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Cambro-Ordovician Conodonts from the Burke River Structural Belt Queensland

BY

E. C. DRUCE & P. J. JONES

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CORRIGENDA

Fig. 15. For *Oneodotodus erectus* read *Oneotodus erectus.*

Fig. 23, caption. Delete "holotype" before CPC8746.

Fig. 24, caption. For (d) read (e) and vice versa: (d) *D. tenuis* Moskalenko. CPC8909. (e) *D. suherectus* Branson & Mehl. CPC8902.

p. 112, Locality of CPC8743 is 1/122, *not* 1/22.

SUMMARY

Conodonts from the Upper Cambrian Chatsworth Limestone and Gola Beds and the Lower Ordovician (Tremadocian) Ninmaroo Formation were examined in order to determine the sequence of conodont species. Over 5000 specimens from 600 trough-samples representing a total of 10,000 feet of section were identified. Fifty-three species are described, of which 13 are new and 2 have been given open nomenclature. They are referred to 16 genera, of which one, *Strigaconus,* is new, and two are indeterminate.

No Assemblage Zones could be erected for the Upper Cambrian. However, six Assemblage Zones (in ascending order — *Cordylodus proavus, Oneotodus bicuspatus-Drepanodus simplex, Cordylodus oklahomensis-C. lindstromi, Cordylodus prion-Scolopodus, Cordylodus rotundatus-C. angulatus,* and *Chosonodina herfurthi-Acodus)* are erected in the Tremadocian. Comparison of our zones with previously described conodont sequences from Europe, North America, and Korea shows that they can be used for intercontinental correlation. Local correlation of sections sampled over a distance of 59 miles shows a diachronous rise of the lithological members of the Ninmaroo Formation to the south.

The phylogenetic relationships of Upper Cambrian and Tremadocian conodont species are discussed. Two root-stocks are recognized in the Upper Cambrian — the coelocerodontids, and the westergaardodinids. A development from a coelocerodontid ancestor of *Oneotodus nakamurai* Nogami gave rise to the majority of Tremadocian species, which are characterized by diverse cordylodids and scolopodids. The minor westergaardodinid root-stock gave rise to only two species of *Chosonodina.*

Rates of sedimentation (calculated from the thicknesses of the conodont Assemblage Zones) show a general decrease upwards throughout the sequence, and a decrease southwards along the outcrop, from Black Mountain to Mount Datson.

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INTRODUCTION

Although the nature, function, and affinities of conodonts are uncertain (see Lindström, 1964, pp. 118-130), they are one of the most sensitive and useful fossil groups for stratigraphic zonation and correlation.

Considerable study of Silurian (Walliser, 1964), Devonian (Bischoff & Ziegler, 1957; Ziegler, 1962), and Carboniferous (Bischoff, 1957; Voges, 1959; Collinson, Scott, & Rexroad, 1962; Rhodes, Austin, & Druce, 1969) conodonts has enabled these authors to erect assemblage zones which can be recognized regionally and used in intercontinental correlation.

The purpose of the present paper is to investigate and describe the sequence of conodont species in the Upper Cambrian and Lower Ordovician (Tremadocian) of the Burke River Structural Belt, western Queensland (Öpik, 1960, p. 93). The erection of assemblage zones will enable detailed correlation of Lower Ordovician (Tremadocian) sediments in and between basins in Australia, and intercontinental correlations on the basis of conodonts previously described from the Far East, North America, and Europe.

The Cambro-Ordovician sequence is exposed in the Boulia region as a narrow meridional belt of folded and faulted limestone domes flanked by Lower Cretaceous rocks on the east and Lower Cretaceous and Tertiary rocks on the west (Fig. 1). Structurally, it is the southern part of the Burke River Structural Belt (Öpik, 1960, p. 93), and extends south-southeast from Mount Merlin through Signal Hill (on Duchess 1:250,000 Sheet), west of Digby Peaks, through Black Mountain, Mount Ninmaroo, and Mount Datson, to Dribbling Bore. Geomorphologically, it forms a series of isolated emergent inliers, rising no higher than 500 feet above the plain.

During the last ten years our knowledge of the Cambrian and Ordovician geology of northwestern Queensland has been rapidly advanced by the published work of Öpik (1956b, 1960, 1961a, b, 1963, 1966, 1967, 1968). Before 1956 publications were few. As references to these previous investigations have been presented by Whitehouse (1936), Öpik (1956b), Smith (1968), and Casey (1968), only those directly concerned with the Lower Palaeozoic sequence of the Boulia area will be mentioned here.

Whitehouse (1930, p. 23) made the first mention of Ordovician strata in western Queensland. He divided his 'North-Western Basin' into two parts — 'a northerly

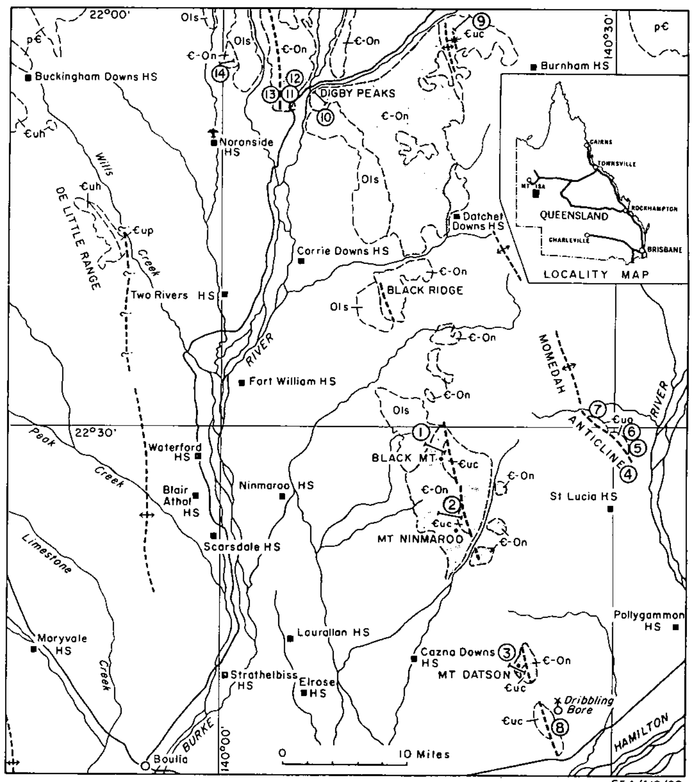

Fig. 1 **Distribution of the Cambro-Ordovician rocks in the Boulia region, and positions of sections. Ols = Swift Formation; C-On = Ninmaroo Formation; Cuc = Chatsworth Limestone; Cuo = Gola Beds; Cuh = O'Hara Shale; Cup = Pomegranate Limestone; pC = Precambrian; Undesignated: Mesozoic and Cainozoic.**

or Templeton Basin of Cambrian deposits, and a southerly or Boulia Basin of Ordovician beds — since the rocks of the two ages have quite different structures'.

In a series of papers Whitehouse (1936, 1939, 1941, 1945) described fossils he had collected from the Cambrian and Tremadocian sequence, and his work formed the starting point for the later palaeontological and biostratigraphical studies of Öpik. Whitehouse constructed a scale of regional stages based on trilobite and nautiloid genera because, as Öpik (1956b, p. 2) pertinently said, 'a stratigraphy based on the sequence of rock-units was at that time beyond the reach of a single explorer'.

In the first of these papers, Whitehouse (1936, p. 69) reported thick fossiliferous limestones well exposed in the folded and faulted country of Black Mountain (Mount Unbunmaroo), Mount Ninmaroo, and Mount Datson. He noted platy blue limestone similar to those of the Cambrian Georgina Limestones in the lower part of the section, and recorded ellesmeroceroid nautiloids, echinoderm ossicles, and an orthid brachiopod in the higher beds of the Black Mountain section, which he concluded to be lower Tremadocian in age. Whitehouse named the whole sequence the Ninmaroo Series and the *Ellesmeroceras* Stage, the youngest of his succession of stages, which he placed in the 'Lower Ozarkian (Lower Tremadocian)'.

In the Chatsworth area, immediately to the north of the Boulia 1:250,000 Sheet, Öpik (1956b, p. 23) recorded two Upper Cambrian limestones — the Pomegranate Limestone (early Upper Cambrian), and an unnamed one.

In 1957, a joint geological party from the Bureau of Mineral Resources and the Geological Survey of Queensland mapped the Boulia area (Casey, 1959, 1968; Öpik, 1960). The following results were relevant to the Lower Palaeozoic geology of the area.

(i) The unnamed limestone near Chatsworth was formally named the Chatsworth Limestone (Casey, 1959, p. 32, 33). Öpik (1960, p. 100) gives the age as Franconian and Trempealeauan.

(ii) The Ninmaroo Limestone exposed at Black Mountain, Mount Ninmaroo, and Mount Datson was renamed 'Ninmaroo Formation' — a term which was restricted to the Tremadocian part, that is, the upper beds of dolomite, intraformational breccia, and two-tone calcarenite, which contains many ellesmeroceroid nautiloids, brachiopods, and some gastropods. The lower beds of platy blue limestones, exposed in the anticlinal cores, were referred to the Chatsworth Limestone (Casey, 1959, p. 33). As redefined, the base of the Ninmaroo Formation along the Burke River Structural Belt is Tremadocian, but in the Glenormiston area, 100 miles to the west, it is uppermost Upper Cambrian (Öpik, 1960, p. 101; 1963, p. 16, 24).

(iii) Upper Cambrian limestone and dolomite in the Dribbling Bore area, identified as Chatsworth Limestone, represent the southernmost exposure of Cambrian strata in the Boulia area (Casey, 1959, p. 33; Öpik, 1960, p. 96).

(iv) Upper Cambrian limestones exposed as inliers in the Momedah Anticline, east of Black Mountain, were named the Gola Beds (Casey, 1959, p. 32), and regarded as belonging to the sequence of the Chatsworth Limestone (Öpik, 1960, p. 100).

(v) The Lower Ordovician Swift Formation unconformably overlies the Ninmaroo Formation in the Swift Hills, north of the Boulia area, and west of Black Mountain and Mount Ninmaroo (Casey, 1959, p. 33), and contains brachiopods, pelecypods, and trilobites of Lower Arenigian age (Öpik, 1960, p. 102). The formation consists of about 60 feet of siltstone, chert, sandstone, silicified coquinite, and calcarenite.

Further details of the Lower Palaeozoic geology of the Boulia region have been recorded in an unpublished report (Casey et al., 1960), which is on open file at the Bureau of Mineral Resources, Canberra.

In 1959, G. A. Brown (1961) carried out a detailed petrological study of the Chatsworth Limestone and Ninmaroo Formation for a Master's degree thesis (unpublished) at Melbourne University.

Öpik (1961a, p. 41) in his detailed report on the Cambrian geology and palaeontology of the headwaters of the Burke River, predicted that the same sequence 'extends south and should be present below the surface of the Burke River Structural Belt'. This prediction was confirmed in 1963, by the drilling of Phillips-Sunray Black Mountain No. 1 Well, which penetrated 1569 feet of Upper Cambrian sediments (Chatsworth Limestone 590 feet; O'Hara Shale 162 feet; Pomegranate Limestone 817 feet), 2259 feet of Middle Cambrian sediments, 438 feet of Lower Cambrian Mount Birnie Beds, and 1245+ feet of Upper Proterozoic? shale.

To the west of the Burke River Structural Belt, Cambrian sediments lie below the Lower Cretaceous in Phillips-Sunray Beantree No. 1 Well, which penetrated 1301 feet of early Upper Cambrian Pomegranate Limestone and 136 feet of early Middle Cambrian Beetle Creek Formation before entering crystalline basement at 1740 feet (1169 feet below sea level). Farther west, the Pomegranate Limestone crops out as a small inlier at the base of the De Little Range, on Wills Creek, about 5-7 miles south of Buckingham Downs station (Öpik, 1963, p. 17).

The Boulia 1:250,000 geological map, with explanatory notes, has recently been issued (Casey, 1968).

Acknowledgments

Dr A. A. Öpik has given us the benefit of his extensive knowledge of Upper Cambrian and Tremadocian stratigraphy and palaeontology, and has aided us at every stage. The line drawings of conodont species were produced by Mr F. Hadzel. The mobile laboratory was operated by Messrs A. T. Wilson and A. J. Palfreyman.

Cambrian. Among the first described conodonts (by Pander, 1856), were specimens from the early Ordovician strata of the Baltic provinces of Russia. However, it was not until a century later that Cambrian conodonts were first recorded (Müller, 1956). In 1959 Müller described the systematic palaeontology and stratigraphic distribution of Upper Cambrian conodonts from Northern Europe (Germany and Sweden) and North America. The majority of Müller's samples were from undoubted Upper Cambrian formations; however, C. C. Branson (1957) pointed out that other palaeontological evidence suggests that the Signal Mountain Limestone of the Arbuckle Mountains, Oklahoma, is Lower Ordovician. Müller (1956, p. 1335) also drew attention to doubt concerning the Cambrian age of the Signal Mountain Limestone.

In his taxonomic paper, Müller erected a new genus, *Westergaardodina,* for U and W-shaped conodonts discovered in the Upper Cambrian. These fossils had been previously illustrated by Wiman (1893) and Westergaard (1953) as problematical fossils. Lindström (1964) considers that these objects are not true conodonts; but they are treated as conodonts here.

Controversy also surrounds the origin and function of the paraconodont *Rhombocorniculum,* erected by Walliser (1958) to include cone-shaped microfossils with a rhomboidal pattern from the late Lower Cambrian Comley Limestone of Shropshire, England. The type species *(R. comleyense* Walliser 1958 = *Helenia cancellata* Cobbold, 1921) may belong to the genus *Helenia* Walcott, 1889, which according to Fisher (1962, p. W124) represents the supports of a large hyolithid.

In 1961 Cambrian conodonts were reported from the United States (Koucky, Cygan, & Rhodes; Goodwin) and Australia (Jones). The conodonts mentioned by Jones from the Chatsworth Limestone form part of the present paper.

It was not until 1966 that further taxonomic descriptions of Cambrian conodonts were published and the geographical occurrence was extended to China (Nogami, 1966) and Denmark (Poulsen, 1966). The paper by Nogami deals with species from the Upper Cambrian Kushan Beds and includes forms referable to *Westergaardodina* and *Proacodus,* neither of which was included in the Conodontophorida by Lindström (1964).

The lower limit of the stratigraphic range of conodonts was extended by Poulsen (1966) into what he regarded as late Lower Cambrian (i.e. post-Olenellian, pre-Paradoxidian). Poulsen (p. 4) records that the specimens come from the Middle Cambrian Kalby Clay *(Tomagnostus fissus — Ptychagnostus atavus* Zone) on the island of Bornholm, but he considers that they are reworked from the *Strenuella linnarsonni* Zone. In Norway, the *Strenuella linnarsonni* Zone lies above the Lower Cambrian (Olenellian) *Holmia,* and below the *Paradoxides oelandicus* faunas (Kiaer, 1916, p. 111; Öpik, 1968). Recently Nogami (1967) has published part two of his Chinese Cambrian conodonts, describing species from the late Upper Cambrian Yencho Beds of northeast China.

Tremadocian. Conodonts from the Tremadocian of the Baltic provinces of Russia were included in the first taxonomic description of conodonts by Pander (1856). Since then further papers have been published on the same fauna from Estonia (Öpik, 1927, 1929, 1930, 1931, 1956a; Viira, 1966). Similar conodonts from the Leningrad region (Sergeeva, 1962, 1963, 1966) and southern Sweden (Lindström, 1954, 1960, 1964), have also been described.

In the United States, Tremadocian conodonts have been recorded from the Prairie du Chien Beds of the Upper Mississippi Valley (Furnish, 1938), the Stonehenge Limestone of Pennsylvania (Sando, 1958), and the Monocline Valley Formation of Nevada (Longwell & Mound, 1967). The lowest beds of the El Paso Formation of Texas and Arizona (Ethington & Clark, 1964), may be of Tremadocian age. Ethington & Clark (1965) also record Tremadocian conodonts from the Columbia Ice Fields Section of Alberta, Canada.

In 1964, Müller described conodonts from part of the Great Limestone Series of Korea, of Tremadocian age. Recently Tremadocian conodonts have been recorded from a basal Palaeozoic formation of the Nochixtlan region of Mexico (Pantoja - Alor & Robison, 1967). A Lower Ordovician fauna from the Chun Stage (part at least of which is possibly Tremadocian) of the Siberian Platform was described by Moskalenko (1967).

Cambrian and Lower Ordovician (Tremadocian) zonation. As yet no Cambrian conodont zonation has been proposed, for lack of both numbers of specimens and knowledge of their stratigraphic distribution. Furthermore, the Cambrian species are simple, lacking the varied morphological features which are the basis for the erection of species. Therefore many Cambrian species appear to be long-ranging and, apart from indicating a Cambrian age, are of little use in erecting assemblage zones.

In the Tremadocian there is a greater degree of diversification and more possibility of defining conodont assemblage zones. In studies of the Tremadocian-Arenigian sequence of the Baltic States, Lindström (1954, 1960), Sergeeva (1963), and Viira (1966) all erected a single assemblage zone for the Tremadocian. Lindström's Zone I in Sweden is characterized by *Cordylodus angulatus* Pander, *C. rotundatus* Pander, *Oistodus inaequalis* Pander, and *Oneotodus variabilis* Lindström. All these species, apart from *O. inaequalis,* are characteristic of the Tremadocian *Cordylodus angulatus* Zone in the Leningrad region (Sergeeva, 1963). In Estonia the Tremadocian Pakerort Stage yields *C. angulatus* and *C. rotundatus,* which are the zonal indices for the basal conodont zone (Viira, 1966).

STRATIGRAPHY

The Cambro-Ordovician sequence of the Burke River Structural Belt

The geology of the Boulia area is shown in Figure 1. The conodonts of the Upper Cambrian Chatsworth Limestone and Gola Beds and the Lower Ordovician Ninmaroo Formation were studied in detail.

Chatsworth Limestone

The Chatsworth Limestone is a fossiliferous sequence of thin-bedded and laminated calcarenite and calcilutite, with minor calcareous sandstone, coquinite, and intraformational conglomerate. The calcareous sandstone shows minor cross-stratification, scour-and-fill structures, and ripple marks. Some beds are banded with light and darker grey limestone, giving a 'two-tone' appearance, which weathers selectively. Ultimately they weather into friable 'marl'.

In the Duchess Sheet area, south of Pomegranate Creek, bare pediments on gently folded Chatsworth Limestone occupy a large area in the Burke River Plain, some four miles northwest of Chatsworth homestead (locality D124, Carter & Öpik, 1963, p. 22). This is the lower part of the Chatsworth Limestone, containing brachiopods *(Billingsella, Eoorthis),* and trilobites *(Pseudagnostus, Geragnostus, Paramansuyella,* and *Maladiodella).* North of D124 another pediment of Chatsworth Limestone is present, but without fossils, and its contact with the underlying O'Hara Shale is not exposed (Öpik, 1963, p. 20-1). In the Pomegranate Creek area, the O'Hara Shale overlies the Pomegranate Limestone (D120b) of the *Irvingella tropica — Agnostotes inconstans* Zone, the youngest zone of the Idamean Stage (Öpik, 1963, p. 9). Öpik (1960, p. 107) noted that the Manchurian forms *Paramansuyella* aff. *puteata* Endo and *Maladiodella* aff. *splendens* Endo in the lower part of the Chatsworth Limestone indicate a correlation with the Daizanian stage. In terms of the American scale, Öpik (1960, p. 107) suggested that it corresponds to the lower Franconian. He later argued (Öpik, 1963, p. 22), however, that because of a possible intra-Franconian break, together with a barren sequence covering the interval between the basal Franconian *Irvingella tropica — Agnostotes inconstans* Zone and the strata containing *Paramansuyella,* the qualification 'lower' is questionable. He therefore gave a general Franconian age for that part of the Chatsworth Limestone exposed in the Pomegranate Creek area (Öpik, 1963, p. 21). Fossiliferous thick-bedded Chatsworth Limestone resting unconformably on Middle Cambrian sediments, some five miles north of Mount Merlin, was also given a Franconian age (Öpik, 1960, chart).

In the Boulia Sheet area, south of Chatsworth homestead, and 16 miles east-northeast of Digby Peaks homestead (lat. 22°03'S; long. 140°18'E), Casey (1959, p. 33) reported 520 feet of Chatsworth Limestone in the type section. Neither the base nor the top of the formation is exposed in this area. The fossils from the type section are not yet described.

In the south, at Black Mountain, Mount Ninmaroo, and Mount Datson, the Chatsworth Limestone is well exposed as inliers on the western part of domes faulted against the Ninmaroo Formation to the east. At Dribbling Bore, faulting has only affected the folded Chatsworth Limestone; no Ninmaroo Formation has been exposed. Brecciation and secondary dolomitization is evident at many places along the fault plane (Casey, 1968, p. 14). Öpik (1960, p. 100; chart) gives the age of the Chatsworth Limestone in the Boulia area as Franconian and Trempealeauan. Trilobites (prosaukiids and agnostids), brachiopods (both phosphatic and calcareous), and sponge spicules are abundant, but not yet described. Öpik (1960, p. 100) gives a total thickness for the Chatsworth Limestone of the order of 2000 feet; we measured 1420 feet at Black Mountain (the base is not exposed), and 590 feet of the formation was penetrated by the Black Mountain No. 1 Well.

Gola Beds

The Gola Beds are fossiliferous calcarenite and calcilutite beds with minor intraformational breccia, which crop out as two small inliers (lat. 22°30'S; long. 140°30'E) along the Momedah Anticline (a post-Cretaceous structure), eight miles east of Black Mountain (Casey, 1959, p. 32). Öpik (1960, p. 100) used the name 'Gola Beds' in an informal sense, because although its fossils (Richardsonellidae, *Kaolishania, Koldinioidia, Pagodia, Pseudagnostus,* and, perhaps, *Sinosaukia)* have not yet been located in the Chatsworth Limestone, they are part (Trempealeauan) of the same sequence. He added (op. cit.) 'moreover, the absence of these fossils in the Chatsworth Limestone may be connected with a not yet detected break'. Dr J. H. Shergold, of the Bureau of Mineral Resources, is currently studying the trilobites from both the Gola Beds and the Chatsworth Limestone, in order to solve this problem. The base of the Gola Beds is not exposed and the top is concealed beneath Lower Cretaceous sediments. An estimated exposed thickness of 150 feet was recorded by Casey (1959, p. 32); we measured a total thickness of about 320 feet.

Ninmaroo Formation

The Ninmaroo Formation conformably overlies the Chatsworth Limestone at Black Mountain, Mount Ninmaroo, and the southernmost exposure at Mount Datson. North of Black Mountain, it crops out at Black Ridge, Digby Peaks, Signal Hill, and the Swift Hills (Fig. 1). The base of the Ninmaroo Formation is marked by cross-bedded dolomite and sandy dolomite showing scour-and-fill structures; its top is eroded and is unconformably overlain by the Lower Ordovician (Arenigian) Swift Formation.

Both Brown (1961, unpubl.) and Casey (1968, p. 10) recognize six lithological divisions within the formation (members of Brown and 'units' of Casey); these are:

Member 1 — the basal unit, consisting of cross-bedded dolomite at Black Mountain and Mount Ninmaroo, and sandy dolomite at Mount Datson.

Member 2 — the first richly fossiliferous unit (nautiloids and ribeirioids), of variable lithology, consisting of calcarenite, calcilutite, two-tone limestone, dolomite, cross-bedded limestone, intraformational conglomerate, oolite and chert nodules. It is present on Black Mountain, Mount Ninmaroo, and Mount Datson.

Member 3 — characterized by the higher proportion of two-tone limestone, and minor calcarenite, intraformational conglomerate, and 'marl'. It is present at Black Mountain, Mount Ninmaroo, Mount Datson, and Digby Peaks.

Member 4 — distinguished by large thicknesses of intraformational conglomerate; its base is marked by detrital, often cross-bedded limestone, overlying the last persistent two-tone limestone of Member 3. It is recognizable at Black Mountain, Mount Ninmaroo, Mount Datson, and Digby Peaks.

Member 5 — characterized by massive white crystalline crinoidal limestone, interbedded with 'marl', oolitic calcarenite and intraformational conglomerate. The top of this unit, west of Mount Ninmaroo and Black Mountain, is marked by a distinctive massive bed which contains nautiloids, polyzoans, sponges, and brachiopods. Member 5 also contains algae and ribeirioids, and is also present at Black Mountain and possibly at Black Ridge.

Member 6 — consists of cherty dolomitic limestone and silicified yellow siltstone, and contains trilobites (asaphids, dikelocephalids, and leiostegiids), brachiopods, gastropods, sponge spicules, and algae. It is present at Black Mountain, Mount Ninmaroo, and Black Ridge. Brown (1961, unpubl.) reports that massive beds of Member 5 commonly occur interbedded with Member 6. He interprets the sponge bed at the top of Member 5 as a bar separating two facies — an open-water facies (Member 5) from a lagoonal facies (Member 6).

Öpik (1960, p. 101) listed the following fossils from the main, Tremadocian, part of the Ninmaroo Formation (Black Mountain area): calcareous algae with filaments preserved; asaphid trilobites, and a relative of *Leiostegium;* the ribeirioid genera *Eopteria* Billings, *Euchasma* Billings, and cf. *Ribeiria* Sharpe; syntrophioid brachiopods, and an orthoid *(Finkelnburgia);* gastropods — a raphistomid (rare) and *Ceratopea* (silicified opercula, abundant); two genera of Monoplacophora *(Archinacella* Ulrich & Schofield and *Proplina* Kobayashi).

To the west, in the Glenormiston area, along the lower reach of Pituri Creek (left bank), the basal unit of the Ninmaroo Formation has interbedded sandstone with the trilobites *Saukia, Sinosaukia, Pagodia,* and *?Tellerina,* and several other forms that indicate a Trempealeauan age (Öpik, 1960, p. 101).

Öpik (op. cit.) gave the thickness of the Ninmaroo Formation as about 2000 feet; Casey *(in* Smith, 1968, in prep.) measured a thickness of 1950 feet at Black Mountain.

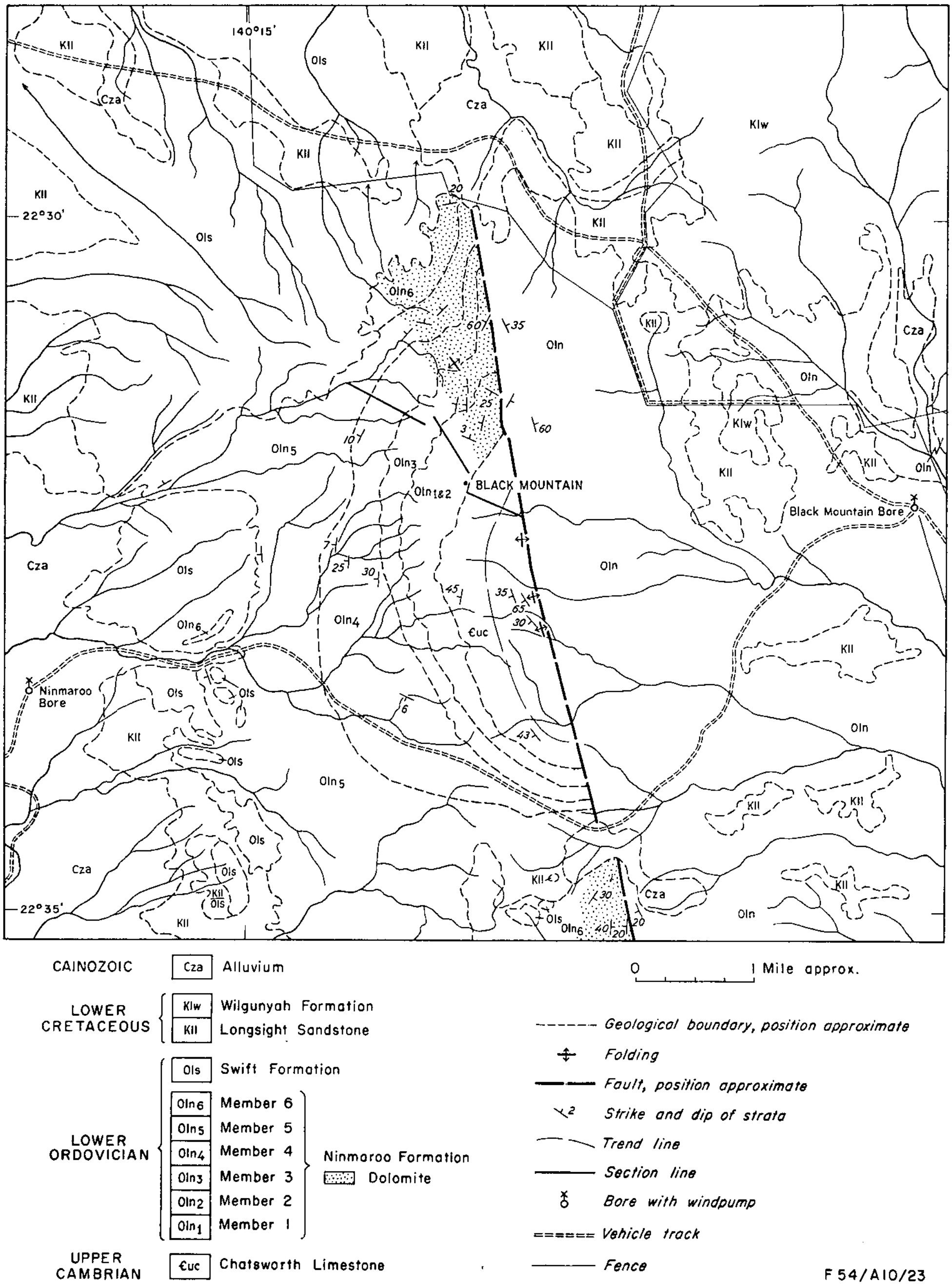

Fig. 2A Geology of Black Mountain (adapted from G. A. Brown, 1961), and position of Section 1, the type section of the Ninmaroo Formation.

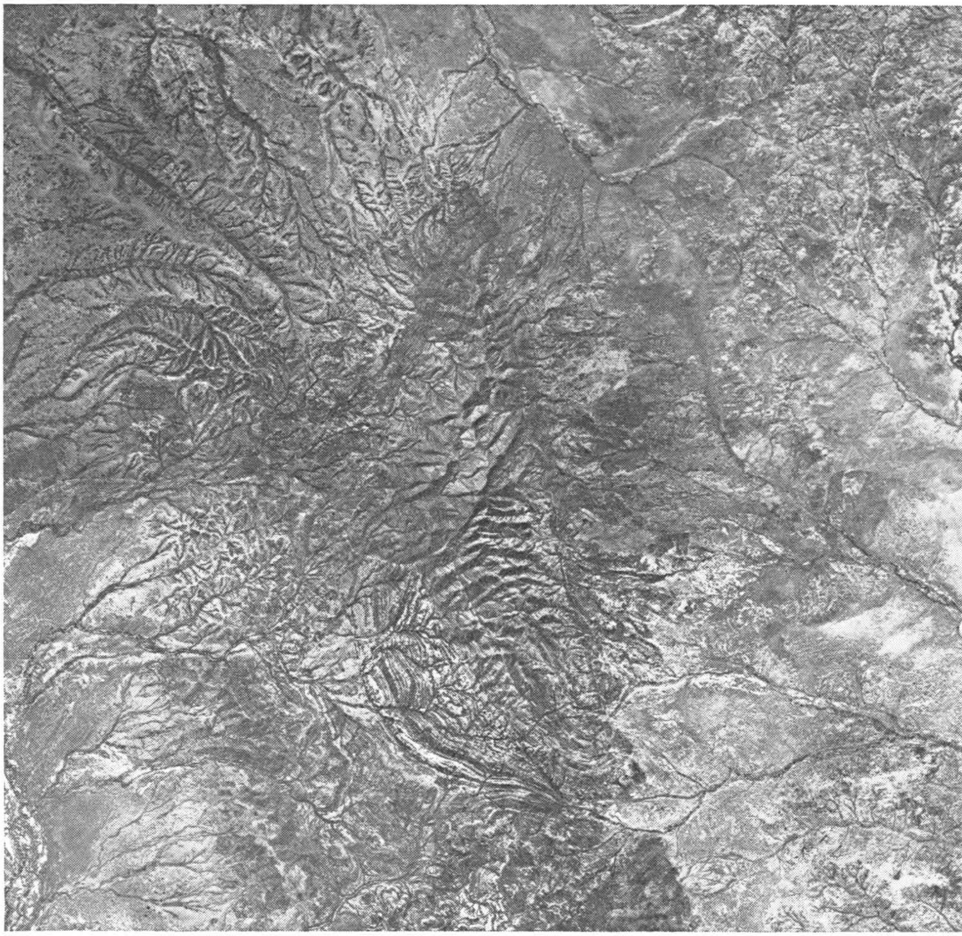

Fig. 2B **Air-photograph of Black Mountain, at the same scale as Fig. 2A.**

Stratigraphy of the areas from which conodonts are described

Black Mountain

The Black Mountain section was measured as close to the section-line of G. A. Brown as possible (Fig. 2A, 2B). The section was started close to the Black Mountain Fault, and continued northwest, with several northeasterly offsets along the strike. Whitehouse (1936, p. 69, footnote) records a small outcrop of gneiss at the base of Black Mountain, and suggests the presence of basement rocks close to the surface (a suggestion later confirmed by evidence from Beantree No. 1 Well). Although no outcrop of gneiss was seen at Black Mountain, scattered boulders of granitic gneiss and micaceous schist have been observed by Brown (1961, unpubl.) east of Mount Ninmaroo. These were boulders from the basal conglomerate of the Lower Cretaceous Longsight Sandstone, which crops out nearby.

The Chatsworth Limestone at Black Mountain begins with interbedded 'marl' and hard calcarenite beds (200 feet), which gradually gives way to interbedded calcarenite and calcilutite (100 feet), followed by thin-bedded sandy calcarenite (100 feet). Interbedded 'marl' and calcarenite reappear (200 feet), with rare trilobites, phosphatic brachiopods, and worm burrows. The incompetent beds of 'marl' are often contorted between the calcarenite beds. Above this sequence are thick beds of calcilutite containing coquinites of trilobites and brachiopods (100 feet). The overlying beds (between 700 feet and 1420 feet, the top of the formation) include calcarenite, two-tone limestone, calcareous sandstone, and intraformational conglomerate. Fossils (trilobites and brachiopods) are scattered, except in a sequence of thin-bedded strata with current ripple marks, cross-bedding, and scour-and-fill structures.

At 1420 feet above the base of the section, the change from sandy calcarenite of the Chatsworth Limestone to the dolomite of the basal member of the Ninmaroo Formation coincides with the incoming of nautiloids, which is taken as the Cambrian-Ordovician boundary. Member 1 of the Ninmaroo Formation consists of 40 feet of sandy cross-bedded lenses of dolomite or dolomitic limestone with scour-and-fill structures. Lenses of sandstone up to 3 feet thick are cross-bedded and contain calcareous layers, partly silicified. A bed of friable 'marl' occurs irregularly at the base of the dolomite.

The heterogeneous Member 2 consists of all rock types except dolomite. It is 560 feet thick, and contains nautiloids, ribeirioids, and echinoderm ossicles. The top part of the unit is cross-bedded.

Member 3 is a fairly regular sequence, 620 feet thick, of two-tone limestone, calcarenite, calcilutite, and 'marl', with minor intraformational conglomerate. Bituminous beds are common, and nautiloids, ribeirioids, gastropods *(Ceratopea),* brachiopods, and algae are scattered throughout.

The base of Member 4 is marked by thin-bedded, cross-bedded ripple-marked calcarenite and calcilutite with interbeds of intraformational conglomerate and 'marl'. Intraformational conglomerate dominates the overlying sequence, with interbeds of 'marl', calcarenite, calcilutite, oolite, and some two-tone limestone. Member 4 is 220 feet thick, and contains nautiloids, ribeirioids, gastropods *(Ceratopea),* and brachiopods.

Member 5 consists of 680 feet of massive white crystalline limestone with minor 'marl', calcarenite, oolite, intraformational conglomerate, and friable calcareous sandstone. It contains nautiloids, ribeirioids, gastropods *(Ceratopea),* brachiopods, and echinoderm ossicles. The top of this unit is marked by laminated grey limestones with chert interbeds, which contain trilobites. The uppermost beds also contain sponges and polyzoans.

Above the sponge bed about 100 feet was measured into Member 6. The lower part of this unit consists of dolomitic and siliceous beds containing asaphid trilobites and sinistral gastropods. The remainder consists of poor outcrops of massive dolomite beds, which were not collected.

Mount Ninmaroo

The Mount Ninmaroo section (Fig. 3) was started close to the Black Mountain Fault, and was continued west-northwest for about 1.4 miles.

The Chatsworth Limestone at Mount Ninmaroo consists of calcarenites and 'marls', with minor intraformational conglomerate and coquinite. Some sandy beds and a few bituminous layers occur, and minor cross-bedding. A thickness of 280 feet of Chatsworth Limestone was measured below the basal member of the Ninmaroo Formation. A prosaukid trilobite found 170 feet below the Chatsworth-Ninmaroo boundary indicates a Franconian age.

Member 1 of the Ninmaroo Formation is only 20 feet thick, but it forms a prominent bench of cross-bedded dolomite.

Member 2 consists of 540 feet of thick-bedded dolomite and minor dolomitized intraformational conglomerate and calcilutite. Above the dolomite are intraformational conglomerates and cross-bedded calcarenite. Fossils are scattered and fragmentary.

Member 3 is made up of 500 feet of two-tone limestone, 'marl', calcilutite, sandy calcarenite, and intraformational conglomerate, with some chert nodules and chert beds. Nautiloids, ribeirioids, gastropods, echinoderm ossicles, and algae are present. A cross-stratified thin-bedded calcarenite with chert nodules is present near the top of the unit. This is followed by the thick intraformational conglomerate of Member 4, in which 'marl' becomes more prominent higher in the sequence. It is 420 feet thick, and contains nautiloids, ribeirioids, gastropods, and echinoderm ossicles.

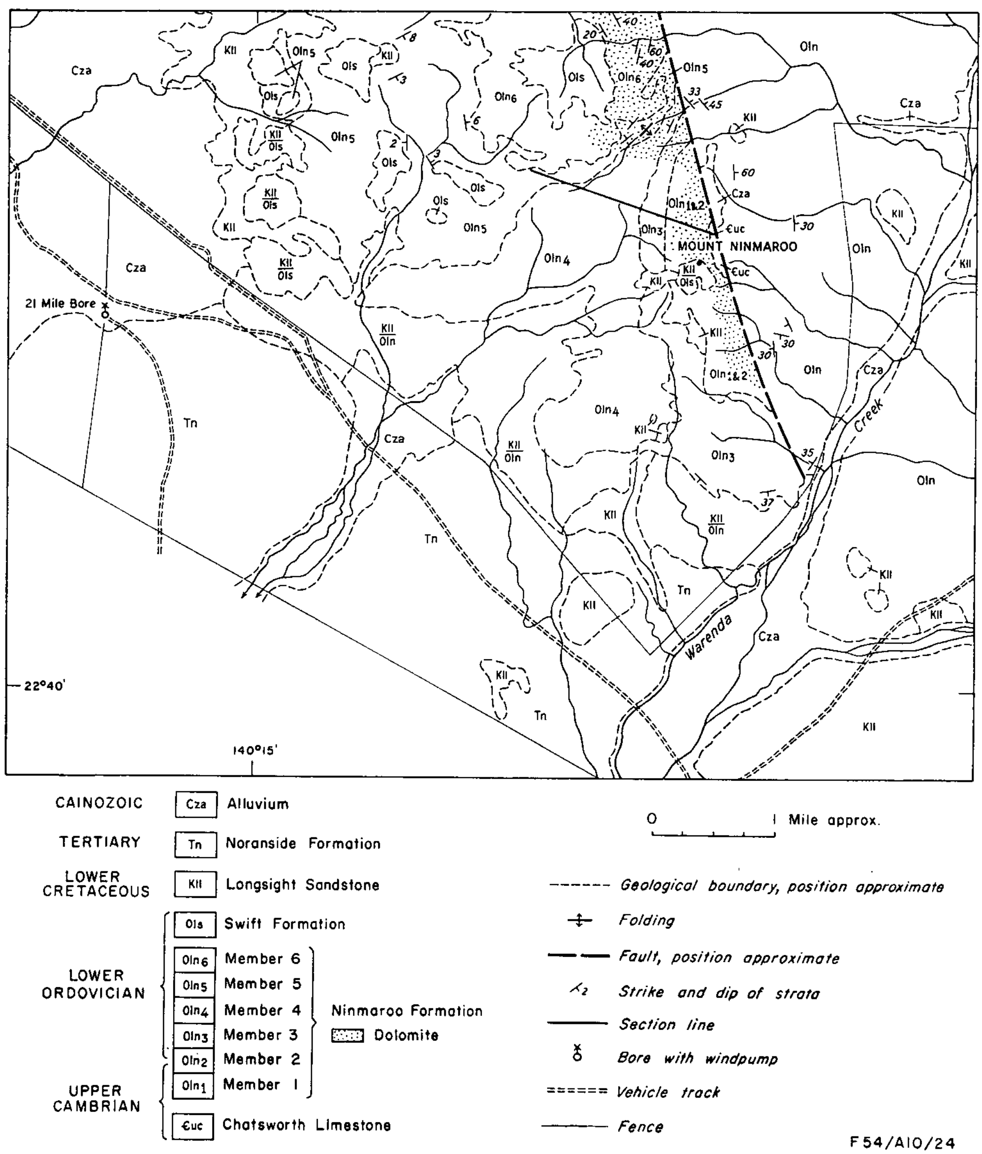

Fig. 3 **Geology of Mount Ninmaroo (adapted from G. A. Brown, 1961), and position of Section 2.**

Member 5 consists of 400 feet of massive thick-bedded crystalline limestone, with red-weathered cross-bedded sandy limestone. Much of the crystalline limestone, however, is friable and either does not crop out or is largely disintegrated. The top of the unit is marked by a thick bed of white limestone containing nautiloids, echinoderm ossicles, polyzoans, and sponges.

Above the sponge-polyzoan bed, about 40 feet was measured into Member 6. In the lower part are isolated patches of dolomitized breccia, and above this a fine laminated dolomite-calcite rock, which was probably deposited in a lagoon. Asaphid trilobites occur at the base of the unit.

Mount Datson

The Mount Datson section (Fig. 4) was measured from close to the fault west-northwest for 450 yards to the base of the Ninmaroo Formation (locality 3/33). Here a prominent dolomite bed was traced northwards for 700 yards along the strike, where the Ninmaroo Formation was measured in a northwesterly direction for 740 yards from Member 1 (locality 3/34) to the top of Member 4 (locality 3/97).

The Chatsworth Limestone at Mount Datson is 660 feet thick, and consists mainly of medium-bedded sandy calcarenite, with minor intraformational conglomerate, coquinite, and 'marl'. Cross-bedding, scour-and-fill, and slumping are rare. Trilobites occur near the base, and some brachiopods are present higher in the section.

Member 1 of the Ninmaroo Formation on Mount Datson is 20 feet thick, and is represented by beds of cross-bedded sandy dolomite.

Member 2 is 500 feet thick, the lower 40 feet consisting of dolomitic limestone, followed by 120 feet of sandy calcarenite and 'marl'. This is overlain by 190 feet of dolomite, followed by 150 feet of sandy cross-bedded calcarenite, intraformational conglomerate, and crystalline limestone to the base of Member 3. Fossils include nautiloids, brachiopods, and echinoderm ossicles.

Member 3 is 540 feet thick, with two-tone limestone common at the base and again towards the top of the sequence. The central part consists mainly of calcarenite and calcilutite, with some 'marl', and intraformational conglomerate, and a few cross-stratified sandy beds. Nautiloids, ribeirioids, gastropods *(Ceratopea)*, brachiopods, and echinoderm ossicles are found throughout.

Member 4 is 220 feet thick, consisting of sandy laminated cross-bedded calcarenite, 'marl', some intraformational conglomerate and coquinite, and a bed of oolite. The main development of intraformational conglomerate is absent. Nautiloids, brachiopods, gastropods, and echinoderm ossicles are common. The member is overlain by massive dolomite beds which were not collected (Datson Member of Brown).

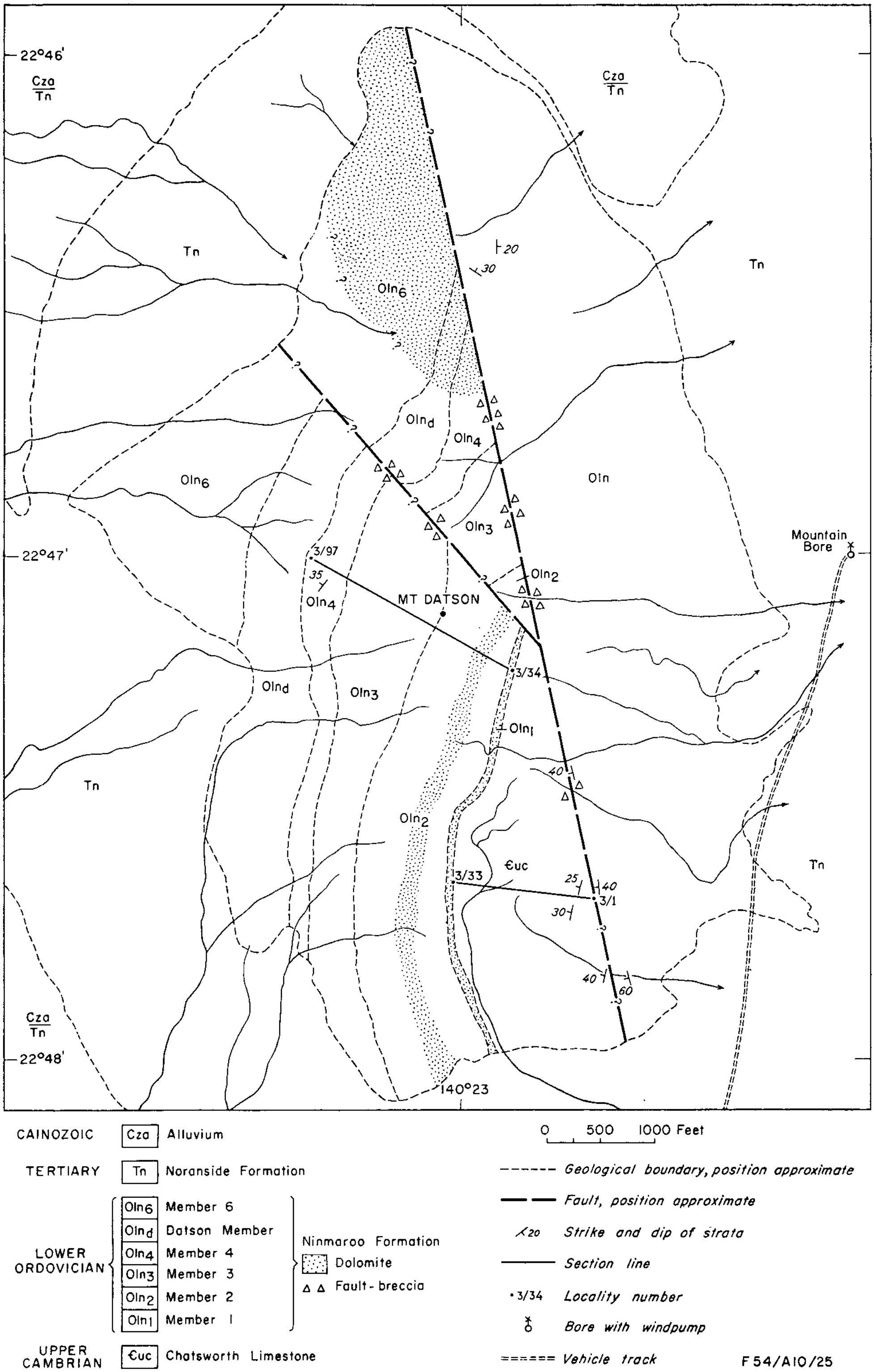

Fig. 4 Geology of Mount Datson (adapted from G. A. Brown, 1961), and position of Section 3.

Momedah Anticline

Three sections of the Gola Beds were measured along the northeastern limb of the Momedah Anticline. The southernmost section consists of two fossil localities, B750 and B752 (see Boulia 1:250,000 Sheet), which together represent a thickness of at least 180 feet (the base of the Gola Beds was not seen). Locality B750, representing the upper part of the section (locality 5, Fig. 5A, 5B), consists of 35 feet of two-tone calcilutite and calcarenite, which dips at 13° to the northeast. Here seven samples were taken at 5-foot intervals. Locality B752 (locality 4, Fig. 5A) is a fossiliferous light-grey calcarenite, some 145 feet stratigraphically below the lowermost part of B750 (sample 5/1), separated by an area of no outcrop, along which the track leading to Momedah Bore is situated.

A second section (locality 6, Fig. 5A) was measured on the northeast side of this track at locality B751, situated one mile northwest of B750. Here 180 feet of two-tone calcilutite and calcarenite with a dip of 13°NE was sampled at intervals of 20 feet. Allowing, however, for intervals of no outcrop, a total thickness of 320 feet was measured.

A third section (locality 7, Fig. 5A) was situated near fossil locality B753 (see Boulia 1:250,000 Sheet), at the point where a north-south fence crosses the axis of the Momedah Anticline. Again the northeastern limb of the anticline was measured, in which two-tone calcilutite dips at 40° near the axis, 30° in the centre part of the section, and 60° near the top of the section, where ferruginized limestone may suggest the presence of a fault. A thickness of 130 feet was sampled at intervals of 5 feet; however, allowing for intervals of no outcrop, a total thickness of 320 feet was measured.

Dribbling Bore

At Dribbling Bore (locality 8, Fig. 6) an inlier of Chatsworth Limestone is exposed in two elongated domes, the axes of which trend north, and slightly west of north. The western dome is truncated by a normal fault trending north-northwest, which has downthrown the main outcrop of Chatsworth Limestone to the east. Brecciation and secondary dolomitization are associated with the fault on the north and west sides of the western dome.

The formation consists of fine and medium-grained calcarenite with coarse-grained lenses. The calcarenite is thin to medium-bedded, with some sandy cross-laminae and ripple marks. No section was measured, but Casey et al. (1960, unpubl.) estimated a thickness of about 200 feet. Spot samples were taken up-dip at intervals of 0.1 mile on the ground. Trilobites and brachiopods in localities B776, 777, and 778 (see Boulia 1:250,000 Sheet) suggest a Franconian age.

Chatsworth and Digby Peaks

The Chatsworth Limestone, in its type section (locality 9, Fig. 7), dips at 5°SW, and was sampled for 440 feet between localities B54 and B51 (see Boulia

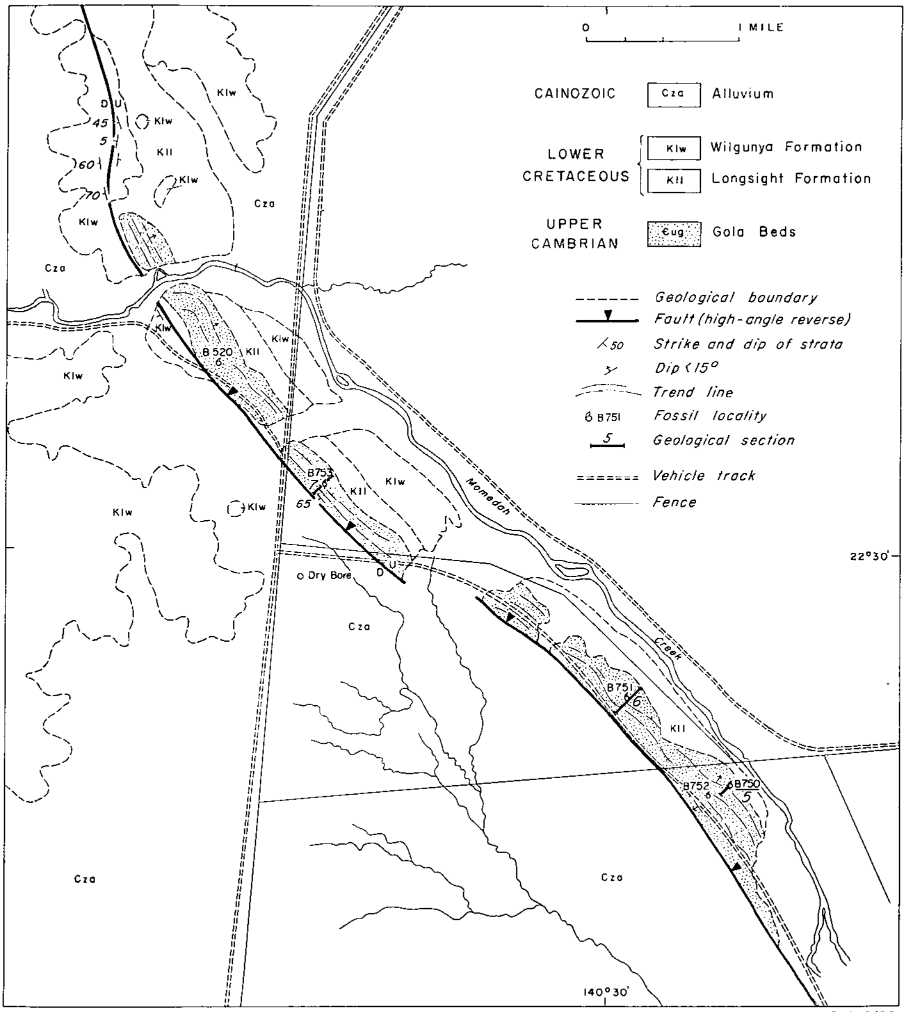

Fig. 5A Geology of Momedah Anticline, and positions of Sections 4, 5, 6 and 7.

Fig. 5B Air-photograph of Momedah Anticline, at same scale as Fig. 5A.

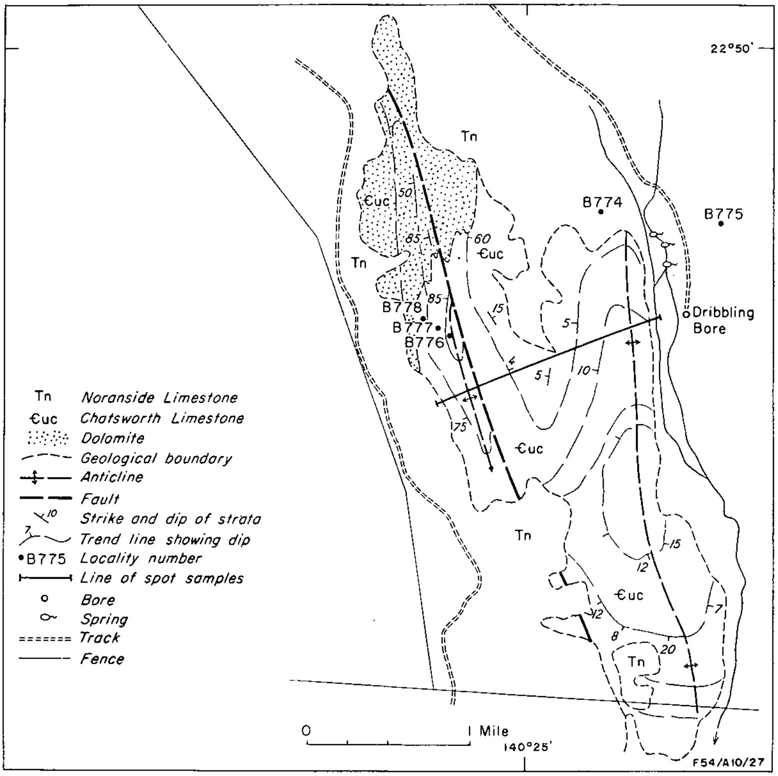

Fig. 6 Geology of the Dribbling Bore area, and positions of spot-samples at locality 8.

1:250,000 Sheet). This excluded the upper 80 feet of the type section between B791A and B792. The section begins with 210 feet of laminated coarse calcarenite with interbeds of fine calcarenite and calcilutite. This is followed upwards by 30 feet of thin-bedded calcarenite, two-tone calcarenite, and sandy interbeds, 60 feet of laminated and fine-bedded calcarenite and calcilutite, and 130 feet of fine-grained sandy calcarenite. The uppermost samples were taken from 5 feet of cross-bedded and slumped calcareous sandstone, dipping at 3°SW, followed by 5 feet of laminated fine-grained calcarenite and calcilutite. Fossils are scattered throughout the section, and in places are concentrated in coquinites (trilobites, blastoids, brachiopods, and gastropods). These are undescribed.

At Digby Peaks (locality 10, Fig. 8) 180 feet of Ninmaroo Formation was measured, consisting of 80 feet of Member 3, and 100 feet of Member 4. The base of Member 3 is concealed under the alluvium of the Mort River. Two-tone limestone crops out in the bed of the river, and contains small curved nautiloids and pyrite crystals. The upper part of the sequence contains calcarenite, intra-formational conglomerate, and 'marl', with bituminous calcilutite, chert nodules, nautiloids, ribeirioids, and echinoderm ossicles. The base of Member 4 is marked by laminated cross-bedded sandy limestone with pyrite crystals, which is in turn overlain by intraformational conglomerate, 'marl', calcarenite, and oolite, often with chert nodules. Nautiloids, ribeirioids, and gastropods are present. The eroded top of Member 4 is unconformably overlain by the Swift Formation.

Signal Hill Fault Zone and West Swift Hills

West of Digby Peaks, between the Burke River and the Signal Hill Fault Zone, three spot samples were taken along the Telegraph Line (localities 11 and 12, Fig. 8). The lower beds consist of 200 feet of interbedded bituminous calcarenite and two-tone limestone (Member 3). This is overlain by 270 feet of intraformational conglomerate, with interbedded calcarenite, two-tone limestone, and minor chert nodules (Member 4). Curved nautiloids and gastropods *(Ceratopea)* are present. Sample 12/1 was taken near the base of the member, and sample

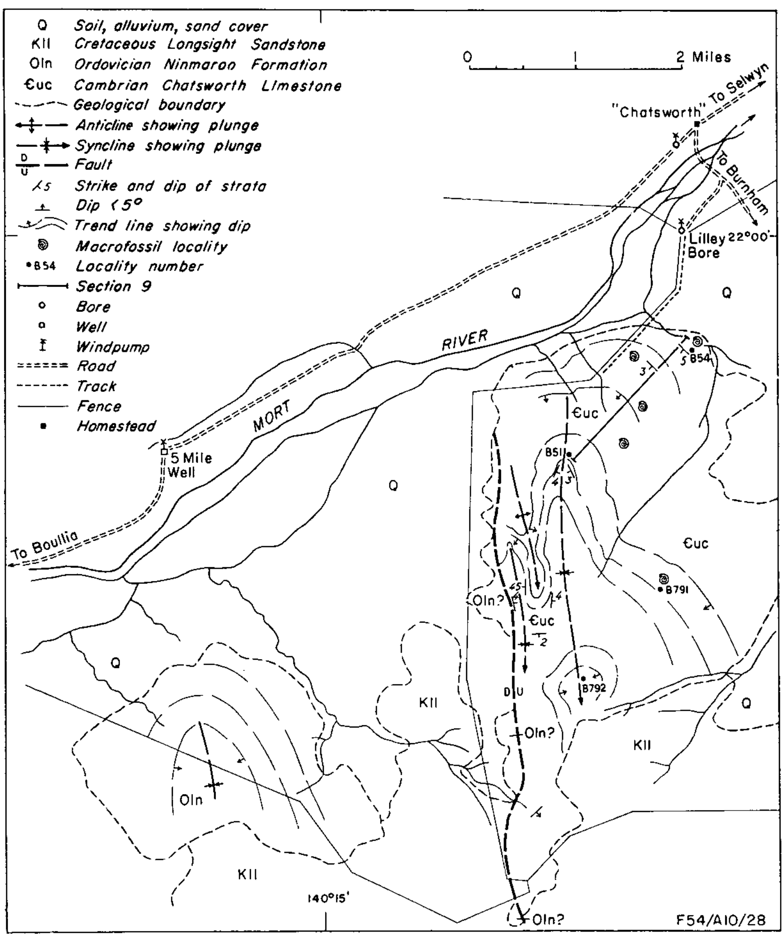

Fig. 7 **Geology of the Chatsworth area, and position of Section 9, the type section of the Chatsworth Limestone.**

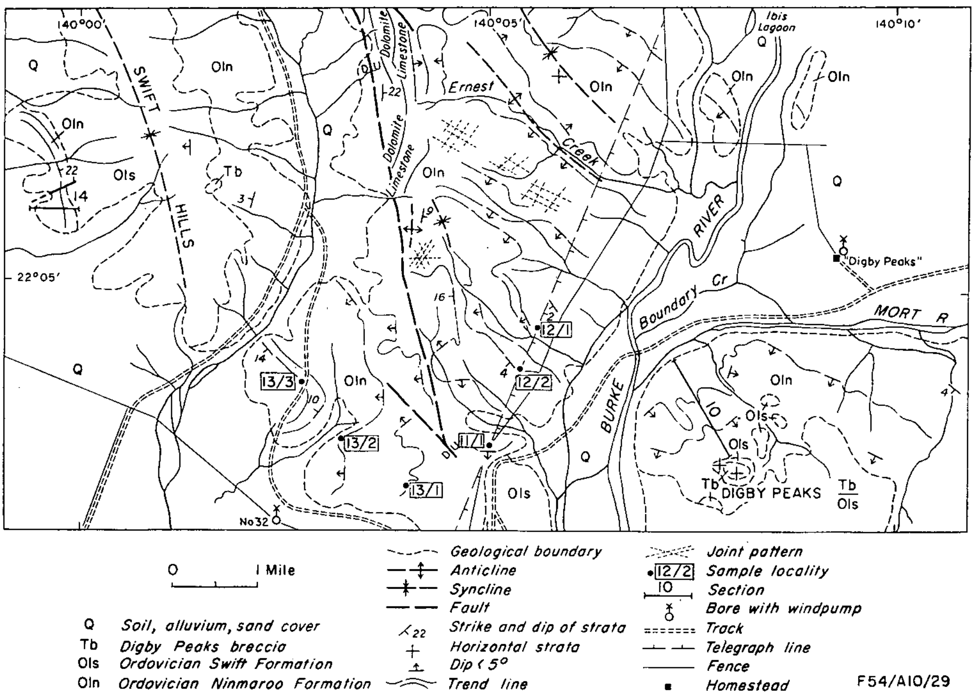

Fig. 8 **Geology of the Digby Peaks/Swift Hills area (adapted from Casey, 1968), and positions of Sections 10 and 14 and sample localities 11, 12 and 13.**

12/2 near the top. The upper beds consist of about 240 feet of laminated calcarenite, with minor intraformational conglomerate, becoming sandier at the top of the hill (sample 11/1); this part of the succession is identified as Member 5.

Member 5 was also sampled on the west side of the Signal Hill Fault Zone (locality 13, Fig. 8), where Member 4 is either faulted out or was never deposited.

West of the Swift Hills (locality 14, Fig. 8), 560 feet of Ninmaroo Formation was measured, starting with 140 feet of Member 3 (two-tone limestone, sandy calcarenite, and minor calcilutite), succeeded by 250 feet of Member 5 (calcarenite, sandy and dolomitic in parts, with minor calcilutite and chert beds); interbedded coquinites include nautiloids, brachiopods and echinoderm ossicles. Member 4 is absent. Member 5 is overlain by Member 6, which consists of 170 feet of thin-bedded calcite-dolomite rock, sandy calcarenite, silicified in part, interbedded coquinites with nautiloids, and chert nodules.

CONODONT FAUNAS

ABUNDANCE OF SPECIMENS AND RELATION TO ENVIRONMENT

A mobile acid laboratory was used (Druce & Wilson, 1967); over 10,000 feet of section was trough sampled at 20-foot intervals. Altogether fourteen weeks were spent at the localities; some 600 samples weighing over 1400 kgm were crushed, acidified, and picked. They yielded about 5000 specimens, of which after sorting, 3560 were identified.

Further specimens were recorded from spot samples collected at 50-foot intervals in measured sections by G. A. Brown in 1959.

The Cambrian part of the sequence yielded scattered conodonts; 65 percent of the samples were barren. In the Black Mountain section the conodonts were confined to the lower 600 feet, apart from isolated occurrences between 1220 and 1340 feet. The yield ranged from 1 to 250 specimens per kilogram. In the Mount Ninmaroo and Mount Datson sections conodonts occurred in scattered samples, with low yields of up to three specimens per kilogram.

The Gola Beds yielded a few specimens from isolated samples in the section.

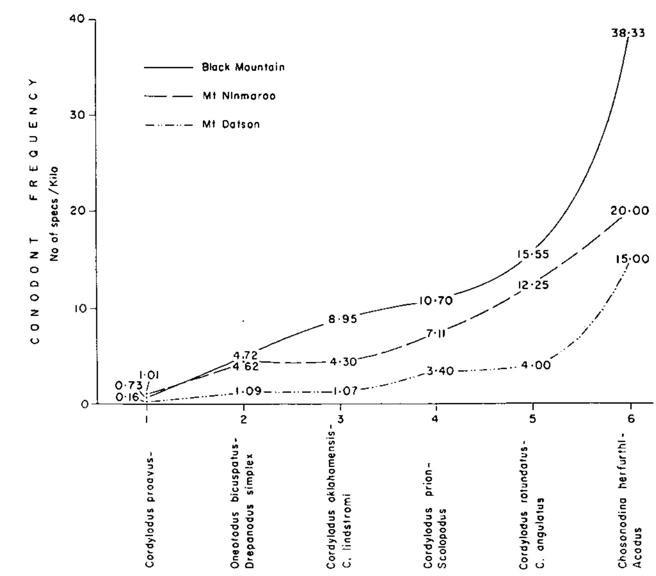

Fig. 9 Mean frequencies of conodont specimens per kilogram throughout the zonal succession at Black Mountain, Mt Ninmaroo, and Mt Datson.

The Ninmaroo Formation was considerably richer: conodonts were found in 70.4 percent of all samples examined. The mean frequencies of conodont specimens (per kilogram) throughout the zonal succession at Black Mountain, Mount Ninmaroo, and Mount Datson indicate an increase in abundance upwards in time, and a decrease in abundance southwards from Black Mountain to Mount Datson (Fig. 9).

The mean abundance of each Member shows the same trend (Fig. 10).

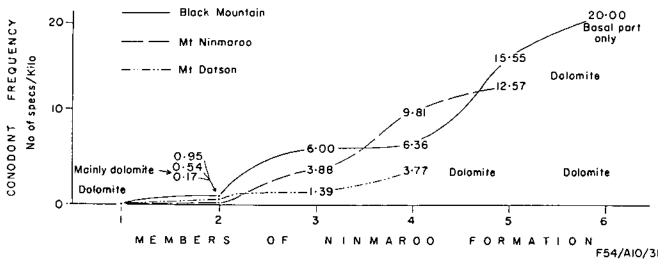

Fig. 10 **Mean frequencies of conodont specimens per kilogram throughout the members of the Ninmaroo Formation at Black Mountain, Mt Ninmaroo, and Mt Datson.**

TABLE 1

Assemblage Zone	Rate of sedimentation in feet per 1000 years		
	Black Mt	Mt Ninmaroo	Mt Datson
Chosonodina herfurthi-Acodus [1]	?	?	?
Cordylodus rotundatus-C. angulatus	0.43	0.29	0.12 [2]
Cordylodus prion-Scolopodus	0.41	0.43	0.24
Cordylodus oklahomensis-C. lindstromi	0.48	0.24	0.50
Oneotodus bicuspatus-Drepanodus simplex	0.22	0.22	0.14
Cordylodus proavus	0.98	0.46	0.46

[1] No data can be given for the uppermost zone as its upper limit is undefined.

[2] It is noteworthy that even the slowest Tremadocian sedimentation in the Burke River Structural Belt (0.12 feet per 1000 years) is still 36 times as fast as the rate that sediment accumulated on the early Ordovician sea floor in Sweden, which according to Lindström (1964, p. 70) does not seem to have exceeded, on the average, 1 mm in 1000 years. This may perhaps account for our low yields in comparison with the Swedish material.

Lindström has pointed out several times (1959, p. 429; 1960, p. 89; 1964, p. 68) that conodont frequency appears to be inversely proportional to the speed of sedimentation. Therefore, the general upward increase in abundance at Black Mountain, Mount Ninmaroo, and Mount Datson may perhaps be related to a possible gradual decrease in the rate of sedimentation over the Burke River Structural Belt during Tremadocian time. In order to test this suggestion, the rate of sedimentation for each zone in all three sections was calculated (Table 1) by using the thicknesses of the zones, which are taken as six equal intervals of Tremadocian time, totalling five million years (Harland, Smith, & Wilcock, 1964).

In general, the rate of sedimentation appears to decrease gradually, then increases, and finally decreases (Fig. 11).

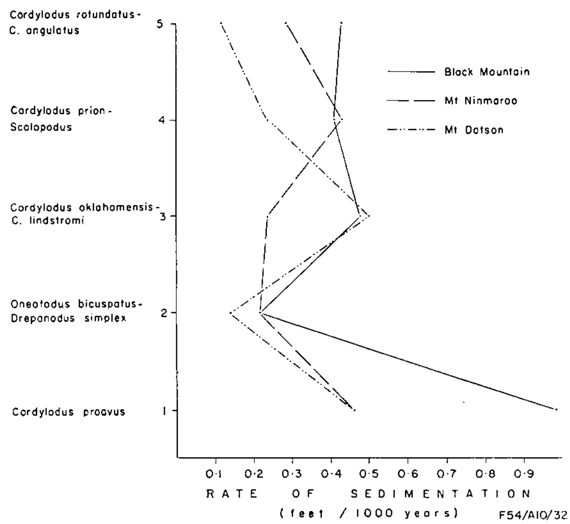

Fig. 11 Rates of sedimentation throughout the zonal succession at Black Mountain, Mt Ninmaroo, and Mt Datson.

The overall results show that there is no close relationship between conodont frequency and rate of sedimentation (Fig. 12). Other factors such as the presence of dolomite and phylogenetic evolutionary rates should also be considered, and these are discussed later.

A few observations lend some support to the suggestion that conodont frequency appears to be inversely proportional to the speed of sedimentation. At Mount Datson, as the speed of sedimentation between successive zones decreases, so the mean abundance increases; the reverse relationship applies between the *Oneotodus bicuspatus* — *Drepanodus simplex* and the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zones. At both Black Mountain and Mount Ninmaroo, the decrease in the speed of sedimentation between the *Cordylodus proavus* and the *Oneotodus bicuspatus* — *Drepanodus simplex* Assemblage Zones is accompanied by an increase in mean abundance. Indeed, the latter zone was deposited at the same speed at both localities (0.22 feet per 1000 years) and the corresponding figures of the mean abundance are very close (4.62 specimens per

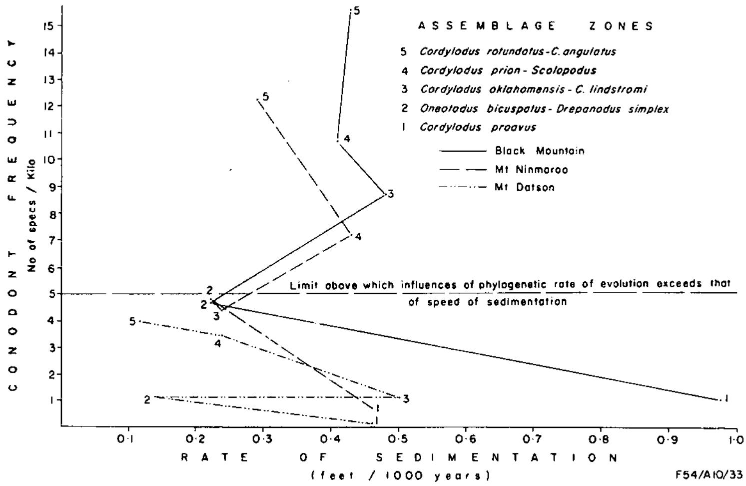

Fig. 12 Relationship of conodont frequency to rate of sedimentation.

kilogram for Black Mountain; 4.72 for Mount Ninmaroo). At Mount Ninmaroo, as the speed of sedimentation per 1000 years increases from 0.22 feet in the *Oneotodus bicuspatus — Drepanodus simplex* Assemblage Zone to 0.24 feet in the *Cordylodus oklahomensis — C. lindstromi* Assemblage Zone, the mean abundance decreases from 4.72 specimens per kilogram to 4.30. For zones containing more than five specimens per kilogram, there is an increase in conodont frequency irrespective of whether the rate of sedimentation is decreasing or increasing.

Dolomite also influences the mean abundance of conodonts. The deposition of primary dolomite may require environmental conditions inimical to the conodont bearing animal, and the secondary effects of dolomitization may possibly destroy them. Furthermore, the difficulties in processing dolomite samples to a point where all specimens are recovered produces anomalously low yields. Therefore, anomalous variation of mean abundance within the same zone could be attributed, at least in part, to the presence of dolomite beds. For example, the *Cordylodus proavus* Assemblage Zone at Mount Ninmaroo (0.73 specimens per kilogram) yielded fewer conodonts than that at Black Mountain (1.01), at less than half the speed of sedimentation (0.46 feet, compared to 0.98 feet per 1000 years). The reason for this is probably that dolomite is absent in the *Cordylodus proavus* Assemblage Zone at Black Mountain, but is a major constituent at Mount Ninmaroo. Similarly, at both Mount Ninmaroo and Mount Datson, sediments accumulated at the same rate (0.46 feet per 1000 years) during the *Cordylodus proavus* Assemblage Zone, but because this zone at Mount Datson contains only the lower dolomitic part of Member 2, it has only 0.16 specimens per kilogram, compared to 0.73 at Mount Ninmaroo.

It appears that neither speed of sedimentation nor the influence of dolomite in the Tremadocian of the Burke River Structural Belt can fully explain the conodont frequencies of more than five specimens per kilogram (Fig. 12). This increase in mean abundance may be a function of the increase in the number of species passing from older to younger zones. In other words, conodont frequency may also be a function of phylogenetic rates of evolution.

STATISTICAL ANALYSIS OF THE FAUNA

The data presented in this paper were analysed statistically using an agglomerative and polythetic programme, CENTCLAS (Williams et al., 1966), on a Control Data 3600 computer at the CSIRO Division of Computing Research, Canberra. Both a qualitative analysis using presence and absence and a quantitative analysis using actual numbers of species present were used. Details of the analysis are the subject of a separate paper (Druce) which is to be submitted for publication. In summary the analysis produced three major groupings:

1. Large indistinct groups of species;
2. Groups consisting of a single species;
3. Groups of closely associated species.

The large indistinct group is composed of species which are members of an evolutionary sequence or are rare in the sections examined. The single species groups are root-stocks from which many of the lower Ordovician species and

QUALITATIVE ANALYSIS	QUANTITATIVE ANALYSIS		? CONODONTIFER
Coelocerodontus burkei	*Coelocerodontus burkei*		*Coelocerodontus burkei*
Sagittodontus furnishi	*Sagittodontus furnishi*	1	*Sagittodontus furnishi*
Westergaardodina bicuspidata	*Westergaardodina bicuspidata*		*Westergaardodina bicuspidata*
	Coelocerodontus rotundatus		
Coelocerodontus primitivus	*Coelocerodontus primitivus*	2	*Coelocerodontus primitivus*
Oneotodus gallatini	*Oneotodus gallatini*		*Oneotodus gallatini*
Sagittodontus dahlmani	*Sagittodontus dahlmani*		*Sagittodontus dahlmani*
Cordylodus proavus		3	*Cordylodus proavus*
Cordylodus cf. C. proavus			*Cordylodus cf. C. proavus*
Acodus oneotensis	*Acodus oneotensis*		*Acodus oneotensis*
Chosonodina herfurthi	*Chosonodina herfurthi*	4	*Chosonodina herfurthi*
Scololodus iowensis	*Scolopodus iowensis*		*Scolopodus iowensis*
Scolopodus staufferi	*Scolopodus staufferi*		*Scolopodus staufferi*
Scolopodus asymmetrica	*Scolopodus asymmetrica*	5	*Scolopodus asymmetrica*
	Drepanodus subarcuatus		*Drepanodus subarcuatus*
Cordylodus caseyi			
Cordylodus intermedius			
Scopolodus triplicatus			
Cordylodus angulatus	*Cordylodus angulatus*		*Cordylodus angulatus*
Cordylodus rotundatus	*Cordylodus rotundatus*	6	*Cordylodus rotundatus*
	Oneotodus variabilis		*Oneotodus variabilis*
Oneotodus erectus			
Oneotodus datsonensis	*Oneotodus datsonensis*	7	*Oneotodus datsonensis*
Drepanodus simplex	*Drepanodus simplex*		*Drepanodus simplex*
	Oneotodus bicuspatus		*Oneotodus bicuspatus*
	Acanthodus uncinatus		*Acanthodus uncinatus*
	Cordylodus oklahomensis	8	*Cordylodus oklahomensis*
	Scandodus furnishi		*Scandodus furnishi*

F54/A10/34

Fig. 13 Statistical analysis.

genera developed. The groups of closely associated species usually contain three units; eight such groups were recognized, of which six are considered to be valid assemblages. The groupings are presented in Figure 13. Conodontifers 5 and 8 appear to be fortuitous groupings. From Figure 13 it can be seen that there is little difference between the qualitative and quantitative analysis, suggesting that the amount of information gained is not greatly increased by using the longer and more expensive quantitative methods.

STRATIGRAPHICAL DISTRIBUTION OF CONODONT FAUNAS

The precise ranges of all conodont species are shown in Figure 14.

There is a marked faunal change between the conodonts from the Chatsworth Limestone and those from the Ninmaroo Formation. The Chatsworth Limestone is characterized by species of the genera *Coelocerodontus, Oneotodus, Sagittodontus,* and *Westergaardodina.* Only one species, *Oneotodus nakamurai* Nogami, ranges into the Ninmaroo Formation.

The ranges of individual species tend to give a false picture because of the poor recovery of conodonts in the upper half of the Chatsworth Limestone at Black Mountain and the Chatsworth Limestone at Mount Ninmaroo and Mount Datson. Furthermore, the Chatsworth Limestone at Chatsworth, which is considered to be older than the Chatsworth Limestone at Black Mountain (Öpik, pers. comm), failed to yield conodonts.

The basal part of the Ninmaroo Formation in the Burke River Structural Belt yields a conodont assemblage characterized by *Oneotodus nakamurai* Nogami and simple cordylodids. These are joined, higher in the sequence, by species of *Oneotodus* and *Drepanodus* which characterize the *Oneotodus bicuspatus* — *Drepanodus simplex* Assemblage Zone.

The cordylodids then diversify, and the first occurrence of *Scandodus* and *Acanthodus* marks the beginning of the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone. They diversify further in the *Cordylodus prion* — *Scolopodus* Assemblage Zone, where they are associated with the first scolopodids, which become predominant, both in number and species, in the upper part of the Formation. The scolopodids are extremely varied in the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone, and are joined by further species of *Drepanodus, Cordylodus,* and the first occurrence of the genus *Chosonodina.*

The uppermost zone is characterized by the occurrence of *Acodus* and species of *Acanthodus, Chosonodina,* and *Scolopodus. Acodus* is represented by one species, *A. oneotensis* Furnish, which is confined to the *Chosonodina herfurthi* — *Acodus* Assemblage Zone. There are two species of *Acanthodus* — *A. uncinatus* Furnish, which is present in the lower *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone, and *A. costatus* sp. nov., which is confined to the *Chosonodina*

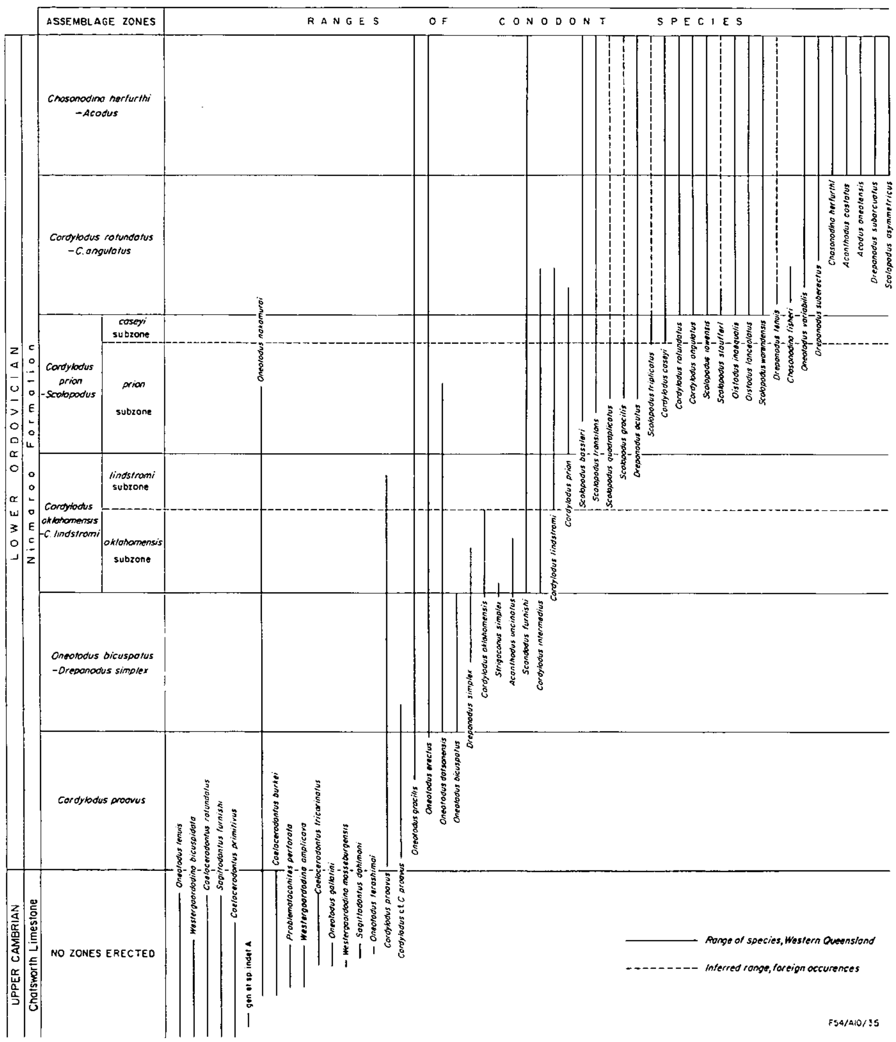

Fig. 14 **Distribution of conodont species. A composite chart based on distribution at Black Mountain, Mt Ninmaroo, and Mt Datson.**

herfurthi — *Acodus* Assemblage Zone. This zone is characterized by *Chosonodina herfurthi* Müller; the other chosonodinid species, *C. fisheri* sp. nov., is confined to the lower part of the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone.

The genus *Cordylodus* is varied and widespread in the Tremadocian. The first species, *C. proavus* Müller, is simple and occurs in the basal *Cordylodus proavus* Assemblage Zone. It is followed by *C. intermedius* Furnish, *C. lindstromi* sp. nov., and *C. oklahomensis* Müller in the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone. *C. prion* Lindström occurs in the *Cordylodus prion* — *Scolopodus* Assemblage Zone. The two youngest species are *Cordylodus angulatus* Pander and *C. rotundatus* Pander, which occur in the *Cordylodus rotundatus* — *C. angulatus* and *Chosonodina herfurthi* — *Acodus* Assemblage Zones.

The genus *Drepanodus* is represented by five species, three of which, *D. tenuis* Moskalenko, *D. suberectus* (Branson & Mehl), and *D. subarcuatus* Furnish, occur in the upper two zones. *D. acutus* Pander ranges from the *Cordylodus prion* — *Scolopodus* Assemblage Zone to the top of the section and *D. simplex* Branson & Mehl is confined to the upper part of the *Oneotodus bicuspatus* — *Drepanodus simplex* and the lower part of the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zones.

Two species of *Oistodus, O. inaequalis* Pander and *O. lanceolatus* Pander, are present and have identical ranges from the base of the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone to the top of the section.

Oneotodus is the only genus represented in both the Chatsworth and Ninmaroo Formations. Four species, *O. gallatini* Müller, *O. nakamurai* Nogami, *O. tenuis* Müller, and *O. terashimai* Nogami, occur in the Chatsworth Limestone. Of these, only *O. nakamurai* Nogami ranges into the Ninmaroo Formation. There in the basal two zones, it is joined by several species, *O. bicuspatus* sp. nov., *O. datsonensis* sp. nov., *O. erectus* sp. nov., and *O. gracilis* (Furnish). *O. variabilis* Lindström is confined to the upper two zones.

The paraconodont genus *Problematoconites* is represented by a single species, *P. perforata* Müller, in the Chatsworth Limestone.

Sagittodontus is also confined to the Cambrian in western Queensland and is represented by two species, *S. dahlmani* Müller and *S. furnishi* (Müller).

Scandodus is represented by a single species, *S. furnishi* Lindström, in the upper four zones of the Ninmaroo Formation.

Scolopodus is well represented in the sections, nine species being identified. Five, *S. bassleri* (Furnish), *S. gracilis* Ethington & Clark, *S. quadraplicatus* Branson & Mehl, *S. transitans* sp. nov., and *S. triplicatus* Ethington & Clark, first occur in the *Cordylodus prion* — *Scolopodus* Assemblage Zone. A further three species, *S. iowensis* Furnish, *S. staufferi* Furnish, and *S. warendensis* sp. nov., occur in the overlying *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone.

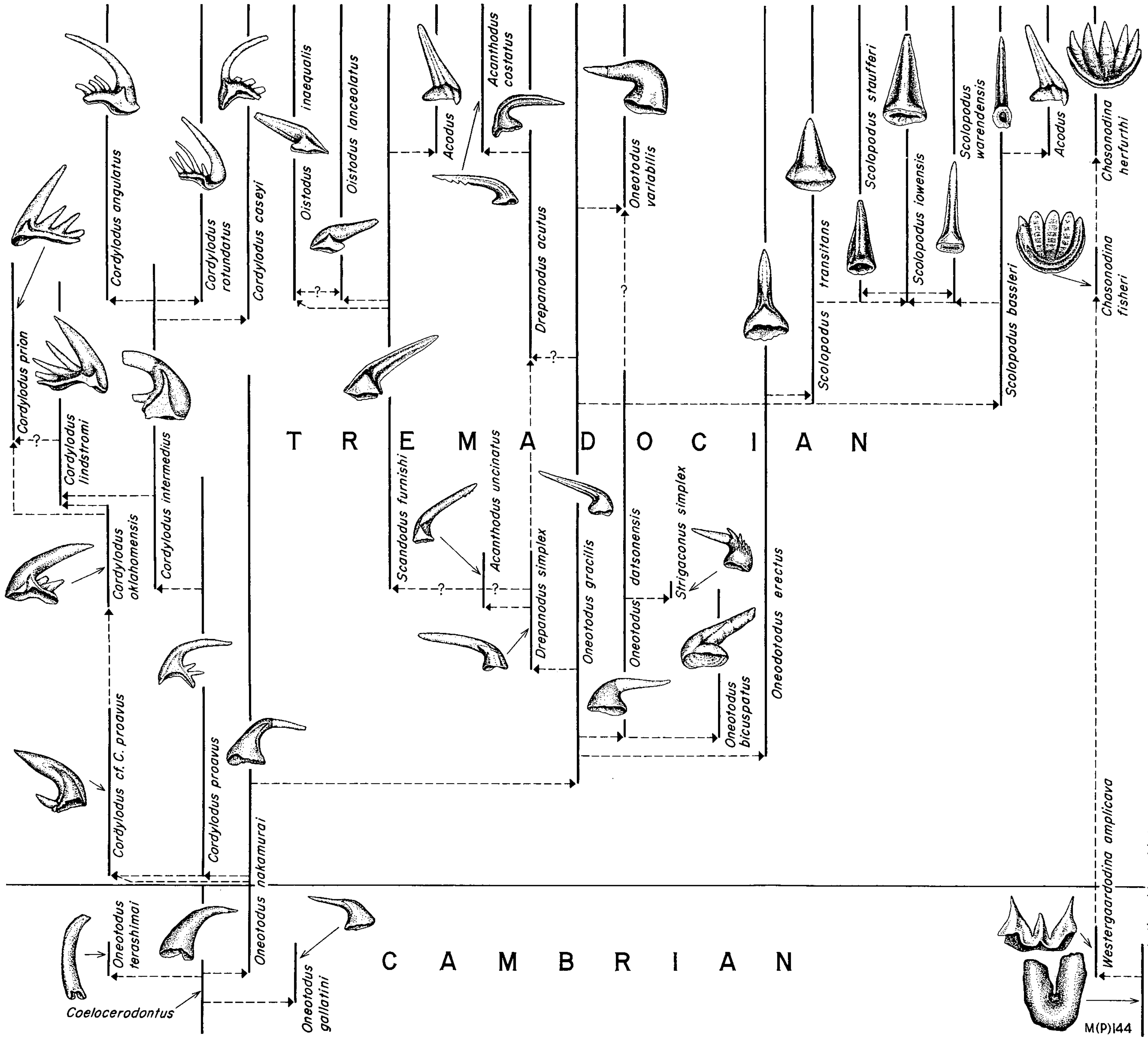

Fig. 15 **Phylogenetic relationships between Cambrian and Tremadocian species from western Queensland.**

A single species, *S. asymmetricus* sp. nov., is confined to the *Chosonodina herfurthi — Acodus* Assemblage Zone.

The new genus *Strigaconus* is monospecific; *S. simplex* sp. nov. is confined to the boundary between the *Oneotodus bicuspatus — Drepanodus simplex* and *Cordylodus oklahomensis — C. lindstromi* Assemblage Zones.

The bizarre genus *Westergaardodina* is confined to the Chatsworth Limestone and is represented by three species, *W. amplicava* Müller, *W. bicuspidata* Müller, and *W. mossebergensis* Müller. Finally, two generically indeterminate forms were recovered, one from the basal *Cordylodus proavus* Assemblage Zone (sp. B) and the other from the Chatsworth Limestone (sp. A).

PHYLOGENY OF CAMBRO-ORDOVICIAN CONODONTS (Fig. 15)

In the Cambrian there appear to be two basic root-stocks, the simple cones on the one hand and the bizarre U and W-shaped westergaardodinids on the other.

The simple cones appear to have developed from a coelocerodontid ancestor, a simple, hollow, thin-walled, erect to reclined cusp. At least three species of the genus *Oneotodus* developed from it. *O. terashimai* Nogami developed by a slimming of the base and contraction of the cusp to give a small recurved 'nipple'. Both *O. gallatini* Müller and *O. nakamurai* Nogami developed by the lengthening of the cusp and, in the case of *O. nakamurai,* the addition of 'white matter'.

Oneotodus nakamurai Nogami passes up into the Tremadocian and forms the root stock for the diversified cones, bars, and blades found in the Tremadocian. The cordylodids developed from *O. nakamurai,* the earliest being *Cordylodus proavus* Müller, which is almost identical with *O. nakamurai* except for the development of auxiliary denticles on the postero-aboral face. *Cordylodus* cf. *C. proavus* Müller developed at the same time, either from *O. nakamurai* or *C. proavus,* by the flattening in cross-section of the essentially circular cusp.

C. proavus and *C.* cf. *C. proavus* give us the two lines of cordylodid development. *C. proavus* produced *C. intermedius* Furnish by alteration of the basal cavity from a simple erect cone to an inclined one with an anteriorly pointing apex. Convolution of this apex and changes in the antero-aboral angle gave rise to *Cordylodus angulatus* Pander and *C. rotundatus* Pander.

Cordylodus oklahomensis Müller is probably developed from *C.* cf. *C. proavus* by the development of blade-like denticles on the posterior bar. *Cordylodus lindstromi* sp. nov. probably developed from either *C. oklahomensis* or *C. intermedius* by the development of secondary cavity apices beneath the posterior bar denticles. *Cordylodus prion* Lindström is similar to *C. oklahomensis,* but the main cusp is reduced and the posterior bar is lengthened and bears taller, laterally compressed denticles. The exact relationship of *Cordylodus caseyi* sp.

nov. is not clear, but it probably developed from *Cordylodus intermedius* by flaring of the cavity wall.

Apart from being ancestral to the cordylodids, *Oneotodus nakamurai* Nogami is also the root-stock for the Tremadocian oneotodids. *Oneotodus gracilis* (Furnish) developed by a decrease in the size of the base and an increase in the size of the cusp. This species, which is extremely common in the Tremadocian, appears to be the direct ancestor of all the simple cones found in the Tremadocian.

A distinct lateral compression of the cusp marked the incoming of the genus *Drepanodus,* which is represented in the early Tremadocian by *D. simplex* Branson & Mehl. The acquisition of denticles on the postero-oral face of the cusp produces *Acanthodus uncinatus* Furnish.

A questionable development from *Drepanodus simplex* or perhaps *Oneotodus gracilis* is *Scandodus furnishi* Lindström, which is erect and laterally compressed. *S. furnishi* gave rise, in the late Tremadocian, to the oistodids *O. inaequalis* Pander and *O. lanceolatus* Pander by the posterior tilting of the cusp with respect to the base. These two species appear to be very closely related. The development of a ridge on the flattened lateral face of *S. furnishi* produced the genus *Acodus.* This genus probably had a polyphyletic origin, being also developed from a scolopodid ancestor, *Scolopodus bassleri* (Furnish).

The development of later drepanodids is questionable, and it is possible that they developed from both *Drepanodus simplex* and *Oneotodus gracilis.* One species, *D. acutus* Pander, characterized by a costa developed on the inner anterior face, appears to be ancestral to *Acanthodus costatus* sp. nov., suggesting that the genus *Acanthodus* developed from *Drepanodus* at more than one time.

Oneotodus gracilis (Furnish) is also ancestral to the development of oneotodids. In the early Tremadocian an increase in the reclination of the cusp produced *O. datsonensis* sp. nov., which is closely related to *O. bicuspatus* sp. nov., characterized by deep sulci on both faces. The bizarre genus *Strigaconus* probably developed from *O. datsonensis* by the addition of secondary denticles on the anterior face of the base. The late Tremadocian form *O. variabilis* Lindström could have developed either from *O. datsonensis* or *O. gracilis.*

A proclined cusp distinguishes *O. erectus* sp. nov., which is very close to *O. gracilis. O. erectus* is the ancestor of the scolopodids. The development of a posterior costa and a laterally compressed cusp with flattened anterior and posterior faces distinguishes *Scolopodus transitans* sp. nov. The further development of a posterior costa marks the incoming of *S. iowensis* Furnish, *S. staufferi* Furnish, and *S. warendensis* sp. nov., which can be distinguished by the varied development of this posterior costa.

One scolopodid, *S. bassleri* (Furnish), is developed directly from *O. gracilis* by the addition of lateral costae. *S. warendensis* sp. nov. could also have been developed from *S. bassleri* by the increase in size of the lateral costae and the straightening of the cusp.

The second Cambrian root stock is the westergaardodinids. Simple U-shaped forms, *W. bicuspidata* Müller, developed into W-shaped forms, *W. amplicava* Müller. Although there appears to be a blank in the early Tremadocian, the palm-shaped conodonts of the late Tremadocian, referred to the genus *Chosonodina,* appear to be closely related. The simplest chosonodinid is *C. fisheri* sp. nov., which has five denticles. This is succeeded by *C. herfurthi* Müller, with seven denticles. Further development of asymmetry probably gave rise to the later species *C. lunata* Harris & Harris, and also the genus *Coleodus*. The unique genus *Loxodus* Furnish may also belong to this lineage.

CONODONT ASSEMBLAGE ZONES

A series of six biostratigraphic zones has been established for the Tremadocian. No zones have been erected for the Cambrian part of the sequence. The stratigraphic distribution of species in the Cambrian and the possibilities of erecting a zonation are discussed in the review of the stratigraphic distribution of the conodont faunas (see below).

Cordylodus proavus Assemblage Zone

Characteristic species: Cordylodus proavus Müller, *C.* cf. *C. proavus* Müller, *Oneotodus gracilis* (Furnish), and *O. nakamurai* Nogami.

Limits: The base is drawn at the first occurrence of *Cordylodus proavus* and *C.* cf. *C. proavus* and above the last occurrence of *Coelocerodontus burkei*. In the Black Mountain and Mount Datson sections this corresponds to the boundary between the Chatsworth Limestone and the Ninmaroo Formation.

The upper limit is marked by the first occurrence of *Oneotodus datsonensis* sp. nov. and *O. bicuspatus* sp. nov.

Remarks: This zone can be recognized in the Black Mountain, Mount Ninmaroo, Mount Datson, and West Swift Hills sections. It occupies the basal 820 feet of the Ninmaroo Formation at Black Mountain and the basal 380 feet at Mount Datson. At Mount Ninmaroo the zone occurs in the interval 300-680 feet in the Ninmaroo Formation. In the West Swift Hills section it occupies the lowest 140 feet of the exposed section in the Ninmaroo Formation.

Oneotodus nakamurai Nogami ranges throughout the zone from the Chatsworth Limestone. *Cordylodus proavus* Müller occurs throughout the zone; *C.* cf. *C. proavus* Müller occurs first just above the base of the zone, and last in the overlying zone. The long-ranging species *Oneotodus gracilis* (Furnish) occurs first in the upper third, and *O. erectus* sp. nov. in the uppermost part of the zone.

Oneotodus bicuspatus — *Drepanodus simplex* Assemblage Zone

Characteristic species: Cordylodus proavus Müller, *Drepanodus simplex* Branson & Mehl, *Oneotodus bicuspatus* sp. nov., *O. datsonensis* sp. nov., *O. erectus* sp. nov., *O. gracilis* (Furnish), and *O. nakamurai* Nogami.

Limits: The lower limit is marked by the first occurrence of *Oneotodus bicuspatus* sp. nov. and *O. datsonensis* sp. nov. The upper limit is marked by the last occurrence of *Oneotodus bicuspatus,* and the first occurrence of *Scandodus furnishi* Lindström and *Cordylodus intermedius* Furnish.

Remarks: This zone occupies the intervals 820-1000 feet at Black Mountain, 680-860 feet at Mount Ninmaroo, 380-500 feet at Mount Datson and 140-460 feet in the West Swift Hills. *Cordylodus* cf. *C. proavus* Müller disappears in the lowest one-fifth of the zone. *Drepanodus simplex* Branson & Mehl is present in the upper half of the zone. Three species, *Cordylodus oklahomensis* Müller, *Strigaconus simplex* gen. et sp. nov., and *Acanthodus uncinatus* (Furnish), occur in the very uppermost part.

Cordylodus oklahomensis — *C. lindstromi* Assemblage Zone

Characteristic species: Acanthodus uncinatus Furnish, *Cordylodus intermedius* Furnish, *C. lindstromi* sp. nov., *C. oklahomensis* Müller, *C. proavus* Müller, *Drepanodus simplex* Branson & Mehl, *Oneotodus datsonensis* sp. nov., *O. erectus* sp. nov., *O. gracilis* (Furnish), *O. nakamurai* Nogami, *Scandodus furnishi* Lindström, and *Strigaconus simplex* gen. et sp. nov.

Limits: The base of the zone is marked by the last occurrence of *Oneotodus bicuspatus* sp. nov. and the first occurrence of *Scandodus furnishi* Lindström and *Cordylodus intermedius* Furnish. The upper limit is marked by the first occurrence of *Cordylodus prion* Lindström. Two subzones can be delineated; the lower is characterized by *C. oklahomensis* Müller and the upper by *C. lindstromi* sp. nov.

Remarks: At Black Mountain the zone occupies the interval 1000-1400 feet of the Ninmaroo formation. Each subzone is 200 feet thick. At Mount Ninmaroo it occurs in the interval 860-1060 feet; the lower subzone is 120 feet thick, the upper 80 feet thick. The zone is present in the Mount Datson section in the interval 500-920 feet, the lower subzone being 320 feet thick and the upper only 100 feet thick. In the West Swift Hills, this zone occupies the interval 460-520 feet. It is also present at Digby Peaks (0-180 feet), and along the Telegraph Line.

Strigaconus simplex gen. et sp. nov. is restricted to the lowermost part of the zone; other species which disappear in the lower subzone are *Drepanodus simplex* Branson & Mehl and *Acanthodus uncinatus* Furnish. The final appearance of *Cordylodus oklahomensis* Müller and the first occurrence of *C. lindstromi* sp. nov. mark the boundary between the two subzones. Within the upper subzone *Cordylodus proavus* Müller disappears.

Cordylodus prion — *Scolopodus* Assemblage Zone

Characteristic species: Cordylodus caseyi sp. nov., *C. intermedius* Furnish, *C. lindstromi* sp. nov., *C. prion* Lindström, *Drepanodus acutus* Pander, *Oneotodus datsonensis* sp. nov., *O. erectus* sp. nov., *O. gracilis* (Furnish), *O. nakamurai* Nogami, *Scandodus furnishi* Lindström, *Scolopodus bassleri* (Furnish), *S. gracilis* Ethington & Clark, *S. quadraplicatus* Branson & Mehl, *S. transitans* sp. nov., and *S. triplicatus* Ethington & Clark.

Limits: The base of the zone is marked by the first occurrence of *Cordylodus prion* Lindström. The upper limit is marked by the first appearance of *Cordylodus angulatus* Pander, *C. rotundatus* Pander, *Oistodus inaequalis* Pander, *O. lanceolatus* Pander, *Scolopodus iowensis* (Furnish), *S. staufferi* (Furnish), and *S. warendensis* sp. nov.

Two subzones are recognized; the upper can be distinguished by the presence of *Cordylodus caseyi* sp. nov.

Remarks: This zone occupies the intervals 1400-1740 feet at Black Mountain, 1060-1420 feet at Mount Ninmaroo, and 920-1120 feet at Mount Datson. The thicknesses of the lower and upper subzones are 240 and 100 feet at Black Mountain, 260 and 100 feet at Mount Ninmaroo, and 180 and 20 feet at Mount Datson. The zone also occurs along the Telegraph Line, three miles west of Digby Peaks.

Within the zone the genus *Scolopodus* makes a first appearance, and is represented by five species. *S. bassleri* (Furnish) and *S. transitans* sp. nov. occur in the upper three-quarters, and *S. gracilis* Ethington & Clark and *S. quadraplicatus* Branson & Mehl in the upper half, of the lower subzone. *S. triplicatus* Ethington & Clark occurs in the upper subzone. *S. quadraplicatus* Branson & Mehl and *S. gracilis* Ethington & Clark both make their last appearance in the basal part of the upper subzone. *Oneotodus nakamurai* Nogami and *O. datsonensis* sp. nov. both disappear in the lower subzone. *Drepanodus acutus* Pander makes a first appearance in the upper half of the lower subzone. The lower limit of the upper subzone is marked by the first occurrence of *Cordylodus caseyi* sp. nov., and *S. triplicatus* Ethington & Clark makes a first appearance immediately below this.

Cordylodus rotundatus — *C. angulatus* Assemblage Zone

Characteristic species: Chosonodina fisheri sp. nov., *Cordylodus angulatus* Pander, *C. caseyi* sp. nov., *C. intermedius* Furnish, *C. rotundatus* Pander, *Drepanodus acutus* Pander, *D. suberectus* (Branson & Mehl), *Oneotodus erectus* sp. nov., *O. gracilis* (Furnish), *O. variabilis* Lindström, *Scandodus furnishi* Lindström, *Scolopodus bassleri* (Furnish), *S. iowensis* (Furnish), *S. transitans* sp. nov., *S. warendensis* sp. nov., *Oistodus inaequalis* Pander, and *O. lanceolatus* Pander.

Limits: The lower limit is marked by the first occurrence of *Cordylodus angulatus* Pander, *C. rotundatus* Pander, *Oistodus inaequalis* Pander, *O. lanceolatus* Pander, *S. iowensis* (Furnish), *S. staufferi* (Furnish), and *S. warendensis* sp. nov. The upper limit is marked by the first occurrence of *Chosonodina herfurthi* Müller, *Acanthodus costatus* sp. nov., *Acodus oneotensis* Furnish, *Drepanodus subarcuatus* Furnish, and *Scolopodus asymmetricus* sp. nov.

Remarks: This zone occupies the intervals 1740-2100 feet at Black Mountain, 1420-1660 feet at Mount Ninmaroo and 1120-1220 feet at Mount Datson. It is also present at locality 13/2 south of Signal Hill. Three species, *Chosonodina fisheri* sp. nov., *Scolopodus staufferi* (Furnish), and *Drepanodus tenuis* Moskalenko, are confined to the lower part of the zone; *Cordylodus intermedius* Furnish, *C. lindstromi* sp. nov., and *C. prion* Lindström make their last appearance in the lower part of the zone; *D. suberectus* (Branson & Mehl) and *Oneotodus variabilis* Lindström first occur in the central part of the zone.

Chosonodina herfurthi — *Acodus* Assemblage Zone

Characteristic species: Acanthodus costatus sp. nov., *Acodus oneotensis* Furnish, *Chosonodina herfurthi* Müller, *Cordylodus angulatus* Pander, *C. caseyi* sp. nov., *C. rotundatus* Pander, *D. suberectus* (Branson & Mehl), *D. subarcuatus* Furnish, *Oistodus inaequalis* Pander, *O. lanceolatus* Pander, *Oneotodus erectus* sp. nov., *O. gracilis* (Furnish), *O. variabilis* Lindström, *Scandodus furnishi* Lindström, *Scolopodus asymmetricus* sp. nov., *S. bassleri* (Furnish), *S. iowensis* (Furnish), *S. transitans* sp. nov., and *S. warendensis* sp. nov.

Limits: The lower limit is marked by the first occurrence of *Acanthodus costatus* sp. nov., *Acodus oneotensis* Furnish, *Chosonodina herfurthi* Müller, *Drepanodus subarcuatus* Furnish, and *Scolopodus asymmetricus* sp. nov. The upper limit is not fixed because the zone occupies the uppermost part of the sampled section; the overlying beds consist of massive dolomite.

Remarks: The dolomitic members (Member 6 at Mount Ninmaroo and Black Mountain; Datson Member and Member 6 at Mount Datson), have yielded extremely sparse conodonts referable to this zone: the abundant faunas representing the zone occur in strata below the dolomite, which are 20 feet thick at Black Mountain, 220 feet at Mount Ninmaroo and 60 feet at Mount Datson. The zone is also present at Black Ridge.

No species make either a first or final appearance within the zone.

LOCAL CORRELATION

The Black Mountain section is taken as the type section; it is the thickest and most complete and yielded a more abundant fauna than any of the other sections.

The Chatsworth Limestone is 1420 feet thick at Black Mountain, and the faunas could be recognized in the Mount Ninmaroo and Mount Datson sections.

The highest occurrence of a conodont species indicative of the Cambrian — *Coelocerodontus tricarinatus* (Nogami) — is at 1240 feet; the lithological boundary between the Chatsworth Limestone and the Ninmaroo Formation is at 1420 feet (Casey, 1968); and the first truly Ordovician fauna, containing *Cordylodus,* is at 1880 feet. Until further evidence, from other fossil groups, enable the Cambrian-Tremadocian boundary to be located more precisely, we have placed it at Casey's lithological boundary. The six assemblage zones of the Ninmaroo Formation at Black Mountain can be recognized in other sections (Fig. 16).

Black Mountain-Mount Ninmaroo-Mount Datson

Cambrian. Cambrian faunas are present in the basal 580 feet of the Mount Ninmaroo section. The lithological boundary between the Chatsworth Limestone and the Ninmaroo Formation is at 280 feet; the highest Cambrian species (*Coelocerodontus burkei*) occurs at 580 feet and the lowest Ordovician species (*Cordylodus proavus*) at 680 feet. The time-stratigraphic boundary is placed arbitrarily above the last occurrence of *Coelocerodontus burkei.* Thus 300 feet of the Ninmaroo Formation at Mount Ninmaroo is of Cambrian age, probably Trempealeauan (see p. 15). This includes Member 1 and half of Member 2 of Brown (1961, unpubl.). At Mount Datson the lowermost 660 feet of the section is of Cambrian age. The last appearance of Cambrian conodonts (*Coelocerodontus burkei*) is at 620 feet, the lithological boundary between the Chatsworth Limestone and the Ninmaroo Formation is at 660 feet, and the first appearance of Ordovician conodonts (*Cordylodus*) is at 680 feet. The time-stratigraphic boundary is arbitrarily placed at the lithological boundary.

Ordovician. The lowest zone, the *Cordylodus proavus* Assemblage Zone, includes Members 1 and 2 and the lower part of Member 3 at Black Mountain; at Mount Ninmaroo it includes the upper part of Member 2 and the lower part of Member 3; and at Mount Datson it is confined to Member 1 and the lower three-quarters of Member 2. The thickness of the zone is 820 feet at Black Mountain, and 380 feet at both Mount Ninmaroo and Mount Datson. This suggests that the rate of sedimentation at Black Mountain was twice that at Mount Ninmaroo and Mount Datson during *proavus* time.

The *Oneotodus bicuspatus — Drepanodus simplex* Assemblage Zone is present in the central part of Member 3 at Black Mountain and at Mount Ninmaroo. At Mount Datson it occupies all but the uppermost part of the upper quarter of Member 2. This zone is 180 feet thick at both Black Mountain and Mount Ninmaroo and 120 feet thick at Mount Datson, so the rate of sedimentation was probably slightly less at Mount Datson than at Mount Ninmaroo or Black Mountain.

The *Cordylodus oklahomensis — C. lindstromi* Assemblage Zone ranges over the upper part of Member 3 and the lower three-quarters of Member 4 at Black

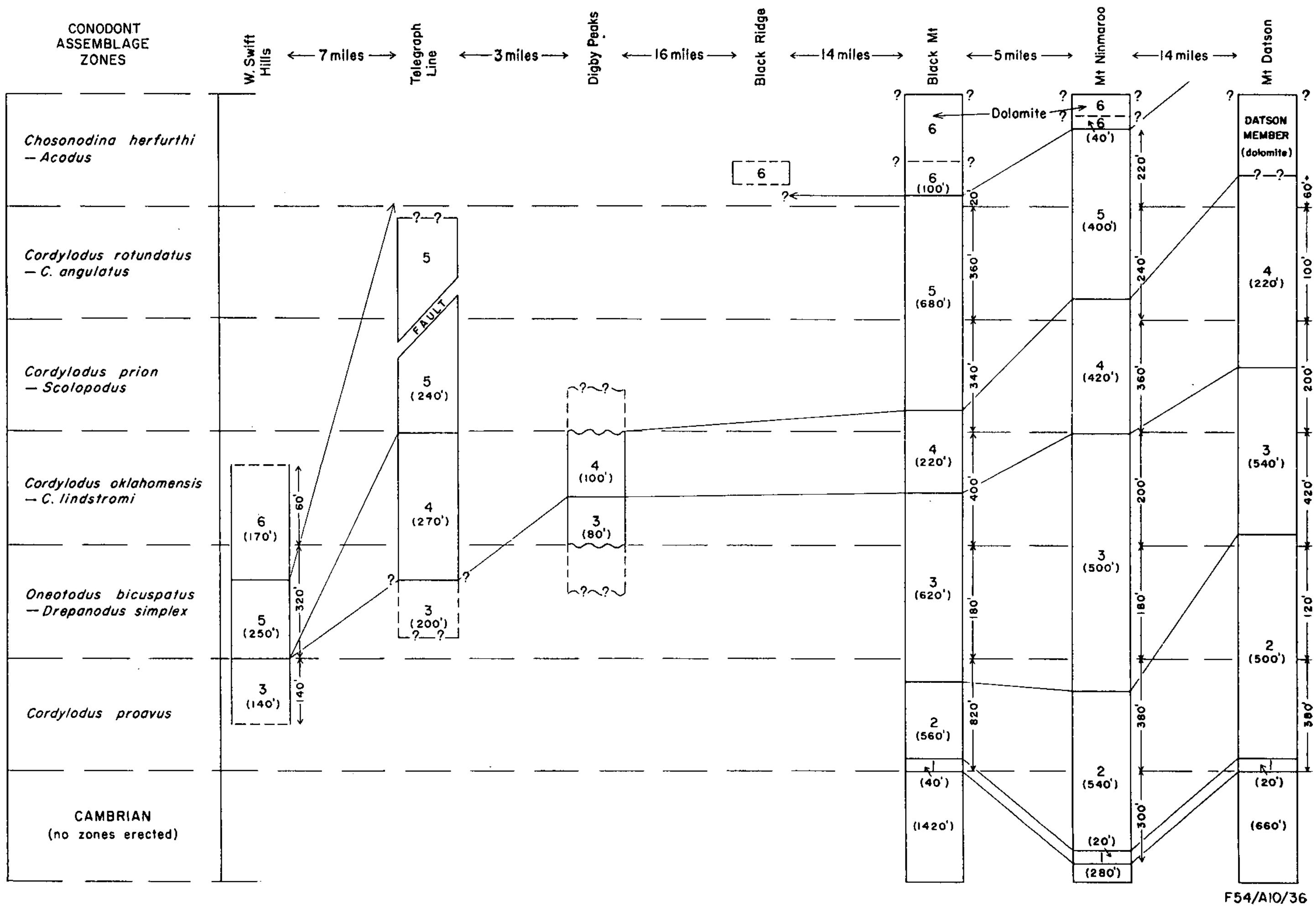

Fig. 16 Correlation of the lithological members of the Ninmaroo Formation, based on Tremadocian conodont assemblage zones.

Mountain; at Mount Ninmaroo it includes the upper third of Member 3; and at Mount Datson the uppermost part of Member 2 and the lower three-quarters of Member 3. The thickness of the zone is 420 feet at Mount Datson and 400 feet at Black Mountain but only 200 feet at Mount Ninmaroo: the rate of sedimentation was twice as fast at Mount Datson and Black Mountain as it was at Mount Ninmaroo. The two subzones delineated at Black Mountain were also recognizable at Mount Ninmaroo and Mount Datson.

The *Cordylodus prion — Scolopodus* Assemblage Zone includes the uppermost part of Member 4 and the lower third of Member 5 at Black Mountain. At Mount Ninmaroo the zone is equivalent to all but the uppermost part of Member 4 and at Mount Datson it includes the upper quarter of Member 3 and the lower third of Member 4.

The thickness of the zone ranges from 360 feet at Mount Ninmaroo, 340 feet at Black Mountain to 200 feet at Mount Datson. The rate of sedimentation appears to have been roughly the same at Black Mountain and Mount Ninmaroo but much slower at Mount Datson in *prion* time.

The *Cordylodus angulatus — C. rotundatus* Assemblage Zone is confined to all but the uppermost part of Member 5 at Black Mountain; at Mount Ninmaroo it includes the upper part of Member 4 and the lower half of Member 5; and at Mount Datson it is confined to the central part of Member 4. The thickness of this zone varies greatly, suggesting vastly different rates of sedimentation. At Mount Datson the zone is only 100 feet thick. At Mount Ninmaroo it is 240 feet thick, and at Black Mountain 360 feet thick, a rate of sedimentation nearly four times as fast as at Mount Datson.

The *Chosonodina herfurthi — Acodus* Assemblage Zone is present in the uppermost part of Member 5 at Black Mountain and Mount Ninmaroo, and in the upper part of Member 4 at Mount Datson. The Mount Datson Member at Mount Datson, overlying Member 4, and Member 6 at all three localities are dolomite units and yield only rare and scattered conodonts of this zone.

Dribbling Bore

A series of fourteen spot samples was examined from a traverse across the inlier from northeast to southwest. Only one sample, BOU8/7 (Fig. 6), yielded conodonts, which included *Coelocerodontus burkei* sp. nov. and *Oneotodus nakamurai* Nogami. These species are Cambrian in age; both are known from the Chatsworth Limestone.

Black Ridge

A single sample collected from Black Ridge (Fig. 1) by G. A. Brown yielded the following species: *Acodus oneotensis* Furnish, *Oneotodus gracilis* (Furnish), *Scolopodus bassleri* (Furnish), and *Scolopodus asymmetricus* sp. nov. These characterize the *Chosonodina herfurthi* — *Acodus* Assemblage Zone, the uppermost conodont zone of the Ninmaroo Formation.

Chatsworth and Digby Peaks

The Chatsworth Limestone was sampled near Chatsworth homestead (Fig. 7). Altogether 35 kilograms of rock were examined, but no conodonts were recovered.

At Digby Peaks (Fig. 8) a section 180 feet thick was trough-sampled every 20 feet. The conodonts recovered were: *Oneotodus datsonensis* sp. nov., *O. erectus* sp. nov., *O. gracilis* (Furnish), and *O. nakamurai* Nogami. These species cannot be placed in any one assemblage zone because they are long-ranging. They are no older than the *Oneotodus bicuspatus* — *Drepanodus simplex* Assemblage Zone and no younger than *Cordylodus prion* subzone of the *Cordylodus prion* — *Scolopodus* Assemblage Zone.

West Swift Hills

One section, measuring 560 feet, was trough-sampled at 20-foot intervals in the western margin of the Swift Hills (Fig. 8). The conodonts recovered from the basal 140 feet were: *Cordylodus proavus* Müller, *Cordylodus* cf. *C. proavus* Müller, and *Oneotodus nakamurai* Nogami. This combination of species is found in the basal Tremadocian *Cordylodus proavus* Assemblage Zone.

At a height of 140 feet new species occur, and between 140 and 460 feet, *Oneotodus bicuspatus* sp. nov., *O. datsonensis* sp. nov., *O. erectus* sp. nov., *O. gracilis* (Furnish), and *O. nakamurai* Nogami were collected. These species are indicative of the *Oneotodus bicuspatus* — *Drepanodus simplex* Assemblage Zone, *O. bicuspatus* being confined to this zone.

In the top 60 feet, *O. bicuspatus* is absent. However, specimens which appear to be intermediate between *O. erectus* sp. nov. and *Scolopodus transitans* sp. nov. are present, suggesting that the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone or even perhaps the *Cordylodus prion* — *Scolopodus* Assemblage Zone is present in the top few feet of the section.

Gola Beds

The conodonts of the Gola Beds (Fig. 5A) comprise five species: *Coelocerodontus burkei* sp. nov., *C. rotundatus* sp. nov., *C. tricarinatus* (Nogami), *Oneotodus nakamurai* Nogami, and *Sagittodontus furnishi* (Müller).

All these species are known from the Chatsworth Limestone at Black Mountain, where they range through most of the section. The presence of *C. tricarinatus*

(Nogami), which ranges through the interval 500-1240 feet at Black Mountain, suggests that the Gola Beds are equivalent to the upper, rather than the lower, part of the Chatsworth Limestone at Black Mountain. However, the paucity of conodonts in the Gola Beds, both in individuals and in taxa, makes the evidence tenuous.

INTERCONTINENTAL CORRELATION

Cambrian (Fig. 17)

As yet no conodont assemblage zones have been erected for the Cambrian System. However, the work of Müller (1959) and Nogami (1966, 1967) has shown that the assemblages from the upper Upper Cambrian differ from those from the lower Upper Cambrian.

The assemblages from the Chatsworth Limestone and those described by Müller from Europe have eight species in common:

Coelocerodontus primitivus (Müller) (=*Furnishina primitiva)*
Oneotodus gallatini Müller
O. tenuis Müller
Sagittodontus dahlmani Müller
S. furnishi (Müller) (=*Furnishina furnishi)*
Westergaardodina amplicava Müller
W. bicuspidata Müller
W. mossebergensis Müller

Of these, the species with the most diagnostic ranges are *Coelocerodontus primitivus, Sagittodontus dahlmani,* and *Westergaardodina amplicava.* In Western Europe, *C. primitivus* ranges from Zone 5b to 5e, *S. dahlmani* from 5c to 5e, and *W. amplicava* from 5d to 6a. Furthermore, *Westergaardodina mossebergensis* does not range any higher than Zone 5d.

This suggests that the interval up to 600 feet in the Chatsworth Limestone at Black Mountain is equivalent to Zone 5d of Northern Europe. The remainder of the Chatsworth Limestone (600-1420 feet) is probably equivalent to Zones 5e and 6a.

Among the conodonts described by Nogami the following species are common between the Chatsworth Limestone and the Upper Cambrian Kushan Formation of China (Nogami, 1966):

Oneotodus tenuis Müller
Sagittodontus dahlmani Müller (=*S. dunderbergiae*)
S. furnishi Müller (= *Furnishina furnishi*)
Westergaardodina mossebergensis Müller

The presence of *S. dahlmani* and *W. mossebergensis* suggests a possible equivalence to Zones 5c or 5d. However, the presence in the Kushan Formation of *Scandodus oelandicus* Müller, which is confined to Zones 2, 3, and 4 in Europe,

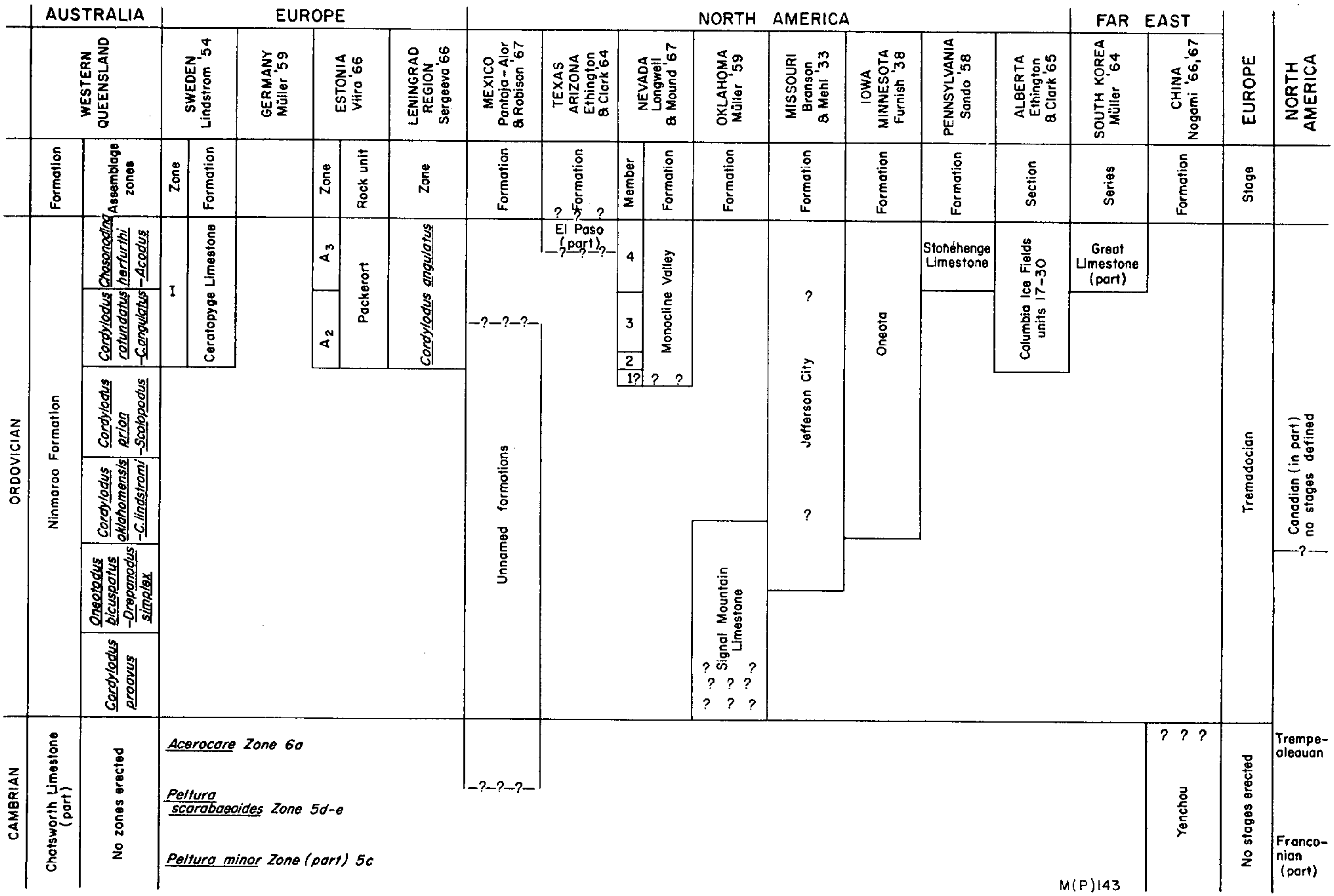

Fig. 17 Intercontinental correlation of Tremadocian conodont assemblage zones established in western Queensland.

and the evidence from the trilobite faunas (Öpik, pers. comm.) suggest that the Kushan Formation is older than the Chatsworth Limestone at Black Mountain.

The uppermost Upper Cambrian Yencho Formation (Nogami, 1967) has several species in common with the Chatsworth Limestone:

Coelocerodontus tricarinatus (Nogami) (=*Hertzina? tricarinata)*
C. primitivus (Müller) (=*Furnishina primitiva)*
Oneotodus gallatini Müller
O. nakamurai Nogami
O. tenuis Müller
O. terashimai Nogami
Problematoconites perforata Müller
Sagittodontus dahlmani Müller (=*S. dunderbergiae*)
S. furnishi (Müller) (=*Furnishina furnishi*)
Westergaardodina amplicava Müller
W. bicuspidata Müller

This assemblage differs from the older Kushan assemblage in possessing four new species, *Acodus cambricus* Nogami, *Oneotodus nakamurai* Nogami, *Oneotodus terashimai* Nogami, and *Coelocerodontus tricarinatus* (Nogami), of which the latter three are present in the Chatsworth Limestone at Black Mountain. Of these three species *C. tricarinatus* (Nogami) ranges from 500 to 1240 feet in the Black Mountain section, *O. nakamurai* Nogami from 300 feet upwards into the Ordovician, and *O. terashimai* Nogami is present at 620 feet. Of the other common species, *Westergaardodina amplicava* Müller ranges from 420 to 620 feet and *Problematoconites perforata* Müller from 420 to 680 feet

Thus it would appear that the interval between 420 feet and the top of the Chatsworth Limestone is equivalent to the uppermost Upper Cambrian Yencho Formation of China.

In comparing the conodonts from the Chatsworth Limestone with those reported from North American Cambrian formations (Müller, 1959), we find that although the following species are common to both North America and Australia they are all, with one exception, long-ranging:

Coelocerodontus primitivus (Müller) (=*Furnishina primitiva)*
Oneotodus gallatini Müller
O. tenuis Müller
Sagittodontus dahlmani Müller (=*S. dunderbergiae*)
S. furnishi (Müller) (=*Furnishina furnishi*)
Westergaardodina bicuspidata Müller

The only species which suggests an uppermost Upper Cambrian age and a broad equivalence to the Chatsworth Limestone is *Sagittodontus dahlmani* Müller, which ranges from the 5c to 5e Zones in Europe, but occurs in lower Upper Cambrian *Dunderbergia* Zone in Nevada and the lower Upper Cambrian Kushan Formation in China.

At present, there is no possibility of an Upper Cambrian correlation between North America and Australia based on conodonts.

Ordovician (Fig. 17)

North America. Faunas typical of the basal zone, the *Cordylodus proavus* Assemblage Zone, have been recorded from two localities.

Müller (1959, p. 473) records both *Cordylodus proavus* Müller and *C. oklahomensis* from the uppermost beds of the Signal Mountain Limestone of Oklahoma, USA. In the Ninmaroo Formation these species occur together in the *Cordylodus oklahomensis* subzone of the *C. oklahomensis* — *C. lindstromi* Assemblage Zone, suggesting a correlation between the top part of the Signal Mountain Limestone and the interval 2420-2620 feet in the Black Mountain section. However, the Signal Mountain Limestone could include the *Cordylodus proavus* Assemblage Zone.

Both *Cordylodus proavus* and *C. oklahomensis* have been recorded from a Lower Palaeozoic section in Mexico (Pantoja-Alor & Robison, 1967). However, the association of *Hertzina* sp. (=*Coelocerodontus* sp.) and *Oneotodus tenuis* Müller on the one hand, and the presence of *Cordylodus angulatus* Pander on the other, suggest that this section ranges from the Upper Cambrian to the uppermost Tremadocian and includes the *Cordylodus proavus* Assemblage Zone.

The previous discussion suggests that the Signal Mountain Limestone and the Mexican Lower Palaeozoic section include the *Oneotodus bicuspatus*—*Drepanodus simplex* Assemblage Zone, although no conodonts diagnostic of this zone have been recorded from them. *Drepanodus simplex* Branson & Mehl has been recorded from the Jefferson City Formation of Missouri, USA (Branson & Mehl, 1933). This suggests that part, at least, of the Jefferson City Formation is of this age, although the remainder of the fauna appears to be younger.

As previously indicated, the Signal Mountain Limestone is probably equivalent to the lower subzone of the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone. This zone is also represented by the Prairie du Chien Group (Furnish, 1938). The Prairie du Chien Group contains several species common to the Ninmaroo Formation. They include the following: the ranges in brackets refer to the range of the species in the Ninmaroo Formation.

Acanthodus uncinatus Furnish (lower *Cordylodus oklahomensis* subzone)

Acodus oneotensis Furnish (*Chosonodina herfurthi* — *Acodus* Assemblage Zone)

Cordylodus intermedius Furnish (*Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone to *C. rotundatus* — *C. angulatus* Assemblage Zone)

Cordylodus rotundatus Pander (*C. rotundatus* — *C. angulatus* Assemblage Zone to *Chosonodina herfurthi* — *Acodus* Assemblage Zone)

Drepanodus subarcuatus Furnish (*Chosonodina herfurthi* — *Acodus* Assemblage Zone)

Oneotodus gracilis (Furnish) (*Cordylodus proavus* Assemblage Zone to *Chosonodina herfurthi* — *Acodus* Assemblage Zone)

Scolopodus bassleri (Furnish) (*Cordylodus prion* — *Scolopodus* Assemblage Zone to *Chosonodina herfurthi* — *Acodus* Assemblage Zone)

Scolopodus iowensis (Furnish) (*Cordylodus rotundatus* — *C. angulatus* Assemblage Zone to *Chosonodina herfurthi* — *Acodus* Assemblage Zone)

Scolopodus quadraplicatus Branson & Mehl (*Cordylodus prion* — *Scolopodus* Assemblage Zone)

Scolopodus staufferi (Furnish) (lower *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone)

Scolopodus warendensis sp. nov. (*Cordylodus rotundatus* — *C. angulatus* Assemblage Zone to *Chosonodina herfurthi*—*Acodus* Assemblage Zone)

The Prairie du Chien Group contains species indicative of the zones from the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone to the *Chosonodina herfurthi* — *Acodus* Assemblage Zone.

Acanthodus uncinatus Furnish is confined to the *Cordylodus oklahomensis* subzone of the *C. oklahomensis* — *C. lindstromi* Assemblage Zone in Australia, indicating that at least the lower part of the Prairie du Chien Group is of this age.

All the other species range up into either the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone or the *Chosonodina herfurthi* — *Acodus* Assemblage Zone. Two species, *Acodus oneotensis* Furnish and *Drepanodus subarcuatus* Furnish, are confined to the latter zone, suggesting that this zone is present in the Prairie du Chien Group.

In 1964 Ethington & Clark described conodonts from the El Paso Formation of Texas and Arizona.

The species common to this and the Australian assemblages include:

Acodus oneotensis Furnish
Drepanodus subarcuatus Furnish
D. suberectus (Branson & Mehl)
Oistodus lanceolatus Pander
Oneotodus gracilis (Furnish) (=*O. simplex* of Ethington & Clark)
Scandodus furnishi Lindström
Scolopodus gracilis Ethington & Clark
S. quadraplicatus Branson & Mehl
S. staufferi (Furnish) (=*Acontiodus staufferi*)
S. triplicatus Ethington & Clark
S. warendensis Druce & Jones (=*Acontiodus iowensis* Furnish)

The presence of *Scolopodus gracilis* and *S. triplicatus* suggests a correlation between the El Paso Formation and the *Cordylodus prion — Scolopodus* and *Cordylodus rotundatus — C. angulatus* Assemblage Zones. However, the El Paso Formation contains the genera *Gothodus* and *Oepikodus,* which are Arenigian and younger than both the Prairie du Chien Group (Ethington & Clark, 1964, p. 686) and the Ninmaroo Formation. This suggests that the upper limits of the ranges of the scolopodids in the present study are not their true limits.

It is possible that the El Paso Formation is, in part, as old as the *Chosonodina herfurthi — Acodus* Assemblage Zone. Conodonts have been recently reported from the Lower Ordovician Monocline Valley Formation of Nevada (Longwell & Mound, 1967). Their range chart accompanying the paper lists the following species known from the Australian sections:

Acodus oneotensis Furnish
Cordylodus rotundatus Pander
(=*C. subangulatus* Furnish)
Drepanodus subarcuatus Furnish
Oistodus lanceolatus Pander
Scandodus furnishi Lindström
Scolopodus gracilis Ethington & Clark
S. quadraplicatus Branson & Mehl
S. staufferi (Furnish)
(=*Acontiodus staufferi*)

In comparing the ranges of these species from the Monocline Valley Formation and the Ninmaroo Formation, it appears that Member 3 of the Monocline Valley Formation lies within the *Cordylodus rotundatus — C. angulatus* Assemblage Zone and Member 4 is within the *Chosonodina herfurthi — Acodus* Assemblage Zone.

The paucity of species in Members 1 and 2 of the Monocline Valley Formation makes it difficult to correlate these members with the Australian sequence. It is possible that Members 1 and 2 are no older than the *Cordylodus rotundatus — C. angulatus* Assemblage Zone.

Member 5 contains *Gothodus costulatus* Lindström and we consider it to be younger than the *Chosonodina herfurthi — Acodus* Assemblage Zone.

A Lower Ordovician fauna was illustrated by Sando (1958) from the Beekmantown Group, Pennsylvania. Five species are common to this and the Australian faunas:

Acanthodus costatus sp. nov. (=*Acanthodus* sp. A)
Cordylodus angulatus Pander (=*Cyrtoniodus?* sp.)
Drepanodus acutus Pander (=*Drepanodus* sp. A)
Scolopodus asymmetricus sp. nov. (=*Distacodus* sp. B)
S. quadraplicatus Branson & Mehl

All except the last species occur together in the *Chosonodina herfurthi — Acodus* Assemblage Zone in Australia. *Cordylodus angulatus* Pander and *Scolopodus asymmetricus* sp. nov. occur in the Stonehenge Limestone, together with *Acanthodus costatus* sp. nov. and *Drepanodus acutus* Pander (Sando, 1958,

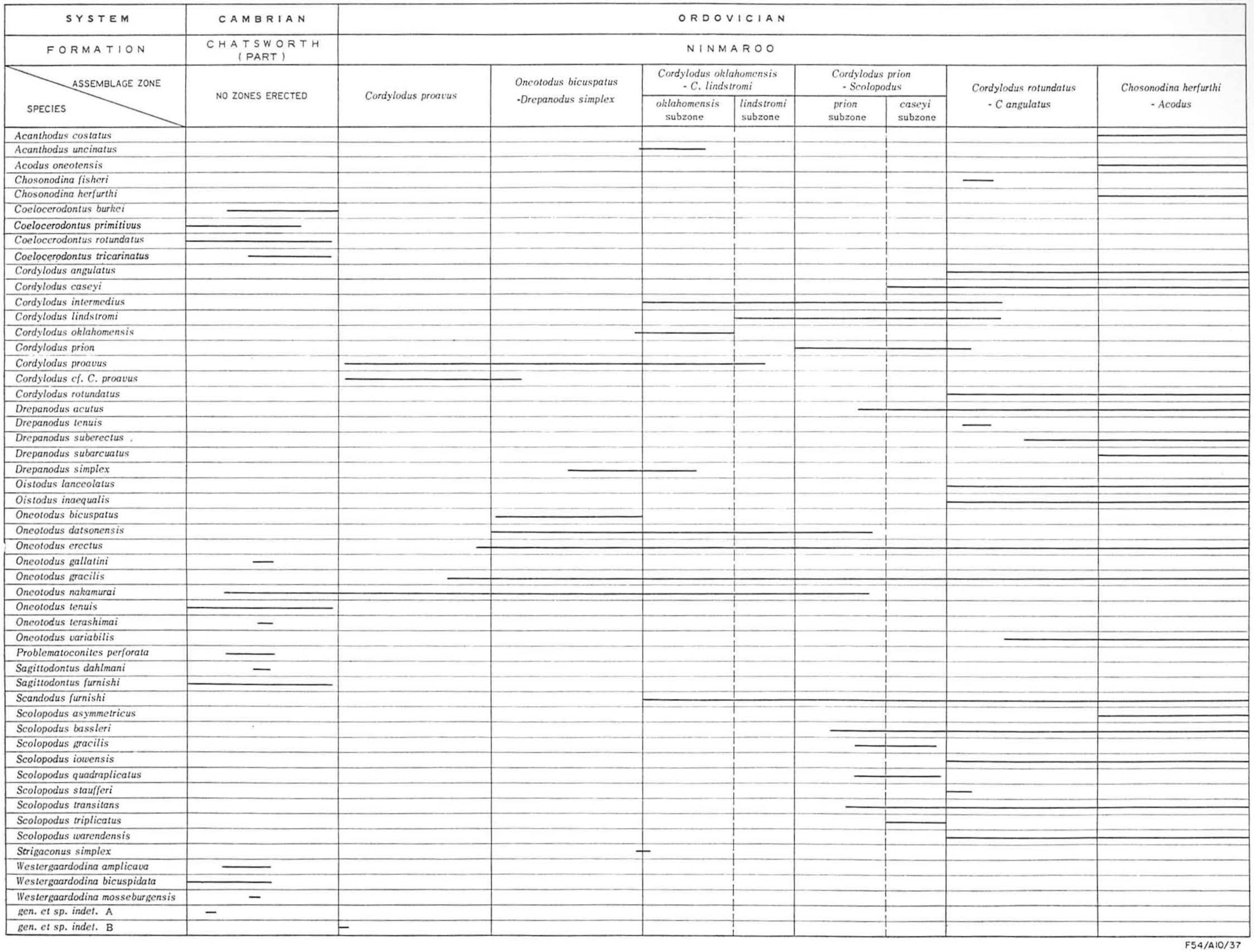

Fig. 18 Ranges of conodonts species from the Late Cambrian and Early Ordovician of western Queensland, arranged alphabetically.

pl. 1). The two latter species range upwards into the overlying Rockdale Run Formation, where they are joined by *Scolopodus quadraplicatus* Branson & Mehl.

Early Ordovician conodonts have been reported from Canada (Ethington & Clark, 1965). Some species recovered from Units 17 to 30 in the Columbia Ice Fields Section, Alberta, are known from Australia. They include:

Cordylodus angulatus Pander
Drepanodus subarcuatus Furnish
D. suberectus (Branson & Mehl)
Oistodus inaequalis Pander
Oneotodus variabilis Lindström
Scolopodus gracilis Ethington & Clark
S. quadraplicatus Branson & Mehl
S. warendensis sp. nov. (=*Acontiodus staufferi* Furnish)

Apart from the scolopodids, these species are known from the *Cordylodus rotundatus* — *C. angulatus* and *Chosonodina herfurthi* — *Acodus* Assemblage Zones. The general association of the scolopodids in these zones suggests that the restricted ranges of these species in Western Queensland are not the true ones.

Europe. Conodonts of earliest Ordovician age are known from Sweden (Lindström, 1954, 1960), Estonia (Öpik, 1927, 1929; Viira, 1966) and the Baltic Provinces of Russia (Pander, 1856; Sergeeva, 1962, 1963, 1966).

Pander (1856, p. 14) originally reported conodonts from several localities in black shale (=*Dictyonema* Shale or A_3 Zone), and in the overlying 'Greensand' (=Glaukonitsand or $B_{1\alpha}$ Zone). He found that the 'Greensand' contained the most conodonts, and his main collecting locality was probably in the vicinity of the village of Koporie and Jurjewo (op. cit., p. 14, 15). Koporie is about 50 miles west-southwest of Leningrad and 39 miles northeast of Narva. Five species described by Pander are present in western Queensland. They are:

Cordylodus angulatus Pander
C. rotundatus Pander
Drepanodus acutus Pander
Oistodus lanceolatus Pander
O. inaequalis Pander

These species occur in the slightly older *Cordylodus rotundatus* — *C. angulatus* and *Chosonodina herfurthi* — *Acodus* Assemblage Zones of Queensland (see discussion on Estonian conodonts, below).

In 1954, Lindström described an extensive fauna from the Tremadocian and Arenigian rocks of south-central Sweden. Many species are in common with the Australian fauna. They include:

Cordylodus angulatus Pander
C. prion Lindström
C. rotundatus Pander
Drepanodus suberectus (Branson & Mehl)
Oistodus inaequalis Pander
O. lanceolatus Pander
Oneotodus variabilis Lindström
Scandodus furnishi Lindström

In Australia *Cordylodus prion* Lindström has a last occurrence in the basal part of the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone and, except for a solitary specimen in the Tomten section (Lindström, 1954, pl. 8, 9), in Sweden, this species is confined to the Ceratopyge Limestone of the Stora Backor section. The remaining species, except *Drepanodus suberectus* (Branson & Mehl) and *Oistodus lanceolatus* Pander (which range into the Arenigian Limbata Limestone), characterize the Ceratopyge Limestone assemblage of the Tremadocian (Lindström, 1954, p. 530). Furthermore, all these species occur in western Queensland, in the *Cordylodus rotundatus* — *C. angulatus* and *Chosonodina herfurthi* — *Acodus* Assemblage Zones. Thus, the two upper zones of the Ninmaroo Formation are equivalent to the Ceratopyge Limestone of Sweden, i.e. Zone 1 of Lindström (1954, 1960).

In Estonia, Öpik recorded *Cordylodus rotundatus* Pander and *Drepanodus arcuatus* Pander below the Glaukonitsand (Pakerort Stage) from the *Dictyonema* Shale — A_3 Zone (1927, p. 39), and unnamed conodonts from the older *Obolus* Sandstone — $A_2\beta$-γ Zone (1929, p. 16). He later (1956a, p. 100) reported a conodont from the lower *Acrotreta* — *Lingulella* Zone ($A_2\alpha$), which he regarded as either the base of the Tremadocian or the top of the Upper Cambrian.

Many of the conodonts originally described by Pander have been collected from the Suhkrumägi section, Tallinn, and a range chart has been published by Viira (1966). The three species reported from the Tremadocian Maardu 'member' (A_2 or *Obolus* Sandstone), *Cordylodus angulatus* Pander, *C. prion* Lindström, and *C. rotundatus* Pander, are all present in the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone of Australia, suggesting a correlation of this zone with the early Pakerort (A_2) Stage of Estonia.

Four other species, *Drepanodus suberectus* (Branson & Mehl), *Oistodus inaequalis* Pander, *O. lanceolatus* Pander, and *Oneotodus variabilis* Lindström, are present in the Leetse (B_1) Stage *1 of Estonia and are also present in the upper part of the Ninmaroo Formation. However, Viira (1966, p. 150) did not recover any conodonts from the *Dictyonema* Shale and overlying clays (A_3), and he records a hiatus between the Leetse and Pakerort stages, corresponding to the *Ceratopyge* beds of Scandinavia *2. It is probable that the upper part of the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone and the *Chosonodina herfurthi* — *Acodus* Assemblage Zone may be equivalent to the A_3 shales and clays, which yielded no conodonts, and the pre-Glaukonitsand (Leetse-Stage) hiatus.

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*1. The $B_1\alpha$ Zone also contains *Drepanodus sculponea* Lindström, and *Acodus deltatus* Lindström (Viira, 1966), and is considered by us to be younger than our uppermost zone. These species indicate Lindström's Zone 2 (1954), which he regarded as basal Arenigian. However, it is stressed that despite the detailed work of Tjernvik (1956), the exact correlation between the Ceratopyge — Hunneberg interval of Scandinavia and the Tremadocian — Arenigian interval of Britain is still open to doubt.

*2. According to Röömusoks (1960, p. 63), the Leetse (B_1) Stage overlies the Pakerort ($A_{2\text{-}3}$) Stage with a hiatus corresponding to the Ceratopyge beds of Scandinavia, and is therefore, lowermost Arenigian, in Scandinavian terms. However, other authors (e.g. Öpik, 1930, p. 14, 15; Sokolov et al., 1960, p. 55) regard the Leetse Stage as equivalent to the Ceratopyge beds, or in other words, uppermost Tremadocian.

Early Ordovician conodonts have been described by Sergeeva (1962, 1963, 1966) from the Leningrad region of the USSR, and a zonation of the upper part of the Pakerort (A_2-$_3$) Stage, and the overlying Leetse (Glaukonitsand, B_1) was presented. The occurrence of *Cordylodus angulatus* Pander, *C. prion* Lindström, and *C. rotundatus* Pander in both the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone and Sergeeva's *Cordylodus angulatus* Zone (upper A_2-$_3$) suggests that the two zones are time equivalents; however, the Russian zone probably includes our *Chosonodina herfurthi* — *Acodus* Assemblage Zone as well. *Oneotodus variabilis* Lindström also occurs in the *Cordylodus angulatus* Zone of the Leningrad region and in the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone in western Queensland.

Two species, *Oistodus inaequalis* Pander, and *O. lanceolatus* Pander, are recorded from both the overlying Leetse (B_1) Stage (*Drepanodus sculponea* Zone of Sergeeva) in the Leningrad region, and in our *Cordylodus rotundatus* — *C. angulatus* and *Chosonodina herfurthi* — *Acodus* Assemblage Zones. We consider our zones are older than the Leetse Stage (see above), and the ranges of these three species are extended downward into the Tremadocian.

Moskalenko (1967) has described conodonts from the Lower Ordovician of the Siberian Platform, which contains three species, *Drepanodus tenuis* Moskalenko, *Oneotodus gracilis* (Furnish), and *Scolopodus quadraplicatus* Branson & Mehl, which occur in the Ninmaroo Formation. The remaining species, which include some belonging to the genera *Acodina* and *Acodus* and relatively advanced species of the genus *Oistodus* (*O. forceps* Lindström, *O. parallelus* Pander) suggest an Arenigian age. The range of *Drepanodus tenuis* Moskalenko must therefore be Upper Tremadocian to Lower Arenigian.

Far East. Early Ordovician conodonts have been described from South Korea by Müller (1964). The fauna bears a striking resemblance to that of the *Chosonodina herfurthi* — *Acodus* Assemblage Zone. Of the eight species described, six occur in the uppermost zone of the Ninmaroo Formation. They are:

Acodus oneotensis Furnish
Chosonodina herfurthi Müller
Drepanodus subarcuatus Furnish
Oistodus inaequalis Pander (=*Oistodus gracilis* of Müller)
Scolopodus bassleri (Furnish) (=*Scandodus rectus* of Müller)
S. iowensis (Furnish) (=*Acontiodus* cf. *A. propinquus* of Müller)

These species are characteristic of the *Chosonodina herfurthi* — *Acodus* Assemblage Zone. Therefore at least part of the Great Limestone Series of South Korea is equivalent to the uppermost part of the Ninmaroo Formation.

CONCLUSIONS

1. The Upper Cambrian and Lower Ordovician (Tremadocian) faunas of the Burke River Structural Belt include conodont species which are mutually exclusive, except for one species — *Oneotodus nakamurai* Nogami.

2. Conodont zonation of the Upper Cambrian Chatsworth Limestone and Gola Beds is not possible. Although the species indicate an Upper Cambrian age, they are all long-ranging, and unsuitable for biostratigraphic zonation. However, our material is closely related to conodonts described from the Upper Cambrian of North America, Europe, and China.

3. The Tremadocian Ninmaroo Formation of the Burke River Structural Belt can be divided into six Assemblage Zones, most of which can be recognized in Europe, North America, and Korea.

4. The lower four conodont Assemblage Zones of the Ninmaroo Formation are not present in most of the Tremadocian sections in Europe, North America, and Korea. Only a Lower Palaeozoic section in Mexico, the Signal Mountain Limestone of Oklahoma, and possibly the Jefferson City Formation of Missouri are partial equivalents of these lower zones.

5. Two conodont root-stocks are recognized in the Upper Cambrian; the coelocerodontids and the westergaardodinids. *Oneotodus nakamurai* Nogami is ancestral to all the Tremadocian cones and bars, except the chosonodinids, which are probably related to the westergaardodinids.

6. The Tremadocian is characterized by considerable diversification of the cordylodids and the scolopodids.

7. The lower 300 feet of the Ninmaroo Formation at Mount Ninmaroo is Upper Cambrian, on conodont evidence. The probability of a Trempealeauan age for this part of the Ninmaroo Formation is strengthened by the occurrence of a Franconian prosaukiid 170 feet below the top of the Chatsworth Limestone.

8. Transgression of the sea from north to south during the Tremadocian is indicated by a diachronous rise in the stratigraphical position of the lithological members of the Ninmaroo Formation. A southerly shoreline is postulated for the Burke River Structural Belt.

9. Conodont frequency per unit weight of sample increases upwards throughout the sequence. It decreases in a southerly direction along the strike from Black Mountain to Mount Datson.

10. Rates of sedimentation (calculated from the thicknesses of the Assemblage Zones) shows a general decrease upwards throughout the sequence, and a

decrease southwards along the outcrop, from Black Mountain to Mount Datson.

11. Lindström's suggestion that conodont frequency appears to be inversely proportional to the rate of sedimentation is only valid when phylogenetic diversification is not taking place. The presence of dolomite is also an inhibiting factor.

SYSTEMATIC PALAEONTOLOGY

Genus ACANTHODUS Furnish 1938

Type species: *Acanthodus uncinatus* Furnish, 1938

ACANTHODUS COSTATUS sp. nov.

(Pl. 5, figs 1a-5c; Text-fig. 19a)

1958 *Acanthodus* sp. A. Sando, *Bull. geol. Soc. Amer.*, 69, pl. 2, fig. 20.

1962 *Acanthodus uncinatus* Furnish; Hass, *Treatise on Invertebrate Paleontology, Part W, Miscellanea,* p. W45, fig. 23.3.

1964 *Acanthodus* cf. *uncinatus* Furnish; Lindström, *Conodonts,* p. 137, fig. 47f.

Derivation of name: From the lateral costae on the cusp.

Type locality and horizon: Black Mountain, Boulia, western Queensland. Uppermost part of the Tremadocian Ninmaroo Formation.

Material: 49 specimens; holotype CPC8850, paratypes CPC8851-4.

Range: Chosonodina herfurthi — Acodus Assemblage Zone.

Diagnosis: An acanthodid with a lateral costa on both sides of the cusp.

Description: The unit is reclined and consists of a base and a denticulate cusp. The base is small, elliptical in cross-section, and excavated by a conical basal cavity. The apex of the cavity is near the anterior face at the point of flexure. The cusp is gently reclined and laterally compressed, with posterior and anterior knife-edges. On each lateral face a strong costa is developed which diminishes towards both the base and the oral termination. In some specimens a secondary costa is developed for a short distance immediately posterior to the main costa. On the posterior knife-edge of the cusp serrations are developed into aborally-pointing denticles. 'White matter' is developed in the cusp.

Remarks: A. costatus is easily distinguished from *A. uncinatus* Furnish by the presence of lateral costae. Hass (1962) referred, and Lindström (1964) compared, specimens with costae to *A. uncinatus*. Specimens referred to a new species, *Drepanodus lineatus*, by Furnish (1938) could belong to the same species. Both illustrated specimens (Furnish, 1938, pl. 41, figs 33, 34) have the oral terminations of the cusp missing, and although they exhibit the beginnings of what might be posterior dentition, it is impossible to say with certainty whether they are morphologically similar to *A. costatus*. If they are, as was suggested by Ethington & Clark (1965, p. 187) then *A. costatus* becomes a junior synonym of *A. lineatus* (Furnish).

Apart from the distinct morphological differences between *A. uncinatus* and *A. costatus*, the ranges of the two species are distinct: *A. costatus* is younger, occurring in the *Chosonodina herfurthi* — *Acodus* Assemblage Zone, whereas *A. uncinatus* occurs in the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone.

Occurrence: The species has been recorded from the Stonehenge Limestone and overlying Rockdale Run Formation of Pennsylvania by Sando (1958 = *A.* sp. A) and from the Stonehenge Limestone by Hass (1962 = *A. uncinatus*). It is also known from the Dry Creek Shale of Montana (Lindström, 1964 = *A.* cf. *uncinatus* Furnish). In Queensland it occurs in the Black Mountain, Mount Datson, and Black Ridge sections.

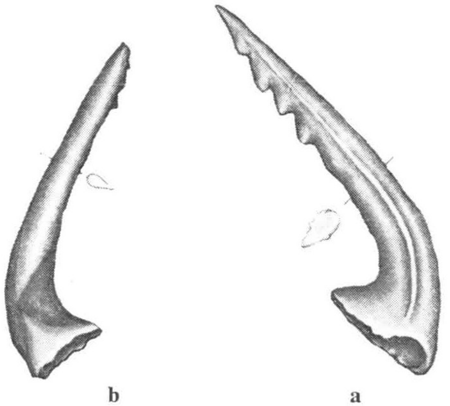


Fig. 19 (a) *Acanthodus costatus* sp. nov. holotype CPC8850, lateral view, x 75.
(b) *A. uncinatus* Furnish. CPC8846, lateral view, x 32.

ACANTHODUS UNCINATUS Furnish, 1938

(Pl. 6, figs 9a-12c; Text-fig. 19b)

1938 *Acanthodus uncinatus* Furnish, *J. Paleont.*, 12, 337, pl. 42, fig. 30, text-fig. 2B.
non 1962 *Acanthodus uncinatus* Furnish; Hass, *Treatise on Invertebrate Paleontology, Part W, Miscellanea*, p. W45, fig. 23.3. (=*A. costatus* sp. nov.)

Material: 37 specimens; CPC8846-9 figured.

Range: Lower *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone.

Description: A reclined unit with a base and cusp. The base is small, elliptical in cross-section, and unornamented. It contains a basal cavity which is cone-shaped, with the apex near the anterior margin at the point of flexure. The cusp is long and blade-like, bearing anterior and posterior knife-edges. On the posterior edge serrations are developed which are inclined aborally. The cusp is filled with 'white matter.'

Remarks: *A. uncinatus* differs from *A. costatus* in lacking any ornament on the cusp apart from the posterior dentition.

Occurrence: *A. uncinatus* is known from the Oneota Dolomite of Minnesota, USA (Furnish, 1938). Specimens reported from the Stonehenge Limestone by Hass (1962) are considered to belong to *A. costatus* sp. nov. In Queensland the species is present in the Black Mountain and Mount Ninmaroo sections.

Genus Acodus Pander 1856

Type species: *Acodus erectus* Pander, 1856

Acodus oneotensis Furnish, 1938

(Pl. 12, figs 3a-7c; Text-fig. 20)

1938 *Acodus oneotensis* Furnish, *J. Paleont.*, 12, 325, pl. 42, figs 26-29.
1964 *Acodus oneotensis* Furnish; Ethington & Clark, *J. Paleont.*, 38, 686.
1964 *Acodus oneotensis* Furnish; Müller, *N. Jb. Geol. Paläont. Abh.* 119, 95, pl. 13, figs 1a, b, 8.

Material: 21 specimens; CPC8857-61 figured.

Range: *Chosonodina herfurthi* — *Acodus* Assemblage Zone.

Description: Unit reclined, consisting of a base and a cusp with three costae. The base is slightly flared, subcircular to subquadrate in cross-section. The cusp is gently reclined and laterally compressed, with anterior and posterior knife-edges which extend on to the base as costae. The inner face is gently convex; the outer face is convex, with a strong median ridge which extends on to the base as a third costa. The basal cavity is shallow, with slightly flared lips.

Remarks: Some specimens have a truly circular base and are identical with Furnish's illustrated specimens (1938, pl. 42, figs 26-29). In others the base has a quadrate cross-section, and occasionally a triangular cross-section similar to the specimens illustrated by Müller (1964, pl. 13, fig. 1a). Even though there is a considerable range of variation between these extremes they are all included in the same species. Furnish (1938, p. 325) notes that 'there is a considerable range of variation within this species, but it does not seem advisable to propose more than a single name for the unit.'

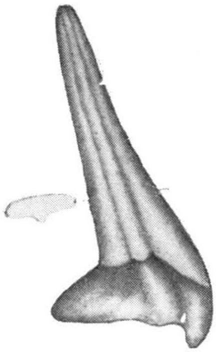


Fig. 20 *Acodus oneotensis* Furnish. CPC8858, outer lateral view, x 60.

Occurrence: The species was originally described from the Oneota Dolomite of Minnesota and Iowa, USA (Furnish, 1938). It has also been reported from the El Paso Formation of Texas and Arizona (Ethington & Clark, 1964), and the Monocline Valley Formation of Nevada (Longwell & Mound, 1967). Specimens compared to *A. oneotensis* were described by Müller (1964) from Lower Ordovician strata in South Korea.

In Queensland the species has been recovered from the Black Mountain, Mount Ninmaroo, Mount Datson, and Black Ridge sections.

Genus CHOSONODINA Müller, 1964

Type species: *Chosonodina herfurthi* Müller, 1964

The genus was originally described from Lower Ordovician strata in South Korea (Müller, 1964, p. 99). Müller notes that it is similar to *Westergaardodina* and also distinguishes between it and *Chirognathus* and *Rhipidognathus,* which both lack the elongate basal cavity which extends over the whole aboral and lateral faces of the chosonodinid unit.

Harris & Harris (1965, p. 45) questionably placed a new species, *lunata,* in the genus *Chosonodina.* They point out that apart from being bowed, *C. lunata* is similar to a contemporary species of the genus *Coleodus. C. lunata* can be distinguished from *C. herfurthi* by the symmetry. *C. herfurthi* is bilaterally symmetrical, whereas *C. lunata* is asymmetrical. Mound (1965, p. 13) suggests that *C. lunata* and specimens which he identified as *Coleodus* cf. *C. simplex* Branson & Mehl may belong to the same species. This interpretation is probably correct, and Mound's specimen should be more correctly assigned to *Chosonodina. Coleodus* should be restricted to those species which have reclined, subparallel, fused denticles forming a continuous blade (Lindström, 1964, p. 143).

There is probably a continuous link between the genera *Westergaardodina, Chosonodina,* and *Coleodus.* The simplest *Chosonodina, C. fisheri* sp. nov., probably developed from *Westergaardodina amplicava* Müller by a reduction in size of the lateral teeth and an increase in size of the central tooth to give a unit with even dentition. An increase in the number of denticles resulted in *C. herfurthi* Müller, which is bilaterally symmetrical and possesses up to seven denticles.

This increase in dentition is also noted in *C. lunata* Harris & Harris, which is also asymmetrical and is probably a transitional species to *Coleodus simplex* Branson & Mehl.

CHOSONODINA FISHERI sp. nov.

(Pl. 4, figs 7a-8c; Text-fig. 21a)

Derivation of name: In honour of Dr N. H. Fisher, Bureau of Mineral Resources.

Type locality and horizon: Mount Ninmaroo, Boulia, western Queensland. Tremadocian Ninmaroo Formation (*Cordylodus rotundatus* — *C. angulatus* Assemblage Zone).

Material: 9 specimens; holotype CPC8762, paratype CPC8761.

Range: Cordylodus rotundatus — *C. angulatus* Assemblage Zone.

Diagnosis: A lyre-shaped chosonodinid with only three median denticles.

Description: A thin palmate, lyre-shaped, symmetrical unit bearing five denticles two developed laterally and three medially. Overall the unit is concavo-convex with a basal cavity extending along the aboral and both lateral faces. The two lateral denticles are upright, with free tips which curve outwards. The outer lateral faces are deeply excavated by the basal cavity. The three median denticles are upright, fanning out slightly orally. Their terminations are bluntly rounded and they have an elliptical cross-section.

The basal cavity is shallow, wide, and trough-like. The lip on the convex side extends farther aborally than the lip on the concave side.

Remarks: C. fisheri differs from *C. herfurthi* Müller in the number and morphology of the denticles. *C. fisheri* bears only three median denticles as opposed to the five or more present in *C. herfurthi.* They are stubby, with blunt terminations, whereas the denticles of *C. herfurthi* are spear-shaped with sharp oral terminations.

Occurrence: C. fisheri has only been found in the *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone of the Ninmaroo Limestone at Mount Ninmaroo and in sample 13/2 west of the Telegraph Line near Digby Peaks.

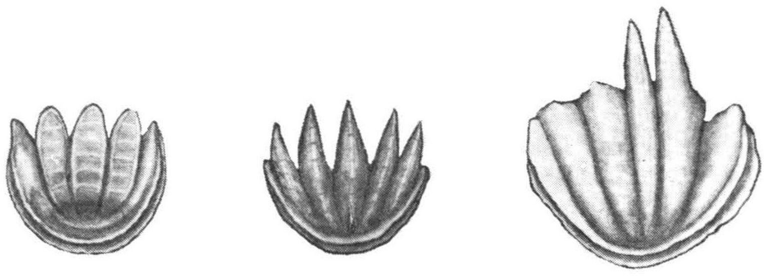


Fig. 21 (a) *Chosonodina fisheri* sp. nov. holotype CPC8762, view of concave side, x 60. (b) *C. herfurthi* Müller. CPC8760, view of concave side, x 60. (c) *C. herfurthi*. CPC8764, view of concave side, x 60.

CHOSONODINA HERFURTHI Müller, 1964

(Pl. 4, figs 1a-6c, 9a, b; Text-fig. 21b, c)

1964 *Chosonodina herfurthi* Müller, *N. Jb. Geol. Paläont. Abh.*, 119, 99, pl. 13, figs 3a-c.

Material: 48 specimens; CPC8758-60, 8763-6 figured.

Range: Chosonodina herfurthi — Acodus Assemblage Zone.

Description: Unit palmate, concavo-convex, bearing five or more denticles and an elongate basal cavity. The dentition consists of five median denticles and two lateral denticles. The lateral denticles are minute in the juveniles, giving the impression that only five denticles (rather than seven) are present. The basal cavity extends along the outer face of the lateral denticles. The denticles are spear-shaped with sharp oral terminations and are diamond-shaped in cross-section, bearing a medial ridge on both the inner and outer faces.

The basal cavity is shallow, wide, and trough-like, extending along the aboral and lateral faces.

Remarks: The differences between *Chosonodina herfurthi* Müller and *C. fisheri* sp. nov. are discussed under the latter species.

Occurrence: The only previously recorded occurrence of this species is from the Cambro-Ordovician Great Limestone Series of South Korea (Müller, 1964).

Genus COELOCERODONTUS Ethington, 1959

Type species: *C. trigonius* Ethington, 1959

The genus *Coelocerodontus* was erected by Ethington (1959, p. 273) to include simple hollow horn-shaped cones with thin walls and a central cavity which extends to the tip of the tooth. The edges are keeled.

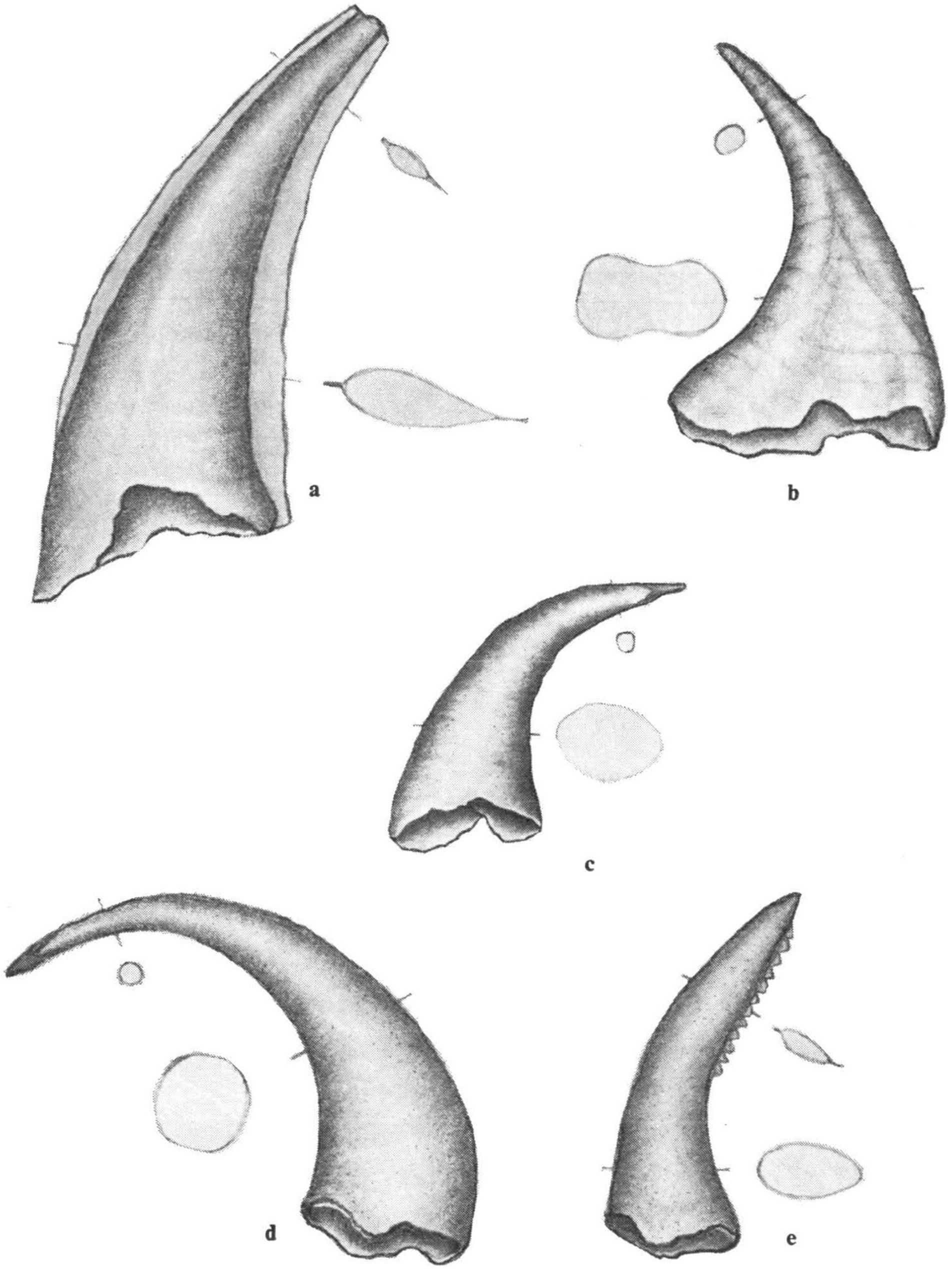


Fig. 22 (a, e) *Coelocerodontus burkei* sp. nov.: (a) paratype CPC8781, lateral view; (e) paratype CPC8779, showing additional denticles. (b) *C. primitivus* (Müller). CPC8798, lateral view. (c, d) *C. rotundatus* sp. nov.: (c) paratype CPC8784, lateral view; (d) holotype CPC8783, lateral view. All x 100.

Lindström (1964, p. 139) places *Hertzina* Müller, 1959, in synonymy with *Coelocerodontus* and suggests that *Belodella* Ethington, 1959, may also be a junior synonym. Poulsen (1966, p. 4) considers that *Hertzina* is a distinct genus, differing from *Coelocerodontus* in possessing only two costae. But the diagnosis proposed by Ethington clearly includes forms such as these, and *Hertzina* is considered to be a junior synonym of *Coelocerodontus*.

Belodella appears to be a distinct Devonian genus characterized by the development of true denticles on the posterior face. *Furnishina primitiva* Müller appears to be more correctly assigned to *Coelocerodontus*. This species is a simple horn-shaped cone with thin lateral walls enclosing a central cavity which extends to the tip of the tooth. It lacks distinct costae, but the close morphological relationship between *C. primitivus, C. rotundatus* sp. nov., and *C. burkei* sp. nov. suggests that the generic description of *Coelocerodontus* should be expanded to include forms without true costae.

Other species of *Furnishina,* notably *F. furnishi* Müller and *F. asymmetrica* Müller, would be more correctly placed in *Sagittodontus* Rhodes, as we have done here. There is a possibility that *Coelocerodontus* and *Sagittodontus* are synonymous and that *Coelocerodontus* should be classed as a junior synonym of *Sagittodontus*. The barb-like aboral projections figured in such species as *S. dahlmani* Müller appear to be the result of breakage rather than original morphological characters. If this is so then there appears to be no valid reason for distinguishing the genera.

Coelocerodontus is the oldest known conodont genus, occurring definitely in the Middle Cambrian *Ptychagnostus* (*Triplagnostus*) *gibbus* Zone (Müller, 1959), and probably even in the older Zone of *Strenuella linnarssoni* (Poulsen, 1966) of pre-Paradoxidian, post-Olenellian age (Öpik, 1968).

COELOCERODONTUS BURKEI sp. nov.

(Pl. 11, figs 5a-12b; Text-fig. 22a, e)

Derivation of name: refers to the explorer R. Burke, and to the Burke River.

Type locality and horizon: Black Mountain, Boulia, western Queensland; Upper Cambrian Chatsworth Limestone.

Material: 74 specimens; holotype CPC8782, paratypes CPC8776-81, 8790.

Range: Chatsworth Limestone.

Diagnosis: An unornamented coelocerodontid with a circular to elliptical cross-section.

Description: The unit consists of a simple hollow cone with an extremely thin outer sheath. It is erect to gently reclined and is elliptical in cross-section, with knife-edges, often produced as thin flanges. In some specimens the posterior oral part of the knife-edge breaks down to form denticles, which are inclined aborally. In most specimens the cusp is minute, but some specimens with cusps up to one fifth the size of the base have been noted. These specimens also appear to have thicker sheaths. All specimens possess a basal filling, which is commonly opaque and white.

Remarks: C. burkei is characterized by its unornamented sheath and its elliptical cross-section with well developed knife-edges. The apical denticles are similar to those seen in *Acanthodus*. Associated with this species are hollow cones with thick walls which are identical with *C. burkei* but lack the translucent sheath; they are possibly the basal fillings of the original sheath. A specimen (CPC8791) is figured as *Coelocerodontus* cf. *C. burkei* sp. nov. on Plate 9, fig. 7a-c.

COELOCERODONTUS PRIMITIVUS (Müller, 1959)

(Pl. 9, figs 5a-6c; 8a-c; Text-fig. 22b)

1959 *Furnishina primitiva* Müller, *Z. dtsch. geol. Ges.*, 111, 453, pl. 11, figs 1-4.

Material: 35 specimens; CPC8797, 8798, 8814 figured.

Range: Chatsworth Limestone.

Description: The unit is a simple hollow cone with a slightly flared aboral outline. The base is conical with an elliptical to subtriangular cross-section and flaring edges. The cusp is very short and is amber in colour. The basal cavity extends over the whole unit.

Remarks: The species is close to *C. rotundatus* sp. nov. but possesses an elliptical cross-section and a flaring base. It appears to be intermediate between *C. rotundatus* and *C. tricarinatus* (Nogami).

Occurrence: C. primitivus has been recorded from the Upper Cambrian (Zone 5 — *Peltura*) of northern Europe and from the Deadwood Formation of South Dakota, USA (Müller, 1959). It has also been recorded from the upper Upper Cambrian Yencho Formation of northeast China (Nogami, 1967).

COELOCERODONTUS ROTUNDATUS sp. nov.

(Pl. 9, figs 10a-13b; Text-fig. 22c, d)

Derivation of name: From the circular cross-section.

Type locality and horizon: Black Mountain, Upper Cambrian Chatsworth Limestone.

Material: 41 specimens; holotype CPC8783, paratypes CPC8784, 8785, 8792.

Range: Chatsworth Limestone.

Diagnosis: A simple coelocerodontid with a circular cross-section.

Description: The unit is a simple hollow cone shaped like a cow's horn, with a circular cross-section. The cusp is minute, the basal cavity extending to the oral extremity of the unit. No costae are present.

Remarks: The inclusion of *rotundatus* in *Coelocerodontus* stretches the diagnosis of the genus to include forms without keels. However, the essentially thin walls and hollow cone point to its close relationship to coelocerodontids. The species closely resembles *C. burkei* sp. nov., but lacks the anterior and posterior keels. Specimens referred to *Oneotodus* aff. *gallatini* Müller by Hamar (1966, p. 79) from the Arenigian 4aβ Zone of Norway are probably reworked specimens of *C. rotundatus*.

COELOCERODONTUS TRICARINATUS (Nogami, 1967)

(Pl. 11, figs 1a-4c)

1967 *Hertzina(?) tricarinata* Nogami, *Mem. Coll. Sci. Univ. Kyoto,* 33, 214, pl. 6, figs 5-8; text-fig. 2A, B, C, D.

1967 *Acodus cambricus* Nogami (part), *ibid.,* 213, pl. 6, fig. 2 only; text-fig. 1C, D only (figs 1, 3, 4; text-fig. 1A, B = *A. cambricus).*

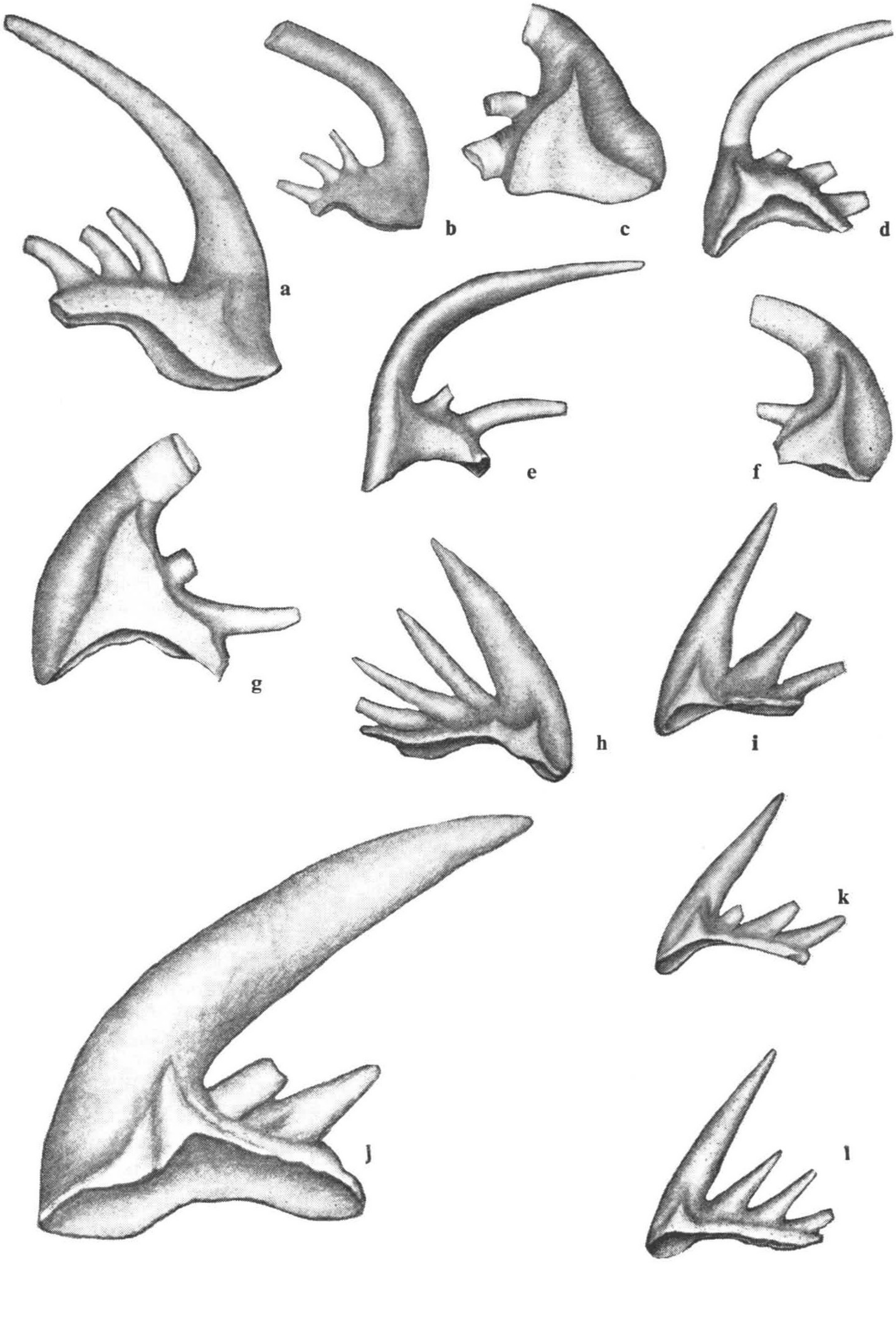
Material: 28 specimens; CPC8786-9 figured.

Range: Chatsworth Limestone.

Description: The unit is a simple hollow cone with a short recurved cusp. The walls of the cusp are corrugated with one or two broad, rounded, lateral costae on either side.

Remarks: Nogami (1967, p. 214) tentatively placed this species in *Hertzina.* The species is characterized by its hollow cone shape and we have referred it to *Coelocerodontus.* The species probably developed from *Coelocerodontus rotundatus* sp. nov. by the addition of lateral costae. *Acodus cambricus* Nogami, 1967, may be an intermediate form, although it has not been found in our collections. All specimens of *A. cambricus* figured by Nogami which possess more than one lateral costa are considered to belong to *C. tricarinatus.* It is possible that *A. cambricus* is a coelocerodontid.

Occurrence: C. tricarinatus (Nogami) was originally described from the Yencho Formation of northeast China (Nogami, 1967, p. 215).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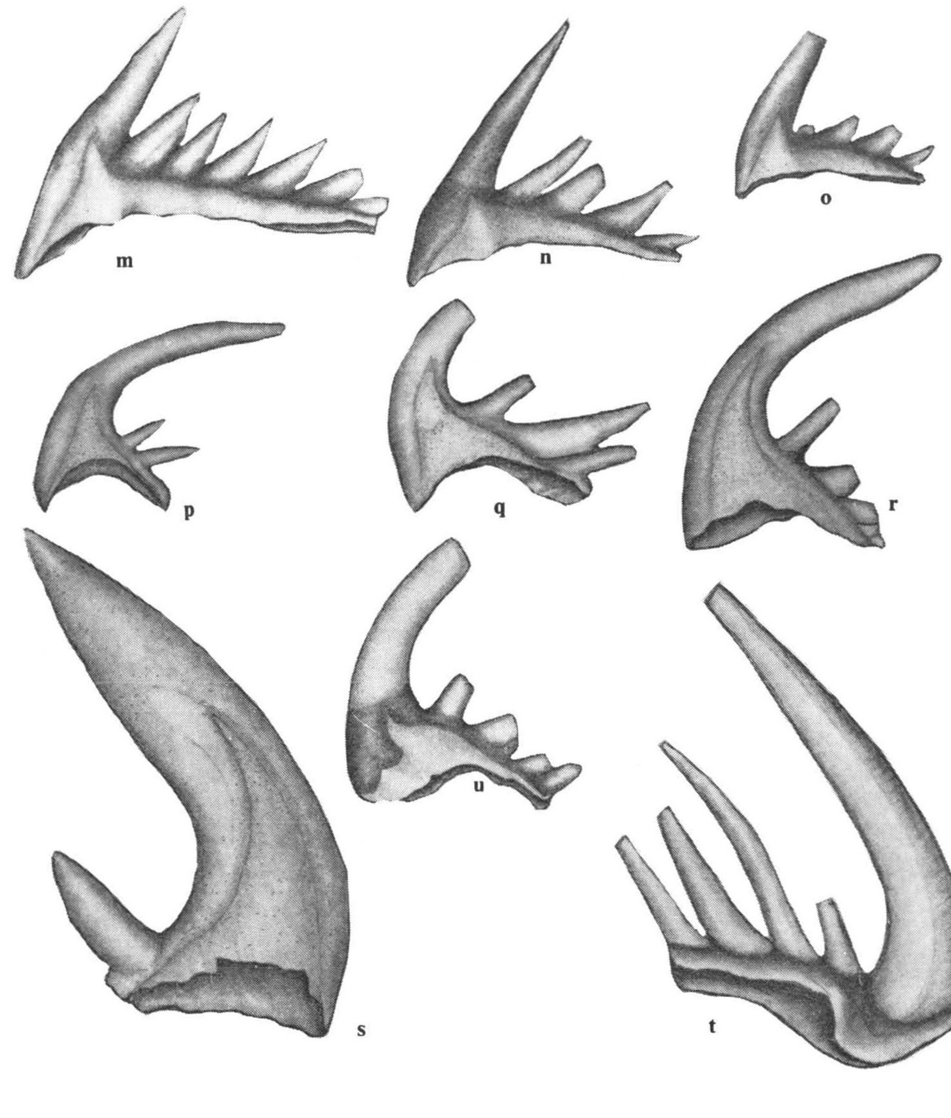

Fig. 23 (a, b) *Cordylodus angulatus* Pander, lateral views: (a) CPC8736; (b) CPC8737. (c) *C.* cf. *angulatus*. holotype CPC8746, lateral view. (d, e) *C. caseyi* sp. nov.: (d) holotype CPC8750, inner lateral view; (e) paratype CPC8751, outer lateral view. (f, g) *C. intermedius* Furnish, lateral views: (f) CPC8742, (g) CPC8743. (h) *C. lindstromi* sp. nov., lateral view: holotype CPC8767, (j) *C. oklahomensis* Müller. CPC8727, lateral view. (i, k-o) *C. prion* Lindström, lateral views: (i) CPC8729, (k) CPC8731, (l) CPC8732, (m) CPC8733, (n) CPC8734, (o) CPC8735, (p-r) *C. proavus* Müller, lateral views: (p) CPC8718, (q) CPC8719, (r) CPC8720, (s) *C.* cf. *proavus* CPC8724, (t) *C. rotundatus* Pander CPC8752, lateral view. (u) *C.* sp. A. CPC8738, lateral view. All x 60.

Genus CORDYLODUS Pander, 1856

Type species: *Cordylodus angulatus* Pander, 1856

CORDYLODUS ANGULATUS Pander, 1856
(Pl. 3, figs 4a-7b; Text-fig. 23a, b)

1856 *Cordylodus angulatus* Pander, *Monog. foss. Fische Sil. Syst. russ.-balt. Gouvts,* 33, pl. 2, figs 28-31, 34; pl. 3, fig. 10.
1954 *Cordylodus angulatus* Pander; Lindström (part) *Geol. Fören. Stockh. Förhandl.,* 76, 551, pl. 5, fig. 9, text-fig. 3G only (text-fig. 3E = *C. lindstromi* sp. nov.).
?1958 *Belodus* sp. A., Sando, *Bull. geol. Soc. Amer.,* 69, pl. 2, fig. 23.
1960 *Cordylodus angulatus* Pander; Lindström, *21st int. geol. Cong.,* 7, 89, text-fig. 1-I-1.
?1964 *Cordylodus angulatus* Pander; Lindström, *Conodonts,* text-fig. 50h.
?1965 *Cordylodus angulatus* Pander; Ethington & Clark, *Brigham Young Univ. geol. Stud.,* 12, 189, pl. 1, fig. 7.

Material: 16 specimens; CPC8736, 8737, 8739, 8740 figured; CPC8757 unfigured.

Range: Cordylodus rotundatus — C. angulatus Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Description: The unit consists of a posteriorly elongated base and a main cusp. The basal cavity occupies most of the base and is shaped like a 'Phrygian cap.' In one specimen (Pl. 3, fig. 7a, b) the lip of the basal cavity is flared on the inner side. The main cusp is curved posteriorly and is entirely filled with 'white matter.' The three or four bar denticles are developed on the posterior extension of the base; they increase in height and posterior inclination posteriorly. They are entirely filled with 'white matter.'

Remarks: C. angulatus is confined to specimens whose basal cavity is shaped like a 'Phrygian cap' (Lindström, 1954, p. 551, text-fig. 3G). Specimens with an erect basal cavity and an extension or extensions beneath the bar denticles (op. cit., text-fig. 3E) are referred to a separate species (*C. lindstromi* sp. nov.) as was suggested by Lindström (1954, p. 551). Two specimens figured by Pander (1856, pl. 2, figs 26, 27) and referred to *C. angulatus* are considered by us to be unidentifiable.

C. angulatus probably developed from *C. intermedius* Furnish by the development of a sigmoidal anterior basal cavity wall and a more reclined basal cavity apex.

In the synonymy list, queried entries are made when details of the basal cavity are lacking.

Occurrence: The species is known from the *Obolus — Dictyonema* beds and rarely from the Glauconitic Sandstone in the Leningrad region of the USSR

(Sergeeva, 1966) and from the Baltic States (Pander, 1856; Viira, 1966). In Sweden Lindström records it in the *Ceratopyge forficula* zone and the Lower Planilimbata Limestone of south central Sweden.

In North America it has been recorded from the Columbia Ice Fields section of Alberta (Ethington & Clark, 1965), and probably from the Stonehenge Limestone of Pennsylvania (as *Belodus* sp. A, Sando, 1958). Recently the species (identified by D. L. Clark) has been recorded from a basal Palaeozoic formation in the Nochixtlan region of Mexico (Pantoja-Alor & Robison, 1967).

CORDYLODUS cf. C. ANGULATUS Pander, 1856

(Text-fig. 23c)

Material: 2 specimens; CPC8746, figured; CPC8741 unfigured.

Description: This form is transitional between *C. intermedius* and *C. angulatus*. It differs from both in the configuration of the basal cavity. The anterior margin is considerably convex and is farther from the anterior margin of the unit than that of *C. intermedius*. However, the cavity has not yet developed a 'Phrygian cap' outline characteristic of *C. angulatus*.

CORDYLODUS CASEYI sp. nov.

(Pl. 2, figs 9a-12c; Text-fig. 23d, e)

Derivation of name: In honour of J. N. Casey, Bureau of Mineral Resources, who gave us considerable help and advice.

Type locality and horizon: Black Mountain, Boulia, west Queensland. Tremadocian Ninmaroo Formation.

Material: 12 specimens; holotype CPC8750 — paratypes CPC8748-9, 8751.

Range: Cordylodus prion — Scolopodus Assemblage Zone (*Cordylodus caseyi* subzone) to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Diagnosis: A cordylodid with a triangular basal cross-section and a fine main cusp circular in cross-section.

Description: The unit consists of an expanded base with a denticulate posterior process and a reclined main cusp. The main cusp is long and slender, circular in cross-section and completely filled with 'white matter.' The base is greatly expanded on the inner side to give a triangular cross-section. The basal cavity is large and is of the *intermedius* type: a concave anterior margin and the apex directed toward the anterior margin of the unit. In some specimens a thick flange is developed on the outer-anterior portion of the base.

Remarks: *C. caseyi* probably developed from *C. intermedius* by flaring of the inner basal cavity lip.

CORDYLODUS INTERMEDIUS Furnish, 1938
(Pl. 3, figs 1a-3b; Text-fig. 23f, g)

1938 *Cordylodus intermedius* Furnish, *J. Paleont.*, 12, 338, pl. 42, fig. 31; text-fig. 2C.

Material: 9 specimens; CPC8742, 8743, 8745 figured; CPC8744 unfigured.

Range: *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone — lower *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone.

Description: The unit consists of a main cusp and a base with a posterior denticulate extension. The main cusp is reclined above the apex of the cavity and is entirely filled with 'white matter.' The base is conical with a posterior extension bearing up to three isolated denticles which lie parallel to the reclined portion of the main cusp.

The basal cavity is distinctive; the anterior margin is gently concave and the apex is directed toward the anterior margin of the cusp.

Remarks: In gross morphology this species resembles *C. proavus* Müller, but the basal cavity is distinctive. *C. intermedius* probably developed from *C. proavus* by alteration of the anterior margin of the basal cavity. The species is transitional between *C. proavus* and *C. angulatus* Furnish.

Lindström (1954, p. 551) places *C. intermedius* in synonymy with *C. angulatus*, but the two species are distinct morphologically, and *C. intermedius* is, in fact, ancestral to *C. angulatus*.

Occurrence: Furnish (1938, p. 338) records this species from the 'Blue Earth' beds underlying the Oneota Dolomite in Minnesota, USA.

CORDYLODUS LINDSTROMI sp. nov.
(Pl. 1, figs 7a-9b; Pl. 2, fig. 8a-c; Text-fig. 23h)

1954 *Cordylodus angulatus* Pander; Lindström (in part), *Geol. Fören. Stockh. Förhandl.*, 76, fig. 3E only.

Derivation of name: In honour of Dr M. Lindström.

Type locality and horizon: Black Mountain, Tremadocian Ninmaroo Formation.

Material: 12 specimens; holotype CPC8767, paratypes CPC8747, 8753, 8754.

Range: *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone (*C. lindstromi* subzone) to lower *C. rotundatus* — *C. angulatus* Assemblage Zone.

Diagnosis: A cordylodid with a distinctive basal cavity with two or more apices.

Description: The unit is very similar to *C. angulatus* and *C. prion*, but the basal cavity is distinctive. Instead of the usual single apex terminating beneath the main cusp there are two or more apices, one beneath the main cusp and the others beneath the posterior bar denticles.

Remarks: Lindström (1954, p. 551) noted this type of basal cavity and suggested that it could serve to distinguish a separate species.

CORDYLODUS OKLAHOMENSIS Müller, 1959

(Pl. 5, figs 6a-7c; Text-fig. 23j)

1959 *Cordylodus oklahomensis* Müller, *Z. dtsch. geol. Ges.*, 111, 447, pl. 15, fig. 15, 16; text-fig. 3A.

Material: 4 specimens; CPC8726, 8727 figured.

Range: Immediately below base of *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone to lower *C. oklahomensis* — *C. lindstromi* Assemblage Zone (*C. oklahomensis* subzone).

Description: The unit consists of a main cusp and a posteriorly produced denticulate base. The main cusp is fairly erect and is extremely laterally compressed, with posterior and anterior knife-edges. 'White matter' is present in the cusp but it is not filled completely as in most other cordylodid species. The base is fairly shallow and has an inner lateral flare and a posterior denticulate extension.

The posterior extension bears up to three fairly large, laterally compressed, posteriorly inclined denticles containing 'white matter.' The inner lateral flare is situated at the junction of the posterior face of the main cusp and the posterior process. It gives the base a subtriangular cross-section.

Remarks: This species is very close to *C. prion* Lindström, but is distinguished by the lateral flaring of the inner cavity lip.

Occurrence: The species was originally described from the Signal Mountain Limestone of Oklahoma (Müller, 1959), thought to be of lowermost Ordovician age (Branson, 1957). It is also reported from a basal Palaeozoic formation in the Nochixtlan region of Mexico (Pantoja-Alor & Robison, 1967).

Cordylodus prion Lindström, 1954

(Pl. 2, figs 1a-7b; Text-fig. 23i, k-o)

1954 *Cordylodus prion* Lindström, *Geol. Fören. Stockh. Förhandl.*, 76, 552, pl. 5, figs 14-16.

Material: 11 specimens; CPC8729-35 figured.

Range: Cordylodus prion — Scolopodus Assemblage Zone to lower *Cordylodus rotundatus — C. angulatus* Assemblage Zone.

Description: The unit consists of a main cusp and an elongate posterior bar with a small base. The main cusp is erect, extremely laterally compressed, and blade-like. The posterior bar is elongate and saw-like, bearing up to five short subtriangular denticles inclined posteriorly. The base is small and the cavity is shallow, extending along the bar with a shallow apex beneath the main cusp.

Remarks: There is considerable variation in the configuration of the anterior margin of the unit; in some specimens it is convex, in others concave or very occasionally sigmoidal. Variation also occurs in the degree of flaring of the basal cavity lips.

C. prion probably developed from *C.* cf. *C. proavus,* which has a blade-like main cusp, by the elongation of the posterior process and a change in the nature and an increase in the number of bar denticles.

Occurrence: Lindström (1954, p. 553) records the species from the *Ceratopyge forficula* zone of the Tremadocian of south-central Sweden. It is also known from the *Cordylodus angulatus* zone of the upper part of the *Obolus-Dictyonema* beds of the Lower Ordovician of the Leningrad region of the USSR (Sergeeva, 1966) and the A_2 zone of the Tremadocian in Estonia (Viira, 1966).

Cordylodus proavus Müller, 1959

(Pl. 1, figs 1a-6; Text-fig. 23p, q, r)

1959 *Cordylodus proavus* Müller; *Z. dtsch. geol. Ges.*, 111, 448, pl. 15, figs 11, 12, 18; text-fig. 3B.

Material: 32 specimens; CPC8718-8723 figured.

Range: Cordylodus proavus Assemblage Zone to *Cordylodus oklahomensis — C. lindstromi* Assemblage Zone.

Description: The unit consists of a denticulate base and a main cusp. The main cusp is reclined at the tip of the basal cavity; from this point to the oral termination, the cusp is entirely filled with 'white matter.'

The base is produced posteriorly and bears up to three isolated denticles which lie parallel to the reclined portion of the main cusp. A large conical basal cavity is present; the apex is centrally situated in the main cusp; posteriorly the cavity extends along the denticulate extension. In many specimens the cavity is filled with 'basal bone.'

Remarks: C. proavus appears to be the simplest cordylodid and ancestral to all the other Tremadocian species. It probably developed from a simple oneotodid, possibly *Oneotodus nakamurai* Nogami.

Occurrence: The species was originally described from the Signal Mountain Limestone of Oklahoma, USA, originally thought to be Upper Cambrian (Müller, 1959) but now placed in the Lower Ordovician (Branson, 1957). *C. proavus* is also known from a basal Palaeozoic formation in the Nochixtlan region of Mexico (Pantoja-Alor & Robison, 1967).

CORDYLODUS cf. C. PROAVUS Müller, 1959

(Pl. 1, figs 10a-12b; Text-fig. 23s)

Material: 24 specimens; CPC8724, 8725, 8728 figured.

Range: Cordylodus proavus Assemblage Zone to lowermost *Oneotodus bicuspatus — Drepanodus simplex* Assemblage Zone.

Description: This form is similar to *C. proavus* in having a large erect basal cavity. It differs in being erect and laterally compressed.

Remarks: The variant may have developed from *Cordylodus proavus* by additional growth on the main cusp. This is well illustrated in Plate 1, figures 12a, b, where regrowth has transformed the primary reclined *Cordylodus proavus* into an erect and laterally compressed form.

CORDYLODUS ROTUNDATUS Pander, 1856

(Pl. 3, figs 8a-10c; Text-fig. 23t)

1856 *Cordylodus rotundatus* Pander, *Monog. foss. Fische Sil. Syst. russ.-balt. Gouvts,* 33, pl. 2, figs 32, 33.
1903 Conodont. *Cordylodus angulatus* Pander?; Wiman, *Bull. geol. Inst. Uppsala,* 6, 66, pl. 3, figs 42, 43.
1906 Conodont. Moberg & Segerberg, *Medd. Lunds geol. Faltklubb, Ser. B.,* 2, 62, pl. 1, figs 17, 18.
1909 Conodont. Westergaard, *Lunds Univ. Arsskr.,* 5, 77, pl. 5, figs 28, 29.
1938 *Cordylodus subangulatus* Furnish, *J. Paleont.,* 12, 338, pl. 42, fig. 32, text-fig. 2D.
Synonymy list from:
1954 *Cordylodus rotundatus* Pander; Lindström, *Geol. Fören. Stockh. Förhandl.,* 76, 553, pl. 5, figs 17-20, text-fig. 3F.

Material: 22 specimens; CPC8752, 8755, 8756 figured.

Range: Cordylodus rotundatus — C. angulatus Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Description: The unit consists of a main cusp and a posterior bar. The main cusp is massive, erect, and ellipsoidal in cross-section. The antero-aboral junction is rounded and is composed of the two lips of the basal cavity. The posterior bar is long and bears at least four elongate, isolated, posteriorly inclined needle-like denticles.

The aboral outline is strongly convex. The basal cavity extends along the posterior bar and beneath the main cusp. The apex is situated beneath the main cusp and is directed anteriorly, the basal cavity being shaped like a 'Phrygian cap.'

Remarks: C. rotundatus differs from *C. angulatus* Pander in possessing a rounded antero-aboral margin which is bisected by the basal cavity.

Occurrence: The species is known from the Lower Ordovician (Pakerort and Leetse Stages) of the Baltic region (Pander, 1856; Öpik, 1927; Viira, 1966). In Sweden it is abundant in the *Ceratopyge forficula* Zone (Lindström, 1954; Wiman, 1903; Waern, 1952). *C. subangulatus,* recorded by Furnish (1938, p. 338) from the Oneota Dolomite of Minnesota ('Blue Earth' beds), is a junior synonym of *C. rotundatus.* Longwell & Mound (1967) have also recorded *C. subangulatus* from Member 3 of the Monocline Valley Formation of Nevada. Recently Sergeeva (1966) has recorded *C. rotundatus* from the *Cordylodus angulatus* Zone of the Tremadocian *Obolus-Dictyonema* Beds of the Leningrad region.

CORDYLODUS sp. A

(Pl. 8, figs 10a, b; Text-fig. 23u)

Material: 2 specimens; CPC8738 figured.

Remarks: This unit is extremely close to *Cordylodus angulatus* Pander. The only difference is in the shape of the basal cavity, which has the basic 'Phrygian cap' outline but possesses two apices. The second apex is situated in the medial portion of the anterior face of the cavity.

Genus DREPANODUS Pander, 1856

Type species: *Drepanodus arcuatus* Pander, 1856

DREPANODUS ACUTUS Pander, 1856

(Pl. 20, figs 5a-7c; Text-fig. 24a)

1856 *Drepanodus acutus* Pander, *Monog. foss, Fische Sil. Sys. russ.-balt. Gouvts,* 21, pl. 2, fig. 9.

Material: 10 specimens; CPC8900, 8907, 8908 figured.

Range: Cordylodus prion — Scolopodus Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Description: The unit is recurved and consists of a cusp and a base. The base is large, oval in cross-section, and completely excavated by a large basal cavity. The apex of the cavity is medial and is recurved with the cusp.

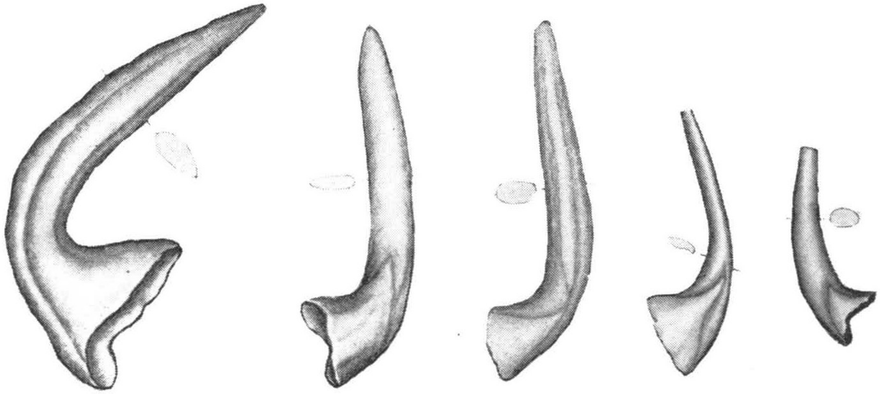

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Fig. 24 *Drepanodus,* lateral views. (a) *D. acutus* Pander CPC8907. (b) *D. simplex* Branson & Mehl. CPC8896. (c) *D. subarcuatus* Furnish CPC8903. (d) *D. suberectus* Branson & Mehl. CPC8902. (e) *D. tenuis* Moshalenko CPC8909. All x 32.

The cusp lies at right-angles to the base and is circular to laterally compressed in cross-section. A rounded costa is developed on the anterior face, extending on to the base and halfway to the oral termination. The cusp is completely filled with 'white matter.'

Occurrence: The species was originally described from the Baltic Provinces of Russia (Pander, 1856). In western Queensland it occurs in the Black Mountain and Mount Ninmaroo sections.

DREPANODUS SIMPLEX Branson & Mehl, 1933

(Pl. 13, figs 1a-4c; Text-fig. 24b)

1933 *Drepanodus simplex* Branson & Mehl, *Missouri Univ. Stud.*, 8, 58, pl. 4, fig. 2.
1959 *Oneotodus* sp. indet., Müller, *Z. dtsch. geol. Ges.*, 111, 458, pl. 13, fig. 15.
1961 *Drepanodus simplex* Branson & Mehl, Wolska, *Acta palaeont. polon.*, 6, 349, pl. 2, fig. 8.

Material: 67 specimens; CPC8896-9 figured.

Range: Oneotodus bicuspatus — Drepanodus simplex Assemblage Zone to *Cordylodus oklahomensis — C. lindstromi* Assemblage Zone.

Description: A simple cone unit with a small base and an elongate flattened cusp. The base is shallow and has a circular cross-section. It is excavated by a conical basal cavity. The cusp is reclined, and elongate. The aboral half is circular to ellipsoidal in cross-section, but the oral half is extremely laterally compressed, with anterior and posterior knife-edges. The medial portion is wide and the oral termination is upturned slightly.

Remarks: D. simplex appears to be closely related to *Acanthodus uncinatus* Furnish, though it lacks the ancillary dentition on the postero-oral edge. The two species often occur in the same sample, although *D. simplex* occurs earlier than *A. uncinatus.*

Occurrence: D. simplex was originally described from the Lower Ordovician Jefferson City Formation of Missouri (Branson & Mehl, 1933). In western Queensland it is present in the Black Mountain, Mount Ninmaroo, and Mount Datson sections. It also occurs in the Signal Mountain Limestone of Oklahoma (Müller, 1959). In Poland, *D. simplex* has been found in an erratic boulder associated with a stratigraphic admixture (Wolska, 1961).

DREPANODUS SUBARCUATUS Furnish, 1938

(Pl. 20, figs 1a-4c; Text-fig. 24c)

1938 *Drepanodus subarcuatus* Furnish, *J. Paleont.*, 12, 328, pl. 41, figs 2, 3.
1943 *Oistodus larapintinensis* Crespin, *Trans. Roy. Soc. S. Aust.*, 67, 231, pl. 31, figs 1-3 (*non* figs 4-13).
1964 *Drepanodus subarcuatus* Furnish; Ethington & Clark, *J. Paleont.*, 38, 689, pl. 113, figs 15, 20. (Synonymy.)
1965 *Drepanodus subarcuatus* Furnish; Mound, *Tulane Studies Geol.*, 4, 19, pl. 2, figs 14, 18, 19.

Material: 112 specimens; CPC8903-6 figured.

Range: Chosonodina herfurthi — Acodus Assemblage Zone.

Remarks: Mound (1965, p. 19) remarks that the species is highly variable and extremely common. We have examined the type specimens of *Oistodus larapintinensis* Crespin, 1943, and consider that the holotype (CPC234) and two paratypes (CPC235-6) are conspecific with *Drepanodus subarcuatus* Furnish, 1938. The remaining paratypes appear to belong to different genera, and these will be discussed in a forthcoming paper on Ordovician conodonts from central Australia.

Occurrence: The species is common in Ordovician rocks.

Drepanodus suberectus (Branson & Mehl, 1933)

(Pl. 12, figs 1a-2c; Text-fig. 24d)

1933 *Oistodus suberectus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 111, pl. 9, fig. 7.
1966 *Drepanodus suberectus* (Branson & Mehl); Bergström & Sweet, *Bull. Amer. Paleont.*, 50, 330, pl. 35, figs 22-27. (Synonymy.)

Material: 12 specimens; CPC8901, 8902 figured.

Range: Cordylodus rotundatus—C. angulatus Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Remarks: Bergström & Sweet (1966, p. 330) have united the form-species *Drepanodus homocurvatus* Lindström, *D. suberectus* (Branson & Mehl), and *Oistodus inclinatus* Branson & Mehl into a single taxon, *D. suberectus* (Branson & Mehl). The forms described here are all referable to the *D. suberectus* element. The other two elements have not been recognized in the present faunas.

Occurrence: D. suberectus is a common form in Ordovician rocks.

Drepanodus tenuis Moskalenko, 1967

(Pl. 12, figs 8a-c; Text-fig. 24e)

1967 *Drepanodus tenuis* Moskalenko, *New data on the biostratigraphy of the Lower Palaeozoic of the Siberian Platform*, 107, pl. 23, figs 5-11.

Material: 2 specimens; CPC8909 figured.

Range: Cordylodus rotundatus — C. angulatus Assemblage Zone.

Description: The unit is slightly reclined and consists of a base and a laterally compressed cusp. The base is excavated by a large conical cavity. The cavity apex is situated medially. The cusp is laterally compressed, with anterior and posterior knife-edges and gently rounded faces.

Remarks: Our specimens are very similar to those figured by Moskalenko (1967, p. 108).

Occurrence: The species was originally described from the Chun Stage of the Lower Ordovician on the Siberian Platform, USSR (Moskalenko, 1967).

Genus OISTODUS Pander, 1856

Type species: *Oistodus lanceolatus* Pander, 1856

OISTODUS INAEQUALIS Pander, 1856

(Pl. 12, figs 10a-13b; Text-fig. 25a)

1856 *Oistodus inaequalis* Pander, *Mon. foss. Fische Sil. Sys. russ.-balt. Gouvts,* 27, pl. 2, fig. 37.

1944 *Oistodus inaequalis* Pander; Branson & Mehl, *in* Shimer & Shrock, *Index fossils of North America,* 240, pl. 93, fig. 44.

1954 *Oistodus inaequalis* Pander; Lindström, *Geol. Fören. Stockh. Förhandl.,* 76, 576, pl. 3, figs 52-57.

1964 *Oistodus gracilis* Branson & Mehl; Müller (partim), *N. Jb. Geol. Paläont. Abh.,* 119, 97, pl. 12, figs 5, 7 (*non* pl. 13, fig. 7 = *O. gracilis).*

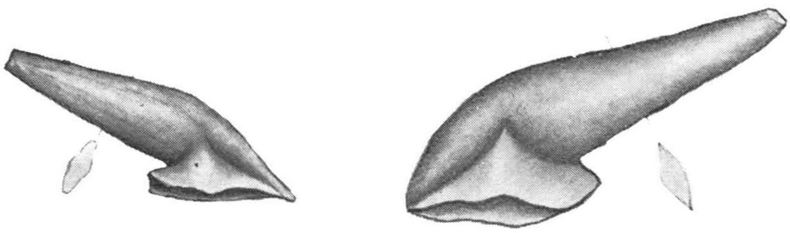
Material: 28 specimens; CPC8868, 8871-3 figured.

Range: Cordylodus rotundatus—C. angulatus Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Description: The unit consists of a shallow base and an erect to reclined cusp. The base is flared, diamond-shaped in cross-section. The cavity is shallow and occupies the whole of the base, which is produced posteriorly as a short process. The cusp is laterally compressed, with faint rounded lateral costae and anterior and posterior knife-edges. The anterior margin is straight to gently curved and the posterior margin is straight.

Remarks: The species can be distinguished from *O. lanceolatus* by the more erect cusp.

Occurrence: O. inaequalis has been recorded from Estonia (Viira, 1966) and the Baltic Region of the USSR (Pander, 1856; Sergeeva, 1966) in the Leetse Stage. Müller (1964) described specimens from Lower Ordovician strata in South Korea, placing them in *O. gracilis* Branson & Mehl.



a b

Fig. 25 (a) *Oistodus inaequalis* Pander. CPC8872, lateral view. (b) *O. lanceolatus* Pander CPC8869, lateral view. Both x 32.

OISTODUS LANCEOLATUS Pander, 1856
(Pl. 6, figs 6a-8c; Text-fig. 25b)

1856 *Oistodus lanceolatus* Pander, *Mon. foss. Fische Sil. Sys. russ.-balt. Gouvts,* 27, pl. 2, figs 17, 18, 19.

1964 *Oistodus lanceolatus* Pander; Ethington & Clark, *J. Paleont.*, 38, 693, pl. 113, fig. 12; pl. 114, figs 1, 5. (Synonymy to 1962.)

1965 *Oistodus lanceolatus* Pander; Ethington & Clark, *Brigham Young Univ. geol. Stud.*, 12, 195.

Material: 10 specimens; CPC8867, 8869, 8870 figured.

Range: Cordylodus rotundatus—C. angulatus Assemblage Zone to *Chosonodina herfurthi* — *Acodus* Assemblage Zone.

Description: The unit is a simple cone consisting of a base and a cusp. The base is shallow and elongate, with a rounded anterior edge and an elongate posterior process. The whole of the base is excavated to form a basal cavity which extends along the posterior process. The cavity lips are flared to give the base a diamond-shaped cross-section. The cusp is recurved and laterally compressed. The aboral half is wide, with anterior and posterior knife-edges. A rounded costa is present on both lateral faces. The oral half is more needle-like and has a sharp oral termination.

Occurrence: O. lanceolatus was originally described by Pander from the Baltic Provinces. It has also been recorded by Viira (1966) from the $B_1\beta$ and $B_{11}\alpha_1$ Zones of Estonia, and by Sergeeva (1966) from the *Prioniodus elegans* and *Prioniodus evae* Subzones of the *Drepanodus sculponea* Zone of the Leningrad region. In Sweden it occurs rarely in the upper part of the Lower Planilimbata Limestone, commonly in the Upper Planilimbata Limestone, and sparsely in the Limbata Limestone (Zones 2, 3, and 4 of Lindström, 1954, p. 532; see also Lindström, 1957, 1960).

In Scotland the species has been recovered from Arenigian strata at Ravengill, Lanarkshire (Lamont & Lindström, 1957). In North America the species is found in the Lower Ordovician El Paso Formation of Texas and Arizona (Ethington & Clark, 1964), the Columbia Ice Fields section, Alberta (Ethington & Clark, 1965), and the Monocline Valley Formation of Nevada, where it ranges as low as Member 3 (Longwell & Mound, 1967).

In Queensland the species has been recovered from the Black Mountain, Mount Ninmaroo, and Mount Datson sections.

Genus ONEOTODUS Lindström, 1954

Type species: *Distacodus? simplex* Furnish, 1938

ONEOTODUS BICUSPATUS sp. nov.
(Pl. 14, figs 5a-8c; Text-fig. 26a, b)

Derivation of name: From the thickening of the cusp to give the appearance of twin fused cusps.

Type locality and horizon: Black Mountain, Tremadocian Ninmaroo Formation, *Oneotodus bicuspatus* — *Drepanodus simplex* Assemblage Zone.

Material: 15 specimens; holotype CPC8912, paratypes CPC8910, 8911, 8913.

Range: Oneotodus bicuspatus — *Drepanodus simplex* Assemblage Zone.

Diagnosis: A simple oneotodid with a thickening of the anterior face to give the impression of two cusps fused together.

Description: The unit is a simple cone consisting of a base and a cusp. The base is shallow and flared, with a subcircular cross-section. The basal cavity is shallow and broad.

The cusp is elongate, reclined, and circular in cross-section, and filled with 'white matter.' On the anterior face the unit is thickened as a second cusp completely fused to and merging with the main cusp in a medial position. Between the two fused cusps there is a groove on both lateral faces extending on to the base. Although a secondary base is developed there is only one growth axis and the basal cavity possesses only one apex, situated beneath the main cusp.

Remarks: Although the secondary cusp destroys the circular cross-section of the unit it is referred to *Oneotodus* because the two cusps are individually indistinguishable from *Oneotodus datsonensis* sp. nov.

Occurrence: In western Queensland the species is found in the Black Mountain, Mount Ninmaroo and Mount Datson sections.

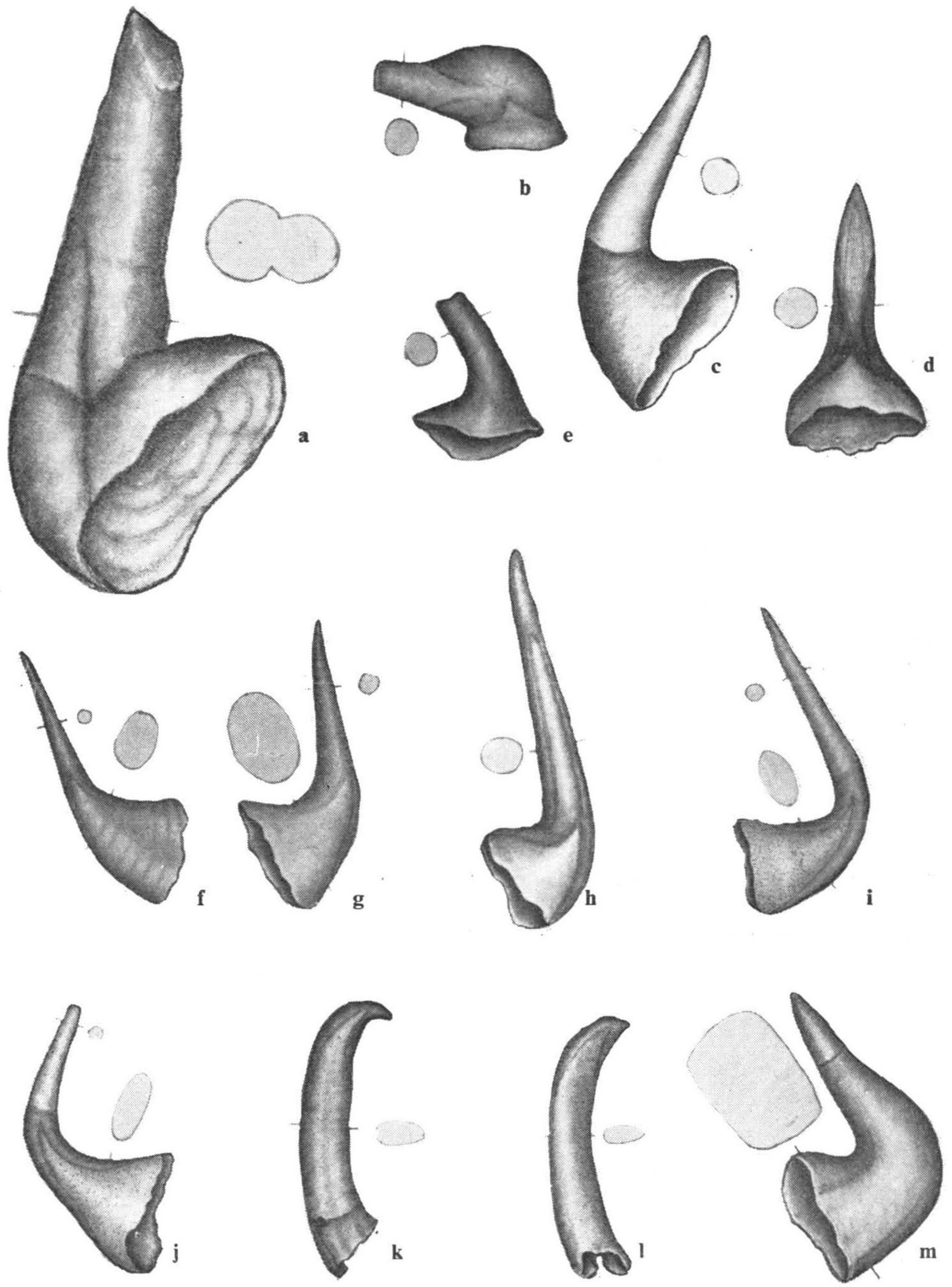


Fig. 26 *Oneotodus,* lateral views: (a, b) *O. bicuspatus* sp. nov. (a) holotype CPC8912. (b) paratype CPC8910. (c) *O. datsonensis* sp. nov. paratype CPC8915. (d) *O. erectus* sp. nov. paratype CPC8825. (e) *O.* cf. *erectus* CPC8829. (f, g) *O, gallatini* Müller: (f) CPC8799. (g) CPC8805. (h) *O. gracilis* (Furnish) CPC8191. (i, j) *O. nakamurai* Nogami: (i) CPC8795. (j) CPC8807. (k, l) *O. terashimai* Nogami: (k) CPC8809. (l) CPC8813. (m) *O. variabilis* Lindström. CPC8918. All x 60.

ONEOTODUS DATSONENSIS sp. nov.

(Pl. 14, figs 1a-4c; Text-fig. 26c)

1959 *Oneotodus* sp. A. Müller, *Z. dtsch. geol. Ges.*, 111, 458, pl. 13, fig. 17.

Derivation of name: After Mount Datson.

Type locality and horizon: Black Mountain, Tremadocian Ninmaroo Formation.

Material: 78 specimens; holotype CPC8916, paratypes CPC8914, 8915, 8917.

Range: Oneotodus bicuspatus — Drepanodus simplex Assemblage Zone to *Cordylodus prion — Scolopodus* Assemblage Zone.

Diagnosis: A short oneotodid sharply reclined through 90° and with an upturned oral termination.

Description: The unit is short and fairly massive, consisting of a base and a cusp. The cusp is slightly longer than the base, which is conical and circular in cross-section. A deep conical basal cavity occupies the base. The cusp is very sharply reclined through 90° and is stout and relatively short. The oral termination is flexed upward. The cusp is completely filled with 'white matter.'

Remarks: O. datsonensis is probably developed from *O. nakamurai* Nogami. It closely resembles *O. variabilis* Lindström, but is distinguished by the circular basal outline and the upturning of the oral termination of the cusp.

Occurrence: The species is found in the Black Mountain, Mount Ninmaroo, and Mount Datson sections. The specimen illustrated by Müller (1959, pl. 13, fig. 17) is probably referable to this species and was recovered from the Signal Mountain Limestone of Oklahoma, USA.

ONEOTODUS ERECTUS sp. nov.

(Pl. 15, figs 2a-9; Text-fig. 26d)

Derivation of name: From the erect cusp.

Type locality and horizon: Black Mountain, Tremadocian Ninmaroo Formation, *Cordylodus prion — Scolopodus* Assemblage Zone.

Material: 65 specimens; holotype CPC8823, paratypes CPC8821, 8822, 8824-28 figured.

Range: Upper *Cordylodus prion* Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Diagnosis: An oneotodid with a proclined cusp.

Description: The unit is a simple cone consisting of a base and a cusp. The base is conical; in some forms it is fairly deep and in others extremely shallow. The cross-section of the base varies from circular to ellipsoidal. The cusp is proclined and is circular in cross-section. It is needle-like and filled with 'white matter.' In some specimens the cusp is extremely long and thin; in others it is shorter and stouter. The unit bears no ornament.

Remarks: The species is easily recognized by its proclined cusp. It appears to be ancestral to species of *Scolopodus* found higher in the section.

Occurrence: The species occurs throughout the Ninmaroo Formation except for the lower part of the *Cordylodus prion* Assemblage Zone. It is known from Black Mountain, Mount Ninmaroo, Mount Datson, and the Swift Hills and Digby Peaks areas.

ONEOTODUS cf. O. ERECTUS sp. nov.

(Pl. 20, figs 8a, b; Text-fig. 26e)

Remarks: A single specimen (CPC8829) resembles *O. erectus* but is distinguished by a large frill-like base.

ONEOTODUS GALLATINI Müller, 1959

(Pl. 9, figs 9a-c; Pl. 10, figs 9a-10c; Text-fig. 26f, g)

1959 *Oneotodus gallatini* Müller, *Z. dtsch. geol. Ges.*, 111, 457, pl. 13, figs 5-10, 18.

Material: 15 specimens; CPC8799, 8805, 8926 figured.

Range: Chatsworth Limestone.

Description: The unit is an erect simple cone with circular cross-section. The base is slightly expanded, with a deep conical basal cavity extending to the point of flexure. The cusp is straight and is amber in colour, lacking 'white matter.' The surface of the unit is rough.

Remarks: O. gallatini can be distinguished from *O. nakamurai* by its generally larger size and the absence of 'white matter' from the cusp. The surface roughness is similar to that seen in our specimens of *Sagittodontus dahlmani* Müller.

Occurrence: O. gallatini has been described from the Upper Cambrian Gallatin Limestone of Wyoming, USA (Müller, 1959). It is also known from the

Deadwood Formation, South Dakota, the Dugway Mountains, Utah (*Eoorthis* Subzone), and the Dunderberg Shale and Windfall Formation of Nevada (op. cit.). In Northern Europe the species ranges throughout the Upper Cambrian (op. cit.), above the basal zone of *Agnostus pisiformis*.

In China it is reported from the upper Upper Cambrian Yencho Formation (Nogami, 1967).

ONEOTODUS GRACILIS (Furnish, 1938)

(Pl. 14, figs 9a-13b; Pl. 15, figs 1a-c; Text-fig. 26h)

1938 *Distacodus? gracilis* Furnish, *J. Paleont.*, 12, 327, pl. 42, fig. 23.
1964 *Oneotodus simplex* (Furnish); Ethington & Clark, *J. Paleont.*, 38, 695, pl. 114, fig. 13.
1967 *Oneotodus gracilis* (Furnish); Moskalenko, *New data on the biostratigraphy of the Lower Palaeozoic of the Siberian Platform*, 111, pl. 24, figs 3, 4.

Material: 1371 specimens; CPC8919-24 figured.

Range: Cordylodus proavus Assemblage Zone to *Chosonodina herfurthi—Acodus* Assemblage Zone.

Description: A long slender oneotodid with a large cone-shaped base. The cross-section is circular and the base is deeply excavated by a conical basal cavity. The cusp is gently reclined through 45° to 90°. It is long, slender, and circular in cross-section. It is transparent except for a thin column of 'white matter' developed along the growth axis. The cusp is three to four times as long as the base.

Remarks: O. gracilis can be distinguished from *O. nakamurai* Nogami by the much greater cusp/base ratio. *O. nakamurai* has a cusp/base ratio of about one, whereas in *O. gracilis* the ratio is about 3 to 4; furthermore the development of 'white matter' is entirely different. *O. gracilis* differs from *O. datsonensis* sp. nov. and *O. variabilis* Lindström in being long and slender and not so abruptly reclined. In the Queensland fauna some forms are nearly erect and others are greatly reclined. It is possible that these two variants represent different species.

Occurrence: The species is known from the Shakopee Formation of Minnesota and Wisconsin, USA (Furnish, 1938). It has also been reported from the Chun Stage of the Lower Ordovician of the Siberian Platform (Moskalenko, 1967).

ONEOTODUS NAKAMURAI Nogami, 1967

(Pl. 10, figs 1-8b; Text-fig. 26i, j)

1967 *Oneotodus nakamurai* Nogami, *Mem. Coll. Sci. Univ. Kyoto*, 33, 216, pl. 1, figs 9-13.

Material: 262 specimens; CPC8793-6, 8806, 8807, 8810 figured.

Range: Chatsworth Limestone.

Description: The unit is a simple reclined oneotodid; the cusp and the base are of equal length. The base is subtriangular and laterally compressed. The cross-section varies from subtriangular through ellipsoidal to circular. The whole of the base is excavated to form a basal cavity which is filled with white opaque 'basal bone'; the walls are thin and amber. The cusp is needle-like; at its base it is translucent and amber, but the remaining three-quarters are filled with 'white matter.' Most specimens are reclined but some are erect. In some specimens the cusp is much shorter than the base and in others it is longer.

Remarks: This is a very varied species; in base-cusp length ratio, in base cross-section, and in the curvature of the unit. However, it is very distinctive with the clearly marked division of amber and 'white matter' in the cusp. It is this 'white matter' which distinguishes the species from *O. gallatini* Müller.

Occurrence: The species was originally described from the uppermost Upper Cambrian Yencho Formation of northeast China (Nogami, 1967).

ONEOTODUS TENUIS Müller, 1959

1959 *Oneotodus tenuis* Müller, *Z. dtsch. geol. Ges.*, 111, 457, pl. 13, figs 11, 13, 14, 20.
1966 *Oneotodus tenuis* Müller; Nogami, *Mem. Coll. Sci. Univ. Kyoto,* 32, 356, pl. 9, figs 11, 12.

Material: 4 specimens.

Range: Chatsworth Limestone.

Remarks: A very slender proclined oneotodid. All the present specimens are broken but they are very similar to those figured by Müller and Nogami.

Occurrence: The species occurs in the Upper Cambrian of the USA, in the Gallatin Limestone of Wyoming, the Deadwood Formation of South Dakota, and the Dunderberg Shale and Windfall Formation of Nevada (Müller, 1959). In Europe it ranges from the Middle Cambrian *Ptychagnostus (Triplagnostus) gibbus* Zone to the top of the Upper Cambrian (op. cit). In China, it occurs in the Upper Cambrian Kushan and Yencho Formations (Nogami, 1966, 1967).

ONEOTODUS TERASHIMAI Nogami, 1967
(Pl. 10, figs 11a-12c; Text-fig. 26k, l)

1967 *Oneotodus terashimai* Nogami, *Mem. Coll. Sci. Univ. Kyoto,* 33, 217, pl. 1, figs 14-16.

Material: 2 specimens; CPC8809, 8813 figured.

Range: Chatsworth Limestone.

Description: The unit is a proclined simple hollow cone and is laterally compressed. The base is extremely long and tubular, subcircular in cross-section. The cusp is minute and is recurved. It appears as a horizontal nipple. The basal cavity extends to the base of the nipple and is filled with friable 'basal bone.'

Remarks: The species is unlike any other species of oneotodid.

Occurrence: O. terashimai was originally described from the uppermost Upper Cambrian Yencho Formation of northeast China (Nogami, 1967).

ONEOTODUS VARIABILIS Lindström, 1954
(Pl. 13, figs 5a-c; Text-fig. 26m)

1954 *Oneotodus variabilis* Lindström, *Geol. Fören. Stockh. Förhandl.* 76, 582, pl. 2, figs 14-18; pl. 4, figs 4, 5; text-fig. 6.

1965 *Oneotodus variabilis* Lindström; Ethington & Clark, *Brigham Young Univ. geol. Stud.*, 12, 197.

Material: 12 specimens; CPC8918 figured.

Range: Cordylodus rotundatus — C. angulatus Assemblage Zone.

Remarks: O. variabilis can be distinguished from *O. datsonensis* sp. nov. by the irregular basal cavity, often triangular or quadrate in outline. The oral termination of the cusp in *O. datsonensis* is also upturned. In their discussion of *O. variabilis* from the Columbia Ice Fields section, Alberta, Ethington & Clark (1965, p. 197) state that the base in cross-section does not exhibit strong basal expansion, and the unit has a right-angled posterior margin; therefore their specimens may belong to *O. datsonensis*.

Occurrence: The species was originally described from the Tremadocian *Ceratopyge* Limestone of south-central Sweden (Lindström, 1954); single specimens were recorded from two sections in the Arenigian Lower Planilimbata Limestone (op. cit., pl. 9). It also occurs in the Columbia Ice Fields sections of Alberta, Canada (Ethington & Clark, 1965). Sergeeva (1966) records the species from the *Cordylodus angulatus* and *Drepanodus sculponea* Zones. In Estonia the species is confined to the base of the $B_{1\alpha}$ Zone (Viira, 1966).

Genus PROBLEMATOCONITES Müller, 1959

Type species: *P. perforata* Müller, 1959

The genus was first described by Müller (1959, p. 471), who included it in his Order Paraconodontida (1962, p. W248). Nogami (1967) reports the genus

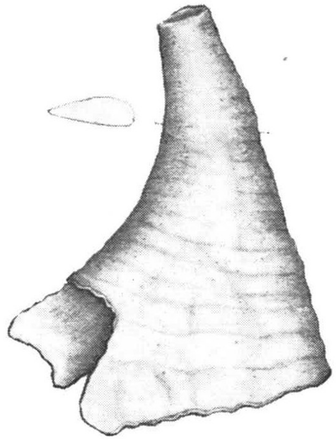


Fig. 27 *Problematoconites perforata* Müller CPC8804, lateral view x 100.

from China. Our specimens appear similar to true conodonts and bear a striking resemblance to basal cone material. It is possible that these forms are indeed basal cones.

PROBLEMATOCONITES PERFORATA Müller, 1959
(Pl. 8, figs 11a, b; Text-fig. 27)

1959 *Problematoconites perforata* Müller, *Z. dtsch. geol. Ges.*, 111, 471, pl. 15, figs 17a, b.

Material: 3 specimens; CPC8804 figured.

Range: Chatsworth Limestone.

Description: The unit is a simple cone with a deep basal cavity. In cross-section it is elliptical, the base flaring slightly. The cusp is subcircular in cross-section and is erect. The base is patterned by small perforations and by horizontal ridges. The unit is opaque and cream in colour, resembling some of the basal cavity fillings seen in this study.

Remarks: Müller (1962, p. W248) considers that these microfossils are paraconodonts. The presence of a species, originally described from the Upper Cambrian of northern Europe, in the Upper Cambrian of Australia illustrates the fact that paraconodonts may be as useful as true conodonts in intercontinental correlation.

Occurrence: The species is recorded throughout the Upper Cambrian (excluding the basal *Agnostus pisiformis* Zone) of northern Europe (Müller, 1959, table 3). It is also present in the Yencho Formation of northeast China (Nogami, 1967).

Genus SAGITTODONTUS Rhodes, 1953

Type species: *S. robustus* Rhodes, 1953

Rhodes (1953, p. 310) erected *Sagittodontus* to include single stout denticles, triangular in cross-section with three more or less flattened faces and sharp dividing edges. Aboral surface deeply excavated so that whole unit is hollow. The genera *Sagittodontus* and *Coelocerodontus* appear to be very close. Ethington (1959, p. 273) states that the thin walls of *Coelocerodontus* distinguish it, though Rhodes, in his generic description of *Sagittodontus,* does not indicate the wall thickness. In this paper *Sagittodontus* has been restricted to include widely flaring pyramoidal cones, whereas species which lack basal flaring and are simple cones with up to four knife edges, are referred to *Coelocerodontus.*

For a discussion of the genus *Furnishina,* see the general remarks under *Coelocerodontus.*

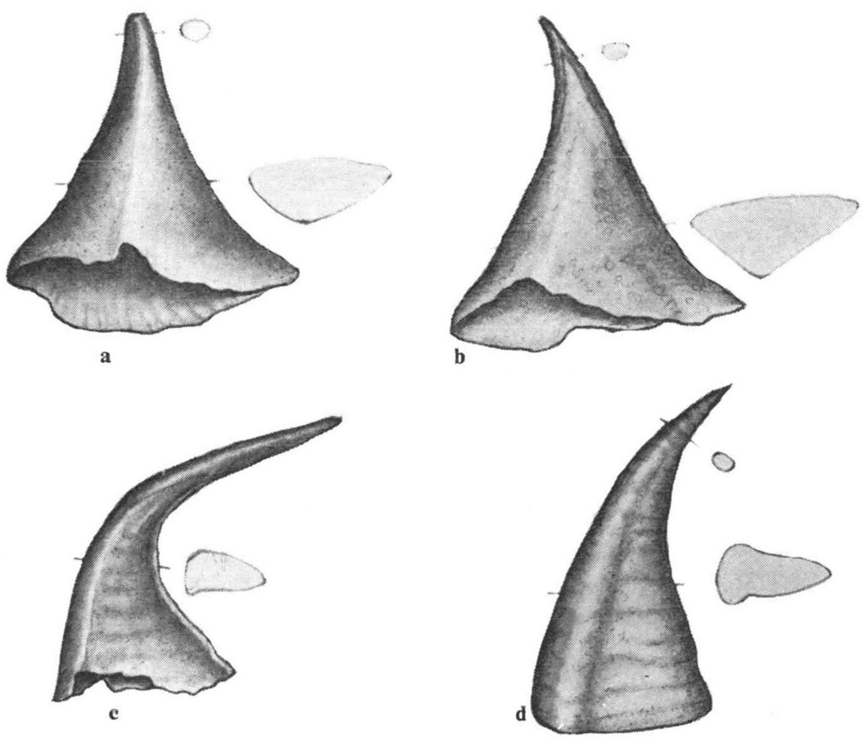


Fig. 28 (a, b) *Sagittodontus dahlmanni* Müller: (a) CPC8802, posterior view. (b) CPC8803, lateral view. (c, d) *S. furnishi* Müller, lateral views: (c) CPC8811. (d) CPC8815. All x 80.

Sagittodontus dahlmani Müller, 1959

(Pl. 8, figs 6a-9c; Text-fig. 28a, b)

1959 *Sagittodontus dahlmani* Müller, *Z. dtsch. geol. Ges.*, 111, 460, pl. 14, figs 5, 7, 10.
1959 *Sagittodontus dunderbergiae* Müller, *Ibid.*, 461, pl. 14, fig. 9.
1959 *Sagittodontus* n. sp. aff. *dunderbergiae* Müller, *Ibid.*, 461, pl. 14, fig. 8.
1966 *Sagittodontus dunderbergiae* Müller; Nogami, *Mem. Coll. Sci. Univ. Kyoto*, 32, 357, pl. 9, figs 8-10.

Material: 11 specimens; CPC8800-3 figured.

Range: Chatsworth Limestone.

Description: The unit is a simple hollow cone with a triangular cross-section. It is flared, with knife-edges laterally and a flat anterior face. The posterior face is produced posteriorly to form the third apex. The cusp is minute and is gently inclined posteriorly. The surface of the base is rough, having an almost nodular appearance. The basal cavity is large, extending over the whole unit.

Remarks: The present specimens are closest to *S. dunderbergiae* Müller, but we consider that specimens figured as *S. dahlmani* Müller are adult specimens and that the differences between *S. dunderbergiae* and *S. dahlmani* are essentially the result of preservation.

Occurrence: S. dahlmani Müller occurs in the Upper Cambrian of Sweden (Zone 5-*Peltura*) and erratic boulders in Germany (Müller, 1959). *S. dunderbergiae* occurs in North America in the Upper Cambrian Dunderberg Formation of Nevada (op. cit.) and in the Kushan and Yencho Formation (Upper Cambrian) of north and northeast China (Nogami, 1966, 1967).

Sagittodontus furnishi (Müller, 1959)

(Pl. 9, figs 1a-4c; Text-fig. 28c, d)

1959 *Furnishina furnishi* Müller, *Z. dtsch. geol. Ges.*, 111, 452, pl. 11, figs 5, 6, 8, 9, 11-15, 17, 18; pl. 12, figs 1, 6; text-fig. 6D, E.
1966 *Furnishina furnishi* Müller; Nogami, *Mem. Coll. Sci. Univ. Kyoto*, 32, 354, pl. 9, figs 5-7.

Material: 52 specimens; CPC8808, 8811, 8812, 8815 figured.

Range: Chatsworth Limestone.

Description: The unit consists of a base and a cusp. The base is flared and thin-walled. The major flaring is posterior, giving an ellipsoidal cross-section with a flattened anterior face producing two sharp anterior edges. The cusp is gently curved posteriorly and is triangular in cross-section. It possesses two lateral and one posterior costae. The posterior costa dies away toward the flaring base, but the two lateral costae continue on to the base to form the anterolateral edges. The cusp is excavated over most of its length and often contains a white infilling.

Remarks: One specimen (Pl. 9, fig. 2a, b) is tentatively referred to this species. It may be the oval half of a very large specimen.

Occurrence: S. furnishi is known from the Gallatin Limestone and Gros Ventre Formation of Wyoming, the Deadwood Formation of South Dakota, the Dugway Mountains of Utah, and the Eureka District of Nevada in North America (Müller, 1959). In Sweden and Germany it ranges from the Middle Cambrian *Ptychagnostus (Triplagnostus) gibbus* Zone throughout the Upper Cambrian (op. cit.). It is also known from the upper Cambrian Kushan and Yencho Beds of north and northeast China (Nogami, 1966, 1967).

Genus Scandodus Lindström, 1954

Type species: *Scandodus furnishi* Lindström, 1954

Scandodus furnishi Lindström, 1954
(Pl. 13, figs 6a-9c; Text-fig. 29)

1954 *Scandodus furnishi* Lindström, *Geol. Fören. Stockh. Förhandl.*, 76, 592, pl. 5, fig. 3.
1957 *Scandodus furnishi* Lindström; Lindström, *Ibid.*, 79, 164.
1962 *Scandodus furnishi* Lindström; Hass, *Treatise Inv. Paleont.*, part W, p. W44, fig. 22.7.
1964 *Scandodus furnishi* Lindström; Ethington & Clark, *J. Paleont.*, 38, 698, pl. 114, figs 11, 24.
1964 *Scandodus furnishi* Lindström; Lindström, *Conodonts,* 138, fig. 47d.
non-1967 *Scandodus* cf. *furnishi* Lindström; Moskalenko, *New data on the biostratigraphy of the Lower Palaeozoic of the Siberian Platform,* 113, pl. 25, figs 1-2; text-fig. 15.

Material: 32 specimens; CPC8862-5 figured.

Range: Cordylodus oklahomensis — C. lindstromi Assemblage Zone to the *Cordylodus rotundatus — C. angulatus* Assemblage Zone.

Description: A simple erect unit consisting of a base and cusp. The base is small, has an ovate cross-section, and contains a conical basal cavity with an apex near the anterior margin. The cavity lip is flared slightly more on the inner side than on the outer, giving the impression that the cavity opens toward the inner side. The cusp is erect to proclined, laterally compressed, with anterior and posterior knife-edges. The cusp is about five times as tall as the base.

Remarks: This form appears to be ancestral to the oistodids, particularly *O. inaequalis* Pander.

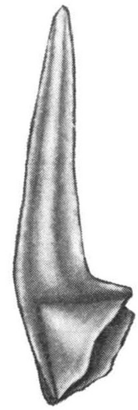


Fig. 29 *Scandodus furnishi* Lindström. CPC8862, lateral view x 32.

Occurrence: The species was first reported from the Arenigian of Sweden (Lindström, 1954, 1957, 1964). The only other reported occurrences are in North America, from the Lower Ordovician El Paso Formation of Texas and Arizona (Ethington & Clark, 1964), and from the Lower Ordovician Monocline Valley Formation (Member 3) of Nevada (Longwell & Mound, 1967).

Genus SCOLOPODUS Pander, 1856

Type species: *Scolopodus sublaevis* Pander, 1856

SCOLOPODUS ASYMMETRICUS sp. nov.
(Pl. 19, figs 3a-7c; Text-fig. 30a)

Derivation of name: From the asymmetric development of the lateral costae.

Type locality and horizon: Black Mountain, upper part of the Tremadocian Ninmaroo Formation.

Material: 9 specimens; holotype CPC8890, paratypes CPC8886-9.

Range: Chosonodina herfurthi — *Acodus* Assemblage Zone.

Diagnosis: A scolopodid with costae developed on both sides. A single costa is developed on the inner side and two on the outer side.

Description: The unit consists of a base and a cusp. The base is shallow with an elliptical cross-section. The cusp is massive, reclined, and generally elliptical

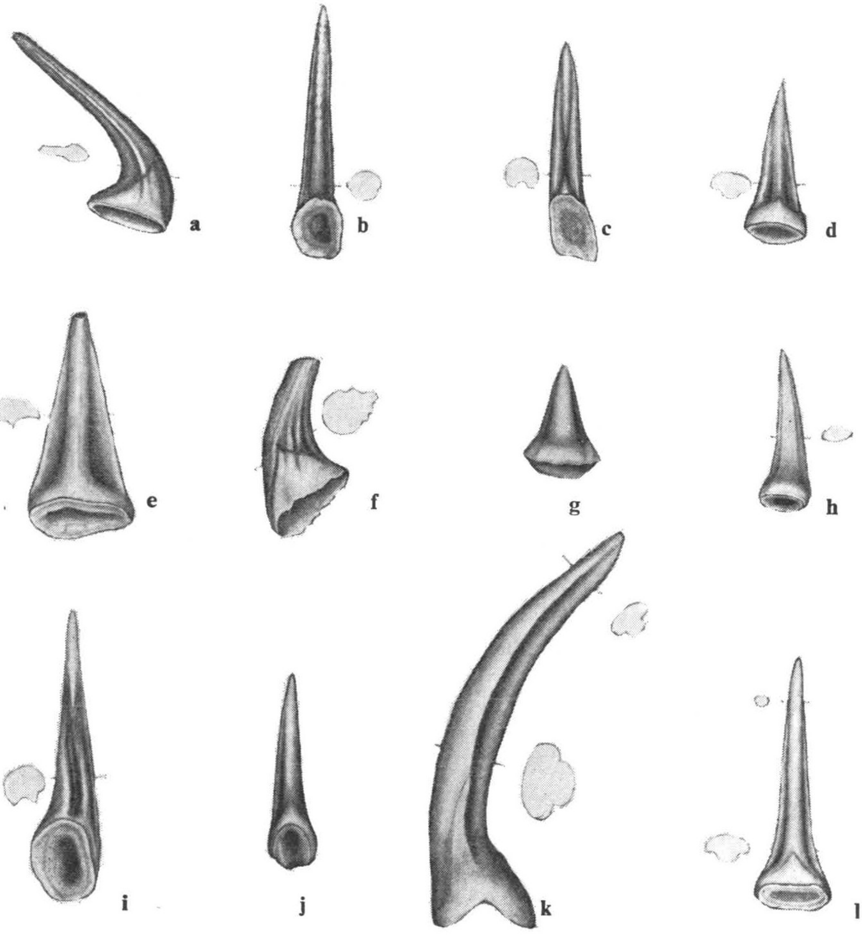


Fig. 30 (a) *Scolopodus asymmetricus* sp. nov. CPC8889, paratype, lateral view. (b) *S. bassleri* (Furnish) CPC8892, posterior view. (c) *S. gracilis* Ethington & Clark CPC8879, posterior view. (d, e) *S. iowensis* (Furnish), posterior views: (d) CPC8841. (e) CPC8856. (f) *S. quadraplicatus* Branson & Mehl. CPC8885, lateral view. (g, h) *S. transitans* sp. nov. posterior views: (g) CPC8830, paratype (h) CPC8831, paratype (i, j) *S. triplicatus* Ethington & Clark, posterior views: (i) CPC8878 (j) CPC8882 (k, l) *S. warendensis* sp. nov. (k) CPC8842, holotype, lateral view, (l) CPC8891, paratype, posterior view. All x 40.

in cross-section. Deep grooves are developed in the lateral faces and rounded costae separate them. A single costa is developed on the inner side and two on the outer side. Both the anterior and posterior faces are rounded. The basal cavity is conical with its apex developed near the anterior face at the point of flexure.

Remarks: This species is unlike any previously described scolopodid.

Occurrence: S. asymmetricus is confined to the *Chosonodina herfurthi—Acodus* Assemblage Zone in the Black Mountain and Mount Datson sections in western Queensland.

SCOLOPODUS BASSLERI (Furnish, 1938)

(Pl. 17, figs 1a-4d; Text-fig. 30b)

1938 *Paltodus bassleri* Furnish, *J. Paleont.*, 12, 331, pl. 42, fig. 1.

1938 *Paltodus variabilis* Furnish, *Ibid.*, 331, pl. 42, figs 9, 10, text-fig. 1E.

?1941 *Paltodus variabilis* Furnish; Graves & Ellison, *Univ. Missouri School Min. Metall., tech. Ser.*, 14(2), 5, pl. 2, fig. 17.

?1954 *Scandodus rectus* Lindström (partim), *Geol. Fören. Stockh. Förhandl.*, 76, 593, pl. 4, fig. 21 only (pl. 4, figs 22-25 = *S. rectus).*

1960 *Scolopodus* n. sp. 2, Lindström, *21st int. geol. Cong.*, 7(7), 93, fig. 5 (6.7).

1963 *Scolopodus cornuformis* Sergeeva, *Palaeont. Zh.*, 93, pl. 7, figs 1-3, text-fig. 1.

non 1963 *Paltodus variabilis* Sergeeva, *Ibid.*, 99, pl. 7, figs 10-12, text-fig. 5 (junior homonym of *P. variabilis* Furnish, 1938).

1964 *Scandodus rectus* Lindström; Müller, *N. Jb. Geol. Paläont. Abh.*, 119, 98, pl. 12, figs 1a, b; 6; 10a, b.

non 1965 *Paltodus variabilis* Furnish; Mound, *Tulane Stud. Geol.*, 4, 31, pl. 4, figs 13, 14.

Material: 720 specimens; CPC8892-5 figured.

Range: Cordylodus prion — Scolopodus Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Description: The unit is a simple elongate cone consisting of a shallow base and a needle-like cusp. The base is not expanded, and is completely excavated by a large conical basal cavity. The apex of the cavity is situated near the anterior margin at the point of flexure. The cusp is elongate and either erect or reclined. It possesses two lateral costae which are separated by broadly rounded anterior and posterior faces. The exact positioning of the costae varies; in some specimens they are arranged symmetrically, in others they are symmetrical in the aboral half and asymmetrical in the oral half owing to a twisting of the cusp. In still other cases they are asymmetrical over the whole cusp.

Remarks: S. bassleri appears to be the most simple scolopodid, probably developed from an oneotodid ancestor. The development of asymmetry in the positioning of the costae shows a trend towards *S. triplicatus* Ethington & Clark.

The two species erected by Furnish (1938, p. 331) are probably conspecific end members of this development.

Occurrence: Abundant in the Oneota Dolomite of Minnesota and Iowa, USA (Furnish, 1938). *Scolopodus bassleri* (Furnish) may be present in the Fort Peña Beds of Texas (Graves & Ellison, 1941, p. 5), the Columbia Ice Fields section, Alberta (Ethington & Clark, 1965, p. 198), and the Lower Ordovician Monocline Valley Formation (Member 3) of Nevada (Longwell & Mound, 1967, p. 409), because we consider that *Paltodus variabilis* Furnish is probably a junior synonym of this species. It has been reported as *Scolopodus* n. sp. 2 from the *Raniceps — Obtusicauda* limestone of Sweden (Lindström, 1960, p. 93), and as *S. cornuformis* Sergeeva, 1963, from the Volchov and Kunda Stages of the Leningrad region (Sergeeva, 1963, p. 93), and from the Kunda, Aseri, and Lasnamaigi Stages of Estonia (Viira, 1966, p. 151). It is also known from Lower Ordovician strata in South Korea, where it was described as *Scandodus rectus* Lindström (Müller, 1964). When all occurrences are considered, the simple species *Scolopodus bassleri* (Furnish) ranges from later Tremadocian to late Llanvirnian.

In western Queensland it is extremely abundant in the Black Mountain, Mount Ninmaroo, and Mount Datson sections and the Digby Peaks area.

SCOLOPODUS GRACILIS Ethington & Clark, 1964
(Pl. 17, figs 5a-7d; Pl. 18, figs 5a-d; Text-fig. 30c)

1964 *Scolopodus gracilis* Ethington & Clark, *J. Paleont.*, 38, 699, pl. 115, figs 2-4, 8, 9; text-figs 2D, G.

1965 *Scolopodus gracilis* Ethington & Clark; Ethington & Clark, *Brigham Young Univ. geol. Stud.*, 12, 200.

Material: 5 specimens; CPC8879-81, 8883 figured.

Range: Cordylodus prion — Scolopodus Assemblage Zone.

Description: A simple cone unit consisting of a base and cusp. The base is shallow and completely excavated; the basal cavity is large, with its oral apex near the anterior margin at the point of flexure. The cusp is erect and lacks ornament apart from a deep groove in the postero-aboral margin.

Remarks: The present specimens are very similar to those figured by Ethington & Clark (1964).

Occurrence: The species was originally described from the Ordovician El Paso Formation of Texas and Arizona (Ethington & Clark, 1964). It is also known from the Lower Ordovician Columbia Ice Fields sections of Alberta, Canada (Ethington & Clark, 1965) and the Lower Ordovician Monocline Valley Formation of Nevada (Longwell & Mound, 1967). In Queensland the species is known from the Black Mountain and Mount Ninmaroo sections.

SCOLOPODUS IOWENSIS (Furnish, 1938)
(Pl. 16, figs 1a-7e; Text-fig. 30d, e)

1938 *Acontiodus iowensis* Furnish, *J. Paleont.*, 12, 325, pl. 42, figs 16, 17.
non 1964 *Acontiodus iowensis* Furnish; Ethington & Clark, *J. Paleont.*, 38, 687, pl. 113, fig. 3 (= *Scolopodus warendensis* sp. nov.)
1964 *Acontiodus* cf. *A. propinquus* Furnish; Müller, *N. Jb. Geol. Paläont. Abh.*, 119, 96, pl. 12, fig. 8.

Material: 19 specimens; CPC8836-41; 8856 figured.

Range: Cordylodus rotundatus—C. angulatus Assemblage Zone to *Chosonodina herfurthi* — *Acodus* Assemblage Zone.

Description: The unit is erect to proclined, consisting of a base and cusp. The base is short, elliptical in cross-section, and without ornament. The basal cavity is extremely shallow. The cusp is proclined and is extremely laterally compressed, giving lateral knife edges which die away at the base. The anterior face is rounded and unornamented. The posterior face bears a broad rounded costa separated from the lateral edges by troughs. The cusp is elongately triangular in outline.

Remarks: S. iowensis developed from *S. transitans* sp. nov. by increased lateral compression and the development of a posterior rounded costa. In North America (Furnish, 1938), *S. propinquus* (Furnish), which possesses a deep sulcus with a costa in the aboral portion, appears to be ancestral to *S. iowensis*. *S. propinquus* and *S. transitans* may be geographical variants, or *S. propinquus* may be an intermediate form between *S. transitans* and *S. iowensis* which is not present in our collections. *S. iowensis* appears to be very similar to *Acontiodus latus* Pander.

Occurrence: S. iowensis was originally recorded from the Lower Ordovician Oneota Dolomite of Iowa and Minnesota (Furnish, 1938). The specimen identified as *Acontiodus iowensis* by Ethington & Clark from the Lower Ordovician El Paso Formation of Texas and Arizona (1964) should be more correctly referred to *S. warendensis* sp. nov. The species has been recorded, as *A.* cf. *propinquus* Furnish, from the Lower Ordovician of South Korea (Müller, 1964). In Queensland the species is known from the Black Mountain, Mount Ninmaroo, Mount Datson, and Swift Hills sections.

SCOLOPODUS QUADRAPLICATUS Branson & Mehl, 1933
(Pl. 18, figs 6a-7c; Text-fig. 30f)

1933 *Scolopodus quadraplicatus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 63, pl. 4, figs 14, 15.
1938 *Scolopodus quadraplicatus* Branson & Mehl: Furnish, *J. Paleont.*, 12, 332, pl. 41, figs 1-12.
1941 *Scolopodus quadraplicatus* Branson & Mehl; Graves & Ellison, *Miss. Sch. Min. Metall. Bull., tech. Ser.*, 14, pl. 1, fig. 10; pl. 3, figs 2, 5.

1958 *Scolopodus quadraplicatus* Branson & Mehl; Sando, *Bull. geol. Soc. Amer.*, 69, 842, pl. 2, fig. 21.

1964 *Scolopodus quadraplicatus* Branson & Mehl; Ethington & Clark, *J. Paleont.*, 38, 699, pl. 115, figs 12, 25.

1965 *Scolopodus quadraplicatus* Branson & Mehl; Ethington & Clark, *Brigham Young Univ. geol. Stud.*, 12, 201.

1965 *Scolopodus quadraplicatus* Branson & Mehl; Mound, *Tulane Stud. Geol.*. 4, 34, pl. 4, figs 26, 30.

1967 *Scolopodus quadraplicatus* Branson & Mehl; Moskalenko, *New data on the biostratigraphy of the Lower Palaeozoic of the Siberian Platform*, 114, pl. 25, figs 3-5; text-fig. 16.

Material: 4 specimens; CPC8884-5 figured.

Range: Cordylodus prion — Scolopodus Assemblage Zone.

Description: The unit is a simple cone possessing four costae on the lateral and posterior faces. Our specimens are very similar to previously described specimens.

Occurrence: S. quadraplicatus has not previously been described outside North America, where it occurs in the Lower Ordovician Jefferson City Formation of Missouri (Branson & Mehl, 1933); the Lower Ordovician Rockdale Run Formation of Pennsylvania (Sando, 1958); the Lower Ordovician Prairie du Chien Group of Wisconsin, Missouri, and Iowa (Furnish, 1938); the Ordovician Maravillas Formation of Texas (Graves & Ellison, 1941); the Lower Ordovician El Paso Formation of Texas and Arizona (Ethington & Clark, 1964); the Ordovician Joins Formation of Oklahoma (Mound, 1965); the Lower Ordovician Monocline Valley Formation of Nevada (Longwell & Mound, 1967); and the Lower Ordovician Columbia Ice Fields section of Alberta (Ethington & Clark, 1965). Very recently, it has been recorded from the Lower Ordovician Chun Stage of Siberia (Moskalenko, 1967). In Queensland it occurs in the Black Mountain and Mount Ninmaroo sections.

SCOLOPODUS STAUFFERI (Furnish, 1938)
(Pl. 18, figs 8a-9d)

1938 *Acontiodus staufferi* Furnish (partim), *J. Paleont.*, 12, 326, pl. 42, fig. 11, text-fig. 1K only (pl. 42, fig. 12 = *S. warendensis).*

1964 *Acontiodus staufferi* Furnish; Ethington & Clark, *J. Paleont.*, 38, 687, pl. 113, figs 4, 9.

1964 *Scolopodus robustus* Ethington & Clark, *Ibid.*, 700, pl. 113, fig. 7; pl. 115, figs 18, 21; text-fig. 2A.

non 1965 *Acontiodus staufferi* Furnish; Ethington & Clark, *Brigham Young Univ. geol. Stud.*, 12, pl. 2, fig. 14 (= *S. warendensis).*

?1965 *Acontiodus staufferi* Furnish; Mound, *Tulane Stud. Geol.*, 4, 12, pl. 1, fig. 22.

Material: 2 specimens; CPC8874-5 figured.

Range: Basal *Cordylodus rotundatus — C. angulatus* Assemblage Zone.

Description: A simple cone composed of a shallow excavated base and an erect cusp with a grooved posterior costa. The cusp also bears two lateral costae which extend on to the base, whereas the posterior costa terminates at the base-cusp junction. The basal cavity is a simple cone with an apex near the anterior margin.

Remarks: The relationship between *S. staufferi* and *S. warendensis* sp. nov. is discussed under the latter species.

Occurrences: The species has been recorded from the Shakopee Formation of Wisconsin (Furnish, 1938); the El Paso Formation of Texas and Arizona (Ethington & Clark, 1964); and the Joins Formation of Oklahoma (Mound, 1965). In Queensland it is restricted to a single horizon in the Black Mountain section.

SCOLOPODUS TRANSITANS sp. nov.

(Pl. 15, figs 10a-15c; Text-fig. 30g, h)

Derivation of name: The species is transitional between *Oneotodus* and *Scolopodus*.

Type locality and horizon: Black Mountain, upper part of the Tremadocian Ninmaroo Formation.

Material: 35 specimens; holotype CPC8835, paratypes CPC8830-4.

Range: Cordylodus prion — Scolopodus Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Diagnosis: A primitive scolopodid lacking costae.

Description: The unit is extremely simple, consisting of a base and cusp. The base is shallow, with an elliptical cross-section, and possesses a shallow basal cavity. The cusp is triangular, stout, and slightly laterally compressed, giving acute lateral angles. The cusp is proclined. Both anterior and posterior faces are gently rounded.

Remarks: This species is extremely simple and is not typical of the genus *Scolopodus*. It is transitional between *Oneotodus* and *Scolopodus*, forming a link between *O. erectus* sp. nov. and *S. iowensis*. Because it lacks a circular cross-section it cannot be placed in *Oneotodus*, and though it is not typical of *Scolopodus* the close relationship between it and *S. iowensis* suggests that it belongs in the genus.

In North America the precursor of *S. iowensis* is probably *S. propinquus* Furnish, which is characterized by a posterior sulcus. The relationships are discussed under *S. iowensis*.

Occurrence: S. transitans is present in the Black Mountain, Mount Ninmaroo, Mount Datson, and Swift Hills sections in Queensland. The closely related species *S. propinquus* Furnish is known from the Oneota Formation of Iowa and Minnesota (Furnish, 1938) and the Monocline Valley Formation of Nevada (Longwell & Mound, 1967). Forms compared to *S. propinquus* also occur in the latter formation.

SCOLOPODUS TRIPLICATUS Ethington & Clark, 1964

(Pl. 18, figs 1a-4d; Text-fig. 30i, j)

1964 *Scolopodus triplicatus* Ethington & Clark, *J. Paleont.*, 38, 700, pl. 115, figs 20, 22-24; text-fig. 2C.

Material: 9 specimens; CPC8876-8, 8882 figured.

Range: Upper *Cordylodus prion* — *Scolopodus* Assemblage Zone to lower *Cordylodus rotundatus* — *C. angulatus* Assemblage Zone.

Description: The unit consists of a small shallow excavated base and an erect cusp. The whole of the base is occupied by the basal cavity, the apex of which is situated near the anterior margin at the point of flexure. The cusp possesses three costae, one lateral and two posterior. These costae die away on the base and toward the oral termination. The cusp contains 'white matter.'

Remarks: Our specimens are very similar to those figured by Ethington & Clark (1964, p. 700).

Occurrence: The species was originally described from the Lower Ordovician El Paso Formation of Texas and Arizona (Ethington & Clark, 1964). In Queensland it has been recovered from the Black Mountain and Mount Ninmaroo sections.

SCOLOPODUS WARENDENSIS sp. nov.

(Pl. 16, figs 8a-11c; Pl. 19, figs 1a-2c; Text-fig. 30k, l)

1938 *Acontiodus staufferi* Furnish (partim), *J. Paleont.*, 12, 326, pl. 42, fig. 12 only. (Pl. 42, fig. 11, text-fig. 1K = *S. staufferi)*

1964 *Acontiodus iowensis* Furnish; Ethington & Clark, *J. Paleont.*, 38, 687, pl. 113, fig. 3.

non 1964 *Acontiodus staufferi* Furnish; Ethington & Clark, *Ibid.*, 687, pl. 113, figs 4, 9 (= *S. staufferi).*

1965 *Acontiodus staufferi* Furnish; Ethington & Clark, *Brigham Young Univ. geol. Stud.*, 12, pl. 2, fig. 14.

non 1965 *Acontiodus staufferi* Furnish; Mound, *Tulane Stud. Geol.*, 4, 12, pl. 1, fig. 22 (= *S. staufferi).*

Derivation of name: From Warenda Creek.

Type locality and horizon: Black Mountain, upper part of the Tremadocian Ninmaroo Formation.

Material: 32 specimens; holotype CPC8842, paratypes CPC8843-5, 8855, 8891.

Range: Cordylodus rotundatus—C. angulatus Assemblage Zone to *Chosonodina herfurthi — Acodus* Assemblage Zone.

Diagnosis: An elongate erect scolopodid with a posterior costa lacking a median groove.

Description: The unit is erect and consists of a base and a cusp. The base is small, with an elliptical cross-section and a shallow cone-like basal cavity. The cusp is elongate and sharply pointed. It bears lateral costae which are rounded and extend on to the base. The anterior face is rounded; the posterior face bears a narrow rounded costa separated from the lateral costae by deep troughs.

Remarks: In describing his new species *A. staufferi* Furnish includes specimens with a posterior median costa both lacking and possessing median grooves. We consider that these are two separate species because specimens possessing a median groove are extremely rare in our material. Furnish illustrates *A. staufferi* in cross-section showing a median groove, so we have restricted the definition of that species to include those forms alone. Forms lacking the median groove are placed in the new species *S. warendensis.*

The species developed from *S. iowensis* by elongation of the cusp, deepening of the troughs, and an increase in size of the posterior median costa.

Occurrence: S. warendensis occurs in the Shakopee Formation of Wisconsin (Furnish, 1938) and in the El Paso Formation of Arizona and Texas (Ethington & Clark, 1964). A specimen identified as *A. staufferi* was illustrated from the Columbia Ice Fields section of Alberta (Ethington & Clark, 1965). *A. staufferi* has been reported from Member 3 of the Monocline Valley Formation of Nevada (Longwell & Mound, 1967); it was not illustrated, and could be either *S. staufferi* or *S. warendensis.*

In Queensland the species is known from the Black Mountain and Mount Ninmaroo sections.

Genus STRIGACONUS nov.

Type species: *Strigaconus simplex* sp. nov.

Derivation of name: From the Latin *striga,* bristle, and *conus,* cone.

Type locality and horizon: Black Mountain, Tremadocian Ninmaroo Formation.

Diagnosis: A simple cone conodont with additional minute denticles scattered over the surface of the cone.

Description: The unit is a simple cone with a circular cross-section resembling the genus *Oneotodus*. The complete surface of the cone is covered with minute denticles resembling bristles.

Remarks: Strigaconus is closely allied to *Oneotodus* and probably developed from it by the addition of the minute surface denticles. The only other genus which is comparable is the Middle-Upper Ordovician *Strachanognathus* Rhodes, 1953, which possesses an additional denticle on the anterior side.

Occurrence: The genus has an extremely limited occurrence at the base of the *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone at Black Mountain, Mount Ninmaroo, and Mount Datson in the Boulia area, western Queensland.

STRIGACONUS SIMPLEX gen. nov., sp. nov.
(Pl. 6, figs 1a-5b; Text-fig. 31)

Derivation of name: From Latin *simplex,* simple.

Type locality and horizon: Black Mountain, Tremadocian Ninmaroo Formation, *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone.

Material: 9 specimens; holotype CPC8820, paratypes CPC8817-9, 8866.

Range: Uppermost *Oneotodus bicuspatus* — *Drepanodus simplex* Assemblage Zone to lowermost *Cordylodus oklahomensis* — *C. lindstromi* Assemblage Zone.

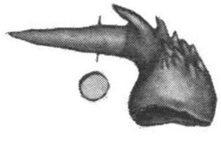


Fig. 31 *Strigaconus simplex* gen. et sp. nov. holotype CPC8820, lateral view. x 60.

Diagnosis: A simple cone unit with additional denticles developed on the anterior and lateral faces of the unit.

Description: A reclined unit consisting of a base and a cusp. The base is conical, and circular in cross-section, deeply excavated to form a conical basal cavity filled with basal bone. On the anterior and lateral faces of the base are developed additional denticles, which vary in their nature and density. In some specimens they are scattered and needle-like; in others they are closely developed and are rounded and blunt. All these additional denticles contain 'white matter.' The cusp is comparatively long, terminating in a point, and is completely filled with 'white matter.'

Remarks: S. simplex is closely related to the genus *Oneotodus,* from which it appears to have developed.

Occurrence: S. simplex has an extremely restricted occurrence at the base of the *Cordylodus oklahomensis — C. lindstromi* Assemblage Zone of the Ninmaroo Formation of western Queensland.

Genus WESTERGAARDODINA Müller, 1959

Type species: *W. bicuspidata* Müller, 1959

The genus *Westergaardodina* was erected by Müller (1959, p. 465) for U and W-shaped conodonts which are bilaterally symmetrical and possess a large basal cavity often divided into two lateral cavities. The genus had already been noted by Wiman (1893, 1903) and Westergaard (1953).

Müller (1959, 1962) regarded *Westergaardodina* as a true conodont, but Lindström (1964, p. 32; p. 175) did not, on the grounds that it is morphologically and chemically distinct from the conodonts. He states (p. 32) that it is usually black and is not attacked by hydrochloric acid, although Müller's X-ray analysis shows that the fossil is composed of apatite.

In the present fauna no specimens of the genus were black; most were a translucent amber to milky white. A few specimens were replaced by iron minerals, but this replacement was also seen in *Oneotodus nakamurai,* which possesses abundant 'white matter' which Lindström (op. cit., p. 17) considers to be a characteristic of true conodonts. Morphologically the genus appears to be related to true conodonts. *W. amplicava* appears to be the connecting link with *Chosonodina* and *Coleodus* (see later). *Westergaardodina* has also been described from China (Nogami, 1966), although no discussion of its affinities is included.

Müller (1959, p. 467) gives the range of the genus as Middle Cambrian to Lower Ordovician (Tremadocian). Lindström (1964, p. 32) states that it is common in the Lower Ordovician and occurs in the Middle Ordovician. In Australia the genus appears to be confined to the Cambrian: no specimens were recovered from the extensive sampling of Tremadocian and Arenigian sections in Queensland, New South Wales, and the Northern Territory.

Westergaardodina amplicava Müller, 1959

(Pl. 8, figs 1a-3b)

1959 *Westergaardodina amplicava* Müller, *Z. dtsch. geol. Ges.*, 111, 467, pl. 14, figs 13, 16.

Material: 3 specimens; CPC8771, 8774, 8775 figured.

Range: Chatsworth Limestone.

Description: A W-shaped westergaardodinid with three major projections. The lateral projections are usually twice as large as the medial projection, although in some specimens one lateral projection is large and the other small. Each projection is subtriangular in cross-section, with a flat outer face and a keeled inner face. The basal cavity extends over the whole aboral surface and to the tip of each projection. It is sometimes filled with 'basal bone.'

Remarks: The species appears to be ancestral to the genus *Chosonodina,* which occurs in the Tremadocian. It appears to be a true conodont, being amber coloured and translucent and possessing 'basal bone.'

Occurrence: The species is confined to the uppermost Upper Cambrian of northern Europe (Zones 5d to 6a) (Müller, 1959). It is also known from the uppermost Upper Cambrian Yencho Formation of northeast China (Nogami, 1967).

Westergaardodina bicuspidata Müller, 1959

(Pl. 7, figs 1a-4d; Text-fig. 32)

1959 *Westergaardodina bicuspidata* Müller, *Z. dtsch. geol. Ges.*, 111, 468, pl. 15, figs 1, 4, 7, 9, 10, 14.

1966 *Westergaardodina bicuspidata* Müller: Hamar, *Norsk geol. Tidsskr.*, 46, 80, pl. 6, fig. 1; text-fig. 2, no. 3.

Material: 18 specimens; CPC8768-8770, 8772 figured.

Range: Chatsworth Limestone.

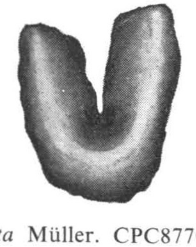


Fig. 32 *Westergaardodina bicuspidata* Müller. CPC8770, front view x 32.

Description: A U-shaped westergaardodinid with massive cusps. Each cusp is thick, with a flat outer and a convex inner face. Both cusps are of equal length. The specimens are translucent and a whitish amber in colour. The basal cavity is situated on the outer margin of each cusp in an oral position.

Remarks: No phosphatic balls were found in the residues containing these forms; thus it would appear that the phosphatic balls found by Müller together with this species are not closely associated with it.

Occurrence: The species occurs throughout the Upper Cambrian of northern Europe and in the Deadwood Formation, South Dakota, and Conant Creek area, Wyoming, in the USA (Müller, 1959, tables 1 and 3). It has been reported from the Upper Cambrian Kushan and Yencho Formations of China (Nogami, 1966, 1967). The species illustrated by Hamar (1966) from the Middle Ordovician Ampyx Limestone (4aβ) is possibly reworked.

WESTERGAARDODINA MOSSEBERGENSIS Müller, 1959
(Pl. 8, figs 4a-c)

1959 *Westergaardodina mossebergensis* Müller, *Z. dtsch. geol. Ges.*, 111, 470, pl. 14, figs 11, 12, 15.

1966 *Westergaardodina mossebergensis* Müller; Nogami, *Mem. Coll. Sci. Univ. Kyoto*, Ser. B, 32, 360, pl. 10, figs 1, 2.

Material: 1 specimen, CPC8773.

Range: Chatsworth Limestone.

Description: The unit is U-shaped, with wide, thin, laterally compressed arms. The aboral part of the unit is thickened and possesses a medial trough which does not extend on to the lateral arms. The unit is translucent and white in colour.

Remarks: The species can be distinguished from *W. bicuspidata* by the basal cavity. In *W. bicuspidata* it is developed on the outer apical portions of the lateral arms, whereas in *W. mossebergensis* the cavity is essentially aboral.

Occurrence: The species ranges from Zone 1 to Zone 5d of the Upper Cambrian of Northern Europe (Müller, 1959). It has also been recorded from the Upper Cambrian Kushan Formation of north and northeast China (Nogami, 1966).

gen. et. sp. indet. A
(Pl. 8, fig. 5)

Material: 1 specimen; CPC8816 figured.

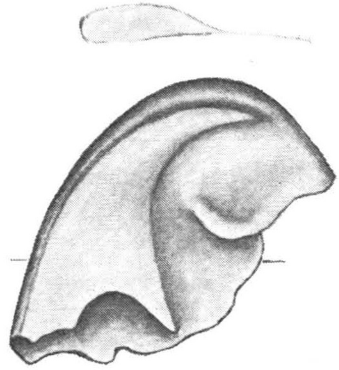


Fig. 33 Gen. et sp. indet. B. CPC8925, lateral view x 80.

Description: A simple hollow erect cone. The unit is completely filled with 'basal bone.' It is easily distinguishable by the nodular surface ornament. The nodes are subspherical and are scattered irregularly over the surface.

gen. et. sp. indet. B

(Pl. 12, figs 9a, b; Text-fig. 33)

Material: 2 specimens; CPC8925 figured.

Two specimens appear to be a pathological development of *Coelocerodontus burkei* sp. nov. The posterior portion of the cusp is developed into a broad 'sail.' Within the 'sail' there are horizontal bands of 'white matter.'

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ADDENDUM

Since this Bulletin was submitted for publication, the results of several studies of conodonts from Cambro-Ordovician and Lower Ordovician sediments have been published.

The most recent (Miller, 1969; Clark & Miller, 1969), describe the conodont fauna of the Notch Peak Limestone (Cambro-Ordovician) from the House Range, western Utah; this study is especially important because in many aspects (i.e., taxonomy, stratigraphy and phylogeny) it may be compared with our own. Miller described typical Cambrian conodonts from Member 5 and the lower part of Member 6 of the Notch Peak Limestone, which are associated with the trilobite genus *Euptychaspis* (=*Saukia* Zone of Trempealeauan age). Four of the nine conodont species from these beds are present in the Chatsworth Limestone of the Burke River structural belt: *Oneotodus gallatini* Müller, *O. tenuis* Müller, *Proconodontus mulleri* Miller (= our *Coelocerodontus burkei)* and *P. notchpeakensis* Miller (= our *Oneotodus nakamurai* Nogami, in part). The *Symphysurina* Zone of basal Canadian age is marked by the presence of this genus 100 feet above the *Euptychaspis* fauna, still in Member 6. In the interval between the highest occurrence of *Euptychaspis* and the lowest occurrence of *Symphysurina* the typical Ordovician conodont genera *Cordylodus* Pander, *Acodus* Pander and *Acontiodus* Pander first appear and persist into the *Symphysurina* Zone. At least six of some 20 conodont species described from this part of Member 6 of the Notch Peak Limestone are also present in our three lowermost assemblage zones in the Ninmaroo Formation: *Cordylodus proavus* Müller, *C. oklahomensis* Müller, *C. lindstromi* sp. nov. (= *C. oklahomensis* of Miller, in part), *Hirsutodontus hirsutus* Miller (= our *Strigaconus simplex), Fryxellodontus inornatus* Miller (= our gen. et sp. indet. B), and *Oneotodus nakamurai* Nogami. It is noteworthy that in Utah, the uppermost part of the range of *Coelocerodontus mulleri* (Miller) overlaps the basal part of the range of *Cordylodus proavus* Müller; also *C. proavus* and *C. oklahomensis* have much the same range which persists into the *Symphysurina* Zone of the House Limestone. The studies of Clark & Miller (1969) independently confirm our views on early conodont phylogeny — particularly the idea that *Oneotodus nakamurai* Nogami developed from a coelocerodontid ancestor.

Thus, it appears that the conodont-bearing interval between the highest occurrence of *Euptychaspis* and the lower occurrence of *Symphysurina* in Member 6 of the Notch Peak Limestone is approximately equivalent to our basal three assemblage zones. This interval may be entirely Trempealeauan, or entirely Canadian, or parts of both. The possibility of a Trempealeauan age is favoured, if one considers the results of the work of Robison & Pantoja-Alor (1968) in Mexico.

These authors describe the trilobites originally listed in a brief note by Pantoja-Alor and Robison (1967) on the discovery of Palaeozoic rocks in the Nochixtlan region, Oaxaca, Mexico. The trilobites were collected from the lower part of the Palaeozoic sequence, now named the Tiñu Formation by Pantoja-Alor (1968), and include genera in common with faunas of Tremadocian age, previously described from Argentina, Great Britain, eastern Canada and Scandinavia. This association is relevant to the correlation of North American faunas with those of the Tremadocian of Europe.

Robison & Pantoja-Alor (1968) recognized two groups of species within the Tiñu Formation, a lower group (the *Parabolina* assemblage) and an upper group (the *Peltocare* assemblage). The *Parabolina* trilobite assemblage is very similar to early Tremadocian faunas of Europe and South America, and includes the genera *Parabolina, Parabolinella,* and *Angelina.* These are also a few genera in common with North American faunas, e.g., *Saukia* and *Richardsonella,* which suggests a correlation with the *Saukia* Zone (Trempealeauan).

Conodonts (identified by D. L. Clark) associated with the *Parabolina* assemblage include *Cordylodus proavus* Müller, *C. oklahomensis* Müller, and *C. angulatus* Pander. Both *Cordylodus proavus* and *C. oklahomensis* occur with *Saukia globosa* Robison & Pantoja-Alor, suggesting that our basal three assemblage zones may be partly equivalent of the Trempealeauan, and are of lower Tremadocian age.

Two other papers have been published which describe younger conodonts of definite Lower Ordovician (Canadian) age.

The first (Mound, 1968) describes the conodonts from the lower Arbuckle Group, Arbuckle Mountains, Oklahoma. Mound referred the conodonts of the McKenzie Hill Formation to his *Chosonodina herfurthi — Loxodus bransoni* Assemblage Zone, which contains six species which characterize the *Chosonodina herfurthi — Acodus* Assemblage Zone of Australia: *Chosonodina herfurthi* Müller, *Cordylodus rotundatus* Pander, *Drepanodus parallelus* Branson & Mehl (= *D. subarcuatus* Furnish), *Oneotodus variabilis* Lindström, *Scolopodus bassleri* (Furnish) (= *Paltodus variabilis* Furnish), and *Scolopodus iowensis* (Furnish). Thus, a correlation between these two late Tremadocian assemblage zones can be suggested. Mound also describes a younger conodont fauna (his *Scolopodus quadraplicatus quadruplicatus* Assemblage Zone) in the Cool Creek Formation, which overlies the McKenzie Hill Formation; this is younger than our fauna.

The second paper (Igo & Koike, 1966) describes conodonts from Ordovician and Silurian limestones from the Langkawi Islands, Malaya. In general, these appear to be younger than our fauna; however, four species — *Acodus oneotensis* Furnish, *Oistodus lanceolatus* Pander, *Scolopodus bassleri* (Furnish), and *S. staufferi* (Furnish) are present in the lowest part of the Setul Limestone. This suggests that our *Chosonodina herfurthi — Acodus* Assemblage Zone may be present in Malaya.

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REGISTER OF FIGURED SPECIMENS

Name of conodont species	Slide Numbers of Figured Specimens	Sample Number Locality	Formation
Acanthodus costatus sp. nov.	CPC8850 Holotype	B694–Black Mt.	Ninmaroo (Member 5)
	CPC8851 Paratype	B694–Black Mt.	Ninmaroo (Member 5)
	CPC8852 Paratype	B694–Black Mt.	Ninmaroo (Member 5)
	CPC8853 Paratype	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8854 Paratype	B456/7–Mt Datson	Ninmaroo (Member 4)
Acanthodus uncinatus Furnish	CPC8846	2/60–Mt Ninmaroo	Ninmaroo (Member 3)
	CPC8847	1/126–Black Mt.	Ninmaroo (Member 3)
	CPC8848	1/126–Black Mt.	Ninmaroo (Member 3)
	CPC8849	1/126–Black Mt.	Ninmaroo (Member 3)
Acodus oneotensis Furnish	CPC8857	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8858	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8859	B694–Black Mt.	Ninmaroo (Member 5)
	CPC8860	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8861	B914–Black Ridge	Ninmaroo (Member 6)
Chosonodina fisheri sp. nov.	CPC8761 Paratype	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8762 Holotype	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
Chosonodina herfurthi Müller	CPC8758	1/178–Black Mt.	Ninmaroo (Member 5)
	CPC8759	1/179–Black Mt.	Ninmaroo (Member 6)
	CPC8760	1/180–Black Mt.	Ninmaroo (Member 6)
	CPC8763	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8764	B694–Black Mt.	Ninmaroo (Member 5)
	CPC8765	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8766	B694–Black Mt.	Ninmaroo (Member 5)
Coelocerodontus burkei sp. nov.	CPC8776 Paratype	1/19–Black Mt.	Chatsworth Lst.
	CPC8777 Paratype	1/20–Black Mt.	Chatsworth Lst.
	CPC8778 Paratype	1/22–Black Mt.	Chatsworth Lst.
	CPC8779 Paratype	1/22–Black Mt.	Chatsworth Lst.
	CPC8780 Paratype	1/33–Black Mt.	Chatsworth Lst.
	CPC8781 Paratype	1/33–Black Mt.	Chatsworth Lst.
	CPC8782 Holotype	1/35–Black Mt.	Chatsworth Lst.
	CPC8790 Paratype	3/17–Mt Datson	Chatsworth Lst.
Coelocerodontus sp. cf. *C. burkei*	CPC8791	B552=1/26–Black Mt.	Chatsworth Lst.

Name of conodont species	Slide Numbers of Figured Specimens	Sample Number Locality	Formation
Coelocerodontus primitivus (Müller)	CPC8797	1/26–Black Mt.	Chatsworth Lst.
	CPC8798	1/4–Black Mt.	Chatsworth Lst.
	CPC8814	3/5–Mt Datson	Chatsworth Lst.
Coelocerodontus rotundatus sp. nov.	CPC8783 Holotype	1/22–Black Mt.	Chatsworth Lst.
	CPC8784 Paratype	1/22–Black Mt.	Chatsworth Lst.
	CPC8785 Paratype	1/22–Black Mt.	Chatsworth Lst.
	CPC8792 Paratype	B552=1/26–Black Mt.	Chatsworth Lst.
Coelocerodontus tricarinatus (Nogami)	CPC8786	1/26–Black Mt.	Chatsworth Lst.
	CPC8787	1/33–Black Mt.	Chatsworth Lst.
	CPC8788	1/33–Black Mt.	Chatsworth Lst.
	CPC8789	1/34–Black Mt.	Chatsworth Lst.
Cordylodus angulatus Pander	CPC8736	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8737	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8739	B689–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8740	B683–Black Mt.	Ninmaroo (Member 5)
	CPC8757 (unfigured)	B694–Black Mt.	Ninmaroo (Member 5)
Cordylodus sp. cf. *C. angulatus*	CPC8746	1/159–Black Mt.	Ninmaroo (Member 5)
	CPC8741 (unfigured)	1/159–Black Mt.	Ninmaroo (Member 5)
Cordylodus caseyi sp. nov.	CPC8748 Paratype	1/159–Black Mt.	Ninmaroo (Member 5)
	CPC8749 Paratype	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8750 Holotype	1/179–Black Mt.	Ninmaroo (Member 6)
	CPC8751 Paratype	B456/7–Mt Datson	Ninmaroo (Member 4)
Cordylodus intermedius Furnish	CPC8742	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8743	1/22–Black Mt.	Ninmaroo (Member 3)
	CPC8744 (unfigured)	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8745	1/154–Black Mt.	Ninmaroo (Member 5)
Cordylodus lindstromi sp. nov.	CPC8753 Paratype	3/89–Mt Datson	Ninmaroo (Member 4)
	CPC8754 Paratype	1/146–Black Mt.	Ninmaroo (Member 5)
	CPC8747 Paratype	2/86–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8767 Holotype	1/152–Black Mt.	Ninmaroo (Member 5)
Cordylodus oklahomensis Müller	CPC8727	1/121–Black Mt.	Ninmaroo (Member 3)
	CPC8726	2/64–Mt Ninmaroo	Ninmaroo (Member 3)

Cordylodus prion Lindström	CPC8729	1/142–Black Mt.	Ninmaroo (Member 4)
	CPC8730	1/153–Black Mt.	Ninmaroo (Member 5)
	CPC8731	1/153–Black Mt.	Ninmaroo (Member 5)
	CPC8732	2/86–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8733	1/142–Black Mt.	Ninmaroo (Member 4)
	CPC8734	3/82–Mt Datson	Ninmaroo (Member 3)
	CPC8735	2/75–Mt Ninmaroo	Ninmaroo (Member 4)
Cordylodus proavus Müller	CPC8718	2/64–Mt Ninmaroo	Ninmaroo (Member 3)
	CPC8719	1/100–Black Mt.	Ninmaroo (Member 2)
	CPC8720	1/94–Black Mt.	Ninmaroo (Member 2)
	CPC8721	1/99–Black Mt.	Ninmaroo (Member 2)
	CPC8722	1/122–Black Mt.	Ninmaroo (Member 3)
	CPC8723	3/75–Mt Datson	Ninmaroo (Member 3)
Cordylodus sp. cf. *C. proavus*	CPC8724	1/98–Black Mt.	Ninmaroo (Member 2)
	CPC8728	B870–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8725	1/100–Black Mt.	Ninmaroo (Member 2)
Cordylodus rotundatus Pander	CPC8752	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8755	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8756	2/94–Mt Ninmaroo	Ninmaroo (Member 5)
Cordylodus sp. A	CPC8738	B689–Black Mt.	Ninmaroo (Member 5)
Drepanodus acutus Pander	CPC8900	1/149–Black Mt.	Ninmaroo (Member 5)
	CPC8907	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8908	B456/7–Mt Datson	Ninmaroo (Member 4)
Drepanodus simplex Branson & Mehl	CPC8896	3/59–Mt Datson	Ninmaroo (Member 2)
	CPC8897	2/55–Mt Ninmaroo	Ninmaroo (Member 3)
	CPC8898	2/55–Mt Ninmaroo	Ninmaroo (Member 3)
	CPC8899	1/119–Black Mt.	Ninmaroo (Member 3)
Drepanodus subarcuatus Furnish	CPC8903	1/177–Black Mt.	Ninmaroo (Member 5)
	CPC8804	1/177–Black Mt.	Ninmaroo (Member 5)
	CPC8905	1/177–Black Mt.	Ninmaroo (Member 5)
	CPC8906	B456/7–Mt Datson	Ninmaroo (Member 4)
Drepanodus suberectus (Branson & Mehl)	CPC8901	1/167–Black Mt.	Ninmaroo (Member 5)
	CPC8902	1/179–Black Mt.	Ninmaroo (Member 6)
Drepanodus tenuis Moskalenko	CPC8909	1/162–Black Mt.	Ninmaroo (Member 5)

Name of conodont species	Slide Numbers of Figured Specimens	Sample Number Locality	Formation
Oistodus inaequalis Pander	CPC8868	2/92–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8871	1/159–Black Mt.	Ninmaroo (Member 5)
	CPC8872	B679–Black Mt.	Ninmaroo (Member 5)
	CPC8873	B454–Mt Datson	Ninmaroo (Member 4)
Oistodus lanceolatus Pander	CPC8867	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8869	2/87–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8870	1/159–Black Mt.	Ninmaroo (Member 5)
Oneotodus bicuspatus sp. nov.	CPC8910 Paratype	1/119–Black Mt.	Ninmaroo (Member 3)
	CPC8911 Paratype	1/119–Black Mt.	Ninmaroo (Member 3)
	CPC8912 Holotype	1/114–Black Mt.	Ninmaroo (Member 3)
	CPC8913 Paratype	B663–Black Mt.	Ninmaroo (Member 3)
Oneotodus datsonensis sp. nov.	CPC8914 Paratype	2/62–Mt Ninmaroo	Ninmaroo (Member 3)
	CPC8915 Paratype	2/54–Mt Ninmaroo	Ninmaroo (Member 3)
	CPC8916 Holotype	1/126–Black Mt.	Ninmaroo (Member 3)
	CPC8917 Paratype	1/119–Black Mt.	Ninmaroo (Member 3)
Oneotodus erectus sp. nov.	CPC8821 Paratype	1/118–Black Mt.	Ninmaroo (Member 3)
	CPC8822 Paratype	1/143–Black Mt.	Ninmaroo (Member 4)
	CPC8823 Holotype	1/146–Black Mt.	Ninmaroo (Member 5)
	CPC8824 Paratype	2/60–Mt Ninmaroo	Ninmaroo (Member 3)
	CPC8825 Paratype	2/77–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8826 Paratype	3/85–Mt Datson	Ninmaroo (Member 3)
	CPC8827 Paratype	3/82–Mt Datson	Ninmaroo (Member 3)
	CPC8828 Paratype	3/53–Mt Datson	Ninmaroo (Member 2)
Oneotodus sp. cf. *O. erectus*	CPC8829	1/144–Black Mt.	Ninmaroo (Member 5)
Oneotodus gallatini Müller	CPC8926	1/39–Black Mt.	Chatsworth Lst.
	CPC8799	1/29–Black Mt.	Chatsworth Lst.
	CPC8805	1/30–Black Mt.	Chatsworth Lst.
Oneotodus gracilis (Furnish)	CPC8919	B440–Mt Datson	Ninmaroo (Member 2)
	CPC8920	3/89–Mt Datson	Ninmaroo (Member 4)
	CPC8921	3/89–Mt Datson	Ninmaroo (Member 4)
	CPC8922	1/122–Black Mt.	Ninmaroo (Member 3)
	CPC8923	3/81–Mt Datson	Ninmaroo (Member 3)
	CPC8924	3/81–Mt Datson	Ninmaroo (Member 3)

Oneotodus nakamurai Nogami	CPC8793	1/22–Black Mt.	Chatsworth Lst.
	CPC8794	1/22–Black Mt.	Chatsworth Lst.
	CPC8795	1/22–Black Mt.	Chatsworth Lst.
	CPC8796	1/22–Black Mt.	Chatsworth Lst.
	CPC8806	B552–Black Mt.	Chatsworth Lst.
	CPC8807	B552–Black Mt.	Chatsworth Lst.
	CPC8810	B556–Black Mt.	Chatsworth Lst.
Oneotodus terashimai Nogami	CPC8809	1/31–Black Mt.	Chatsworth Lst.
	CPC8813	1/31–Black Mt.	Chatsworth Lst.
Oneotodus variabilis Lindström	CPC8918	1/173–Black Mt.	Ninmaroo (Member 5)
Problematoconites perforata Müller	CPC8804	1/33–Black Mt.	Chatsworth Lst.
Sagittodontus dahlmani Müller	CPC8800	1/30–Black Mt.	Chatsworth Lst.
	CPC8801	1/32–Black Mt.	Chatsworth Lst.
	CPC8802	1/32–Black Mt.	Chatsworth Lst.
	CPC8803	1/39–Black Mt.	Chatsworth Lst.
Sagittodontus furnishi (Müller)	CPC8808	B552–Black Mt.	Chatsworth Lst.
	CPC8811	1/16–Black Mt.	Chatsworth Lst.
	CPC8812	1/30–Black Mt.	Chatsworth Lst.
	CPC8815	2/6–Mt Ninmaroo	Chatsworth Lst.
Scandodus furnishi Lindström	CPC8862	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8863	1/160–Black Mt.	Ninmaroo (Member 5)
	CPC8864	1/145–Black Mt.	Ninmaroo (Member 5)
	CPC8865	1/144–Black Mt.	Ninmaroo (Member 5)
Scolopodus asymmetricus sp. nov.	CPC8886 Paratype	1/181–Black Mt.	Ninmaroo (Member 6)
	CPC8887 Paratype	1/180–Black Mt.	Ninmaroo (Member 6)
	CPC8888 Paratype	B694–Black Mt.	Ninmaroo (Member 5)
	CPC8889 Paratype	B694–Black Mt.	Ninmaroo (Member 5)
	CPC8890 Holotype	B456/7–Mt Datson	Ninmaroo (Member 4)
Scolopodus bassleri (Furnish)	CPC8892	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8893	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8894	1/149–Black Mt.	Ninmaroo (Member 5)
	CPC8895	1/149–Black Mt.	Ninmaroo (Member 5)
Scolopodus gracilis (Ethington & Clark)	CPC8879	2/84–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8880	1/153–Black Mt.	Ninmaroo (Member 5)
	CPC8881	1/152–Black Mt.	Ninmaroo (Member 5)
	CPC8883	1/149–Black Mt.	Ninmaroo (Member 5)

Name of conodont species	Slide Numbers of Figured Specimens	Sample Number Locality	Formation
Scolopodus iowensis (Furnish)	CPC8836	1/159–Black Mt.	Ninmaroo (Member 5)
	CPC8837	1/166–Black Mt.	Ninmaroo (Member 5)
	CPC8838	1/179–Black Mt.	Ninmaroo (Member 6)
	CPC8839	2/86–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8840	2/86–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8841	2/86–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8856	B694–Black Mt.	Ninmaroo (Member 5)
Scolopodus quadraplicatus Branson & Mehl	CPC8884	1/152–Black Mt.	Ninmaroo (Member 5)
	CPC8885	1/149–Black Mt.	Ninmaroo (Member 5)
Scolopodus staufferi (Furnish)	CPC8874	1/159–Black Mt.	Ninmaroo (Member 5)
	CPC8875	1/159–Black Mt.	Ninmaroo (Member 5)
Scolopodus transitans sp. nov.	CPC8830 Paratype	1/159–Black Mt.	Ninmaroo (Member 5)
	CPC8832 Paratype	2/82–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8833 Paratype	2/87–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8834 Paratype	1/147–Black Mt.	Ninmaroo (Member 5)
	CPC8835 Holotype	1/147–Black Mt.	Ninmaroo (Member 5)
Scolopodus triplicatus Ethington & Clark	CPC8876	1/153–Black Mt.	Ninmaroo (Member 5)
	CPC8877	1/159–Black Mt.	Ninmaroo (Member 5)
	CPC8878	2/85–Mt Ninmaroo	Ninmaroo (Member 4)
	CPC8882	1/152–Black Mt.	Ninmaroo (Member 5)
Scolopodus warendensis sp. nov.	CPC8842 Holotype	B456/7=3/95–Mt Datson	Ninmaroo (Member 4)
	CPC8843 Paratype	2/102–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8844 Paratype		
	CPC8845 Paratype	2/100–Mt Ninmaroo	Ninmaroo (Member 5)
	CPC8855 Paratype	B456/7–Mt Datson	Ninmaroo (Member 4)
	CPC8891 Paratype	2/89–Mt Ninmaroo	Ninmaroo (Member 5)
Strigaconus simplex sp. nov.	CPC8817 Paratype	3/59–Mt Datson	Ninmaroo (Member 2)
	CPC8818 Paratype	2/57–Mt Ninmaroo	Ninmaroo (Member 3)
	CPC8819 Paratype	1/122–Black Mt.	Ninmaroo (Member 3)
	CPC8820 Holotype	1/122–Black Mt.	Ninmaroo (Member 3)
	CPC8866 Paratype	B440–Mt Datson	Ninmaroo (Member 2)

Westergaardodina amplicava Müller	CPC8771	1/22B–1 Black Mt.	Chatsworth Lst.
	CPC8774	B556=1/30–Black Mt.	Chatsworth Lst.
	CPC8775	B552=1/26–Black Mt.	Chatsworth Lst.
Westergaardodina bicuspidata Müller	CPC8768	1/12–Black Mt.	Chatsworth Lst.
	CPC8769	1/16–Black Mt.	Chatsworth Lst.
	CPC8770	1/16–Black Mt.	Chatsworth Lst.
	CPC8772	1/12–Black Mt.	Chatsworth Lst.
Westergaardodina mossebergensis Müller	CPC8773	1/29–Black Mt.	Chatsworth Lst.
gen. et. sp. indet. A	CPC8816	1/12–Black Mt.	Chatsworth Lst.
gen. et. sp. indet. B	CPC8925	3/37–Mt Datson	Ninmaroo (Member 2)

PLATES

All magnifications x 80

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Cordylodus proavus Müller, 1959 70

Fig. 1. Lateral view of specimen CPC8718 (a) uncoated, (b) coated.
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Cordylodus lindstromi sp. nov. 68

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Cordylodus cf. *C. proavus* Müller, 1959 71

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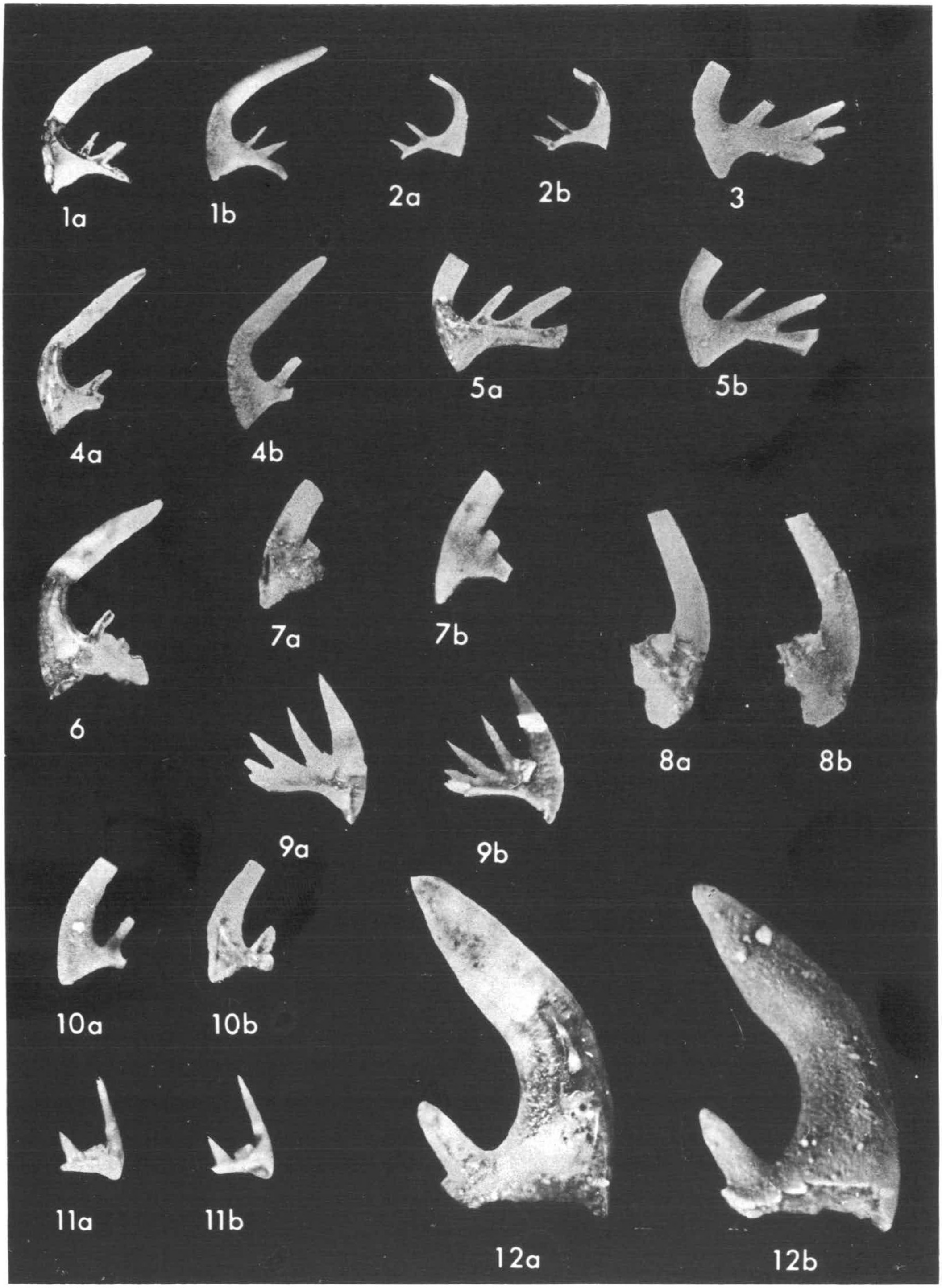
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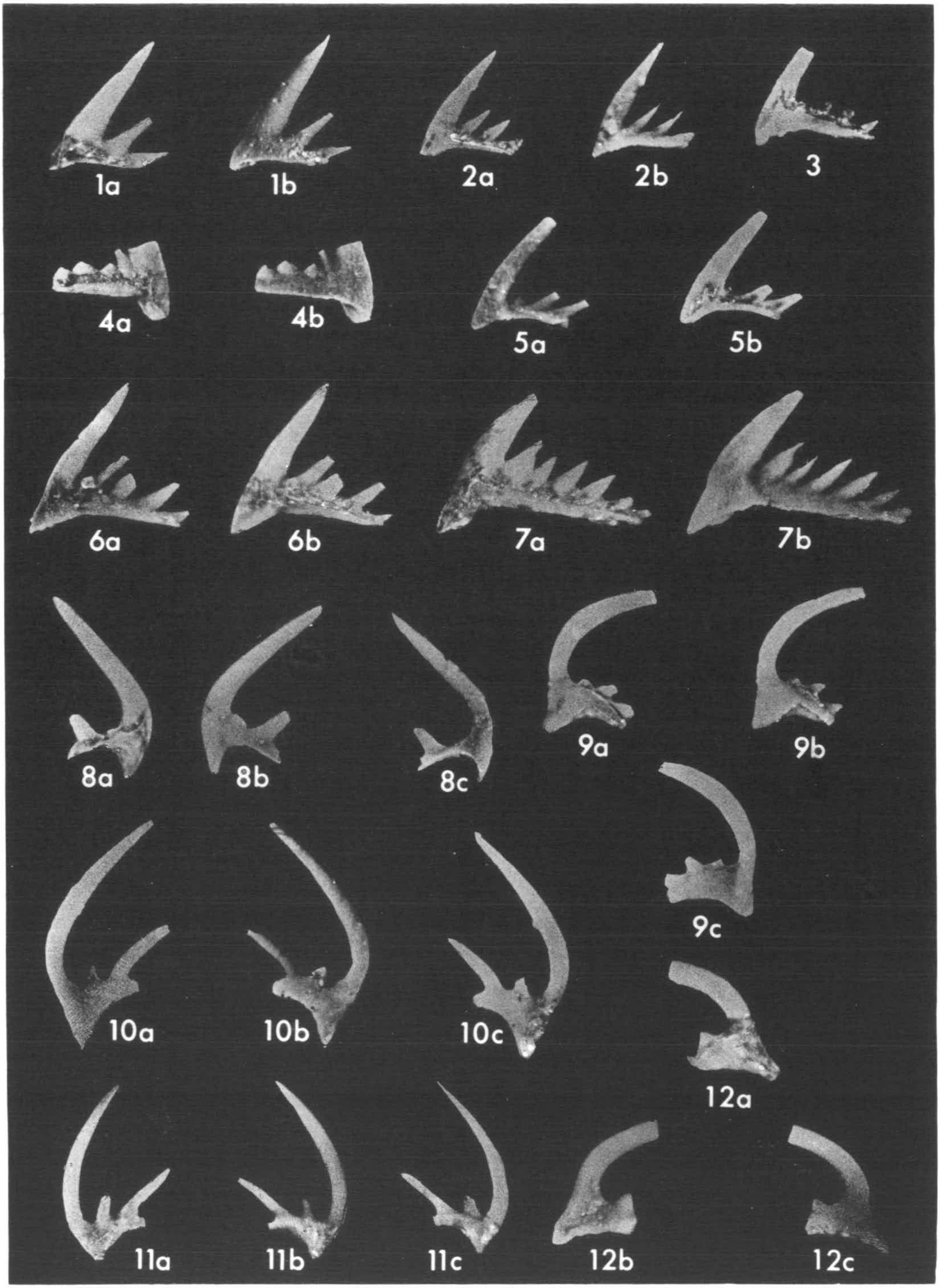
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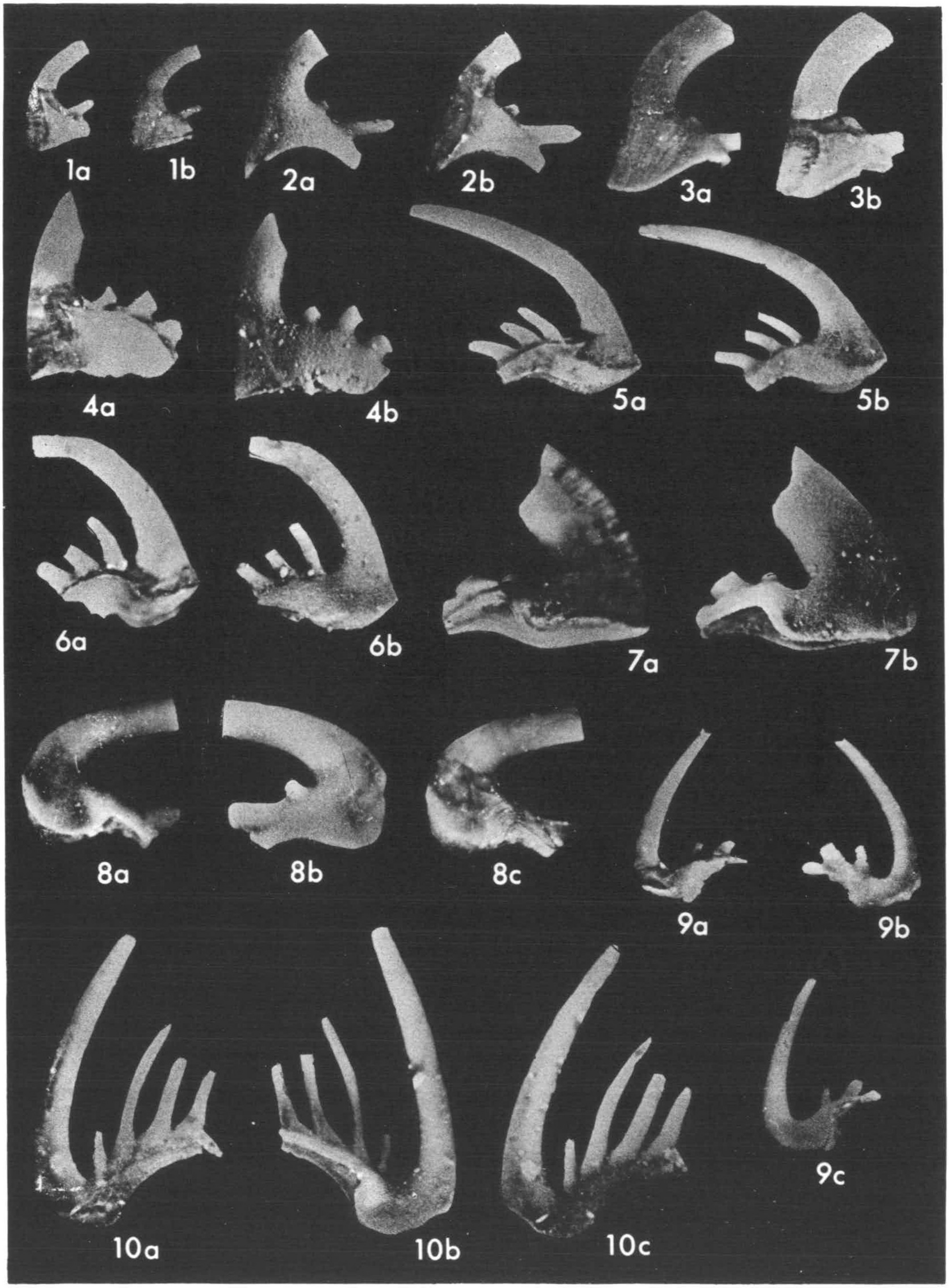
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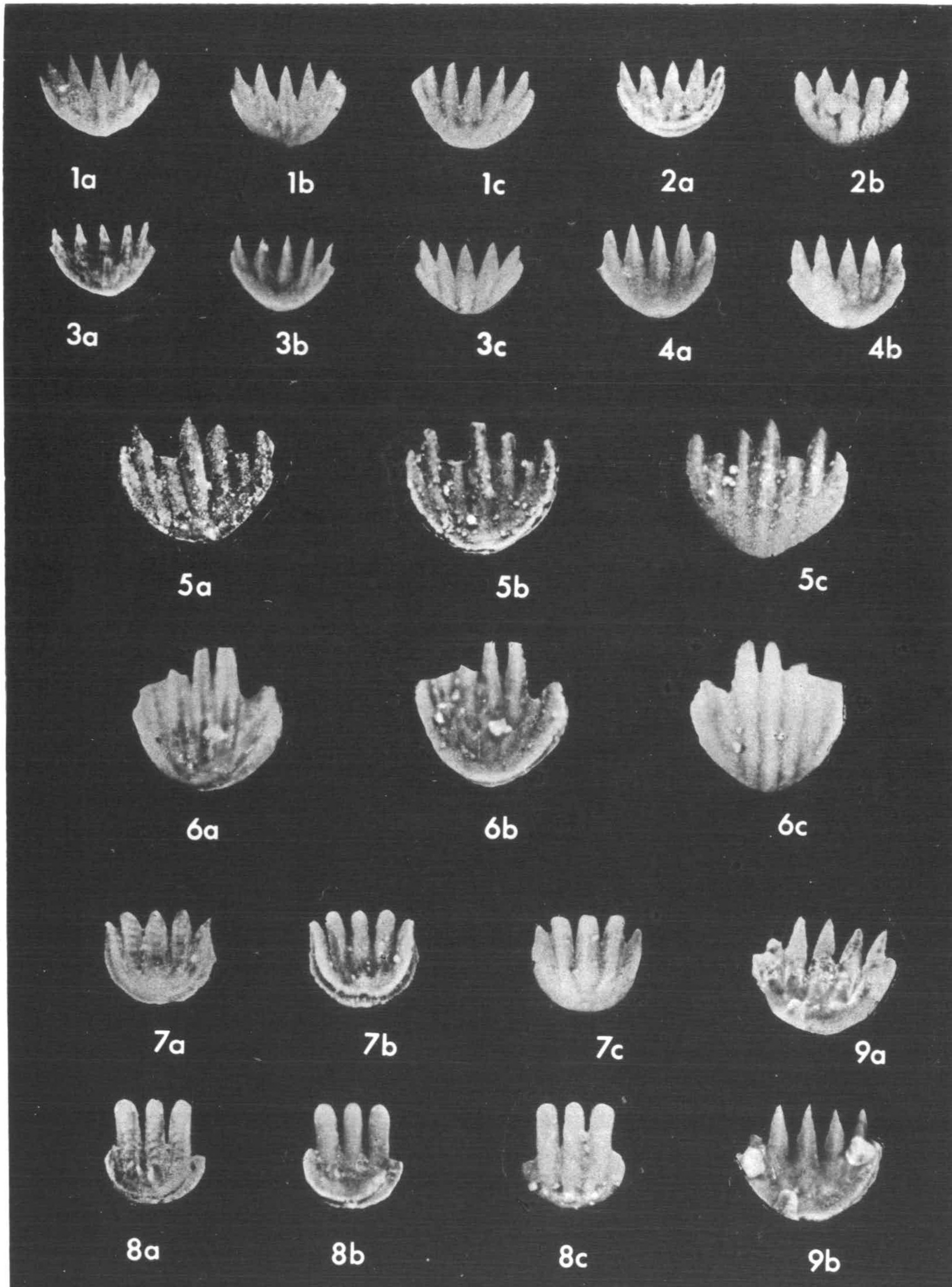
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Acanthodus costatus sp. nov. 54

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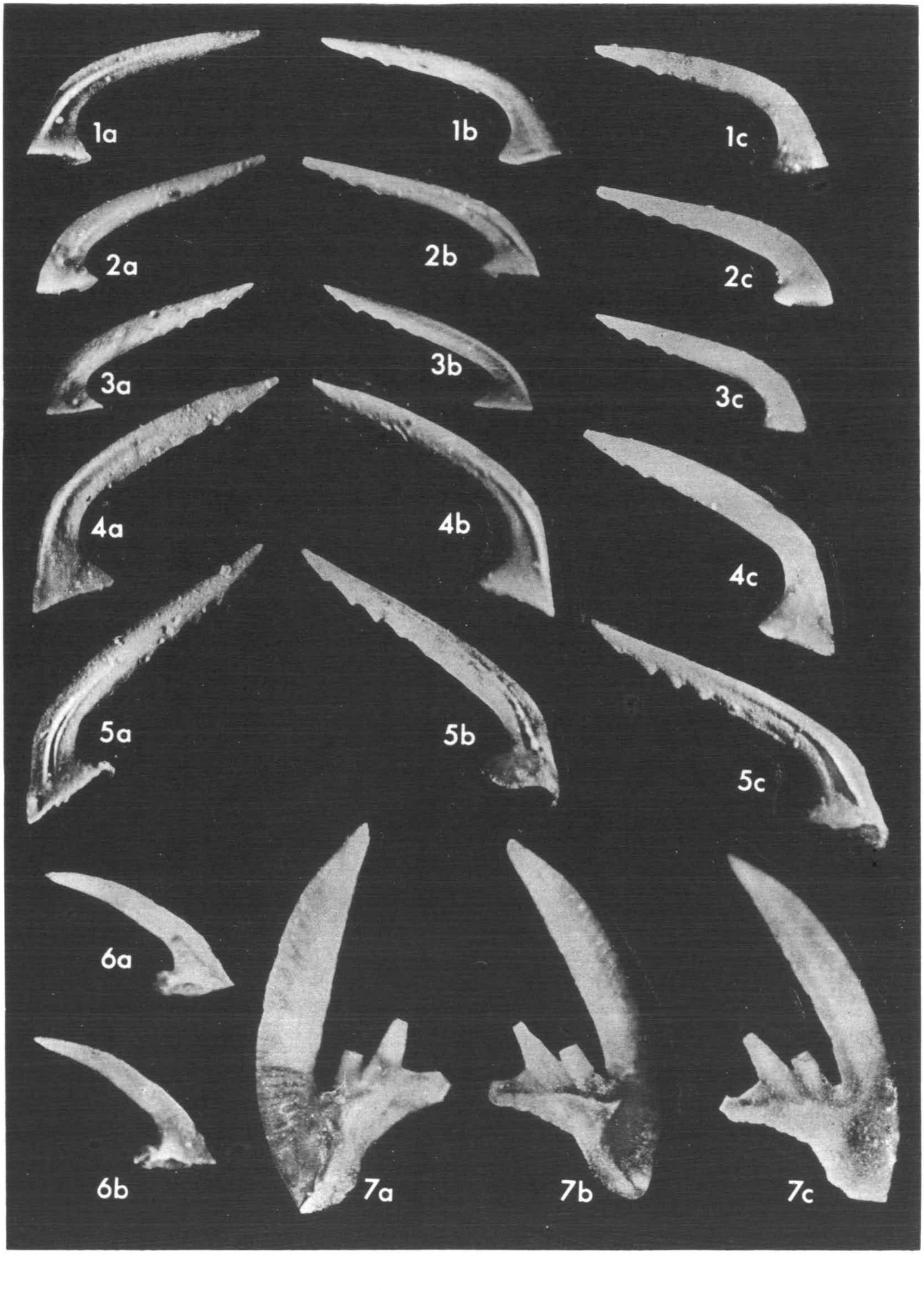
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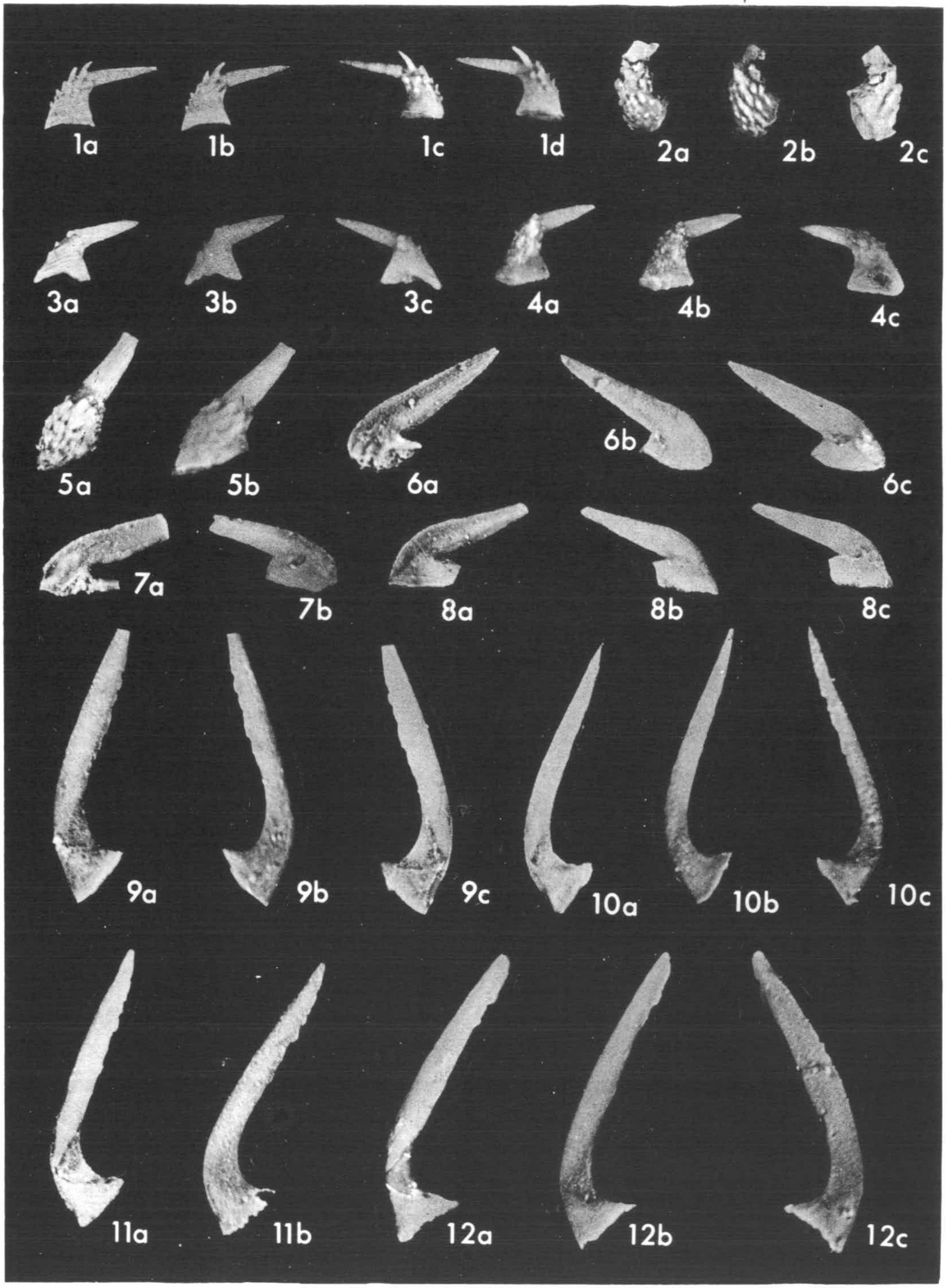
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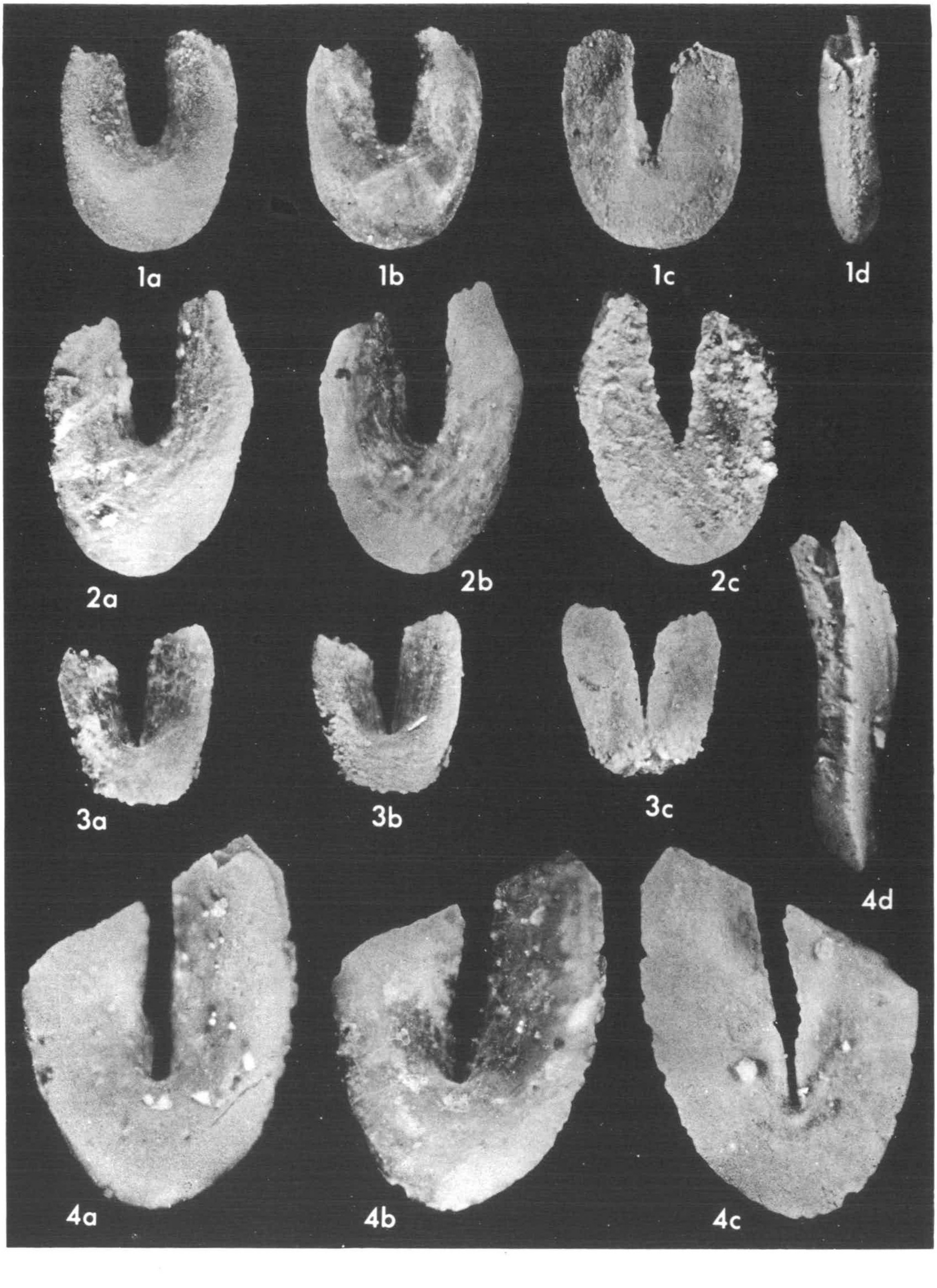
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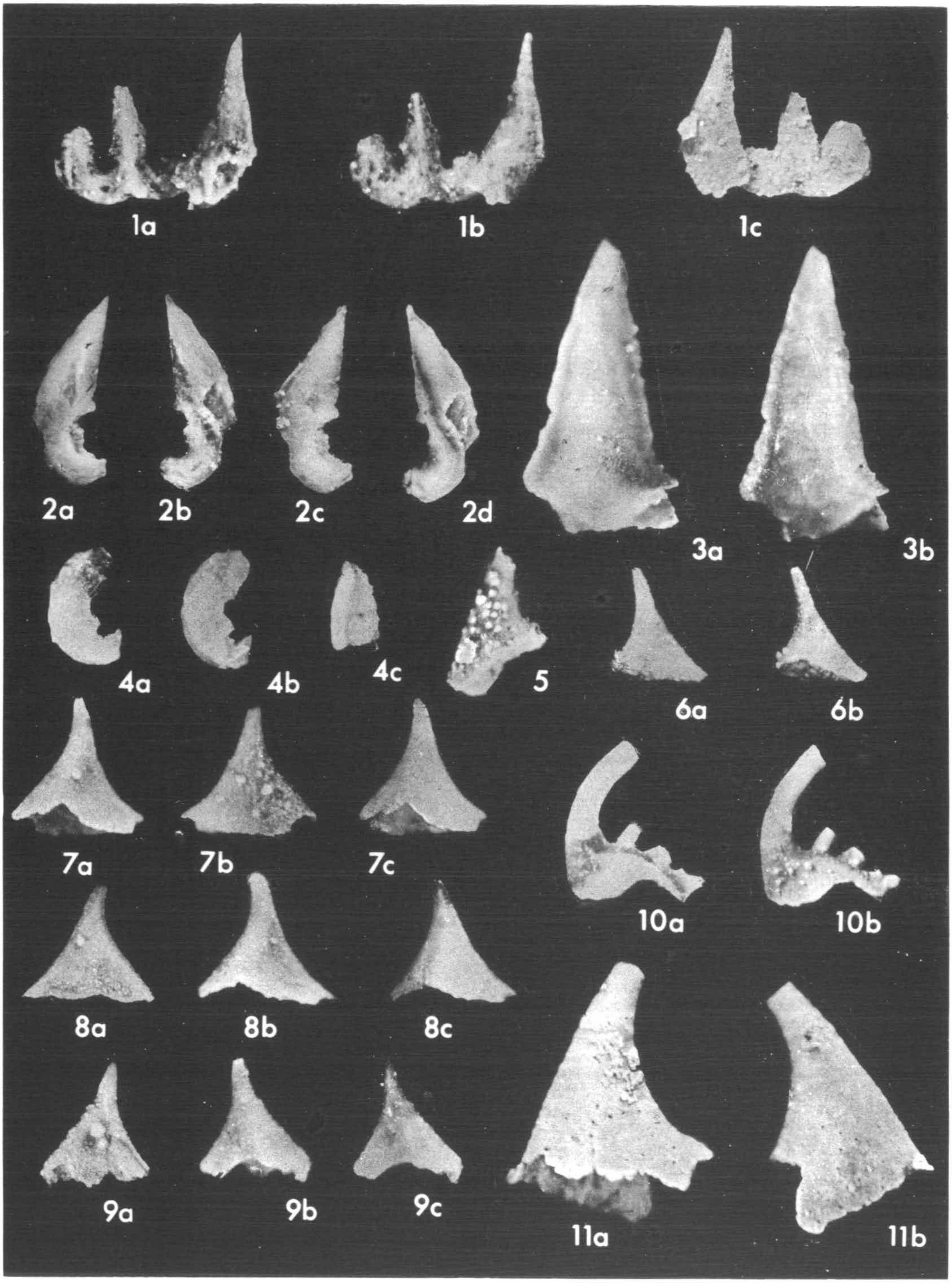
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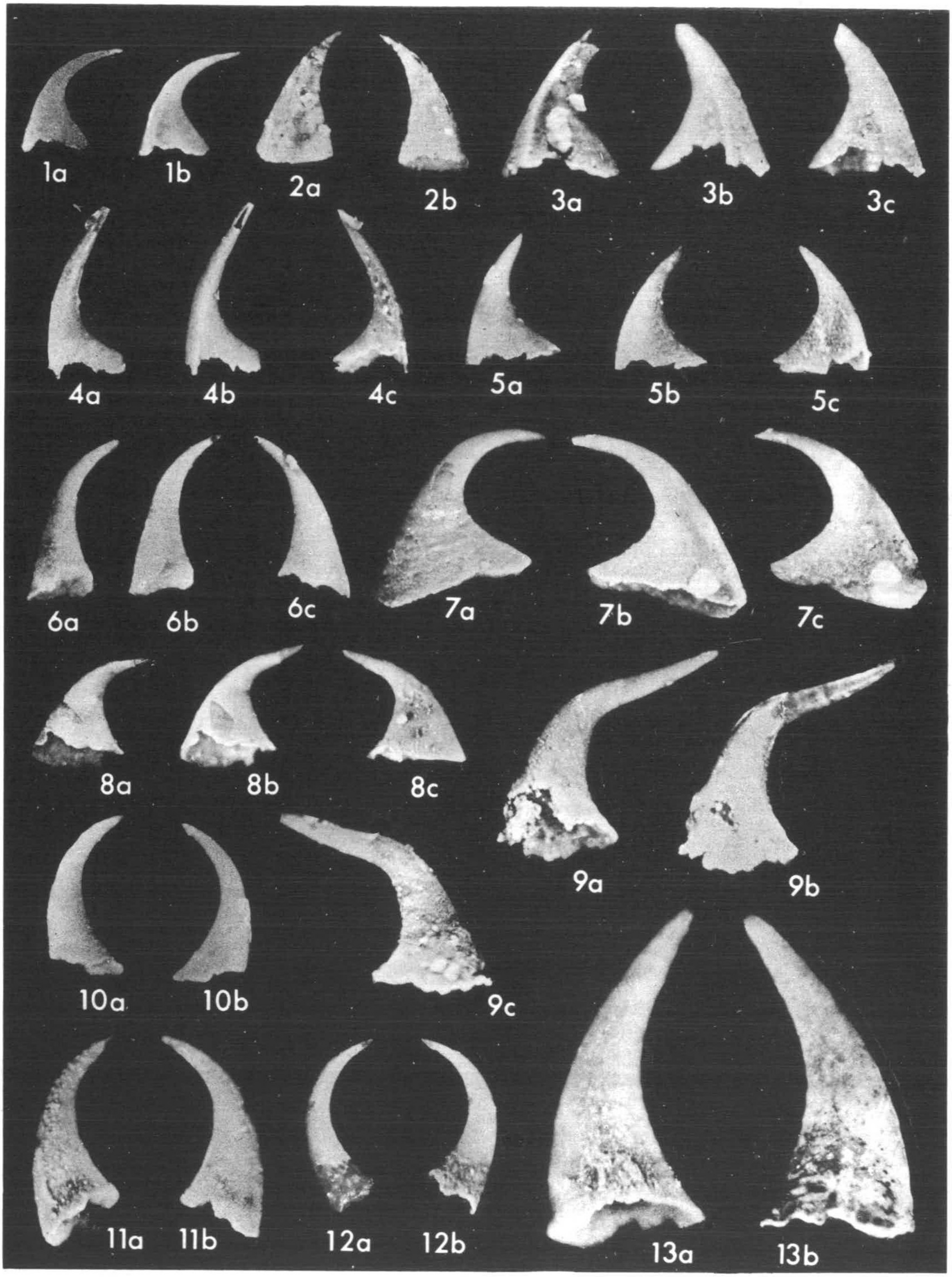
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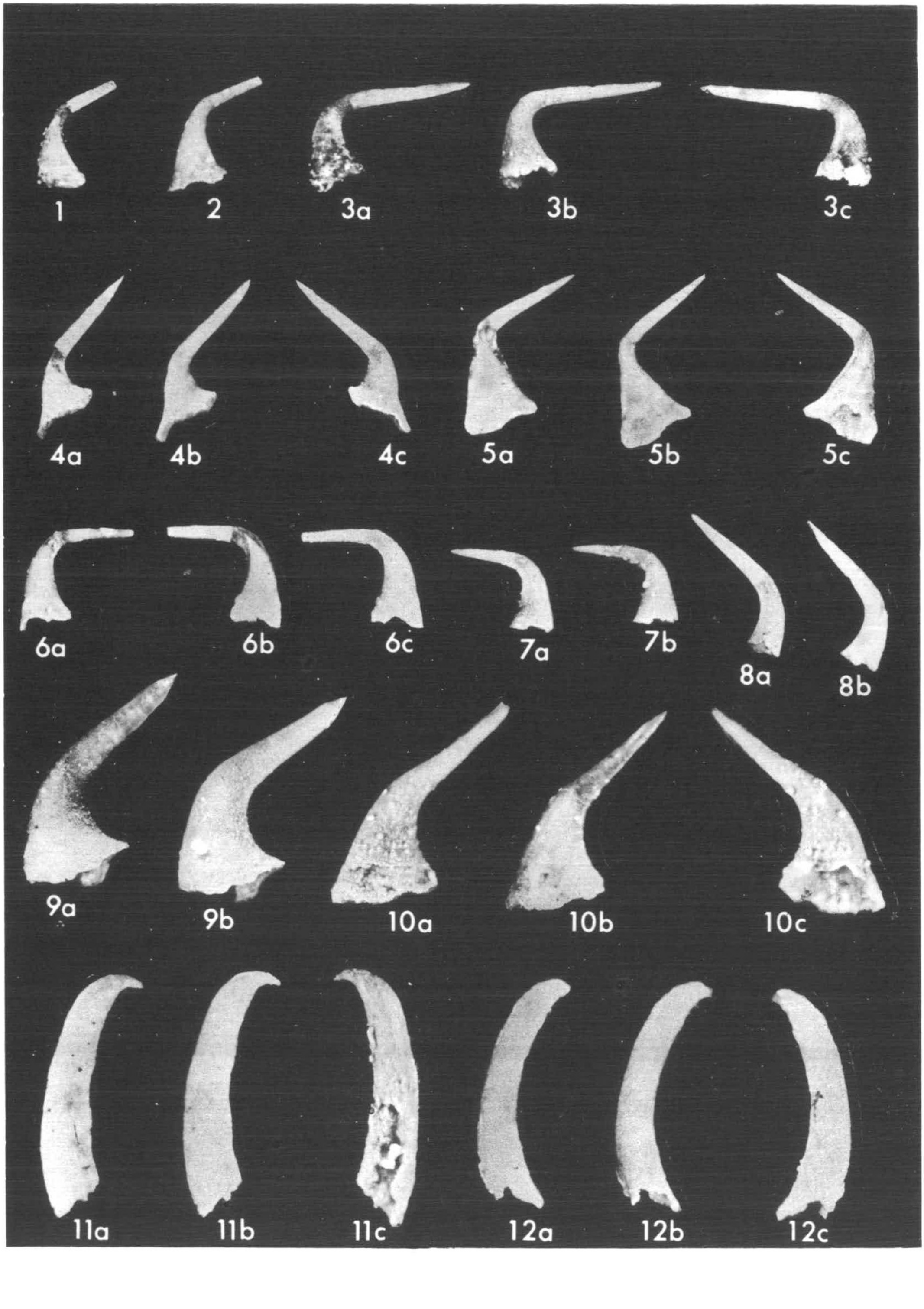
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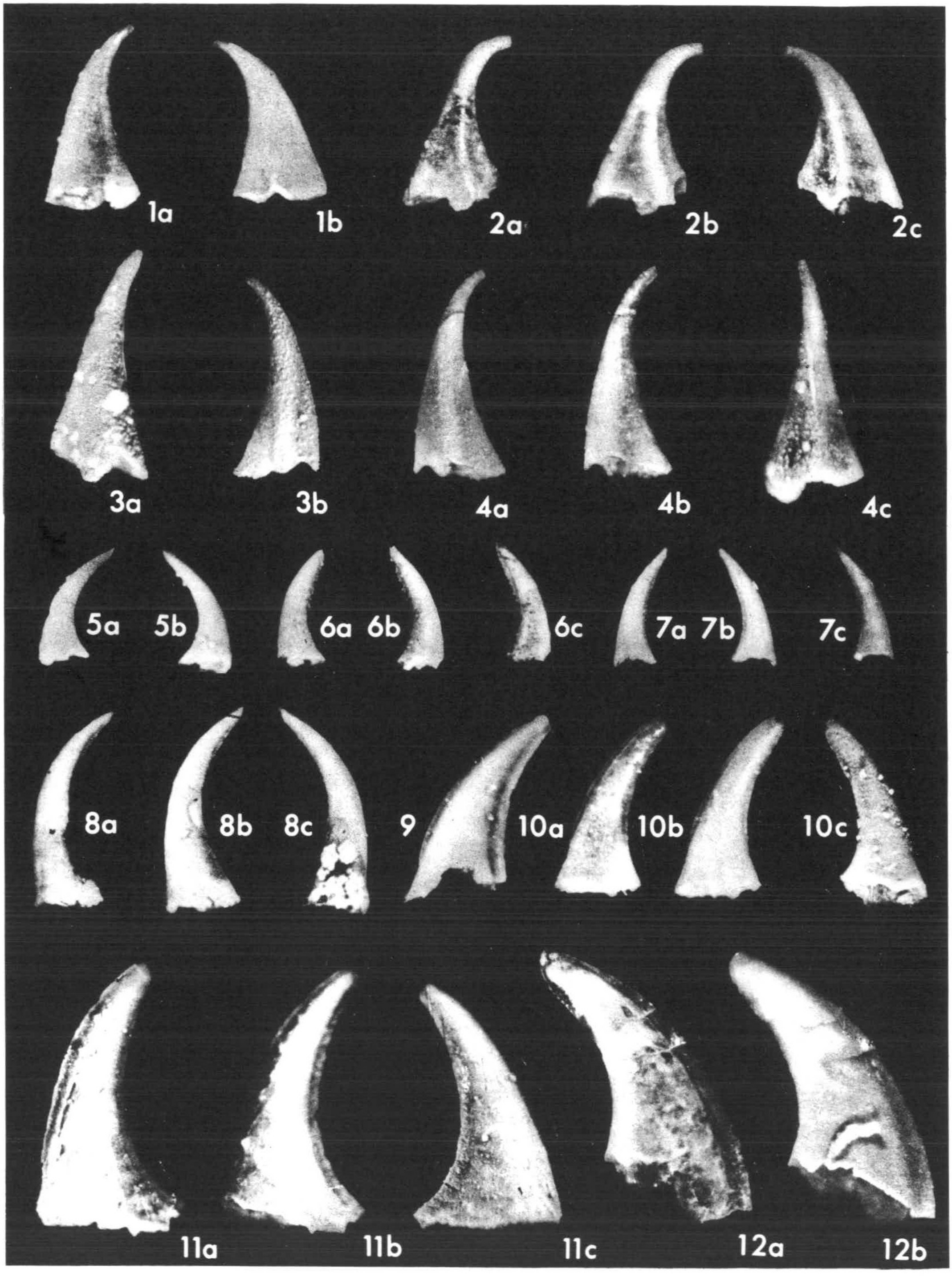
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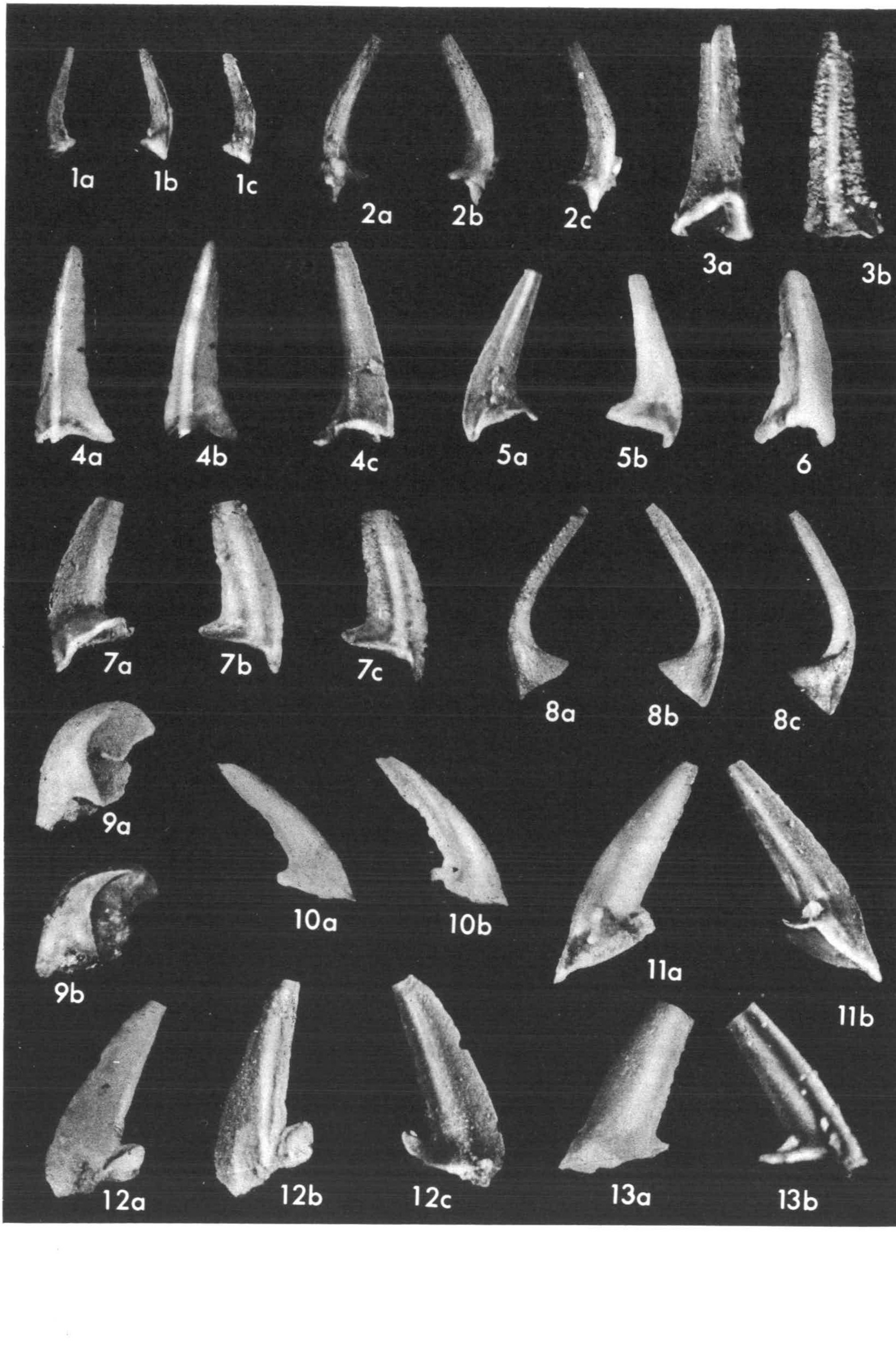
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	b	Lateral view of coated specimen CPC8863.	
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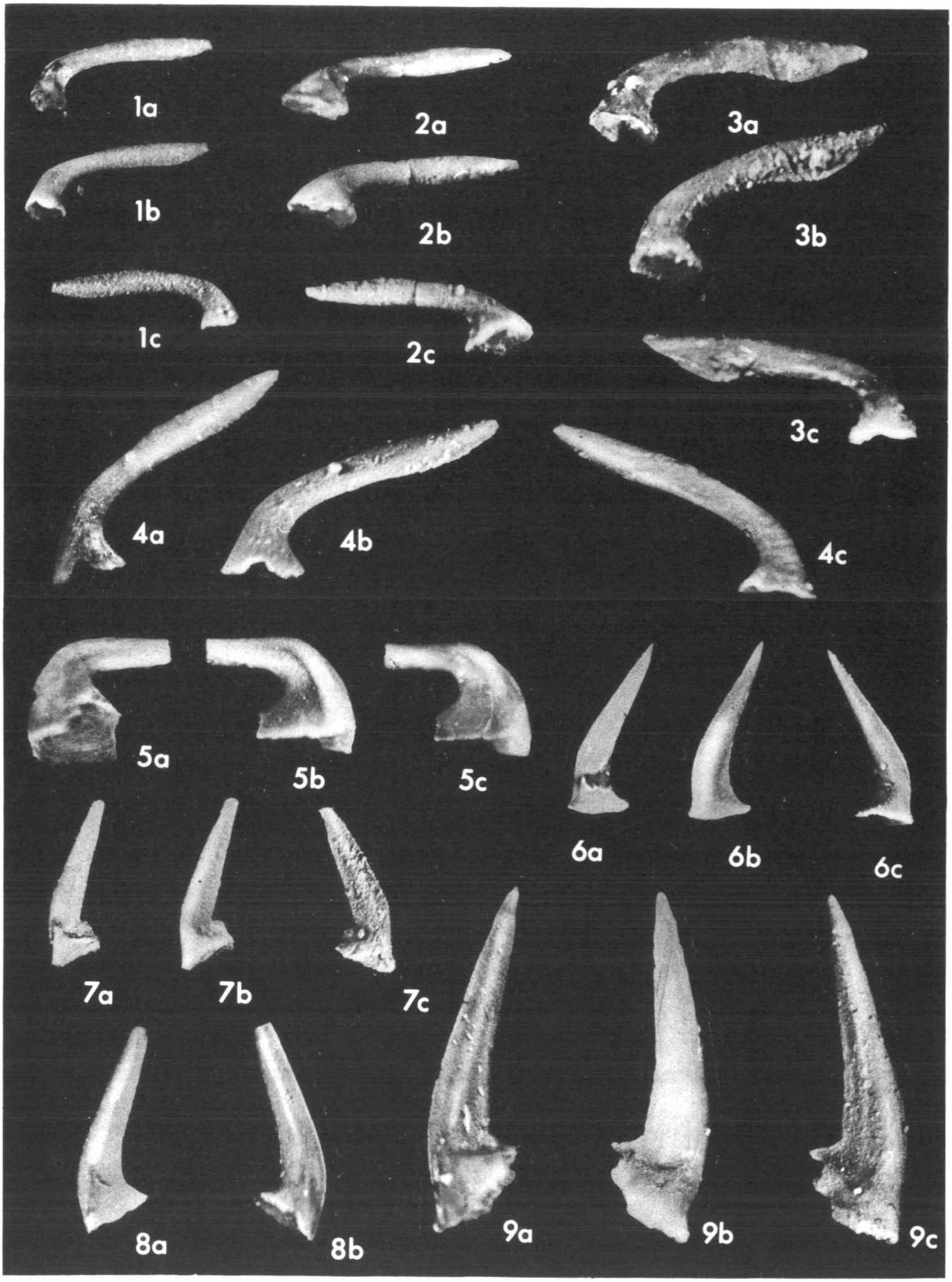
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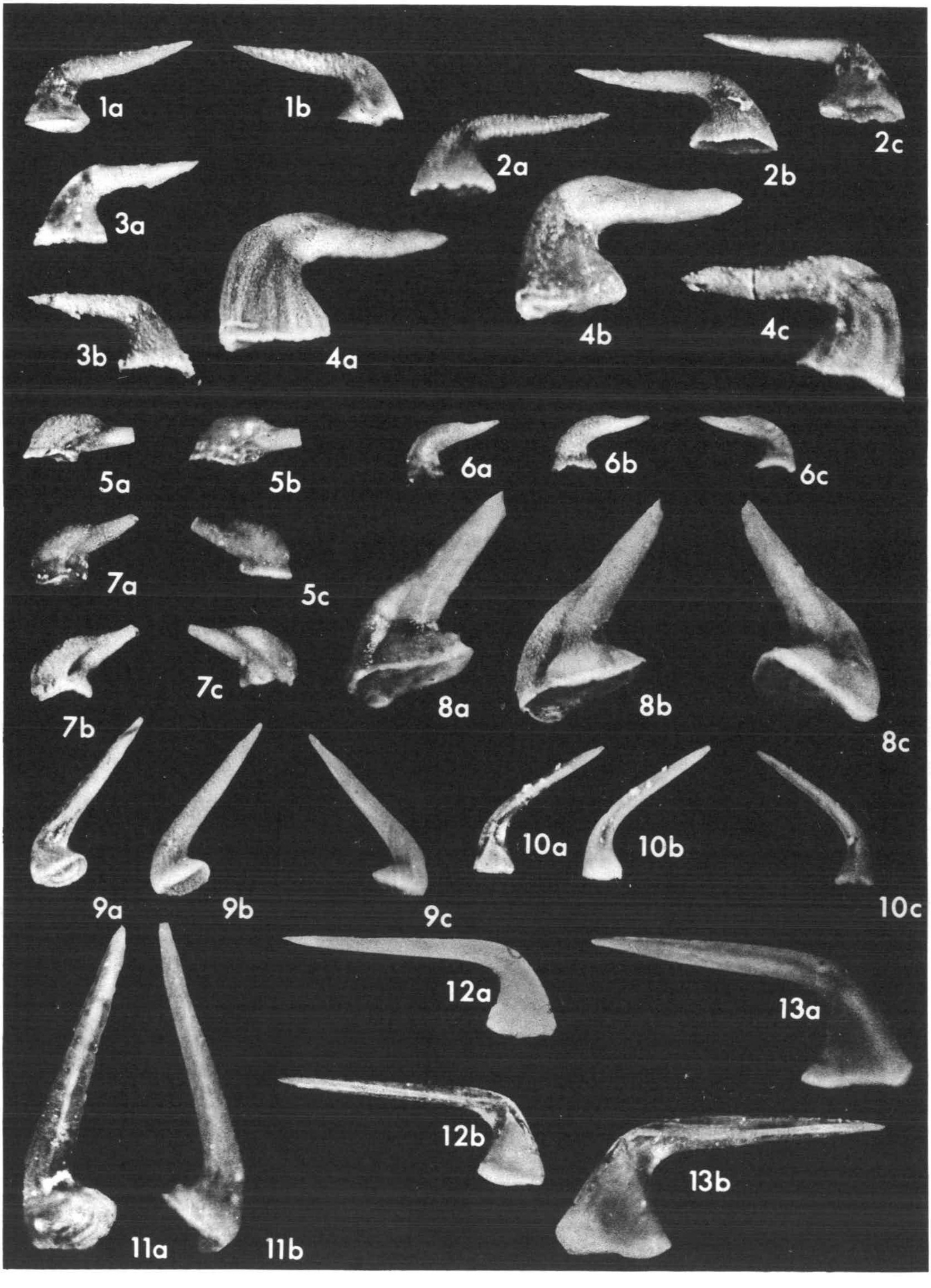
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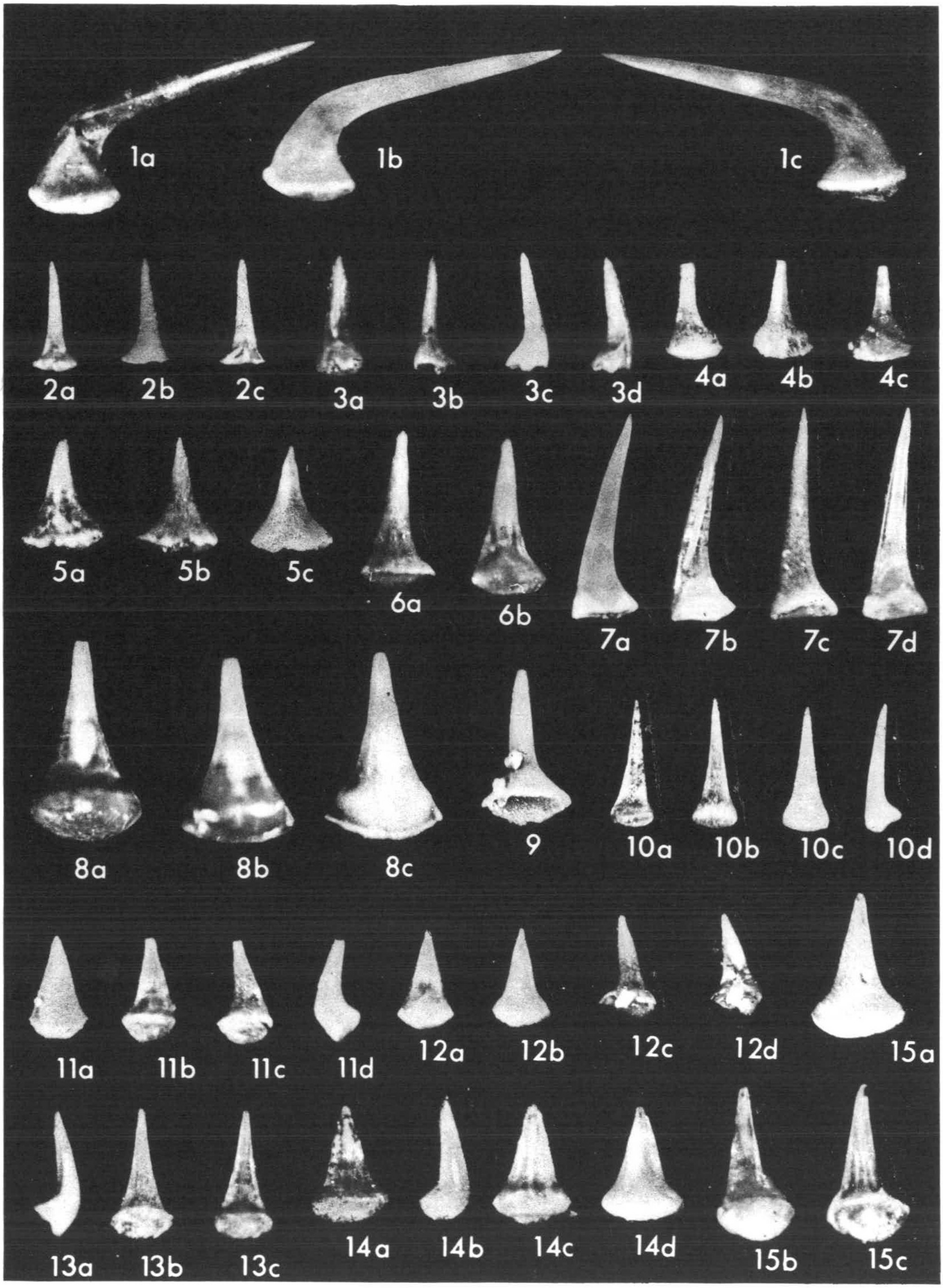
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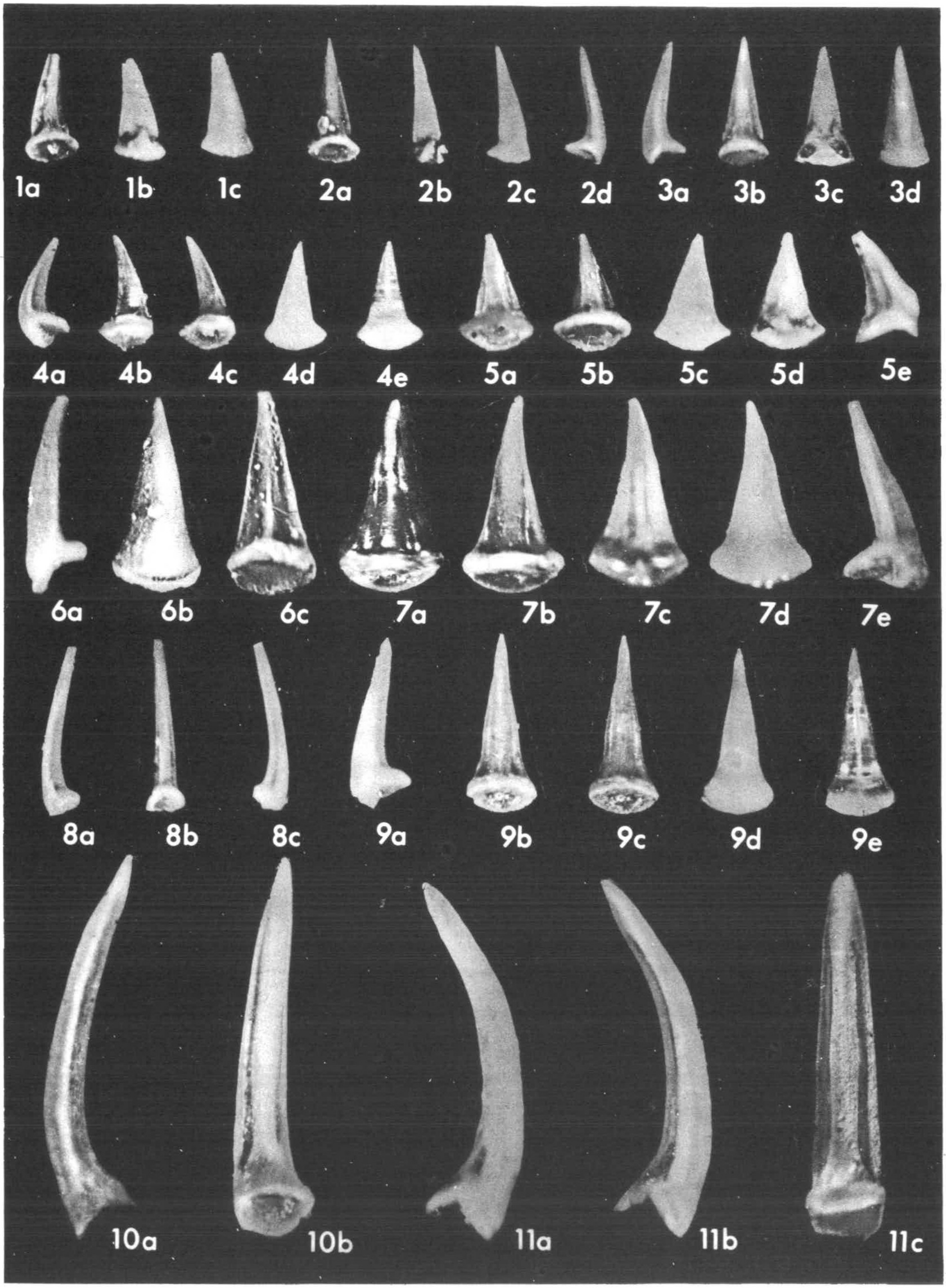
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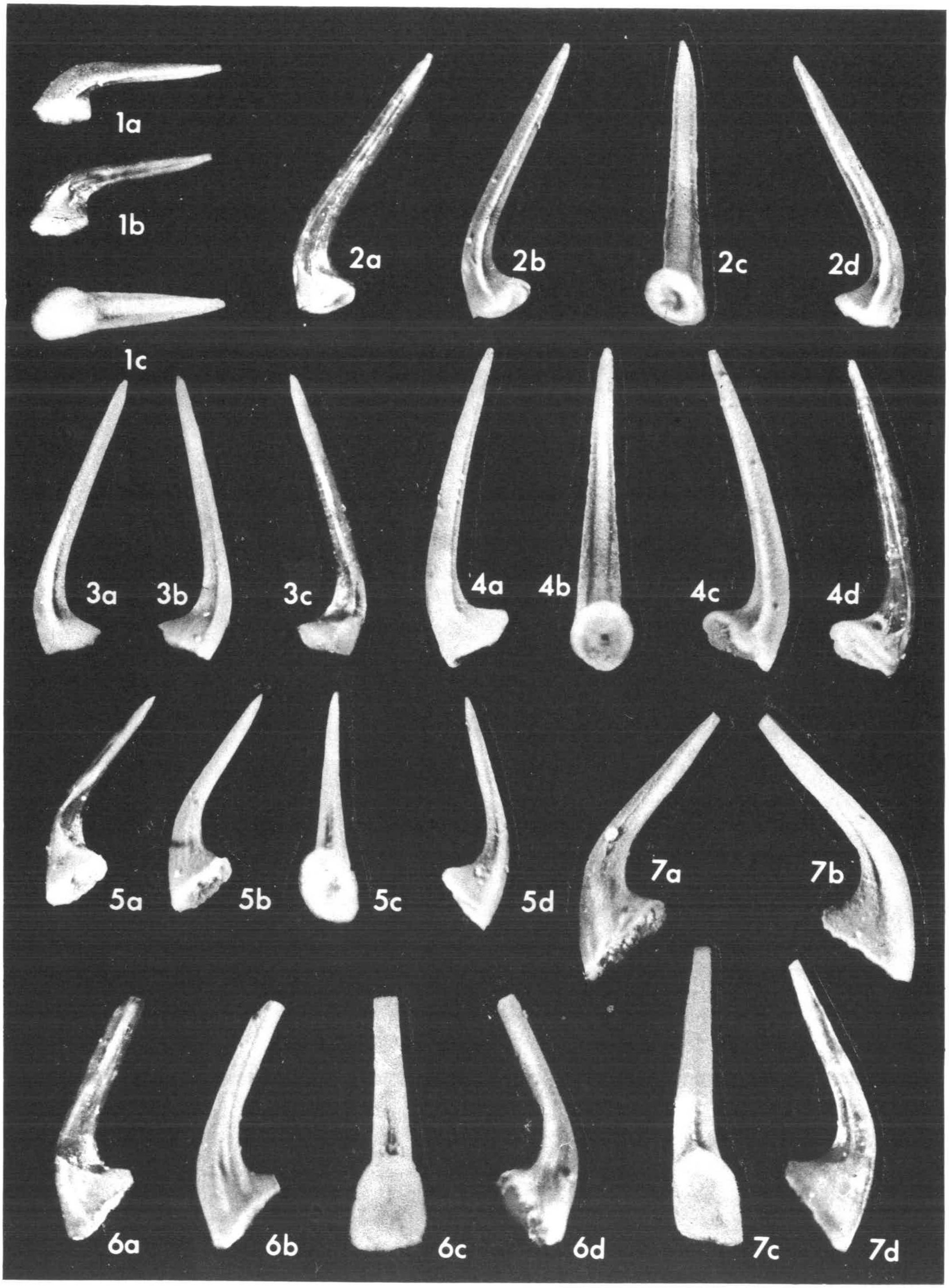
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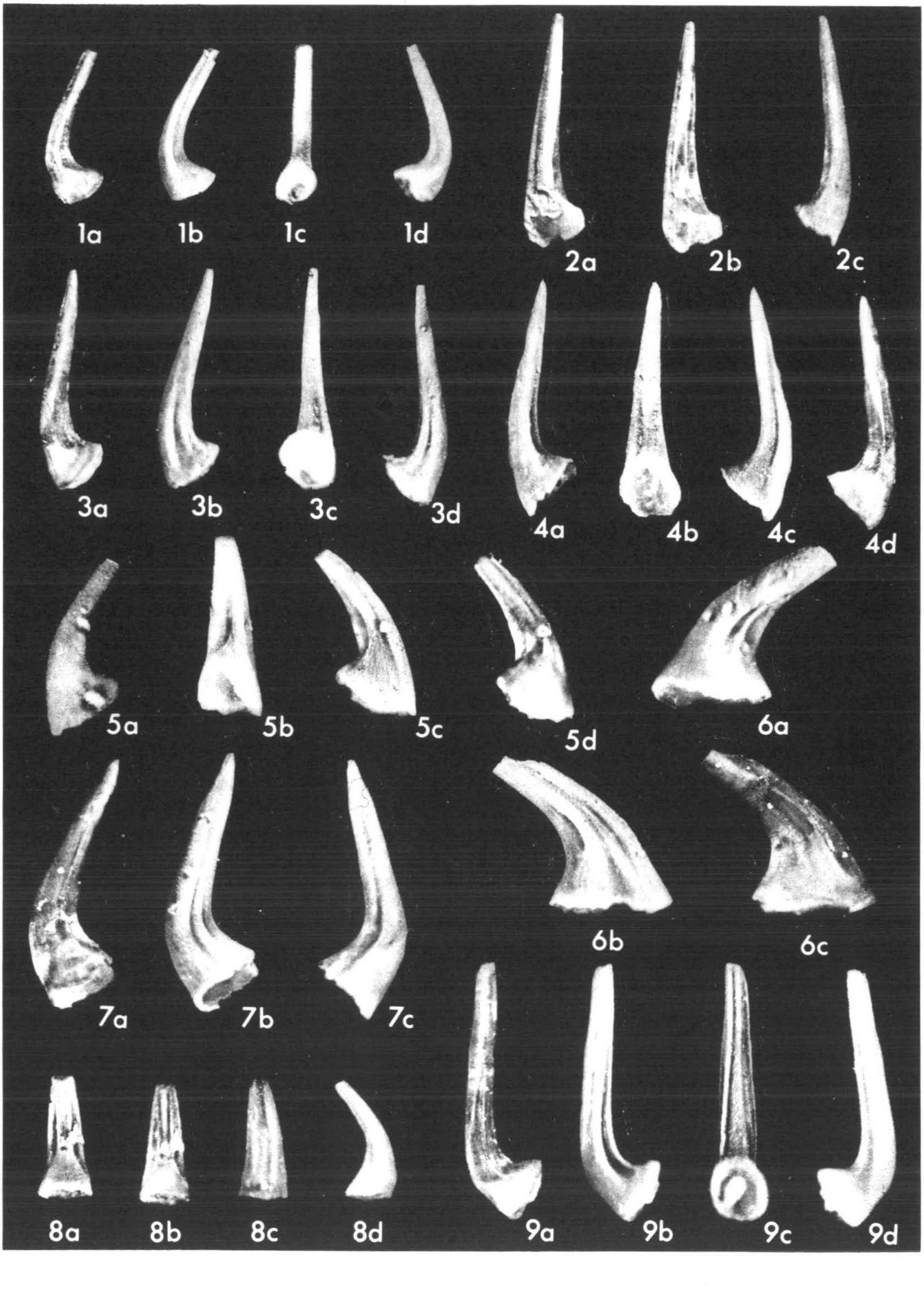
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b, c Lateral views of coated paratype CPC8887.
Fig. 7 a Lateral view of uncoated paratype CPC8888.
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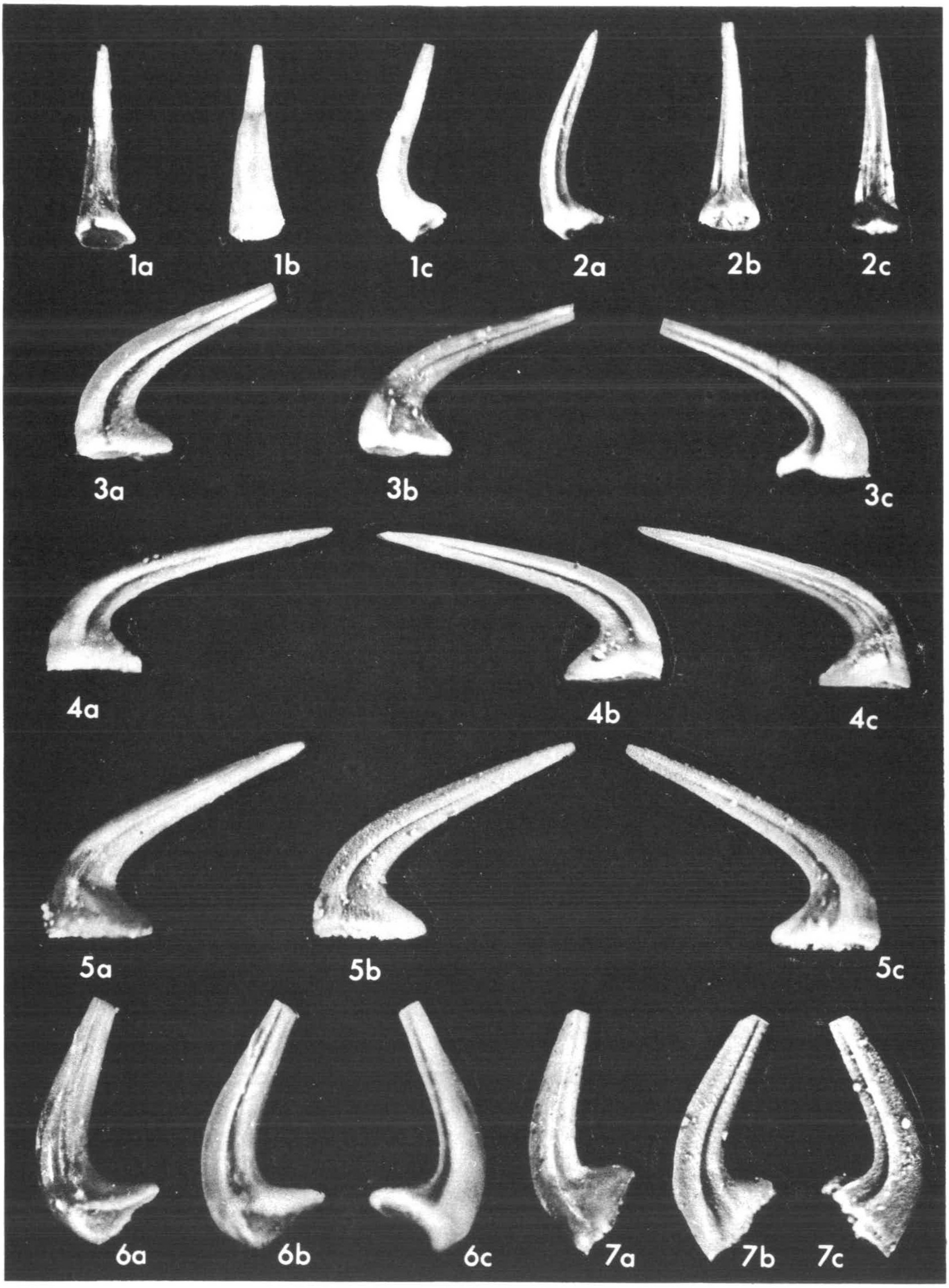
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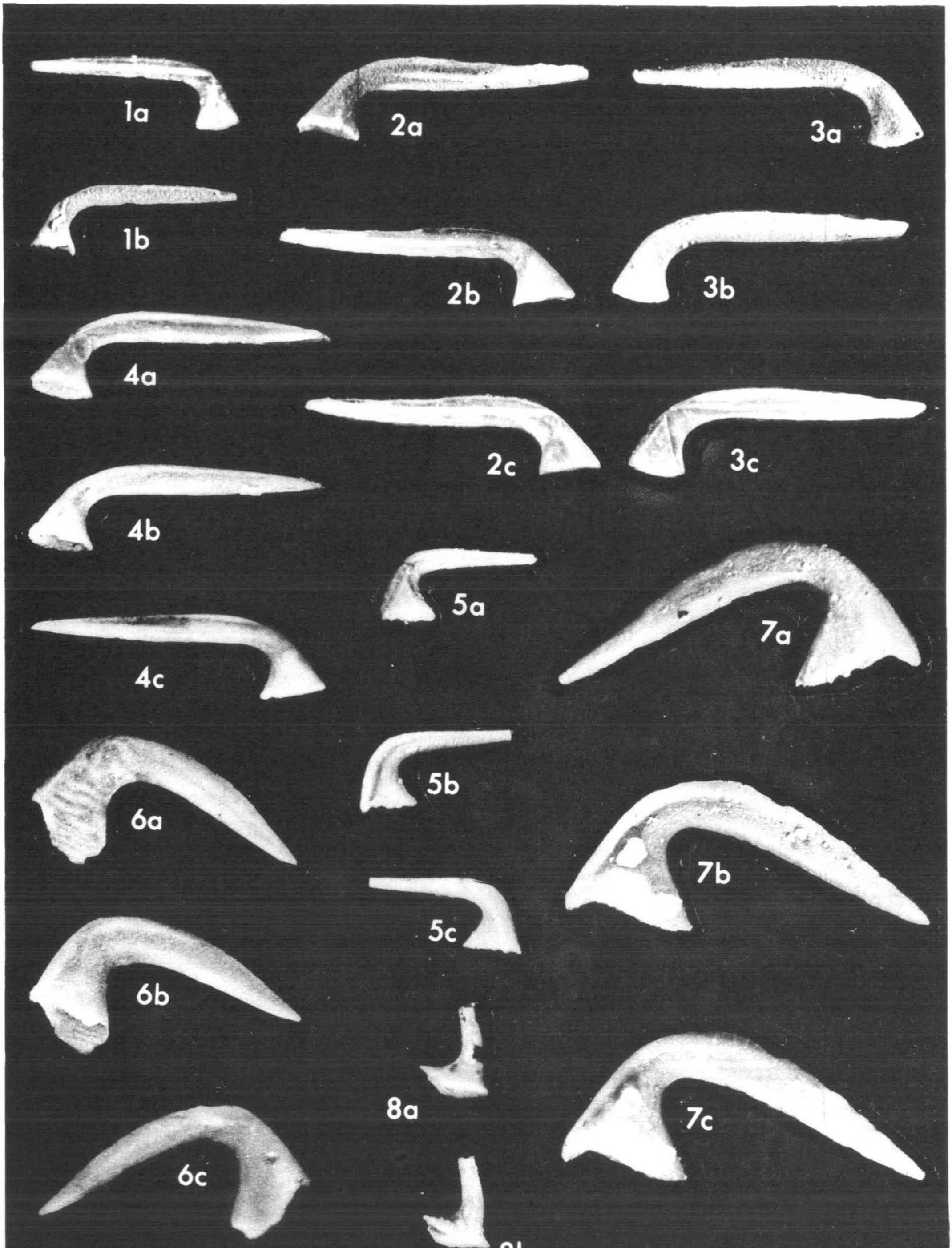
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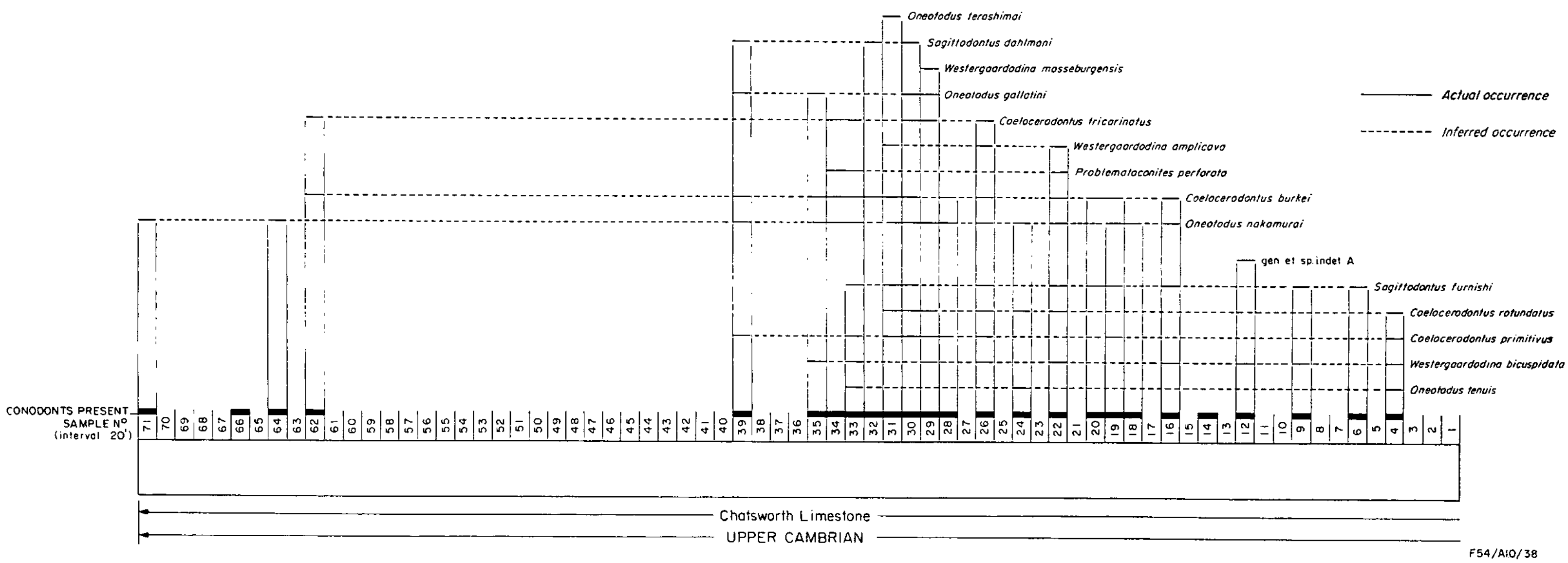
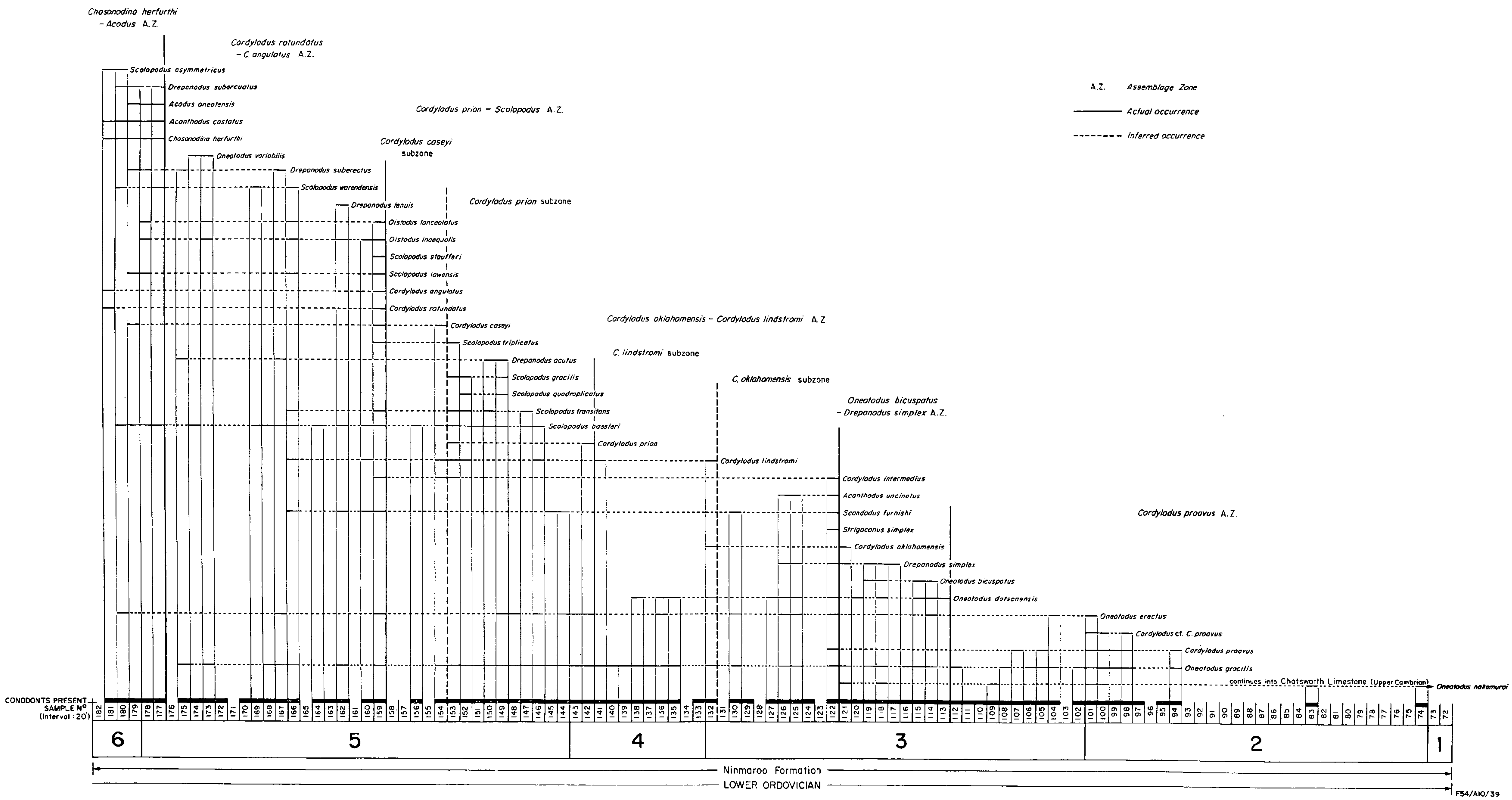
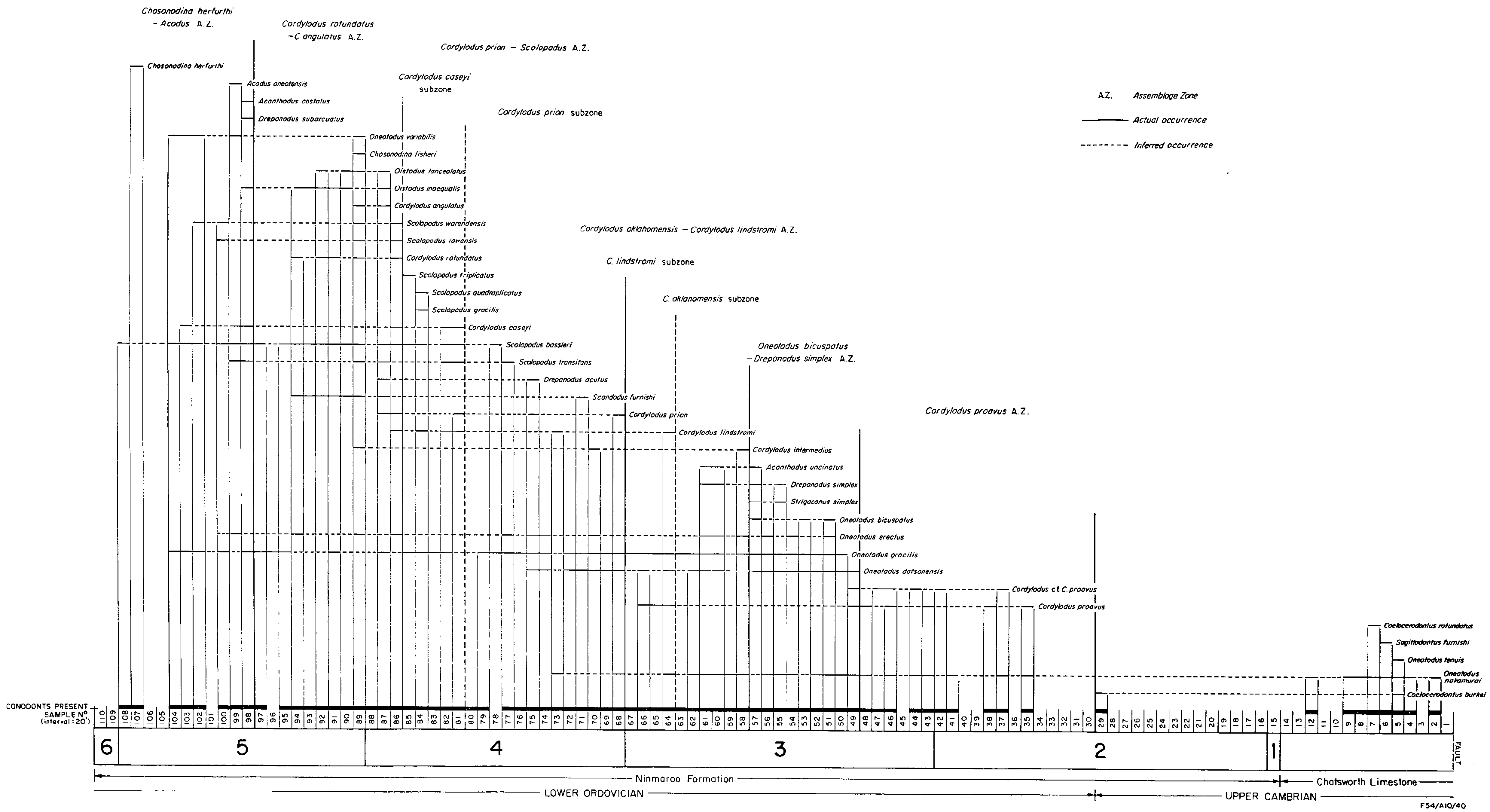


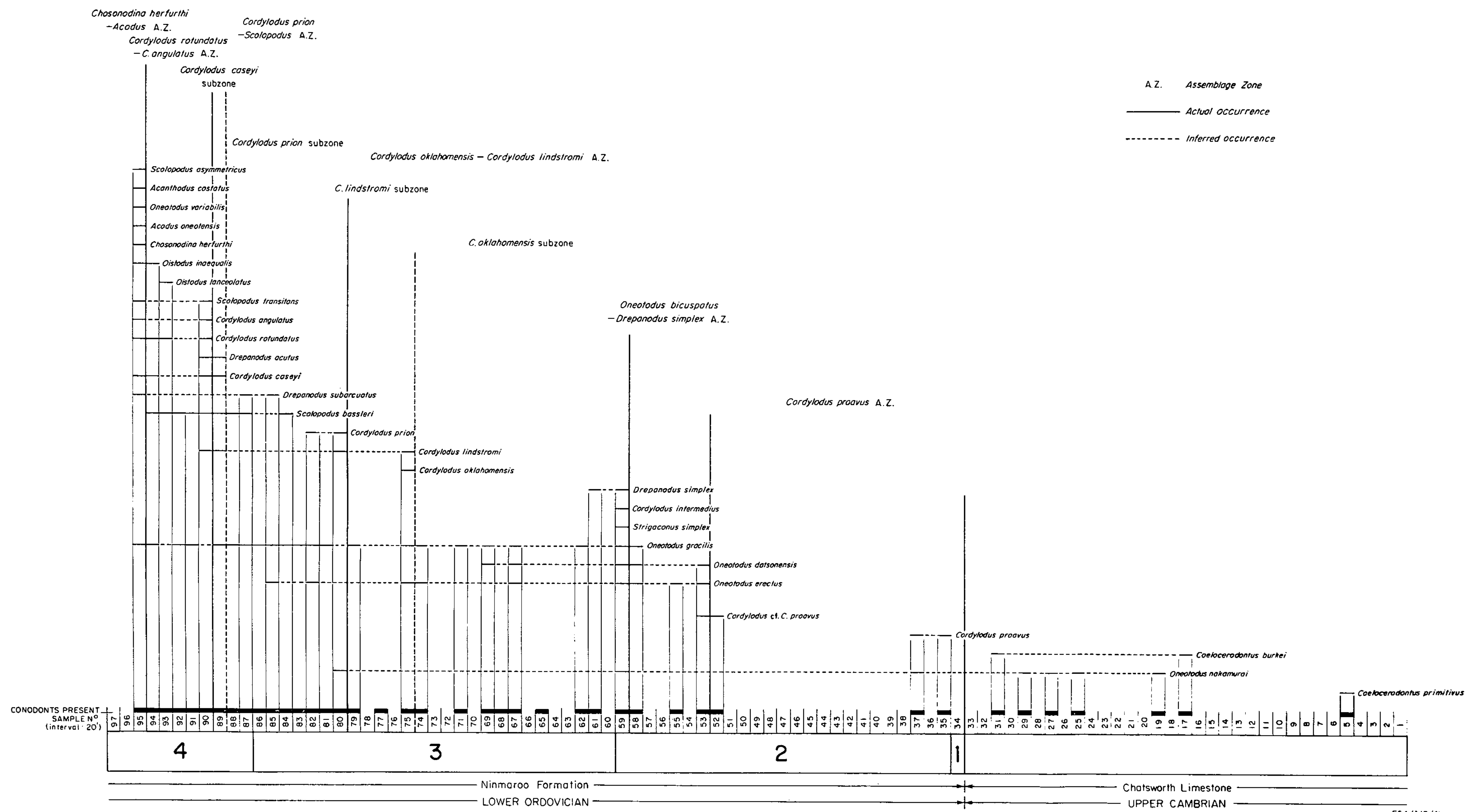
1. Species distribution, Black Mountain (Chatsworth Limestone)



2. Species distribution, Black Mountain (Ninmaroo Formation)



3. Species distribution, Mount Ninmaroo



4. Species distribution, Mount Datson