah Limestone at a low angle of unconformity - well displayed on the western face of Gair Rock.

BOTTOM OF SECTION

UUUUUUUUUUUUUUUU UNCONFORMITY - separating the dark grey silty BELL POINT LIMESTONE above from the pale grey WARATAH LIMESTONE below.

Note: Two sections were measured in the Waratah Limestone at Bell Point, one at Gair Rock and the other at Mushroom Rock. Both sections commence at the unconformity and proceed due east across the wave-cut platform until the section is covered by the sea.

Bell Point (continued)

WARATAH LIMESTONE : Mushroom Rock Member

MUSHROOM ROCK SECTION

"""""""""""""""""""""" Section offset - 20 m to the south.

UUUUUUUUUUUUUUU UNCONFORMITY.

General Description: A succession of light to medium grey limestones, fine to medium grained, porous, thickly bedded, dipping 35-37° to the west, striking due north; pale yellowish-brown on weathering; macrofossils rare, but all samples yielding conodonts : more prolific in the lower half.

	2.0 m	Limestone - as above, with large, irregular infillings (up to 70 cm thick & 3 m in length) of dark grey to black quartzitic siltstone - probably Bell Point Limestone material infilling old solution channels.
320	1.3 m	Limestone - as above, with smaller infillings.
321	1.9 m	Limestone - as above, but without infillings.
322	3.1 m	Limestone - as before.
323	5.0 m	Limestone - as before.
324	4.7 m	Limestone - as before.
325	5.4 m	Limestone - as before.

Bell Point (continued)

Gap	3.4 m	No outcrop - sea channel.
326	2.3 m	Limestone - as before.
	2.8 m	Limestone - as before.
327	0.5 m	Limestone - as before.
328	4.5 m	Limestone - as before.
329	1.9 m	Limestone - as before.
330	3.0 m	Limestone - as before.
331	2.2 m	Limestone - as before.
G.B.1		
332	1.4 m	Limestone - as before.
333	1.2 m	Limestone - as before.
334	3.6 m	Limestone - as before.
**********		Section covered by sea.

Bell Point (continued)

WARATAH LIMESTONE : Mushroom Rock Member

GAIR ROCK SECTION

"""""""""""""""""""""" Section offset - 10 m to the north.

UUUUUUUUUUUUUUU UNCONFORMITY.

General Description: A succession of light to medium grey limestones, fine to medium grained, porous, thickly bedded, dipping 35-37° to the west, striking due north; pale yellowish-brown on weathering; macrofossils rare, but most samples yielding conodonts. Dark grey to black siltstones are found infilling old solution channels in the uppermost 10 m of the section.

20	1.6 m	Limestone - as above.
19	1.6 m	Limestone - as above.
18	2.3 m	Limestone - as above.
17	3.6 m	Limestone - as above.
16	0.7 m	Limestone - as above.
15	1.8 m	Limestone - as above.
14	3.6 m	Limestone - as above.
13	2.3 m	Limestone - as above.

Bell Point (continued)

""""""""""""""""""""		Section offset - 24 m to the north.
12	0.7 m	Limestone - as above.
11	2.1 m	Limestone - as above.
10	2.1 m	Limestone - as above.
""""""""""""""""""""""		Section offset - 15 m to the south.
9	2.5 m	Limestone - as above.
8	1.1 m	Limestone - as above.
""""""""""""""""""""""		Section offset - 16 m to the south.
7	1.6 m	Limestone - as above.
6	1.4 m	Limestone - as above.
5	2.0 m	Limestone - as above.
4	2.3 m	Limestone - as above.
2	0.5 m	Limestone - as above.
1	2.7 m	Limestone - as above.
0	1.0 m	Limestone - as above.
**********		Section covered by sea.

Bell Point (continued)

Total thickness of BELL POINT LIMESTONE ..... 76.5 m

Exposed thickness of Mushroom Rock Member ..... 50.2 m

Exposed thickness of Lower Grinder Member .....119.2 m

Total thickness of exposed WARATAH LIMESTONE .....169.4 m

Total thickness of complete Bell Point Section .....245.9 m

A field map of Bell Point showing the various section traverses and other salient features, is included overleaf.

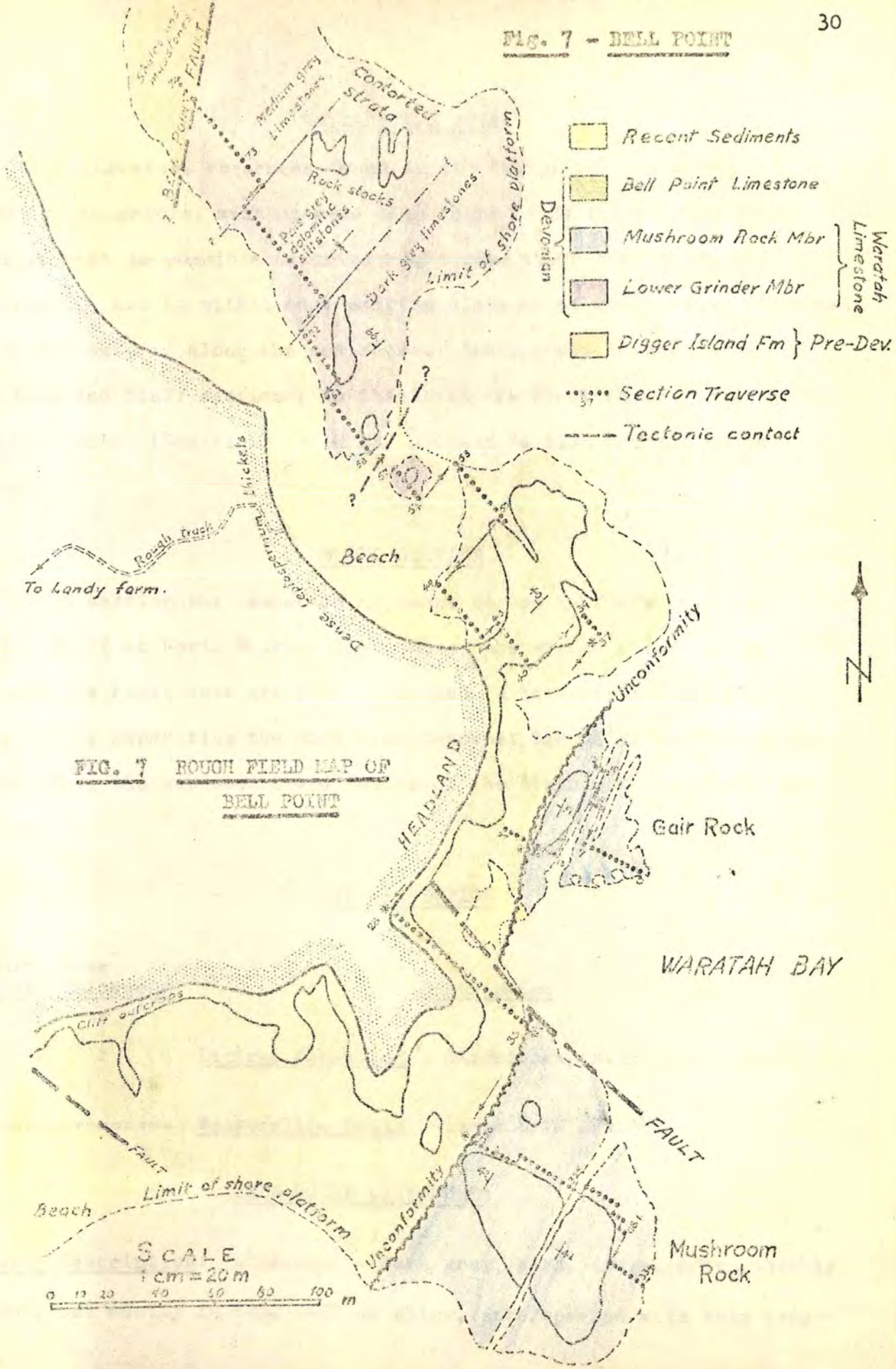


FIG. 7 ROUGH FIELD MAP OF BELL POINT

WALKERVILLE AREA

The limestone sequences found in the Walkerville area are readily accessible, much more-so than those of Bell Point and Point Grinder. It is possible to drive right onto the beach at South Walkerville and be within easy walking distance of the various outcrops, which are exposed along the sea shore. Immediately to the north are the Kiln and Bluff sections; to the south are Black Stack, Robin Rocks and Bird Rock (See Figs. 17 to 28 and Section Profiles - in pocket).

BLUFF SECTION

This section was commenced adjacent to the cliff-face known as The Bluff at North Walkerville. Here, the mashed rocks of the Walkerville Fault zone are well displayed in both cliff and shore (Fig. 27), separating the dark limestones of the Bluff Section to the south, from the sandstones and shales of the Liptrap Formation to the north.

TOP OF SECTION

Sample Number	True Thickness	Description
	?	Liptrap Formation : Sandstones, siltstones, shales.
	==========	Walkerville Fault (zone 8-10 m wide)

BELL POINT LIMESTONE:

General Description: Limestone - dark grey, hard, dense, often thickly bedded, but mostly in beds 5-30 cm thick, interspersed with thin beds

BLUFF SECTION, WALKERVILLE (continued)

of calcareous shale 1-2 cm thick. Intense shattering of rock, meshed by calcite veins, increasing in proximity to faults. Limestone with abundant Amphipora (biostromal). Strike of beds varies from 30-40° ; dipping 42-54° to the west. Total thickness = 63.4 m.

163 366	0.5 m	Limestone - as above. Sample 163, 2 pieces, yielding conodonts. All other samples from the Bluff were barren.	
367	2.0 m	Limestone - as above.	
159	9.3 m	Limestone - as above.	) Samples from parallel section, 90 m east on wave-cut platform.
159 b	3.5 m	Limestone - as above.	
160	5.7 m	Limestone - as above.	
164	0.7 m	Limestone - as above.	
165	5.2 m	Limestone - as above, with some stromatoporoids.	
161	0.2 m	Limestone - as above.	) Samples from parallel section - as above.
162 369	3.2 m	Limestone - as above.	
	3.0 m	Limestone - as above, but increased shattering.	
166	1.0 m	Limestone - as above.	

Bluff Section, Walkerville (continued)

167 3.7 m Limestone - as before.

7.4 m Limestone - as before.

168 7.9 m Limestone - as before.

169 6.4 m Limestone - as before.

========= 2.4 m THRUST FAULT - a zone of black pug.

The remaining beds show a marked increase in dip (72-80°); strike 60°.

140 1.2 m Limestone - dark grey, dense, finely crystalline; shattered & meshed by numerous calcite veins - fractures approximately vertical to bedding planes; abundant Amphipora in middle 30 cm.

141 0.7 m Limestone - dark grey to black, in layers 5-15 cm thick; slightly fractured - near vertical calcite veins, 2-8 mm thick.

142 0.8 m Limestone - as before, but leached and impregnated in places producing an orange-brown colour; dolomitic or silty in lower 60 cm, with angular fragments (1-5 cm long) of grey-black limestone containing scattered shell remains, solitary corals and Amphipora (2.5 cm long) - especially in topmost 12 cm of the lower 60 cm of the unit. The uppermost 15 cm is interspersed with many shell fragments and

Bluff/Kiln Sections, Walkerville (continued)

branched Amphipora. Towards the bottom, the unit grades into slightly calcareous siltstone, with some rugose corals present.

N.B. This unit paraconformably overlies the pale, whitish grey limestone of the Kiln Section (See Figs.25,26.)

143 Lithological Sample 143 shows the direct contact of Bluff and Kiln units, with no apparent tectonic thrusting as previously thought.

BASE OF BLUFF SECTION

UUUUUUUUUUUUUUUU UNCONFORMITY

WARATAH LIMESTONE : Mushroom Rock Member:

TOP OF KILN SECTION

144 0.2 m Limestone - whitish grey, finely crystalline, with a grey-brown tint on weathering, exceedingly shattered and meshed with calcite veins in proximity to a fault, not observed directly, because of sand cover.

145 2.9 m Limestone - as above.

146 3.1 m Limestone - as above.

147 3.1 m Limestone - as above.

148 3.1 m Limestone - as above.

Kiln Section, Walkerville (continued)

4.9 m Limestone - as before, dipping 60-65°.

22.6 m Limestone - as before, but with coarsely crystalline fragments of calcite forming irregular patches and veins to the extent of 70 % of the limestone.

Note: This "northern slice" of the Kiln Section has an exposed thickness of 39.9 m. The section ends in the sea.

The "southern slice" of the Kiln Section commences at the erosion surface level with the top of the cliff and the old lime kiln. It is the first outcrop of limestone in cliff section at the northern end of the South Walkerville surfing beach. Total thickness = 15.4 m.

TOP OF SECTION. (Dip = 17-22°; Strike = 70°)

343 3.7 m Limestone - badly weathered, much iron staining.

152 1.0 m Limestone - light to medium grey, fine grained; in beds 5-30 cm thick; but with massive appearance. Abundant stromatoporoids and corals - fragmental. Conodonts present.

342 1.0 m Limestone - as before, but without macrofossils.

341 2.7 m Limestone - as before, but medium grained and slightly dolomitic.

151 1.0 m Limestone - grey, medium to coarse grained; with occasional stromatoporoids (up to 5 cm long) and

some corals. Impregnated to give a greyish-brown.

340 1.3 m Limestone - pale grey, fine grained, dense; with occasional stromatoporoids (up to 11 cm long) and abundant corals. Sample 340 yielded conodonts.

339, 150 1.0 m Limestone - pale, whitish grey, coarse grained, very porous, crystalline; in beds 10-45 cm thick. Both samples yielded conodonts.

338 0.7 m Limestone - as before, but medium grained. Sample 338 yielded conodonts.

337, 149 2.0 m Limestone - as before, but in beds 30-60 cm thick. Both samples yielded conodonts.

336 1.0 m Limestone - medium grey, medium grained, with very coarse bioclastic material in lowermost 20 cm.

BOTTOM OF SECTION : Section covered by sand of South Walkerville Beach.

THE BLACK STACK

The name "Black Stack" has been coined in reference to an outcrop of very dark grey limestone, with low relief, some 15 m thick, which is situated at the southern end of the South Walkerville Beach. The limestone beds strike roughly East-West and dip northwards at an angle of 43°. This sequence rests paraconformably on a Pre-Devonian dolomitic basement. (See Fig. 19).

The Black Stack (continued)

TOP OF SECTION

Sample Number	True Thickness	Description
		WARATAH LIMESTONE : Lower Grinder Member:
365	0.6 m	Limestone - dark grey, medium to coarse grained, very silty, thickly bedded. Isolated outcrop.
	3.0 m	No outcrop - section covered by sand.
364 363 362	2.8 m	Limestone - dark grey, medium grained, silty, interbedded with black calcareous siltstones; limestone often in lenses and patches grading into siltstone (55% of the unit). Beds somewhat contorted and irregular towards the top. The 3 samples, taken from top, middle and bottom of the unit, all yielded conodonts.
361 360 120 359 358	4.9 m	Limestone - medium grey, very argillaceous, thinly bedded, in layers 5-12 cm thick, alternating with very thin beds (1-5 cm thick) of grey-black shales, slightly calcareous. Limestone beds lensing out in places and with some corals present. Samples 361 and 120 yielded conodonts. Samples equally spaced throughout the unit.

The Black Stack (continued)

357 119 356	1.4 m	Limestone - dark grey, very argillaceous, thinly bedded, alternating with very thin beds of black, silty shales and calcareous argillite up to 12 cm thick, with occasional tabulate corals (Favosites). Sample 119 yielded conodonts and ostracodes.
118	0.7 m	Limestone - medium to dark grey, silty, with angular fragments and solitary corals throughout. Sample 118 yielded conodonts.
117 355	0.3 m	Limestone - medium grey, irregular, interfingering with sandy to pebbly layers. Abundant rugose corals and stromatoporoids in uppermost 12 cm. Both samples yielded conodonts.
116 354	0.6 m	Limestone ? Calcareous Argillite - dark grey to black, in beds 5-20 cm thick, silty to sandy. Both samples yielded conodonts and ostracodes.
115 353 114	4.0 m	Limestone - pale grey, fine silty to fine sandy, grading to calcareous siltstone; yellow-brown colour by impregnation and weathering; thinly bedded, in layers 10-30 cm thick, with rich shelly fauna and pebbles in some beds. Fragments of medium grey dolomite and blackish chert increasing towards the bottom. Abundant conodonts.
352	0.3 m	Argillite - pale grey-green, agglomeratic, with

The Black Stack (continued)

small fragments of chert, 5-10 mm in diameter; subrounded pebbles of varying size in a ? tuffaceous matrix.

BOTTOM OF SECTION

UUUUUUUUUUUUUUUU UNCONFORMITY - on pale grey dolomitic basement.

ROBIN ROCKS

Robin Rocks is located about 90 m south-east of the Black Stack, mid-way between South Walkerville and Bird Rock. The limestones rest paraconformably on the same Pre-Devonian dolomitic basement observed at the Black Stack. The section reaches its maximum thickness of only 4.6 m in a small, yellowish rock stack left as an erosion remnant on the fore-shore. The beds strike roughly East-West, dipping to the north at an angle of 27-33° (See Fig. 20).

TOP OF SECTION (erosion surface)

Sample Number	True Thickness	Description
		WARATAH LIMESTONE : Lower Grinder Member:
113	0.4 m	Limestone - pale grey to yellow ochre by weathering and impregnation; fine silty to fine sandy, grading to calcareous siltstone; in beds from 10-60 cm or more; fragments of medium grey dolomite and grey-black chert increasing towards the bottom. Pebbles

Robin Rocks (continued)

		with average diameter of 2 cm common in some bands. Macrofossils abundant in thin beds, include a mixed shelly fauna of tabulate and rugose corals, crinoid stems, brachiopods and some stromatoporoids.
112	2.0 m	Limestone - leached, as above.
111	1.7 m	Limestone - as above.
110	0.5 m	Argillite - pale greenish-grey, red tint due to impregnation by iron compounds; very silty to fine sandy siltstone, almost non-calcareous; with angular fragments of dark grey chert (agglomeratic).
UUUUUUUUUUUUUUUU		UNCONFORMITY. BOTTOM OF SECTION
Basement		Dolomitic material - medium grey, very hard.

BIRD ROCK

Bird Rock refers to a sequence of limestones which project eastwards into Waratah Bay for a distance of several hundred metres. There are three large rock stacks known locally as Inner, Middle and Outer Bird Rocks respectively. The first two are tied to the shore by a rocky platform tumbled with large boulders of ironstone, covered at high tide, but Outer Bird Rock is cut off by a wide sea channel. (Fig. 28). The limestones of Inner and Middle Bird Rocks strike east-west and dip 32° north. A Pre-Devonian dolomitic basement is exposed at Inner Bird Rock and immediately to the south, Cambrian Greenstones

crop out along the fore-shore.

BASAL SEQUENCE, INNER BIRD ROCK

Sample Number	True Thickness	Description
		Top of Section - Erosion Surface
502	5.2 m	Dolomitic Limestone - medium grey, medium grained, yellowish-brown on weathering, argillaceous in parts, thickly bedded.
501	1.0 m	Dolomitic Limestone - as above, but more argillaceous.
500	0.5 m	Dolomitic Limestone - as above, but conglomeratic.
UUUUUUUUUUUUUUUU		DISCONFORMITY? Bottom of section.
0500	?	Pre-Devonian dolomitic basement?

INNER BIRD ROCK

This sequence is located immediately south of the basal section (Fig. 17) just described, and reaches a thickness of 21 m.

Sample Number	True Thickness	Description
		WARATAH LIMESTONE : Mushroom Rock Member:
		Top of Section - Erosion Surface.
351	15.0 m	Limestone - pale grey, medium to coarse grained, silty, with darker fine-sandy inclusions; somewhat

Inner Bird Rock (continued)

		leached and weathered to yellow-brown colour. Well bedded, in beds 30-60 cm thick
350	2.1 m	Limestone - as above.
349	1.5 m	Limestone - as above.
348	1.0 m	Limestone - as above.
""""""""""""""""""""""""		Section offset - about 30 m south. (sea channel).
347	1.4 m	Limestone - as above, but increased silt and somewhat dolomitic, with small fragments of quartz.
**********		Section covered by sea.

....

MIDDLE BIRD ROCK

This section was measured on the wave-cut platform along the western edge of Middle Bird Rock (Fig. 12), bearing 330°, roughly in the direction of dip, normal to strike. Exposed thickness = 68 m.

Sample Number	True Thickness	Description
		WARATAH LIMESTONE : Mushroom Rock Member:
		General description: Light grey limestones, fine grained, well bedded, in beds up to 2 m thick, silty in parts; some calcite veining in upper part; macrofossils rare or absent; conodonts not found.

Middle Bird Rock (continued)

**********		Section covered by sea.
137	19.4 m	Limestone - light grey, fine grained, thickly bedded, in beds up to 2 m thick; silty in parts.
""		Section offset - 15 m east.
136	16.2 m	Limestone - as above.
""		Section offset - 9 m east.
135	12.9 m	Limestone - as above.
134	9.7 m	Limestone - as above.
133	6.5 m	Limestone - as above.
132	3.2 m	Limestone - as above.
130	?	Limestone - as above.
**********		Section covered by sea.

....

SUMMARY OF WALKERVILLE SECTIONS DESCRIBED

STRATIGRAPHIC UNITS			EXPOSED THICKNESS
BELL POINT LIMESTONE :			
Bluff Section			63.4 m
WARATAH LIMESTONE :			
Mushroom Rock Member -	Kiln	Northern slice	39.9 m
		Southern slice	15.4 m
	Bird Rock	Middle	67.9 m
		Inner	21.0 m
Lower Grinder Member		Black Stack	15.0 m
		Robin Rocks	4.6 m

FIG. 17 WALKERVILLE

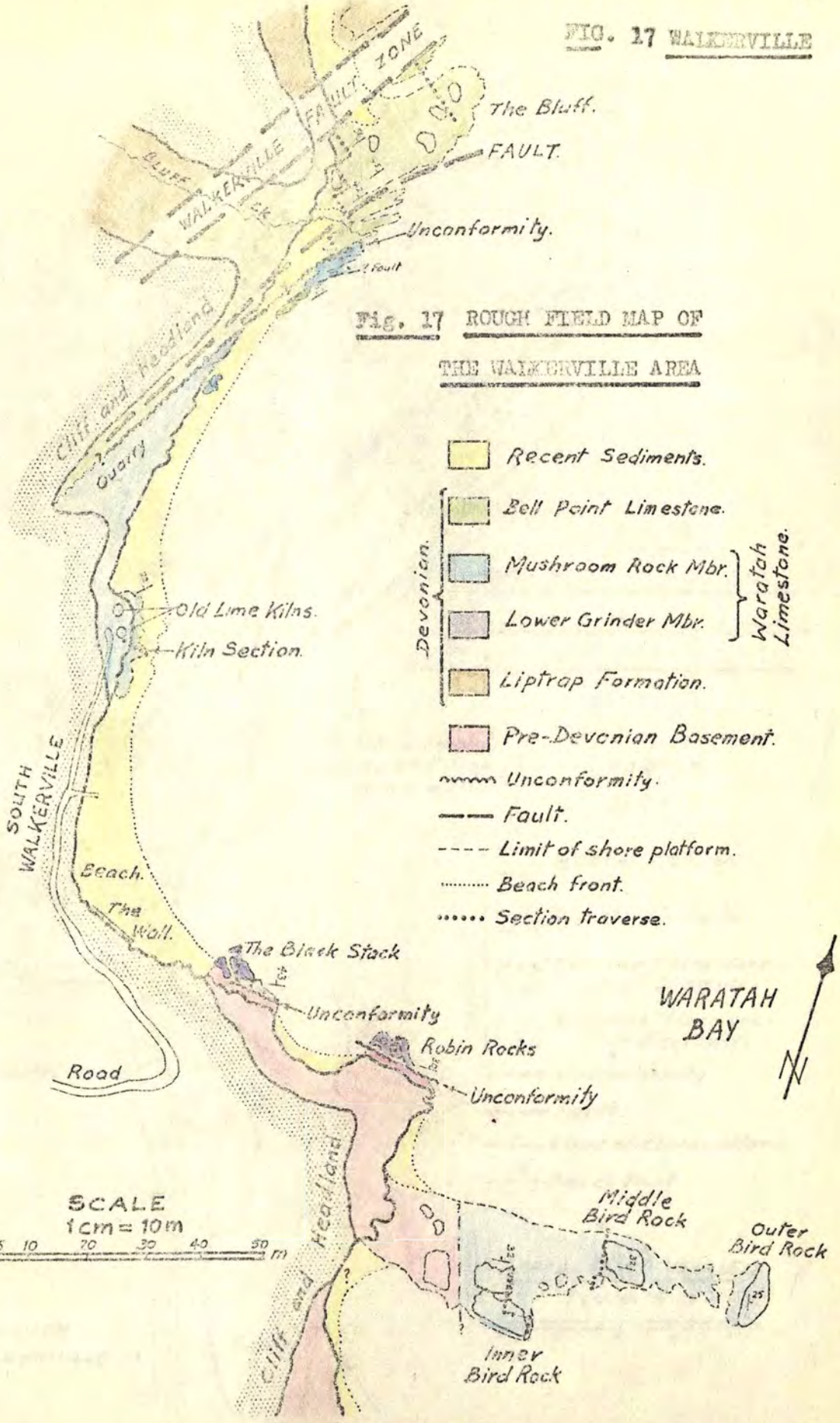
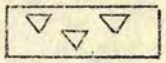
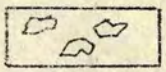
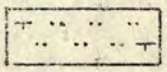


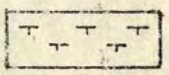
Fig. 17 ROUGH FIELD MAP OF THE WALKERVILLE AREA

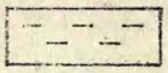
KEY TO SYMBOLS USED WITH STRATIGRAPHIC SECTIONS

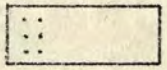

Chert

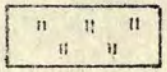

Agglomerate

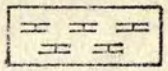

Siltstone

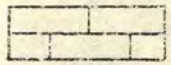

Shale

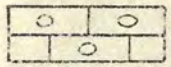

Argillite

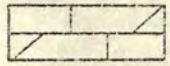

Silty Fm

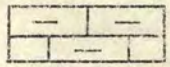

Tuffaceous Fm

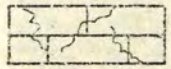

Calcareous Fm


Limestone - stratified


Limestone conglomerate

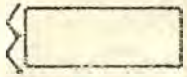

Limestone - dolomitic

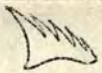

Limestone - argillaceous


Limestone - calcite veined


Concretions or nodules


Igneous / metamorphic basement


Tectonic disturbance


Conodonts


Ostracodes


Stromatoporoids


Amphipora


Rugose corals


Tabulate corals


Fish remains


Brachiopods

Gastropods (Waratahella)


Gastropod remains


Shell fragments


Crinoid columnals

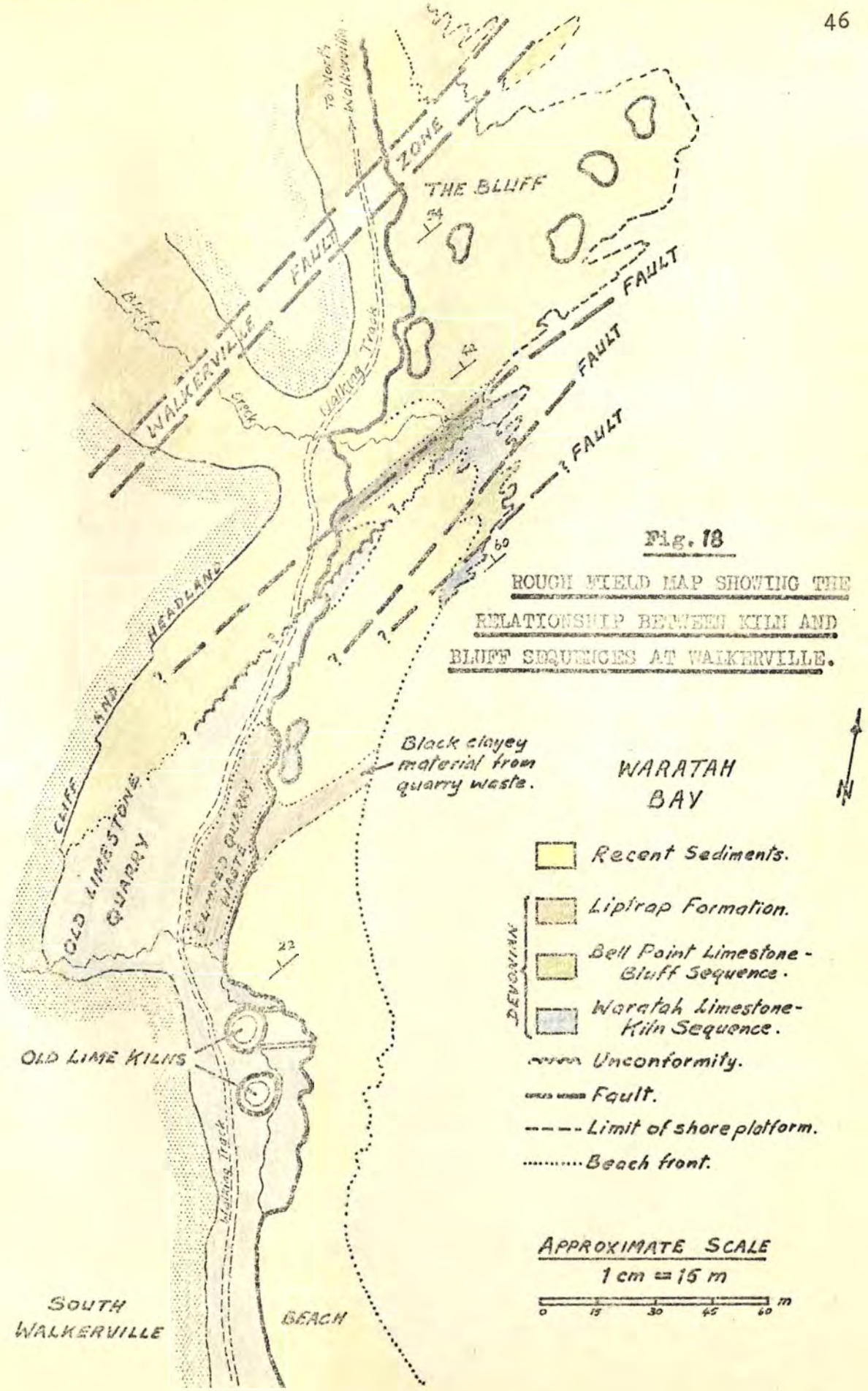


Fig. 18

ROUGH FIELD MAP SHOWING THE RELATIONSHIP BETWEEN KILN AND BLUFF SEQUENCES AT WALKERVILLE.

MUSHROOM ROCK SECTION

WARATAH BAY
VICTORIA

SCALE : 1cm = 1m

m 0 5 10 15 20 25 30 35 40 45 50

1971 SAMPLES

SAMPLE NUMBER / POSITION

334 333 332 N°1 GB. 331 330 329 328 327 326 325 324 323 322 321 320

STRATIGRAPHIC COLUMN

Datum : Low tide mark

Section continues into SEA

Gap { sea channel

UNCONFORMITY

BELL POINT LIMESTONE

UNITS MEASURED

3·0m 0·6m 1·2m 1·4m 2·2m 3·0m 1·9m 4·5m 0·5m 2·8m 2·3m 3·4m 5·4m 4·7m 5·0m 3·1m 1·9m 1·3m 2·0m

DESCRIPTIVE NOTES

WARATAH LIMESTONE, MUSHROOM ROCK MEMBER

A succession of pale grey, medium to coarse-grained, porous calcarenites; in fairly thick beds (0·5 – 1·0m); relatively clean and without interbedded siltstones or shales. Limestones weather to a pale yellowish-brown colour.

Evidence of dark, silty material infilling old solution channels, particularly in the top-most units. This material probably derived from the dark, silty Bell Point Limestone immediatly above the unconformity.

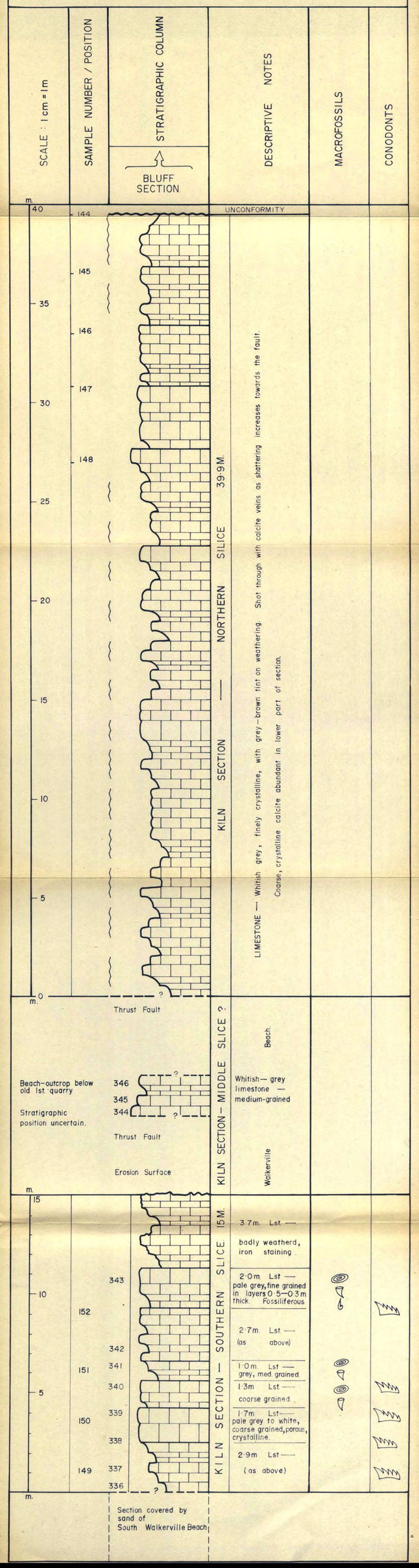
MACROFOSSILS

Macrofossils not obviots, but some corals, stromatopoids, and abundant crinoid stems occur throughout the section, particularly towards the top

CONODONTS

KILN SECTION

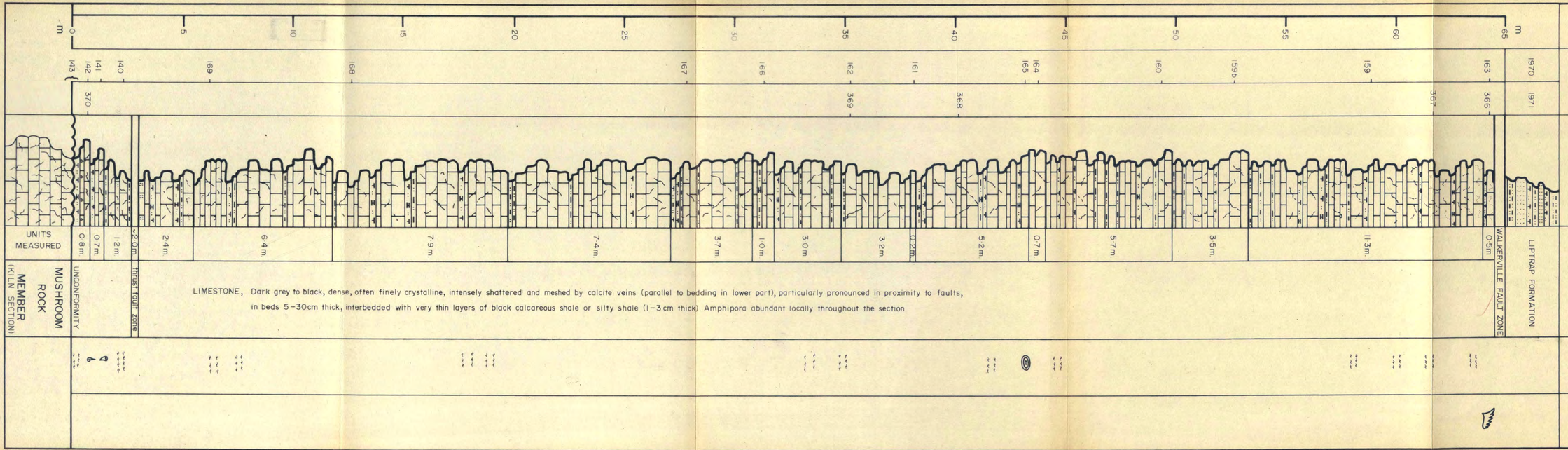
WARATAH BAY
VICTORIA



BLUFF SECTION

WARATAH BAY

VICTORIA



GAIR ROCK SECTION

WARATAH BAY
VICTORIA

m 0 5 10 15 20 25 30 35 40 m

SCALE : 1cm = 1m

1970 SAMPLES 0 – 2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

SAMPLE NUMBER/ POSITION

Section continues into SEA

Datum : Low tide mark.

STRATIGRAPHIC COLUMN

UNITS MEASURED

2·7m | 0·5m | 2·3m | 2·0m | 1·4m | 1·6m | 1·1m | 2·5m | 2·1m | 2·1m | 0·7m | 2·3m | 3·6m | 1·8m | 0·7m | 3·6m | 2·3m | 1·6m | 1·6m

UNCONFORMITY

BELL POINT LST.

WARATAH LIMESTONE, MUSHROOM ROCK MEMBER

DESCRIPTIVE NOTES

LIMESTONE, a succession of pale grey, medium to coarse – grained, porous calcarenites; in fairly thick beds (0·5 – 1·0m); clean and without interbedded siltstones or shales.

Limestone weathers to a pale yellow – brown colour. Macrofossils not obvious.

The top few metres show evidence of infilling of dark silty material into old solution channels, probably from the unit above the unconformity.

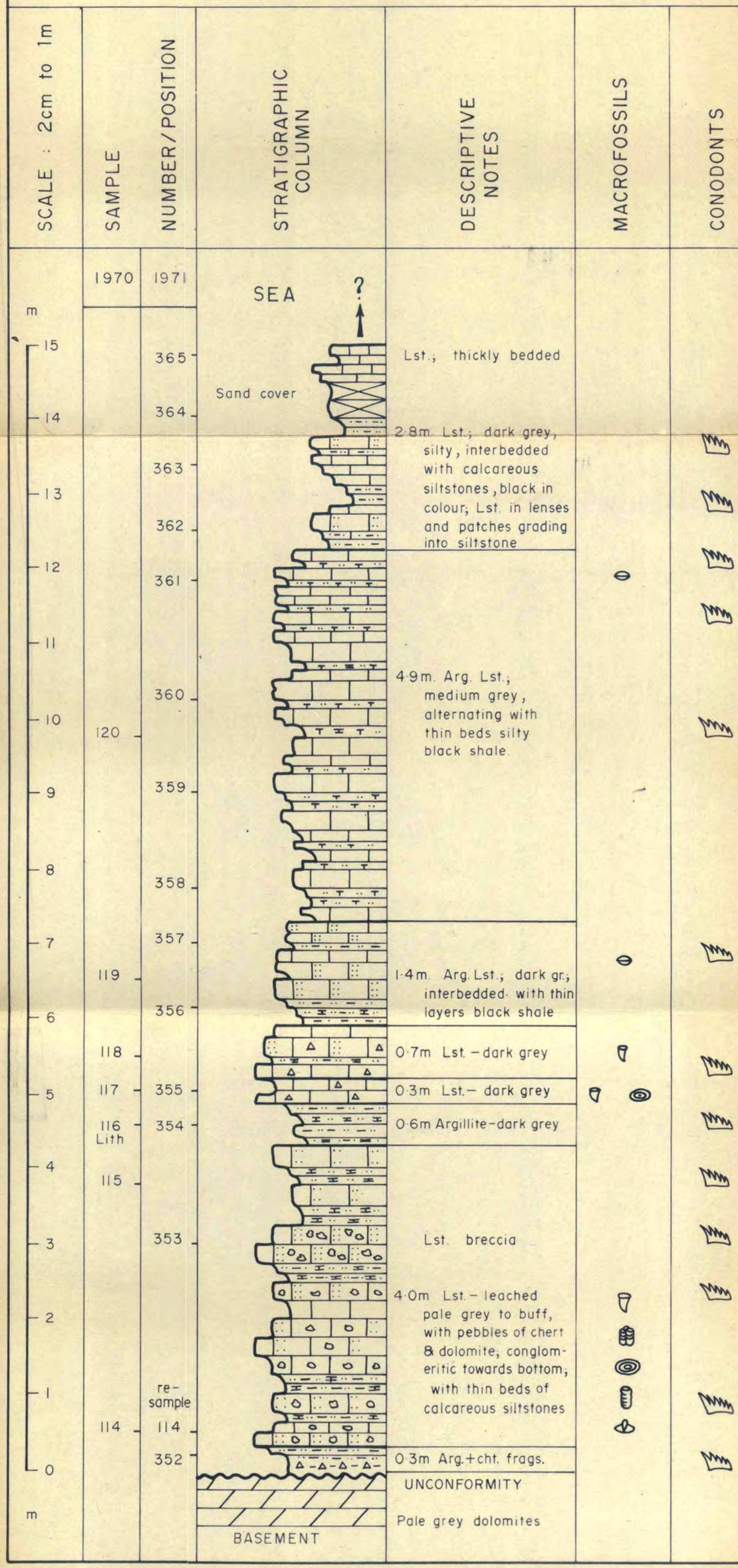
MACROFOSSILS

Macrofossils not obvious but some corals and crinoid stems occur throughout the section, particularly towards the top.

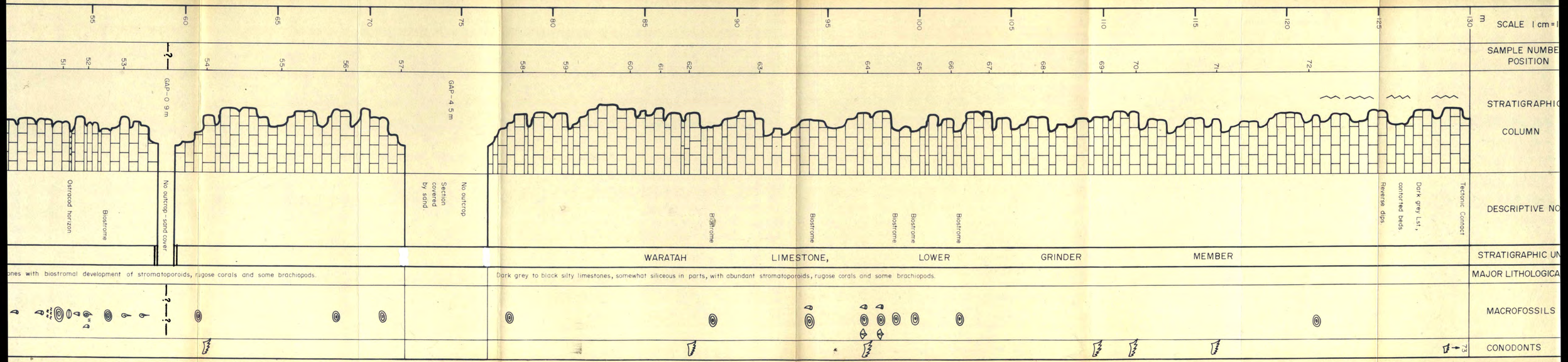
CONODONTS

'BLACK STACK'

BETWEEN ROBINS' ROCKS AND 'THE WALL'



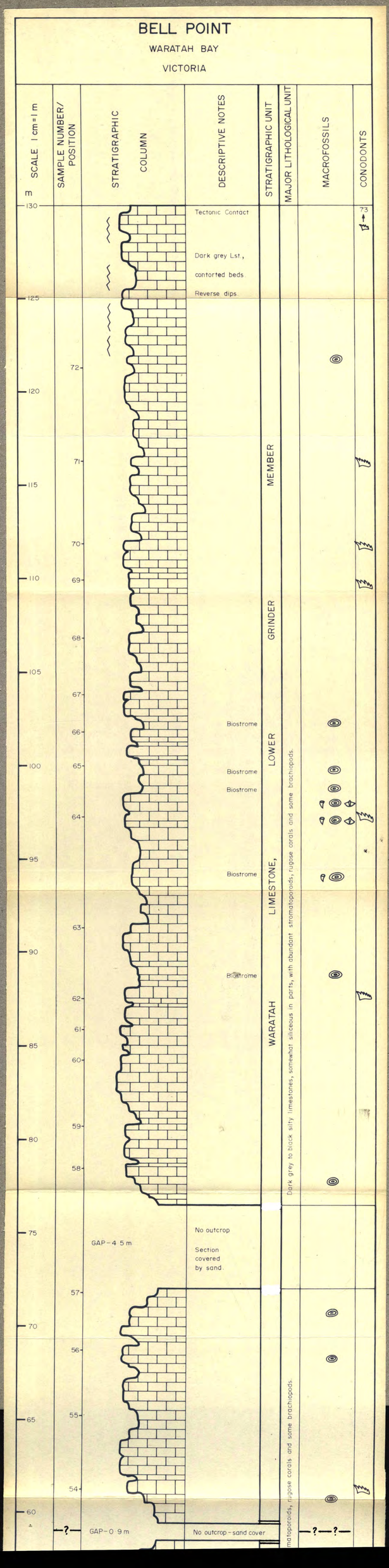
m
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Lith Y
GAP 0.5m
Channel
GAP - 0.9m
MUSHROOM ROCK SECTION
Lst UNCONFORMITY
Lst
Siltst 4.8m calc Siltst
Silt 1.4m Sh
Lst 0.9m calc Siltst
Siltst 1.9 calc Sh
"WARATAHELLA ZONE"
Guide horizon for section offset
Section offset 73m North
SEA CHANNEL
16.4 m arg lst
Lenses arg lst
Section offset 9m West
Evidence of cyclic sedimentation
Biostrome
Ostracod horizon
Biostrome
No outcrop - sand cover
WARATAH LIMESTONE
BELL
POINT
LIMESTONE
MUSHROOM ROCK MEMBER
Dark grey, calcareous siltstones.
Dark grey to black, argillaceous limestones, alternating with thinly bedded shales.
Argillaceous limestones.
Medium to dark grey limestones with biostromal development of stromatoporoids, rugose corals and some brachiopods.

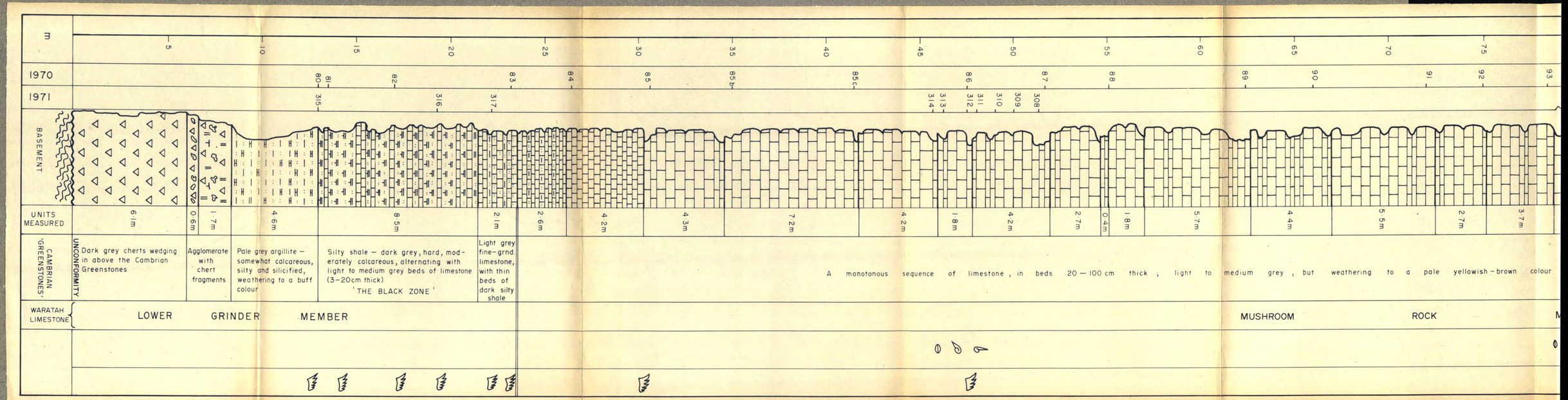

m
SCALE 1 cm = 1
SAMPLE NUMBE
POSITION
STRATIGRAPHIC
COLUMN
DESCRIPTIVE NO
STRATIGRAPHIC UN
MAJOR LITHOLOGICA
MACROFOSSILS
CONODONTS
GAP - 0 9 m
GAP - 4 5 m
Ostracod horizon
Biostrome
No outcrop - sand cover
Section covered by sand
No outcrop
Biostrome
Biostrome
Biostrome
Biostrome
Biostrome
Reverse dips
Dark grey Ls t, contorted beds
Tectonic Contact
WARATAH LIMESTONE, LOWER GRINDER MEMBER
ones with biostromal development of stromatoporoids, rugose corals and some brachiopods.
Dark grey to black silty limestones, somewhat siliceous in parts, with abundant stromatoporoids, rugose corals and some brachiopods.

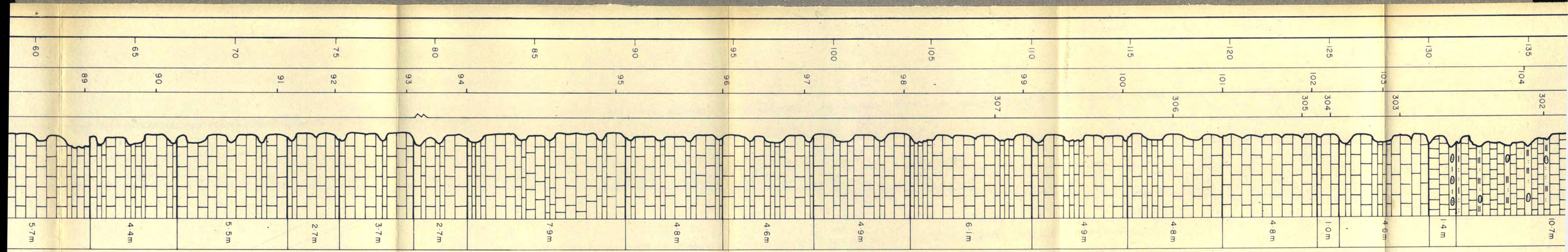
BELL POINT

WARATAH BAY

VICTORIA




m
1970
1971
BASEMENT
UNITS MEASURED
6·1m
0·6m
1·7m
4·6m
8·5m
2·1m
2·6m
4·2m
4·3m
7·2m
4·2m
1·8m
4·2m
2·7m
0·4m
1·8m
5·7m
4·4m
5·5m
2·7m
3·7m
CAMBRIAN 'GREENSTONES'
UNCONFORMITY
Dark grey cherts wedging in above the Cambrian Greenstones
Agglomerate with chert fragments
Pale grey argillite – somewhat calcareous, silty and silicified, weathering to a buff colour
Silty shale – dark grey, hard, moderately calcareous, alternating with light to medium grey beds of limestone (3–20cm thick)
'THE BLACK ZONE'
Light grey fine-grnd. limestone, with thin beds of dark silty shale
A monotonous sequence of limestone, in beds 20 – 100 cm thick; light to medium grey, but weathering to a pale yellowish-brown colour
WARATAH LIMESTONE
LOWER GRINDER MEMBER
MUSHROOM ROCK



light to medium grey, but weathering to a pale yellowish-brown colour; medium to coarse grained, with locally abundant corals, stromatoporoids and crinoid stems.

MUSHROOM ROCK MEMBER

POINT GRINDER

WARATAH BAY
VICTORIA