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CONODONT BIOSTRATIGRAPHY OF THE UPPER DEVONIAN
REEF COMPLEXES OF THE CANNING BASIN, WESTERN
AUSTRALIA.

The University of Michigan, Ph.D., 1971
Geology

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**CONODONT BIOSTRATIGRAPHY OF THE UPPER DEVONIAN
REEF COMPLEXES OF THE CANNING BASIN,
WESTERN AUSTRALIA**

**by
Edric Charles Druce**

**A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Geology and Mineralogy)
in The University of Michigan
1971**

Doctoral Committee:

**Professor Frank H. T. Rhodes, Chairman
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Professor Donald F. Eschman
Professor Jack L. Hough
Associate Professor Charles I. Smith**

PREFACE

The geological maps, sections, and distribution charts are in the pocket of Volume II. They will be of considerable use during the reading of this dissertation.

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I INTRODUCTION

During 1968 a joint Bureau of Mineral Resources/Western Australia Geological Survey field party undertook detailed mapping and palaeontological collecting in the Lennard Shelf area of the Canning Basin, Western Australia. This was a continuation of extensive work done by Playford & Lowry (1966) on the mapping of the Devonian reef complexes exposed in this area. Playford and Cockbain of the West Australian Survey are describing the detailed geology of the south-eastern part of the complex in the Emanuel-Laidlaw-Lawford Range and Teichert Hills area (Fig. 17). Their study includes detailed studies of sedimentary petrology (Playford), algae, brachiopods, and stromatopoids (Cockbain), corals (Jell) and cephalopods (Peterson).

1. Location and access: The Devonian reef complexes outcrop along the northern margin of the Canning Basin in the Kimberley Division of Western Australia. The area is subdivided into cattle stations. The partially sealed Great Northern Highway parallels the southern margin of the outcrop of the reef complexes, linking Derby, Fitzroy Crossing, and Halls Creek. Derby is the main town (pop. 1000) and it is a port on King Sound, served by a coastal shipping service. Fitzroy Crossing (pop. 24) is a small settlement serving the local cattle industry. Halls Creek (pop. 150) is a small mining and pastoral center serving the extreme western part of Western Australia. Derby is serviced by a daily air-link between Perth and Darwin and there is a station run which provides the majority of cattle stations with a weekly service. All homesteads are equipped with transceiver radio wireless sets linked with Royal Flying Doctor base stations at Wyndham and Derby for medical and telegraphic calls (Fig. 1).

Access to the exposures is by means of station tracks, where these are available; otherwise it is cross-country.

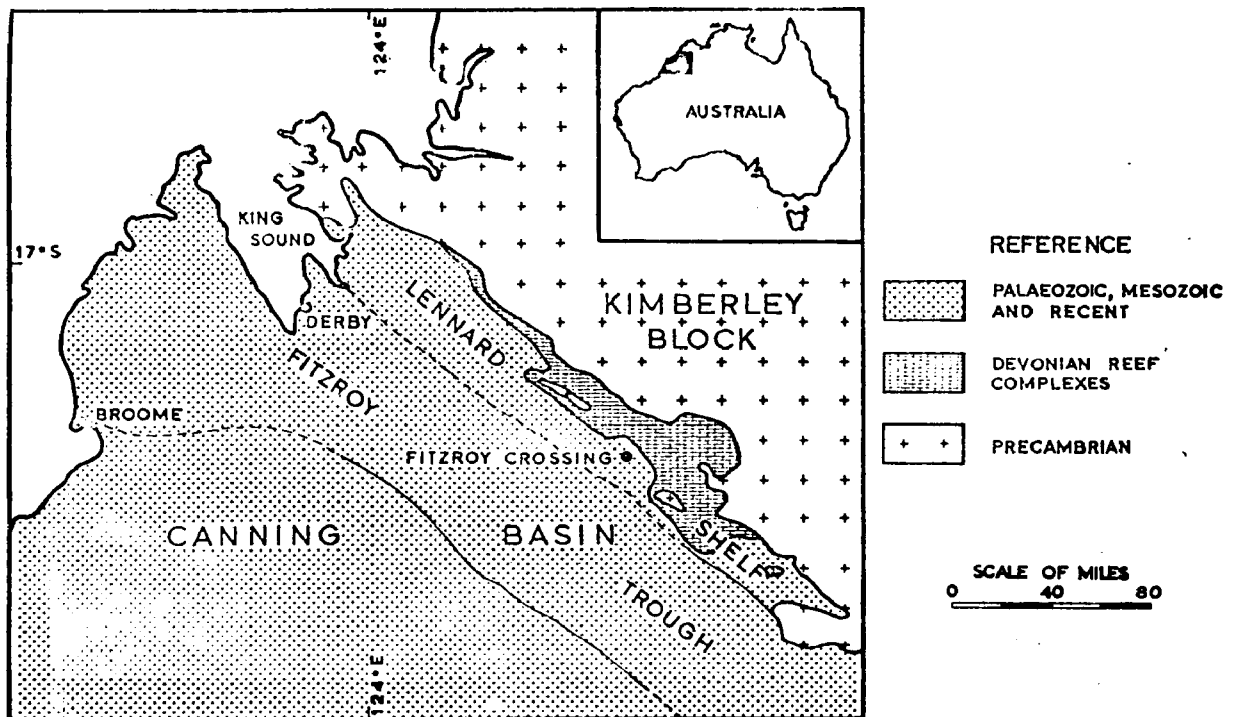


**Figure 1 - Locality Map, Lennard Shelf, Western Australia.
(After Playford & Lowry, 1966)**

2. Climate: The area is characterized by a warm, dry winter and a hot, wet summer, the rainfall ranging from 30 inches in the Napier Range to 18 inches near Christmas Creek (Playford & Lowry, 1966); 85 per cent of this rainfall falls in the summer months.

3. Flora and Fauna: The limestone ranges are generally devoid of vegetation except in low areas where soil has developed. The soil-covered areas are covered with spinifex (Triodia) and other grasses including Mitchell grass and trees, largely species of Eucalyptus, with Bauhinia, the baobab (Adansonia), the stinkwood (Gyrocarpus), the cotton bush (Cochlospermum), the hop bush (Dodonaea), and wattles (Acacia). The black soil areas generally lack trees, but have a thick covering of grass (Playford & Lowry, 1966).

II GEOLOGY

1. Introduction

The Canning Basin is the largest sedimentary basin in Western Australia and the second largest in Australia. It has an area of approximately 175,000 square miles, roughly the size of Spain (Veevers & Wells, 1961).

The sediments overlie Precambrian basement, composed of metamorphic and sedimentary rocks. The Palaeozoic sediments consist of widespread marine Ordovician limestones, shales and sandstones, which are about 3,000 feet thick. No Silurian rocks are known from the basin, but there are extensive Upper Devonian reefs developed, especially on the northern margin and possibly in the southern area. The initial deposition of the reefs began in the Givetian. In the Fitzroy Trough up to 7,000 feet of Carboniferous and 14,000 feet of Permian sediments are developed. These deposits are thinner elsewhere (Veevers & Wells, 1961).

The basin, apart from its seaward extension, is surrounded by Precambrian rocks, although the southern boundary of the basin is unknown and its elucidation must wait until detailed mapping of the Officer Basin to the south has been completed.

There is a series of structural regions within the basin, all of which trend NW-SE. The southwestern margin is formed by the Wallal Platform, and in a northeasterly direction there are successively the Samphire Depression, La Grange Platform, Broome Swell, Fitzroy Trough, and Lennard Shelf (Napier Platform of Veevers & Wells, 1961).

2. Lennard Shelf (Figs. 16-18)

The Lennard Shelf is developed on Precambrian granites, gneisses, schists and metasediments of the Lamboo Complex (Guppy et al., 1958) and quartzite, conglomerate and schist of the King Leopold

Beds. The basement is shallow, less than 5,000 feet deep (Veevers & Wells, 1961); it is mainly crystalline; the only known sediments are in the Oscar Ridge inlier. They probably do not extend further into the basin and they have deformed in the King Leopold Mobile Zone. The oldest Palaeozoic sediments are Ordovician shales and limestones of the Emanuel Formation (2,450 feet thick) and dolomite and limestone of the Gap Creek Formation (630+ feet thick), which together constitute the Prices Creek Group. Parts of the succession are abundantly fossiliferous. Öpik (in Guppy & Öpik, 1950) records brachiopods, ostracods, conodonts, trilobites, gastropods, nautiloids, and graptolites (*ibid.*). The conodonts are currently being studied by McTavish in Marburg. Öpik and Tomlinson have studied the shelly faunas and conclude that the Ordovician section ranges in age from early Tremadocian in Samphire Marsh No. 1 Bore (core 10, 6185-87) (Tomlinson in Johnstone, 1960) up to the Llanvirnian-Llandeilian (Öpik, pers. comm.). In terms of the newly erected Australian Ordovician stages, the Samphire Marsh No. 1 horizon is of Datsonian age (Jones *et al.*, 1971).

Unconformably overlying the Prices Creek Group are the Devonian reef complexes which are discussed below (p. 6). Overlying the reef complexes is a sequence of interbedded limestones and terrigenous sediments of Upper Devonian and Lower Carboniferous age, referred to the Fairfield Formation (Playford & Lowry, 1966). The unit was originally mapped as Upper Devonian Fairfield Beds by geologists of the Bureau of Mineral Resources but Thomas (1959) found that the upper part was of Lower Carboniferous age, and he proposed the name "Laurel Beds" for the Carboniferous portion. Playford & Lowry (1966) state that they cannot distinguish the two units in mapping and they have elevated the Fairfield Beds to the status of a formation, and include the Laurel Beds within this concept.

Overlying the Devonian and Carboniferous are scattered outcrops of the Lower Permian Grant Formation, consisting of quartz

sandstone, conglomerate and shale of glacial origin (McWhae et al., 1958). The most common lithology observed is a yellow-brown, siliceous, medium-grained quartz sandstone. One of the conglomerate beds exposed 2 3/4 miles east-northeast of Pinnacle Spring is believed to be a marine tillite. It contains boulders up to five feet across, consisting of granite, quartzite, rhyolite, chert, quartz and other rocks. Some show faceting and well-marked parallel striations. Associated with the conglomerate is a calcareous sandy siltstone which contains fragmentary crinoid columnals and is presumably a marine deposit (Playford & Lowry, 1966). Other Permian Formations in the area are the Poole Sandstone, and the Noonkanbah and Liveringa Formations.

The Poole Sandstone consists of white and brown, well-bedded, ferruginous fine-grained micaceous quartz sandstone with minor shale. Cross-bedding, ripple marks, and worm tracks indicate deposition in shallow water (Veevers & Wells, 1961). The Poole Sandstone is divided into two members, the Nura Nura and the Cuncudgerie Sandstone Members (*ibid.*), but they cannot be recognised in the Lennard Shelf area.

Scattered outcrops of Jurassic and Quaternary deposits are known (Playford & Lowry, 1966, p. 23). Three exposures of leucite lamproite lavas occur and have been dated as Jurassic by the Rb/Sr method (Prider, 1960).

The Quaternary alluvial deposits are extensive near the rivers and larger streams and are inundated during periods of flood. They are usually deposits of red sandy loam. The black soil plains are composed of dark grey to black clay soils with prominent gilgai features. They are a type of patterned ground made by a series of ridges and depressions in the surface of the plain which give rise to a rough hummocky surface (Playford & Lowry, 1966).

3. The Devonian Reef Complexes

The first geological work in the reef complexes was done by Hardman in 1883 as part of Brooking's Kimberley exploring expedition.

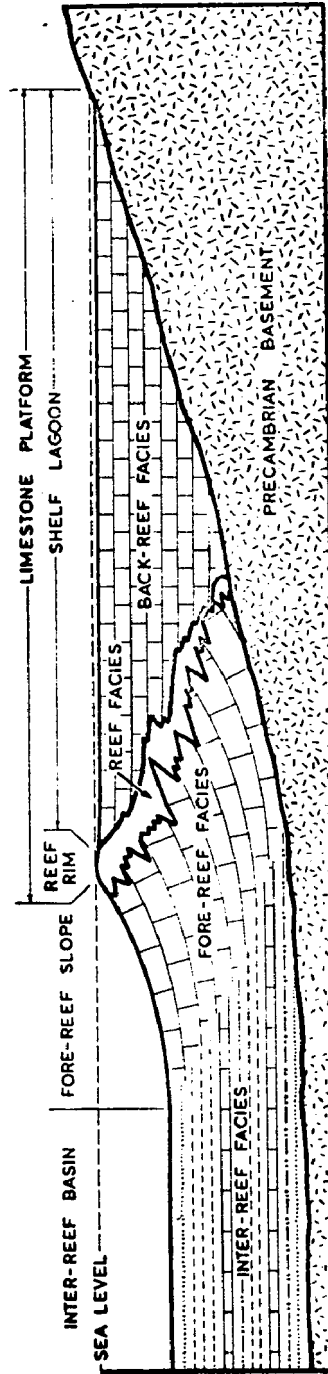


Figure 2 - Diagrammatic cross-section illustrating the structure and facies relationships of a typical reef complex of the Canning Basin, approximate dimensions 2 miles across. (After Playford & Lowry, 1966)

Hardman described the "Carboniferous Limestone" ranges of the West Kimberley area (1884) and his fossil collections were studied in England (Nicholson, 1890; Hinde, 1890; and Foord, 1890) where it was recognized that the fauna was Devonian (Playford & Lowry, 1966).

The first interpretation of the limestones as a reef complex was by Wade (1924, 1936, 1938). Subsequent work by geologists of Caltex (Australia) Oil Development Pty. Ltd. enlarged the stratigraphic knowledge of the northern part of the Canning Basin (Playford & Lowry, 1966).

In 1947 the Bureau of Mineral Resources began field work in the Canning Basin, which continued annually until 1958. The work consisted of geological mapping; seismic, gravity, and aeromagnetic surveys; and stratigraphic drilling parties. The results of this major survey have been reported by Traves *et al.* (1957), Guppy *et al.* (1958) and Brunnschweiler (1954, 1957). Other major reports have been published by McWhae *et al.* (1958) and the latest detailed study on the reef complexes by Playford & Lowry (1966). Playford (1968) compares the Lennard Shelf reefs with extensive and multitypical reef complexes in Alberta, Canada.

Playford & Lowry recognize four main facies in the reef-complexes: the reef, back-reef, fore-reef, and inter-reef facies (Fig. 2).

According to Playford & Lowry (1966, p. 30) the reefs usually grew upwards and outwards, advancing over their own talus deposits. The reef rim is built of a framework of colonial organisms which are essentially in situ, having formed a wave resistant barrier which supplied fore-reef talus. The reef rim isolated the back-reef shelf lagoon which was shallow with occasional inter-tidal mud flats (Fig. 4).

(i) Reef Facies - Playford & Lowry (1966, p. 36) refer the reef facies to a single formation, the Windjana Limestone. It is normally a massive, or crudely bedded limestone, built up of a framework of colonial organisms in their approximate growth position (Pls. 25 & 38).

Important fossils in the reef include the blue-green algae,

Renalcis and Chabakovia, and stromatoporoids, including Stachyodes and Actinostroma (Pls. 37 & 38). Other algae include Rothpletzella, Girvanella, Parachaetetes, and Solenopora (Playford & Lowry, p. 46; Wray, 1967).

Sponges are common, including Sphaerospongia and Striato-spongia; also present is the problematic fossil, Receptaculites. Corals are abundant only where the reef is narrow and merges with the back-reef facies; they include Hexagonaria. Brachiopods are present, usually in pockets, and are commonly Pugnax. Goniatites are rare.

(ii) Back-Reef Facies - Playford & Lowry (1966, p. 47) refer all the back-reef deposits to a single formation, the Pillara Limestone (Pl. 3). Five sub-facies are recognized: the stromatoporoid, birdseye-limestone, oolite, coral, and oncolite sub-facies (*ibid.*, p. 49-59).

The stromatoporoid sub-facies (Pls. 39 & 40) is the commonest sub-facies, consisting of biostromal beds from a few inches to about three feet in thickness, built up of the remains of stromatoporoids, especially Amphipora and Actinostroma. They are extensively dolomitized in certain areas. Playford & Lowry do not record any late Famennian occurrences of this facies.

The birdseye-limestone sub-facies (Pl. 41) consists of medium-bedded limestone, characterized by small (1-10 mm) patches of sparry calcite, in a ground mass of calcilutite or calcarenite. Playford & Lowry (p. 54) interpret this sub-facies as an algal mat deposit. It comprises the majority of the late Famennian back-reef.

The oolite sub-facies (Pl. 42) is composed of coarse to fine ooliths and is virtually devoid of fossils apart from oncolites and large pelecypods (Eumegalodon). Playford & Lowry (p. 58) compare it to the oolite sand of the Great Bahama Bank.

The coral sub-facies is restricted to the Givetian and early Frasnian parts of the reef-complex. It is characterized by the presence of biostromal beds of branching corals, including Alveolites,

Thamnapora, Hexagonaria, Disphyllum, Temnophyllum and Donia. They are especially common close to the reef.

The oncolite sub-facies (Pl. 43) is restricted in distribution. It is composed of beds of oolite or calcarenite containing abundant algal oncolites. The oncolites commonly contain a nucleus of a gastropod or crinoid columnal.

(iii) Fore-Reef and Inter-Reef Facies - Playford & Lowry divide the fore-reef into several formations distinguished by their different lithological characters. In the northwest portion both the fore- and inter-reef facies are referred to the Napier Formation; it is dominantly limestone with some calcareous sandstone and siltstone and occasional shale and conglomerate. Megabreccias composed of enormous blocks of reef limestone are common. Algae, sponges and abundant brachiopods are often present in the upper parts of the fore-reef facies adjoining the reef.

In the southeastern part of the area Playford & Lowry (1966, fig. 28) divide the fore- and inter-reef facies into five formations.

The Sadler Limestone (fore-reef) (Pl. 26) and Gogo Formation are of early Frasnian age. The Sadler Limestone is composed of yellow-grey limestone, with minor interbedded calcareous shales. The limestones are fine-grained, sparry to micritic, intraclastic calcarenites. It is richly fossiliferous, being characterized by abundant brachiopods (Veevers, 1959; Coleman, 1961). Also present are corals (Hill, 1954, 1965), gastropods, bryozoans (Ross, 1961), and ammonoids (Glenister, 1958). The Gogo Formation is poorly exposed but is believed to consist of shale and siltstone, with thin lenticular limestones and layers of abundant limestone nodules. It contains an early Frasnian goniatite fauna (Glenister, 1958), radiolarians, sponge spicules, and ostracodes (Glenister & Crespín, 1959) and well preserved fish and crustacean remains being described by Dr. E. I. White of the British Museum and Dr. W. D. Ian Rolfe.

The Sadler Limestone and Gogo Formation are of approximately the same age and intertongue with one another. Playford & Lowry (p. 75) interpret the Gogo Formation as the inter-reef facies equivalent to the fore-reef Sadler Limestone.

The Virgin Hills Formation is a sequence of red limestone, calcareous siltstone, and sandstone. It overlies the Sadler Limestone and Gogo Formations and Playford & Lowry (p. 76) consider it to include both fore- and inter-reef facies. Fossils are abundant, especially goniatites (Teichert, 1941, 1943), nautiloids (Teichert, 1939, 1940), brachiopods (Veevers, 1959), corals (Hill, 1954), sponges (Howell, 1952). Also recorded are arenaceous foraminifera, radiolaria, and ostracodes (Glenister & Crespin, 1959). The foraminifera were described by Glenister (1961).

The Bugle Gap Limestone is a fore-reef facies which inter-fingers with the upper part of the Virgin Hills Formation (Playford & Lowry, p. 81). It consists of white to pink, intraclastic, sparry, fine to very coarse-grained calcarenite. Crinoidal debris is abundant and depositional dips are as high as 30° (*ibid.*). Fossils are comparatively rare but include brachiopods (Veevers, 1959) and corals (Hill, 1954).

The Piker Hills Formation is the youngest formation of the reef complex and, like the Virgin Hills Formation, is considered by Playford & Lowry (p. 82) to include both fore- and inter-reef facies. Faunally, brachiopods are abundant (Veevers, 1959) and ammonoids, foraminifera and bryozoans (Ross, 1961) are known.

4. Collecting Localities

The majority of samples were collected from measured sections. Occasional samples were collected as spot samples. All the samples of Windjana Limestone (reef) were as spot samples, but usually along a section line. Because of the steep depositional dip of the fore-reef beds, up to 35° (Playford & Cockbain, 1969), the thicknesses measured were not true thicknesses. Sections in poorly outcropping

and ? flat-lying Gogo Formation (inter-reef) were collected at 0.1 mile intervals. The sections are numbered, but the sample numbers are not duplicated, so they were usually identified by the sample number range. A summary of the stratigraphic range of each section is given in Fig. 3 .

Section 1 (Fig. 19)

Location and Samples:

Samples BG 19001 - BG 19024, Bugle Gap, Run 5, Photo 5133.

Fore-reef deposits 50 yards due East of southern end of McWhae Ridge. Sample interval five feet. The section began in thin-bedded nodular limestones (Gogo Formation), the base of the Virgin Hills Formation began at the base of Sample BG 19008 which was one foot thick. The next 22 feet of section was covered; Sample BG 19009 is the Goniatite Bed. There is a five foot covered interval above both BG 19010 and BG 19011. Samples BG 19008 - BG 19016 consist of fine limestones and shale interbeds. BG 19017 and BG 19018 are massive limestones with a stromatolite bed in Sample BG 19018. BG 19019 - BG 19024 consist of alternating thin limestones with shales and massive limestones.

Age and Zonation:

Samples BG 19001 - BG 19006 represent the Lower Polygnathus asymmetricus Zone and the Middle Polygnathus asymmetricus Zone is represented by Samples BG 19007 and BG 19008 and includes both the uppermost Gogo Formation and the basal Virgin Hills Formation at this point. The Upper Polygnathus asymmetricus Zone is represented by Samples BG 19009 (above a 22 foot gap) to BG 19012. The sequence then appears to be condensed. Sample BG 19013 represents the Ancyrognathus triangularis Zone and Sample BG 19014 the Lower Palmatolepis gigas Zone. It was not possible to distinguish

Stratigraphic Range of Sections Sampled

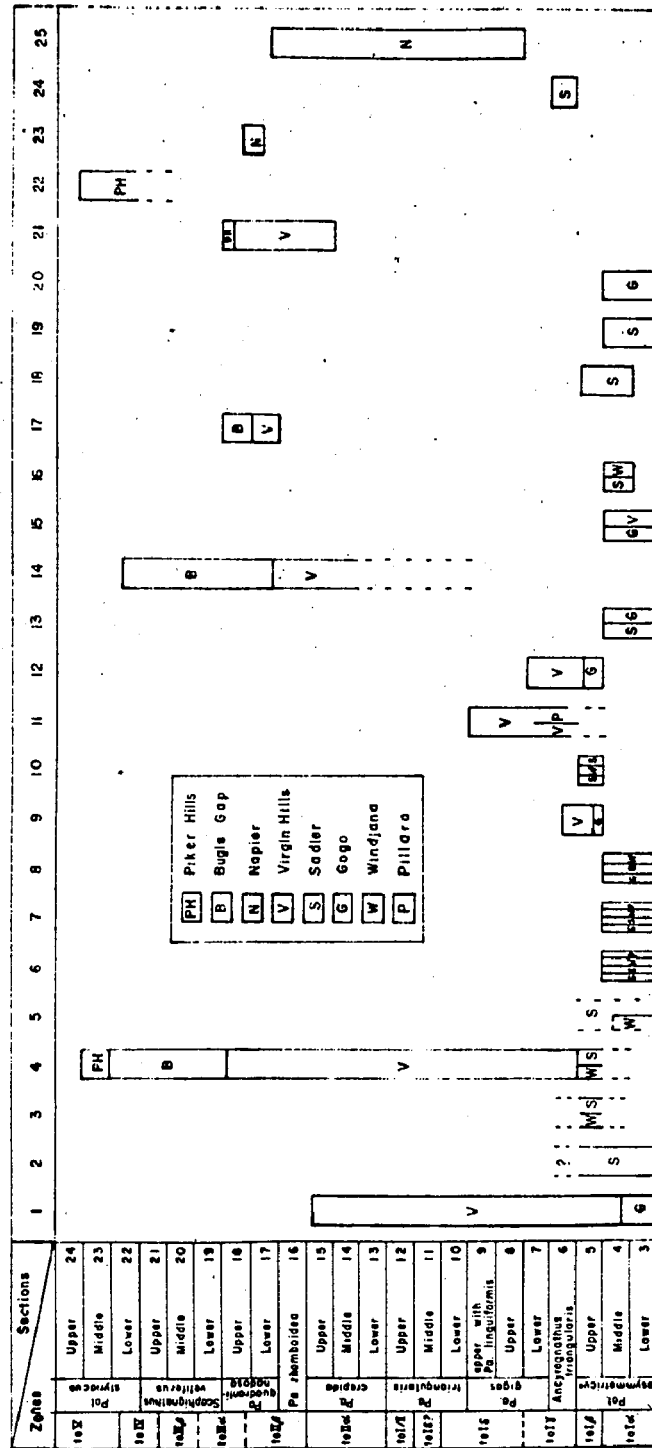


Figure 3

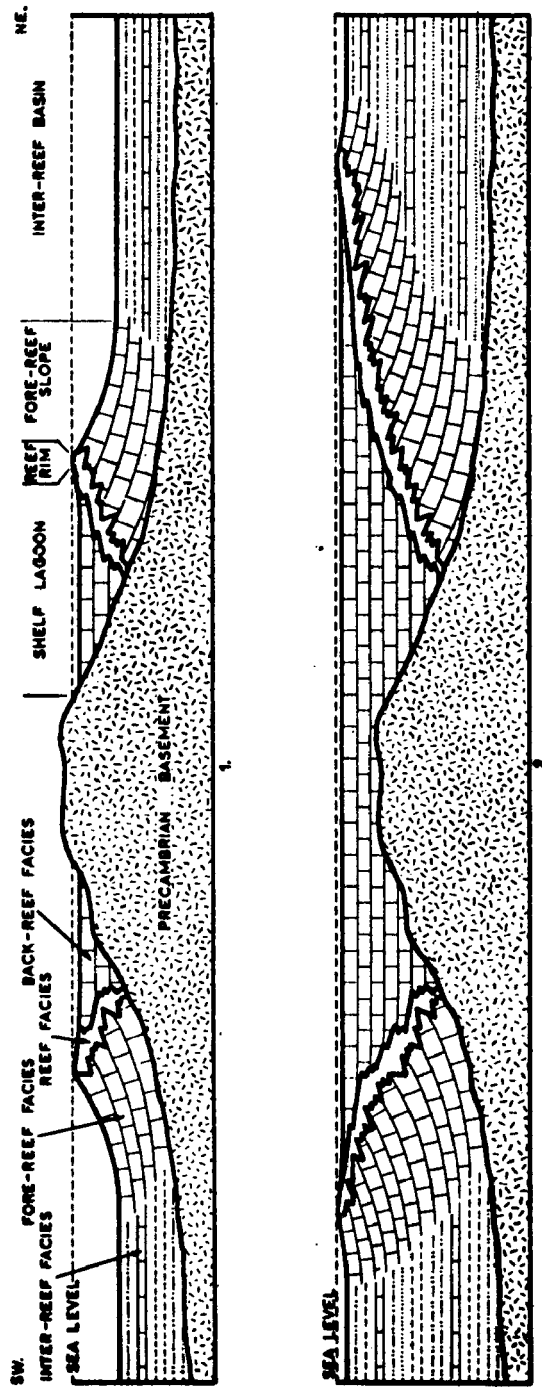


Figure 4 - Diagrammatic cross sections illustrating development of the Oscar Range reef complex. (After Playford & Lowry, 1966)

between the Upper Palmatolepis gigas Zone and the uppermost part with Palmatolepis linguiformis in this section and they are represented in Samples BG 19015 and BG 19016. The Lower and Middle Palmatolepis triangularis Zones are present in Sample BG 19017 and the Upper Palmatolepis triangularis Zone is represented by the stromatolite horizon (basal BG 19018), whereas the upper part of BG 19018 represents the Lower Palmatolepis crepida Zone. The Middle Palmatolepis crepida Zone is represented by the uppermost part of Sample BG 19018 and BG 19019 and the remainder of the section to BG 19024 represents the Upper Palmatolepis crepida Zone.

Section 2

Location and Samples:

Samples BG 19025 - BG 19042, Bugle Gap Run 5, Photo 5133, fore-reef deposits running East from core of reef in the central part of McWhae Ridge. All samples consist of massive Sadler Limestone trough sampled at five-foot intervals.

Age and Zonation:

The conodont fauna is sparse and lacks good zone fossils. Age assignments are questionable but Samples BG 19025 - BG 19032 probably belong to the Lower and Middle Polygnathus asymmetricus Zone. Samples BG 19033 - BG 19042 belong to the Upper Palmatolepis asymmetricus Zone because they contain Polygnathus normalis. No upper limit can be placed on this section.

Section 3

Location and Samples:

Samples BG 19043 - BG 19050, Bugle Gap Run 5, Photo 5133, reef and fore-reef running East from south end of McWhae Ridge towards the base of Section 1. Reef samples are spot-samples, fore-reef collected in five-foot intervals.

Age and Zonation:

Sample BG 19043 is Windjana Limestone (reef) and is one of the few reef samples obtained which yielded conodonts. None of the specimens in this section is very useful for dating but the reef probably belongs to the Upper Polygnathus asymmetricus Zone. Samples BG 19044 - BG 19050 are from the Sadler Limestone which is probably of Upper Polygnathus asymmetricus age.

Section 4 (Fig. 20)

Location and Samples:

Samples BG 19051 - BG 19183, BG 19448A - BG 19457; Bugle Gap Run 5, Photo 5133. This is the longest and most complete section and includes reef, fore-reef and possibly inter-reef deposits. The section begins at McWhae Ridge and runs northeast toward Mimbi Creek. Samples are usually trough samples over five-foot intervals. Samples BG 19051 - BG 19056 are spot samples of Windjana Limestone (reef) which yielded very few conodonts. BG 19057 and BG 19058 were 20-foot samples of Sadler Limestone.

Samples BG 19059 - BG 19061 were collected from thin shales and limestones belonging to the Virgin Hills Formation. The sequence is condensed in this region and samples BG 19064 to BG 19072 were re-collected at a section 50 yards away at one-foot intervals (BG 19448A - BG 19457). Samples BG 19073 to BG 19104 are five-foot samples in the Virgin Hills Formation. Samples BG 19105 to BG 19130 are from the Bugle Gap Limestone, collected at ten-foot intervals, and BG 19131 to BG 19181 are from the same formation at 20-foot intervals. Samples BG 19182 and BG 19183 are five-foot samples from the Piker Hills Formation.

Age and Zonation:

Samples BG 19051 - BG 19058 yielded a few conodonts. It was impossible to date these samples, but they are probably of Late Polygnathus asymmetricus Zone age. Samples BG 19059 and BG 19061

contain fragments of ancyrodelellids and palmatolepids and can probably be referred to the Ancyrognathus triangularis Zone which can be recognised in BG 19062. The subsidiary section (BG 19448A - BG 19457) begins in the Lower Palmatolepis gigas Zone (BG 19448A) and continues to the base of the Palmatolepis triangularis Zone (BG 19453B). As in Section 1 the Upper and uppermost (with Palmatolepis linguiformis) Palmatolepis gigas Zones could not be separated. Samples BG 19452C - 19452E include the first stromatolite horizon. Samples BG 19453B - BG 19453D represent the Lower Palmatolepis triangularis Zone and BG 19453E - BG 19454C represent the Middle Palmatolepis triangularis Zone. The Upper Palmatolepis triangularis Zone is confined to BG 19454D and the basal part of BG 19455 which is the second stromatolite bed. The Lower Palmatolepis crepida Zone is represented in the upper part of Sample BG 19455 and the Middle Palmatolepis crepida Zone is present in Samples BG 19456 and BG 19457. Samples BG 19072 and BG 19073 represents the Upper Palmatolepis crepida Zone. The Palmatolepis rhomboidea Zone is present in Samples BG 19074 through BG 19077. The Lower Palmatolepis quadrantinodosa Zone begins with the third stromatolite bed in Sample BG 19078 and ranges up through Sample BG 19106. BG 19105 is the base of the Bugle Gap Limestone. The interval BG 19107 through BG 19120 is referable to the Upper Palmatolepis quadrantinodosa Zone. The subzones of the Scaphignathus veliferus Zone cannot be readily recognized and the Zone ranges from Sample BG 19121 through BG 19160. The Lower Polygnathus styriacus Zone is present in the interval BG 19161 and BG 19181. The boundary between the Lower and Middle Polygnathus styriacus Zone is between BG 19181 and BG 19182. The Piker Hills Formation is only about 10 feet thick and it can all be referred to the Middle Polygnathus styriacus Zone.

Samples BG 19184 through BG 19200 and BG 19401 through BG 19447 were collected in the McWhae Ridge, Cave Spring area in an attempt to

elucidate the Windjana (reef), Sadler (fore-reef), and Pillara (back-reef) Limestones. Most of the faunas belonged to the Icriodus sequence of Seddon (1970).

Section 5

Location and Samples:

Samples BG 19458 - BG 19481, Bugle Gap Run 4, Photo 5118. Reef and fore-reef deposits from a section through Lloyd Hill atoll. The samples were collected at five-foot intervals and at ten-foot intervals from Sample BG 19472.

Age and Zonation:

The reef and lagoonal deposit samples failed to yield any conodonts. The fore-reef deposits yielded the Icriodus sequence. The sequence is probably of Polygnathus asymmetricus Zone age.

Section 6

Location and Samples:

Samples BG 19482 - BG 19493, Bugle Gap Run 4, Photo 5118. Section from Lloyd Hill atoll through Gogo Formation (inter-reef) (spot sampled at 0.10 mile interval) northeast to the Laidlaw Range, where the section crossed Sadler Limestone (fore-reef), Windjana Limestone (reef) and into Pillara Limestone (back-reef).

Age and Zonation:

Only the Gogo Formation and the Sadler Limestone yielded conodonts. They are referable to the Lower and Middle Polygnathus asymmetricus Zones. All formations appear to be the same age.

Section 7 (Fig. 21)

Location and Samples:

Samples BG 19494 - BG 19507, Bugle Gap Run 4, Photo 5117. Section W.S.W. from Laidlaw Range to Emanuel Range across Paddy's Valley, traversing Gogo Formation (inter-reef)

sediments, folded into a gentle syncline and Windjana Limestone (?) (reef) and Pillara Limestone (back-reef) in the Emanuel Range.

Age and Zonation:

The sediments are all of Polygnathus asymmetricus Zone age, mainly Lower and Middle; no conodonts were recovered from the Pillara Limestone.

Section 8

Location and Samples:

Samples BG 19508 - BG 19521, Bugle Gap Run 3, Photo 5110. Section northwest from Wade Knoll, including Windjana Limestone (reef) and Sadler Limestone (fore-reef) and ? Gogo (inter-reef).

Age and Zonation:

Only the Sadler and Gogo Limestones yielded conodonts. They are referable to the Lower and Middle Polygnathus asymmetricus Zone.

Section 9 (Fig. 22)

Location and Samples:

Samples BG 19543 - BG 19550; BG 19530 - BG 19542, Bugle Gap Run 3, Photo 5105. Section from tributary south of Mt. Pierre Creek, east of Waggon Pass to Balme Knoll, and east to McIntyre Knolls, through Gogo (inter-reef) and Virgin Hills (inter-reef) Formations.

Age and Zonation:

The complete section is referable to the Upper Polygnathus asymmetricus Zone, although spot samples near McIntyre Knolls showed the presence, at least, of the Ancyrognathus triangularis Zone. The Gogo - Virgin Hills boundary is at the base of Sample BG 19547.

Section 10

Location and Samples:

Samples BG 19551 - BG 19562, Bugle Gap Run 3, Photo 5107. East-West traverse across reef complex at Waggon Pass, collecting spot samples of Sadler Limestone (fore-reef), Windjana Limestone (reef), and more Sadler Limestone.

Age and Zonation:

The samples were barren, except for the Sadler, which is assigned to the Upper Polygnathus asymmetricus Zone.

Section 11

Location and Samples:

Samples BG 19563 - BG 19572, Bugle Gap Run 2, Photo 5094. Spot samples along creek about two miles northeast of Galeru Gorge, in Windjana Limestone (reef) and Virgin Hills Formation (fore-reef) and questionable back-reef sediments.

Age and Zonation:

The reef (Sample BG 19564) is probably of Polygnathus asymmetricus Zone age. The questionable back-reef is either of Ancyrognathus triangularis or Palmatolepis gigas Zone age. The fore-reef deposits are of Lower and Upper Palmatolepis gigas Zone age.

Section 12 (Fig. 23)

Location and Samples:

Samples BG 19577 - BG 19586, Bugle Gap Run 3, Photo 5107. Samples collected at five-foot intervals at low hill about one mile southwest of the western end of Waggon Pass. The section begins in the Gogo Formation (inter-reef) and Virgin Hills Formation (inter-reef); the base of Sample BG 19579 represents the base of the Virgin Hills Formation.

Age and Zonation:

The Gogo Formation samples are of Upper Polygnathus

asymmetricus Zone and the Virgin Hills samples range from the same zone up to the Lower Palmatolepis gigas Zone.

Section 13

Location and Samples:

Samples BG 19587 - BG 19600; BG 21001 - BG 21003, Bugle Gap Run 4, Photo 5118. Section from Glenister Knolls due east, traversing Sadler (fore-reef) and Gogo (inter-reef) Formations. There is some interfingering of Sadler and Gogo Formations.

Age and Zonation:

The section is confined to the Lower and Middle Polygnathus asymmetricus Zone.

Section 14 (Fig. 24)

Location and Samples:

Samples BG 21011 - BG 21062, Bugle Gap Run 5, Photo 5136. Section southwest from Cadjebut Fault, two miles northwest of Pinnacle Spring. Section through Virgin Hills Formation (fore-reef) and Bugle Gap Limestone trough sampled at 10-foot intervals.

The Virgin Hills - Bugle Gap boundary is at the base of Sample BG 21023.

Age and Zonation:

The section runs from the Middle Palmatolepis crepida Zone (BG 21011 - BG 21012) through the Upper P. gigas Zone (BG 21013), Palmatolepis rhomboidea Zone (BG 21014 - BG 21019), Lower Palmatolepis quadrantinodosa Zone (BG 21020 - BG 21028), Upper Palmatolepis quadrantinodosa Zone (BG 21029 - 21050), Lower Scaphignathus veliferus Zone (? BG 21051 - BG 21052), Middle Scaphignathus veliferus Zone (BG 21053 - BG 21056), Upper Scaphignathus veliferus Zone (BG 21057 - BG 21058), into the Lower Polygnathus styriacus Zone (BG 21059 - BG 21062). Spot samples collected northwest along the Cadjebut Fault indicate the presence of Virgin Hills strata as old as the uppermost Palmatolepis gigas Zone.

Section 15

Location and Samples:

Samples BG 21064 - BG 21076, Bugle Gap Run 4, Photo 5120. Section from Gogo Formation (inter-reef), Virgin Hills Formation (fore-reef) and Pillara Limestone (back-reef) in the east side of the Lawford Range 1.5 miles S.S.W. of the southwest corner of Teichert Hills.

Age and Zonation:

The Pillara Limestone did not yield any conodonts but the fore- and inter-reef samples are referred to the Lower and/or Middle Polygnathus asymmetricus Zone.

Section 16

Location and Samples:

Samples BG 21077 - BG 21088, Bugle Gap Run 4, Photo 5120. Section from Virgin Hills Formation (fore-reef), Sadler Limestone (fore-reef), Windjana Limestone (reef) and Pillara Limestone (back-reef) at the southwest end of the Teichert Hills.

Age and Zonation:

The Virgin Hills Formation proved to be barren, as did the back-reef samples. The Sadler Limestone (BG 21081 - BG 21082) and Windjana Limestone (BG 21083) yielded faunas of Middle Polygnathus asymmetricus Zone age.

Section 17

Location and Samples:

Samples BG 21093 - BG 21102, Bugle Gap Run 6, Photo 5145. Section of Virgin Hills Formation and Bugle Gap Limestone from Ngumban Cliff near Pinnacle Spring east and then south-southeast.

Age and Zonation:

Sample BG 21093 is immediately above the stromatolite bed and is of Lower Palmatolepis quadrantinodosa Zone age. The Upper

Palmatolepis quadrantinodosa Zone begins at the base of Sample BG 21099, which is the base of the Bugle Gap Limestone. No younger zones were recognized.

Samples BG 21103 - BG 21127 were all spot samples collected around the northern rim of the Lawford Range; only the fore-reef samples (Virgin Hills Formation) yielded conodonts, which generally indicated a Lower Palmatolepis gigas Zone. Samples BG 21128 - BG 21149 were all spot samples of Pillara Limestone (back-reef), collected on a traverse between Lawford Spring and the southern rim of the eastern Lawford Range. No conodonts were recovered. Samples BG 21150 - BG 21167 were spot samples of Virgin Hills Formation in the Old Bohemia area. They ranged in age from Lower Palmatolepis crepida age up to the Palmatolepis rhomboidea Zone. Samples BG 21171 - BG 21186 were collected in Pillara Limestone (back-reef) along Kunian Gap in the Emanuel Range and yielded no conodonts.

Section 18

Location and Samples:

Samples BG 21187 - BG 21204. Section collected on northeast side of Kudata Gap, Emanuel Range in Sadler Limestone (fore-reef).

Age and Zonation:

Those samples which yielded conodonts indicate the Middle and/or Upper Polygnathus asymmetricus Zone.

Section 19

Location and Samples:

Samples BG 21205 - BG 21239. Section of Sadler Limestone (fore-reef) at Sadler Ridge, northeast side of Emanuel Range.

Age and Zonation:

The samples which yielded conodonts indicate the Lower and/or Middle Polygnathus asymmetricus Zone.

Section 20

Location and Samples:

Samples BG 21240 - BG 21255. Section of Gogo Formation (inter-reef) along Long's Well Creek, northeast side of Emanuel Range.

Age and Zonation:

All the samples which yielded conodonts indicate the Lower and/or Middle Polygnathus asymmetricus Zone.

Section 21 (Fig. 25)

Location and Samples:

Samples BG 21256 - BG 21282. Section along creek from Margaret River west to Needle-Eye Rocks ($125^{\circ} 52' \text{ E}$; $18^{\circ} 16' \text{ S}$). Trough samples at 10-foot intervals were collected through the Virgin Hills Formation into the Piker Hills Formation, the base of which was drawn at the base of sample BG 21281.

Age and Location:

The section ranges from the Upper Palmatolepis crepida Zone (BG 21256 - BG 21265), through the Palmatolepis rhomboidea Zone (BG 21266), Lower Palmatolepis quadrantinodosa Zone (BG 21267) as high as the Upper Palmatolepis quadrantinodosa Zone (BG 21268 - BG 21282).

Samples BG 21283 - BG 21287 were collected in Pillara Limestone (back-reef) and Sadler Limestone (fore-reef) from the south end of the Home Range, but yielded no conodonts.

Samples BG 21288 - BG 21341 were collected in Pillara Limestone (back-reef) and Sadler Limestone (fore-reef) through Menyous Gap in the Pillara Range.

Samples BG 21342 - BG 21351 were collected from the Fairfield Formation (post-reef platform carbonates and shales) at the eastern edge of the Horseshoe Range.

Section 22

Location and Samples:

Samples BG 21352 - BG 21359. Section at the end of the Piker Hills; trough-samples at five-foot intervals in the Piker Hills Formation (inter-reef).

Age and Zonation:

The age of the section cannot be accurately determined; it is younger than the Upper Palmatolepis quadrantinodosa Zone. Sample BG 21355 is of Lower Polygnathus styriacus Zone age and Samples BG 21358 - BG 21359 are of Middle Polygnathus styriacus Zone age.

Section 23

Location and Samples:

Samples BG 21360 - BG 21365, Section of spot samples taken through the Napier Formation two miles west of the mouth of Geikie Gorge.

Age and Zonation:

All samples yielded a fauna indicative of the boundary between the Lower and Upper Palmatolepis quadrantinodosa subzones.

Section 24

Location and Samples:

Samples BG 21367 - BG 21372, Bugle Gap Run 4, Photo 5121. Section of five-foot samples in Sadler Limestone (fore-reef) and Windjana Limestone (reef).

Age and Zonation:

Only one sample (BG 21371) yielded an abundant fauna, which indicated the Ancyrognathus triangularis Zone.

Section 25**Location and Samples:**

Samples BG 21612 - BG 21629. Section taken at Narlarla Lead Mine in the Napier Formation.

Age and Zonation:

The section ranges in age from the Upper Palmatolepis gigas Zone up to the Lower Palmatolepis quadrantinodosa Zone. Two stromatolite beds occur, one at the base of the Lower Palmatolepis crepida Zone and the other at the base of the Lower Palmatolepis quadrantinodosa Zone.

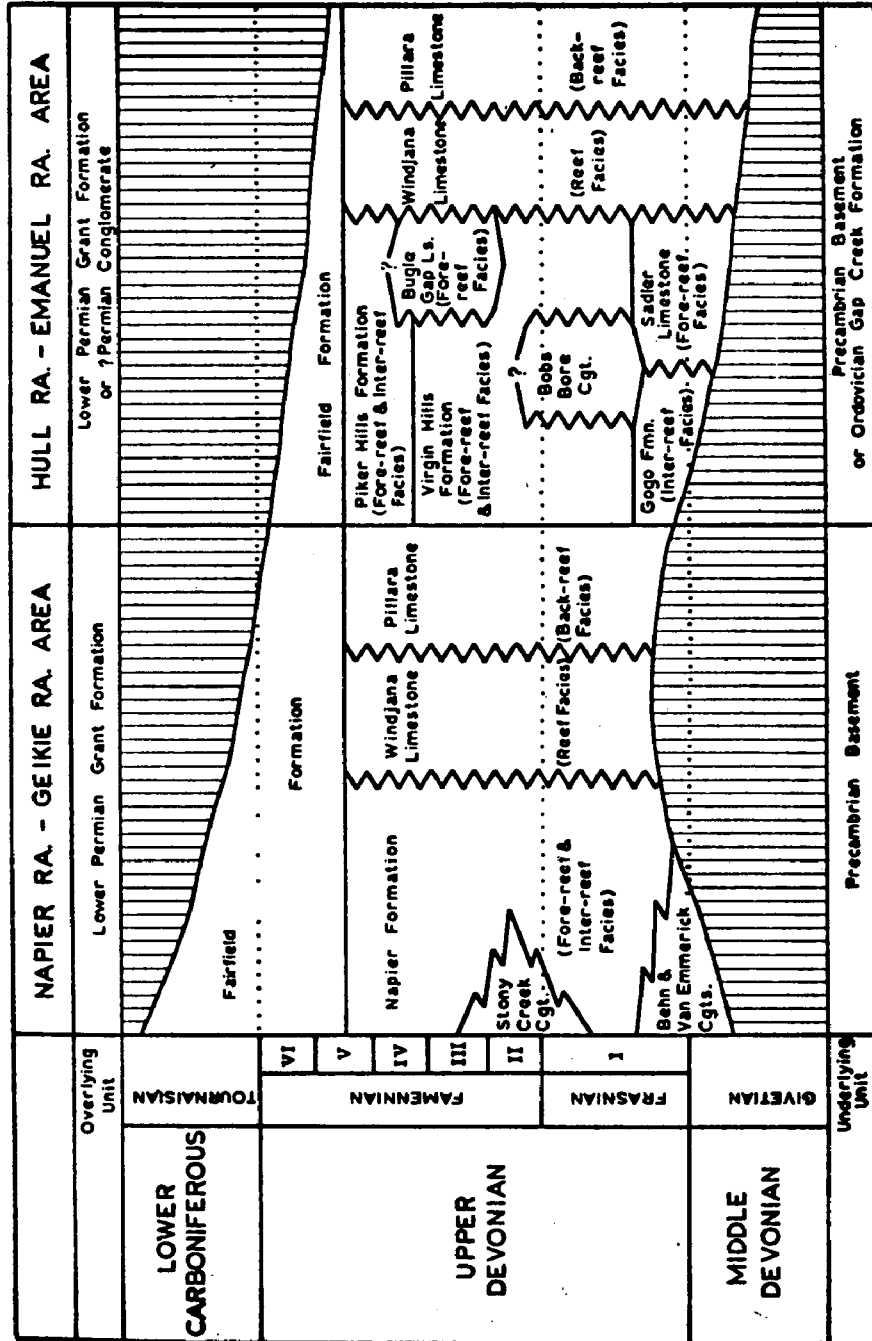


Figure 5 - Stratigraphic correlation chart of Devonian formations, Lennard Shelf, Canning Basin. (After Playford & Lowry, 1966)

III CONODONTS

1. Introduction

Conodonts are microscopic fossils usually about one mm in length, but in some cases as large as five mm. They were first described in 1856 from the Baltic area by Pander. His specimens were recovered from the early Ordovician greensand of Estonia, the conodont faunas of which have since been described by Öpik (1927, 1930, 1936) and Viira (1966). An interesting sidelight is that Öpik, whilst working in the Bonaparte Gulf Basin of northwestern Australia, discovered a glauconitic sandstone rich in early Ordovician conodonts. In honor of Dr. Pander, he named the locality Pander Ridge and the sandstone the Pander Greensand (Öpik, in Guppy et al., 1958; Jones, in press).

Conodont studies can be divided into three periods: the classic period until about 1950; the development period up to very recently; and the present, the diversification period, in which conodont ecology and the nature of the conodont animal are major research areas.

(i) Classical Period - After Pander's initial discoveries, conodont studies were slow to multiply. Many reports of conodonts from the British Isles were published, although no major papers on taxonomy appeared (Harley, 1861; Moore, 1864, 1870; Young, 1880; Smith & Jones, 1881). The presence of conodonts in North America was first reported by Hinde (1879) from the Devonian and questionably Cambro-Ordovician of Canada and the United States (see Lindström, 1964, pp. 3-4). In a paper published in 1913, Hadding described Ordovician conodonts from black shales with graptolites. This was to prove extremely valuable in equating the new conodont zones with the established graptolite zones. Later, Lindström (1957) found associated conodonts and graptolites in the Ordovician of Sweden and Great Britain.

The study of conodonts increased considerably in the nineteen twenties and nineteen thirties and was mainly centred in the United States. The presence of abundant, well preserved conodonts in black

shales, mainly of Devonian age, encouraged many workers to study them. Published papers include those of Bryant (1921), Ulrich & Bassler (1926), and Hibbard (1927). These were followed by Holmes (1928), who published a bibliography of conodonts which greatly stimulated further research, especially in the United States.

Branson & Mehl, in innumerable papers between 1934 and 1938, laid the foundation for modern conodont studies by systematically describing faunas of Ordovician, Silurian, Devonian and Carboniferous age. Other papers by Huddle (1934), Stauffer (1935a, 1935b, 1938, 1940) and Furnish (1938), also appeared at this time.

During this period natural assemblages were described contemporaneously in North America (Scott, 1934) and Germany (Schmidt, 1934).

(ii) Development Period - These studies, which were essentially taxonomic, laid the basis for the second period of conodont studies, the development period. This took place in Europe and resulted in the discovery that conodont faunas changed in a rapid temporal succession and could be used to solve stratigraphic problems. This was the result of work on the Ordovician (Rhodes, 1953, 1955; Lindström, 1954), Silurian (Rhodes, 1953) and Devonian (Beckmann, 1949, 1953; Sannemann, 1955a, b) Systems. Beckmann's work was important because he compared his German material with faunas from rocks of a similar age in North America. The first zonation scheme for the Upper Devonian was erected by Sannemann (1955b).

The zonation of the Upper Devonian and Lower Carboniferous was refined and expanded in a classical series of papers by Bischoff (1956; 1957), Bischoff & Ziegler (1956; 1957), Helms (1959), Voges (1959; 1960) and Ziegler (1956; 1957; 1958a, b; 1962; 1965). This development, together with the publication of Fay's catalogue (1952), and Ash's (1961; 1963) and Ellison's (1962; 1963; 1964; 1967) bibliographies and Hass's (1962) treatise, stimulated a massive increase in

conodont studies.

The description of new faunas, the erection of further zonation schemes, the refinement of taxonomy and the correlation of conodont bearing strata on a world-wide basis had begun. Study was extended to Cambrian faunas which were first reported by Müller (1956) and described by him later (1959).

2. Methods (Pls. 29-36)

The methods of recovery used were similar to those outlined by Druce and Wilson (1967). A mobile laboratory consisting of an 18' x 8' trailer with overhead water tanks was used to house the library and for microscopic work. The general processing of samples was carried out in the open air.

Samples were collected from measured sections. Most sections were trough-sampled through five-foot intervals, though in some of the thicker sections, especially in the Bugle Gap Limestone, the intervals were at 10 or rarely 20 feet. In other cases where the sequence appeared to be condensed, the sampling interval was reduced to one foot. Reef samples were all spot samples, usually on a section line.

The samples were collected in heavy duty plastic bags, the average weight being two kilograms in the pilot samples. The samples were returned to the laboratory area where they were crushed in a three inch jaw crusher mounted on the rear of a 4-wheel drive truck and driven by a 2 h.p. power kerosene engine.

Each sample was crushed into one-quarter inch chips and then sieved through an 8-mesh sieve to remove the "fines." The "fines" were collected and bagged and returned to Canberra for ostracod analysis. Many samples contained ostracods and the crushing action tends to liberate them from the matrix.

The chips were retained and about 0.5 kilogram of each sample was placed in a two gallon polyethylene bucket and a measured portion of crystalline monochloroacetic acid was added. The monochloroacetic

acid was transported in 44 gallon drums by sea to Derby and then by truck to the laboratory site.

Water was added, pumped in from a nearby spring and the buckets were left 24 hours to react. After 24 hours, all the limestone had reacted and the samples were then sieved through a 120 mesh sieve, the "fines" being discarded. The residue was then dried in the sun and bottled ready for separation.

Six separation funnels were mounted on an outdoor bench and each sample was separated in bromoform (S.G. 2.9); the light fraction was discarded and the heavy fraction was washed with white spirit (methylated spirit) and dried.

These concentrated residues were then searched under a binocular microscope and all conodonts and fragments still possessing a basal cavity were removed onto a slide. These specimens were then mounted on 100 square slides, each specimen to its own individual square. Rough identifications were made in the field to aid in the mapping and problematical or abundant faunas were re-collected.

On return to the main laboratory all specimens which could not be identified with previously described forms were photographed and their distribution recorded. These were then checked systematically, using all known conodont publications.

After identification or designation as new species, each was described and its range and occurrence, and, when possible, its phylogenetic relationships were recorded. Specimens were selected for illustration purposes; all photographs were taken on Ilford KB14 film using a Leitz Orthomat microscope camera.

3. Nature of Faunas

(i) Introduction - Altogether, some 770 samples were collected from the various facies of the reef-complex, and some 5500 specimens were recovered which could be assigned to a species. Many fragments which could be referred only to genera were also recovered.

The distribution of conodonts was far from uniform. The back-reef and reef facies were virtually devoid of conodonts, a fact noted by Seddon (1970, p. 726), which is dissimilar to the known occurrences in the Bonaparte Gulf Basin (Druce, 1969). This discrepancy is probably due to a difference in depth of the back-reef and reef facies in the two areas. The Bonaparte Gulf sediments probably accumulated in slightly deeper waters, allowing the presence of Biozone II faunas in those regions (see below).

Within the fore-reef deposits the faunas are not consistent. Seddon (1970, p. 727) records an Icriodus sequence and a Palmatolepis sequence. I have recognised three biozones within the fore-reef (see below). It is extremely difficult to correlate Biozones I and II with the standard sequence of zones developed from Biofacies III faunas. The cone genera, and icriodids and polygnathids do not appear to be of great chronological importance and tend to occur in the section whenever the ecological conditions were suitable. The deeper part of the fore-reef and the inter-reef sediments usually yield good faunas.

A total of 233 species (and subspecies) referable to 34 genera was identified. The genus Palmatolepis was represented by 35 species (and subspecies), Polygnathus by 33, Icriodus by 23 subspecies, and Spathognathodus by 15 (most of which have been left in open nomenclature). The charts on pp. 33-50 show the stratigraphical distribution of all species described.

(ii) Generic Distribution -

Acodina (4 species). This genus is common in Biozones I and II. The species show some chronological division. A. formosa occurs throughout the Frasnian and into the lower part of the Famennian. A. inopinata begins in the late Frasnian and continues into the Middle Famennian; A. sammemanni occurs in the Lower and Middle Famennian and A. zionensis is confined to the Middle Famennian. However, these species may all be ecologically controlled, and the stratigraphic ranges determined from my samples may not hold true in other regions or even in the same basin.

- 101 *Acodina formosa*
- 102 *Acodina inopinata*
- 103 *Acodina sannemanni*
- 104 *Acodina zionensis*
- 105 *Ancyrodella buckeyensis*
- 106 *Ancyrodella curvata*
- 107 *Ancyrodella gigas*
- 108 *Ancyrodella ioides*
- 109 *Ancyrodella lobata*
- 110 *Ancyrodella nodosa*
- 111 *Ancyrodella rotundiloba* s.s.
- 112 *Ancyrodella rotundiloba alata*
- 113 *Ancyrodella rotundiloba binodosa*
- 114 *Ancyrodella rugosa*
- 115 *Ancyrodella* sp. nov. A
- 116 *Ancyrognathus asymmetricus*
- 117 *Ancyrognathus altus*
- 118 *Angulodus* sp. cf. *A. pergracilis*
- 119 *Angulodus* sp.
- 120 *Apatognathus varians* s.s.
- 121 *Apatognathus varians klapperi*
- 122 *Apatognathus* sp. nov. A
- 123 *Apatognathus* sp. A
- 124 *Apatognathus* sp. B
- 125 *Apatognathus* sp. C
- 126 *Belodella devonica*
- 127 *Belodella erecta*

[illegible]

- 128 *Belodella resima*
- 129 *Belodella costata*
- 130 *Belodella triangularis*
- 131 *Bryantodus macrodentes*
- 132 *Bryantodus nitidus*
- 133 *Bryantodus typicus*
- 134 *Camptognathus conus*
- 135 *Camptognathus erectus*
- 136 *Drepanodus* sp.
- 137 *Elsonella* sp.
- 138 *Enantiognathus lipperti*
- 139 *Enantiognathus* cf. *E. inversus*
- 140 *Falcodus aculeatus*
- 141 *Falcodus guntharii*
- 142 *Falcodus variabilis*
- 143 *Falcodus* cf. *F. variabilis*
- 144 *Falcodus* sp. nov. A
- 145 *Falcodus* sp.
- 146 *Falcodus* sp. indet.
- 147 *Hibbardella* (*Diplododella*) *alternata*
- 148 *Hibbardella* (*Hibbardella*) *angulata*
- 149 *Hibbardella* (*Diplododella*) *aurita*
- 150 *Hibbardella* (*Hassognathus*) *franca*
- 151 *Hibbardella* (*Hibbardella*) *multidens*
- 152 *Hibbardella* (*Diplododella*) *plana*
- 153 *Hibbardella* (*Hassognathus*) *separata*
- 154 *Hibbardella* (*Hassognathus*) sp.

- 155 *Hindeodella brevis*
- 156 *Hindeodella compressa*
- 157 *Hindeodella corpulenta*
- 158 *Hindeodella subtilis*
- 159 *Hindeodella uncata*
- 160 *Hindeodella* cf. *H. moweri*
- 161 *Hindeodella* sp. A
- 162 *Hindeodella* sp. B
- 163 *Hindeodella* sp. C
- 164 *Hindeodella* sp. D
- 165 *Hindeodella* sp. E
- 166 *Icriodus alternatus* s.s.
- 167 *Icriodus alternatus costatus*
- 168 *Icriodus alternatus curvirostratus*
- 169 *Icriodus alternatus cymbiformis*
- 170 *Icriodus alternatus elegantulus*
- 171 *Icriodus alternatus* subsp. a
- 172 *Icriodus arkonensis* s.s.
- 173 *Icriodus arkonensis* subsp. a
- 174 *Icriodus arkonensis* subsp. b
- 175 *Icriodus arkonensis* subsp. c
- 176 *Icriodus brevis* s.s.
- 177 *Icriodus brevis darbyensis*
- 178 *Icriodus brevis spicatus*
- 179 *Icriodus brevis* subsp. a
- 180 *Icriodus brevis* subsp. b
- 181 *Icriodus incrassatus* s.s.

- 182 *Icriodus incrassatus* subsp. a
- 183 *Icriodus incrassatus* subsp. b
- 184 *Icriodus incrassatus* subsp. c
- 185 *Icriodus symmetricus* s.s.
- 186 *Icriodus symmetricus circularis*
- 187 *Icriodus symmetricus expansus*
- 188 *Icriodus symmetricus* subsp. nov. a
- 189 *Kladognathus* sp.
- 190 *Ligonodina magnidens*
- 191 *Ligonodina panderi*
- 192 *Ligonodina spiculata*
- 193 *Ligonodina* sp. nov. A
- 194 *Ligonodina* sp. nov. B
- 195 *Ligonodina* sp.
- 196 ?*Ligonodina* sp.
- 197 *Lonchodina arcuata*
- 198 *Lonchodina perlonga*
- 199 *Lonchodina typicalis*
- 200 *Lonchodina* sp. A
- 201 *Lonchodina* sp.
- 202 *Neoprioniodus armatus* - *alatus* group
- 203 *Neoprioniodus semiseparatus*
- 204 *Neoprioniodus* sp.
- 205 *Nothognathella abbreviata*
- 206 *Nothognathella abnormis*
- 207 *Nothognathella brevidonta*
- 208 *Nothognathella falcata*

Species 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- 209 *Nothognathella iowensis*
- 210 *Nothognathella klapperi*
- 211 *Nothognathella palmatoformis*
- 212 *Nothognathella polygnathoidea*
- 213 *Nothognathella sublaevis*
- 214 *Nothognathella typicalis*
- 215 *Nothognathella* sp. nov. A
- 216 *Ozarkodina homoarcuata*
- 217 *Ozarkodina immersa*
- 218 *Ozarkodina* ? *lacera*
- 219 *Ozarkodina macra*
- 220 *Ozarkodina versa*
- 221 *Ozarkodina* sp. A
- 222 *Ozarkodina* sp. B
- 223 *Ozarkodina* sp. C
- 224 *Ozarkodina* sp. D
- 225 *Ozarkodina* sp. E
- 226 *Ozarkodina* sp. F
- 227 *Ozarkodina* ? sp.
- 228 *Palmatodella delicatula*
- 229 *Palmatodella unca*
- 230 *Palmatodella* sp. A
- 231 *Palmatolepis delicatula*
- 232 *Palmatolepis distorta*
- 233 *Palmatolepis foliacea*
- 234 *Palmatolepis gigas*
- 235 *Palmatolepis glabra* s.s.

- 236 *Palmatolepis glabra acuta*
- 237 *Palmatolepis glabra elongata*
- 238 *Palmatolepis glabra pectinata*
- 239 *Palmatolepis gracilis*
- 240 *Palmatolepis hassi*
- 241 *Palmatolepis linguiformis*
- 242 *Palmatolepis minuta s.s.*
- 243 *Palmatolepis minuta loba*
- 244 *Palmatolepis minuta schleizia*
- 245 *Palmatolepis perlobata s.s.*
- 246 *Palmatolepis perlobata sigmoidea*
- 247 *Palmatolepis proversa*
- 248 *Palmatolepis punctata*
- 249 *Palmatolepis quadrantinodosa inflexoidea*
- 250 *Palmatolepis quadrantinodosa marginifera*
- 251 *Palmatolepis quadrantinodosolobata*
- 252 *Palmatolepis regularis*
- 253 *Palmatolepis rugosa ampla*
- 254 *Palmatolepis rugosa grossi*
- 255 *Palmatolepis cf. rugosa trachytera*
- 256 *Palmatolepis subgracilis*
- 257 *Palmatolepis subperlobata s.s.*
- 258 *Palmatolepis subperlobata subsp. A*
- 259 *Palmatolepis subrecta*
- 260 *Palmatolepis tenuipunctata*
- 261 *Palmatolepis transitans*
- 262 *Palmatolepis triangularis*

- 263 *Palmatolepis unicornis*
- 264 *Palmatolepis* cf. *P. triangularis*
- 265 *Palmatolepis* sp. nov. A
- 266 *Pelekysgnathus elevatus*
- 267 *Pelekysgnathus* sp.
- 268 *Polygnathellus multidentatus*
- 269 *Polygnathellus* cf. *P. typicalis*
- 270 *Polygnathus asymmetricus* s.s.
- 271 *Polygnathus asymmetricus ovalis*
- 272 *Polygnathus australis*
- 273 *Polygnathus brevilaminus*
- 274 *Polygnathus collinsoni*
- 275 *Polygnathus decorosus*
- 276 *Polygnathus delicatulus*
- 277 *Polygnathus fallax*
- 278 *Polygnathus foliatus*
- 279 *Polygnathus germanus* s.s.
- 280 *Polygnathus germanus* subsp. A
- 281 *Polygnathus germanus* subsp. B
- 282 *Polygnathus glaber* s.s.
- 283 *Polygnathus irregularis*
- 284 *Polygnathus janeti*
- 285 *Polygnathus nodosus*
- 286 *Polygnathus normalis*
- 287 *Polygnathus norrisi*
- 288 *Polygnathus obliquicostatus*
- 289 *Polygnathus pennatus*

[illegible]

- 290 *Polygnathus perplexus*
- 291 *Polygnathus pollocki*
- 292 *Polygnathus seddoni*
- 293 *Polygnathus semicostatus*
- 294 *Polygnathus spatulatus*
- 295 *Polygnathus subserratus*
- 296 *Polygnathus triphyllatus*
- 297 *Polygnathus* cf. *P. webbi*
- 298 *Polygnathus xylus*
- 299 *Polygnathus znepolensis*
- 300 *Polygnathus* sp. nov.
- 301 *Polygnathus* sp. A
- 302 *Polygnathus* sp. B
- 303 *Polylophodonta confluens*
- 304 *Polylophodonta elongata*
- 305 *Prioniodina* ? *smithi*
- 306 *Pseudopolygnathus* sp. A
- 307 *Scaphignathus veliferus*
- 308 *Scaphignathus zieglerei*
- 309 *Scutula bipennata*
- 310 *Scutula sinepennata*
- 311 *Scutula venusta*
- 312 *Scutula* sp. A
- 313 *Scutula* sp. B
- 314 *Spathognathodus bohlenanus*
- 315 *Spathognathodus* cf. *S. brevis*
- 316 *Spathognathodus fitzroyi*

- 317 *Spathognathodus* cf. *S. robustus*
- 318 *Spathognathodus stabilis*
- 319 *Spathognathodus strigosus*
- 320 *Spathognathodus* sp. nov. A
- 321 *Spathognathodus* sp. B
- 322 *Spathognathodus* sp. C
- 323 *Spathognathodus* sp. D
- 324 *Spathognathodus* sp. E
- 325 *Spathognathodus* sp. F
- 326 *Spathognathodus* sp. G
- 327 *Spathognathodus* sp. H
- 328 *Spathognathodus* sp. I
- 329 *Synprioniodina* cf. *S. alternata*
- 330 *Synprioniodina* sp. A
- 331 *Synprioniodina* sp. B
- 332 *Tripodellus robustus*
- 333 Gen. et sp. nov.

Ancyrodella (11 species). This genus is confined to the Frasnian. The ranges and phylogenetic affinities are presented in Figure 20.

Ancyrognathus (2 species). The genus is rare in the Canning Basin. Both species occur in the Palmatolepis gigas Zone.

Angulodus (2 species). Both species are rare and occur in the Famennian.

Apatognathus (6 species). This genus is probably ecologically controlled. Specimens all occur in the Famennian, except for Apatognathus sp. C which occurs in the Frasnian. Apatognathus sp. A ranges from the early Frasnian up to the Middle Famennian.

Belodella (5 species). This genus appears to be virtually confined to Biofacies I. The majority of samples of Biofacies I are of early Frasnian age and all species are confined to that horizon in my faunas. However, this does not necessarily indicate the true range even in the Canning Basin.

Bryantodus (3 species). B. typicus is early Frasnian; B. nitidus ranges from the base of the Frasnian into the early Famennian; B. macrodentus is of early Famennian age.

Camptognathus (2 species). Both species are confined to the early Frasnian.

Drepanodus (1 species). This species is facies controlled and, in the present faunas, is restricted to the early Frasnian.

Elsotella (1 species). The single species ranges from Middle Frasnian to Middle Famennian.

Enantiognathus (2 species). This genus appears to be facies controlled and in the present faunas occurs in the early Frasnian.

Falcodus (7 species). All the species except F. guntharii and Falcodus sp. indet. occur in the Famennian.

Hibbardella (8 species). All the species are long ranging, except H. (H.) multidentis which is confined to the Frasnian and H. (Hassognathus) franca which is restricted to the Middle Famennian.

Hindeodella (11 species). Many of the distinctive hindeodellids are not referable to any known species. These species, which have been left in open nomenclature, have restricted ranges and may be important. The described species are all long-ranging.

Icriodus (23 species). The distribution, facies control, and nomenclature problems are discussed under the generic heading in the systematics.

Kladognathus (1 species). The single species is rare, but ranges throughout the Frasnian into the early Famennian.

Ligonodina (7 species). All the species which are represented by more than one or two specimens appear to be long-ranging.

Lonchodina (5 species). All the species are early Frasnian in age, except Lonchodina sp., which is of late Frasnian age. The genus appears to be facies controlled to some extent, being common in Biofacies II faunas.

Neoprioniodus (3 species). The Neoprioniodus armatus-alatus group and Neoprioniodus semiseparatus are long-ranging. Neoprioniodus sp. is confined to the Middle Famennian.

Nothognathella (11 species). Nothognathellids are varied and are relatively short-ranging. A discussion on their range and relationships will be found under the generic heading in the systematic part (Fig. 25).

Ozarkodina (12 species). The ozarkodinids are a very varied group and, though of distinctive morphology, they are difficult to assign to existing species and have been left in open nomenclature. Two named species, O. homoarcuata and O. ? lacera are confined to the Famennian. O. immersa and O. macra are both long-ranging.

Palmatodella (3 species). P. delicatula ranges in age from late Frasnian to the Middle Famennian. P. unca and P. sp. A are both restricted to the Middle Famennian.

Palmatolepis (35 species). The palmatolepids in the Canning Basin exhibit the same chronological and phylogenetic relationships discussed and illustrated by Ziegler (1962) and Helms (1963).

Pelekygnathus (2 species). This genus is probably ecologically controlled and ranges of individual species may depend on water depth rather than time. P. elevatus is restricted to the early Frasnian and P. sp. to the late Famennian in the present faunas.

Polygnathellus (2 species). Both P. multidentis and P. cf. P. typicalis are restricted to the early Frasnian.

Polygnathus (33 species). The genus has three distinct "groups" in the Devonian, the germanus group (nodocostatus group of Helms, 1961), the decorosus group and the asymmetricus group. The germanus group is probably a member of Biofacies III (see later) and the species present in the Canning Basin agree closely both in range and phylogenetic relationships with the original specimens from Europe (Helms, 1961).

The decorosus group appears to belong to Biofacies II and is much more plastic in its morphological characters and the species are difficult to isolate. Early Frasnian forms are referable to P. xylus, P. foliatus, P. australis, P. janeti, P. pollocki, P. spatulatus, P. seddoni, and P. cf. P. webbi. Some of these species are restricted in their range and may be useful biostratigraphically. Late Frasnian forms include P. decorosus and P. pennatus. Early Famennian forms are P. delicatulus, P. glaber s.s., and P. obliquicostatus. The Late Famennian is characterized by P. collinsoni and P. znepolensis. P. subserratus is Late Famennian, but is probably of different lineage, being closely related to the pseudopolygnathids.

The asymmetricus group probably gave rise to the palmatolepids.

and does not play an important role in the polygnathid phylogeny. However, P. dengleri, and possibly P. fallax, should be considered part of this group.

The enigmatic P. norrisi cannot be assigned to any of these groups.

Polylophodonta (2 species). Both polylophodontids are stratigraphically restricted. P. confluens occurs in the Palmatolepis rhomboidea and Lower Palmatolepis quadrantinodosa Zones and P. elongata ranges throughout the P. quadrantinodosa Zone.

Prioniodina (1 species). The ubiquitous species P. ? smithi ranges through most of the Famennian section.

Pseudopolygnathus (1 species). The single species is present in the Middle Polygnathus asymmetricus Zone.

Scaphignathus (2 species). S. ziegleri is the oldest species occurring in the Lower Palmatolepis quadrantinodosa Zone, whereas S. veliferus first occurs in the Lower Scaphignathus veliferus Zone. Both range up to the Lower Polygnathus styriacus Zone.

Scutula (5 species). Most species are of Famennian age, but S. venusta ranges down into the Middle Frasnian and S. sp. A is restricted to the uppermost Palmatolepis gigas Zone.

Spathognathodus (15 species). Many of the spathognathodids are distinctive but do not appear to belong to any distinct species. They have been left in open nomenclature. Many of them have restricted ranges and may be useful biostratigraphically if they are valid species. The named species are all of Famennian age in the present faunas.

Synprioniodina (3 species). S. cf. S. alternata is long ranging but both S. sp. A and S. sp. B are restricted to the Middle Famennian.

Tripodellus (1 species). The ubiquitous T. robustus is present in the Middle Famennian.

(iii) General Discussion - Three genera, Hindeodella, Ozarkodina and Spathognathodus are represented by large numbers of, as yet, undescribed species. This may be due to them being Biofacies II representatives and tending to be of "plastic" morphology.

This is the third and most diverse fauna described from the Canning Basin. However, in comparison with the faunas described by Glenister and Klapper (1966) and Seddon (1970) some genera and species known to occur elsewhere in the Basin are not present in my faunas.

They include:

Ancyrognathus princeps (Miller and Youngquist)

A. triangularis Youngquist

Palmatolepis crepida Sannemann

Palmatolepis delicatula clarki Ziegler

Palmatolepis helmsi Ziegler

Palmatolepis rhomboidea Sannemann

Pelekyognathus nodosus Thomas

Playfordia primitiva (Bischoff and Ziegler)

Polygnathus ancyrognathoides Ziegler

Polygnathus dengleri Bischoff and Ziegler

Polygnathus pennatuloidea Holmes

Spathognathodus aculeatus (Branson and Mehl)

4. Lithological Distribution of Faunas

Windjana Limestone - The reef facies was virtually devoid of conodonts. Only at three localities, at the southern tip of McWhae Ridge, and at two localities in the Teichert Hills, were good faunas recovered. They were all indicative of Biofacies II and probably indicate slightly deeper water in these regions than in the majority of the barrier reef.

Pillara Limestone - The back-reef yielded virtually no conodonts. When present they were always fragmentary. The only recorded faunas are of S. costatus Zone age from the Burrumundi Range (Glenister and

Klapper, 1966) and the Oscar Range (Seddon, 1970).

Sadler Limestone - This fore-reef deposit often contains good conodont faunas. The "nautiloid bed" is especially productive, whereas the "oncolite bed" yields poor faunas. In most cases they are of Biofacies II aspect but occasionally Biofacies III elements are present. Glenister and Klapper (1966, text-fig. 2) show the Sadler Limestone confined to the Lower Polygnathus asymmetricus Zone but Seddon (1970, p. 732) identifies Sadler as young as the Upper P. asymmetricus Zone. My evidence suggests that the Sadler is commonly as young as this.

Gogo Formation - This inter-reef facies unit commonly yields abundant conodonts of Biofacies III aspect. The majority of faunas are Lower and Middle Polygnathus asymmetricus Zone age, but in at least one locality (Section 12) the Gogo is as young as Upper P. asymmetricus Zone.

Virgin Hills Formation - The fore-reef deposits close to the reef facies are sometimes barren but usually the Virgin Hills Formation yields abundant conodonts. The oldest Virgin Hills occurs on the east-central part of the Lawford Range (Section 15). In general however, it is oldest in the South (Section 1, McWhae Ridge); the base becomes progressively younger northward and is as young as the Upper P. asymmetricus Zone at Section 12. In every section where an upper contact is seen, the Virgin Hills is overlain by Bugle Gap Limestone, except at Needle-Eye Rocks where it is overlain by Piker Hills Formation. The three contacts are on an east-west line and the oldest upper contact is in the west (Section 14, Lower Palmatolepis quadrantinodosa) and the youngest in the east (Section 4; Upper P. quadrantinodosa Zone).

Bugle Gap Limestone - This fore- and inter-reef facies contains conodonts, though never in great abundance. Its lower boundary has been discussed above. In only one section is it overlain by another formation (Section 4). The Piker Hills overlies it and the boundary

marks the lower limit of the Middle Polygnathus styriacus Zone.

Piker Hills Formation - This inter-reef deposit is seen in only three sections. In the McWhae Ridge - Mimbi Creek section (Section 4) it is of Middle Polygnathus styriacus Zone age. At Piker Hills (Section 22) it is the same age and ranges down into the lower subzone but the lower boundary is not seen. The Margaret River - Needle Eye Rocks sections (21) show a lower limit in the Upper Palmatolepis quadrantinodosa Zone. This suggests that the facies change to Piker Hills Formation was much later in the south than in the north.

Napier Formation - This fore-reef and inter-reef facies yields good faunas. The Napier was seen in only two sections. At Geikie Gorge (Section 23) it is of Palmatolepis quadrantinodosa Zone age, but in the Narlarla section (25) it is as old as the Palmatolepis gigas Zone and ranges into the P. quadrantinodosa Zone.

Fairfield Formation - The Devonian part of this formation failed to yield any conodonts, though I have previously recovered specimens from the Lower Carboniferous part (Laurel Formation of other authors [Playford and Lowry, 1966, p. 90]).

The Stromatolite Horizons - Altogether three stromatolite horizons are known in the Canning Basin. They are of Upper Palmatolepis gigas Zone (to I δ), Upper Palmatolepis triangularis Zone (basal Famennian), and earliest Lower Palmatolepis quadrantinodosa Zone (to II β) ages. The oldest horizon is known only from section 4 north-east of McWhae Ridge. The middle horizon, however, is more widespread, being known from both the east and west sides of McWhae Ridge and also from Narlarla in the Napier Range, some 130 miles to the northwest. The upper horizon is the widest known; it is recorded from both sides of McWhae Ridge, at Ngumban Cliff, and at Narlarla. The fact that these horizons are of exactly the same age over wide areas is significant, and means that depositional conditions over wide areas

of the reef complex changed at the same time. The horizons are also marked by a condensed conodont succession.

5. Zonation

The ready applicability of the German conodont zones to the Canning Basin faunas has been noted by Glenister and Klapper (1966, p. 784). However, Seddon (1970, p. 727) points out that, although the zonation is usable in most cases, faunas belonging to Biofacies II (Icriodus sequence of Seddon) lack the index fossils of Biofacies III (Palmatolepis sequence of Seddon) and the zonation is inapplicable in these cases. (For further information on Biofacies readers are referred to the Appendix).

Seddon suggests the erection of a separate zonation based on Biofacies II faunas and designates three early Frasnian zones based on Icriodus. However, the present faunas suggest that these icriodids are ecologically controlled and, given the right conditions, are probably long ranging. Further research may show that a Biofacies II zonation, which is usable, can be erected. I feel that the decorosus group polygnathids probably offer the best solution, but once again their "plastic" nature may defeat the idea.

At the present time the only reliable way to correlate Biofacies II and III is to walk the outcrop!

In considering the applicability of the German zonation we run into the problem of cyclicity of reasoning. In the present study I have plotted the range charts of species in the Canning Basin, and then added the German ranges to each index species. In this way the presence of the zones was very apparent. The only problem is that all the other species are now used to give interpretive zonal ages. In this fashion the zonation tends to be self-proving! However, the fact that the succession of faunas is identical in both Australia and Europe is compelling evidence for applicability.

Not only is the succession of faunas identical but the gross aspect

of the faunas is the same. There is consistency of species between Europe, North America and Australia; no species, not even bars and blades have radically different ranges. Thirdly, there is a consistency of association of conodont species. For example, two separate groups, the palmatolepids and the polygnathids of the germanus group, give the same zonation. Finally, there is a consistency of association between the conodonts and other members of the fauna, particularly the ammonoids. Both groups give the same relative age wherever they are found. This suggests that the German conodont zones are worldwide and probably represent the closest approximation to a chronological unit of any fossil zone.

The zonation is discussed below and the relationship of each individual species present in that zone is discussed. In some cases where ecologic factors are paramount, the ranges discussed may not be applicable in any other area, or for that matter, to any other samples from the same Basin! Altogether, nine Zones, divided into twenty-two subzones, can be recognized. In the following discussion the upper boundary of each zone will include all discussion on the lowest boundary of the succeeding zone.

Polygnathus asymmetricus Assemblage Zone.

This zone is found in the Windjana Limestone, Sadler Limestone, Gogo Formation, and the Virgin Hills Formation. It is divided into three subzones.

Lower Polygnathus asymmetricus Zone

No strata older than this subzone were identified, although fore-reef deposits containing a Biofacies II fauna may represent the underlying Schmidtognathus hermanni Zone.

In the present faunas the upper limit is marked by the last occurrence of Ancyrodella rugosa Branson and Mehl, Ligonodina spiculata (Ulrich and Bassler), Nothognathella sublaevis Sannemann, Ozarkodina versa (Stauffer), Spathognathodus sp. F, and S. sp. G.

The upper limit is also marked by the first occurrence of

Camptognathus erectus sp. nov., Hindeodella uncata Hass, H. sp. E, Icriodus incrassatus s.s. Youngquist and Peterson, I. symmetricus subsp. nov. a, Nothognathella klapperi Uyeno, Ozarkodina sp. A, O. sp. C, Palmatolepis punctata (Hinde), P. transitans Müller, Pelekysgnathus elevatus (Branson and Mehl), Polygnathus australis sp. nov., P. pollocki sp. nov., Pseudopolygnathus sp. A, and Spathognathodus sp. nov. A.

Other important species present in this subzone include Ancyrodella buckeyensis Stauffer, A. gigas Youngquist, A. lobata Branson and Mehl, A. rotundiloba s.s. (Bryant), A. rotundiloba alata Glenister and Klapper, A. rotundiloba binodosa Uyeno, A. sp. nov. A, Polygnathus asymmetricus s.s. Bischoff and Ziegler, P. asymmetricus ovalis Glenister and Klapper, P. foliatus Bryant, P. janeti sp. nov. and P. spatulus Youngquist.

Middle Polygnathus asymmetricus Zone

The upper limit of this subzone is drawn at the last occurrence of Ancyrodella rotundiloba alata Glenister and Klapper, A. rotundiloba binodosa Uyeno, A. sp. A, Belodella devonica (Stauffer), B. erecta (Rhodes and Dineley), B. striata Druce, B. triangularis (Stauffer), Icriodus brevis s.s. Stauffer, I. brevis darbyensis Klapper, I. brevis subsp. a, Polygnathus spatulus Youngquist, and Pseudopolygnathus sp. A.

First occurrences include Ancyrodella curvata (Branson and Mehl), A. ioides Ziegler, Palmatolepis hassi Müller and Müller, P. proversa Ziegler, P. subrecta Miller and Youngquist, Polygnathus decorosus Stauffer, P. normalis Miller and Youngquist, P. seddoni sp. nov., and P. sp. A.

Other important species in the zone include Ancyrodella buckeyensis Stauffer, A. gigas Youngquist, A. lobata Branson and Mehl, A. rotundiloba s.s. (Bryant), P. asymmetricus s.s. Bischoff and Ziegler, P. asymmetricus ovalis Glenister and Klapper, P. foliatus Bryant, and P. janeti sp. nov.

Upper Polygnathus asymmetricus Zone

The upper limit of this subzone is drawn at the last occurrence of Ancyrodella rotundiloba s.s. (Bryant), Belodella erecta (Rhodes and Dinely), Camptognathus conus Pollock, C. erectus sp. nov., Icriodus brevis spicatus Youngquist and Peterson, Icriodus symmetricus subsp. nov. a, Lonchodina arcuata Ulrich and Bassler, L. typicalis Ulrich and Bassler, Palmatolepis proversa Ziegler (which is confined to this zone), Palmatolepis transitans Müller, Polygnathellus multidentis (Ulrich and Bassler), Polygnathus asymmetricus s.s. Bischoff and Ziegler, P. asymmetricus ovalis Glenister and Klapper, P. janeti sp. nov. and P. seddoni sp. nov., which is restricted to this zone.

The upper limit also marks the first occurrence of Ancyrodella nodosa Ulrich and Bassler, Nothognathella abbreviata Branson and Mehl, N. abnormis Branson and Mehl, N. falcata Helms, N. iowensis Youngquist, and Palmatolepis unicornis Miller and Youngquist.

Other important species occurring in this zone are Ancyrodella buckeyensis Stauffer, A. curvata Branson and Mehl, A. gigas Youngquist, A. lobata Branson and Mehl, Palmatolepis hassi Müller and Müller, P. punctata (Hinde), Polygnathus australis sp. nov., P. foliatus Bryant, and P. pollocki sp. nov.

Ancyrognathus triangularis Zone

This zone is present in the Virgin Hills Formation and at one locality (Section 24) in the Sadler Limestone.

Its upper limit is marked by the last occurrence of Ancyrodella lobata Branson and Mehl, Hibbardella (H.) angulata (Hinde), H. (H.) multidentis, Icriodus symmetricus s.s. Branson and Mehl, Lonchodina perlonga Bassler, Nothognathella abnormis Branson and Mehl, N. klapperi Uyeno, Palmatolepis hassi Müller and Müller, P. punctata (Hinde), Pelekysgnathus elevatus (Branson and Mehl), Polygnathus australis sp. nov.

First occurrences at the upper boundary include Nothognathella

typicalis Branson and Mehl, Palmatolepis foliacea Youngquist, P. gigas Miller and Youngquist, Scutula venusta Sannemann.

Important species present in this zone include Ancyrodella buckeyensis Youngquist, A. curvata Branson and Mehl, A. gigas Youngquist, A. ioides Ziegler, Palmatolepis subrecta Miller and Youngquist, P. foliatus Bryant, and P. pollocki sp. nov.

Palmatolepis gigas Zone

This zone is divided into two subzones; the Upper subzone is further divided into an uppermost subzone with Palmatolepis linguiformis. The zone occurs in the Virgin Hills and the Napier Formations.

Lower Palmatolepis gigas Zone

The upper boundary is marked by the last occurrence of Ancyrodella ioides Ziegler, Bryantodus typicus Bassler, Falcodus guntharii Ziegler, Icriodus symmetricus circularis Youngquist and Peterson, I. symmetricus expansus Branson and Mehl, Palmatolepis foliacea Youngquist, P. unicornis Miller and Youngquist, Polygnathus foliatus Bryant, and P. pollocki sp. nov.

First occurrences at the upper boundary of the subzone include Ancyrognathus asymmetricus (Ulrich and Bassler), A. altus Müller and Müller, and Palmatolepis linguiformis Müller.

Important species occurring in this zone include Ancyrodella buckeyensis Youngquist, A. curvata Branson and Mehl, A. gigas Youngquist, A. nodosa Branson and Mehl, and Palmatolepis subrecta Miller and Youngquist.

Upper Palmatolepis gigas Zone

This subzone and the upper subzone with Palmatolepis linguiformis cannot be successfully differentiated, so they are considered together here. In one section, at Narlarla (Section 25) it is possible to recognize this uppermost subzone. Normally, I have terminated the range of species in the Upper P. gigas Zone if they do not extend into the Lower

Palmatolepis triangularis Zone.

The upper boundary of the zone can be recognized by the final occurrence of Ancyrodella buckeyensis Youngquist, A. curvata Branson and Mehl, A. gigas Youngquist, A. nodosa Branson and Mehl, Ancyrognathus asymmetricus (Ulrich and Bassler) and A. altus (Müller and Müller) (both confined to this dual zone), Nothognathella iowensis Youngquist, Palmatolepis linguiformis Müller, and Polygnathus xylus Stauffer.

The upper limit, and lower limit of the Palmatolepis triangularis Zone, is also marked by the first occurrence of Acodina inopinata Stauffer, Icriodus incrassatus subsp. a, Palmatolepis triangularis Sannemann, and Polygnathus pennatus Hinde.

Other important species in the zone include Icriodus arkonensis s.s. Stauffer, Nothognathella abbreviata Branson and Mehl, N. brevidonta Youngquist, Palmatolepis gigas Youngquist, and P. subrecta Miller and Youngquist.

Palmatolepis triangularis Zone

This zone occurs in the Virgin Hills Formation and in the Napier Formation in the Narlarla section (25). The zone is divided into three subzones.

Lower Palmatolepis triangularis Zone

The upper limit of this subzone is drawn at the last occurrence of Nothognathella brevidonta Youngquist and at the first occurrence of Palmatolepis delicatula Branson and Mehl, Scutula bipennata Sannemann, and Spathognathodus stabilis Branson and Mehl.

Other important species in the zone include Palmatolepis gigas Youngquist (whose upper limit is in the lower part of the zone), and Palmatolepis subrecta Miller and Youngquist.

Middle Palmatolepis triangularis Zone

The upper limit of this subzone is marked by the last occurrence of Nothognathella abbreviata Branson and Mehl, and Palmatolepis subrecta Miller and Youngquist and the first occurrence of Palmatolepis

regularis Cooper and P. subperlobata s.s. Branson and Mehl; another important species is Polygnathus cf. P. pennatus Hinde.

Upper Palmatolepis triangularis Zone

The upper limit of this subzone is marked by the first occurrence of Acodina sannemanni sp. nov., Nothognathella polygnathoides Branson and Mehl, Palmatolepis quadrantinosolabata Sannemann, P. tenuipunctata Sannemann, and Polygnathus germanus s.s. Ulrich and Bassler.

Other important species include Icriodus arkonensis subsp. a, I. arkonensis subsp. c, Palmatolepis delicatula Branson and Mehl, P. regularis Cooper (confined to this subzone), P. triangularis Sannemann and Polygnathus pennatus Hinde.

Palmatolepis crepida Zone

This zone occurs in the Virgin Hills Formation and in the Napier Formation. The zone is divided into three subzones all of which can be recognized in the Canning Basin.

Lower Palmatolepis crepida Zone

The upper limit of this subzone is marked by the last occurrence of Acodina formosa Stauffer, Palmatolepis delicatula Branson and Mehl, P. triangularis Sannemann, and Polygnathus decorosus Stauffer. The first occurrences of Nothognathella palmatoformis sp. nov., Palmatolepis minuta s.s. Branson and Mehl, P. minuta loba Helms, P. subperlobata subsp. A, and Polygnathus glaber s.s. Ulrich and Bassler also mark the top of the zone. Another important species in the zone is Palmatolepis subperlobata s.s. Branson and Mehl.

Middle Palmatolepis crepida Zone

The upper limit of this subzone is marked by the last occurrence of Palmatolepis minuta loba Helms and P. tenuipunctata Sannemann. It is also marked by the first occurrence of Palmatolepis glabra s.s. Ulrich and Bassler, P. subgracilis Bischoff, and Scutula sinepennata Ziegler.

Other important species include Icriodus arkonensis subsp. b, Nothognathella polygnathoidea Branson and Mehl, Palmatolepis quadrantinodosolobata Sannemann, P. subperlobata s.s. Branson and Mehl, and Polygnathus germanus s.s. Ulrich and Bassler.

Upper Palmatolepis crepida Zone

The upper limit of this subzone is marked by the last occurrence of Icriodus arkonensis subsp. b, Nothognathella typicalis Bassler, Palmatolepis quadrantinodosolobata Sannemann, P. subgracilis Bischoff, P. subperlobata s.s. Branson and Mehl, and P. subperlobata subsp. A. The first occurrences of Palmatolepis glabra elongata Holmes, P. glabra pectinata Ziegler, P. quadrantinodosa inflexoidea Ziegler, P. quadrantinodosa marginifera Helms, Polygnathus obliquicostatus Ziegler, P. triphyllatus (Ziegler), and Polylophodonta confluens Ulrich and Bassler.

Other important species present in the zone include Nothognathella polygnathoidea Branson and Mehl, Polygnathus germanus s.s. Ulrich and Bassler and P. glaber s.s. Branson and Mehl.

Palmatolepis rhomboidea Zone

This zone occurs in the Virgin Hills Formation and in the Napier Formation at Narlarla.

The upper limit of the zone is marked by the last occurrence of Polygnathus obliquicostatus Ziegler (which is restricted to this zone), and the first occurrence of Apatognathus varians s.s. Branson and Mehl, Falcodus aculeatus Sannemann, Falcodus sp. nov. A, Ozarkodina ? lacera Helms, Palmatolepis distorta Branson and Mehl, P. glabra acuta Helms, P. minuta schleizia Helms, P. perlobata s.s. Ulrich and Bassler, P. rugosa ampla Müller, Polygnathus delicatulus Ulrich and Bassler, P. fallax Helms and Wolska, P. germanus subsp. B, P. norrisi Uyeno, Polylophodonta elongata Druce, Scaphignathus ziegleri Druce, Spathognathodus fitzroyi sp. nov., S. strigosus (Branson and Mehl).

Other important species present in this zone include Nothognathella polygnathoidea Branson and Mehl, Palmatolepis glabra s.s. Ulrich and Bassler, Polygnathus glaber s.s. Branson and Mehl, and Scutula sinepennata Ziegler.

Palmatolepis quadrantinodosa Zone

This zone occurs in the Virgin Hills Formation, Bugle Gap Limestone, Napier Formation, and Piker Hills Formation. It is divided into two subzones, both of which can be recognized in the Canning Basin.

Lower Palmatolepis quadrantinodosa Zone

The upper limit of this zone is marked by the last occurrence of Nothognathella polygnathoidea Branson and Mehl, Palmatolepis distorta Branson and Mehl (confined to this subzone), P. perlobata sigmoidea Ziegler, P. quadrantinodosa inflexoidea Ziegler, and Polygnathus fallax Helms and Wolska (both confined to this zone), P. triphyllatus (Ziegler), Polylophodonta confluens Ulrich and Bassler, and Scutula sinepennata Ziegler.

The first appearance of Acodina zionensis Stauffer, Hibbardella (Hassognathus) franca (Sannemann), Palmatolepis gracilis Branson and Mehl, P. cf. rugosa trachytera Ziegler, Polygnathus perplexus Thomas, and P. znepolensis Spasov.

Other important species which occur in this subzone include Palmatolepis quadrantinodosa marginifera Ziegler, P. glabra elongata Holmes, P. glabra pectinata Ziegler, P. perlobata s.s. Ulrich and Bassler, and Polygnathus germanus s.s. Ulrich and Bassler.

Upper Palmatolepis quadrantinodosa Zone

The upper limit of this subzone is marked by the last appearance of a great number of long-ranging species. This may be influenced somewhat by the change in lithology from the Virgin Hills Formation to the Bugle Gap Limestone, and perhaps to the fewer samples collected of this and subsequent horizons. Among the more important final

occurrences are Palmatolepis glabra acuta Helms, P. minuta schleizia Helms, P. rugosa ampla Müller, P. cf. rugosa trachytera Ziegler (confined to this subzone), Polygnathus delicatulus Ulrich and Bassler, P. germanus s.s. Ulrich and Bassler, and Polylophodonta elongata Druce.

Scaphignathus veliferus Zone

This zone occurs in the Bugle Gap Limestone and the Piker Hills Formation. In Europe this zone is divided into three subzones but in the Canning Basin it is not possible to recognise the subzones. Some long-ranging forms disappear within the zone and some rare species occur within the zone.

The top of the zone is marked by the first occurrence of Palmatolepis rugosa grossi Ziegler, Polygnathus germanus subsp. B, P. irregularis (Thomas) and Spathognathodus bohlenanus Helms.

Important species which occur in the zone include Ozarkodina ? lacera Helms, Palmatolepis glabra s.s. Ulrich and Bassler, P. glabra elongata Holmes, P. glabra pectinata Ziegler, P. gracilis Branson and Mehl, P. minuta s.s. Branson and Mehl, Polygnathus norrisi Uyeno, P. perplexus Thomas, P. semicostatus Branson and Mehl, P. subserratus Branson and Mehl, P. znepolensis Spasov, and Spathognathodus strigosus (Branson and Mehl).

Polygnathus styriacus Zone

This zone occurs in the Bugle Gap Limestone and Piker Hills Formation. In Europe the zone is divided into three subzones and the two lower subzones are represented in the Canning Basin.

Lower Polygnathus styriacus Zone

The upper limit of this subzone is marked by the last occurrence of Palmatolepis glabra elongata Holmes, P. minuta s.s. Branson and Mehl, P. rugosa grossi Ziegler and Polygnathus irregularis (Thomas) (both of which are confined to this subzone), P. semicostatus Branson

and Mehl, and P. znepolensis Spasov. The upper limit is also marked by the first occurrence of Polygnathus collinsoni Druce.

Other important species which occur in the subzone include Palmatolepis perlobata s.s. Ulrich and Bassler, Polygnathus perplexus Thomas and P. subserratus Branson and Mehl.

Middle Polygnathus styriacus Zone

This subzone yields a poor fauna and the division is made on the first occurrence of Polygnathus collinsoni Druce, because this species appears to be of Upper Famennian (to V) age. Other species which occur in this subzone include Palmatolepis gracilis Branson and Mehl, P. perlobata s.s. Ulrich and Bassler, Polygnathus perplexus Thomas and P. subserratus Branson and Mehl.

6. Facies Control

Working independently and in different sedimentary basins both Seddon (1970) and Druce (1969) came to the conclusion that there was some facies control of conodont distribution, especially in reef-complexes. This was not the first suggestion of facies control but it was the first where good exposures and well understood lithologic facies variations could be used to demonstrate these differences. From this study, and those of Seddon (1970a, b) I have postulated that three major biofacies (designated I, II, and III) probably existed throughout the Upper Palaeozoic. The paper in which I have discussed this hypothesis will be published in the Geological Society of America Monograph on Conodont Paleozoology. I have included it as an appendix in this thesis.

The ideas of separate biofacies are important when considering correlation and zonation, and the ideas contained in the appendix are used extensively in those sections on zonation and correlation.

7. Correlation

The fact that European zones and subzones can be recognised in the Canning Basin makes intra-basin correlation relatively easy. However, precise correlation is complicated by the presence of biofacies.

Seddon (1970, p. 727) has discussed in detail the problems of correlation between biofacies faunas. Seddon attempted to construct a parallel zonation based on his "Icriodus Sequence" (my Biofacies II [see above and appendix]). However, from the distribution of the icriodid elements in the present faunas it appears that these forms are essentially controlled by ecological conditions rather than being short ranging species within Biofacies II and, as such, will be of little use in defining Biofacies II zones. At the present time there appears to be little hope of a rapid solution to the problem of correlating the different biofacies.

The polygnathids may offer a solution: they are difficult to work with (see Seddon, 1970, p. 729) and show some plasticity in morphology but considerably less than the accompanying icriodids. Seddon (p. 727) remarked that even when he had erected an "Icriodus Sequence" zonation, it was difficult to correlate it with the "Palmatolepis Sequence" zonation and the correlation was based, in part, on field relationships. This appears to be the most satisfactory of all the methods and the good outcrop in the exposed part of the Devonian Basin makes the task simple.

However, we are left with the problem of dating and correlating subsurface samples. At the present time it is possible to recognize the difference between Frasnian and Famennian Biofacies II and to arrive at some palaeoecological conclusions. Further work will probably refine the zonation and correlation of Biofacies II, but whether it will ever be possible to achieve the fineness of the Biofacies III zones is doubtful.

Reports of conodonts from three other Australian Devonian Basins have been published. A fauna from the Gneudna Formation of the Carnarvon Basin, Western Australia was described by Seddon (1969). This fauna is indicative of Biofacies II and Seddon remarks that it is difficult to correlate the fauna; either a late Middle Devonian or early Frasnian age is possible. The fauna is probably of early Frasnian age and is of equivalent age to the Sadler Limestone.

The conodont faunas of the Devonian reef complexes of the Bonaparte Gulf Basin were described by Druce (1969). These reef-complexes

are of comparable age to the Canning Basin reefs but differ in being relatively poorly exposed, except for the back-reef facies and the virtual absence of any exposed fore-reef deposits. They are possibly connected to the Canning Basin reefs by a northward loop beneath the Sahul Shelf (Playford, 1970).

The Bonaparte Gulf Basin reef complexes also differ in that conodonts, although rare, are normally found in the reef and back-reef facies. They are usually of Biofacies II aspect and suggest that the Bonaparte Gulf Basin reefs were deposited in deeper water than the Canning Basin reefs. The discussion of the correlation of the two basins is presented by Druce (p. 21). The Canning Basin faunas differ in being much richer in species; however, some species are known from the Bonaparte Gulf Basin which are, as yet, unknown in the Canning Basin. They include Neoprioniodus ? tortus Druce and Rhodalepis inornata Druce.

Upper Devonian conodonts have also been reported from the Yarrol Basin, Queensland (Druce, 1970b). They were recovered from a limestone lens in a thick volcanic sequence. The presence of Ancyrognathus asymmetricus (Ulrich and Bassler) suggests an Upper Palmatolepis gigas Zone age (Druce, 1970b, p. 77). However, fragmentary palmatolepids appear to belong to Palmatolepis punctata (Hinde) (Frasnian to I $\propto$ - to I γ) and the presence of P. australis sp. nov. suggests that the fauna may be as old as the Ancyrognathus triangularis Zone (Frasnian to I γ).

8. International Correlation

The work of Glenister and Klapper (1966) and Seddon (1970) showed that many European and North American species are present in the Canning Basin and that the European zonation was readily applicable. The present study demonstrates that virtually all the species which are important in zonation, especially the palmatolepids and polygnathids of the germanus group, are present.

The sequence sampled in the Canning Basin ranges in age from the Lower Polygnathus asymmetricus Zone up to the Middle Polygnathus styriacus Zone, a total of nine zones and twenty-two subzones. Of these, all the zones are readily recognized. Furthermore, the majority of subzones can also be recognized. The exceptions are the Upper Palmatolepis gigas Zone with Palmatolepis linguiformis and the subzones of the Scaphignathus veliferus Zone. The former subzone is recognized in Narlarla Section (25) but cannot be determined in other sections of comparable age.

The European subzones of the Scaphignathus veliferus Zone cannot be recognised and no obvious subdivisions could be distinguished in section 4.

However, the recognition of eighteen of the twenty-two subzones demonstrates the validity of Ziegler's (1962) zones for the world-wide correlation of Upper Devonian strata. The correlation is so precise, even at a distance of some 12,000 miles, that there is no need to erect an Australian zonation and to then correlate it with the European zonation.

Collinson et al. (1962) erected a sequence of Upper Devonian zones for the Upper Devonian sequence in the Mississippi Valley. Altogether, five zones were erected for the Upper Frasnian and Famennian. Of these, three zones are of the same age as the Canning Basin zones. The Palmatolepis proversa - P. triangularis Assemblage Zone is equivalent to the Ancyrognathus triangularis, Palmatolepis gigas and Palmatolepis triangularis Zones. Some of the European name-giver species are present in the American zone and it appears that the European zones can probably be recognised in the Mississippi Valley.

The American Palmatolepis quadrantinodosa - P. glabra Assemblage Zone is equivalent to the European Palmatolepis crepida, Palmatolepis rhomboidea, and Palmatolepis quadrantinodosa Zones. Once again most of the European zone species are present in the American faunas. The Polygnathus irregularis - "Ancyrognathus" quadrata

Assemblage Zone corresponds to the European Scaphignathus veliferus and Polygnathus styriacus Zones. The fauna is rather poor and no European name-givers are present in the list but the presence of P. irregularis (Thomas), and Palmatolepis rugosa Branson and Mehl suggests that the Mississippi Valley faunas are similar to the European faunas and that the European zones can be recognised.

IV SYSTEMATIC PALAEONTOLOGY

1. Introduction

The systematic palaeontology is laid out as follows:

Generic and specific heading

Synonymy (if any)

Derivation of name (if new species)

Material

Localities of figured material

Diagnosis (if new species)

Description

Remarks

Occurrence

Range

Under the generic headings I have discussed the phylogeny, relationships and concepts of only a few genera, notably Ancyrognathus, Icriodus and Nothognathella. Otherwise I have not included generic descriptions.

The synonymy is complete for most species. I have only included illustrated material and where a recent reference with a full synonymy (with which I agree) is available, I have referred the reader to that publication.

The heading material includes number of identified specimens plus the Commonwealth Palaeontological Collection (CPC) number of the figured specimens. These figured specimens are housed in the Bureau of Mineral Resources, Geology and Geophysics, Canberra, Australia.

Under occurrence I have discussed the geographic distribution of each species including both illustrated and listed material from all available papers. Range discusses the stratigraphic distribution of each species.

Genus ACODINA Stauffer, 1940

Type species: Acodina lanceolata Stauffer, 1940.

ACODINA FORMOSA (Stauffer, 1938)

Pl. 17, figs. 1

1938 Acodus formosus Stauffer, J. Paleont., 12, 417, pl. 49, fig. 33.

1961 Acodina delata Stauffer; Lys et al., Rev. Inst. Franc. Petrol.,
16, 543, pl. 1, fig. 1.

1968 Acodina inoptinata (Stauffer), Mound, J. Paleont., 42, 469, pl.
65, fig. 2 only.

Material: 11 specimens, CPC 12849 figured.

Localities of figured material: Sample BG 19018, section 1, McWhae Ridge, Virgin Hills Formation; sample BG 21158, Old Bohemia, Virgin Hills Formation.

Description: An erect acodinid with an ovate base and shallow basal cavity. In some specimens the basal cavity is sub-triangular, opening on the inner side. The cusp is elongate, slightly laterally compressed and tapers to a point.

Occurrence and Range: The species was originally described from Ontario and Ohio (Stauffer, 1938) from the Olentangy Shale of late Devonian age. The French specimens are from Morvan and range from Middle Devonian up to the basal Famennian (to II α). The Canning Basin specimens range from the base of the Frasnian up to the Lower Palmatolepis crepida Zone (to II α).

ACODINA INOPTINATA (Stauffer, 1938)

Pl. 17 figs. 6

1938 Acodus inoptinatus Stauffer, J. Palaeont., 12, 417, pl. 49,
figs. 23, 34, 35.

- 1940 Acodina concava Stauffer, ibid., 14, 418, pl. 60, fig. 31.
- 1940 Acodina covina Stauffer, ibid., 418, pl. 60, fig. 33.
- 1940 Acodina lirata Stauffer, ibid., 419, pl. 60, figs. 18, 45.
- 1940 Acodina ursa Stauffer, ibid., 419, pl. 60, figs. 1, 2.
- 1955 Acodina delata Stauffer; Sannemann, Senck. leth., 36, 126, pl. 1, figs. 15, 16.
- 1955 Acodina lirata Stauffer; Sannemann, ibid., 126, pl. 1, fig. 18.
- 1959 Acodina lirata Stauffer; Helms, Geologie, 8, 641, pl. 4, fig. 10.
- 1961 Acodina lirata Stauffer; Freyer, Freib. Forsch., C95, 31, text-fig. 4.
- 1967 Acodina lirata Stauffer; Wolska, Acta Palaeont. Polonica, 12, 372, pl. 1, figs. 2, 3.
- 1968 Acodina inoptinata (Stauffer); Mound, J. Paleont., 42, 469, pl. 65, figs. 3, 4 [fig. 2 = A. formosa].

Material: 16 specimens, CPC 12850 figured.

Localities of figured material: Sample BG 19018, Section 1, McWhae Ridge, Virgin Hills Formation.

Occurrence: A. inoptinata was first described from Ontario and Ohio (Stauffer, 1938) together with Frasnian index fossils. Elsewhere in North America it is known from Minnesota (Stauffer, 1940) and Alberta, Canada (Mound, 1968). In Europe the species is known from Germany (Sannemann, 1955; Bischoff, 1956; Helms, 1959; and Freyer, 1961), Austria (Schönlaub, 1969), and Poland (Wolska, 1967); Clark & Ethington have described it from North Africa (Spanish Sahara) (1962).

Range: The original specimens were from rocks that are, in part, Frasnian. Both Helms (1959) and Freyer (1961) record it from the toI δ Zone. Wolska (1967) gives the occurrence as Palmatolepis triangularis Zone (toI δ - toI/II). Mound (1968) states that the species occurs in strata of toI γ and toII β /toIII α age. In the Canning Basin the species ranges from the Lower Palmatolepis triangularis Zone (toI δ) up to the Upper Palmatolepis quadrantinodosa Zone (toIII α).

ACODINA SANNEMANNI sp. nov.

Pls. 17, figs. 7

- non 1940 Acodina curvata Stauffer, J. Paleont., 14, 418, pl. 60, figs. 3, 14-16.
- 1955 Acodina curvata Stauffer; Sannemann, Senck. leth., 36, 126, pl. 1, fig. 17.
- 1959 Acodina curvata Stauffer; Helms, Geologie, 8, pl. 4, fig. 12.
- 1961 Acodina curvata Stauffer; Freyer, Freib. Forsch., C95, 31, text-fig. 3.

Material: 30 specimens, Holotype CPC 12851, Paratypes CPC 12852, 12854.

Localities of figured material: Holotype Sample BG 19018, Section 1, McWhae Ridge, Virgin Hills Formation; Paratypes Sample BG 19074, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Diagnosis: An acodinid which is laterally compressed and posteriorly recurved.

Description: An elongate laterally compressed cone, recurved posteriorly. The base is ovate, with a thickened rim; a shallow basal cavity is present. The unit narrows rapidly above the basal cavity and becomes laterally compressed with a knife-like posterior edge reminiscent of the genus Acanthodus of Tremadocian age.

Range: The species ranges from the Lower Palmatolepis crepida Zone (to II $\propto$) up to the Lower Polygnathus styriacus Zone (to IV).

ACODINA ZIONENSIS (Stauffer, 1938)

Pl. 17 figs. 2

- 1938 Acodus zionensis Stauffer, J. Paleont., 12, 417, pl. 49, fig. 30.
- 1940 Acodina lanceolata Stauffer, ibid., 14, 419, pl. 60, figs. 29, 30.
- 1940 Acodina velva Stauffer, ibid., 419, pl. 60, figs. 19, 32, 39, 46.

- 1940 Acodina zionensis Stauffer; Stauffer, ibid., 419, pl. 60, fig. 38.
- 1955 Acodina zionensis (Stauffer); Sannemann, Senck. leth., 36, 127, pl. 1, figs. 13, 14.
- 1961 Acodina zionensis (Stauffer); Freyer, Freib. Forsch., C95, 32, pl. 1, fig. 5.
- 1961 Acodina zionensis (Stauffer), Lys et al., Rev. Inst. Français Petrol., 16, 543, pl. 1, fig. 2.

Material: 2 specimens, CPC 12855-12856 both figured.

Locality of figured material: Sample BG 19105, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Occurrence: The species was originally described from Ohio (Stauffer, 1938). It is also known from Minnesota (Stauffer, 1940), and Alberta, Canada (Mound, 1968). In Europe the species is known from Germany (Sannemann, 1955; Bischoff, 1956; Freyer, 1961, 1965), France (Lys et al., 1961), and Austria (Schönlaub, 1969).

Range: The species was originally described from strata of probable Frasnian age in Ohio (Stauffer, 1938). Bischoff (1956) and Freyer (1961) both record the species from the Frasnian to I S Zone whereas Sannemann's (1955) specimens are from the Famennian (to II α). The Canning Basin specimens are from the uppermost part of the Lower Palmatolepis quadrantinodosa Zone.

Genus ANCYRODELLA Ulrich & Bassler, 1926

Type species: Ancyrodella nodosa Ulrich & Bassler, 1926.

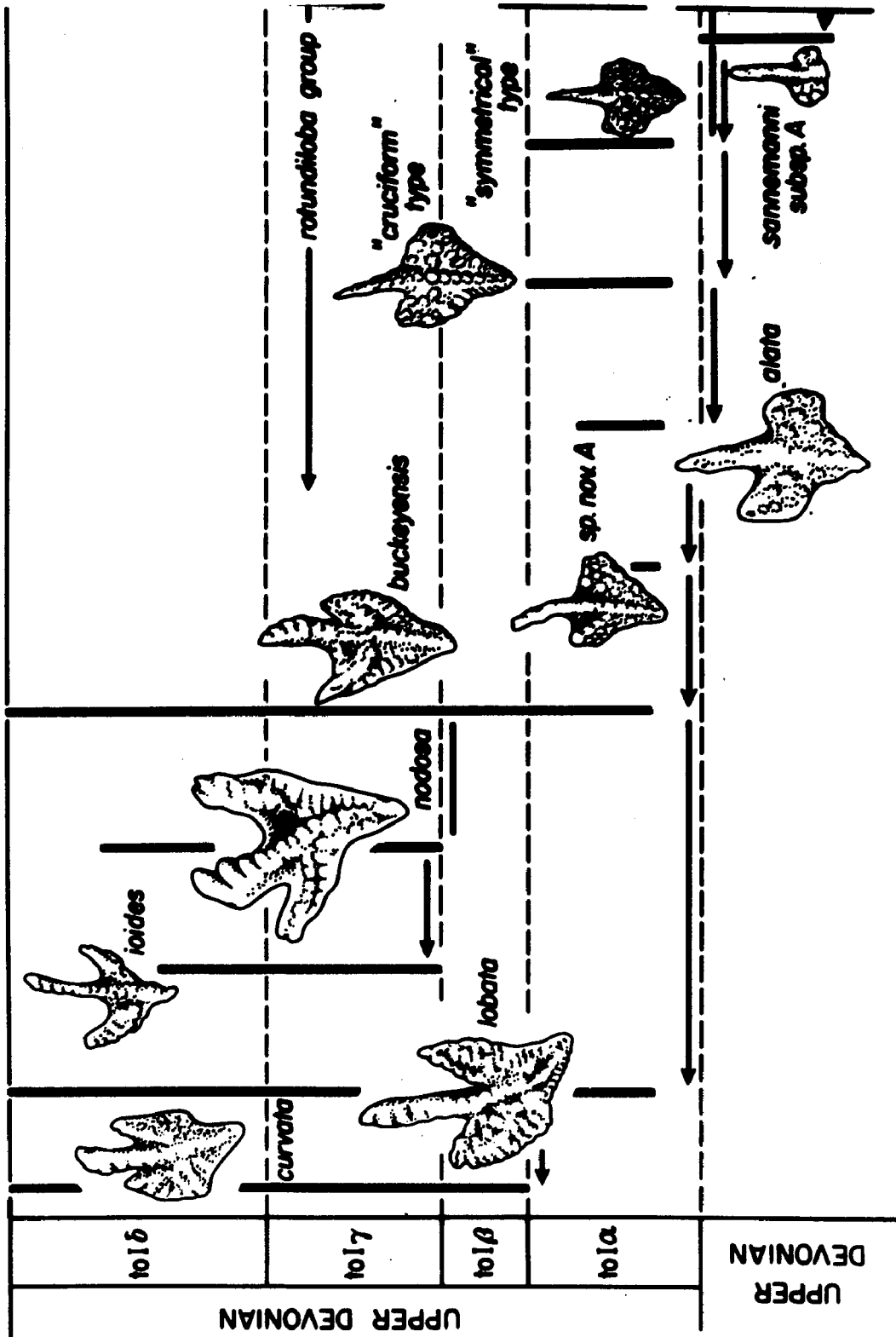
- 1926 Ancyrodella Ulrich & Bassler, U.S. Natl. Mus., Proc., 68, 48.
- 1957 Ancyrodella Müller & Müller, Ulrich & Bassler; J. Paleont., 31, 1090.
- 1957 Ancyropenta Ulrich & Bassler; Müller & Müller, ibid., 1092.
- 1962 Ancyrodella Ulrich & Bassler; Ethington & Furnish, ibid., 36, 1260.

Remarks: In their original description Ulrich & Bassler (1926, p. 48) state that the genus resembles Polygnathus but the platform is anchor-shaped. Their description was slightly expanded by Branson & Mehl (1934, p. 238) who noted the extra keels and carinae. Müller & Müller (1957, p. 1090) examined the Ancyro-group (Ancyroides, Ancyrognathus, Ancyrodella and Ancyropenta) in detail; species such as lobata and curvata with extra lobes were placed in Ancyropenta. Ethington & Furnish (1962, p. 1260), in considering the Ancyro-group, stated that "development of prominent keels and platform lobes is one of the principal characters of Ancyrodella" (see also Ziegler, 1958). Thus, they conclude that Ancyropenta is a junior synonym of Ancyrodella. This view is accepted by Lindström (1964, p. 168).

Phylogeny: The phylogenetic relationships of Ancyrodella were discussed and illustrated in a paper by Ziegler (1962). Ziegler suggests that Ancyrodella arose from a polygnathid ancestor, the first species being rotundiloba, then rugosa to gigas. Ziegler suggests that gigas was the root stock for two trends, one the lobate branch (lobata-curvata), the other the "reduced platform" branch (buckeyensis-nodosa-ioides). The ancestral polygnathid was considered to be P. asymmetrica. This idea was followed by Lindström (1964, p. 100).

Müller & Clark (1967, text-fig. 6) illustrate a sequence of growth stages for A. rotundiloba, the earliest ancyrodellid. These show that juveniles (text-fig. 6a, b) resemble the genus Spathognathodus; in fact, it would be extremely difficult to separate them from subspecies of S. sannemanni, illustrated by Pollock (1968, pl. 61). Mound (1968, p. 470) points out that growth stages of A. curvata also show juveniles reminiscent of spathognathodids (Ethington & Furnish, 1962, pl. 172), and suggests descent from a spathognathodid ancestor (*ibid.*, p. 1260).

Recent papers by Uyeno (1967) and Pollock (1968) on Middle to Upper Devonian faunas from Alberta, Canada, tend to confirm this view. Uyeno (p. 4) erects a new sub-species, binodosa, of A.



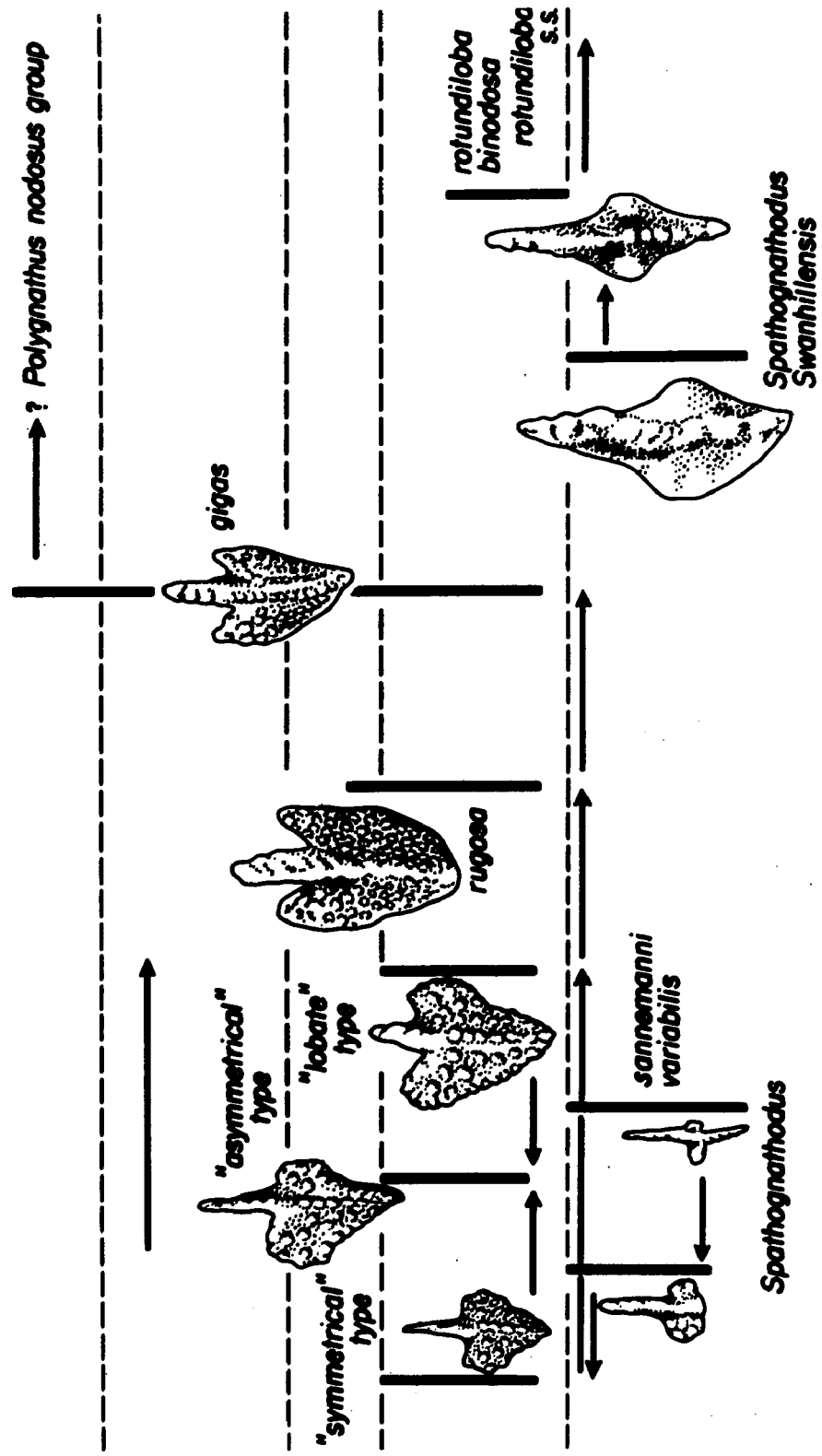


Figure 7 - Phylogenetic relationships of the genus *Ancyrodella*.

rotundiloba having a single denticle on either side of the main carina and lacking any other dentition. Pollock (1968, p. 440) erects a new species, Spathognathodus swanhillensis which is identical to binodosa but lacks the platform nodes. He also described and illustrated several subspecies of Spathognathodus sannemanni which show the development of a transverse basal cavity with nodes developed on the oral surface.

I consider that the genus Ancyrodella is polyphyletic, developing from at least two species of the genus Spathognathodus (Fig. 5).

Spathognathodus sannemanni develops a wide transverse basal cavity with nodes on the oral surface (variabilis of Pollock); the nodes increase in number and a platform is developed (Pollock, 1968, p. 439). The basal cavity remains wide beneath the platform. An increase in the number of nodes and platform size would give A. rotundiloba s.s., the wide basal cavity developed transversely being retained. Conversely, A. rotundiloba s.s. could have developed via A. rotundiloba binodosa from S. swanhillensis. However, this latter species also shows the wide transverse basal cavity present in S. sannemanni. Ancyrodella develops from Spathognathodus by the development of nodes on the oral surface of the cavity and tumidity of the medial part of the blade. The two evolutionary paths described above may in fact be the same, the difference being in the ecological environment.

The similarity of oral ornamentation between A. rotundiloba and Polygnathus cristatus cannot be denied. In spite of this, and however it is interpreted in terms of functional homeomorphy, the very different basal cavities and free blades set them apart. It is interesting to note that P. cristatus is ancestral to P. asymmetricus and Palmatolepis ? disparalvea (Orr & Klapper, 1968) mirroring the zoning of dentition and development of lobation seen in the Ancyrodella group.

Within the genus Ancyrodella two main trends are apparent: one is the lineation of dentition and the other is reduction in platform size. Superimposed on this latter trend is the development of additional lobation.

In the upper part of the Lower Polygnathus asymmetricus Zone, A. rotundiloba shows considerable diversification (see remarks under that species). Two variations appear to be the root stocks for the two major trends. The "cruciform" type gives rise to A. rotundiloba alata which appears to be a "blind alley" and to A. sp. nov. A which shows the development of lateral keels. Development of the lateral carinas and anterior lobation gives A. buckeyensis. From A. buckeyensis two trends are apparent; one of platform reduction gives A. nodosa and then A. ioides (Ziegler, 1962; Ethington, 1965). The second trend is one of lobation and minor platform reduction to give A. lobata and A. curvata. This differs from Bischoff (1956) who suggests that A. nodosa is ancestral to A. lobata and Ziegler (1962) who suggests that lobata was derived from gigas.

The other main branch from A. rotundiloba is characterized by development of linear ornament via "lobate" forms to A. rugosa. Lining of the dentation gives rise to A. gigas. I consider that A. gigas is probably an end member of an evolutionary trend rather than a "root-stock," as suggested by Ziegler (1962).

In both main trends there is a conspicuous fining of the nodose ornament and also a narrowing of the lateral extensions of the basal cavity to a narrow medial trough in the keels and then to absence on the keels.

It is possible that the wide cavity was needed to develop the platform on the blade-like ancestor and that this became obsolescent after the true platform had been formed. If this is the case, then perhaps Ancyrodella could develop into a true polygnathid! Perhaps the linear ornamental A. gigas is ancestral to the P. nodocostatus group which lacks a progenitor at the present time.

ANCYRODELLA BUCKEYENSIS Stauffer, 1938

Pl. 1, figs. 1a,b

- 1938 Ancyrodella buckeyensis Stauffer, J. Paleont., 12, 418, pl. 52, figs. 17, 18, 23, 24.
- 1938 Ancyrodella plena Stauffer, ibid., 418, pl. 52, figs. 21, 22.
- 1945 Ancyrodella buckeyensis Stauffer, Youngquist, J. Paleont., 19, 356, pl. 54, fig. 11.
- 1947 Polygnathus spinulosa Youngquist, ibid., pl. 24, fig. 9.
- 1947 Ancyrodella sp. Miller & Youngquist, J. Paleont., 21, 503, pl. 74, fig. 13.
- 1947 Ancyrodella lobata Branson & Mehl; Miller & Youngquist, ibid., 21, 502, fig. 12.
- 1948 Ancyrodella nodosa Ulrich & Bassler; Youngquist & Miller, J. Paleont., 22, 441, pl. 68, figs. 13, 14.
- 1953 Conodont; Beckmann, Hess. Landesamt Bodenf., Notizb., 81, pl. 2, fig. 3e.
- 1956 Ancyrodella sp. 13 Müller, J. Paleont., 30, pl. 145, fig. 13.
- 1957 Ancyrodella buckeyensis Stauffer; Müller & Müller, J. Paleont., 31, 1091, pl. 136, fig. 5, ?2.
- 1957 Ancyrodella subrotunda Miller & Youngquist; Müller & Müller, ibid., 1092, pl. 136, fig. 6.
- 1958 Ancyrodella buckeyensis Stauffer, Ziegler, Hess. Landesamt Bodenf., Notizb., 87, 40, pl. 11, fig. 7.
- 1958 Ancyrodella gigas Miller & Youngquist; Ziegler (in part) , ibid., pl. 11, fig. 10 only [fig. 8 = A. gigas].
- 1959 Ancyrodella buckeyensis Stauffer; Krebs, Senck. leth., 40, pl. 1, fig. 6.
- 1960 Ancyrodella nodosa Ulrich & Bassler; Müller, Geol. Rundschau, 40, pl. 2, fig. 2.
- 1964 Ancyrodella buckeyensis Stauffer; Budurov & Tschunov, Bull. Inst. Sci. Recherch. Geol., 1, pl. 3, figs. 4a, b.

- 1964 Ancyrodella cf. nodosa Ulrich & Bassler; Budurov & Tschunev, ibid., pl. 3, figs. 7a, b.
- 1965 Ancyrodella buckeyensis Stauffer; Ethington, J. Paleont., 39, 570, pl. 68, fig. 3.
- 1967 Ancyrodella buckeyensis Stauffer, Clark & Ethington, Geol. Soc. Amer. Mem., 103, 29.
- 1969 Ancyrodella buckeyensis Stauffer; Chorowska, Kwart. Geol., 13, 66, pl. 1, figs. 2, 3.

Material: 52 specimens, CPC 12353-12359 figured.

Locality of figured material: Sample BG 19001, Section 1, McWhae Ridge, Gogo Formation; Sample 19537, Section 9, Balme Knoll, Virgin Hills Formation; Sample BF 19584, Section 12, southwest of Waggon Pass, Virgin Hills Formation; Sample BG 21371, Section 24, Teichert Hills, Sadler Limestone.

Description: The unit is arrow shaped. The blade is the same length or somewhat shorter than the platform. The platform is tripartite with two anterior lobes and a posterior extension. The carina is continuous with the blade; in some cases it is slightly constricted at the blade-platform junction with the nodes, tending to be larger in the medial part of the platform. Lateral carinae run along the lobes, being nodose near the main carina but becoming more denticulate toward the anterior terminations. In some cases the carina is developed as an extremely short free blade on each lobe. Apart from the carinae the platform ornamentation consists of ridges normal to the platform margin in juvenile specimens, which tend to break up into two nodes giving double rows paralleling the margin. There is no ornament anterior to the lateral carinae.

In lateral view the free blade is extremely high in its median part, shallowing rapidly posteriorly and less rapidly anteriorly. The denticles are fused, with free chevron tips which are slightly inclined posteriorly.

Aborally, the unit is bisected by a narrow keel with a median

trough. At its mid-point a very small basal cavity is developed; it is diamond-shaped with two apices at the keel junction. The other two apices mark the junction of lateral keels which run anteriorly along the lateral lobes at an angle of about 45° .

Remarks: There is some variation in dentition in this species. Some specimens exhibit fairly coarse nodose ornament, whereas others have much finer nodes or ridges. The lateral carinae are sometimes composed of a fine isolated node which does not fuse with the main carina. In other cases they are composed of many low fused nodes which also fuse with the main carina.

These variations are probably due to two factors. The ornament tends to change from juveniles to adults. The juvenile specimens tend to be finely ornamented with ridges which in the adults become coarser and divided into rows of nodes normal to the platform margin in such a way that rows of nodes parallel to the margin are developed.

The other factor is phylogeny. A. buckeyensis appears to be developed from the A. rotundiloba group. Specimens close to A. rotundiloba show coarse dentition with tall isolated nodes. A. buckeyensis is ancestral to A. nodosa and some specimens show much finer low denticles, similar to the ornament on A. nodosa.

A. buckeyensis can be distinguished from A. rotundiloba by the arrow-shaped platform ornament, the well developed lateral carinae and the less coarse ornament. The difference between A. buckeyensis and A. nodosa is more subtle. In the latter the platform posterior to the lobes is greatly reduced and commonly bears only one row of nodes or ridges, compared with the two or more of A. buckeyensis. The platform outline is triangular in A. buckeyensis; in A. nodosa it is tripartite.

Distribution: The species was originally described from the Upper Devonian Olentangy Shale of Ohio (Stauffer, 1938). In North America the species has also been recorded from the Upper Devonian of Iowa

(Youngquist, 1945; Youngquist, 1947; Miller & Youngquist, 1947; Youngquist & Miller, 1948; Müller, 1956; Müller & Müller, 1957), Arizona (Ethington, 1965) and Utah (Clark & Ethington, 1967).

In Europe the species is abundant in the Frasnian of the Rhenish Schiefergebirge (Bischoff, 1956; Ziegler, 1958; Krebs, 1959; Krebs & Rabien, 1964; Bar, 1968; Schneider, 1969) and the Harz (Meyer, 1965) of Germany. It has been recorded in the Upper Devonian of the Carnic Alps, Austria (Schönlaub, 1969) and from the Montagne Noire of France (Boyer et al., 1968). Budurov & Tschunov (1964) have recorded the species from northwest Bulgaria and it is also known from Poland (Chorowska, 1969).

Müller (1960) illustrates a specimen from the Kimberley District of Western Australia and identifies it as A. nodosa. However, from the illustration the specimen should clearly be referred to A. buckeyensis. Pollock (1968) records the species from the Majeau Lake Fm. (Upper Devonian) of Alberta, Canada.

Range: Ziegler (1958) gives the range of the species as Upper Devonian (upper to I α - to I δ). In the Montagne Noire it has a composite range of middle to I β (γ) - upper to I δ . In all the known occurrences the species is confined to the Frasnian. Krebs (1959) and Krebs & Rabien (1964) record the species as low as the Lower P. asymmetricus Zone (lower to I α). The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to I α) to the Upper Palmatolepis gigas Zone (to I δ).

ANCYRODELLA CURVATA (Branson & Mehl, 1934)

Pl. 1, figs. 4a, b

1934 Ancyrognathus curvata Branson & Mehl, Missouri Univ. Studies, 8, 241, pl. 19, figs. 6, 11.

1938 Ancyrognathus asteroideus Stauffer, J. Paleont., 12, 418, pl. 52, figs. 8, 9.

- 1955 Ancyrognathus curvata Branson & Mehl; Sannemann, N. Jb. Geol. Palaont., Abh., 100, pl. 24, figs. 11a, b.
- 1956 Ancyrodella curvata (Branson & Mehl); Bischoff, Hess. Landesamt. Bodenf., Notizbl., 84, 118, pl. 8, figs. 9-11.
- 1956 Ancyrodella sp. B Hass, U.S. Geol. Surv., Prof. Pap., 286, pl. 4, fig. 20.
- 1957 Ancyrodella curvata (Branson & Mehl); Ziegler in Flügel & Ziegler, Naturw. Ver. Steiermark, Mitt., 87, pl. 1, fig. 8.
- 1957 Ancyropenta asteroideus (Stauffer); Müller & Müller, J. Paleont., 31, 1093, pl. 136, figs. 7a-8.
- 1957 Ancyrodella curvata (Branson & Mehl); Lys, Serre, and Deroo, Rev. Inst. Francais Pet., 12, 795, pl. 7, fig. 1.
- 1958 Ancyrodella curvata (Branson & Mehl); Ziegler, Hess. Landesamt Bodenf., Notizbl., 87, 40, pl. 11, fig. 5.
- 1959 Ancyrodella curvata (Branson & Mehl); Panseri & Barsotti, Not. Comuns. Inst. Geol. Min. Espana, 55, pl. 2, fig. 1.
- 1961 Ancyrodella curvata (Branson & Mehl); Freyer, Freiberger Forsch., C95, 32, pl. 1, fig. 6.
- 1962 Ancyrodella curvata (Branson & Mehl); Ethington & Furnish, J. Paleont., 36, 1261, pl. 172, figs. 12-20.
- 1966 Ancyrodella curvata (Branson & Mehl); Anderson, J. Paleont., 40, 403, pl. 48, figs. 2, 4, 6, 9, 11, 13.
- 1966 Ancyrodella curvata (Branson & Mehl); Glenister & Klapper, J. Paleont., 40, 798, pl. 86, figs. 13-15.
- 1966 Ancyrodella curvata (Branson & Mehl); Koverdynsky & Zikmundova, Vestnik U. U. Geol., 42, pl. 1, figs. 6, 8.
- 1967 Ancyrodella curvata (Branson & Mehl); Wolska, Acta Palaeont. Polon., 12, 373, pl. 1, figs. 12, 13.
- 1967 Ancyrodella curvata (Branson & Mehl); van Adrichem Boogaert, Leidse Geol. Medel., 39, 177, pl. 1, fig. 1.
- 1967 Ancyrodella curvata (Branson & Mehl); Wirth, N. Jb. Geol. Palaont., Abh., 127, 203, pl. 19, figs. 1a, b.

- 1968 Ancyrodella curvata (Branson & Mehl); Mound, J. Paleont., 42, 469, pl. 65, figs. 5, 6 [figs. 13-16 = ? A. buckeyensis].
- 1968 Ancyrodella curvata (Branson & Mehl); Figge, N. Jb. Geol. Palaont. Monats., 197, fig. 3.
- 1970 Ancyrodella curvata (Branson & Mehl); Seddon, J. Geol. Soc. Aust., 16, pl. 16, figs. 3, 4.

Material: 16 specimens: CPC 12360 figured.

Localities of figured material: Sample BG 19014, Section 1, McWhae Ridge, Virgin Hills Formation.

Description: The unit is asymmetrical and the blade is the same length as the platform. The platform is developed as four lobes. One lobe is the posterior extension of the carina and the remainder are lateral. Two are developed as symmetrical anteriorly inclined lobes and the fourth is a posteriorly directed lobe on the outer side. The main carina is an extension of the free blade. Lateral carinae are developed on each lobe. They are composed of low nodes; none of them fuse with the main carina, although all approach the main carina at the same point. The two lateral carinae on the outer side fuse in a large node. Each carina develops as a minute free blade at its termination; the dentition is taller and laterally compressed. Apart from the carinae, ornament is virtually lacking on the platform, apart from small low nodose ridges normal to and confined to the posterior platform margin.

In lateral view the free blade is highest at the anterior and is composed of fused denticles with free posteriorly inclined chevron tips. There is a short free blade at the posterior termination with slightly taller dentition than the carina.

Aborally, the unit is bisected by a main keel in which lies a narrow trough. At its mid-point a diamond-shaped basal cavity is developed with an apices of the diamond corresponding to each keel. Three lateral keels with troughs are present; on the outer side two diverge at 45° and 135° to the main keel from an apex of the basal

cavity; on the inner side a single keel radiates from the opposite apex.

Remarks: Only two species of Ancyrodella lobata and curvata possess the extra lateral lobe directed posteriorly. A. curvata appears to have developed from A. lobata by a reduction in ornament and in massiveness of the lobes. Further reduction of the platform would produce an A. ioides-like form with an extra lobe. No such forms have been described, although one broken specimen in this fauna appears to have four very narrow lobes.

Distribution: The species was originally described from the Upper Devonian Grassy Creek Shale of Missouri (Branson & Mehl, 1934). Elsewhere in North America it has been reported from Iowa (Müller & Müller, 1957; Anderson, 1966), Ohio (Stauffer, 1938), New York State (Oliver et al., 1967) and Alberta (Pollock, 1968; Mound, 1968).

A. curvata is common in Europe, especially Germany, where it has been recorded in the Manticoceras-Stufe (Sannemann, 1955; Bischoff, 1956; Bischoff & Ziegler, 1956; Stoppel, 1958; Walliser, 1958; Ziegler, 1958; Freyer, 1961; Krebs & Rabien, 1964; Meyer, 1965; Zitzmann, 1966; Bering, 1967; Zitzmann, 1967; Figge, 1968; Zitzmann, 1968; Bar, 1968; Schneider, 1969). It has also been recorded in France (Lys, Serre, & Deroo, 1957; Boyer et al., 1968), Austria (Flügel & Ziegler, 1957; Schönlaub, 1969), Poland (Wolska, 1967), Spain (van Adrichem Boogaert, 1967; Wirth, 1967) and Czechoslovakia (Koverdynsky & Zikmundova, 1966).

In North Africa A. curvata has been recorded from the Spanish Sahara (Panseri & Barsotti, 1959; Ethington & Furnish, 1962), Algeria (Remack-Petitot, 1960; Massa, 1965) and Morocco (Massa, 1965). The species has previously been recorded from the Canning Basin by Glenister & Klapper (1966) and Seddon (1970).

Range: Ziegler (1958) gives the range of the species as Upper Devonian (to I₈ - to I₆). Boyer et al. (1968) give roughly the same range for their French occurrences. The species is confined to the Frasnian. In

New York State the species ranges through the Cohocton Series (equivalent to upper to I β - to I δ) (Oliver et al., 1967). The Canning Basin specimens range from the Ancyrognathus triangularis Zone (to I γ) up to the Lower Palmatolepis triangularis Zone (to I δ).

ANCYRODELLA GIGAS Youngquist, 1947

Pl. 1, figs. 2a, b

- 1947 Ancyrodella gigas Youngquist, J. Paleont., 21, 96, pl. 25, fig. 23.
- 1947 Polygnathus rotundiloba Ulrich & Bassler; Youngquist, ibid., 110, pl. 26, fig. 6.
- 1957 Ancyrodella gigas Youngquist; Müller & Müller, J. Paleont., 1091, pl. 142, fig. 1 [non pl. 141, fig. 8 = A. lobata].
- 1958 Ancyrodella gigas Youngquist; Ziegler, Hess. Landesamt Bodenf., Notizbl., 87, 41, pl. 11, figs. 8a, b [non figs. 10a, b = A. buckeyensis].
- 1965 Ancyrodella gigas Miller & Youngquist [sic]; Ziegler, Fortschr. Geol. Rheinld Westf., 9, 538, pl. 1, fig. 1.
- 1965 Ancyrodella gigas Youngquist; Ziegler, ibid., 737, pl. 2, fig. 7.
- 1966 Ancyrodella gigas Youngquist; Anderson, J. Paleont., 40, 403, pl. 48, figs. 10, 14.
- 1968 Ancyrodella gigas Youngquist; Mound, J. Paleont., 42, 470, pl. 65, figs. 17, 18.
- non 1969 Ancyrodella gigas Youngquist; Chorowska, Kwart. Geol., 13, 66, pl. 1, figs. 4, 5 [= A. rotundiloba s.s.].

Material: 9 specimens, CPC 12361-12363 figured.

Localities of figured material: Sample BG 19544, Section 9, Balme Knoll, Gogo Formation.

Description: The platform is arrow-like and bisected by the carina which is a continuation of the anterior free blade. The length of the free

blade is just less than the platform length. No true lateral lobes are present although the outer edges of the platform are produced anteriorly. Similarly, there are no true lateral carinae although each anteriorly produced platform bears a conspicuous row of nodes which approach the carina at a low angle. However, rather than terminating just prior to the main carina or fusing with it the ornament curves to parallel it, terminating near the posterior edge of the platform. Outside both of these rows of nodes secondary rows are developed which parallel them and also terminate at the platform margin. The margin of the platform is crenulate.

In lateral view the blade is higher than the platform. In some cases denticles are fused and share a chevron tip, but in all cases the tips are free and are inclined posteriorly.

Aborally the unit is bisected by a main keel with a medial trough. At mid-point the trough widens slightly to give a very small diamond-shaped cavity. From this run two lateral keels, which terminate at the antero-lateral edges of the platform. No troughs appear to be developed in these keels.

Distribution: The species was originally described from the Upper Devonian of Iowa (Youngquist, 1947). It has also been recorded from the Iowa Upper Devonian by other workers (Müller & Müller, 1957; Anderson, 1966). Elsewhere in North America it has been recorded from Alberta (Clark & Ethington, 1965; Uyeno, 1967; Pollock, 1968; Mound, 1968).

In Europe the species has been recorded from the Upper Devonian of Germany (Ziegler, 1958, 1965a, b; Krebs & Rabien, 1964), Austria (Schönlaub, 1969) and France (Boyer et al., 1968).

Range: Ziegler (1958) gives the range as Upper Devonian to I α - to I δ . Boyer et al., (1968) give a cumulative range of to I α - to I δ /S. The Canning Basin specimens range from the Lower Polygnathus asymmetri-
cus Zone (to I α) up to the Upper Palmatolepis gigas Zone (to I δ).

ANCYRODELLA IOIDES Ziegler, 1958

Pl. 1, figs. 5a,b

- 1958 Ancyrodella ioides Ziegler, Hess. Landesamt. Bodenf., Abh.,
87, 42, pl. 11, figs. 2-4.
- ?1968 Ancyrodella ioides Ziegler; Spasov et al., Inst. Recherch. Geol.
Geophys. Bull., 26, 158, pl. 1, figs. 4, 17.
- ?1970 Ancyrodella ioides Ziegler; Seddon, J. Geol. Soc. Aust., 16,
753, pl. 16, fig. 6.

Material: 7 specimens, CPC 12364-12367 figured.

Localities of figured material: Sample BG 19013, Section 1, McWhae Ridge, Virgin Hills Formation.

Description: Unit cruciform and symmetrical. The anterior free blade is the same length as the platform plus posterior free blade. The carina is continuous with both free blades and is marked by a shortening and fattening of the denticulation. The platform consists of two narrow lateral lobes and a posterior lobe which narrows to form the posterior free blade. The ornament consists of lateral carinae which terminate near the main carina. The lateral carinae are formed of denticles rather than nodes and the denticles increase in size and height toward the lobe termination. The platform margin is crenulate and occasionally a few nodes are present posterior to the lateral carinae.

In lateral view the anterior free blade increases in height anteriorly and is formed of laterally compressed fused denticles, with free posteriorly inclined chevron tips.

Aborally, the unit is keeled; a trough is developed near the mid-point on either side of the small basal cavity. Two lateral keels are present on each platform lobe; they do not contain a trough and meet the median keel at the basal cavity. There is some extension of the cavity along both lateral keels.

Remarks: A. ioides developed from A. nodosa by a general reduction in the platform to give the cruciform plan. It is very difficult to place a boundary between A. nodosa and A. ioides and some of the illustrated specimens, e.g., Spasov et al., 1968; and Seddon, 1970, are probably transitional forms. One of the specimens illustrated here (Pl. 1, fig. 5a) is also a transitional form.

The restricted distribution of A. ioides is interesting; the Canning Basin occurrences are the only ones outside Europe. This suggests that there was some restriction on its movement: all other species of Ancyrodella appear to have a world-wide distribution.

Distribution: The species was originally described from the Adorfstufe of Germany (Ziegler, 1958), and since then it has been recorded in Manticoceras-Stufe strata by several authors (Krebs & Rabien, 1964; Schriel & Stoppel, 1965; Zitzmann, 1968; Bar, 1968; Schneider, 1969). In the rest of Europe the species has been recorded from Austria (Schönlaub, 1969), France (Boyer et al., 1968) and Yugoslavia (Spasov et al., 1967, 1968).

The only record of this species outside Europe is in the Canning Basin (Seddon, 1970). It is noteworthy that the species is unrecorded from North America.

Range: Upper Devonian (middle to I γ - lower to I δ) (Ziegler, 1958). Boyer et al. (1968) extend the range downward to the base of the toI β Zone. The Canning Basin specimens range from the Upper Polygnathus asymmetricus Zone (toI β) up to the Lower Palmatolepis gigas Zone (toI γ).

ANCYRODELLA LOBATA Branson & Mehl, 1934

Pl. 1, figs. 6a,b

1934 Ancyrodella lobata Branson & Mehl, Univ. Missouri Studies, 8, 239, pl. 19, fig. 14; pl. 21, figs. 22, 23.

- 1947 Ancyrodella magister Miller & Youngquist, J. Paleont., 21, 503,
pl. 74, fig. 14.
- 1949 Ancyrodella lobata Branson & Mehl; Beckmann, Senckenbergiana,
30, 155, pl. 4, fig. 1.
- 1955 Ancyrodella lobata Branson & Mehl; Sannemann, N. Jb. Geol.
Palaont., Abh., 100, 331, pl. 24, fig. 2.
- 1957 Ancyrodella gigas Youngquist; Müller & Müller (part), J.
Paleont., 31, 1091, pl. 141, fig. 8 [non pl. 142, fig. 1 =
A. gigas].
- 1957 Ancyropenta longidenticulata Müller & Müller, ibid., 1093,
pl. 136, figs. 3a-c; pl. 137, figs. 1a--2.
- 1958 Ancyrodella lobata Branson & Mehl; Ziegler, Hess. Landesamt
Bodenf., Notizbl., 87, 43, pl. 11, figs. 6, 9.
- 1965 Ancyrodella lobata Branson & Mehl; Krebs & Ziegler, Forschr.
Geol. Rheinld Westf., 9, 754, pl. 1, fig. 14.
- 1966 Ancyrodella lobata Branson & Mehl; Anderson, J. Paleont., 40,
403, pl. 48, figs. 15, 16.
- 1966 Ancyrodella lobata Branson & Mehl; Flajs, N. Jb. Geol. Palaont.,
Abh., 124, 228, pl. 23, fig. 2.
- 1967 Ancyrodella lobata (Branson & Mehl); Wirth, ibid., 127, 203,
pl. 19, figs. 3a-74.
- 1968 Ancyrodella lobata Branson & Mehl; Mound, J. Paleont., 42,
470, pl. 65, figs. 7-12.
- 1970 Ancyrodella lobata Branson & Mehl; Seddon, J. Geol. Soc. Aust.,
16, 753, pl. 16, fig. 2.

Material: 19 specimens, CPC 12368-12372 figured.

Localities of figured material: Sample BG 19534, 19548, Section 9, Balme Knoll; Sample BG 19575, mouth of Waggon Pass, Virgin Hills Formation; Sample BG 19580, Section 12, southwest of Waggon Pass, Virgin Hills Formation; Sample BG 21371, Section 24, Teichert Hills, Sadler Limestone.

Description: The unit is massive, with a free blade the same length as the platform. The carina bisects the curved unit: it is slightly curved and is considerably lower than the free blade with which it merges. The platform is developed as two anteriorly directed lobes, a wide posterior lobe and a lobate extension of the outer posterior platform margin. Platform ornament consists of two lateral carinae which are present on the inner margin of the anterior lobes. They terminate near the main carina. The remainder of the platform anterior to these carinae is covered with nodes. They are arranged in a roughly elongate pattern subparallel to the main carina. Nodes in the lobate outer portion of the platform are developed as an incipient carina at a 45° angle to the main carina.

In lateral view the free blade increases in height anteriorly. The denticles are laterally compressed with free posteriorly inclined chevron tips. They increase in width anteriorly.

Aborally a medial keel with a very narrow trough bisects the unit. At mid-point a basal cavity is present. It is small and is the focal point of the radiating keels beneath the anterior lobes and sometimes the outer posterior lobate portion.

Remarks: The species is easily recognised by the lobate outer margin. It is probably developed from A. rotundiloba and/or A. buckeyensis. Some specimens possess well developed carinae and keels on the postero-lateral lobe; others show an incipient carina and keel. The species appears to be ancestral to A. curvata and can be distinguished by the more massive platform and the less well developed postero-lateral lobe. Stauffer (1938, pl. 52, figs. 28, 29) illustrates a lobate specimen and refers it to a new species A. robusta. No extra lateral keel is present, so it is difficult to decide whether A. robusta is a junior synonym of A. buckeyensis or A. lobata.

Distribution: The species was originally described from the Upper Devonian Grassy Creek Shale of Missouri (Branson & Mehl, 1934).

Other North American occurrences are known from Iowa (Miller & Youngquist, 1947; Müller & Müller, 1957; Anderson, 1966), and Alberta (Pollock, 1968; Mound, 1968).

The species occurs abundantly in Europe, especially in the Manticoceras-Stufe of Germany (Beckmann, 1949, Sannemann, 1955; Bischoff & Ziegler, 1956; Bischoff, 1956; Ziegler, 1958; Freyer, 1961; Krebs & Ziegler, 1965; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970). Elsewhere in Europe it has been recorded from Austria (Flajs, 1966; Schönlaub, 1969), Czechoslovakia (Dvorak & Freyer, 1968), France (Serre & Lys, 1960; Boyer et al., 1968), and Spain (Wirth, 1967).

Seddon (1970) has recorded the species from the Canning Basin and it is also known from Morocco (Massa, 1965).

Range: Ziegler (1958) gives the species range as Upper Devonian (to I α - to I γ). Boyer et al. (1968) give a composite range of to I β - lower to I γ for occurrences in France. The Canning Basin specimens range from the Middle Polygnathus asymmetricus Zone (to I α) up to the Ancyrognathus triangularis Zone (to I γ).

ANCYRODELLA NODOSA Ulrich & Bassler, 1926

Pl. 1, Figs. 2a, b

- 1926 Ancyrodella nodosa Ulrich & Bassler, Proc. U.S. Natl. Mus., 68, 48, pl. 1, figs. 10-13.
- 1926 Ancyrodella hamata Ulrich & Bassler, ibid., 48, pl. 7, fig. 7.
- 1926 Ancyrodella malleus Ulrich & Bassler (part), ibid., 49, pl. 7, fig. 2.
- 1926 Ancyrodella symmetrica Ulrich & Bassler, ibid., 49, pl. 8, fig. 1.
- 1932 Ancyrodella hamata Ulrich & Bassler; Bassler, Tenn. Div. Geol. Bull., 38, 234, pl. 26, fig. 14.

- 1935 Ancyrodella hamata Ulrich & Bassler; Cooper, J. Paleont., 9, 312, pl. 27, fig. 39.
- non 1948 Ancyrodella nodosa Ulrich & Bassler; Youngquist & Miller, J. Paleont., 22, 441, pl. 68, figs. 13, 14 [= A. buckeyensis].
- 1956 Ancyrodella nodosa Ulrich & Bassler; Bischoff, Hess. Landesamt. Bodenf., Notizbl., 84, 119, pl. 8, figs. 12, 15.
- ?1956 Ancyrodella sp. Dineley & Rhodes, Geol. Mag., 93, 245, text-fig. 7.
- 1956 Ancyrodella sp. 12, 14 Müller, J. Paleont., 30, 1340, pl. 145, figs. 12, 14.
- 1957 Ancyrodella hamata Ulrich & Bassler; Müller & Müller, J. Paleont., 31, 1091, pl. 136, fig. 4.
- 1958 Ancyrodella nodosa Ulrich & Bassler; Ziegler, Hess. Landesamt. Bodenf., Notizbl., 87, 44, pl. 11, fig. 1.
- non 1960 Ancyrodella nodosa Ulrich & Bassler; Müller, Geol. Rundschau, 49, 88, pl. 2, fig. 2 [= A. buckeyensis].
- 1966 Ancyrodella nodosa Ulrich & Bassler; Glenister & Klapper, J. Paleont., 40, 798, pl. 86, figs. 5-12.
- 1966 Ancyrodella nodosa Ulrich & Bassler; Spasov, "Strasimir Dimitrov" Inst. Geol. Bull., 15, 96, pl. 1, fig. 13.
- 1966 Ancyrodella nodosa Ulrich & Bassler; Flajs, N. Jb. Geol. Palaont., Abh., 124, 238, pl. 23, fig. 4.
- 1967 Ancyrodella nodosa Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap., 578, 6, pl. 13, figs. 1-4, 7-10.
- 1970 Ancyrodella nodosa Ulrich & Bassler; Seddon, J. Geol. Soc. Aust., 16, 753, pl. 16, fig. 5.

Material: 118 specimens, CPC 12373-12378 figured.

Localities of figured material: Sample BG 19009, Section 1, McWhae Ridge, Virgin Hills Formation; Samples BG 19581, 19582, Section 12, southwest of Waggon Pass, Virgin Hills Formation.

Description: An arrow-shaped unit comprising an anterior free blade and a tripartite platform. This consists of two anterior lobes and a posterior extension. The nodose carina is continuous with the free blade and extends slightly beyond the platform as a free blade. The dentition on this extension reverts to denticles rather than nodes. Two lateral carinae extend along the inner margin of the anterior lobes. They are nodose and arcuate; the dentition reverts to denticles near the anterior terminations. Posterior to the lateral carinae the platform margin is crenulate and the platform bears nodes arranged in a sigmoidal pattern bordering the lateral and main carinae.

In lateral view the free blade increases in height anteriorly. It is composed of laterally compressed, fused denticles with free, posteriorly inclined chevron tips.

Aborally the unit is keeled; at its mid-point a basal cavity is developed which is the focal point for the radiating lateral keels. Median troughs extend along all keels for a short distance.

Remarks: A. nodosa is the median species in the continuous sequence from A. buckeyensis to A. ioides. It is extremely difficult to draw any watertight line between these species. However, in general A. nodosa differs from A. buckeyensis in having a sigmoidal platform outline on both sides and a general reduction of platform ornament. However, it possesses more ornament than A. ioides and the platform extends further posteriorly than that species which is essentially cruciform.

Distribution: The species was originally described from the Upper Devonian Rhinestreet Shale of New York State (Ulrich & Bassler, 1926; Huddle, 1967; Oliver et al., 1967). Bassler (1932, p. 234) states that the species is present in the Hardin Sandstone, Tennessee, although the specimen illustrated is obviously the one from the Rhinestreet Shale illustrated in the 1926 paper. Elsewhere in North America the species is recorded from Iowa (Müller, 1956; Müller & Müller, 1957) and

Alberta (Pollock, 1968).

In Europe the species has been reported many times from the Manticoceras-Stufe (Bischoff, 1956; Ziegler, 1958; Stoppel, 1958; Freyer, 1961; Krebs & Rabien, 1964; Meyer, 1965; Schriel & Stoppel, 1965; Zitzmann, 1966, 1967, 1968). Other occurrences include Austria (Flajs, 1966; Schönlaub, 1969), Bulgaria (Spasov, 1966), France (Boyer et al., 1968) and questionably England (Dineley & Rhodes, 1956).

The species has been reported extensively from the Canning Basin (Müller, 1956; Glenister & Klapper, 1966; Seddon, 1970). It has also been recorded from the Malay Peninsula (Alexander & Müller, 1963).

Range: Upper Devonian (to I δ - to I δ) in Germany (Ziegler, 1958) and in France (Boyer et al., 1968). The Canning Basin specimens range from the Ancyrognathus triangularis Zone (to I δ) up to the Upper Palmatolepis gigas Zone.

ANCYRODELLA ROTUNDILOBA ROTUNDILOBA (Bryant, 1921)

Pl. 2, figs. 1a, b

- 1879 Polygnathus tuberculatus Hinde, Quart. J. Geol. Soc. Lond., 35, 366, pl. 17, fig. 10 only.
- 1921 Polygnathus rotundilobus Bryant, Buffalo Soc. Nat. Sci., Bull., 13, 26, pl. 12, figs. 1-6.
- 1933 Polygnathus tuberculata Hinde; Branson & Mehl, Univ. Missouri Stud., 8, 148, pl. 11, fig. 9.
- 1934 Polygnathus rotundiloba Bryant; Huddle, Bull. Amer. Paleont., 21, 102, pl. 8, figs. 36, 37.
- non 1947 Polygnathus rotundiloba Bryant; Youngquist, J. Paleont., 21, 110, pl. 26, fig. 6 [= A. gigas].
- 1957 Ancyrodella rotundiloba (Bryant); Bischoff & Ziegler, Hess. Landesamt. Bodenf., Abh., 22, 42, pl. 16, fig. 15 [non figs. 5-12, 14, 16, 17 = A. rotundiloba alata].

- 1958 Ancyrodella rotundiloba (Bryant); Ziegler, ibid., Notizbl., 87, 44, pl. 11, fig. 11 [non fig. 12 = A. rotundiloba alata].
- 1959 Ancyrodella rotundiloba (Bryant); Krebs, Senck. leth., 40, 384, pl. 1, fig. 15.
- 1965 Ancyrodella rotundiloba rotundiloba (Bryant); Krebs & Ziegler, Fortschr. Geol. Rheinld Westf., 9, 754, pl. 1, figs. 10-13, 15, 16.
- 1966 Ancyrodella rotundiloba rotundiloba (Bryant); Glenister & Klapper, J. Paleont., 40, 799, pl. 85, figs. 9-13.
- 1967 Ancyrodella rotundiloba (Bryant); Clark & Ethington, Geol. Soc. Amer. Mem., 103, 29, pl. 2, figs. 4, 6, 7, 9, 10, 13-15 [fig. 8 = A. rotundiloba alata].
- 1967 Ancyrodella rotundiloba rotundiloba (Bryant); van Adrichem Boogaert, Leidse Geol. Med., 39, 178, pl. 1, fig. 3.
- 1967 Ancyrodella rotundiloba (Bryant); Müller & Clark, J. Paleont., 41, 908, pl. 116, figs. 1-5; text-fig. 6, c-i, n-p, s-w [non pl. 115, fig. 8; text-fig. 6j-m, q, r = A. rotundiloba alata].
- 1969 Ancyrodella gigas Youngquist; Chorowska, Kwart. Geol., 13, 66, pl. 1, figs. 4, 5.
- 1970 Ancyrodella rotundiloba (Bryant); Seddon, J. Geol. Soc. Aust., 16, 753, pl. 16, fig. 1.

Material: 46 specimens, CPC 12379-12390 figured.

Localities of figured material: Samples BG 19186, 19189, hill at base of Section 1, McWhae Ridge, Gogo Formation; Sample BG 19482, Section 6, Lloyd Hill - Laidlaw Range, Gogo Formation; Sample BG 19534, Section 9, Balme Knoll, Virgin Hills Formation; Sample BG 19598, Section 13, Glenister Knolls, Gogo Formation; Samples BG 21222, 21228, 21229, 21237, Section 19, Sadler Ridge, Sadler Limestone.

Description: Unit heart-shaped to oval. Anterior free blade of equal length to platform. A medial carina bisects the platform; it is a continuation of the free blade and is composed of low nodes. The platform is ornamented by coarse nodes. Sometimes they are arranged irregularly and in other cases they are arranged to give incipient lateral carinae. In some specimens the two halves of the platform are mirror images of one another but sometimes the inner platform is narrower and extends further anteriorly.

In lateral view the free blade is exceptionally high, the highest point being just anterior to the midpoint. It is composed of laterally compressed, fused denticles with posteriorly inclined, free chevron tips.

Aborally, the unit is keeled over its whole length. At about the mid-point a basal cavity is developed; it extends as a cruciform extension along the keel and at right angles to it. The lateral keels are short and do not reach to the crimp. Some specimens (Pl. 2, fig. 1a) have basal "bone" material adhering to the undersurface of the conodont and showing the cruciform attachment pattern. The basal "bone" is opaque and white.

Remarks: A detailed analysis of variation of platform morphology of A. rotundiloba has been presented by Müller & Clark (1967, text-fig. 6) in dealing with a fauna from the lowermost Upper Devonian Squaw Bay Limestone of Michigan.

They recognize three main variations in the adult forms:

- a) "cross pattern" forms which have incipient lateral carinae developed,
- b) "normal pattern" forms which are generally asymmetrical and lack the anterior lobation on both platforms but may be alate (see their text-fig. 6r), and c) "symmetrical" forms with lobation of both anterior-lateral processes.

Glenister & Klapper (1966) have elevated the alate forms to sub-specific rank. Pollock (1968) suggests that even though the subspecies

has the same range as the nominate subspecies, the difference in morphology is sufficient to make the subspecies alata valid. Uyeno (1967) erects a further subspecies binodosa to include forms lacking ornament except for two large nodes, one on each platform. He also leaves in open nomenclature subspecific forms which he distinguishes from rotundiloba s.s. by their coarse nodose dentition. I consider that these belong in the nominate subspecies.

From the published work it appears that A. rotundiloba has at least six recognizable forms. They include: (1) alate forms = alata, (ii) binodose forms = binodosa, (iii) cruciform forms = Müller & Clark text-fig. 6h-m (placed in alata here), (iv) asymmetrical forms = Müller & Clark text-fig. 6o-q (placed in alata here), (v) symmetrical-lobate forms = Müller & Clark text-fig. 6t-w (placed in rotundiloba s.s. here). Work with abundant faunas should help to elucidate some of these differences and show whether they are stratigraphically or ecologically important.

The present faunas show excellent sequences from juvenile forms through to adult forms. They agree strikingly with the growth stages shown by Müller & Clark (1967, text-fig. 6). It would appear that the A. rotundiloba group developed from a spathognathodid ancestor. In fact, it could be polyphyletic; forms such as A. rotundiloba binodosa could have developed from Spathognathodus swanhillensis Pollock, whereas A. rotundiloba s.s. would arise more logically from S. sannemanni n. subsp. A Pollock.

Distribution: The species was originally described from the Upper Devonian Genessee Shale of New York (Bryant, 1921). It had already been illustrated as Polygnathus tuberculatus (Hinde, 1879; Branson & Mehl, 1933) from the Genessee Shale. It has also been recorded in the Appalachians by Oliver et al., (1967). Hass and Huddle (1965) record the species from the Woodford Shale of Oklahoma. The species has been recorded but not illustrated from Alberta (Clark & Ethington, 1965).

In Europe the species has been recorded from Germany (Bischoff & Ziegler, 1957; Ziegler, 1958; Krebs, 1959; Krebs & Ziegler, 1965; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970), Austria (Schulze, 1968; Schönlaub, 1969), France (Boyer et al., 1968), Spain (van Adrichem Boogaert, 1967) and Poland (Chorowska, 1969).

Gupta et al. (1967) record, but do not illustrate the species, from Kashmir. The subspecies has been recorded from the Canning Basin (Glenister & Klapper, 1966; Seddon, 1970).

Range: Ziegler (1958) gives the range in Germany as lowermost Upper Devonian (Middle/Upper Devonian boundary - to I α) Boyer et al. (1968) suggest that the species can get as high as lowermost to I β . The Canning Basin specimens range from the Lower to the lowest Upper Polygnathus asymmetricus Zone (to I α - basal to I β).

ANCYRODELLA ROTUNDILOBA ALATA Glenister & Klapper, 1966

Pl. 2, figs. 3a,b

- 1956 Ancyrodella rotundiloba (Bryant); Hass, U.S. Geol. Surv. Prof. Pap., 286, pl. 4, fig. 21.
- 1957 Ancyrodella rotundiloba (Bryant); Bischoff & Ziegler, Hess. Landesamt. Bodenf., Abh., 22, 42, pl. 16, figs. 5-12, 14, 16, 17 [non fig. 15 = A. rotundiloba s.s.].
- 1958 Ancyrodella rotundiloba (Bryant); Ziegler, Hess. Landesamt. Bodenf., Notizbl., 87, 44, pl. 11, fig. 12 [non fig. 11 = A. rotundiloba s.s.].
- 1966 Ancyrodella rotundiloba alata Glenister & Klapper, J. Paleont., 40, 799, pl. 85, figs. 1-8; pl. 86, figs. 1-4.
- 1967 Ancyrodella rotundiloba (Bryant); Müller & Clark, J. Paleont., 41, 908, pl. 115, fig. 8; text-fig. 6j-m, q, r [non pl. 116, figs. 1-5; text-fig. 6a-i, n-p, s-w = A. rotundiloba s.s.].

1967 Ancyrodella rotundiloba (Bryant); Clark & Ethington, Geol. Soc. Amer. Mem. 103, 29, pl. 2, fig. 8 [figs. 4, 6, 7, 9, 10, 13-15 = A. rotundiloba s.s.].

1968 Ancyrodella rotundiloba alata Glenister & Klapper, J. Paleont., 42, 424, pl. 61, figs. 2, 3.

Material: 8 specimens, CPC 12391-12394 figured.

Localities of figured material: Sample BG 19001, Section 1, McWhae Ridge, Gogo Formation; Sample BG 19482, Section 6, Lloyd Hill-Laidlaw Range, Gogo Formation; Sample BG 21234, Section 19, Sadler Ridge, Sadler Limestone.

Description: This subspecies differs from the nominate subspecies in possessing an alate outline of the platform. In some forms the lateral keels extend farther toward the crimp.

Remarks: I have included forms with a "wing" developed on only one side although these may be a separate subspecies. The variations are discussed under the nominate subspecies.

Distribution: The subspecies was originally described from the Upper Devonian Gogo Formation of the Canning Basin (Glenister & Klapper, 1966). These authors recognized that some of the specimens illustrated by Bischoff & Ziegler (1957) and Ziegler (1958) from Germany belonged to this subspecies. I consider that the specimen illustrated by Hass (1956) from the Chattanooga Shale of Tennessee also belongs to this subspecies.

Recently, the subspecies has been described or recorded from Alberta, Canada (Uyeno, 1967; Pollock, 1968) and Michigan (Müller & Clark, 1967). The latter paper did not recognise the subspecies but it is obvious from the abundant illustrations that the subspecies is present. A specimen assigned to A. rotundiloba by Clark & Ethington (1967, pl. 2, fig. 8) from Utah should also be placed in this subspecies.

Range: None of the authors have given exact range for the subspecies. Uyeno (1967, p. 9) suggests that its earliest occurrence is at the base

of the Middle Polygnathus asymmetricus Zone (to L_{α}). The Canning Basin specimens occur in the Lower and Middle Polygnathus asymmetricus Zone (to L_{α}).

ANCYRODELLA ROTUNDILOBA BINODOSA Uyeno 1967

1967 Ancyrodella rotundiloba binodosa Uyeno, Geol. Surv. Canada
Pap. 67-30, 4, pl. 1, figs. 2, 4, 5.

Material: One specimen.

Locality: Sample BG 19489, Section 6, N.E. of Lloyd Hill, Sadler Formation.

Description: The platform is triangular with very restricted dentition confined to two large nodes, one on either side of the carina. Small nodes are present on part of the margin of the outer platform.

In lateral view the free blade height increases anteriorly. It is composed of laterally compressed denticles with free chevron tips.

Aborally, a large cruciform basal cavity is present which extends along the keel as a narrowing trough and laterally nearly to the crimp.

Remarks: Even though the present specimen does bear extra nodes on one platform it is considered to be so close to binodosa that it is confidently referred to that subspecies. It seems to have developed from Spathognathodus swanhillensis Pollock by development of nodes on the oral portion of the tumid pseudo-platform.

Occurrence and Range: The species was originally described from the Waterways Formation of Alberta, Canada (Uyeno, 1967) and occurs in the uppermost part of the Lower and lowermost part of the Middle Polygnathus asymmetricus Zone (to L_{α}).

ANCYRODELLA RUGOSA Branson & Mehl, 1934

Pl. 2, figs. 2a,b

- 1934 Ancyrodella rugosa Branson & Mehl, Univ. Missouri Stud., 8,
 239, pl. 19, figs. 15, 17.
- 1947 Ancyrodella subrotunda Miller & Youngquist, J. Paleont., 21,
 503, pl. 74, fig. 17.
- 1949 Ancyrodella rugosa Branson & Mehl; Beckmann, Senckenbergi-
 ana, 30, 155, pl. 1, fig. 1; pl. 4, fig. 2.
- 1957 Ancyrodella rugosa Branson & Mehl; Bischoff & Ziegler, Hess.
 Landesamt. Bodenf., Notizbl., 84, 42, pl. 16, fig. 13.
- 1959 Ancyrodella rugosa Branson & Mehl; Krebs, Senck. leth., 40,
 384, pl. 1, fig. 14.
- 1968 Ancyrodella rugosa Branson & Mehl; Pollock, J. Paleont., 42,
 428, pl. 61, fig. 1.

Material: 3 specimens, CPC 12395 figured.

Locality of figured material: Sample BG 21247, Section 20, Longs Well Creek, Gogo Formation.

Description: The unit is quadrate to ovate with a free blade slightly shorter than the platform. The carina is low and nodose, the nodes being similar to the platform nodes. At its junction with the free blade it is practically non-existent. The platform is ornamented with low coarse nodes which are arranged in linear rows subparallel to the carina.

In lateral view the free blade is composed of exceptionally tall, fused, laterally compressed denticles. The height decreases abruptly at the platform junction.

Aborally, a main keel runs the length of the unit. At its mid-point a small diamond-shaped basal cavity is developed, which extends as narrowing troughs along the keel for a short distance. Two lateral keels are developed from the basal cavity but they lack troughs.

Remarks: A. rugosa appears to have developed from A. rotundiloba by lineation of the platform ornament and a reduction of the cruciform basal cavity. The lineation of the platform ornament without the development of lateral carinae suggests that it may be ancestral to A. gigas.

Occurrence: The species was originally described from the Grassy Creek Shale of Missouri (Branson & Mehl, 1934). It has also been recorded from Iowa (Miller & Youngquist, 1947) and Alberta (Pollock, 1968) in North America. In Europe the species has been reported from Germany (Beckmann, 1949; Bischoff & Ziegler, 1957; Krebs, 1959; Meyer, 1965; Krebs & Ziegler, 1965). Gupta et al. (1967) record it from Kashmir.

Range: No exact range has been given, but a composite range from known occurrences suggests that the species is confined to the Polygnathus asymmetricus Zone, although it may occur in the underlying Schmidtognathus hermanni - Polygnathus cristatus Zone. The Canning Basin specimens are from either the Lower or Middle Polygnathus asymmetricus Zone.

ANCYRODELLA sp. nov. A

- 1965 Ancyrodella rotundiloba (Bryant) n. subsp., Krebs & Ziegler, Fortschr. Geol. Rheinld Westf., 9, 754, pl. 1, figs. 6-9.
- ?1966 Ancyrodella n. sp., aff. lobata Branson & Mehl; Flajs, N. Jb. Geol. Palaont., Abh., 124, 228, pl. 24, fig. 8; text-fig. 3b.
- ?1967 Ancyrodella rotundiloba (Bryant); Müller & Clark, J. Paleont., 41, 908, text-fig. 6t only.

Material and Locality: CPC 12352, Sample BG 21003, Section 13, Timanites Hill, near Glenister Knolls; Gogo Formation.

Description: The unit is trefoil-shaped. The free blade is the same length as the platform. The platform is developed as three lobes, two

lateral and one posterior. The unit is bisected by the main carina which is low and nodose, and merges with the free blade. Two lateral carinae are present, bisecting the two lateral lobes. The remainder of the ornamentation consists of low nodes arranged around the platform margins. Laterally, the free blade is tall, composed of fused, laterally compressed denticles. Aborally, the unit resembles A. buckeyensis.

Remarks: This form is probably developed from A. rotundiloba. In fact, the specimen illustrated by Pollock (1968, pl. 61, figs. 2, 3) probably belongs here. The variety has been recognised by several authors but has never been formally named. It is not practical to name it here, only one specimen being present. Because of its dissimilarity aborally to A. rotundiloba, it should probably not be made a subspecies.

Distribution: This distinctive form is known from North America (Müller & Clark, 1967) and Europe (Krebs & Ziegler, 1965; Flajs, 1966).

Range: Unknown, but all illustrated forms are known from faunas of Upper Devonian (to I $\propto$) age. The Canning Basin specimen is from either the Lower or Middle Polygnathus asymmetricus Zone.

ANCYROGNATHUS ASYMMETRICUS (Ulrich & Bassler, 1926)

Pl. 4, figs. 1a,b

- 1926 Palmatolepis asymmetrica Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 50, pl. 7, fig. 18.
- ?1938 Ancyrodella euglypheus Stauffer, J. Paleont., 12, 418, pl. 53, fig. 18.
- 1947 Ancyroides princeps Miller & Youngquist (part), J. Paleont., 21, 505, pl. 75, fig. 2 [non fig. 3 = A. princeps].
- 1947 Ancyroides uddeni Miller & Youngquist, ibid., 505, pl. 74, fig. 16 [non pl. 75, fig. 5 = A. princeps].
- 1948 Ancyroides calvini Miller & Youngquist; Youngquist & Miller, J. Paleont., 22, 441, pl. 68, fig. 16.

- 1948 Ancyroides ornatissimus Youngquist & Miller, ibid., 441,
pl. 68, fig. 18.
- 1956 Ancyrognathus euglypheus Stauffer; Bischoff, Hess. Landesamt
Bodenf., Notizbl., 84, 120, pl. 8, figs. 1-8, 14.
- 1956 Ancyroides aff. A. uddeni Miller & Youngquist; Müller, J.
Paleont., 30, 1340, pl. 145, figs. 15-18.
- 1957 Ancyrognathus euglypheus Stauffer; Lys, Serre, & Deroo,
Rev. Inst. Francais Petrol., 12, 796, pl. 7, fig. 2.
- 1957 Ancyroides asymmetrica (Ulrich & Bassler); Müller & Müller,
J. Paleont., 31, 1098, pl. 138, figs. 8, 9; pl. 141, figs.
4, 6, 7.
- 1958 Ancyrognathus asymmetrica (Ulrich & Bassler); Ziegler, Hess.
Landesamt. Bodenf., Notizbl., 87, 45, pl. 10, figs. 10, 11.
- 1962 Ancyrognathus asymmetrica (Ulrich & Bassler); Ziegler, N. Jb.
Geol. Palaont., Abh., 114, 152, text-figs. 6.
- 1962 Ancyrognathus asymmetrica (Ulrich & Bassler); Bartenstein &
Bischoff in Simon et al., Leitfossilien der Mikropalaont.,
p. 56, pl. 3, figs. 29-32.
- 1962 Ancyrognathus asymmetrica (Ulrich & Bassler); Ethington &
Furnish, J. Paleont., 36, 1262, pl. 172, fig. 11.
- 1963 Ancyrognathus asymmetrica (Ulrich & Bassler); Klapper &
Furnish, Iowa Acad. Sci., Proc. 1962, 69, 406, text-fig.
2/6.
- 1965 Ancyrognathus asymmetrica (Ulrich & Bassler); Krebs & Ziegler,
Fortschr. Geol. Rheinld. Westf., 9, 737, pl. 2, figs. 3, 4.
- 1966 Ancyrognathus asymmetrica (Ulrich & Bassler); Glenister &
Klapper, J. Paleont., 40, 801, pl. 87, figs. 1-5.
- 1966 Ancyrognathus asymmetrica (Ulrich & Bassler); Spasov, Bull.
"Strasimir Dimitrov" Inst. Geol., 15, 96, pl. 1, fig. 10.
- 1966 Ancyrognathus sp. Koverdynsky & Zikmundova, Vestnik U. U.
Geol., 41, 369, pl. 1, figs. 10a, b.

- ?1967 Ancyrognathus asymmetrica (Ulrich & Bassler); Wolska, Acta Palaeont. Polonica, 12, 373, pl. 1, figs. 6a, b.
- 1967 Ancyrognathus asymmetrica (Ulrich & Bassler); Leidse Geol. Medel., 39, 178, pl. 1, figs. 2a-c.
- 1967 Ancyrognathus asymmetrica (Ulrich & Bassler); Huddle, U.S. Geol. Surv. Prof. Pap. 578, 7, pl. 13, figs. 11, 12.

Material: 2 specimens, CPC 12396 figured.

Locality of figured material: Sample BG 21614, Section 25, Narlarla, Napier Formation.

Description: Unit elongate and bifid. Blade situated laterally at anterior end of platform. Carina merges with free blade and is curved, formed of low isolated nodes. The lateral process is situated on the outer posterior margin and bears a carina which joins the main carina at an azygous node. The platform ornament is composed of low round nodes paralleling the main carina, and on the outer side curving to parallel the secondary carina.

In lateral view the carina is very high, sloping anteriorly, with the posteriormost denticle the most massive.

Aborally, the unit is keeled; at about mid-point a small narrow elongate basal cavity is present. A lateral keel fuses with the main keel immediately posterior to the basal cavity.

Remarks: As was pointed out by Glenister & Klapper (1966, p. 801), A. princeps can be distinguished by the convex outer posterior margin.

Occurrence: The species was originally described from the "Hardin sandstone" of Tennessee (Ulrich & Bassler, 1926; Huddle, 1967). Elsewhere in North America it is extremely widespread in the Upper Devonian of Iowa (Miller & Youngquist, 1947; Youngquist & Miller, 1948; Müller & Müller, 1957; Klapper & Furnish, 1963). It is also known from Ohio (Stauffer, 1938).

A. asymmetrica is also known from Germany (Bischoff, 1956;

Ziegler, 1958, 1962; Walliser, 1958; Krebs & Rabien, 1964; Krebs & Ziegler, 1965; Wachendorf, 1966; Bar, 1968; Schneider, 1969), Austria (Schönlaub, 1969), Czechoslovakia (Koverdynsky & Zikmundova, 1966), France (Lys et al., 1957; Boyer et al., 1968), Poland (Wolska, 1967), Spain (van Adrichem Boogaert, 1967), and Yugoslavia (Spasov, 1966).

Ethington & Furnish (1962) record the species from Spanish Sahara and Massa (1965) records it from Algeria. It has also been recorded from the Canning Basin (Müller, 1956; Glenister & Klapper, 1966) and Central Queensland (Druce, 1970) in Australia.

Range: Ziegler (1958) gives the range of the species in Germany as Upper Devonian (to I ξ). Krebs & Rabien (1964) & Ziegler (1962) give the range as Upper gigas Zone (to I ξ). In France the range is to I χ - upper to I ξ (Boyer et al., 1968). The Canning Basin specimens occur in the Upper Palmatolepis gigas Zone.

ANCYROGNATHUS ALTA Müller & Müller, 1957

Pl. 4, figs. 2a,b

1947 Ancyrognathus irregularis Branson & Mehl; Youngquist, J.

Paleont., 21, 97, pl. 25, fig. 21.

?1948 Ancyroides ? rudis Youngquist & Miller, J. Paleont., 22, 442, pl. 68, fig. 19.

1957 Ancyrognathus alta Müller & Müller, J. Paleont., 31, 1094, pl. 138, figs. 4a-c.

?1957 Ancyrognathus aff. A. alta Müller & Müller, ibid., 1095, pl. 141, fig. 5.

Material: CPC 12397 figured.

Locality of figured material: Sample BG 19572, Section 11, northeast of Galeru Gorge, Virgin Hills Formation.

Remarks: The single specimen recovered is badly worn, and only the posterior portion is preserved. The unit is distinguished by the high main and lateral carinae and the complete lack of ornament, apart from the shagreen-like surface.

Distribution: The species has only been recorded from Iowa (Youngquist, 1947; Youngquist & Miller, 1948; Müller & Müller, 1957).

Range: Unknown but confined to lower Upper Devonian. The Canning Basin specimen is from the Upper Palmatolepis gigas Zone.

Genus ANGULODUS Huddle, 1934

Type species: Angulodus walrathi (Hibbard, 1927).

ANGULODUS sp. cf. A. PERGRACILIS (Ulrich & Bassler, 1926)

Pl. 4, figs. 5

cf. 1926 Bryantodus pergracilis Ulrich & Bassler; U.S. Natl. Mus. Proc., 68, 27, pl. 10, fig. 11.

1957 Angulodus gravis Huddle; Bischoff & Ziegler (part), Hess. Landesamt. Bodenf., Abh., 22, 43, pl. 20, figs. 3, 6 only.

cf. 1967 Angulodus pergracilis (Ulrich & Bassler); Huddle, U.S. Geol. Surv., Prof. Pap. 578, 8, pl. 2, figs. 1, 2.

Material: CPC 12398 figured.

Locality of figured material: Sample BG 19019, Section 1, McWhae Ridge, Virgin Hills Formation.

Description: Unit short; the anterior bar is about twice as long as the posterior bar. Both bars are laterally compressed and deep, bearing fine posteriorly inclined denticles which tend to alternate in size. The small ones only just erupt from the oral surface in some instances. The apical denticle is offset to the interior and is slightly more massive than the majority of the bar denticles. The anterior bar is flexed inward through

90° a short distance anterior to the apical denticle; it narrows distally and is deflected downward giving the appearance of a hook. The posterior bar is straight, narrowing slightly posteriorly. The posteriorward slope of the dentition increases distally from the apical denticle. The last two denticles are as massive as the apical denticle. Beneath them are a bundle of small denticles, giving the characteristic angulodid 'hook.'

Aborally, a basal cavity is absent; rather, a narrowing of the bar is seen beneath the apical denticle suggesting that the cavity might be inverted.

Remarks: The species is extremely close to Hindeodella brevis Branson & Mehl, from which it can be distinguished only by the posterior angulodid 'hook.' The offset apical denticle is characteristic of Plectospathodus but the basal cavity is distinctive. This form is very close to Angulodus flexus Druce from the Lower Carboniferous of the Bonaparte Gulf Basin (Druce, 1969), the alternating dentition being the only difference.

Similar forms are also known from the Middle Devonian (Bischoff & Ziegler, 1957), referred (in part) to A. gravis Huddle. The specimen identified as A. sp. by Seddon (1969, pl. 1, fig. 7) is also comparable and the specimen identified by Loranger (1965) as Hindeodella milleri Stauffer possibly belongs here. The Canning Basin specimens are from the Middle Palmatolepis crepida Zone.

ANGULODUS sp.

Pl. 4, figs. 3

Material: CPC 12399-12400 figured.

Localities of figured material: Sample BG 19115, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: The unit is small; the bars are of equal size and slightly to strongly flexed, giving a bowed unit. The apical denticle is offset to the inner side. The denticles are small near to the apical denticles but

toward their terminations the dentition becomes elongate and more posteriorly inclined. On the posterior bar the two terminal denticles are the most massive with a bundle of minute denticles present beneath them.

Aborally, there is no basal cavity. Beneath the apical denticle the bar becomes thinner and an inverted basal cavity may be present.

Remarks: Small symmetrical angulodid units are known from the Carboniferous of England (Angulodus sp. C Rhodes, Austin, & Druce, 1969) and Australia (A. minutus Druce, 1969). The present specimens should be referred to A. minutus but because of the break in the known occurrence I have preferred to leave the nomenclature open.

Philip (1966) illustrates a very similar specimen (pl. 3, fig. 2); however, the presence of a basal cavity is distinctive and sets this form apart. Philip suggests that the species (Plectospathodus heterodentatus Stauffer) is a descendant of the Upper Silurian and Lower Devonian plectospathodids. The offset apical denticles of the present specimens suggests that they may have evolved from a plectospathodid possibly via P. heterodentatus of Philip. The specimen is from the Upper Palmatolepis quadrantinodosa Zone.

Genus APATOGNATHUS Branson & Mehl, 1934

Type species: Apatognathus varians Branson & Mehl, 1934.

Considerable problems have arisen in the naming of "tuning fork" arched blades. However, the taxonomic problems have now been resolved. Apatognathus is restricted to arched units with the bars and denticulation pointing inward; Enantiognathus includes form with bars and denticulation pointing outward; Gnamptognathus is restricted to forms with an additional process.

Varker (1967) discusses some of the taxonomic problems and the probability of a polyphyletic origin for the genus. Druce (1969) points out that, although rare, Apatognathus is known from the early

Carboniferous of Belgium (Conil, 1959) and Great Britain (Rhodes et al., 1969).

The ancestry of Apatognathus is unknown. Collinson et al. (1962) suggest that homeomorphs could have arisen from Synprioniodina. I suggest that Apatognathus sp. A developed from Prioniodina? smithi. Furthermore, A. varians could have developed from forms such as Ligonodina franconica Sannemann (see Bischoff, 1956, pl. 10, fig. 22). Thus, it would appear that Apatognathus is polyphyletic, although the question of whether there was a Visean development of the genus is still in doubt.

APATOGNATHUS VARIANS VARIANS Branson & Mehl, 1934

Pl. 3, figs. 1

- 1934 Apatognathus varians Branson & Mehl, Univ. Missouri Stud., 8, 201, pl. 17, figs. 1, 2 [non pl. 17, fig. 3 = A. varians klapperi].
- non 1939 Apatognathus? variens Branson & Mehl; Cooper, J. Paleont., 13, 385, pl. 47, fig. 30.
- 1956 Apatognathus varians Branson & Mehl; Bischoff & Ziegler, Hess. Landesamt. Bodenf., Notizbl., 84, 145, pl. 14, fig. 3.
- 1958 Apatognathus varians Branson & Mehl; Klapper, J. Paleont., 32, 1085, pl. 141, figs. 6.
- 1961 Apatognathus varians Branson & Mehl; Ethington, Furnish & Wingert, J. Paleont., 35, 763, pl. 90, fig. 11.
- non 1961 Apatognathus varians Branson & Mehl; Freyer, Freiberger Forsch., C-95, 36, pl. 1, fig. 13 [= Gnamptognathus? lipperti].
- 1965 Apatognathus varians Branson & Mehl; Ethington, J. Paleont., 39, 571.
- non 1965 Apatognathus varians Branson & Mehl; Spasov, Trav. geol. Bulgarie, Ser. paleont., 7, 84, pl. 1, fig. 3 [= Gnampto-
gnathus? lipperti].

- 1966 Apatognathus varians Branson & Mehl; Glenister & Klapper, J. Paleont., 40, 803, pl. 96, figs. 14, 15 [fig. 16 = A. sp. nov. A. Druce].
- 1966 Apatognathus varians Branson & Mehl; Klapper, Univ. Kansas Paleont. Cont. Pap. 3, 28, pl. 6, figs. 13, 14 [fig. 12 = A. varians klapperi].
- 1967 Apatognathus varians Branson & Mehl; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 31, pl. 2, fig. 1.
- 1968 Apatognathus varians Branson & Mehl; Mound, J. Paleont., 42, 474, pl. 65, fig. 49.
- 1969 Apatognathus varians Branson & Mehl; Rhodes, Austin, & Druce, Bull. Brit. Mus. Nat. Hist. (Geol.) Suppl. 5, 75, pl. 20, figs. 5a, b.
- 1969 Apatognathus varians varians Branson & Mehl; Druce, Bur. Min. Resour. Austral. Bull. 98, 42, pl. 1, figs. 16a, b.
- 1969 Apatognathus varians ethingtoni Druce, ibid., 43, pl. 1, figs. 12a, b, 15, text-fig. 10.

Material: 15 specimens, CPC 12681 figured.

Localities of figured material: Samples BG 19105, 19138, 19152, 19158, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: An apatognathid with subequal slender bars. Each bar bears long slender denticles arranged in groups of three "en echelon" and each denticle of the trio decreases in size toward the bar terminations. The denticles curve inwards in some specimens by as much as 90° in some cases.

The apical denticle is elongate and slender with a fine costa along each lateral face. It curves inward through about 90° . Subapically, a small basal cavity is developed and on the outer side a wide fringe is present. The separation of the bars varies from subparallel to 30° . The bars also vary considerably in length and width.

Remarks: Druce (1969) erected two new subspecies of A. varians. I suggested that the difference between the nominate subspecies and the new A. varians ethingtoni was the separation and width of the bars. I now consider that this variability is within the range of variability of the nominate subspecies and have placed A. varians ethingtoni in synonymy.

The second subspecies A. varians klapperi I consider to be valid.

Distribution: The species was originally described from the Upper Devonian Grassy Creek Shale of Missouri. Elsewhere in North America it has been reported from Wyoming (Ethington, Furnish & Wingert, 1961; Klapper, 1958), Nevada and Utah (Clark & Ethington, 1967), South Dakota (Klapper & Furnish, 1962; Klapper, 1966) and Alberta (Mound, 1968).

The species is less common in Europe, being reported from the Upper Devonian of Germany (Bischoff & Ziegler, 1956) and the Lower Carboniferous of Great Britain (Rhodes et al., 1969).

In Australia the species is known from the Canning Basin (Glenister & Klapper, 1966) and the Bonaparte Gulf Basin (Druce, 1969) in strata of Famennian age.

Range: In North America the species is recorded from strata correlated with the to V-to VI interval (Collinson et al., 1962; Klapper, 1966) and also in strata equivalent to to II β - to III α in Canada (Mound, 1968).

In Germany the species was recorded from the toV Zone (Bischoff & Ziegler, 1956) and cu III β (Bischoff, 1957); in Britain the species is known from the Lower Carboniferous Z Zone (? = Cu II α). Conil (1959) has reported the species from the Tn I Zone of Belgium.

The Canning Basin specimens range from the Lower P. quadrantodosa Zone (to II β) up to the Spathognathodus costatus Zone (to VI) (Glenister & Klapper, 1966; Klapper, 1966). In the Bonaparte Gulf Basin it occurs in strata equivalent to the toII β - toVI interval. The range of the species would appear to be Upper Devonian (to II β - to VI) and questionably into the Carboniferous (Cu II α). The Canning Basin

specimens range from the Lower Palmatolepis quadrantinodosa Zone (to II β) up to the Lower Polygnathus styriacus Zone (to IV).

APATHOGNATHUS VARIANS KLAPPERI Druce, 1969

Pl. 3, figs. 2

1966 Apathognathus varians Branson & Mehl; Klapper, Univ. Kansas Paleont. Cont. Pap. 3, 28, pl. 6, fig. 12 [figs. 13, 14 = A. varians s.s.].

1969 Apathognathus varians klapperi Druce, Bur. Min. Resourc. Austral. Bull. 98, 44, pl. 1, figs. 13a-14, text-figs. 11.

Material: 5 specimens, CPC 12682 figured.

Localities of figured material: Samples BG 19113, 19160, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Remarks: This subspecies lacks the well developed "en echelon" arrangement of bar denticles characteristic of the nominate subspecies (Ethington, 1961; Druce, 1969). Perhaps, therefore, it should be regarded as a separate species, since the bi- or tri-cuspid nature of the apical area is so distinctive.

Distribution: Bi- or tri-cuspid varieties of A. varians have been reported from Wyoming and South Dakota (Ethington et al., 1961; Klapper & Furnish, 1962; Klapper, 1966). The subspecies was originally described from the Bonaparte Gulf Basin of Australia (Druce, 1969).

Range: In the Bonaparte Gulf the subspecies is present in faunas with an age range of to II β - to VI. The Canning Basin specimens range from the Upper Palmatolepis quadrantinodosa Zone (to III α) up to the Lower Polygnathus styriacus Zone (to IV).

APATOGNATHUS sp. nov. A Druce, 1969

- 1966 Apatognathus varians Branson & Mehl; Glenister & Klapper,
J. Paleont., 40, pl. 96, fig. 16 only.
- 1969 Apatognathus sp. nov. A Druce, Bur. Min. Resour. Austral.,
Bull. 98, 46, pl. 1, figs. 11a, b; text-fig. 12.

Material: A single specimen.

Localities of figured material: Sample BG 19109, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Remarks: Druce (1969, p. 46) points out that this form cannot be placed in any known species. The species is left in open nomenclature because only one specimen is present in this fauna.

Distribution: The species is known only from Australia, being present in both the Canning (Glenister & Klapper, 1966) and the Bonaparte Gulf Basin (Druce, 1969).

Range: Unknown, but appears to be confined to the early Fammenian. The Canning Basin specimen is from the Upper Palmatolepis quadrantinodosa Zone.

APATOGNATHUS cf. sp. A

Material: 5 specimens.

Localities of studied material: Samples BG 19018, Section 1, McWhae Ridge, Virgin Hills Formation; BG 19072, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; BG 21270, Section 21, Margaret River -- Needle Eye Rocks, Virgin Hills Formation.

Description: An asymmetrical apatognathid with bars diverging at 90° . If the anterior bar is orientated vertically, the apical denticle is then vertical and the posterior bar is horizontal. The dentition is fine and the denticulation increases its inclination terminally although the denticles incline toward the apical denticle.

The bar dentition runs onto the lateral faces of the apical denticle.

Remarks: This species probably developed from Prioniodina? smithi by enlargement of the anterior dentition. A closely similar form is illustrated by Ziegler (1962, pl. 12, fig. 8) and referred to Falcodus n. sp. The Canning Basin specimens range from the Upper Polygnathus asymmetricus Zone (to I β) up to the Upper Palmatolepis quadrantinodosa Zone (to III α).

APATOGNATHUS sp. B

Material: One specimen.

Locality of studied material: Sample BG 19107, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: An apatognathid with extremely deep bars. The apical denticle is about twice as tall as any other denticles and is knife-edged. The bar denticles are tallest at the mid-points of the bars, decreasing in size rapidly on either side. The angle between the bars is about 45° and the basal cavity is minute and situated sub-apically.

Remarks: This species resembles Scutula sinepennata Ziegler but lacks the bar flexure and possesses a distinctive apical denticle. The specimen is from the Upper Palmatolepis quadrantinodosa Zone.

APATOGNATHODUS sp. C

1959 Prioniodina n. sp. aff. smithi (Stauffer); Helms, Geologie, 8, 654, pl. 5, fig. 18.

Material: One specimen.

Locality of studied material: Sample BG 19449A, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Description: Arched unit composed of two subequal bars bearing low, upright, discrete dentition. The apical denticle is more than twice as large as the bar denticles and lies in the same plane as the anterior bar; the posterior bar is slightly twisted. There is a minute subapical pit.

Remarks: The present specimen is very close to the specimen illustrated by Helms. It suggests that some apatognathids could be descended from Prioniodina ? smithi. This form occurs in the lower Fammenian of Germany (Helms, 1959). The present specimen occurs in the Upper Palmatolepis gigas Zone.

Genus BELODELLA Ethington, 1959

Type species: Belodus devonicus Stauffer, 1940.

After much doubt, the presence of simple cones in the Devonian is now accepted by most authors. The homeomorphic development of posteriorly denticulate cones in the Devonian have been separated into the genus Belodella by Ethington (1959).

Recently, Lange (1968) has shown that the belodellid-bearing conodontifer might have possessed only that genus and Seddon (1970) points out that the genus has a restricted facies distribution and is common in near reef limestones. This has also been observed by Krebs (1959, p. 378, and pers. comm.), Müller (1962), and Massa (1965) who recorded near-reef rocks of Emsian age in Morocco yielding up to 10%

Belodella triangularis and which is very abundant at many near reef localities. In a limestone lens in a volcanic sequence of Middle Devonian age near Mt. Morgan, Central Queensland, I have recovered a large fauna composed solely of belodellids, and this tends to confirm both interpretations.

BELODELLA DEVONICA (Stauffer, 1940)

Pl. 3, figs. 4

- 1940 Belodus devonicus Stauffer, J. Paleont., 14, 420, pl. 59, figs. 47, 48.
- 1956 Belodus sp. Dineley & Rhodes, Geol. Mag., 93, 245, text-fig. 15.
- 1961 Belodus devonicus Stauffer; Freyer, Freib. Forsch., C-95; 37, text-fig. 16.
- 1966 Belodella devonicus (Stauffer); Clark & Ethington, J. Paleont., 40, 677, pl. 82, figs. 8, 9.
- 1968 Belodella devonica (Stauffer); Lange, Geol. Palaeont., 2, 42, pl. 5, figs. 1-9.

Material: 5 specimens, CPC 12723 figured.

Locality of figured material: Sample BG 19588, Section 13, Glenister Knolls, Gogo Formation.

Description: A slim erect unit with small main denticle. The base is elongate and narrow, elliptical in cross-section; the cavity apex is below the point of recurvature. The posterior margin bears a sequence of fine needlelike denticles which extend along the lateral faces of the main denticle bearing low costae.

Remarks: This species appears to be ancestral to the other belodellids, being simple in plan and lacking anterior flanges and lateral costae. The report of the occurrence of the species by Lange (1968) is of extreme interest. Lange finds nine specimens associated together in a bituminous

blob. He suggests they might be a coprolitic association but the fact remains that they may be a natural assemblage.

Distribution: The species was originally described from the Devonian and associated clays of Minnesota (Stauffer, 1940). It has also been recorded from Lower Devonian rocks in Nevada (Clark & Ethington, 1966) and Upper Devonian of Alberta (Pollock, 1968).

In Europe the species has been reported from the Upper Devonian of Germany (Freyer, 1961; Lange, 1968) and illustrated from the Middle Devonian of England (Dineley & Rhodes, 1956). It has also been recorded from the Lower Devonian of Austria (Schönlaub, 1969), and Bulgaria (Budurov & Tschunev, 1964).

Range: The species is known from Lower Devonian strata (Clark & Ethington, 1966) and also as high as the uppermost Frasnian (Freyer, 1961). The Canning Basin specimens are from the Lower and Middle Polygnathus asymmetricus Zone.

BELODELLA ERECTA (Rhodes & Dineley, 1957)

- 1957 Belodus erectus Rhodes & Dineley, J. Paleont., 31, 359, pl. 38, fig. 8.
- 1958 Belodus triangularis Stauffer; Bischoff & Ziegler, Hess. Landesamt. Bodenf., Notizbl., 86, 94, pl. 15, figs. 8, 9.
- 1964 Belodus n. sp? Budurov & Tschunev, Bull. Inst. Sci. Recherch. Geol., 1, 253, pl. 1, fig. 5.

Material: 2 specimens.

Localities of studied material: Sample BG 19036, Section 2, McWhae Ridge, Sadler Limestone.

Description: A slightly recurved unit with an elongate main denticle. The posterior dentition is fine and small and does not appear on the

posterior margin of the apical denticle. The basal cavity is deep and extends beyond the point of recurvature. The unit is elliptical in cross-section and lacks any well developed costae or knife edges.

Remarks: B. erecta is closely related to B. devonica, having the same cross-section. However, it is more erect with a longer apical denticle.

Distribution: Previously, the species was unrecorded outside Europe. It was initially described from the Devonian limestones of Devon, England (Rhodes & Dineley, 1957). Forms considered to belong to it have been illustrated from the Lower Devonian of the Frankenwald, Germany (Bischoff & Sannemann, 1958). The only other references to the species are from the Upper Devonian of the Vogtlande, Germany (Freyer, 1961), and the Lower Devonian of Northwest Bulgaria (Budurov & Tschunev, 1964).

Range: Rhodes & Dineley (1957) considered their faunas to be Upper Devonian although they note that typical Frasnian genera such as Ancyrodella, Ancyrognathus, Palmatolepis and Icriodus are absent. From the presence of Polygnathus linguiformis, P. varcus and P. xylus, it is probable that the fauna is of late Middle Devonian age. The German specimens come from the Lower Devonian and the highest Frasnian (to I δ). The range of the species is Lower Devonian to uppermost Frasnian. The Canning Basin specimens are from the Lower and/or Middle Polygnathus asymmetricus Zone (to I α).

BELODELLA RESIMA (Philip, 1965)

Pl. 3, figs. 3

1965 Belodus resimus Philip, Proc. Roy. Soc. Victoria, 79, 98, pl. 8, fig. 15-17, 19; text-fig. 2e-f.

1970 Belodella resima Philip; Seddon, J. Geol. Soc. Austral., 16, 752, pl. 14, figs. 13, 17.

Material: 92 specimens, CPC 12720-12722 figured.

Localities of figured material: Samples BG 19462, 19463, 19465, 19474, Section 5, Lloyd Hill, Sadler Limestone; BG 19490, Section 6, Lloyd Hill -- Laidlaw Range, Sadler Limestone.

Description: Unit variable; the base varies from triangular to elongate with subparallel anterior and posterior edges. The main denticle is recurved; its length varies from the length of the posterior denticles to nearly the length of the base. The posterior dentition varies from peg-like isolated denticles to fine, needle-like, fused denticles of unequal length. In some forms the dentition extends along the main denticle; in others it stops well short. In the forms where it extends to the main denticle it may run onto the lateral face in some cases and onto the posterior face in others.

The anterior margin is diagnostic; on one or both edges a distinct costa is developed. This tends to become deeper apically and sometimes runs along the lateral faces of the main denticle. The basal cavity is very deep and extends just beyond the point of recurvature. In the forms with minute main denticles the cavity occupies nearly the whole unit.

Remarks: B. resima is probably ancestral to B. triangularis and developed from B. devonica with the addition of the flanges to the anterior margin.

Distribution: Apart from two occurrences in Australia, in the Lower Devonian of Victoria (Philip, 1965) and the Frasnian of the Canning Basin (Seddon, 1970) the species has only been recorded from Austria (Schönlaub, 1969).

Range: Philip records the species in the Lower Devonian and Seddon records it from to $\text{I}\alpha$ - to $\text{I}\gamma$ strata in the Canning Basin. My specimens are from the Polygnathus asymmetricus Zone (to $\text{I}\alpha$ - to $\text{I}\beta$).

BELODELLA COSTATA Druce, 1970

- ?1964 Bolodus [sic] triangularis Stauffer; Budurov & Tschunev, (part),
Bull. Inst. Sci. Recherch. Geol., 1, 258, pl. 1, fig. 4
 (fig. 2 = B. triangularis).
- 1970 Belodella costatus Druce, Bur. Min. Resour. Austral. Bull.
 108, 78, pl. 12, figs. 1a-3c.

Material: 6 specimens.

Remarks: These specimens agree closely with the Queensland specimens.

Distribution: Apart from a questionable occurrence in Bulgaria, the species is only known from Australia.

Range: The Queensland specimens are from the Frasnian, probably to I.S. The present specimens are from the Lower and/or Middle Polygnathus asymmetricus Zone.

BELODELLA TRIANGULARIS (Stauffer, 1940)

Pl. 3, figs. 5

- 1940 Belodus triangularis Stauffer, J. Paleont., 14, 420, pl. 59,
 fig. 49.
- 1957 Belodus triangularis Stauffer; Rhodes & Dineley, J. Paleont.,
 31, pl. 37, fig. 2 only [fig. 1 = ? B. erecta].
- non 1958 Belodus triangularis Stauffer; Bischoff & Sannemann, Hess.
Landesamt Bodenf., Notizbl., 86, 94, pl. 15, figs. 8, 9
 [= B. erecta].
- 1959 Belodus triangularis Stauffer; Panseri & Barsotti, Notas Commun.
Inst. Geol. Min. Espana, 55, 154, pl. 2, fig. 6.
- 1961 Belodus triangularis Stauffer; Freyer, Freib. Forsch., C95,
 37, text-fig. 17.
- 1961 Belodus triangularis Stauffer; Budurov, Rev. Bulgarian Geol.
Soc., 22, 261, pl. 3, fig. 7.

- ?1961 Belodus triangularis Stauffer; Ly et al., Rev. Inst. Francais Petrol., 16, 544, pl. 1, fig. 4.
- 1964 Belodus triangularis Stauffer; Budurov & Tschunev, Rev. Inst. Sci. Recherch. Geol., 1, 253, pl. 1, fig. 2 [fig. 4 = ? B. striatus].
- 1965 Belodus cf. triangularis Stauffer; Philip, Proc. Roy. Soc. Victoria, 79, 99, pl. 8, fig. 22, 26-28; text-fig. 2c-d.
- 1966 Belodella triangularis (Stauffer); Merrill, Texas J. Sci., 27, 369, pl. 3, figs. 11, 13.
- 1966 Belodella triangularis (Stauffer); Clark & Ethington, J. Paleont., 40, 677, pl. 82, figs. 1, 7.
- ?1968 Belodella triangularis (Stauffer); Schulze, N. Jb. Geol. Palaont., Abh., 130, 185, pl. 16, fig. 14 [? = B. resima].
- 1968 Belodella triangularis (Stauffer); Mound, J. Paleont., 42, 475, pl. 65, fig. 32.
- ?1968a Belodella triangularis (Stauffer); Durdanovic, Geol. Vjesnik, 21, 86, pl. 1, figs. 4, 5.
- ?1968b Belodella triangularis (Stauffer); Durdanovic, ibid., 95, pl. 1, fig. 1.

Material: 9 specimens, CPC 12675 figured

Localities of figured material: Samples BG 19467, 19473, 19481, Section 5, Lloyd Hill, Sadler Limestone; Sample BG 19533, Virgin Hills Formation.

Description: A simple cone unit with a greatly recurved main denticle which lies at nearly 90° to the base. The base is completely excavated by a large pyramidal basal cavity which extends nearly to the point of recurvature. The basal cavity sometimes contains basal "bone" material which is grey/white in colour and exhibits interference colours. In cross section the unit is triangular; the posterior edge bears a row of very fine, short, needle-like denticles crowded together. The anterior edges are

usually dissimilar, one being rounded, the other knife-edged. The cross-section is sometimes an equilateral triangle; in other cases it may be unequilateral. The dentition does not extend onto the main denticle and in some cases terminates laterally on it rather than posteriorly.

Remarks: B. triangularis is easily distinguishable by its triangular cross-section. B. resima has knife-edged costae developed on its posterior face and is sub-triangular in cross-section (see Philip, 1965, text-fig. 2). B. triangularis probably developed from B. resima by inflation of the unit.

Distribution: B. triangularis is the most widely distributed belodellid. It was originally described from the Devonian clays of Minnesota (Stauffer, 1940). Other occurrences in North America are rare. It has been reported from early Devonian fissure fillings in the Burnham Limestone (Ordovician) of Texas (Merrill, 1966); from the Lower Devonian of Nevada (Clark & Ethington, 1966) and the Upper Devonian (Frasnian) of Alberta (Pollock, 1968; Mound, 1968). The unidentified species noted by Orr (1964) from the early Upper Devonian of Illinois may belong to B. triangularis.

In Europe the species has been recorded from the Lower Devonian of Austria (Schulze, 1968; Schönlaub, 1969); the Lower and Middle Devonian of Bulgaria (Budurov, 1961; Budurov & Tschunov, 1964); the Middle Devonian of England (Rhodes & Dineley, 1957); from the Upper Devonian of France (Lys et al., 1961; Boyer et al., 1968); from the Silurian-Devonian boundary as high as the to I Zone of the Upper Devonian in Germany (Freyer, 1961; Schriel & Stoppel, 1965; Zitzmann, 1966, 1968); from the Middle Devonian of Roumania (Mirauta & Mirauta, 1965); and the Lower Devonian of Yugoslavia (Durdanovic, 1968a, b).

Elsewhere, it has been recorded from the Middle Devonian of Spanish Sahara (Panseri & Barsotti, 1959); the Middle Devonian of Afghanistan (Weippert & Wittekindt, 1964) and the Lower Devonian of

Victoria, Australia (Philip, 1965), Queensland, Australia (Druce, 1970), and the Upper Devonian (to I α) of the Canning Basin, Western Australia (Seddon, 1970).

Range: The species is found in Lower, Middle, and Upper Devonian strata. Its earliest occurrence is near the Silurian-Devonian boundary and its latest in the Upper Devonian (to I Zone). The present specimens are from the Lower and/or Middle Polygnathus asymmetricus Zone.

Genus BRYANTODUS Bassler, 1925

Type species: Bryantodus typicus Ulrich & Bassler, 1926

BRYANTODUS MACRODENTUS (Bryant, 1921)

Pl. 3, figs. 8

1921 Prioniodus macrodentatus Bryant, Bull. Buffalo Soc. Nat. Sci., 13, 18, pl. 8, fig. 10.

1957 Bryantodus macrodentatus (Bryant); Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh., 22, 49, pl. 21, fig. 17.

non 1968 Bryantodus macrodentatus (Bryant); Mound, J. Paleont., 42, 479, pl. 65, figs. 45, 47 [= B. typicus].

Material: 7 specimens, CPC 12905 figured.

Localities of figured material: Samples BG 19104, 19105, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone; Sample BG 19543, Section 9, Balme Knoll, Gogo Formation; Sample BG 19598, Glenister Knolls, Gogo Formation.

Description: Arched unit with distinctive dentition. The bar is tumid with ledges developed on one or both sides. The dentition consists of laterally compressed, fused denticles; the anterior bar denticles are high and massive, the posterior denticles are small and decrease in size posteriorly. The basal cavity is small and extends further laterally

on the outer than on the inner side. The unit is keeled over its whole length.

Remarks: This species highly variable in length. Short forms resemble B. petilus Youngquist & Miller and perhaps belong in this species. However, if length is only an intraspecific variation, then B. petilus is a junior synonym of B. macrodentus.

Distribution: The species has been reported from the Upper Devonian of New York (Bryant, 1921) and from the upper Middle Devonian of Germany (Bischoff Ziegler, 1957).

Range: The species ranges from the uppermost Givetian (Bischoff & Ziegler, 1957) into the Frasnian (Bryant, 1921). The Canning Basin specimens are Famennian, ranging from the Lower Palmatolepis crepida Zone up to the Lower Palmatolepis quadrantinodosa Zone.

BRYANTODUS NITIDUS Ulrich & Bassler, 1926

Pl. 3, figs. 7

1926 Bryantodus nitidus Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 24, pl. 4, fig. 8 only.

For complete synonymy see

1968 Bryantodus nitidus Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 10, pl. 2, figs. 8-16.

Material: 48 specimens, CPC 12906 figured.

Localities of figured material: Sample BG 19072, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 19482, Section 6, Lloyd Hill - Laidlaw Range, Gogo Formation; Sample BG 19495, Section 7, Laidlaw Range - Emanuel Range, Sadler Limestone; Sample BG 19547, Section 9, Balme Knoll, Virgin Hills Formation; Sample BG 19582, Section 12, Southwest of Waggon Pass, Virgin Hills Formation.

Description: An arched unit with a tumid base. The basal expansion occurs mainly on the inner face, and sometimes (Pl. 3, fig. 7) this ledge bears low nodes. The apical denticle is situated near the mid-point of the unit and is twice as high and wide as the bar denticles. The anterior bar denticles are larger than the posterior bar denticles; they are all posteriorly inclined, laterally compressed, fused with free chevron tips.

Beneath the apical denticle is a basal cavity which is sub-ovate and is sometimes situated on the outer side rather than being truly medial. The whole unit is keeled and the aboral outline arches through approximately 45° .

Remarks: The species is highly variable but is characterized by the large main denticle and a platform developed on the inner side. I consider that presence or lack of ornamentation on the platform and the flaring of the basal cavity lips are within the range of variation of the species. Development of a strong platform on the outer side gives rise to Polygnathellus germanus.

Distribution: B. nitidus and its junior synonyms have been reported extensively from New York (Ulrich & Bassler, 1926; Youngquist, Hibbard & Reimann, 1948), Ohio (Stauffer, 1938; Bond, 1947) and Indiana (Huddle, 1934).

In Europe the species is known from Germany (Sannemann, 1955; Bischoff, 1957; Freyer, 1961; Stoppel, 1958; Stoppel & Zscheke, 1966; Zitzmann, 1966), Austria (Schönlaub, 1969), Poland (Freyer & Zakowa, 1961), and Italy (Manzoni, 1965).

Range: The species appears to range throughout the Upper Devonian. The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone up to the Upper Palmatolepis crepida Zone.

BRYANTODUS TYPICUS Bassler, 1925

Pl. 3, figs. 6

1925 Bryantodus typicus Bassler, Geol. Soc. Amer. Bull., 36, p. 219.1926 Bryantodus typicus Bassler; Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 21, pl. 6, figs. 11, 12.

For complete synonymy of Ulrich & Bassler's specimens see:

1968 Bryantodus typicus Bassler, Huddle, U.S. Geol. Surv. Prof. Pap. 578, 11, pl. 3, figs. 1-15; pl. 4, figs. 12-15.

I consider the following to be junior synonyms:

1934 Bryantodus attentuatus Branson & Mehl, Univ. Missouri Stud., 8, 219, pl. 16, fig. 4.1938 Bryantodus andersonensis Stauffer, J. Paleont., 12, 419, pl. 49, fig. 17.1938 Bryantodus bryanti Stauffer, ibid., 420, pl. 49, fig. 18.1938 Bryantodus nobilis Stauffer, ibid., 422, pl. 49, fig. 14.1947 Bryantodus iowaensis Youngquist, J. Paleont., 21, 98, pl. 24, fig. 18.1947 Bryantodus machaerodus Youngquist, ibid., 98, pl. 26, fig. 5.1947 Bryantodus flabellatus Miller & Youngquist, J. Paleont., 21, 506, pl. 73, fig. 23.1948 Bryantodus flabellatus Miller & Youngquist; Youngquist & Miller, J. Paleont., 22, 443, pl. 67, fig. 21.1948 Bryantodus nitens Youngquist & Miller, ibid., 444, pl. 68, fig. 1.1956 Bryantodus dignatus Stauffer; Bischoff, Hess. Landesamt Bodenf., Notizbl., 84, 122, pl. 10, fig. 6 only.1957 Bryantodus cf. radiatus (Hinde) (Exempl. B); Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh. 22, 52, pl. 19, fig. 41a, b.1959 Bryantodus sp. Panseri & Barsotti, Not. Comun. Inst. Geol. Min. Espana, 55, 155, pl. 2, fig. 5.1962 Bryantodus dignatus Stauffer; Ethington & Furnish, J. Paleont., 36, 1265, pl. 173, fig. 18.

1968 Bryantodus dignatus Stauffer; Mound, J. Paleont., 42, 478,
pl. 65, fig. 41.

1968 Bryantodus macrodentus (Bryant); Mound, ibid., 479, pl. 65,
figs. 45, 47.

Material: 5 specimens, CPC 12907 figured.

Localities of figured material: Sample BG 19547, Section 9, Balme Knoll, Virgin Hills Formation; Samples BG 19580, 19584, Section 12, southeast of Waggon Pass, Virgin Hills Formation.

Description: An arched blade unit with a tumid bar. The bar is expanded on the inner side to give a narrow ledge. At the apical denticle the ledge widens to give a triangular lip. The blade is formed of laterally compressed, fused denticles with free chevron tips. The apical denticle is larger and wider than the bar denticles and is situated at about one-third to half the distance from the posterior termination.

Beneath the apical denticle is a basal cavity which may be slightly flared beneath the inner projecting lip.

Remarks: Huddle (1968, p. 10) points out that the genus Bryantodus needs a complete revision. There have been many species erected on minor variations and it is difficult to draw any significant specific boundaries. I have considered that species with an extended lip on the inner apical face all belong in B. typicus and that variations in dentition are not specifically distinctive. Thus, one might include Bryantodus radiatus (Bryant) as a senior synonym.

Distribution: I consider that a large number of species should be brought to B. typicus. These various species are known from New York (Ulrich & Bassler, 1926; Huddle, 1968), Ohio (Stauffer, 1938), Iowa (Youngquist, 1947; Miller & Youngquist, 1947; Youngquist & Miller, 1948) and Missouri (Branson & Mehl, 1934). The species is also present in Alberta, Canada (Mound, 1968).

In Europe it has been recorded from Germany (Bischoff, 1956; Bischoff & Ziegler, 1957) and in Africa from Spanish Sahara (Panseri &

Barsotti, 1959; Ethington & Furnish, 1962).

Range: The species appears to be confined to the Frasnian. The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to IX) up to the Lower Palmatolepis gigas Zone (to IX).

Genus CAMPTOGNATHUS Pollock, 1968

Type species: Camptognathus conus Pollock, 1968.

CAMPTOGNATHUS CONUS Pollock, 1968

Pl. 3, figs. 10

?1957 Falcodus sp. c, Bischoff & Ziegler, Hess. Landesamt Bodenf.,
Abh., 22, 56, pl. 19, fig. 32.

?1964 Prioniodina smithi (Stauffer) (sic); Budurov & Tschunev, Bull.
Inst. Sci. Recherch. Geol., 1, 256, pl. 4, fig. 15.

?1965 Angulodus bidentatus Sannemann; Spasov, Trav. Geol. Bulgarie,
Ser. Paleont., 7, 83, pl. 1, figs. 1, 2.

1968 Camptognathus conus Pollock, J. Paleont., 42, 429, pl. 61,
figs. 23-25.

Material: 3 specimens, CPC 12908 figured.

Localities of figured material: Sample BG 19547, Section 9, Balme Knoll, Virgin Hills Formation; Sample 21253, Long's Well Creek, near Sadler Ridge, Gogo Formation.

Description: Bar unit with the anterior bar deflected downward through about 90° . Both bars are deep and have a distinctive pitted surface and bear fine needle-like denticles which are inclined posteriorly. The anterior bar is about half the length of the posterior bar and the denticles decrease in height anteriorly, whereas the posterior bar dentition is even. There is no really distinctive apical denticle but a group of slightly taller denticles are conspicuously recurved posteriorly, although one specimen (Pl. , fig.) has an apical denticle.

Immediately above the aboral edge a narrow flange is developed on both sides of the unit and near along both bars to their terminations.

The basal cavity is very distinctive being cone-shaped, the termination is beneath the denticle situated at the flexive point.

Remarks: Pollock (1968, p. 429) points out that the genus can be distinguished from Falcodus by the cone-like cavity, a feature which also distinguishes it from Dinodus of which it is a homeomorph. Specimens illustrated by Bischoff & Ziegler (1957), Budurov & Tschunev (1964) and Spasov (1965) have a similar morphology, but it is impossible to tell whether the basal cavity is cone-like. Falcodus secundus Youngquist is also very similar but appears to lack the cone-like cavity. It is possible that Camptognathus is ancestral to Dinodus of the Lower Carboniferous.

Distribution and Range: Pollock (1968) records the species from the lower Frasnian of Alberta, Canada. The other previously described specimens which I have tentatively included in this species also appear to be of Frasnian age. The Canning Basin specimens are confined to the Polygnathus asymmetricus Zone (to $I\alpha$ - to $I\beta$).

CAMPTOGNATHUS ERECTUS sp. nov.

Pl. 3, figs. 11

Derivation of name: From the erect dentition on both bars.

Material: 2 specimens. Holotype CPC 12909, Paratype CPC 12909A.

Locality: Sample BG 19547, Section 9, Balme Knoll, Virgin Hills Formation.

Diagnosis: A camptognathid with erect dentition on both bars giving a symmetrical arched unit.

Description: An arched unit composed of two bars of sub-equal length. The unit is arched through 135° and both bars are deep with a pitted surface. The dentition consists of fine needle-like denticles which are inclined towards the apex on both bars. At the apex there is a group of taller denticles but no distinctive apical denticle.

A narrow ledge is present on both sides of both bars immediately above the aboral keel. At the apex there is a ridge on the inner lateral face which extends to the base of the apical group of denticles where it meets the aboral ledge; there is a thickening of the bar at this point and the ledge is bowed out.

The basal cavity is cone-shaped and is present beneath the inner lateral ridge. Narrow troughs run along the keels.

Remarks: In the type species, C. conus, the dentition is posteriorly inclined, i.e., in only one direction. In C. erectus the dentition on each bar is inclined toward the apex of the unit. The present specimens are very close to the Roundya-element of the presumed natural species Elsonella rhenana Lindström & Ziegler but the present species lacks the posterior bar. The present specimens are very close to Dinodus youngquisti Klapper but that species also possesses a posterior bar. Dinodus cf. D. wilsoni Druce lacks a posterior bar and has similar dentition but lacks the cone-like basal cavity.

Lindström & Ziegler (1965) described a presumed natural species from the Middle-Upper Devonian boundary distinguished by the pitted and granular nature of the surface. It contained forms similar to the two species of Camptognathus in these faunas. Pollock (1968) reports that in the lowest Upper Devonian of Alberta, Canada, forms with similar pitted surfaces are present and, although they vary in generic designation, their broad morphologic features are very similar. In the present faunas the two camptognathid species would probably correspond to the Falcodus-element. The only other form with a granular and pitted surface is Falcodus guntharii Ziegler, which is

known from several specimens from different localities. It could correspond to the Oulodus-element.

Range: The present specimens come from the Middle and Upper Polygnathus asymmetricus Zones (to I α - to I β).

Genus DREPANODUS Pander, 1856

Type species: Drepanodus arcuatus Pander, 1856.

DREPANODUS sp.

Pl. 17, figs. 3

Material: 14 specimens, CPC 12853 figured.

Localities of figured material: Samples BG 19462, 19465, Section 5, Lloyd Hill, Sadler Limestone; Sample BG 21218, Section 19, Sadler Ridge, Sadler Limestone.

Remarks: The unit is recurved and laterally compressed. The basal cavity is very deep reaching to the point of recurvature. The anterior margin is slightly wider than the knife-edged posterior margin. The species bears a distinct resemblance to early Tremadocian oneotodids.

Range: The Canning Basin specimens come from the Lower and/or Middle Polygnathus asymmetricus Zone.

Genus ELSONELLA Youngquist, 1945

Type species: Elsonella prima Youngquist, 1945

ELSONELLA sp.

Pl. 3 figs. 13

Material: 3 specimens, CPC 12913 figured.

Localities of figured material: Samples BG 19062, 19105, 19107, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone.

Description: A small symmetrical arched unit with short bars bearing even needle-like denticles up to six in number. Some denticles are fused and they tend to be highest near the bar terminations. The apical denticle is only slightly higher than these denticles.

A minute basal cavity, opening on the inner side, is present beneath the apical denticle.

Remarks: The present specimens are obviously very close to the genus Falcodus, having the same dentition and basal cavity. However, the symmetry of the units places them in Elsonella, even though the bars are not depressed to the usual extent.

Range: The species ranges from the Ancyrognathus triangularis Zone (to I γ) up to the Lower Palmatolepis quadrantinodosa Zone (to II β).

Genus ENANTIOGNATHUS Mosher & Clark, 1965

Type species: Apatognathus inversa Sannemann, 1955.

ENANTIOGNATHUS LIPPERTI (Bischoff, 1956)

Pl. 3, figs. 9

- 1956 Apatognathus lipperti Bischoff, Hess. Landesamt Bodenf.,
Notizbl., 84, 121, pl. 9, figs. 27, 31.
- 1956 Apatognathus lipperti Bischoff; Bischoff & Ziegler, ibid., pl. 14,
figs. 1, 2.
- 1957 Apatognathus lipperti Bischoff; Lys, Serre & Deroo, Inst.
Francais Petrol. Rev., 12, 1040, pl. 1, fig. 4.
- 1957 Apatognathus cf. A. lipperti Bischoff; Lys, Serre & Deroo, ibid.,
797, pl. 7, fig. 7.
- 1958 Apatognathus lipperti Bischoff; Ziegler, Hess. Landesamt
Bodenf., Notizbl., 87, pl. 12, figs. 10, 22.
- 1959 Apatognathus lipperti Bischoff; Helms, Geologie, 8, 663, pl. 1,
fig. 16.

- 1961 Apatognathus lipperti Bischoff; Scott & Collinson, Kansas Geol. Soc., Guidebook, 26th Ann. Conf., pl. 10, fig. 2.
- 1962 Apatognathus lipperti Bischoff; Ethington & Furnish, J. Paleont., 36, 1264, pl. 173, fig. 16.
- 1965 Enantiognathus lipperti (Bischoff); Mosher & Clark, J. Paleont., 39, 559.
- 1966 Gnamptognathus ? lipperti (Bischoff); Glenister & Klapper, J. Paleont., 40, 803, pl. 96, figs. 10-12.
- 1967 Enantiognathus lipperti (Bischoff); Clark & Ethington, Geol. Soc. Amer. Mem. 103, 34, pl. 2, fig. 2.
- 1968 Enantiognathus lipperti (Bischoff); Mound, J. Paleont., 42, 481, pl. 65, figs. 30, 46, 51-54.
- 1970 Enantiognathus lipperti (Bischoff); Seddon, J. Geol. Soc. Austral., 12, 748, pl. 14, figs. 14, 15.

Material: 20 specimens, CPC 12911 figured.

Localities of figured material: Sample BG 19411, east side McWhae Ridge, Sadler Limestone; Sample BG 19585, Section 12, southwest of Waggon Pass, Virgin Hills Formation; Sample BG 19595, Section 13, Glenister Knolls, Gogo Formation; Sample BG 21242, Longs Well Creek, Gogo Formation, Sample BG 21371, east side Teichert Hills, Sadler Limestone.

Description: An arched unit with the dentition inclined outward. At the apex either one or two major denticles are developed which are about twice as large as the bar denticles. The bars, which are flexed to the outer side, vary between being bar-like and blade-like. The bar-like forms bear inclined isolated denticles, whereas the blade-like forms have cyclic needle-like dentition. In some of the bar-like forms some of the denticles are as large as the apical denticles.

A shallow basal cavity is developed on the inner face.

Remarks: The bar- and blade-like forms are very different and possibly should be separated. Glenister & Klapper (1966, p. 804) note that, like Apatognathus varians, this species has monocuspid and bicuspid forms.

Distribution: The species was originally described from the to I δ Zone of the Upper Devonian of Germany (Bischoff, 1956). It has been recorded extensively in Germany (Bischoff & Ziegler, 1956, 1957; Ziegler, 1958, Helms, 1959). Elsewhere in Europe it is known from Austria (Schönlaub, 1969), France (Lys & Serre, 1957), and Portugal (van den Boogaard, 1963).

Ethington & Furnish (1962) record the species from the Spanish Sahara. In North America the species is known from Utah (Clark & Ethington, 1968), Missouri, Illinois (Scott & Collinson, 1961) and Alberta (Uyeno, 1967; Pollock, 1968; Mound, 1968).

Range: Ziegler (1958) gives the range in Germany as Upper Devonian (to I β - to I δ). Glenister & Klapper (1966) extend the range as low as the to I α Zone. The present specimens are all from the Polygnathus asymmetricus Zone.

ENANTIOGNATHUS cf. E. INVERSUS (Sannemann, 1955)

Pl. 3, figs. 12

cf. 1955 Apatognathus inversus Sannemann, Senck. leth., 36, 127, pl. 6, figs. 18a-c.

Material: Single specimen, CPC 12912, from Sample BG 19450C, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: The single specimen recovered shows the outwardly-directed bars and the inwardly-directed apical denticle. The specimen is only compared with E. inversus because the apical denticle is subcircular in cross-section rather than flattened, and the bars are bar-like rather than blade-like.

Range: The type species was described from the Upper Devonian (to $\Pi\alpha$) of Germany. The present specimen is from the upper Frasnian. The present specimen is from the Upper Palmatolepis gigas Zone.

Genus FALCODUS Huddle, 1934

Type species: Falcodus angulatus Huddle, 1934

FALCODUS ACULEATUS Sannemann, 1955

Pl. 3, figs. 16

1955 Falcodus aculeatus Sannemann, Senck. leth., 36, 128, pl. 6, fig. 14.

Material: 4 specimens, CPC 12916 figured.

Localities of figured material: Samples BG 19105, 19113, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: An asymmetrical unit with an elongate depressed anterior bar, bearing small, posteriorly inclined, fused denticles with free tips. The apical denticle is larger than any of the anterior bar denticles and is erect. The posterior bar is about half the length of the anterior bar. It bears a sequence of fused denticles, which increase in height rapidly posteriorly, culminating in two massive denticles which are taller than the apical denticle. On the posterior margin of the ultimate denticle is a sequence of small denticles.

A minute basal cavity is present beneath the apical denticle; it opens on the inner side.

Remarks: This species differs from F. angulus, lacking the distinctive lateral ridge on the bars and in possessing a distinct apical denticle.

Distribution: F. aculeatus was originally described from the Upper Devonian of Germany (Sannemann, 1955). This is the first record of the species outside Germany; other occurrences have been noted by Bischoff (1956) and Stoppel & Zscheke (1966).

Range: The species was originally described from the early Famennian (to II) of Germany (Sannemann, 1955). Bischoff's (1956) specimens came from the early Frasnian (to I) and Stöppel & Zscheke (1966) recorded their specimens from the upper part of the upper Adorf-Stufe (to I). The Canning Basin specimens are from the Palmatolepis quadrantinodosa Zone (to II β - to III α).

FALCODUS GUNTCHARII Ziegler, 1958

Pl. 3, figs. 17

1958 Falcodus guntharii Ziegler, Hess. Landesamt Bodenf., Notizbl., 87, 52, pl. 12, figs. 4-7.

1968 Falcodus guntharii Ziegler, Spasov et al., Inst. Recherch. Geol. Geophys., 26, 159, pl. 1, figs. 2, 3.

Material: CPC 12910 figured.

Locality of figured material: Sample BG 21065, Section 15, east side of Lawford Range, south of Waggon Pass, Gogo Formation.

Description: An arched, erect unit with subequal bars. The bars are of unequal depth and bear laterally-compressed fused denticles with free chevron tips. The denticles increase in height and are inclined towards the apical denticle. The apical denticle is tall and sigmoidal with knife edges and a thick ridge on the inner lateral face.

The aboral edge is thickened to give a pseudo-platform on both sides of both bars and it extends as a lip where it meets the ridge on the apical denticle. Along the aboral margin is a shallow keel with a trough extending along it. The basal cavity cannot be seen because there is a cone of basal "bone" material inserted in the unit which extends along both bars as an open sheath.

Remarks: This specimen exhibits the pitting and granular texture used by Lindström & Ziegler (1965) to distinguish a possible natural species. F. guntharii is very close to Camptognathus erectus sp. nov., but the

presence of an apical denticle on the former is distinctive. Possibly the basal cavity is also different, but I cannot determine its exact nature from the present specimen because of the presence of basal "bone."

Distribution: F. guntharii was originally described from the Adorf-Stufe of Germany (Ziegler, 1958). It has also been recorded from north-west Serbia, Yugoslavia (Spasov et al., 1968).

Range: Ziegler (1958) records the species from the Frasnian (to I β - to I δ). The Yugoslavian specimens are associated with Palmatolepis subrecta which has a range of to I β - to I δ . The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to I α) up to the Lower Palmatolepis gigas (to I δ).

FALCODUS VARIABILIS Sannemann, 1955

Pl 3, figs. 14

- 1955 Falcodus variabilis Sannemann, Senck. leth., 36, 129, pl. 4, figs. 1-4.
For synonymy up to 1961 see:
- 1969 Falcodus variabilis Sannemann; Druce, Bur. Min. Resour. Austral., Bull. 98, 58, pl. 6, figs. 10a, b.
- 1961 Falcodus variabilis Sannemann; Lys et al., Rev. Inst. Francais Petrol., 16, 544, pl. 1, figs. 5, 6.
- 1961 Falcodus variabilis Sannemann; Zimmermann, Freib. Forsch., C-89, pl. 1, figs. 10, 11.
- 1965 Falcodus variabilis Sannemann; Spasov, Trav. Geol. Bulgarie, Ser. Paleont., 7, 84, pl. 1, fig. 4.
- 1967 Falcodus variabilis Sannemann; Nehring, Inst. Geol., Bull. 209, 127, pl. 4, fig. 2.
- 1967 Falcodus variabilis Sannemann; Wolska, Acta Palaeont. Polonica, 12, 376, pl. 1, fig. 9.

- 1967 Falcodus variabilis Sannemann; Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 61, pl. 1, figs. 17, 18.
- 1968 Falcodus variabilis Sannemann; Lange, Geol. Paleont., 2, 40, pl. 2, fig. Fa.
- 1969 Falcodus variabilis Sannemann; Olivieri, Boll. Soc. Paleont. Italiana, 8, 75, pl. 10, fig. 7.

Material: 40 specimens, CPC 12914 figured

Localities of figured material: Samples BG 19079, 19105, 19130, 19151, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone; Sample BG 21014, Section 14, northwest of Pinnacle Spring, Virgin Hills Formation.

Description: A slightly arched unit with the posterior bar is slightly longer than the anterior bar. Both bars are deep and bear tall denticles. The dentition varies, however, between equi-dimensional denticles sub-circular in cross-section, and cyclic needle-like denticles. There is no distinctive apical denticle.

The posterior bar is flexed in some cases and the dentition is inclined to the inner side. The unit varies from sub-symmetrical to highly asymmetrically. There is no distinctive basal cavity.

Remarks: F. variabilis is extremely variable. The dentition varies between isolated peg-like denticles to cyclic needle-like denticles; the symmetry is also highly variable.

Distribution: The species was originally described from the Upper Devonian (to Ilx) of Germany (Sannemann, 1955). Since then, the species has been reported extensively from Germany (Bischoff, 1956; Bischoff & Ziegler, 1956; Bender, 1958; Helms, 1959; Krebs, 1959; Zimmermann, 1961; Freyer, 1961; Schriel & Stoppel, 1965; Freyer, 1965; Zitzmann, 1966; 1968; Stoppel & Zscheke, 1966; and Lange, 1968). Elsewhere in Europe the species is known from Austria (Schönlaub, 1969), Bulgaria

(Spasov, 1965; Spasov & Filipovic, 1967), Czechoslovakia (Zikmundova & Chlupac, 1962; Dvorak & Freyer, 1965), France (Serre & Lys, 1958; Lys et al., 1961; Boyer et al., 1968), Italy (Forti & Nocchi, 1963; Manzoni, 1965; Olivieri, 1969), Poland (Freyer & Zakowa, 1967; Nehring, 1967; Wolska, 1967), and Portugal (van den Boogaard, 1963).

The species is much rarer outside Europe. It has been recorded from the Mississippi Valley (Collinson et al., 1961) and Alberta (Pollock, 1968; Mound, 1968) in North America and from the Bonaparte Gulf Basin, Australia (Druce, 1969).

Range: The species was originally described from the early Famennian (to II) of Germany (Sannemann, 1955); Bischoff & Ziegler (1956) extend the range up into the toV Zone. Nehring (1967) gives the range in Poland as to I δ - toV and in France it is to II β - toV (Boyer et al., 1968). The Canning Basin specimens range from the Middle Palmatolepis crepida Zone (to II α) up to the Lower Polygnathus styriacus Zone (to IV).

FALCODUS cf. F. VARIABILIS Sannemann, 1955

Pl. 3, figs. 15

Material and Locality: CPC 12915 figured, Sample BG 19023, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: A single specimen exhibits the extreme variation of isolated subcircular dentition with no germ denticles. The specimen is from the Upper Palmatolepis crepida Zone (to II α).

FALCODUS sp. nov. A

Pl. 4, fig. 7

Material: 5 specimens, CPC 12416-12419 figured

Localities of figured material: Samples BG 19109, 19113, 19130, 19134, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: Unit composed of a short anterior bar and a posterior bar twice as long as the anterior bar. The anterior bar is depressed through about 60° and flexed inward about 45° . It bears up to six fused needle-like denticles which are recurved posteriorly. The apical denticle is about twice as large as the bar denticles though on one specimen (BG 19113) it is not distinguishable from the bar denticles.

The posterior bar denticles are similar to the anterior ones and are inclined posteriorly tending to increase terminally. A minute basal cavity is present beneath the apical denticle and the aboral margin is finely keeled.

Remarks: Some specimens approximate to Angulodus bidentatus but they lack any depression of the posterior bar and cannot be referred to that genus. I have placed these specimens in Falcodus rather than Hindeodella because of the similarity of the bars, dentition and basal cavity to other falcodids in the fauna. The fine needle-like fused denticles are diagnostic of Falcodus according to Lindström (1964, p. 151).

It is also close to Falcodus tortus Huddle and perhaps should be placed in that species. If so, then those specimens referred to that species by me from the Bonaparte Gulf Basin (Druce, 1969) are probably not F. tortus. The Canning Basin specimens range from the Lower Palmatolepis quadrantinodosa Zone (to II β) to the Upper Polygnathus styriacus Zone (to IV).

FALCODUS sp.

Material and locality: One sample, Sample BG 19113, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: Unit elongate, with bars of equal length, bearing a sequence of fine, posteriorly inclined, needle-like denticles, the terminal ones being the largest and the same order of size as the apical denticle.

Beneath the apical denticle a minute basal cavity is present. The aboral margin is upwardly inclined away from the cavity on both bars.

Remarks: This form is very close to Falcodus variabilis but the unit has been extended into a hindeodellid form.

Hindeodella ? reversa has the same aboral outline but the bars are much longer and the dentition is more hindeodellid-like (Pollock, 1968). The specimen is from the Lower Polygnathus styriacus Zone.

Genus HIBBARDELLA Bassler, 1925

Type species: Prioniodus angulatus Hinde, 1879.

HIBBARDELLA (DIPODODELLA) ALTERNATA

Branson & Mehl, 1934

Pl. 5, figs. 1

- 1934 Diplododella alternata Branson & Mehl, Univ. Missouri Stud., 8, 204, pl. 16, figs. 23, 24.
- 1934 Hibbardella insignis Huddle, Bull. Amer. Paleont., 21, 80, pl. 3, fig. 15.
- 1949 Diplododella alternata Branson & Mehl; Thomas, Geol. Soc. Amer. Bull., 60, 408, pl. 1, fig. 22.
- 1949 Diplodella sp. A Thomas, ibid., 420, pl. 1, fig. 21.
- 1965 Diplododella alternata, Murray & Chronic, J. Paleont., 39, pl. 73, figs. 1, 2.
- 1968 Hibbardella alternata (Branson & Mehl); Mound, J. Paleont., 42, pl. 66 (pl. 2 in text), fig. 3.
- 1969 Hibbardella (Hibbardella) sp. A Druce, Bur. Miner. Resour. Austral. Bull. 98, 66, pl. 8, figs. 11a, b.

Material: 17 specimens, CPC 12401-12404 figured.

Localities of figured material: Samples BG 19001, 19019, Section 1, McWhae Ridge, Gogo and Virgin Hills Formations; BG 19534, Section 9, Balme Knoll, Virgin Hills Formation; BG 19571, Section 11, 2 miles northeast of Galeru Gorge, Virgin Hills Formation.

Description: The anterior arch is symmetrical and the individual bars are of medium length. They bear a sequence of denticles arranged cyclically. The large denticles alternate with one or two minor ones; the tallest denticles are in the middle of each bar. The apical denticle is tall and laterally compressed, extending somewhat slightly onto the posterior bar.

The posterior bar is laterally compressed and bears a sequence of small needle-like denticles which are inclined posteriorly. The basal cavity is minute and is situated beneath the apical denticle.

Remarks: *H. alternata* is distinguished by the denticle alternation on the anterior arch and lateral compression of the bars and apical denticle.

Distribution: The species was originally described from the Upper Devonian of Missouri (Branson & Mehl, 1934). It is also known from Iowa (Thomas, 1949) and Colorado (Murray & Chronic, 1965). In Canada the species is known from Alberta (Pollock, 1968; Mound, 1968) and it has also been described from the Bonaparte Gulf Basin, Australia (Druce, 1969).

Range: The original description of the species was from the lower Upper Devonian. However, Murray & Chronic (1965) describe it from Pennsylvanian strata. The great gap in its stratigraphic range has been closed somewhat by the illustration of forms from the Lower Carboniferous of Australia (Druce, 1969) and the late Famennian of Alberta (Mound, 1968). Thus, it seems that *H. alternata* could range from lowest Upper Devonian up to the Upper Carboniferous. The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to I α) up to the Upper Scaphignathus veliferus Zone (to IV).

HIBBARDELLA (DIPODODELLA) AURITA

(Sannemann, 1955)

Pl. 4, figs. 6

- 1955 Roundya aurita Sannemann, Senck. leth., 36, 153, pl. 2, figs. 3a, b; pl. 5, fig. 11.
- 1957 Ellisonia sp. Lys, Serre, et Deroo, Rev. Inst. Francais Petrol., 12, 799, pl. 8, fig. 4.
- ?1957 Roundya aurita Sannemann; Ziegler in Flügel & Ziegler, Sond. Mitteil. Naturw. Ver. Steiermark, 87, 50, pl. 5, fig. 17, 20.
- 1959 Roundya aurita Sannemann; Helms (part), Geologie, 8, 664, pl. 1, figs. 6a, b [fig. 12 = ? H. multidentis].
- ?1961 Roundya aurita Sannemann; Lys et al., Rev. Inst. Francais Petrol., 16, 553, pl. 5, fig. 7.
- 1962 Roundya aurita Sannemann; Ethington & Furnish, J. Paleont., 36, 1284, pl. 173, fig. 14.
- ?1967 Roundya aurita Sannemann; Spasov & Filipovic, Bulgarian Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 78, pl. 4, fig. 15 [? = H. angulata].
- 1967 Dipododella aurita ? (Sannemann); Müller & Clark, J. Paleont., 41, 911, pl. 116, figs. 9, 10.
- 1967 Roundya aurita Sannemann; Wolska, Acta Palaeont. Polonica, 12, 421, pl. 5, figs. 5, 6.
- 1968 Hibbardella aurita Sannemann; Mound, J. Paleont., 42, 483, pl. 66, figs. 4, 5.

Material: 14 specimens, CPC 12408-12409 figured.

Localities of figured material: Sample BG 19105, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 21015, Section 14, 2 miles northwest of Pinnacle Spring, Virgin Hills Formation; Sample 21206, Section 19, Sadler Ridge, Sadler Limestone.

Description: The anterior arch is small. Both bars are flexed anteriorly and deflected aborally. They bear a sequence of cyclically arranged needle-like denticles. The apical denticle is slightly laterally compressed with an elliptical cross-section and is fairly massive. The posterior bar is laterally compressed and blade-like bearing a sequence of cyclically arranged needle-like denticles. The large denticles are inclined posteriorly and increase in size posteriorly, alternating with two or three small needle-like denticles.

The basal cavity is nearly non-existent, a minute pit being present beneath the apical denticle.

Remarks:

The present specimens are close to the holotype (Sannemann, 1955, pl. 5, fig. 11). However, the paratype (*ibid.*, pl. 2, figs. 3a, b) appears to belong to a different species. Some of the forms illustrated since are similar to the holotype and others are similar to the paratype. Until the original types are re-examined it is impossible to decide whether the difference is intraspecific or which later forms belong to which type. The forms that I have questionably include in the synonymy I consider to be paratype forms.

Distribution and Range:

Because of the nomenclature problems it is impossible to accurately deduce the areal and temporal distribution of H. aurita. However, it appears to be Upper Devonian in age and of world-wide distribution. The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to I $\times$) up to the Upper Palmatolepis quadrantinodosa Zone (to III $\times$).

HIBBARDELLA (DIPODODELLA) PLANA Thomas, 1949

Pl. 5, figs. 4

1949 Hibbardella plana Thomas, Bull. Geol. Soc. Amer. 60, 422, pl. 2, fig. 28.

- non 1959 Roundya plana Helms, Geologie, 8, 654, pl. 6, fig. 26.
- non 1963 Roundya plana Helms; van den Boogaard, Geol. Mynb, 42, 253, table 1.
- non 1967 Roundya plana Helms; Wolska, Acta Palaeont. Polonica, 12, 422, pl. 5, fig. 4.
- non 1968 Hibbardella plana Thomas; Pollock, J. Paleont., 42, 430, pl. 61, figs. 4, 5. [? = H. (D). aurita].
- non 1969 Roundya plana Helms; Schönlaub, J. B. Geol. B. A., 112, 307.

Material and Locality: 2 specimens, CPC 12413 figured; Sample BG 19050, Section 3, McWhae Ridge, Sadler Limestone.

Description: Both specimens have the posterior bar broken. The arch is greatly depressed, the angle between the bars being about 60° . Each bar bears a sequence of squat, laterally compressed, fused denticles. There are up to six denticles on each bar. A low shoulder is present at the bar-denticle junction. The posterior bar is laterally compressed; the apical denticle is broken. The basal cavity is minute and is situated beneath the apical denticle at the junction of the three bars.

Remarks: Until Huddle (1968) showed that the types of Hibbardella illustrated by Ulrich & Bassler (1926) possessed a posterior bar, there was considerable doubt about the generic assignment of conodonts with a posterior bar and anterior arch. Many workers assigned these forms to Roundya as being the oldest described genus with this morphology. Now that the true nature of Hibbardella is known, forms originally placed in Roundya should be brought to Hibbardella and thus Roundya plana becomes a junior homonym and should be renamed.

Distribution: The species is only known from the Maple Mill Shale of Iowa (Thomas, 1949). Druce (1969) illustrates specimens from the Bonaparte Gulf Basin of Australia which he compares to H. plana.

Range: Unknown, but the presence of Ancyrognathus in the same sample in Iowa suggests a Frasnian age (Thomas, 1949). The forms illustrated by Druce (1969) are from the early Carboniferous. The Canning Basin specimens occur in the Lower Polygnathus asymmetricus Zone (to $\text{I}\alpha$) and the Lower Palmatolepis quadrantinodosa Zone (to $\text{II}\beta$).

HIBBARDELLA (HASSOGNATHUS) FRANCA (Sannemann, 1955)

Pl. 4, figs. 8

- 1955 Roundya franca Sannemann, Senck. leth., 36, 153, pl. 5, figs. 5-7.
- 1956 Roundya franca Sannemann; Bischoff, Hess. Landesamt Bodenf., Notizbl., 84, 136, pl. 10, figs. 32-34.
- 1967 Roundya franca Sannemann; Nehring, Inst. Geol. Bull. 209, 157, pl. 4, fig. 9.
- 1967 Roundya franca Sannemann; Wolska, Acta Palaeont. Polonica, 12, 422, pl. 5, fig. 8.

Material and Locality: Single specimen, CPC 12410, from Sample BG 21100, Section 17, Bugle Gap Limestone.

Description: Arch short and depressed to give an angle of about 60° , bearing up to three short isolated denticles on each bar. The posterior bar is elongate and laterally compressed with cyclic dentition. The large denticles, which increase in size posteriorly, alternate with two or three small denticles. The apical denticle is sub-circular in cross-section and recurved and beneath it a small basal cavity occurs.

Distribution: The species was originally described from the Cheiloceras-Stufe of the Frankenwald, Germany (Sannemann, 1955). The species has been reported from elsewhere in Germany by Bischoff (1956), Bender (1958), Freyer (1961), and Zimmermann (1961). The species has also been reported from Austria (Schönlaub, 1969), Italy (Manzoni, 1965) and Poland (Nehring, 1967; Wolska, 1967).

- 1967 Roundya separata (Branson & Mehl); Spasov & Filipovic, Bulg. Akad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 78, pl. 4, fig. 16.
- 1969 Hibbardella (Hassognathus) separata (Branson & Mehl); Rhodes et al., Bull. Brit. Mus. (Nat. Hist.), Geol. Suppl. 5, 117, pl. 25, figs. 13a--14.
- 1969 Hibbardella (Hassognathus) separata (Branson & Mehl); Druce, Bur. Miner. Resc. Austral. Bull. 98, 67.

Material: 5 specimens, CPC 12414-12415 figured.

Locality of figured material: Sample BG 19080, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Description: The anterior arch is short and depressed to give an angle of less than 90° between the bars. The dentition consists of elongate denticles which are isolated, and subcircular in cross-section. The apical denticle is massive and has a trough on the lower posterior face. The basal cavity is sub-triangular and extends along the posterior bar, which is broken in all specimens, as a groove.

Remarks: The trough on the posterior face of the apical denticle is reminiscent of the subgenus Roundya, but the absence of a large basal cavity precludes the inclusion of this species in that subgenus.

Distribution: The species was originally described from the Bushberg Sandstone of Missouri (Branson & Mehl, 1934). It has been illustrated from Arizona as Roundya sp. (Ethington, 1965). It is very common in Germany, having been recorded by Sannemann (1955), Bischoff (1956, 1957), (1961) and Zitzmann (1966). Elsewhere in Europe, it has been recorded from Bulgaria (Spasov & Stefanovic, 1962), Yugoslavia (Spasov & Filipovic, 1967) and Great Britain (Rhodes et al., 1969).

Range: Bischoff (1957) gives the range of Hibbardella separata as Upper Devonian (pre to VI) and a possible occurrence in the Lower Carboniferous (cu II α). Sannemann (1955) records the species from the to II α Zone. In Great Britain (Rhodes et al., 1969) and Australia (Druce, 1969) the species is present in the Lower Carboniferous. The overall range appears to be Upper Devonian (to II α) to Lower Carboniferous (cu II γ). The Canning Basin specimens extend this range down to the Upper Polygnathus asymmetricus Zone (to I β). They range as high as the Upper Palmatolepis quadrantinodosa Zone (to III α).

HIBBARDELLA (HASSOGNATHUS) sp.

Pl. 5, figs. 6

Remarks: A single specimen, CPC 12415A, from Sample 19001, Section 1, McWhae Ridge, Gogo Formation, appears to be an undescribed hibbardellid. The anterior arch is distinctive, being short, depressed and deflected, bearing short, isolated needle-like denticles with a circular cross-section. The apical denticle is tall and slightly laterally compressed. The posterior bar is broken but bears a series of small, extremely isolated, peg-like denticles. An attachment scar is present on both lateral faces. The basal cavity is small and extends along the posterior bar as a narrow groove. The specimen is from the Lower and/or Middle Polygnathus asymmetricus Zone.

HIBBARDELLA (HIBBARDELLA) ANGULATA (Hinde, 1879)

Pl. 5, figs. 2

1879 Prioniodus angulatus Hinde, Quart. J. Geol. Soc. Lond., 35, 360, pl. 15, fig. 17.

For synonymy up to 1948 see:

1968 Hibbardella angulata (Hinde), Huddle, U.S. Geol. Surv. Prof. Pap. 578, 14, pl. 8, figs. 2, 7; pl. 9, fig. 3.

- 1957 Hibbardella angulata (Hinde); Rhodes & Dineley, J. Paleont., 31, 361.
- 1957 Hibbardella n. sp. Rhodes & Dineley, ibid., 362, pl. 38, fig. 13.
- 1957 Roundya sp. c Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh., 22, 113, pl. 21, fig. 13.
- 1961 Roundya sp. c Bischoff & Ziegler; Freyer, Freib. Forsch., C-95, 83, pl. 5, fig. 130.
- 1965 Hibbardella angulata (Hinde); Freyer, Abh. Berichte Naturkunde-museums Gorlitz, 40, 8, text-fig. 1/12.
- 1967 Roundya sp. Spasov & Filipovic, Bulgarian Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 78, pl. 4, fig. 15.
- ?1967 Diplodella aurita? (Sannemann); Müller & Clark, J. Paleont., 41, 911, pl. 116, figs. 9, 10.

Material: 6 specimens, CPC 12405-12407 figured.

Localities of figured material: Sample BG 19419, McWhae Ridge, Sadler Limestone; Sample BG 19534, Balme Knoll, Virgin Hills Formation.

Description: Anterior arch of medium size with the bars making an angle of about 75° . Both arms bear a sequence of tall, isolated denticles, circular in cross-section. The denticles are tallest in the middle of each bar. The bars are circular in cross-section near the apical denticle but are more compressed and bar-like towards their terminations.

The apical denticle is massive and sub-circular in cross-section. The posterior bar is fairly massive with isolated denticles. In all cases the posterior bar is broken and the nature of the posterior termination is unknown.

The basal cavity is situated sub-apically and is triangular with extensions beneath each bar in the form of narrowing troughs.

Remarks: H. angulata is distinguished by its non-cyclic, isolated dentition. It can be distinguished from H. multidentis by the acute angle between the bars; the angle is obtuse in H. multidentis.

Distribution: The species was originally described from New York and Ohio (Hinde, 1879). It is also known from Indiana (Huddle, 1934), Michigan (Müller & Clark, 1967), and Alberta (Pollock, 1968). In Europe the species has been recorded from England (Rhodes & Dineley, 1957), Germany (Bischoff & Ziegler, 1961; Freyer, 1961, 1965) and Bulgaria (Spasov & Filipovic, 1967).

Range: The species was originally described from the early Upper Devonian (Hinde, 1879; Branson & Mehl, 1933; Huddle, 1968). The earliest occurrence appears to be from the Middle Devonian of England (Rhodes & Dineley, 1957). The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to Ix) up to the Ancyrognathus triangularis Zone (to IX).

HIBBARDELLA (HIBBARDELLA) MULTIDENS

Ulrich & Bassler, 1926

Pls. 5, figs. 3

1926 Hibbardella multidens Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 38, pl. 3, figs. 8, 9.

For synonymy see:

1968 Hibbardella multidens Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 14, pl. 8, fig. 10; pl. 9, fig. 1.

Material: 4 specimens, CPC 12411-12412 figured

Locality of figured material: Sample BG 19061, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Description: Anterior arch very long and only slightly depressed. It bears a sequence of short, greatly separated, denticles. The anterior bar is sub-circular and bears isolated peg-like denticles. The basal cavity is sub-triangular and extends along each bar as a rapidly narrowing trough.

Remarks: The low arch with the widely separated denticles distinguish this species.

Distribution: The species was originally described from the Rhinestreet Shale of New York (Ulrich & Bassler, 1926; Huddle, 1968). It has also been recorded from New York by Hibbard (1927) and Youngquist *et al.* (1948). Rhodes & Dineley (1957) recorded similar forms from England.

Range: Unknown but it occurs in the middle Frasnian (to I β) of New York (Huddle, 1968, p. 3). The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to I α) up to the Ancyrognathus triangularis Zone (to I γ).

Genus HINDEODELLA Bassler, 1925

Type species: Hindeodella subtilis Ulrich & Bassler, 1926.

HINDEODELLA BREVIS Branson & Mehl, 1934

Pl. 4, figs. 4

1934 Hindeodella brevis Branson & Mehl, Univ. Missouri Stud., 8, 195, pl. 14, figs. 6, 7.

1934 Hindeodella cf. H. brevis Branson & Mehl, *ibid.*, pl. 14, fig. 12.

1956 Hindeodella brevis Branson & Mehl; Bischoff & Ziegler, Hess. Landesamt Bodenf., Notizbl. 184, 147, pl. 14, figs. 10, 11.

non 1957 Hindeodella brevis Branson & Mehl; Bischoff, *ibid.*, 19, 26, pl. 6, fig. 24 [= H. croka Collinson & Druce].

non 1959 Hindeodella brevis Branson & Mehl; Helms, Geologie, 6, pl. 4, fig. 31 [= H. uncata].

? 1961 Hindeodella brevis Branson & Mehl; Freyer, Freiberger Forsch., C 95, 44, pl. 1, fig. 26.

non 1967 Hindeodella brevis Branson & Mehl; Spasov & Filipovic, Bull. Geol. Inst., Ser. Paleont., 16, 63, pl. 1, figs. 8, 9 [= H. croka Collinson & Druce].

1969 Hindeodella brevis Branson & Mehl; Rhodes, Austin & Druce,
Bull. Brit. Mus. (Nat. Hist.) Geol. Suppl. 5, 119, pl. 31,
 fig. 17.

1969 Hindeodella brevis Branson & Mehl; Druce, Bur. Min. Resour.
Aust. Bull. 98, 67, pl. 10, figs. 1, 2.

Material: 7 specimens, CPC 12420-12421 figured.

Localities of figured material: Sample BG 19023, Section 1, McWhae
 Ridge, Virgin Hills; Sample BG 19115, Section 4, northeast McWhae
 Ridge, Bugle Gap Limestone.

Description: The unit is small, consisting of an anterior and posterior
 bar. The anterior bar is deflected through 90° ; it bears denticles which
 vary from needle-like to massive, depending on the form of the bar.
 Blade-like bars bear needle-like denticles; massive bars, subcircular
 in cross-section bear massive denticles. The posterior bar is twice
 as long as the anterior bar and bears similar dentition. Near the
 posterior termination the denticles become more posteriorly inclined
 and massive.

The apical denticle is slightly offset from the bars. It is born
 on a corresponding thickening on the inner side of the bar. The aboral
 surface is knife-edged, a true basal cavity is absent on many specimens
 but may be represented by an inverted cavity.

Remarks: Hindeodella brevis is very close to both H. corpulenta,
 differing only in being much smaller and having different dentition, and
 to Angulodus flexus Druce, differing in the lack of the downward pro-
 jection of the posterior bar termination.

Distribution: Hindeodella brevis was originally described from the
 Upper Devonian Grassy Creek Shale of Missouri (Branson & Mehl, 1934).
 Elsewhere in North America it has been recorded from the Upper
 Devonian of Alberta, Canada (Pollock, 1968). The species is also known
 from many occurrences in Europe, from the Upper Devonian and Lower

Carboniferous of Austria (Schönlaub, 1969), from the Upper Devonian of Germany (Bischoff & Ziegler, 1956; Stoppel, 1958; Helms, 1959; Freyer, 1961; 1968), the Lower Carboniferous of Great Britain (Rhodes et al., 1969), the Upper Devonian of Italy (Manzoni, 1965), Portugal (Van den Boogaard, 1963), and Poland (Freyer & Zakova, 1967).

Other occurrences include the Upper Devonian of the Spanish Sahara (Ethington & Furnish, 1962) and Lower Carboniferous of the Bonaparte Gulf Basin, Australia (Druce, 1969).

Range: Bischoff & Ziegler (1957) record the species range as Upper Devonian (to I - to V). Rhodes et al. (1969) record the species as high as the uppermost Lower Carboniferous (D₃ Zone). The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to Ix) up to the Upper Palmatolepis quadrantinodosa Zone (to IIx).

HINDEODELLA COMPRESSA Huddle, 1934

Pl. 5, figs. 8

- 1934 Hindeodella compressa Huddle, Bull. Amer. Paleont., 31, 41, pl. 5, fig. 4.
- 1934 Hindeodella elongata Huddle, ibid., 42, pl. 5, figs. 5, 6.
- 1943 Hindeodella elongata Huddle; Cooper & Sloss, J. Paleont., 17, 172, pl. 28, figs. 18, 19, 21, 36.
- 1943 Hindeodella compressa Huddle; Cooper & Sloss, ibid., 172, pl. 28, fig. 25.
- 1961 Hindeodella elongata Huddle; Scott & Collinson, Guidebook, 26th Ann. Field Conf., Kansas Geol. Soc., pl. 2, fig. 15.
- 1961 Hindeodella similis Ulrich & Bassler; Freyer, Freib. Forsch., C95, pl. 1, figs. 30, 31.
- 1964 Hindeodella similis Ulrich & Bassler; Budurov & Tshunev, Bull. Inst. Sci. Recherches Geol., 1, pl. 4, fig. 20.
- 1965 Hindeodella similis Ulrich & Bassler; Spasov, Trav. Geol. Bulgarie, Ser. Paleont., 7, 87, pl. 1, fig. 11.

1968 Hindeodina compressa (Huddle); Mound, J. Paleont., 42, 486,
pl. 66, figs. 20, 25.

1969 Hindeodella compressa Huddle; Druce, Bur. Min. Resour.
Austral., Bull., 98, 68, pl. 9, figs. 8, 9.

Material: 33 specimens, CPC 12432-12436 figured.

Localities of figured material: Sample BG 19049, Section 3, McWhae Ridge, Sadler Limestone; Sample 19007, Section 1, McWhae Ridge, Gogo Formation; Samples BG 19108, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 21229, Section 19, Sadler Ridge, Sadler Limestone.

Description: An elongate unit lacking an apical denticle. The bar is slightly arched and the posterior and anterior bars are often separated by a slightly offset bar denticle. The complete bar dentition is extremely fine but may be cyclic. The posterior inclination increases posteriorly and the termination is sharp, the bar shallowing aborally. The anterior bar is often depressed through about 30° . The basal cavity is minute or absent, the aboral margin being knife-edged.

Remarks: Hass (1959) erected a new genus Hindeodina on the absence of a well developed apical denticle. Lindström (1964) considers Hindeodina to be a junior synonym of Hindeodella and I agree.

Distribution: Hindeodella compressa was originally described from the Upper Devonian New Albany Shale of Indiana (Huddle, 1934). Elsewhere in North America it has been illustrated by Scott & Collinson (1961) from the Upper Devonian Louisiana Limestone of Illinois; from the Devonian/Carboniferous boundary of Alberta and Montana (Cooper & Sloss, 1943) and from the Upper Devonian sub-surface rocks of Alberta (Mound, 1968). In Europe the species has been recorded from Germany (Freyer, 1961) and Bulgaria (Budurov & Tschunov, 1964; Spasov, 1965). It is also known from the Bonaparte Gulf Basin of Australia (Druce, 1969).

Range: The species was originally described from the Upper Devonian New Albany Shale (Huddle, 1934). It is known as low as the Upper Devonian to I γ Zone (Mound, 1968). It has also been recorded from the Carboniferous (Cooper & Sloss, 1943), as high as the Cu II α Zone (Druce, 1969). The Canning Basin specimens extend the range as low as the Lower Polygnathus asymmetricus Zone.

HINDEODELLA CORPULENTA Branson & Mehl, 1934

Pl. 4, figs. 9

1934 Hindeodella corpulenta Branson & Mehl, Univ. Missouri Stud., 8, 281, pl. 22, figs. 32, 33.

For complete synonymy see:

1969 Hindeodella corpulenta Branson & Mehl; Rhodes et al., Bull. Brit. Mus. (Nat. Hist.), Geol., Suppl. 5, 120, pl. 29, figs. 16a - 17c.

1969 Hindeodella corpulenta Branson & Mehl; Druce, Bur. Min. Resour. Aust. Bull. 98, 68, pl. 10, figs. 5-7.

1969 Ligonodina sp. Ziegler, Fortschr. Geol. Rheinld Westf., 17, pl. 2, fig. 19.

Material: 22 specimens, CPC 12422 figured.

Locality of figured material: Sample BG 19422, McWhae Ridge, Sadler Limestone.

Description: Unit massive with a short anterior bar and a long posterior bar. The anterior bar is deflected through 90° and depressed through about 60° . It bears about four small needle-like denticles. The apical denticle is massive and laterally compressed; the oral termination is slightly twisted. The posterior bar is elongate, bearing a sequence of 7 or more tall, isolated, needle-like denticles which increase in height toward the posterior.

A small basal cavity is present beneath the apical denticle. An attachment scar is present of the lower part of both sides of both bars.

Remarks: Hindeodella corpulenta is morphologically close to the genus Ligonodina. It is differentiated from Ligonodina species by the anterior bar, which although deflected through 90^0 , merges posteriorly with the apical denticle rather than laterally. The species is probably an intermediate form between Hindeodella and Ligonodina.

Distribution: Hindeodella corpulenta was originally described from the Bushberg Sandstone of Missouri (Branson & Mehl, 1934). The species or other species considered to be junior synonyms are known from Oklahoma (Cooper, 1939), Indiana (Huddle, 1934), Iowa (Thomas, 1949) and Alberta, Canada (Pollock, 1968).

The species has been illustrated from France (Lys, Serre, & Deroo, 1957) and described from Great Britain (Rhodes et al., 1969). It has also been described from the Bonaparte Gulf Basin of Australia (Druce, 1969).

Range: The majority of occurrences are from the Lower Carboniferous. Rhodes et al. (1969) record the species as high as the top of the Zaphrentis Zone and Druce (1969) records it throughout the Tournaisian in the Bonaparte Gulf Basin, Australia. The species has been recorded from the Upper Devonian Maple Mill Shale of Iowa (Thomas, 1949). The Canning Basin specimens are from the Polygnathus asymmetricus Zone (to ~~IX~~) and range up into the Scaphignathus veliferus Zone (to IV).

HINDEODELLA SUBTILIS Ulrich & Bassler, 1926

Pl. 4, figs. 10

1926 Hindeodella subtilis Ulrich & Bassler, Proc. U.S. Nat. Mus.,
68, 39, pl. 8, figs. 17-19.

For synonymy see:

- 1969 Hindeodella subtilis Ulrich & Bassler; Rhodes et al., Bull. Brit. Mus. (Nat. Hist.), Geol., Suppl. 5, 125, pl. 29, figs. 6a - 7b, 9-106.
- 1961 Hindeodella germana Holmes; Freyer, Freiberger Fortschr., C95, 45, pl. 1, figs. 27, 28.
- ? 1967 Hindeodella germana Holmes; Spasov & Filipovic, Bull. Geol. Inst., Ser. Paleont., 16, 64, pl. 1, fig. 5.
- 1967 Hindeodella germana Holmes; Freyer & Zakowa, Acta Geol. Polonica, 17, 109, pl. 1, fig. 16.
- non 1967 Hindeodella germana Holmes; Nehring, Inst. Geol. Bull. 209, Strat. Paleont. Polsce, 3, 129, pl. 2, fig. 5.
- 1967 Hindeodella deflecta Hibbard; Wolska, Acta Palaeont. Polonica, 12, 378, pl. 2, fig. 13.
- 1967 Hindeodella germana Holmes; Wolska, ibid., 378, pl. 2, fig. 12.
- 1967 Hindeodella subtilis Ulrich & Bassler; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 35, pl. 3, fig. 15.
- 1968 Hindeodella subtilis Ulrich & Bassler; Mound, J. Paleont., 42, 485, pl. 66, figs. 10, 11, 17.
- ? 1968 Hindeodella germana Holmes; Durdanovic, Geol. Vjesnik, 21, 98, pl. 1, fig. 8.
- 1969 Hindeodella subtilis Ulrich & Bassler; Druce, Bur. Min. Resour. Austral. Bull. 98, 69, pl. 10, figs. 3, 4.
- 1969 Hindeodella sp. Ziegler, Fortschr. Geol. Rheinld Westf., 17, pl. 2, fig. 18.
- 1970 Hindeodella alternata Ulrich & Bassler; Seddon, J. Geol. Soc. Austral., 16, pl. 12, fig. 31.
- 1970 Hindeodella subtilis Bassler; Seddon, ibid., pl. 12, fig. 34.

Material: 159 specimens, CPC 12423-12429 figured.

Localities of figured material: Samples BG 19014, 19019, Section 1, McWhae Ridge, Virgin Hills Formation; Samples BG 19167, 19448A, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and

Bugle Gap Limestone; Sample BG 19188, McWhae Ridge, Sadler Limestone; Samples BG 21215, 21216, Section 19, Sadler Ridge, Sadler Limestone.

Description: A laterally compressed hindeodellid with a short anterior bar and a long posterior bar. The anterior bar is depressed and deflected through 30° . The dentition on most specimens is cyclic, two or three small denticles alternate with a much larger denticle. The basal cavity is minute and is situated beneath the apical denticle.

Remarks: Some forms with cyclic dentition have been referred to H. alternata Ulrich & Bassler. There appears to be a complete gradation between cyclic forms and non-cyclic forms. Often the non-cyclic forms have germ denticles which, if they erupted, would give cyclic dentition.

Distribution: Hindeodella subtilis is an ubiquitous species in Upper Devonian and Lower Carboniferous faunas. It has been reported extensively from North America, Europe and Australia.

Range: Bischoff & Ziegler (1956) report the species from as early as the to I Zone of the Upper Devonian. Rhodes et al. (1969) record the species as high as the top of the Lower Carboniferous 'Zaphrentis' Zone. In the Canning Basin the species ranges throughout the section.

HINDEODELLA UNCATA (Hass, 1959)

Pl. 5, figs. 7

1959 Hindeodina uncata Hass, U.S. Geol. Surv. Prof. Pap. 294-J, 383, pl. 47, fig. 6.

1959 Hindeodella brevis Branson & Mehl; Helms, Geologie, 6, pl. 4, fig. 31.

? 1961 Hindeodella cf. H. uncata (Hass); Scott & Collinson, Guidebook, 26th Ann. Field Conf., Kansas Geol. Soc., pl. 2, figs. 18, 19.

1969 Hindeodella uncata (Hass); Druce, Bur. Min. Resour. Austral. Bull., 98, 69, pl. 10, figs. 8-96.

1970 Hindeodella uncata (Hass); Seddon, J. Geol. Soc. Austral., 16, 737, pl. 14, figs. 18, 19.

Material: 4 specimens, CPC 12430-12431 figured.

Localities of figured material: Samples BG 19072, 19109, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone.

Description: A hindeodellid with a long posterior bar and a shorter deflected anterior bar. The deflection of the anterior bar is 90° and occurs about 2 bar denticles to the anterior of the apical denticle. The apical denticle is tall and needle-like and is inclined greatly to the inner side. The posterior bar is straight and bears up to ten large denticles, with small denticles interspersed in a cyclic manner. All the denticles are inclined toward the inner side and posterior termination; the inclination increases posteriorly. A minute cavity is present beneath the apical denticle.

Remarks: Hindeodella uncata can be distinguished from H. brevis by its elongate posterior bar, and from H. croka Collinson & Druce by the lack of a double flexure of the anterior bar.

Distribution: Hindeodella uncata was originally described from the early Mississippian Chappel Limestone of Texas (Hass, 1959). Scott & Collinson (1961) compare specimens from the Louisiana Limestone of Illinois to H. uncata. In Europe the species has been illustrated as H. brevis (Helms, 1959). In Australia it is known from the Bonaparte Gulf Basin (Druce, 1969) and the Canning Basin (Seddon, 1970).

Range: The species was described originally from the Gnathodus punctatus Zone of the Carboniferous of Texas. The specimens illustrated by Scott & Collinson (1961) come from an Upper Devonian horizon

equivalent to VI. The specimens from the Bonaparte Gulf Basin are confined to a Lower Carboniferous strata of Cu II α age (Druce, 1969). Seddon (1970) records the species from the Sadler Limestone of the Canning Basin; he considers the fauna to be about Upper Devonian (to I β). Seddon also points out that the specimens illustrated by Helms come from a to I δ horizon at Saalfeld, Germany. The range of the species appears to be from the Upper Devonian (to I β) up to the Lower Carboniferous (Cu II β). The Canning Basin occurrences extend the range as low as the Middle Polygnathus asymmetricus Zone (to I α).

HINDEODELLA cf. H. MOWERI Stauffer, 1940

Pl. 5, figs. 9

cf. 1940 Hindeodella moweri Stauffer, J. Paleont., 14, 424, pl. 58,
figs. 3-7, 9.

Material: 7 specimens, CPC 12437 figured.

Locality of figured material: Sample BG 19105, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: All specimens are broken with only the anterior bar and a small portion of the posterior bar preserved. The anterior bar is short and depressed through up to 120°. It bears 2 to 4 denticles, one of which (usually the second denticle anterior to the apical denticle) is massive. The apical denticle is laterally compressed and recurved posteriorly.

The basal cavity is quite distinctive. It is a long thin groove situated beneath the apical denticle and the anterior bar with an apex anterior to the apical denticle rather than beneath it as in most hindeodellids.

Remarks: The species is compared to H. moweri Stauffer because in the illustrations of that species the basal cavity appears to be of a similar type. In overall morphology it resembles the Ordovician genus Phragmodus. The Canning Basin specimens occur in the Palmatolepis quadrantinodosa Zone (to II β - to III α).

HINDEODELLA sp. A

Pl. 5, figs. 11

Material: 6 specimens, CPC 12438 - 12439 figured.

Location of figured material: Sample BG 19001, 19007, Section 1, McWhae Ridge, Gogo Formation.

Description: An elongate hindeodellid with a massive apical denticle. Both bars are deep and laterally compressed; in one specimen (pl. 5, fig. 11) a narrow ledge runs along the aboral edge of both sides of the posterior bar. The anterior bar is short and bears up to two massive recurved isolated denticles interspersed with small denticles. The posterior bar is elongate and bears a sequence of tall isolated, posteriorly inclined denticles. The anteriormost denticles are smaller than the denticles of the anterior bar, whereas the posteriormost are taller.

The basal cavity is slit-like and is situated beneath the apical denticle or just anterior to it and extends for a short distance along the anterior bar. The specimens are from the Lower and Middle Polygnathus asymmetricus Zone.

HINDEODELLA sp. B

Pl. 5, fig. 10

Remarks: One specimen, CPC 12440 , from Sample BG 19102, Section 4, northeast of McWhae Ridge, Virgin Hills Formation, resembles H. compressa Huddle but possesses an apical denticle. The

short anterior bar is deflected through 45° and bears six fused needle-like denticles. The apical denticle is broken but is twice as wide as long as the anterior bar and bears five fused and posteriorly inclined denticles. The specimen occurs in the Lower Palmatolepis quadrantinodosa Zone (to $\Pi \beta$).

HINDEODELLA sp. C

Pl. 5, fig. 12

Remarks: Two specimens, CPC 12441 figured, are very similar to Hindeodella subtilis Ulrich & Bassler but differ in having a doubly depressed anterior bar. The dentition is coarse and resembles that of Hindeodella aculeata Huddle which I consider to be a junior synonym of H. subtilis. The specimens are from either the Lower and/or Middle Polygnathus asymmetricus Zone (to $I\alpha$). The illustrated specimen is from Sample BG 19468, Section 5, Lloyd Hill, Sadler Limestone.

HINDEODELLA sp. D

Pl. 5, fig. 13

Remarks: Five specimens, CPC 12442 figured, are unlike any described species of Hindeodella. They consist of short equidimensional anterior and posterior bars. The anterior bar is deflected through 90° and depressed through 60° . This is similar to H. corpulenta but the bar is laterally compressed. The posterior bar differs from H. corpulenta in being short, laterally compressed and deep. The denticles are massive, fused and needle-like.

The aboral margin is knife-like and a minute basal cavity is situated beneath the apical denticle. The specimens are from the Upper Polygnathus asymmetricus Zone (to $I\beta$). The figured specimen is from Sample BG 19543, Section 9, Balme Knoll, Gogo Formation.

HINDEODELLA sp. E

Pl. 5, figs. 14

Remarks: Two specimens, CPC 12443 figured, differ from known hindeodellids in having a very short anterior bar deflected and depressed through 45° . The posterior bar dentition is cyclic and extremely even. This bar is depressed through up to 45° . The extremely even dentition and the depressed posterior bar distinguish it from H. subtilis. The specimens are from the Middle Polygnathus asymmetricus Zone (to Lx). The illustrated specimens are from Sample BG 19482, Section 6, Lloyd Hill, Laidlaw Range, Gogo Formation and Sample BG 21232, Section 19, Sadler Ridge, Sadler Limestone.

Genus ICRIODUS Branson & Mehl, 1934

Type species: Icriodus alternatus Branson & Mehl, 1934.

The genus was erected by Branson & Mehl in 1934 and they named Icriodus expansus as the type species. Unfortunately, they did not describe I. expansus at the time and the illustrations and description of the type species did not appear until 1938. However, in a 1934 publication they did describe I. alternatus and I. symmetricus. In a later publication (Branson & Mehl in Shimer & Schrock, 1944) Icriodus alternatus became the type species by subsequent designation. (I am indebted to Professor F. H. T. Rhodes for drawing my attention to this.)

Apart from the problems of which icriodid is the type species there has also been considerable confusion as to where the boundary between species should be drawn.

In their 1938 paper Branson & Mehl state (p. 158) that species are sharply defined although I. nodosus, I. curvatus and I. expansus approach one another and immature forms of I. symmetricus resemble mature forms of I. cymbiformis. They also point out that species of Icriodus are good horizon markers.

The genus ranges from Silurian (upper Ludlovian latialatus Zone) (Walliser, 1964) to the Devonian (Fammenian, Spathognathodus costatus Zone (to V - VI)) (Klapper, 1966). The Lower Devonian and some Middle Devonian forms either belong to the latericrescens group, which is characterised by the possession of one or more lateral processes or have a close phylogenetic relationship to forms which possess lateral process, i.e., I. woschmidtii. The latericrescens group has been dealt with in detail by Klapper & Ziegler (1967) and also by Carls (1969).

The simple icriodids lacking lateral processes are common in the Middle and Upper Devonian and their detailed nomenclature is in some confusion. As Branson & Mehl (1934, p. 158) state there is a merging of characteristics of some forms and Freyer (1961, p. 49) illustrates the cyclic interrelationship of forms referred to nodosus, symmetricus, and curvatus, from the Upper Devonian of the Vogtlandes, Germany. Clark & Ethington (1967), in discussing the cornutus-rectus-alternatus group (intergrading Icriodus complex of Seddon (1970, p. 735)) state that "a monographic study is necessary to resolve the problems."

Recent studies have thrown light on the relationship of the genus within the conodont animal and also its ecological distribution. Lange (1968) reports the genus in "associations" of Icriodus - Acodina suggesting that some icriodids, at least, were partnered in the conodont animal by simple cone forms. Seddon (1970) distinguishes and Icriodus biofacies, as opposed to a Palmatolepis biofacies. I have also separated an Icriodus fauna from a Palmatolepis fauna and suggested that the Icriodus fauna is a shallow water fauna, whereas the Palmatolepis fauna is a deep water fauna (1970). Seddon (1971) agrees with this broad picture but adds that the faunas may be depth stratified, the Icriodus biofacies living above the Palmatolepis biofacies, rather than adjacent to it, as suggested by my original terminology. I agree with Seddon's suggestion, though it is interesting to note that from the numbers of specimens obtained from samples of differing facies, that the Icriodus

biofacies is much more abundant in the shallow water than in the deeper water environment. This suggests that, even though the Icriodus biofacies may have been able to occupy the upper water niche of the ocean, it preferred to live in near coastal regions or at least in regions where the underlying Palmatolepis fauna was not present.

In examining the icriodid faunas throughout the Devonian sequence of the Canning Basin I have recognised that the presence or absence of Icriodus is related to some extent by the facies and so some extent on probable water depth.

I have suggested that in the Devonian the icriodids with lateral processes and those that lack such processes are probably members of different biofacies (see Appendix). The present study suggests that within the group lacking lateral processes some of the minor morphological characters on which species have been erected could possibly be controlled by facies and/or water depth.

In order to obtain some semblance of order in the taxonomy and also to isolate various characters, I have classified the icriodids on the basis of their oral ornament. I do not wish to convey the idea that oral ornament is either the most important or the only morphological character which can be used. However, surface ornament is easily observed, fairly easy to qualify, and is the most conspicuous part of the icriodid illustrated by all authors over the past forty years.

I have divided the oral ornament into five categories:

1. Symmetrical ornament, characterised by the transverse lineation of the nodes of all three rows.
2. Alternating ornament: characterised by the nodes of the median row alternating with the nodes of the outer rows. Two stages can be recognised, an en echelon arrangement and a true alternating arrangement. The en echelon arrangement is probably an intermediate step between symmetrical ornament and alternating ornament.

3. Irregular ornament: characterised by no true symmetry of node arrangement.
4. Central row reduction: characterised by the partial or complete disappearance of the median row of nodes and complementary enlargement of the lateral rows.
5. Lateral row reduction: characterised by partial disappearance of some lateral nodes. These forms appear to be transitional to the genus Pelekyognathus.

Arbitrarily, I have designated these as species characteristics and thus, in the Upper Devonian at least, there are five species. These are I. symmetricus Branson & Mehl for the symmetrical group; I. alternatus Branson & Mehl for the alternating group; I. incrassatus Youngquist & Peterson for the irregular group; I. arkonensis Stauffer for the group with central row reduction; and I. brevis Stauffer for the group with lateral row reduction.

There are several other characters which these icriodids possess; they are not always present and can also appear on any of the oral ornament types. In the classification scheme I have drawn up a chart (Fig. 21) to show the relationship between these characteristics and the basic oral ornament.

For the sake of clarity in nomenclature, I have assumed these characteristics to be of sub-specific rank. This is useful because it preserves the binomial system. Its limitations are that it cannot take into account more than one prominent subspecific character. In most cases icriodids exhibit only one prominent subspecific characteristic and in the present fauna this type of classification is easy to use. However, some species, noticeably I. corniger, have two prominent subspecific characters and cannot be placed accurately within this classification. This could be solved by the erection of each type of oral ornament as a subgeneric type and each additional characteristic could

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then be of specific or subspecific rank. Some decision will have to be made on the order of priority of these characters and also a trinomial nomenclature system will be introduced. Furthermore, the extension of this system into the other icriodid groups could cause more problems than the system is worth.

As can be seen from Figure 6 many of these morphological combinations have been named. Some, of course, may not exist; others definitely do, being present in the Canning Basin faunas. I have left in open nomenclature the unnamed combinations present in the Canning Basin faunas to avoid any more confusion in icriodid nomenclature.

From Figure 7 it can be seen that icriodids are not present in the complete section. In fact, they come and go repeatedly. The three marked horizons represent stromatolite horizons present in the Bugle Gap area and probably present throughout the Leonard Shelf. These probably represent shallowing of the basin, with current orientated nautiloids being conspicuous on their upper surfaces. In general, the icriodids are associated with these horizons. The nominate subspecies are often present in strata beneath these horizons whereas the other subspecies are absent; conversely, immediately above the stromatolite horizons the nominate subspecies are conspicuous by their absence.

This suggests that the characters used to divide the subspecies are controlled by facies and/or water depth. From Figure 21 it can be seen that the present fauna, the majority of which has been recovered from the shallow water facies of the reef complex, is dominated by certain characters while others are absent. Three characteristics are common, the development of the posterior horn, an elongate basal flare, and a notch in the lateral basal cavity flare. Perhaps these are characteristic of the very shallow water biofacies. Other characters, such as a posterior flare of the cavity lip, posterior blade extension, and the development of lateral carinae, are not present and possibly represent a deeper water facies.

	Upper	24	Unit	Basal	Basal	Posterior	Nominate	Key
Pol	Upper	24	elongation	flare	notch	horn	subspecies	symmetricus
Pol	Middle	23						-----
Pol	Lower	22						-----
Pol	Upper	21						-----
Pol	Middle	20						-----
Pol	Lower	19						-----
Pol	Upper	18						-----
Pol	Lower	17						-----
Pol	Upper	16						-----
Pol	Middle	15						-----
Pol	Lower	14						-----
Pol	Upper	13						-----
Pol	Middle	12						-----
Pol	Lower	11						-----
Pol	Upper	10						-----
Pol	Upper with	9						-----
Pol	Pa. linguiformis	8						-----
Pol	Upper	7						-----
Pol	Lower	6						-----
Pol	Upper	5						-----
Pol	Middle	4						-----
Pol	Lower	3						-----
Pol	Upper	2						-----
Pol	Middle	1						-----
Pol	Lower	0						-----

Text-figure 9

Range chart of subspecies of the genus *Ieriodus* arranged in groups reflecting their subspecific characteristic. Stippling indicates stromatolite horizons.

If, in fact, the minor morphological characters are dependent on environment, then this would explain the plastic nature of the group and the great problems of nomenclature. However, the recognition of this could greatly increase our ability to interpret the environment of deposition of sedimentary rocks and the morphology of sedimentary basins.

ICRIODUS ALTERNATUS ALTERNATUS Branson & Mehl, 1934

Pl. 6, figs. 1a,b

- 1934 Icriodus alternatus Branson & Mehl, Univ. Missouri Stud., 8, 225, pl. 13, figs. 4-6.
- 1938 Icriodus alternatus Branson & Mehl, J. Paleont., 12, 161, pl. 26, figs. 4-6.
- 1938 Icriodus expansus Branson & Mehl; Stauffer, J. Paleont., 12, 430, pl. 52, figs. 19, 20 only.
- 1940 Icriodus expansus Branson & Mehl; Stauffer, J. Paleont., 14, 425, pl. 60, figs. 59, 60, 62, 63.
- 1947 Icriodus alternatus Branson & Mehl; Youngquist & Peterson, J. Paleont., 21, 246, pl. 37, fig. 19 only.
- 1957 Icriodus curvatus Branson & Mehl; Bischoff & Ziegler, Hess. Landesamt Bodenf. Abh. 22, 61, pl. 6, fig. 6a, b.
- 1957 Icriodus elegantulus Stauffer; Lys & Serre, Rev. Inst. Français Petrol., 12, 801, pl. 9, fig. 2.
- 1959 Icriodus alternatus Branson & Mehl; Helms, Geologie, 8, 642, pl. 1, fig. 1; pl. 4, fig. 7.
- 1964 Icriodus alternatus Branson & Mehl; Orr, Ill. State Geol. Surv. Circ. 36, 9, pl. 2, figs. 12a, b, only.
- ? 1964 Icriodus nodosus (Huddle); Budurov & Tschunev, Bull. Inst. Sci. Recherch. Geol., 1, pl. 2, fig. 8.
- 1965 Icriodus alternatus Branson & Mehl; Ethington, J. Paleont., 39, 575, pl. 67, fig. 8.

- 1967 Icriodus symmetricus Branson & Mehl; Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 64, pl. 2, fig. 9 only.
- 1967 Icriodus alternatus Branson & Mehl; Wolska, Acta Palaeont. Polonica, 12, 379, pl. 2, fig. 6 only.
- 1968 Icriodus alternatus Branson & Mehl; Mound, J. Paleont., 42, 486, pl. 66, figs. 13, 15, 19, 24.
- 1968 Icriodus symmetricus Branson & Mehl; Mound, ibid., 488, pl. 66, figs. 40, 41.

Material: 132 specimens, CPC 12445 - 12448 figured.

Location of figured material: Samples BG 19105, 19111, 19113, 19114, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: Elongate platform units about five times as long as wide, bearing nodose ornament. The ornament consists of three linear rows of denticles or nodes. The nodes of the centre row alternate with those of the lateral rows. The alternation can vary from slight with a typical chevron pattern to extreme where the median row denticle is equidistant from two denticles of one lateral row. The amount of alternation tends to increase posteriorly. The median denticle row commonly extends beyond the lateral rows for about two denticles.

The basal cavity extends over the whole unit; it is widest at the posterior where a small pit is often developed. The cavity is nearly symmetrical; on the inner side the lip may be more flared but often it does not flare as far anteriorly.

Remarks: The nominate subspecies is characterized by the alternating dentition and the lack of any of the major morphological characteristics which are present in other subspecies.

Distribution: Illustrated specimens which appear to belong to this subspecies have been described extensively from the United States and Europe. The species was originally described from the Grassy Creek

Shale of Missouri (Branson & Mehl, 1934). Since then, it has been described from Ohio (Stauffer, 1938), Illinois (Orr, 1964), Iowa (Youngquist & Peterson, 1947), Minnesota (Stauffer, 1940) and Arizona (Ethington, 1965). Mound (1968) has illustrated the subspecies from Alberta. In Europe it has been reported from Germany (Bischoff & Ziegler, 1957; Helms, 1959), France (Lys & Serre, 1957), Poland (Wolska, 1967), Bulgaria (Budurov & Tschunev, 1964) and Yugoslavia (Spasov & Filipovic, 1967).

Range: It is impossible to determine the range of the subspecies from previously recorded faunas because the separate subspecies were not individually recognised. In the Canning Basin the subspecies ranges from at least the base of the Upper Devonian to the Upper Palmatolepis quadrantinodosa Zone (to III α).

ICRIODUS ALTERNATUS COSTATUS (Thomas , 1949)

Pl. 6, figs. 2a,b

- ? 1941 Icriodus curvatus Branson & Mehl; Branson & Mehl, J. Sci. Lab. Denison Univ., 35, 192, pl. 7, figs. 2, 14.
- 1949 Pelekysgnathus costata Thomas, Bull. Geol. Soc. Amer., 60, 424, pl. 2, fig. 9.
- 1955 Icriodus cornatus Sannemann, Senck. leth., 36, 130, pl. 4, figs. 19a - 21.
- ? 1961 Icriodus cornatus Sannemann; Freyer, Freib. Forsch., C95, 47, pl. 1, fig. 32; pl. 2, fig. 33.
- 1965 Icriodus incrassatus Youngquist & Peterson; Loranger, privately published, 17, pl. 3, figs. 14-16.
- 1965 Icriodus costatus (Thomas); Anderson, Iowa Acad. Sci., 72, pl. 1, figs. 6, 10.
- 1966 Icriodus costatus (Thomas); Anderson, J. Paleont., 40, 406, pl. 52, figs. 3-5, 10 only.

- 1967 Icriodus cornatus Sannemann; Wolska, Acta Palaeont. Polonica, 12, 380, pl. 2, figs. 5a, b.
- 1969 Icriodus rectus Youngquist & Peterson; Druce, Bur. Miner. Resour. Aust. Bull. 98, 70, pl. 11, figs. 3-5.
- 1970 Icriodus brevis angustulus Seddon, J. Geol. Soc. Aust., 16, 736, pl. 11, figs. 19-24 only.

Material: 10 specimens, CPC 12449-12452 figured.

Localities of figured material: Sample BG 21222, Section 19, Sadler Ridge, Sadler Limestone; Samples BG 21242, 21246, 21257, Section 20, Longs Well Creek, Gogo Formation.

Remarks: This subspecies is characterized by the development of alternating dentition and the horn-like elongation of the posteriormost carina denticles. In this subspecies the extension occurs on both posterior-free denticles. The extension in early forms is nearly vertical but in advanced forms the denticles become fused and incline more to the posterior.

Distribution: The subspecies was originally described from Iowa (Thomas, 1949; Anderson, 1965, 1966). A form questionably assigned to this subspecies was referred to by Branson & Mehl (1941) as Icriodus curvatus from the late Devonian of Missouri. Elsewhere in North America it has been illustrated by Loranger (1965) from Alberta.

In Europe the species has only been illustrated from Germany (Sannemann, 1955; Freyer, 1961) and Poland (Wolska, 1967). In Australia it is known from both the Canning and Bonaparte Gulf Basins (Druce, 1969; Seddon, 1970).

Range: The range of the subspecies is unknown but in the Canning Basin it ranges throughout the Frasnian.

ICRIODUS ALTERNATUS CURVIROSTRATUS Bultynck, 1970

Pl. 6, figs. 3a,b

- 1938 Icriodus nodosus (Huddle); Branson & Mehl, J. Paleont., 12, 160, pl. 26, figs. 14, 15.
- 1947 Icriodus alternatus Branson & Mehl; Youngquist & Peterson, J. Paleont., 21, pl. 37, fig. 21 only.
- 1955 Icriodus nodosus (Huddle); Sannemann, Senck. leth., 36, 130, pl. 4, fig. 18 only.
- 1957 Icriodus nodosus (Huddle); Bischoff & Ziegler, Hess. Landesamt Bodenf. Abh., 22, 62, pl. 6, fig. 2 only.
- 1961 Icriodus nodosus (Huddle); Freyer, Freib. Forsch., C95, 47, pl. 2, fig. 35.
- ? 1965 Icriodus symmetricus Branson & Mehl; Merrill, Texas J. Sci., 17, 379, pl. 4, fig. 6.
- 1967 Icriodus curvatus Branson & Mehl; Wirth, N. Jb. Geol. Palaont. Abh., 127, 214, pl. 20, figs. 17a, b.
- 1967 Icriodus nodosus (Huddle); Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 64, pl. 2, fig. 11.
- 1967 Icriodus nodosus (Huddle); Wolska, Acta Palaeont. Polonica, 12, 380, pl. 2, figs. 1-3.
- 1969 Icriodus nodosus (Huddle); Seddon, J. Roy. Soc. West. Aust., 52, 27, pl. 1, figs. 4a-c, 6a-c.
- 1970 Icriodus nodosus (Huddle); Seddon, J. Geol. Soc. Aust., 16, 736, pl. 11, figs. 27-29, 33-35.
- 1970 Icriodus nodosus curvirostratus Bultynck, Mem. Inst. Geol. Univ. Louvain, 26, 108, pl. 3, figs. 2-4, 8, 9; pl. 4, figs. 1, 5, 6.
- 1970 Icriodus nodosus a Bultynck, ibid., 109, pl. 3, figs. 5, 6, 10; pl. 4, fig. 3, 4.
- 1970 Icriodus symmetricus a Bultynck, ibid., 114, pl. 5, figs. 3a-c, ? 7a,b.

Material: 38 specimens, CPC 12453-12456 figured.

Localities of figured material: Samples BG 19112, 19454 A, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone; Sample BG 21242, Section 20, Longs Well Creek, Gogo Formation.

Remarks: This subspecies is characterized by alternating dentition and the development of a notch in the inner margin of the basal lip. The margin is flared, and develops a sulcus with marked asymmetry of the cavity outline. The subspecies exhibits development from two lineages, one from I. brevis and one from I. alternatus s.s.

Distribution: Forms included in this subspecies have mainly been referred to Icriodus nodosus (Huddle). As has been pointed out by several authors (Glenister & Klapper, 1966; Seddon, 1969), the aboral margin of the holotype is broken and from the illustrations it is impossible to distinguish which subspecific characters it possesses. Furthermore, the holotype is missing at the present time (Glenister & Klapper, p. 805).

Illustrated forms of this subspecies are known from Iowa (Youngquist & Peterson, 1947), Texas (Merrill, 1965) and New York (Branson & Mehl, 1938). In Europe the species is common in Germany (Sanne-mann, 1965; Bischoff & Ziegler, 1957; Freyer, 1961), Poland (Wolska, 1967), Spain (Wirth, 1967) and Yugoslavia (Spasov & Filipovic, 1967). In Belgium, Bultynck (1970) recognized several forms with the basic plan of this subspecies and Icriodus curvirostratus is the first named species erected specifically to cover these characters.

In Australia the species has been recorded from the Carnarvon (Seddon, 1969) and the Canning Basins (Seddon, 1970) of Western Australia.

Range: The range of the subspecies is as low as the early Middle Devonian (Couvinian) (Bultynck, 1970), and as high as the Upper Palmatolepis quadrantinodosa Zone of the Famennian (to III₆) of the Canning Basin.

ICRIODUS ALTERNATUS CYMBIFORMIS Branson & Mehl, 1938

Pl. 6, figs. 4a, b

- 1938 Icriodus cymbiformis Branson & Mehl, J. Paleont., 12, 164, pl. 26, figs. 27-29.
- 1938 Icriodus cymbiformis ? Branson & Mehl; Stauffer, J. Paleont., 430, pl. 52, figs. 11, 13.
- 1940 Icriodus cymbiformis Branson & Mehl; Stauffer, J. Paleont., 14, 425, pl. 60, figs. 37, 51, 56-58, 68.
- 1940 Icriodus expansus Branson & Mehl; Stauffer, ibid., 425, pl. 60, figs. 64, 70, 71 only.
- ?1947 Icriodus symmetricus Branson & Mehl; Youngquist, J. Paleont., 21, 103, pl. 25, fig. 5.
- 1949 Icriodus symmetricus Branson & Mehl; Beckmann, Senckenbergiana, pl. 4, fig. 5, some specimens.
- 1956 Icriodus sp. Hass, U.S. Geol. Surv. Prof. Pap. 286, pl. 4, figs. 4, 5.
- 1957 Icriodus cymbiformis Branson & Mehl; Lys & Serre, Rev. Inst. Français Petrol., 12, 800, pl. 9, fig. 3.
- 1959 Icriodus, cfr. I. curvatus Branson & Mehl; Panseri & Barsotti, Not. Commun. Inst. Geol. Miner. Espana, 55, 156, pl. 1, fig. 3.
- 1959 Icriodus cymbiformis Branson & Mehl; Panseri & Barsotti, ibid., 157, pl. 1, fig. 5.
- 1964 Icriodus alternatus Branson & Mehl; Orr, Ill. State Geol. Surv. Circ. 361, 9, pl. 2, fig. 11 only.
- 1965 Icriodus sp. Philip, J. & Proc. Roy. Soc. N.S.W., 100, 154, pl. 2, fig. 11.
- 1967 Icriodus cymbiformis Branson & Mehl; Wirth, N. Jb. Geol. Palaont. Abh., 127, 215, pl. 20, figs. 18a - 19b.
- 1968 Icriodus alternatus Branson & Mehl; Spasov, Stojanovic - Kuzenko, & Pajic, Inst. Recherch. Geol. Geophys. Bull., 26, 160, pl. 2, fig. 6.

1969 Icriodus alternatus Branson & Mehl; Druce, Bur. Miner. Resour. Aust. Bull. 98, 70, pl. 11, figs. 2a-c.

Material: 16 specimens, CPC 12457-12459 figured.

Localities of figured material: Sample BG 19529, McIntyre Knolls, Virgin Hills; Sample BG 19576, McIntyre Knolls, Virgin Hills Formation; Sample BG 21229, Section 19, Sadler Ridge, Sadler Formation.

Remarks: This subspecies is characterized by the development of an elongate posterior carina. The nominate subspecies usually bears two denticles posterior to the lateral denticles; this species characteristically has four denticles, though often they are fused to give the appearance, orally, of only having two. This character can be seen even in juveniles and the subspecies is one of the easier ones to separate.

Distribution: The species has been illustrated extensively from the midwest of the U.S.A. and in Canada (Stauffer, 1938). In Europe, it has been recorded from Germany (Beckmann, 1949), France (Lys & Serre, 1957), Spain (Wirth, 1967), and Yugoslavia (Spasov et al., 1968). It is also known from North Africa (Panseri & Barsotti, 1959) and Australia (Philip, 1965; Druce, 1969).

Range: The range of the subspecies is unknown but in the Canning Basin it ranges as high as the Lower Scaphignathus veliferus Zone (to III). It ranges as low as the Middle Devonian (Philip, 1965).

ICRIODUS ALTERNATUS ELEGANTULUS Stauffer, 1938

Pl. 6, figs. 5a,b

1938 Icriodus elegantulus Stauffer, J. Paleont., 12, 430, pl. 52, figs. 26, 27.

1955 Icriodus nodosus (Huddle); Sannemann, Senck. leth., 36, 130, pl. 4, fig. 17.

1967 Icriodus alternatus Branson & Mehl; Wirth, N. Jb. Geol. Palaont. Abh., 127, 214, pl. 20, figs. 15-16b.

- 1967 Icriodus nodosus (Huddle); Nehring, Inst. Geol. Poland, Bull.
209, 131, pl. 3, figs. 2a, b (non text fig. 9).
- 1970 Icriodus regularicrescens Bultynck, Mem. Inst. Geol. Univ.
Louvain, 26, 111, pl. 7, figs. 3-5, 7.
- 1970 Icriodus alternatus Branson & Mehl; Druce, Bur. Miner.
Resour. Aust. Bull. 108, 80, pl. 14, figs. 4a-d.

Material: 14 specimens, CPC 12460-12462 figured.

Localities of figured material: Sample BG 21242, Section 20, Long's
Well Creek, Gogo Formation.

Remarks: This subspecies is characterized by alternating dentition and
a flaring basal cavity. The majority of specimens appear to have
developed from an I. brevis lineage, with characteristic peg-like
denticles. The basal flare is very pronounced around the whole unit,
forming a wide apron except at the anterior termination. This sub-
species exhibits two distinct lineages, one from I. brevis, the other
from I. alternatus sub. sp. a.

Distribution: The species was originally described from the Upper
Devonian of Ontario and Ohio (Stauffer, 1938). These are the only
described or illustrated forms from North America.

In Europe the sub-species has been illustrated from Belgium
(Bultynck, 1970), Germany (Sannemann, 1955), Poland (Nehring, 1967)
and Spain (Wirth, 1967). In Australia the species has been illustrated
from central Queensland (Druce, 1970).

Range: The range of the subspecies is unknown but it occurs near the
top of the Couvinian (Middle Devonian)(Bultynck, 1970) and ranges as
high as the Upper Palmatolepis quadrantinodosa Zone (Famennian,
to III α) in the Canning Basin.

ICRIODUS ALTERNATUS subsp. nov. a

Pl. 6, figs. 6a,b

- 1956 Icriodus sp. Hass, U.S. Geol. Surv. Prof. Pap. 286, pl. 4, fig. 6.
- 1967 Icriodus alternatus Branson & Mehl; Wolska, Acta Paleont. Polonica, 12, 379, pl. 2, fig. 4 only.
- 1970 Icriodus curvatus Branson & Mehl; Bultynck, Mem. Inst. Geol. Univ. Louvain, 26, 103, pl. 5, fig. 6 only.
- 1970 Icriodus nodosus n. subsp. b Bultynck, ibid., 109, pl. 3, fig. 7.

Material: 30 specimens, CPC 12463-12466 figured

Localities of figured material: Sample BG 19117, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Samples BG 19534, 19539, Section 9, Balme Knoll, Virgin Hills Formation; Sample BG 19576, McIntyre Knolls, Virgin Hills Formation.

Diagnosis: An icriodid with alternating dentition and a width-length ratio of about 1:7.

Remarks: These forms are very similar to Icriodus alternatus s.s. but show a distinctive elongation of the unit, commonly bearing seven nodes on the lateral rows compared with about five on the nominate subspecies. Forms which bear six lateral nodes can be separated because the nominate subspecies is more massive and wide.

The type of dentition also varies, the nominate subspecies is characterized by isolated, tall peg-like denticles often truly alternating. This subspecies bears low nodes; the medial row nodes are elongate and are connected by low ridges to one another. Occasionally, the lateral row denticles are also connected to the medial row by low ridges and the dentition pattern is often of the chevron type.

Distribution: Elongate specimens bearing alternating dentition have been described by Hass (1956) from Texas. Elsewhere similar forms have

been illustrated by Wolska (1967) from Poland and Bultynck (1970) from Belgium.

Range: The range is unknown, but it must range as low as Middle Devonian (Couvinian) (Bultynck, 1970). In the Canning Basin the subspecies occurs as high as the Upper Devonian Upper Palmatolepis quadrantinodosa Zone (to III α).

ICRIODUS ARKONENSIS ARKONENSIS Stauffer, 1938

Pl. 6, figs. 7a,b

1938 Icriodus arkonensis Stauffer, J. Paleont., 12, 429, pl. 52, figs. 10, 15.

1938 Icriodus expansus Branson & Mehl; Stauffer, ibid. pl. 2, fig. 25 only.

1959 Icriodus cf. nodosus Branson & Mehl; Helms, Geologie, 8, 642, pl. 4, fig. 8.

Material: 4 specimens, CPC 12467 - 12468 figured.

Localities of figured material: Sample BG 19016, Section 1, McWhae Ridge, Virgin Hills Formation; Sample 19454B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Description: An elongate unit, slightly curved with a platform ornament consisting of three rows of nodes. The two lateral rows are composed of massive nodes, some showing transformation to short transverse ridges which are angled slightly to the anterior. The median row is characteristic; the nodes are greatly reduced and are often absent, leaving a median trough. At the posterior termination a median node blocks the trough and posterior to it and separated by a low saddle is an isolated pointed node. This rather characteristic node can be seen in other specimens of other species and subspecies, e.g., I. alternatus curvirostratus (Pl. 6, fig. 3a) and may be a useful

character for tracing lineages. At the posterior end the lateral ornament is often denticulate rather than nodose; commonly the anterior-most denticles of each row are taller than all the other nodes and have sharp oral terminations.

The basal cavity is open but the flaring is not excessive and no asymmetry is developed.

Remarks: The reduction in the median row of dentition is characteristic. This reduction may be complete, leaving a trough, or it may vary from extremely low elongate nodes which alternate with the lateral nodes to only occasional nodes being present.

The development of a medial trough is seen in other genera, e.g., Spathognathodus bipennatus, Patrognathus, Clydagnathus, Taphrognathus, Cavusgnathus and Adetognathus. Presumably this is a functional morphology, possibly related to the ecology.

Distribution: This species is extremely rare, being known from Ontario, Canada, and adjacent to Ohio (Stauffer, 1938). A solitary specimen illustrated by Helms (1959) from Germany also belongs to this species.

Range: The range of the species is unknown. In the Canning Basin it ranges from the uppermost Palmatolepis gigas Zone (to I §) to at least the top of the Lower Palmatolepis crepida Zone and possibly as high as the top of the Upper P. crepida Zone (to II α).

ICRIODUS ARKONENSIS subsp. nov. a

Pl. 6, figs. 8a,b

Material: 14 specimens, CPC 12469-12472 figured.

Locality of figured material: Samples BG 19453D, 19454B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: This subspecies is characterized by the reduction of the median row of nodes and by the increase in size of the posteriormost

isolated denticle. The enlargement of the posteriormost median denticle is seen in other species where it is usually horn-like but in this species it never appears to develop that far. Some specimens exhibit flaring of the cavity but the enlargement of the posteriormost denticle is considered to be of greater importance in assigning specimens to a subspecies.

Distribution and Range: So far this is the only report of this subspecies. In the Canning Basin it occurs in the Upper Palmatolepis triangularis Zone (earliest Famennian).

ICRIODUS ARKONENSIS subsp. nov. b

Pl. 6, figs. 9a,b

Material: 14 specimens, CPC 12473 - 12476 figured.

Localities of figured material: Sample BG 19017, Section 1, McWhae Ridge, Virgin Hills Formation; Samples BG 19453B, E, 19454B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: This subspecies is characterized by the reduction in the median row of nodes and the development of a flaring basal cavity. There is often a slight undulation developed on the inner side of the cavity margin but it is not developed into a distinct notch. In some specimens the posteriormost denticle is more lateral than medial and is often fused with the nearest lateral node, leaving a wide shallow opening on the other posterolateral margin.

Distribution and Range: This subspecies has only been recorded from the Canning Basin where it ranges from the Middle Palmatolepis triangularis Zone (basal Famennian) to possibly the Upper Palmatolepis crepida Zone (to $\Pi\alpha$).

ICRIODUS ARKONENSIS subsp. nov. c

Pl. 6, figs. 10a,b

Material: 16 specimens, CPC 12477 - 12480 figured.**Localities of figured material:** Samples BG 19453B, 19454B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.**Remarks:** This subspecies is characterized by the reduction of the median row of nodes and the development of a marked notch in the inner basal cavity margin. There is also a distinct lateral shift in the usually medial posteriormost denticle to produce an asymmetrical platform ornament. The posteriormost denticle is fused to one lateral row of denticles and is separated by a wide opening from the other lateral row.**Distribution and Range:** This subspecies is only known from the Canning Basin, where it occurs in the Upper Palmatolepis triangularis Zone.**ICRIODUS BREVIS BREVIS Stauffer, 1940**

Pl. 7, figs. 1a,b

1940 Icriodus brevis Stauffer, J. Paleont., 14, 424, pl. 60, figs. 36, 43, 44, 52.1947 Icriodus parvus Youngquist & Peterson, J. Paleont., 21, 248, pl. 37, figs. 11, 12.1962 Icriodus nodosus Huddle (sic.); Budurov, Rev. Bulg. Geol. Soc., 23, 263, pl. 2, figs. 3a, b only.1965 Icriodes (sic.) n. sp. Krebs & Ziegler, Fortschr. Geol. Rheinld. Westf., 9, pl. 2, figs. 14, 15 only.1968 Icriodus angustus Stewart & Sweet; Mound, J. Paleont., 42, 487, pl. 66, figs. 23, 33.**Material:** 24 specimens, CPC 12481 - 12482 figured.

Localities of figured material: Sample BG 19057, Section 4, northeast of McWhae Ridge, Sadler Limestone; Sample BG 21242, Section 20, Long's Well Creek, Gogo Formation.

Description: A short unit with peg-like denticles. The denticles are arranged in an alternating pattern but this species can be distinguished from I. alternatus by the occasional missing lateral denticle and the fact that the median row tends to be much longer than the lateral rows which often consist of only three or four denticles. The median row commonly bears 7-9 denticles and there is a conspicuous posterior carina usually formed of three laterally compressed denticles. The denticles developed on the platform are low and nodose. There is often an anterior blade developed usually consisting of two laterally compressed denticles.

Remarks: The peg-like denticles and the fact that some lateral denticles are often missing are very characteristic. The species is very close to Pelekyognathus, species of which are commonly found in the same samples.

Distribution: The species was originally described from the Devonian and associated clays of Minnesota (Stauffer, 1940). Since then, it has been illustrated from Iowa (Youngquist & Peterson, 1947) and Alberta (Mound, 1968). In Europe, it has been illustrated by Krebs & Ziegler (1965) from Germany and by Budurov (1962) from Bulgaria. In Australia, Seddon (1970) has illustrated forms from the Canning Basin.

Range: The range of the nominate subspecies is unknown but in the Canning Basin it occurs in the Lower and Middle Polygnathus asymmetricus Zone.

ICRIODUS BREVIS DARBYENSIS Klapper, 1958

Pl. 7, figs. 2a,b

- ? 1956 Icriodus cornutus Sannemann; Bischoff, Hess Landesamt Bodenf. Notizbl., 84, 125, pl. 10, fig. 42.
- 1958 Icriodus darbyensis Klapper, J. Paleont., 32, 1086, pl. 141, figs. 9, 11, 12.
- 1961 Pelekyognathus darbyensis (Klapper); Ethington, Furnish & Wingert, J. Paleont., 35, 765, pl. 90, figs. 12-17.
- ? 1965 Icriodus cymbiformis Branson & Mehl; Loranger, private publ., 16, pl. 3, figs. 11-13.
- 1965 Icriodus costatus (Thomas); Anderson, Iowa Acad. Sci., 72, pl. 1, figs. 1, 2, 4, 5.
- 1966 Icriodus costatus (Thomas); Anderson, J. Paleont., 40, 406, pl. 52, figs. 1, 2 only.
- 1968 Icriodus cornutus Sannemann; Mound, J. Paleont., 42, 487, pl. 66, figs. 32, 34, 35.
- 1970 Icriodus brevis angustulus Seddon, J. Geol. Soc. Aust., 16, 736, pl. 11, figs. 13-18 only.

Material: 12 specimens, CPC 12483 - 12486 figured.

Localities of figured material: Sample BG 19050, Section 3, McWhae Ridge, Sadler Limestone; Sample BG 21242, Section 20, Long's Well Creek, Gogo Formation.

Remarks: This subspecies is characterized by the irregular occurrence of the lateral dentition, peg-like denticles and the extension of the posteromedial denticles into a horn.

The horn develops first by an increase in height and often fusion of the posteriormost two denticles. In later development the fusion is complete and the horn tends to be inclined posteriorly. This type of horn development was seen in I. alternatus.

A further development in this subspecies is an increase in height

in other but not all platform denticles. Often they are lateral or anterior denticles.

Distribution: This subspecies was first described by Klapper (1958) from Wyoming. It has also been illustrated from Wyoming by Ethington et al. (1961); from Iowa (Anderson, 1965, 1966); and from Alberta (Loranger, 1965; Mound, 1968). There is a solitary questionable occurrence in Germany (Bischoff, 1956).

Seddon (1970) has illustrated forms from the Canning Basin, Australia.

Range: The range of the subspecies is unknown but in the Canning Basin it occurs in the Lower and Middle Polygnathus asymmetricus Zone.

ICRIODUS BREVIS SPICATUS Youngquist & Peterson, 1947

Pl. 7, figs. 3a,b

1947 Icriodus brevis spicatus Youngquist & Peterson, J. Paleont.,
21, 248, pl. 37, figs. 8, 9.

1968 Icriodus n. sp. Pollock, J. Paleont., 42, 431, pl. 61, figs.
6, 7, 13, 14, 16, 17 only.

1969 Icriodus sp. Druce, Bur. Miner. Resour. Aust. Bull. 98, 71,
pl. 11, figs. 6a-c.

Material: 3 specimens, CPC 12487-12488 figured.

Localities of figured material: Sample BG 19594, Section 13, Glenister Knolls, Gogo Formation; Sample BG 21246, Section 20, Long's Well Creek, Gogo Formation.

Remarks: A subspecies characterized by the irregular development of the lateral peg-like dentition and an asymmetrical basal cavity.

The inner side of the cavity develops a sulcus and a distinct notch in the margin anterior to the sulcus.

Distribution: The subspecies was first described by Youngquist & Peterson (1947) from Iowa. Elsewhere, it has been illustrated from Alberta, Canada (Pollock, 1968) and the Bonaparte Gulf Basin, Australia (Druce, 1969).

Range: The range of the subspecies is unknown but in the Canning Basin it ranges throughout the Polygnathus asymmetricus Zone.

ICRIODUS BREVIS subsp. nov. a

Pl. 7, figs. 4

1967 Icriodus parvus Youngquist & Peterson, Clark & Ethington,
 Geol. Soc. Amer. Mem. 103, 39, pl. 3, fig. 11.

1968 Icriodus n. sp. Pollock, J. Paleont., 42, 431, pl. 61, figs. 8, 9,
 15, 18.

? 1968 Icriodus alternatus Branson & Mehl; Lange, Geol. Palaeont., 2,
 pl. 6, fig. 1c.

Material: 3 specimens, CPC 12489 figured.

Locality of figured material: Sample BG 21242, Section 20, Long's Well Creek, Gogo Formation.

Remarks: A subspecies characterized by a small platform ornamented by peg-like denticles and irregular development of the lateral denticles and a wide flaring basal cavity producing an apron all around the unit. The flare is widest at the posterior, narrowing anteriorly and extending beyond the anterior termination as a "siphon."

Distribution: The subspecies has been illustrated from the Great Basin by Clark & Ethington (1967) and Alberta (Pollock, 1968). The specimens illustrated by Lange (1968) could belong here but also could be referred to I. alternatus elegantulus.

Range: The range of the subspecies is unknown but in the Canning Basin it occurs in the Lower and Middle Polygnathus asymmetricus Zone.

ICRIODUS BREVIS subsp. nov. b

Pl. 7, fig. 5a,b

Material: 4 specimens, CPC 12490-12492 figured.**Locality of figured material:** Samples BG 19058, 19117, Section 4, northeast of McWhae Ridge, Sadler and Bugle Gap Limestones.**Remarks:** A subspecies characterized by an anterior extension of the median row to form an anterior-free blade. The lateral dentition is still irregular; odd lateral denticles may occur on the anterior-free blade.**Distribution:** This is the first time that this subspecies has been illustrated.**Range:** In the Canning Basin it occurs in the Frasnian Polygnathus asymmetricus Zone and as high as the Famennian Upper Palmatolepis quadrantinodosa Zone.**ICRIODUS INCRASSATUS INCRASSATUS**

Youngquist & Peterson, 1947

Pl. 7, figs. 6a,b

1947 Icriodus incrassatus Youngquist & Peterson, J. Paleont., 21, 247, pl. 37, figs. 1, 2, 25.1949 Icriodus constrictus Thomas, Bull. Geol. Soc. Amer., 60, 416, pl. 1, fig. 25.1965 Icriodus constrictus Thomas; Anderson, Iowa Acad. Sci., 72, pl. 1, figs. 11, 13, 15.1966 Icriodus constrictus Thomas; Anderson, J. Paleont., 40, pl. 52, figs. 14-16.1966 Icriodus constrictus Thomas; Klapper, Univ. Kansas Paleont. Contr. Pap. 3, 29, pl. 6, fig. 18.**Material:** 4 specimens, CPC 12493 figured.

Locality of figured material: Sample BG 21090, Cave Spring, Sadler Limestone.

Description: A species characterized by irregular arrangement of the nodes, the pattern is neither truly alternating nor developed in rows. Many lateral nodes are extended as transverse ridges, breaking up any symmetry in the ornament. The nominate subspecies lacks the characteristics used to distinguish the subspecies.

Remarks: Icriodus brevis also exhibits irregular dentition but the irregularity is due to non-development, whereas in this species it is due to irregular growth of platform nodes destroying any ornament symmetry.

Distribution: The species was first described from Iowa (Youngquist & Peterson, 1947) and is common in that state (Thomas, 1949; Anderson, 1965, 1966). The only other record is from Wyoming (Klapper, 1966).

Range: The range is unknown but in the Canning Basin it ranges from the Middle Polygnathus asymmetricus Zone (Frasnian to Ioc) as high as the Famennian Upper Palmatolepis quadrantinodosa Zone (to III β).

ICRIODUS INCRASSATUS subsp. nov. a

Pl. 7, figs. 9a,b

1966 Icriodus cornutus Sannemann; Glenister & Klapper, J. Paleont.,
40, 804, pl. 95, figs. 2, 3.

Material: 101 specimens, CPC 12494-12498 figured.

Localities of figured material: Sample 19016, 19018, Section 1, McWhae Ridge, Virgin Hills Formation; Sample 19454D, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21011, Section 14, 2 miles northwest of Pinnacle Spring, Virgin Hills Formation.

Remarks: A subspecies characterized by extremely irregular development of the platform ornament and a large posterior horn. The platform ornament developed from an alternating pattern by the enlargement and extension of the lateral nodes into transverse and diagonal ridges which fuse with medial nodes, either adjacent or posteriorly. The posterior horn is very well developed. Sometimes, it consists of one lateral set of denticles which increase in height and incline posteriorly. The horn and ridge may curl inwardly and leave an opening on the other posterolateral margin, a character seen in the subspecies of arkonensis which developed a horn. Other horns are produced by the extension and growth of both lateral rows to form a rampart with a central trough. Still other horns are produced by the extension of the median row with no participation by the lateral rows.

Distribution: The subspecies has been illustrated from the Canning Basin (Glenister & Klapper, 1966). So far, this is the only known occurrence.

Range: In the Canning Basin the subspecies ranges from the Lower Palmatolepis triangularis Zone (uppermost Frasnian) as high as the upper Palmatolepis quadrantinodosa Zone (to II β).

ICRIODUS INCRASSATUS subsp. nov. b

Pl. 7, figs. 8a,b

Material: 2 specimens, CPC 12499 figured.

Locality of figured material: Sample BG 19018, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: This subspecies is characterized by its irregular dentition and the flaring of the basal cavity. The flaring is greatest on the outer side and at the posterior end.

Distribution and Range: The subspecies has only been recorded from the Canning Basin where it occurs in the Famennian Lower Palmatolepis crepida Zone (to II α).

INCRIODUS INCRASSATUS subsp. nov. c

Pl. 7, figs. 7a, b

Material: 10 specimens, CPC 12500-12503 figured.

Localities of figured material: Samples BG 19106, 19115, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 19594, Section 13, Glenister Knolls, Gogo Formation; Sample BG 21242, Section 20, Long's Well Creek, Gogo Formation.

Remarks: This species is characterized by irregular dentition and an asymmetrical cavity with a distinct notch in the outer edge. The irregular dentition shows that this subspecies is closely related to the nominate subspecies and that forms with a horn and a flaring base belong to a different lineage. The posteriormost denticle of the median row on some specimens is very similar to Icriodus arkonensis s.s.

Distribution and Range: The subspecies is known only from the Canning Basin where it ranges from the Lower Polygnathus asymmetricus Zone (to I $\propto$) up to the Upper Palmatolepis quadrantinodosa Zone (to III $\propto$).

ICRIODUS SYMMETRICUS SYMMETRICUS

Branson & Mehl, 1934

Pl. 8, figs. 1a, b

- 1934 Icriodus symmetricus Branson & Mehl, Univ. Missouri Stud., 8, 226, pl. 13, figs. 1-3.
- 1938 Icriodus symmetricus Branson & Mehl; Branson & Mehl, J. Paleont., 12, 161, pl. 26, figs. 1-3.
- 1960 Icriodus expansus Branson & Mehl; Müller, Geol. Rundsch., 49, pl. 2, fig. 3.
- 1961 Icriodus symmetricus Branson & Mehl; Freyer, Freib. Forsch., C95, 48, text-fig. 36 (right hand side).
- 1962 Icriodus curvatus Branson & Mehl; Budurov, Rev. Bulg. Geol. Soc., 23, 263, pl. 2, figs. 5a, b, 7a-c, 9a-10.

- 1964 Icriodus symmetricus Branson & Mehl; Orr, Ill. State Geol. Surv.
Circ. 361, 10, pl. 2, figs. 15a, b.
- 1966 Icriodus symmetricus Branson & Mehl; Anderson, J. Paleont.,
 40, 407, pl. 52, fig. 7.

Material: 62 specimens, CPC 12504 - 12507 figured.

Localities of figured material: Samples BG 19534, 19537, Section 9, Balme Knoll, Virgin Hills Formation; Sample BG 21229, Sadler Ridge, Sadler Formation.

Description: An elongate icriodid with distinctive oral dentition. The dentition is arranged in three linear rows; each denticle is subjacent. The medial row nodes are elongate anteroposteriorly with a low ridge connecting each. The lateral nodes are also connected to median nodes especially in the posterior half. The nodes number 7-9 in each row. The medial row extends posteriorly beyond the lateral rows. The extension is of two or three denticles and may show some tendency towards a horn-like development.

Distribution: The nominate subspecies was originally described from the Grassy Creek Shale of Missouri (Branson & Mehl, 1934). The subspecies has also been illustrated from Illinois (Orr, 1964) and Iowa (Anderson, 1966). In Europe the species has been illustrated from Germany (Müller, 1960; Freyer, 1961) and Bulgaria (Budurov, 1962).

Range: The exact range of the nominate subspecies is unknown. In the Canning Basin it is recorded from the Lower Polygnathus asymmetricus Zone (to I ∞) up to the Ancyrognathus triangularis (to I γ) of the Frasnian.

ICRIODUS SYMMETRICUS CIRCULARIS
 Youngquist & Peterson, 1947

Pl. 8, figs. 2a, b

- 1947 Icriodus circularis Youngquist & Peterson, J. Paleont., 21, 246,
 pl. 37, fig. 15.

- 1959 Icriodus nodosus (Huddle); Bischoff & Ziegler, Hess. Landesamt Bodenf. Abh., 22, 62, pl. 6, figs. 2, 3.
- ? 1967 Icriodus nodosus (Huddle); Wirth, N. Jb. Geol. Palaont. Abh., 127, 218, pl. 20, figs. 24a, b.
- 1967 Icriodus cornutus Sannemann; Clark & Ethington, Geol. Soc. Amer. Bull. 103, 37, pl. 3, figs. 3, 4.
- 1970 Icriodus nodosus rectirostratus Bultynck, Mem. Inst. Geol. Univ. Louvain, 26, 107, pl. 3, fig. 1; pl. 30, figs. 7, 8.

Material: 29 specimens, CPC 12508 - 12511 figured.

Localities of figured material: Sample BG 19534, Section 9, Balme Knoll, Virgin Hills Formation; Sample BG 21235, Section 19, Sadler Ridge, Sadler Limestone.

Remarks: A subspecies characterized by the development of linear dentition both longitudinally and transversely and by an asymmetrical development of the basal cavity with a distinct notch in the inner margin. Forms from both the elongate and short linear dentition are illustrated.

Distribution: The subspecies was originally described from Iowa (Youngquist & Peterson, 1947). The only other illustrated occurrence in North America is from the Great Basin of Utah - Nevada (Clark & Ethington, 1967).

In Europe the subspecies has been illustrated by Bischoff & Ziegler (1959) from Germany, Bultynck (1970) from Belgium, and Wirth (1967) from Spain though the assignment is questionable.

Range: The range of the subspecies is unknown but in the Canning Basin it ranges from the Lower Polygnathus asymmetricus Zone (to I α) as high as the Lower Palmatolepis gigas Zone (to I γ).

ICRIODUS SYMMETRICUS EXPANSUS Branson & Mehl, 1938

Pl. 8, figs. 3a,b

- 1938 Icriodus expansus Branson & Mehl; J. Paleont., 12, 160, pl. 26, figs. 18-21.
- 1949 Icriodus cf. I. rectus Youngquist & Peterson; Thomas, Geol. Soc. Amer. Bull., 60, pl. 1, figs. 17, 18.
- 1965 Icriodus sp. Merrill, Texas J. Sci., 17, 380, pl. 4, fig. 7 only.
- 1965 Icriodus iowaensis Youngquist & Peterson; Anderson, Iowa Acad. Sci., 72, pl. 1, figs. 17, 18.

Material: 16 specimens, CPC 12512 - 12515 figured.

Localities of figured material: Sample BG 19537, Section 9, Balme Knoll, Virgin Hills Formation; Sample BG 21191, Section 18, Kudata Gap, Sadler Limestone; Samples BG 21231, 21232, Section 19, Sadler Ridge, Sadler Limestone.

Remarks: This subspecies is characterized by the development of linear dentition both longitudinally and laterally and by its relative shortness. Commonly only five or six nodes are developed in the lateral rows and the unit is wider than the nominate subspecies. The central row extends about two nodes beyond the lateral rows.

The subspecies is easily recognized from the nominate subspecies and it appears that they could have developed along different phylogenetic lines.

Distribution: The original description was by Branson & Mehl (1938) from several localities in Missouri, New York, Ohio, Indiana, Arkansas and Michigan.

The subspecies has also been described from Iowa (Thomas, 1949; Anderson, 1966), and Texas (Merrill, 1965). This is the first record outside North America.

Range: The range of the subspecies is unknown but in the Canning Basin it ranges from the Lower Polygnathus asymmetricus Zone (to I α) as high as the Lower Palmatolepis gigas Zone (to I γ).

ICRIODUS SYMMETRICUS subsp. nov. a

Pl. 8, figs. 4a, b

Material: 2 specimens, CPC 12516-12517, both figured.

Locality of figured material: Sample BG 19534, Section 9, Balme Knoll, Virgin Hills Formation.

Remarks: A subspecies characterized by the development of linear dentition both longitudinally and transversely and a flaring basal cavity. The flaring tends to be greatest on the inner side and possesses a crinkle in the basal apron showing the close relationship to forms with a well developed basal notch.

Distribution and Range: The subspecies is only known from the Canning Basin, though some specimens illustrated by Bultynck (1970) as I. regularicrescens probably belong to it. In the Canning Basin it occurs in the upper half of the Polygnathus asymmetricus Zone.

Phylogeny of Icriodus

It is rather difficult to discuss Icriodus phylogeny, owing to the plastic nature of the genus in its evolutionary development and the state of flux of the nomenclature. However, in discussing the major denticle types (species in this publication) it is possible to see some phylogenetic development. I am going to discuss only the phylogenetic development in the Upper Devonian, although, in fact, it is probable that similar homeomorphic developments took place in the Middle Devonian.

In the Upper Devonian it appears that there were three Middle Devonian root stocks. The first is Pelekyognathus which is known from

the earliest Devonian and presumably has contributed to the icriodid stock at several times. Secondly, there is Icriodus symmetricus s.s., which ranges from the Middle Devonian into the Frasnian; and thirdly, there is Icriodus symmetricus expansus, which also ranges from Middle Devonian into Frasnian.

The main phylogenetic changes appear to take place because of changes in environment, probably mainly water depth, but there is a general chronologic change from transverse linear dentition to alternating dentition. Forms referred to Icriodus symmetricus are not known from strata younger than the Lower Palmatolepis gigas Zone (Frasnian to I δ). I. symmetricus seems to develop along two lineages. Firstly, the transverse linear dentition breaks down and becomes alternating. Intermediate forms show the development of alternating dentition on the posterior half and transverse linear dentition on the anterior half. Specimens of I. alternatus with I. symmetricus ancestors commonly show chevron type alternation. I. symmetricus also develops into I. arkonensis by reduction of the central row of nodes with the formation of a trough. The lateral nodes become elongate transversely and pear-shaped.

A subspecies of I. symmetricus, expansus appears to be a separate lineage, and is characteristically shorter and wider. In the early Frasnian it gives rise to Icriodus incrassatus which ranges up to the Upper Palmatolepis quadrantinodosa Zone. It should be noted that not all the subspecies of I. incrassatus are of the I. symmetricus expansus lineage. This evolutionary trend is probably an adaption to a shallower water environment.

The third ancestral form is Pelekyognathus. This genus is considered to be a shallow water genus (Druce, 1969, in press; Seddon, 1970) and it shows an intimate evolutionary relationship with Icriodus brevis (Klapper, 1966; Seddon, 1970). In the present faunas the evolutionary development is seen in the early Frasnian and also in the

Famennian. The development of icriodid dentition appears to be an adaption to a deeper water environment, although I. brevis is considered to be a shallow water form with respect to the overall conodont fauna. If the development of icriodid dentition is just an environmental adaption there is not necessarily any chronological importance to its development and those horizons which show it in the Canning Basin are just periods of changing conditions in that particular Basin. The discovery of transitions from Pelekysgnathus to Icriodus brevis in other Basins would thus not necessarily be time correlative with the changes in the Canning Basin, but rather would indicate similar changes in that basin.

Icriodus brevis itself develops into forms referable to I. alternatus. As we have seen, I. alternatus forms can also develop from the I. symmetricus lineage; it may be distinguished by symmetrical alternation of the denticles rather than the chevron type developed in I. symmetricus. This difference probably disappears with time. However, I. alternatus forms probably developed in the Middle Devonian both from I. symmetricus forms and from Pelekysgnathus, and possibly from other lineages as well.

Icriodus alternatus also gave rise to I. arkonensis. In some specimens of arkonensis the median row is reduced, rather than absent, and the alternating nature of the dentition can be seen. The transformation seems to have taken place by reduction in height and elongation of the medial nodes. Eventually, the medial row disappears with the formation of a trough.

Unfortunately, this phylogeny is of little use in interpreting chronostratigraphy because these evolutionary sequences probably occur more than once and possibly at different horizons in different basins. For example, I. arkonensis develops in the Middle Devonian of Ontario (Stauffer, 1938; Stumm & Wright, 1958); its only other known occurrence is in the Canning Basin where it occurs in the latest Frasnian and early Famennian.

Phylogenetic Relationships Between Subspecies of the
Genus *Icriodus*

The minor characters on which I have based my subspecific divisions appear to be environmentally controlled. For example, in Figure 21 it can be seen that of the many modifications which can affect icriodids, only a few are found in the present fauna, but that, when they are present, they tend to be found on all dentition forms (species). This suggests that these modifications are environmental rather than phylogenetic. In Figure 8 we see that these modifications are commonly found in sediments directly overlying stromatolite horizons whose upper surface is covered by orientated nautiloids. Playford & Cockbain (1969) consider these horizons to be basinwide shallowing of the Upper Devonian sea. Thus, it would appear that the major environmental feature affecting the possession of minor characters is water depth. The development of wide-flaring basal cavity, an asymmetrical cavity with a distinct notch, and a posterior horn are considered to be shallow water modifications. It is interesting that, considering that conodonts were probably covered by tissue (Lindström, 1964, p. 123), all these features increase the area and power of attachment of the conodont unit, presumably giving the animal greater efficiency in the higher energy environments.

However, at the species level (i.e., platform ornamentation) environmental considerations are also obvious. *Icriodus brevis* is a shallow water form, whereas *I. symmetricus* appears to be a deeper water form, as is *I. alternatus*. *I. arkonensis* and *I. incrassatus* appear to be shallow water forms or more probably intermediate in depth.

Thus, in response to environment three possible changes can take place:

1. Changes within a species at the subspecific level. Thus, the surface ornament remains constant but the alteration of minor characters is sufficient to change the subspecific designation.

Text-figure 10. Distribution chart and possible ecological relationships of the genus Icriodus. Stippled lines represent stromatolite horizons.

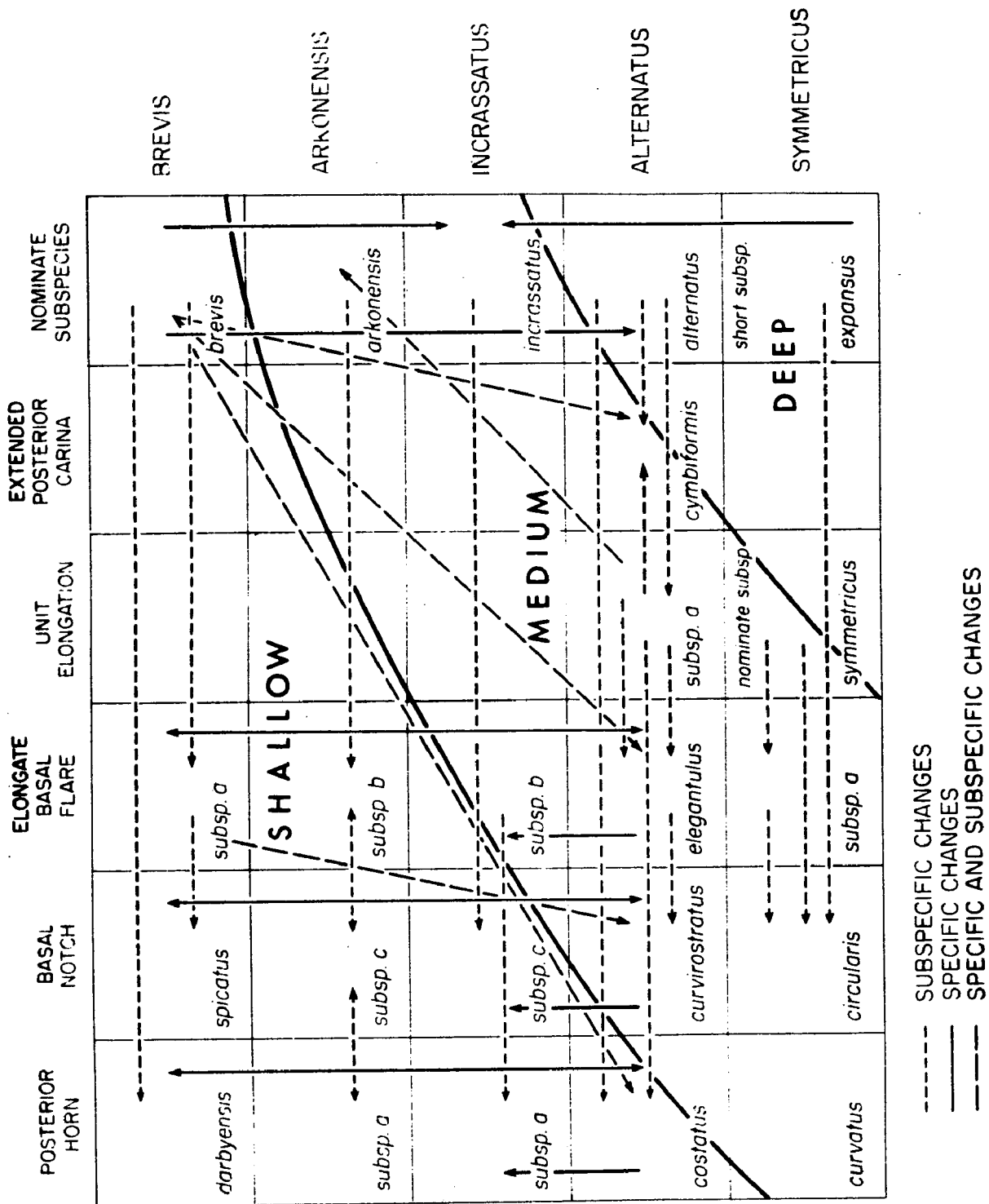
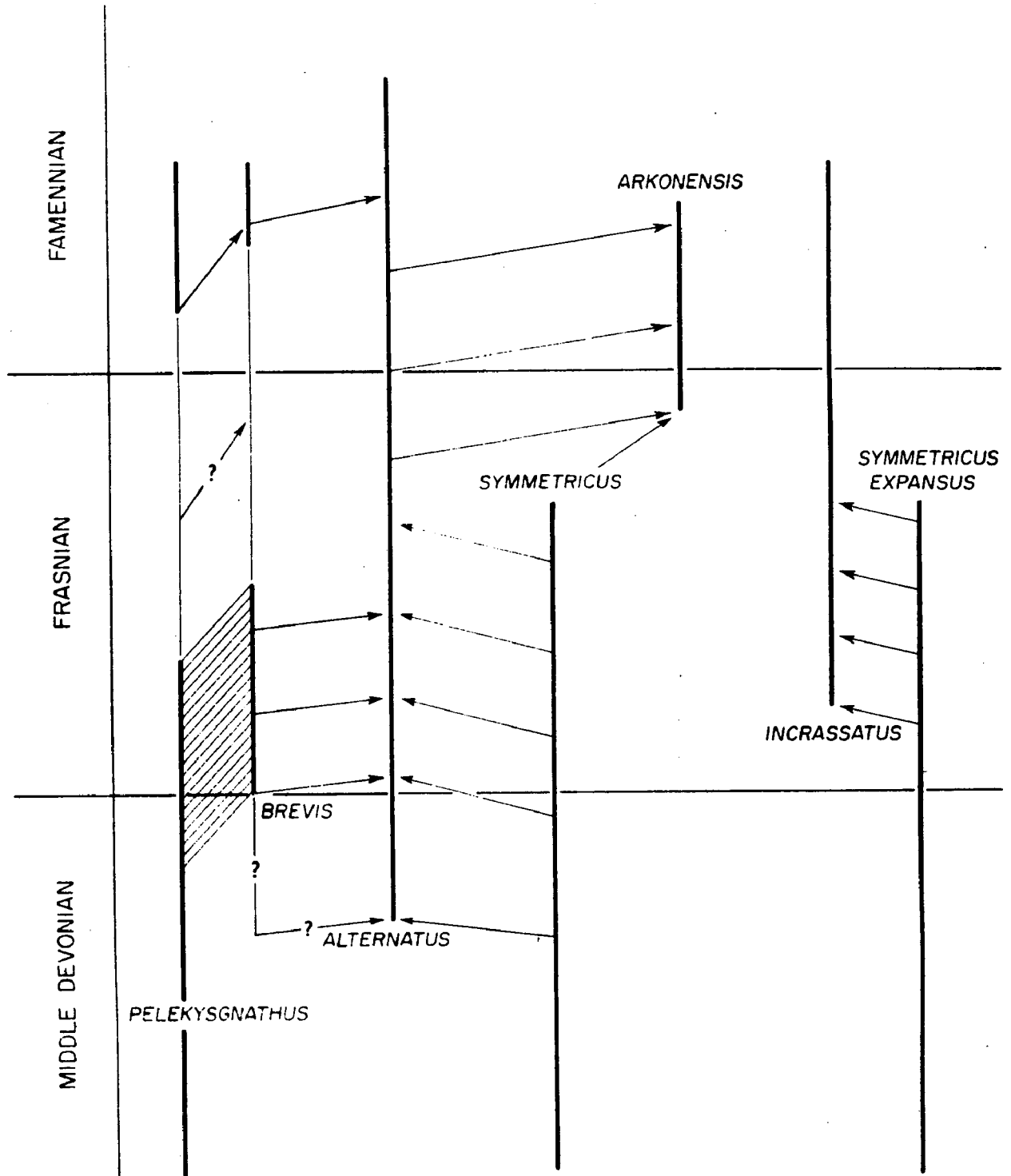


FIG. 11 - PHYLOGENY OF THE GENUS *ICRIODUS* IN THE UPPER DEVONIAN

2. Changes at specific rank but with the minor characters remaining constant. In these cases only the surface ornament is changed.
3. Changes at both specific and subspecific level. In these cases both the surface ornament and minor characters are altered.

This is represented by Figure 9 , and it is suggested that a depth pattern can be superimposed on this information.

The taxonomy suggested here is also shown to be artificial. For instance, subspecies of Icriodus incrassatus may be more closely related to subspecies of other species than to their fellow subspecies.

Conclusions

The apparent dependence of icriodid morphology on environment makes a sensible nomenclature for the group extremely difficult. The solution suggested here is that morphologic characters can be used to divide the Upper Devonian icriodids but that this division will elucidate the environment rather than the phylogeny.

Certain characters (wide flaring basal cavity, basal asymmetry, and horn-like nodes) are considered to be shallow-water adaptations rather than phylogenetic characters. If this is correct, then it would appear that a close study of these characters in other genera may show similar environmental adaptations.

Similarly, the presence of a median trough or irregular dentition, or symmetrical dentition, may be important in ecological considerations.

Genus KLADOGNATHUS Rexroad, 1958

Type species: Cladognathus prima Rexroad, 1957.

?KLADOGNATHUS sp.

Pl. 8, figs. 5

Material: Two specimens, CPC 12522-12523, both figured.

Localities of figured material: Samples BG 19001, 19019, Section 1, McWhae Ridge, Gogo and Virgin Hills Formations.

Remarks: Two specimens appear to be pathologic variants of Hindeo-
della, possessing an extra lateral process at or near the apical denticle.
In both cases the process is short, bearing five isolated denticles on
one specimen and two on the other. The overall plan is similar to
Kladognathus Rexroad. However, this genus is typically Chesterian
(upper Lower Carboniferous) and is not known from any other horizons.
Thus, I prefer to regard these forms as pathological rather than being
true representatives of the genus Kladognathus. The specimens come
from the Lower Polygnathus asymmetricus Zone and the Middle
Palmatolepis crepida Zone.

Genus LIGONODINA Bassler, 1925

Type species: Ligonodina pectinata Ulrich & Bassler, 1926.

LIGONODINA MAGNIDENS Ulrich & Bassler, 1926

Pl. 8, figs. 11

1926 Ligonodina magnidens Ulrich & Bassler, U.S. Natl. Mus. Proc.,
68, 12, pl. 2, figs. 5, 6.

For complete synonymy up to 1968 see:

1968 Ligonodina magnidens Ulrich & Bassler; Huddle, U.S. Geol.
Surv. Prof. Pap. 578, 18, pl. 9, fig. 8; pl. 10, figs. 9, 12,
14-16; pl. 11, figs. 1-4.

1970 Ligonodina magnidens Ulrich & Bassler; Seddon, J. Geol. Soc. Aust., 16, 753, pl. 15, figs. 11, 15.

Material: 14 specimens, CPC 12524 - 12525 figured.

Localities of figured material: Sample BG 19016, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19081, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Description: An arched ligonodinid unit. The apical denticle is massive, twice as large as any bar denticles and is slightly twisted and laterally compressed. The lateral bar is short and at an angle of 90° to the rest of the unit and is depressed through 45° . It is situated slightly behind the apical denticle, and bears up to five needle-like isolated denticles which curve toward the posterior of the unit.

The posterior bar is fairly massive and long, bearing a sequence of denticles which increase greatly in size and posterior inclination toward the posterior termination. The dentition on some specimens is cyclic, large and small denticles alternating.

Remarks: This species can be distinguished from L. panderi by the slightly anterior position of the lateral bar with respect to the apical denticle.

Distribution: Apart from the previous recognition of this species in the Canning Basin (Seddon, 1970) it has only been reported from the Rhine-street Shale Member of the West Falls Formation, New York (Huddle, 1968).

Range: In New York the species occurs in a horizon dated as to I(β). In the Canning Basin the species ranges from the Lower Polygnathus asymmetricus Zone (to I α) as high as the Lower Palmatolepis quadrantinodosa Zone (to II β).

LIGONODINA PANDERI (Hinde , 1879)

Pl. 8, figs. 8

- 1879 Prioniodus panderi Hinde, Quart. J. Geol. Soc. Lond., 35, 361,
pl. 16, fig. 4.

For complete synonymy up to 1968 see:

- 1968 Ligonodina panderi (Hinde); Huddle, U.S. Geol. Surv. Prof.
Pap. 578, 19, pl. 9, fig. 11; pl. 10, figs. 1-8, 11.

- 1970 Ligonodina panderi (Hinde); Seddon, J. Geol. Soc. Aust., 16,
752, pl. 15, figs. 8, 10.

Material: 20 specimens, CPC 12526-12527 figured.

Localities of figured material: Sample BG 19583, Section 12, southwest
of Waggon Pass, Virgin Hills Formation.

Description: An elongate ligonodinid with a long posterior bar and
short lateral bar. The apical denticle is massive, twice as tall and
wide as any bar denticles, laterally compressed, twisted and posteriorly
inclined. The lateral bar is short, depressed through about 60° , and
recurved slightly towards the posterior of the unit. The denticles
number from 2 to 4 and are isolated, needle-like, and are inclined
towards the posterior of the unit. The posterior bar is elongate,
bearing a sequence of isolated, needle-like denticles.

The basal cavity is situated beneath the apical denticle and
extends along the posterior bar as a narrowing trough.

Remarks: The clean sweep of the anterior face of the apical denticle
and the anterior face of the lateral process distinguishes this species
from L. magnidens.

Distribution: The holotype comes from Kettle Point, Ontario. The
species is also known from New York, Ohio and Indiana (Huddle, 1968).
Huddle also points out that the species is known from Germany and
France. Recently, the species has been described from the Canning
Basin (Seddon, 1970).

Range: Huddle (1968) records the range as Eifelian to Upper Famennian. In the Canning Basin the species ranges from Lower Polygnathus asymmetricus Zone (to I $\times$) as high as the Upper Palmatolepis quadrantinodosa Zone (to III $\times$).

LIGONODINA SPICULATA (Ulrich & Bassler, 1926)

Pl. 8, figs. 6

1926 Prioniodus spiculatus Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 9, pl. 9, figs. 2, 3.

For complete synonymy up to 1968 see:

1968 Ligonodina spiculata Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 21, pl. 9, fig. 10.

Material: CPC 12528 figured.

Locality of figured material: Sample BG 21226, Section 19, Sadler Ridge, Sadler Limestone.

Description: A ligonodinid with an elongate lateral bar, bearing five isolated denticles which are curved towards the posterior. The posterior bar is elongate and bears up to eight isolated, needle-like denticles.

Distribution: The species was originally described from the 'Hardin Sandstone', Tennessee. This is the only other record of the species. In the Canning Basin the single specimen was recovered from earliest Frasnian strata.

LIGONODINA sp. nov. A

Pl. 8, figs. 10

Material: 6 specimens, CPC 12529 figured.

Locality of figured material: Sample BG 19005, Section 1, McWhae Ridge, Gogo Formation.

Description: A delicate ligonodinid with fairly deep bars and a deep and slightly flared basal cavity. The dentition is small, cyclic, and needle-like.

Range: The species ranges from the Lower Polygnathus asymmetricus Zone (to I α) as high as the Upper Palmatolepis gigas Zone (to I δ).

LIGONODINA sp. nov. B

Pl. 8, figs. 12

Material: 4 specimens, CPC 12530 figured.

Locality of figured material: Sample BG 19113, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: A massive ligonodinid with a reflexed lateral bar. The apical denticle is nearly upright and is massive. The lateral bar is flexed towards the posterior and is then reflexed toward the anterior. The posterior bar bears four massive denticles toward the posterior end. The anterior half of the bar bears minute needle-like denticles.

Range: The species ranges from the Upper Polygnathus asymmetricus Zone (to I β) as high as the Upper Palmatolepis quadrantinodosa Zone (to II α).

LIGONODINA sp.

Pl. 8, fig. 9

Material: 2 specimens, CPC 12531 figured.

Locality of figured specimen: Sample BG 19061, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Description: A small ligonodinid with no conspicuous apical denticle. The lateral bar curves away from the posterior bar and bears three small denticles. Both bars are deep, the posterior bar bears a sequence of denticles which increase in height posteriorly. They are fused at their bases with free chevron tips.

Range: The two specimens occur in the Frasnian Ancyrognathus triangularis Zone and the basal Famennian Zone of Palmatolepis triangularis.

? LIGONODINA sp.

Pl. 8, fig. 7

Material: A single specimen, CPC 12532 figured.

Locality of figured material: Sample BG 19166, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: A small arched unit with needle-like denticles. The lateral bar is flexed and deflected through about 45° but the peculiar inclination of all the bar denticles gives the impression that it is just a simple arched unit.

Occurrence: The single specimen was recovered from the Lower Polygnathus styriacus Zone (to IV).

Genus LONCHODINA Bassler, 1925

Type species: Lonchodina typicalis Ulrich & Bassler, 1926.

LONCHODINA ARCUATA Ulrich & Bassler, 1926

Pl. 9, figs. 3

1926 Lonchodina arcuata Ulrich & Bassler, U.S. Natl. Mus. Proc.,
68, 32, pl. 5, fig. 15.

1968 Lonchodina arcuata Ulrich & Bassler; Huddle, U.S. Geol. Surv.
Prof. Pap. 578, 21, pl. 11, figs. 5-13 (Synonymy).

Material: 20 specimens, CPC 12831 - 12834 figured.

Localities of figured specimens: Sample BG 19502, Section 7, Laidlaw Range - Emanuel Range, Gogo Formation; Sample BG 19534, Section 9, Balme Knoll, Gogo Formation; Samples BG 19582, 19585, Section 12, southwest of Waggon Pass, Virgin Hills Formation.

Occurrence: The species was originally described from the "Hardin Sandstone" of Tennessee (Ulrich & Bassler, 1926; Huddle, 1968). It is also known from Indiana (Huddle, 1934), Missouri (Branson & Mehl, 1934) and New York (Holmes, 1928). In Europe it has been reported from Germany (Bischoff & Ziegler, 1956, 1957) and France (Lys & Serre, 1957). Ethington & Furnish (1962) report the species from the Spanish Sahara.

Range: Unknown; Bischoff & Ziegler (1957) record it from the Middle Devonian. In the Canning Basin the species occurs throughout the Polygnathus asymmetricus Zone.

LONCHODINA PERLONGA Ulrich & Bassler, 1926

Pl. 9, figs. 2

- 1926 Lonchodina perlonga Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 32, pl. 5, figs. 6, 7.
- 1968 Lonchodina perlonga Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 22, pl. 12, figs. 1-3 (Synonymy).

Material: 5 specimens, CPC 12835 - 12836 figured.

Localities of figured material: Sample BG 19583, Section 12, southwest of Waggon Pass, Virgin Hills Formation; Sample BG 21371, Section 24, Teichert Hills, Sadler Limestone.

Occurrence and Range: The species has only been reported from New York (Ulrich & Bassler, 1926) in the Ancyrognathus triangularis Zone (Frasnian to I γ). The present specimens range from the Polygnathus asymmetricus Zone into the Ancyrognathus triangularis Zone.

LONCHODINA TYPICALIS Bassler, 1925

Pl. 9, figs. 4

- 1925 Lonchodina typicalis Bassler, Geol. Soc. Amer. Bull., 36, 219.
- 1926 Lonchodina typicalis Bassler; Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 31, pl. 5, fig. 1 only.
- 1968 Lonchodina typicalis Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 23, pl. 12, figs. 14-22 (Synonymy).

Material: 15 specimens, CPC 12837 - 12839 figured.

Localities of figured material: Sample BG 19543, Section 9, Balme Knoll, Gogo Formation; Samples BG 19594, 21003, Section 13, Glenister Knolls, Gogo Formation.

Occurrence and Range: The species was originally described from the Ancyrognathus triangularis Zone of the West Falls Formation of New

York (Ulrich & Bassler, 1926). It is also known from Indiana (Huddle, 1934), Iowa (Youngquist & Miller, 1948), and Ohio (Bond, 1947). It is also known from Europe where it has been reported from the Givetian up to the Frasnian (Bischoff & Ziegler, 1957). The Canning Basin specimens are all from the Polygnathus asymmetricus Zone.

LONCHODINA sp. A

Pl. 9, figs. 1

Material: 12 specimens, CPC 12840-12842 figured.

Localities of figured material: Sample BG 19538, Section 9, Balme Knoll, Virgin Hills Formation; Sample BG 21107, 4 miles northeast of Galeru Gorge, Virgin Hills Formation; Sample BG 21210, Section 19, Sadler Ridge, Sadler Limestone; Sample BG 21371, Section 24, Teichert Hills, Sadler Limestone.

Remarks: These specimens are similar to L. discreta Ulrich & Bassler, which Huddle (1968, p. 22) considers falls within the range of variability of L. arcuata.

Range: The specimens range from the Lower Polygnathus asymmetricus Zone up to the Ancyrognathus triangularis Zone.

OZARKODINA ? sp. Seddon, 1970

Pl. 24 figs. 6-10

1970 Ozarkodina ? sp. Seddon, J. Geol. Soc. Aust., 16, 752, pl. 14, figs. 8, 12, 16, 20, 22.

Material: 64 specimens, CPC 12844 - 12848 figured.

Localities of figured material: Sample BG 19001, Section 1, McWhae Ridge, Gogo Formation; Sample 19050, Section 3, McWhae Ridge, Sadler Limestone; Sample BG 19123, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 19421, McWhae Ridge, Sadler Limestone.

Remarks: Seddon (1970, p. 752) points out that this is a very variable form ranging in morphology from spathognathodid to polygnathellid forms with bryantodid, ozarkodinid and prioniodinid variants. I can add nothing to this except that it is common in shallow water samples. It ranges from the Polygnathus asymmetricus Zone up to the Upper Palmatolepis quadrantinodosa Zone.

LONCHODINA sp.

Remarks: A single specimen, CPC 12843, was found. It is distinguished by the tumid bar development and in this respect resembles the Lower Carboniferous genus Geniculatus. The dentition is formed of fine, needle-like, isolated denticles running along the mid-line of the unit. A shallow basal cavity is present beneath the main cusp. The specimen is from the Middle Palmatolepis triangularis Zone, Sample BG 19454B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Genus NEOPRIONIODUS Rhodes & Müller, 1956

Type species: Prioniodus conjunctus Gunnell, 1931.

NEOPRIONIODUS ARMATUS - ALATUS group

Pl. 9, figs. 8, 9

1879 Prioniodus ? alatus Hinde, Quart. J. Geol. Soc. Lond., 35, 361, pl. 16, fig. 5.

1879 Prioniodus armatus Hinde, ibid, 360, pl. 15, figs. 20, 21.
For complete synonymy of both species see:

1968 Neoprioniodus alatus (Hinde); Huddle, U.S. Geol. Surv. Prof. Pap. 578, 25, pl. 6, figs. 1, 2.

1968 Neoprioniodus armatus (Hinde); Huddle, ibid, 25, pl. 6, fig. 11, pl. 7, figs. 1, 4.

Material: 18 specimens, CPC 12533-12538 figured.

Localities of figured material: Sample BG 19001, Section 1, McWhae Ridge, Gogo Formation; Samples BG 19072, 19170, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone; Sample BG 19583, Section 12, southwest of Waggon Pass, Virgin Hills Formation; Sample BG 21361, Section 23, Geikie Gorge, Napier Formation.

Remarks: Freyer (1961, p. 78) demonstrates that there is a complete gradation from N. armatus to N. alatus. N. armatus is distinguished by having a narrower main cusp and a longer posterior bar. N. alata has a wide apical denticle formed by the fusion of bar denticles and a reduced posterior bar with considerable fusion of the bar denticles. The specimens in this fauna vary between both end members but many of them appear to be mid-way between and so I have discussed the two species as a group rather than separately.

Huddle (1968, p. 25) notes that secondary dentition is often present on the ante-cusp. He suggests that this may be the result of a synprioniodinid ancestry. However, the presence of secondary denticles on the ante-cusp does not appear to be necessarily inherited and the majority of neoprioniodid species exhibit secondary dentition on some specimens. The development may be due to ecological rather than phylogenetic factors.

Distribution: The species are widely distributed around the world. They were first described by Hinde from New York State, and since then have been reported from Ohio (Stauffer, 1938; Bond, 1947), Indiana (Huddle, 1934), Michigan (Müller & Clark, 1967), Illinois (Orr, 1964), Iowa (Youngquist, 1945; Youngquist & Peterson, 1947), Missouri (Branson & Mehl, 1934; Scott & Collinson, 1961), Tennessee (Hass, 1956), Oklahoma (Cooper, 1939), Nevada (Clark & Ethington, 1967), Montana (Cooper & Sloss, 1943) and Alberta (Mound, 1968). In Europe

the species are common in Germany (Beckmann, 1949; Sannemann, 1955; Bischoff, 1956; Bischoff & Ziegler, 1957; Helms, 1959; Zimmerman, 1960; Freyer, 1961; and Stoppel & Zscheked, 1966). It has also been reported from Britain (Rhodes & Dineley, 1957); Portugal (Boogaard, 1963); France (Lys & Serre, 1957; Boyer et al., 1968); Belgium (Bultynck, 1970); Austria (Schönlaub, 1969); Czechoslovakia (Friakova, 1964); and Poland (Nehring, 1967; Wolska, 1967).

Elsewhere the only report is from the Canning Basin (Seddon, 1970).

Range: The species occur as low as the Middle Devonian (Eifelian) (Bultynck, 1970). The youngest occurrence is in the Lower Carboniferous pre-Welden shale of Oklahoma (Cooper, 1939). The Canning Basin specimens range throughout the section.

NEOPRIONIODUS SEMISEPERATUS (Branson & Mehl, 1934)

Pl. 9, figs. 6

1934 Prioniodus semiseperatus Branson & Mehl, Univ. Missouri Stud., 8, 206, pl. 15, figs. 9, 10.

Material: 14 specimens, CPC 19540 - 19541 figured.

Localities of figured material: Sample BG 19104, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21225, Section 19, Sadler Ridge, Sadler Limestone.

Description: A neoprioniodid with a massive apical denticle and a long deflected and depressed posterior bar. The bar denticles number up to 15 and are discrete or barely fused at their bases and are about one-third the size of the apical denticle. The fairly deep posterior bar is marked on its lower half by an attachment scar and in some specimens by an inverted basal cavity. A basal pit is situated beneath the apical denticle and on the inner side there is slight flaring of the aboral cavity lip.

Remarks: Huddle (1968, p. 25) includes N. semiseperatus in N. armatus. However the much greater depression of the posterior bar, its greater depth, and attachment scar all serve to distinguish it. Branson & Mehl (1934) note germ denticles on the ante-cusp and several specimens in the present fauna also exhibit this feature.

Distribution and Range: The species was originally described from the Upper Devonian Grassy Creek shale of Missouri (Branson & Mehl, 1934). In the Canning Basin the species ranges from the base of the Upper Devonian as high as the Famennian lower Polygnathus styriacus Zone (to IV).

NEOPRIONIODUS sp.

Pl. 9, figs. 5

Material: 11 specimens, CPC 12539 figured.

Localities of figured material: Sample BG 21278, Section 21, Margaret River -- Needle Eye Rock, Virgin Hills Formation.

Description: A delicate neoprioniodid with a fragile apical denticle and a short posterior bar bearing a sequence of fine needle-like, partially fused denticles. The ante-cusp is fairly long and a small basal cavity is situated at the junction of the bar and the posterior face of the ante-cusp. The ante-cusp occasionally bears fine denticles and some forms have developed enough of an anterior bar to be referred to Euprioniodina.

Range: The species is stratigraphically restricted in the Canning Basin being confined to the Palmatolepis rhombiodes and P. quadrantinodosa Zones of the Famennian (to II β - lower to III α).

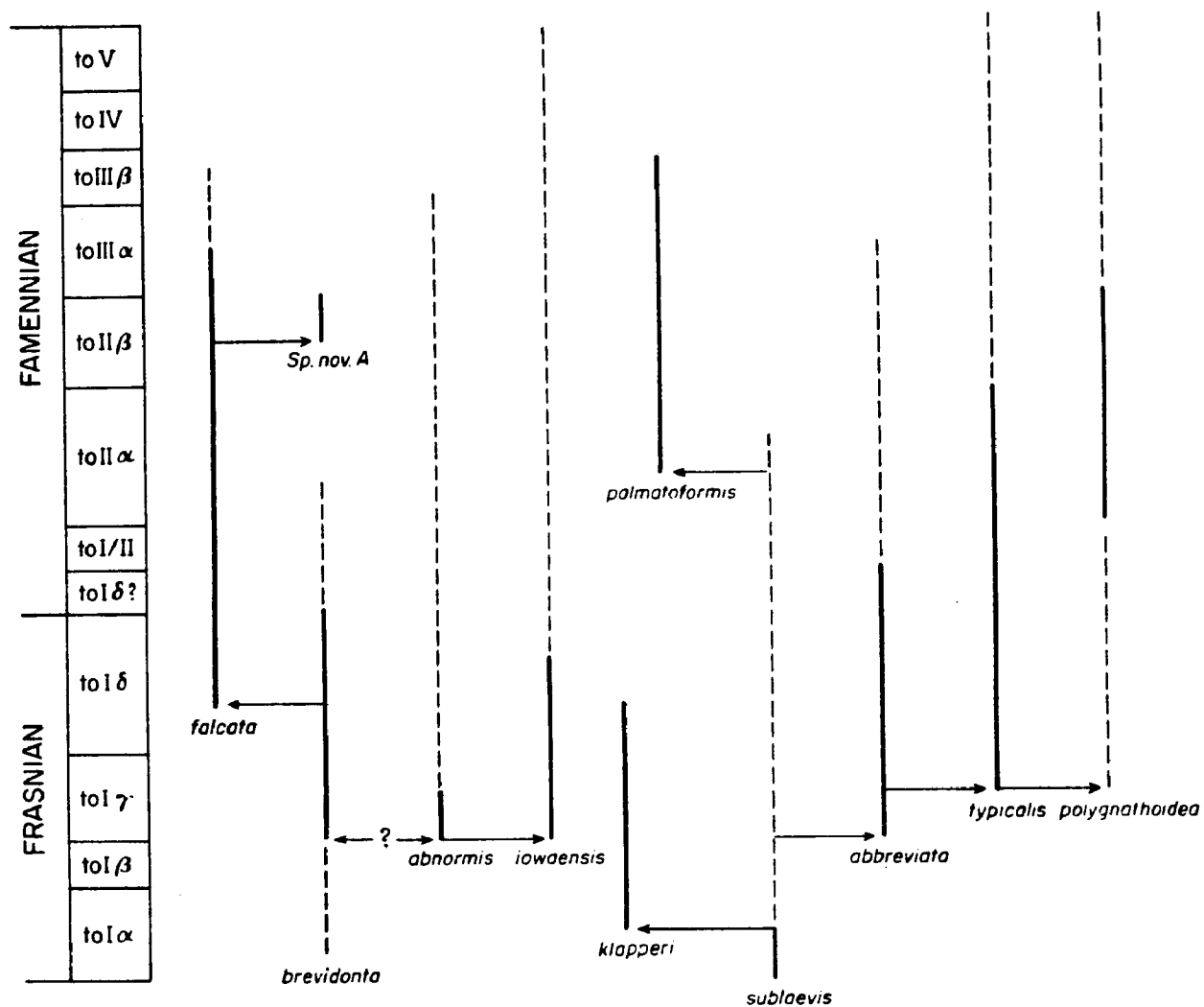


Figure 12 - Phylogeny of the genus Nothognathella.

Genus NOTHOGNATHELLA Branson and Mehl, 1934

Type species: Nothognathella typicalis Branson and Mehl, 1934.

This genus was erected by Branson and Mehl to include arched forms with the development of "an outer and inner flange."

Nothognathellids have the basic morphology of ozarkodinids with the addition of platforms. The general phylogenetic tendency of the group is to develop an increasing large and nodose platform and reduce the posterior blade and become pseudo-platforms. These general phylogenetic tendencies are recorded in Figure 10. The ranges in the Canning Basin differ from the maximum ranges for the species when world occurrences are considered. This may be due, in part, to misidentification of species, but in some cases, N. sublaevis Sanne-mann, for example, the discrepancy is obvious.

There appear to be two lines of evolution of the nothognathellids. One root stock is N. sublaevis and the other is either N. abnormis Branson and Mehl or N. brevidonta Youngquist. I prefer N. abnormis because of its obvious primitive character; however, it apparently appears later in the geologic column than N. brevidonta.

Nothognathella sublaevis group.

N. sublaevis is characterized by a cox-comb-like blade with small ornate platforms confined to the posterior end. It gives rise to two species, N. klapperi, an aberrant line in which two of the blade denticles become enlarged, one over the basal cavity and the other half way to the anterior termination. The platform is larger and bears nodes rather than "shagreen" ornament as in N. sublaevis. The other species is N. abbreviata Branson and Mehl, which is very similar to N. sublaevis in platform development with the addition of nodes, but shows some reduction of the posterior carina blade heights.

The next development is N. typicalis Branson and Mehl where the reduction of the blade height continues and the platforms are enlarged

and nodose. The culmination of this development is N. polygnathoidea where the platform is as large or larger than most polygnathid platforms and the anterior part of the blade has developed as a free blade and the posterior part is low and carina-like. One late development from N. sublaevis is a large platform retaining the "shagreen" ornament. The posterior part of the blade is greatly reduced and the unit looks like a palmatolepid but lacks the azygous node. I have named it N. palmatoformis.

Nothognathella abnormis group.

The most primitive form in the other line is N. abnormis Branson and Mehl, which is little more than an ozarkodinid with a lateral flexure at the posterior end with the development of some tumidity. This species probably gives rise to two other species; N. iowensis is characterized by having a platform developed on the inner side only. (Youngquist's specimens varied somewhat, some having platforms on both sides, but he states [1945, p. 363] "[the] outer nodose flange.... at best is not well developed.") The other development is seen in N. brevidonta Youngquist where the posterior flexure is present and platforms are developed on both sides near this termination. The blade is still convex on its oral margin.

Increased flexure and the extension of the platforms anteriorly is seen in N. falcata Helms. This line culminates in N. sp. nov. A where the flexure exceeds 90° , the platforms are extensively developed especially on the outer side and ornamented with nodes and transverse ridges, and the posterior part of the blade is reduced in height.

Although nothognathellids do not appear to have the zonal significance of the palmatolepids or polygnathids, the fact that they show phylogenetic development may help in refining their ranges. Furthermore, it is interesting to note that an ozarkodinid ancestor can produce obvious platform types. This may be extremely important in determining the phylogeny and evolutionary development of the whole conodont skeleton.

NOTHOGNATHELLA ABBREVIATA Branson & Mehl, 1934

Pl. 10, figs. 1a,b

- 1934 Nothognathella abbreviata Branson & Mehl, Univ. Missouri Stud., 8, 229, pl. 13, fig. 15.
- 1961 Nothognathella aff. N. abbreviata Branson & Mehl; Lys et al., Rev. Inst. Francais Petrole, 16, 546, pl. 2, fig. 5.
- 1966 Nothognathella abbreviata Branson & Mehl; Anderson, J. Paleont., 40, 407.
- 1968 Nothognathella abbreviata Branson & Mehl; Mound, J. Paleont., 42, 495, pl. 67, figs. 18, 19.

Material: 8 specimens, CPC 12542 figured.

Locality of figured material: Sample BG 19454B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Description: A nothognathellid with a very high anterior and low posterior carina and lacking an apical denticle. The anterior carina is composed of about eight tall fused denticles with free chevron tips. They are equi-dimensional and are inclined slightly posteriorly. The posterior carina is composed of about 10 very low nodose denticles. The platforms are unequal in size; the inner platform is situated at the midpoint of the unit narrowing rapidly anteriorly and slowly to the posterior termination. The outer platform is very narrow and is situated entirely in the posterior half of the unit.

Remarks: N. abbreviata can be distinguished from N. typicalis by the lack of a massive apical denticle. It differs from N. brevidonta in possessing a carina of unequal height.

Distribution: The species was originally described from the Grassy Creek shale (middle Famennian) of Missouri (Branson & Mehl, 1934). Lys et al. (1961) record a form with affinities to N. abbreviata from the early Famennian of Morvan, France. Anderson (1966) has recorded

the species from the Juniper Hill Member of the Lime Creek Formation of North-central Iowa. The other North American occurrence is from Alberta where Mound (1968) records it from the lower middle Duvernay Formation of Alberta.

Range: Mound (1968) and Anderson (1966) both record it from early Frasnian (to I) strata. Branson & Mehl's specimens were probably middle Famennian and those figured by Lys et al. (1961) are early Famennian. In the Canning Basin the species ranges from the Ancyrognathus triangularis Zone (to I γ) as high as the Middle Palmatolepis triangularis Zone (basal Famennian). The range of the species is apparently basal Frasnian as high as middle Famennian (to II or to III).

NOTHOGNATHELLA ABNORMIS Branson & Mehl, 1934

Pl. 10, figs. 2a, b

- 1934 Nothognathella (?) abnormis Branson & Mehl, Univ. Missouri Stud., 8, 231, pl. 14, figs. 1, 2.
- ? 1948 Nothognathella (?) abnormis Branson & Mehl; Youngquist & Miller, 22, 447, pl. 67, fig. 5.
- 1955 Nothognathella abnormis Branson & Mehl; Sannemann, Senck. leth., 36, 132, pl. 6, fig. 16, 17.
- 1957 Nothognathella (?) abnormis Branson & Mehl; Lys & Serre, Rev. Inst. Francais Petrole, 12, 1047, pl. 4, figs. 6a, b.
- 1959 Nothognathella (?) abnormis Branson & Mehl; Helms, Geologie, 8, 663, pl. 4, figs. 5, 6.
- 1967 Nothognathella ? abnormis Branson & Mehl; Wolska, Acta Palaeont. Polonica, 12, 383, pl. 3, fig. 9.
- 1967 Nothognathella abnormis Branson & Mehl; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 45, pl. 6, fig. 17.
- 1967 Nothognathella abnormis Branson & Mehl; Nehring, Inst. Geol., Bull. 209, 135, pl. 5, figs. 4, 5.

- 1968 Nothognathella abnormis Branson & Mehl; Spasov et al., Inst. Recherch Geol. Geophys., 26, 160, pl. 1, fig. 5.
- ? 1970 Nothognathella abnormis Branson & Mehl; Seddon, J. Geol. Soc. Aust., 16, 751, pl. 12, figs. 22-25.

Material: 8 specimens, CPC 12543-12546 figured.

Locality of figured specimens: Sample BG 19583, Section 12, southwest of Waggon Pass, Virgin Hills Formation.

Description: A nothognathellid with a reduced platform. The unit is arched and bowed, the carina being highest in the mid-portion. Toward the anterior the carina is high, composed of fused denticles with free chevron tips. In the posterior half the carina is low and formed of low nodose denticles, occasionally isolated. The posterior termination is deflected inward through 45° - 70° . In some specimens there is little platform developed, just a tumidity at about mid-bar height. This tumidity expands into genuine platforms especially in the inner side at about mid-point. On the outer side the platform development is confined to the posterior portion.

The unit is keeled but no definite cavity is present.

Remarks: N. abnormis is the most ozarkodinid-like of the nothognathellids. Greater platform development leads to N. brevidonta; greater flexure leads to N. cf. N. valida.

Distribution: The species was originally described from the Grassy Creek Formation of Missouri (Branson & Mehl, 1934). Elsewhere in North America it has been reported from the Sweetland Creek Shale of Iowa (Youngquist & Miller, 1947) and from the Pilot Shale of Utah (Clark & Becker, 1960; Clark & Ethington, 1967).

The species is very common in Europe, especially in Germany (Sannemann, 1955; Bischoff, 1956; Bischoff & Ziegler, 1956; Flügel & Ziegler, 1957; Ziegler, 1958; Stoppel, 1958; Helms, 1959; Freyer, 1961; Schriel & Stoppel, 1965; Stoppel & Zscheke, 1966). Elsewhere

in Europe the species has been recorded from Austria (Schönlaub, 1969), France (Lys & Serre, 1957; Serre & Lys, 1958; Boyer et al., 1968), Poland (Nehring, 1967; Wolska, 1967) and Yugoslavia (Spasov et al., 1968).

Range: The original description of the species from the Grassy Creek shale is from strata of Famennian age (to II - to III). The species is known from the Frasnian in North America (Youngquist & Miller, 1947); the species has been reported from the Pilot Shale (Frasnian to I γ).

The range in Europe is similar; the majority of ranges indicate a first occurrence in the to I γ zone of the Frasnian (Bischoff, 1956; Freyer, 1961; Helms, 1959; Wolska, 1967). However, Nehring (1967) gives a first occurrence in the to I δ zone. The upper limit is also variable; in France it is in the to II α zone of the Famennian. Helms (1959) and Wolska (1967) also record the upper limit as to II while Stoppel (1958) records the species from the to II β zone. Nehring (1967), once again extends the range as high as the to III β zone.

In the Canning Basin the species is rare and has only been recorded from the to I γ horizon.

N. abnormis has an absolute range of to I γ - to III β .

NOTHOGNATHELLA BREVIDONTA Youngquist, 1947

Pl. 10, figs. 3a,b

1947 Nothognathella brevidonta Youngquist, J. Paleont., 21, 108, pl. 25, fig. 1.

1956 Nothognathella brevidonta Youngquist; Bischoff, Hess. Landesamt Bodenf., Notizbl., 84, 127, pl. 10, fig. 29.

1967 Nothognathella brevidonta Youngquist; Nehring, Inst. Geol., Bull. 209, 137, pl. 5, fig. 7.

Material: 12 specimens, CPC 12547-12550 figured.

Localities of figured material: Sample BG 19014, Section 1, McWhae Ridge, Virgin Hills Formation; Samples BG 19583, 19584, Section 12, southwest of Waggon Pass, Virgin Hills Formation; Sample BG 21371, east side Teichert Hills, Sadler Limestone.

Description: An arched nothognathellid with a conspicuous platform on the inner side. The arching varies from as little as 30° to near 90° . The platform is well developed, especially on the inner side where it stretches from end to end, being widest in the middle and gradually narrowing to both terminations. The ornament consists of "shagreen" in some cases and isolated nodes and faint transverse ridges at the platform edge on others. The medial carina consists of a sequence of up to 28 low nodose denticles fused at their bases with free tips. The unit is deflected through about 70° as well as being arched. Sometimes the carina is sinuous. The outer platform is extremely narrow and is roughly the same width over the unit length.

In aboral view the unit is keeled. At about the platform midpoint the keel bifurcates for a short distance forming a small, shallow pit. In some specimens the pit is asymmetric and is similar to the cavity in Schmidtognathus Ziegler, 1966.

Remarks: The species appears to have developed from N. abbreviata by an increase in size of the platform and reduction in height of the anterior portion of the carina. It is also probable that some of the more flexed specimens could have developed from N. abnormis by increase in platform width.

Distribution: The species was originally described from a shale horizon overlying the Cedar Valley Limestone of Iowa (Youngquist, 1947). The only other record of the species in North America is from Alberta (Uyeno, 1967). In Europe the species is known from France (Serre & Lys, 1958), Germany (Bischoff, 1956; Stoppel, 1958; Stoppel & Zscheke, 1966) and Poland (Nehring, 1957).

Range: The original record of the species is from Frasnian strata. In Alberta, Uyeno (1967) records the species from a horizon within the to I α zone. In Europe the species is recorded in the Frasnian (Bischoff, 1956; Stoppel & Zscheke, 1966) and in the to II α zone of the Famennian (Stoppel, 1958). Nehring gives a range of Frasnian (to I δ) to Famennian (to II α).

In the Canning Basin the species is restricted to the Frasnian (to I γ - to I δ). The range of the species appears to be Frasnian (to I α) to Famennian (to II α).

NOTHOGNATHELLA FALCATA Helms, 1959

Pl. 10, figs. 4a, b

1959 Nothognathella (?) falcata Helms, Geologie, 8, 645, pl. 5, fig. 27a, b.

1967 Nothognathella? falcata Helms; Wolska, Acta Palaeont. Polonica, 12, 384, pl. 3, fig. 8.

Material: 12 specimens, CPC 12551-12554 figured.

Localities of figured material: Sample BG 19018, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19451B, Section 4, north-east of McWhae Ridge, Virgin Hills Formation; Sample BG 21267, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Description: A slightly arched and distinctly deflected nothognathellid. The posterior bar is deflected through 90°. Both bars are tumid and narrow platforms along both sides of both platforms. The carina is composed of low fused denticles with free tips. They are always inclined posteriorly and near the point of flexure are often outwardly inclined. The unit is keeled but no basal pit is obvious.

Remarks: The extreme deflection of the posterior bar is similar to that seen in N. abnormis and some specimens of N. brevidonta.

Previous illustrations of the species show little development of

platforms though the species was questionably assigned to Nothognathella. The present specimens have good platforms and the assignment to the genus Nothognathella appears to be correct.

Distribution: The species has previously been reported exclusively from Europe. It was originally described from Germany (Helms, 1959). Other reports of the species are known from Portugal (Boogaard, 1963) and Poland (Wolska, 1967).

Range: The original report of the species from the Saalfelder Upper Devonian was from a Famennian (to III ?) horizon. The Portuguese occurrence is from strata considered to be to IV and/or to V (Boogaard, 1963). The Polish range is Famennian (to II β - to IV).

In the Canning Basin the species ranges from Frasnian (to I δ) (uppermost Palmatolepis gigas Zone) to Famennian (to III α) (upper Palmatolepis quadrantinodosa Zone). The overall range appears to be to I δ - to IV.

NOTHOGNATHELLA IOWAENSIS Youngquist, 1945

Pl. 10, figs. 5a, b

1945 Nothognathella iowaensis Youngquist, J. Paleont., 19, 363,
pl. 55, fig. 7.

1956 Nothognathella iowaensis Youngquist; Bischoff & Ziegler, Hess.
Landesamt Bodenf., Notizbl., 84, 151, pl. 14, fig. 17.

? 1961 Nothognathella iowaensis Youngquist; Freyer, Freib, Forsch.,
C95, 56, pl. 2, fig. 59; pl. 3, fig. 60.

1966 Nothognathella iowaensis Youngquist; Anderson, J. Paleont.,
40, 407, pl. 50, fig. 3.

Material: 3 specimens, CPC 12555 - 12556 figured.

Locality of figured material: Sample BG 19528, McIntyre Knolls,
Virgin Hills Formation; Sample 19547, Section 9, Balme Knoll, Virgin
Hills Formation.

Description: A nothognathellid with a platform virtually restricted to the inner posterior portion of the unit. The carina is composed of up to 25 laterally compressed, fused denticles with free chevron tips. The anterior half consists of tall denticles and is gently curved; the posterior part consists of much lower denticles and is slightly curved in the opposite direction, producing a sigmoidal carina.

The platform is virtually restricted to the posterior half of the unit. It is mainly present on the inner side and bears sparse low nodes and the edge is sometimes serrated. On the outer side a faint ridge is present suggesting a latent outer platform. The unit is keeled with a minute pit present at the point of flexure of the unit.

Remarks: N. iowaensis and N. klapperi are the two nothognathellids which greatly resemble the genus Elictognathus. The carina in both cases is high and comb-like, with the highest denticles near the point of flexure.

Distribution: The species was originally described from the Independence shale of Iowa (Youngquist, 1945). It has also been recorded from the Juniper Hill Member of the Lime Creek Formation (Anderson, 1966). The only other record of the species from North America is from Alberta (Pollock, 1968). In Europe the species is common in Germany (Bischoff & Ziegler, 1956; Stoppel, 1958; Freyer, 1961; Stoppel & Zscheke, 1966). The other European occurrences are in Austria (Schulze, 1968; Schönlaub, 1969).

Range: Original specimens come from the Frasnian of southeastern Iowa (Youngquist, 1945) and also occur in the Frasnian of north-central Iowa (Anderson, 1966). The specimens reported by Pollock (1968) are post to I α Frasnian age. In Europe Frasnian forms are reported by Freyer (1961), and Stoppel & Zscheke (1966). However, the species is common in the Famennian. Bischoff & Ziegler (1956) record it from to II β - to III strata. Freyer (1961) shows a range of

Frasnian (to I §) up to late Famennian (to V), and Stoppel records the species in strata of to II ∞ age. In the Canning Basin the species is confined to the Frasnian and ranges from the Ancyrognathus triangularis Zone (to I ∞) up to the top of the Palmatolepis gigas Zone (to I δ).

The overall recorded range is Frasnian (? to I β) up to the late Famennian (to V).

NOTHOGNATHELLA KLAPPERI Uyeno, 1967

Pl. 10, figs. 7a, b

1967 Nothognathella klapperi Uyeno, Geol. Surv. Canada Pap. 67 - 30, 5, pl. 1, figs. 7, 8; pl. 2, fig. 1.

Material: 2 specimens, CPC 12557 figured.

Locality of figured material: Sample BG 19548, Section 9, Balme Knoll, Virgin Hills Formation.

Description: A nothognathellid with a small platform restricted to the inner posterior part of the unit. The blade is distinctive, the posterior part is fairly low with a high apical denticle over the cavity. The anterior blade is saddle-shaped in profile with a secondary peak near the anterior end.

Remarks: N. klapperi is very close to N. iowaensis but can be distinguished by the double peak of tall denticles on the blade. As Uyeno pointed out (p. 6) this species is a homeomorph of Elictognathus.

Distribution and Range: Uyeno (1967) records it in the Middle Polygnathus asymmetricus Zone (Frasnian to I ∞) of the Waterways Formation of Alberta. In the Canning Basin the species ranges from the Middle Polygnathus asymmetricus Zone as high as the Ancyrognathus triangularis Zone (to I ∞).

NOTHOGNATHELLA PALMATOFORMIS sp. nov.

Pl. 17, fig. 8

1966 Nothognathella sublaevis Sannemann; Glenister & Klapper,
J. Paleont., 40, 806, pl. 95, figs. 7-9.

Derivation of name: From the general similarity of the platform to the genus Palmatolepis.

Material: 12 specimens, Holotype, CPC 12558, Paratypes, CPC 12559 - 12561.

Localities of figured material: Holotype, Sample BG 19019, Section 1, McWhae Ridge, Virgin Hills Formation; Paratypes, Sample BG 19019, 19023, Section 1, Virgin Hills Formation, Sample BG 19130, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Diagnosis: A nothognathellid with a well developed platform bearing "shagreen" ornament.

Description: The platform is well developed on both sides of the carina. The outer platform has a convex outer edge and is subparallel to the convex carina. The inner platform is wide and with a well-developed notch just anterior to the mid-point. Both platforms bear shagreen-like ornament. The carina is tallest in the anterior half and extends anteriorly as a short free blade. The posterior half is much shorter and on some specimens barely reaches the posterior termination.

In aboral view the unit is keeled but lacks a basal cavity. In specimens where the carina does not reach the spatulate posterior termination the keel also terminates before reaching the margin.

Remarks: Glenister & Klapper (1966) note that their specimens of N. sublaevis are more advanced than those illustrated by Sannemann but the possession of shagreen-like ornament is diagnostic. I have

separated this species from N. sublaevis because the platform shows greater development and closely approaches the genus Palmatolepis.

Distribution and Range: The only record of the species at the present is from the Canning Basin although a specimen illustrated by Clark & Becker (1960, pl. 2, fig. 2) may belong here. N. palmatoformis ranges from the Middle Palmatolepis crepida as high as the Middle Scaphignathus veliferus (Famennian to II α - to III β) Zone.

NOTHOGNATHELLA POLYGNATHOIDEA Branson & Mehl, 1934

Pl. 10, figs. 8a,b

- 1934 Nothognathella polygnathoidea Branson & Mehl, Univ. Missouri Stud., 8, 228, pl. 13, figs. 16-20.
- 1944 Nothognathella polygnathoidea Branson & Mehl; Branson, ibid., 19, pl. 28, figs. 34-36, 39, 40.
- 1961 Nothognathella polygnathoidea Branson & Mehl; Freyer, Freib. Forsch., C-95, 56, pl. 3, fig. 61.
- ? 1968 Nothognathella (?) af. N. polygnathoidea Branson & Mehl; Mound, J. Paleont., 42, 496, pl. 67, figs. 27-29 (fig. 28 not named in plate descriptions).

Material: 4 specimens, CPC 12562 figured.

Localities of figured material: Sample BG 19018, Section 1, McWhae Ridge, Virgin Hills Formation.

Description: A nothognathellid with a very well developed platform. The carina is straight and high in its anterior part with a lower curved posterior part. The platform on the inner side is very well developed with a convex margin and is ornamented with low nodes which are concentrated near the margin. The platform on the inner side is restricted to the posterior portion; it is widest near the carina flexure and narrows towards the posterior termination. It is ornamented with low nodes which are fused into transverse ridges near the margin. The aboral side

is keeled.

Remarks: Like P. palmatoformis this nothognathellid approaches the genus Palmatolepis. The platform approaches very closely to that of Palmatolepis foliacea Youngquist but it lacks an azygous node.

Distribution: The species was originally described from the Grassy Creek shale of Missouri (Branson & Mehl, 1934; Branson, 1944). Mound has recorded questionable specimens from Alberta (1968). The only record from Europe is by Freyer (1961) who describes it from the Vogtlandes.

Range: The Grassy Creek shale is early Famennian in age (Collinson et al., 1962). The specimens recorded by Freyer (1961) come from widely different horizons, Frasnian (to I γ) and Famennian (to V). In the Canning Basin the species ranges from the Lower Palmatolepis crepida Zone (to II α) as high as the Lower Palmatolepis quadrantinodosa Zone (to II β).

NOTHOGNATHELLA SUBLAEVIS Sannemann, 1955

Remarks: A single broken specimen was recovered from the Lower Polygnathus asymmetricus Zone (Frasnian to I α).

NOTHOGNATHELLA TYPICALIS Branson & Mehl, 1934

Pl. 10, figs. 6a, b

- 1934 Nothognathella typicalis Branson & Mehl, Univ. Missouri Stud., 8, 227, pl. 13, figs. 7, 8.
- 1944 Nothognathella typicalis Branson & Mehl; Branson, ibid., 19, 157, pl. 28, figs. 16, 17.
- 1955 Nothognathella typicalis Branson & Mehl; Sannemann, Senck. leth., 36, 133, pl. 3, figs. 11a, b.
- 1959 Nothognathella typicalis Branson & Mehl; Helms, Geologie, 8, 645, pl. 1, figs. 8-10; pl. 4, figs. 26-28.

- ? 1961 Nothognathella cf. typicalis Branson & Mehl; Zimmermann,
Freib. Forsch., C-89, 189, pl. 4, fig. 9.
- 1967 Nothognathella typicalis Branson & Mehl; Wolska, Acta Palaeont.
Polonica, 12, 384, pl. 3, fig. 10.
- 1967 Nothognathella typicalis Branson & Mehl; Nehring, Inst. Geol.
Biul. 209, 134, pl. 2, figs. 7a, b.
- ? 1968 Nothognathella typicalis Branson & Mehl; Spasov et al., Inst.
Rech. Geol. Geophys. Bull. 26, 160, pl. 2, fig. 16.

Material: 16 specimens, CPC 12563 - 12566 figured.

Localities of figured material: Samples BG 19014, 19016, 19018, Section 1, McWhae Ridge, Virgin Hills Formation; Sample 21011, Section 14, 2 miles northwest of Pinnacle Spring, Virgin Hills Formation.

Description: The blade is extremely high in the anterior part, gradually increasing in height toward the posterior and terminating in a massive apical denticle. The posterior half of the carina is extremely low and consists of about 8 low nodose denticles; the anterior part consists of about 8 laterally compressed, basally fused denticles with free chevron tips.

The platform is widest medially narrowing to the posterior termination. Both platform edges are sigmoidal and both platforms bear low nodes. In aboral view the unit is keeled with a faint pit present beneath the apical denticle.

Remarks: N. typicalis is close to N. abbreviata but the platform is developed more in N. typicalis.

Distribution: The species was originally described from the Grassy Creek Shale of Missouri (Branson & Mehl, 1934; Branson, 1944). This is the only record from North America but it is common in Europe, especially in Germany (Sannemann, 1955; Bischoff & Ziegler, 1956; Stoppel, 1958; Helms, 1959; Zimmermann, 1961; Freyer, 1961; Stoppel & Zscheke, 1966) and Poland (Freyer & Zakowa, 1967; Nehring, 1967;

Wolska, 1967). Elsewhere in Europe it has been reported from Austria (Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), France (Boyer et al., 1968), Italy (Manzoni, 1965), Yugoslavia (Spasov et al., 1968) and Portugal (Boogaard, 1963).

Range: The original description was from the Grassy Creek Shale of Missouri of early Famennian age. The earliest record of the species is in the Frasnian (to I^Y) of Poland (Nehring, 1967) and France (Boyer et al., 1968). The latest occurrence is late Famennian (to V) reported by Freyer (1961) (who gives a range of to I^δ - to V) and Bischoff & Ziegler (1963). In the Canning Basin the species ranges from the Lower Palmatolepis gigas Zone (to I^Y) up to the Upper Palmatolepis crepida Zone (to II^α).

NOTHOGNATHELLA sp. nov. A

Pl. 17 fig. 5

Material: 3 specimens, CPC 12567-12568 figured.

Localities of figured material: Samples BG 19083, 19106, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone.

Description: A highly flexed and arched nothognathellid. The unit is flexed through 90° and arched through 45°; platforms are developed on both sides of the carina which is massive in the anterior part with tall fused denticles with free chevron tips, and composed of low fused nodes in the posterior part. The inner platform is narrow with small nodes at the platform margin. The outer platform is massive and near the point of flexure it is elevated into a secondary blade with a fluted margin with broad transverse ridges. Aborally, the unit is keeled.

Remarks: This species is similar to N. postsublaevis in possessing a secondary carina formed by the outer platform margin. However, in N. sp. nov. A the carina is at unit mid-point whereas in N. sublaevis it is

at the posterior end of the unit.

Distribution: So far the only record is from the Canning Basin where it occurs in the Lower Palmatolepis quadrantinodosa Zone (Famennian, to II $\times$).

Genus OZARKODINA Branson & Mehl, 1933

Type species: Ozarkodina typica Branson & Mehl, 1933

OZARKODINA HOMOARCUATA Helms, 1959

Pl. 9 figs. 7

- 1934 Subbryantodus arcuatus Branson & Mehl, Univ. Missouri Stud.,
8, 286, pl. 23, figs. 10, 11.
- 1934 Subbryantodus flexus Branson & Mehl, ibid., 286, pl. 23, fig.
12.
- non 1934 Ozarkodina arcuata Branson & Mehl, ibid., 193, pl. 17, fig. 7.
- 1955 Subbryantodus arcuatus Branson & Mehl; Sannemann, Senck.
leth., 36, 154, pl. 4, fig. 15.
- 1956 Ozarkodina arcuata (Branson & Mehl); Bischoff & Ziegler, Hess.
Landesamt Bodenf., Notizbl., 84, 152, pl. 13, fig. 24.
- 1959 Ozarkodina homoarcuata Helms, Geologie, 8, 646, pl. 2, fig. 5.
- 1961 Ozarkodina homoarcuata Helms; Freyer, Freib. Forsch.,
C-95, 58, pl. 3, figs. 64-66.
- 1967 Ozarkodina homoarcuata Helms; Freyer & Zakowa, Acta Geol.
Polonica, 17, pl. 2, fig. 14.
- 1967 Ozarkodina homoarcuata Helms; Nehring, Inst. Geol. Bull., 209,
138, pl. 5, fig. 6.
- 1967 Ozarkodina homoarcuata Helms; Wolska, Acta Palaeont.
Polonica, 12, 385, pl. 4, fig. 13.
- 1969 Ozarkodina homoarcuata Helms; Druce, Bur. Miner. Resour.
Aust. Bull. 98, 80, pl. 15, figs. 2, 3.

1969 Ozarkodina homoarcuata Helms, Olivieri, Boll. Soc. Paleont. Italiana, 8, 90, pl. 13, figs. 14, 15.

Material: 14 specimens, CPC 12569, 12570 figured.

Localities of figured material: Samples BG 19104, 19117, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone.

Remarks: The distinctive arcuate form distinguishes this species from ozarkodinids.

Distribution: The species was originally described from the Lower Carboniferous Bushberg Sandstone from a locality at Frenchman's Creek, Missouri (Branson & Mehl, 1934) which contains abundant reworked Devonian Grassy Creek conodonts. The only other report of the species in North America is by Pollock (1968) from Alberta, Canada.

In Europe the species is extensive in Germany (Bischoff & Ziegler, 1953; Helms, 1959; Freyer, 1961; Schriel & Stoppel, 1965; Meyer, 1965; Stoppel & Zscheded, 1966; Freyer, 1968) and Poland (Freyer & Zakowa, 1967; Wolska, 1967; Nehring, 1967). Elsewhere in Europe it has been reported from Austria (Schönlaub, 1969), France (Boyer et al., 1968), and Portugal (Boogaard, 1963). In Australia the species is present in the Bonaparte Gulf Basin (Druce, 1969).

Range: The species was originally described from Carboniferous strata but it is possible that it is reworked from the Devonian Grassy Creek Formation (Fammenian). Nehring (1967) records the species from the Frasnian (to I α) to the late Fammenian (to V). Boyer et al. (1968) record the species from the late Frasnian (to I δ) into the early Carboniferous (cu I). Pollock (1968) records the species in the earliest Frasnian. Helms (1959) gave a range of Fammenian (to III - to VI) for the species but it appears that the complete range is earliest Frasnian (to I α) to earliest Carboniferous (cu I). In the Canning Basin the species ranges from the Middle Palmatolepis crepida (to II α) Zone up to the Lower

Polygnathus styriacus (to IV).

OZARKODINA IMMERSA (Hinde , 1879)

Pl. 9, figs. 15

- 1879 Polygnathus immersus Hinde, Quart. J. Geol. Soc. Lond., 35, 335, pl. 16, fig. 21.
- 1931 Bryantodus inequalis Holmes; Cooper, J. Paleont., 5, 147, pl. 20, fig. 5.
- 1934 Bryantodus immersus (Hinde); Branson & Mehl, Univ. Missouri Stud., 8, 1-10, pl. 11, fig. 22.
- 1938 Ctenognathus elegans Stauffer, J. Paleont., 12, 424, pl. 48, figs. 9-12.
- 1938 Ctenognathus falcatus Stauffer, ibid., 425, pl. 48, figs. 1, 5.
- 1938 Ctenognathus firmus Stauffer, ibid., 425, pl. 48, figs. 2, 6, 15.
- 1940 Ctenognathus elegans Stauffer; Stauffer, J. Paleont., 14, 422, pl. 59, figs. 3-5, 8.
- 1945 Ctenognathus falcatus Stauffer, Youngquist, J. Paleont., 19, 358, pl. 55, fig. 1.
- 1947 Ctenognathus falciformis Stauffer; Youngquist, J. Paleont., 21, 96, pl. 25, fig. 3.
- 1950 Ozarkodina sp. Youngquist & Downs, J. Paleont., 24, 670, pl. 87, figs. 1, 2.
- 1955 Ozarkodina elegans (Stauffer); Sannemann, Senck. leth., 36, 133, pl. 6, fig. 9.
- 1957 Ozarkodina elegans (Stauffer); Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh., 22, 76, pl. 20, figs. 29-33.
- 1961 Ozarkodina regularis Branson & Mehl; Freyer, Freib. Forsch., C-95, 59, pl. 3, fig. 70.
- 1962 Ozarkodina elegans (Stauffer); Budurov & Tschunev, Bull. Inst. Sci. Recherch. Geol., 1, pl. 4, fig. 13.
- 1965 Ozarkodina elegans (Stauffer); Ethington, J. Paleont., 39, 577, pl. 68, fig. 15.

- 1967 Ozarkodina immersa (Hinde); Müller & Clark, J. Paleont., 41, 915, pl. 117, fig. 13.
- 1967 Ozarkodina immersa (Hinde); Clark & Ethington, Geol. Soc. Amer. Bull. 103, 43, pl. 6, fig. 10.
- 1968 Ozarkodina elegans (Stauffer); Mound, J. Paleont., 42, 497, pl. 67, figs. 32, 37.
- 1969 Ozarkodina elegans (Stauffer); Druce, Bur. Miner. Resour. Aust. Bull. 98, 78, pl. 16, figs. 1a, b.
- 1969 Ozarkodina immersa (Hinde); Seddon, J. Roy. Soc. W. Aust., 52, 27, pl. 1, figs. 10, 11.
- 1969 Ozarkodina immersa (Hinde); Olivieri, Boll. Soc. Paleont. Italiana, 8, 91, pl. 10, figs. 4a, b; pl. 13, fig. 6.
- 1970 Ozarkodina immersa (Hinde); Seddon, J. Geol. Soc. Aust., 16, 752, pl. 14, fig. 2.

Material: 55 specimens, CPC 12571-12573 figured.

Localities of figured material: Sample BG 19023, Section 1, McWhae Ridge, Virgin Hills Formation; Samples BG 19071, 19108, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone.

Remarks: Ozarkodina immersa can be differentiated from O. macra in that it lacks the really massive apical denticle. However, the two species appear to grade into one another. In some specimens the apical denticle is the same size as the bar denticles and can only be distinguished by its apical position.

Distribution: The species is extremely widespread having been recorded extensively in North America and Europe. The species is also present in the Bonaparte Gulf, Canning, and Carnarvon Basins in Australia (Druce, 1969; Seddon, 1969; 1970).

Range: The earliest record of the species is in the Upper Givetian (Bischoff & Ziegler, 1957). The majority of the reports are from the

Frasnian and Famennian but Youngquist & Downs (1951) record it from the early Mississippian of Iowa. In the Canning Basin the species ranges throughout the Devonian sequence.

cf. OZARKODINA ? LACERA Helms, 1959

Pl. 9, figs. 10

Material: 11 specimens, CPC 12518-12521 figured.

Localities of figured material: Samples BG 19105, 19140, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 21093, Ngumbyan Cliff, Virgin Hills Formation, Sample BG 21271, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Description: The unit is arched, consisting of an anterior blade and posterior platform. The anterior blade consists of 7 to 8 tall posteriorly inclined denticles which increase in height posteriorly. The denticles are fused at their bases with free chevron tips. The apical denticle is about twice as high as the blade denticles and is posteriorly inclined and inwardly bowed. The posterior bar is tumid on both sides. The dentition varies from the original bar denticles with occasional platform denticles to complete coverage of the platform by brush-like denticles which completely mask the original bar denticles. The platform is usually flexed outward at the apical denticle. The platform varies from elongate with sub-parallel margins, or pear-shaped.

Aborally, the unit is keeled; a minute pit may be present beneath the apical denticle but often a basal cavity appears to be absent.

Remarks: The development of brush-like denticles has been recorded previously. Müller (1969) has studied many specimens belonging to various form-genera, and notes that Sannemann's (1955) nov. gen. et. sp. is a brush-like form. Previously, Uyeno (1967) had referred brush-like polygnathids to P. norrisi. Uyeno points out that Helms (1959) illustrated one form which he included in Polygnathus diversus.

Müller records specimens from Northwest Germany, Eastern Thuringia, Carinthian Alps and Morocco. He points out that there appears to be no relation between the occurrence and substrate, region or facies, and considers them to be pathologic sports.

It is difficult to interpret these forms. They are only known from the Upper Devonian but within the Upper Devonian they range in age from early Frasnian (to I (β) γ) to the late Famennian (to VI). It is also difficult to interpret these forms as a pathologic variant. The broad similarity of the polygnathid forms and the wide distribution of such forms suggests that they may have been a useful adaption albeit for only a short duration.

These brush-like forms may be extremely useful in determining the skeletal make-up of the original conodontifer since it is probable that all elements of the unit developed this dentition. In one sample I have forms referable to Ozarkodina, Polygnathus and Hindeodella and it is possible that they are all associated in the same animal. Nearly every sample that yielded Ozarkodina ? lacera also yielded a brush-like polygnathid.

Distribution and Range: Müller (1969) refers to ozarkodinids with brush-like dentition but does not illustrate any forms. Thus, at the present the species is confined to the Canning Basin. It ranges from the Lower Palmatolepis quadrantinodosa Zone (to II β) as high as the Middle Scaphignathus veliferus Zone (to III β). It is interesting to note that in the Canning Basin its first occurrence is at about the same horizon as the demise of the icriodids.

OZARKODINA MACRA Branson & Mehl, 1934

Pl. 9, figs. 17

- 1934 Ozarkodina macra Branson & Mehl, Univ. Missouri Stud., 8, 192, pl. 17, fig. 5.
- 1955 Ozarkodina regularis Sannemann (part); Senck. leth., 36, 133, pl. 6, fig. 5.

- 1957 Ozarkodina macra Branson & Mehl; Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh., 22, 77, pl. 12, figs. 13a, b; pl. 13, figs. 9a, b.
- 1957 Ozarkodina cf. O. macra Bischoff & Ziegler, ibid., 78, pl. 13, figs. 11a, b; pl. 19, figs. 43.
- 1957 Ozarkodina lata Bischoff & Ziegler, ibid., 22, 76, pl. 20, figs. 9-16.
- 1967 Ozarkodina macra Branson & Mehl; Clark & Ethington, Geol. Soc. Amer. Bull. 103, 48, pl. 4, fig. 2; pl. 5, fig. 2.
- 1968 Ozarkodina macra Branson & Mehl; Mound, J. Paleont., 42, 497, pl. 67, figs. 24, 34, 38, 40.
- 1970 Ozarkodina macra Branson & Mehl; Bultynck, Mem. Inst. Geol. Univ. Louvain, 26, 120, pl. 24, fig. 1.

Material: 168 specimens, CPC 12574-12576 figured.

Localities of figured material: Sample BG 19016, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19584, Section 12, southwest of Waggon Pass, Virgin Hills Formation.

Remarks: Ozarkodina macra is characterized by the massive apical denticle and fine bar dentition. As noted before, it appears to be transitional to O. immersa.

Distribution: The species was originally described from Missouri (Branson & Mehl, 1934); elsewhere in North America it has been reported from Arizona (Ethington, 1965), the Great Basin (Clark & Ethington, 1967) and Alberta (Clark & Ethington, 1965; Mound, 1968). In Europe the species is common in Germany (Bischoff & Ziegler, 1957; Sannemann, 1956; Freyer, 1965; Schriel & Stoppel, 1965), and is also present in Austria (Schönlaub, 1969), Belgium (Bultynck, 1970), and Roumania (Mirauta & Mirauta, 1965). In the Canning Basin it ranges throughout the sequence.

OZARKODINA VERSA (Stauffer, 1940)

Pl. 9, figs. 16

1940 Bryantodus versus Stauffer, J. Paleont., 14, 421, pl. 59,
figs. 10, 14-16, 21.

Material: 3 specimens, CPC 12577 figured.

Locality of figured material: Sample BG 19170, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: An ozarkodinid characterized by a virtually straight aboral margin. The apical denticle is massive, at least twice as wide and twice as tall as the largest bar denticle. The bar denticles are elongate, basally fused, posteriorly inclined with free needle-like tips. The smallest denticles are situated nearest the apical denticle on both bars. There is a small basal cavity present beneath the apical denticle.

Distribution and Range: The species was originally described from clays overlying the Devonian Cedar Valley Limestone at Austin, Minnesota. The three specimens come from widely different horizons ranging from (to I α) as high as (to IV).

OZARKODINA sp. A

Pl. 9, figs. 18

Material: 1 specimen, CPC 12578 figured, from sample BG 19008, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: A single specimen is very distinctive; it is highly arched with long needle-like denticles fused at their bases but free over most of their length. The apical denticle is twice as large as the bar denticles and all are posteriorly inclined. The basal cavity is large and flaring beneath the apical denticle and extending along both bars as a narrowing groove. The specimen was recovered from the Middle Polygnathus asymmetricus Zone (to I α).

OZARKODINA sp. B

Pl. 8, figs. 13

Material: 12 specimens, CPC 12579 figured.Localities of figured material: Sample BG 19538, Section 9, Balme Knoll, Virgin Hills Formation.Remarks: A robust ozarkodinid with a massive apical denticle about four times as large as the bar denticles. The bars are elongate, bearing up to ten short denticles which are basally fused and posteriorly inclined, the massive denticles situated at the anterior end. The bars are slightly tumid forming a ledge at the base of the denticles. The basal cavity is distinctive; it is small and subapical but is widely flared and often contains basal "bone" material.Range: The species ranges from the Middle Polygnathus asymmetricus Zone (to I α) as high as the Ancyrognathus triangularis Zone (to I γ).

OZARKODINA sp. C

Pl. 9, figs. 12

Material: 6 specimens, CPC 12581 figured.Locality of figured material: Sample BG 19421, Cave Spring, Sadler Limestone.Remarks: An ozarkodinid with distinctive pear-shaped denticles. The denticles are tumid and are widest above their fused bases. The tips are free and are subtriangular. All denticles are recurved posteriorly. The bar is tumid and an attachment scar runs just above the aboral margin.Range: The species ranges from the Lower Polygnathus asymmetricus (to I α) as high as the Upper Palmatolepis triangularis Zone (to I/II).

OZARKODINA sp. D

Pl. 9, figs. 14

Material: 4 specimens, CPC 12582 figured.

Locality of figured material: Sample BG 19014, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: An ozarkodinid lacking a prominent apical denticle, and with fine needle-like denticles and a twisted posterior bar. The basal cavity appears to be inverted. This species is similar to Bryantodus sp. illustrated by Spasov & Filipovic (1967).

Range: This species ranges from the Lower Palmatolepis gigas Zone (to I δ) as high as the Lower Palmatolepis triangularis Zone (to I δ).

OZARKODINA sp. E

Pl. 10, figs. 9

Material: 1 specimen, CPC 12583, from sample BG 21354, Section 22, Piker Hills, Piker Hills Formation.

Remarks: A crescent-shaped ozarkodinid lacking an obvious apical denticle. The denticles, twelve in number, are elongate and needle-like with fused bases; they are tallest centrally, decreasing rapidly in size towards the terminations. No basal cavity is obvious.

Range: The single specimen comes from the Lower Polygnathus styriacus Zone (to IV).

OZARKODINA sp. F

Pl. 9, figs. 19

Material: Single specimen, CPC 12584, from sample BG 19101, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: An ozarkodinid with a massive apical denticle and extremely

short bars. The anterior bar is deflected and slightly depressed and bears four denticles basally fused with free chevron tips. A germ denticle is present immediately anterior to the apical denticle. The apical denticle is laterally compressed and is recurved. The posterior bar is twisted and bears three triangular and virtually isolated denticles.

Beneath the apical denticle there is a faint depression. The unit is rather hindeodellid and/or ligonodinid in its appearance but the fact that the bars are of the same order of size suggests that it may belong in Ozarkodina.

Range: The specimen comes from the Lower Palmatolepis quadrantinodosa Zone (to II β).

Genus PALMATODELLA Bassler, 1925

Type species: Palmatodella delicatula Ulrich & Bassler, 1926.

PALMATODELLA DELICATULA Ulrich & Bassler, 1926

1925 Palmatodella delicatula Bassler, Bull. Geol. Soc. Amer., 36, 219.

1926 Palmatodella delicatula Ulrich & Bassler, Proc. U.S. Nat. Mus., 72, 29, pl. 10, fig. 10.

For complete synonymy up to 1966 see:

1969 Palmatodella delicatula Ulrich & Bassler; Druce, Bur. Miner. Aust. Bull. 98, 85, pl. 17, fig. 1.

1966 Palmatodella delicatula Ulrich & Bassler; Spasov & Filipovic, Geol. Glasnik, 2, 45, pl. 3, fig. 16.

1967 Palmatodella delicatula Ulrich & Bassler; Nehring, Inst. Geol. Bull. 209, 140, pl. 2, fig. 6.

1967 Palmatodella delicatula Ulrich & Bassler; Spasov & Filipovic, Bulgarien Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 69, pl. 2, fig. 13.

- 1967 Palmatodella delicatula Ulrich & Bassler; Wolska, Acta Palaeont. Polonica, 12, 386, pl. 5, figs. 1, 2.
- 1967 Palmatodella delicatula Ulrich & Bassler; Freyer & Zakowa, Acta Geol. Polonica, 17, 111, pl. 1, fig. 3.
- 1968 Palmatodella delicatula Ulrich & Bassler; Mound, J. Paleont., 42, 498, pl. 67, figs. 30, 33, 36.
- 1968 Palmatodella delicatula Ulrich & Bassler; Spasov et al., Inst. Recherch. Geol. Geophys. Bull. 26, 161, pl. 1, fig. 1.
- 1968 Palmatodella delicatula Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 27, pl. 6, fig. 7.
- 1969 Palmatodella delicatula Bassler; Olivieri, Boll. Soc. Paleont. Italiana, 8, 93, pl. 15, figs. 8-10.

Material: 27 specimens.

Remarks: All the specimens are broken but fit into the general concept of P. delicatula with some forms similar to P. orthogonica present. The species is well-known and I have not illustrated it.

Distribution: The species was originally described from Alabama (Ulrich & Bassler, 1926; Huddle, 1968). Elsewhere in North America it has been described from Arkansas (Cooper, 1931; 1935), Arizona (Ethington, 1965), Illinois and Missouri (Scott & Collinson, 1961), Indiana (Huddle, 1934) and Ohio (Bond, 1947). In Canada the species is common in Alberta (Uyeno, 1967; Pollock, 1968; Mound, 1968) and is also present in Ontario (Winder, 1962, 1966). The species is virtually ubiquitous in Europe and is especially common in Germany (Sannemann, 1955; Bischoff, 1956; Bischoff & Ziegler, 1956, 1957; Bischoff, 1957; Ziegler, 1958; Bender, 1958; Stoppel, 1958; Helms, 1959; Zimmermann, 1960; Freyer, 1961; Reichstein, 1961; Schriel & Stoppel, 1965; Freyer, 1965; Meyer, 1965; Zitzmann, 1966; Stoppel & Zscheke, 1966; Freyer, 1968). It has also been reported from Austria (Schönlaub, 1969), Bulgaria (Spasov, 1965), Czechoslovakia (Koverdynsky & Zikmundova, 1966; Zikmundova & Chlupac, 1962), France (Lys & Serre, 1957; Serre &

Lys, 1958; Lys et al., 1961; Boyer et al., 1963), Italy (Manzoni, 1965), Yugoslavia (Spasov & Stevanovic, 1962; Spasov & Filipovic, 1966, 1967; Spasov et al., 1968), Poland (Nehring, 1967; Freyer & Zakowa, 1967; Wolska, 1967), Portugal (Boogaard, 1963) and Spain (Boogaard, 1965).

P. delicatula is also known from Spanish Sahara, Africa (Ethington & Furnish, 1962) and from the Canning Basin (Glenister & Klapper, 1966) and Bonaparte Gulf Basin (Druce, 1969) in Australia.

Range: The species was originally described from the Gassaway Member of the Chattanooga Shale in Tennessee and Alabama (Ulrich & Bassler, 1926; Huddle, 1968). The earliest occurrence is in the basal Frasnian (to I α) (Ziegler, 1958) and the species ranges as high as the uppermost Famennian (to VI) (Helms, 1959; Freyer, 1961; and Nehring, 1967). In the Canning Basin specimens have been recovered from the uppermost Palmatolepis gigas Zone (to I δ) up to the Middle Scaphignathus veliferus Zone (to III β).

PALMATODELLA UNCA Sannemann, 1955

Pl. 10, figs. 10

- 1955 Palmatodella unca Sannemann, Senck. leth., 36, 134, pl. 4, figs. 10, 11.
- 1961 Palmatodella unca Sannemann; Freyer, Freib. Forsch., C-95, 61, pl. 3, fig. 75.
- 1967 Palmatodella unca Sannemann; Nehring, Inst. Geol. Bull. 209, 141, pl. 3, figs. 3, 4.
- 1967 Palmatodella unca Sannemann; Wolska, Acta Palaeont. Polonica, 12, 387, pl. 4, figs. 1, 2.

Material: 2 specimens, CPC 12585 figured.

Locality of figured material: Sample BG 21269, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Description: P. unca is an extremely delicate unit with an elongate anterior bar which is depressed through nearly 90° . The bar dentition is confined to germ denticles which just erupt at the surface. The posterior bar is very short and bears compressed needle-like denticles which are tallest near the apex. No basal cavity is apparent.

Remarks: This is the first record of the species outside Europe. Some specimens in the fauna show transition between P. unca and P. delicatula and they have been placed in P. delicatula.

Distribution: The species was originally described from the early Famennian (to $\text{II}\alpha$) of Germany (Sannemann, 1955). The majority of reports of the species are from Germany (Bischoff & Ziegler, 1956; Ziegler, 1958; Stoppel, 1958; Zimmermann, 1960; Freyer, 1961, 1965; and Stoppel & Zscheded, 1966), but recently it has been reported from Poland (Nehring, 1967; Wolska, 1967) and Austria (Schönlaub, 1969).

Range: The species was originally described from the Famennian (to $\text{II}\alpha$) (Sannemann, 1955). The earliest record of the species is from the late to $\text{I}\gamma$ (Ziegler, 1958). Freyer (1961) gives the range as Frasnian (to $\text{I}\delta$) to late Famennian (to VI). In Poland the species is confined to the early Famennian (Nehring, 1967; Wolska, 1967). In the Canning Basin the two specimens come from the Palmatolepis quadrantinodosa Zone (to $\text{II}\beta$ - to $\text{III}\alpha$).

PALMATODELLA sp. A

Pl. 10, figs. 11

Material: A single specimen, CPC 12586, from Sample BG 19104, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Description: An elongate palmatodellid with a slim anterior bar, a sequence of seven small isolated triangular denticles on the anterior half. The main denticle is massive and leaf-like with anterior and posterior knife-edges. The posterior bar is greatly reduced and consists of three

fused denticles, the largest being the posteriormost. There is a slight lateral projection on the posterior bar. No basal cavity is apparent.

Remarks: This form may be an extreme variant of P. unca. The single specimen comes from the Lower Palmatolepis quadrantinodosa Zone (to II β).

Genus PALMATOLEPIS Ulrich & Bassler, 1926

Type species: Palmatolepis perlobata Ulrich & Bassler, 1926.

PALMATOLEPIS DELICATULA DELICATULA

Branson & Mehl, 1934

Pl. 11, figs. 1a,b

- 1934 Palmatolepis delicatula Branson & Mehl, Univ. Missouri Stud.,
8, 237, pl. 18, figs. 4, 10.
- ? 1951 Palmatolepis marginata Stauffer; Hass, Bull. Amer. Assoc.
Petrol. Geol., 35, 2534, pl. 1, fig. 18.
- ? 1956 Palmatolepis marginata Stauffer; Hass, Ardmore Geol. Soc.
Guide Book, 30, fig. 14.
- ? 1956 Palmatolepis marginata Stauffer; Hass, U.S. Geol. Surv. Prof.
Pap. 286, 17, pl. 4, figs. 25, 26.
- 1957 Palmatolepis marginatus Stauffer; Lys & Serre, Rev. Inst.
Francais Petrol., 804, pl. 11, fig. 4.
- 1960 Palmatolepis (Manticolepis) marginata (Stauffer) var. A; Clark
& Becker, Geol. Soc. Amer. Bull., 71, 1672, pl. 1,
figs. 9, 11.
- 1962 Palmatolepis marginata marginata Stauffer; Ziegler, Hess.
Landesamt Bodenf., Abh., 38, 61, pl. 2, figs. 13-19;
text-fig. 4.
- 1963 Palmatolepis marginata marginata Stauffer; Klapper & Furnish,
Iowa Acad. Sci., 69, fig. 2.2.
- 1965 Palmatolepis delicatula delicatula Branson & Mehl; Bouckaert &

Ziegler, Mem. Expl. Cartes Geol. Minieres Belg., 5, 21,
pl. 2, fig. 4.

- 1966 Palmatolepis delicatula delicatula Branson & Mehl; Glenister &
Klapper, J. Paleont., 40, 807, pl. 95, fig. 17.
- 1967 Palmatolepis delicatula delicatula Branson & Mehl; Clark &
Ethington, Geol. Soc. Amer. Mem. 103, 50, pl. 4, fig. 12.
- 1967 Palmatolepis delicatula delicatula Branson & Mehl; Wolska,
Acta Palaeont. Polonica, 12, 389, pl. 6, figs. 6, 7.
- 1969 Palmatolepis delicatula delicatula Branson & Mehl; Schönlaub,
J. B. Geol. B. A., 112, 306, pl. 2, fig. 6.
- 1968 Palmatolepis marginata marginata Stauffer; Schulze, N. Jb.
Palaeont. Abh., 130, 207, pl. 19, fig. 13.
- 1969 Palmatolepis delicatula delicatula Branson & Mehl; Olivieri,
Boll. Soc. Paleont. Italiana, 8, 97, pl. 11, figs. 6-8b;
pl. 16, figs. 1-3b.

Material: 23 specimens, CPC 12587-12590 figured.

Locality of figured material: Sample BG 19018, Section 1, McWhae
Ridge, Virgin Hills Formation.

Description: A small palmatolepid with a diamond-shaped outline. The
inner platform is triangular, both anterior and posterior margins being
straight. The outer platform is very narrow and begins well posterior
to the inner platform. The ornament consists of virtually smooth
"shagreen" ridges. The free blade is low formed of denticles of equal
height. It fuses with the carina which decreases in height towards the
azygous node. Posterior to the azygous node the carina is short and
decreases in height, disappearing about halfway to the posterior termina-
tion.

Remarks: The virtually unornamented platform and the straight anterior
inner platform margin set the nominate subspecies apart from P.
delicatula clarki.

Distribution: The species was originally described from Missouri (Branson & Mehl, 1934). It has also been reported from Arkansas (Hass, 1951, 1956), Tennessee (Hass, 1956), Iowa (Klapper & Furnish, 1963), and Nevada (Clark & Ethington, 1967). In Europe the species is common in Germany (Bischoff & Ziegler, 1956; Ziegler, 1962; Wachendorf, 1966; Zitzmann, 1967; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970). It has also been reported from Austria (Schulze, 1968), Belgium (Bouckaert & Ziegler, 1965), France (Lys & Serre, 1957), Italy (Olivieri, 1969), and Poland (Freyer & Zakowa, 1967; Wolska, 1967). Glenister & Klapper (1966) have illustrated the species from the Canning Basin, Australia.

Range: The species was originally described from the Grassy Creek Shale of Missouri (Branson & Mehl, 1934). Collinson et al. (1962) consider that the Grassy Creek is of early Famennian (to II - to III) age. Bischoff & Ziegler (1956) record the species from late Famennian (to V) strata but they do not illustrate any specimens so there is some doubt about the identification. Ziegler (1962) records the species from the Middle Palmatolepis triangularis Zone, but in Table 2 he shows the species ranging into the earliest Palmatolepis crepida Zone, a range similar to that recorded by Wolska (1967) from Poland. In the Canning Basin the range is identical, Middle Palmatolepis triangularis Zone as high as the Lower Palmatolepis crepida Zone. This range was also recorded by Glenister & Klapper (1966).

PALMATOLEPIS DISTORTA Branson & Mehl, 1934

Pl. 11, figs. 3a,b

- 1934 Palmatolepis distorta Branson & Mehl, Univ. Missouri Stud., 8, 237, pl. 18, figs. 13, 14.
- 1934 Palmatolepis pectenifera Huddle, Bull. Amer. Paleont., 21, 107, pl. 9, figs. 6, 7.

- 1955 Palmatolepis distorta Branson & Mehl; Sannemann, N. Jb. Geol. Palaont., Abh., 100, 326, pl. 24, fig. 24.
- 1956 Palmatolepis distorta Branson & Mehl; Hass, U.S. Geol. Surv. Prof. Pap. 286, 19, pl. 2, fig. 1.
- 1956 Palmatolepis (Palmatolepis) distorta Branson & Mehl; Müller, Abh. Senck. Naturf. Ges. 494, 26, pl. 7, figs. 20, 21.
- 1957 Palmatolepis distorta Branson & Mehl; Ziegler in Flügel & Ziegler, Naturw. Ver. Steiermark, Mitt., 57, pl. 1, fig. 5.
- 1959 Palmatolepis distorta Branson & Mehl; Helms, Geologie, 8, 674, pl. 5, fig. 24.
- non 1960 Palmatolepis (Palmatolepis) distorta Branson & Mehl; Clark & Becker, Geol. Soc. Amer. Bull., 71, 1669, pl. 2, figs. 2, 6 - 8.
- 1962 Palmatolepis distorta Branson & Mehl; Ziegler, Hess Landesamt Bodenf., Abh., 38, 57, pl. 5, figs. 8-13.
- 1963 Palmatolepis (Panderolepis) distorta distorta Branson & Mehl; Helms, Geologie, 12, text-fig. 2.26.
- 1963 Palmatolepis distorta Branson & Mehl; Abdusselamoglu, Bull. Miner. Res. Expl. Inst. Turkey, 60, 4, pl. 1, fig. 6.
- non 1965 Palmatolepis (Panderolepis) distorta (Branson & Mehl); Spasov, Acad. Bulg. Sci., Trav. Geol. Bulgarie, Ser. Paleont., 7, 93, pl. 2, fig. 11.
- 1966 Palmatolepis distorta Branson & Mehl; Spasov, Acad. Bulg. Sci., Bull. "Strasimir Dimitrov" Inst. Geol., 15, 96, pl. 1, fig. 9.
- 1966 Palmatolepis distorta Branson & Mehl; Glenister & Klapper, J. Paleont., 40, 809, pl. 89, fig. 8; pl. 91, figs. 2, 4.
- ? 1967 Palmatolepis distorta Branson & Mehl; N. Jb. Geol. Palaont. Abh., 127, 219, pl. 21, fig. 14.
- 1967 Palmatolepis distorta Branson & Mehl; Spasov & Filipovic, Acad. Bulg. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 69, pl. 3, fig. 3-5.

- 1967 Palmatolepis distorta Branson & Mehl; Kodsi, N. Jb. Geol. Palaont., Monats., 27, 421, pl. 6, fig. 1.
- 1967 Palmatolepis distorta Branson & Mehl; Nehring, Inst. Geol. Bull., 209, 145, pl. 1, fig. 4.
- 1967 Palmatolepis distorta Branson & Mehl; Wolska, Acta. Palaeont. Polonica, 19, 390, pl. 8, figs. 11, 12.
- 1967 Palmatolepis distorta Branson & Mehl; Boogaert, Leidse Geol. Med., 39, 182, pl. 2, fig. 24.
- 1968 Palmatolepis distorta Branson & Mehl; Schulze, N. Jb. Geol. Palaont., Abh., 130, 206, pl. 19, fig. 14.
- 1969 Palmatolepis distorta Branson & Mehl; Olivieri, Boll. Soc. Paleont. Italiana, 8, 98, pl. 17, figs. 5-7.

Material: 3 specimens, CPC 12591 figured.

Locality of figured material: Sample 19095, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: Ziegler (1962) and Glenister & Klapper (1966) all point out that the distinguishing feature of this species is the convex nature of the anterior inner platform and this separates the species from P. glabra pectinata.

Distribution: The species was originally described from the Grassy Creek Shale of Missouri (Branson & Mehl, 1934). Other occurrences of the species in North America are reported from Indiana (Huddle, 1934), Tennessee (Hass, 1956) and New York (Oliver et al., 1967).

The species is common in Europe and has been reported extensively from Germany (Sannemann, 1955; Bischoff & Ziegler, 1956; Bender, 1958; Walliser, 1958; Helms, 1959, 1963; Kronberg et al., 1960; Ziegler, 1962; Henningsen, 1965; Meyer, 1965; Zitzmann, 1966; Wachendorf, 1966; Bering, 1967; Lutzens, 1967; Meischner & Schneider, 1967; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970).

Elsewhere in Europe it has been reported from Austria (Ziegler in

Flügel & Ziegler, 1957; Kodosi, 1967; Schulze, 1968; and Schönlaub, 1969), Bulgaria (Spasov, 1965, 1966), Czechoslovakia (Zikmundova & Chlupac, 1962), Italy (Manzoni, 1965; Olivieri, 1969), Yugoslavia (Spasov & Filipovic, 1967), Poland (Freyer & Zakowa, 1967; Nehring, 1967; Wolska, 1967), Portugal (Boogaard, 1963), and Spain (Budinger & Kullmann, 1964; Wirth, 1967; and Boogaert, 1967).

The only other recorded occurrences of the species are in Turkey (Abudusselamoglu, 1963) and the Canning Basin, Australia (Glenister & Klapper, 1966).

Range: The species was originally described from the early Famennian Grassy Creek Shale of Missouri (Branson & Mehl, 1934). Ziegler (1962) gives the range as Lower Palmatolepis quadrantinodosa Zone (to II β) to Lower Scaphignathus veliferus Zone (to III α). Helms (1963) shows the species ranging from the late to II into the to III β . Wirth (1967) gives the same range as Ziegler but Nehring (1967) suggests that the species may range into to III β strata, i.e., the Middle Scaphignathus veliferus Zone. In the Canning Basin the species is known only from the Lower Palmatolepis quadrantinodosa Zone (to II β).

PALMATOLEPIS FOLIACEA Youngquist, 1945

Pl. 11, figs. 2a, b

- 1945 Palmatolepis foliaceus Youngquist, J. Paleont., 19, 364, pl. 56, figs. 11, 12.
- 1957 Palmatolepis foliacea (Youngquist); Müller & Müller, J. Paleont., 31, 1102, pl. 140, figs. 6-9.
- 1958 Palmatolepis foliacea Youngquist; Ziegler, Hess. Landesamt Bodenf., Notizbl., 87, 59, pl. 7, figs. 8, 16.
- non 1960 Palmatolepis (Manticolepis) foliacea (Youngquist); Clark & Becker, Bull. Geol. Soc. Amer., 71, 1670, pl. 1, fig. 13 (= P. hassi)
- 1962 Palmatolepis foliacea Youngquist; Ziegler, N. Jb. Geol. Paläont., Abh., 114, 166, text-fig. 8 (centre left).

- 1963 Palmatolepis (Manticolepis) foliacea (Youngquist); Helms,
 Geologie, 12, 456, text-fig. 2.5.
- 1966 Palmatolepis foliacea (Youngquist); Anderson, J. Paleont., 407,
 408, pl. 48, fig. 7, 8.
- 1967 Palmatolepis foliacea Youngquist; Clark & Ethington, Geol.
 Soc. Amer. Mem. 103, 51, pl. 8, figs. 3, 14.

Material: 8 specimens, CPC 12592-12595 figured.

Locality of figured material: Samples BG 21104, 21108, north face of Lawford Range, 2 miles east of Galeru Gorge, Virgin Hills Formation.

Description: A pear-shaped palmatolepid with the inner platform slightly larger than the outer platform. Both platforms are ornamented with sparse nodes which are more conspicuous towards the platforms' margins.

The free blade fuses with the carina and consists of laterally compressed fused denticles with free chevron tips; they number about twenty. They are of about equal height but the posteriormost four denticles decrease in height rapidly toward the azygous node. The azygous node is low, circular, and needle-tipped; the nodes of the posterior carina are similar type and extend about half the distance to the posterior termination.

Distribution: The species was originally described from Iowa (Youngquist, 1945). It has been reported extensively from Iowa (Müller & Müller, 1957; Klapper & Furnish, 1963; Anderson, 1966); the only other record from North America is from Nevada and Utah (Clark & Ethington, 1967). In Europe the species has been reported extensively from Germany (Ziegler, 1958, 1962; Helms, 1963; Krebs & Rabien, 1964; Schriel & Stoppel, 1965; Wachendorf, 1966; Lutzens, 1967; Bar, 1968; Schneider, 1969) but it has not been reported from the remainder of Europe.

Glenister & Klapper (1966) record one specimen from the

Canning Basin. The species appears to be restricted in its distribution.

Range: The species was originally described from the Frasnian Independence Shale of Iowa (Youngquist, 1945; Müller & Müller, 1957). It is also present in the late Frasnian Carro Gordo Member of the Lime Creek Formation (Anderson, 1966). Ziegler (1958) gives the range as being confined to the late to I Zone of the Frasnian as does Helms (1963). Ziegler (1962) extends the range down to include the early to I δ Zone and Clark & Ethington (1967) give the range as Ancyrognathus triangularis and Lower Palmatolepis gigas Zone.

The Canning Basin specimen comes from the Lower Palmatolepis gigas Zone.

PALMATOLEPIS GIGAS Miller & Youngquist, 1947

Pl. 12, figs. 1a,b

- 1926 Palmatolepis perlobata (part) Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 49, pl. 7, fig. 23 only.
- 1934 Palmatolepis perlobata Ulrich & Bassler; Branson & Mehl; Univ. Missouri Stud., 8, 234, pl. 18, fig. 24.
- 1947 Palmatolepis gigas Miller & Youngquist, J. Paleont., 21, 512, pl. 75, fig. 1.
- 1956 Palmatolepis rhenana Bischoff, Hess. Landesamt Bodenf., Notizbl., 84, 129, pl. 8, figs. 26-28, 30; pl. 10, fig. 7.
- 1956 Palmatolepis (Manticolepis) prominens Müller, Senck. Naturf. Ges., Abh., 494, 22, pl. 5, figs. 25, 26, 28-30.
- 1956 Palmatolepis (Manticolepis) nasuta Müller, ibid., 23, pl. 6, figs. 31-35.
- 1956 Palmatolepis subrecta Miller & Youngquist; Hass, U.S. Geol. Surv. Prof. Pap. 286, 19, pl. 3, fig. 14; pl. 4, figs. 14, 15.
- 1957 Palmatolepis (Manticolepis) amana Müller & Müller, J. Paleont., 31, 1101, pl. 140, fig. 5.

- 1957 Palmatolepis (Manticolepis) flabelliformis Stauffer; Müller & Müller, ibid., 1101, pl. 139, fig. 3-6.
- 1958 Palmatolepis rhenana Bischoff; Ziegler, Hess. Landesamt Bodenf., Notizbl., 87, 63, pl. 4, fig. 15, 16; pl. 5, figs. 1-10; pl. 6, figs. 1-3, 7; pl. 8, fig. 20.
- 1963 Palmatolepis (Manticolepis) rhenana (Bischoff); Helms, Geologie, 12, text-fig. 2.11.
- 1965 Palmatolepis gigas Miller & Youngquist; Ethington, J. Paleont., 39, 579, pl. 68, figs. 14, 16.
- 1966 Palmatolepis gigas Miller & Youngquist; Anderson, J. Paleont., 40, 408, pl. 49, figs. 1, 2, 4-10, 16, 20.
- 1966 Palmatolepis gigas Miller & Youngquist; Glenister & Klapper, J. Paleont., 40, 810, pl. 88, fig. 12.
- 1966 Palmatolepis (Manticolepis) rhenana Bischoff; Koverdynsky & Zikmundova, Vestnik U.U.G., 42, 369, pl. 1, fig. 1, 2.
- 1966 Palmatolepis gigas Miller & Youngquist; Winder, J. Paleont., 40, 1281, pl. 156, fig. 11.
- 1967 Palmatolepis gigas Miller & Youngquist; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 51, pl. 4, fig. 19.
- 1967 Palmatolepis gigas Miller & Youngquist; Boogaert, Leidse Geol. Med., 39, 182, pl. 2, fig. 27.
- 1968 Palmatolepis gigas Miller & Youngquist; Mound, J. Paleont., 42, 499, pl. 68, fig. 1-3, 6.
- 1970 Palmatolepis gigas Miller & Youngquist; Seddon, J. Geol. Soc. Aust., 16, 753, pl. 16, fig. 9.

Material: 14 specimens, CPC 12612-12615 figured.

Localities of figured material: Samples BG 19014, 19016, Section 1, McWhae Ridge, Virgin Hills Formation; Sample 19451A, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; BG 21108, 2 miles northeast of Galeru Gorge, Virgin Hills Formation.

Description: A palmatolepid with a prominent lateral lobe. The inner platform is extended as a long distinct lateral lobe, the axis of which is anterior to the azygous node. The outer platform is narrow with a sigmoidal margin. The anterior-free blade merges with the carina; they are composed of about 25 fused needle-like denticles which are tallest near the anterior termination, decreasing rapidly in height anteriorly and slowly posteriorly to the azygous node. The azygous node is isolated and circular in cross-section. The posterior carina is composed of nodes similar to the azygous node but smaller, decreasing in size posteriorly until they merge with the scattered nodose ornament of the platform. The overall form of the carina is sigmoidal. In some specimens (Pl. 12, fig. 1a) a lateral carina is present; it extends about half the distance to the lateral lobe termination.

Remarks: P. gigas is closely similar to P. subrecta but the elongate lateral lobe serves to distinguish it from P. subrecta.

Distribution: The species was originally described from the Sweetland Creek Shale (Frasnian) of Iowa (Miller & Youngquist, 1947), although it had already been illustrated from the "Hardin sandstone" of Tennessee (Ulrich & Bassler, 1926; Huddle, 1968) and the Grassy Creek shale of Missouri (Branson & Mehl, 1934). It has been reported from other localities in Iowa (Klapper & Furnish, 1963; Anderson, 1966) and from Arizona (Ethington, 1965), New York (Oliver et al., 1967), Utah (Clark & Ethington, 1967) and from Alberta (Mound, 1968), and Ontario (Winder, 1966) in Canada.

In Europe the majority of occurrences are in Germany (Bischoff, 1956; Ziegler, 1958; Walliser, 1958; Helms, 1963; Krebs & Rabien, 1964; Schriel & Stoppel, 1965; Stoppel & Zscheke, 1966; Wachendorf, 1966; Lutzens, 1967; Schneider, 1969). Elsewhere in Europe it is known from Austria (Schönlau, 1969), Belgium (Bouckaert & Ziegler, 1965), Czechoslovakia (Koverdynsky & Zikmundova, 1966) and Spain (Boogaert, 1967).

Both Glenister & Klapper (1966) and Seddon (1970) have recorded the species in the Canning Basin.

Range: The species was originally described from the Frasnian Sweetland Creek Shale of Iowa (Miller & Youngquist, 1947). Ziegler (1958, 1962) gives a range of late to I⁸ (Lower Palmatolepis gigas Zone) into the to I⁶ (Lower Palmatolepis triangularis Zone). This range is confirmed by Helms (1963). In the Canning Basin the species has an identical range of Lower Palmatolepis gigas Zone into the lower part of the Lower Palmatolepis triangularis Zone.

PALMATOLEPIS GLABRA GLABRA

Ulrich & Bassler, 1926

Pl. 11, figs. 4a, b

- 1926 Palmatolepis glaber (sic) Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 51, pl. 9, fig. 20.
- 1934 Palmatolepis glabra Ulrich & Bassler; Branson & Mehl, Univ. Missouri Stud., 8, 233, pl. 18, figs. 9, 26.
- ? 1947 Palmatolepis glabra Ulrich & Bassler; Bond, Ohio J. Sci., 47, 33, pl. 2, fig. 25.
- 1955 Palmatolepis glabra Ulrich & Bassler; Sannemann, Senck. leth., 36, 135, pl. 1, fig. 4.
- 1956 Palmatolepis (Palmatolepis) glabra Ulrich & Bassler; Müller, Senck. Naturf. Ges. Abh., 494, 25, pl. 7, figs. 8-10, 13, 14.
- 1956 Palmatolepis glabra Ulrich & Bassler; Bischoff, Hess. Landesamt Bodenf., Notizbl., 84, 128, pl. 8, figs. 34, 35.
- 1956 Palmatolepis glabra Ulrich & Bassler; Hass, U.S. Geol. Surv. Prof. Pap. 286, pl. 3, figs. 15-17.
- 1957 Palmatolepis glabra Ulrich & Bassler; Hass in Cloud et al., Geol. Soc. Amer. Bull., 68, pl. 4, fig. 6.

- 1959 Palmatolepis glabra Ulrich & Bassler α morphotype Scott & Collinson, J. Paleont., 33, 559, pl. 75, figs. 1-5.
- 1959 Palmatolepis glabra Ulrich & Bassler β morphotype Scott & Collinson, ibid., pl. 75, figs. 6, 7, 9.
- 1960 Palmatolepis glabra glabra Ulrich & Bassler; Ziegler, Fortschr. Geol. Rheinld Westf., 6, 7, pl. 1, figs. 11-13.
- 1961 Palmatolepis glabra Ulrich & Bassler; Lys et al., Rev. Inst. Francais Petrole, 16, 548, pl. 3, fig. 1.
- 1963 Palmatolepis glabra Branson & Mehl (sic); Abdusselamoglu, Bull. Min. Res. Expl. Inst. Turkey, 60, 4, pl. 1, fig. 4.
- 1963 Palmatolepis (Panderolepis) serrata (Hinde) subsp. a Helms, Geologie, 12, 478, pl. 1, fig. 2; text-fig. 2.
- 1965 Palmatolepis glabra glabra Ulrich & Bassler; Freyer, Abh. Berich. Naturk. Mus. Gorlitz, 40, V/9, text-fig. 1.1.
- 1965 Palmatolepis glabra glabra Ulrich & Bassler; Bouckaert & Ziegler, Mem. Expl. Cartes. Geol. Min. Belg., 5, 23, pl. 3, fig. 8.
- 1966 Palmatolepis glabra glabra Ulrich & Bassler; Glenister & Klapper, J. Paleont., 40, 811, pl. 89, figs. 6, 7; pl. 90, fig. 3.
- 1966 Palmatolepis glabra glabra Ulrich & Bassler; Spasov & Filipovic, Geol. glasnik, 11, 45, pl. 3, figs. 4, 5.
- 1967 Palmatolepis glabra glabra Ulrich & Bassler; Wirth, N. Jb. Geol. Palaont. Abh., 127, 219, pl. 21, fig. 2.
- 1967 Palmatolepis glabra Ulrich & Bassler; Nehring, Inst. Geol. Bull. 209, 146, pl. 3, figs. 6a, b.
- 1967 Palmatolepis glabra glabra Ulrich & Bassler; Boogaert, Leidse Geol. Med., 39, 182, pl. 2, fig. 25.
- 1967 Palmatolepis glabra glabra Ulrich & Bassler; Wolska, Acta Palaeont. Polonica, 12, 390, pl. 7, figs. 8-12b; text-fig. 7.
- 1967 Palmatolepis glabra glabra Ulrich & Bassler; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 51, pl. 9, fig. 8.

- 1968 Palmatolepis glabra Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 29, pl. 14, figs. 2-16.
- 1968 Palmatolepis glabra glabra Ulrich & Bassler; Spasov et al., Inst. Recherch. Geol. Geophys. Bull., 26, 162, pl. 2, fig. 15.
- 1968 Palmatolepis glabra glabra Ulrich & Bassler; Manzoni, G. Geol. 34, 661, pl. 62, fig. 10.
- 1969 Palmatolepis glabra glabra Ulrich & Bassler; Olivieri, Boll. Soc. Paleont. Italiana, 8, 100, pl. 17, figs. 1-4.

Material: 80 specimens, CPC 12596-12599 figured.

Localities of figured material: Sample BG 19019, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19072, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21261, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Remarks: The outer platform parapet is the diagnostic character of the nominate subspecies. In P. glabra pectinata the parapet is elongate and reaches to the azygous node. In P. glabra elongata the parapet is restricted to the anterior part and is relatively more elevated; when this elevation becomes triangular the specimens are referred to P. glabra acuta. The parapet on the nominate subspecies is low and of medium length. The relationships of P. serrata (Hinde) and P. glabra are discussed by Huddle (1968, p. 30).

Distribution: The species was originally described from the "Hardin sandstone" of Tennessee (Ulrich & Bassler, 1928; Huddle, 1968). It has also been reported from Missouri (Branson & Mehl, 1934) and Nevada (Clark & Ethington, 1967).

The species is very common in Europe and has been reported extensively from Germany (Sannemann, 1955; Müller, 1956; Bischoff, 1956; Bischoff & Ziegler, 1956; Ziegler, 1960; Kronberg et al., 1960; Ziegler, 1962; Helms, 1963; Freyer, 1965; Wachendorf, 1966; Bering, 1967; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970). It

has also been reported from Austria (Ziegler in Flügel & Ziegler, 1957; and Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), Czechoslovakia (Koverdynsky & Zikmundova, 1962), France (Lys et al., 1961; Boyer et al., 1968), Italy (Manzoni, 1965, 1968; Olivieri, 1969), Yugoslavia (Spasov & Filipovic, 1966; Spasov et al., 1968), Poland (Nehring, 1967; Wolska, 1967), Portugal (Boogaard, 1963), and Spain (Wirth, 1967; Boogaert, 1967).

Elsewhere the species has been reported from Morocco (Massa, 1965), Turkey (Abdusselamoglu, 1963) and Australia (Glenister & Klapper, 1966).

Range: The original description of the species was from the "Hardin sandstone" which is of problematical age. The only accurately dated occurrence in North America is from the Palmatolepis rhomboidea Zone (early to II β). Ziegler (1962) records the range as Lower Palmatolepis quadrantinodosa Zone (late to II β) up to the Upper Scaphignathus veliferus Zone (to III β - IV). However, it seems that the species can range as low as the Upper Palmatolepis crepida Zone (late to II α) (Wirth, 1967; Wolska, 1967; Boyer et al., 1968).

In the Canning Basin the species ranges from the Upper Palmatolepis crepida Zone (late to II α) as high as the Middle Scaphignathus veliferus Zone (to III β).

PALMATOLEPIS GLABRA ACUTA Helms, 1963

Pl. 16, figs. 4a,b

- 1960 Palmatolepis (Palmatolepis) distorta Clark & Becker, Geol. Soc. Amer. Bull., 71, 1669, pl. 2, fig. 8.
- 1962 Palmatolepis glabra n. subsp. A Ziegler, Hess. Landesamt. Bodenf. Abh., 38, 59, pl. 5, figs. 1, 2.
- 1963 Palmatolepis (Panderolepis) serrata acuta Helms, Geologie, 12, 468, pl. 3, figs. 1-4, 6.

- 1967 Palmatolepis glabra n. subsp. A Ziegler; Clark & Ethington,
 Geol. Soc. Amer. Mem., 103, 52, pl. 4, fig. 18.
- 1967 Palmatolepis glabra acuta Helms; Wolska, Acta Palaeont.
 Polonica, 12, 394, pl. 8, figs. 13, 14; text-fig. 10.
- 1969 Palmatolepis glabra acuta Helms; Olivieri, Boll. Soc. Paleont.
 Italiana, 8, 101, pl. 17, figs. 8, 9.

Material: 6 specimens, CPC 12607, 12608 figured.

Locality of figured material: Sample BG 21267, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Remarks: The subspecies is easily distinguished from P. glabra elongata by the upright triangular parapet on the outer margin. In some specimens the parapet is not conspicuously triangular but the outer platform is always wider at the anterior termination than it is at the posterior termination of the parapet.

Distribution: The subspecies was originally described from Germany (Helms, 1963) (see also Bar (1960), Schneider (1969)), and has been reported from Poland (Freyer & Zakowa, 1967; Wolska, 1967) and Italy (Manzoni, 1965; Olivieri, 1969). The only reference to the species in North America is from Nevada (Clark & Becker, 1960; Clark & Ethington 1967).

Range: The subspecies was originally described from Famennian to III strata (Helms, 1963). Ziegler (1962b) gives the range as Palmatolepis rhomboidea Zone (to II β) up to Lower Palmatolepis quadrantinodosa Zone (late to II β). Wolska (1967) records the species in the Palmatolepis quadrantinodosa Zone and Clark & Ethington report it from the Palmatolepis rhomboidea Zone. In the Canning Basin the specimens occur in samples from the boundary between the Lower and Upper Palmatolepis quadrantinodosa Zones.

PALMATOLEPIS GLABRA ELONGATA Holmes, 1928

Pl. 11, figs. 7a,b

- 1928 Palmatolepis elongata Holmes, Proc. U.S. Nat. Mus., 72, 33,
pl. 11, fig. 13.

For complete synonymy up to 1966 see:

- 1969 Palmatolepis glabra elongata Holmes; Druce, Bur. Miner. Res.
Austral. Bull. 98, 87, pl. 17, fig. 9.
- 1967 Palmatolepis glabra elongata Holmes; Wirth, N. Jb. Geol.
Palaont. Abh., 127, 220, pl. 21, figs. 5, 6.
- 1967 Palmatolepis glabra elongata Holmes; Spasov & Filipovic,
Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16,
69, pl. 3, figs. 1, 2.
- 1967 Palmatolepis glabra elongata Holmes; Boogaert, Leidse Geol.
Med., 39, 182, pl. 2, fig. 26.
- 1967 Palmatolepis glabra elongata Holmes; Freyer & Zakowa, Acta.
Geol. Polonica, 17, 111, pl. 2, fig. 7.
- 1967 Palmatolepis glabra elongata Holmes; Wolska, Acta Palaeont.
Polonica, 12, 391, pl. 8, figs. 1-5, text-fig. 8.
- 1969 Palmatolepis glabra elongata Holmes; Olivieri, Boll. Soc.
Paleont. Italiana, 8, 102, pl. 19, figs. 9a - 11.

Material: 10 specimens, CPC 12600-12602 figured.

Localities of figured material: Sample BG 21014, Section 14, 2 miles northwest of Pinnacle Spring, Virgin Hills Formation; Sample BG 21267, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Remarks: The distinctive parapet on the outer platform of this subspecies was mentioned under the nominate subspecies. The unit is also distinguished by being slimmer than the other subspecies apart from P. glabra acuta.

Distribution: The subspecies was originally described from the Famennian Chatanooga Shale of Alabama (Holmes, 1928). Elsewhere in North America it has been reported from Arkansas (Cooper, 1935; Hass, 1951), Indiana (Huddle, 1934), and Nevada (Clark & Ethington, 1965).

In Europe the subspecies has been reported extensively from Germany (Walliser, 1958; Helms, 1959; Kronberg et al., 1960; Ziegler, 1960, 1962; Freyer, 1965; Bering, 1967; Meischner & Schneider, 1967, 1970; Dvorak & Freyer, 1968; Bar, 1968; Schneider, 1969). It has also been reported from Austria (Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), Czechoslovakia (Koverdynsky & Zikmundova, 1962), France (Boyer et al., 1968), Italy (Manzoni, 1965, 1968; Forti & Nocchi, 1963; Olivieri, 1969) including Sardinia (Olivieri, 1965), Yugoslavia (Spasov & Filipovic, 1967), Poland (Freyer & Zakowa, 1967; Wolska, 1967), Portugal (Boogaard, 1963), and Spain (Wirth, 1967; Boogaert, 1967).

The subspecies is also known from Morocco (Massa, 1965) and Australia (Glenister & Klapper, 1966; Druce, 1969).

Range: The subspecies was originally described from an unknown horizon in the Chattanooga Shale. The species has been recorded from the Palmatolepis rhomboidea Zone (early to II β). Ziegler (1962) records the species from the Lower Palmatolepis quadrantinodosa Zone up to the Upper Scaphignathus veliferus Zone, and this range is also recorded by Wirth (1967). However, Boyer et al. (1968) record the species in the late to II α Zone of the Montagne Noir of France.

In the Canning Basin the species ranges from the Palmatolepis rhomboidea Zone as high as the Lower Polygnathus styriacus Zone (to IV).

PALMATOLEPIS GLABRA PECTINATA Ziegler, 1962

Pl. 11, figs. 6a,b

- 1962 Palmatolepis glabra pectinata Ziegler, Hess. Landesamt Bodenf. Abh., 38, 59, pl. 4, fig. 16; pl. 5, figs. 3-5.
For complete synonymy to 1966 see:
- 1969 Palmatolepis glabra pectinata Ziegler; Druce, Bur. Miner. Res. Austral. Bull. 98, 87, pl. 17, figs. 7, 8; pl. 18, figs. 1a-3.
- 1966 Palmatolepis glabra pectinata Ziegler, Glenister & Klapper, J. Paleont., 40, 814, pl. 89, figs. 1-3, 5, 9, 10; pl. 90, figs. 4, 5; pl. 91, figs. 1, 3, 5.
- 1967 Palmatolepis glabra pectinata Ziegler; Wirth, N. Jb. Geol. Palaont. Abh., 127, 220, pl. 21, figs. 3, 4.
- 1967 Palmatolepis glabra pectinata Ziegler; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 52, pl. 4, fig. 8.
- non 1967 Palmatolepis glabra pectinata Ziegler; Freyer & Zakowa, Acta Geol. Polonica, 17, 137, pl. 2, fig. 8 (= P. glabra s.s.)
- 1967 Palmatolepis glabra pectinata Ziegler; Wolska, Acta Palaeont. Polonica, 12, 392, pl. 8, figs. 6-9; text-fig. 9.
- 1968 Palmatolepis glabra pectinata Ziegler; Manzoni, G. Geol., 34, 662, pl. 62, figs. 8, 9.
- 1968 Palmatolepis glabra pectinata Ziegler; Schulze, N. Jb. Geol. Palaont. Abh., 130, 207, pl. 19, fig. 10.
- 1969 Palmatolepis glabra pectinata Ziegler; Olivieri, Boll. Soc. Paleont. Italiana, 8, 103, pl. 17, figs. 10-136.

Material: 154 specimens, CPC 12603-12606 figured.

Localities of figured material: Samples BG 19083, 19102, 19108, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone; Sample BG 21361, Section 23, Geikie Gorge, Napier Formation.

Remarks: This subspecies is easily recognised by the elongate outer platform parapet. One specimen (Pl. 11, figs. 6a,b) has a sigmoidal outline and is fairly narrow. It is a variant not illustrated by Scott & Collinson (1959).

Distribution: The subspecies was originally described from Germany (Ziegler, 1962a) where it has been extensively recorded (Sannemann, 1955; Zimmermann, 1960; Freyer, 1961, 1965; Ziegler, 1962b; Helms, 1963; Wachendorf, 1966; Meischner & Schneider, 1967, 1970; Bering, 1967; Dvorak & Freyer, 1968; Bar, 1968; Schneider, 1969). Elsewhere in Europe the species has been recorded from Austria (Kodsi, 1967; Schulze, 1968; Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), Italy (Manzoni, 1968; Olivieri, 1969), Spain (Wirth, 1967), and Poland (Freyer & Zakowa, 1967; Wolska, 1967).

In North America the subspecies is reported by Scott & Collinson (1959) from Illinois and by Clark & Ethington (1967) from Nevada. Winder (1966) has recorded the species from Ontario, Canada.

Range: The subspecies was originally described from the upper Cheiloceras - Stufe of Germany (Ziegler, 1962a) and the range was given as Upper Palmatolepis crepida Zone (latest to II α) as high as Upper Palmatolepis quadrantinodosa Zone (lowest to III α).

This range is extended into the Scaphignathus veliferus Zone by Wolska (1967). The species occurs in the Palmatolepis rhomboidea Zone in North America (Clark & Ethington, 1967). In the Canning Basin the species ranges from the Palmatolepis rhomboidea Zone as high as the Middle Scaphignathus veliferus Zone.

PALMATOLEPIS GRACILIS GRACILIS

Branson & Mehl, 1934

Pl. 11, figs. 5a,b

- 1934 Palmatolepis gracilis Branson & Mehl, Univ. Missouri Stud., 8, 238, pl. 18, figs. 2, 8 (non fig. 5).
- 1962 Palmatolepis gracilis Branson & Mehl; Mehl & Ziegler, J. Sci. Lab., Denison Univ., 45, 200, pl. 1, figs. 1a-2b.
(complete synonymy up to 1962)
- For complete synonymy from 1962 to 1965 see:
- 1969 Palmatolepis gracilis gracilis Branson & Mehl; Druce, Bur. Miner. Resour. Austral. Bull. 98, 88, pl. 17, figs. 3a - 5b.
- 1966 Palmatolepis gracilis gracilis Branson & Mehl; Glenister & Klapper, J. Paleont., 40, 814, pl. 90, fig. 6.
- 1967 Palmatolepis gracilis Branson & Mehl; Wirth, N. Jb. Geol. Palaont. Abh., 127, 221, pl. 2, fig. 1.
- 1967 Palmatolepis gracilis gracilis Branson & Mehl; Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geo. Inst. Ser. Paleont., 16, 70, pl. 2, figs. 7, 8; pl. 3, figs. 19, 20.
- 1967 Palmatolepis gracilis deflectens Müller; Spasov & Filipovic, ibid., pl. 1, fig. 7.
- 1967 Palmatolepis gracilis gracilis Branson & Mehl; Boogaert, Leidse Geol. Med., 39, 182, pl. 2, figs. 28, 29.
- 1967 Palmatolepis deflectens deflectens Müller; Freyer & Zakowa, Acta Geol. Polonica, 17, 126, pl. 2, fig. 3.
- 1967 Palmatolepis gracilis Branson & Mehl; Wolska, Acta Palaeont. Polonica, 12, pl. 11, figs. 1-5.
- 1968 Palmatolepis gracilis Branson & Mehl; Schulze, N. Jb. Geol. Palaont. Abh., 130, 207, pl. 19, fig. 16.
- 1969 Palmatolepis gracilis gracilis Branson & Mehl; Matthews, Paleontology, 12, 269, pl. 47, fig. 9.

1969 *Palmatolepis gracilis gracilis* Branson & Mehl; Olivieri, Boll. Soc. Paleont. Italiana, 8, 104, pl. 20, figs. 6, 7.

Material: 10 specimens, CPC 12609 - 12611 figured.

Localities of figured material: Samples BG 19171, 19173, 19182, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone and Piker Hills Formation.

Remarks: A palmatolepid with a greatly reduced platform centered around the azygous node. The blade is relatively high and free.

Distribution: The species was originally described from Missouri (Branson & Mehl, 1934). It has also been recorded from Wyoming (Klapper, 1958). In Europe the great number of reports of the species from Germany have been listed by Mehl & Ziegler (1962). Elsewhere it has been reported from Austria (Ziegler in Flügel & Ziegler, 1957; Schulze, 1968; Schönlaub, 1969), Bulgaria (Spasov, 1965), England (Matthews, 1969), Italy (Manzoni, 1965, 1968; Olivieri, 1969), Yugoslavia (Spasov & Filipovic, 1967), Poland (Freyer & Zakowa, 1967; Wolska, 1967), and Spain (Boogaert, 1967; Wirth, 1967).

The species has been reported from both the Bonaparte Gulf Basin (Druce, 1969) and the Canning Basin (Glenister & Klapper, 1966) in Australia.

Range: The species was originally described from the Famennian Grassy Creek Shale of Missouri (Branson & Mehl, 1934). Ziegler (1962) gives the German range as *Palmatolepis rhomboidea* Zone (early to II β) up to the Upper *Spathognathodus costatus* Zone (to VI). The only extension of the range is by Matthews (1969) who records the species in a Lower Carboniferous fauna but he (p. 266) states that "the limits of occurrence seen in the Upper Devonian by Ziegler can be accepted as real."

In the Canning Basin the species ranges from the Upper *Palmatolepis quadrantinodosa* Zone (to III α) into the Middle *Polygnathus styriacus* Zone (to V).

PALMATOLEPIS HASSI Müller & Müller, 1957

Pl. 12, figs. 2a,b

- 1957 Palmatolepis (Manticolepis) hassi Müller & Müller, J. Paleont., 31, 1102, pl. 139, fig. 2; pl. 140, figs. 2, 4.
- 1958 Palmatolepis hassi Müller & Müller; Ziegler, Hess. Landesamt. Bodenf. Abh., 87, 60, pl. 7, figs. 3-7, 10, 13.
- 1962 Palmatolepis hassi Müller & Müller; Ziegler, N. Jb. Geol. Palaont., Abh., 114, 166, text-fig. 8 (part).
- 1963 Palmatolepis hassi Müller & Müller; Klapper & Furnish, Iowa Acad. Sci., 69, 406, fig. 2, 9.
- 1967 Palmatolepis hassi Müller & Müller; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 52, pl. 8, fig. 13.
- 1968 Palmatolepis hassi Müller & Müller; Figge, N. Jb. Geol. Palaont., Monats., 13, 198, fig. 2.

Material: 14 specimens, CPC 12616-12618 figured.

Localities of figured material: Samples BG 19009, 19012, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: Palmatolepis hassi is closely related to several species. It is very similar to P. subrecta but it lacks a secondary carina, has a less sigmoidal keel, and possesses a more nodose platform. P. subperlobata can be distinguished by its upward arching posterior tip (Müller & Müller, 1957)

Distribution: The species was originally described from the Independence Shale of Iowa (Müller & Müller, 1957; Klapper & Furnish, 1963). It has also been reported from Utah (Clark & Ethington, 1967) and Alberta, Canada (Pollock, 1968).

The species has been reported from Europe, especially Germany (Ziegler, 1958, 1962; Krebs & Rabien, 1964; Schriel & Stoppel, 1965; Stoppel & Zscheke, 1966; Wachendorf, 1966; Figge, 1968; Bar, 1968; Schneider, 1969). The only other report of the species from

Europe is in the Montagne Noir, France (Boyer et al., 1968).

Range: In Iowa the species is present in the Ancyrognathus triangularis Zone (to I β) (Klapper & Furnish, 1963). Ziegler (1958) gives the range in Germany as late Upper Polygnathus asymmetricus Zone (to I β) to the Upper Palmatolepis gigas Zone (to I δ). In Utah the species is present in either the Upper Polygnathus asymmetricus Zone or the Ancyrognathus triangularis Zone.

In the Canning Basin the species is present in both the Polygnathus asymmetricus and Ancyrognathus triangularis Zones.

PALMATOLEPIS LINGUIFORMIS Müller, 1956

Pl. 12, figs. 3a,b

- 1956 Palmatolepis (Palmatolepis) linguiformis Müller, Senck.
Naturf. Gesell. Abh., 494, 24, pl. 7, fig. 1-7.
- 1960 Palmatolepis (Palmatolepis) linguiformis Müller; Clark &
Becker, Geol. Soc. Amer. Bull., 71, 1672, pl. 1, fig. 14.
- 1958 Palmatolepis crepida Sannemann; Ziegler, Hess. Landesamt.
Bodenf., Notizbl., 87, 59, pl. 9, figs. 5, 7, 12.
- 1963 Palmatolepis (Manticolepis) linguiformis Müller; Helms,
Geologie, 12, text-fig. 2.12.
- 1966 Palmatolepis linguiformis Müller; Glenister & Klapper, J.
Paleont., 40, 815, pl. 88, figs. 4, 5.
- 1967 Palmatolepis linguiformis Müller; Wolska, Acta Palaeont.
Polonica, 12, pl. 6, figs. 9-106.
- 1967 Palmatolepis linguiformis Müller; Clark & Ethington, Geol.
Soc. Amer. Mem., 103, 53, pl. 4, fig. 16.

Material: 2 specimens, CPC 12619 figured.

Locality of figured material: Sample BG 19448E, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: P. linguiformis is a small, nearly rectangular species with platforms which extend nearly to the anterior termination of the free blade. Glenister & Klapper (1966, p. 816) note that the fact that both platforms merge with the blade at about the same position and this distinguishes it from Palmatolepis crepida.

Distribution: The species was originally described from Wildungen, Germany (Müller, 1956) and has been reported extensively in Germany (Ziegler, 1958, 1962; Bender, 1958; Freyer, 1961; Helms, 1963; and Lutzens, 1967). It has also been reported from Austria (Schönlaub, 1969) and Poland (Wolska, 1967). Outside Europe the species is rare, having been reported from Australia (Glenister & Klapper, 1966), and from Utah (Clark & Becker, 1960; Clark & Ethington, 1967).

Range: The species was first described from the upper part of the Manticoceras - Stufe (Müller, 1956). Ziegler (1962) records the species as occurring in the Upper Palmatolepis gigas Zone (to 16). Clark & Ethington (1967) also record the species in this zone in North America. However, Wolska (1967) records the species from the Palmatolepis triangularis Zone. In the Canning Basin the species occurs in the Upper Palmatolepis gigas Zone.

PALMATOLEPIS MINUTA MINUTA Branson & Mehl, 1934

Pl. 12, figs. 4a, b

1934 Palmatolepis minuta Branson & Mehl, Univ. Missouri Stud., 8, 236, pl. 18, figs. 1, 6, 7.

For complete synonymy up to 1966 see:

1969 Palmatolepis minuta minuta Branson & Mehl; Druce, Bur. Miner. Res. Austral. Bull. 98, 89, pl. 17, fig. 7, 8, pl. 18, figs. 1a - 3.

1966 Palmatolepis minuta minuta (Branson & Mehl); Anderson, J. Paleont., 40, 408, pl. 49, fig. 18.

- 1966 Palmatolepis minuta Branson & Mehl; Spasov & Filipovic,
Geol. Glasnik, 11, 45, pl. 3, fig. 2.
- 1967 Palmatolepis minuta minuta Branson & Mehl; Spasov & Filipovic, Bulgarian Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 70, pl. 3, figs. 6, 7.
- 1967 Palmatolepis minuta (Branson & Mehl); Nehring, Inst. Geol. Bull. 209, 147, pl. 3, figs. 5a, b (pl. 1, figs. 3a, b = P. minuta schleizia).
- 1967 Palmatolepis minuta minuta Branson & Mehl; Kodsí, N. Jb. Geol. Palaont. Monatsch., 27, pl. 6, fig. 2.
- 1967 Palmatolepis minuta Branson & Mehl; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 53, pl. 9, fig. 2.
- 1967 Palmatolepis minuta minuta Branson & Mehl; Wolska, Acta Palaeont. Polonica, 12, 397, pl. 7, figs. 1-4; text-fig. 11.
- 1968 Palmatolepis minuta Branson & Mehl; Spasov et al., Inst. Recherch. Geol. Geophys. Bull., 26, 161, pl. 2, figs. 7, 8.
- 1969 Palmatolepis minuta minuta Branson & Mehl; Olivieri, Boll. Soc. Paleont. Italiana, 8, 106, pl. 20, figs. 1-4.

Material: 360 specimens, CPC 12620-12622 figured.

Localities of figured material: Sample BG 19019, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19455, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Samples 21267, 21271, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Remarks: The species P. minuta has been divided into three subspecies, both P. minuta loba and P. minuta schleizia being lobate forms. However there is a large amount of variation in platform area and margin and this species may bear being looked at more closely.

Distribution: The species was originally described from Missouri

(Branson & Mehl, 1934), elsewhere in North America it has been reported from Iowa (Anderson, 1966), Utah & Nevada (Clark & Becker, 1960; Clark & Ethington, 1967), and in Alberta (Clark & Ethington, 1965) and Ontario, Canada (Winder, 1966).

In Europe the subspecies has been reported extensively from Germany (Sannemann, 1955a, b; Bischoff, 1956; Müller, 1956; Zimmermann, 1960; Freyer, 1961, 1965, 1968; Ziegler, 1962; Helms, 1963; Henningsen, 1965; Wachendorf, 1966; Bering, 1967; Dvorak & Freyer, 1968; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970). The subspecies has also been reported from Austria (Kodsi, 1967; Schönlaub, 1969), Bulgaria (Spasov, 1966), Czechoslovakia (Zikmundova, 1964), France (Boyer et al., 1968), Italy (Manzoni, 1968; Olivieri, 1969), Yugoslavia (Spasov & Filipovic, 1966, 1967; Spasov et al., 1968), and Poland (Freyer & Zakowa, 1967; Nehring, 1967; Wolska, 1967).

Other reports of the subspecies are from Turkey (Abduselmoglu, 1963) and Australia (Glenister & Klapper, 1966; Druce, 1969).

Range: The species was originally described from the Famennian Grassy Creek Shale of Missouri (Branson & Mehl, 1934). Elsewhere in North America the species occurs in the Lower Palmatolepis crepida and Palmatolepis rhomboidea Zones of Utah and Nevada (Clark & Ethington, 1967).

In Europe Ziegler (1962) gives the range as Upper Palmatolepis triangularis Zone (to I/II) up to the Upper Scaphignathus veliferus Zone (to IV). A similar range to that recorded by Nehring (1967) and Wolska (1967). In the Canning Basin the species ranges from the Lower Palmatolepis crepida Zone (to II α) up to the earliest Lower Polygnathus styriacus Zone (to IV).

PALMATOLEPIS MINUTA LOBA Helms, 1963

Pl. 12, figs. 5a,b

- 1963 Palmatolepis (Deflectolepis) minuta loba Helms, Geologie, 12, 470, pl. 2, figs. 13, 14; pl. 3, fig. 12; text-fig. 2.33.
- 1966 Palmatolepis minuta loba Helms; Glenister & Klapper, J. Paleont., 40, 818.
- 1967 Palmatolepis minuta loba Helms; Wolska, Acta Palaeont. Polonica, 12, 398, pl. 7, figs. 5-7; text-fig. 12.
- 1969 Palmatolepis minuta loba Helms; Olivieri, Bull. Soc. Paleont. Italiana, 8, 107, pl. 20, fig. 5a, b.

Material: 41 specimens, CPC 12623-12624 figured.

Localities of figured material: Sample BG 19019, Section 1, McWhae Ridge, Virgin Hills Formation; Sample 21262, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Remarks: The conspicuous inner platform distinguishes this subspecies.

Distribution: The subspecies was originally described from the Rheinisches Schiefergebirge, Germany (Helms, 1963). The only other reports of the subspecies are from Italy (Olivieri, 1969), Poland (Freyer & Zakowa, 1967; Wolska, 1967), and Australia (Glenister & Klapper, 1966).

Range: The subspecies was described by Helms (1963) from the Upper Palmatolepis crepida Zone. Wolska (1967) also reports the subspecies from the P. crepida Zone. In the Canning Basin the subspecies occurs in the Lower and Middle Palmatolepis crepida Zone (to II α).

PALMATOLEPIS MINUTA SCHLEIZIA Helms, 1963

Pl. 12, figs. 6a,b

- 1963 Palmatolepis (Deflectolepis) schleizia Helms, Geologie, 12, 471, pl. 3, fig. 13; pl. 4, figs. 1-11, (for synonymy).
- 1966 Palmatolepis schleizia Helms; Spasov, Bulg. Acad. Sci., Bull. "Strasimir Dimitrov" Inst. Geol., 15, 96, pl. 1, fig. 15.
- 1967 Palmatolepis minuta schleizia Helms; Wolska, Acta Palaeont. Polonica, 12, 399, pl. 7, figs. 13-16; text-fig. 13.
- 1967 Palmatolepis schleisia (sic) Helms; Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 73, pl. 3, figs. 21, 22.
- 1968 Palmatolepis schleizia Helms; Manzoni, G. Geol., 34, 665, pl. 62, fig. 13.
- 1969 Palmatolepis minuta schleizia Helms; Olivieri, Boll. Soc. Paleont. Italiana, 8, 107, pl. 20, figs. 8, 10.

Material: 3 specimens, CPC 12625-12626 figured.

Localities of figured material: Samples BG 19081, 19116, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone.

Remarks: This subspecies is distinguished by having a reduced but still lobate platform with conspicuous rolled platform edges.

Distribution: The species was originally described from Thuringia, Germany (Helms, 1963). It has also been reported from Germany by Sannemann (1955), Müller (1956), Helms (1969), Ziegler (1962), Bering (1967), Lutzens (1967), Schneider (1969), and Meischner & Schneider (1970). Elsewhere in Europe it is known from Austria (Schönlaub, 1969), Bulgaria (Spasov, 1966), France (Boyer et al., 1968), Italy (Manzoni, 1968; Olivieri, 1969), Poland (Freyer & Zakowa, 1967; Wolska, 1967), and Yugoslavia (Spasov & Filipovic, 1967).

Range: The subspecies was originally described from the Middle Scaphignathus veliferus Zone (Helms, 1963). Ziegler (1962) records it from the Palmatolepis rhomboidea Zone (to II β) up to the Middle Polygnathus styriacus Zone (to V). In the Canning Basin the subspecies occurs in the Palmatolepis quadrantinodosa Zone as it does in France (Boyer et al., 1968) and Poland (Wolska, 1967).

PALMATOLEPIS PERLOBATA PERLOBATA

Ulrich & Bassler, 1926

Pl. 13, figs. 1a,b

- 1926 Palmatolepis perlobata Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 49, pl. 7, fig. 22.

For complete synonymy up to 1965 see:

- 1966 Palmatolepis perlobata perlobata Ulrich & Bassler; Glenister & Klapper, J. Paleont., 40, 818, pl. 92, figs. 8, 13; pl. 93, figs. 1-6.
- 1966 Palmatolepis perlobata Ulrich & Bassler; Winder, J. Paleont., 40, 1275, pl. 156, fig. 4.
- 1967 Palmatolepis perlobata schindewolfi Müller; Wirth, N. Jb. Geol. Palaont. Abh., 127, 221, pl. 21, figs. 9-13.
- 1967 Palmatolepis perlobata schindewolfi Müller; Spasov & Filipovic, Bulg. Acad. Sci., Bull., Geol. Inst., Ser. Paleont., 16, 71, pl. 2, fig. 6; pl. 3, figs. 9, 10.
- ? 1967 Palmatolepis perlobata schindewolfi Müller; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 53, pl. 4, fig. 5.
- 1967 Palmatolepis perlobata schindewolfi Müller; Freyer & Zakowa, Acta Geol. Polonica, 17, 136, pl. 2, fig. 1.
- 1967 Palmatolepis perlobata perlobata Ulrich & Bassler; Wolska, Acta Palaeont. Polonica, 12, 400, pl. 10, figs. 1-8; pl. 12, figs. 8, 9; text-fig. 14.

- 1968 Palmatolepis perlobata schindewolfi Müller; Schulze, N. Jb. Geol. Palaont. Abh., 130, 207, pl. 19, fig. 9.
- ? 1968 Palmatolepis perlobata schwindewolfi Müller; Manzoni, G. Geol., 34, 663, pl. 62, fig. 15.
- 1968 Palmatolepis perlobata schindewolfi Muller; Spasov et al., Inst. Recherch. Geol. Geophys., Bull., 26, 161, pl. 2, fig. 1.
- 1968 Palmatolepis perlobata Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 32, pl. 15, figs. 1-10; pl. 16, figs. 8, 9.
- 1969 Palmatolepis perlobata schindewolfi Müller; Matthews, Palaeontology, 12, 269. -1.47, figs. 1-3.

Material: 15 specimens, CPC 12627-12630 figured.

Localities of figured material: Samples BG 19083, 19100, 19183, Section 4, northeast of McWhae Ridge, Virgin Hills and Piker Hills Formations.

Remarks: There has been some discussion about the differences between P. perlobata s.s. and P. perlobata schindewolfi. Glenister & Klapper (1966, p. 818) consider that the two subspecies are indistinguishable because the coarse ornament and secondary carina are highly variable. Clark & Ethington (1967, p. 53) do not consider that Glenister & Klapper's views are substantiated by their illustrations. Huddle (1968, p. 33) thinks that the two subspecies can be distinguished but that it is difficult to describe.

The variation in ornamentation may be due to ecological factors and until such time as a detailed study of the species is completed, I prefer to accept the view of Glenister & Klapper, and to place P. perlobata schindewolfi in the nominate subspecies.

Distribution: This species is extensive in its occurrence. It was originally described from Tennessee (Ulrich & Bassler, 1926; Huddle,

1968). Elsewhere in North America it occurs in Indiana (Huddle, 1934), Iowa (Thomas, 1949), Missouri (Branson & Mehl, 1934); Texas (Hass, 1959) and Nevada (Clark & Ethington, 1967). Winder (1966) has recorded the species from Ontario.

In Europe the species has been reported extensively from Germany (Sannemann, 1955; Bischoff, 1956; Müller, 1958; Ziegler, 1958, 1962; Helms, 1959, 1963; Zitzmann, 1966, 1967; Meischner & Schneider, 1967; Bering, 1967; Freyer, 1968; and Bar, 1968). Elsewhere in Europe the species has been reported from Austria (Kodsi, 1967; Schulze, 1968; Schönlaub, 1969), England (Matthews, 1969), Italy (Manzoni, 1968), Yugoslavia (Spasov & Filipovic, 1967; Spasov et al., 1968), Poland (Freyer & Zakowa, 1967; Wolska, 1967), Portugal (Boogaard, 1963) and Spain (Wirth, 1967). The species is also known from Australia (Glenister & Klapper, 1966).

Range: The species was originally described from Famennian strata in Tennessee (Ulrich & Bassler, 1926; Huddle, 1968). Clark & Ethington (1967) record the species from a horizon of probable Upper Palmatolepis crepida Zone age. Ziegler (1962) records the composite range of the two subspecies as Upper Palmatolepis triangularis Zone (to I/II) as high as the Lower Spathognathodus costatus Zone (to V). In the Canning Basin the species ranges from the Lower Palmatolepis quadrantinodosa Zone (to II β) up to the Middle Polygnathus styriacus Zone (to V).

PALMATOLEPIS PERLOBATA SIGMOIDEA Ziegler, 1962

Pl. 13, figs. 2a,b

- 1956 Palmatolepis (Palmatolepis) schindewolfi Müller, Senck.
 Naturf. Ges. Abh., 494, 27, pl. 8, figs. 22, 24, 28 only.
- 1962 Palmatolepis perlobata sigmoidea Ziegler, Hess. Landesamt.
 Bodenf. Abh., 38, 71, pl. 8, figs. 7, 9-11.
- 1963 Palmatolepis (Palmatolepis) perlobata sigmoidea Ziegler,
 Helms, Geologie, 12, text-fig. 2.48.

? 1963 Palmatolepis perlobata Sannemann (sic.); Abdusselamoglu,
Bull. Min. Res. Expl. Inst. Turkey, 60, 4, pl. 1, fig. 9.

Material: Single specimen, CPC 12631 figured.

Locality of figured material: Sample BG 19105, Section 4, northeast of
 McWhae Ridge, Bugle Gap Limestone.

Remarks: The expanded lobate posterior inner platform edge is the
 distinguishing feature of this subspecies.

Distribution: The subspecies was originally described from Germany
 (Ziegler, 1958) and it has also been recorded from that country by
 Müller (1956) and Helms (1963). The only other reference to the species
 is from Belgium (Bouckaert & Ziegler, 1965). A specimen illustrated
 as P. perlobata by Abdusselamoglu (1963) from Turkey is tentatively
 placed in this subspecies.

Range: Ziegler (1962) records the range as Lower Palmatolepis quad-
rantinodosa Zone (to II β) up to the Upper Polygnathus styriacus Zone
 (to V). In the Canning Basin the single specimen comes from the
 latest Lower Palmatolepis quadrantinodosa Zone.

PALMATOLEPIS PROVERSA Ziegler, 1958

Pl. 13, figs. 3a,b

- 1958 Palmatolepis proversa Ziegler, Hess. Landesamt Bodenf.
 Abh., 87, 62, pl. 3, figs. 11, 12; pl. 4, figs. 1-14.
- 1947 Palmatolepis marginata Stauffer; Youngquist, J. Paleont., 21,
 108, pl. 24, figs. 4, 14.
- 1947 Palmatolepis sp. Youngquist, ibid., 108, pl. 24, fig. 5.
- 1958 Palmatolepis (Manticolepis) sp. Müller & Müller, J. Paleont.,
 31, 1104, pl. 142, fig. 12.
- 1963 Palmatolepis (Manticolepis) proversa Ziegler, Helms,
 Geologie, 12, text-fig. 2.7.

- 1963 Palmatolepis proversa Ziegler; Klapper & Furnish, Iowa Acad. Sci., Proc. 1962, 406, text-fig. 2.8.
- 1966 Palmatolepis proversa Ziegler; Winder, J. Paleont., 40, 1275, pl. 156, fig. 14.
- 1968 Palmatolepis proversa Ziegler; Mound, J. Paleont., 42, 500, pl. 68, figs. 14, 16, 21; pl. 71, ? figs. 15, 19.

Material: 11 specimens, CPC 12632-12633 figured.

Locality of figured material: Sample BG 19548, Section 9, Balme Knoll, Virgin Hills Formation.

Remarks: P. proversa is distinguished by its strongly anteriorly directed lateral platform lobe. The acute angle of the inner platform margin distinguishes the species from P. punctata (Hinde).

Distribution: The species was originally described from Adorf, Germany (Ziegler, 1958, 1962). It has also been reported by Helms (1963), Krebs & Rabien (1964), Schriel & Stoppel (1965), Wachendorf (1966), Dvorak & Freyer (1968), Bar (1968), and Schneider (1969), from Germany. Elsewhere in Europe it has been recorded from Austria (Schönlaub, 1969).

In North America the species is known from Iowa (Müller & Müller, 1957; Klapper & Furnish, 1963) and from Ontario (Winder, 1966) and Alberta (Mound, 1968) in Canada. Glenister & Klapper (1966) record the species from the Canning Basin.

Range: Ziegler (1962) records the range as Frasnian (to I α - to I δ), Middle Polygnathus asymmetricus Zone to the lower part of the Lower Palmatolepis gigas Zone. In North America the species occurs in the Ancyrognathus triangularis Zone (to I δ) (Klapper & Furnish, 1963). In the Canning Basin the species occurs in either the Upper Polygnathus asymmetricus or the Ancyrognathus triangularis Zones.

PALMATOLEPIS PUNCTATA (Hinde, 1879)

Pl. 13, figs. 4a,b

- 1879 Polygnathus punctatus Hinde, Quart. J. Geol. Soc., Lond.,
35, 367, pl. 17, fig. 14.

For complete synonymy up to 1965 see:

- 1966 Palmatolepis punctata (Hinde); Glenister & Klapper, J. Paleont.,
40, 819, pl. 88, fig. 8, 9.
- 1966 Palmatolepis punctata (Hinde); Winder, J. Paleont., 40, 1275,
pl. 156, fig. 13.
- 1968 Palmatolepis punctata (Hinde); Huddle, U.S. Geol. Surv. Prof.
Pap. 578, 33, pl. 16, figs. 1-3.
- 1968 Palmatolepis punctata (Hinde); Mound, J. Paleont., 42, 500,
pl. 68, figs. 4, 5, 10-13.
- 1970 Palmatolepis punctata (Hinde); Seddon, J. Geol. Soc. Aust.,
16, 753, pl. 16, fig. 7.

Material: 25 specimens, CPC 12634-12636 figured.

Locality of figured material: Sample BG 19548, Section 9, Balme
Knoll, Virgin Hills Formation.

Remarks: Palmatolepis punctata is distinguished by its virtually
straight carina, coarse dentition and downturned posterior termination.
P. unicornis can be distinguished by its sigmoidal carina and P.
proversa by its anteriorly pointing lateral lobe.

Distribution: The species was originally described from New York
(Hinde, 1879; Branson & Mehl, 1933). Other occurrences in North
America include New York (Ulrich & Bassler, 1926; Oliver et al.,
1967; Huddle, 1968), Iowa (Müller & Müller, 1957), and Texas (Hass,
1959). In Canada the species is known from Alberta (Mound, 1968)
and Ontario (Winder, 1966).

In Europe most of the reported occurrences of the species

are from Germany where it was originally referred to P. martenbergensis Müller (Müller, 1956; Bischoff & Ziegler, 1957; Bischoff & Sannemann, 1958; Ziegler, 1958; Meyer, 1965; Schneider, 1969).

Other European occurrences are in Austria (Schönlaub, 1969), Bulgaria (Budurov & Tschunev, 1964), and France (Boyer et al., 1968).

The species has been reported twice from the Canning Basin, Australia (Glenister & Klapper, 1966; Seddon, 1970).

Range: The species was originally described from the Famennian Genesee Shale of New York (Hinde, 1879; Branson & Mehl, 1933). Ziegler (1962) records the range as base of Middle Polygnathus asymmetricus Zone (to I α) up to the Lower Palmatolepis gigas Zone (to I δ). In the Canning Basin the species ranges from the Middle Polygnathus asymmetricus Zone to the Ancyrognathus triangularis Zone.

PALMATOLEPIS QUADRANTINODOSA INFLEXOIDEA

Ziegler, 1962

Pl. 14, figs. 2a,b

- 1962 Palmatolepis quadrantinodosa inflexoidea Ziegler, Hess.
Landesamt Bodenf. Abh., 38, 74, pl. 5, figs. 14-18.
- 1962 Palmatolepis (Panderolepis) elegans Helms in Müller, Treatise
on Invertebrate Paleontology, Pt. W, Miscellanea, W 89,
text-fig. 47.58.
- 1963 Palmatolepis (Panderolepis) inflexoidea Ziegler, Helms,
Geologie, 12, 482, pl. 3, figs. 5, 7-9, 11; text-fig. 2.58.
- 1966 Palmatolepis quadrantinodosa inflexoidea Ziegler; Glenister
& Klapper, 40, 820, pl. 93, figs. 11, 12.
- 1967 Palmatolepis quadrantinodosa inflexoidea Ziegler; Spasov &
Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser.
Paleont., 16, 71, pl. 3, figs. 14, 15.
- 1969 Palmatolepis quadrantinodosa inflexoidea Ziegler; Olivieri,
Boll. Soc. Paleont. Italiana, 8, 110, pl. 19, figs. 4-6.

Material: 5 specimens, CPC 12641-12642 figured.

Locality of figured material: Sample BG 19080, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: P. quadrantinodosa inflexoidea is an elongate subspecies showing some affinities to the P. glabra group. The ornament is "shagreen"-like and the subspecies is conspicuous because of the absence of an outer platform parapet.

Distribution: The subspecies was originally described from Germany (Ziegler, 1962). Other German occurrences have been noted by Helms (1963), Budinger & Kullman (1964), Wachendorf (1966), Bering (1967), Bar (1968), and Schneider (1969). It has also been reported from France (Boyer et al., 1968), Italy (Manzoni, 1965; Olivieri, 1969), and Yugoslavia (Spasov & Filipovic, 1967). The only record of the subspecies outside Europe is from the Canning Basin, Australia (Glenister & Klapper, 1966).

Range: Ziegler (1962) gives the range as upper part of the Palmatolepis rhomboidea Zone into the Lower Palmatolepis quadrantinodosa Zone (all to II β). However, Boyer et al., (1968) record the subspecies as low as the Palmatolepis crepida Zone (to II α) in the Coumiac section, France. In the Canning Basin the subspecies has the same range as in Germany.

PALMATOLEPIS QUADRANTINODOSA MARGINIFERA

Helms, 1959

Pl. 14, figs. 1a, b

1959 Palmatolepis quadrantinodosa marginifera Ziegler (sic.)

Helms, Geologie, 8, 649, pl. 5, figs. 22, 23.

For complete synonymy up to 1965 see:

1966 Palmatolepis quadrantinodosa marginifera Helms; Glenister & Klapper, J. Paleont., 40, 820, pl. 91, figs. 6-15.

- 1966 Palmatolepis quadrantinodosa marginifera Ziegler (sic.);
Spasov, Bulg. Acad. Sci., Bull. "Strasimir Dimitrov"
Inst. Geol., 15, 96, pl. 1, fig. 14.
- 1966 Palmatolepis quadrantinodosa marginifera Helms; Winder,
J. Paleont., 40, 1275, pl. 156, fig. 3.
- 1967 Palmatolepis quadrantinodosa marginifera Ziegler (sic.);
Wirth, N. Jb. Geol. Paleont. Abh., 127, 222, pl. 21,
fig. 7, 8.
- 1967 Palmatolepis quadrantinodosa marginifera Ziegler (sic.);
Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst.
Ser. Paleont., 16, 72, pl. 3, fig. 8, 16.
- 1967 Palmatolepis quadrantinodosa marginifera Ziegler (sic.);
Kodsi, 424, text-fig. 6, 11.
- 1967 Palmatolepis quadrantinodosa marginifera Ziegler (sic.);
Boogaert, Leidse. Geol. Med., 39, 183, pl. 2, fig. 30.
- ? 1967 Palmatolepis quadrantinodosa marginifera Ziegler (sic.);
Clark & Ethington, Geol. Soc. Amer. Mem. 103, 55, pl.
5, fig. 5.
- 1967 Palmatolepis quadrantinodosa marginifera Helms; Wolska,
Acta Palaeont. Polonica, 12, pl. 9, figs. 10-13; text-
fig. 15.
- 1969 Palmatolepis quadrantinodosa marginifera Helms; Olivieri,
Boll. Soc. Paleont. Italiana, 8, 110, pl. 19, figs. 1-3.

Material: 18 specimens, CPC 12637-12640 figured.

Localities of figured material: Samples BG 19089, 19130, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone; Samples BG 21267, 21275, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Remarks: There has been some problem over the authorship of this subspecies. The first publication of the name was by Helms (1959) who used the name from a Ziegler MS which was published in 1962.

The subspecies is small and ovate and can be distinguished from the nominate subspecies by a ridge-like parapet on the outer platform rather than a group of nodes.

Distribution: The species was originally described from Thuringia, Germany (Helms, 1959). Other German occurrences have been noted by Bischoff & Ziegler (1956), Müller (1956), Ziegler (1962), Helms (1963), Wachendorf (1966), Bering (1967), Meischner & Schneider (1967; 1970), Lutzens (1967), Dvorak & Freyer (1968), Freyer (1968), Bar (1968), and Schneider (1969). Other European countries from which the sub-species has been recorded include Austria (Ziegler in Flugel & Ziegler, 1957; Kodosi, 1967; Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), France (Boyer et al., 1968), Italy (Manzoni, 1965; Olivieri, 1969), Yugoslavia (Spasov & Filipovic, 1967), Poland (Freyer & Zakowa, 1967; Wolska, 1967), and Spain (Boogaert, 1967; Wirth, 1967).

The subspecies has been recorded from three localities in North America, the Mississippi Valley (Scott & Collinson, 1961), Utah (Clark & Ethington, 1967) and Ontario, Canada (Winder, 1966).

Range: Helms (1959) recorded the species from the Famennian to III Zone. Ziegler (1962) records the range from the upper part of the Palmatolepis rhomboidea Zone (to II β) as high as the lowest part of the Scaphignathus veliferus Zone (to III α). The species seems to be most common in the Palmatolepis quadrantinodosa Zone (to II β) (Boyer et al., 1968; Clark & Ethington, 1967) but its presence in the S. veliferus Zone is confirmed by Glenister & Klapper (1966) and Wolska (1967). In the Canning Basin the subspecies ranges from the Palmatolepis rhomboidea Zone (to II β) into the Lower Scaphignathus veliferus Zone (to III α).

PALMATOLEPIS QUADRANTINODOSALOBATA

Sannemann, 1955

Pl. 14, figs. 3a,b

- 1955 Palmatolepis quadrantinodosalobata Sannemann, N. Jb. Geol. Palaont., Abh., 100, 328, pl. 24, fig. 6.
- For complete synonymy up to 1964 see:
- 1966 Palmatolepis quadrantinodosalobata Sannemann; Glenister & Klapper, J. Paleont., 40, 821, pl. 92, figs. 1-3.
- 1965 Palmatolepis quadrantinodosalobata Sannemann; Bouckaert & Ziegler, Mem. Expl. Cart. Geol. Min. Belg. Mem. 5, 23, pl. 1, figs. 9-12.
- 1967 Palmatolepis quadrantinodosalobata Sannemann; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 54, pl. 9, figs. 1, 4.
- 1967 Palmatolepis quadrantinodosalobata Sannemann; Nehring, Inst. Geol. Bull. 209, 143, pl. 2, fig. 1.
- 1967 Palmatolepis quadrantinodosalobata Sannemann; Wolska, Acta Palaeont. Polonica, 12, 403, pl. 13, figs. 5-10.
- 1969 Palmatolepis quadrantinodosalobata Sannemann; Olivieri, Boll. Soc. Paleont. Italiana, 8, 112, pl. 18, figs. 9-11.

Material: 6 specimens, CPC 12643-12644 figured.

Locality of figured material: Sample BG 19018, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19455, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: P. quadrantinodosalobata is easily recognized by the nodose parapet on the outer platform and the elongate lateral lobe on the inner platform.

Distribution: The species was originally described from Germany (Sannemann, 1955). It has also been recorded by Bischoff (1956),

Müller (1956), Stoppel (1958), Bender (1958), Walliser (1958), Helms (1959; 1963); Freyer (1961), Ziegler (1962), Schriel & Stoppel (1965), Zitzmann (1966), Wachendorf (1966), Stoppel & Zscheke (1966); Bar (1968), Schneider (1969), Meischner & Schneider (1970). The species is also known from Austria (Ziegler in Flügel & Ziegler, 1957; Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), Czechoslovakia (Dvorak et al., 1959), France (Lys et al., 1961; Boyer et al., 1968), Italy (Olivieri, 1969), Poland (Freyer & Zakowa, 1967; Nehring, 1967; Wolska, 1967), and Spain (Boogaard, 1965).

In North America the species has been reported from the Mississippi Valley (Scott & Collinson, 1961), Iowa (Anderson, 1964), Tennessee (Hass, 1956), New York (Oliver et al., 1967) and Utah (Clark & Becker, 1960; Clark & Ethington, 1967). Other occurrences are in Morocco (Massa, 1965) and Australia (Glenister & Klapper, 1966).

Range: Ziegler (1962) restricts the species to the Palmatolepis crepida Zone. However, he notes that transitional forms are present in the Palmatolepis triangularis Zone. This range was confirmed in North America (Clark & Ethington, 1967). In the Canning Basin the species is confined to the Palmatolepis crepida Zone (to II α).

PALMATOLEPIS cf. P. REGULARIS Cooper, 1931

Pl. 14, figs. 4a,b

cf. 1931 Palmatolepis regularis Cooper, J. Paleont., 5, 242, pl. 28, fig. 36.

For synonymy up to 1964 see:

- 1966 Palmatolepis cf. P. regularis Cooper; Glenister & Klapper, J. Paleont., 40, 821, pl. 92, figs. 14-16.
- 1967 Palmatolepis cf. regularis Cooper; Wolska, Acta Palaeont. Polonica, 12, 404, pl. 6, figs. 11-15

1969 Palmatolepis cfr. P. regularis Cooper; Olivieri, Boll Soc. Paleont. Italiana, 8, 113, pl. 19, figs. 12a, b.

Material: 7 specimens, CPC 12645-12646 figured.

Locality of figured material: Sample BG 19455, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: Glenister & Klapper (1966, p. 822) point out that the original specimen is embedded in shale and only the aboral surface can be seen. The sigmoidal carina with equidimensional platforms on either side is diagnostic.

Distribution: The species was originally described from Oklahoma (Cooper, 1931) and the only other record of the species in North America is by Bond (1947).

In Europe the species is common in Germany (Sannemann, 1955; Bischoff, 1956; Bischoff & Ziegler, 1956; Bender, 1958; Stoppel, 1958; Walliser, 1958; Ziegler, 1962; Helms, 1963; Bar, 1968). The species is also known from Austria (Ziegler in Flügel & Ziegler, 1957; Schönlaub, 1969), Italy (Olivieri, 1969) and Poland (Freyer & Zakowa, 1967; Wolska, 1967). Apart from the listing of the species from Morocco (Massa, 1965) the only other record of the species is from the Canning Basin (Glenister & Klapper, 1966).

Range: The species was originally described from the Woodford Formation of Oklahoma (Cooper, 1931). Ziegler (1962) gives the range as Upper Palmatolepis triangularis Zone to the top of the Palmatolepis crepida Zone. The species appears to be common in the Palmatolepis crepida Zone and in the Canning Basin it occurs in this zone.

PALMATOLEPIS RUGOSA AMPLA Ziegler, 1962

Pl. 14, figs. 6a,b

- 1956 Palmatolepis (Palmatolepis) ampla Müller, Senck. Naturf. Ges. Abh., 494, 28, pl. 9, figs. 35, 36.
- 1961 Palmatolepis ampla (Müller), Freib. Forsch., C-95, 62, pl. 3, figs. 78, 79.
- 1962 Palmatolepis rugosa ampla Müller; Ziegler in Kronberg et al., Forsch. Geol. Rheinld Westf., 3, 38, pl. 2, figs. 1-9; pl. 1, fig. 6; text-figs. 12, 13.
- 1962 Palmatolepis rugosa ampla Müller; Ziegler, Hess. Landesamt Bodenf. Abh., 38, 78, pl. 8, fig. 15.
- ? 1965 Palmatolepis (Palmatolepis) ampla Müller; Spasov, Bulg. Acad. Sci., Trav. Geol. Bulg., Ser. Paleont., 7, 92, pl. 2, fig. 8.
- 1967 Palmatolepis rugosa ampla Müller; Wolska, Acta Paleont. Polonica, 12, 405, pl. 11, fig. 9a-10.
- 1967 Palmatolepis rugosa ampla Müller; Boogaert, Leidse Geol. Mem., 39, 183, pl. 2, fig. 31.
- 1969 Palmatolepis rugosa ampla Müller; Schönlaub, JB. Geol. B.A., 112, 306, pl. 2, fig. 9.

Material and Locality: Single specimen, CPC 12648 figured, from Sample BG 19119, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Remarks: The lack of coarse ornament distinguishes this subspecies from other subspecies of P. rugosa.

Distribution: This is the first report of the subspecies outside Europe. The subspecies was first described from Germany (Müller, 1956) since when it has been frequently reported (Bender, 1958; Freyer, 1961; Ziegler, 1962a, b; Henningsen, 1965; Bering, 1967; Bar, 1968; Schneider, 1969). Elsewhere in Europe it is known from Austria

(Schönlaub, 1969), Bulgaria (Spasov, 1965), Poland (Freyer & Zakowa, 1967; Wolska, 1967), and Spain (Boogaert, 1967).

Range: The subspecies was originally described from the Famennian Platyclymenia - Stufe (Müller, 1956). Freyer (1961) does not record the subspecies outside the to V Zone; however, Ziegler (1962b) gives the range as Upper Palmatolepis quadrantinodosa Zone (to III α) up to at least the Middle Scaphignathus veliferus Zone (to III β). The Canning Basin specimen occurs in the Upper Palmatolepis quadrantinodosa Zone.

PALMATOLEPIS RUGOSA GROSSI Ziegler, 1962

Pl. 14, figs. 5a,b

- 1962 Palmatolepis rugosa grossi Ziegler in Kronberg et al.,
Fortschr. Geol. Rheinld Westf., 3, 37, pl. 1, figs. 1, 2.
- 1962 Palmatolepis rugosa grossi Ziegler; Ziegler, Hess. Lande-
samt Bodenf. Abh., 38, 78, pl. 8, fig. 8.
- 1966 Palmatolepis rugosa grossi Ziegler; Spasov, Bulg. Acad. Sci.,
Bull. "Strasimir Dimitrov" Inst. Geol., 15, 96, pl. 1,
fig. 11.
- 1967 Palmatolepis rugosa grossi Ziegler; Spasov & Filipovic, Bulg.
Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 72,
pl. 2, figs. 1, 2, 4.
- 1967 Palmatolepis rugosa grossi Ziegler; Wolska, Acta Palaeont.
Polonica, 12, 406, pl. 10, fig. 4; pl. 11, figs. 8a, b.

Material: 2 specimens, CPC 12647 figured.

Locality of figured specimen: Sample BG 19163, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Distribution: The species was originally described from the Rheinisches Schiefergebirge (Ziegler in Kronberg et al., 1962) and since then has been reported extensively from Germany (Ziegler, 1962;

Helms, 1963; Henningsen, 1965; Bering, 1967; Meischner & Schneider, 1967; Bar, 1968; Schneider, 1969). The other records of the species are from Austria (Schönlaub, 1969), Yugoslavia (Spasov, 1966; Spasov & Filipovic, 1967), and from Poland (Freyer & Zakowa, 1967; Wolska, 1967). This is the first record of the species outside Europe.

Range: The species was originally described from the Famennian (to III α) (Ziegler, 1962a) and later Ziegler (1962b) gives the range as Upper Palmatolepis quadrantinodosa Zone (to III α) as high as the Upper Scaphignathus veliferus Zone (to IV), a range confirmed by Wolska (1967). The Canning Basin specimens extend the range slightly, coming from the basal part of the Lower Polygnathus styriacus Zone.

PALMATOLEPIS cf. P. SUBGRACILIS Bischoff, 1956

Pl. 15 figs. 1a,b

cf. 1956 Palmatolepis subgracilis Bischoff, Hess. Landesamt Bodenf. Notizbl., 84, 130, pl. 9, figs. 12, 19; pl. 10, fig. 13.

Material: 5 specimens, CPC 12649 figured.

Locality of figured material: Sample BG 19023, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: Glenister & Klapper (1966, p. 822) point out that P. subgracilis can be recognized as a palmatolepid by the presence of a distinctive azygous node. The present specimens lack an azygous node but in every other respect they resemble Glenister & Klapper's specimens although the lateral platform of some of my specimens is reduced to a single node. The present specimens are closest to the genus Spathognathodus. Two interpretations are possible, either Palmatolepis is a polyphyletic genus or one branch of Palmatolepis evolved into a spathognathodid form.

Range: The present specimens occur in the Upper Palmatolepis crepida

Zone which agrees with the German range of Upper Palmatolepis crepida Zone to Palmatolepis rhomboidea Zone.

PALMATOLEPIS SUBPERLOBATA Branson & Mehl, 1934

Pl. 15, figs. 4a,b

- 1934 Palmatolepis subperlobata Branson & Mehl, Univ. Missouri Stud., 8, 235, pl. 18, figs. 11, 21.

For complete synonymy up to 1965 see:

- 1966 Palmatolepis subperlobata Branson & Mehl; Glenister & Klapper, J. Paleont., 40, 822, pl. 92, figs. 5-7.
- non 1965 Palmatolepis superlobata (sic.) Branson & Mehl; Loranger, privately published, 16, pl. 3, figs. 9, 10 (? = P. proversa).
- 1965 Palmatolepis subperlobata Branson & Mehl; Bouckaert & Ziegler, Mem. Cart. Geol. Min. Belg., 5, 22, pl. 2, figs. 12, 13.
- 1966 Palmatolepis subperlobata Branson & Mehl; Winder, J. Paleont., 40, 1275, pl. 156, fig. 9.
- ? 1966 Palmatolepis (Manticolepis?) subperlobata (Branson & Mehl); Vestnik U.U.G., 42, 369, pl. 1, fig. 5.
- 1967 Palmatolepis subperlobata Branson & Mehl; Clark & Ethington, Geol. Soc. Amer. Mem., 103, 55, pl. 8, fig. 16; pl. 9, figs. 5, 6 (fig. 12 = subsp. a.).
- 1967 Palmatolepis subperlobata Branson & Mehl; Wolska, Acta Palaeont. Polonica, 12, 407, pl. 12, figs. 7a, b, 10.
- 1969 Palmatolepis subperlobata Branson & Mehl; Olivieri, Boll. Soc. Paleont. Italiana, 8, 115, pl. 18, figs. 12a - 13b.

Material: 26 specimens, CPC 12651-12654 figured.

Localities of figured material: Samples BG 19454D, 19455, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21011, Section 14, 2 miles northwest of Pinnacle Spring, Virgin Hills Formation.

Remarks: P. subperlobata can be distinguished from P. tenuipunctata by the presence of a well developed lateral lobe. It differs from P. triangularis in having "shagreen" ornament. Specimens with an elongate lateral lobe have been isolated as P. subperlobata subsp. a. Helms.

Distribution: The species was originally described from Missouri (Branson & Mehl, 1934). Other reports of the species from North America include New York (Oliver et al., 1967), Nevada and Utah (Clark & Becker, 1960; Clark & Ethington, 1967), Ohio (Bond, 1947) and Tennessee (Hass, 1956).

In Europe the species is common in Germany (Sannemann, 1955a, b; Bischoff, 1956; Bischoff & Ziegler, 1956; Walliser, 1958; Helms, 1959, 1963; Kronberg et al., 1962; Ziegler, 1962a, b; Schriel & Stoppel, 1965; Zitzmann, 1966; Wachendorf, 1966; Stoppel & Zscheke, 1966; Bering, 1967; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970). Other occurrences in Europe include Austria (Ziegler in Flügel & Ziegler, 1957; Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), Czechoslovakia (Koverdynsky & Zikmundova, 1966), France (Serre & Lys, 1958; Lys et al., 1961), Italy (Olivieri, 1969), Poland (Freyer & Zakowa, 1967; Wolska, 1967), and Spain (Boogaard, 1965).

Other locations include Morocco (Massa, 1965) and the Canning Basin, Australia (Glenister & Klapper, 1966).

Range: The species was originally described from the Famennian Grassy Creek Shale (Branson & Mehl, 1934). In North America the species has been described from the Middle Palmatolepis triangularis as high as the Palmatolepis rhomboidea Zone. Ziegler (1962) records the range in Germany as Lower Palmatolepis triangularis Zone as high as the Upper Palmatolepis crepida Zone (to I δ - to II α). Wolska (1967) records the species as high as the Palmatolepis quadrantinodosa Zone (to II β).

The Canning Basin specimens range from the Upper Palmatolepis triangularis Zone as high as the Upper Palmatolepis crepida Zone.

PALMATOLEPIS SUBPERLOBATA subsp. a Helms, 1963

Pl. 15, figs. 5a,b

- 1963 Palmatolepis subperlobata subsp. a Helms, Geologie, 12, 458, pl. 1, fig. 19; text-fig. 2.17.
- 1966 Palmatolepis superlobata (sic.) Branson & Mehl; Spasov, Bulg. Acad. Sci., Bull. "Strasimir Dimitrov" Inst. Geol., 15, 96, pl. 1, fig. 16.
- 1966 Palmatolepis subperlobata Branson & Mehl; Spasov & Filipovic, Geol. Glas. 11, 46, pl. 3, figs. 1, 2.

Material: 10 specimens, CPC 12655-12657 figured.

Localities of figured material: Sample BG 19019, 19020, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19455, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: Helms (1963) distinguished a subspecies of P. subperlobata on the presence of an elongate lateral lobe. This morphological variant is easy to distinguish and is possibly of stratigraphic value. Olivieri (1969) erects a new species, P. delicatalobata, with an elongate lobe but the ornament appears to be nodose rather than "shagreen"-like.

Distribution and Range: The subspecies was originally recognized from German faunas (Helms, 1963) and the only other record of the subspecies is from Yugoslavia (Spasov, 1966; Spasov & Filipovic, 1966). The subspecies ranges throughout the Famennian Cheiloceras-Stufe and possibly into the Platyclymenia-Stufe.

In the Canning Basin the subspecies ranges throughout the Palmatolepis crepida Zone.

PALMATOLEPIS SUBRECTA Miller & Youngquist, 1947

Pl. 15, figs. 7a,b

- 1947 Palmatolepis subrecta Miller & Youngquist, J. Paleont., 21,
513, pl. 75, figs. 7-11.

For complete synonymy up to 1965 see:

- 1966 Palmatolepis subrecta Miller & Youngquist; Glenister &
Klapper, J. Paleont., 40, 823, pl. 88, figs. 1-3.
- 1966 Palmatolepis subrecta Miller & Youngquist; Anderson, ibid.,
409, pl. 49, figs. 11-15, 17, 19.
- 1966 Palmatolepis subrecta Miller & Youngquist; Winder, ibid.,
1275, pl. 156, fig. 8.
- 1967 Palmatolepis subrecta Miller & Youngquist; Boogaert, Leidse
Geol. Med., 39, 183, pl. 2, fig. 32.
- 1967 Palmatolepis subrecta Miller & Youngquist; Clark & Ethington,
Geol. Soc. Amer. Mem. 103, 55, pl. 4, fig. 4; pl. 9,
fig. 9.
- 1967 Palmatolepis subrecta Miller & Youngquist; Spasov & Filipovic,
Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16,
73, pl. 3, fig. 18.
- 1967 Palmatolepis subrecta Miller & Youngquist; Wolska, Acta
Palaeont. Polonica, 12, 407, pl. 12, figs. 1-6.
- 1968 Palmatolepis subrecta Miller & Youngquist; Mound, J. Paleont.,
42, 501, pl. 68, figs. 7, 15, 17; pl. 71, figs. 5-7, 9, 10.
- 1968 Palmatolepis subrecta Miller & Youngquist; Spasov et al.,
Bull. Inst. Recherch. Geol. Geophys., 26, 162, pl. 1,
figs. 8, 9, 14, 15.
- 1968 Palmatolepis subrecta Miller & Youngquist; Huddle, U.S.
Geol. Surv. Prof. Pap. 578, 34, pl. 16, figs. 5, 6, 7.
- 1970 Palmatolepis subrecta Miller & Youngquist; Seddon, J. Geol.
Soc. Aust., 16, 753, pl. 16, fig. 8.

Material: 157 specimens, CPC 12658 - 12661 figured.

Localities of figured material: Samples BG 19448A, 19451B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Samples BG 19581, 19585, Section 12, southwest of Waggon Pass, Virgin Hills Formation.

Remarks: This species is quite variable but is characteristically ornamented with coarse nodes. However, juvenile specimens show little ornament and the nodes are a late ontogenetic development. Juveniles also possess a slightly different platform shape, the lateral lobe is poorly developed and the platform is rhomboid in outline. However, the posterior termination is always downturned distinguishing it from P. triangularis. The difference between P. subrecta and P. gigas is less distinct, the inner platform of P. gigas tends to be larger and the lateral lobe is more elongate. Some specimens show a transition to P. coronata.

Distribution: The species was originally described from Iowa (Miller & Youngquist, 1947). Several other occurrences in Iowa have been noted (Youngquist & Miller, 1948; Müller & Müller, 1957; Klapper & Furnish, 1963; and Anderson, 1966). Elsewhere in North America the species is known from Arkansas (Hass, 1951), New York (Oliver et al., 1967), Ohio (Stauffer, 1938), Oklahoma (Hass & Huddle, 1965), Tennessee (Hass, 1956; Huddle, 1968), and Utah (Clark & Becker, 1960; Clark & Ethington, 1967). It is also known from Alberta (Clark & Ethington, 1965; Mound, 1968) and Ontario, Canada (Winder, 1966).

In Europe the species is extremely common in Germany (Bischoff, 1956; Müller, 1956; Ziegler, 1958, 1962a, b; Helms, 1959; Krebs & Rabien, 1964; Meyer, 1965; Schriel & Stoppel, 1965; Stoppel & Zscheke, 1966; Wachendorf, 1966a, b; Zitzmann, 1967; Bering, 1967; Bar, 1968; Schneider, 1969). Elsewhere in Europe the species has been reported from Austria (Flajs, 1966; Schulze, 1968; and Schönlau, 1969), Belgium (Bouckaert & Ziegler, 1965), Czechoslovakia

(Friakova, 1961), France (Boyer et al., 1968), Yugoslavia (Spasov & Stefanovic, 1962; Spasov & Filipovic, 1967; and Spasov et al., 1968), Poland (Wolska, 1967), and Spain (Boogaert, 1967).

In Africa the species has been noted in the Spanish Sahara (Ethington & Furnish, 1962) and Morocco (Massa, 1965), and the Canning Basin, Australia, has previously yielded specimens (Glenister & Klapper, 1966; Seddon, 1970).

Range: The species was originally described from the Frasnian Sweetland Creek Shale of Iowa (Miller & Youngquist, 1947). In North America it has been recorded from the Palmatolepis gigas Zone (Clark & Ethington, 1967). Ziegler (1962) records the European range as Upper Palmatolepis asymmetricus Zone (to I β) up to the Middle Palmatolepis triangularis Zone (basal Famennian).

The Canning Basin specimens range from the Upper Polygnathus asymmetricus Zone up to the Middle Polygnathus triangularis Zone.

PALMATOLEPIS TENUIPUNCTATA Sannemann, 1955

Pl. 15, figs. 6a,b

- 1955 Palmatolepis tenuipunctata Sannemann, Senck. leth., 36, 136, pl. 6, fig. 22.

For complete synonymy up to 1965 see:

- 1966 Palmatolepis tenuipunctata Sannemann; Glenister & Klapper, J. Paleont., 40, 824, pl. 89, fig. 4; pl. 92, figs. 9-11.
- 1965 Palmatolepis tenuipunctata Sannemann; Bouckaert & Ziegler, Mem. Expl. Cart. Geol. Min., 5, 21, pl. 2, figs. 10, 11.
- ? 1965 Palmatolepis tenuipunctata Sannemann; Olivieri, Boll. Soc. Paleont. Ital., 4, 51, pl. 5, figs. 5a, b.
- 1967 Palmatolepis tenuipunctata Sannemann; Nehring, Inst. Geol. Bull. 209, 147, pl. 1, figs. 1, 2.

- 1967 Palmatolepis tenuipunctata Sannemann; Clark & Ethington,
Geol. Soc. Amer. Mem. 103, 56, pl. 9, fig. 11.
- 1967 Palmatolepis tenuipunctata Sannemann; Wolska, Acta Palaeont.
Polonica, 12, 408, pl. 13, figs. 11-13; text-fig. 16.
- 1969 Palmatolepis tenuipunctata Sannemann; Olivieri, Boll. Soc.
Paleont. Italiana, 8, 117, pl. 18, figs. 1, 2.

Material: 50 specimens, CPC 12662-12665 figured.

Localities of figured material: Sample BG 19455, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: P. tenuipunctata is transitional between P. subperlobata and P. glabra s.s. However, the elongate unit with a small lateral lobe is distinctive.

Distribution: The species was originally described from the Frankenswald, Germany (Sannemann, 1955). Since then it has been reported extensively from Germany (Müller, 1956; Bischoff, 1956; Bischoff & Ziegler, 1957; Stoppel, 1958; Walliser, 1958; Helms, 1959, 1963; Freyer, 1961; Ziegler, 1962a, b, c; Zitzmann, 1966; Wachendorf, 1966a, b; Stoppel & Zscheke, 1966; Bering, 1967; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970). Elsewhere in Europe the species has been recorded in Austria (Ziegler in Flügel & Ziegler, 1957; Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), France (Serre & Lys, 1958; Lys et al., 1961; Boyer et al., 1968), Italy (Olivieri, 1965, 1969), and Poland (Nehring, 1957; Wolska, 1967).

There are only three reports of the species outside Europe; Utah, U.S.A. (Clark & Becker, 1960; Clark & Ethington, 1967), Morocco (Massa, 1965), and Australia (Glenister & Klapper, 1966).

Range: Sannemann (1955) described the original species from the Famennian to II α Zone. Freyer (1961) recorded the species from to I δ Zone up to the to II α Zone. Ziegler (1962) recorded the range as Upper Palmatolepis triangularis Zone (to I/II) up to the Upper

Palmatolepis crepida Zone (to II ∞). This is also the range in Poland (Wolska, 1967). In North America, Clark & Ethington (1967) recorded it from the Upper P. triangularis and Lower P. crepida Zone. In the Canning Basin the species ranges throughout the P. crepida Zone.

PALMATOLEPIS TRANSITANS Müller, 1956

Pl. 15, figs. 3a,b

- 1956 Palmatolepis (Manticolepis) transitans Müller, Senck. Naturf. Ges. Abh., 494, 18, pl. 1, figs. 1, 2.
- 1957 Palmatolepis transitans Müller; Bischoff & Ziegler; Hess. Landesamt Bodenf. Abh., 22, 81, pl. 16, figs. 23-27.
- 1958 Palmatolepis transitans Müller; Ziegler, Hess. Landesamt Bodenf., Notizbl., 87, 66, pl. 1, figs. 9, 11-13; pl. 2, figs. 1-3, 8.
- 1959 Palmatolepis transitans Müller; Krebs, Senck. leth., 40, 379, pl. 1, fig. 2.
- 1962 Palmatolepis transitans Müller; Ziegler, N. Jb. Geol. Palaont., Abh., 114, 166, part of text-fig. 8.
- 1963 Palmatolepis (Manticolepis) transitans Müller; Helms, Geologie, 12, 454, text-fig. 2.3.
- 1964 Palmatolepis transitans Müller; Budurov & Tschunov, Bull. Inst. Sci. Recherch. Geol., 1, 255, pl. 2, figs. 2a, b; ?9.
- 1965 Palmatolepis transitans Müller; Ziegler, Fortschr. Geol. Rheinld. Westf., 9, 538, pl. 1, fig. 2.
- 1967 Palmatolepis transitans Müller; Boogaert, Leidse Geol. Med., 39, 183, pl. 2, fig. 33.

Material: 2 specimens, CPC 12666-12667 figured.

Localities of figured material: Sample BG 19534, 19544, Section 9, Balme Knoll, Gogo and Virgin Hills Formation.

Remarks: P. transitans, as its name implies, is transitional between

the genera Polygnathus and Palmatolepis. It can be distinguished from polygnathids by the presence of an azygous node. It differs from other species of Palmatolepis in having a straight carina. The presence of an azygous node places it firmly in the genus Palmatolepis.

Distribution: The species was originally described from Adorf, Germany (Müller, 1956). Since then it has been described from the Adorf-Stufe several times (Ziegler, 1958; Krebs, 1959; Ziegler, 1962; Krebs & Rabien, 1964). Other occurrences in Germany are reported by Bischoff & Ziegler (1957), Ziegler (1965) and Bar (1968). Previously, the species was only known from Europe and it has been reported from Austria (Flajs, 1966; Schulze, 1968; Schönlaub, 1969), Bulgaria (Budurov & Tschunев, 1964), France (Boyer et al., 1968), and Spain (Boogaert, 1967).

Range: Ziegler (1958) gives the range as Middle-Upper Devonian boundary up to the basal part of the to I γ Zone. Flajs (1966), however, shows the species restricted to the lower part of the Polygnathus asymmetricus Zone (to I α) in Austria. Boyer et al., (1968), however, suggest that the species is possibly present in the lowest part of the to I Zone in France. In the Canning Basin the species is present in the Middle to Upper Polygnathus asymmetricus Zone (to I α - β).

PALMATOLEPIS TRIANGULARIS Sannemann, 1955

Pl. 16, figs. 3a,b

1955 Palmatolepis triangularis Sannemann, N. Jb. Geol. Palaont., Abh., 100, 327, pl. 24, fig. 3.

For complete synonymy to 1964 see:

1966 Palmatolepis triangularis Sannemann; Glenister & Klapper, J. Paleont., 40, 825, pl. 92, figs. 17, 18.

? 1964 Palmatolepis triangularis Sannemann; Budurov & Tschunев, Bull. Inst. Sci. Recherch. Geol., 1, 256, pl. 3, figs. 1a,

- b; 5, 6a, b; 9, 10a, b; pl. 4, figs. 1a, b.
- 1965 Palmatolepis triangularis Sannemann; Freyer, Abh. Berich. Naturk. Gorlitz, 40, V8, text-fig. 1.4.
- 1965 Palmatolepis triangularis Sannemann; Bouckaert & Ziegler, Mem. Expl. Cart. Geol. Min. Belg., 5, 21, pl. 1, figs. 1-6.
- 1966 Palmatolepis triangularis Sannemann; Anderson, J. Paleont., 40, 409, pl. 48, figs. 3, 12, 18?; pl. 49, fig. 3.
- 1967 Palmatolepis triangularis Sannemann; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 56, pl. 9, figs. 7, 13, 14.
- non 1967 Palmatolepis triangularis Sannemann; Nehring, Inst. Geol. Bull. 209, 142, pl. 14, fig. 11 (? = P. minuta); pl. 5, figs. 10a, b (= P. quadrantinodosalobata).
- 1967 Palmatolepis triangularis Sannemann; Wolska, Acta Palaeont. Polonica, 12, 410, pl. 13, figs. 1-4b.
- 1968 Palmatolepis triangularis Sannemann; Lange, Geol. Palaeont., 2, 41, pl. 2, fig. Pa.
- 1969 Palmatolepis triangularis Sannemann; Olivieri, Boll. Soc. Paleont. Italiana, 8, 118, pl. 18, figs. 3a-5.

Material: 125 specimens, CPC 12668-12671 figured.

Localities of figured material: Samples BG 19453E, 19454A, 19454B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: P. triangularis is easily distinguished by its upturned posterior termination, otherwise in general outline and ornamentation it is extremely similar to P. subrecta.

Distribution: The species was originally described from the Frankwald, Germany, by Sannemann (1955). Since that time it has been recorded many times from Germany (Müller, 1956; Bischoff, 1956; Bischoff & Ziegler, 1956, 1957; Ziegler, 1962a, b, c; Helms, 1959, 1963; Freyer, 1961, 1965; Kronberg et al., 1962; Schriel & Stoppel,

1965; Zitzmann, 1966, 1967; Wachendorf, 1966; Stoppel & Zscheke, 1966; Bering, 1967; Lange, 1968; Bar, 1968; Schneider, 1969). Elsewhere in Europe the species has been reported from Austria (Ziegler, in Flügel & Ziegler, 1957; Schönlaub, 1969), Bulgaria (Budurov & Tschunov, 1964), Belgium (Bouckaert & Ziegler, 1965), Czechoslovakia (Friakova, 1964; Dvorak et al., 1959), France (Lys & Serre, 1957; Serre & Lys, 1958; Lys et al., 1961; Boyer et al., 1968), Italy (Olivieri, 1969), and Poland (Freyer & Zakowa, 1967; Wolska, 1967).

The species is rarer in North America but is known from Iowa (Klapper & Furnish, 1963; Anderson, 1964, 1966), Missouri (Branson & Mehl, 1934), New York (Oliver et al., 1967), Nevada and Utah (Clark & Becker, 1960; Clark & Ethington, 1967) and Tennessee (Hass, 1956).

The only other records of the species are from Morocco (Massa, 1965) and Australia (Glenister & Klapper, 1966).

Range: The species was originally described from the upper to I and lower to II Zones of the Frankenwald (Sannemann, 1955). Helms (1959) records the species from the uppermost to I δ Zone as does Freyer (1961). Ziegler (1962) recorded the range as Palmatolepis triangularis Zone (to I δ) into the Middle Palmatolepis crepida (to II). Boyer et al. (1968) find the same range in France.

In North America Clark & Ethington (1967) recorded the range as Middle Palmatolepis triangularis Zone up to the Lower Palmatolepis crepida Zone. The Canning Basin specimens have exactly the same range as the Great Basin specimens.

PALMATOLEPIS cf. P. TRIANGULARIS Sannemann, 1955

Pl. 16, figs. 5

Material and Locality: Single specimen, CPC 12674 figured, from Sample BG 19017, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: The single specimen is close to P. triangularis but differs in

having an extra inner lateral lobe immediately anterior to the main lobe. This specimen comes from the Lower Palmatolepis triangularis Zone.

PALMATOLEPIS UNICORNIS Miller & Youngquist, 1947

Pl. 16 figs. 2a,b

- 1947 Palmatolepis unicornis Miller & Youngquist, J. Paleont., 21, 514, pl. 75, fig. 15.

For complete synonymy up to 1965 see:

- 1966 Palmatolepis unicornis Miller & Youngquist; Glenister & Klapper, J. Paleont., 40, 826, pl. 88, figs. 10, 11.
- 1966 Palmatolepis unicornis Miller & Youngquist; Winder, ibid., 1275, pl. 156, fig. 10.
- 1967 Palmatolepis unicornis Miller & Youngquist; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 56, pl. 4, fig. 13; pl. 9, fig. 3.

Material: 22 specimens, CPC 12672-12673 figured.

Localities of figured material: Samples BG 19583, 19584, Section 12, southwest of Waggon Pass, Virgin Hills Formation.

Remarks: Palmatolepis unicornis can be distinguished from other palmatolepids of similar shape by its high anterior-free blade termination. It differs from P. punctata in having a more sigmoidal carina and the inner lobe being adjacent to the azygous lobe (Glenister & Klapper, 1966, p. 826).

Distribution: The species was originally described from Iowa (Miller & Youngquist, 1947) and subsequently it has been recorded again from that state (Müller & Müller, 1957; Klapper & Furnish, 1963). Elsewhere in North America the species has been recorded from Oklahoma (Hass & Huddle, 1965), Tennessee (Hass, 1956) and Utah (Clark &

Ethington, 1967) and from Ontario, Canada (Winder, 1966).

In Europe the species has only been described and recorded from Germany (Ziegler, 1958, 1962; Walliser, 1958; Krebs & Rabien, 1964; Meyer, 1965; Wachendorf, 1966; Stoppel & Zscheke, 1966; Bar, 1968).

Range: The species was originally described from the Frasnian Sweetland Creek Shale of Iowa (Miller & Youngquist, 1947). Ziegler (1962) records the range of the species from the upper part of Ancyrognathus triangularis Zone (to I 7) to the top of the Palmatolepis gigas Zone (to I 8). Clark & Ethington (1967) record the species in the Lower Palmatolepis gigas Zone in North America.

In the Canning Basin the species appears to be restricted to the Lower Palmatolepis gigas Zone.

PALMATOLEPIS sp. nov. A

Pl. 16, figs. 1

Material: 4 specimens, CPC 12675 figured.

Locality of figured material: Sample BG 19077, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: This species is a small elongate palmatolepid with narrow sub-equal platforms. The platforms extend along the free blade anterior to the azygous node. The platform outline is reminiscent of P. minuta or perhaps P. distorta manca Helms. However, subspecies of P. minuta show platform reduction in an area posterior to the azygous node. P. distorta manca shows considerable lateral flexing at the azygous node. The present specimens show some warping of the platform but no flexure. The specimens come from the Palmatolepis rhomboidea and Lower Palmatolepis quadrantinodosa Zones.

PALMATOLEPIS sp. nov. B

Pl. 15, figs. 2a,b

1966 Palmatolepis quadrantinodosa marginifera Helms; Glenister & Klapper (part), J. Paleont., 40, 820, pl. 91, fig. 6 only.

Material and Locality: Single specimen, CPC 12650 figured from Sample BG 19092, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: Palmatolepis quadrantinodosa marginifera has, typically, a rather elongate rhomboidal platform outline. A single specimen in the present fauna and one illustrated by Glenister & Klapper (pl. 91, fig. 6) are pear-shaped and have extensive nodes developed on the anterior part of the inner platform. These characters are certainly distinct from P. quadrantinodosa marginifera which typically bears "shagreen" ornament.

The present specimen comes from the Lower Palmatolepis quadrantinodosa Zone.

Genus PELEKYSGNATHUS Thomas, 1949

Type species: Pelekysgnathus inclinatus Thomas, 1949.

PELEKYSGNATHUS ELEVATUS (Branson & Mehl, 1938)

Pl. 22, figs. 1

- 1938 Icriodus elevatus Branson & Mehl, J. Paleont., 12, 160, pl. 26, figs. 18-21.
- 1955 Pelekysgnathus planus Sannemann, Senck. leth., 36, 149, pl. 4, figs. 22, 23.
- 1961 Pelekysgnathus planus Sannemann; Lys et al., Rev. Inst. Francais Petrole, 16, 551, pl. 2, fig. 11.
- 1967 Pelekysgnathus planus Sannemann; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 57, pl. 6, figs. 1, 14.
- 1967 Pelekysgnathus sp. Spasov & Filipovic, Bulgarian Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 73, pl. 1, fig. 16.
- 1967 Pelekysgnathus planus Sannemann; Nehring, Inst. Geol. Bull. 209, 153, pl. 1, fig. 6, 7.
- 1968 Pelekysgnathus elevatus (Branson & Mehl); Pollock, J. Paleont., 42, 435, pl. 62, figs. 24-26.
- 1968 Pelekysgnathus cf. P. plana Sannemann; Mound, J. Paleont., 42, 502, pl. 68, fig. 18.
- 1969 Pelekysgnathus peejayi Druce, Bur. Miner. Resour. Aust. Bull. 98, 90, pl. 18, figs. 4a-7c; text-fig. 18.
- 1970 Pelekysgnathus planus Sannemann; Seddon, J. Geol. Soc. Aust., 16, 738, pl. 11, figs. 1-12.
- 1969 Pelekysgnathus planus Sannemann; Olivieri, Boll. Soc. Paleont. Italiana, 8, 120, pl. 10, figs. 3a, b; pl. 13, figs. 11a-12.

Material: 12 specimens, CPC 12763-12766 figured.

Localities of figured material: Sample BG 19056, Sample 4, northeast of McWhae Ridge, Sadler Limestone; Sample 21092, Cave Spring, Sadler

Limestone; Sample BG 21242, Section 19, Longs Well Creek, Gogo Formation.

Remarks: Seddon (1970, p. 737) notes that P. elevatus and P. planus are probably conspecific. Pollock (1968) illustrates specimens of P. elevatus which are within the range of variability of P. planus as defined by Clark & Ethington (1967, p. 57). The broadening of the concept of P. planus to include most pelekygnathids that lack a massive posterior denticle and an arched aboral margin, means that P. peejayi Druce is a junior synonym of P. elevatus. Seddon (1970, pl. 11, figs. 10-12) illustrates a specimen with a lateral denticle on either side of the carina; my fauna also contains one identical specimen which is intermediate between Icriodus and Pelekygnathus. I prefer to think of specimens with lateral ornament as belonging in Icriodus.

Distribution: The species was originally described from Missouri (Branson & Mehl, 1938) and has since been recorded from Utah (Clark & Ethington, 1967) and Alberta (Pollock, 1968; Mound, 1968) in North America. In Europe the species has been described as P. planus from Germany (Sannemann, 1955) where it has also been noted by Bischoff & Ziegler (1956), Ziegler (1959; 1962), and Bar (1968). Elsewhere it has been reported from Austria (Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), Czechoslovakia (Friakova, 1964), France (Lys et al., 1961), Italy (Olivieri, 1969), Yugoslavia (Spasov & Filipovic, 1967), and Poland (Nehring, 1967). The species is also present in Australia (Druce, 1969; Seddon, 1970).

Range: The species was originally described from the Mineola Formation (Middle Devonian) of Missouri (Branson & Mehl, 1938). Clark & Ethington (1967) record the range in the Great Basin as Middle Palmatolepis triangularis Zone through Lower P. crepida Zone. Both Pollock (1968) and Mound (1968) recorded the species from the Lower Frasnian Duvernay Formation. In Europe the first record of the species was in the Famennian (to II α) of Germany (Sannemann, 1955). Ziegler (1962)

records the range as Upper Palmatolepis triangularis Zone to the Lower Palmatolepis quadrantinodosa Zone. Nehring (1967) records the range in Poland as late Frasnian up to the top of the Famennian to IV Zone. In the Bonaparte Gulf Basin the species is present in the early Famennian (to II β - to III α) (Druce, 1969). In the Canning Basin the species ranges from the Middle Polygnathus asymmetricus Zone up to the Ancyrognathus triangularis Zone. The overall range of the species appears to be Middle Devonian to late Famennian (to VI) but the majority of occurrences appear to be in the Frasnian and earliest Famennian.

PELEKYSGNATHUS sp.

Pl. 22, figs. 2

Remarks: A single specimen, CPC 12667 , from the upper 2 feet of the Piker Hills Formation, Sample BG 19183, Section 4, northeast of McWhae Ridge, is distinctive. It bears an elongate posterior denticle resembling P. inclinatus but it lacks the conspicuous aboral arching of P. inclinatus. Seddon (1970) notes that there are two distinct groups of pelekysgnathids, one with a highly arched aboral margin, and the other with a straight aboral margin. Using this criterion this specimen belongs to the second group with P. elevatus. The dentition consists of five fused denticles, only two having free tips, the remainder forming a "sail."

Another odd feature is the development of twin apices at the posterior end of the basal cavity which is filled with basal "bone." The apices correspond to the growth axis of the two posteriormost denticles. This specimen occurs in the Middle Polygnathus styriacus Zone (to V).

Genus POLYGNATHELLUS Bassler, 1925

Type species: Polygnathellus typicalis Bassler, 1925

POLYGNATHELLUS MULTIDENS (Ulrich & Bassler, 1926)

Pl. 22, figs. 12

- 1926 Bryantodus multidens Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 22, pl. 6, fig. 15 [pl. 6, fig. 16 = Bryantodus nitidus].
- 1926 Bryantodus conjunctus Ulrich & Bassler, ibid., 24, pl. 4, fig. 9 [pl. 4, fig. 8 = B. nitidus].
- 1926 Polygnathellus typicalis (part) Bassler; Ulrich & Bassler, ibid., 53, pl. 1, fig. 3 [pl. 1, figs. 1, 2 = P. typicalis].
- 1926 Polygnathellus curvatus Ulrich & Bassler, ibid., 54, pl. 1, fig. 4.
- 1948 Bryantodus obtusicuspus Youngquist, Hibbard, & Reimann, J. Paleont., 22, 51, pl. 15, fig. 6.
- non 1956 Bryantodus multidens Ulrich & Bassler; Bischoff, Hess. Landesamt Bodenf., Notizbl., 84, 122, pl. 10, figs. 1, 2. [? = P. germanus].
- 1957 Bryantodus colligatus (Bryant); Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh., 22, 47, pl. 19, fig. 39.
- ? 1967 Bryantodus multidens Ulrich & Bassler; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 33, pl. 3, fig. 14.
- 1967 Bryantodus colligatus (Bryant); Müller & Clark, J. Paleont., 41, 910, pl. 117, figs. 2, 9.
- 1968 Polygnathellus multidens (Ulrich & Bassler); Huddle, U.S. Geol. Surv. Prof. Pap. 578, 36, pl. 4, figs. 2-5.
- 1968 Bryantodus chesteri Youngquist (part); Mound, J. Paleont., 42, 478, pl. 65, fig. 35 only.
- 1970 Polygnathellus multidens (Ulrich & Bassler); Seddon, J. Geol. Soc. Austral., 16, 752, pl. 14, fig. 24.

Material: 38 specimens, CPC 12769-12772 figured.

Localities of figured material: Sample BG 19001, Section 1, McWhae Ridge, Gogo Formation; Sample BG 19543, Section 9, Balme Knoll, Gogo Formation; Sample 19585, Section 12, southwest of Waggon Pass, Virgin Hills Formation; Sample BG 19598, Section 13, Glenister Knolls, Gogo Formation.

Description: Elongate arched bar unit with tumid base which is expanded as a narrow platform along both sides of bar. The unit bears a row of laterally compressed fused denticles with free chevron tips. The denticles tend to be highest in the mid-region above the basal cavity and generally higher on the anterior than on the posterior portion.

At the point of flexure which is developed slightly anterior to or at the mid-point, a basal cavity is developed. It is slightly flared and is situated within a deep keel which runs the length of the unit.

Remarks: P. multidentis is close to Bryantodus, being separated from it by the development of definite platforms on both sides of the bar.

P. multidentis probably developed from Bryantodus nitidus by growth of the platform and reduction of the apical denticle.

Distribution: The species was originally described from the Upper Devonian Rhinestreet Shale of New York State (Ulrich & Bassler, 1926; Youngquist, Hibbard, & Reimann, 1948; Huddle, 1968). Elsewhere in North America it is known from Utah (Clark & Ethington, 1967) and Alberta (Mound, 1968) who described forms referable to P. multidentis as Bryantodus chesteri. It has also been recorded in Austria (Schönlaub, 1969). Specimens from Michigan have been referred to Bryantodus colligatus (Bryant) (Müller & Clark, 1967). The species has also been recorded from Arizona (Ethington, 1965). The species has been recorded as B. colligatus from Germany (Bischoff & Ziegler, 1957), Spanish Sahara (Ethington & Furnish, 1962), and the Canning Basin, Australia (Seddon, 1970).

Range: The species ranges from the upper Middle Devonian (Bischoff & Ziegler, 1957) as high as the I/II boundary in the Upper Devonian (Clark & Ethington, 1967). The majority of the occurrences are in the Frasnian.

POLYGNATHELLUS cf. P. TYPICALIS Bassler, 1925

Pl. 22, fig. 15

cf. 1926 Polygnathellus typicalis Bassler; Ulrich & Bassler, U.S. Natl. Mus. Proc. 68, 53, pl. 1, figs. 1, 2.

Material: Single specimen, CPC 12773 figured, from Sample BG 19541, Section 9, Balme Knoll, Virgin Hills Formation.

Remarks: The single broken specimen is referred to P. typicalis because of the well-developed ornamented platform developed on either side of the bar. It closely resembles forms referred to P. n. sp. by Clark & Ethington (1967).

Genus POLYGNATHUS Hinde, 1879

Type species: Polygnathus dubius Hinde, 1879.

POLYGNATHUS ASYMMETRICUS ASYMMETRICUS

Bischoff & Ziegler, 1957

Pl. 17, figs. 10a,b

1957 Polygnathus dubia asymmetrica Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh., 22, 88, pl. 16, figs. 18, 20-22; pl. 21, fig. 3.

1958 Polygnathus dubia asymmetrica Bischoff & Ziegler; Ziegler, Hess. Landesamt Bodenf. Notizbl., 87, pl. 1, figs. 4-6, 8, 10.

1959 Polygnathus dubia asymmetrica Bischoff & Ziegler; Krebs, Senck. leth., 40, 384, pl. 1, fig. 3.

- 1966 Polygnathus asymmetrica asymmetrica Bischoff & Ziegler;
Flajs, N. Jb. Geol. Palaont. Abh., 124, 230, pl. 26,
figs. 1-9.
- 1966 Polygnathus asymmetrica asymmetrica Bischoff & Ziegler;
Glenister & Klapper, J. Paleont., 40, 828, pl. 88, figs.
6, 7.
- 1967 Polygnathus dubia asymmetrica Bischoff & Ziegler (= asym-
metrica asymmetrica Bischoff & Ziegler); Clark & Ething-
ton, Geol. Soc. Amer. Mem., 103, 61, pl. 7, fig. 18.
- 1967 Polygnathus asymmetrica asymmetrica Bischoff & Ziegler;
Boogaert, Leidse Geol. Med., 39, 183, pl. 2, fig. 36.
- ? 1968 Polygnathus asymmetrica asymmetrica Bischoff & Ziegler;
Mound, J. Paleont., 42, 503, pl. 68, figs. 8, 9.

Material: 33 specimens, CPC 12676-12679 figured.

Localities of figured material: Sample BG 19186, McWhae Ridge, Gogo Formation; Sample BG 19544, Section 9, Balme Knoll, Gogo Formation; Sample BG 21253, Section 20, Longs Well Creek, Gogo Formation.

Remarks: The nomenclature problems caused by the fact that the lectotype of P. dubia Hinde is fragmentary have been adequately covered by Glenister & Klapper (1966, p. 828) and Clark & Ethington (1967, p. 58). Because the name P. asymmetricus asymmetricus is well known and understood and also is a zone name giver, I prefer to use it rather than P. dubius asymmetricus Hinde which is possibly technically correct.

Distribution: The species was originally described from Germany (Bischoff & Ziegler, 1957). Other German occurrences have been reported by Ziegler (1958), Krebs (1959), Helms (1963), Krebs & Rabien (1964), Bar (1968), and Schneider (1969). Other European countries from which the subspecies has been recorded include Austria (Flajs, 1966; Schulze, 1968; and Schönlaub, 1969) and Spain (Boogaert, 1967).

Reports of the subspecies from North America are concentrated in Alberta (Clark & Ethington, 1965; Uyeno, 1967; Pollock, 1968; Mound, 1968), the only other occurrence being from Nevada (Clark & Ethington, 1967). Glenister & Klapper (1966) have reported the species from the Canning Basin, Australia.

Range: Ziegler (1962) records the range as throughout the Frasnian Polygnathus asymmetricus Zone (to I α - to I β). All other reports of the subspecies are within this range and in the Canning Basin the range is identical with that in Germany.

POLYGNATHUS ASYMMETRICUS OVALIS

Ziegler & Klapper, 1964

Pl. 17, figs. 11a,b

- 1949 Polygnathus dubia Hinde; Beckmann, Senckenbergiana, 30, 154, pl. 1, fig. 3; pl. 2, fig. 10; pl. 4, fig. 4.
- 1957 Polygnathus dubia dubia Hinde; Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh., 22, 88, pl. 16, fig. 19; pl. 21, fig. 1.
- 1958 Polygnathus dubia dubia Hinde; Ziegler, Hess. Landesamt Bodenf., Notizbl., 87, pl. 1, figs. 1-3, 7.
- 1963 Polygnathus dubia dubia Hinde; Helms, Geologie, 12, text-fig. 2.1.
- 1964 Polygnathus asymmetrica ovalis Ziegler & Klapper, J. Paleont., 38, 422.
- 1965 Polygnathus asymmetrica ovalis Ziegler & Klapper; Ziegler, Fortschr. Geol. Rheinld. Westf., 9, 538, pl. 1, figs. 3, 4.
- 1966 Polygnathus asymmetrica ovalis Ziegler & Klapper; Flajs, N. Jb. Geol. Palaont. Abh., 124, 239, pl. 25, figs. 1-3.
- 1967 Polygnathus dubius Hinde; Müller & Clark, J. Paleont., 41, 916, pl. 115, figs. 5a-6.

1967 Polygnathus dubia dubia Hinde (= asymmetrica ovalis Ziegler & Klapper); Clark & Ethington, Geol. Soc. Amer. Mem. 103, 60 pl. 7, figs. 14, .5; pl. 8, figs. 8, 9.

1968 Polygnathus asymmetrica ovalis Ziegler & Klapper, J. Paleont., 42, 504, pl. 69, figs. 4, 5.

Material: 15 specimens, CPC 12680-12681 figured.

Localities of figured material: Samples BG 19001, 19007, Section 1, McWhae Ridge, Gogo Formation; Sample BG 19482, Section 6, Lloyd Hill - Laidlaw Range, Gogo Formation.

Remarks: The problems of nomenclature due to Hinde's specimens being fragmentary have been discussed by Ziegler, Klapper, & Lindstrom (1964) and Clark & Ethington (1967). I prefer to keep the name P. asymmetricus ovalis because, at the present time, the zone in which it occurs is labelled the P. asymmetricus Zone. Müller & Clark (1967) note that the range of P. asymmetricus s.s. and P. asymmetricus ovalis are identical but that in their fauna only the latter was present, suggesting that the difference may be real rather than imaginary. The distribution of the two subspecies throughout the world is very similar; faunas containing one subspecies usually contain both. However, there are exceptions apart from the Squaw Bay fauna of Müller & Clark, including faunas reported by Beckman (1949), Schriel & Stoppel (1965), and Ziegler (1965) from Germany. One fauna reported by Krebs (1959) contains P. asymmetricus but lacks P. asymmetricus ovalis.

Distribution and Range: Ziegler, Klapper & Lindström (1964) selected a form illustrated by Ziegler (1958) from the Adorfstufe, Germany. Other German occurrences have been reported by Beckmann (1949), Bischoff & Ziegler (1957), Helms (1963), Krebs & Rabien (1964), Schriel & Stoppel (1965), Ziegler (1965), Bar (1968), Schneider (1969), and Meischner & Schneider (1970). Other European occurrences are

confined to Austria (Flajs, 1966; Schulze, 1968, and Schönlaub, 1969).

In North America the species has been reported from Alberta (Clark & Ethington, 1965; Uyeno, 1967; Pollock, 1968; and Mound, 1968), Michigan (Müller & Clark, 1967), and Nevada (Clark & Ethington, 1967). Glenister & Klapper (1966) have reported it from the Canning Basin, Australia.

POLYGNATHUS AUSTRALIS sp. nov.

Pl. 17, figs. 12a - 13b

- 1965 Polygnathus normalis Miller & Youngquist s.l.; Krebs & Ziegler, Forsch. Geol. Rheinld. Westf., 9, pl. 2, fig. 1.
- 1970 Polygnathus sp. Druce, Bur. Miner. Resc. Aust. Bull. 108, 81, pl. 14, figs. 1a-3b.
- 1970 Polygnathus sp. Seddon, J. Geol. Soc. Aust., 16, 753, pl. 16, figs. 13, 14.

Derivation of name: From its common occurrence in Australia.

Material: 14 specimens, holotype CPC 12685 , paratypes CPC 12684, 12686.

Localities of figured material: Holotype BG 19412, east side of McWhae Ridge, Virgin Hills Formation; Paratypes BG 19425, 1 mile north of Cave Spring, Sadler Limestone; Sample BG 19577, Section 12, south-west of Waggon Pass, Gogo Formation.

Diagnosis: A polygnathid with a massive platform equal in length to the free blade and bearing transverse ridge ornament on the anterior half and nodes on the posterior half.

Description: An elongate lanceolate unit, the platform being slightly larger than the free blade. The free blade is tall, its highest point being at its mid-point. It consists of about seven fused denticles with free chevron tips.

The platform is deep in the anterior part and shallow in the posterior part. In the posterior part two adcarinal troughs are present and the platform edges are upturned, bearing strong transverse ridges. The ridges are often fused laterally into pairs. Posteriorly, the platform is wider and the troughs disappear to be replaced by low unornamented areas. The posterior area is ornamented by low diffuse nodes. The carina is slightly bowed and consists of low nodes which decrease in size posteriorly.

Aborally, the unit is strongly keeled. The basal cavity is situated in the anterior quarter of the platform and is small and circular.

Remarks: This species belongs to a group of polygnathids characterized by P. foliatus Bryant. P. australis differs from P. foliatus in the nodose platform ornament. P. webbi is also a member of this group but differs in platform ornament and also in platform symmetry, P. webbi being very narrow on the inner platform. P. australis develops from P. foliatus by a broadening of the posterior part of the platform and the breakdown of the transverse ridges into nodes. P. amanus can be distinguished by the transverse ridges and disappearance of the carina in the posterior half.

Occurrence: At the present the species is known only from Australia, being originally described from Frasnian strata in Queensland (Druce, 1970b). Seddon (1970) also records it from the Canning Basin.

Range: The species was illustrated from the boundary beds of the Middle/Upper Devonian in Germany (Krebs & Ziegler, 1965). The Queensland specimens come from late Frasnian, possibly to I δ (Druce, 1970b). The West Australian specimens of Seddon (1970) come from the Palmatolepis gigas Zone (to I δ). In the present fauna the species is common in the Polygnathus asymmetricus Zone (to I α - to I β). The species range appears to be essentially Frasnian.

POLYGNATHUS BREVILAMINUS Branson & Mehl, 1934

Pl. 18, figs. 1a,b

- 1934 Polygnathus brevilamina Branson & Mehl, Univ. Missouri Stud., 8, 246, pl. 21, figs. 3-6.
- For complete synonymy up to 1966 see:
- 1968 Polygnathus brevilamina Branson & Mehl; Mound, J. Paleont., 42, 504, pl. 69, figs. 6, 7.
- 1967 Polygnathus brevilamina Branson & Mehl; Wirth, N. Jb. Geol. Palaont. Abh., 127, 224, pl. 21, figs. 15-17.
- 1967 Polygnathus cf. brevilamina Branson & Mehl; Wolska, Acta Palaeont. Polonica, 12, 411, pl. 14, figs. 5a, b.
- 1968 Polygnathus brevilamina Branson & Mehl; Schulze, N. Jb. Geol. Palaont. Abh., 130, 211, pl. 20, figs. 5, 6.
- 1969 Polygnathus cf. P. brevilamina Branson & Mehl; Druce, Bur. Miner. Resc. Aust. Bull., 98, 92, pl. 19, figs. 1-4.

Material: 45 specimens, CPC 12689 figured.

Localities of figured material: Sample BG 19452D, 19453D, 19454B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: Polygnathus brevilaminus has recently been the subject of a study by Anderson & Ozias (1966). They discuss the validity of the genus Ctenopolygnathus used by Müller & Müller to distinguish polygnathiform species intermediate between Spathognathodus and Polygnathus. Anderson & Ozias conclude that the distinction between Polygnathus and Ctenopolygnathus is not valid; however, P. brevilaminus does appear to be a polygnathid development from a spathognathid ancestor and Ctenopolygnathus may be usefully used as a subgeneric name for such forms.

Anderson & Ozias also point out that there is considerable variation in morphology, especially in platform size and situation

although in gross morphology, especially blade profile there is consistency. This species is easily distinguishable and Anderson & Ozias comment that broader species concepts should be used. However, using very broad species concepts it is extremely difficult to place many Frasnian polygnathids in named species.

Occurrence: The species was originally described from the Grassy Creek Shale, Missouri (Branson & Mehl, 1934). Elsewhere in North America it has been recorded from Iowa (Müller & Müller, 1957; Youngquist & Peterson, 1947; Anderson, 1964, 1966; Anderson & Ozias, 1966), Arizona (Ethington, 1962), Utah (Clark & Becker, 1960), and Alberta (Mound, 1968).

In Europe the species is common in Germany (Sannemann, 1955; Bischoff, 1956; Bischoff & Ziegler, 1956; Stoppel, 1958; Freyer, 1961; Ziegler, 1962; and Bar, 1968). Other European occurrences include Austria (Schulze, 1968), Czechoslovakia (Friakova, 1964), Poland (Wolska, 1967) and Spain (Wirth, 1967).

The species has also been reported from the Bonaparte Gulf Basin, Australia (Druce, 1969).

Range: The species was originally described from the Famennian Grassy Creek Shale of Missouri (Branson & Mehl, 1934). It is also abundant in the early Famennian Sheffield Formation of Iowa (Anderson, 1966). Ziegler (1962) gives the range in Germany as Manticoceras and Cheiloceras - Stufen (to I - to II) although both Bischoff & Ziegler (1956) and Freyer (1961) record the species from Famennian to V strata.

In the Canning Basin the species ranges from the Lower Polygnathus asymmetricus Zone (Frasnian to I) as high as the Lower Palmatolepis quadrantinodosa Zone (Famennian to II β).

POLYGNATHUS COLLINSONI Druce, 1969

Pl. 18, figs. 2a,b

- 1961 Polygnathus communis Branson & Mehl; Scott & Collinson,
Kansas Geol. Soc., 26th Ann. Field Conf. Guidebook,
 130, pl. 1, figs. 8, 10 only.
- 1969 Polygnathus collinsoni Druce, Bur. Miner. Resc. Aust. Bull.
 98, 93, pl. 23, figs. 3, 4; text-fig. 19.

Material: 12 specimens, CPC 12690-12691 figured.

Localities of figured material: Sample BG 19183, Section 4, northeast of McWhae Ridge, Piker Hills Formation.

Remarks: The present specimens agree closely with those described by me from the Bonaparte Gulf Basin. One specimen (pl. 18, fig. 2a) shows a crenulate margin suggesting a transversed ridged ancestor.

Occurrence: The species was first illustrated from the Louisiana Limestone of the Mississippi Valley (Scott & Collinson, 1961). The only other reported occurrence is from the Bonaparte Gulf Basin (Druce, 1969).

Range: The Louisiana Limestone, from which the species was first recovered, is considered to be late Famennian (to VI) by Collinson et al. (1962). In the Bonaparte Gulf Basin the species is present with Polygnathus znepolensis of to V - to VI age (Spasov, 1965). The present specimens are probably of Middle Polygnathus styriacus Zone age.

POLYGNATHUS DECOROSUS Stauffer, 1938

- 1938 Polygnathus decorosus Stauffer, J. Paleont., 12, 438, pl. 53,
 figs. 1, 5, 6, 10, 11, 15, 16, 20, 30.
- 1970 Polygnathus decorosus Stauffer; Seddon, J. Geol. Soc. Aust.,
 16, 738, pl. 12, figs. 17-19.

Material: 75 specimens, CPC 12692-12694 figured.

Localities of figured material: Sample BG 19007, Section 1, McWhae Ridge, Gogo Formation; Sample BG 19449B, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: Seddon (1970, pl. 739) has discussed in detail the problems of differentiating P. decorosus and P. xylus. Seddon suggests that the ranges of P. decorosus and P. xylus differ. This is probably true but there is some overlap in range and in morphology. Smooth forms (P. xylus) show considerable variation in platform morphology and ornamented forms (P. decorosus) appears to be transitional to or from other polygnathids. A complete revision of Frasnian polygnathids other than the P. asymmetricus group is needed.

Distribution and Range: Because of the wide interpretation of the species by many conodont workers it is impossible to comment on the range and occurrence of P. decorosus as originally designated by Stauffer. A revision of polygnathids from the Frasnian will provide information on ranges which may be stratigraphically useful.

POLYGNATHUS DELICATULUS Ulrich & Bassler, 1926

Pl. 18, figs. 4a,b

1926 Polygnathus delicatulus Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 45, pl. 7, figs. 9, 10.

non 1939 Polygnathus delicatula Ulrich & Bassler, Cooper, J. Paleont., 13, 400, pl. 40, figs. 37, 38 (= P. radinus Cooper).

1956 Polygnathus rimulata Ulrich & Bassler; Bischoff & Ziegler, Hess. Landesamt Bodenf., Notizbl., 84, 158, pl. 12, fig. 7.

1958 Polygnathus wyomingensis Klapper, J. Paleont., 32, 1090, pl. 142, figs. 5-8.

- 1961 Polygnathus wyomingensis Klapper; Ethington et al., J. Paleont., 35, 765, pl. 90, figs. 1-3.
- 1966 Polygnathus delicatula Ulrich & Bassler; Klapper, Univ. Kansas Paleont. Contr., Pap. 3, 22, pl. 6, figs. 7, 9, 10.
- 1968 Polygnathus delicatula Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 38, pl. 14, figs. 20, 22-24; pl. 16, fig. 19.
- 1968 Polygnathus delicatula Ulrich & Bassler; Mound, J. Paleont., 42, 506, pl. 69, figs. 23, 24.

Material: 10 specimens, CPC 12695-12697 figured.

Localities of figured material: Samples BG 19097, 19107, BG 19109, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone.

Description: The unit consists of a free blade and platform of about equal length. The free blade consists of about nine fused denticles with free chevron tips; they are usually tallest in the central region, but some specimens have the highest denticles at the anterior end. The free blade and carina are continuous; the carina is composed of low fused nodes and runs to the posterior termination where the nodes become more isolated. In lateral view the carina is higher than the platform margins.

The platform is lanceolate and bears two fairly deep adcarinal troughs. The ornament consists of scattered nodes arranged into a rough linearity. They are situated a short distance in from the platform margin and in lateral view these nodes are higher than the platform margin, though not as high as the carina.

In lateral view the unit is keeled, the keel deepens at the platform/free blade junction and merges with the aboral margin of the free blade.

In aboral view the basal cavity is slit-like and situated on the anterior part of the platform within the deepening keel.

Remarks: Klapper (1966, p. 22) distinguishes P. delicatulus from P. symmetricus on the basal cavities; in P. delicatulus the cavity is situated in the raised keel whereas in P. symmetricus it is set into the platform. However, Huddle (1968, p. 38) who, like Klapper, examined the type material of P. delicatulus described the cavity as "a large, shallow, thick-lipped pit." The present specimens have a basal cavity similar to that described by Klapper.

Distribution: The species was originally described from the "Hardin Sandstone," Tennessee (Ulrich & Bassler, 1926; Huddle, 1968). It is also known from the Wyoming (Klapper, 1958, 1966; Ethington et al., 1961) and Alberta (Mound, 1968). In Europe it has been recorded by Bischoff & Ziegler (1956) from Germany and by Boogaert (1967) from Spain.

Range: The "Hardin Sandstone" was originally thought to be Mississippian but Huddle (1968) points out that the formation contains Ordovician, Middle Devonian, Frasnian, and Famennian conodonts and the whole fauna is probably reworked. The Wyoming specimens come from strata equivalent to the to V Zone (Klapper, 1966), and the questionable Alberta specimen from Famennian strata. The German specimens come from to V strata and the Spanish forms from to V/to VI. The Canning Basin specimens come from the Palmatolepis quadrantinodosa Zone (to II β /to III α).

POLYGNATHUS FALLAX Helms & Wolska, 1967

Pl. 18, figs. 5a,b

1960 Polygnathus cf. procera Sannemann; Zimmermann, Freib. Forsch., C89, 192, pl. 6, figs. 2a, b.

1967 Polygnathus fallax Helms & Wolska, Acta Palaeont. Polonica, 12, 231, text-figs. 3a, b.

Material: 4 specimens, CPC 12698-12699 figured.

Localities of figured material: Sample 19080, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21093, Section 17, Ngumban Cliff, Virgin Hills Formation.

Description: Unit lanceolate with platform about four times as long as the free blade. The free blade is tallest in the mid-region. The platform is elongate and lanceolate, bearing irregular transverse ridges which occasionally break down into scattered nodes. Adcarinal troughs are present in the extreme anterior. The carina merges with the free blade and consists of low fused nodes. In lateral view the unit is slim and slightly bowed.

In aboral view the unit is keeled with a small elongate basal cavity. The platform bears a chine.

Remarks: Helms & Wolska (1967) point out that the species is close to P. pennatulus Ulrich & Bassler. It differs in the ornament which is much finer in P. fallax. The species is very close to P. dengleri and it is difficult to tell them apart. The ornament of P. dengleri tends to be more nodose and the blade is usually shorter. The very distinctive ranges of the two species, P. dengleri is Frasnian, suggests that they are homeomorphs.

Distribution: The first record of the species was from Saxony, Germany (Zimmermann, 1960). Helms & Wolska (1967) record the species from Germany and Poland.

Range: In Europe the species occurs in all but the lowermost part of the P. quadrantinodosa Zone (Helms & Wolska, 1967, p. 233, table 1). In the Canning Basin the species occurs in the same zone.

POLYGNATHUS FOLIATUS Bryant, 1921

Pl. 18, figs. 7a,b

- 1921 Polygnathus foliatus Bryant, Bull. Buffalo Soc. Nat. Sci., 13, 24, pl. 10, figs. 13-16.
- 1957 Polygnathus foliata Bryant; Bischoff & Ziegler, Hess. Landesamt Bodenf., Abh., 22, 90, pl. 4, figs. 1-4.
- 1957 Polygnathus foliata Bryant; Müller & Müller, J. Paleont., 31, 1086, pl. 135, fig. 1.
- 1959 Polygnathus foliata Bryant; Helms, Geologie, 8, 651, pl. 1, figs. 2a-3; pl. 4, figs. 3, 4.
- 1964 Polygnathus foliata Bryant; Budurov & Tschunov, Bull. Inst. Sci. Recherch. Geol., 1, 256, pl. 2, figs. 12, 13, 19a-c, 22a-c.
- ? 1965 Polygnathus foliata Bryant; Olivieri, Boll. Soc. Paleont. Ital., 4, 28, pl. 5, fig. 7.
- 1967 Polygnathus foliata Bryant; Müller & Clark, J. Paleont., 41, 916, pl. 115, fig. 4.
- 1967 Polygnathus foliata Bryant; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 61, p15, fig. 7; pl. 7, fig. 7.
- 1970 Polygnathus foliatus Bryant; Seddon, J. Geol. Soc. Aust., 16, 751, pl. 13, fig. 6.

Material: 140 specimens, CPC 12700-12703 figured.

Localities of figured material: Sample BG 19561, Section 10, Waggon Pass, Sadler Limestone; Sample BG 19594, Section 13, Glenister Knolls, Gogo Formation; Sample BG 21197, Section 18, Kudata Gap, Sadler Limestone; Sample BG 21234, Section 19, Sadler Ridge, Sadler Limestone.

Description: The unit consists of a free blade and platform of equal length. The free-blade consists of about twelve laterally compressed fused denticles with free chevron tips. Some denticles are suppressed

and do not erupt on the oral surface. The denticle height is reasonably constant giving a rectangular free blade. The anteriormost denticles are most likely to be the largest. The carina is a continuation of the free blade and consists of low fused nodes which become more infrequent toward the posterior termination.

The platform is asymmetrical, the outer part being flared at its mid-point. The platform edges are upturned and are separated from the carina by adcarinal troughs which deepen anteriorly. The ornament consists of short transverse ridges on the platform margin. In some specimens these are so short that they are node-like. In many specimens the posteriormost ornament is completely nodose.

Aborally, the unit is keeled and a slit-like cavity is present in the keel near the junction of the blade and platform. In many specimens "basal bone" material is present over nearly all the aboral platform area.

Remarks: One specimen (Pl. 18, figs. 8a,b) is only compared to P. foliatus. The free blade is considerably shorter and the platform is more symmetrical and the ornament is more distinct. Three specimens of this form were recovered and appear to be intermediate between P. foliatus and P. dengleri.

Müller & Müller (1957) drew a very wide interpretation of the species including P. decorosus and P. xylus within it. Most workers would prefer to keep these forms separate and even though there is considerable intergradation between species it is possible to recognize them apart.

Distribution: The species was first described from New York State (Bryant, 1921). Elsewhere in North America it has been recorded from Iowa (Müller & Müller, 1957; Klapper & Furnish, 1962), Michigan (Müller & Clark, 1967), Nevada (Clark & Ethington, 1967), and Alberta (Clark & Ethington, 1965).

In Europe the species has been recorded from Germany

(Bischoff & Ziegler, 1957; Helms, 1959; Schriel & Stoppel, 1965; Zitzmann, 1966; Stoppel & Zscheke, 1966). Elsewhere in Europe the species has been recorded from Austria (Schulze, 1968; Schönlaub, 1969), Belgium (Bultynck, 1965), Bulgaria (Buderov & Tschunov, 1964), Italy (Manzoni, 1965; Olivieri, 1965), and Poland (Freyer & Zakowa, 1967).

P. foliatus has also been reported from Morocco (Massa, 1965), Afghanistan (Weippert & Wittekindt, 1964), and Australia (Seddon, 1970).

Range: The species was originally described from the Conodont bed near Buffalo. The fauna contains P. linguiformis and Ancyrodella rotundiloba and is thus of Middle/Upper Devonian boundary age (Bryant, 1921). Other North American occurrences include the Frasnian Independence Shale of Iowa (Müller & Müller, 1957) and the Middle P. asymmetricus Zone in Nevada (Clark & Ethington, 1967). Clark & Ethington also report the form from the Famennian Palmatolepis crepida Zone, but this appears to be anomalous.

In Europe Bischoff & Ziegler record the species from the Eifel-Stufe which is very early and these forms may represent a P. foliatus ancestor rather than P. foliatus s.s. Ziegler (1962) gives the range as Upper Middle Devonian to Upper Palmatolepis crepida Zone (to II α). Schulze (1968) records the species from the early Upper Devonian and Freyer & Zakowa (1967) record it from lowermost to II strata. Bultynck records it from the latest Couvinian in Belgium. In the Canning Basin the range is Lower Polygnathus asymmetricus Zone as high as the Lower Palmatolepis gigas Zone (to I α - to I γ).

POLYGNATHUS GERMANUS GERMANUS

Ulrich & Bassler, 1926

Pl. 18, figs. 6a,b

- 1926 Polygnathus germanus Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 46, pl. 7, fig. 11, 12.

For complete synonymy up to 1962 see:

- 1968 Polygnathus germana Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 38, pl. 14, figs. 29, 30.
- 1967 Polygnathus nodocostata nodocostata Branson & Mehl; Wirth, N. Jb. Geol. Palaont. Abh., 127, 229, pl. 22, fig. 10.
- 1967 Polygnathus nodosocostata nodosocostata (sic.) Branson & Mehl; Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 75, pl. 1, fig. 19.
- 1967 Polygnathus nodocostata nodocostata Branson & Mehl; Nehring, Inst. Geol. Bull. 209, 150, pl. 4, fig. 10; text-fig. 23.
- 1967 Polygnathus nodocostata Branson & Mehl; Wolska, Acta Palaeont. Polonica, 12, 414, pl. 17, figs. 1, 2.
- ? 1967 Polygnathus nodocostata Branson & Mehl; Loranger, privately published, 16, pl. 3, figs. 7, 8.
- 1968 Polygnathus nodocostata Branson & Mehl; Mound, J. Paleont., 42, 507, pl. 69, figs. 26, 27.
- 1968 Polygnathus nodocostata nodocostata Branson & Mehl; Spasov et al., Inst. Recherch. Geol. Geophys., 26, 162, pl. 2, fig. 11.
- 1969 Polygnathus nodocostatus nodocostatus Branson & Mehl; Druce, Bur. Miner. Resc. Aust. Bull. 98, 101, pl. 19, fig. 6 (synonymy from 1962 to 1966).
- 1969 Polygnathus nodocostatus nodocostatus Branson & Mehl; Olivieri, Boll. Soc. Paleont. Italiana, 8, 125, pl. 22, figs. 1-5b.

Material: 40 specimens, CPC 12704-12707 figured.

Locality of figured material: Sample BG 19024, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 21014, Section 14, 2 miles northeast of Pinnacle Spring, Virgin Hills Formation; Sample BG 21262, 21263, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Remarks: Glenister & Klapper (1966, p. 829) point out that the lectotype of P. nodocostatus Branson & Mehl is in fact within the limits of P. nodocostatus incurvus Helms. The holotype of P. germanus also appears to be the same as P. nodocostatus incurvus. However, these are two easily recognised forms, one with X-shaped ornament and one with parallel linear ornament and perhaps the form with linear ornament should be erected as a subspecies.

Distribution: P. germanus is one of the commonest polygnathids. It was originally described from the "Hardin sandstone" of Tennessee (Ulrich & Bassler, 1926; Huddle, 1968). It has also been reported from Arkansas (Cooper, 1931), Indiana (Huddle, 1934), Iowa (Klapper & Furnish, 1962; Anderson, 1966), Ohio (Bond, 1947), Utah (Beach, 1961), Wyoming (Klapper, 1958) and Alberta (Loranger, 1967; Mound, 1968).

In Europe the species is common in Germany (Helms, 1961; Freyer, 1961; Zimmermann, 1961; Ziegler, 1962; and Bering, 1967). It has also been reported from Austria (Schulze, 1968; Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), France (Boyer et al., 1968), Italy (Manzoni, 1965), Yugoslavia (Spasov & Filipovic, 1967; Spasov et al., 1968), Poland (Nehring, 1967; Wolska, 1967), and Spain (Boogaard, 1965; Wirth, 1967; Boogaert, 1967). In Australia the species has been recorded by Glenister & Klapper (1966) and Druce (1969) from the Canning and Bonaparte Gulf Basins respectively.

Range: Helms (1961) records the range from to I § up to the to III Zone.

Ziegler (1962) amends the range, to the Famennian (to $\text{II } \beta$ - to V) Palmatolepis rhomboidea Zone up to the Upper Polygnathus styriacus Zone. In the Canning Basin the species ranges from the Lower Palmatolepis crepida Zone (to $\text{II } \alpha$) up to the Upper Palmatolepis quadrantinodosa Zone (to $\text{III } \alpha$).

POLYGNATHUS GERMANUS subsp. nov. A

Pl. 19, figs. 2a,b

Remarks: One specimen (CPC 12708) from sample 19082, Section 4, northeast of McWhae Ridge, Virgin Hills Formation, shows a breakdown in the carina nodes in the posterior half. The platform ornament is nodose but they are not arranged in a linear fashion except in the anterior half of the platform. The specimen comes from the Lower Palmatolepis quadrantinodosa Zone (to $\text{II } \beta$).

POLYGNATHUS GERMANUS subsp. nov. B

Pl. 19, figs. 1a,b

1961 Polygnathus nodocostata nodocostata Branson & Mehl, Helms, Geologie, 10, text-fig. 17, late to III specimen.

Remarks: One specimen, CPC 12709 , from sample 19164, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone, is very similar to a specimen illustrated by Helms (1961). The unit is sub-triangular with deep anterior carinal troughs and subparallel linear nodose platform ornament. The ornament is similar to that of P. germanus s.s. and it is the platform shape which is distinctive. Helms' specimen is from the late to III Zone and the present specimen comes from the Lower Polygnathus styriacus (to IV) Zone so the platform shape may be distinctive enough to separate a subspecies useful in zonation.

POLYGNATHUS GLABER GLABER

Ulrich & Bassler, 1926

Pl. 19, figs. 3a, b

- 1926 Polygnathus glaber Ulrich & Bassler, U.S. Natl. Mus. Proc., 68, 46, pl. 7, fig. 13.
- 1955 Polygnathus glaber Ulrich & Bassler; Sannemann, Senck. leth., 36, 149, pl. 3, fig. 14.
- 1956 Polygnathus glabra Ulrich & Bassler, Bischoff, Hess. Landesamt Bodenf., Notizbl.,
- 1961 Polygnathus glaber Ulrich & Bassler; Lys et al., Rev. Inst. Francais Petrol., 16, 552, pl. 5, figs. 1, 2.
- 1962 Polygnathus glabra glabra Ulrich & Bassler; Ziegler, Hess. Landesamt Bodenf. Abh., 38, 89, pl. 10, figs. 18-20.
- ? 1965 Polygnathus glabra Ulrich & Bassler; Spasov, Bulg. Acad. Sci., Trav. Geol. Bulg., Ser. Paleont., 7, 96, pl. 2, fig. 16.
- 1966 Polygnathus glabra glabra Ulrich & Bassler; Glenister & Klapper, J. Paleont., 40, 829, pl. 94, figs. 5, 6.
- 1966 Polygnathus glabra glabra Ulrich & Bassler; Spasov & Filipovic, Geol. Glasnik, 11, 47, pl. 3, figs. 20, 21.
- 1967 Polygnathus glabra glabra Ulrich & Bassler; Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 74, pl. 6, fig. 10.
- 1967 Polygnathus glaber Ulrich & Bassler; Nehring, Inst. Geol. Bull. 209, 149, pl. 4, fig. 5.
- 1967 Polygnathus glabra glabra Ulrich & Bassler; Wolska, Acta Palaeont. Polonica, 12, 413, pl. 15, figs. 1a, b.
- 1968 Polygnathus glabra Ulrich & Bassler; Huddle, U.S. Geol. Surv. Prof. Pap. 578, 39, pl. 15, figs. 13-17.
- 1969 Polygnathus glabra glabra Ulrich & Bassler; Schönlaub, J. B. Geol. B. A., 112, 307, pl. 2, fig. 14.

1969 Polygnathus glaber glaber Ulrich & Bassler; Olivieri, Boll. Soc. Paleont. Italiana, 8, 122, pl. 21, figs. 1a-5b.

Material: 65 specimens, CPC 12710 - 12713 figured.

Localities of figured material: Sample BG 19007, Section 1, McWhae Ridge, Gogo Formation; Sample BG 19077, 19082, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21015, Section 14, 2 miles northwest of Pinnacle Spring, Virgin Hills Formation.

Remarks: The present specimens all appear to fall within the limits of P. glaber s.s. No specimens of P. glaber bilobatus were recovered. Helms & Wolska (1967) erected a new subspecies, P. glaber medius, distinguished by a carina formed of isolated nodes. Some of the specimens from the upper range exhibit some isolation of the nodes but not as much as that figured by Helms & Wolska.

Distribution: The species was originally described from the "Hardin sandstone" (Ulrich & Bassler, 1926) but is probably reworked (Huddle, 1968, p. 39). Unusually, this is the only record of the species from the North American continent.

In Europe the species is common, especially in Germany (Sannemann, 1955; Bischoff & Ziegler, 1956; Ziegler, 1956, 1962; Stoppel, 1958; Helms, 1959; Zimmermann, 1960; Freyer, 1961; Schriel & Stoppel, 1965; Henningsen, 1965; Zitzmann, 1966; Stoppel & Zscheke, 1966; Bering, 1967; Bar, 1968; Schneider, 1969). The species is also known from Austria (Schulze, 1968; Schönlaub, 1969), Belgium (Bouckaert & Ziegler, 1965), Bulgaria (Spasov, 1965), France (Serre & Lys, 1958; Lys et al., 1961), Italy (Manzoni, 1965, 1968; Olivieri, 1969), Yugoslavia (Spasov & Filipovic, 1966, 1967; Nehring, 1967; Wolska, 1967), and Spain (Boogaard, 1965; Wirth, 1967; Boogaert, 1967). The only other report of the species is from the Canning Basin, Australia (Glenister & Klapper, 1966).

Range: The original specimens are probably reworked and thus no information on the species range is available from North America. In Europe Ziegler gives the range as Lower Palmatolepis crepida Zone (to II α) up to the Upper P. quadrantinodosa Zone (to III α). However, Nehring suggests that the range may be as low as lowest Frasnian (to I α). In the Canning Basin the species ranges from the Middle Palmatolepis crepida Zone up to the boundary between the Lower and Upper P. quadrantinodosa Zone. One specimen (Pl. 19, fig. 3b) occurs in the Middle Polygnathus asymmetricus Zone. This specimen has a markedly asymmetrical platform and may be ancestral to P. glaber s.s.

POLYGNATHUS IRREGULARIS (Thomas, 1949)

Pl. 19, figs. 4a,b

- 1949 Palmatolepis ? irregularis Thomas, Geol. Soc. Amer. Bull., 60, 416, pl. 2, fig. 27.
- 1949 Polygnathus granulosa Branson & Mehl; Thomas, ibid., pl. 1, fig. 34 (non fig. 33 = P. nodocostatus s.s.).
- 1961 Polygnathus irregularis (Thomas); Helms, Geologie, 10, 685, pl. 3, figs. 3, 5-7.

Material: 8 specimens, CPC 12714 - 12716 figured.

Localities of figured material: Sample BG 19170, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 21059, Section 14, 2 miles northwest of Pinnacle Spring, Bugle Gap Limestone; Sample BG 21355, Section 23, Napier Formation.

Description: An asymmetric unit with a large platform and a short free blade. The free blade consists of between seven and ten laterally compressed fused denticles with free chevron tips; they are tallest in the mid-part of the blade. The free-blade is continuous with the carina which is low and nodose and is conspicuously bent at about its mid-point

similarly to a palmatolepid carina. The platform is ovate and bears nodose ornament. On the outer platform, which is the largest, the nodes are often partially fused to give sinuous ridges which tend to parallel the carina. The inner platform bears irregular nodes which, in some specimens are fused into a single elongate ridge. In the anterior half deep adcarinal grooves are present separating "siphonal ridges" from the carina. Posteriorly, the troughs become shallow and the "siphonal ridges" merge with the carina near the major carinal flexure.

In aboral view the platform is fairly flat with a longitudinal keel containing a slit-like basal cavity in the anterior half.

Distribution: The original description of the species was from Iowa (Thomas, 1949). The only other reports of the species are from Germany (Helms, 1961; Bar, 1968).

Range: Thomas's specimens came from the Maple Hill Shale of Iowa considered to be equivalent to the early Saverton of to IV age (Collinson et al., 1961). Helms (1961) records the species from the latest to IV Zone in Germany. In the Canning Basin the species occurs in the Lower Polygnathus styriacus Zone (to IV).

POLYGNATHUS JANETI sp. nov.

Pl. 19, figs. 5a,b

Derivation of name: For my wife.

Material: 10 specimens, CPC 12717 (holotype), CPC 12718-12719 (paratypes).

Localities of figured material: Holotype, Sample BG 19418, Cave Spring, Sadler Limestone; Sample BG 19482, Section 6, Lloyd Hill - Laidlaw Range, Gogo Formation; Sample BG 19536, McIntyre Knolls, Virgin Hills Formation.

Diagnosis: A polygnathid with a large platform virtually devoid of ornament except for a pitted surface and faint ridges on the posterior half.

Description: A polygnathid with a large platform, nearly twice as large as the free blade which consists of about seven fused, laterally compressed denticles. They have free chevron tips and are tallest in the mid-region. The free blade merges with the carina which consists of fused nodes which tend to be widest medially and die out posteriorly. The platform is asymmetric and twisted in many specimens. The platform margins tend to be upturned but in some specimens platform is virtually flat. The ornament consists of minute pitting; some faint transverse ridges are seen on most specimens; in the juveniles the ridges are more conspicuous. In the anterior part, deep adcarinal troughs are present.

Aborally, the unit is flat with a longitudinal keel with an elongate pit set in the anterior part of it.

Remarks: Smooth platformed polygnathids occur in the Devonian and Carboniferous. P. communis differs in having an elongate rectangular free blade. P. glaber differs in having a pear-shaped platform. P. collinsoni possesses lateral siphons.

Distribution and Range: This is the first record of the species and it occurs throughout the Polygnathus asymmetricus Zone.

POLYGNATHUS NODOUNDATUS Helms, 1961

Pl. 20, figs. 6a,b

- 1961 Polygnathus nodoundata Helms, Geologie, 10, 690, pl. 1, figs. 9-11, 20; pl. 2, figs. 7, 11-14; text-fig. 8.
- 1962 Polygnathus bicavata Ziegler, Hess. Landesamt Bodenf. Abh., 38, 86, pl. 10, figs. 1, 3, 6-8.

- 1967 Polygnathus nodoundata Helms; Kodsi, N. Jb. Geol. Palaont.
Mh., 27, 426, fig. 6, 7.
- 1967 Polygnathus nodoundata Helms; Wolska, Acta Palaeont.
Polonica, 12, 414, pl. 15, fig. 8.
- 1968 Polygnathus nodoundata Helms; Mound, J. Paleont., 42, 508,
 pl. 69, figs. 15, 16.

Material: 2 specimens, CPC 12720-12721 figured.

Locality of figured material: Samples BG 21361, 21362, Section 23, Geikie Gorge, Napier Formation.

Description: An ovate polygnathid with an irregular nodose platform. The carina terminates before the posterior margin; it consists of low fused nodes with shallow troughs on either side. The dentition is irregularly nodose. The nodes are larger in the posterior part and fuse to form ridges parallel to the carina. In aboral view the unit is keeled with a minute slit-like basal cavity inset near the anterior end.

Remarks: The figured specimen is slimmer than most specimens referred to this species by other authors. However, it seems to fall within the range of variability illustrated by Helms (1961, pl. 1, fig. 20).

Distribution: The species was originally described from Thuringia, Germany (Helms, 1961). Other reports of the species in Germany have been made by Ziegler (1962), Henningsen (1965), Bering (1967), Bar (1968), Schneider (1969), and Meischner & Schneider (1970). Other European occurrences are noted from Austria (Kodsi, 1967) and Poland (Wolska, 1967).

In North America the species has been reported by Mound (1968) from Alberta.

Range: Helms (1961) records the species from the middle to III Zone of the Famennian. Ziegler (1962) gives the range as Upper Palmatolepis

quadrantinodosa Zone (to III α) as does Wolska (1967), Henningsen (1965), and Bering (1967). Kodosi records the range as to I - to III but his range chart shows a restricted range within the to III Zone. In the Canning Basin the species occurs in the Lower/Upper Palmatolepis quadrantinodosa Zone boundary.

POLYGNATHUS NORMALIS Miller & Youngquist, 1947

Pl. 20, figs. 1a,b

- 1947 Polygnathus normalis Miller & Youngquist, J. Paleont., 21, 515, pl. 74, fig. 4.

For complete synonymy to 1966, see:

- 1969 Polygnathus normalis Miller & Youngquist; Druce, Bur. Miner. Res. Austral. Bull. 98, 102, pl. 19, figs. 7a-106.
- 1967 Polygnathus normalis Miller & Youngquist; Wirth, N. Jb. Geol. Paläont. Abh., 127, pl. 22, figs. 8, 9.
- 1967 Polygnathus normalis ssp. Wirth, ibid., 230, pl. 22, figs. 5-7.
- 1967 Polygnathus normalis Miller & Youngquist; Clark & Ethington, Geol. Soc. Amer. Mem. 103, 63, pl. 5, fig. 10 (non pl. 4, fig. 3 = ?P. cf. webbi).
- ? 1967 Polygnathus normalis Youngquist & Miller (sic.); Loranger, privately published, 15, pl. 3, figs. 5, 6.
- 1967 Polygnathus normalis Miller & Youngquist; Wolska, Acta Palaeont. Polonica, 12, 415, pl. 14, figs. 9-11.
- 1968 Polygnathus normalis Miller & Youngquist; Mound, J. Paleont., 42, 509, pl. 69, figs. ?30, ?31; pl. 70, figs. 1, 2, 5.
- 1968 Polygnathus normalis Müller & Youngquist (sic.); Spasov et al., Inst. Recherch. Geol. Geophys. Bull., 26, 162, pl. 2, fig. 13.
- 1970 Polygnathus normalis Miller & Youngquist; Seddon, J. Geol. Soc. Aust., 16, 753, pl. 16, figs. 19-22.

Material: 550 specimens, CPC 12722-12725 figured.

Localities of figured material: Samples BG 19014, 19023, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19071, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 19548, Section 9, Balme Knoll, Virgin Hills Formation.

Remarks: Stratigraphically this species shows some variation and it may be possible to subdivide it into subspecies. Younger specimens become progressively smaller with a more denticulate outer anterior margin. The youngest specimens show an almost complete lack of platform ornament.

Distribution: P. normalis is one of the most common species of polygnathids and has been reported extensively from North America, Europe, Asia, North Africa and Australia.

Range: Ziegler (1962) gives the range as Upper Middle Devonian to Upper Palmatolepis triangularis Zone (Famennian to I/II). The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone as high as the Lower Scaphignathus veliferus Zone (to III α).

POLYGNATHUS NORRISI Uyeno, 1967

Pl. 20, figs. 3a,b

- 1959 Polygnathus diversa Helms, Geologie, 8, 674, pl. 5, fig. 8 only.
- 1967 Polygnathus norrisi Uyeno, Geol. Surv. Canada Pap. 67-30, 10, pl. 2, figs. 4, 5.
- 1968 Polygnathus sp. a Schulze, N. Jb. Geol. Palaont. Abh., 130, 217, pl. 20, fig. 18.
- 1969 Polygnathus, Müller, Palaont. Z., 43, 67, pl. 6, figs. 1, 4.
- 1969 Polygnathus diversus Helms; Müller, ibid., pl. 6, fig. 2.

Material: 8 specimens, CPC 12726 - 12728 figured.

Localities of figured material: Samples BG 19108, 19109, BG 19117, BG 19147, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Description: An elongate unit with distinctive brush-like platform ornament. The free blade is elongate, low and rectangular, composed of about fourteen fused denticles with free chevron tips. The platform is about the same length as the free blade and is narrow and triangular. The dentition, which consists of a multitude of fine needle-like denticles is diagnostic.

Remarks: The present specimens differ from Uyeno's specimens of P. norrisi in having a low, long blade, unlike the short, high blade of P. norrisi. The platform is also smaller in the present specimens. Müller (1969) considers that the brush-like ornament seen in several genera, is a pathologic differentiation, and if this is correct, then this peculiar ornament cannot be used to differentiate a separate species. The rather different ranges of P. norrisi from Canada and Australia suggest this although, in general, the forms already described by Helms (1959) and Müller (1969) tend to be of the same age. It is possible that this type of denticulation is a response to a particular environment but Müller notes that there appears to be no relation between the occurrence and substrate, region and facies.

However, this type of denticulation may be useful in determining the composition of natural assemblages. The present specimens usually occur with O? lacera (which has brush-like dentition) and sometimes a brush-like hindeodellid.

Distribution: This form was originally described from Germany (Helms, 1959) and have also been reported from Germany and Austria (Müller, 1969). The species was originally described from Alberta, Canada (Uyeno, 1967).

Range: Uyeno (1967) records P. norrisi from the Lower Polygnathus asymmetricus Zone (Frasnian to I α). However, the European specimens

are from the Famennian (to III - to V) (Müller, 1969). In the Canning Basin the species ranges from the uppermost Lower Palmatolepis quadrantinodosa Zone (to II β) up to at least the Middle Scaphignathus veliferus Zone (to III β).

POLYGNATHUS OBLIQUICOSTATUS Ziegler, 1962

Pl. 20, figs. 2a,b

- 1962 Polygnathus obliquicostata Ziegler, Hess. Landesamt Bodenf. Abh., 38, 92, pl. 11, figs. 8-12.
- 1966 Polygnathus obliquicostata Ziegler; Klapper, Univ. Kansas Paleont. Contr., Pap. 3, 22, pl. 6, figs. 2, 4.
- ? 1969 Polygnathus obliquicostata Ziegler; Schönlaub, J. B. Geol. B. A., 112, 307, pl. 2, fig. 6.
- 1969 Polygnathus obliquicostatus Ziegler; Olivieri, Boll. Soc. Paleont. Italiana, 8, 128, pl. 23, figs. 4a-5.

Material and Locality: A single specimen CPC 12729, Sample 21015, Section 14, 2 miles northwest of Pinnacle Spring, Virgin Hills Formation.

Remarks: A single specimen falls within the range of the species as illustrated by Ziegler (1962). P. obliquicostatus differs from P. semicostatus Branson & Mehl in the lack of a tongue-like posterior projection and in possessing a carina in the posterior half. It appears to have developed from P. normalis Miller & Youngquist by the development of strong oblique ridges on the posterior half of the platform. Specimens compared to P. obliquicostatus by Glenister & Klapper (1966, p. 830) probably belong to P. znepolensis Spasov although the forms are only described and not illustrated.

Distribution: The species was originally described from Germany (Ziegler, 1962) and has also been reported by Bering (1967) from the Kellerwald and the Sauerland (Bar, 1968). The form illustrated by

Schönlaub (1969) from Austria is questionable and may not belong to this species. Boyer et al. (1968) record the species from the Montagne Noir of France, and Olivieri (1969) records it from Sardinia.

The only record of the species from North America is by Klapper (1966) from Wyoming.

Range: Ziegler (1962, p. 93) gives the range as Lower and Middle Polygnathus styriacus Zone (to IV - to V). Klapper's specimens come from the Lower Spathognathodus costatus Zone (to V). The single specimen from the Canning Basin occurs in the Lower Palmatolepis quadrantinodosa Zone (to II β) which appears to be anomalous.

POLYGNATHUS cf. P. PENNATUS Hinde, 1879

Pl. 20, figs. 4a,b

cf. 1879 Polygnathus pennatus Hinde; Quart. J. Geol. Soc., Lond., 35, 366, pl. 16, fig. 17; pl. 17, fig. 8.

cf. 1933 Polygnathus pennata Hinde; Branson & Mehl, Univ. Missouri Stud., 8, 144, pl. 11, fig. 3.

Material: 25 specimens, CPC 12730-12731 figured.

Localities of figured material: Samples BG 19453B, 19454D, Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: The present specimens are very similar to P. pennatus illustrated by Branson & Mehl from Hinde's specimens. If anything, the ornament is slightly coarser than that in those specimens. However, Branson & Mehl suggest that the species is usually less ornamented than the specimen figured by them. This, together with the range discrepancy and the fact that the posterior margin of the present specimens exhibit considerable variation prevents inclusion in P. pennatus. There is some resemblance to P. triangularis Branson & Mehl (1934, pl. 21, fig. 20).

Range: In the Canning Basin this form ranges throughout the Palmatolepis triangularis Zone (Frasnian/ Famennian boundary).

POLYGNATHUS PERPLEXUS Thomas, 1949

Pl. 20, figs. 5a,b

- 1949 Polygnathus perplexa? Thomas, Geol. Soc. Amer. Bull., 60, 418, pl. 2, fig. 23.
- 1959 Polygnathus perplexa Thomas; Helms, Geologie, 8, 652, pl. 6, fig. 27.
- 1961 Polygnathus perplexa (Thomas); Helms, Geologie, 10, 692, pl. 1, figs. 18, 19; pl. 4, figs. 1-3, 5; text-fig. 10.
- non 1966 Polygnathus cf. P. perplexa (Thomas); Anderson, J. Paleont., 40, 413, pl. 5, figs. 7, 9, 11, 14.
- 1967 Polygnathus perplexa (Thomas); Wolska, Acta Paleont. Polonica, 12, 415, pl. 15, figs. 9-11.
- 1969 Polygnathus perplexus Thomas; Olivieri, Boll Soc. Paleont. Italiana, 8, 129, pl. 22, figs. 6-7c.

Material: 5 specimens, CPC 12732-12733 figured.

Localities of figured material: Sample BG 19114, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 21355, Section 22, Piker Hills, Piker Hills Formation.

Description: A lanceolate polygnathid with a short free-blade consisting of about eight fused denticles with free chevron tips highest in the mid-region. The free-blade merges with the carina which is ridge-like, composed of fused nodes. Either side of the carina are deep troughs separating siphons. The outer siphon is distinctive, being developed into a denticulate blade. Both siphons continue to near the posterior end of the unit. On the outer side the platform edges are tumid and bear linear rows of nodes. Aborally, the unit is keeled with a slit-like basal cavity in the anterior part.

Remarks: The presence of a secondary lateral blade is seen in other specimens such as P. normalis Miller & Youngquist and P. communis dentatus Druce.

Distribution: The species was originally described from Iowa (Thomas, 1949) and this is the only record of the species from North America. In Europe the species is noted from Belgium (Bouckaert & Ziegler, 1965), France (Boyer et al., 1968), Germany (Helms, 1959, 1961; Bering, 1967; Bar, 1968; Schneider, 1969; Meischner & Schneider, 1970), Poland (Wolska, 1967), Italy (Olivieri, 1969), and Portugal (Boogaard, 1963).

Range: The original specimens came from the Maple Mill Shale of Iowa (Thomas, 1949) which is probably equivalent to the lower part of the Saverton Shale (probably Famennian to IV). Helms (1961) records the range as Famennian (highest to III and to IV), and this is a similar range indicated by Wolska (1967). However, Boyer et al., (1968, fig. 7) record the species from the early to III α Zone. The Canning Basin specimens have a range of Upper Palmatolepis quadrantinodosa Zone (to III α) as high as the Middle Polygnathus styriacus Zone (to V).

POLYGNATHUS POLLOCKI sp. nov.

Pl. 21, figs. 1a,b

1968 Polygnathus n. sp. A Pollock, J. Paleont., 142, 436, pl. 62, figs. 32, 33, 38.

Derivation of name: After Dr. C. A. Pollock.

Material: 16 specimens, CPC 12734 (holotype),
CPC 12735, 12736 (paratypes), figured.

Localities of figured types: Holotype, Sample BG 19543, Section 9, Balme Knoll, Gogo Formation; Paratypes, Sample BG 19554, Section 10, Waggon Pass, Sadler Formation; Sample BG 21207, Section 15, Sadler Ridge, Sadler Limestone.

Diagnosis: A polygnathid with a very elongate and narrow platform.

Description: An elongate unit with a narrow platform about twice as long as the free blade. The platform is between five and six times as long as wide. The free blade consists of between six and ten denticles which are basally fused with free chevron tips. The highest denticles are mainly in the anterior part. The free blade merges with the low carina which consist of nodes fused into a ridge. The platform consists of two deep continuous adcarinal troughs, and virtually unornamented platform edges. Sometimes the platform edges bear serrations giving the appearance of nodes.

Aborally, the unit is keeled and the basal cavity is present at the junction of the blade and platform. Often there is "basal bone" attached at the cavity.

Remarks: This species probably developed from the P. xylus - P. decorosus group by simple elongation of the platform which is very distinctive. The present specimens agree closely with those figured and described by Pollock, although my specimens have a smaller basal cavity.

Distribution and Range: Pollock specimens occur in strata considered to belong to the Polygnathus asymmetricus Zone in Alberta, Canada. In the Canning Basin the species ranges from the Middle Polygnathus asymmetricus Zone (to I α) as high as the Lower Palmatolepis gigas Zone (to I γ).

POLYGNATHUS SEDDONI sp. nov.

Pl. 21, figs. 2a,b

Derivation of name: After Dr. G. Seddon who was the first to recognise facies control of conodonts in the Canning Basin.

Material: 63 specimens, CPC 12737 (holotype),
CPC 12738 - 12740 (paratypes).

Localities of figured types: Holotype and paratypes, Sample BG 19543, Section 9, Balme Knoll, Gogo Formation.

Diagnosis: A polygnathid with a distinctive lower secondary platform anterior to the main platform.

Description: An asymmetrical polygnathid consisting of a short free blade and relatively large platform. The free blade consists of about six laterally compressed fused denticles with free chevron tips. The denticles tend to be of equal height but decrease in height posteriorly. The free blade merges with the carina which consists of low nodes, fused in the anterior and isolated in the posterior half.

The platform is very distinctive consisting of a normal posterior platform but with a lower platform anteriorly. The posterior platform is ornamented by transverse ridges which are often broken into nodes.

The anterior platform is often wider than the posterior platform especially on the inner side. It is much lower and is fused with the carina low anteriorly, often asymmetrical the inner lateral junction being anterior to the outer. This platform is characteristically smooth.

In lateral view the platform is slim and the two levels are distinctive. Aborally, the unit has a narrow, low keel. A small elongate basal cavity is present in the anterior quarter of the platform.

Remarks: The peculiar secondary platform is unlike any platform of described polygnathids.

Range: The Canning Basin specimens are from the Upper Polygnathus asymmetricus Zone (to I β) and the Ancyrognathus triangularis Zone (to I γ) and appears to be a good index fossil for the middle Frasnian.

POLYGNATHUS SEMICOSTATUS Branson & Mehl, 1934

Pl. 21, figs. 3

- 1934 Polygnathus semicostata Branson & Mehl; Univ. Missouri Stud.,
8, 247, pl. 21, figs. 1, 2.
- 1949 Polygnathus semicostata Branson & Mehl; Thomas, Geol. Soc.
Amer. Bull., 60, 407, pl. 1, fig. 23.
- 1961 Polygnathus semicostata Branson & Mehl; Beach, Brigham
Young Univ., Geol. Stud., 8, 46, pl. 5, figs. 9, 10.
- 1965 Polygnathus semicostata Branson & Mehl; Ethington, J.
Paleont., 39, 583, pl. 68, fig. 5.
- 1968 Polygnathus semicostata Branson & Mehl; Mound, J. Paleont.,
42, 511, pl. 70, figs. 3, 10.

Material: 6 specimens, CPC 12741 figured.

Localities of figured material: Sample BG 19144, Section 4, northeast
of McWhae Ridge, Bugle Gap Limestone.

Description: A polygnathid with a tongue-like posterior projection and a
short free-blade. The free-blade is composed of about five fused
denticles with free chevron tips; it is tallest at the mid-point.

The platform is large and symmetrical with crenulate margins
and short transverse ridges. Near the carina the platform is smooth and
gently trough-like. The posterior termination is extended as a tongue
and the carina does not extend onto it and it is ornamented by transverse
ridges.

Remarks: This species is a homeomorph of the Middle Devonian Polygnath-
us linguiformis but the tongue-like posterior process is much narrower
and less deflected.

Distribution: The species was originally described from Missouri
(Branson & Mehl, 1934). Other North American occurrences include
Iowa (Thomas, 1949), Arizona (Ethington, 1965), New York (Oliver et al.,

1967), Utah (Beach, 1961), and Alberta, Canada (Mound, 1968). It has been reported from Germany (Helms, 1961), Belgium (Bouckaert & Ziegler, 1965) in Europe and also Morocco (Massa, 1965).

Range: P. semicostatus was first described from the Grassy Creek Shale which is of to II - lowest to IV age according to Collinson et al., (1962). Oliver et al., (1967) record it from the to II β Zone. Mound (1968) records the species from strata of to II β / to III α age in Alberta. Helms (1961) records the species from the to V Zone. The Belgium specimens are from strata considered by Bouckaert & Ziegler (1965) to be of to II - to III age. The Moroccan specimens come from a to III horizon (Massa, 1965, p. 109). The Canning Basin specimens are from the Upper Scaphignathus veliferus Zone (to III β) and Lower Polygnathus styriacus Zone (to IV).

POLYGNATHUS SPATULATUS Youngquist, 1947

Pl. 21, figs. 4

1947 Polygnathus spatulatus Youngquist, J. Paleont., 21, 110,
 pl. 26, fig. 4.

Material: 2 specimens, CPC 12742 figured.

Location of figured material: Sample BG 19186, McWhae Ridge, Gogo Formation.

Description: A polygnathid with a platform slightly shorter than the free-blade. The free-blade of about ten fused denticles with free chevron tips. The blade is high, the tallest denticles being anterior but not anteriormost. They slope rapidly posteriorly to merge with the nodose carina which tends to be widest at its mid-point and disappears before the posterior termination.

The platform is ovate, ornamented with short transverse ridges with a crenulate platform margin. Smooth troughs which deepen anteriorly are present either side of the carina.

Remarks: This species can be distinguished from P. decorosus by the high blade and from P. xylus by the ornamented platform.

Distribution and Range: The species was originally described from the Frasnian shale in Iowa (Youngquist, 1947). The Canning Basin specimens come from the Lower Polygnathus asymmetricus Zone (Frasnian to I α).

POLYGNATHUS SUBSERRATUS Branson & Mehl, 1934

Pl. 21, figs. 5

- 1934 Polygnathus subserrata Branson & Mehl, Univ. Missouri Stud., 8, 248, pl. 20, figs. 17-19.
- 1959 Polygnathus subserrata Branson & Mehl, Geologie, 8, 652, pl. 2, fig. 23; pl. 6, fig. 10.
- 1967 Polygnathus subserrata Branson & Mehl; Kodosi, N. Jb. Palaeont. Mh., 27, 426, pl. 6, figs. 9, 10.
- 1967 Polygnathus subserrata Branson & Mehl; Wolska, Acta Palaeont. Polonica, 12, 417, pl. 26, figs. 8-10.
- 1969 Polygnathus subserratus Branson & Mehl; Olivieri, Boll. Soc. Paleont. Italiana, 8, 130, pl. 24, figs. 3a-c.

Material: 14 specimens, CPC 12743-12746 figured.

Localities of figured material: Samples BG 19160, 19161, 19182, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone and Piker Hills Formation.

Description: A polygnathid with a platform and a free blade of equal length. The free blade consists of about five laterally compressed denticles with fused bases and free posteriorly inclined free tips. The free blade merges with the carina which is composed of low fused denticles and extends posteriorly beyond the platform termination.

The platform is irregular, especially in juvenile forms and consists of blunt denticles which diverge from the blade-like carina at

between 30° and 45° to the horizontal. The platform margins are crenulate but become less so in adult forms as the platform denticles become tumid producing a flatter oral surface.

In aboral view the basal cavity is narrow and elongate with thick lips extending along the majority of the unit. A fine trough runs along the unit with a pit near the blade-platform junction.

Remarks: The morphology of P. subserratus suggests a close relationship to Spathognathodus as noted by Helms (1959). The denticulate carina, the irregular growth of the platform ornament and spathognathoid basal cavity are all similar to features found in Lower Carboniferous platform species which have developed from Spathognathodus. The genus Polygnathus is polyphyletic as is the genus Pseudopolygnathus; the tracing of the different Spathognathodus - Polygnathus transitions in the Devonian and Carboniferous may be possible if the subtle differences in the basal cavity or perhaps in the free blade are studied.

Distribution: The species was originally described from Missouri (Branson & Mehl, 1934). This is the only North American reference to the species. All other occurrences are from Europe, including Austria (Kodsi, 1967), Germany (Helms, 1961; Ziegler, 1962), Poland (Wolska, 1967), and Portugal (Boogaard, 1963). The specimens compared to P. subserratus by Bischoff & Ziegler (1957) although they look very similar to the present forms are probably homeomorphs, being Middle Devonian in age.

Range: The species was originally described from the Grassy Creek Shale of Missouri (Branson & Mehl, 1934) considered by Collinson et al. (1962) as Famennian (to II - basal to IV). Helms (1959) gives the German range as uppermost to III and to IV. Ziegler (1962) extends the range from the Middle Scaphignathus veliferus Zone (to III β) as high as the Middle Polygnathus styriacus Zone (to V), a range which Wolska (1967) records from Poland. In the Canning Basin the species ranges from the Upper Scaphignathus veliferus Zone (to III β /to IV boundary) up to the Middle Polygnathus styriacus Zone (to V).

POLYGNATHUS TRIPHYLLATUS (Ziegler , 1960)

Pl. 21, figs. 6

- 1960 Polylophodonta ? triphyllata Ziegler, Fortschr. Geol. Rheinld. Westf., 6, 12, pl. 1, fig. 5; pl. 2, figs. 1, 2 (pub. 1962).
- 1961 Polygnathus triphyllata (Ziegler); Helms, Geologie, 10, 696, pl. 1, figs. 2, 3; pl. 3, figs. 12, 15-17.
- 1965 Polygnathus nodocostata nodocostata Branson & Mehl; Bouckaert & Ziegler, Mem. Expl. Cartes Geol. Min. Belgique Mem. 5, pl. 4, fig. 3 only.
- 1967 Polygnathus triphyllata (Ziegler); Wolska, Acta Paleont. Polonica, 12, 417, pl. 17, fig. 4.
- 1969 Polygnathus triphyllatus (Ziegler); Olivieri, Boll. Soc. Paleont. Italiana, 8, 130, pl. 23, figs. 1a, b.

Material: 6 specimens, CPC 12747-12749 figured.

Localities of figured material: Sample BG 19075, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21267, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Distribution: P. triphyllatus was first described from reworked pebbles in the Triassic of Germany (Ziegler, 1960). Other records of the species in Europe are furnished by Bouckaert & Ziegler (1965) from Belgium, Freyer & Zakowa (1967) and Wolska (1967) from Poland, and Boyer et al. (1968) from France, Helms (1961) and Bar (1968) from Germany, and Olivieri (1969) from Italy.

Range: The species was first described from Cheiloceras Zone (to II) pebbles (Ziegler, 1960), and Helms (1961) gives the range as highest to II. Wolska (1967) records the species from the Palmatolepis quadrantinodosa Zone (to II β /to III α) and Freyer & Zakowa (1967) record it from the Lower Palmatolepis quadrantinodosa Zone (to II β) in Poland. In France Boyer et al. (1968) record it from the to II β and lowermost to III β Zone in France.

POLYGNATHUS cf. P. WEBBI Stauffer, 1938

Pl. 21, figs. 7

cf. 1938 Polygnathus webbi Stauffer, J. Paleont., 12, 413, pl. 53,
figs. 25, 26, 28, 29.

1970 Polygnathus sp. cf. P. webbi Stauffer, J. Geol. Soc. Aust.,
16, 739, pl. 16, figs. 18, 23, 24.

Material: 220 specimens, CPC 12750 - 12752 figured.

Localities of figured material: Samples BG 19533, 19534, 19546,
Section 9, Balme Knoll, Virgin Hills Formation.

Remarks: Seddon (1970) points out the extreme variability of the Canning Basin forms. He also mentions the P. webbi - P. normalis transition; it seems that there is also a P. webbi - P. seddoni transition as well.

Distribution and Range: Polygnathus webbi is an extremely widespread species and very variable. The Canning Basin specimens are from the Polygnathus asymmetricus Zone (to $I\alpha$ /to $I\beta$).

POLYGNATHUS XYLUS Stauffer, 1938

Pl. 21, figs. 8

1940 Polygnathus xylus Stauffer, J. Paleont., 14, 430, pl. 60,
figs. 42, 50, 54, 65-67, 72-74, 78, 79.

1970 Polygnathus xylus Stauffer; Seddon, J. Geol. Soc. Aust., 12,
740, pl. 12, figs. 20, 21; pl. 13, figs. 3-5, 11-13.

Material: 540 specimens, CPC 12753-12756 figured.

Localities of figured material: Sample BG 19032, Section 2, McWhae Ridge, (also sample BG 19188) Sadler Limestone.

Remarks: Seddon (1970, p. 738) has discussed in detail the similarities and differences between P. decorosus and P. xylus and under P.

xylus and under P. decorosus I have discussed some of the relationships in the present fauna. Some of the forms appear to be transitional to P. brevilaminus.

Distribution and Range: It is difficult to determine the occurrence of P. xylus until the P. decorosus - P. xylus group is finally sorted out. The range appears to be at least Middle Devonian to Frasnian. The Canning Basin specimens range from the Lower Polygnathus asymmetricus Zone (to I α) as high as the Upper Palmatolepis gigas Zone (to I δ).

POLYGNATHUS ZNEPOLENSIS Spasov, 1965

Pl. 21, figs. 10

- 1965 Polygnathus znepolensis Spasov, Trav. Geol. Bulgarie, Ser. Paleont. 7, 96, pl. 3, figs. 1, 2.
- 1966 Polygnathus cf. P. obliquicostata Ziegler; Glenister & Klapper, J. Paleont., 40, 830.
- 1969 Polygnathus znepolensis Spasov; Druce, Bur. Miner. Aust. Bull. 98, 106, pl. 26, figs. 1a-3c.

Material: 44 specimens, CPC 12757 - 12759 figured

Localities of figured material: Samples BG 19168, 19170, 19172, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Remarks: The present specimens are identical to those from the Bonaparte Gulf and I have concluded that those specimens mentioned as P. cf. P. obliquicostatus by Glenister & Klapper (1966, p. 830) also belong in P. znepolensis.

Distribution and Range: The species was originally described from late Famennian (to V - to VI) age strata in Bulgaria (Spasov, 1965). The only other record of the species is from the Bonaparte Gulf Basin in strata presumed to be to V age because of the occurrence of P. znepolensis and P. collinsoni Druce (Druce, 1969). The present specimens

range in age from the Upper Palmatolepis quadrantinodosa Zone (to III) to the Lower Polygnathus styriacus Zone (basal to V).

POLYGNATHUS sp. nov.

Pl. 21, figs. 9

Remarks: A single specimen, CPC 12760 , appears to belong to a new species belonging to the P. germanus group. The platform is rectangular and is ornamented by a low nodose carina and low, isolated nodes which are arranged in a longitudinal linear fashion, the nodes tending to alternate with the nodes in the adjacent row. The free blade is missing. The specimen is from the Lower Polygnathus styriacus Zone (to IV), Sample BG 19170, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

POLYGNATHUS sp. A

Pl. 21, figs. 12

Remarks: A single specimen, CPC 12761 , is similar to Palmatolepis transitans but lacks an azygous node and the platform is much slimmer. The platform is asymmetrical with an upturned nodose platform margin. The remainder of the platform is ornamented by small, low isolated nodes. The free blade is massive; it merges with the carina which is also massive, with large, high nodes. The specimen comes from the Upper Polygnathus asymmetricus Zone (to I β), Sample BG 19009, Section 1, McWhae Ridge, Virgin Hills Formation.

POLYGNATHUS sp. B

Pl. 21, figs. 11

Remarks: A single specimen, CPC 12762 , consists of a tall blade and a lanceolate platform. The platform bears nodose ornament but the linear nodes forming the carina in the posterior do not fuse with the

free-blade in the anterior. This is characteristic of P. diversus Helms and this specimen may belong to that species. The specimen is from the Polygnathus asymmetricus Zone, Sample BG 21200, Section 19, Kudata Gap, Sadler Limestone.

Genus **POLYLOPHODONTA** Branson & Mehl, 1934

Type species: Polygnathus gyratilineatus Ulrich & Bassler, 1926.

POLYLOPHODONTA CONFLUENS (Ulrich & Bassler, 1926)

Pl. 22, figs. 5

- 1926 Polygnathus confluens Ulrich & Bassler, Proc. U.S. Natl. Mus., 68, 46, pl. 7, figs. 14, 15.

For synonymy to 1964, see:

- 1966 Polylophodonta confluens (Ulrich & Bassler); Glenister & Klapper, J. Paleont., 40, 831, pl. 94, figs. 10, 11.
- 1967 Polylophodonta confluens (Ulrich & Bassler); Nehring, Inst. Geol. Bull. 209, 153, pl. 3, fig. 9; pl. 5, fig. 2.
- 1967 Polylophodonta confluens (Ulrich & Bassler); Wolska, Acta Palaeont. Polonica, 12, 418, pl. 17, fig. 7.
- 1968 Polylophodonta confluens (Ulrich & Bassler); Huddle, U.S. Geol. Surv. Prof. Pap. 578, 42, pl. 17, figs. 1, 2, 8, 9, 11.
- 1969 Polylophodonta confluens (Ulrich & Bassler); Druce, Bur. Miner. Res. Aust. Bull. 98, 109, pl. 34, figs. 3a, b.

Material: 2 specimens, CPC 12784 figured.

Locality of figured material: Sample BG 21014, Section 14, 2 miles northwest of Pinnacle Spring, Virgin Hills Formation.

Distribution: The species was originally described from Tennessee (Ulrich & Bassler, 1926) where it was also found by Hass (1956). Elsewhere in North America it is known from Missouri (Branson & Mehl,

1934), New York (Oliver et al., 1967), and Texas (Hass, 1959).

In Europe the species has been recorded from Germany (Helms, 1961; Ziegler, 1962; Bar, 1968; Schneider, 1969) and Poland (Nehring, 1967; Wolska, 1967).

Range: The age of the 'Hardin sandstone' of Tennessee is problematical because the conodont fauna is probably reworked (Huddle, 1968). The only reported range in North America is by Oliver et al. (1967, fig. 17) who show it restricted to the upper part of the to II β Zone.

In Europe Helms (1961) reports P. confluens from the lower to III Zone. Ziegler (1962) records the range as confined to the to II β Zone. Wolska gives the range as P. quadrantinodosa Zone (upper to II β) whereas Nehring records it from the to III α / to III β Zone in Poland. The Canning Basin specimens range from the Palmatolepis rhomboidea Zone up to the P. quadrantinodosa Zone (to II β).

POLYLOPHODONTA ELONGATA Druce, 1969

Pl. 22, figs. 10

1969 Polylophodonta elongata Druce, Bur. Miner. Res. Aust. Bull.
98, 110, pl. 34, figs. 1a-2c; text-fig. 23.

Material: 10 specimens, CPC 12785-12787 figured.

Localities of figured material: Sample BG 19019, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19111, Section 4, northeast of McWhae Ridge, Bugle Gap Formation; Sample BG 21361, Section 23, Geikie Gorge, Napier Formation.

Remarks: The present specimens are identical to those from the Bonaparte Gulf Basin (Druce, 1969).

Distribution and Range: P. elongata is only known from Australia. The Bonaparte Gulf Basin specimens are probably of to II age; they occur with P. confluens. The Canning Basin specimens come from the Lower and Upper Palmatolepis quadrantinodosa Zone (upper to II β).

Genus PRIONIODINA Bassler, 1925

Type species: Prioniodina subcurvata Ulrich & Bassler, 1926.

PRIONIODINA ? SMITHI (Stauffer, 1935)

Pl. 22, figs. 6

1938 Prioniodus smithi Stauffer, J. Paleont., 12, 441, pl. 50, fig. 26.

1969 Prioniodina ? smithi Stauffer; Druce, Bur. Miner. Aust. Bull., 98, 112, pl. 34, fig. 7; pl. 38, figs. 7a, b. (Synonymy).

Material: 52 specimens, CPC 12788-12790 figured.

Localities of figured material: Sample BG 19023, Section 1, McWhae Ridge, Virgin Hills Formation; Sample BG 19092, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21265, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Distribution: P. ? smithi is a very common form in the Famennian and appears to be usually associated with Palmatodella delicatula.

Range: Helms (1961) gives the range as Frasnian (to I 6) up to the Famennian (to VI). Wolska (1967) gives the range as Palmatolepis triangularis Zone up to the Spathognathodus costatus Zone (to I 6 - to VI).

Genus PSEUDOPOLYGNATHUS Branson & Mehl, 1934

Type species: Pseudopolygnathus primus Branson & Mehl, 1934.

PSEUDOPOLYGNATHUS sp. A

Pl. 22, figs. 11

Material: 3 specimens; CPC 12791-12792 figured.

Locality of figured material: Sample BG 19007, Section 1, McWhae Ridge, Gogo Formation.

Description: The unit consists of a free blade and an asymmetrical platform. The free blade is low, consisting of about six denticles which are fused but have very short free tips. The free blade merges with the carina which is very high and is composed of denticles similar to those of the free blade; they become shorter, stubbier and more discrete posteriorly. The carina does not reach to the posterior termination.

The platform is asymmetrical and is smooth, ornamented by occasional isolated low nodes. In aboral view the basal cavity mirrors the shape of the platform. It is shallow and greatly extended, especially on one side.

Remarks: This appears to be one of the earliest pseudopolygnathids, occurring in the Polygnathus asymmetricus Zone.

Genus SCAPHIGNATHUS Ziegler, 1960

Type species: Scaphignathus veliferus Ziegler, 1960.

SCAPHIGNATHUS VELIFERUS Helms, 1959

Pl. 22, figs. 3

- 1959 Scaphignathus velifera Helms, Geologie, 8, 655, pl. 2, fig. 19;
 pl. 5, figs. 20, 28 (ex. Ziegler M.S.).
- 1961 Scaphignathus velifera Ziegler; Freyer, Freib. Fortschr. C95,
 83, pl. 5, fig. 132.
- 1962 Scaphignathus velifera Ziegler; Ziegler, Hess. Landesamt
 Bodenf. Abh., 38, 102, pl. 11, figs. 19-24.
- 1962 Scaphignathus velifera Ziegler, Fortschr. Geol. Rheinld.
 Westf., 6, 403, pl. 3, figs. 1-6 (preprint 1960).
- non 1965 Scaphignathus velifera Helms; Bouckaert & Ziegler, Mem.
 Expl. Cartes Geol. Min. Belgique, 5, 27, pl. 5, figs. 5-7
 (= transitional forms from Spathognathodus to Scaphi-
 gnathus ziegleri).

- 1966 Scaphignathus velifera Helms; Glenister & Klapper, J. Paleont.,
40, 834, pl. 94, figs. 1, 2 (fig. 4 = S. ziegleri).
- non 1967 Scaphignathus velifera Ziegler; Wirth, N. Jb. Geol. Palaont.
Abh., 127, 232, pl. 23, fig. 1 (= S. ziegleri).
- 1967 Scaphignathus velifera Ziegler; Freyer & Zakowa, Acta Geol.
Polonica, 17, 111, pl. 2, fig. 9.
- non 1967 Scaphignathus velifera Ziegler; Boogaert, Leidse Geol. Med.,
39, 185, pl. 3, fig. 12 (= S. ziegleri).
- 1967 Scaphignathus velifera Helms; Wolska, Acta Palaeont. Polonica
12, 423, pl. 16, fig. 4.5.
- 1969 Scaphignathus velifera Ziegler; Schonlaub, J. B. Geol. B.A.,
112, 307, pl. 2, figs. 15, ?17.
- 1969 Scaphignathus veliferus Helms; Olivieri, Boll. Soc. Paleont.
Italiana, 8, 138, pl. 23, figs. 6a-7.

Material: 24 specimens, CPC 12774-12776 figured.

Localities of figured material: Samples BG 19161, 19164, Section 4,
northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 21365,
Section 23, Geikie Gorge, Napier Formation.

Remarks: I erected a new species, S. ziegleri to include specimens of
Scaphignathus lacking a medial carina or possessing a carina restricted
to the posterior end (Druce, 1969). Some of the specimens figured by
other authors are clearly distinguishable as S. ziegleri and have been
included under that species.

Distribution: The species was originally described from Germany
(Helms, 1959), since when it has been extensively reported (Freyer,
1961; Zimmermann, 1961; Ziegler, 1962b, c; Schriel & Stoppel, 1965;
Freyer, 1968; Dvorak & Freyer, 1968; Bar, 1968; Schneider, 1969;
Meischner & Schneider, 1969). Elsewhere in Europe it occurs in
Austria (Schönlaub, 1969), France (Boyer et al., 1968), Italy (Manzoni,
1965, 1968; Olivieri, 1969), Poland (Freyer & Zakowa, 1967; Wolska,

1967), and Portugal (Boogaard, 1963). The only records of the species outside Europe are from Wyoming (Klapper, 1966) and the Canning Basin (Glenister & Klapper, 1966).

Range: The species was originally described from the highest to III and ? to IV Zones in Germany (Helms, 1959). Ziegler (1962b) gives the range as Scaphignathus veliferus Zone (to III α) into the lowest Polygnathus styriacus Zone (to IV). This range is also recorded from Poland (Wolska, 1967). The Canning Basin specimens range from the Lower Scaphignathus veliferus (upper to III α) Zone into the Lower Polygnathus styriacus Zone (to IV).

SCAPHIGNATHUS ZIEGLERI Druce, 1969

Pl. 22, figs. 4

- 1966 Scaphignathus velifera Helms; Glenister & Klapper (part), J. Paleont., 40, pl. 94, fig. 4 only (figs. 1, 2 = S. veliferus).
- 1967 Scaphignathus velifera Ziegler; Wirth, N. Jb. Geol. Palaont. Abh., 127, 232, pl. 23, fig. 1.
- 1967 Scaphignathus velifera Ziegler; Boogaert, Leidse Geol. Med., 39, 185, pl. 3, fig. 12.
- 1969 Scaphignathus ziegleri Druce, Bur. Miner. Res. Aust. Bull. 98, 117, pl. 38, figs. 4a - 6; text-fig. 25.

Material: 42 specimens, CPC 12777-12779 figured.

Localities of figured material: Sample BG 19105, 19111, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone; Sample BG 21061, Section 14, 2 miles northwest of Pinnacle Spring, Bugle Gap Limestone.

Remarks: One specimen (Pl. 22 ,fig. 4), is very close to Spathognathodus but differs in having two rows of nodes with no median groove. Specimens illustrated by Bouckaert & Ziegler (1965, pl. 5, figs. 5-7) as S. veliferus are very similar but are more massive and the platform is wider but still lacks a median carina or trough. It is

probable that Scaphignathus developed from Spathognathodus by the addition of a row of lateral nodes virtually fused to the bar denticles.

This pseudo-platform widened to give forms illustrated by Bouckaert & Ziegler which should be a new species. The transverse ridges then broke down to give a double row of lateral nodes with a medial trough (S. ziegleri) and finally a medial row of nodes was added (S. veliferus).

Distribution: S. ziegleri was originally described from the Bonaparte Gulf Basin, Australia (Druce, 1969) and it has been reported previously from the Canning Basin (Glenister & Klapper, 1966). The only other illustrations of the species are both from Spain (Boogaert, 1967; Wirth, 1967).

Range: The species was originally described from the early Famennian part of the Ningbing Limestone (to II β - to III α) (Druce, 1969). In the Canning Basin the species ranges from the Lower Palmatolepis quadrantinodosa Zone as high as the Lower Polygnathus styriacus Zone (to II β - to IV).

Genus SCUTULA Sannemann, 1955

Type species: Scutula venusta Sannemann, 1955.

SCUTULA BIPENNATA Sannemann, 1955

Pl. 22, figs. 8

- 1955 Scutula bipennata Sannemann, Senck. leth., 36, 154, pl. 4, figs. 5, 8, 9.
- 1967 Scutula bipennata Sannemann; Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 79, fig. 17, 18.
- 1967 Scutula bipennata Sannemann; Wolska, Acta Palaeont. Polonica, 12, 423, pl. 5, figs. 11, 12.

- 1969 Scutula bipennata Sannemann; Druce, Bur. Miner. Res. Aust.
Bull., 98, 118, pl. 38, figs. 8a, b (Synonymy to 1966).
- 1969 Scutula bipennata Sannemann; Olivieri, Boll. Soc. Paleont.
Italiana, 8, 139, pl. 10, figs. 6a, b; pl. 24, figs. 8-9b.

Material: 24 specimens, CPC 12780-12781 figured.

Localities of figured material: Sample BG 195453E, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21271, Section 21, Margaret River - Needle Eye Rocks, Virgin Hills Formation.

Distribution: The species was originally described from Germany (Sannemann, 1955) and it has been subsequently reported by Bischoff, 1956; Ziegler, 1958; Helms, 1959; Freyer, 1961; and Zitzmann, 1966). It has also been reported from the following European countries: Austria (Schönlaub, 1969), Bulgaria (Spasov, 1965), France (Lys & Serre, 1957; Lys et al., 1961; Boyer et al., 1968), Italy (Olivieri, 1969), Yugoslavia (Spasov & Filipovic, 1966, 1967), Poland (Wolska, 1967), and Spain (Boogaard, 1965). The only other reports of the species are from the Mississippi Valley (Scott & Collinson, 1961) and Australia (Glenister & Klapper, 1966; Druce, 1969).

Range: Freyer (1961) gives the range of S. bipennata as Frasnian (to I δ) up to Famennian (to VI). Wolska (1967) gives the range as Palmatolepis triangularis Zone (to I δ) up to the Spathognathodus costatus Zone (to VI). The Canning Basin specimens range from the Palmatolepis rhomboidea (lowest to II β) Zone up to the Middle Scaphignathus veliferus Zone (to III β).

SCUTULA SINEPENNATA Ziegler, 1958

- 1958 Scutula sinepennata Ziegler, Hess. Landesamt Bodenf.,
Notizbl., 87, 71, pl. 12, fig. 29, 25.
- 1959 Scutula ? thuringa Helms, Geologie, 8, 656, pl. 5, figs. 16a, b;
 text-fig. 3.
- ? 1964 Scutula cf. venusta Sannemann; Budurov & Tschunov, Bull.
Inst. Sci. Recherch. Geol., 1, 259, pl. 5, figs. 3, 4.
- 1967 Scutula sinepennata Ziegler; Clark & Ethington, Geol. Soc.
Amer. Mem. 103, 66, pl. 6, fig. 16.
- 1968 Scutula sinepennata Ziegler; Lange, Geol. Palaeont., 2, 40,
 pl. 2, fig. Sc.
- 1970 Scutula sinepennata Ziegler; Seddon, J. Geol. Soc. Austral.,
 16, 752, pl. 14, fig. 6.

Material: 3 specimens, CPC 12782 figured.

Localities of figured material: Samples BG 19101, 19106, Section 4,
 northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap
 Limestone.

Description: Unit arched and flexed. Both bars are of equal length;
 they are greatly flexed near the apex, the flexure then decreasing to give
 a pinched-in apical area. There is no typical apical denticle. The
 dentition in this area is fine and inclined inward, the inclination being
 greatest at the point of maximum bar flexure. There is apparent basal
 cavity, but a minute break in the aboral margin may represent the
 cavity.

Remarks: As was pointed out by Clark & Ethington (1967, p. 67) this
 species is atypical of Scutula, having no additional bars. In many
 respects it resembles Apatognathus but lacks a significant apical
 denticle. Lange (1968) records S. sinepennata in a conodont group
 (? natural assemblage) which he considers to be a coprolitic association.

In the same group are two Palmatolepis triangularis which ranges from to I δ up to to II α (Ziegler, 1962).

Distribution: The species was originally described from the middle Manticoceras-Stufe in Germany (Ziegler, 1958) and also from the Saalfelder Upper Devonian under the name S. ? thuringia Helms (1959, p. 656). Scutula cf. venusta of Budurov & Tschunov (1964) resembles S. sinepennata from the illustration but its presence in strata of Cu II (Lower Carboniferous) is anomalous. Clark & Ethington (1967) have recorded the species from Utah and Seddon illustrates specimens from the Canning Basin, Australia. The species has also been reported from Italy (Manzoni, 1965), Poland (Wolska, 1967), and Portugal (Boogaard, 1963).

Range: The species was originally described from the middle Manticoceras-Stufe (to I (β) γ) (Ziegler, 1958). Scutula ? thuringia has a range of to III - to IV (Helms, 1959). In N. America it has been recovered from strata correlated with upper to I γ . Seddon (1970) also records it in strata of to I γ age. The Canning Basin specimens are from the Middle Palmatolepis crepida Zone (to II α) up to the Lower Palmatolepis quadrantinodosa Zone (to II β).

SCUTULA VENUSTA Sannemann, 1955

Pl. 22, figs. 7

- 1955 Scutula venusta Sannemann, Senck. leth., 36, 155, pl. 4, figs. 6, 7.
- 1967 Scutula venusta Sannemann; Wolska, Acta Palaeont. Polonica, 12, 424, pl. 5, fig. 13.
- 1969 Scutula venusta Sannemann; Olivieri, Boll. Soc. Paleont. Italiana, 8, 140, pl. 10, figs. 8, 9; pl. 24, fig. 10 (Synonymy).

Material: 8 specimens, CPC 12783 figured.

Localities of figured material: Sample BG 19014, Section 1, McWhae Ridge, Virgin Hills Formation.

Distribution: The species was originally described from Germany (Sannemann, 1955) and it has subsequently been reported many times (Ziegler, 1958; Helms, 1959; Zimmermann, 1960; Freyer, 1961). It has also been reported from Austria (Schulze, 1968; Schönlaub, 1969), Bulgaria (Budurov & Tschunov, 1964), France (Serre & Lys, 1958), Italy (Manzoni, 1965; Olivieri, 1969), Poland (Freyer & Zakowa, 1967; Nehring, 1967; Wolska, 1967), and Portugal (Boogaard, 1963). The only other records of the species are from Utah (Clark & Ethington, 1965) and the Canning Basin (Glenister & Klapper, 1966).

Range: Freyer (1961) gives the range as Frasnian (to I δ) as high as the Famennian (to VI). Wolska (1967) gives the range as Palmatolepis crepida Zone (to II α) up to the Scaphignathus veliferus Zone (to IV). The Canning Basin specimens range from the Middle Palmatolepis triangularis Zone (to I δ) up to the Lower Palmatolepis quadrantinodosa Zone (to II β).

SCUTULA sp. A

Material: 2 specimens.

Locality of figured material: Sample BG 19016, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: Two specimens appear to be intermediate between Apato-gnathus and Scutula. The unit is arched with deep bars and an inclined apical denticle. The bars are short and bear short needle-like denticles. The specimens are from the uppermost Palmatolepis gigas Zone.

SCUTULA sp. B

Material: 3 specimens.

Locality of figured material: Sample BG 19019, Section 1, northeast of McWhae Ridge, Virgin Hills Formation.

Remarks: This form is very similar to Scutula sp. A but instead of a definite apical denticle there is a crest of denticles situated asymmetrically on the unit. The specimens range from the Palmatolepis triangularis Zone (to I β) up to the Upper Palmatolepis crepida Zone (to II α).

Genus SPATHOGNATHODUS Branson & Mehl, 1941

Type species: Spathodus primus Branson & Mehl, 1933.

SPATHOGNATHODUS BOHLENANUS Helms, 1959

Pl. 22, figs. 14

- 1959 Spathognathodus bohlenanus Helms, Geologie, 8, 658, pl. 6,
 figs. 5-8.
- 1962 Spathognathodus bohlenanus Helms; Ziegler, Hess. Landesamt
 Bodenf. Abh., 38, 106, pl. 12, figs. 25, 26, 29-35.
- 1967 Spathognathodus bohlenanus Helms; Spasov & Filipovic, Bulg.
 Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 80, pl.
 5, fig. 7, 13; pl. 7, fig. 6.
- 1967 Spathognathodus bohlenanus Helms, Wolska, Acta Palaeont.
 Polonica, 12, 426, pl. 18, fig. 4-6.
- ? 1968 Spathognathodus bohlenanus Helms; Manzoni, Gior. Geol., 34,
 674, pl. 62, fig. 14.
- 1969 Spathognathodus bohlenanus Helms; Olivieri, Boll. Soc. Paleont.
 Italiana, 8, 143, pl. 12, figs. 2a, b, pl. 26, figs. 2a-c.

Material: Single specimen, CPC 12793 , Sample BG 19170, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Remarks: A single specimen is elongate and shallow with tall needle-like denticles tallest near the cavity. The basal cavity is conical.

Distribution: The species was originally described from Thuringia, Germany (Helms, 1959). Ziegler (1962) has also reported it from Germany, as have Bar (1968), Schneider (1969), and Meischner & Schneider, 1970). It has also been reported from Austria (Schulze, 1968; Schönlaub, 1969), Italy (Manzoni, 1968; Olivieri, 1969), Jugoslavia (Spasov & Filipovic, 1967), Poland (Wolska, 1967), and Portugal (Boogaard, 1963). This is the first report of the species outside Europe.

Range: Helms (1959) records the species from the to IV/V boundary. Ziegler (1962) records the species from the Middle Scaphignathus veliferus Zone (to III β) up to the Upper Polygnathus styriacus Zone (to V). Wolska (1967) extends the range down to the Palmatolepis quadrantinodosa Zone (to III α). The Canning Basin specimen is from the Lower Polygnathus styriacus Zone (to IV).

SPATHOGNATHODUS cf. S. BREVIS Bischoff & Ziegler, 1957

Pl. 22, figs. 13

cf. 1957 Spathognathodus brevis Bischoff & Ziegler, Hess. Landesamt Bodenf. Abh., 22, 116, pl. 19, figs. 24, 27-29.

Material: Single specimen, CPC 12794 , Sample BG 19020, Section 1, McWhae Ridge, Virgin Hills Formation.

Remarks: The specimen consists of a long anterior bar composed of seven laterally compressed fused denticles with free, posteriorly inclined free tips. There is another denticle over the basal cavity which is more posteriorly inclined than the bar denticles. Anterior to this denticle there is a single low denticle. The cavity is asymmetrical and is

greatly flared on one side. The short anterior process sets it apart from S. brevis (which is probably a pelekysgnathid). It is also similar to some specimens of Palmatolepis subgracilis Bischoff. The specimen comes from the Upper Palmatolepis crepida Zone.

SPATHOGNATHODUS FITZROYI sp. nov.

Pl. 22, figs. 9

Derivation of name: From the Fitzroy River.

Material: 6 specimens, CPC 12795 holotype,
CPC 12796 paratype.

Localities of figured material: Holotype, Sample BG 19130, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Diagnosis: A flexed spathognathodid characterized by massive denticles on the posterior half.

Description: A spathognathodid with massive denticles. Anterior to the basal cavity there are five or six denticles which are most massive in the mid-region. The denticles are fused and some are compacted and do not erupt at the surface. Those that do have tall, triangular free tips. The unit is flexed through about 30° and the posterior part bears about four denticles, two of which, in the mid-region, are massive.

Aborally, the unit is knife-edged. The basal cavity is situated at the point of flexure and is a narrow slit, widest at the anterior with narrow but rounded lips.

Remarks: No described species of Spathognathodus is similar to this form.

Range: The species ranges from the Lower Palmatolepis quadrantinodosa Zone (to $\text{II}\beta$) up to the Lower Scaphignathus veliferus Zone (to $\text{III}\alpha$).

SPATHOGNATHODUS cf. S. ROBUSTUS (Branson & Mehl, 1934)

Pl. 23, figs. 2

cf. 1934 Spathodus robustus Branson & Mehl, Univ. Missouri Stud., 8,
189, pl. 17, fig. 21.

Material: 2 specimens, CPC 12797 figured.

Locality of figured material: Sample BG 19167, Section 4, northeast of
McWhae Ridge, Bugle Gap Limestone.

Remarks: The present specimens appear to be close to S. robustus
but they lack the thick aboral edge mentioned by Branson & Mehl (1934,
p. 189).

Rhodes et al. (1969) and Druce (1969) have described specimens
from the Lower Carboniferous compared by then to S. robustus. The
original types came from the late Famennian Grassy Creek Shale of
Missouri and thus there appears to be two homeomorphic developments
of S. robustus. The present specimens are from the Lower Polygnathus
styriacus Zone (to IV) and thus are probably referable to S. robustus s.s.

SPATHOGNATHODUS STABILIS (Branson & Mehl, 1934)

1934 Spathodus stabilis Branson & Mehl, Univ. Missouri Stud., 8,
188, pl. 17, fig. 20.

1958 Spathognathodus stabilis (Branson & Mehl); Bischoff & Ziegler,
Hess. Landesamt Bodenf., Notizb., 84, 167, pl. 13, fig.
11.

1959 Spathognathodus stabilis (Branson & Mehl); Helms, Geologie,
8, 658, pl. 3, fig. 5; pl. 5, fig. 1; pl. 6, fig. 12, 13.

1961 Spathognathodus stabilis (Branson & Mehl); Freyer, Freib.
Forsch., C95, 88, text-fig. 148.

1962 Spathognathodus stabilis (Branson & Mehl); Ziegler, Hess.
Landesamt Bodenf. Abh., 38, 112, pl. 13, figs. 1-10.

- 1966 Spathognathodus stabilis (Branson & Mehl); Klapper, Univ. Kansas Paleont. Inst. Pap. 3, 23, pl. 5, fig. 7 [non fig. 6].
- 1967 Spathognathodus stabilis (Branson & Mehl); Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 81, pl. 5, figs. 8, 11, 16, 17.
- 1967 Spathognathodus stabilis (Branson & Mehl); Wolska, Acta Palaeont. Polonica, 12, 428, pl. 19, figs. 1-3.
- ? 1968 Spathognathodus stabilis (Branson & Mehl); Mound, J. Paleont., 42, 514, pl. 70, figs. 19, 23.
- 1969 Spathognathodus stabilis (Branson & Mehl); Olivieri, Boll. Soc. Paleont. Italiana, 8, 145, pl. 12, figs. 3a-c; pl. 26, figs. 3-66.

Material: Six specimens, CPC 12798-12801 figured.

Localities of figured material: Samples BG 19454A, BG 19092, BG 19107, Section 4, northeast of McWhae Ridge, Virgin Hills Formation, and Bugle Gap Limestone.

Remarks: The figured specimens are very similar to illustrated specimens of S. stabilis except that the cavity is not greatly flared in the smaller specimens. The species appears to arise from the same stock as S. strigosus.

Occurrence: The species was originally described from the Grassy Creek Shale of Missouri (Branson & Mehl, 1934). Elsewhere in North America the species has been recorded from Wyoming (Klapper, 1966) and Alberta, Canada (Mound, 1968). In Europe the species has been reported from Germany (Bischoff & Ziegler, 1956; Helms, 1959; Freyer, 1961, 1968; Ziegler, 1962; Henningsen, 1965B, 1968), Austria (Schönlaub, 1969), France (Boyer et al., 1968), Italy (Olivieri, 1969), Jugoslavia (Spasov & Filipovic, 1967), Poland (Wolska, 1967), and Portugal (Boogaard, 1963).

Range: The age of the Grassy Creek Shale is late Famennian (Collinson et al., 1962). Bischoff & Ziegler (1956) give the European range as to III to Lower Carboniferous. Ziegler (1962) gives the range as Middle Scaphignathus veliferus Zone (to III β) as high as the Upper Spathognathodus costatus Zone (to VI). Wolska (1967) extends the range down to the Palmatolepis quadrantinodosa Zone (to II β). The Canning Basin specimens range from the Middle Palmatolepis triangularis Zone (basal Famennian), an even earlier first occurrence, as high as the basal part of the Upper Palmatolepis quadrantinodosa Zone.

SPATHOGNATHODUS STRIGOSUS (Branson & Mehl, 1934)

Pl. 23, figs. 6

- 1934 Spathodus strigosus Branson & Mehl, Univ. Missouri Stud., 8, 187, pl. 17, fig. 17.
- 1956 Spathognathodus strigosus (Branson & Mehl); Bischoff & Ziegler, Hess. Landesamt Bodenf. Notizbl., 84, 167, pl. 13, fig. 15.
- 1961 Spathognathodus strigosus (Branson & Mehl); Freyer, Freib. Forsch., (95, 88, text-fig. 14⁰)
- 1962 Spathognathodus strigosus (Branson & Mehl); Ziegler, Hess. Landesamt Bodenf., Abh., 38, 111, pl. 12, figs. 21-23.
- 1967 Spathognathodus strigosus (Branson & Mehl); Spasov & Filipovic, Bulg. Acad. Sci., Bull. Geol. Inst., Ser. Paleont., 16, 81, pl. 5, figs. 14, 15; pl. 7, figs. 7, 8.
- 1967 Spathognathodus strigosus (Branson & Mehl); Wolska, Acta Palaeont. Polonica, 12, 428, pl. 18, figs. 9-15.

Material: 50 specimens, CPC 12802 - 12808 figured.

Localities of figured material: Samples BG 19087, 19089, 19133, 19147, 19160, 19173, 19174, Section 4, northeast of McWhae Ridge, Virgin Hills Formation and Bugle Gap Limestone.

Remarks: In the Canning Basin faunas S. strigosus is usually represented in most faunas by a single specimen but it ranges over enough time to show some evolutionary development. In the earliest part of the Lower Palmatolepis quadrantinodosa Zone the specimens are small and the anterior denticles are of the same order of height as the remainder. The denticles tend to be needle-like and the cavity is in the posterior half. The cavity tends to move to a more medial position and the "step" in the aboral margin tends to flatten out. The anterior denticles tend to become about twice as massive as the bar denticles and tend to form a blade, and the denticles themselves are laterally compressed and fused with free tips. The specimens in the Lower Polygnathus styriacus Zone exhibit all these characters. The two end members of this sequence are easily distinguished but in the middle part of the range, however, these characters are all intermediate.

Another feature is that the earliest specimens tend to be small, whereas the later specimens are more massive.

S. strigosus appears to have developed from a S. stabilis type form (see Pl. 23, figs. 1) which may be ancestral to both S. strigosus and S. stabilis. S. strigosus appears to be ancestral to most of the Carboniferous spathognathids.

Distribution: S. strigosus was originally described from the Grassy Creek Shale of Missouri (Branson & Mehl, 1934). The only other report of the species is by Thomas (1949) from Iowa. However, Mound (1968) places S. strigosus in synonymy with S. gradatus (Youngquist) and this appears to be substantially correct, particularly for the early forms. This extends the occurrence in North America to Alberta (Mound) and a second occurrence in Iowa (Youngquist, 1945), and possibly Minnesota (Stauffer, 1940) if S. gratiosus (Stauffer) is placed in synonymy.

In Europe the species is known from Germany (Bischoff & Ziegler, 1956; Freyer, 1961, 1968; Ziegler, 1962; Henningsen, 1965; and Bar, 1968). It has also been recorded from Austria (Schönlaub,

1969), Jugoslavia (Spasov & Filipovic, 1967), and Poland (Wolska, 1967).

Range: The species was originally described from the late Famennian Grassy Creek Shale of Missouri (Branson & Mehl, 1934). Ziegler (1962) gives a range of Lower Palmatolepis quadrantinodosa Zone to Upper Spathognathodus costatus Zone. However, if S. gradatus is a senior synonym, then the range is extended into the Frasnian, the fauna including Ancyrodella and Ancyrognathus triangularis. The Canning Basin specimens range from Lower Palmatolepis quadrantinodosa Zone (to II β) up to the Lower Polygnathus styriacus Zone (to IV) but ancestral forms are present in the Middle Palmatolepis triangularis Zone (see Pl. 23, figs. 3).

SPATHOGNATHODUS sp. A

Pl. 23, figs. 7

Material: 2 specimens, CPC 12899 figured.

Locality of figured material: Sample BG 19007, Section 1, McWhae Ridge, Gogo Formation.

Remarks: A small spathognathodid somewhat similar to S. stabilis in having a flaring posterior cavity. However, the dentition is characteristic; the blade is formed by denticles of equal height, fused with very short free tips. In the posterior the bar is depressed and the denticles become lower and isolated.

This species appears to develop into Pseudopolygnathus sp. A, which occurs in the same sample. This is probably the earliest development of Pseudopolygnathus from Spathognathodus. The specimens come from the Middle Polygnathus asymmetricus Zone.

SPATHOGNATHODUS sp. B

Pl. 23, figs. 4

Remarks: A single specimen, CPC 12810 , from Sample BG 19129, from Section 4, northeast of McWhae Ridge, is unusual. It is extremely short and tall. It is composed of thirteen denticles which are tallest and most massive in the mid-part of the anterior half. They decrease rapidly in height both anteriorly and posteriorly. The cavity is elongate and is confined to the posterior half. The specimen resembles a foreshortened S. stabilis, and it comes from the Lower Scaphignathus veliferus Zone (to III α).

SPATHOGNATHODUS sp. C

Pl. 23, figs. 9, 11

Remarks: Two specimens, CPC 12811-12812 , are characterized by their tall free blade and the development of lateral dentition. Although both specimens display these characters, they differ in detail. In one specimen (Pl. 23 , figs. 11) the blade is highest at its mid-point, whereas the other is highest at the posterior end (Pl. 23 , figs. 9). The first specimen also possesses a fairly deep bar with laterally compressed denticles with free chevron tips. The latter specimen has a lower bar with isolated denticle tips. In both specimens the denticles erupt from the slightly tumid bar.

The basal cavity is narrow and elongate, situated at the mid-point at the point of flexure of the aboral margin.

Laterally, nodose spathognathodids are known from the late Famennian (S. aculeatus), but it is characterized by a flaring basal cavity and peg-like lateral denticles connected by a low ridge to the main bar.

The present specimens are from the Middle Scaphignathus veliferus Zone (to III β) and the Lower Polygnathus styriacus Zone

(to IV), Samples BG 19145, 19170, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

SPATHOGNATHODUS sp. D

Pl. 23, figs. 3

Remarks: One specimen, CPC 12813, is a small spathognathodid with denticles of nearly equal height. The denticles number fifteen and have fused bases with tall triangular free tips. One of the denticles above the basal cavity is slightly larger than the others and posterior to it the bar denticles are slightly smaller than the average bar denticles. The basal cavity is situated in the anterior part of the posterior half of the unit and is elongate with gently flared lips. The aboral margin is virtually straight. The general form of the unit suggests an ozarkodinid ancestor. The specimen is from the Middle Palmatolepis triangularis Zone (basal Famennian), Sample BG 19453E from Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

SPATHOGNATHODUS sp. E

Pl. 23, figs. 13

Remarks: A single specimen, CPC 12814, is distinguished by its extremely tall denticles with fused bases but with long discrete tips and a tumid bar at the unit mid-point. The tumid part bears a few small, low nodes on the oral surface. The specimen bears some resemblance to Polygnathellus. It is from the Middle Palmatolepis triangularis Zone (basal Famennian), Sample BG 19453E, from Section 4, northeast of McWhae Ridge, Virgin Hills Formation.

SPATHOGNATHODUS sp. F

Pl. 23, figs. 12

Remarks: Two specimens, CPC 12815, figured, are characterized by a massive denticle situated over the basal cavity. The two denticles at the anterior end are also massive and are separated from the median denticle by five smaller and narrower denticles. Posterior to the median denticle there are about five more smaller denticles. The basal cavity is relatively small and situated at the point of downward flexure of the aboral margin. The presence of a well developed denticle over the basal cavity is reminiscent of S. steinhornensis and S. primus from the Lower Devonian and Upper Silurian respectively. The present specimens are from the Lower Polygnathus asymmetricus Zone (to I α); the figured specimen is from the base of the section immediately southwest of McWhae Ridge, Gogo Formation.

SPATHOGNATHODUS sp. G

Pl. 23, figs. 8

Remarks: A single specimen, CPC 12816, is characterized by a deep bar and minute needle-like free denticle tips. The unit is comparatively small but the series of seventeen isolated, needle-like denticle tips are unusual. The anterior and the posterior margins are convex and the aboral margin is straight with a small basal cavity at the mid-point. The specimen is from the Lower Polygnathus asymmetricus Zone (to I α), from Sample BG 19188 at the base of the section immediately southwest of McWhae Ridge in Sadler Limestone interfingering with Gogo Formation.

SPATHOGNATHODUS sp. H

Pl. 23, figs. 5

Remarks: Four specimens, CPC 12817, figured, are distinctive because of their convex aboral margin and apparent lack of a basal cavity. The denticles are approximately equidimensional and are characteristically elongate and needle-like. They number about nine. The specimens range from the Ancyrognathus triangularis Zone (to I γ) up to the Lower Scaphignathus veliferus Zone (to III α). The figured specimen is from Sample BG 19061, Section 4, northeast of McWhae Ridge, Sadler Limestone.

SPATHOGNATHODUS sp. I

Pl. 23, figs. 10

Remarks: A small simple spathognathodid with equidimensional denticles consisting of about eleven denticles which are slightly taller in the mid-region. The posterior inclination of the denticles gradually increases toward the posterior. The basal cavity is elongate with slightly flared lips and is situated in the posterior half, extending to the posterior termination. The species appears to be a development of S. stabilis and could be ancestral to both the protognathodias and the S. cf. S. cristulus spathognathodids in the lowest Carboniferous. The specimen is from the Lower Polygnathus styriacus Zone (to IV), from Sample BG 19173, from Section 4, northeast of McWhae Ridge, Bugle Gap Limestone, (CPC 12817).

Genus SYNPRIONIODINA Bassler, 1925

Type species: Synprioniodina alternata Ulrich & Bassler, 1926.

SYNPRIONIODINA cf. S. ALTERNATA Bassler, 1925

Pl. 24, figs. 1

Material: 65 specimens, CPC 12819-12823 figured.

Localities of figured material: Sample BG 19049, Section 3, McWhae Ridge, Sadler Limestone; Samples BG 19453 B, E, Section 4, northeast of McWhae Ridge, Virgin Hills Formation; Sample BG 21234, Section 20, Long's Well Creek, Gogo Formation.

Remarks: Clark & Ethington (1967, p. 64) note that the genera Euprioniodina, Neoprioniodus, Prioniodina and Synprioniodina are linked by transitional species and that the existing species also intergrade. They state that "a careful revision of the entire group is desirable as well as necessary." The present specimens are not abundant enough to even attempt any rationalization of this complex. The fauna contains forms referable to S. alternata and to S. prona, but the two intergrade. I have included all these forms under the present heading. The earlier forms are mostly referable to S. alternata whereas the later forms are mostly of S. prona type. They range in age from the Upper Polygnathus asymmetricus Zone as high as the Lower Palmatolepis quadrantinodosa Zone.

SYNPRIONIODINA sp. A

Pl. 24, figs. 3

Material: 5 specimens, CPC 12824 - 12825 figured.

Localities of figured material: Samples BG 19107, 19147, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

Remarks: A synprioniodid with a short posterior bar and a relatively long anterior bar. The anterior bar is depressed through about 70° and bears about seven needle-like denticles which decrease in height anteriorly and are fused for the majority of their length. The apical denticle is massive, about 3 times as wide and twice as long as the largest bar denticle. The posterior bar is twice as deep as the anterior bar and bears about 12 denticles which are needle-like, basally fused with long free tips. The basal cavity opens at the junction of the bar and the apical denticle. The species ranges from the Lower Palmatolepis quadrantinodosa Zone (to II β) probably as high as the Middle Scaphignathus veliferus Zone (to III β). A specimen figured by Bond (1947, pl. 1, fig. 13) is very close and is probably the same species. Unfortunately Bond left his specimen in open nomenclature.

SYNPRIONIODINA sp. B

Pl. 24, figs. 2

Remarks: Two specimens, CPC 12826 from Sample BG 19107, and CPC 12827 from 19108, from Section 4, northeast of McWhae Ridge (Bugle Gap Limestone), are distinctive in having long posterior bars and a small apical denticle. The posterior bar bears about thirty denticles which are needle-like and tall; in the posterior half the dentition tends to be cyclic. The apical denticle is small and is only just wider than the bar denticles which are fused to either face. The anterior bar is short and bears about five needle-like denticles which decrease in height rapidly anteriorly. The basal cavity is small and subapical. These specimens are close to Synprioniodina newalbanyensis Huddle; they are from the lower part of the Upper Palmatolepis quadrantinodosa Zone.

Genus TRIPODELLUS Sannemann, 1955Type species: Tripodellus flexuosus Sannemann, 1955.TRIPODELLUS ROBUSTUS Bischoff, 1957

Pl. 24, figs. 4

- 1957 Tripodellus robustus Bischoff, Hess. Landesamt Bodenf., Abh.,
19, 58, pl. 6, fig. 40.
- 1967 Tripodellus robustus Bischoff; Spasov & Filipovic, Bulg. Acad.
Sci., Bull. Geol. Inst., Ser. Paleont., 16, 82, pl. 6,
fig. 18, 20.
- 1967 Tripodellus robustus Bischoff; Wolska, Acta Palaeont. Polonica,
12, 430, pl. 5, fig. 7.
- 1969 Tripodellus robustus Bischoff; Druce, Bur. Miner. Res.
Aust. Bull. 98, 139, pl. 41, figs. 2a-3. (Synonymy to
1966).
- 1969 Tripodellus robustus Bischoff, Olivieri, Boll. Soc. Paleont.
Italiana, 8, 146, pl. 8, figs. 11, 12; pl. 26, figs. 11, 12.

Material: 40 specimens, CPC 12828 - 12829 figured.Localities of figured material: Samples BG 19107, 19108, Section 4,
northeast of McWhae Ridge, Bugle Gap Limestone.Remarks: Some of the specimens have tumid bars, giving distinct
shoulders at the base of the denticles, especially on the anterior bar.Distribution: The species was originally described from Germany
(Bischoff, 1957) and has been reported from there by Helms (1959),
Freyer (1961, 1968), Schneider (1969), and Meischner & Schneider
(1970). It has also been reported from Austria (Schönlaub, 1969),
France (Boyer et al., 1968), Italy (Olivieri, 1969), Yugoslavia (Spasov
& Filipovic, 1965, 1967), Poland (Freyer & Zakowa, 1967), and
Portugal (Boogaard, 1963).

Range: Bischoff (1957) gives the range as uppermost Devonian but this is the bottom of his section. Wolska (1967) gives the range as Palmatolepis quadrantinodosa Zone up to the Scaphignathus veliferus Zone. The Canning Basin specimens range from the Lower Palmatolepis quadrantinodosa Zone up to the Upper Scaphignathus veliferus Zone.

gen. nov. et sp. nov. Druce, 1969

Pl. 24, figs. 5

1969 gen. nov. et sp. nov. Druce, Bur. Miner. Resour. Aust. Bull.,
98, 140, pl. 41, figs. 4a, b.

Remarks: A single specimen, CPC 12830, is very similar to that illustrated from the Bonaparte Gulf Basin. However, it is slightly more asymmetrical with one bar reduced and the other extended; although the unit is twisted, the twisting is less. There is also a certain resemblance to Neoprioniodus ? tortus Druce. The specimen is from the Lower Polygnathus styriacus Zone (to IV), Sample BG 19172, Section 4, northeast of McWhae Ridge, Bugle Gap Limestone.

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APPENDIX 1

UPPER PALAEOZOIC AND TRIASSIC CONODONT DISTRIBUTION AND THE RECOGNITION OF BIOFACIES

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ABSTRACT

Over the last decade knowledge of the world-wide distribution of conodont genera has increased considerably and extends to all continents except Antarctica. Maps showing zoogeographic distribution for various time divisions are presented.

In general, the faunal aspects of shallow and deep water deposits differ. Simple morphologic forms predominate in the former, represented in the Upper Devonian by the Icriodus-Polygnathus-simple cone assemblage and in the lowest Carboniferous by the Spathognathus-Polygnathus-Clydagnathus assemblage. However, deep water faunas contain complex morphological types including Palmatolepis and Ancyrodella in the Upper Devonian and Siphonodella and Pseudopolygnathus of the triangulus group in the lowest Carboniferous. Exotic and bizarre genera including the Upper Devonian Ancyrognathus, Playfordia and Polylophodonta and the Lower Carboniferous Dinodus, Doliognathus, Dollymae, Scaliognathus and Staurognathus appear to be confined to deep water faunas. The faunal assemblages are not mutually exclusive, reduced numbers of "shallow" platform elements being common in deep water faunas. Deep water platform elements are rare in shallow water faunas, and are also numerically rich in species.

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Zonations based exclusively on deep water faunas are difficult to apply to shallow water deposits. Thus, it is important that species belonging to the simple platform genera, e.g., Icriodus, Polygnathus, Spathognathodus, etc., be recorded though they may be relatively long-ranging. Furthermore, they appear to be the "root-stock" from which many complex and bizarre genera developed.

INTRODUCTION

Following the spectacular demonstration by Sannemann (1955) that differing conodont faunas followed one another in stratigraphic order in the Upper Devonian of Germany a detailed conodont stratigraphy for much of the Devonian and Carboniferous of Germany was erected (Bischoff, 1956, 1957; Bischoff and Sannemann, 1958; Bischoff and Ziegler, 1956, 1957; Voges, 1959; Ziegler, 1956, 1958, 1962).

This classical palaeontological research was rapidly extended to other areas and conodonts have now been recorded from every continent except Antarctica. This expanded research demonstrated that the conodont stratigraphy worked out in Germany was readily applicable to the great majority of areas.

The fact that many of these faunas were obtained from calcareous sediments dispelled the contention that "the limestones and decidedly calcareous sediments, for instance are, by comparison with other types of rocks, sparsely supplied with or almost devoid of conodonts (Branson and Mehl, 1933, p. 8). Thus Müller (1962, p. W89) was able to comment that "conodonts are not confined to sedimentary facies, since the same species is found to occur in different lithologies" although he points out that conodonts have not been found in non-marine sediments.

However, it is interesting to note that in an earlier paper (Müller, 1956) he remarked that in the Upper Devonian there was "a strong change in the relative abundance of partial-genera which obviously is not due to different age."

This same fact was also noted by Merrill (1962) in Pennsylvanian strata in the Appalachian Basin where the different ratios of abundance between the platform genera Cavusgnathus and Streptognathodus bear little relationship to age.

The continued work on Ordovician faunas on both sides of the Atlantic has demonstrated that during much of the Ordovician at least two faunal provinces existed (Lindström, 1964, p. 44) and, in fact, sub-provinces can be recognized (Barnes et al., this vol.).

The considerable increase in conodont publications in the last ten years, especially those dealing with the Upper Palaeozoic, has given us a much clearer understanding of conodont distribution.

In considering the geographic distribution of Upper Devonian to Triassic platform genera I have plotted all reported occurrences of each genus for various series and in some cases, i.e., Frasnian, for stages. The Permian and Triassic occurrences were plotted for systems. Even though there has been a considerable extension in the geographic distribution of published faunas during the last few years, there are several factors which limit the amount of information obtainable in this way.

The data are obviously restricted to areas where strata of the particular age are present, in most cases at the surface. Furthermore, the data are restricted to areas where detailed geological and palaeontological work has been concentrated.

Even so, we have very little data for the U.S.S.R., not because geologists have not been extremely active but because biostratigraphic interpretations have been made using fossils other than conodonts. Recently, the picture has changed and there are an increasing number of faunas being reported from Russia. In the next few years this information could greatly help in determining geographic distribution.

Finally, the human element affects the data. In some cases conodont publications do not describe the complete conodont faunas but only selected species and genera. This has been counteracted to some extent in this study by using only platform-genera, since it is usually the bars and blades which are left undescribed. The majority of conodont publications illustrate the fauna and in these cases it is a

comparatively easy task to determine if the genus reported has been identified correctly. However, in this study I have included information contained only in faunal lists assuming that the generic identifications are correct. This factor becomes increasingly important when dealing with the earlier literature, and in recent literature on the Triassic, where there is considerable generic synonymy owing to the large number of papers published at the same time in many different countries.

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UBIQUITOUS GENERA	GENERA WITH PATCHY DISTRIBUTION	GEOGRAPHICALLY RESTRICTED GENERA
Simple cone group (L. Devonian) II	Simple cone group (M. Dev - Famenn) II	Ancyrodelloides II or IIIB
Ancyrodella II	Cavusgnathus IV	Bactrognathus II or IIIB
Ancyrognathus II	Celsignodolella I and II	?Mestognathus IV
Gnathodus	Clydagnathus IV	
Icriodus (L. Dev. - Fras- nian) II	Dinodus II	
Idiognathodus II	Doliognathus II	
Palmatolepis II	Dolymae I	
Polygnathus II and I	Eognathodus IIIA	
Pseudopolygnathus IIIA	Furnishius II or IIIB	
Siphonodella II	Gladigondolella II	
Spathognathodus (L. Dev.; Famen - Viséan) I and II	Gondolella II	
Streptognathodus (U. Carb.) II	Icriodus (Famennian) II	
	Idiognathoides II and IIIB	
	Neogondolella II	
	Paragondolella II	
	Patrognathus IIIA	
	Pelekysgnathus I or II	
	Platyvillosus I or IIIB?	
	Polygnathus germana group II	
	Polylophodonta II	
	Scaliognathus II	
	Scaphignathus IV	
	Spathognathodus (M. Dev - Fras; U. Carb - Perm)	
	Staurognathus IV?	
	Streptognathodus (Permian) II	
	Taphrognathus I	
	Tardogondolella II	

FIGURE 15

ANALYSIS OF GENERIC DISTRIBUTION

The majority of genera considered here are of the platform type. I have also included the genera Pelekysgnathus and Spathognathodus, which appear to be intimately associated with platform genera, and also the simple cone genera, as a group, because they appear to be restricted in their distribution. I have not included newly described platform genera for which there is little information on their distribution (e.g., Schmidtognathus Ziegler, 1965; Adetognathus Lane, 1967; Rhodalepis Druce, 1969). Each genus is dealt with separately.

The simple cone group (Fig. 1-3)

For a number of years the simple cone elements which are often present in faunas of Devonian age were considered to be reworked from older strata. Rhodes and Dineley (1957, p. 356) noted that an extension of range of cone forms into the Devonian appeared unlikely because of over two hundred Devonian faunas then known there were only three (Bond's Ohio Shale fauna, Stauffer's Cedar Valley fauna, and their Devon fauna) with anomalous occurrences of cones. Ethington (1959, p. 271) suggested that there was no reason why these cones in Devonian strata should not, in fact, be of Devonian age. The considerable information published on Silurian faunas over the last decade has shown that Ethington was correct and "Silurian" cones extend into the Devonian. In fact, the majority of Lower Devonian faunas contain cone elements. Those that appear to lack cone elements occur in North America, Europe, and Australia. This absence may be more apparent than real; for example, some of the faunas reported by Philip and Pedder (1967) were in a review publication where the important zone platform genera were mentioned but the complete fauna has, as yet, not been described.

In the Middle Devonian the picture changes somewhat; cones are far less common and although known from every region from which conodont faunas have been described they are present in only about 50% of those faunas. Once again the idea that they were not of Devonian age or that they were of little stratigraphic use and should be ignored may have produced a somewhat unrealistic picture. However, cones in Middle Devonian faunas may vary in frequency from absent, as they are in the Moore Creek Limestone of New South Wales (Philip, 1966) to being the sole element of the fauna as in a Middle Devonian limestone near Mount Morgan in Queensland.

In the Frasnian cones are even rarer, being present in only about one third of reported faunas, and the same is the case in the Famennian. No undoubted Carboniferous cone forms are known.

The general picture of the distribution of Devonian cone elements is that they are not restricted geographically. However, their ubiquity in the Lower Devonian is followed by a reduction of occurrences in the Middle Devonian which continues into the Upper Devonian until finally all cone genera appear to become extinct before the beginning of the Carboniferous Period.

Ancyrodella

The genus *Ancyrodella* is virtually confined to the Frasnian. It is a ubiquitous genus being present in more than 75% of published Upper Devonian faunas. It is absent in a few faunas from North America (Bond, 1947; Orr, 1964; Loranger, 1965), Europe (Helms, 1959; Fraikova, 1961; Dvorak, Freyer, Slezak, 1959; Olivieri, 1965) and Australia (Druce, 1969, 1970b; Seddon, 1969).

Ancyrodelloides

This genus is confined to the Lower Devonian and is restricted to Europe, being absent in North America, Africa, Asia, and Australia. In Europe the genus is not ubiquitous, being reported in only five of the twenty-seven recorded faunas. Apart from the original discovery

in the Frankenwald of Germany (Bischoff and Sannemann, 1958) the genus is confined to Southern Europe, being reported from Central Spain (Carls, 1969), the Alpine region (Schulze, 1968; Schonlaub, 1969) and Yugoslavia (Spasov and Veselinovic, 1963). Where numbers of specimens are given the genus is never abundant.

Ancyrognathus

Ancyrognathus is virtually restricted to the Frasnian. It is present in about 60% of the described Frasnian faunas and is generally absent in those faunas which also lack Ancyrodella. However, the Sardinian fauna (Olivieri, 1965) and the Bonaparte Gulf (Druce, 1969) and Queensland faunas (Druce, 1970b) in Australia do contain the genus; but it is noticeable that even when present in these faunas it is rare. In my collections from the Canning Basin I have recovered three specimens from a fauna of several thousand specimens. Glenister and Klapper (1966) also recorded the relative scarcity of this genus, finding only eleven specimens in their extensive faunas. A fauna from Malaya (Muller, 1967) possesses Ancyrodella but lacks Ancyrognathus. In Alberta two faunas with Ancyrodella (Pollock, 1969) lack Ancyrognathus and where it does occur it is recorded as rare (Mound, 1968).

Overall, the distribution of Ancyrognathus is world-wide, although less so than Ancyrodella. It is abundant in Europe, the United States, and North Africa and is present, though rare, in Canada and Australia.

Bactrognathus

The genus Bactrognathus is present in Late Tournaisian strata in North America. It probably developed from "flexed barlike spathognathodids (Thompson, 1967)," and although several species are barlike because of its ancestry and the development of a platform in some species (i.e., B. excavata) I have included it in the present paper.

The genus is confined to North America; the one report from Europe (Austin and Rhodes in Conil et al., 1969, table 1) is questioned

by those authors. The genus has not been recorded from Africa, Asia, or Australia. Within North America the genus is restricted to the mid-continent region, extending as far west as southwest New Mexico (Burton, 1964). This limited occurrence in North America may be illusionary; the genus has a restricted time range in the late Tournaisian and the majority of faunas described from the western part of the continent are of early Tournaisian age.

Cavusgnathus (Fig. 4, 5)

The genus Cavusgnathus has a range of Viséan to Namurian. In the Viséan it is known from North America, Europe, Africa, Asia, and Australia. It is ubiquitous in North America but in Europe, the only other continent with significant faunas, the genus appears to be more restricted in its distribution. It is known from England and Scotland (Rhodes et al., 1969) but absent or very rare in Ireland (Aldridge et al., 1968; Collinson and Druce, in press). It is present in all reported faunas from Germany but absent in France (Pelhate, 1962), Belgium (Austin and Rhodes in Conil et al., 1969), Spain (Wirth, 1967), and Yugoslavia (Spasov and Filipovic, 1967; Spasov et al., 1968; Durdanovic, 1968).

In the Namurian it is very rare in Europe, the only record being from the earliest Namurian of Scotland (Clarke, 1960); later Namurian strata in the same area failed to yield the genus (Currie et al., 1936). The genus has been reported from North Africa (Remack-Petitot, 1960) but is absent in Sinai (Omara, 1965). In Asia and Australia the genus is absent except for one locality in Japan (Koike, 1967). However, both recorded South American faunas include Cavusgnathus (Fulfaro, 1965; Stibane, 1967) and in North America 50% of the Upper Carboniferous faunas contain the genus.

In general, the genus is present in most North American faunas in the Viséan and has a patchy distribution in Europe. In the Upper Carboniferous the genus is not commonly found outside the Americas.

Celsigondolella (Fig. 6)

The recent avalanche of publications on Triassic faunas has resulted in many morphological forms being given more than one name. Since my knowledge of Triassic faunas is, at best, second-hand, it was necessary to decide which names appear, to me at least, to belong to the same genus. Thus under the heading Celsigondolella Kozur, 1967, I have included Neospathodus Mosher, 1968. Forms referred to as Spathognathodus divergens by Bender and Stoppel (1965) and by Jordan (1969) also belong in this genus.

Celsigondolella is known from North America, Europe, and Asia. It is absent from Diebel's (1956) Cameroon fauna which Mosher (1967) considers to be of Triassic age and is thus probably reworked. Its distribution in Europe is patchy; it has been recorded from eight of twenty-two faunas. In North America it is present in three of five faunas and in Asia it is present in seven of eleven faunas. This patchy distribution cannot be explained by the differing ages of the faunas because the genus appears to range throughout the Triassic (Mosher, 1968a, b).

Clydagnathus

The genus Clydagnathus is an early Tournaisian homeomorph of Cavusgnathus. Since it was only published in 1969 (Rhodes, Austin and Druce), there are as yet no further references to it in the literature. However, it is known to occur in the Bonaparte Gulf Basin (Druce, 1969) and from outcrops of the Fairfield Formation of the Lennard Shelf and in the Subsurface of the Canning Basin.

Specimens referred to as Spathognathodus cf. aciedentatus (E. R. Branson) by Stoppel (1970) would be referred by me to Clydagnathus. It is extremely rare in its occurrence and is clearly restricted. In England it occurs in the Avon Gorge section (Rhodes et al., 1969) and yet only sixty miles away in strata of the same age it is absent (Matthews, 1969b).

Dinodus

Although the genus Dinodus is a bar type genus, I have included it in this survey because it appears to be one of the few bar and blade genera which is not ubiquitous.

It is found in North America, Europe and Australia but has not been found in Asia or Africa. In both North America and Europe it shows extremely patchy distribution, being present in eight out of twenty-one North American faunas and three out of seventeen European faunas. In Australia it is present in the Bonaparte Gulf in one isolated locality. Faunas of the same age within a radius of thirty miles, although yielding abundant conodonts, failed to yield Dinodus.

Doliognathus

The genus Doliognathus is confined to the Tournaisian and is unknown outside Europe and North America. On both continents it shows patchy distribution; in North America it is present in Missouri (Branson and Mehl, 1941), Texas (Hass, 1959) and New Mexico (Burton, 1966), in a total of five faunas out of twenty-one recorded.

In Europe it is known from Germany (Voges, 1959; Kronberg et al., 1960; Bar, 1968), Belgium (Austin and Rhodes in Conil et al., 1969), England (Matthews, 1969a), Spain (Marks and Wensink, 1970) and Italy (Manzoni, 1966), a total of seven faunas out of seventeen recorded.

Dolymae

The genus Dolymae is of late Tournaisian age and is very rare. It was first described from the Chappel Limestone of Texas (Hass, 1959) and this is the only record of the genus in North America. However, in Europe it has been reported from Germany (Voges, 1959; Bar, 1968), Italy (Manzoni, 1966) and France (Boyer et al., 1968). Apart from the occurrence in the Montagne Noire all these faunas contain Doliognathus. However, not all faunas with Doliognathus contain Dolymae; the relationship between these two genera is similar to that

between Ancyrodella and Ancyrognathus in terms of occurrence. Additionally, there is a striking morphological similarity between Doliognathus and Ancyrognathus.

Eognathodus

The genus Eognathodus is typically Lower Devonian. I have included under this heading some forms referred to Spathognathodus by Klapper (1966, 1969). S. bipennatus nevadensis is very close to Eognathodus and has a distinctive posteriorly situated basal cavity. Even if these eognathodid forms should be more correctly referred to Spathognathodus, they are still a very distinctive group. Their distribution is distinctly patchy, whereas other species of Spathognathodus, mostly belonging to the steinhornensis genus, are virtually ubiquitous.

The majority of occurrences of Eognathodus are in Australia, seven of the ten reported Lower Devonian faunas contain it. Elsewhere, it is extremely rare; in North America it has been reported from Nevada (Klapper, 1966) and from the Yukon Territory (Klapper, 1969) with five North American Lower Devonian faunas apparently lacking the form. In Europe, only one of the twenty-seven reported Lower Devonian faunas that came from the Carnic Alps (Skala, 1969) contains this form (referred to as Spathognathodus bidentatus nevadensis).

Furnishius

The Triassic genus Furnishius has only been reported from Nevada (Clark, 1959). A morphologically similar genus Pseudofurnishius has been reported from Spain (Boogaard, 1966) and also from Israel (Huddle, 1970). Both these genera are extremely rare and are unknown in the other thirty-seven published Triassic faunas. A form referred to as Spathognathodus ? sp. inc. by Diebel from the Cameroons belongs to the genus Pseudofurnishius.

Gladigondolella

This monospecific genus is essentially Triassic in age although there was possibly a Permian ancestor; the genus does not range above the Middle-Upper Triassic boundary (Mosher, 1968). It is found in North America, Europe, Asia and the East Indies. In North America it is extremely rare; Mosher and Clark figure one in their 1965 paper (Mosher, 1968, p. 937). All other North American faunas lack the genus (Youngquist, 1952; Muller, 1956; Clark, 1959; Mosher, 1968).

In Europe the genus is restricted to the Alpine region (Huckriede, 1958; Mosher, 1968; Spasov and Ganey, 1960) and to Greece (Bender et al., 1960; Bender, 1967). However, some Alpine faunas, other than Upper Triassic, lack the genus (Stefanov, 1962; Flugel and Petak, 1964; Staesche, 1964; Spasov, 1965; Buderov and Stefanov, 1965; Chatalov and Stefanov, 1966; Ganey and Stefanov, 1967; and Hirsch, 1969). A fauna from Roumania with Alpine ammonoids also lacks the genus (Mirauta, 1964). The genus is absent from the Germanic Muschelkalk (Mosher, 1968), from Spain (Hirsch, 1966; Boogaard, 1966) and Sardinia (Cherchi, 1967).

The genus appears to be absent in the Indian subcontinent; four faunas are known and all are Lower Triassic (Huckriede, 1958; Srivastava and Mandwai, 1966; Fuchs and Mostler, 1969; and Sweet, 1970). In Malaya the genus is present in one fauna (Nogami, 1968) and absent in another (Igo et al., 1965). The genus has been found in Timor (Nogami, 1968) and Japan (Nogami, 1968; Hayashi, 1968). The Jurassic conodonts reported by Nohda and Setoguchi (1967) are considered by Mosher (1967) to be Triassic in age. The fauna lacks *Gladigondolella* but that may be due to its possible Upper Triassic age.

Gondolella

The genus *Gondolella* is known from the late Carboniferous, but I have only plotted it for the Permian period where it is present in eight of the fifteen described faunas. It is not geographically restricted. It

is present in some faunas from Western North America and not in others (Youngquist et al., 1951; Clark and Ethington, 1962; Rhodes, 1963). It is present in Greenland and Sicily but not in Greece or Germany (Bender and Stoppel, 1965). Preliminary indications are that it is absent in Kashmir (Kummel and Teichert, 1966; Sweet, 1970) and Thailand (Igo and Koike, 1966). The genus is present in China (Ching, 1960) and Japan (Hayashi, 1965) but in another fauna it was absent (Hayashi, 1963).

Gnathodus

The genus Gnathodus ranges from earliest Tournaisian to Upper Carboniferous. In the Tournaisian it is present in every fauna described from Europe. In North America, however, there is a much more patchy distribution. The genus is virtually absent in the west (Knechtel and Hass, 1938; Cooper and Sloss, 1943; Beach, 1961; Ethington, 1965; Klapper, 1966; Sandberg and Klapper, 1967), but it has been reported from the Canadian Rockies (Muller, 1962). In the Mississippi Valley the genus is fairly common but some faunas do lack it (Anderson, 1969). There is a solitary report of the genus from North Africa (Remack-Petitot, 1960) but it is not present in the fauna from Syria (Stoppel, 1970).

In the Viséan the genus is ubiquitous and is known from every reported fauna. In the Upper Carboniferous the genus is common, being present in over 80% of the faunas. The faunas lacking the genus are from South Dakota (Jennings, 1959), the Sinai peninsula (Omara, 1965) and South Korea (Gabert et al., 1965).

In overall view the genus Gnathodus has a patchy distribution in the Tournaisian but in the Viséan and Upper Carboniferous the genus becomes ubiquitous.

Icriodus

The genus Icriodus is confined to the Devonian although occasional specimens are found in Lower Carboniferous strata. In the

Lower Devonian the genus is common. The major area where the genus is absent is Australia where more than half the reported faunas lack it. However, many of the reports are in a general summary by Philip (1967) and thus the absence may be fortuitous rather than real. However, Philip (1966, p. 443) notes that in Victoria the genus is virtually absent. Several faunas from Yugoslavia and Bulgaria lack the genus (Spasov, 1960; Spasov and Veselinovic, 1963; Durdanovic, 1968) whilst several others contain it (Budurov and Tschunev, 1964; Ramovs and Schulze, 1967). In the Middle Devonian the genus is common but its distribution is noticeably patchy in Europe; it is absent in several faunas (Rhodes and Dineley, 1957; Kockel, 1958; Rabitz, 1962).

In the Frasnian the genus is ubiquitous, but in the Famennian the distribution is patchy; this is especially so in Europe, although only 60% of the faunas reported from North America include the genus.

Overall, the genus is common in the Lower and Middle Devonian (patchy in Europe) and is ubiquitous in the Frasnian; in the Famennian, however, the distribution becomes very patchy especially in Europe.

Idiognathodus

The genus Idiognathodus is of Upper Carboniferous age. It is extremely common and is present in 80% of reported Upper Carboniferous faunas. It is absent in faunas from Scotland (Currie, 1934), Belgium (Bouckaert and Higgins, 1963; Higgins and Bouckaert, 1968) and Japan (Igo and Koike, 1968). The absence in Belgium is unusual because the genus is present in Northern France (Lys et al., 1962).

Idiognathoides

The genus Idiognathoides is typically Upper Carboniferous. It shows extremely patchy distribution, especially in the Americas where it is known from only 50% of the eight North American faunas and is absent in the two known South American faunas (Fulfaro, 1965; Stibane, 1967). In Europe it is known from England (Matthews and Moore, 1967) though absent in Scotland (Currie et al., 1936). It is absent in North

Africa (Remack-Petitot, 1960) and Sinai (Omara, 1965). In the Far East it is present in Malaysia (Igo and Koike, 1968) and at one locality in Japan (Igo and Koike, 1967) but absent in two others (Igo and Koike, 1964, 1965) and in South Korea (Gabert et al., 1965). The genus has been recorded from Australia (Palmieri, 1969).

Mestognathus

The genus Mestognathus is essentially a Viséan form. It is known from only two localities outside Europe; it has been found on Cape Breton Island, Nova Scotia (Globensky, 1967) and in Australia (Druce, 1969). It is interesting to note that the only North American locality is in an area of the continent which has a distinctly European fauna and was possibly part of Europe during the Carboniferous period. No other American faunas contain the genus. In Europe its distribution is patchy; it is common in Germany (Bischoff, 1957) and Great Britain (Higgins, 1961; Rhodes et al., 1969) and is also found in Spain (Marks and Wensink, 1970).

Neogondolella

Bender and Stoppel (1965) noted that Gondolella mombergensis Tatge differed from Permian faunas and in passing referred to it as Neogondolella mombergensis (Tatge) (Mosher, 1970b). Bender (1967) defined and illustrated the new genus Neogondolella and included forms such as Gondolella navicula Huckriede within the genus. Mosher (1968) considers that the ontogeny of G. navicula is distinctive and erected a new genus Paragondolella to include forms which do not show distinctive platform development in the young stages. I have plotted the species referred to as Paragondolella as a separate unit though it should be noted that there does appear to be some difficulty distinguishing Neogondolella mombergensis from Paragondolella navicula (see Hirsch, 1969, p. 86). I have excluded forms referred to Neogondolella by Mosher (1968, text fig. 1) which are included under Tardogondolella Bender 1967 rather than Epigondolella Mosher 1968 as suggested by

Mosher (1970b).

Neogondolella has been reported in about half the described Triassic faunas but is present on all continents from which Triassic conodonts are known, except Africa which has only yielded Diebel's (1956) problematical fauna from the Cameroons. In North America it is present in some faunas and not in others (Mosher, 1968) and in Europe it shows patchy distribution, being usually present in the Germanic Muschelkalk facies (Huckriede, 1958; Kozer, 1968a, b), but not present in the Spanish Muschelkalk regions (Boogaard, 1966; Hirsch, 1966). The Alpine and Balkan region yields the genus in about half the reported faunas. Elsewhere in the general Tethyan region, it is absent in Israel (Huddle, 1970) and Malaya (Ishii and Nogami, 1965; Igo et al., 1965; Nogami, 1968) but present in the Himalayan region (Huckriede, 1958; Srivastava and Mandwai, 1966; Fuchs and Mostler, 1969; and Sweet, 1970) and in Timor (Hayashi, 1968).

In Japan the distribution is patchy, being present in some faunas (Nogami, 1968) and absent in others (Igo and Koike, 1966; Sakagami et al., 1968).

Palmatolepis

The genus Palmatolepis is uniquely Upper Devonian although there have been some anomalous reports of Devonian species in Carboniferous strata (Matthews, 1969b). In the Frasnian it is present in nearly every reported fauna. However, there are a few faunas which lack the genus, noticeable in North America (Stauffer, 1940; Orr, 1964; Loranger, 1965; and Muller and Clark, 1967) and in Australia (Druce, 1969; Seddon, 1969). The single Frasnian fauna reported from Russia also lacks Palmatolepis (Ovnatanova and Lyashenko, 1966). In the Famennian the genus is known from every locality except one in Iowa (Anderson, 1965).

Paragondolella

Under Paragondolella Mosher, 1968, I have included forms referred to as Neogondolella navicula in Bender (1967), and as Gondolella navicula by many authors.

The genus is of Triassic age; its distribution is remarkably similar to that of Gladigondolella. However, it is known from a few more localities in North America (Mosher, 1968) although it is rare.

Patrognathus

The genus Patrognathus is restricted to the Lower Tournaisian (Rhodes et al., 1969). The distribution chart is thus unreal because some of the faunas plotted are of Upper Tournaisian age. However, the genus is very rare. Apart from its initial discovery in England it has not been recorded from Europe. The only other occurrences are two in North America (Klapper, pers. comm.; Anderson, 1969). The genus is unknown in Africa, Asia and Australia. It may be present in the Franco-Belgian province; Conil et al., (1964) report Taphrognathus (a homeomorph) from the Lower Tournaisian.

Pelekysgnathus

The genus Pelekysgnathus is known from Lower and Upper Devonian strata. There have been a few reports from Middle Devonian strata (Boyer et al., 1968) and unpublished information on Middle Devonian faunas may show the presence of the genus in that Series (Klapper, 1969). I have plotted Lower Devonian occurrences and also Upper Devonian, including Frasnian and Famennian, both plots showing that there is patchy distribution of the genus.

In the Lower Devonian the genus has mainly been reported from Europe with only two known localities in North America, both in the Canadian Arctic (Klapper, 1968). At the present time no Lower Devonian pelekysgnathids have been reported from Africa, Asia, or Australia.

The Upper Devonian faunas also show a patchy distribution. However, they are more widespread than those of the Lower Devonian,

and are known from Australia, Europe and North America. In all three continents the genus is present in some faunas but absent in closely adjacent faunas. The genus is absent from described faunas of Late Devonian age in Africa and Asia.

Platyvillosus

The Triassic genus Platyvillosus is extremely rare, occurring in only three faunas. It is known from two localities in Nevada (Clark et al., 1964; J. W. Collinson, 1968). In Europe Staesche (1964) has described a form Polygnathus gardenae from the Lower Triassic of the South Tirol which clearly belongs in this genus. It is also possible that Staesche's new genus Eurygnathodus is a junior synonym of Platyvillosus.

Polygnathus

This Devonian and Carboniferous genus is virtually ubiquitous. In the Lower Devonian its distribution is somewhat patchy but this, for the most part, is due to the inclusion of pre-polygnathid lower Lower Devonian faunas in the plot. In the Middle Devonian the only known fauna lacking the genus is from the Middle Devonian part of the Flume Formation of Alberta (Clark and Ethington, 1965). In the Frasnian, Famennian, and Tournaisian the genus is ubiquitous. For Famennian occurrences I plotted the P. germanus group separately; it is fairly common, being present in about 65% of the faunas, but it has a patchy distribution.

Polylophodonta

The genus Polylophodonta is restricted to the Famennian. It is known from North America, Europe and Australia but is unknown in Asia and Africa. Both in Europe and North America it has a patchy distribution; in North America it is present in less than 50% of the reported faunas and in Europe in less than 25% and it is restricted to the Central European region. In Australia it is present in both described faunas (Glenister and Klapper, 1966; Druce, 1969).

Pseudopolygnathus

The genus Pseudopolygnathus ranges from late Upper Devonian through the Tournaisian; I have only plotted the Tournaisian occurrences which are virtually ubiquitous. The only faunas lacking the genus are in North America (Cooper and Sloss, 1943; Youngquist and Downs, 1951; Ethington, 1965; Anderson, 1969).

Scaliognathus

The genus Scaliognathus is monotypic and is confined to the late Tournaisian. Its distribution is extremely patchy but this may be due, in part, to its restricted range within the Tournaisian. In Europe it is present in over 60% of faunas and shows an odd distribution. It is absent in the Avon Gorge section of England (Rhodes et al., 1969), but is present in a fauna only 60 miles away (Matthews, 1969b). In North America the genus was originally described from Missouri by Branson and Mehl (1941). Since then it has only been reported in four other faunas (Hass, 1959; Burton, 1965; Thompson, 1967; Thompson and Fellows, 1970). The genus has not yet been found in Australia but it is known from Africa (Remack-Petitot, 1960).

Scaphignathus

The genus Scaphignathus is middle and late Famennian in age. Its distribution is extremely patchy. In Europe it is known from ten of thirty-four faunas; in North America the genus is only known from Montana (Klapper, 1966; Sandberg and Klapper, 1967). The genus is present in Australia (Glenister and Klapper, 1966; Druce, 1969), but is absent in North Africa (Remack-Petitot, 1960; Massa, 1965).

Siphonodella

The genus Siphonodella is confined to the Tournaisian. It is ubiquitous in its distribution; three faunas in which it is not present are all probably too young to contain the genus; they include one from New Mexico (Burton, 1966), one from Eire (Austin and Aldridge, 1969) and

one from Spain (Marks and Wensink, 1970). Only one fauna which is apparently of the right age lacks the genus (Stoppel, 1970), although it is extremely scarce in some faunas (Rhodes et al., 1969).

Spathognathodus

The genus Spathognathodus is extremely long-ranging with a total range of Ordovician to at least Permian. Triassic forms which have been referred to Spathognathodus have been included under Celsigondolella in this paper. In the Lower Devonian the genus is ubiquitous, only six out of the forth-five Lower Devonian faunas lack it; it is known from North America, Europe, Africa, Asia and Australia. In the Middle Devonian its distribution is patchy and even though it has been reported from the same continents it is present in only about 50% of faunas on each continent. This is also the case in the Frasnian. In North America it is present in 55% of the faunas; it is present in all the faunas west of the Mississippi-Missouri rivers and absent in the majority east of those rivers. In Europe it is present in only 35% of reported faunas although there is no obvious geographic restriction. The genus has not yet been reported from the Frasnian of Africa and India but it is present in Malaya, and in one of four recorded Australian faunas. In the Famennian the genus is common, being absent in only twelve of fifty-four faunas, and this percentage is also true of the Tournaisian (nine of thirty-eight) and Viséan (five of twenty-seven faunas).

In the Upper Carboniferous and Permian the genus reverts to its patchy distribution (present in twelve of twenty-three Upper Carboniferous faunas).

In the Permian the genus is probably confined to the early Permian and is known in North America (Clark and Ethington, 1962; Rhodes, 1963) and India (Sweet, 1970). Late Permian forms referred to Spathognathodus from Europe should more correctly be referred to Celsigondolella.

In the time interval considered Spathognathodus begins as a ubiquitous genus in the Lower Devonian, becomes patchy in its distribution in the Middle Devonian and Frasnian, reverts to being ubiquitous in the Famennian, Tournaisian, and Viséan and finally shows patchy distribution in the Upper Carboniferous and Permian when it becomes extinct.

Staurognathus

The genus Staurognathus is restricted to the late Tournaisian and hence the abundance plot gives a slightly inaccurate picture of its distribution. However, it is a rare genus, being present in only five faunas in North America from whence it was first described (Branson and Mehl, 1941; Hass, 1959; Burton, 1965; and Thompson, 1967; Thompson and Fellows, 1970) and in these faunas it is rare (Hass, p. 393); Thompson (p. 56) found only one specimen, but Thompson and Fellows (p. 114) report twenty-one specimens.

In Europe the only reference I can find to the species is by Austin and Rhodes in Conil et al. (1969, text fig. 1) where a questionable specimen was recorded. The only other occurrence is in Australia, where I found a single specimen in Queensland (Druce, 1970c). Apart from the Australian occurrence the distributions of Staurognathus and Bactrognathus are identical.

Streptognathodus

The genus Streptognathodus is an Upper Carboniferous to Permian genus, an interval from which there are comparatively few faunas reported. The distribution of Streptognathodus is patchy although it is known from all continents from which Upper Carboniferous-Permian conodont faunas have been reported. In the Upper Carboniferous the genus is slightly more abundant, about 70% of faunas, than in the Permian, 50% of faunas.

Taphrognathus

The genus Taphrognathus is of Viséan age. The genus is typically North American and occurs in about half of the reported faunas. In Europe it is known only from the British Isles (Rhodes et al., 1969); the genus has not been reported from continental Europe. The only other occurrence is in Australia (Druce, 1969, 1970c).

Tardogondolella

Under the generic heading of Tardogondolella Bender, 1967, I have included Metapolygnathus Hayashi, 1968, and Epigondolella Mosher, 1968. The genus occurs in all continents from which Triassic forms have been described and is represented in about 50% of the faunas. It shows a distribution similar to Gladigondolella and Paragondolella.

FAUNAL DIFFERENCES

The analysis of generic distribution for the platforms produces three groups (Fig. 15). Firstly, there is a ubiquitous group which appears in more than 65% and often 70% of faunas which could contain them; secondly, a group with patchy distribution, present in fewer than 65% and often 50% of faunas; finally, there is the geographically restricted group. I have included after the generic name the probable symmetry group of Lane (1968).

Ubiquitous group

This consists of eleven genera and the simple cone group. The majority of the genera are good zonal indices (e.g., Palmatolepis, Siphonodella, Streptognathodus). Some genera belong in this group during only part of their Upper Palaeozoic existence; they include the simple cone group, and Icriodus, Spathognathodus and Streptognathodus. All these forms move into the patchy distribution group during the final period before their extinction. However, other genera remain in this group until extinction (Gnathodus, Polygnathus), whilst in others it is impossible to see any movement between groups because of their short life history (Ancyrodella, Siphonodella). With regard to Lane's symmetry classes over 80% of the group are Class II. Polygnathus and Spathognathodus can be Class I but are, for the most part, Class II. Thus, only one genus, Pseudopolygnathus does not belong to Class II; it is Class IIIA, which is apparently the closest approach to pure symmetry which asymmetrical units can attain.

Patchy Distribution Group

This is a large group consisting of twenty-four genera and the simple cone group. For the most part it consists of genera with a limited stratigraphic range. All Lane's symmetry classes are represented, but there is a considerable increase in the presence of classes other than Class II. With respect to the ubiquitous group Class I

increases from 8% to 14% (possibly 0% to 14%), Class II decreases from 83% to 50% (possibly 91% to 50%), Class III increases from 8% to 16%, and Class IV increases from 0% to 16%.

Geographically Restricted Genera

This group consists of only three genera, one of which is questionably assigned to this group. Ancyrodelloides of Lower Devonian age is entirely restricted to Europe. Bactrognathus of Tournaisian age is restricted to North America although a single questionable specimen has been reported from Europe (Austin and Rhodes in Conil et al., 1969). The Viséan genus Mestognathus probably belongs in the patchy distribution group since it is known from Europe and Australia. It is, however, conspicuous by its absence from faunas in the United States. There is a distinct possibility that as more faunas are described, these genera will be transferred to the patchy distribution group. If the distribution charts had been prepared three years ago the genera Eognathodus, Furnishius, Patrognathus, Platyvillosus, Scaphignathus and Staurognathus would all have been placed in the geographically restricted group!

With only three genera in this group it is difficult to reach any conclusions with regard to symmetry classes. Mestognathus is Class IV but I am not sure whether Ancyrodelloides and Bactrognathus are Class II or Class IIIB.

Provincialism

At the generic level there appears to be virtually no provincialism in Upper Palaeozoic faunas. Mosher (1968, p. 916) has suggested that Triassic faunas show that there were at least three provinces in Triassic times, the Muschelkalk, Alpine and North American provinces. Mosher's divisions are at the specific level, and possibly at this level there is true provincialism, with species restricted to well defined geographic areas, but at the generic level this is not so. The Gladi-gondolella tethydis fauna is mainly found in the Alpine region but the

species is known in North America (Mosher and Clark, 1965) and in the Far East (Ishii and Nogami, 1966; Nogami, 1966; Hayashi, 1968). Some faunas from the Alpine province lack this fauna (see above). In the Middle Triassic the overall view is that there is a fauna which is usually found in the Alpine region (Gladigondolella teythidis fauna) but is also known from elsewhere; another fauna which is typically found in the Germanic Muschelkalk but is also found in the Alpine region and North America (Gondolella mombergensis fauna); and a third fauna characterised by Tardogondolella mungoensis which is North American but also occurs in the Cameroons (Diebel, 1956), Sardinia (Cherchi, 1967), probably in Japan (Hayashi, 1968) and very rarely in the Alpine province (Mosher, 1968). Thus, the "provincialism" appears to be numerical rather than complete exclusion of some elements.

"Facies control"

Several suggestions have been put forward to account for this type of provincialism and the patchy distribution of many genera. Merrill (1962) was among the first to note "facies" control and subsequently (1969; this vol.) has demonstrated that various biofacies exist in Pennsylvanian (Upper Carboniferous) strata in North America. He recognizes a Cavusgnathus biofacies in the Appalachian region and a Mid-continent Gondolella biofacies. Merrill (pers. comm.) believes that salinity is probably one factor which influences conodont distribution. He says that "Increasing knowledge from geographically and stratigraphically expanded collections has increased the complexity of known variations. This increase in complexity has not contradicted the earlier conclusions, but has provided additional examples of differences, not all of which can be presently attributed to particular provinces or biofacies." (1969)

Recent work in Australia has shown that biofacies are present in Upper Devonian and Lower Carboniferous faunas (Seddon, 1970a; Druce, 1969). In the Bonaparte Gulf Basin I have shown that the faunal

associations of the various facies of the reef complex (Ningbing Limestone) differ. The back-reef facies is dominated by Pelekysgnathus associated with Polygnathus and Spathognathodus. The fore and inter-reef facies were dominated by Palmatolepis, Polylophodonta and Scaphignathus with undenticulate spathognathodids and Spathognathodus ziegleri; Pelekysgnathus is absent. Seddon (1970a, p. 727) recognises both the Pelekysgnathus fauna (his Icriodus sequence) and the Palmatolepis fauna (his Palmatolepis sequence). Additionally, I have observed a third biofacies, the Belodella biofacies which Seddon included in his Icriodus sequence. All these biofacies are present in the fore-reef - inter-reef sequence. The reef facies is virtually barren of conodonts; Seddon records only Hibbardella and Synprioniodina from one locality and all my reef samples are barren.

Samples collected from the fore-reef facies at its contact with the reef facies contain the Belodella biofacies consisting of Belodella with occasionally a few specimens of Acodina. Further from the reef the Icriodus biofacies appears. It is characterized by Icriodus, Pelekysgnathus, Polygnathus and a few specimens of Belodella. Palmatolepis, Ancyrodella and Ancyrognathus are absent (Seddon, 1970a, p. 727). Seddon also notes the profusion of icriodid species and the large size of the bar and blade elements.

The Palmatolepis biofacies appears in the inter-reef facies. The height of the reef above the inter-reef sea floor (i.e., the probable depth of water) was the order of 50 m (Playford and Cockbain, 1969). The Frasnian Palmatolepis biofacies is characterized by Palmatolepis, Ancyrodella and Ancyrognathus; it does contain elements of the other biofacies but they are greatly reduced in number.

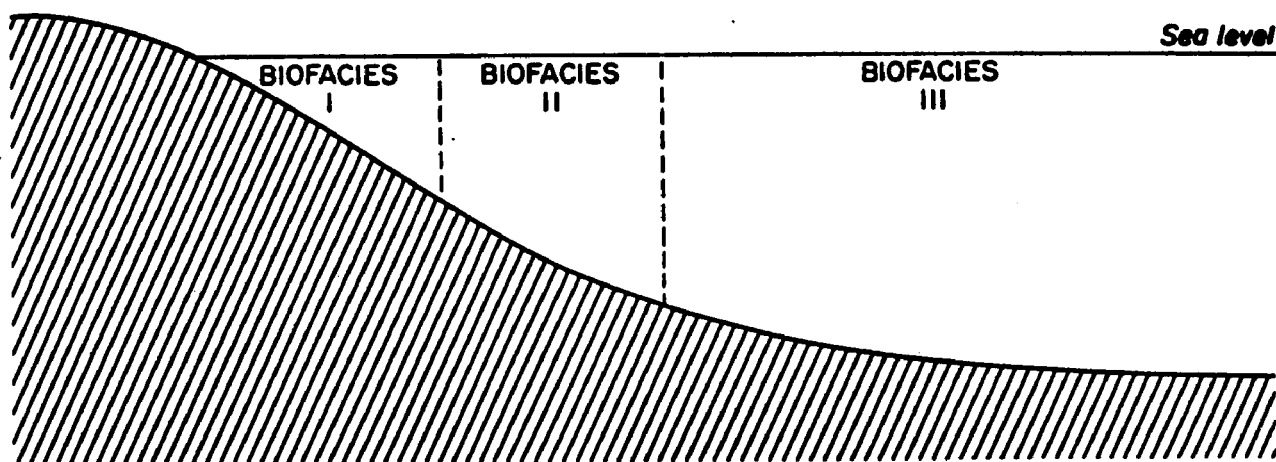
Seddon refers to the biofacies boundary as a biological filter which allows elements of the Icriodus biofacies to pass into the Palmatolepis biofacies but not vice versa. He has suggested (Seddon, in press) that these biofacies relationships could be produced by depth

stratification of the faunas. Thus, if a certain biofacies only lived at a depth of greater than X_m , then, if the water depth was less than X_m , that fauna would be excluded. This would certainly explain the one-way filter system which is also apparent between the Belodella biofacies and the Icriodus biofacies.

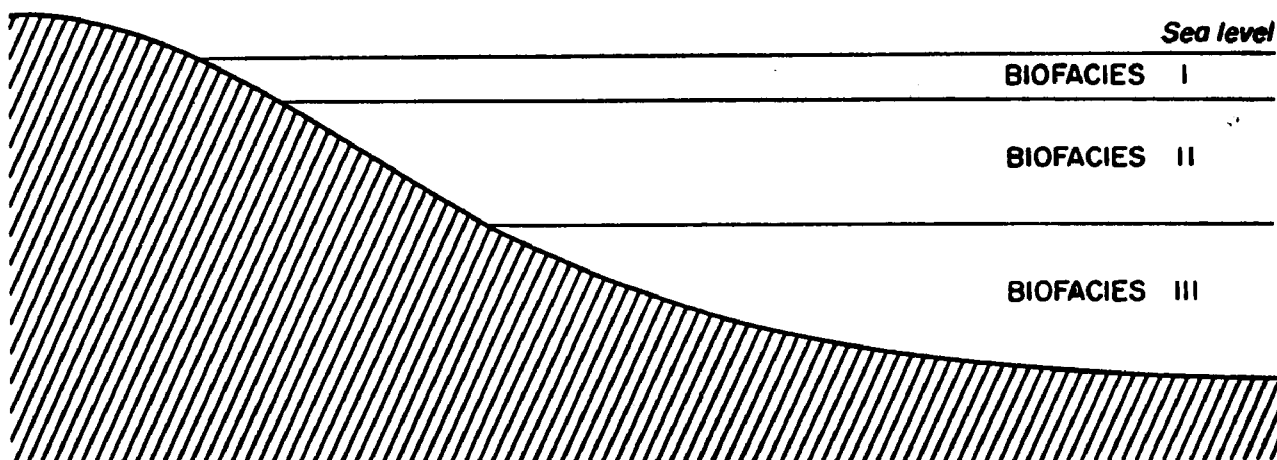
I have suggested a slightly different solution by calling the Icriodus biofacies a shallow-water fauna and the Palmatolepis fauna a deep-water fauna (Druce, 1970d), perhaps implying a relationship to distance from shore and absence of the shallow-water fauna from the deep-water areas. I shall have more to say about the two interpretations below.

The close relationship between the reef and the near-reef facies of reef complexes and the genus Belodella has been noted by Krebs (1959, p. 378; pers. comm.) and by Müller (1962) who noted that both Icriodus and "Belodus" are near-reef forms and they may have become adapted to a benthonic mode of life. It is possible that the presence and exclusiveness of a Belodella biofacies is caused by different factors (good protection from predators?) to those which cause the Icriodus and Palmatolepis biofacies. However, the very similar inter-action between the three biofacies suggest that the causes are similar.

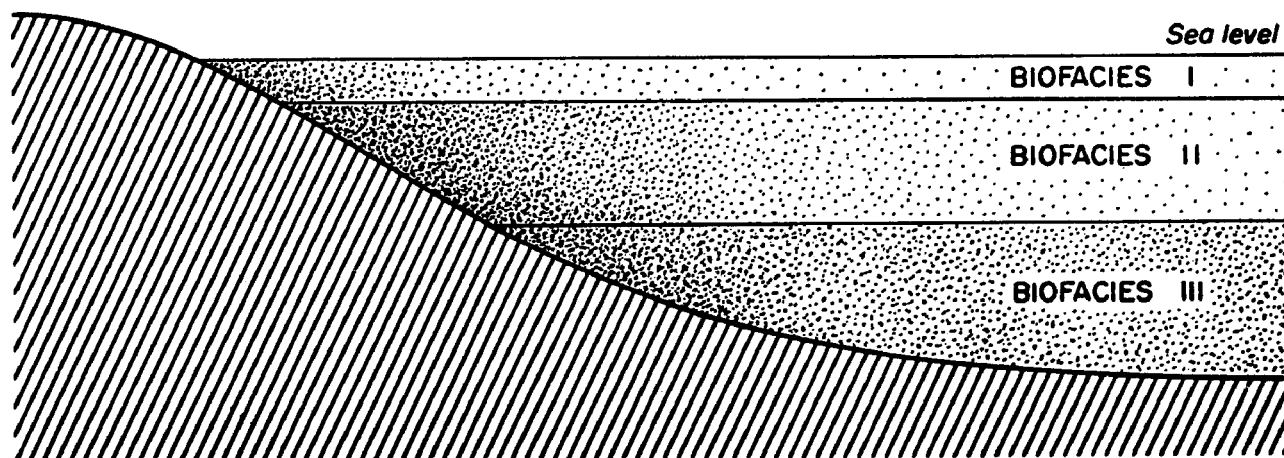
In the Lower Carboniferous of the Bonaparte Gulf two biofacies are present, although one is known from only one locality. The Spathognathodus biofacies is found in the southeastern part of the basin considered by Veevers and Roberts (1968) to be a shallow near shore (5 - 15 miles?) platform area receiving terrigenous material from the east with a gradual change from terrigenous to calcareous deposits seaward (p. 134). The Spathognathodus biofacies is characterized by Spathognathodus, Polygnathus, Pseudopolygnathus and Clydagnathus. The Siphonodella biofacies is known from a single locality within a reef-complex in the northwestern part of the basin some 40 miles from



A. Original suggestion of Druce (1970)



B. Suggestion of Seddon (1970)



C. Present interpretation, relative darkness is relative abundance

Figure 14 - Conodont biofacies and distribution.

the nearest outcrops containing the Spathognathodus biofacies. Little is known about the environment of deposition except that it is near the outer rim of the reef. The Siphonodella biofacies is characterized by Siphonodella, Dinodus, Elictognathus, and Pseudopolygnathus of the triangulus group. There is some interchange of elements between the facies; Siphonodella is found, but is rare, in the Spathognathodus biofacies. Spathognathodus is present in the Siphonodella biofacies but the species are simple, unornamented forms, the laterally nodose species being confined to the Spathognathodus biofacies. The pseudopolygnathids also divide between the two biofacies, the triangulus group in the Siphonodella biofacies and the dentilineatus group (closely related to the laterally nodose spathognathodids) in the Spathognathodus biofacies.

The presence of recognisable biofacies in the Upper Devonian, Lower Carboniferous and Upper Carboniferous suggests that biofacies may have been present throughout the Lower Devonian to Triassic interval. The maximum number of biofacies recognized in one region during any one time interval is three in the Upper Devonian; this does not imply that there were three biofacies present throughout the Upper Palaeozoic or that three is necessarily the maximum number of biofacies at any one time.

Building a model for the other time intervals is partly intuitive but I have also incorporated any information on facies control or differences in conodont fauna between different lithologies. Of particular use have been the papers by Carls and Gandl (1969) in the Lower Devonian, Bultynck (1970) in the Middle Devonian, Aldridge et al. (1968), in the Viséan, and Mosher's many papers in the Triassic.

Finally, I have used the criterion of similar morphology. For example, if simple cones are members of Biofacies I in the Frasnian, then they probably are also Biofacies I in the other Devonian stages. Furthermore, Pelekygnathus and Celsigondolella are homeomorphs

and because Pelekysgnathus is a Biofacies II representative in the Upper Devonian, then Celsigondolella is probably a Biofacies II representative in the Triassic.

Using these criteria I have constructed a possible biofacies model for each time interval considered in the distribution charts. The nearest-shore (equivalent to the Belodella biofacies) is recognized as Biofacies I, the next furthest from the shore (Icriodus biofacies) as Biofacies II, and the farthest (Palmatolepis biofacies) as Biofacies III.

POSSIBLE BIOFACIES IN THE UPPER PALEOZOIC

Introduction

In considering the distribution of genera in the Upper Paleozoic I recognized three groups; ubiquitous genera, genera with patchy distribution, and geographically restricted genera. If biofacies exist and are not depth stratified, then one would expect patchy distribution but not necessarily geographic restriction. If there is depth stratification, then the genera belonging to the deeper zones should show patchy distribution, whereas the genera of the uppermost zone would be ubiquitous. However, three factors operate against the satisfactory interpretation of distribution; firstly, the majority of conodont zonations have been erected, using faunas characteristic of Biofacies III. Thus later workers, whose prime consideration was correlation with European standard sequences, would search diligently and long for the elements of Biofacies III which often are present but are always rare in other biofacies. Secondly, the elements of Biofacies I or II which are usually less exotic and aesthetically attractive can be easily overlooked and ignored in rich samples of Biofacies III. Thirdly, most reported conodont faunas are an amalgamation of individual faunas from diverse localities within a wide geographic area. Thus any subtle differences in individual faunas are masked, and on the distribution maps genera which are possibly restricted to a biofacies will appear to be ubiquitous. The various chronobiofacies are discussed below and tabulated in Figure 16.

Lower Devonian

From my own observations on Upper Silurian faunas and Lower Devonian faunas in Australia Biofacies I appears to be represented by the simple cone group, especially Panderodus. In the Lower Devonian the simple cone group is ubiquitous and this is born out by observation that it does occur, often quite abundantly, within the other biofacies.

STRATIGRAPHIC DIVISIONS	BIOFACIES I	BIOFACIES II	BIOFACIES III	BIOFACIES IV
Lower Devonian	simple cones (Panderodus)	Icriodus (simple) II	Icriodus (complex) II	Ancyrodelloides ?
		Pelekygnathus I or II	Ancyrodelloides ? II	
		Spathognathodus (simple) I or II	Spathognathodus (complex)	
Middle Devonian	simple cones (Belodella)	Icriodus II		
		Spathognathodus I or II	Polygnathus (complex) II	
		Polygnathus (simple) II		
Frasnian	simple cones (Belodella)	Icriodus II	Ancyrodella II	
		Pelekygnathus I or II	Ancyrognathus II	
		Polygnathus (simple) II	Palmatolepis II	
Famennian	simple cones (Acodina)	Icriodus II	Palmatolepis II	
		Pelekygnathus I or II	Polygnathus (germanus grp) II	
		Spathognathodus (nodose) IIIA	Polyphodonta II	
		Scaphignathus ? IV		

Figure 15. Distribution of conodont genera with respect to biofacies.

Tournaisian	Clydagnathus IV	Dinodus II	
	Polygnathus (inornatus grp)	Doliognathus ? II	Doliognathus ?
	Pseudopolygnathus (ex tr. grp) IIIA	Dolymae ? I	Dolymae ?
	Spathognathodus (nodose) IIIA	Scaliognathus II	
		Staurognathus ? IV ?	Staurognathus ?
	Clydagnathus ? IV	Siphonodella II	
	Patrognathus II	Bactrognathus ? II	
	Gnathodus (simple) II	Gnathodus (complex) II	
		Pseudopolygnathus triangulus grp. IIIB	
Viséan	Cavusgnathus		
	Cavusgnathus ? IV	Gnathodus (simple) II	Gnathodus (complex) II
	Mestognathus IV		
	Spathognathodus I or II		
	Taphrognathus ? I		
	Gnathodus (simple) II	Gnathodus (complex) II	
	Cavusgnathus ? IV	Spathognathodus I or II	
		Cavusgnathus ? IV	
early Upper Carboniferous			

Figure 15 (Continued)

late Upper Carboniferous	Streptognathodus II	Gondolella II
	Idiognathoides II or IIIB	Idiognathodus II
	Spathognathodus I or II	
Permian	Spathognathodus ? I or II	Gondolella II
	Celsigondolella I or II	
Triassic	Celsigondolella ? I or II	Gladigondolella II
	bar and blades ?	Neogondolella II
	Celsigondolella I or II	Paragondolella II
		Furnishius ? II or IIIB
		Platyvillosus I or IIIB

Figure 15 (Continued)

Massa (1965, p. 63) also finds this distribution, noting that in reef limestones Belodella is extremely abundant and is often associated with "Oneotodus", but that it also occurs in inter-reef areas. Carls and Gandl (1969) have discussed Lower Devonian biofacies in terms of energy of environment. They recognise a high energy fauna consisting largely of Icriodus with a few Spathognathodus and Pelekysgnathus, all of which are massive (the simple cone forms are considered to have been removed by breakage and winnowing). Seddon (1970a) noted that elements in Biofacies II tend to be massive. The fauna in the next higher energy level consists of the same forms with more abundant Spathognathodus and Pelekysgnathus which are more delicate. Finally, there is a biofacies with Spathognathodus remscheidensis. The first two biofacies, from their generic makeup, would appear to be Biofacies II. I am not sure where the S. remscheidensis biofacies fits but am inclined to consider it as all belonging to Biofacies II. Barnett (this volume) shows that S. remscheidensis was more abundant in sub-littoral lagoons, biostromal reefs, and crinoid meadows than in further seaward environments. In their pie-diagrams Carls and Gandl show that some faunas are dominated by simple cones and others by Icriodus and that this distribution is independent of chronology.

Biofacies III is more of a problem, on pure morphological grounds; the advanced members of the Icriodus latericrescens group and I. pesavis could form Biofacies III. The fauna illustrated by Bischoff and Sannemann (1958) could be Biofacies III, containing spathognathodids with well developed oral denticulation on the cavities and lateral platforms, and species of Ancyrodelloides. Ancyrodelloides is geographically restricted, which is unusual if it is a Biofacies III member. However, its life-span is extremely short and if it is a Biofacies III member, then it could perhaps give some clues as to conodont migration rates. If icriodids with advanced platforms are

indicative of Biofacies III, then this might explain the dearth of Icriodus in faunas from Victoria, Australia (Philip, 1965, 1966) which I consider to be of Biofacies II aspect.

The position of the genus Polygnathus with respect to Biofacies is problematical but I feel that it is probably present in both II and III.

Middle Devonian

Information on biofacies in the Middle Devonian is scarce. Bultynck (1970, p. 142-3) notes that the conodont fauna tends to be dependent on the position of the sample within the reef complex. He makes no mention of faunas composed largely of simple cones but a fauna from Middle Devonian limestones near Mount Morgan, Queensland is composed solely of belodellids and is presumably Biofacies I. Bultynck reports that Polygnathus occurs in the muddy base of the first Couvnanian biostrome but that higher in the same reef-mass it virtually disappears and the fauna consists of one species of Spathognathodus and abundant Icriodus. This difference could possibly reflect Biofacies II and III. Biofacies II may be characterized by Icriodus, some Spathognathus and occasional Polygnathus (possibly with simple platforms and ornament?); he suggests P. linguiformis belongs in a shallow water environment. The fauna listed by Mirauta and Mirauta (1964) from the Middle Devonian of Roumania and one from the late Middle Devonian of Illinois (Orr, 1964) appear to be Biofacies II faunas. Biofacies III may be characterized by Polygnathus particularly ones with advanced nodose ornament.

Frasnian

The biofacies present in the Frasnian have already been discussed. For completeness they are: Biofacies I - Belodella; Biofacies II - Icriodus, Pelekysganthus, simple polygnathids; Biofacies III - Palmatolepis, Ancyrognathus, Ancyrodella.

Some described faunas fit into this biofacies plan. Stauffer's (1940) faunas from the Devonian and associated clays of Minnesota

contain abundant elements of Biofacies I and Biofacies II to the apparent exclusion of Biofacies III elements. Conodonts described from the Sheffield Formation of North-Central Iowa (Youngquist and Peterson, 1947) are indicative of Biofacies II as is the fauna from the Ireton Formation of Alberta (Loranger, 1965). Another fauna from Alberta, from the Waterways Formation (Uyeno, 1967) and the fauna from the Lingle Formation of Illinois (Orr, 1964) also appear to belong to Biofacies II. The fauna described by Youngquist (1947) from a shale above the Cedar Valley Limestone contains elements of Biofacies II and III. However, the elements of Biofacies II, especially the bar and blade elements, are massive, whereas the elements of Biofacies III are small.

The fauna described by Müller and Clark (1967) from the Squaw Bay Limestone of Michigan appears to be exclusively Biofacies III. The genus Icriodus is absent (p. 904). In northern Spain (Boogaert, 1967) reports that in the shallow water Asturo-Leonese facies "aberrant Frasnian conodont faunas were recovered from the coarse-grained detrital limestones." These faunas lack the conodonts diagnostic for the Frasnian zones, such as the genera Ancyrodella, Ancyrognathus, and Palmatolepis.

Famennian

Information on Famennian biofacies is limited. In the Bonaparte Gulf Basin I recognized only two biofacies which are II and III. If there is a Biofacies I in the Famennian, then it probably consists of the simple cone group, probably Acodina. A fauna with Acodina is known from the upper part of the Wabamun Group of Alberta (Mound, 1968); it is associated with other cone forms, bars and blades, Pelekysgnathus, simple polygnathids, and Spathognathodus. The genera Palmatolepis and Icriodus are absent. This would appear to be a mixture of Biofacies I and II although the absence of Icriodus is puzzling.

Biofacies II occurs in the Bonaparte Gulf Basin and consists of Pelekysgnathus and Spathognathodus; once again Icriodus is absent. However, a typical Biofacies II fauna from the Aplington Formation of Iowa (Anderson, 1965) contains abundant Icriodus and simple polygnathids. Some of the icriodids are transitional to (or from) Pelekysgnathus (p. 295) and the presence of either of the two genera may indicate biosubfacies.

Biofacies III is characterized by Palmatolepis, polygnathids of the germanus group, and Polylophodonta. The genus Scaphignathus is a puzzle; it has a very patchy distribution and its general morphology suggests Biofacies II, but it is present in Biofacies III faunas in Australia.

Boogaert (1967) notes that there are two biofacies in the late Famennian of Northern Spain. One fauna from the Asturo-Leonese facies (the Asturo-Leonese Basin was very shallow [p. 173]) is composed of Spathognathodus and Polygnathus, whereas the fauna from the Palentine facies (where deposition was below wave-base, and possibly there was great depth to the basin, although Boogaert suggests quiet shallow water) contains Palmatolepis. Boogaert (p. 157) states that the distribution appears to be controlled by the facies.

Tournaisian

The simple cone group which characterizes Biofacies I in the Devonian is not known from strata younger than Famennian. The two biofacies in the Bonaparte Gulf are probably Biofacies II and III. If Biofacies I exists in the Tournaisian, then it possibly consists solely of asymmetrical units, e.g., Clydagnathus. I have recovered faunas in which this is the only platform genus present. In the Lower Tournaisian Biofacies II is characterized by laterally nodose spathognathodids, pseudopolygnathids other than the triangulus group, Polygnathus (especially the inornatus group), and Clydagnathus. Patrognathus is also a typical Biofacies II element.

Biofacies III is the Siphonodella biofacies; occurring with the name-giver are Dinodus, Elictognathus, and pseudopolygnathids of the triangulus group. The more exotic genera present in the Tournaisian, for example Doliognathus, Dollymae, Scaliognathus and Staurognathus, are also rare members of Biofacies III and possibly represent a deeper or at least different biofacies (Biofacies IV?). The genus Bactrognathus also appears to belong to Biofacies III but its restriction to North America is puzzling. Gnathodus is difficult to assign; the simple gnathodids closely related to Spathognathodus are probably Biofacies II, whereas the highly ornamented species are characteristic of Biofacies III.

The different biofacies can be recognised in places other than the Bonaparte Gulf. In England the fauna described by Rhodes et al. (1969) is obviously Biofacies II, and it contains very rare "siphonodellids...only sixty miles away a Biofacies III fauna with virtually no elements of Biofacies II is found (Matthews, 1969), and a similar fauna is also present in Cornwall (Matthews, 1969a). In Spain Boogaert (1967) notes that some Lower Tournaisian faunas lack zonal guide forms and consist of Polygnathus and Spathognathus (Biofacies II) and that these occur in the same section as samples with good guide fossils (Biofacies III). A fauna reported by Stoppel (1970) from Syria belongs to Biofacies II with Spathognathodus and Polygnathus.

North American faunas also display the same biofacies. Anderson (1969) notes that the type Gilmore City Formation of northern Iowa is poor in conodonts; the only platform is Patrognathus. This is probably Biofacies II, as is the fauna from the English River Formation of Washington County, Iowa, which consists of Polygnathus and Spathognathodus. Biofacies III is extremely common and often contains some elements of the Biofacies II fauna, especially polygnathids of the inornatus group; Klapper's (1966) faunas from Montana and Wyoming are distinctly Biofacies III.

Viséan

Several authors have suggested that Viséan faunas are facies controlled (Meischner, in press; Varker, 1967; Aldridge et al., 1968). Varker notes that Apatognathus is confined to the coral-brachiopod facies and is absent from the goniatite facies. This suggests Biofacies II and it is interesting to note that Apatognathus is also typical of Biofacies II in the Upper Devonian. Austin and Rhodes (1969) describe an "assemblage" of Apatognathus with simple spathognathodids, which also are probably indicative of Biofacies II.

Aldridge et al. (1968) point out that the distributions of Mestognathus, Cavusgnathus and Gnathodus are not universal and are, to some extent, controlled by ecological conditions. Cavusgnathus is very rare in North Wales and in Ireland. The Irish faunas are from the goniatite facies whereas the North Wales faunas are from the coral-brachiopod facies. Thus, there seems to be some extra control on the genus Cavusgnathus. Perhaps it is a Biofacies I representative. Mestognathus is probably Biofacies II, even though it occurs occasionally in the goniatite facies (Higgins, 1961). Taphrognathus is also indicative of Biofacies II.

The genus Gnathodus is probably split between Biofacies II and III. The more ornamented forms such as the bilineatus and girtyi groups possibly belonging to Biofacies III whereas Biofacies II possibly contains the simpler commutatus and homopunctatus groups. Analysis of the distribution of various species and subspecies of Gnathodus with respect to facies could provide interesting information.

Upper Carboniferous

Merrill (1970; this volume) has pointed out that various conodont biofacies existed during the Upper Carboniferous. In the abstract (1970) he points out that there was a Cavusgnathus biofacies and a Gondolella biofacies. In the Viséan Cavusgnathus is probably Biofacies I and this is probably true of the Upper Carboniferous. The Gondolella

biofacies would thus be Biofacies II.

Rexroad (1958) noted that there was a northern faunal province with Cavusgnathus and a southern faunal province dominated by Gnathodus. The genus Gnathodus is ancestral to Streptognathodus and Idiognathodus.

In the early Upper Carboniferous Cavusgnathus possibly represents Biofacies I; in the late Upper Carboniferous Biofacies I may not be represented in known faunas. Biofacies II is characterized by Gnathodus in the early part and Streptognathodus and Idiognathoides in the later part. Biofacies III is problematical but possibly consisted of Gnathodus in the early part and Gondolella and Idiognathodus in the later part.

A fauna from the coral-brachiopod bearing strata in Malaya (Igo and Koike, 1968) appears to be of Biofacies II type with abundant Idiognathoides and Spathognathodus.

Permian

Permian faunas are poorly known. The only reference to biofacies is by Clark and Ethington (1962), who noted that some faunas which lack Gondolella contain Streptognathodus and vice versa. This distribution is also observed in the faunas described by Bender and Stoppel (1965). The fauna from Greece lacks Gondolella but contains Streptognathodus whereas the faunas from Sicily and Greenland have Gondolella but lack Streptognathodus. This may, however, be due to their age, rather than their facies.

The fauna from the Zechstein is very interesting, lacking both Gondolella and Streptognathodus but containing Spathognathodus (Bender and Stoppel, 1965), or Celsigondolella (Jordan, 1969); it may be Biofacies I.

Triassic

Mosher (1968) has discussed in detail the provincialism of Triassic faunas. I have discussed the geographic distribution of

Triassic genera and prefer to think of Mosher's faunas as biofacies, rather than provincial entities.

The Neogondolella mombergensis assemblage typical of the Muschelkalk would then be Biofacies II, living in the shallow waters of the Muschelkalk sea. The geosynclinal Alpine fauna of Gladigondolella tethydis would be Biofacies III. The North American faunas contain Celsigondolella which is a homeomorph of Pelekygnathus and Tardogondolella which is a homeomorph of Polygnathus. This suggests Biofacies II in comparison with the Upper Devonian. The distribution of both genera is similar and I conclude that this is a world-wide Biofacies II. Is the Neogondolella mombergensis fauna another and different Biofacies II? It is certainly possible, which would suggest true provincialism. However, the fauna is known from many parts of the world and this would suggest that perhaps it is intermediate between Biofacies II and III or that the Celsigondolella-Tardogondolella fauna is Biofacies I and the Neogondolella fauna is a unique Biofacies II.

The recognition of biofacies in the Triassic is extremely difficult and there appear to be many factors affecting the distribution of elements. For example, Hirsch (1969) has shown that successive horizons within the Alpine sequence may possess greatly varying percentages of Gladigondolella tethydis and Paragondolella navicula (including Neogondolella mombergensis) ranging from 90% P. navicula in horizon one to only 30% in horizon four. Furthermore, Igo et al. (1965) have described a fauna from Malaya which completely lacks platform elements and which is composed of massive bars and blades with species of Celsignodolella. Perhaps this is Biofacies I.

CONCLUSIONS

1. Biofacies can be recognised in Upper Paleozoic conodont faunas. Originally they were recognised in the Pennsylvanian (Upper Carboniferous) of North America where closely adjacent faunas had very different generic makeup. Devonian and Lower Carboniferous biofacies have been recognised in Australia where the generic content of the fauna is dependent on proximity to reef bodies which has been interpreted as a depth differentiation.
2. The cause of this is unknown but salinity, water depth, and depth stratification have been offered as suggestions.
3. A biofacies is often manifest in numbers of specimens (or lack of) rather than their complete exclusion, although this can occur. It appears that the biological filter did not always operate at the same intensity.
4. Up to three biofacies can be recognised in the Upper Paleozoic.
5. Biofacies I is thought to occur at very shallow depths and is characterized by simple cone forms. If it existed after Famennian times, then it was possibly characterized by asymmetrical units (Class IV of Lane [1968]).
6. Biofacies II is thought to occur at intermediate depths, perhaps up to 50 metres, and is characterized by 'simple' units, possibly Lane's Class I but more likely Class II, and complex units of Class IIIA or IV.
7. Biofacies III is presumed to occur below a depth of about 50 m and is characterized by complex genera of Class II and a few of Class IIIA (which is the closest to perfect symmetry that asymmetrical forms can approach).

8. Evolutionary complexity in simple Class I and II genera tends to promote the genus (or new genus) from Biofacies II to III. In other words the root stock from which the platform genera appear to have developed is commonly characteristic of Biofacies II.
9. The forms with ubiquitous distribution are characteristically Biofacies III which is the opposite of what one would expect if conodonts are depth stratified. However, the fact that many conodont papers deal with faunas from widely differing geographic and stratigraphic localities could account for this. The forms represented by Biofacies III are also the important zone species and an intense search is always undertaken for these genera and species. These two factors operate to give the impression that Biofacies III forms are ubiquitous.
10. All Biofacies appear ubiquitous suggesting that depth layering rather than total water depth is the controlling factor. However, the absence or scarcity of Biofacies I and II faunas in Biofacies III faunas is puzzling. Apparently abundance of specimens within each zone with respect to distance from shore varies from modest presence to complete absence. This suggests that there is a factor, other than depth, affecting the distribution of biozones, possibly the absence of a complete food chain, or predation by the underlying conodont biofacies. Even if Biofacies II could exist in all but the shallowest marine seas it certainly preferred a near-shore habitat in most cases (Fig. 17).
11. The apparent sudden influx of complex platform genera and the lack of information with regard to their phylogeny could be the result of only sampling Biofacies III at a given interval. The origin of such genera as Icriodus, Polygnathus and some of the complex Tournaisian genera was probably from faunas living in Biofacies II.

12. The presence or absence of biofacies and their characteristics and number would be a lot clearer if specific, rather than generic, distribution is considered. It is obvious that some genera, especially Spathognathodus, Icriodus, Polygnathus, Pseudopolygnathus, and Gnathodus, are not confined to any one biofacies but that individual species or species groups probably are.
13. The recognition of biofacies, especially at the specific level will greatly aid in the deduction of natural assemblages, especially the distribution of bars and blades with respect to platforms. In order to achieve greater understanding of both biofacies and natural assemblages it is important that the whole fauna be described and radical differences in element abundance noted and compared to the lithology and palaeoenvironment of the sampled horizon.
14. Recognition of conodont biofacies could be a major factor in Palaeozoic regional basinal analysis and the interpretation of palaeogeography. Conodonts have already proven themselves to be equal to any other fossil group with regard to relative age determinations and correlation; it is distinctly possible that we may now provide equally important ecologic information.

PLATES

PLATE 1

Ancyrodella buckeyensis Stauffer, 1938

- Fig. 1a Oral view of specimen CPC 12353.
b Aboral view of specimen CPC 12353.

Ancyrodella nodosa Ulrich & Bassler, 1926

- Fig. 2a Aboral view of specimen CPC 12373.
b Oral view of specimen CPC 12373.

Ancyrodella gigas Youngquist, 1947

- Fig. 3a Oral view of specimen CPC 12361.
b Aboral view of specimen CPC 12361.

Ancyrodella curvata (Branson & Mehl, 1934)

- Fig. 4a Oral view of specimen CPC 12360.
b Aboral view of specimen CPC 12360.

Ancyrodella ioides Ziegler, 1958

- Fig. 5a Oral view of specimen CPC 12364.
b Aboral view of specimen CPC 12364.

Ancyrodella lobata Branson & Mehl, 1934

- Fig. 6a Oral view of specimen CPC 12368.
b Aboral view of specimen CPC 12368.

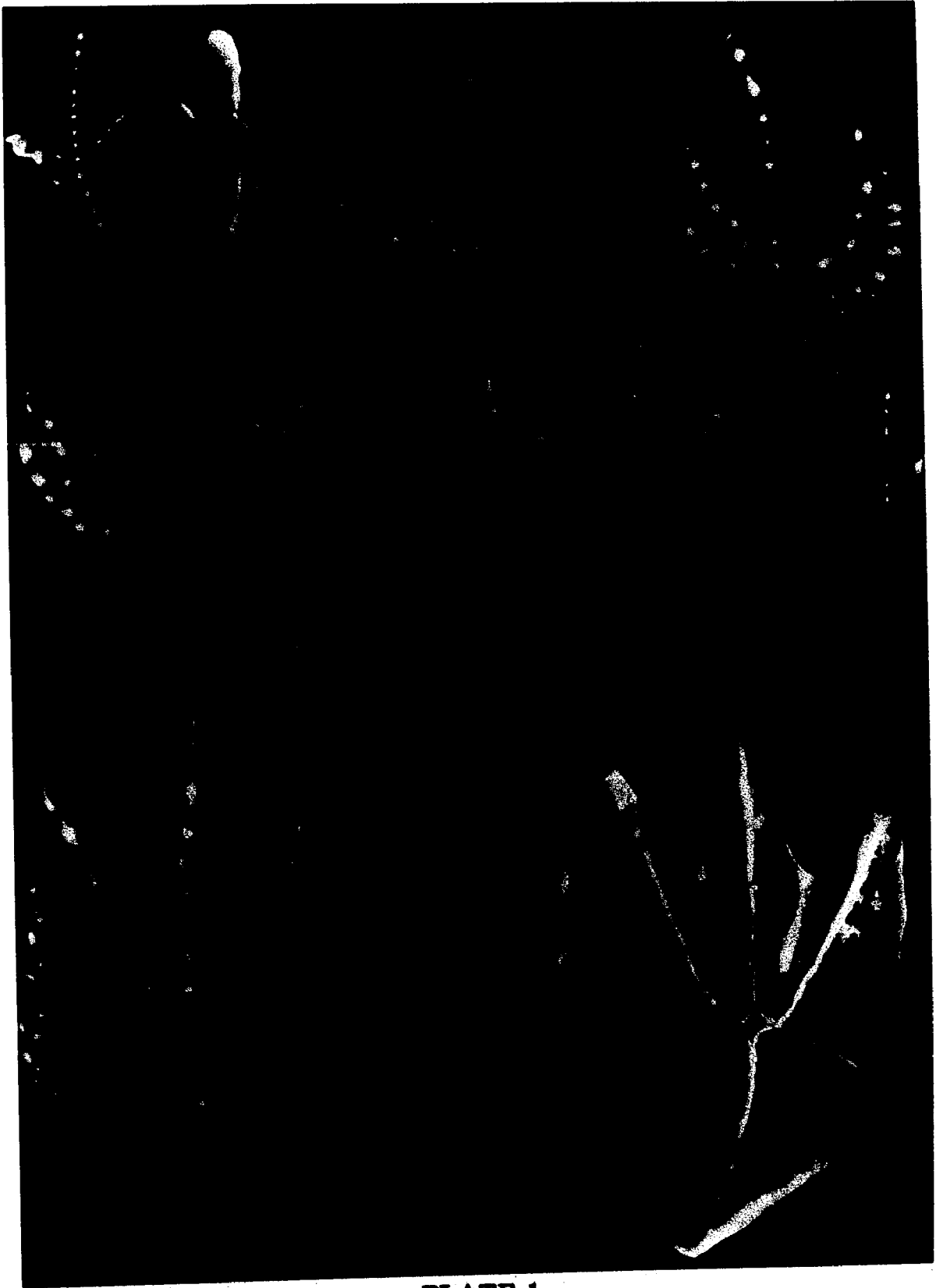


PLATE 1

PLATE 2

Ancyrodella rotundiloba rotundiloba (Bryant, 1921)

- Fig. 1a Oral view of specimen CPC 12379.
b Aboral view of specimen CPC 12379.

Ancyrodella rugosa Branson & Mehl, 1934

- Fig. 2a Aboral view of specimen CPC 12395.
b Oral view of specimen CPC 12395.

Ancyrodella rotundiloba alata Glenister & Klapper, 1966

- Fig. 3a Aboral view of specimen CPC 12391.
b Oral view of specimen CPC 12391.



PLATE 2

PLATE 3

Apatognathus varians varians Branson & Mehl, 1934

Fig. 1 Lateral view of specimen CPC 12681.

Apatognathus varians klapperi Druce, 1969

Fig. 2 Lateral view of specimen CPC 12682.

Belodella resima (Philip, 1965)

Fig. 3 Lateral view of specimen CPC 12720.

Belodella devonica (Stauffer, 1940)

Fig. 4 Lateral view of specimen CPC 12723.

Belodella triangularis (Stauffer, 1940)

Fig. 5 Lateral view of specimen CPC 12675.

Bryantodus typicus Bassler, 1925

Fig. 6 Lateral view of specimen CPC 12907.

Bryantodus nitidus Ulrich & Bassler, 1926

Fig. 7 Lateral view of specimen CPC 12906.

Bryantodus macrodentatus (Bryant, 1921)

Fig. 8 Lateral view of specimen CPC 12905.

Enantiognathus lipperti (Bischoff, 1956)

Fig. 9 Lateral view of specimen CPC 12911.

Camptognathus conus Pollock, 1968

Fig. 10 Lateral view of specimen CPC 12908

Camptognathus erectus sp. nov.

Fig. 11 Lateral view of holotype CPC 12909.

Enantiognathus cf. E. inversus (Sannemann, 1955)

Fig. 12 Lateral view of specimen CPC 12912.

Elsonella sp.

Fig. 13 Anterior view of specimen CPC 12913.

Falcodus variabilis Sannemann, 1955

Fig. 14 Lateral view of specimen CPC 12914.

Falcodus cf. F. variabilis Sannemann, 1955

Fig. 15 Lateral view of specimen CPC 12915.

Falcodus aculeatus Sannemann, 1955

Fig. 16 Lateral view of specimen CPC 12916.

Falcodus guntharii Ziegler, 1958

Fig. 17 Lateral view of specimen CPC 12910.



PLATE 3

PLATE 4

Ancyrognathus asymmetricus (Ulrich & Bassler, 1926)

Fig. 1a Aboral view of specimen CPC 12396.

b Oral view of specimen CPC 12396.

Ancyrognathus alta Müller & Müller, 1957

Fig. 2a Oral view of specimen CPC 12397.

b Aboral view of specimen CPC 12397.

Angulodus sp.

Fig. 3 Lateral view of specimen CPC 12399.

Hindeodella brevis Branson & Mehl, 1934

Fig. 4 Lateral view of specimen CPC 12420.

Angulodus sp. cf. A. pergracilis (Ulrich & Bassler, 1926)

Fig. 5 Lateral view of specimen CPC 12398.

Hibbardella (Diplododella) aurita (Sannemann, 1955)

Fig. 6 Lateral view of specimen CPC 12407.

Falcodus sp. A

Fig. 7 Lateral view of specimen CPC 12416.

Hibbardella (Hassognathus) franca (Sannemann, 1955)

Fig. 8 Lateral view of specimen CPC 12410.

Hindeodella corpulenta Branson & Mehl, 1934

Fig. 9 Lateral view of specimen CPC 12422.

Hindeodella subtilis Ulrich & Bassler, 1926

Fig. 10 Lateral view of specimen CPC 12423.

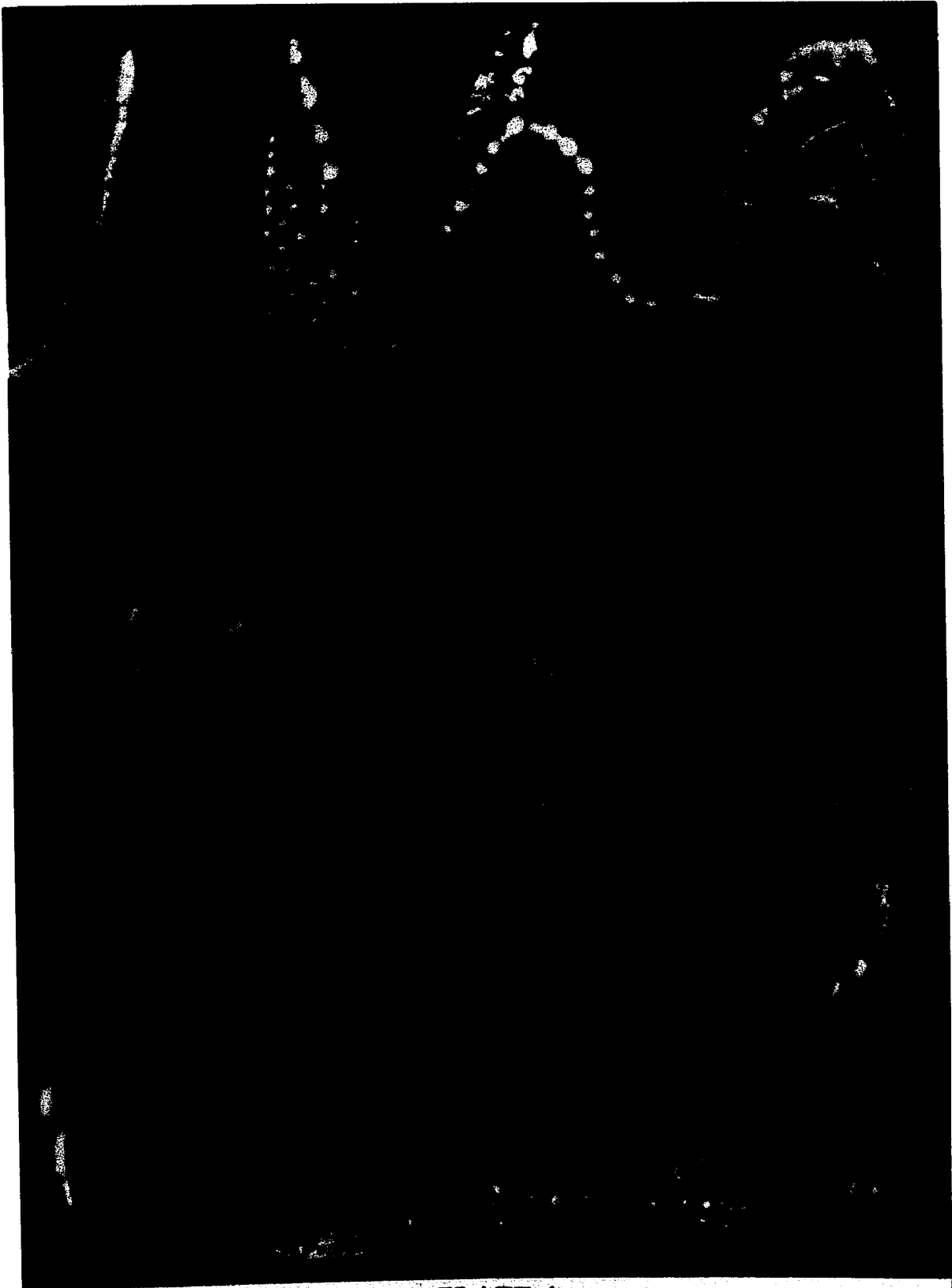


PLATE 4

PLATE 5

Hibbardella (Diplododella) alternata Branson & Mehl, 1934

Fig. 1 Posterior view of specimen CPC 12401.

Hibbardella (Hibbardella) angulata (Hinde, 1879)

Fig. 2 Posterior view of specimen CPC 12405.

Hibbardella (Hibbardella) multidens Ulrich & Bassler, 1926

Fig. 3 Posterior view of specimen CPC 12411.

Hibbardella (Diplododella) plana Thomas, 1949

Fig. 4 Posterior view of specimen CPC 12413.

Hibbardella (Hassognathus) separata (Branson & Mehl, 1934)

Fig. 5 Posterior view of specimen CPC 12414.

Hibbardella (Hassognathus) sp.

Fig. 6 Lateral view of specimen CPC 12415A.

Hindeodella uncata (Hass, 1959)

Fig. 7 Lateral view of specimen CPC 12430.

Hindeodella compressa Huddle, 1934

Fig. 8 Lateral view of specimen CPC 12432.

Hindeodella cf. H. moweri Stauffer, 1940

Fig. 9 Lateral view of specimen CPC 12437.

Hindeodella sp. B

Fig. 10 Lateral view of specimen CPC 12440.

Hindeodella sp. A

Fig. 11 Lateral view of specimen CPC 12438.

Hindeodella sp. C

Fig. 12 Lateral view of specimen CPC 12441.

Hindeodella sp. D

Fig. 13 Lateral view of specimen CPC 12442.

Hindeodella sp. E

Fig. 14 Lateral view of specimen CPC 12443.

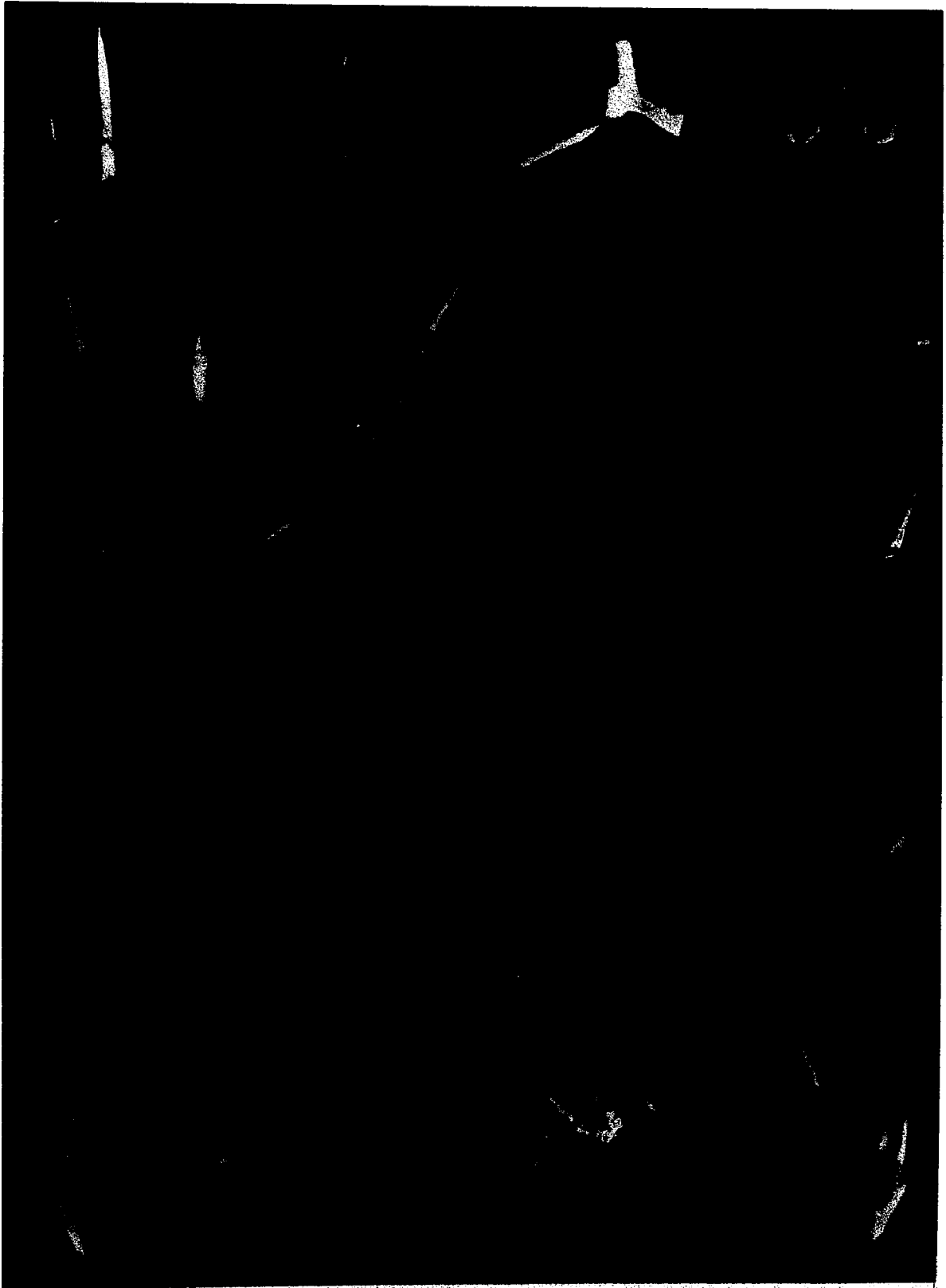


PLATE 5

PLATE 6

Icriodus alternatus alternatus Branson & Mehl, 1934

Fig. 1a Aboral view of specimen CPC 12445.

b Oral view of specimen CPC 12445.

Icriodus alternatus costatus (Thomas, 1949)

Fig. 2a Oral view of specimen CPC 12449.

b Aboral view of specimen CPC 12449.

Icriodus alternatus curvirostratus Bultynck, 1970

Fig. 3a Oral view of specimen CPC 12453.

b Aboral view of specimen CPC 12453.

Icriodus alternatus cymbiformis Branson & Mehl, 1938

Fig. 4a Oral view of specimen CPC 12457.

b Aboral view of specimen CPC 12457.

Icriodus alternatus elegantulus Stauffer, 1938

Fig. 5a Oral view of specimen CPC 12460.

b Aboral view of specimen CPC 12460.

Icriodus alternatus subsp. a

Fig. 6a Oral view of specimen CPC 12463.

b Aboral view of specimen CPC 12463.

Icriodus arkonensis arkonensis Stauffer, 1938

Fig. 7a Aboral view of specimen CPC 12467.

b Oral view of specimen CPC 12467.

Icriodus arkonensis subsp. nov. a

Fig. 8a Aboral view of specimen CPC 12469.

b Oral view of specimen CPC 12469.

Icriodus arkonensis subsp. nov. b

Fig. 9a Oral view of specimen CPC 12473.

b Aboral view of specimen CPC 12473.

Icriodus arkonensis subsp. nov. c

Fig. 10a Aboral view of specimen CPC 12477.

b Oral view of specimen CPC 12477.

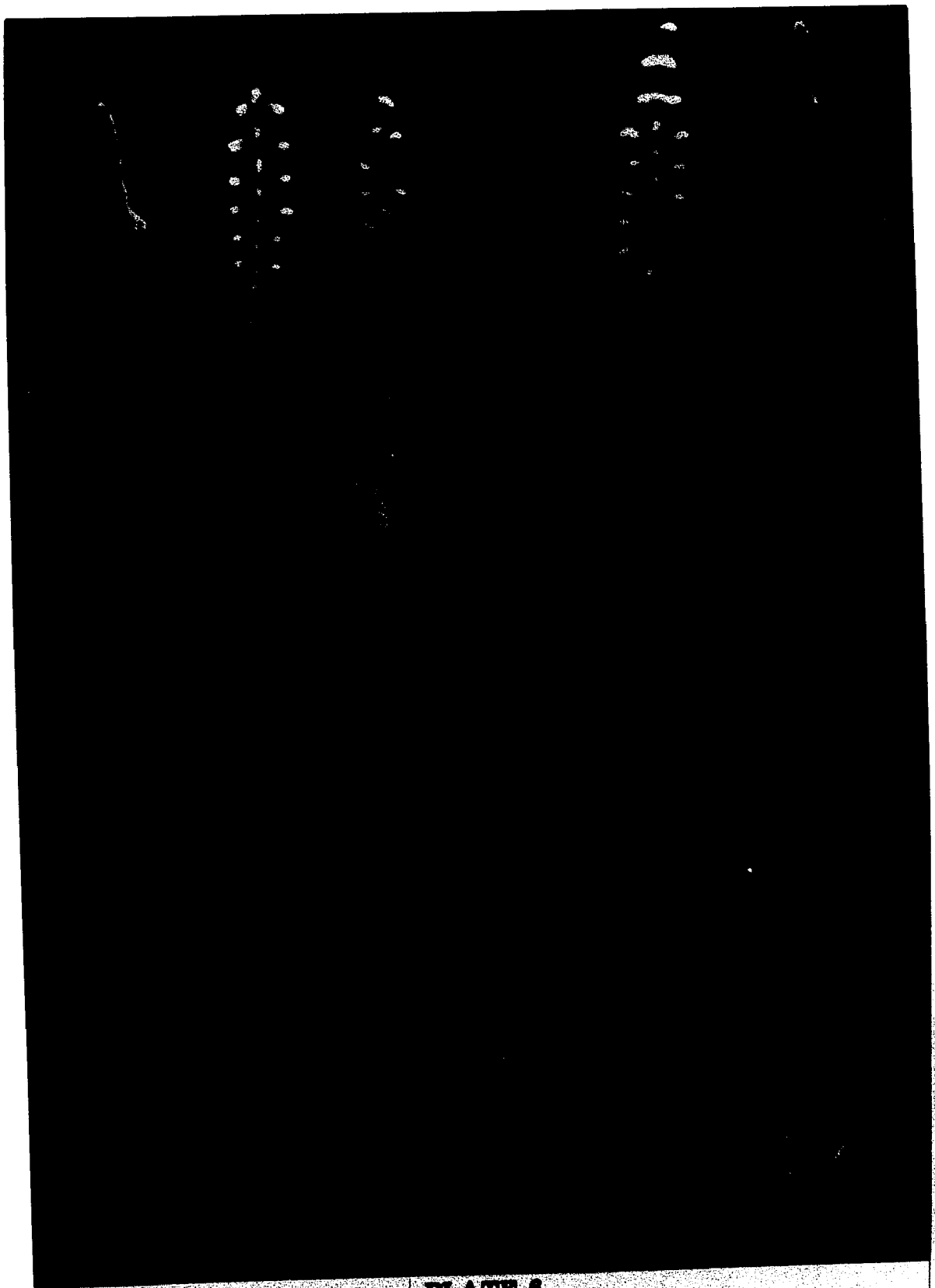


PLATE 6

PLATE 7

Icriodus brevis brevis Stauffer, 1940

- Fig. 1a Oral view of specimen CPC 12481.
b Aboral view of specimen CPC 12481.

Icriodus brevis darbyensis Klapper, 1958

- Fig. 2a Oral view of specimen CPC 12483.
b Aboral view of specimen CPC 12483.

Icriodus brevis spicatus Youngquist & Peterson, 1947

- Fig. 3a Aboral view of specimen CPC 12487.
b Oral view of specimen CPC 12487.

Icriodus brevis subsp. nov. a

- Fig. 4 Oral view of specimen CPC 12489.

Icriodus brevis subsp. nov. b

- Fig. 5a Oral view of specimen CPC 12490.
b Aboral view of specimen CPC 12490.

Icriodus incrassatus incrassatus Youngquist & Peterson, 1947

- Fig. 6a Oral view of specimen CPC 12493.
b Aboral view of specimen CPC 12493.

Icriodus incrassatus subsp. nov. c

- Fig. 7a Oral view of specimen CPC 12500.
b Aboral view of specimen CPC 12500.

Icriodus incrassatus subsp. nov. b

- Fig. 8a Aboral view of specimen CPC 12499.
b Oral view of specimen CPC 12499.

Icriodus incrassatus subsp. nov. a

- Fig. 9a Aboral view of specimen CPC 12494.
b Oral view of specimen CPC 12494.

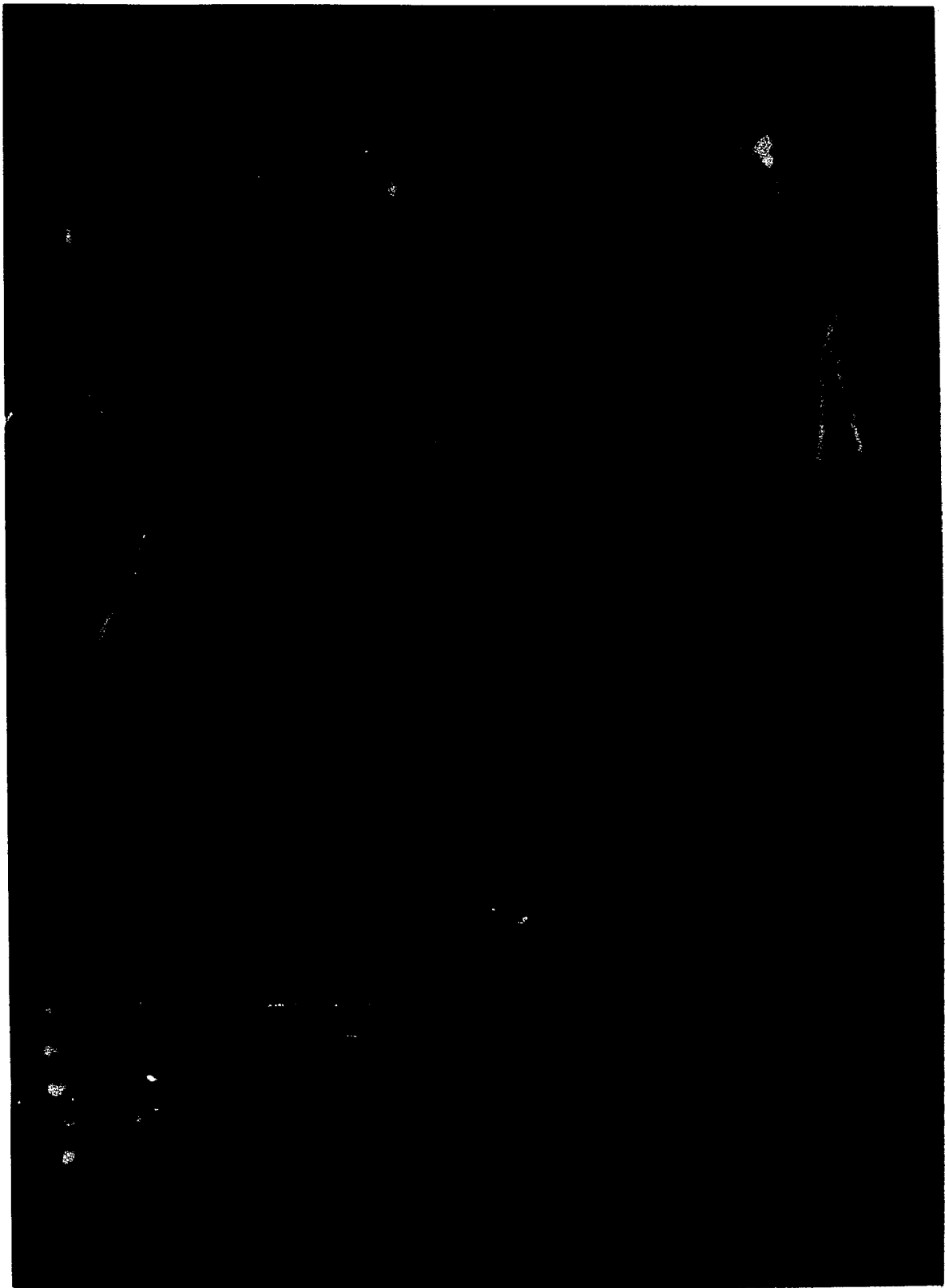


PLATE 7

PLATE 8

Icriodus symmetricus symmetricus Branson & Mehl, 1934

Fig. 1a Oral view of specimen CPC 12504.

b Aboral view of specimen CPC 12504.

Icriodus symmetricus circularis Youngquist & Peterson, 1947

Fig. 2a Oral view of specimen CPC 12508.

b Aboral view of specimen CPC 12508.

Icriodus symmetricus expansus Branson & Mehl, 1938

Fig. 3a Aboral view of specimen CPC 12513.

b Oral view of specimen CPC 12513.

Icriodus symmetricus subsp. nov. a

Fig. 4a Oral view of specimen CPC 12516.

b Aboral view of specimen CPC 12516.

? Kladognathus sp.

Fig. 5 Lateral view of specimen CPC 12522.

Ligonodina spiculata (Ulrich & Bassler, 1926)

Fig. 6 Lateral view of specimen CPC 12528.

? Ligonodina sp.

Fig. 7 Lateral view of specimen CPC 12532.

Ligonodina panderi (Hinde, 1879)

Fig. 8 Lateral view of specimen CPC 12526.

Ligonodina sp.

Fig. 9 Lateral view of specimen CPC 12531.

Ligonodina sp. nov. A

Fig. 10 Lateral view of specimen CPC 12529.

Ligonodina magnidens Ulrich & Bassler, 1926

Fig. 11 Lateral view of specimen CPC 12524.

Ligonodina sp. nov. B

Fig. 12 Lateral view of specimen CPC 12530.

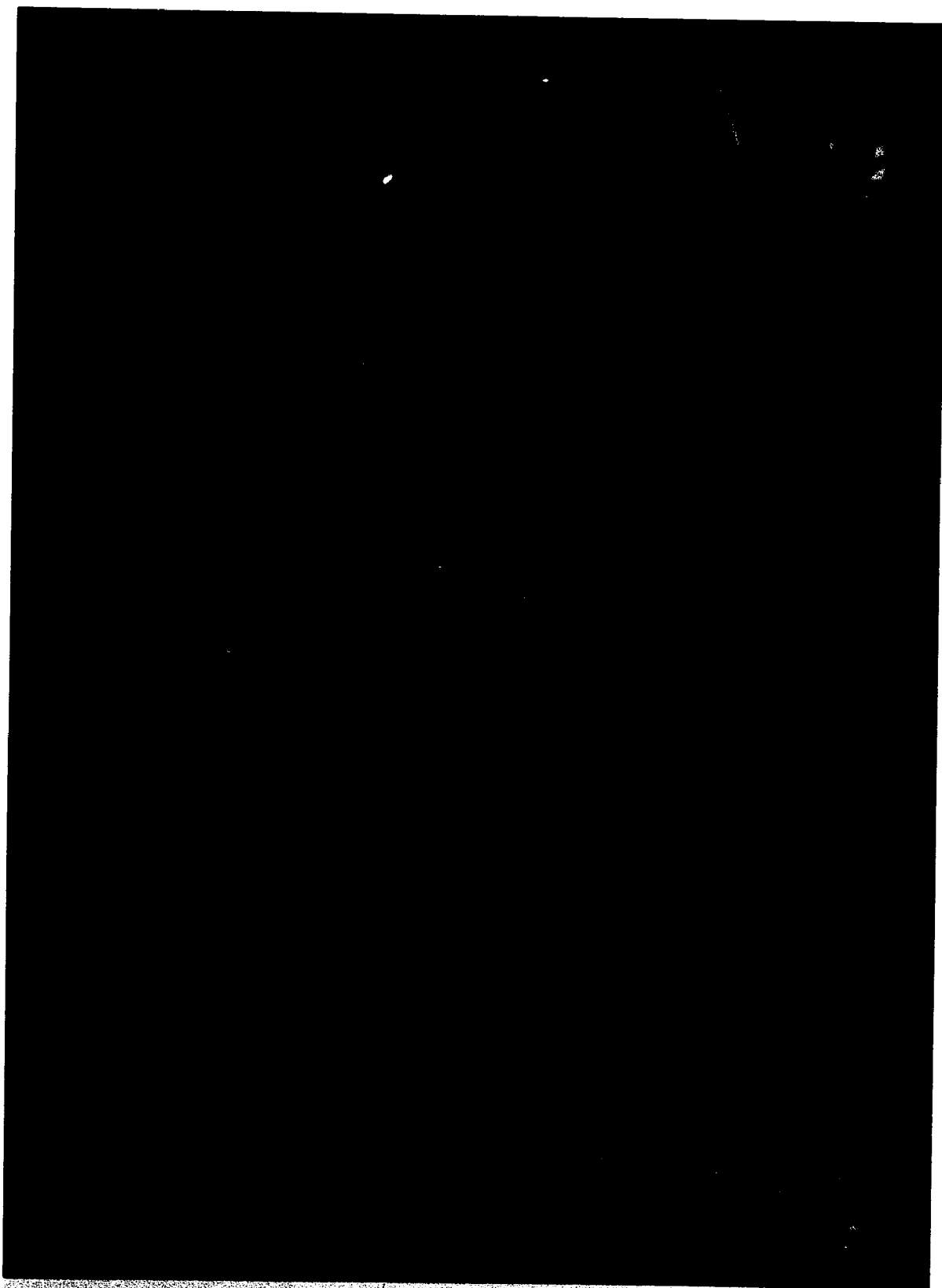


PLATE 8

PLATE 9

Lonchodina sp. A

Fig. 1 Lateral view of specimen CPC 12840.

Lonchodina perlonga Ulrich & Bassler, 1926

Fig. 2 Lateral view of specimen CPC 12835.

Lonchodina arcuata Ulrich & Bassler, 1926

Fig. 3 Lateral view of specimen CPC 12831.

Lonchodina typicalis Bassler, 1925

Fig. 4 Lateral view of specimen CPC 12837.

Neoprioniodus sp.

Fig. 5 Lateral view of specimen CPC 12539.

Neoprioniodus semiseperatus (Branson & Mehl, 1934)

Fig. 6 Lateral view of specimen CPC 12540.

Ozarkodina homoarcuata Helms, 1959

Fig. 7 Lateral view of specimen CPC 12569.

Neoprioniodus armatus-alatus group

Fig. 8 Lateral view of specimen CPC 12536.

9 Lateral view of specimen CPC 12533.

Ozarkodina ? lacera Helms, 1959

Fig. 10 Lateral view of specimen CPC 12518.

Ozarkodina ? sp. Seddon, 1970

Fig. 11 Lateral view of specimen CPC 12844.

Ozarkodina sp. C

Fig. 12 Lateral view of specimen CPC 12581.

Ozarkodina sp. B

Fig. 13 Lateral view of specimen CPC 12579.

Ozarkodina sp. D

Fig. 14 Lateral view of specimen CPC 12582.

Ozarkodina immersa (Hinde, 1879)

Fig. 15 Lateral view of specimen CPC 12571.

Ozarkodina versa (Stauffer, 1940)

Fig. 16 Lateral view of specimen CPC 12577.

Ozarkodina macra Branson & Mehl, 1934

Fig. 17 Lateral view of specimen CPC 12574.

Ozarkodina sp. A

Fig. 18 Lateral view of specimen CPC 12578.

Ozarkodina sp. F

Fig. 19 Lateral view of specimen CPC 12584.

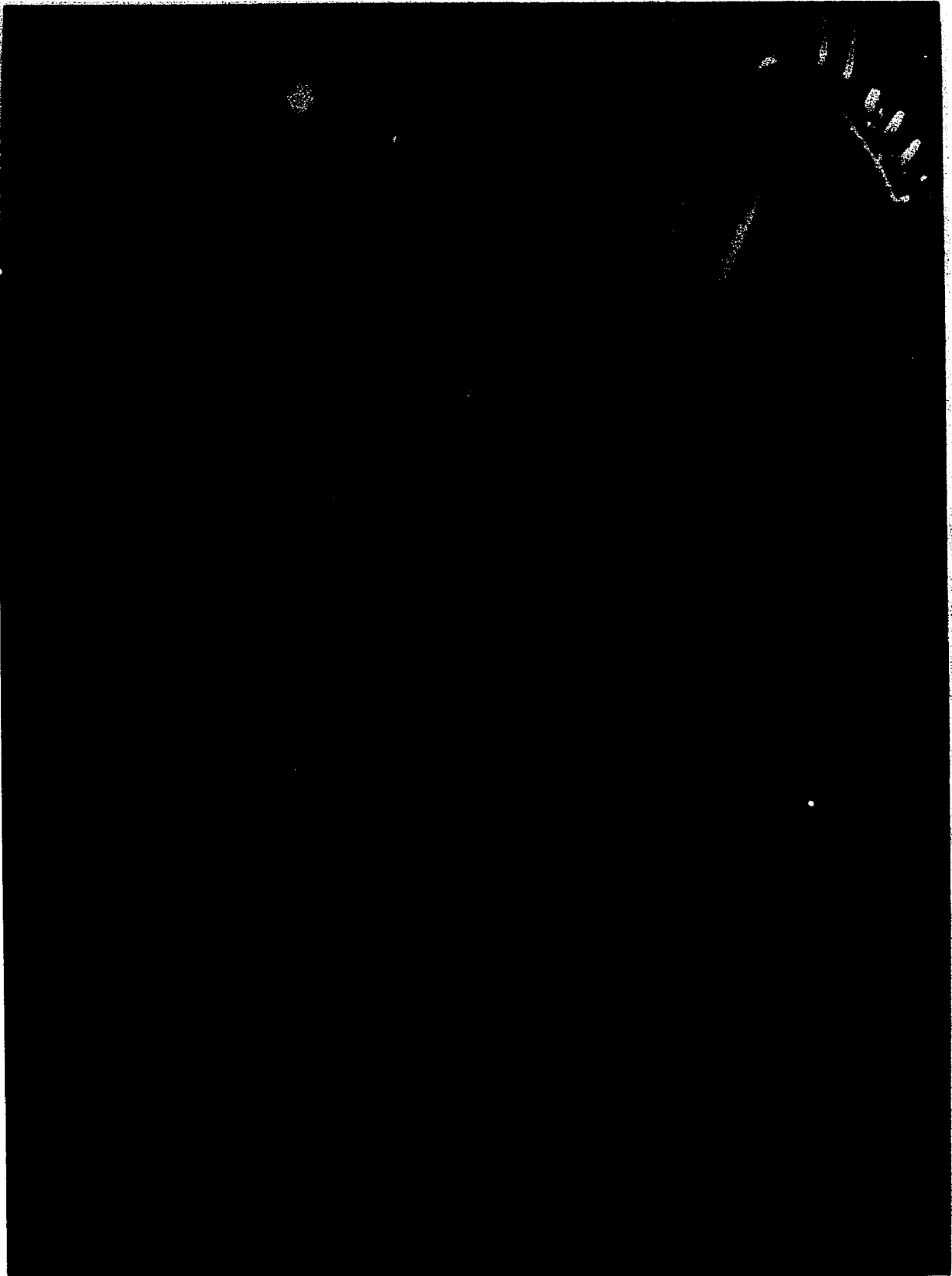


PLATE 9

PLATE 10

Nothognathella abbreviata Branson & Mehl, 1934

Fig. 1a,b Lateral views of specimen CPC 12542.

Nothognathella abnormis Branson & Mehl, 1934

Fig. 2a,b Lateral views of specimen CPC 12543.

Nothognathella brevidonta Youngquist, 1947

Fig. 3a Oral view of specimen CPC 12547.

b Aboral view of specimen CPC 12547.

Nothognathella falcata Helms, 1959

Fig. 4a Lateral view of specimen CPC 12551.

b Aboral view of specimen CPC 12551.

Nothognathella iowaensis Youngquist, 1945

Fig. 5a Oral view of specimen CPC 12555.

b Aboral view of specimen CPC 12555.

Nothognathella typicalis Branson & Mehl, 1934

Fig. 6a Oral view of specimen CPC 12563.

b Aboral view of specimen CPC 12563.

Nothognathella klapperi Uyeno, 1967

Fig. 7a,b Lateral views of specimen CPC 12557.

Nothognathella polygnathocidea Branson & Mehl, 1934

Fig. 8a Aboral view of specimen CPC 12562.

b Oral view of specimen CPC 12562.

Ozarkodina sp. E

Fig. 9 Lateral view of specimen CPC 12583.

Palmatodella unca Sannemann, 1955

Fig. 10 Lateral view of specimen CPC 12585.

Palmatodella sp. A

Fig. 11 Lateral view of specimen CPC 12586.

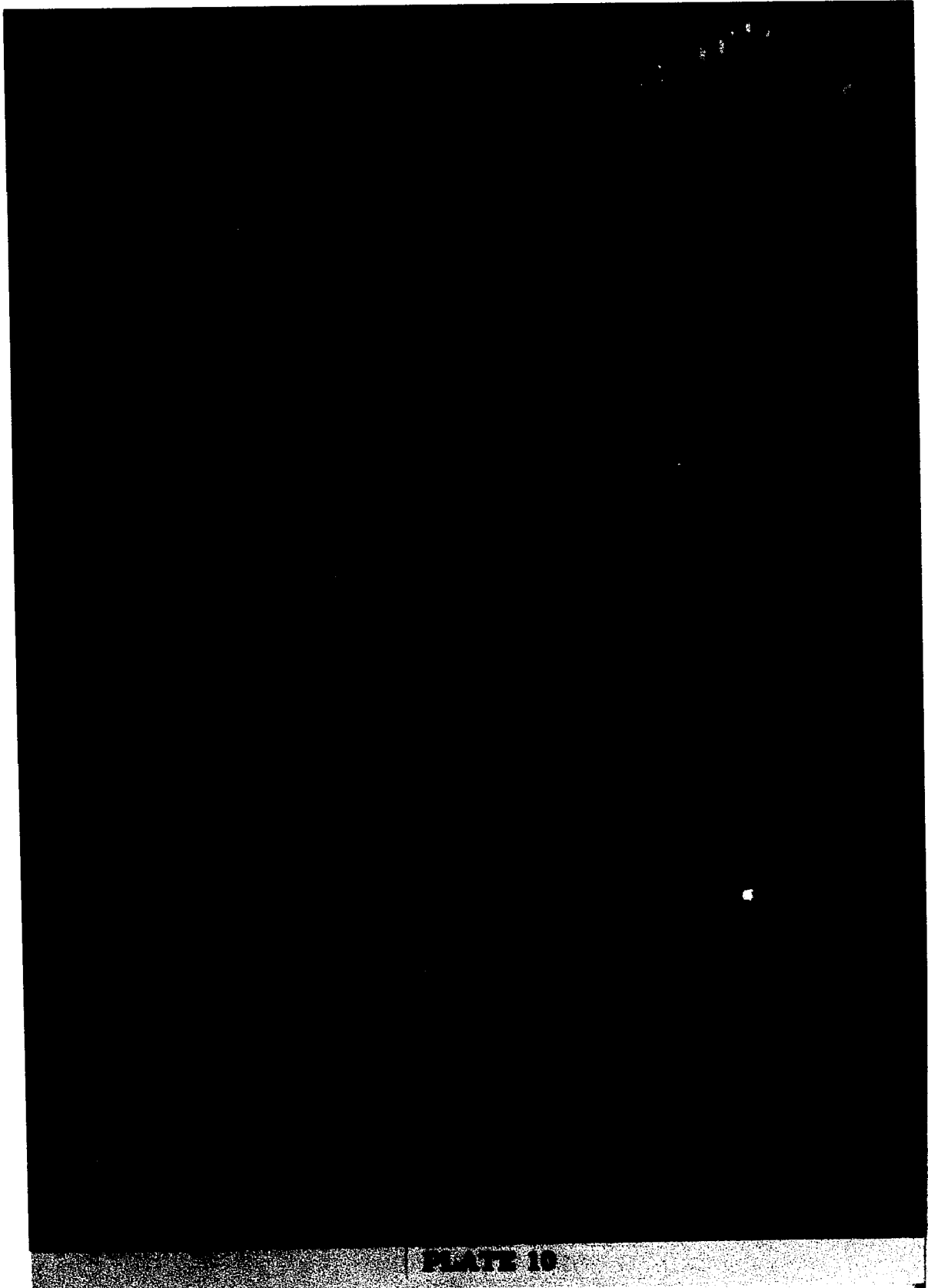


PLATE 10

PLATE 11

Palmatolepis delicatula delicatula Branson & Mehl, 1934

- Fig. 1a Oral view of specimen CPC 12587.
b Aboral view of specimen CPC 12587.

Palmatolepis foliacea Youngquist, 1945

- Fig. 2a Oral view of specimen CPC 12592.
b Aboral view of specimen CPC 12592.

Palmatolepis distorta Branson & Mehl, 1934

- Fig. 3a Oral view of specimen CPC 12591.
b Aboral view of specimen CPC 12591.

Palmatolepis glabra glabra Ulrich & Bassler, 1926

- Fig. 4a Aboral view of specimen CPC 12596.
b Oral view of specimen CPC 12596.

Palmatolepis gracilis gracilis Branson & Mehl, 1934

- Fig. 5a Oral view of specimen CPC 12609.
b Aboral view of specimen CPC 12609.

Palmatolepis glabra pectinata Ziegler, 1962

- Fig. 6a Aboral view of specimen CPC 12603.
b Oral view of specimen CPC 12603.

Palmatolepis glabra elongata Holmes, 1928

- Fig. 7a Oral view of specimen CPC 12600.
b Aboral view of specimen CPC 12600.

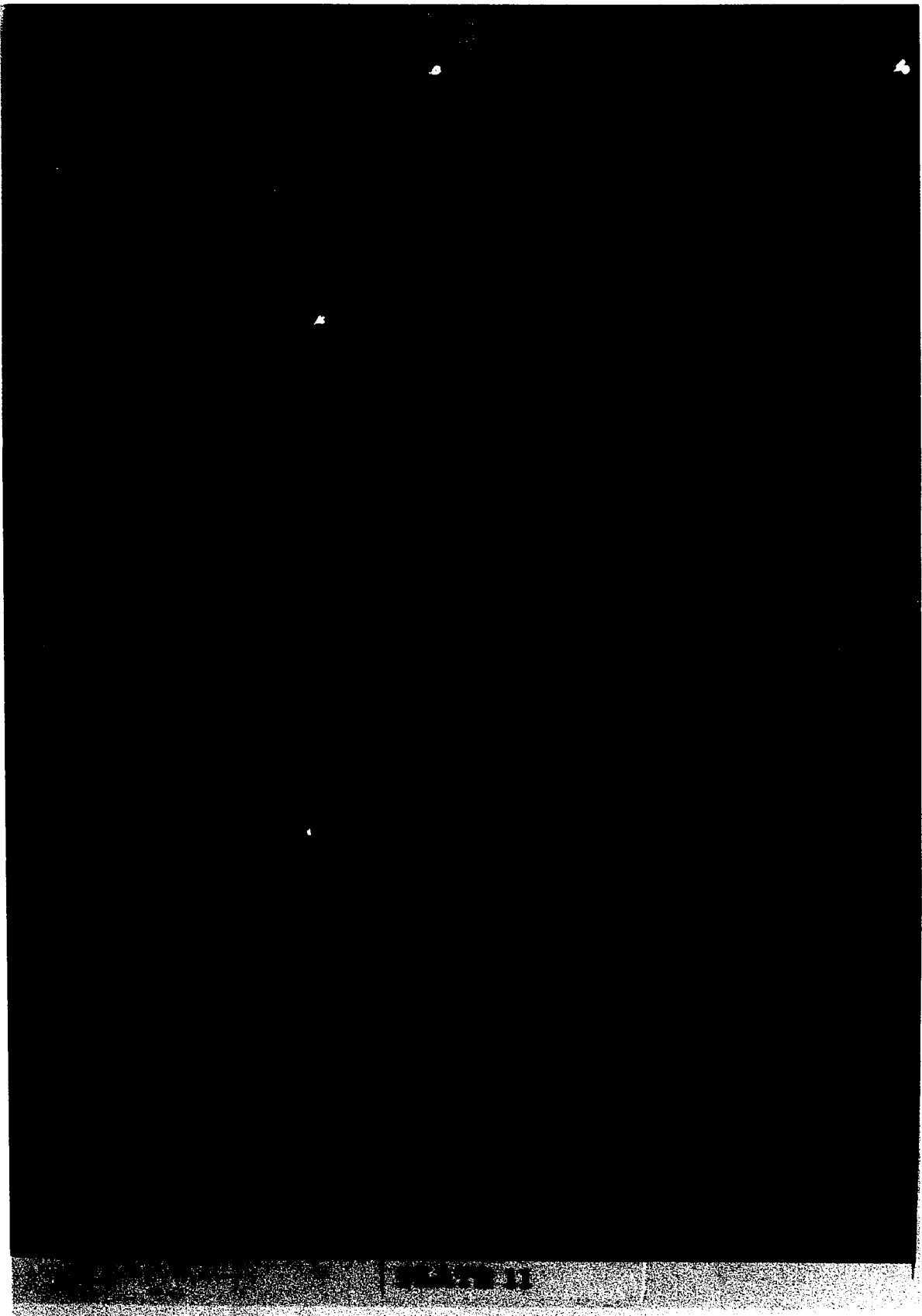


PLATE 12

Palmatolepis gigas Miller & Youngquist, 1947

- Fig. 1a Oral view of specimen CPC 12612.
b Aboral view of specimen CPC 12612.

Palmatolepis hassi Müller & Müller, 1957

- Fig. 2a Aboral view of specimen CPC 12616.

Palmatolepis linguiformis Müller, 1956

- Fig. 3a Oral view of specimen CPC 12619.
b Aboral view of specimen CPC 12619.

Palmatolepis minuta minuta Branson & Mehl, 1934

- Fig. 4a Oral view of specimen CPC 12621.
b Aboral view of specimen CPC 12621.

Palmatolepis minuta loba Helms, 1963

- Fig. 5a Oral view of specimen CPC 12623.
b Aboral view of specimen CPC 12623.

Palmatolepis minuta schleizia Helms, 1963

- Fig. 6a Aboral view of specimen CPC 12625.
b Oral view of specimen CPC 12625.

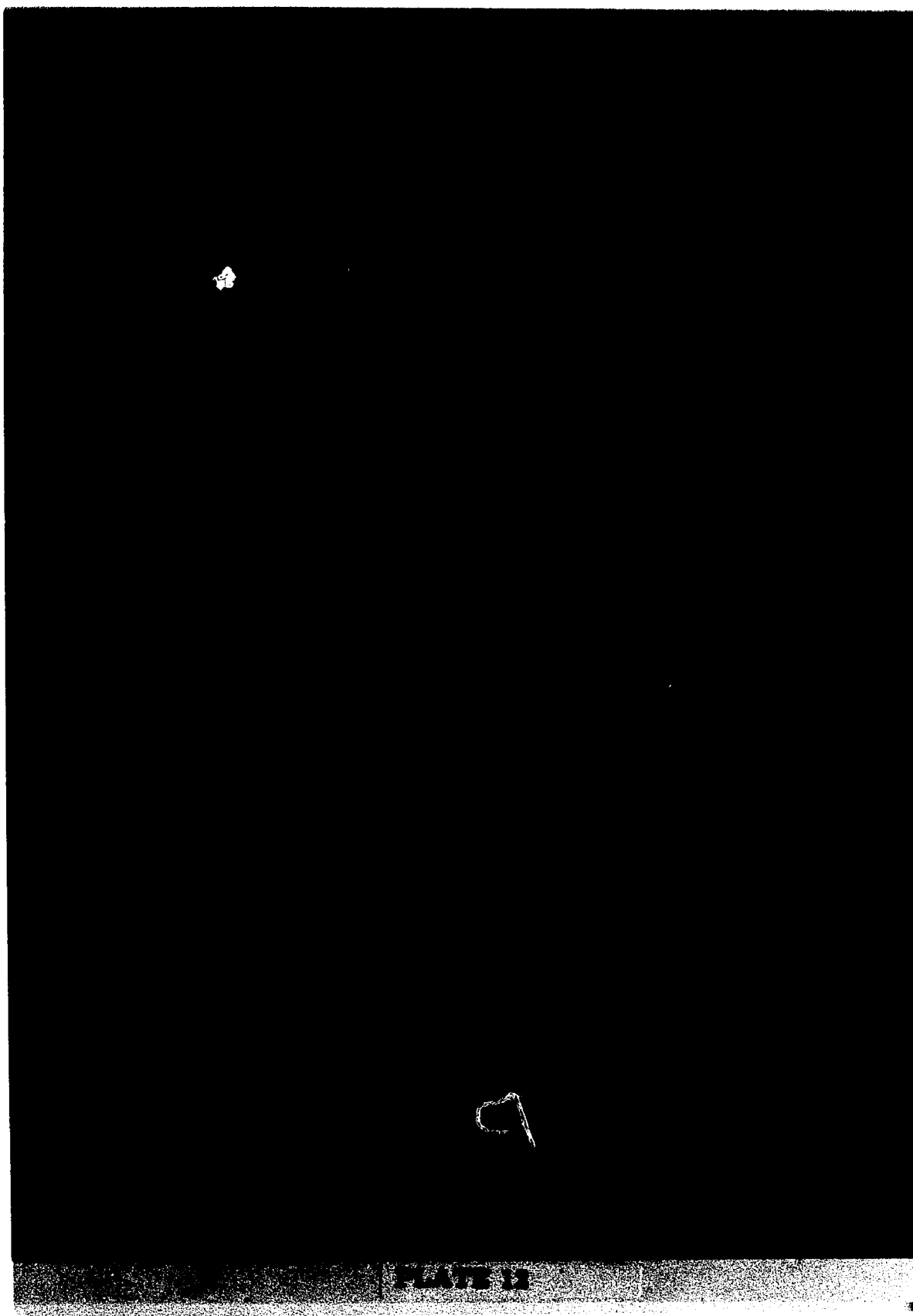


PLATE II

PLATE 13

Palmatolepis perlobata perlobata Ulrich & Bassler, 1926

Fig. 1a Aboral view of specimen CPC 12627.

b Oral view of specimen CPC 12627.

Palmatolepis perlobata sigmoidea Ziegler, 1962

Fig. 2a Oral view of specimen CPC 12631.

b Aboral view of specimen CPC 12631.

Palmatolepis proversa Ziegler, 1958

Fig. 3a Oral view of specimen CPC 12632.

b Aboral view of specimen CPC 12632.

Palmatolepis punctata (Hinde, 1879)

Fig. 4a Oral view of specimen CPC 12634.

b Aboral view of specimen CPC 12634.

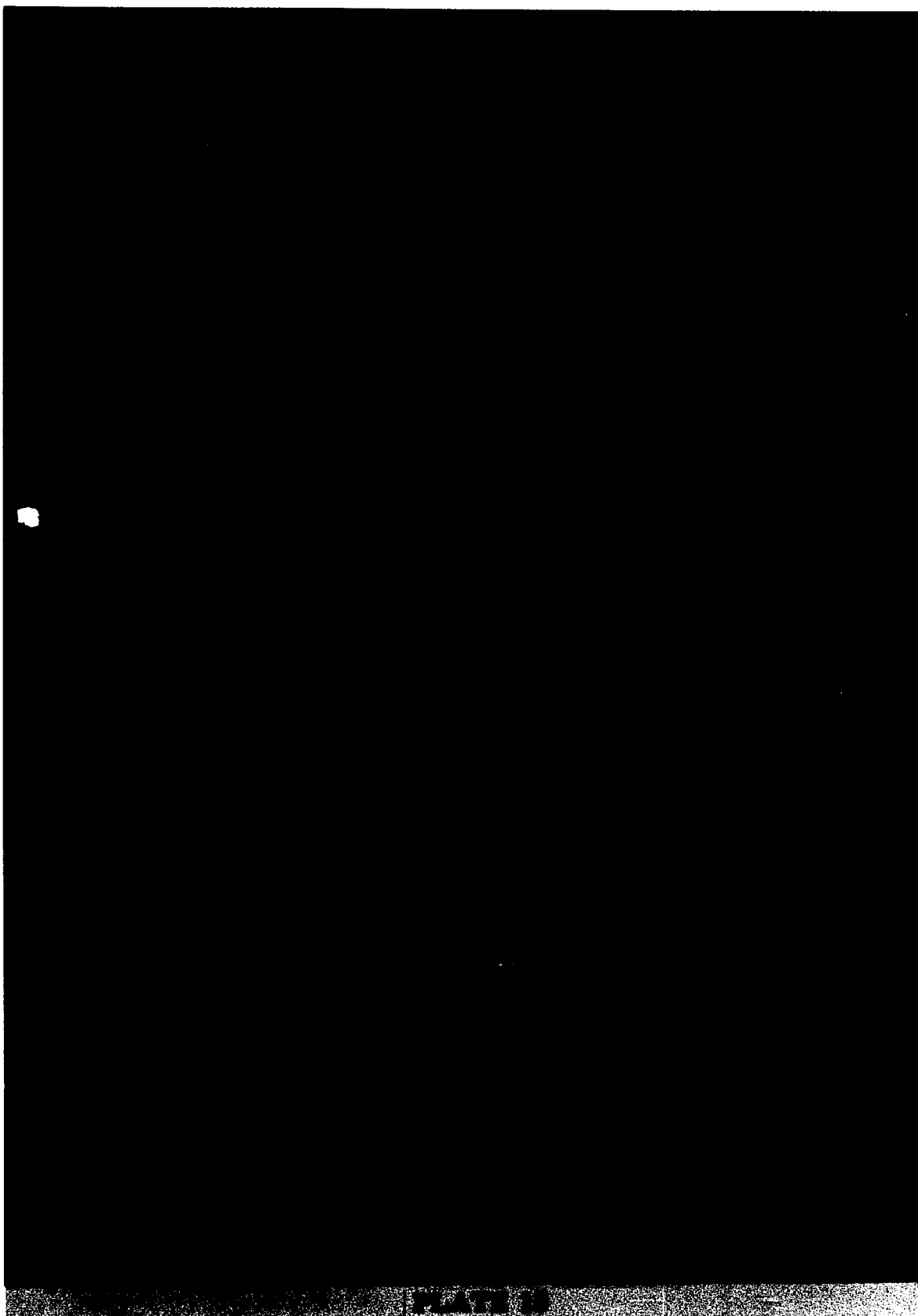


PLATE 14

Palmatolepis quadrantinodosa marginifera Helms, 1959

- Fig. 1a Oral view of specimen CPC 12637.
b Aboral view of specimen CPC 12637.

Palmatolepis quadrantinodosa inflexoidea Ziegler, 1962

- Fig. 2a Oral view of specimen CPC 12641.
b Aboral view of specimen CPC 12641.

Palmatolepis quadrantinodosalobata Sannemann, 1955

- Fig. 3a Aboral view of specimen CPC 12643.
b Oral view of specimen CPC 12643.

Palmatolepis cf. P. regularis Cooper, 1931

- Fig. 4a Oral view of specimen CPC 12645.
b Aboral view of specimen CPC 12645.

Palmatolepis rugosa grossi Ziegler, 1962

- Fig. 5a Oral view of specimen CPC 12647.
b Aboral view of specimen CPC 12647.

Palmatolepis rugosa ampla Ziegler, 1962

- Fig. 6a Aboral view of specimen CPC 12648.
b Oral view of specimen CPC 12648.

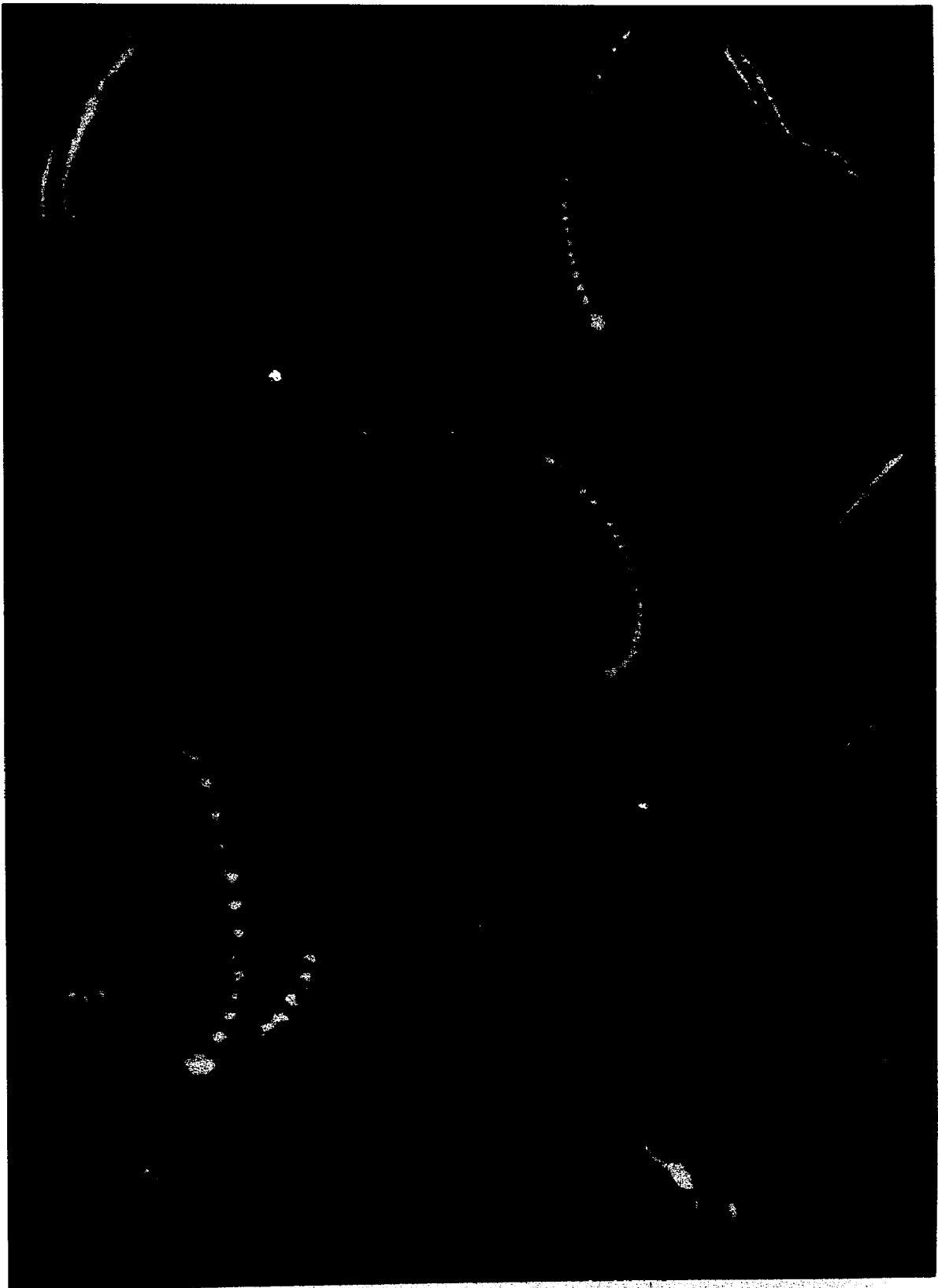


PLATE 14

PLATE 15

Palmatolepis cf. P. subgracilis Bischoff, 1956
Fig. 1a, b Lateral views of specimen CPC 12649.

Palmatolepis sp. nov. B
Fig. 2a Oral view of specimen CPC 12650.
b Aboral view of specimen CPC 12650.

Palmatolepis transitans Müller, 1956
Fig. 3a Oral view of specimen CPC 12666.
b Aboral view of specimen CPC 12666.

Palmatolepis subperlobata Branson & Mehl, 1934
Fig. 4a Aboral view of specimen CPC 12651
b Oral view of specimen CPC 12651.

Palmatolepis subperlobata subsp. a Helms, 1963
Fig. 5a Aboral view of specimen CPC 12655.
b Oral view of specimen CPC 12655.

Palmatolepis tenuipunctata Sannemann, 1955
Fig. 6a Oral view of specimen CPC 12662.
b Aboral view of specimen CPC 12662.

Palmatolepis subrecta Miller & Youngquist, 1947
Fig. 7a Oral view of specimen CPC 12658.
b Aboral view of specimen CPC 12658.

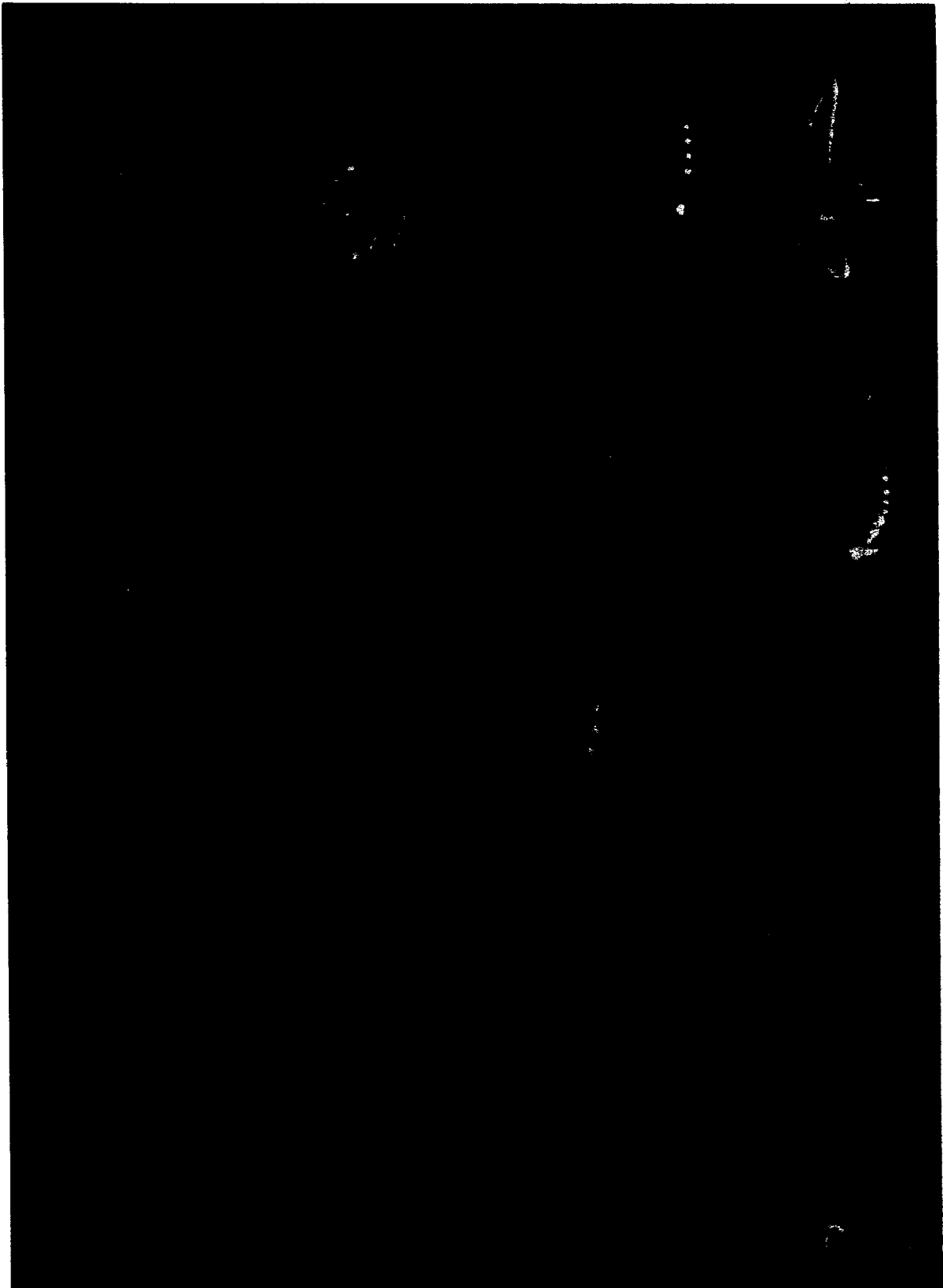


PLATE 16

Palmatolepis sp. nov. A

Fig. 1 Oral view of specimen CPC 12675.

Palmatolepis unicornis

Fig. 2a Oral view of specimen CPC 12672.

b Aboral view of specimen CPC 12672.

Palmatolepis triangularis

Fig. 3a Oral view of specimen CPC 12668.

b Aboral view of specimen CPC 12668.

Palmatolepis glabra acuta Helms, 1963

Fig. 4a Aboral view of specimen CPC 12607.

b Oral view of specimen CPC 12607.

Palmatolepis cf. P. triangularis Sannemann, 1955

Fig. 5 Oral view of specimen CPC 12674.

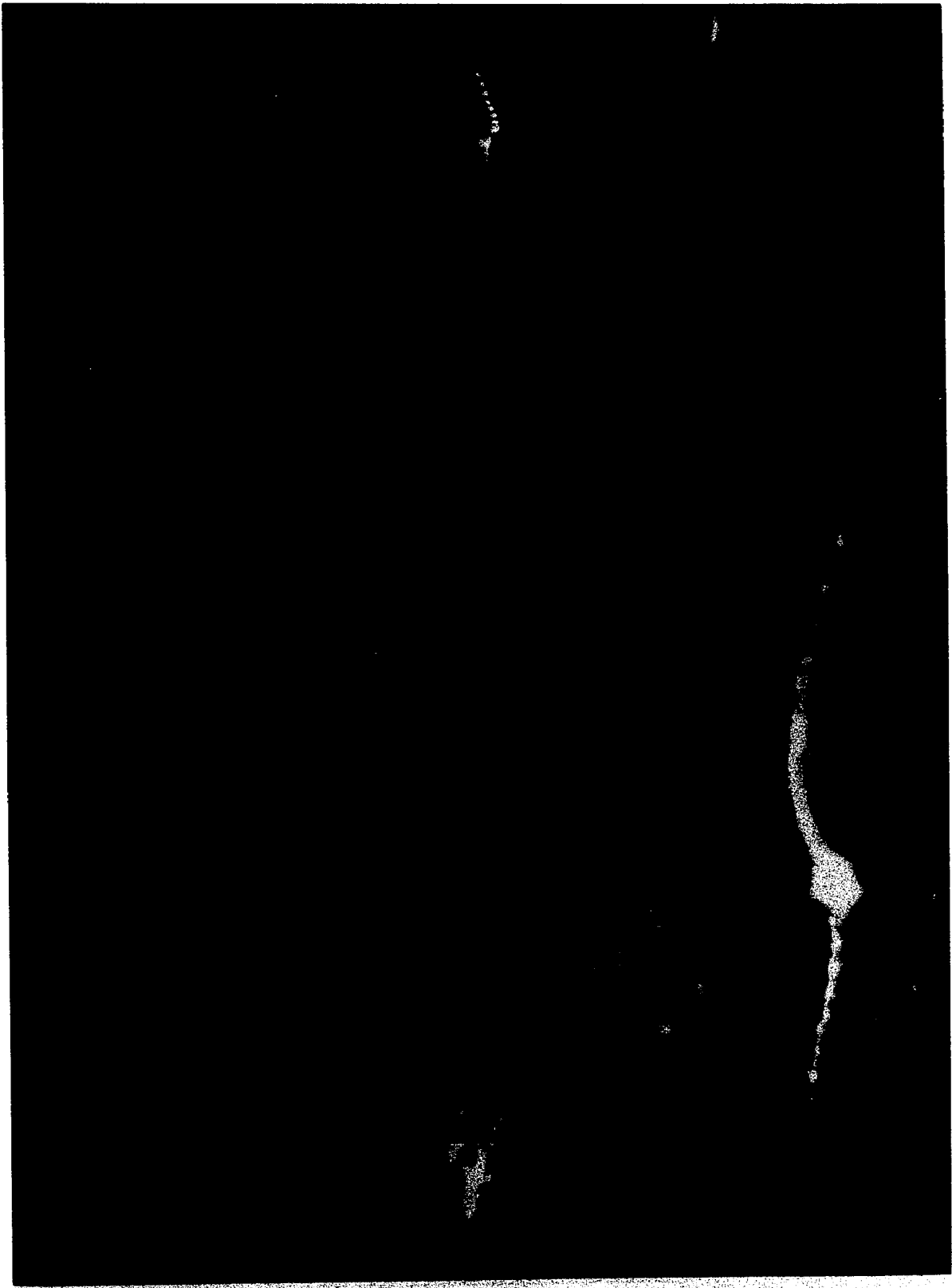


PLATE 17

Acodina formosa Stauffer, 1940

Fig. 1 Posterior view of specimen CPC 12849.

Acodina zionensis (Stauffer, 1938)

Fig. 2 Lateral view of specimen CPC 12852.

Drepanodus sp.

Fig. 3 Lateral view of specimen CPC 12853.

Nothognathella typicalis Branson & Mehl, 1934

Fig. 4 Oral view of specimen CPC 12563.

Nothognathella sp. nov. A

Fig. 5 Oral view of specimen CPC 12567.

Acodina inopinata (Stauffer, 1938)

Fig. 6 Lateral view of specimen CPC 12850.

Acodina sannemanni sp. nov.

Fig. 7 Lateral view of holotype CPC 12851.

Nothognathella palmatoformis sp. nov.

Fig. 8 Oral view of holotype CPC 12558.

Nothognathella polygnathoidea Branson & Mehl, 1934.

Fig. 9 Oral view of specimen CPC 12562.

Polygnathus asymmetricus asymmetricus

Fig. 10a Aboral view of specimen CPC 12704.

b Oral view of specimen CPC 12704.

Polygnathus asymmetricus ovalis Glenister & Klapper, 1966

Fig. 11a Oral view of specimen CPC

b Aboral view of specimen CPC

Polygnathus australis sp. nov.

Fig. 12a Aboral view of paratype CPC 12684.

b Oral view of paratype CPC 12684.

13a Aboral view of holotype CPC 12685.

b Oral view of holotype CPC 12685.

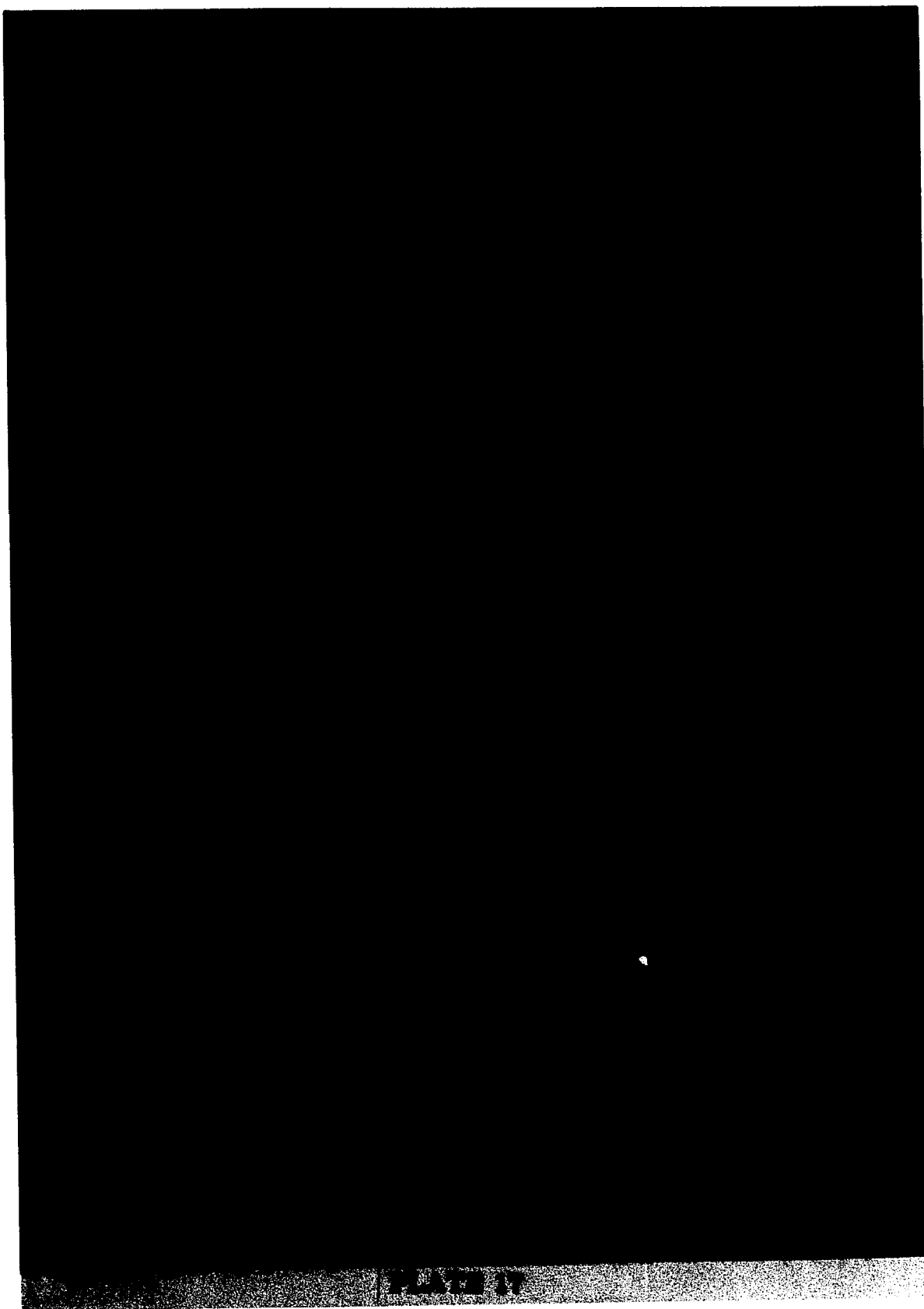


PLATE 18

Polygnathus brevilaminus Branson & Mehl, 1934

Figs. 1a,b Aboral and oral view of specimen CPC 12689.

Polygnathus collinsoni Druce, 1969

Figs. 2a,b Aboral and oral view of specimen CPC 19690.

Polygnathus decorosus Stauffer, 1938

Figs. 3a,b Aboral and oral view of specimen CPC 12692.

Polygnathus delicatulus Ulrich & Bassler, 1926

Figs. 4a,b Aboral and oral view of specimen CPC 12695.

Polygnathus fallax Helms & Wolska, 1967

Figs. 5a,b Oral and aboral view of specimen CPC 12698.

Polygnathus germanus germanus Ulrich & Bassler, 1926

Figs. 6a,b Oral and aboral view of specimen CPC 12704.

Polygnathus foliatus Bryant, 1921

Figs. 7a,b Oral and aboral view of specimen CPC 12700.

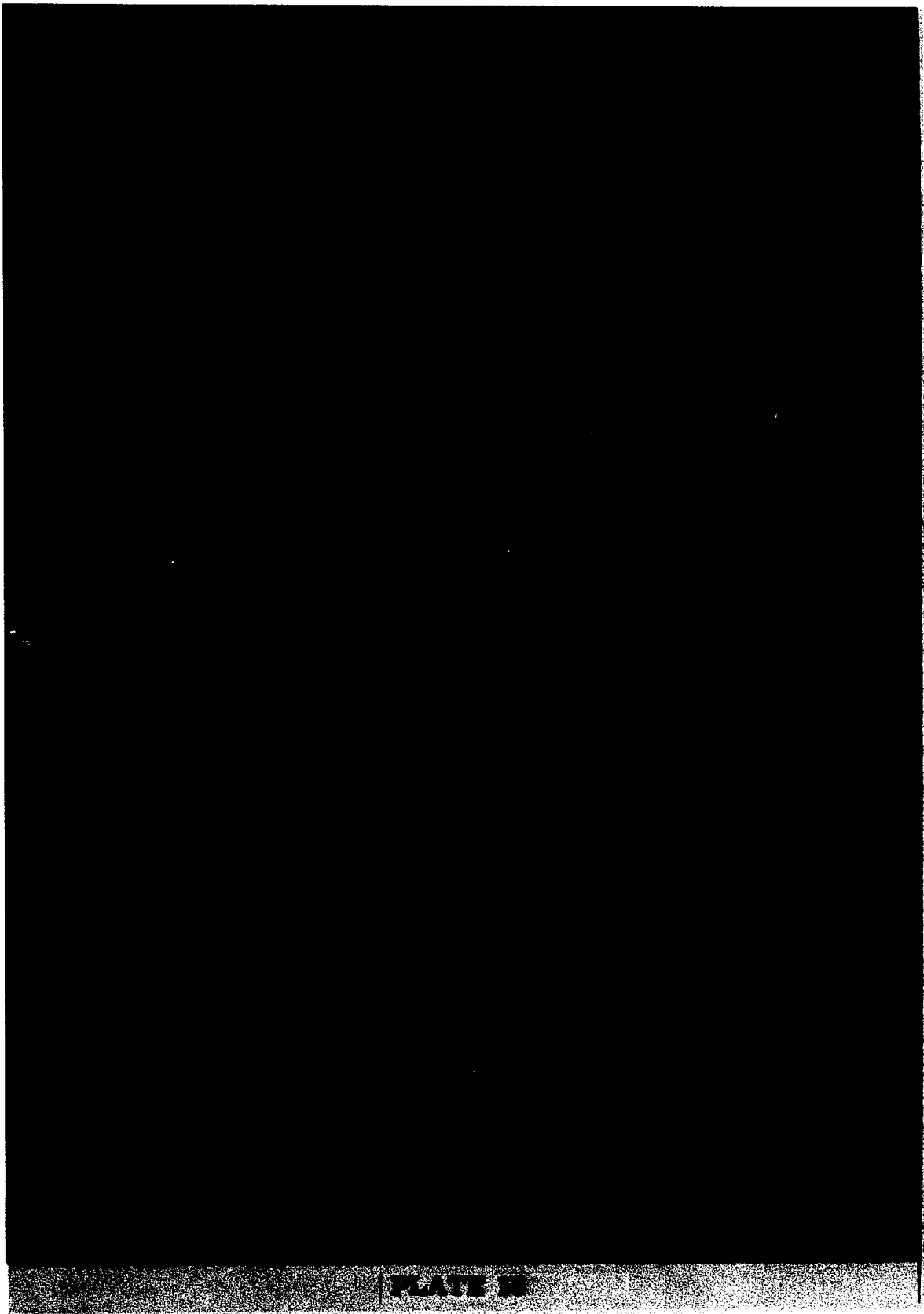


PLATE II

PLATE 19

Polygnathus germanus subsp. nov. B

Figs. 1a, b Oral and aboral views of specimen CPC 12709.

Polygnathus germanus subsp. nov. A

Figs. 2a, b Aboral and oral views of specimen CPC 12708.

Polygnathus glaber glaber Ulrich & Bassler, 1926

Figs. 3a, b Oral and aboral views of specimen CPC 12711.

Polygnathus irregularis (Thomas, 1949)

Figs. 4a, b Oral and aboral views of specimen CPC 12714.

Polygnathus janeti sp. nov.

Figs. 5a, b Oral and aboral views of holotype CPC 12717.

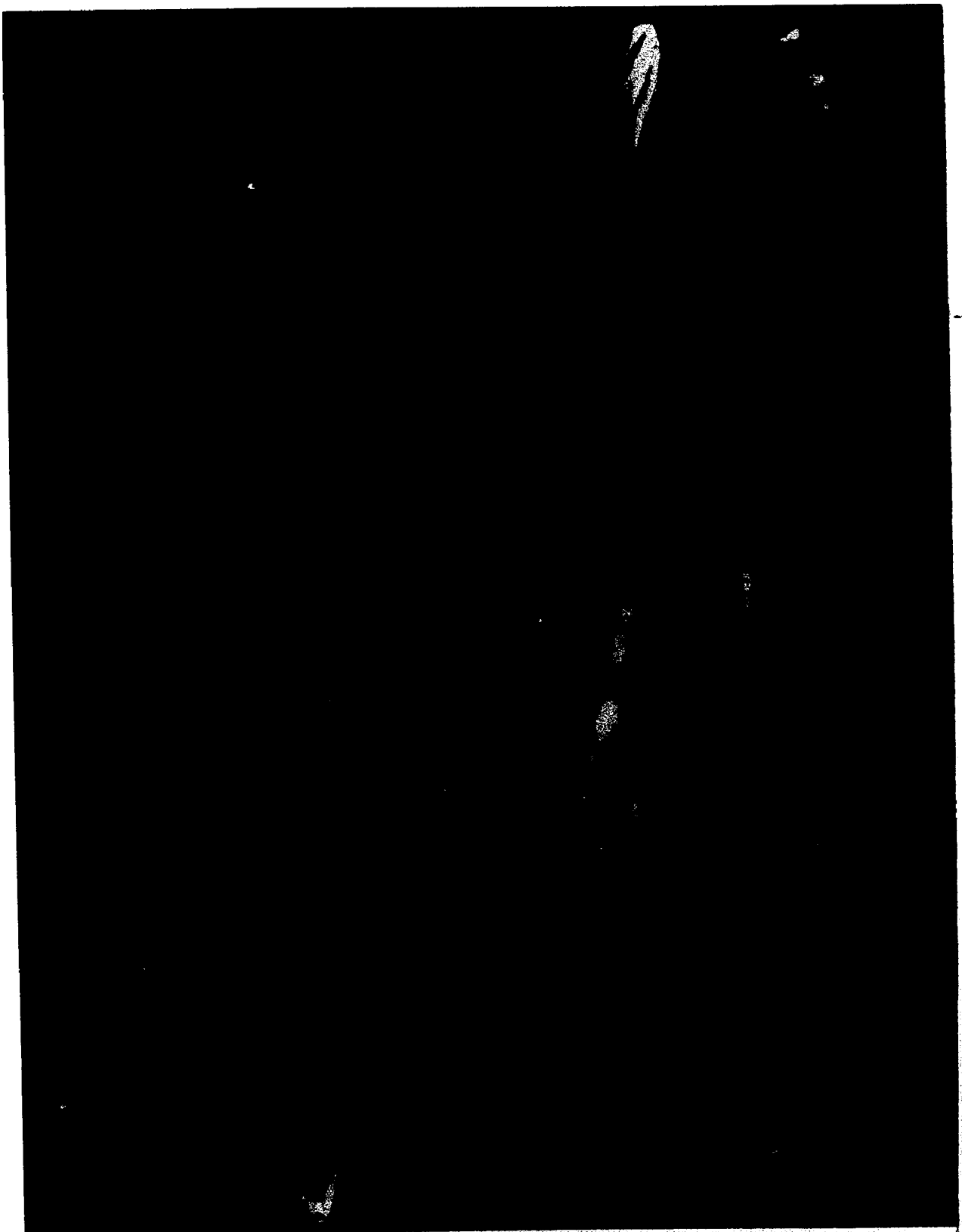


PLATE 19

PLATE 20

Polygnathus normalis Miller & Youngquist, 1947

Figs. 1a,b Aboral and oral views of specimen CPC 12722.

Polygnathus obliquicostatus Ziegler, 1962

Figs. 2a,b Aboral and oral views of specimen CPC 12729.

Polygnathus norrisi Uyeno, 1967

Figs. 3a,b Aboral and oral views of specimen CPC 12726.

Polygnathus cf. P. pennatus Hinde, 1879

Figs. 4a,b Oral and aboral views of specimen CPC 12730.

Polygnathus perplexus Thomas, 1949

Figs. 5a,b Aboral and oral views of specimen CPC 12732.

Polygnathus nodoundatus Helms, 1961

Figs. 6a,b Oral and aboral view of specimen CPC 12721.

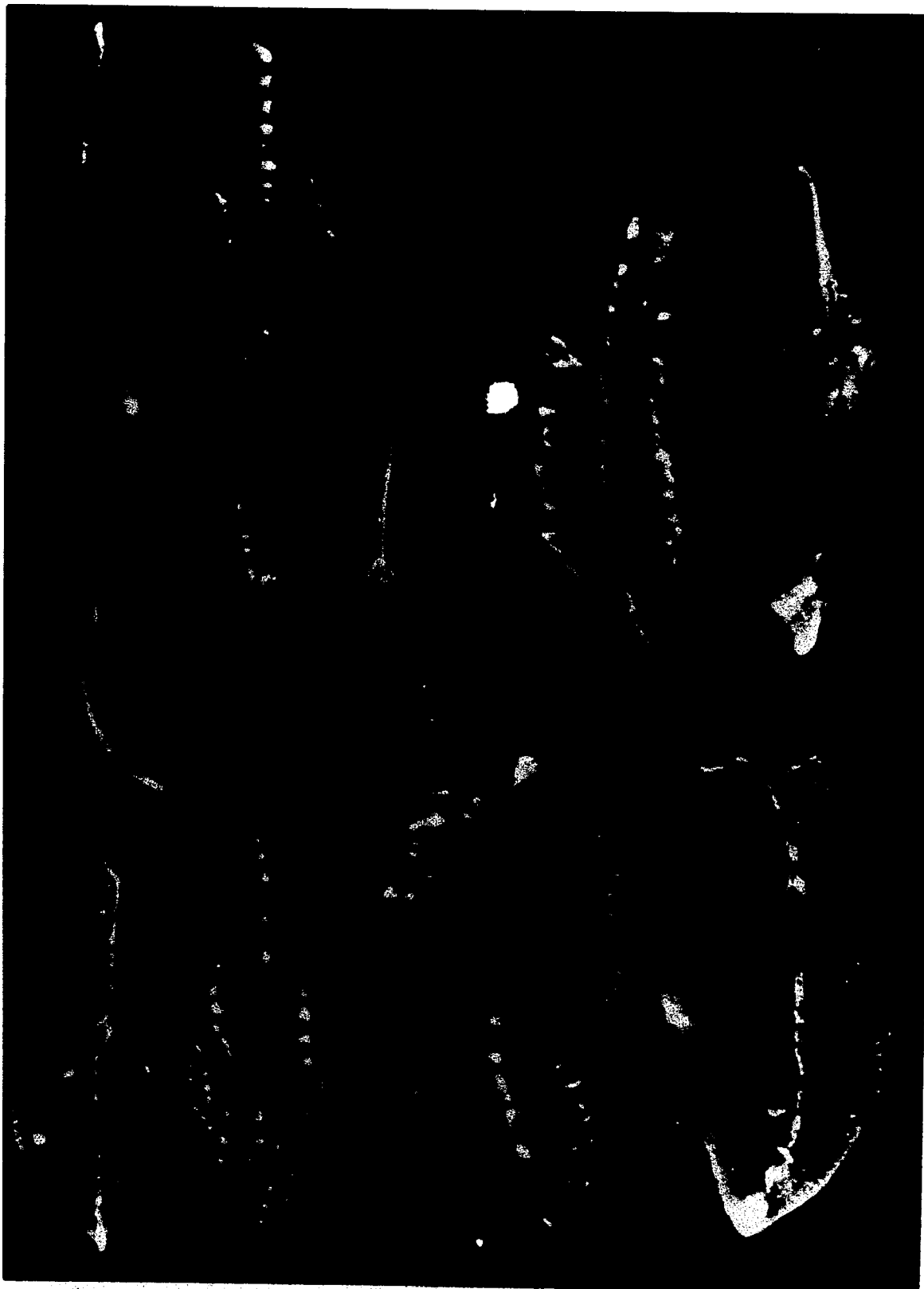


PLATE 20

PLATE 21

Polygnathus pollocki sp. nov.

Figs. 1a,b Oral and aboral views of holotype CPC 12734.

Polygnathus seddoni sp. nov.

Figs. 2a,b Aboral and oral views of holotype CPC 12737.

Polygnathus semicostatus Branson & Mehl, 1934

Fig. 3 Oral view of specimen CPC 12741.

Polygnathus spatulatus Youngquist, 1947

Fig. 4 Oral view of specimen CPC 12742.

Polygnathus subserratus Branson & Mehl, 1934

Fig. 5 Oral view of specimen CPC 12743.

Polygnathus triphyllatus (Ziegler, 1960)

Fig. 6 Oral view of specimen CPC 12747.

Polygnathus cf. P. webbi Stauffer, 1938

Fig. 7 Oral view of specimen CPC 12750.

Polygnathus xylus Stauffer, 1938

Fig. 8 Oral view of specimen CPC 12753.

Polygnathus sp. nov.

Fig. 9 Oral view of specimen CPC 12760.

Polygnathus znepolensis Spasov, 1965

Fig. 10 Oral view of specimen CPC 12757.

Polygnathus sp. B

Fig. 11 Oral view of specimen CPC 12762.

Polygnathus sp. A

Fig. 12 Oral view of specimen CPC 12761.

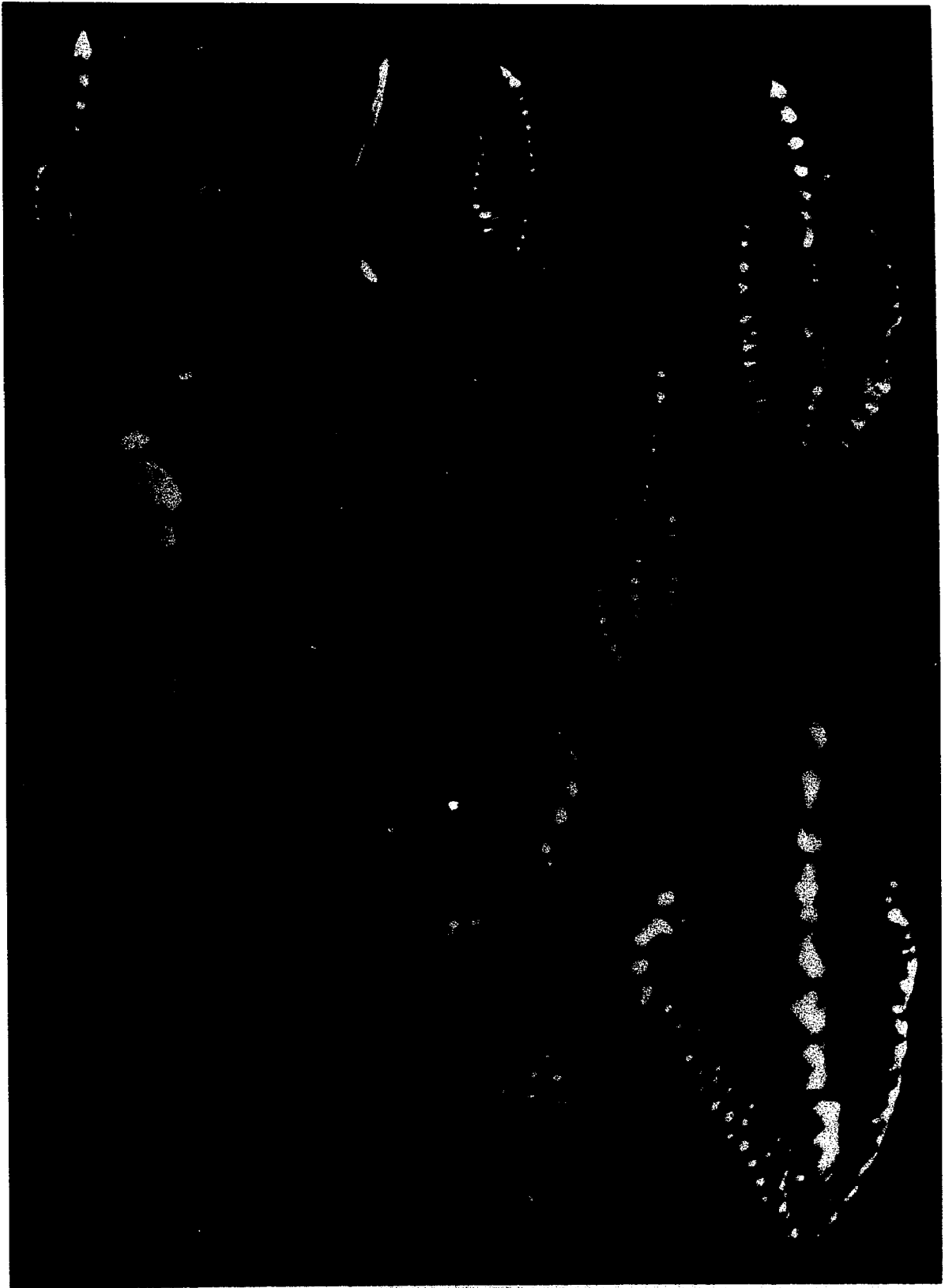


PLATE 21

PLATE 22

Pelekysgnathus elevatus (Branson & Mehl, 1938)

Fig. 1 Lateral view of specimen CPC 12763.

Pelekysgnathus sp.

Fig. 2 Lateral view of specimen CPC 12767.

Scaphignathus veliferus Helms, 1959

Fig. 3 Oral view of specimen CPC 12774.

Scaphignathus ziegler Druce, 1969

Fig. 4 Oral view of specimen CPC 12777.

Polylophodonta confluens (Ulrich & Bassler, 1926)

Fig. 5 Oral view of specimen CPC 12784.

Prioniodina ? smithi (Stauffer, 1935)

Fig. 6 Lateral view of specimen CPC 12788.

Scutula venusta Sannemann, 1955

Fig. 7 Lateral view of specimen CPC 12783.

Scutula bipennata Sannemann, 12780

Fig. 8 Anterior view of specimens CPC 12780.

Spathognathodus fitzroyi sp. nov.

Fig. 9 Lateral view of holotype CPC 12795.

Polylophodonta elongata Druce, 1969

Fig. 10 Oral view of specimen CPC 12785.

Pseudopolygnathus sp. A

Fig. 11 Oral view of specimen CPC 12791.

Polygnathellus multident (Ulrich & Bassler, 1926)

Fig. 12 Lateral view of specimen CPC 12769.

Spathognathodus cf. S. brevis Bischoff & Ziegler, 1957

Fig. 13 Lateral view of specimen CPC 12794.

Spathognathodus bohlenanus Helms, 1959

Fig. 14 Lateral view of specimen CPC 12793.

Polygnathellus cf. P. typicalis Bassler, 1925

Fig. 15 Lateral view of specimen CPC 12773.

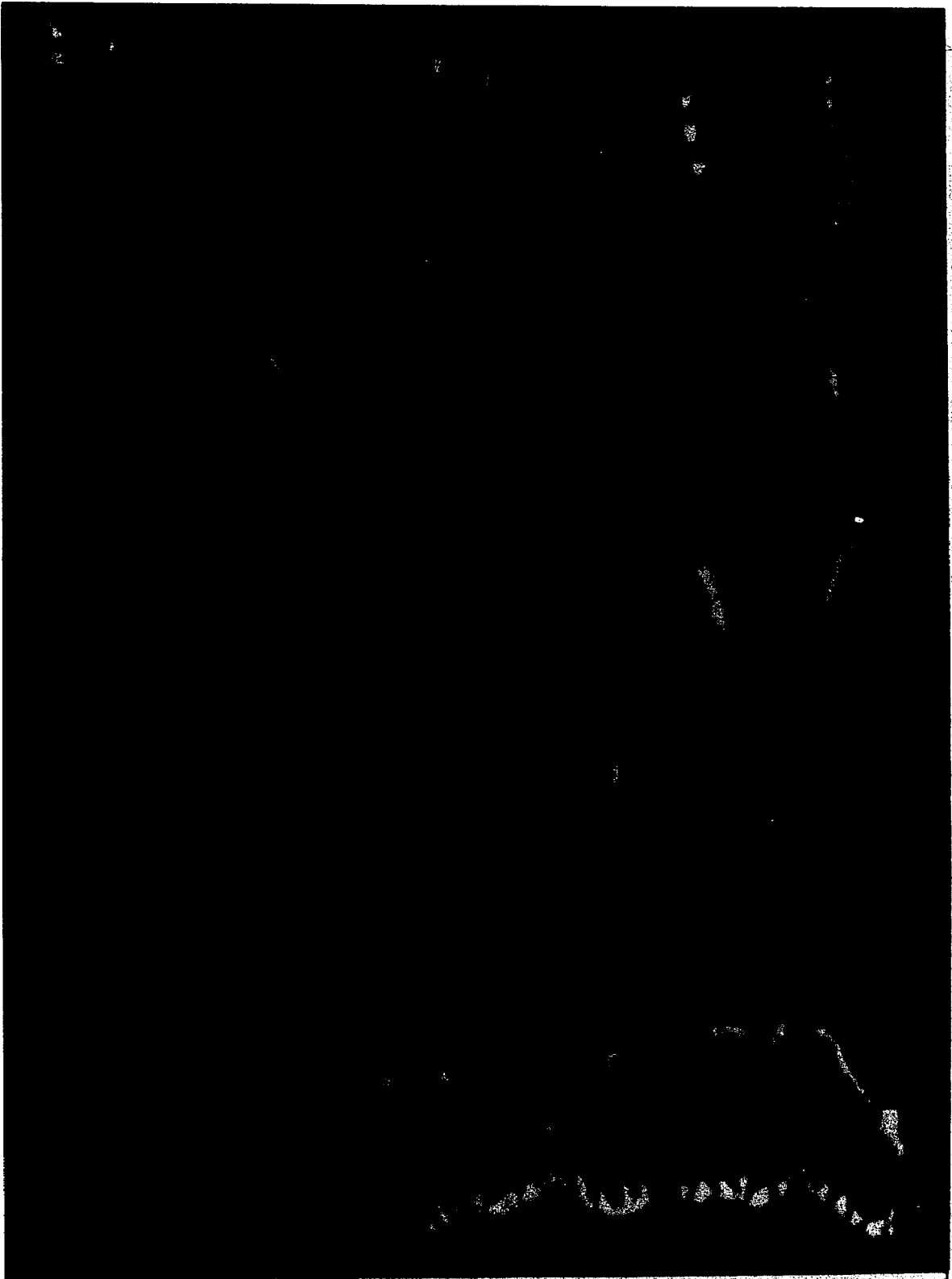


PLATE 23

Spathognathodus stabilis (Branson & Mehl, 1934)

Fig. 1 Lateral view of specimen CPC 12798.

Spathognathodus cf. S. robustus (Branson & Mehl, 1934)

Fig. 2 Lateral view of specimen CPC 12797.

Spathognathodus sp. D

Fig. 3 Lateral view of specimen CPC 12813.

Spathognathodus sp. B

Fig. 4 Lateral view of specimen CPC 12810.

Spathognathodus sp. H

Fig. 5 Lateral view of specimen CPC 12817.

Spathognathodus strigosus (Branson & Mehl, 1934)

Fig. 6 Lateral view of specimen CPC 12802.

Spathognathodus sp. A

Fig. 7 Lateral view of specimen CPC 12809.

Spathognathodus sp. G

Fig. 8 Lateral view of specimen CPC 12816.

Spathognathodus sp. C

Fig. 9 Lateral view of specimen CPC 12811.

Fig. 11 Lateral view of specimen CPC 12812.

Spathognathodus sp. I

Fig. 10 Lateral view of specimen CPC 12818.

Spathognathodus sp. F

Fig. 12 Lateral view of specimen CPC 12815.

Spathognathodus sp. E

Fig. 13 Lateral view of specimen CPC 12814.

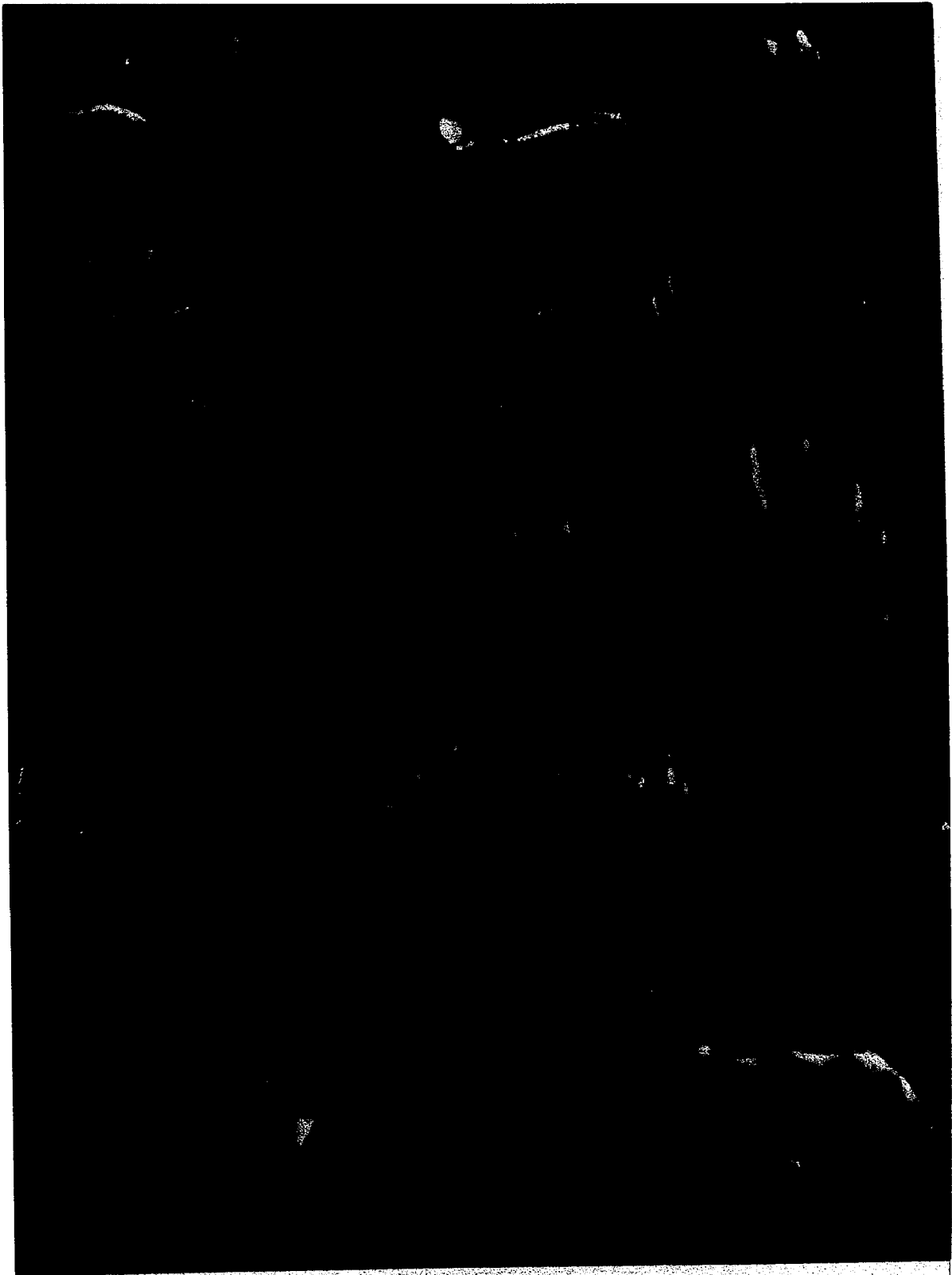


PLATE 23

PLATE 24

Synprioniodina cf. S. alternata Bassler, 1925

Fig. 1 Lateral view of specimen CPC 12819.

Synprioniodina sp. B

Fig. 2 Lateral view of specimen CPC 12827.

Synprioniodina sp. A

Fig. 3 Lateral view of specimen CPC 12824.

Tripodellus robustus Bischoff, 1957

Fig. 4 Lateral view of specimen CPC 12828.

gen. nov. et sp. nov. Druce, 1969

Fig. 5 Oral view of specimen CPC 12830.

Ozarkodina ? sp.

Fig. 6 Lateral view of specimen CPC 12844.

Fig. 7 Lateral view of specimen CPC 12846.

Fig. 8 Lateral view of specimen CPC 12848.

Fig. 9 Lateral view of specimen CPC 12845.

Fig. 10 Lateral view of specimen CPC 12847.

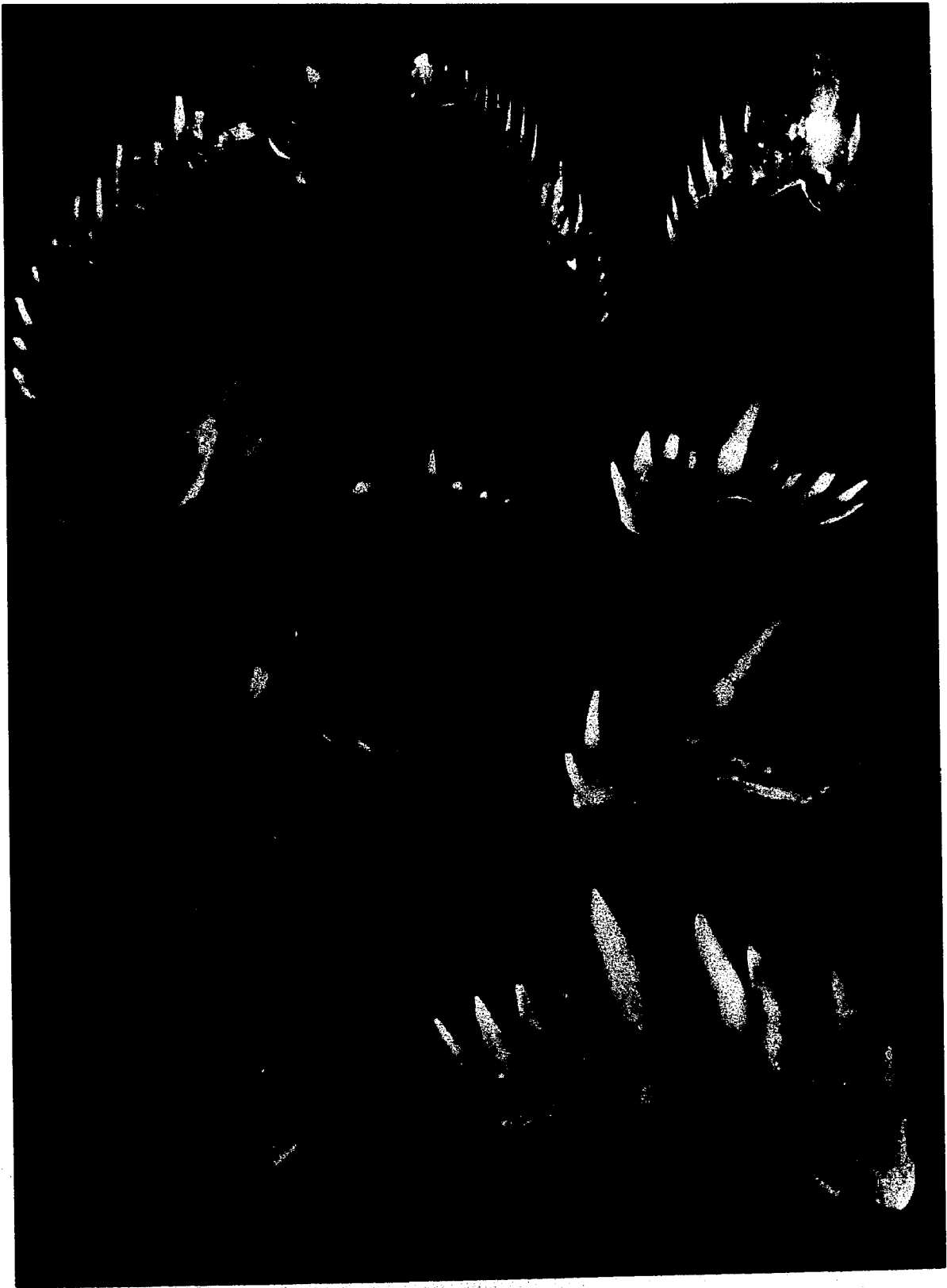


PLATE 24

**PLATE 25**

Photograph of reef complex at Windjana Gorge showing three major facies. Figures on point bar at lower left show scale.

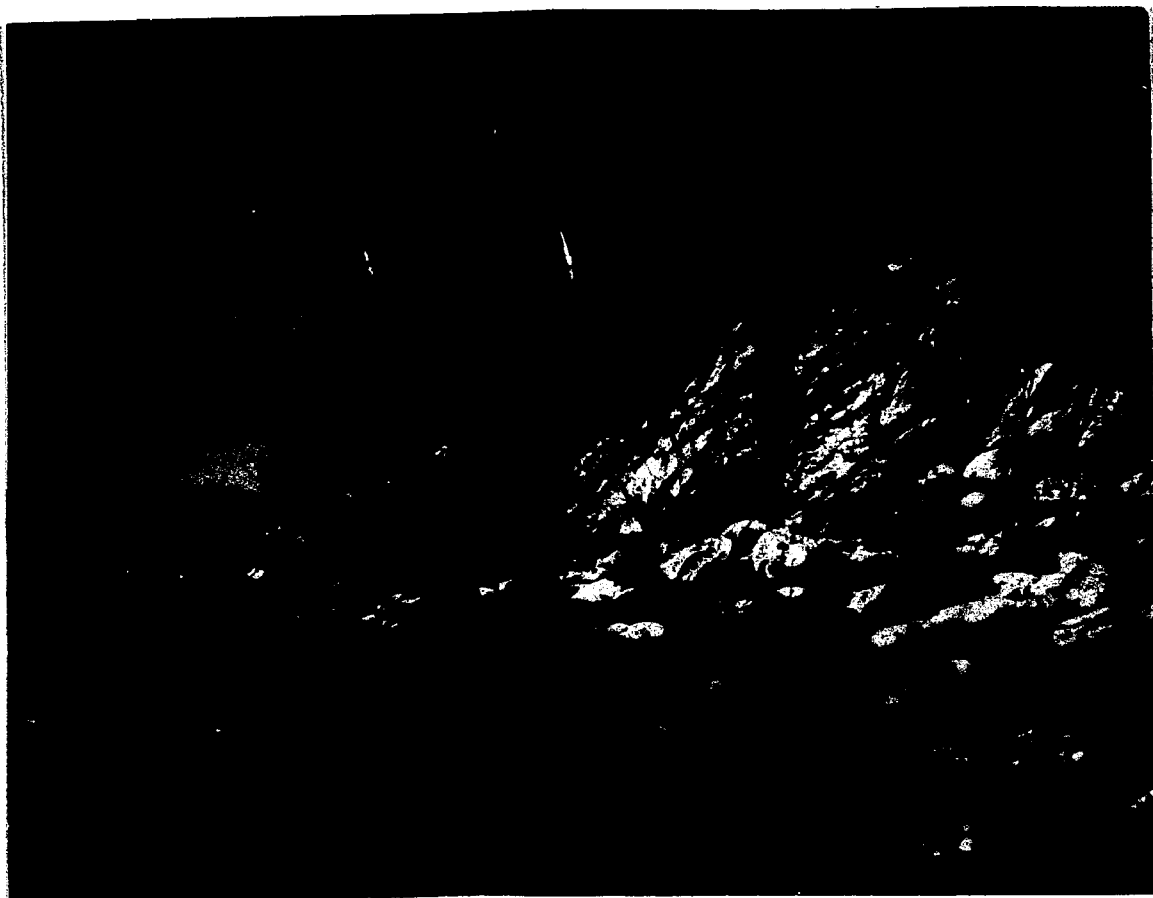


PLATE 26

Photograph showing depositional dip of fore-reef Sadler Limestone.

**PLATE 27**

Photograph of horizontally bedded dolomitic back-reef facies.

**PLATE 28**

Eroded atoll with barrier reef in background.

PLATE 29

Collecting samples in field, pilot samples weigh about 2 kgs (4.4 lbs).

PLATE 30

Field laboratory: microscope room and library in trailer; Monochloroacetic acid in large red drums; samples stored in plastic bags and broken down in plastic buckets.

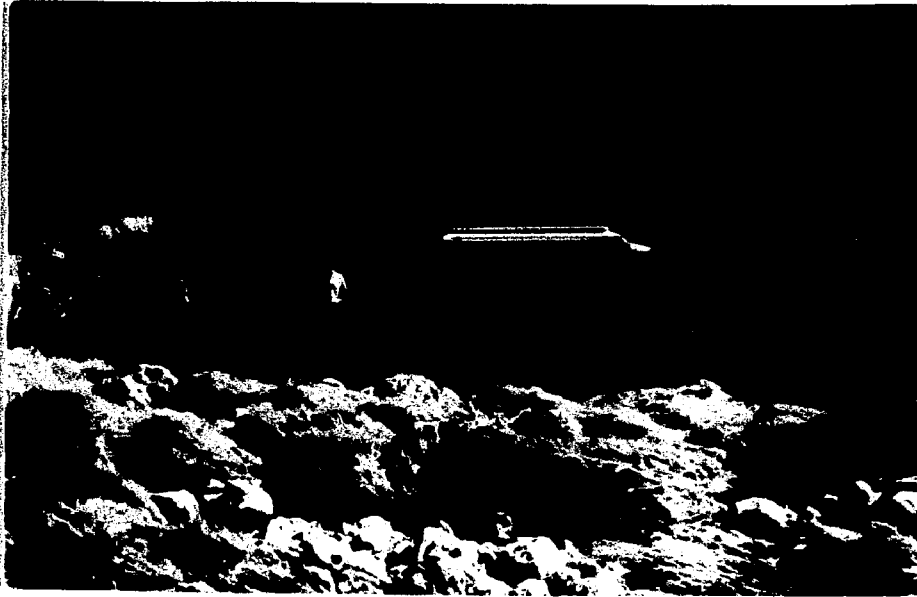


PLATE 29



PLATE 30

PLATE 31

Crushing samples into $\frac{1}{2}$ " chips in mobile jaw crusher.

PLATE 32

Removing "fines" (under $1/8$ ") after crushing to prevent rapid acid neutralization. "Fines" are kept for ostracod pickings.



PLATE 31

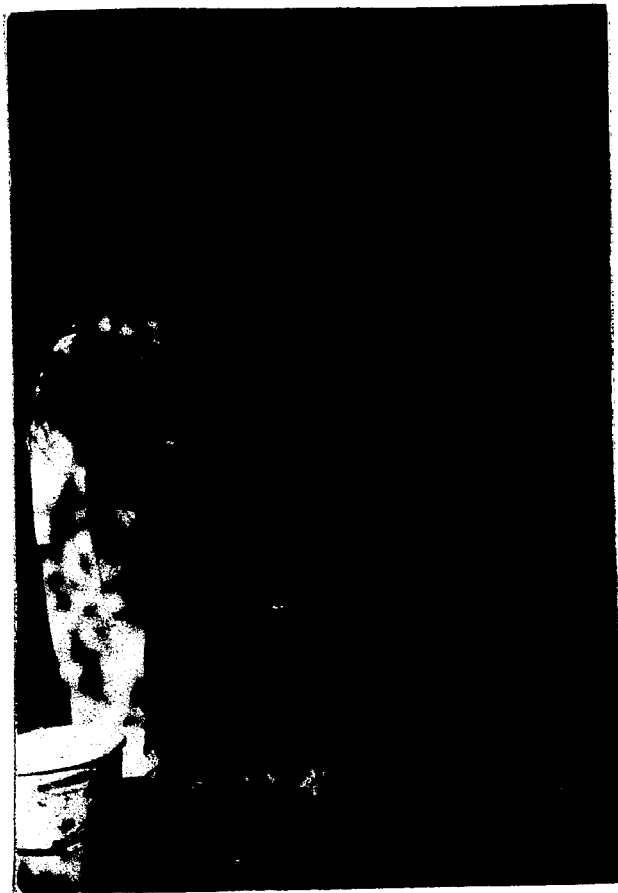


PLATE 32

PLATE 33

Adding monochloroacetic acid to crushed sample in bucket. Each bucket contains 0.5 kg (about 1 lb) of rock which will break down in a 24 hour period.

PLATE 34

Washing residue through 30 and 120 mesh screens. The residue in the 120 mesh screen is retained.



PLATE 33



PLATE 34

PLATE 35

Drying washed residue.

PLATE 36

**Separating dried residue using bromoform (S.G. 2.9);
conodonts separate in the heavy fraction.**

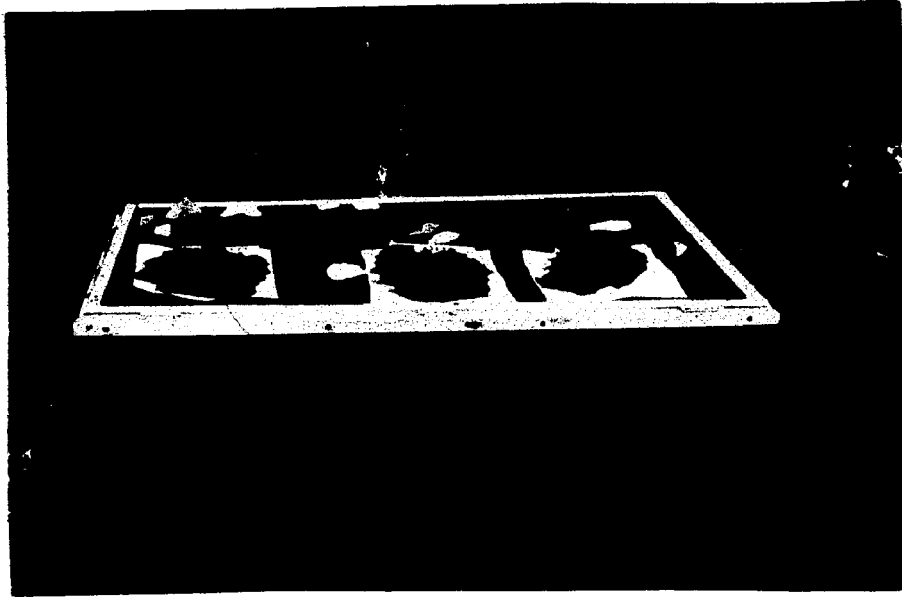
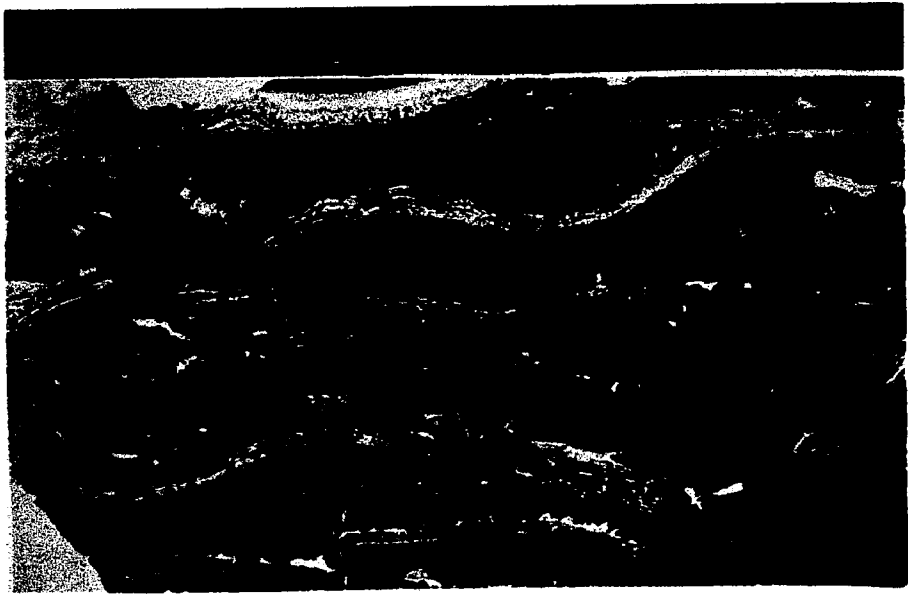


PLATE 35



PLATE 36

**PLATE 37**

Photograph of a thin section of lamellar stromatoporoids in a matrix of calcilutite and micrite, pelletoid, fine-grained calcarenite.

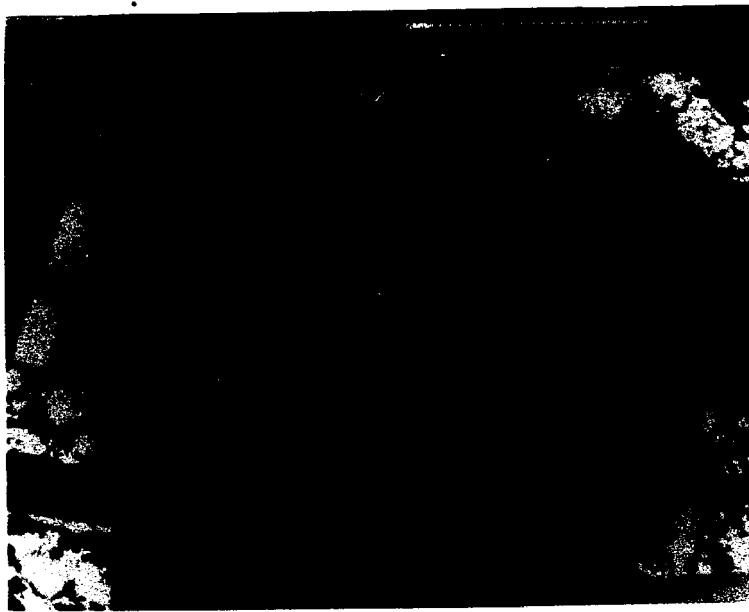
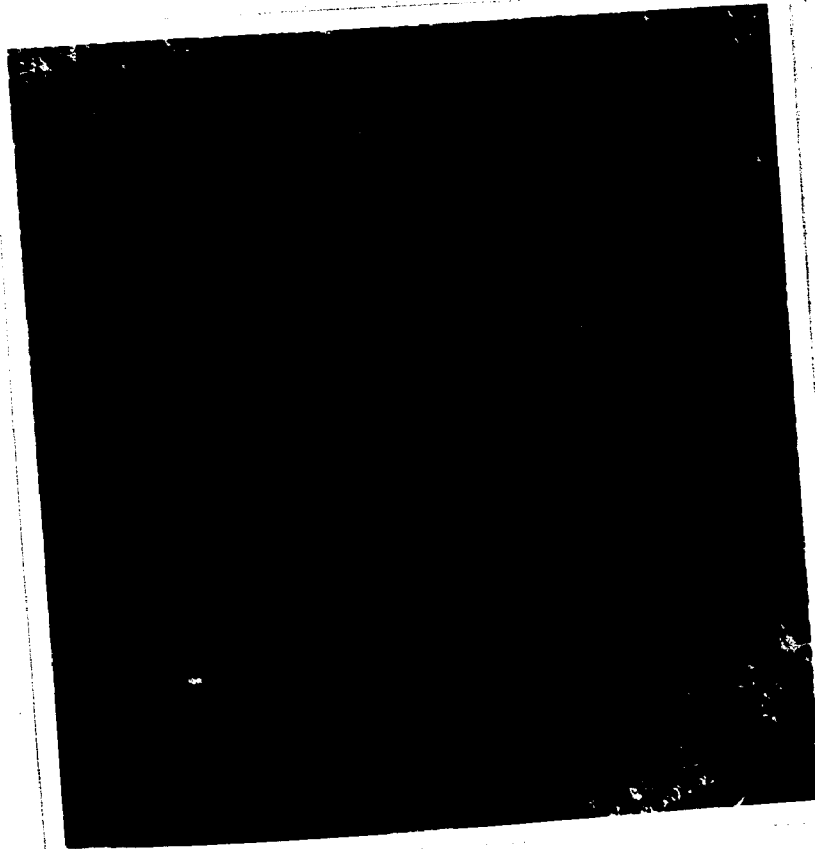


PLATE 38

Photograph of a thin section of stromatoporoid-algal limestone showing dense colonies of Renalcis encrusting branches of the stromatoporoid Stachyodes. The interstices between the colonies are filled with alternating bands of red and yellow calcilutite.

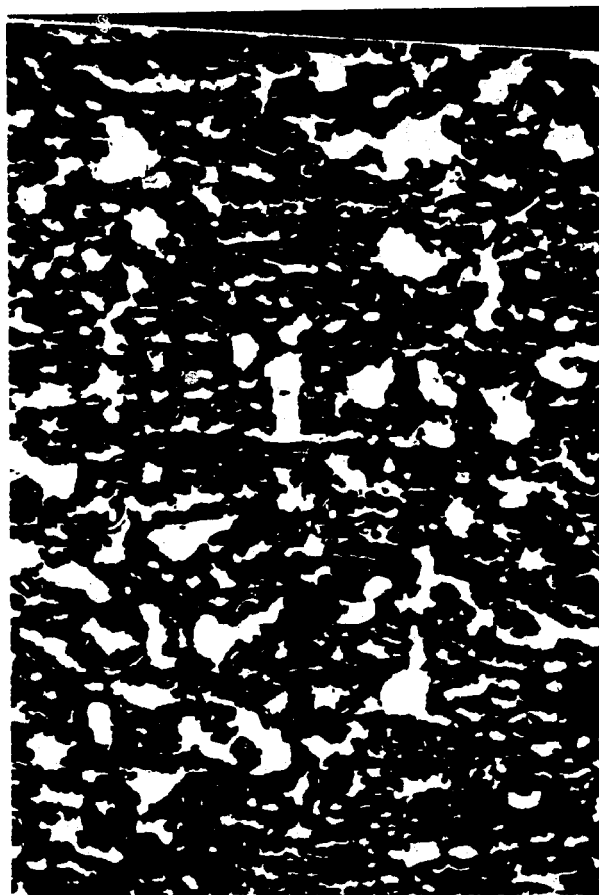
**PLATE 39**

Photograph of stromatoporoid sub-facies: Amphipora limestone.



PLATE 40

**Photograph of thin section of stromatoporoid sub-facies: Amhipora
with head of Actinostroma.**

**PLATE 41**

Photograph of thin section of birdseye sub-facies: a framework of micritic limestone with irregular patches and stringers of clear sparry calcite.

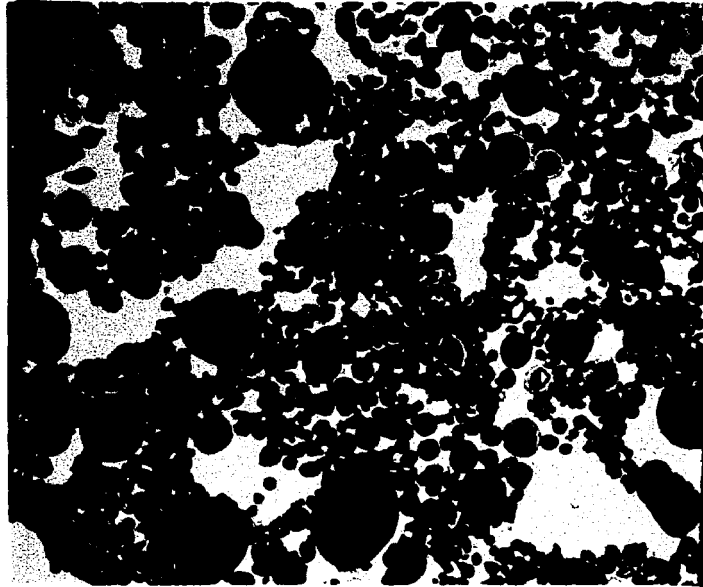


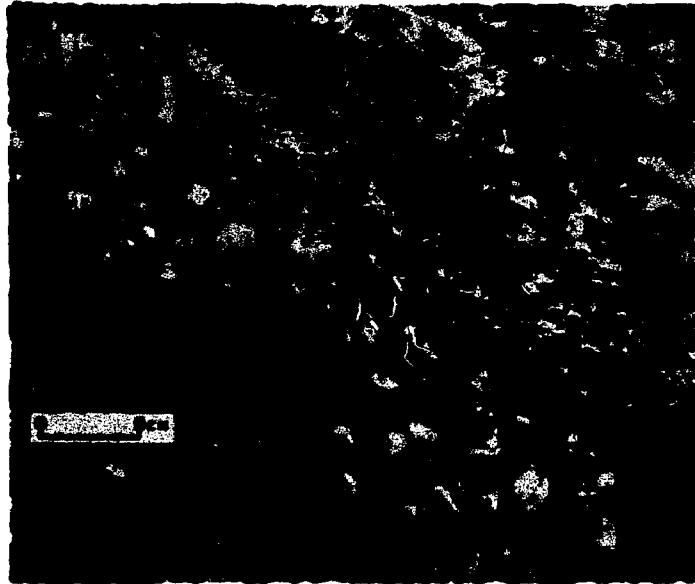
PLATE 42

Photograph of thin section of oolite sub-facies: poorly sorted, coarse-grained oolite with birdseye spar (white).



PLATE 43

Photograph of oncolite sub-facies: weathered surface showing algal nodules.

**PLATE 44**

Photograph showing capped oncolites demonstrating the depositional dip of 35° .

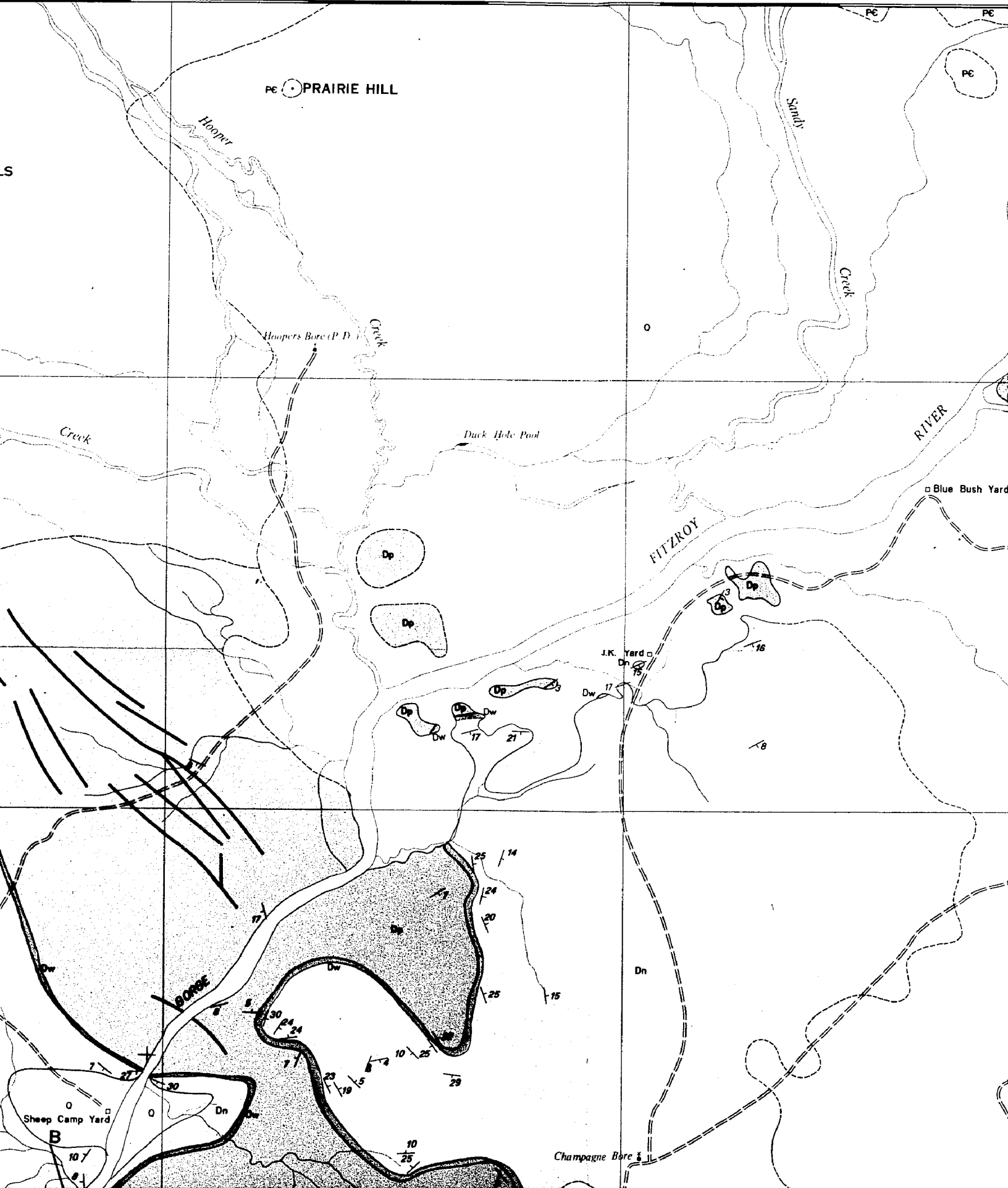


PLATE 45

Photograph of thin-section of the reef-facies: biogenic, sparry, fine-grained calcirudite with fragmentary stromatoporoids, brachiopods and other fossils with intraclasts of turbid micrite.

370

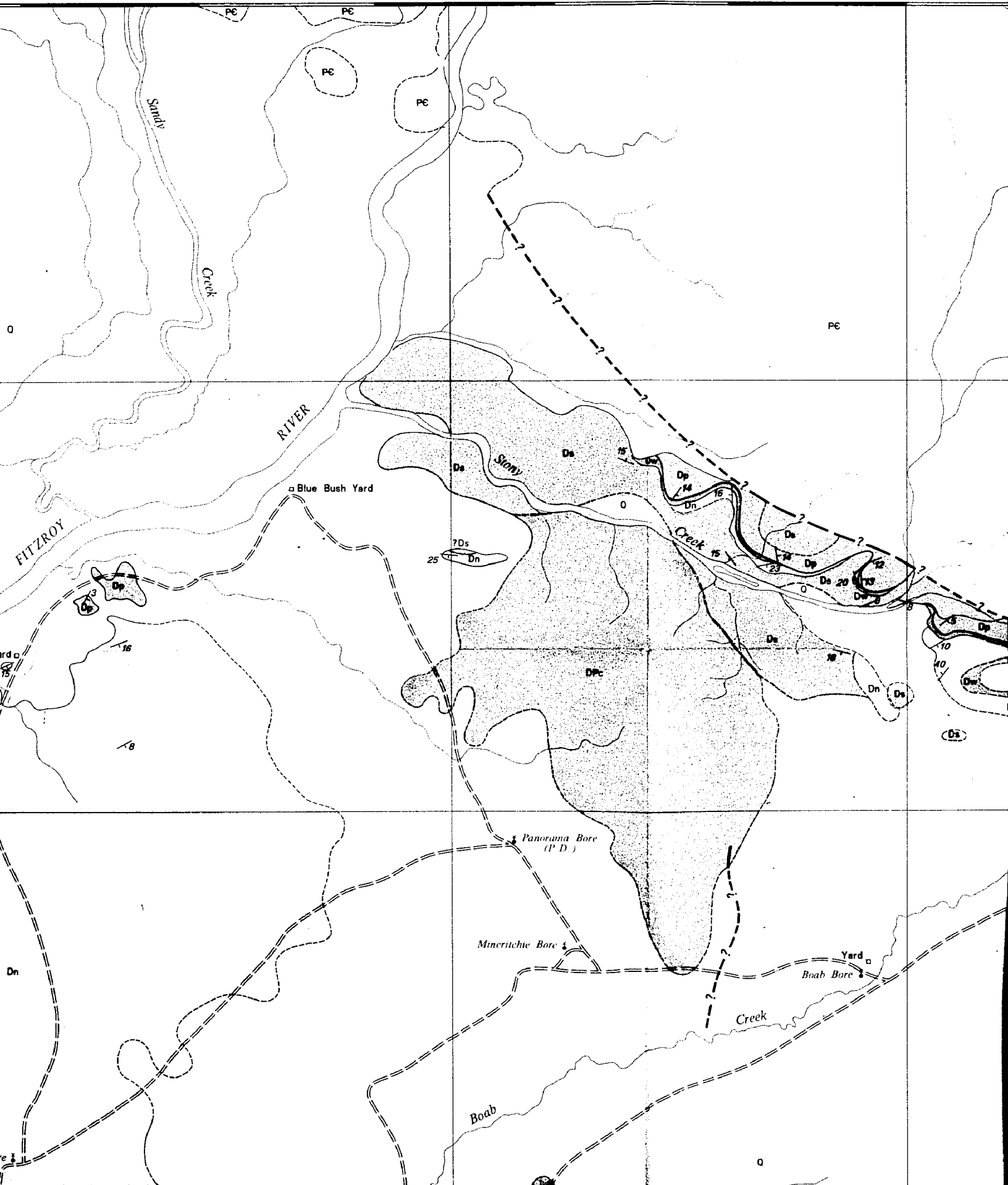
380 50'

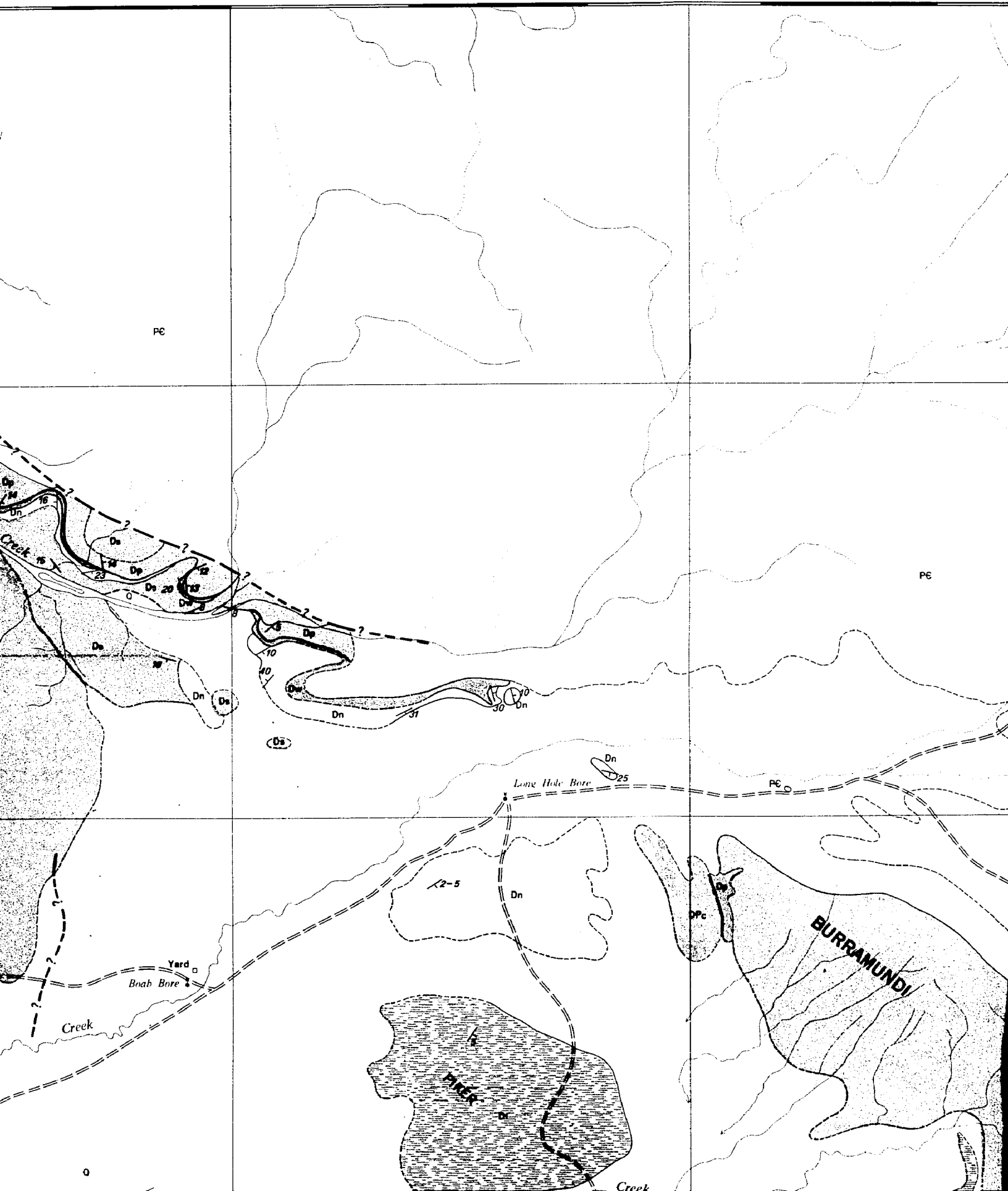


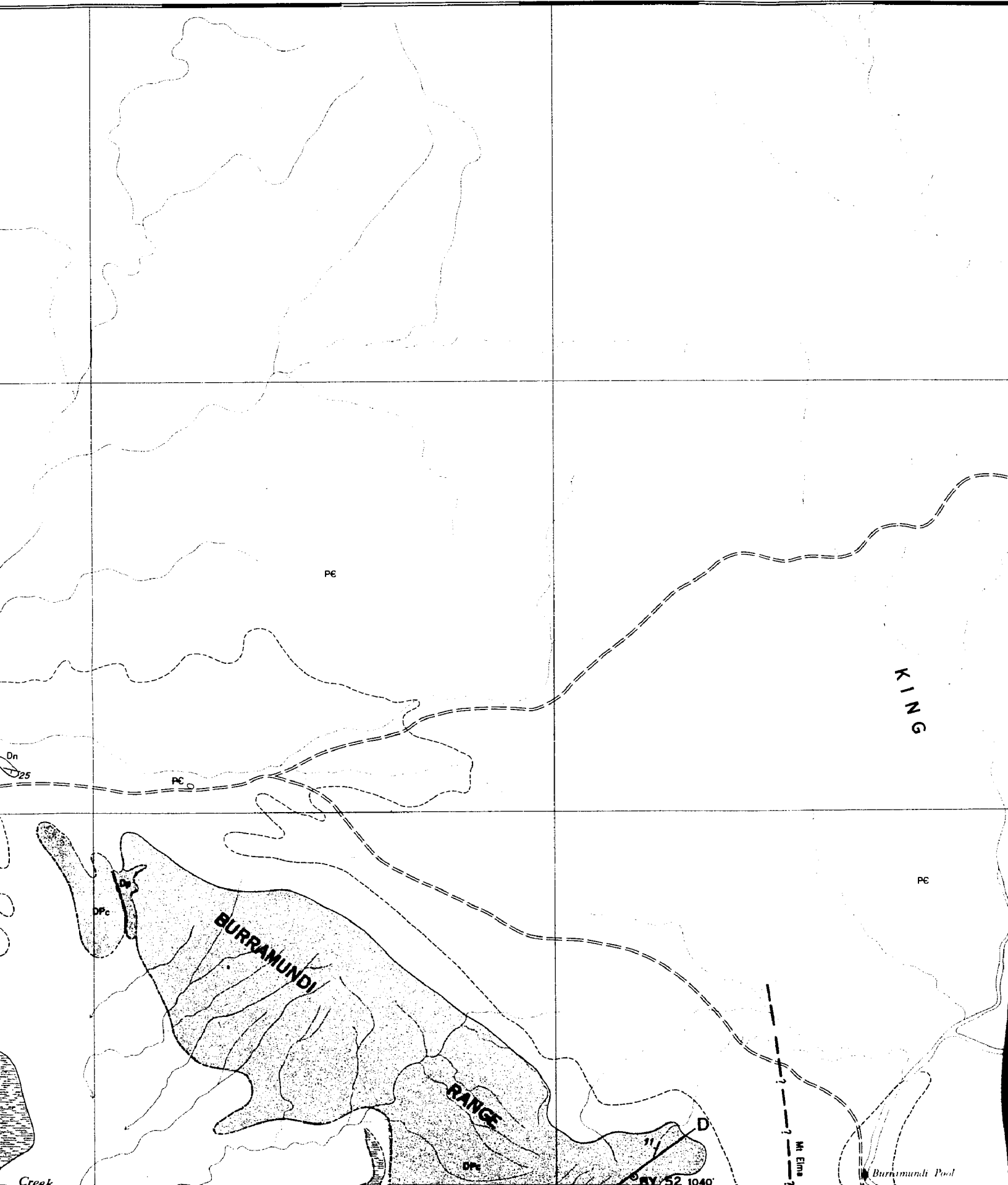
50'

390

126° 00'
400







10° 420

430000Y E

126° 19'

17° 50'

2750000Y N

LANSLOWNE APPROX 50M

2740

18° 00'

KING

PC

RIVER

LEOPOLD

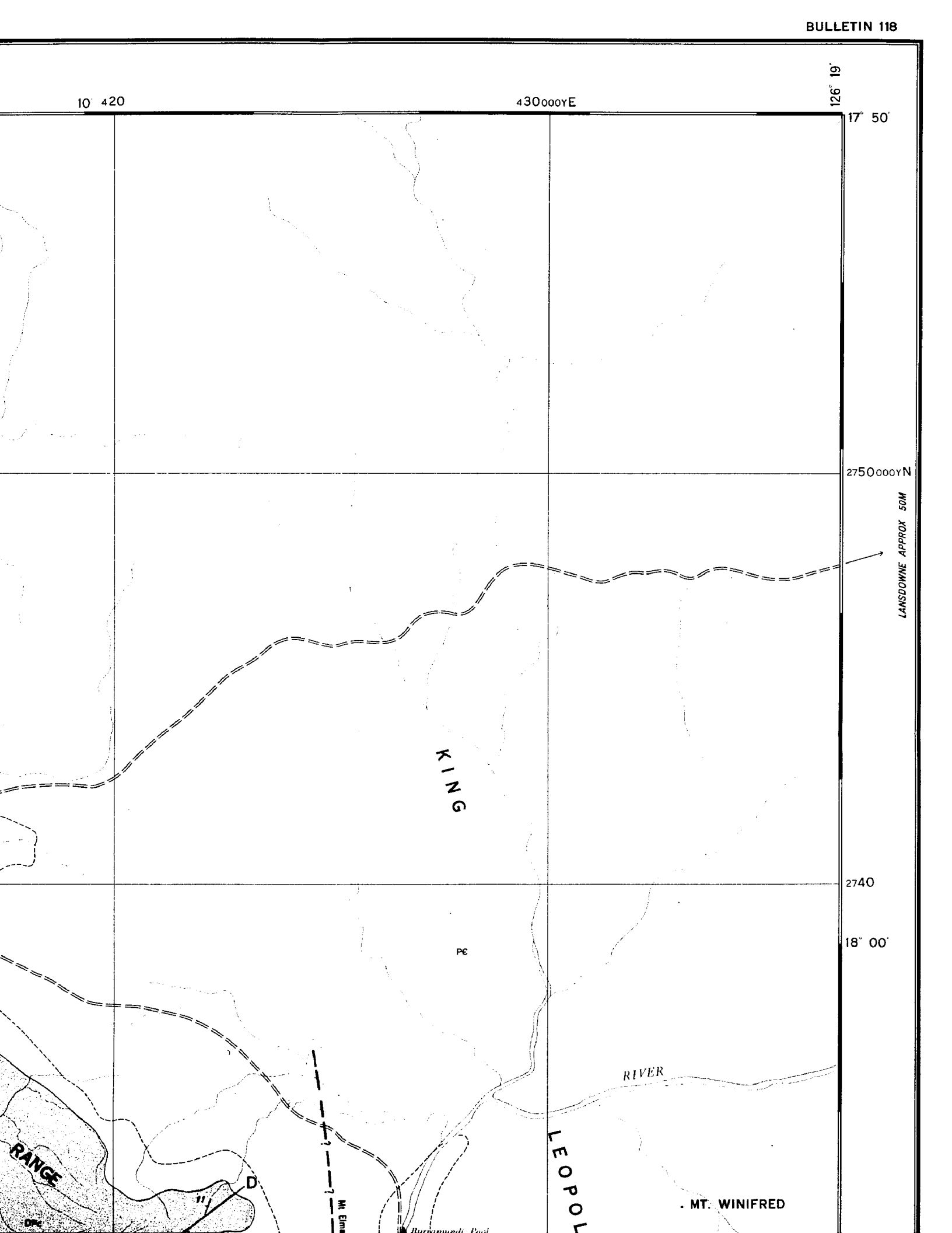
MT. WINIFRED

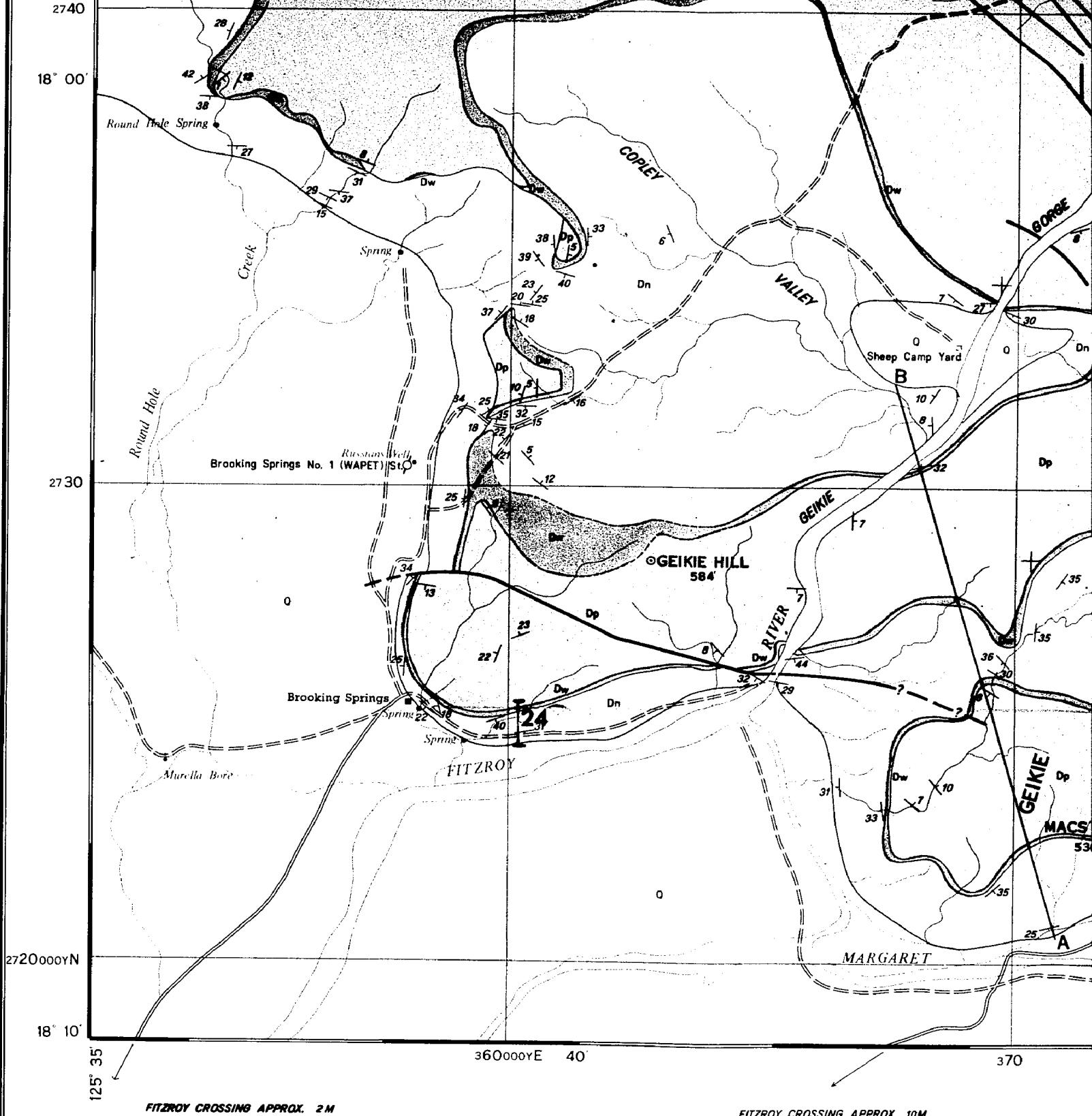
RANGE

D

Mt. Elmore

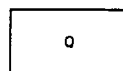
Burnhamundi Pool





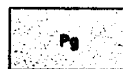
REFERENCE

QUATERNARY

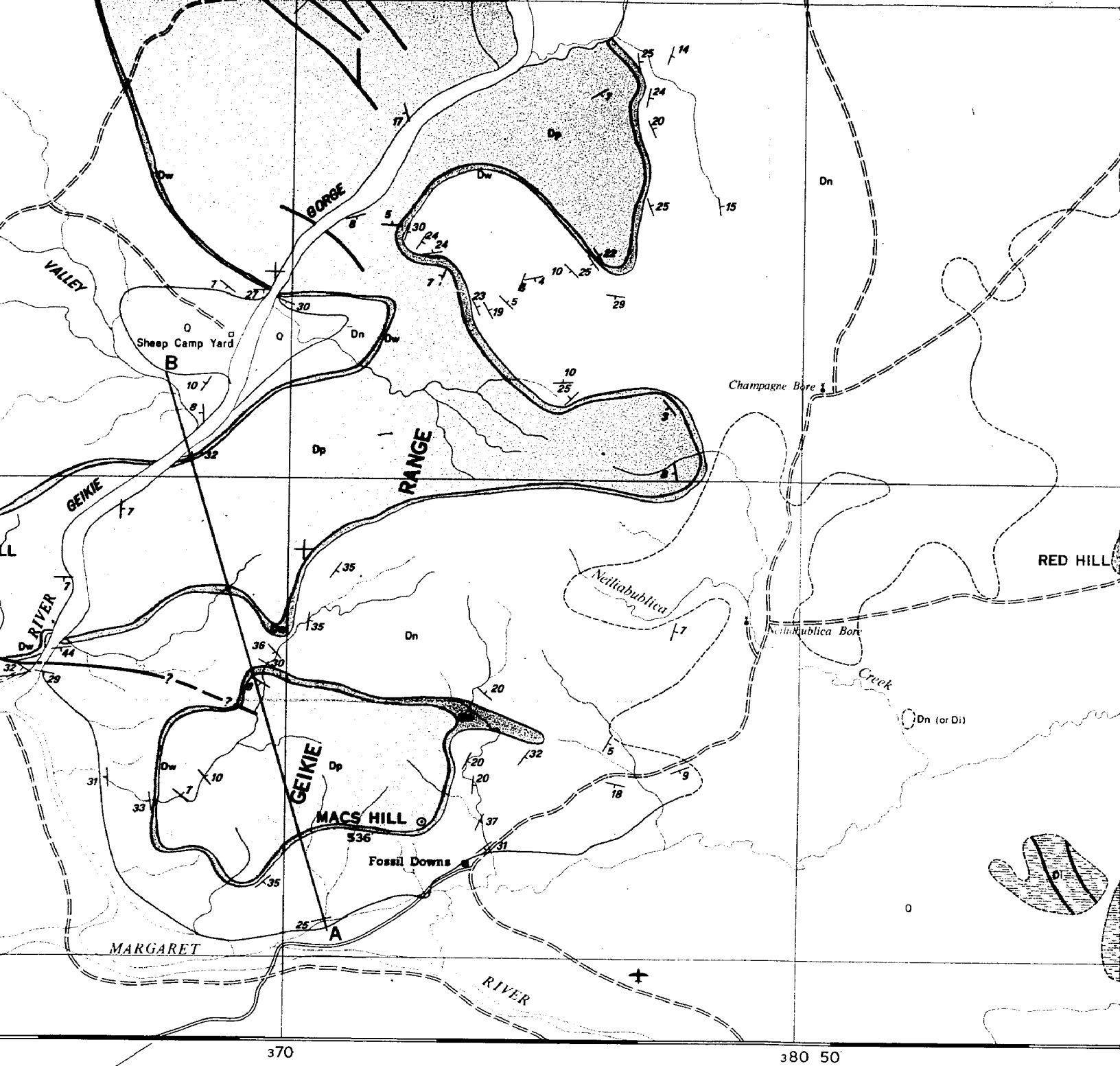


Superficial deposits

PERMIAN



Grant Formation

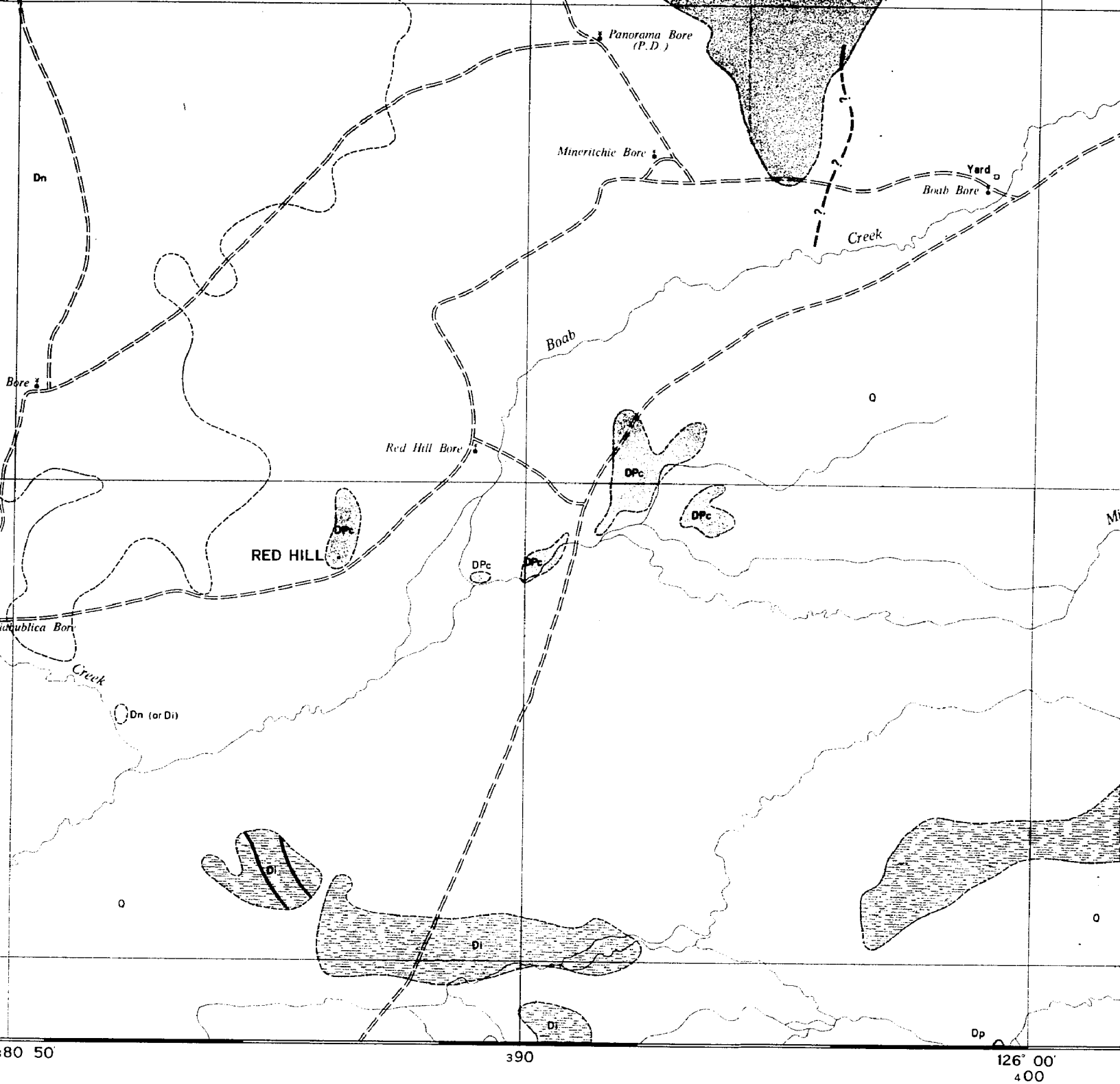


FITZROY CROSSING APPROX. 10M

deposits

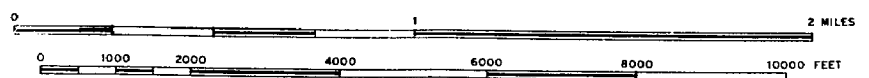
ion

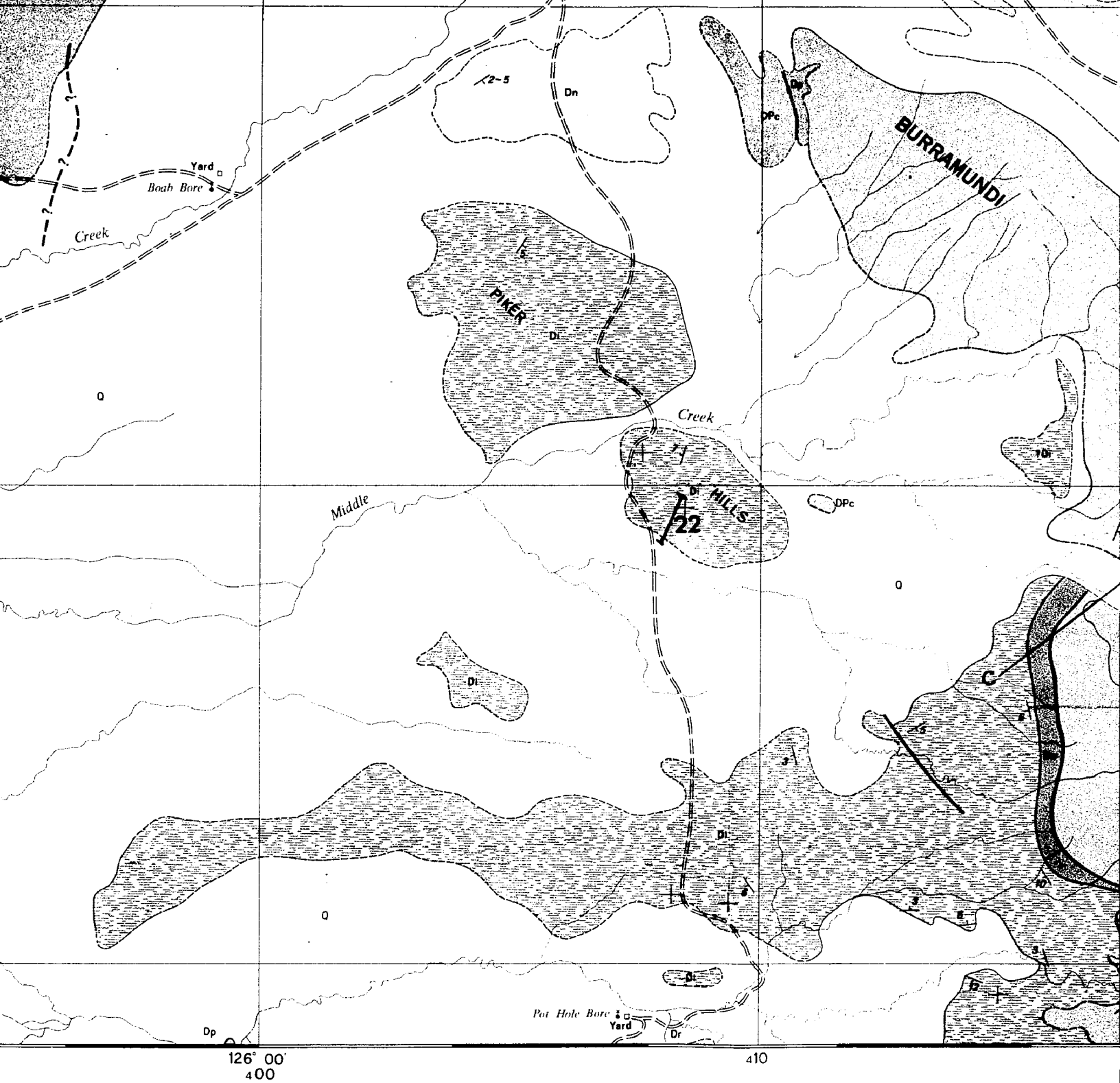
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CROSS SECTIONS

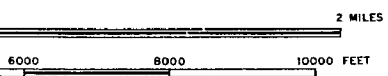
NATURAL SCALE (MAP SCALE X 3)





IONS

P SCALE X 3)



RANGE

GEIKIE

18° 10'

125° 35'

360000E 40'

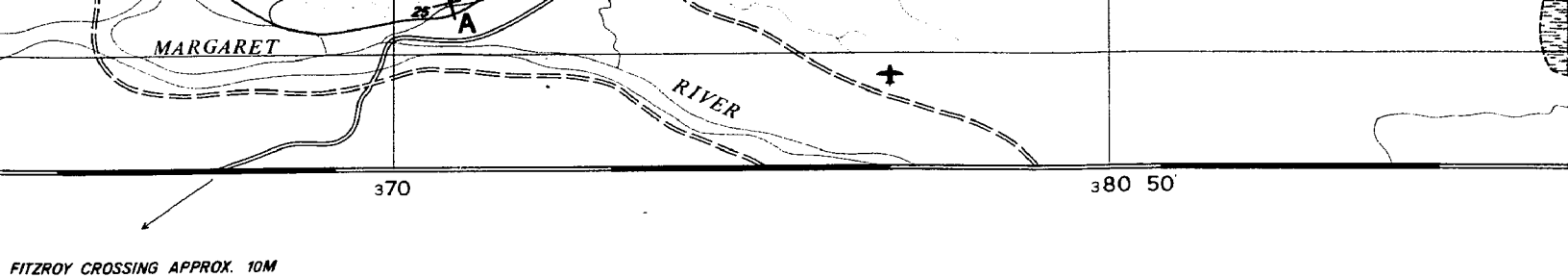
370

FITZROY CROSSING APPROX. 2M

FITZROY CROSSING APPROX. 10M

REFERENCE

DEVONIAN	QUATERNARY	O	Superficial deposits
	PERMIAN	Pg	Grant Formation
	DEVONIAN AND ?PERMIAN	DPc	Undifferentiated conglomerates
	Famennian	Dcl	Fairfield Formation
		Di	Piker Hills Formation FORE - REEF AND INTER - REEF FACIES
	Famennian and/or Frasnian	Ds	Stony Creek Conglomerate
	Famennian - Frasnian	Dn	Napier Formation FORE - REEF AND INTER - REEF FACIES
		Dr	Virgin Hills Formation FORE - REEF AND INTER - REEF FACIES
	Famennian - ?Givetian	Dw	Windjana Limestone REEF FACIES
		Dp	Pillara Limestone BACK - REEF FACIES
	Frasnian - ?Givetian	Dd	Sadler Limestone FORE - REEF FACIES
		Dg	Gogo Formation INTER - REEF FACIES
	PRECAMBRIAN	PE	Basement complex



deposits

tion

ted conglomerates

mation

Formation
AND INTER - REEF FACIES

Conglomerate

mation
AND INTER - REEF FACIES

Formation
AND INTER - REEF FACIES

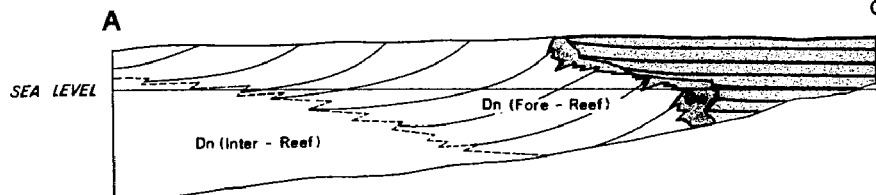
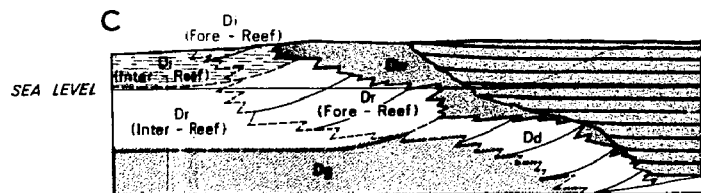
mestone
S

stone
F FACIES

stone
F FACIES

ation
EF FACIES

complex



Geological boundary, position accurate

Geological boundary, position approximate

Trend lines

Fault - position accurate

position approximate

concealed

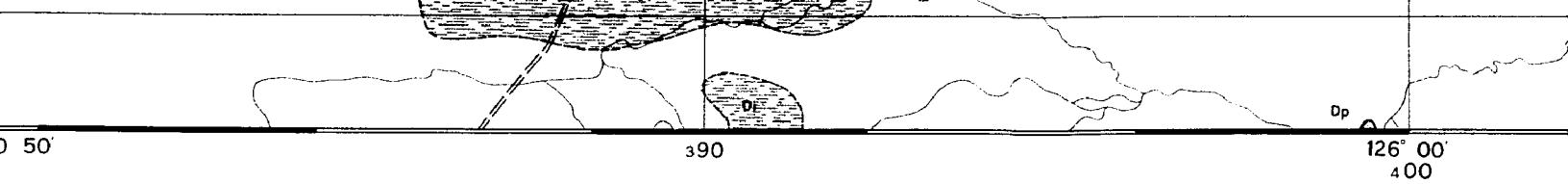
inferred

inferred, concealed

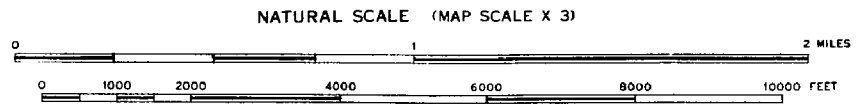
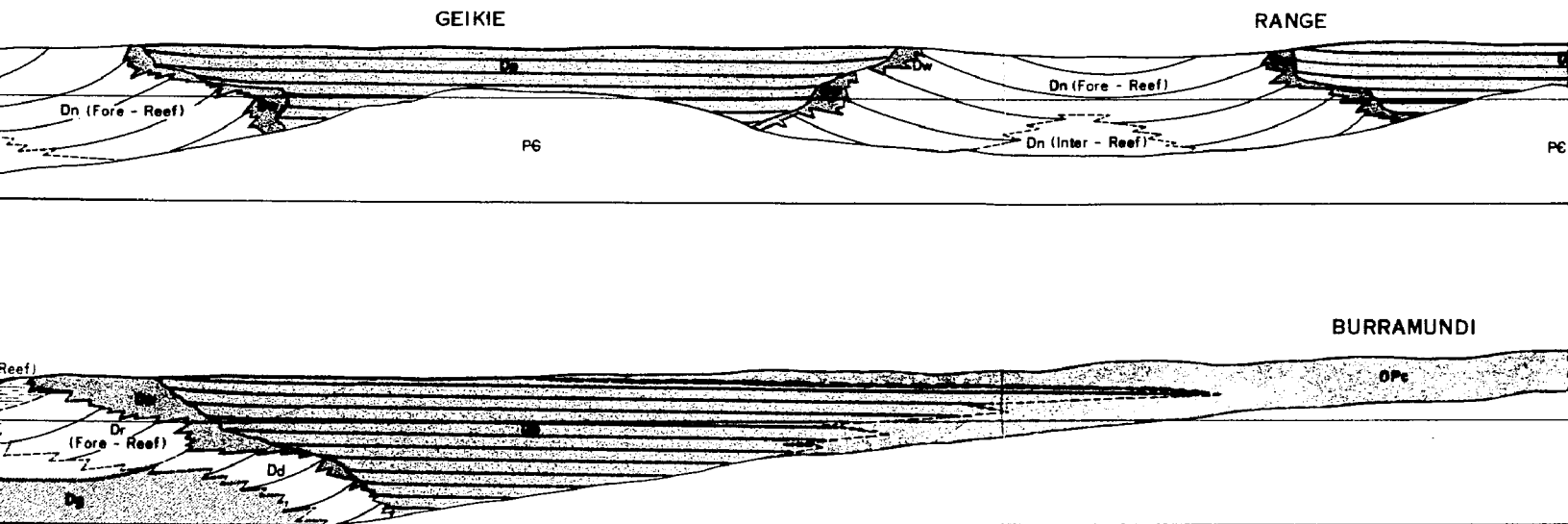
Dip and strike of bedding

Horizontal bedding

Stratigraphic well



CROSS SECTIONS

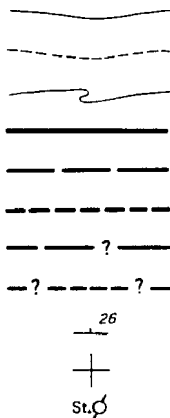


SYMBOLS

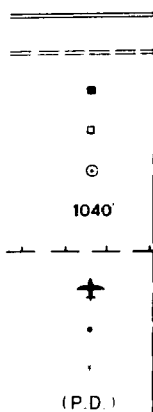
boundary, position accurate
boundary, position approximate

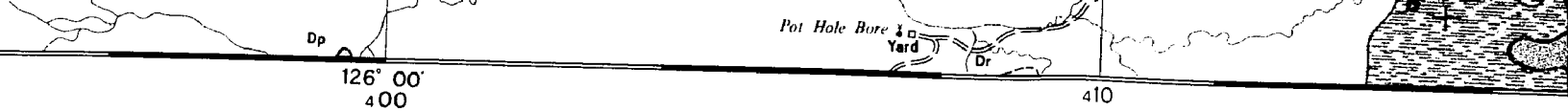
on accurate
on approximate
led
d
d, concealed
e of bedding

lding
vell



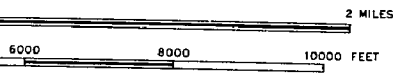
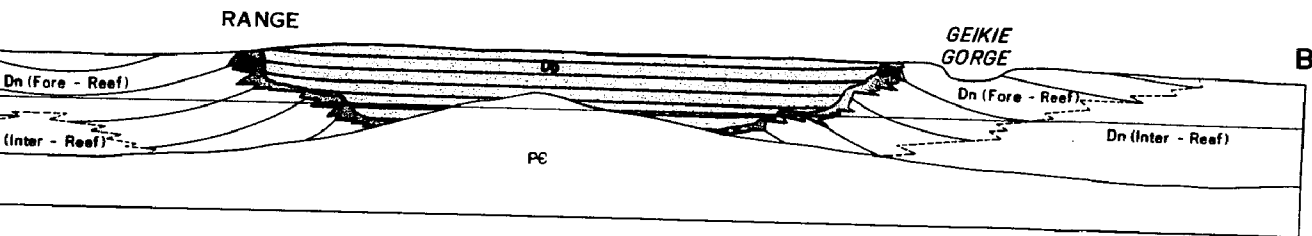
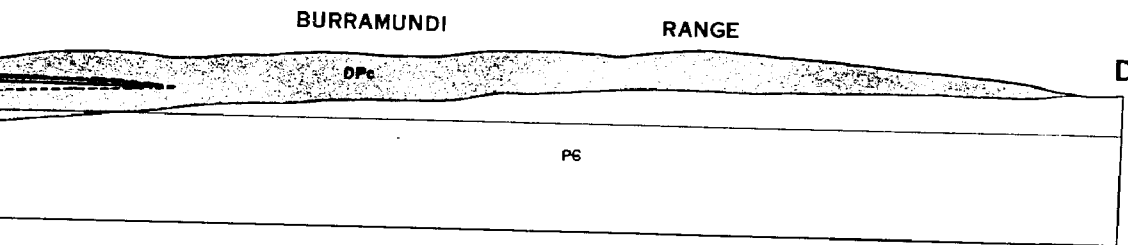
Road
Track
Homestead
Yard
Trigonometrical station, minor
Elevation in feet
Telegraph line
Airfield
Bore, well or waterhole
Windpump
Position doubtful





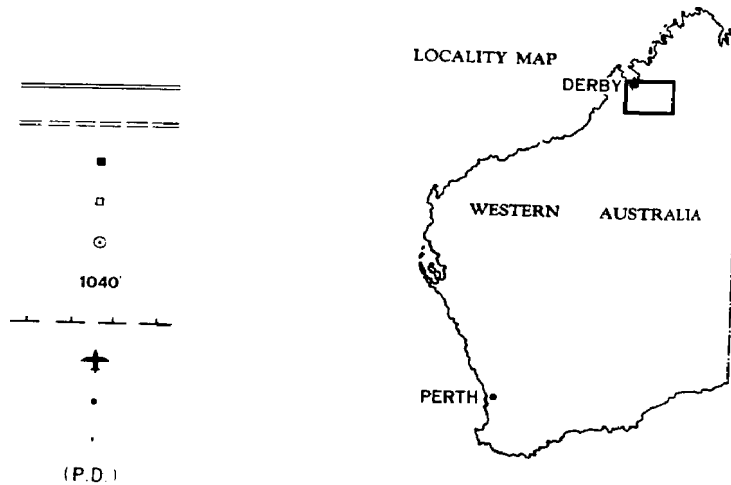
TIONS

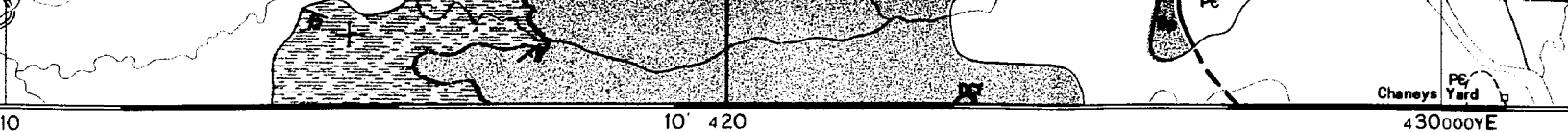
P SCALE X 3)



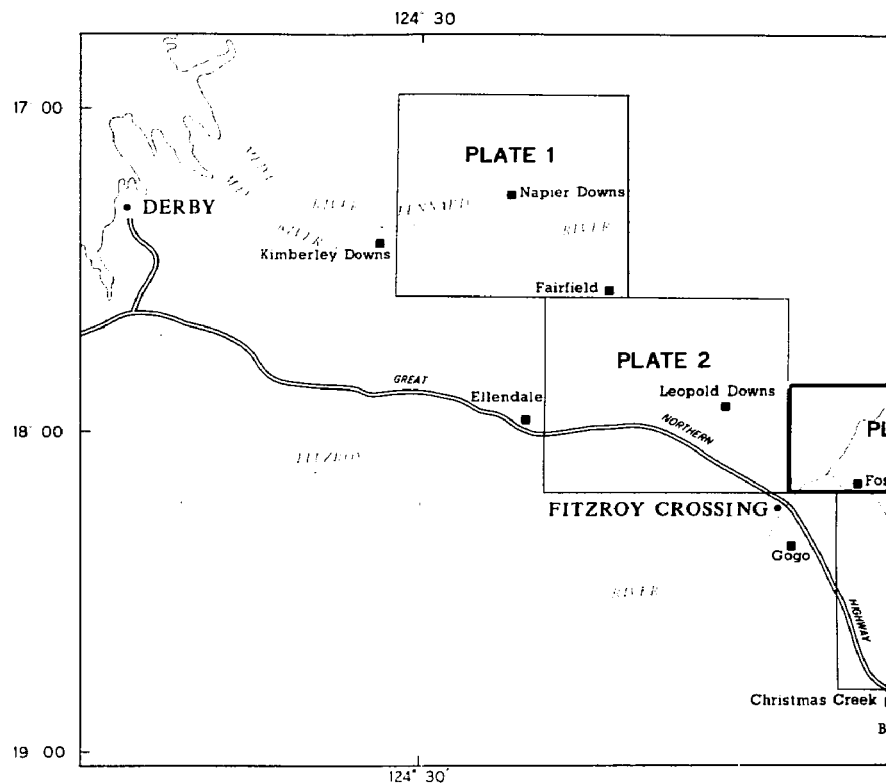
on, minor

hole

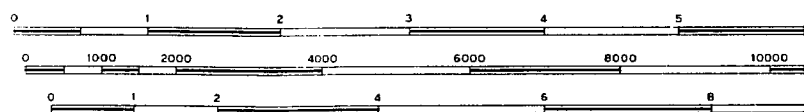




LOCATION DIAGRAM



SCALE 1 : 100.000



TRANSVERSE MERCATOR PROJECTION ZONE 3

The last three digits of the grid number are omitted

Grid interval 10,000 yards

Magnetic Declination approximately 3°E

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

CANNING BASIN

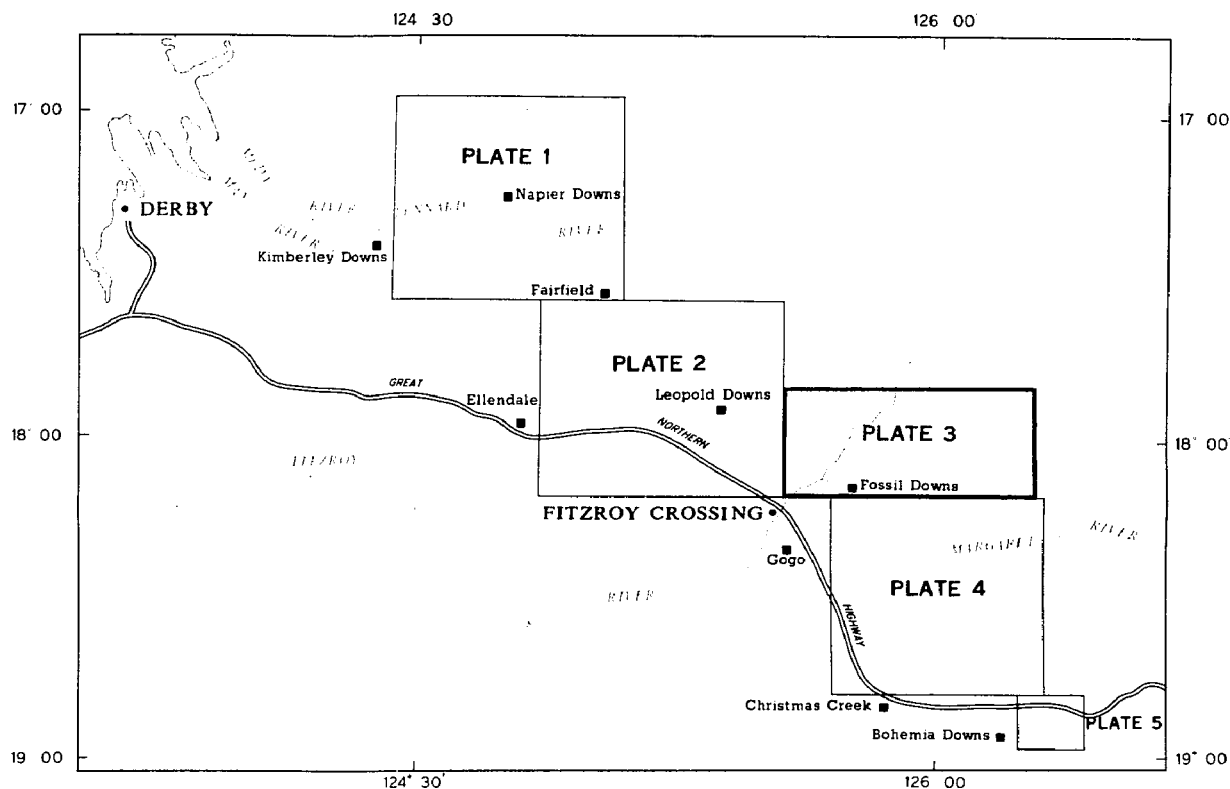
GEIKIE RANGE

BURRAMUNDI RANGE

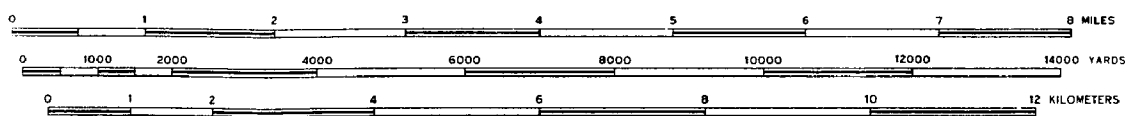
Geology by P. E. Playford and D. C. Lowry 1963



LOCATION DIAGRAM



SCALE 1 : 100,000



TRANSVERSE MERCATOR PROJECTION ZONE 3

The last three digits of the grid number are omitted

Grid interval 10,000 yards

Magnetic Declination approximately 3°E

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

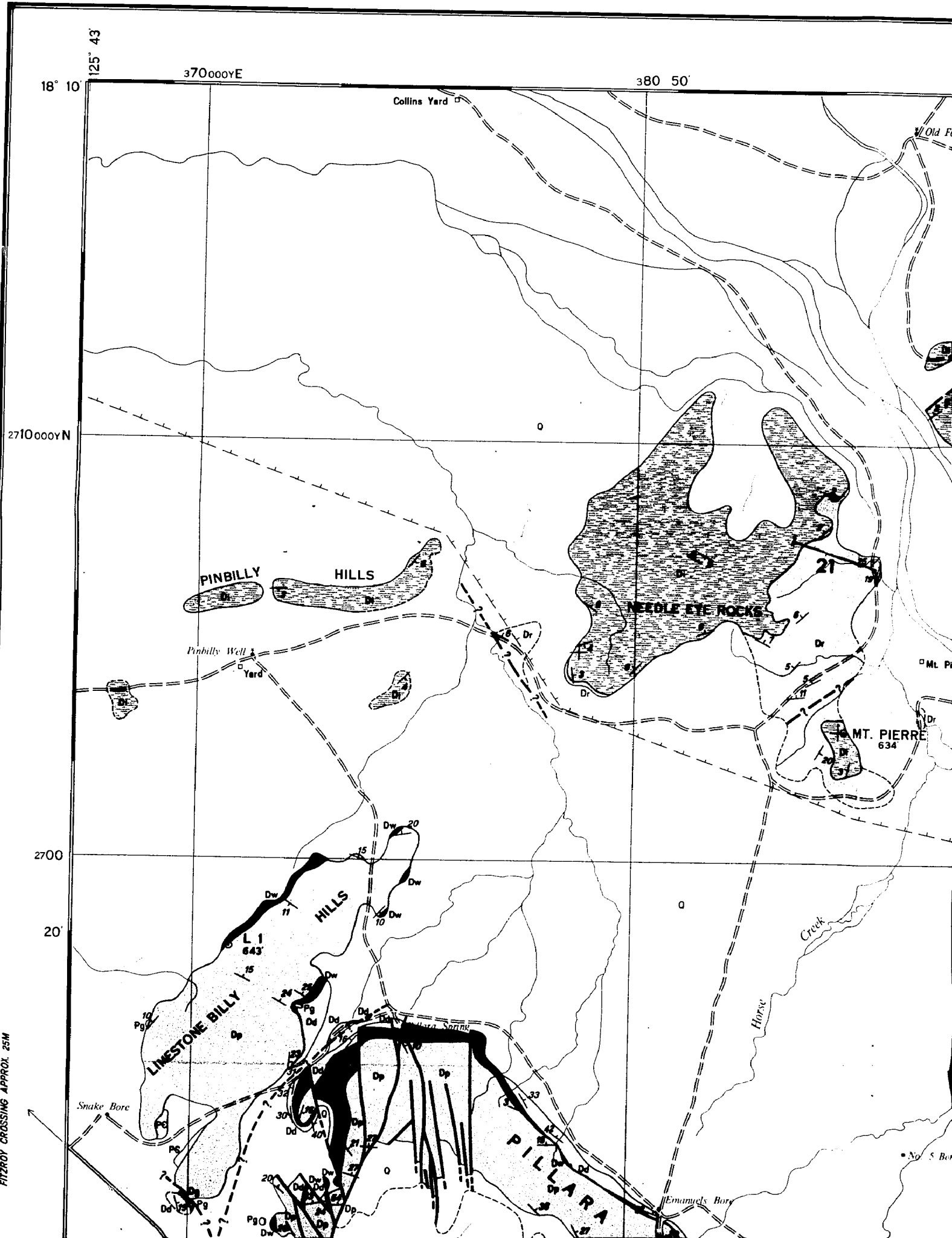
CANNING BASIN

GEIKIE RANGE -

BURRAMUNDI RANGE AREA

Geology by P. E. Playford and D. C. Lowry 1963

PLATE 3

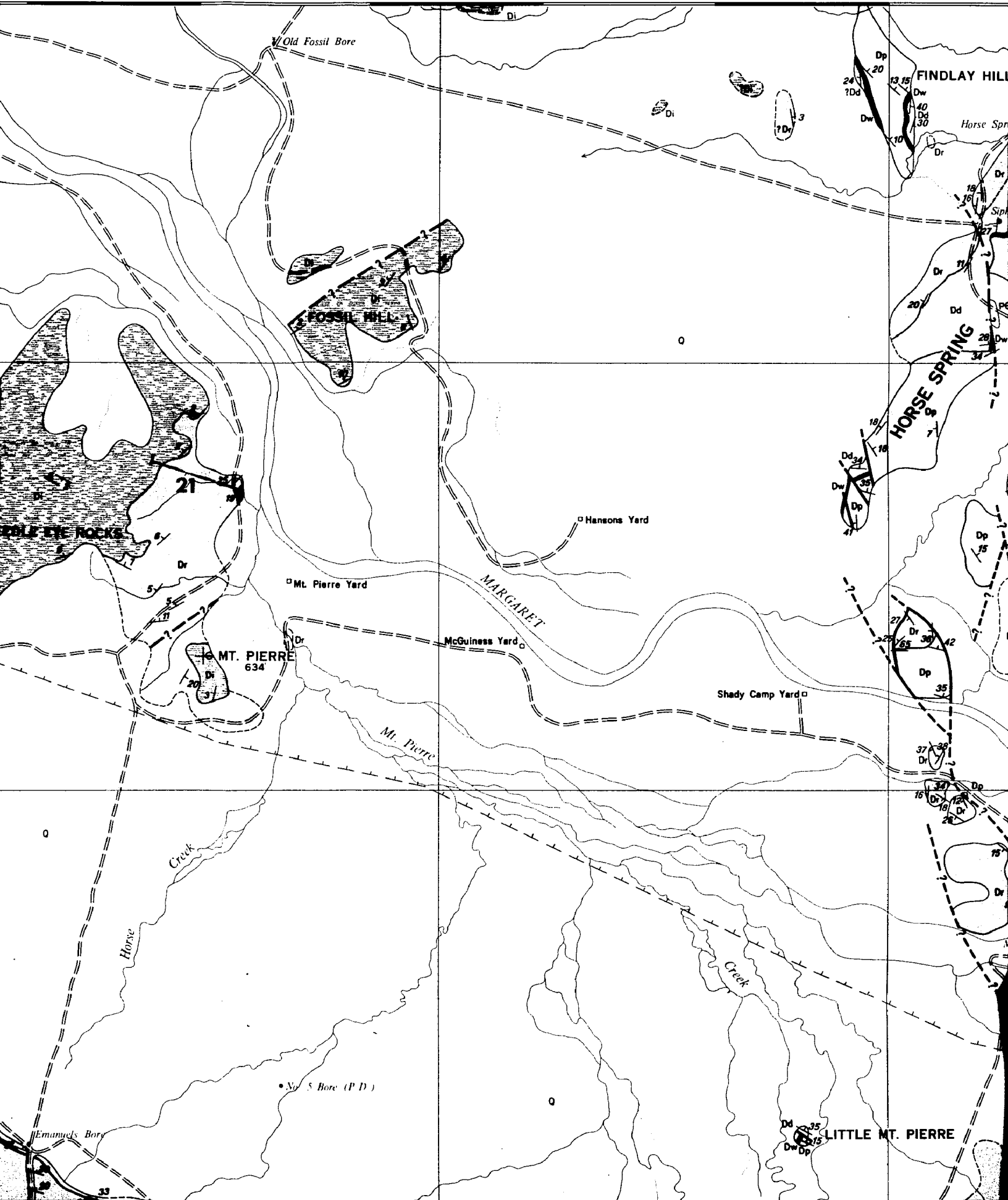


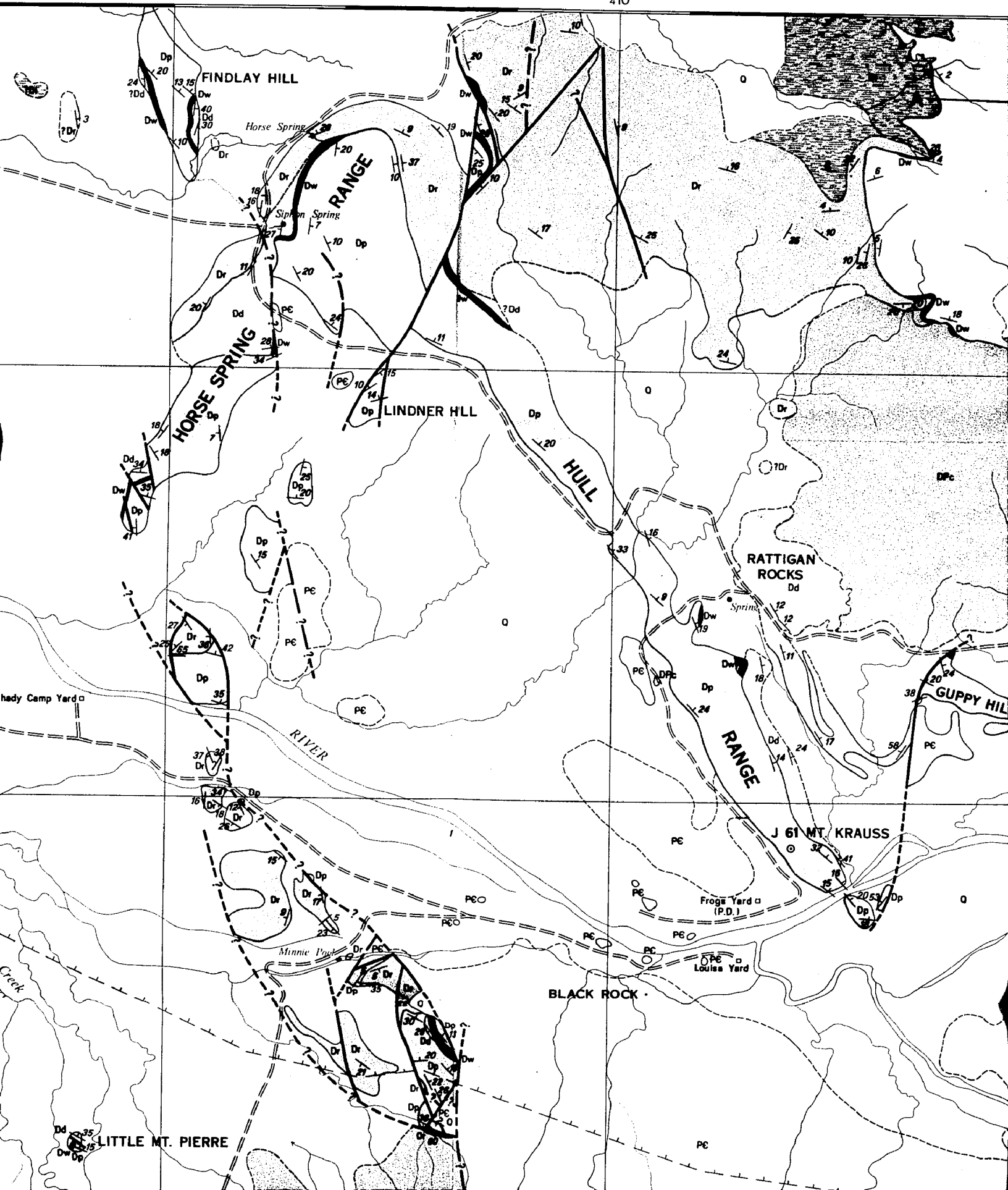
FITZROY CROSSING APPROX. 25M

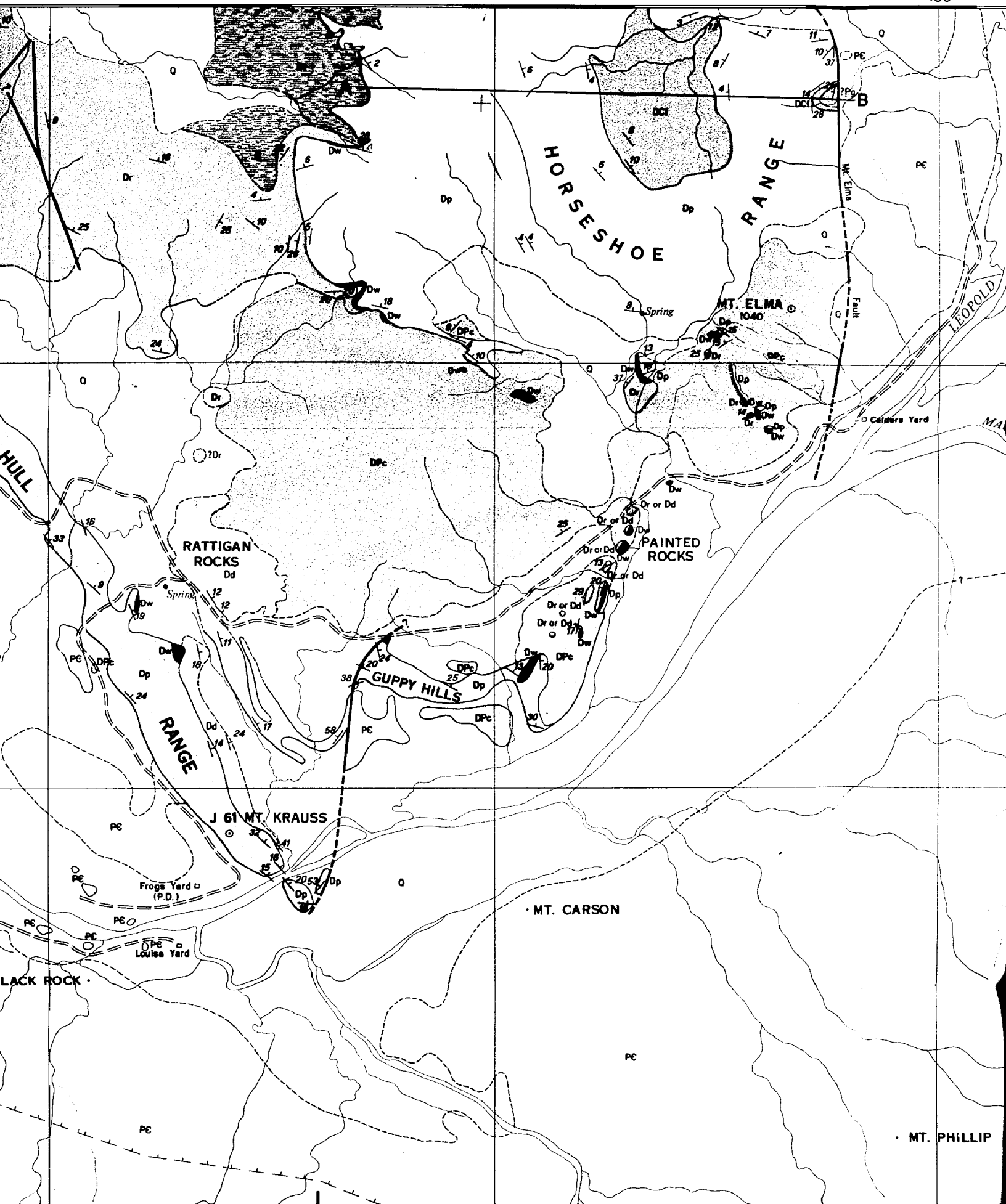
0 50'

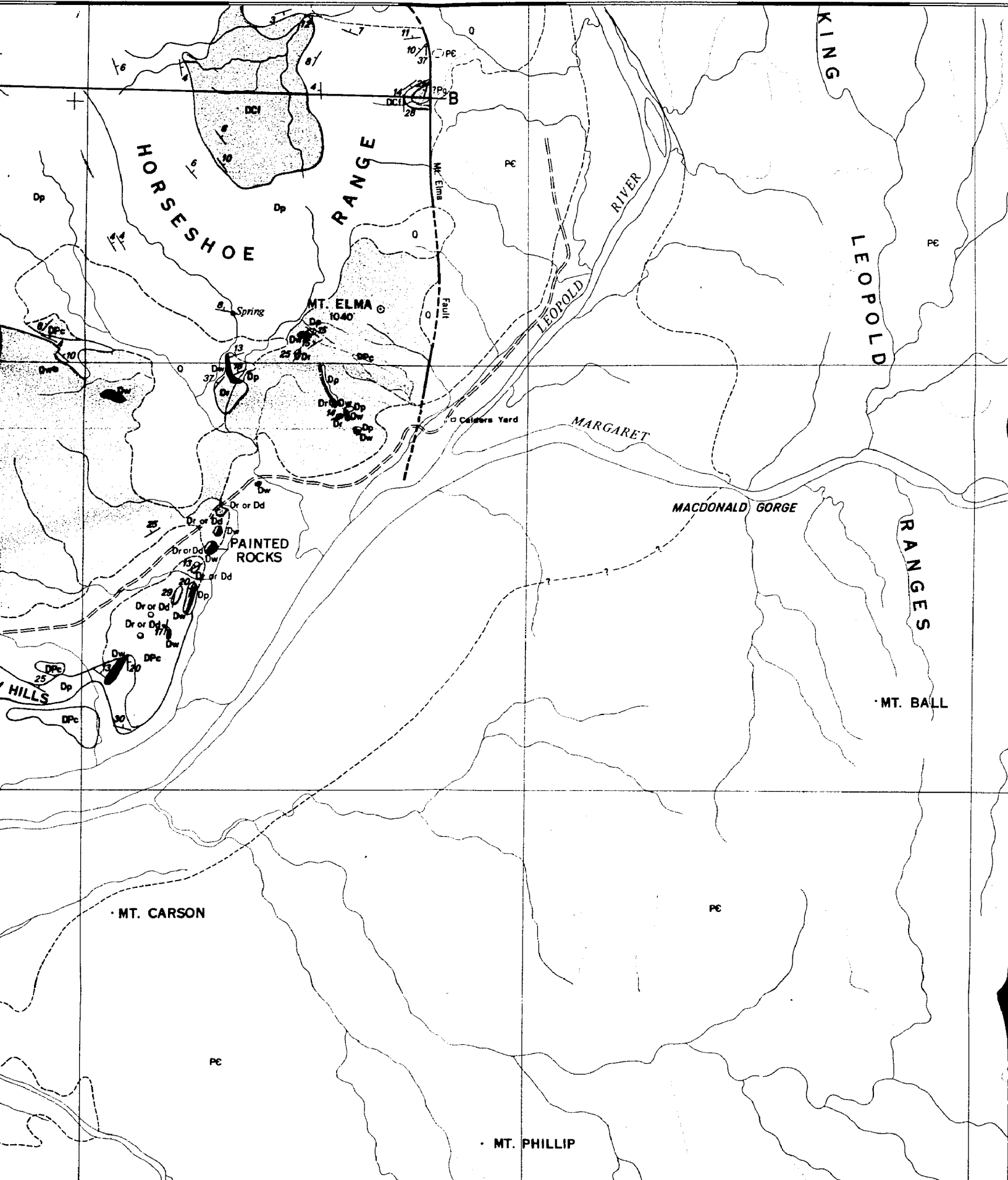
390

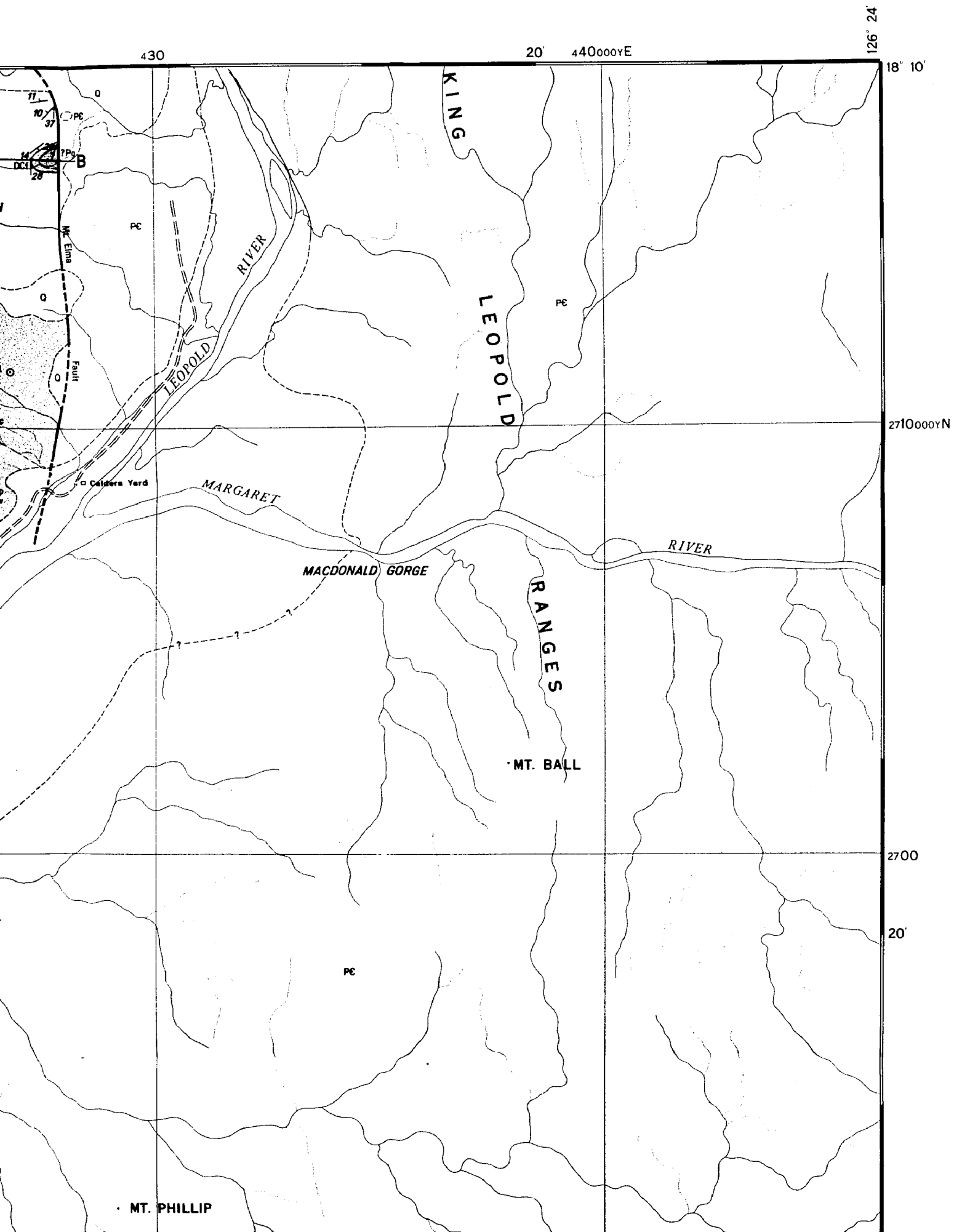
400
126° 00'



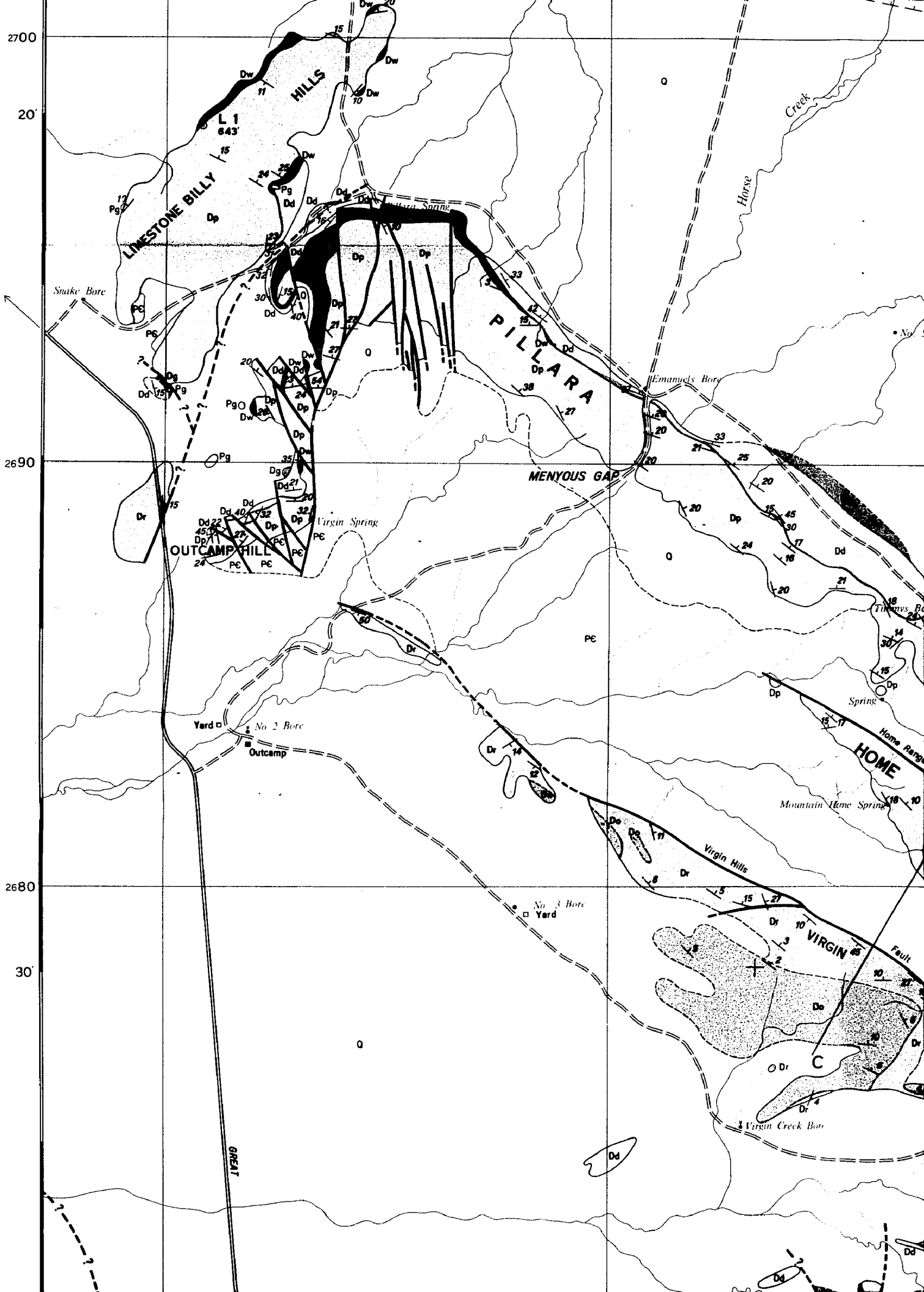


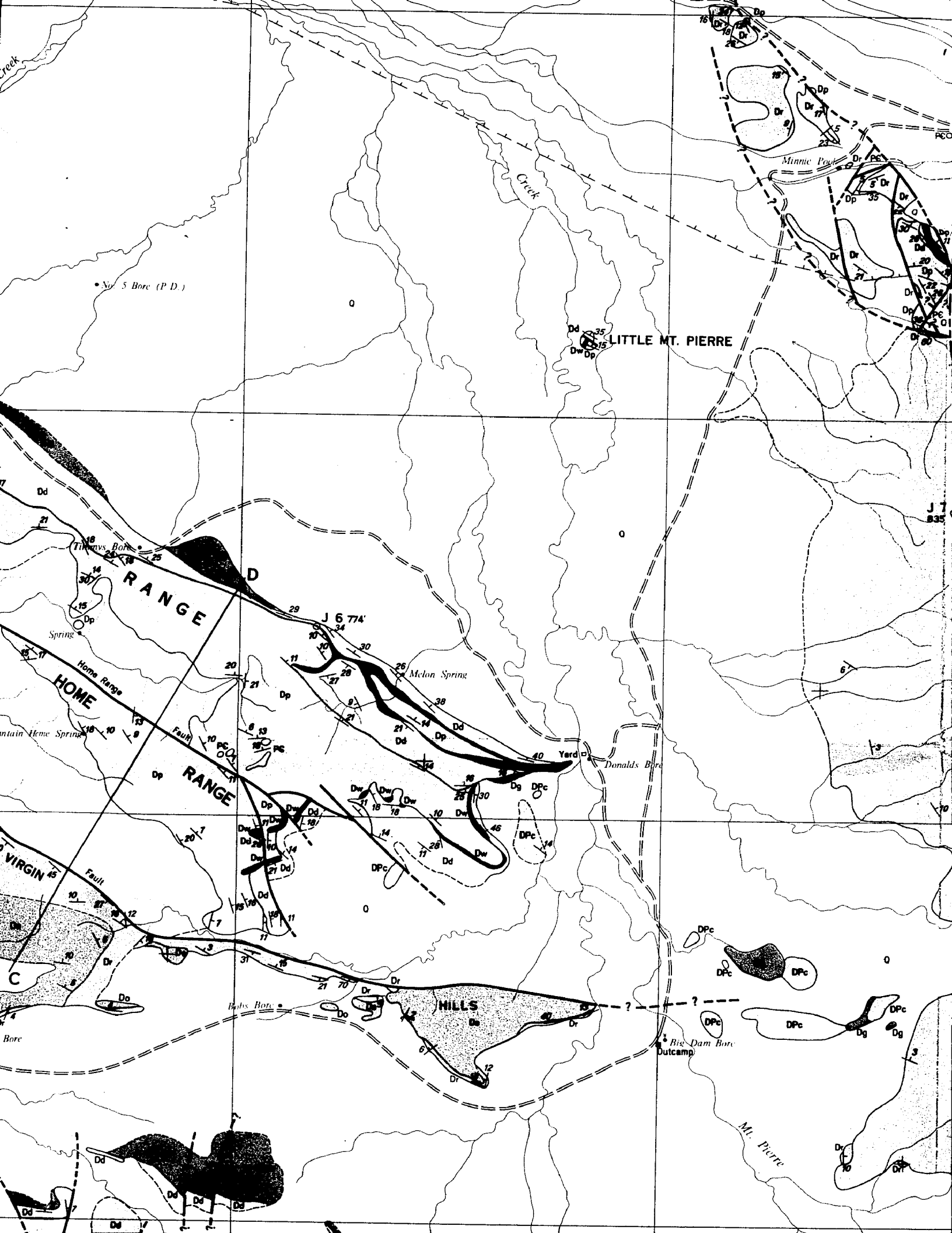


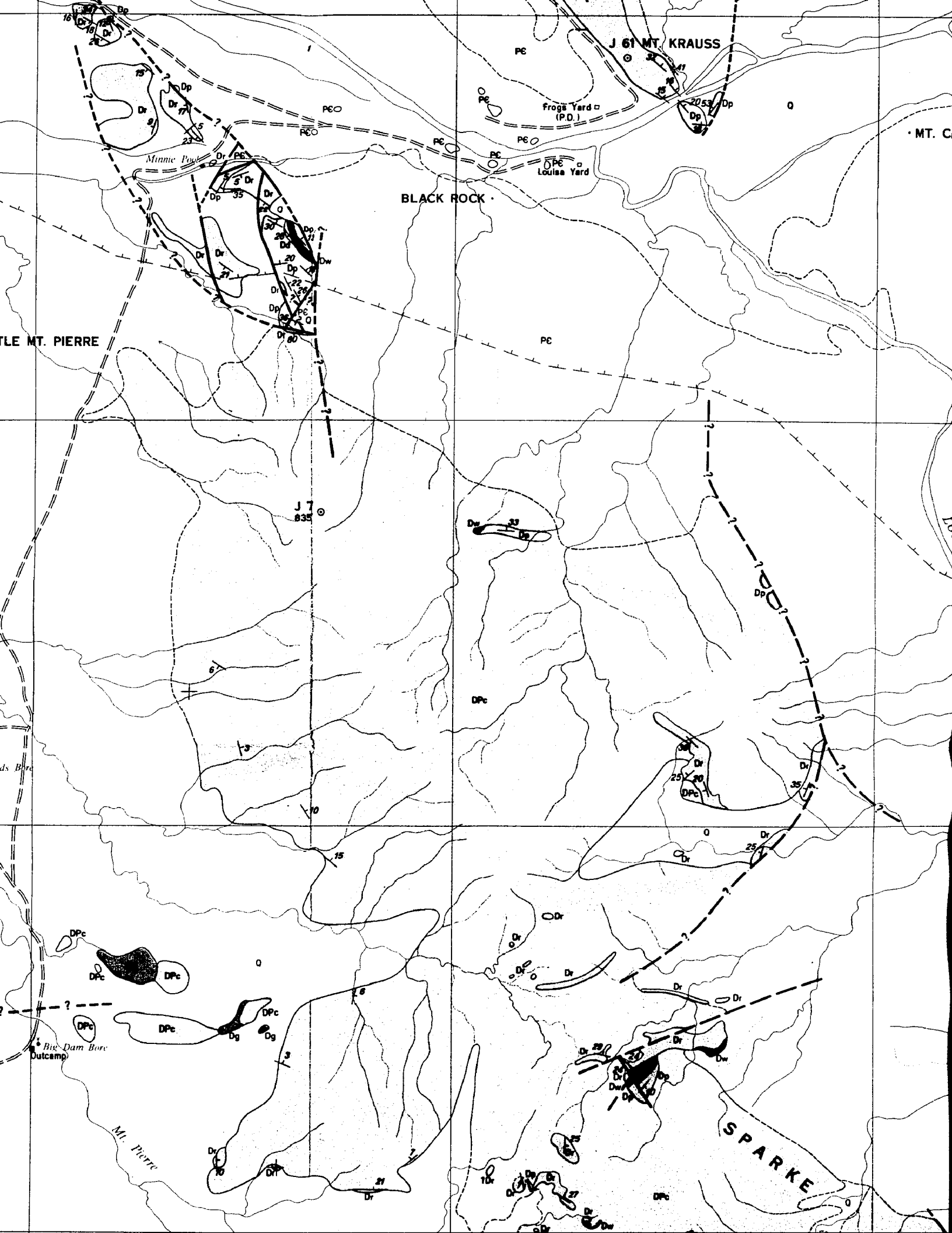


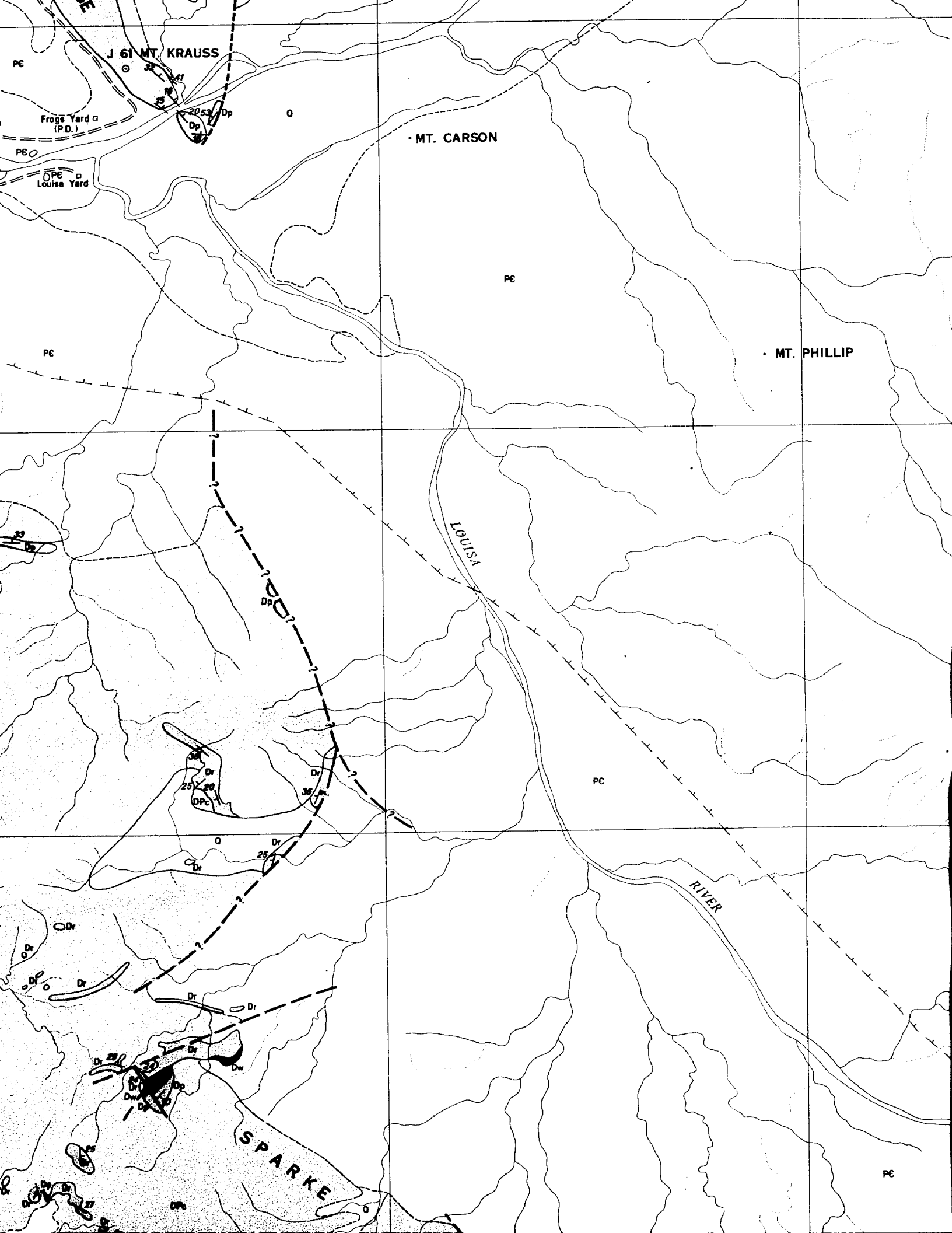


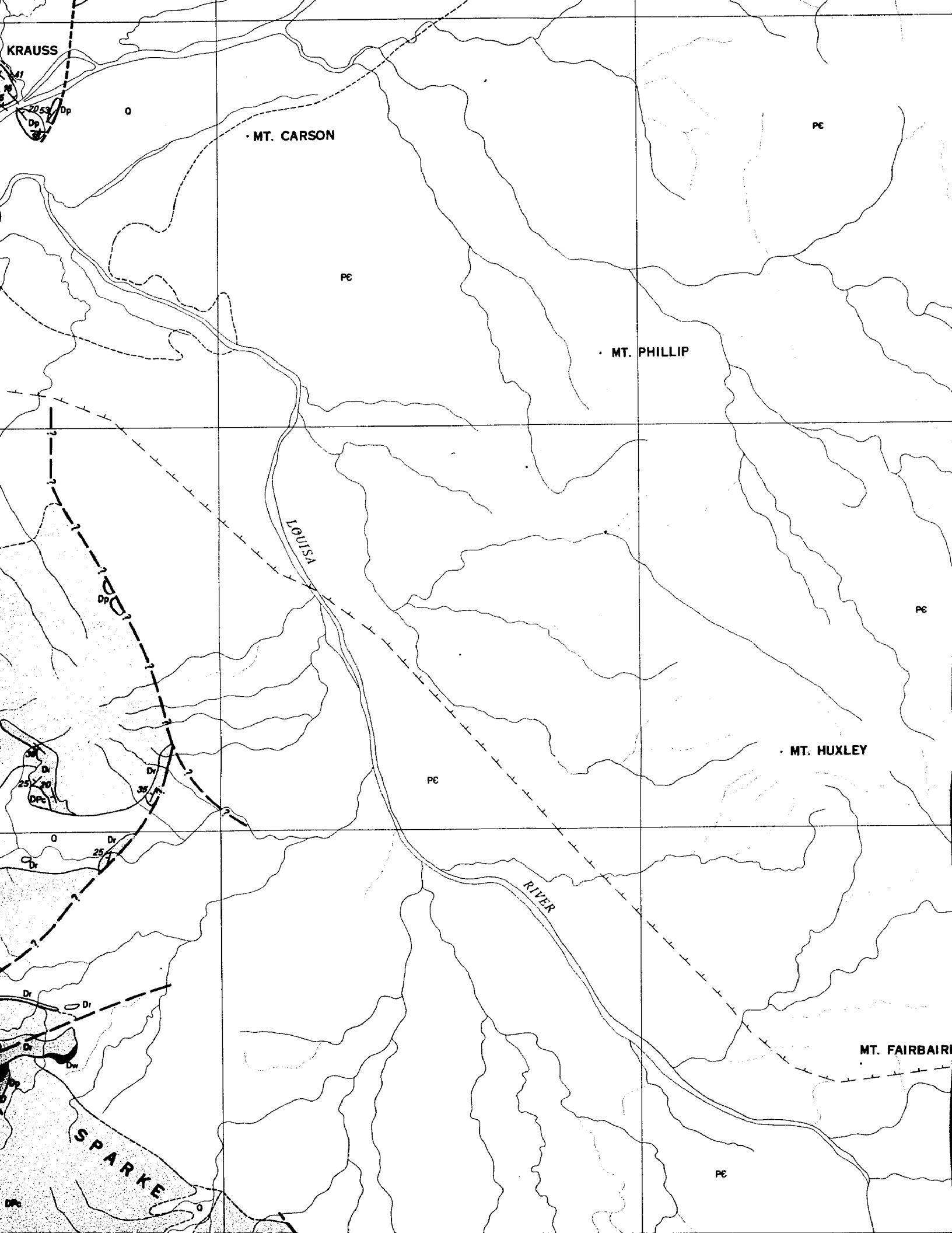
FITZROY CROSSING APPROX 25M

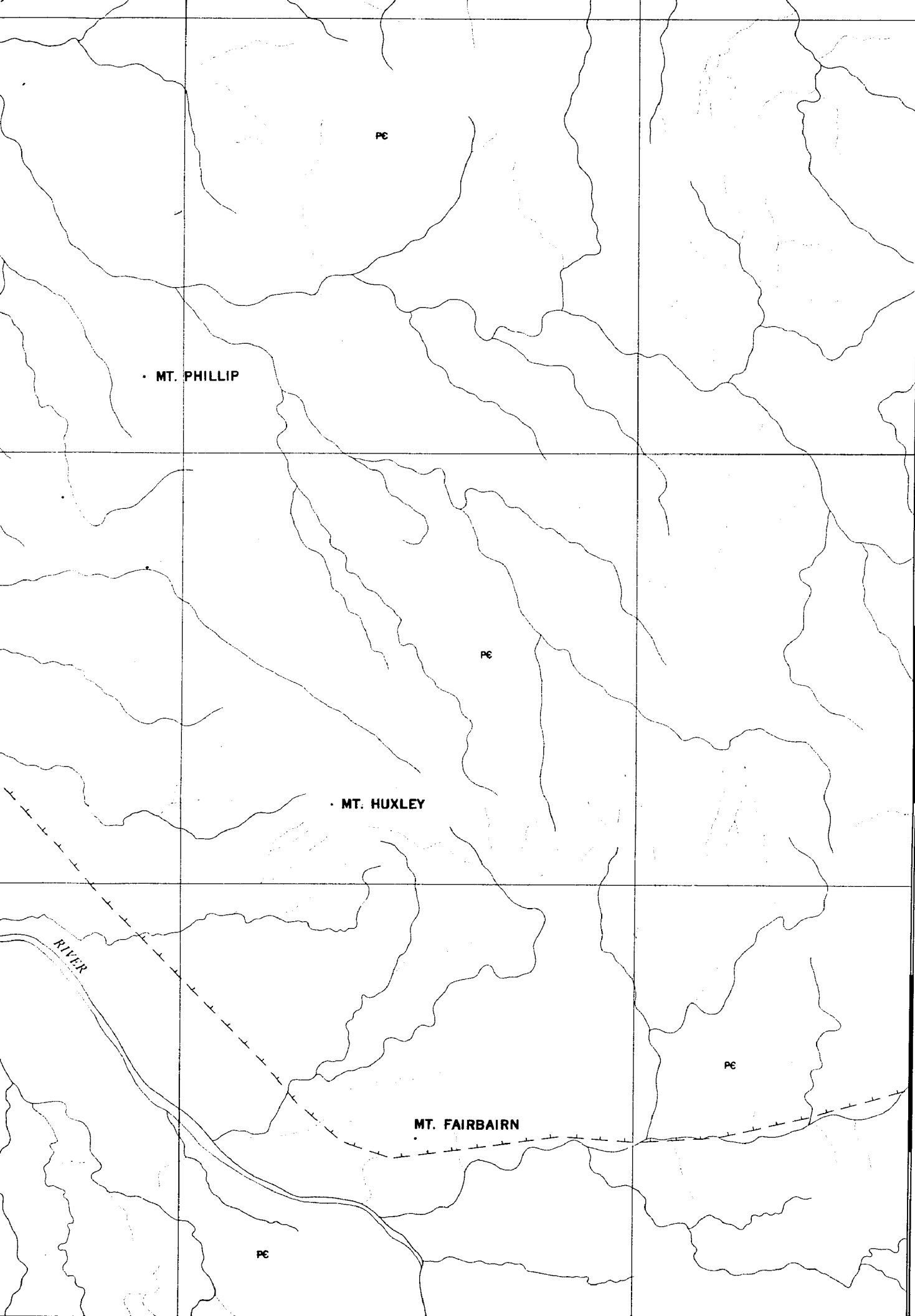












2700

20'

2690

2680

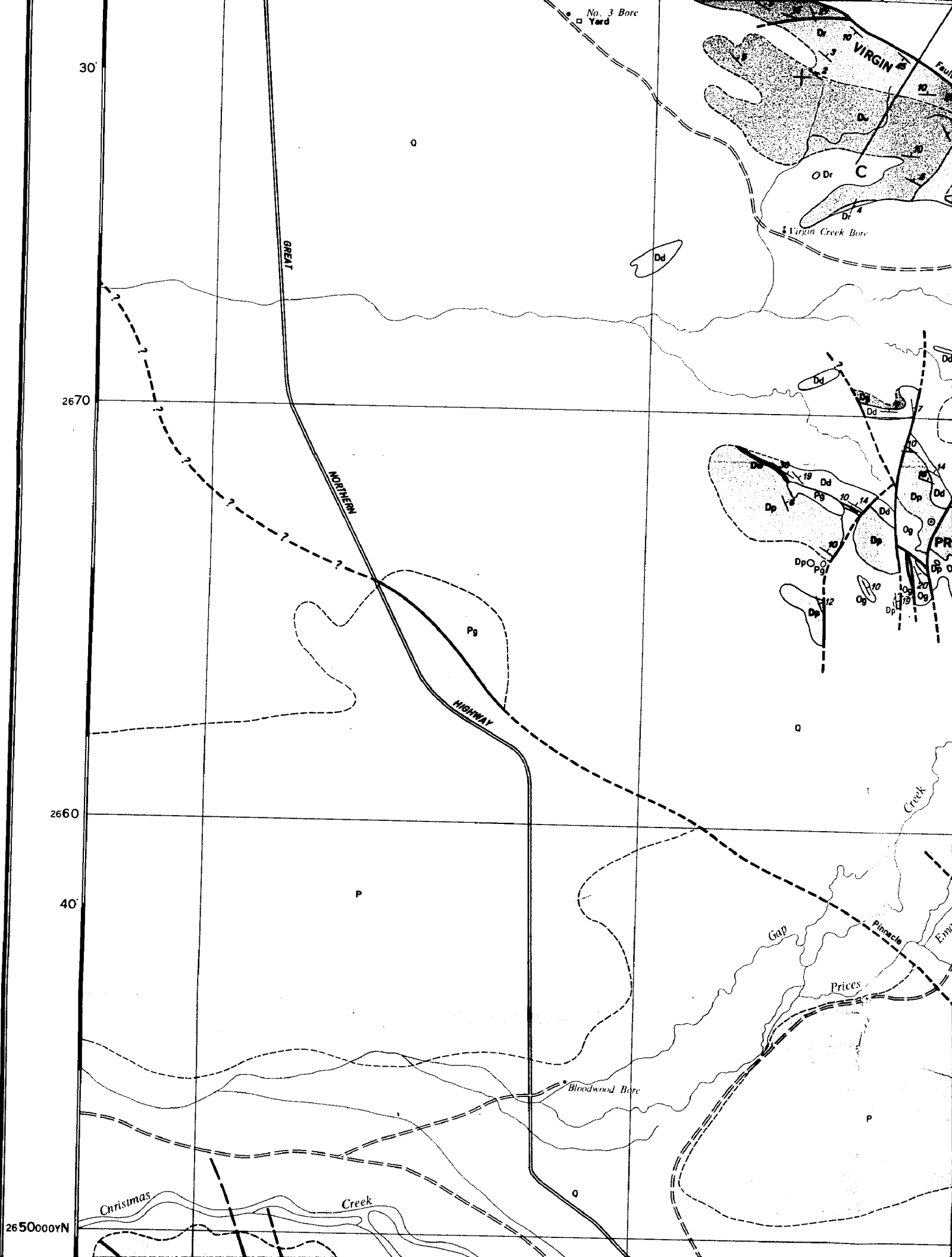
30'

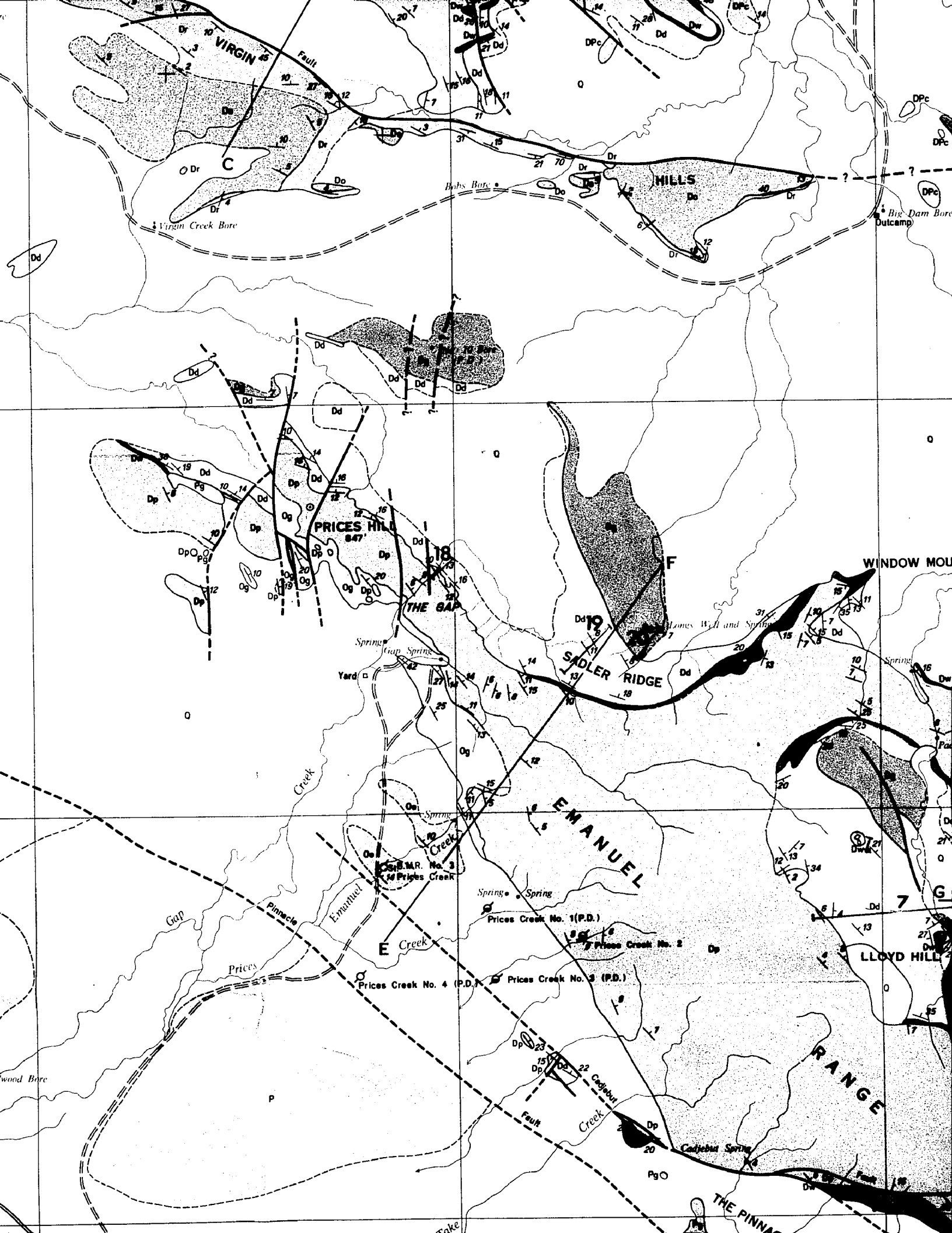
• MT. PHILLIP

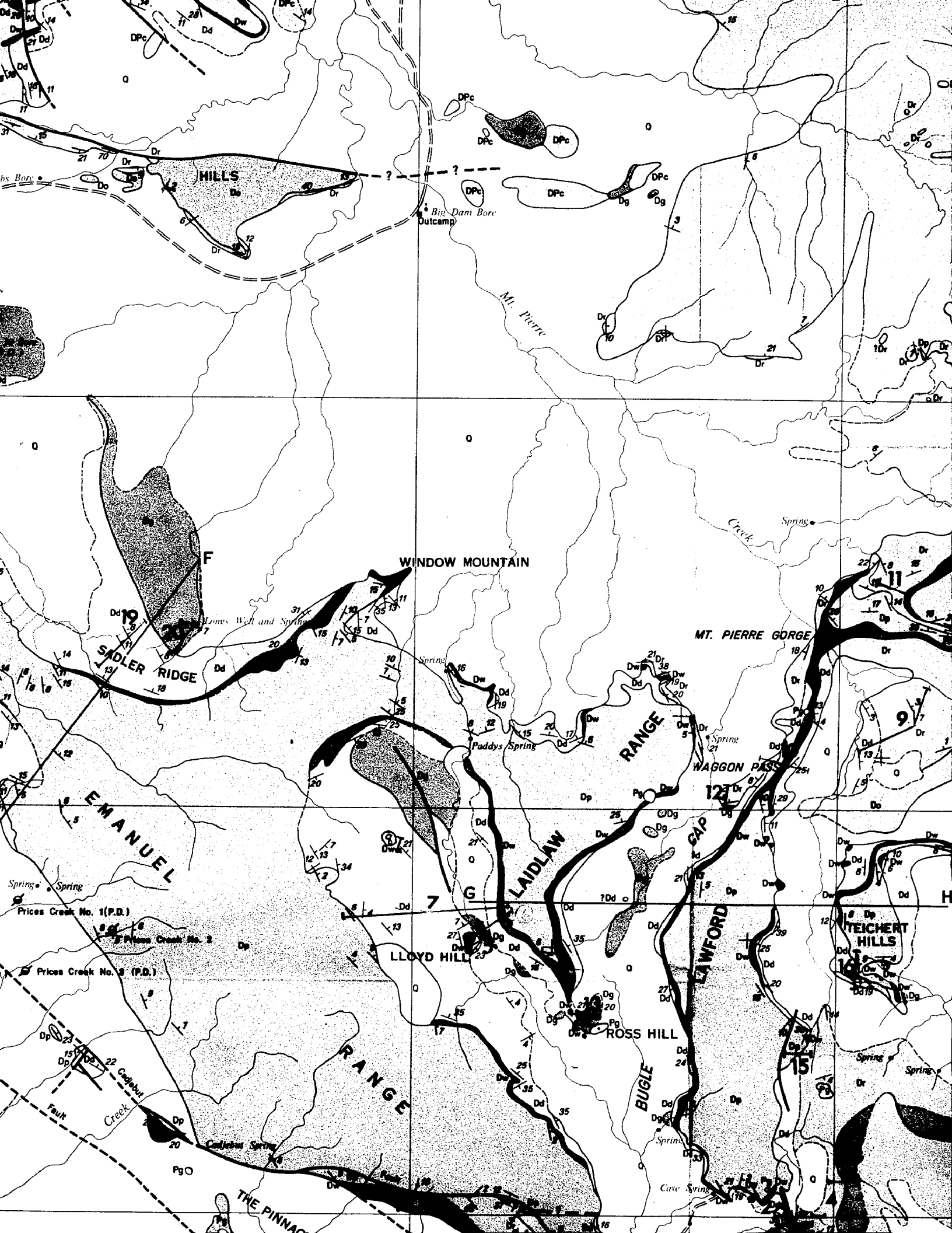
• MT. HUXLEY

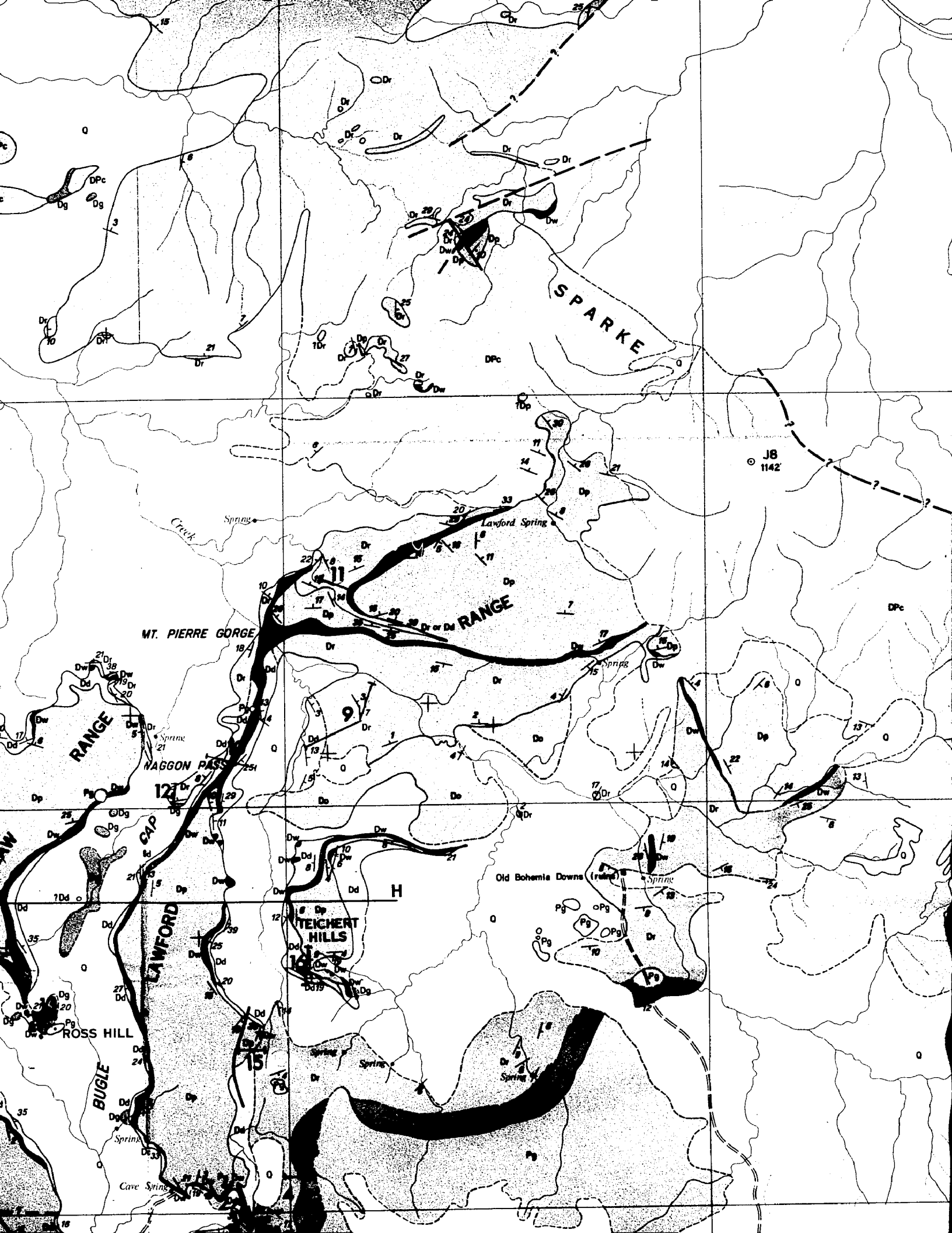
• MT. FAIRBAIRN

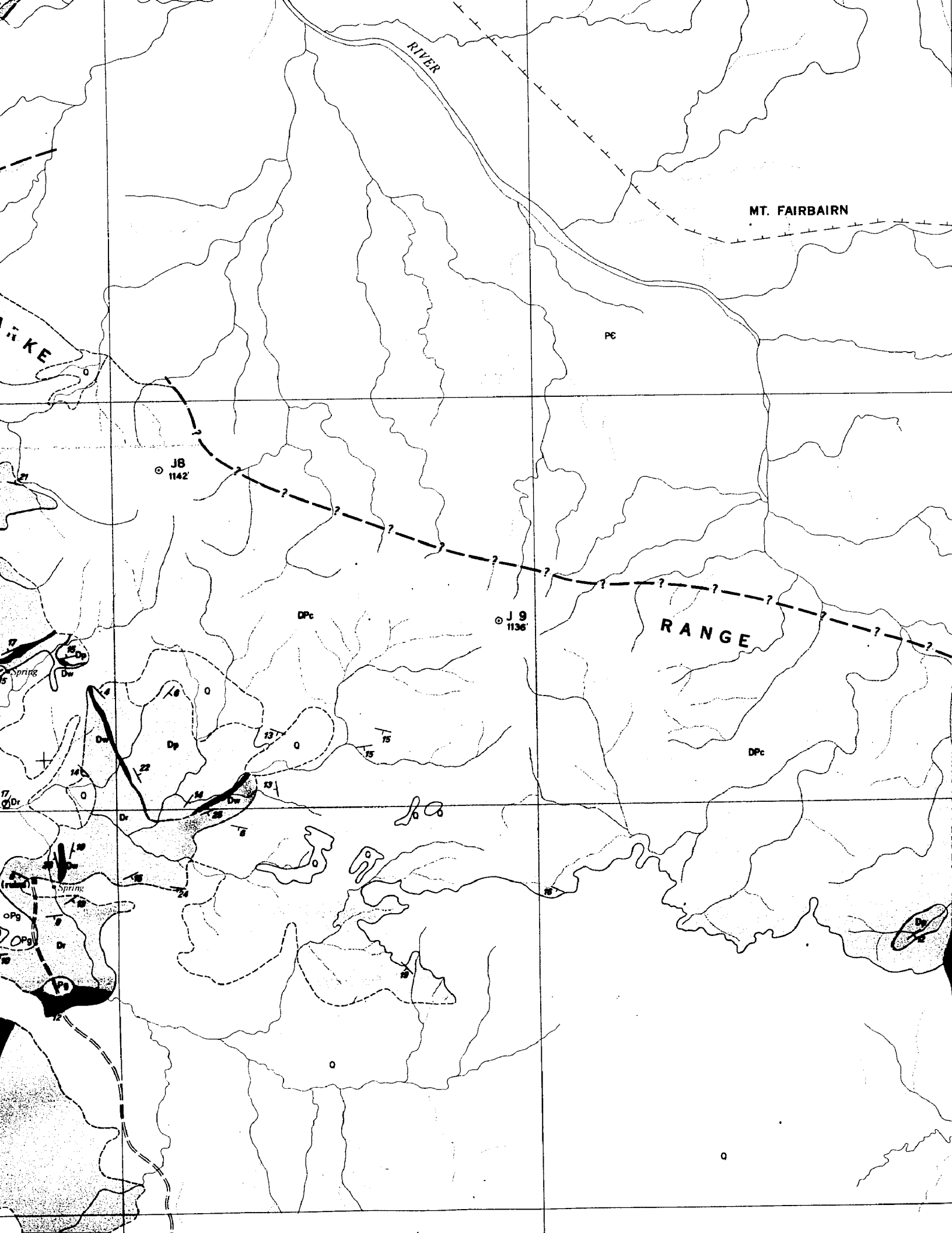
RIVER

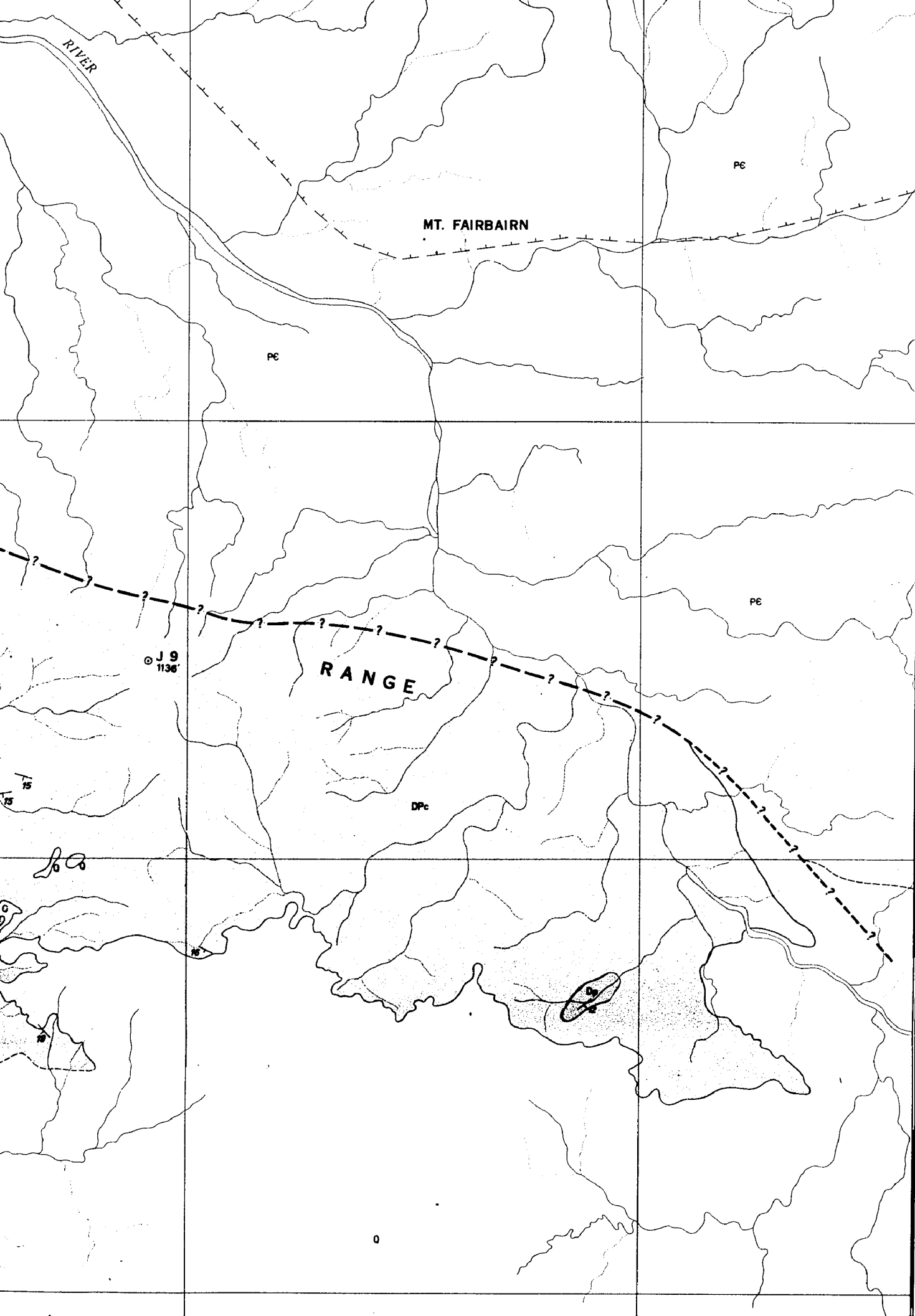












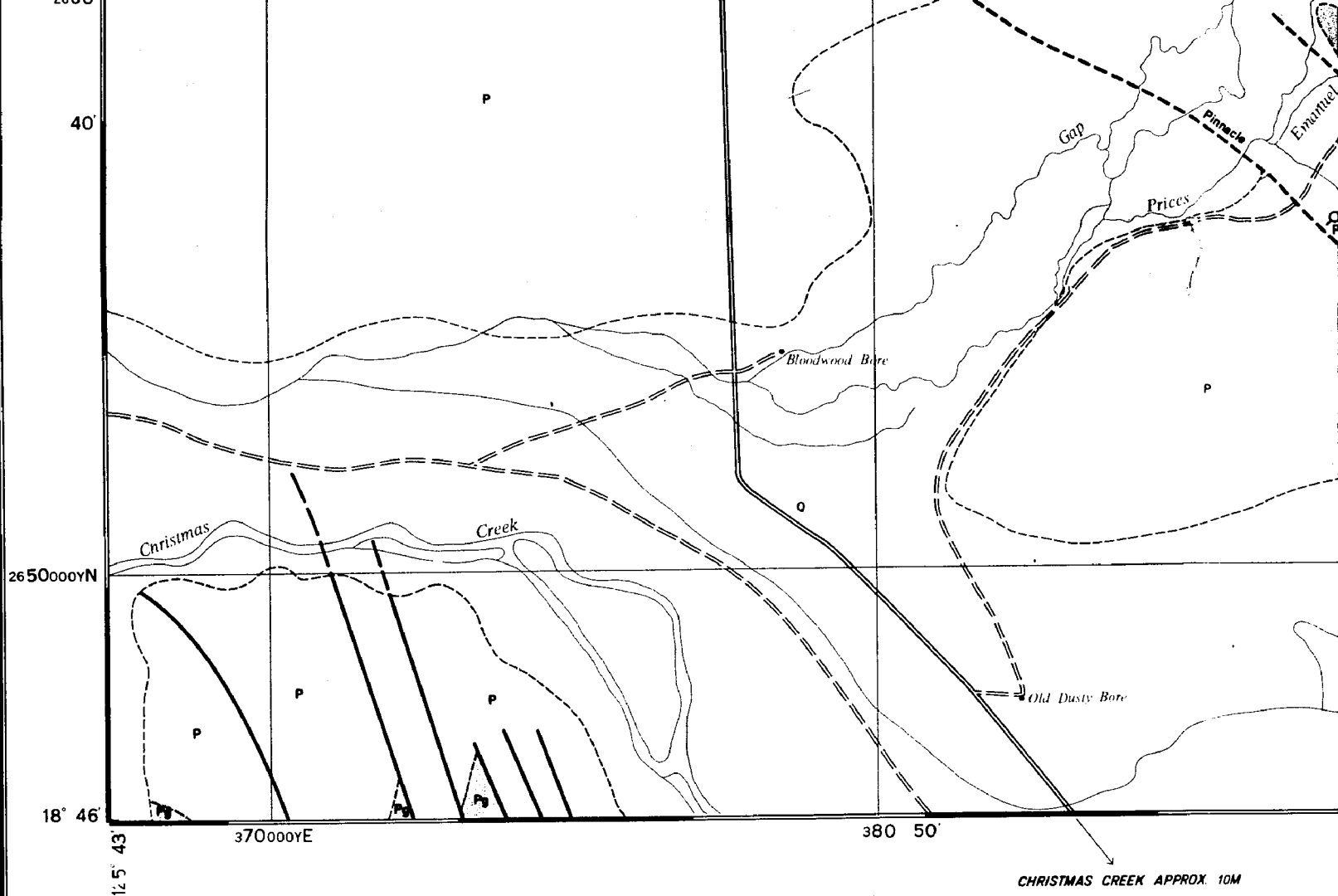
30'

2670

2660

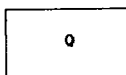
40'

2650000yN



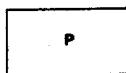
REFERENCE

QUATERNARY



Superficial deposits

PERMIAN

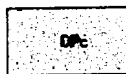


Poole Sandstone, Noonkanbah Formation and Liveringa Formation



Grant Formation

DEVONIAN AND ?PERMIAN



Undifferentiated conglomerates

Famennian



Fairfield Formation



Piker Hills Formation
FORE - REEF AND INTER - REEF FACIES



Bugle Gap Limestone
FORE - REEF FACIES

Famennian - Frasnian



Virgin Hills Formation
FORE - REEF AND INTER - REEF FACIES

?Famennian -



Bobs Bore Conglomerate

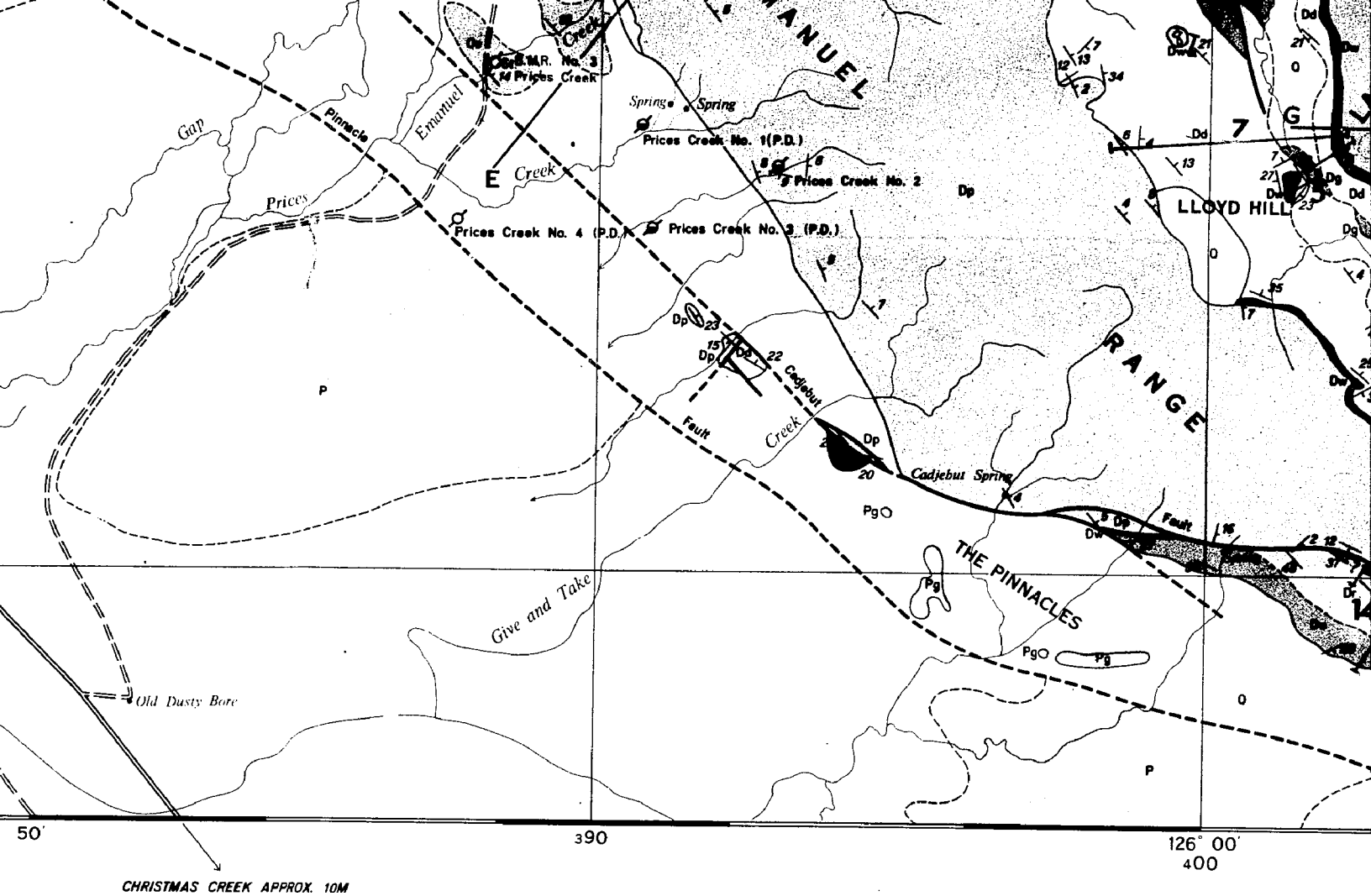
SYMBOLS

- Geological boundary, position accurate
- Geological boundary, position approximate
- Trend lines
- Fault - position accurate
- position approximate
- concealed
- inferred
- inferred, concealed
- Dip and strike of bedding
- Horizontal bedding

Highway

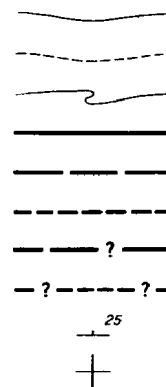
Road

Track

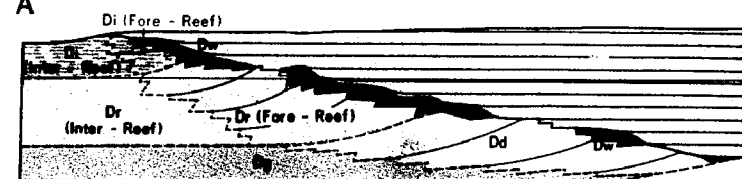


SYMBOLS

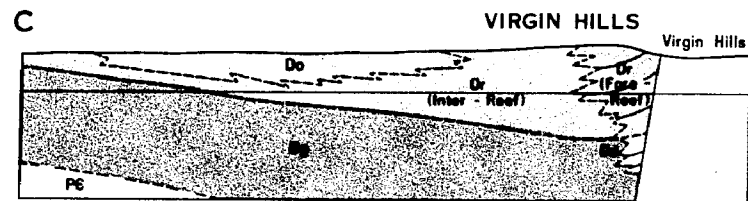
Geological boundary, position accurate
 Geological boundary, position approximate
 Trend lines
 Fault - position accurate
 position approximate
 concealed
 inferred
 inferred, concealed
 Dip and strike of bedding
 Horizontal bedding



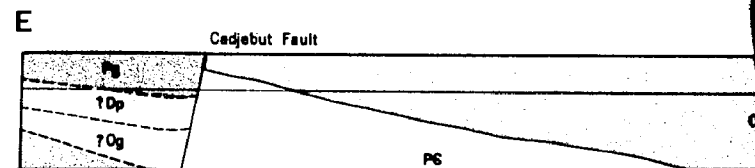
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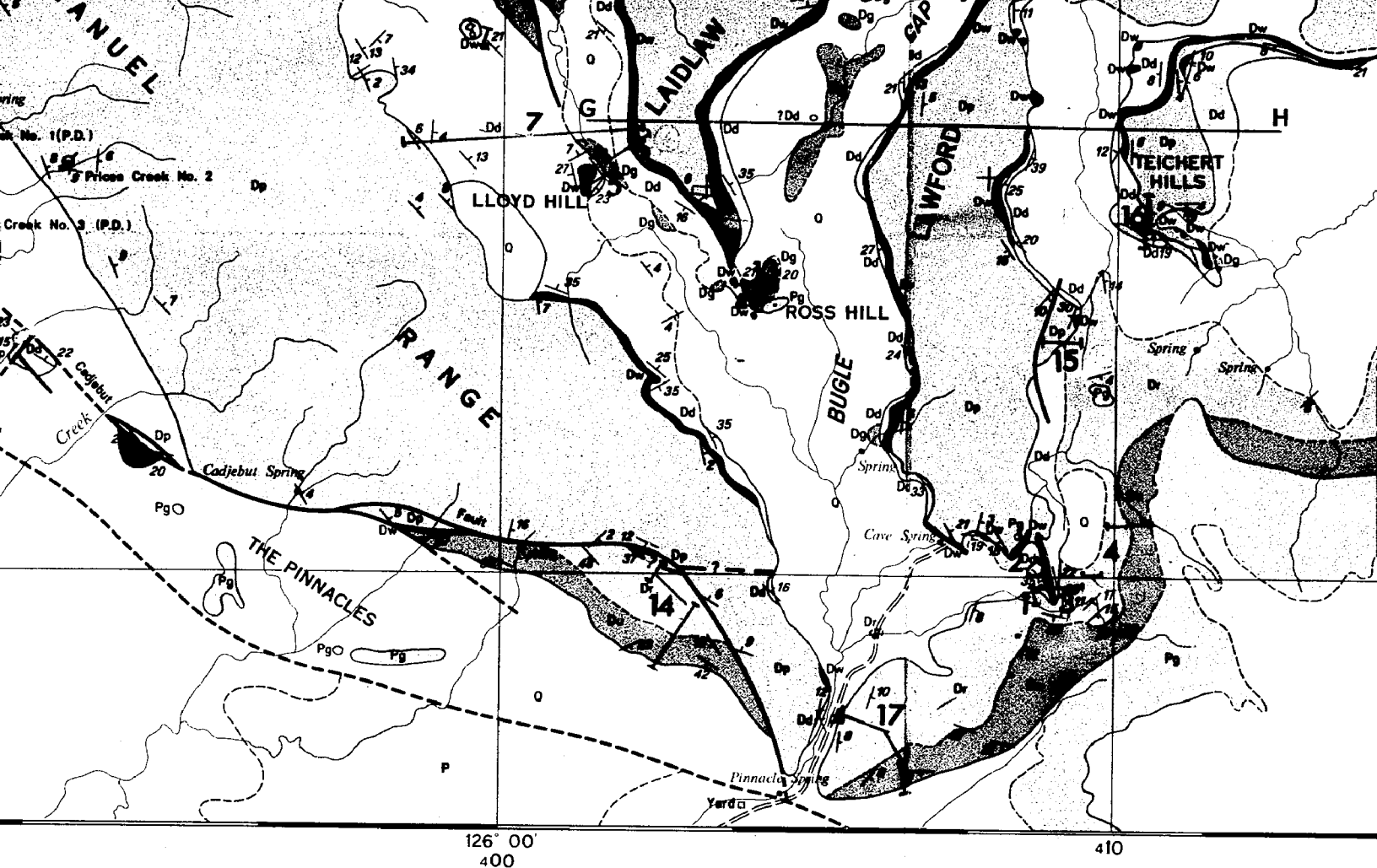


C

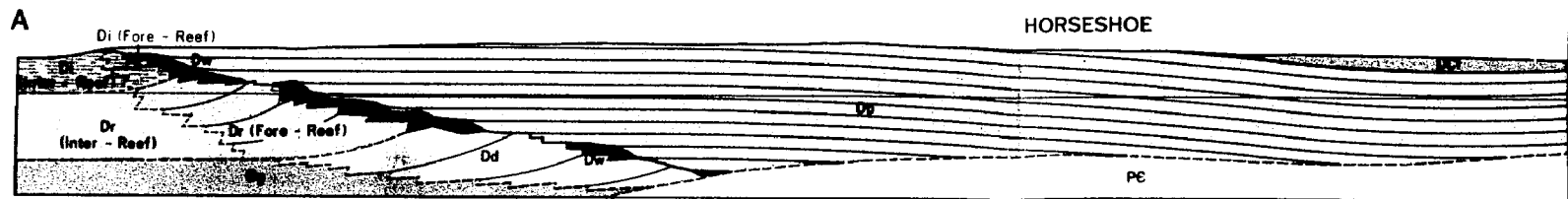
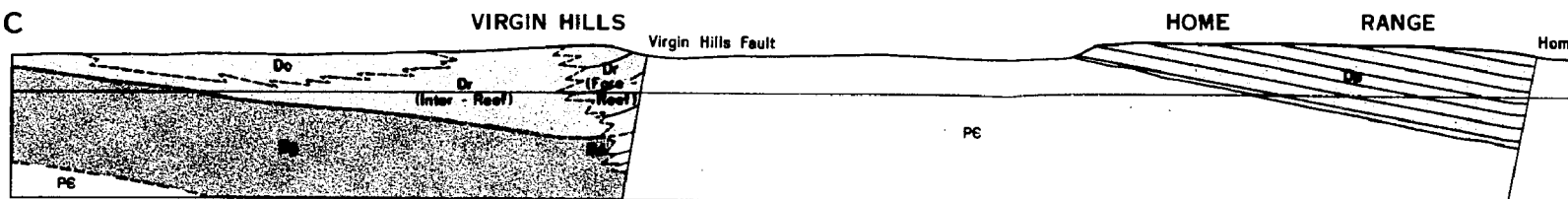
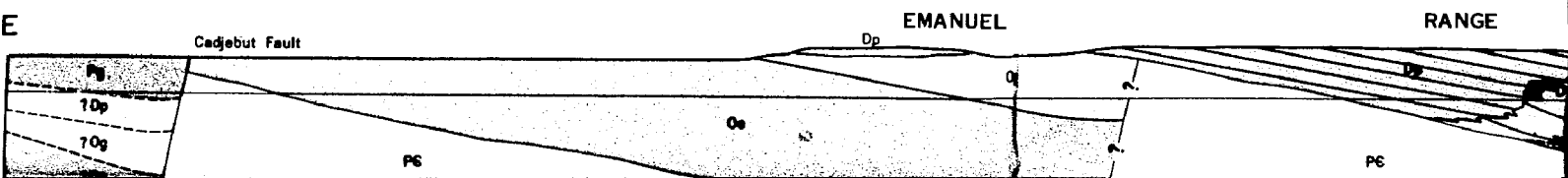


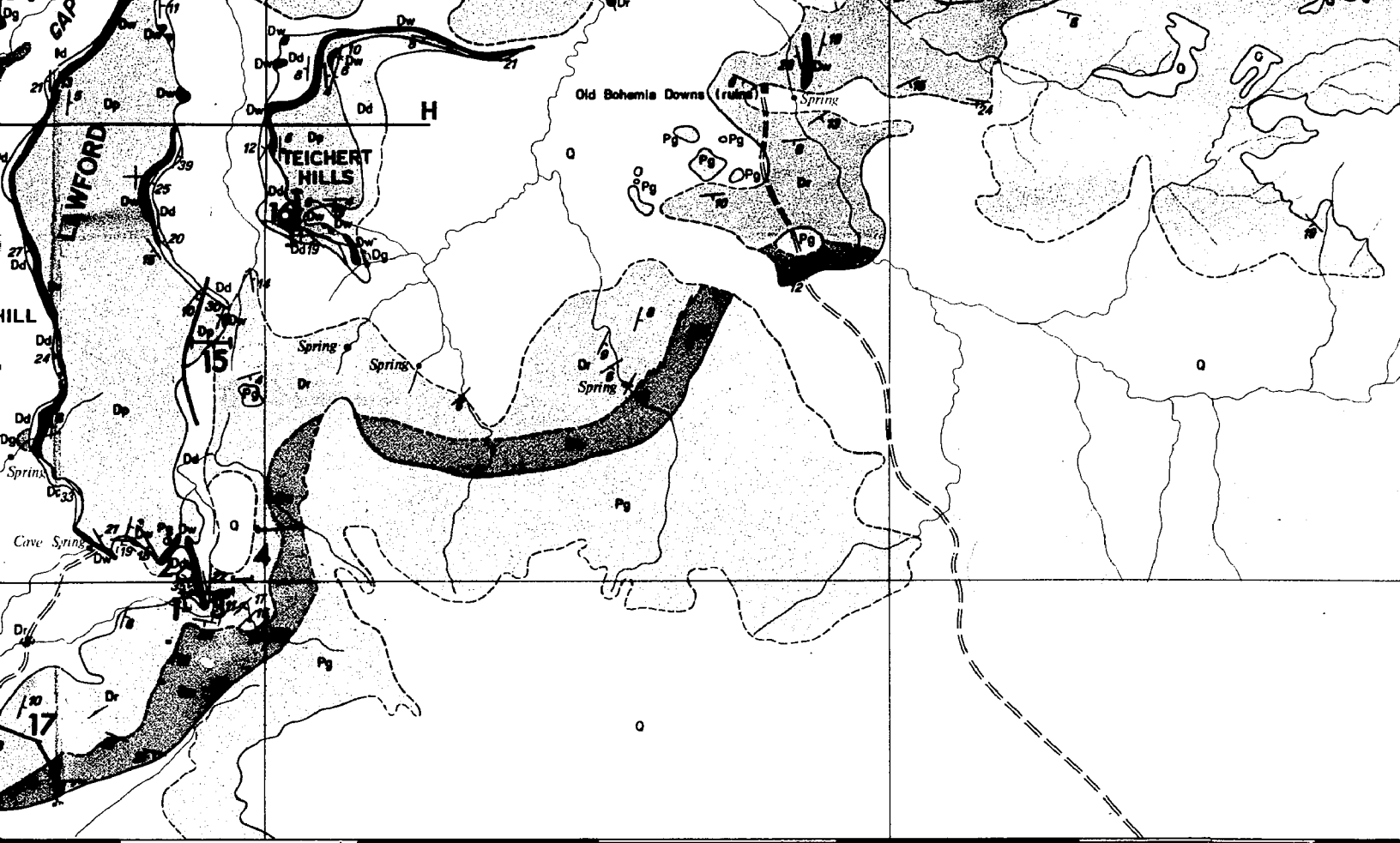
E





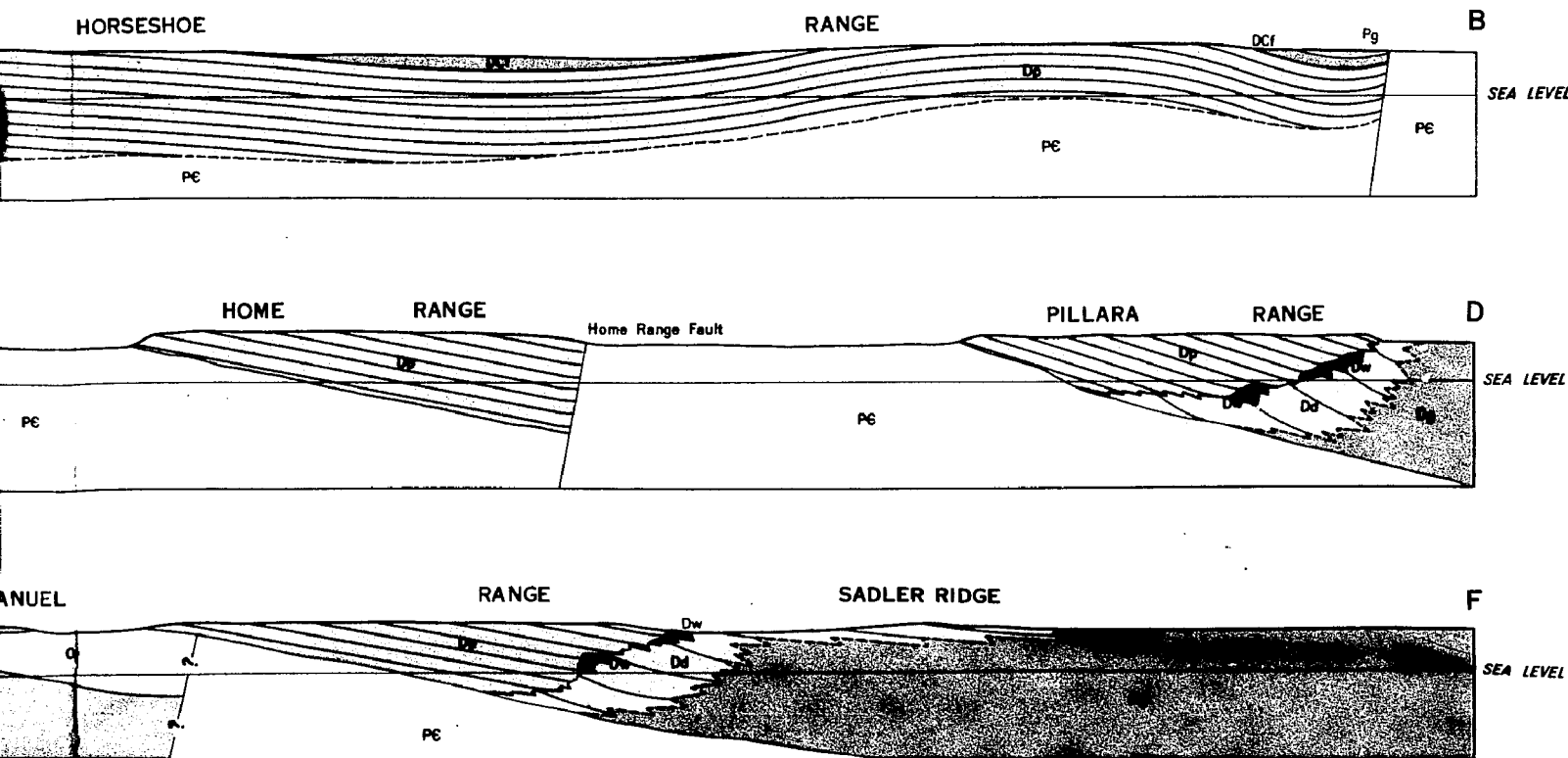
CROSS SECTIONS

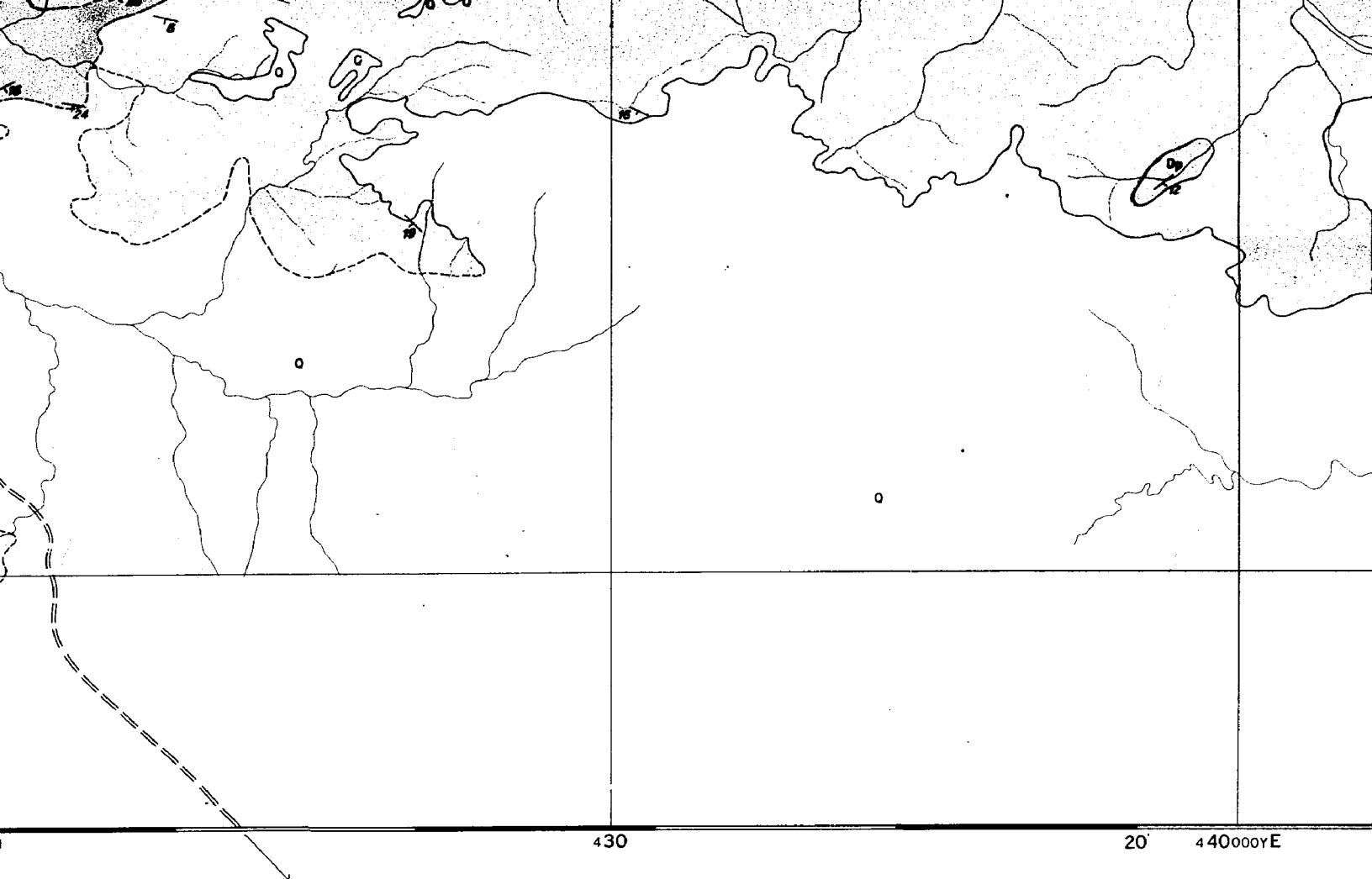




BOHEMIA DOWNS APPROX. 10M

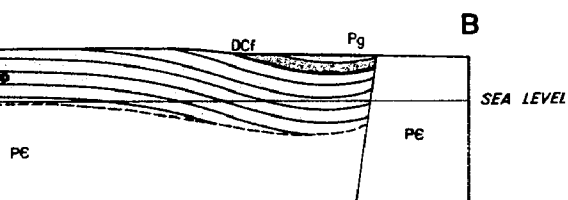
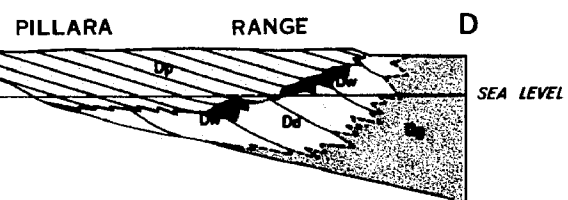
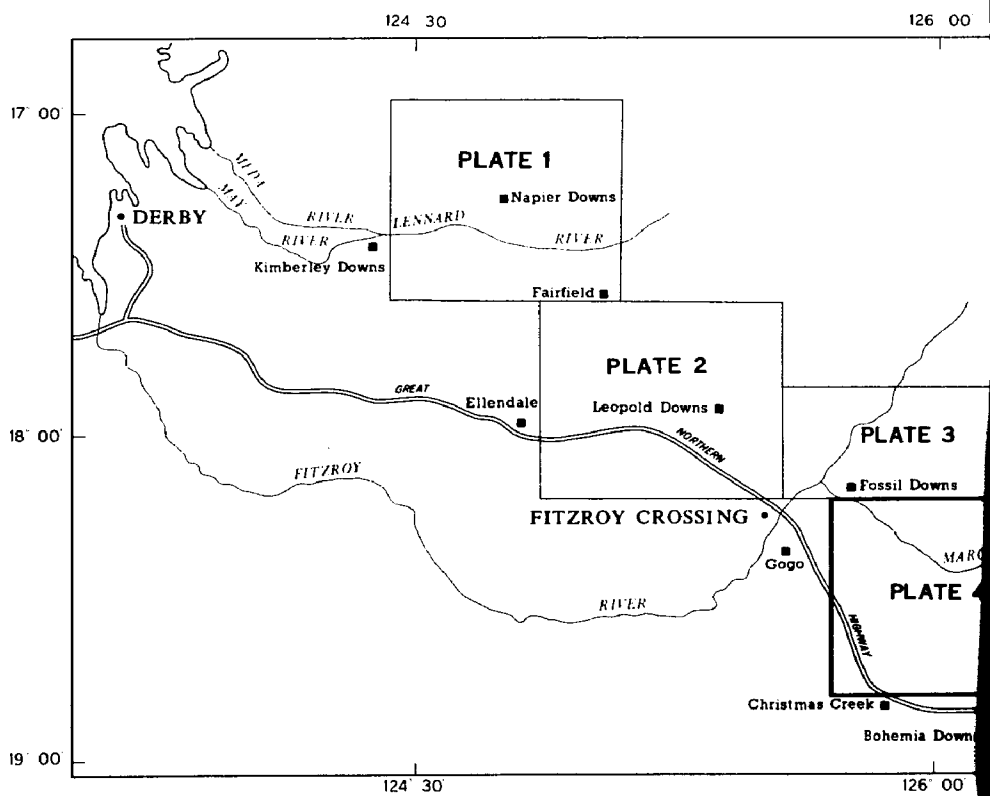
CROSS SECTIONS

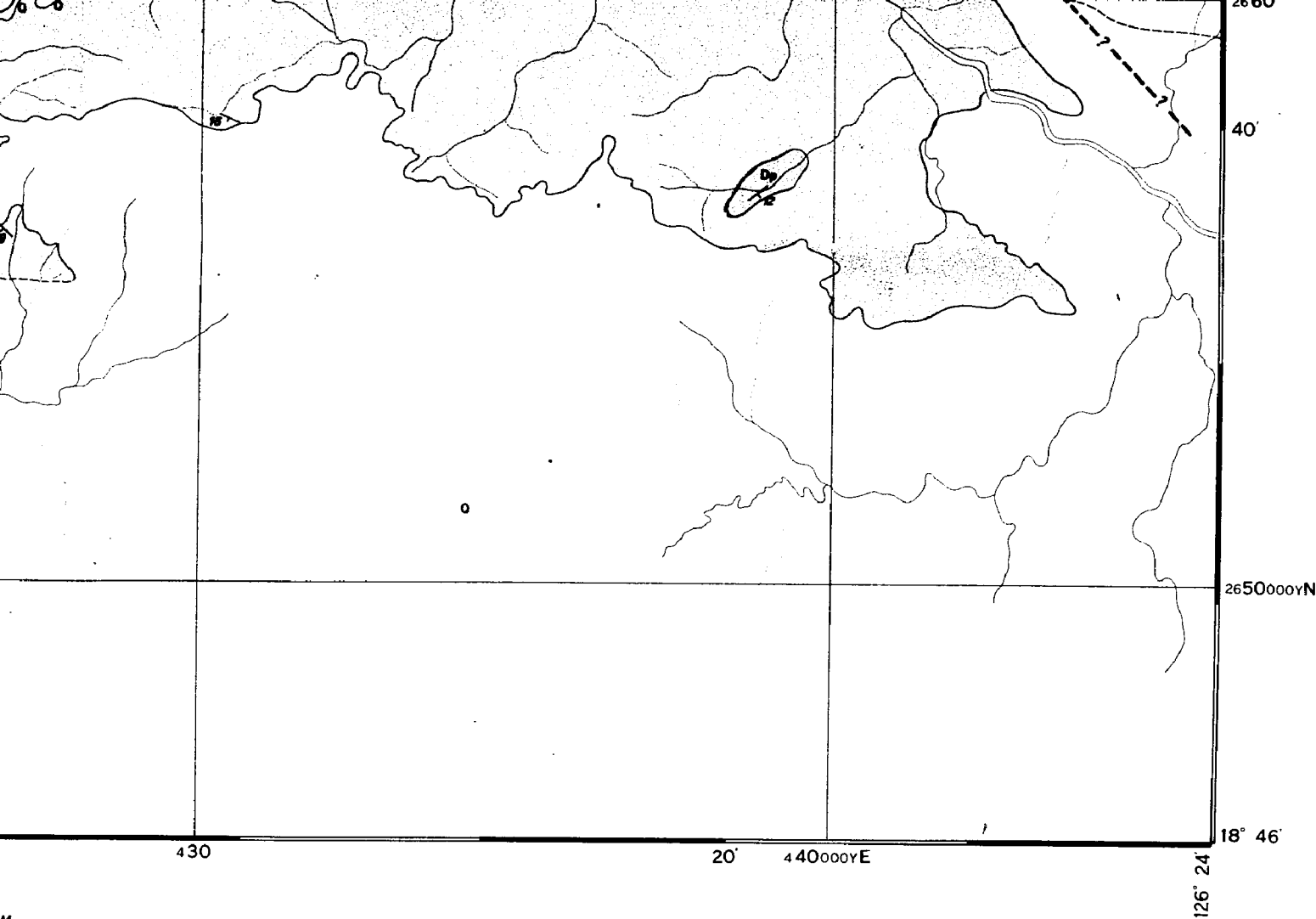




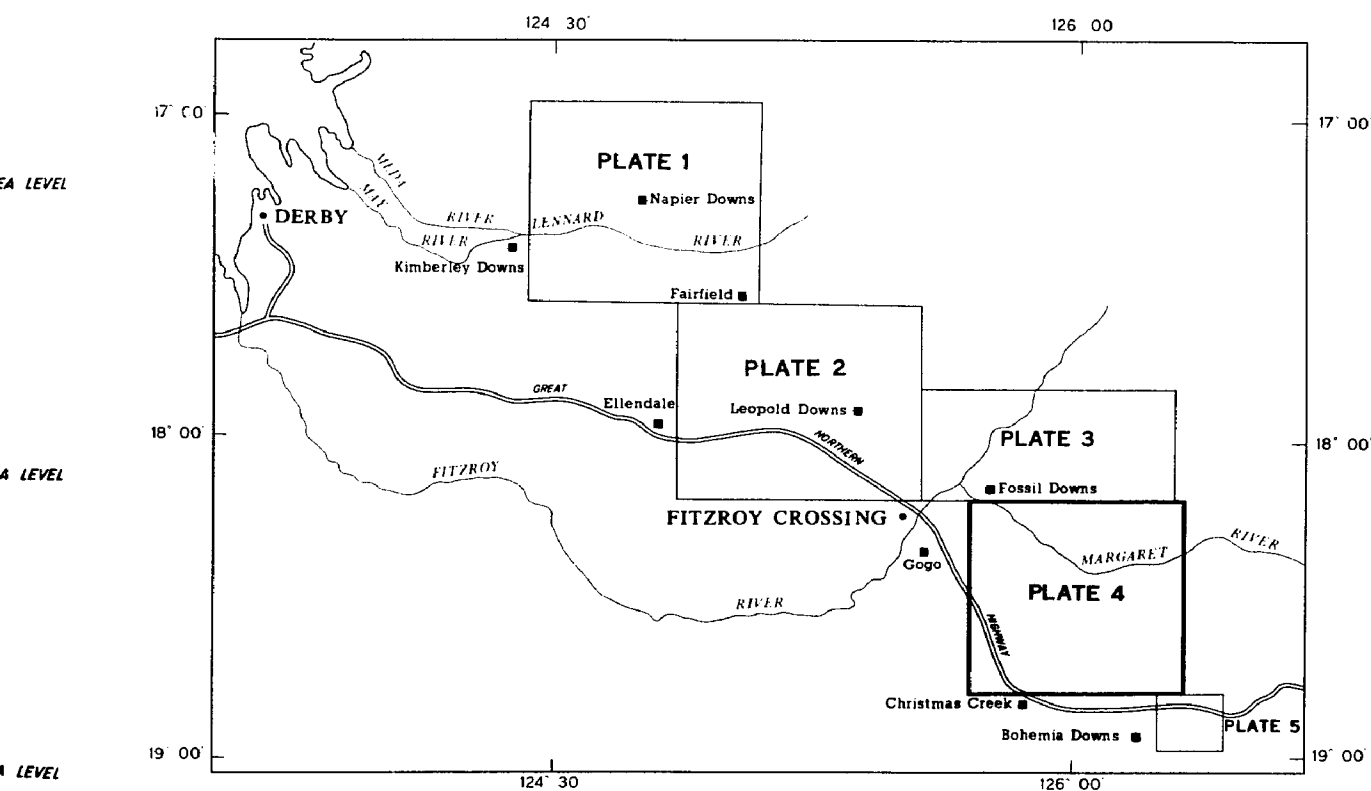
BOHEMIA DOWNS APPROX. 10M

LOCATION DIAGRAM





LOCATION DIAGRAM



18° 46'

125° 43'

370000E

380 50'

CHRISTMAS CREEK APPROX. 10M

REFERENCE

QUATERNARY

Q

Superficial deposits

PERMIAN

P

Poole Sandstone, Noonkanbah Formation and Liveringa Formation

Pg

Grant Formation

DEVONIAN AND
?PERMIAN

DPc

Undifferentiated conglomerates

Famennian

DGf

Fairfield Formation

Dp

Piker Hills Formation
FORE - REEF AND INTER - REEF FACIES

Ds

Bugle Gap Limestone
FORE - REEF FACIES

Famennian -
Frasnian

Dr

Virgin Hills Formation
FORE - REEF AND INTER - REEF FACIES

?Famennian -
Frasnian

Dc

Bobs Bore Conglomerate

Famennian -
Givetian

Dp

Windjana Limestone
REEF FACIES

Pillara Limestone
BACK - REEF FACIES

Frasnian -
Givetian

Dd

Sadler Limestone
FORE - REEF FACIES

Dg

Gogo Formation
INTER - REEF FACIES

ORDOVICIAN

Og

Gap Creek Formation

Oe

Emanuel Formation

PRECAMBRIAN

PC

Basement complex

SYMBOLS

- Geological boundary, position accurate
- Geological boundary, position approximate
- Trend lines
- Fault - position accurate
- position approximate
- concealed
- inferred
- inferred, concealed
- Dip and strike of bedding
- Horizontal bedding
- Highway
- Road
- Track
- Homestead
- Yard
- Trigonometrical station, minor
- Elevation in feet
- Telegraph line
- Bore, well or waterhole
- Windpump
- Position doubtful
- Dry well (abandoned)
- Abandoned well with show of oil
- Stratigraphic well

DEVONIAN

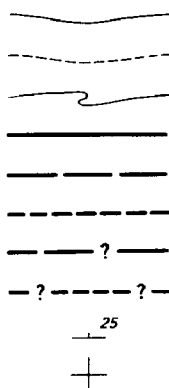
390

126° 00'
400

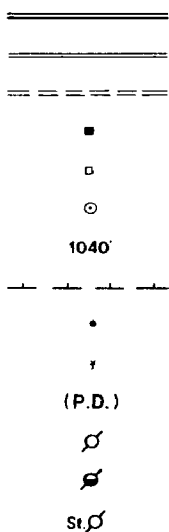
CHRISTMAS CREEK APPROX. 10M

SYMBOLS

cal boundary, position accurate
cal boundary, position approximate
lines
position accurate
position approximate
concealed
inferred
inferred, concealed
strike of bedding
tal bedding



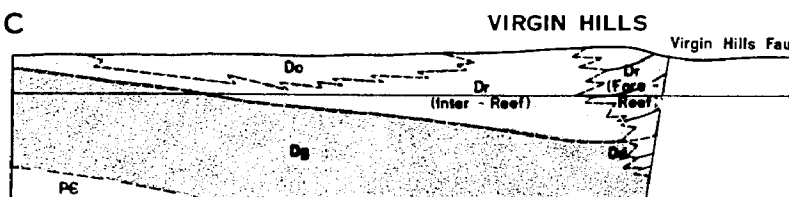
lead
metrical station, minor
n in feet
ph line
well or waterhole
mp
n doubtful
ell (abandoned)
ned well with show of oil
aphic well



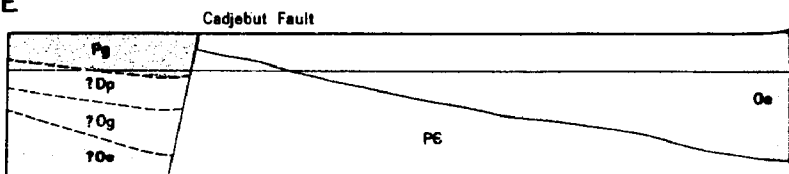
A



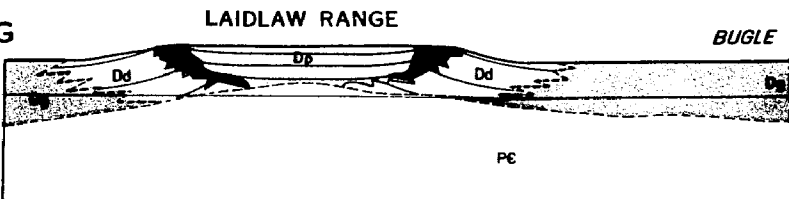
C



E



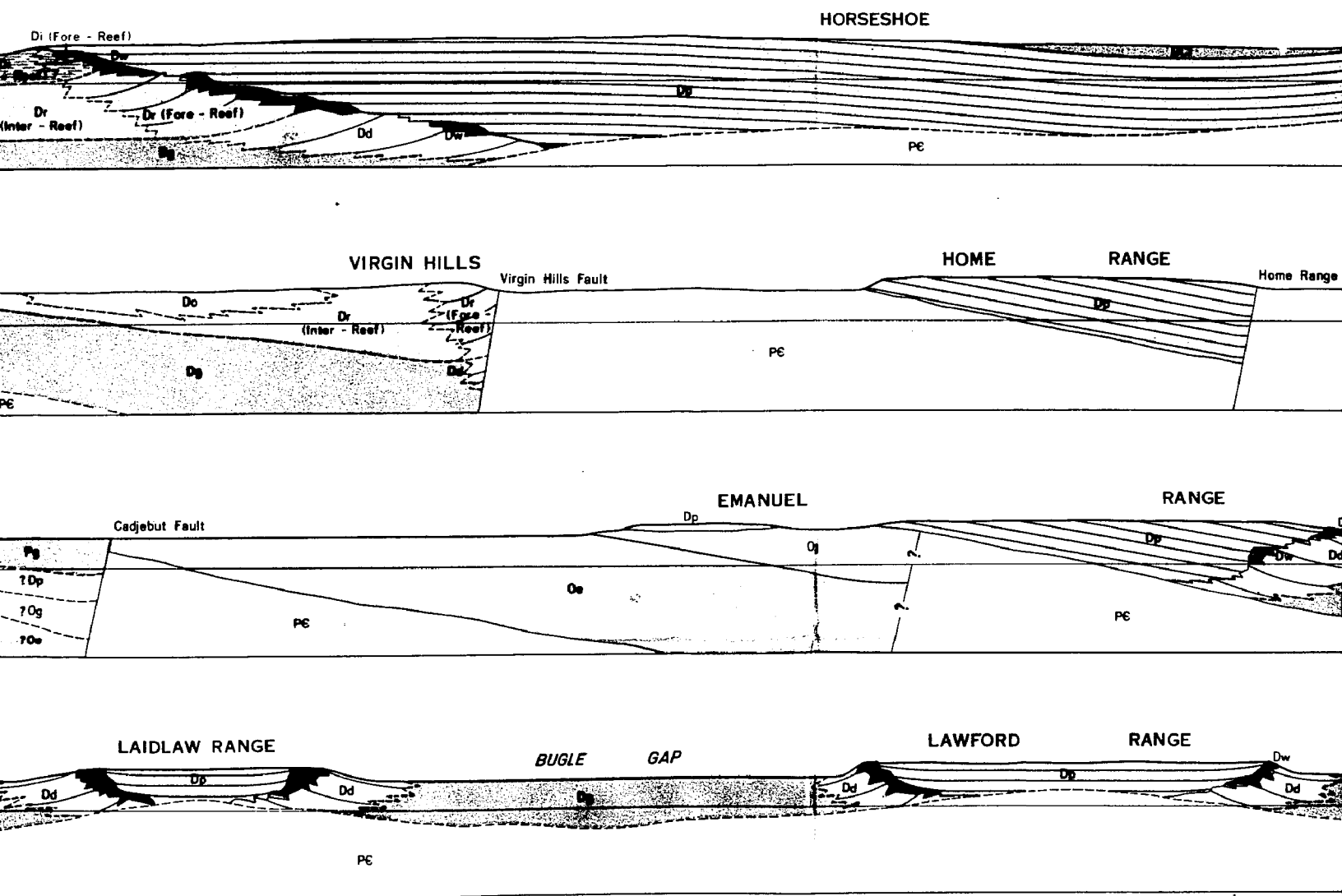
G



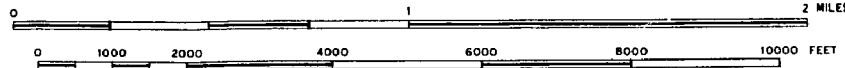
126° 00'
400

410

CROSS SECTIONS



NATURAL SCALE (MAP SCALE X 3)

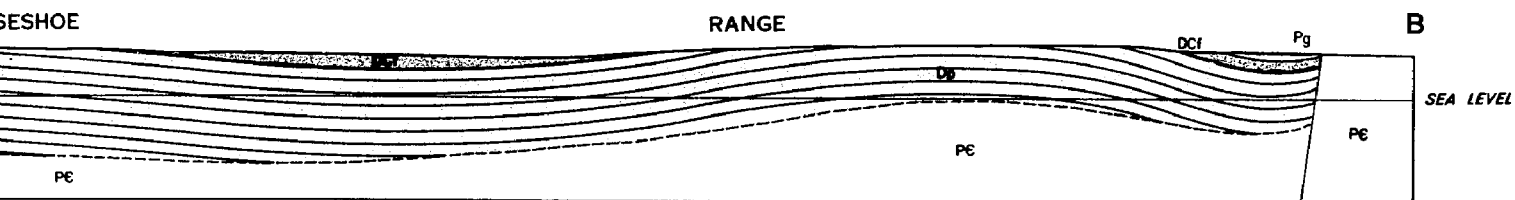
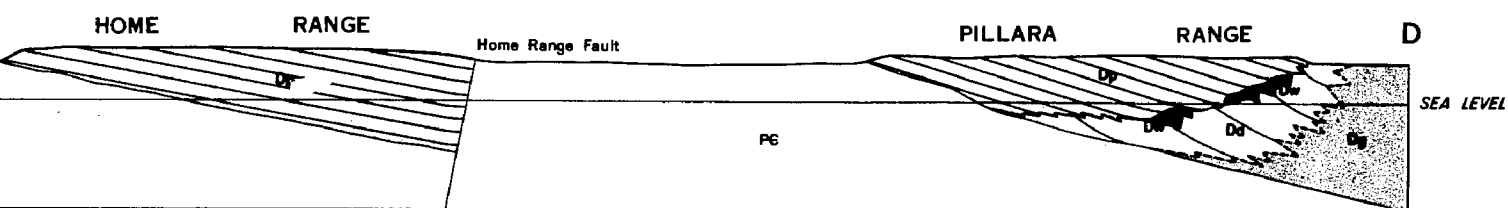
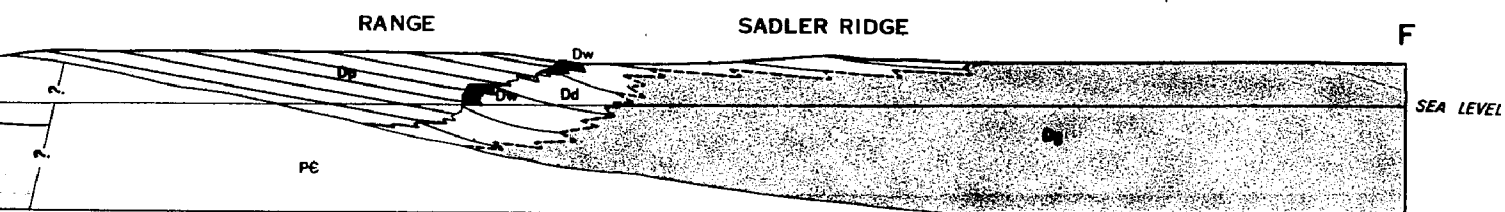
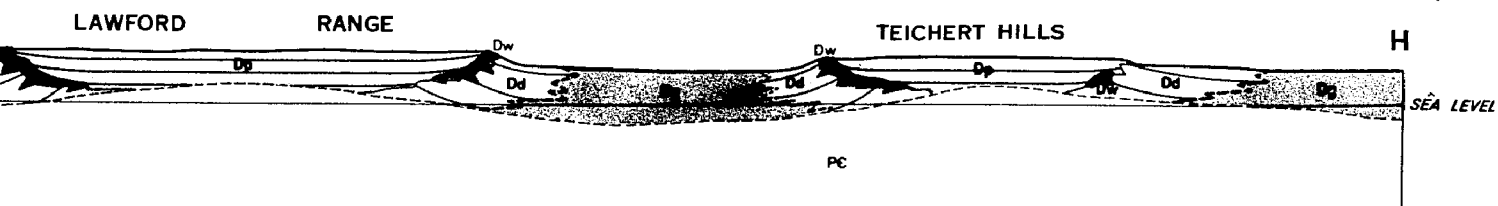


410

10' 420

BOHEMIA DOWNS APPROX. 10M

CROSS SECTIONS



NATURAL SCALE (MAP SCALE X 3)



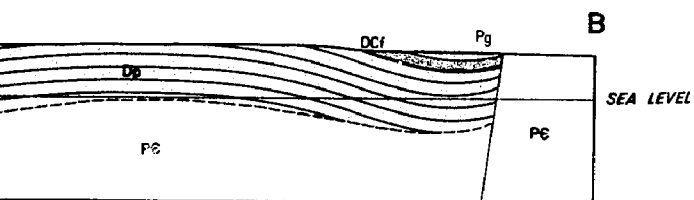
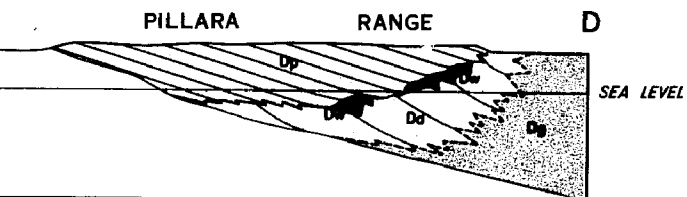
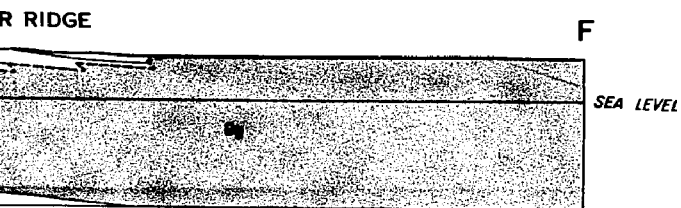
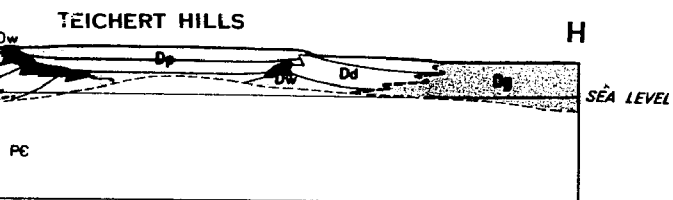
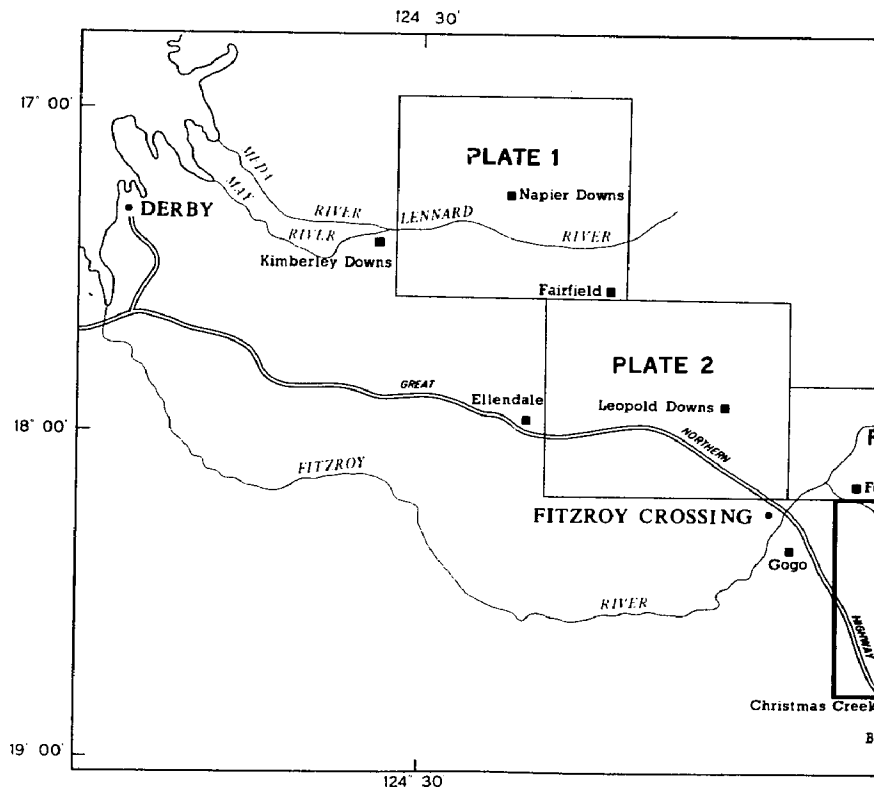
10' 420

430

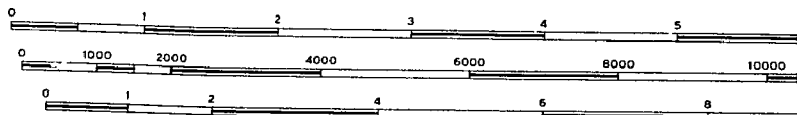
20' 440000

BOHEMIA DOWNS APPROX. 10M

LOCATION DIAGRAM



SCALE 1:100,000



TRANSVERSE MERCATOR PROJECTION ZONE 3

The last three digits of the grid number are omitted

Grid interval 10,000 yards

Magnetic Declination approximately 3°E

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

CANNING BASIN

HULL RANGE -

EMANUEL RANGE A

Geology by P. E. Playford and D. C. Lowry 1963

430

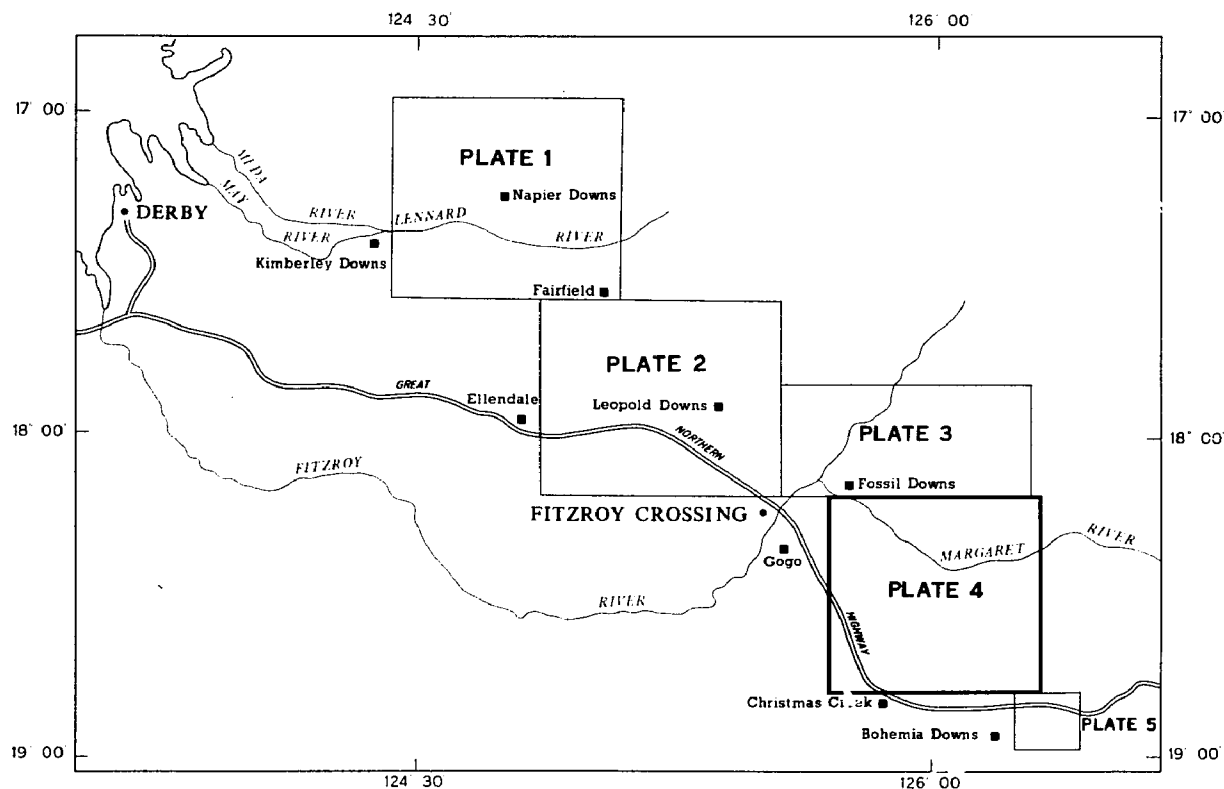
20'

440000E

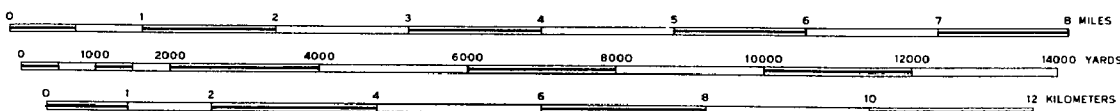
18° 46'

126° 24'

LOCATION DIAGRAM



SCALE 1:100,000



TRANSVERSE MERCATOR PROJECTION ZONE 3

The last three digits of the grid number are omitted

Grid interval 10,000 yards

Magnetic Declination approximately 3°E

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

CANNING BASIN

HULL RANGE -

EMANUEL RANGE AREA

Geology by P. E. Playford and D. C. Lowry 1963

PLATE 4

DERBY APPROX. 50M.

16° 57' 17° 00' 18° 00' S

124° 00' 125° 00' E

Alexander River

Meda River

May River

Lennard River

Hawkstone Peak No. 1

Kimberley Downs

Napier Downs

MT. NORTH

Sisters No. 1

Ellendale

Calwyayardah

Myroodah

MT. WYNNE

Van Emmerick Range

Barker

Sixty Seven Mile Bar

Grant Range

Liveringa

Blaze

DCr

Df

Drb

Dprb

P

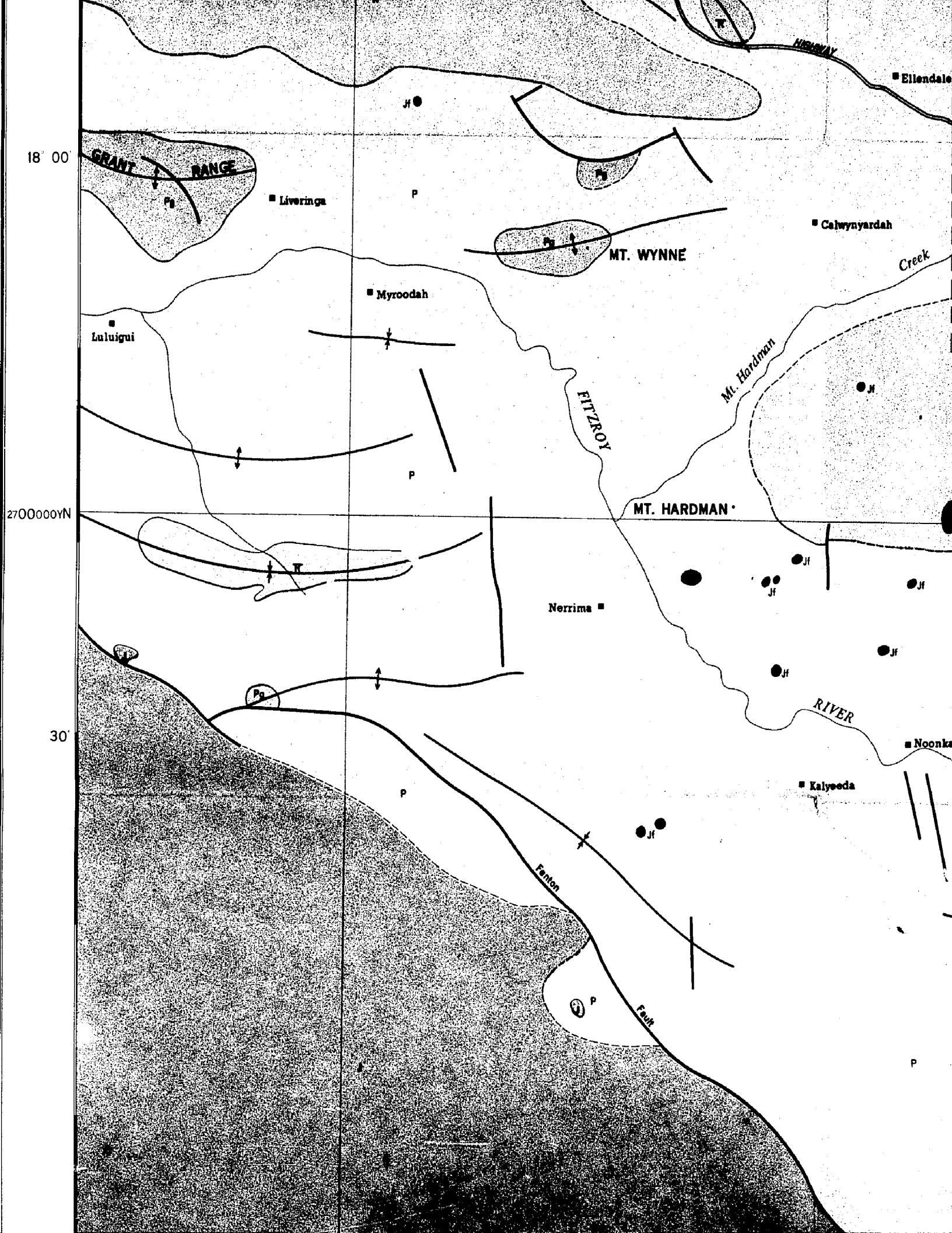
R

X

Creek

Creek

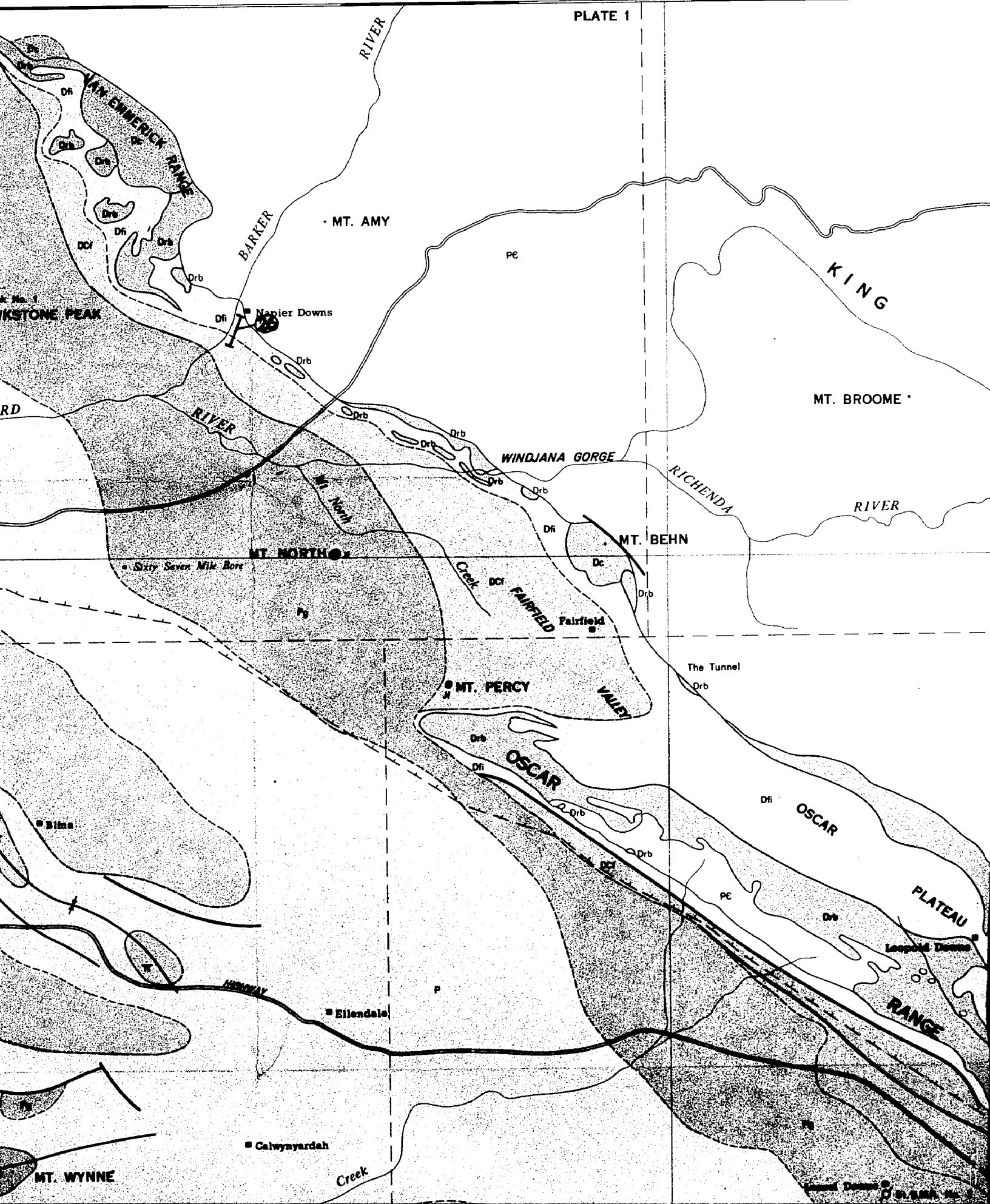
Creek



125° 00'

3000000E

PLATE 1



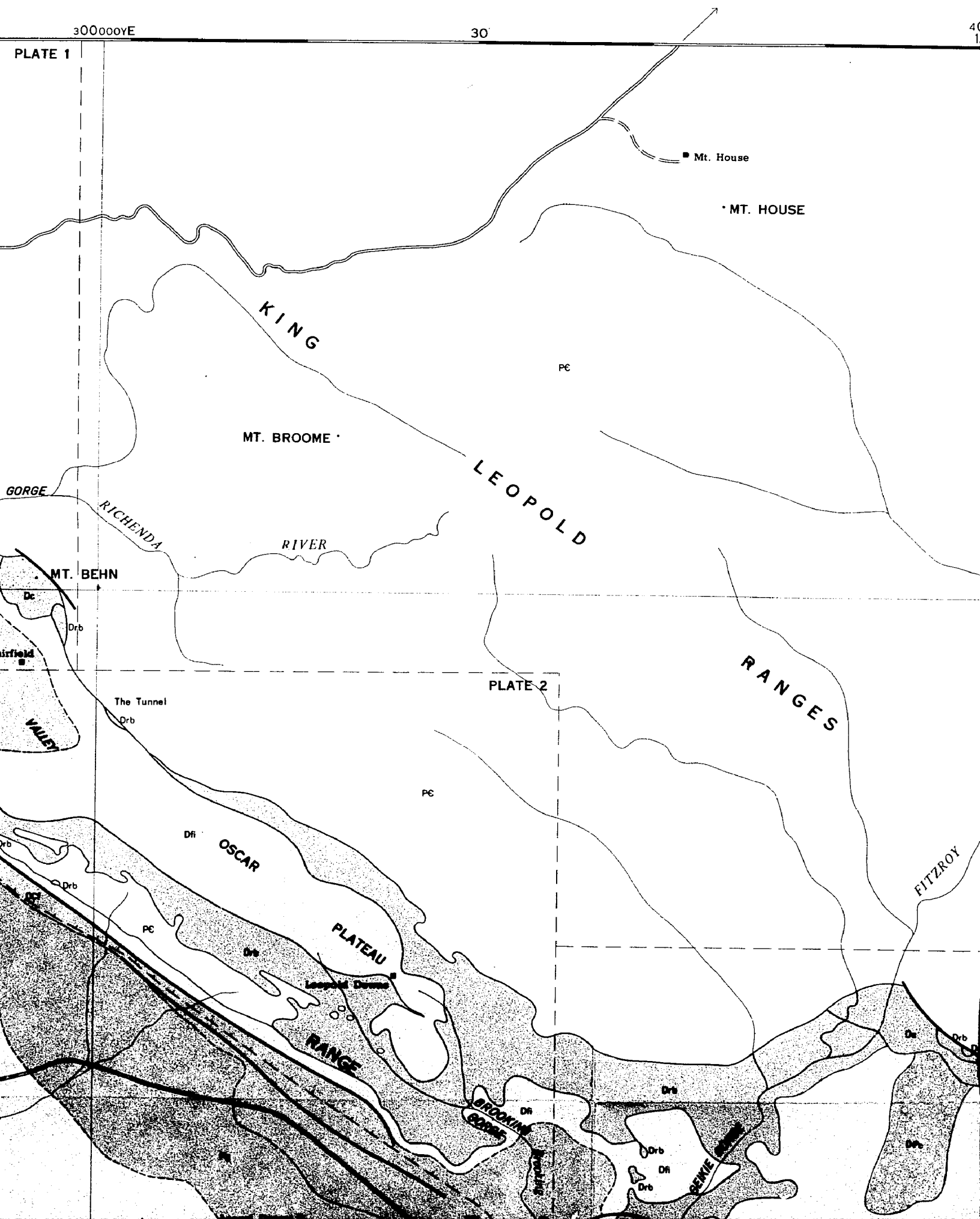


300000E

30

40
1

PLATE 1



■ Mt. House

• MT. HOUSE

MT. BROOME

KING

LEOPOLD

RIVER

RICHENDA

GORGE

MT. BEHN

Airfield

VALLEY

The Tunnel

PLATE 2

RANGES

FITZROY

OSCAR

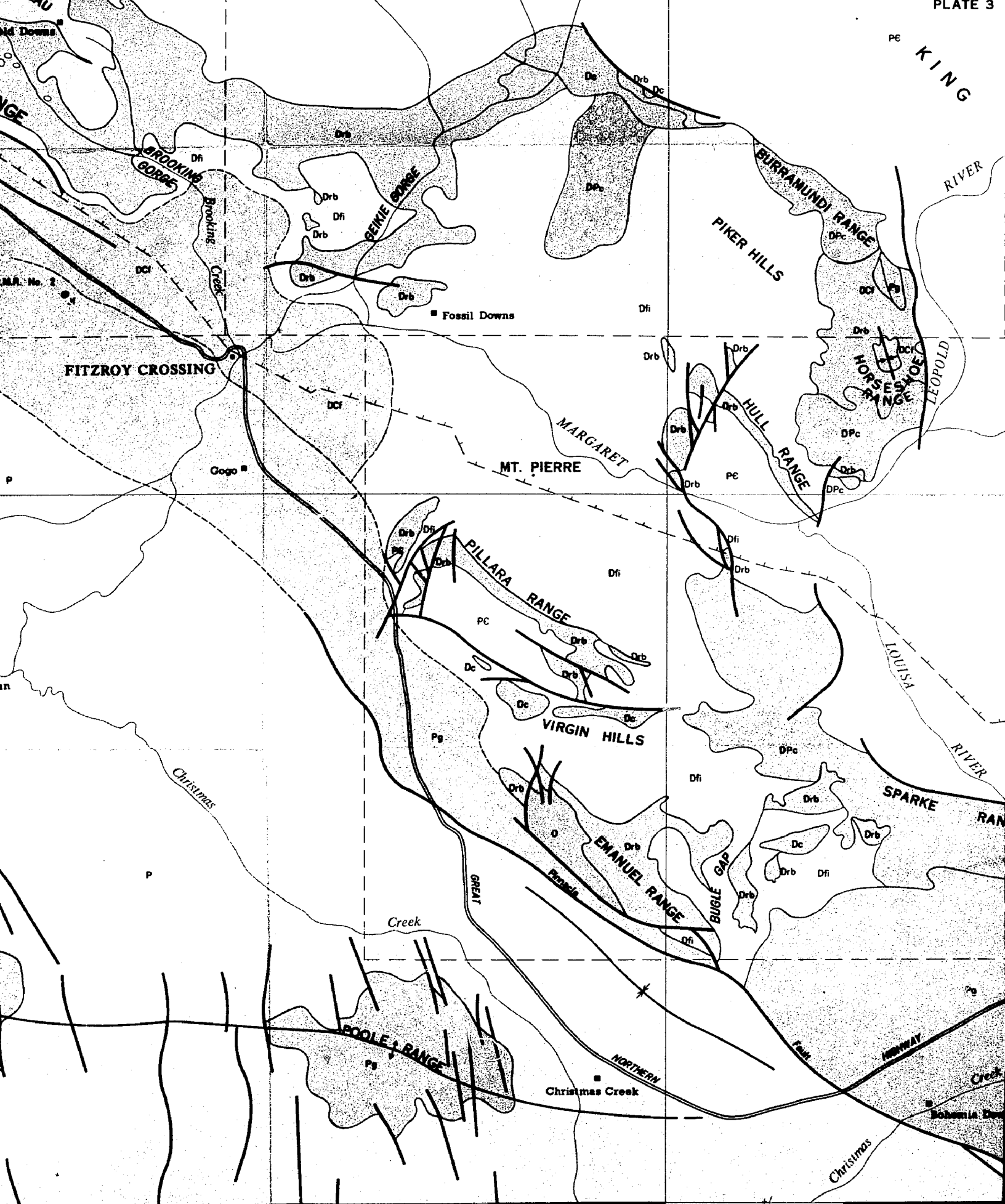
PLATEAU

Leopold Dome

RANGE

BROOME

GENIE



400000YE
126 00

30'

126 33

16° 57'

17° 00'

HOUSE

PE

2800000YN
30

RIVER

RANGES

FITZROY

PLATE 3

PE

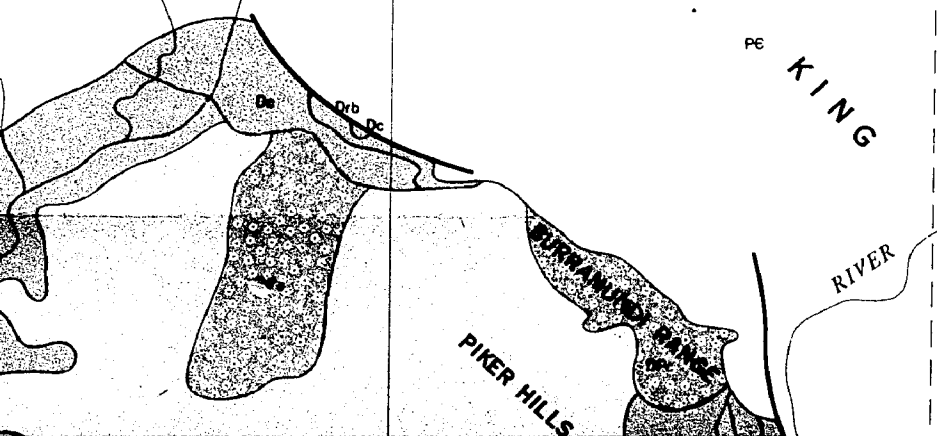
KING

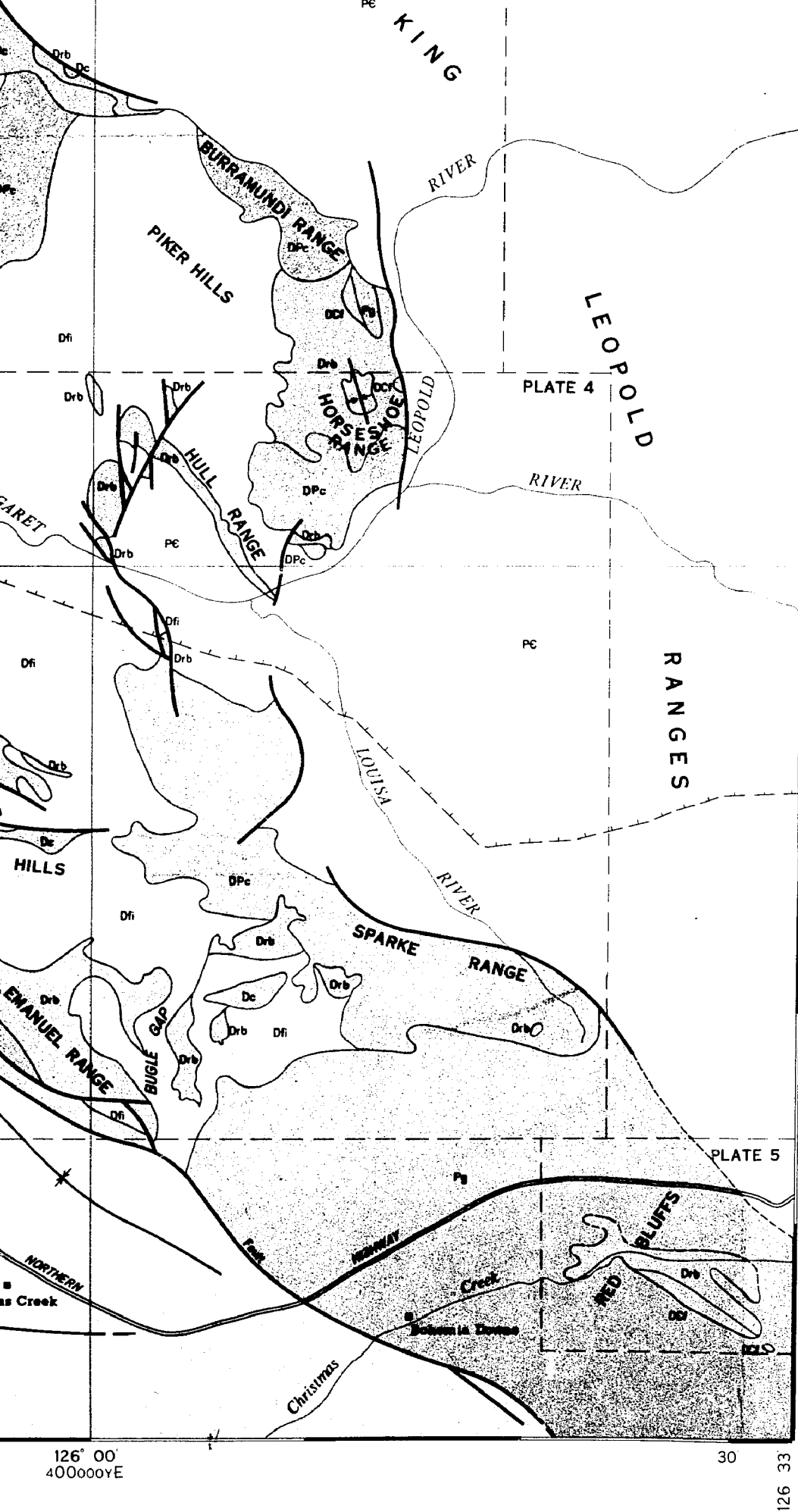
18° 00'

RIVER

PIKER HILLS

BURNANUO RANGE



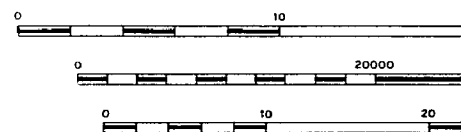


- Geological boundary, position
- Geological boundary, position
- Fault
- Anticline
- Syncline
- Highway
- Road
- Water Bore
- Telegraph line
- Abandoned well, dry
- Abandoned well, show of oil
- Abandoned well, show of oil
- Stratigraphic well

LOCALITY M

WEST

SC



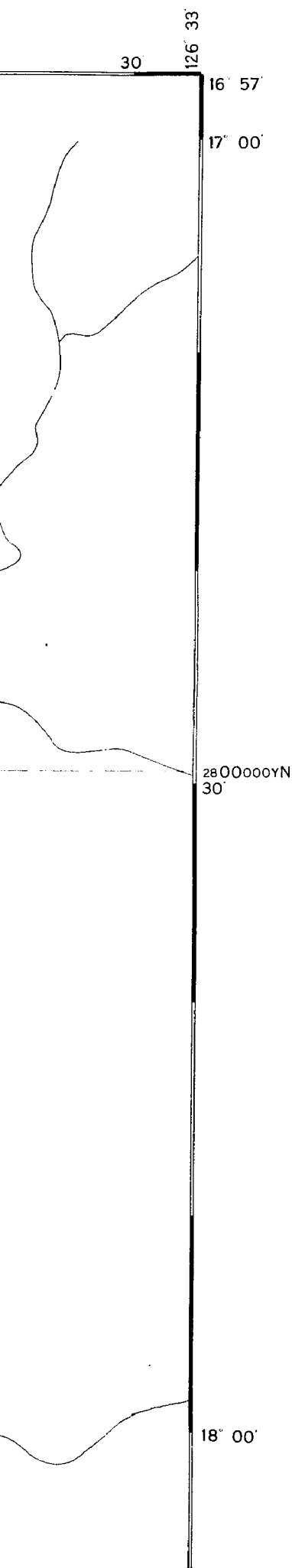
HALLS CREEK APPROX. 100M.

TRANSVERSE M
Grid
Magnetic

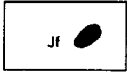
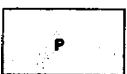
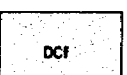
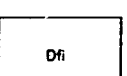
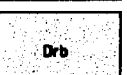
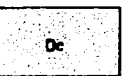
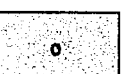
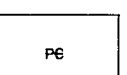
GEOLOGICAL SUR
SOL

NORTHERN

Permian and Mesozoic geology af



REFERENCE

?CRETACEOUS		Meda Formation
JURASSIC		Alexander, Jarlemai, James and Barbwire Formations
		Fitzroy Volcanics
TRIASSIC		Erskine Sandstone and Blina Shale
PERMIAN		Poole, Noonkanbah and Liveringa Formations
		Grant Formation
DEVONIAN AND ?PERMIAN		Undifferentiated conglomerates
L. CARBONIFEROUS - U. DEVONIAN		Fairfield Formation
DEVONIAN		FORE - REEF AND INTER - REEF FACIES
		REEF AND BACK - REEF FACIES
		Van Emmerick, Behn, Stony Creek and Bobs Bore Conglomerates
ORDOVICIAN		Emanuel Formation and Gap Creek Formation
PRECAMBRIAN		Basement complex

SYMBOLS

Geological boundary, position accurate

Geological boundary, position approximate

Fault

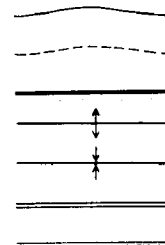
Anticline

Syncline

Highway

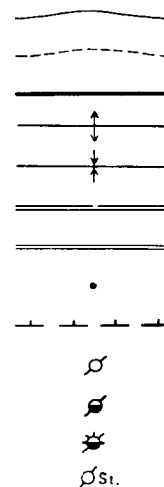
Road

Water Bore



SYMBOLS

Geological boundary, position accurate
 Geological boundary, position approximate
 Fault
 Anticline
 Syncline
 Highway
 Road
 Water Bore
 Telegraph line
 Abandoned well, dry
 Abandoned well, show of oil
 Abandoned well, show of oil and gas
 Stratigraphic well



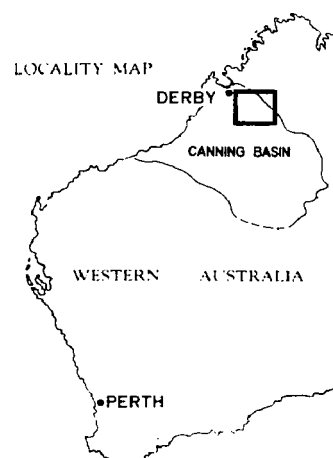
IEOPOLD

RANGES

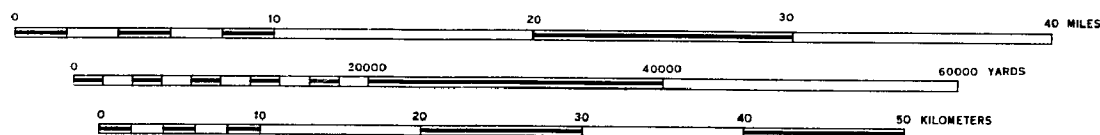
18° 00'

2700000Y

30'



SCALE 1:500,000



TRANSVERSE MERCATOR PROJECTION ZONE 3

Grid interval 100,000 yards

Magnetic Declination approximately 3°E

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

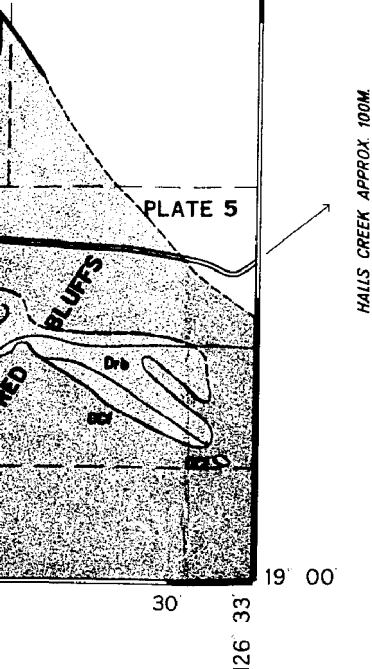
SOLID GEOLOGY

PART OF

NORTHERN CANNING BASIN

Permian and Mesozoic geology after Bureau of Mineral Resources Map WA3E - 17

PLATE 6



Gogo	Virgin Hills										FORMATION
19024 19023 19022 19021 19020 19019 19018 19017 19016 19015 19014 19013 19012 19011 19010 19009 19008 19007 19006 19005 19004 19003 19002 19001	SAMPLE NUMBER										
Polygnathus asymmetricus			P. gig		P. tri		Palm. crepida				ZONE
			A. triang								SUBZONE SPECIES
											<p>Icriodus symmetricus s.s. Ancyrodella rotundiloba alata Ancyrodella buckeyensis Polygnathus asymmetricus ovalis Polygnathus xylus Polygnathus foliatus Polygnathus pollocki Ozarkodina macra Lonchodina arcuata Neoproniodus armatus Nothognathella sublaevis Icriodus alternatus s.s. Ancyrodella rotundiloba s.s. Enantiognathus lipperti Ligonodina sp. nov. A Synphoniodina cf. S. alternata Palmatolepis punctata Polygnathus decorosus Pseudopolygnathus sp. A Spathognathodus sp. nov. A Pelekyognathus elevatus Hindeodella uncata Hindeodella compressa Ancyrodella nodosa Palmatolepis hassi Palmatolepis subrecta Polygnathus seddoni Polygnathus normalis Scutula venusta Ancyrodella ioides Ozarkodina sp. D Ancyrodella curvata Palmatolepis gigas Polygnathus brevilaminus Nothognathella brevidonta Nothognathella typicalis Hindeodella subtilis Ancyrodella buckeyensis Icriodus alternatus cymbiformis Icriodus arkonensis s.s. Nothognathella abnormis Ligonodina magnidens Scutula sp. A Neoproniodus sp. C Icriodus alternatus elegantulus Icriodus arkonensis subsp. b Icriodus incrassatus subsp. a Palmatolepis triangularis Palmatolepis subperlobata Icriodus alternatus curvirostratus Icriodus incrassatus subsp. b Palmatolepis minuta loba Palmatolepis delicatula Palmatolepis regularis Nothognathella cf. N. falcata Nothognathella polygnathoides Apatognathus sp. A Palmatodella delicatula Palmatolepis quadrantinosolebata Ligonodina panderi Acodina formosa Acodina sannemannii Acodina inopinata Palmatolepis tenuipunctata Palmatolepis glabra s.s. Palmatolepis minuta s.s. Nothognathella Polygnathus germanus s.s. Polygnathus glaber s.s. Prioniodina? smithi Tripodellus robustus Scutula bipennata Palcodus variabilis Ozarkodina immersa Hibbardella (Dipicododella) alternata Scutula sp. B Palmatolepis glabra pectinata Palmatolepis subgracilis Hindeodella brevis</p>

Figure 19 - Distribution chart of species in Section 1.

Gogo	Virgin Hills	FORMATION	
19543	19547	SAMPLE NUMBER	
19544	19548		
19545	19549		
19546	19550		
19547	19551		
19548	19552		
19549	19553		
19550	19554		
19551	19555		
19552	19556		
19553	19557		
19554	19558		
19555	19559		
19556	19560		
19557	19561		
19558	19562		
19559	19563		
19560	19564		
19561	19565		
19562	19566		
19563	19567		
19564	19568		
19565	19569		
19566	19570		
19567	19571		
19568	19572		
19569	19573		
19570	19574		
19571	19575		
19572	19576		
19573	19577		
19574	19578		
19575	19579		
19576	19580		
19577	19581		
19578	19582		
19579	19583		
19580	19584		
19581	19585		
19582	19586		
19583	19587		
19584	19588		
19585	19589		
19586	19590		
19587	19591		
19588	19592		
19589	19593		
19590	19594		
19591	19595		
19592	19596		
19593	19597		
19594	19598		
19595	19599		
19596	19600		
19597	19601		
19598	19602		
19599	19603		
19600	19604		
19601	19605		
19602	19606		
19603	19607		
19604	19608		
19605	19609		
19606	19610		
19607	19611		
19608	19612		
19609	19613		
19610	19614		
19611	19615		
19612	19616		
19613	19617		
19614	19618		
19615	19619		
19616	19620		
19617	19621		
19618	19622		
19619	19623		
19620	19624		
19621	19625		
19622	19626		
19623	19627		
19624	19628		
19625	19629		
19626	19630		
19627	19631		
19628	19632		
19629	19633		
19630	19634		
19631	19635		
19632	19636		
19633	19637		
19634	19638		
19635	19639		
19636	19640		
19637	19641		
19638	19642		
19639	19643		
19640	19644		
19641	19645		
19642	19646		
19643	19647		
19644	19648		
19645	19649		
19646	19650		
19647	19651		
19648	19652		
19649	19653		
19650	19654		
19651	19655		
19652	19656		
19653	19657		
19654	19658		
19655	19659		
19656	19660		
19657	19661		
19658	19662		
19659	19663		
19660	19664		
19661	19665		
19662	19666		
19663	19667		
19664	19668		
19665	19669		
19666	19670		
19667	19671		
19668	19672		
19669	19673		
19670	19674		
19671	19675		
19672	19676		
19673	19677		
19674	19678		
19675	19679		
19676	19680		
19677	19681		
19678	19682		
19679	19683		
19680	19684		
19681	19685		
19682	19686		
19683	19687		
19684	19688		
19685	19689		
19686	19690		
19687	19691		
19688	19692		
19689	19693		
19690	19694		
19691	19695		
19692	19696		
19693	19697		
19694	19698		
19695	19699		
19696	19700		
19697	19701		
19698	19702		
19699	19703		
19700	19704		
19701	19705		
19702	19706		
19703	19707		
19704	19708		
19705	19709		
19706	19710		
19707	19711		
19708	19712		
19709	19713		
19710	19714		
19711	19715		
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19713	19717		
19714	19718		
19715	19719		
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19718	19722		
19719	19723		
19720	19724		
19721	19725		
19722	19726		
19723	19727		
19724	19728		
19725	19729		
19726	19730		
19727	19731		
19728	19732		
19729	19733		
19730	19734		
19731	19735		
19732	19736		
19733	19737		
19734	19738		
19735	19739		
19736	19740		
19737	19741		
19738	19742		
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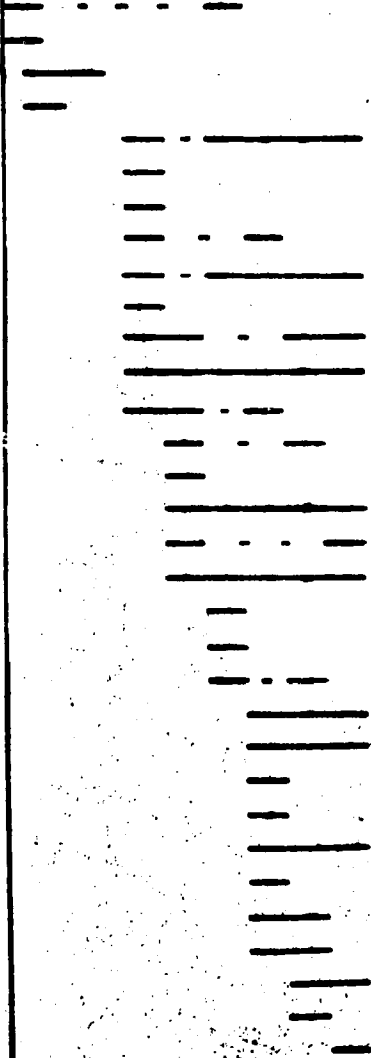
GoGo	Virgin Hills	FORMATION	
Upper Pol. asymm.	Ancyrognathus triangularis	CONODONT ZONE	
19585 19584 19583 19582	19581 19580 19579 19578 19577	SAMPLE NUMBER ←	SPECIES ↓
		Polygnathus australis Icriodus alternatus cymbiformis Polygnathus seddoni Polygnathus asymmetricus ovalis Palmatolepis unicornis Ancyrodella lobata Polygnathus cf. P. webbi Bryantodus typicus Bryantodus nitidus Ozarkodina immersa Palmatolepis subrecta Ancyrodella nodosa Polygnathus xylus Icriodus alternatus s.s. Nothognathella abbreviata Ozarkodina macra Lonchodina arcuata Hindeodella subtilis Synprioniodina cf. S. alternata Palmatodella delicatula Lonchodina sp. A Ancyrodella buckeyensis Ancyrodella ioides Neoproniodus armatus Lonchodina perlonga Ligonodina panderi Falcodus guntharii Nothognathella abnormis Nothognathella brevidonta Enantiognathus lippereti Hindeodella compressa Hibbardella (Diplododella) alternata	

Figure 23 - Distribution chart of species in Section 12.

Virgin Hills	Bugle Gap	FORMATION
21011 21012 21013 21014 21015 21016 21017 21018 21019 21020	21021 21022 21023 21024 21025 21026 21027 21028 21029 21030 21031 21032 21033 21034 21035 21036 21037 21038 21039 21040 21041 21042 21043 21044 21045 21046 21047 21048 21049 21050	21051 21052 21053 21054 21055 21056 21057 21058 21059 21060 21061 21062
Pa. crop. Mid.	Pa. rhomboida Supp.	Scaphignathus veliferus Low.
	Palmatolepis quadrantinosus Upper	Mid.
		Upp.
		Poly. styriacus
Palmatolepis subperlobata Palmatolepis perlobata Nothognathella typica Icriodus incrassatus subsp. a Nothognathella polygnathoides Palmatolepis minuta s.s. Polygnathus glaber s.s. Ozarkodina homocarcuata Palmatolepis glabra pectinata Palmatolepis glabra s.s. Palmatolepis tenuipunctata Polygnathus germanus s.s. Hindeodella corpulenta Palmatolepis glabra elongata Polygnathodonta confluent Neopriodontus sp. B Ozarkodina macra Falcodus variabilis Polygnathus obliquicostatus Hibbardella (Diplodocella) aurita Falcodus sp. nov. A Polygnathus normalis Hibbardella (Diplodocella) alternata Polygnathus fallax Hibbardella (H) plana Palmatolepis distorta Scaphignathus ziegleri Polygnathodonta elongata Polygnathus delictus Hindeodella subtilis Polygnathus norrisi Polygnathus perplexa Tripodellus robustus Polygnathus semicostatus Polygnathus irregularis Acodina sanneimanni		

Figure 24 - Distribution chart of species in Section 14.

