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DEPARTMENT OF ENERGY,
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PAPER 67-30

CONODONT ZONATION, WATERWAYS FORMATION
(UPPER DEVONIAN), NORTHEASTERN AND
CENTRAL ALBERTA

(Report, 1 figure and 2 plates)

T. T. Uyeno



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ABSTRACT

Two conodont zones are recognized in the Waterways Formation of northeastern and central Alberta. Conodonts of the lower two members of this formation, the Firebag and Calumet, may be assigned to the Lower Polygnathus asymmetrica Zone ($toI\alpha$ of German sequence), and those of the upper three members, the Christina, Moberly, and Mildred, to the Middle Polygnathus asymmetrica Zone ($toI\alpha$). Both zones are defined in the Rhenish Schiefergebirge of Germany, and are the lowermost Upper Devonian conodont zones of the Manticoceras-Stufe.

Only platform and some blade-like conodonts are considered in this study. They consist of 28 species and 5 subspecies, referable to 10 genera. Six new taxa are described and illustrated, of which the following are formally named: Ancyrodella rotundiloba binodosa, Nothognathella klapperi, Polygnathus incompleta, and Polygnathus norrisi.



CONODONT ZONATION, WATERWAYS FORMATION (UPPER DEVONIAN), NORTHEASTERN AND CENTRAL ALBERTA

INTRODUCTION

This summary account presents a conodont zonation of the Waterways Formation of northeastern and central Alberta. A list of selected platform and some blade-like conodont species is given below, with descriptions and illustrations of the more important new taxa. The remainder of this selected fauna will be treated in detail in a future report.

Warren (1933) proposed the name Waterways Formation for a sequence of Devonian limestone and shale exposed on the Athabasca River below McMurray, and noted that it carries a "Portage fauna". Subsequently, the age of this formation, and its partial subsurface equivalent the Beaverhill Lake Formation, has been subject to debate. In recent years, Loranger (1965) considered the Waterways Formation as Middle Devonian (Givetian), whereas McGill (1966) has suggested that it is Upper Devonian (Frasnian). The object of the current work is to determine whether study of the conodonts can aid in more clearly establishing the age of the formation, and thereby clarify the position of the Middle-Upper Devonian boundary in central and northeastern Alberta.

For the stratigraphy, history of investigations, lists of macrofossils, and description of the Waterways Formation, the reader is referred to Norris (1963).

Most of the cores studied herein from central Alberta are from wells in the vicinity of the Judy Creek field and the term Waterways is used here instead of Beaverhill Lake, a more commonly used name for its partial subsurface equivalent, as has been suggested by Murray (1965).

For this investigation, 259 samples of the Waterways Formation from 35 sections along the Athabasca River, and the Clearwater River and its tributaries, were studied. Fifty of these samples were collected in 1956 by Dr. A. W. Norris of the Geological Survey of Canada, and the rest by the author in 1964. In addition, 318 cored samples from nine wells scattered through northeastern and central Alberta, were also examined. Localities of the sections and wells investigated are indicated on Figure 1, and in the Appendix.

The author gratefully acknowledges the following persons who gave their time and effort in discussion of various problems arising during this study: Dr. B. F. Glenister and Dr. W. M. Furnish, University of Iowa; Dr. G. Klapper, Pan American Petroleum Corp., Research Center, Tulsa;

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Dr. R. L. Ethington, University of Missouri; Dr. W. Ziegler, Geologisches Landesamt Nordrhein-Westfalen, Krefeld; and several colleagues at the Geological Survey of Canada. Some conodont specimens were supplied by Dr. R. Green, Research Council of Alberta, Edmonton, and by Dr. U. Mayr, formerly of University of Ottawa. Able assistance in the field was provided by Mr. O. E. Engstrom, McMurray, Alberta, and Mr. G. W. Graff.

RESULTS OF INVESTIGATION

General. The distribution of platform and some blade-like conodont species within the Waterways Formation is shown on Table 1. A total of 1,968 specimens are referable to 10 genera, 28 species, and 5 subspecies. Those conodont species useful for zonation of the lower Manticoceras-Stufe (Ziegler, 1958, 1962; Bischoff and Ziegler, 1957) are represented by 193 specimens, or about 10 per cent of the total number of selected specimens. The number of specimens of each species recovered from each member of the Waterways Formation, including the Swan Hills Member, is shown on Table 2. On Table 1 occurrences in the Swan Hills Member have been omitted because the exact correlation of this member to the reference section of the Waterways Formation (of Norris, 1963) is not known.

Table 2 lists the selected conodont species studied from the Waterways Formation. Of these, only the following are described in this paper:

Ancyrodella rotundiloba binodosa n. subsp.

A. rotundiloba subsp. A

Nothognathella klapperi n. sp.

Polygnathus incompleta n. sp.

P. norrisi n. sp.

Spathognathodus? sp.

Conodont zonation. The zone fossil of the lowermost Upper Devonian conodont zone Polygnathus asymmetrica asymmetrica, and/or P. asymmetrica ovalis were found in the Firebag, Christina, Moberly, and Mildred Members of the Waterways Formation (see Table 2). In Germany, the complete stratigraphic range of these subspecies is from the base to the top of the P. asymmetrica Zone (toI α -toI β) (Ziegler, 1962). In addition, Ancyrodella rotundiloba ranges from the middle part of the Lower P. asymmetrica Zone to the top of the Middle P. asymmetrica Zone (Ziegler, 1962). In the Waterways Formation, the three subspecies of Ancyrodella rotundiloba range from the middle part of the Calumet to the top of the Moberly Member, and are also present in the Swan Hills Member.

In the German standard succession, Ancyrodella gigas Youngquist appears at the base of the Middle P. asymmetrica Zone (toI α) and ranges up to the Upper Palmatolepis gigas Zone (toI δ) (Ziegler, 1958, 1962). In the

Waterways Formation, this species occurs from near the base of the Christina (?) to the Mildred Member. On this basis, the base of the Christina Member is considered to be the base of the Middle P. asymmetrica Zone.

In summary, species of conodonts considered to be indicative of Late Devonian age were found throughout the Waterways Formation. In terms of Ziegler's (1962) conodont zonation, the lower two members of the Waterways Formation, the Firebag and Calumet, may be assigned to the Lower Polygnathus asymmetrica Zone (α), and the upper three members, the Christina, Moberly, and Mildred, to the Middle Polygnathus asymmetrica Zone (α). In the standard German sections and in Australia, these are the lowest conodont zones associated with Upper Devonian ammonoids (Krebs and Ziegler, 1966; Glenister and Klapper, 1966). Ziegler (1966) established a transitional zone between proven Middle Devonian (with Maenioceras) and Upper Devonian (with Pharciceras) strata; he named it the Schmidtognathus hermanni-Polygnathus cristata Zone and considered the position of the Middle-Upper Devonian boundary to lie within this zone.

Correlation of the Waterways Formation. In terms of the standard Upper Devonian succession in Germany, the conodont fauna of the Waterways Formation correlates with the lowest Manticoceras-Stufe.

Conodonts of the North Evans Limestone of New York were first described by Hinde (1879) and later restudied by Bryant (1921). Ziegler (1962) assigned the North Evans conodont fauna to the Lower P. asymmetrica Zone. This unit, therefore, may be correlated with the Waterways Formation.

Müller and Müller (1957, p. 1,078) recorded that, on the basis of conodonts, the Squaw Bay Limestone of Michigan and the Genundewa Limestone of New York are both equivalent to the Lower Adorf (Manticoceras) Stufe. The Squaw Bay contains the goniatite Koenenites cooperi Miller. Miller (1938, p. 130) noted that, "In Europe the genus Koenenites is limited to the basal portion of the Upper Devonian - that is, to the lower portion of "Oberdevonstufe I" - and presumably the Michigan form is also of early Upper Devonian age".

Hass and Huddle (1965, p. D129) noted that a conodont assemblage of early Late Devonian age containing Ancyrodella rotundiloba is present in the basal portion of the Woodford Shale of Oklahoma, "and is the same assemblage as that found in the basal sandstone of the Chattanooga Shale as exposed along the Eastern Highland Rim of central Tennessee, the lower part of the New Albany Shale of Indiana, and the Genundewa Limestone Member of the Genessee Formation (Upper Devonian) of New York". To this we may now add the Waterways Formation of Alberta.

SYSTEMATIC PALAEOONTOLOGY

Genus ANCYRODELLA Ulrich and Bassler, 1926

Type species. Ancyrodella nodosa Ulrich and Bassler, 1926.

Remarks. As noted elsewhere in this paper, morphological similarity and relative stratigraphic positions of Spathognathodus? sp. [described herein] and Ancyrodella rotundiloba binodosa n. subsp., suggest a possible phylogenetic relationship between them.

Ancyrodella rotundiloba (Bryant)

1921. Polygnathus rotundilobus BRYANT, pp. 26-27, Pl. XII, figs. 1-6, p. 26, text-fig. 7 [Pl. XII, fig. 1 is lectotype designated by Ziegler, 1958, p. 44].
1966. Ancyrodella rotundiloba rotundiloba (Bryant). GLENISTER and KLAPPER, p. 799, Pl. 85, figs. 9-13.

Diagnosis. Glenister and Klapper's (1966, p. 799) diagnosis of this species may be emended to indicate that the basal cavity varies considerably in size. It may be small, or relatively large so as to occupy a large part of the aboral surface of the platform. In the latter case, the relative size of the basal cavity is less in the larger, more mature specimens than in the smaller, juvenile ones.

Range. Ziegler (1962) recorded the range of this species from the Lower P. asymmetrica Zone (to α) to the top of the Middle P. asymmetrica Zone (to α).

Ancyrodella rotundiloba binodosa n. subsp.

Plate I, figures 2, 4, 5

Description. Subspecies characterized by a pair of large nodes, one on each side of the triangular platform. Platform otherwise free of ornamentation, although a few incipient nodes may occur. Carina composed of a few short, stubby denticles. Free blade high, composed of a few denticles. Basal cavity relatively large, occupying most of the aboral surface of the platform, especially of smaller specimens. Secondary keels developed only incipiently.

Remarks. Two juvenile specimens were obtained from the base of the Christina Member (one illustrated on Pl. I, fig. 5). These individuals exhibit a platform with the oral surface mostly occupied by large nodes. Most of the aboral surface of the platform is occupied by a relatively large basal cavity. In mature individuals, the platform attained a relatively larger size in proportion to the free blade, and the basal cavity and the two nodes, although still large, occupied a proportionately smaller area. The juvenile specimens are morphologically similar to Spathognathodus? sp. [described herein].

The subspecific name is given for the characteristic pair of large nodes on the platform.

Occurrence. Waterways Formation, from middle Calumet to basal Christina, and Swan Hills Members.

Types. Holotype, GSC No. 22819, GSC loc. 29089; Paratypes, GSC Nos. 22820 and 22821, GSC locs. 63115 and 63382, respectively.

Ancyrodella rotundiloba subsp. A

Plate I, figures 1, 3, 6

Description. Platform triangular to oval, sculptured with extremely coarse nodes; some specimens with a pair of larger nodes, one on each side of the platform. Free blade composed of a few high denticles. Basal cavity small, diamond-shaped [e.g., Pl. I, fig. 6a], or large with flaring lips, in some specimens bifurcating at the termini [e.g., Pl. I, fig. 3a]. Secondary keels only incipiently developed. Aboral surface of platform almost flat to highly undulating.

Remarks. Some specimens included in this subspecies are similar to Ancyrodella rotundiloba rotundiloba (Bryant) in platform outline and shape of the basal cavity. Others have a more oval platform with large basal cavity. All, however, bear extremely coarse nodes in contrast to the finer ornamentation of the typical subspecies.

Occurrence. Waterways Formation, from middle Calumet to upper Moberly Members.

Types. Specimens, GSC Nos. 22822, 22823, and 22824, GSC locs. 62691, 63119, and 62828, respectively.

Genus NOTHOGNATHELLA Branson and Mehl, 1934

Type species. Nothognathella typicalis Branson and Mehl, 1934.

Nothognathella klapperi n. sp.

Plate I, figures 7, 8; Plate II, figure 1

Diagnosis. Nothognathella with two apices: apical denticle located about two-thirds the blade length from the anterior end, a group of high denticles occurring near the anterior end. Blade strongly incurved posteriorly with denticles extremely inclined and almost in the plane of the platform. Platform widest posteriorly on the inner side of the blade.

Description. Blade only moderately arched, with two apices: the main apical denticle located about two-thirds the blade length from the anterior end, a group of high denticles occurring near the anterior end. Denticles numerous and fused almost to their apices; those on posterior portion less robust than anterior ones. Denticles near the anterior end erect to only slightly inclined. The apical denticle, however, inclined at about 45 degrees to the plane of the platform. Denticles posterior to the apical denticle successively more inclined, so that, together with strong incurving of the blade, those at the extreme posterior end lie almost in the same plane as the platform.

In oral view, blade straight to only slightly incurved, but strongly incurved at the extreme posterior end. Platform on inner side widest posteriorly, gradually narrowing anteriorly. Outer platform much smaller, restricted to region around the apical denticle. In mature specimens, oral surfaces of platform ornamented with small nodes.

Aboral side flat under platform, with moderately high keel extending the entire length of the blade. Keel straight with a point of deflection near the mid-length of blade, at site of a small oval basal cavity.

Remarks. Nothognathella klapperi differs from other species of this genus in having a strongly incurved posterior end of the blade, and extremely inclined posterior denticles. N. brevidonta Youngquist differs from this species in possessing small equal-sized platforms restricted to the mid-length of the blade on both sides, short, stout denticles, and a straight aboral keel which curves near the posterior end. Basal cavity of the holotype of N. brevidonta was not observed (Youngquist, 1947, p. 108).

Some specimens of N. iowaensis Youngquist previously reported elsewhere (e.g., Anderson, 1966) also possess two apices. This species, however, may be distinguished by its greater arching, short denticles, and lack of strong curvature.

Nothognathella klapperi is a homeomorph of a Lower Carboniferous genus, Elictognathus, and is superficially similar to E. lacerata (Branson and Mehl). Common features of these species are the inward curvature of the posterior end of the blade, and the two apices, although these features are not always present in E. lacerata (Klapper, 1966).

The specific name is for Dr. Gilbert Klapper, Research Center, Pan American Petroleum Corp., Tulsa.

Occurrence. Waterways Formation, from basal Christina to basal Mildred Members.

Types. Holotype, GSC No. 22825, GSC loc. 64010; Paratypes, GSC Nos. 22826 and 22827, GSC locs. 77128 and 64010, respectively.

Genus POLYGNATHUS Hinde, 1879

Type species. Polygnathus robusticostata Bischoff and Ziegler, 1957 [pending decision on proposal to International Commission on Zoological Nomenclature by Ziegler, Klapper, and Lindström, 1964].

Polygnathus incompleta n. sp.

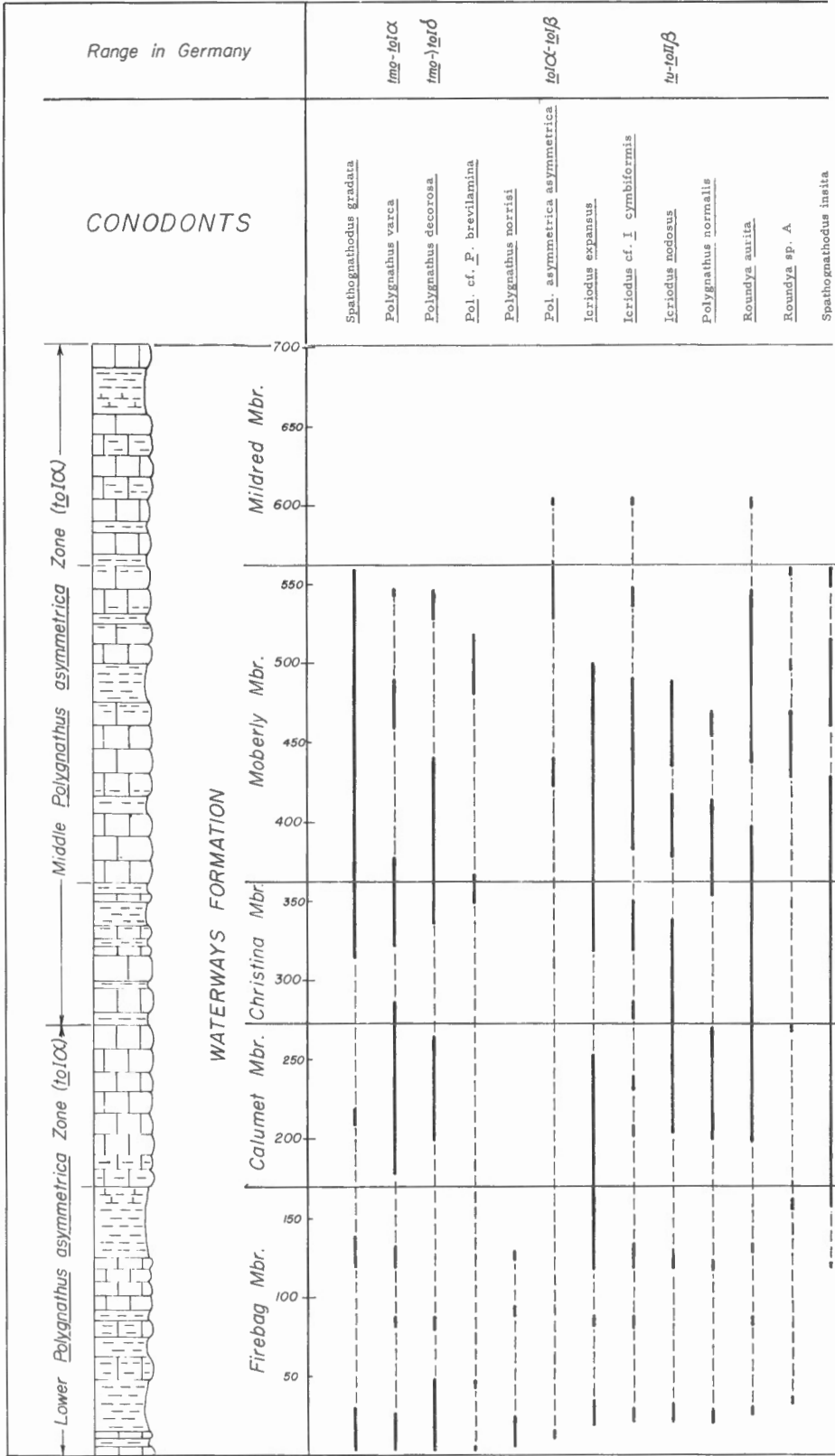
Plate II, figures 6, 7

Diagnosis. Polygnathus with smooth or weakly ornamented, elongated platform. Carina composed of fused denticles, not extending to posterior end. Two or three small nodes may occur posterior to ridge-like carina.

Description. Platform elongate, smooth, or indistinctly ornamented with vague ribs near the margins. Carina ridge-like, presumably resulting from fusion of a series of denticles. In some specimens, 2 or 3 extremely small nodes may occur posterior to the ridge-like structure. Deep troughs present on oral surface of the platform, one on either side of the carina, which unite and continue posterior of the carina. Free blade, of about the same length as the platform, and high anteriorly. Entire unit slightly to moderately incurved. In lateral view, free blade straight, and platform gently arched. Aboral side keeled throughout, except at the site of the basal cavity near the anterior end of the platform.

Remarks. The smooth to indistinctly ornamented platform of this species is a feature also common to Polygnathus communis Branson and Mehl, and Polygnathus glabra Ulrich and Bassler. A number of other features differentiate it from these two species. In P. communis the platform is much wider with only shallow troughs adjacent to the carina, and the carina extends to the posterior end of the platform. In P. glabra, the platform has a round anterior outline with pointed posterior end.

The specific name is given for the incomplete carina which does not extend to the posterior end.



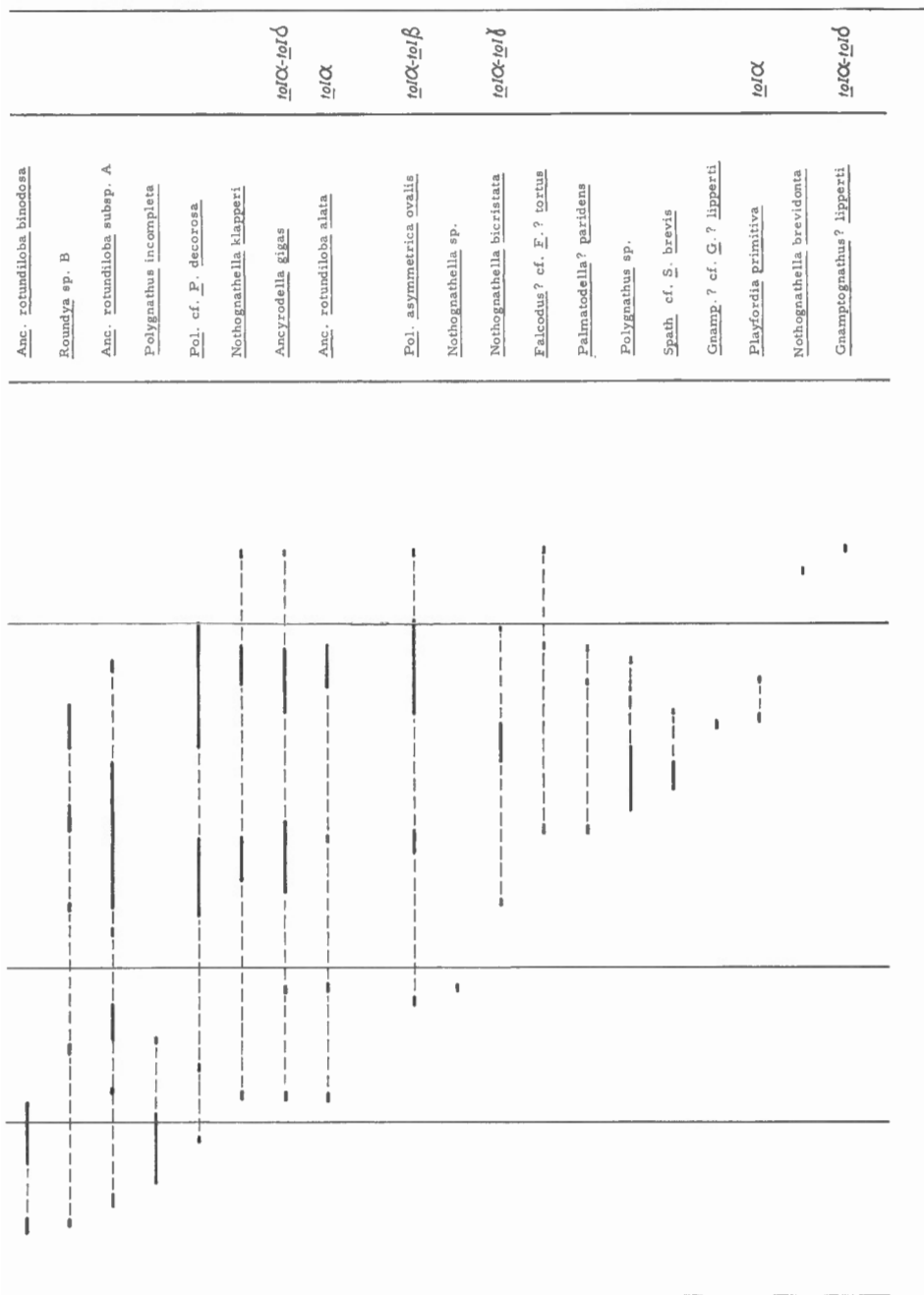


TABLE 1. STRATIGRAPHIC DISTRIBUTION OF SELECTED CONODONT SPECIES IN THE WATERWAYS FORMATION (equated to the Reference Section in the Bear Biltmore No. 1 well, depth 981 to 1,682.5 feet).

Note: Range of species in Germany given in terms of standard European ammonoid zones.

: See Belyea, 1952, pp. 36-44, and Norris, 1963, p. 153 for details of the Reference Section.

Occurrence. Waterways Formation, from middle Calumet to middle Christina, and Swan Hills Members.

Types. Holotype, GSC No. 22828, GSC loc. 63389; Paratype, GSC No. 22829, GSC loc. 63113.

Polygnathus norrisi n. sp.

Plate II, figures 4, 5

Diagnosis. Polygnathus species having platform with subparallel sides and fluted margins. Oral surface of platform characterized by plates arranged in reversed chevron patterns.

Description. Platform about twice as long as wide, with posterior end abruptly pointed or somewhat smoothly tapering. Lateral margins of platform subparallel with slight constriction near mid-length. Oral surface of platform with numerous thin plate-like projections. On the holotype (Pl. II, fig. 5b) these projections are directed anteriorly at the anterior end, and posteriorly at the opposite end, creating reversed chevron patterns. Anterior margins of the platform directed anteriorly, at about 60 degrees to the carina. Viewed laterally, these plates appear as a series of needle-like projections occurring in groups. Carina inconspicuous, composed of a series of fused nodes standing only slightly higher than the platform. Free blade short, about half the length of the platform, with 6 to 10 denticles. Aboral side with straight keel under platform and blade, and a shallow, slit-like basal cavity near the anterior part of the platform.

Remarks. Two somewhat different morphological types are included in this species, but it is believed that the differences are due to preservation. Three of the five specimens available are deformed, the free blade being bent and inclined against the platform, or the platform itself being twisted.

A juvenile form of Polygnathus diversa Helms, illustrated by Helms (1959, Pl. V, fig. 8), bears superficial resemblance to P. norrisi. P. diversa, however, has a carina and free blade that are slightly offset, and a platform with numerous, needle-like projections.

Although only five specimens were recovered from the Waterways Formation, they differ sufficiently from previously described species to warrant description.

The specific name is for Dr. A. W. Norris, Geological Survey of Canada, Ottawa.

Occurrence. Waterways Formation, Firebag Member.

Types. Holotype, GSC No. 22830, GSC loc. 62737; Paratype, GSC No. 22831, GSC loc. 77112.

Genus SPATHOGNATHODUS Branson and Mehl, 1941

Type species. Spathodus primus Branson and Mehl, 1933.

Spathognathodus? sp.

Plate II, figures 2, 3

Description. Blade with form similar to that of Spathognathodus insita (Stauffer) but with lateral denticles on both sides. Lateral denticles directly over the basal cavity, as outgrowths from sides of the blade rather than from a distinct platform. These denticles are erect, some comparable in size to those on posterior half of the blade, others smaller, and up to five in number. Two or more lateral denticles may fuse to form a short ridge.

Remarks. The Waterways material includes juvenile specimens of Ancyrodella rotundiloba binodosa n. subsp., which, in possessing only incipiently developed platforms, exhibit forms similar to those of the present species. The latter, however, is closer to Spathognathodus than to Ancyrodella as it lacks the distinct platform of Ancyrodella, and possesses denticles merely as outgrowths of the lateral sides. Spathognathodus? sp. occurs in the upper part of the Firebag Member, and Ancyrodella rotundiloba binodosa occurs from the middle part of the Calumet through basal Christina Members. This may indicate a possible phylogeny and origin of Ancyrodella, relating it with Spathognathodus.

Occurrence. Waterways Formation, Firebag Member, Richfield Oil Corp. Pony Creek No. 2 well.

Types. Specimens, GSC Nos. 22832 and 22833, GSC locs. 77110 and 77112, respectively.

CONODONTS	Members of the WATERWAYS FORMATION											Total
	Mildred	Moberly		Christina		Calumet		Firebag		Swan Hills		
	S	O*	S	O	S	O	S	O	S	S		
<u>Ancyrodella gigas</u> Youngquist	1		21		3							25
<u>A. rotundiloba alata</u> Glenister and Klapper			3		8							11
<u>A. rotundiloba binodosa</u> n. subsp.					5	4	1				2	12
<u>A. rotundiloba</u> subsp. A			48	6	2	2		1				59
<u>Falcodus?</u> cf. <u>F. ? tortus</u> Huddle	1		13									14
<u>Gnamptognathus?</u> <u>lipperti</u> (Bischoff)	1										1	2
<u>G. ? cf. G. ? lipperti</u> (Bischoff)			1									1
<u>Icriodus</u> cf. <u>I. cymbiformis</u> Branson and Mehl	1	23	16	2	10	8	1	4	9	1		75
<u>I. expansus</u> Branson and Mehl		56	12	9	10	61	11	13	10	1		183
<u>I. nodosus</u> (Huddle)		43	3		9	12	1	6	9	1		84
<u>Nothognathella bicristata</u> Youngquist and Miller		4										4
<u>N. klapperi</u> n. sp.	5		23		1							29
<u>N. brevidonta</u> Youngquist	1											1
<u>N. sp.</u>					1							1
<u>Palmatodella?</u> <u>paridens</u> Huddle			8									8
<u>Playfordia primitiva</u> (Bischoff and Ziegler)			2									2
<u>Polygnathus asymmetrica asymmetrica</u> Bischoff and Ziegler	9		16						1			26
<u>P. asymmetrica ovalis</u> Ziegler and Klapper	18	1	40		1							60
<u>P. cf. P. brevilamina</u> Branson and Mehl		4	2		1				2	2		11
<u>P. decorosa</u> Stauffer			8		2	7	5		12	10		44
<u>P. cf. P. decorosa</u> Stauffer	1	2	34		1		2					40
<u>P. norrisi</u> n. sp.								2	3			5
<u>P. varca</u> Stauffer		6	2	3	9	38	6	1	4	3		72
<u>P. normalis</u> Miller and Youngquist		3	1	1		12	4	4			1	26
<u>P. incompleta</u> n. sp.					5	22	12				2	41
<u>P. sp.</u>		44	1									45
<u>Roundya aurita</u> Sannemann	1	34	9		11	10	1	1	2	3		72
<u>R. sp. A</u>		8					1		2	1		12
<u>R. sp. B</u>		7	1		1	1						10
<u>Spathognathodus</u> cf. <u>S. brevis</u> Bischoff and Ziegler		7										7
<u>S. gradata</u> (Youngquist)		92	11	1	9	10	5	22	4	4		158
<u>S. insita</u> (Stauffer)		146	2	8	3	608	42	5	8	2		824
<u>S. ? sp.</u>									4			4

TABLE 2. Chart showing the number of Conodont specimens studied from the Waterways Formation. *O = Outcrops, S = Subsurface

APPENDIX

The following is a list of localities (stations) along the Athabasca River, and the Clearwater River and its tributaries, used in this study. The station and rock unit numbers shown here and in the plate explanations refer to those listed in Norris (1963). The figure in brackets refers to the number of samples studied from that station.

Athabasca River:

Firebag Member: Stn. 103 (22)
Calumet Member: Stns. 101, 102 (14)
Christina Member: Stn. 93 (3)
Moberly Member: Stn. 92 (13)
 Stn. 79 (22)
 Stn. 70 (21)
 Stn. 55 (4)
 Stn. 47 (3)
 Stn. 23-1 (8)
 Stn. 22-1 (5)
 Stn. 8a (7)

Clearwater River and its tributaries:

Firebag Member: Stn. 158 (3)
 Stn. 164 (7)
 Stn. 38UA (5) (not marked on Norris' (1963)
 Fig. 4; located on the south bank of Clearwater
 River, 0.6 mile downstream from the mouth of High Hill
 River)
Calumet Member: Stn. 168 (1)
 Stn. 171 (4)
 Stn. 172 (2)
 Stn. 173 (4)
 Stn. 176 (2)
 Stn. 45UA (1) (not marked on Norris' (1963)
 Fig. 4; located on the north bank of Clearwater River,
 16.7 miles downstream from the mouth of High Hill River)
 Stn. 178 (3)
 Stn. 181 (3)
 Stn. 182 (1)
Christina Member: Stn. 184 (7)
 Stn. 187 (6)
 Stn. 189 (3)
 Stn. 190 (3)
 Stn. 191 (1)

Moberly Member:	Stn. 192 (7)
	Stn. 193 (5)
	Stn. 196 (6)
	Stn. 194 (1)
	Stn. 202 (5)
	Stn. 203 (6)
	Stn. 205 (1)

The following is a list of well localities from northeastern and central Alberta. The figure in brackets refers to the number of samples studied from that well. The initial numbers (1 to 9) are those shown on Figure 1.

1. Alberta Government Salt Well No. 1:
Lot 8, McMurray townsite, lsd. 6, sec. 21, tp. 38, rge. 9, W4th mer. (30)
2. Industrial Minerals Limited Salt Well No. 1:
Lsd. 1, sec. 10, tp. 89, rge. 9, W4th mer. (29)
3. Richfield Oil Corporation Pony Creek No. 2:
Lsd. 9, sec. 1, tp. 80, rge. 8, W4th mer. (23)
4. Union Red Earth 2-22:
Lsd. 2, sec. 22, tp. 88, rge. 8, W5th mer. (29)
5. Calstan Standard Oil of British Columbia House Mountain 2-6:
Lsd. 2, sec. 6, tp. 70, rge. 10, W5th mer. (30)
6. Shell Swan Hills 6-31:
Lsd. 6, sec. 31, tp. 67, rge. 12, W5th mer. (20)
7. Imperial Shell Burntwood 12-6:
Lsd. 12, sec. 6, tp. 64, rge. 12, W5th mer. (29)
8. Imperial Judy Creek 6-7:
Lsd. 6, sec. 7, tp. 63, rge. 10, W5th mer. (73)
9. California Standard Cynthia S.W. 16-21:
Lsd. 16, sec. 21, tp. 49, rge. 13, W5th mer. (55)

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PLATE I

All figures X 45

Figures 1, 3, 6:

Ancyrodella rotundiloba subsp. A

1a, 1b, aboral and oral views of specimen GSC No. 22822, from Moberly Member, Station 92, Athabasca River, Rock Unit 36, 25.0 to 26.2 feet above river level, GSC loc. 62691.

3a, 3b, aboral and oral views of specimen GSC No. 22823, from Christina Member, Station 184, Christina River, Rock Unit 40, 0 to 1 foot above river level, GSC loc. 63119.

6a, 6b, aboral and oral views of specimen GSC No. 22824, from Moberly Member, Station 70, Athabasca River, Rock Unit 32, 14.6 to 16.4 feet above river level, GSC loc. 62828.

Figures 2, 4, 5:

Ancyrodella rotundiloba binodosa n. subsp.

2a, 2b, aboral and oral views of Holotype, GSC No. 22819, from Calumet Member, Station 181, Clearwater River, Rock Unit 35, 5.5 to 7.6 feet above river level; collected by A. W. Norris, GSC loc. 29089.

4a, 4b, aboral and oral views of Paratype, GSC No. 22820, from Calumet Member, Station 181, Clearwater River, Rock Unit 35, 5.5 to 6.5 feet above river level, GSC loc. 63115.

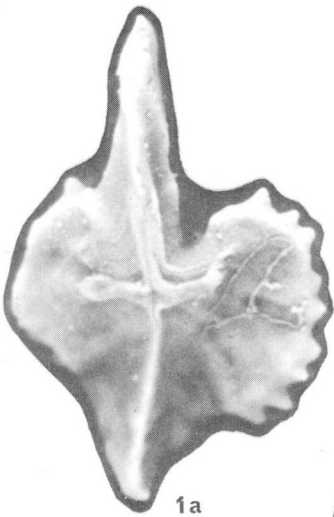
5a, 5b, aboral and oral views of Paratype, GSC No. 22821, from Christina Member, California Standard Cynthia S. W. 16-21 well, depth 11,736.9 to 11,739.2 feet, GSC loc. 63382.

Figures 7, 8:

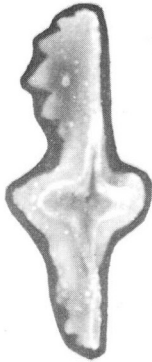
Nothognathella klapperi n. sp.

7a, 7b, inner lateral and aboral views of Paratype, GSC No. 22826, from Mildred Member, Shell Swan Hills 6-31 well, depth 9,353 feet, GSC loc. 77128.

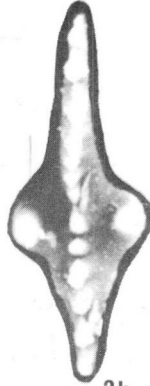
8, aboral view of Paratype, GSC No. 22827, from Moberly Member (?), Imperial Judy Creek 6-7 well, depth 8,516.3 to 8,518.7 feet, GSC loc. 64010.



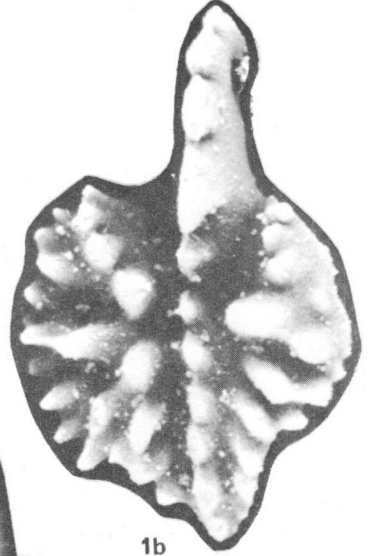
1a



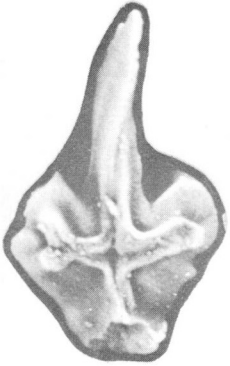
2a



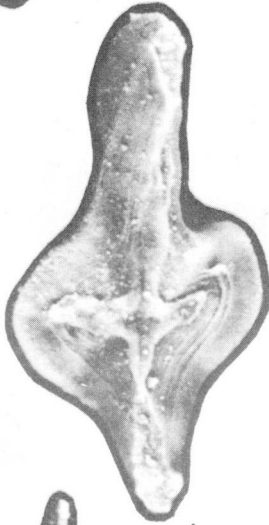
2b



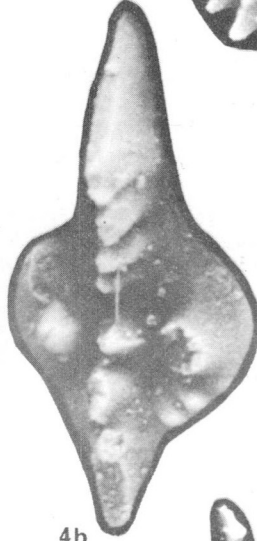
1b



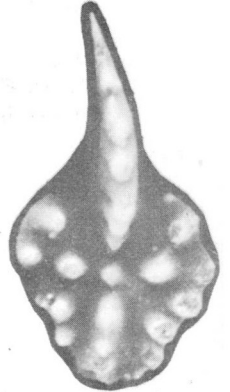
3a



4a



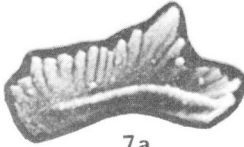
4b



3b



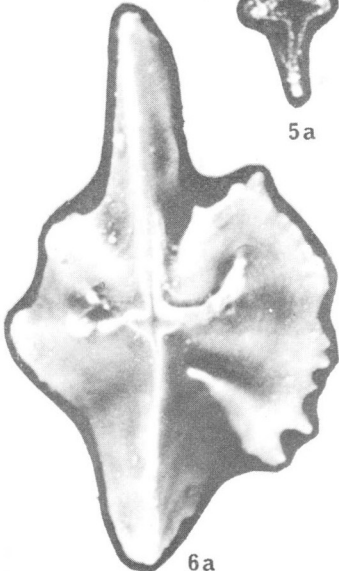
5a



7a



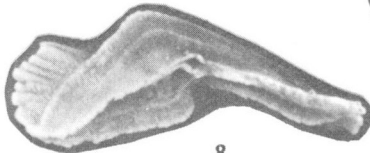
5b



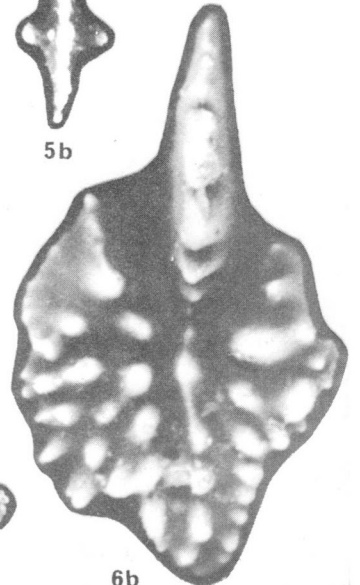
6a



7b



8



6b

PLATE II

All figures X 45

Figure 1:

Nothognathella klapperi n. sp.

1a, 1b, 1c, 1d, oblique lateral, inner lateral, oral, and aboral views of Holotype, GSC No. 22825, from Moberly Member (?), Imperial Judy Creek 6-7 well, depth 8,516.3 to 8,518.7 feet, GSC loc. 64010.

Figures 2, 3:

Spathognathodus ? sp.

2a, 2b, 2c, lateral, oral, and aboral views of specimen GSC No. 22832, from Firebag Member, Richfield Oil Corp. Pony Creek No. 2 well, depth 1,541 to 1,542 feet, GSC loc. 77112.

3a, 3b, 3c, oral, aboral, and lateral views of specimen GSC No. 22833, from Firebag Member, Richfield Oil Corp. Pony Creek No. 2 well, depth 1,512 to 1,517 feet, GSC loc. 77110.

Figures 4, 5:

Polygnathus norrisi n. sp.

4a, 4b, 4c, outer lateral, oral, and aboral views of Paratype, GSC No. 22831, from Firebag Member, Richfield Oil Corp. Pony Creek No. 2 well, depth 1,541 to 1,542 feet, GSC loc. 77112.

5a, 5b, 5c, aboral, oral, and inner lateral views of Holotype, GSC No. 22830, from Firebag Member, Station 103, Athabasca River, Rock Unit 2, 6.51 to 6.74 feet above river level, GSC loc. 62737.

Figures 6, 7:

Polygnathus incompleta n. sp.

6a, 6b, 6c, inner lateral, oral, and aboral views of Holotype, GSC No. 22828, from Calumet Member, California Standard Cynthia S.W. 16-21 well, depth 11,754.1 to 11,756.6 feet, GSC loc. 63389.

7a, 7b, 7c, aboral [showing large basal plate], oral, and inner lateral views of Paratype, GSC No. 22829, from Calumet Member, Station 181, Clearwater River, Rock Unit 34, 3.5 to 4.5 feet above river level, GSC loc. 63113.

