8.

SUMMARY OF CONODONT BIOSTRATIGRAPHY OF THE BLUE FIORD AND BIRD FIORD FORMATIONS (LOWER-MIDDLE DEVONIAN) AT THE TYPE AND ADJACENT AREAS, SOUTHWESTERN ELLESMERE ISLAND, CANADIAN ARCTIC ARCHIPELAGO

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Uyeno, T.T. and Klapper, G., Summary of conodont biostratigraphy of the Blue Fiord and Bird Fiord formations (Lower-Middle Devonian) at the type and adjacent areas, southwestern Ellesmere Island, Canadian Arctic Archipelago; in Current Research, Part C, Geological Survey of Canada, Paper 80-1C, p. 81-93, 1980.

Abstract

Conodonts of the Blue Fiord Formation in sections located 2.5 km and 30 km (near Sor Fiord) east of the type section in southwestern Ellesmere Island, are assignable to (in ascending order): ***dehiscens***, ***gronbergi***, ***inversus***, *and* ***serotinus*** *zones (approximately Pragian-Zlichovian boundary to Dalejan stages, Lower Devonian). The upper part of the underlying Eids Formation in this area also contains conodonts of the* ***dehiscens*** *Zone. The Blue Fiord Formation is diachronous as it has yielded conodonts of Eifelian age on Grinnell Peninsula, Devon Island, and on Cornwallis and Bathurst islands.*

The Bird Fiord Formation at its type section, also on southwestern Ellesmere Island, yielded conodonts that are either long-ranging or new, and thus cannot be so precisely dated. Brachiopods from the upper part of the formation, however, are assignable to the ***Warrenella kirki*** *Zone which, in Nevada, coincides with part of the conodont* ***kockelianus*** *Zone (late Eifelian). The Bird Fiord Formation is similarly diachronous, and on Bathurst Island it has been regarded as Eifelian to Givetian in age.*

A new genus, ***Steptotaxis****, is introduced.*

Introduction

The Blue Fiord Formation and the overlying Bird Fiord Formation were named by McLaren (in Fortier et al., 1963, p. 318-328) for 1159 m and 900 m, respectively, of strata exposed in the vicinity of Blue Fiord on southwestern Ellesmere Island (see Fig. 8.1). The Blue Fiord Formation was originally divided by McLaren (op. cit.) into two units, informally designated as the limestone and shale (lower) member (732 m thick), and the overlying brown limestone (upper) member (427 m). Kerr and Thorsteinsson (1972) similarly divided the Bird Fiord Formation into a lower member, consisting of limestone and shale that are variably quartzose and green weathering, and an upper member, consisting of sandstone that is partly calcareous and mainly of red or green colour. The thicknesses of the individual Bird Fiord members were not given. The type sections for these formations were subsequently selected by McLaren (in Kerr and Thorsteinsson, 1972).

The material on which the present study is based was collected by Uyeno in 1969 from the Blue Fiord Formation exposed along creeks located 2.5 km east of the type section, and from the type section of the Bird Fiord Formation (section 1 on Fig. 8.1; see also Uyeno and McGregor, 1970, section 5; base of section at UTM Zone 16X, 518000 E, 8574500 N and the top of section at UTM Zone 16X, 518750 E, 8569000 N; these are approximately equivalent to lat. 77°14.2'N, long. 86°16.5'W, and lat. 77°11.1'N, long. 86°14.5'W, respectively), and from the Blue Fiord Formation by Klapper and A.E.H. Pedder in 1971 from the Sor Fiord section, located some 30 km east of the type section (section 2 on Fig. 8.1; base of section at lat. 77°17'12"N, long. 85°07'00"W, and top of section at lat. 77°15'48"N, long. 85°03'30"W). The collection from the Bird Fiord Formation at the type section is supplemented by three samples collected by R. Thorsteinsson in 1979 (loc. 1-3, Fig. 8.1).

The conodont faunas summarized herein are discussed more extensively by Uyeno (in preparation) and by Klapper (in Pedder and Klapper, in preparation). In this paper, Uyeno is responsible for the identification of conodonts from the type area of the Blue Fiord and Bird Fiord formations, and Klapper for the Eids and Blue Fiord formations at Sor Fiord. A part of this paper is based on the unpublished Sor Fiord manuscript prepared by Klapper in 1978.

The Ordovician through Lower Devonian conodont succession found in two wells located near the present study area (designated on Fig. 8.1), has been studied previously by Uyeno and Barnes (in Mayr et al., 1978).

Incidental to the main thrust of this paper, we note the presence of two-hole echinoderm ossicle **Gasterocoma**? **bicaula** Johnson and Lane in both the Blue Fiord and Bird Fiord formations at their type area (section 1 of Fig. 8.1). It ranges almost throughout the Blue Fiord Formation (from the **dehiscens** to **serotinus** Zones), and in the Bird Fiord it occurs at GSC loc. 83767. As noted elsewhere, the interval at and near the latter locality cannot be as precisely dated, but may possibly be of Eifelian age.

Previous Conodont Studies

Insofar as is known, this is only the second report on conodonts from the Bird Fiord Formation. The studies on conodonts from the Blue Fiord Formation, or strata that at least have been mapped as such by others, are more extensive and include the following:

Klapper (1969, Fig. 3) described conodonts from three samples collected by A.R. Ormiston in 1961 from the lower part of what was then mapped as Blue Fiord Formation (30, 45, and 90 m above the base of the formation) at Sutherland River, Devon Island. These collections, which are now referred to the Disappointment Bay Formation (Thorsteinsson, in preparation), with **Polygnathus foveolatus** Philip and Jackson (= **P. inversus** Klapper and Johnson of the present paper) and **Steptotaxis glenisteri** were regarded as Early Devonian, Emsian (Klapper, 1969, Fig. 4).

Uyeno (in McGregor and Uyeno, 1972, p. 13-16) described conodonts from the Blue Fiord and Bird Fiord formations on the east side of Young Inlet, northeastern

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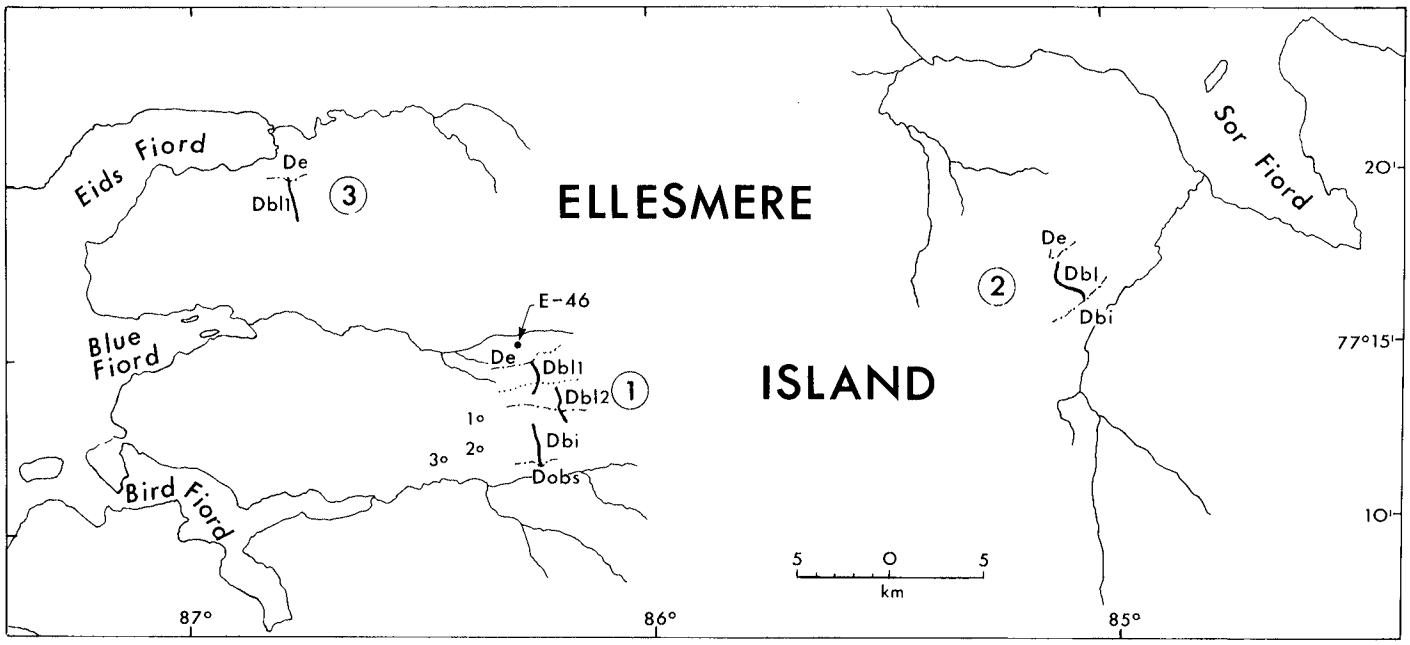
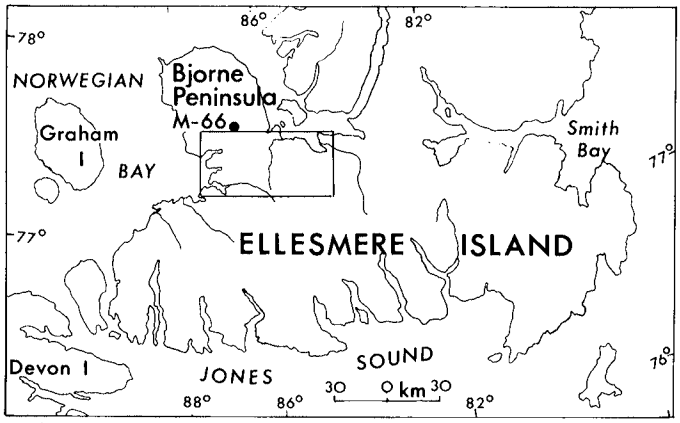




De = *Eids Fm.* *Dbi* = *Bird Fiord Fm.*
Db11 = *limestone and shale (lower) member*
Db12 = *brown limestone (upper) member, Blue Fiord Fm.*
Dobs = *Strathcona Fiord Fm., Okse Bay Group.*
formational contact, intraformational contact (after Kerr and Thorsteinsson, 1972).

Figure 8.1. *Index map showing the locations of (1) the Blue Fiord Formation exposed along creeks located 2.5 km east of the type section, and the type section of the Blue Fiord Formation, and (2) the Eids and Blue Fiord formations at the Sor Fiord section. The section of the Blue Fiord Formation near Eids Fiord, studied by Weyant (1975), is shown as (3). Three small circles mark the locations of R. Thorsteinsson's Bird Fiord collections (see Appendix: 1 = C-76076, 2 = C-76075, and 3 = C-76074). Two well-sites shown are E-46 = Panarctic ARCO et al. Blue Fiord E-46, and M-66 = Panarctic Tenneco et al. CSP Eids M-66 (see Mayr et al., 1978). Small scale map shows the geographic position of the enlarged map.*

Bathurst Island (see Kerr, 1974, section 20, p. 6, 111-114). The entire suite of Blue Fiord collections, from the intervals of 5 to 274 m above the base of the formation (total thickness of formation at this section is 276 m), was tentatively regarded as Eifelian. A similar fauna, also dominated by **Icriodus,** was found in the highest bed of the Blue Fiord Formation at Rookery Creek, west-central Cornwallis Island (in an undescribed collection made by R. Thorsteinsson in 1976; GSC loc. C-63567). This fauna is similarly regarded as Eifelian in age. In collections made by Ormiston in 1962 from 134 m and 147 m above the base of the Blue Fiord Formation at Twilight Creek on Bathurst Island (located some 35 km southwest of the Young Inlet section; see Ormiston, 1967, p. 144-146, and Kerr, 1974, section 25, p. 118), **Icriodus norfordi** Chatterton occurs in small faunas similarly regarded as Eifelian (Klapper and Johnson, 1980, p. 444, Table 7). These beds are the source of the types of **Deltadechenella bathurstensis** Ormiston (1967, p. 105). **Icriodus norfordi** was illustrated (Klapper and Johnson, 1980, Pl. 3, fig. 25, 26) from the nearby Warner River section (Ormiston, 1967, p. 36, Fig. 2; a sample from 107 m above the base of the Blue Fiord Formation, which also contains **Scutellum depressum** Cooper and Cloud). The Bird Fiord conodonts from the Young Inlet section were tentatively dated as Eifelian-Givetian, with the boundary placed approximately in the lower part of the formation.

In undescribed collections made by Kerr from Kerr's member C_1, high in the Blue Fiord Formation at Grove Lake on Grinnell Peninsula, Devon Island (GSC loc. C-22892), Klapper identified **Eognathodus bipennatus** (Bischoff and Ziegler) of the robust kind previously illustrated by Bultynck (1970, Pl. 19, fig. 1) and species of **Icriodus,** together indicative of an Eifelian age.

Weyant (1975) illustrated and listed conodonts from the lower 530 m (entirely within the lower limestone and shale member) of the Blue Fiord Formation, from a section southeast of the head of Eids Fiord (section 3 on Fig. 8.1). The specimens illustrated in lower view and identified by Weyant (1975, Pl. 1, fig. 39, 41) as **Polygnathus foveolatus** from 156 m above the base of the formation, compare most closely with **P.** aff. **P. perbonus** (Philip). **Steptotaxis glenisteri** (Klapper) was illustrated from 156 m and 158 m above the base of the formation (Weyant, 1975, Pl. 1, fig. 31, 33, 34). Weyant (op. cit.) concluded that the conodont fauna of the lower part of the Blue Fiord Formation at this section is Emsian in age, a conclusion with which we agree.

The important sequence of **Polygnathus** found in the Eids and Blue Fiord formations in the Sor Fiord section was summarized by Klapper and D.B. Johnson (1975, Fig. 4), and Blue Fiord conodonts from this section were listed in Table 5 and 6 by Klapper and J.G. Johnson (1980).

Table 8.1

Correlation of Lower and Middle Devonian conodont zones with stages in Europe (from Klapper and Johnson, 1980, Text-fig. 1)

CONODONT ZONES	STAGES	
kockelianus	Eifelian	Couvinian
australis		
costatus costatus		
patulus	Emsian	?
serotinus		Dalejan
inversus/laticostatus		Zlichovian
gronbergi		
dehiscens		Pragian
kindlei	?	

Note: A lower part of the Pragian and the uppermost parts of the Eifelian-Couvinian are not shown. Leading contenders for the Lower-Middle Devonian boundary, under consideration by the International Subcommission on Devonian Stratigraphy, are levels corresponding to the bases of the Couvinian and Eifelian Stages, or approximately the bases of the **patulus** Zone and the upper part of the **patulus** Zone, respectively. the **partitus** Zone was introduced by Weddige, Werner, and Ziegler (1979, p. 161) for the informal upper part of the **patulus** Zone of Klapper, Ziegler, and Mashkova (1978, p. 107), an action which thus restricted the scope of the **patulus** Zone. In this paper, however, we continue to use the **patulus** Zone in the unrestricted sense.

The Blue Fiord Formation in the subsurface of Cameron and Vanier islands, was examined for lithofacies interpretation and conodont biostratigraphy (Uyeno and Mayr, 1979). While no consistent paleoecological relationship was found between the conodont faunas and the lithofacies of the enclosing rocks, the age of the formation was found to range from the probable **gronbergi-inversus** zones through **serotinus** Zone to the **patulus** and/or **costatus costatus** zones. The correlation of the conodont zones mentioned in this paper with stages in Europe is shown on Table 8.1.

In the Strathcona Fiord section, located 11 km southwest of Strathcona Fiord (see Trettin, 1978, p. 116, Fig. 66 and section 11, Fig. 7), the upper beds of the Blue Fiord (GSC loc. C-26496) yielded only **Pandorinellina expansa** (Uyeno and Mason). As noted on Figures 8.2 and 8.3, this is a long-ranging species, extending from about mid-part of the Blue Fiord Formation to the upper part of the overlying Bird Fiord Formation. The accompanying brachiopods were questionably dated as Emsian by J.G. Johnson, D.G. Perry, and R.E. Smith. (This section was sampled for conodonts by Uyeno, see Uyeno and McGregor, 1970, section 6.)

Incidental to the study of the conodonts of the underlying Eids Formation in the subsurface of northwestern Victoria Island, conodonts from the Blue Fiord Formation outcropping on the larger of the nearby Princess Royal Islands were illustrated and listed by Uyeno (in Mayr et al., 1980, p. 215, Pl. 32.1, fig. 53-55). These include **Polygnathus inversus** and **Pandorinellina** sp., the latter in all probability being the same as that found in this study (Fig. 8.2, GSC loc. 83742).

Previous Age Determinations of the Blue Fiord and Bird Fiord Formations and Their Correlatives
(based on other than conodont faunas)

McLaren (in Fortier et al., 1963, p. 322, 324, 326, 328) considered the Blue Fiord and Bird Fiord formations in the type area as Middle Devonian in age, and tentatively suggested correlations with the Eifelian and Givetian stages, respectively.

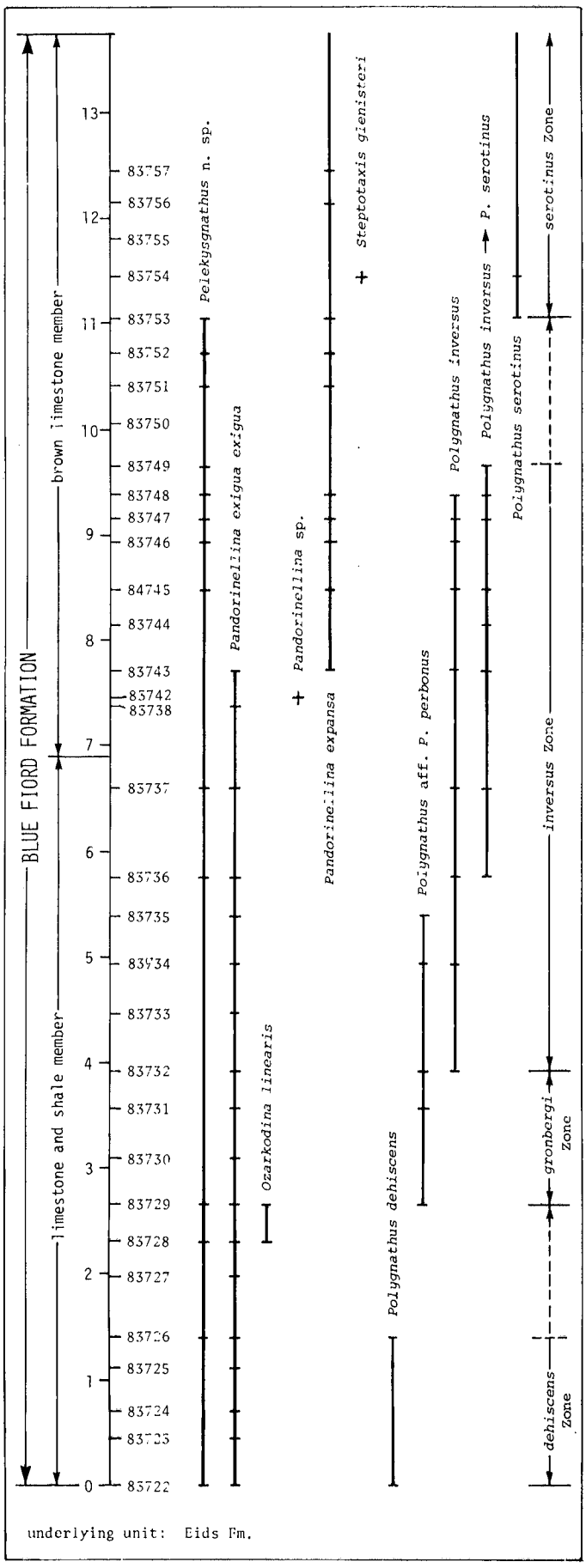
Ormiston (1967), on evidence of trilobite studies, regarded the Blue Fiord on northern Bathurst Island (principally at Twilight Creek) as Eifelian in age, and suggested that older (Emsian?) beds are present in units that were mapped earlier as Blue Fiord Formation and located east of Bathurst Island [specifically at Sutherland River, Devon Island, and Goose Fiord, Ellesmere Island; localities with **Prodrevermannia sverdrupi** (Tolmachoff); Ormiston, 1967, p. 19, 58, Fig. 5; 1975, p. 394]. The beds at Sutherland River are now referred to the Disappointment Bay Formation, and those at Goose Fiord require further refinement for correct assignment (Thorsteinsson, in preparation, Table 1). Ormiston (1967, p. 23) further suggested that the Eifelian-Givetian boundary may be within the basal 60 m of the Bird Fiord Formation at Twilight Creek, thus indicating a Givetian age for the remainder of the formation. In central Bathurst Island, some 45 km southwest of Twilight Creek, the lower two-thirds of the Bird Fiord Formation was considered to be of probable late Eifelian age (Johnson and Perry, 1976, p. 617). At that locality, the Blue Fiord Formation is missing and the Bird Fiord rests directly on the Eids Formation.

In Ormiston's collection of Disappointment Bay fossils (specifically, those from 30 m above the base of the formation; the conodonts identified by Klapper, 1969, cited earlier) from Sutherland River, Devon Island, J.G. Johnson (in Harper et al., 1967, p. 430, footnote) noted the presence of **Phragmostrophia** sp. He also identified **P.** sp. aff. **P. merriami** Harper et al. in McLaren's collection (in Fortier et al., 1963, p. 320; GSC loc. 26513) from the Blue Fiord Formation, about 180 m above the base of the formation, on the south side of Eids Fiord, southwestern Ellesmere Island. Johnson (op. cit.) concluded that both collections are Emsian in age.

Correlation of Blue Fiord and Bird Fiord Polygnathus Sequence

The **Polygnathus** sequence of the Blue Fiord and Bird Fiord formations is given far greater weight for correlation than the other conodonts, because species of the genus form an integral part of the zonation of the upper part of the Lower Devonian (and, incidental to this study, the lower part of the Middle Devonian) in western North America (Klapper, 1977a) and in Europe (Weddige and Ziegler, 1977; Klapper, 1977b; Klapper et al., 1978). The **Polygnathus** species are widespread in the Northern Hemisphere and Australia, whereas some of the non-**Polygnathus** species used in the zonation in Europe (Weddige and Ziegler, 1977, Fig. 1) are unknown in North America (see also Klapper and Johnson, 1980). Similarly, two of the numerically dominant conodonts in these formations, **Pandorinellina exigua exigua** (Philip) and **P. expansa**, are unknown in Europe, and four others, **Pelekysgnathus** n. sp. and **Steptotaxis** n. spp. A, B, and C, are new. **Ozarkodina linearis** (Philip) is also unknown in Europe.

Polygnathus dehiscens Philip and Jackson (Pl. 8.1, fig. 1-4), which occurs near the top of the Eids Formation at Sor Fiord (GSC loc. C-12504), and in the lower 141 m of the lower member of the Blue Fiord Formation at its type area (GSC loc. 83722 and 83725), is the nominal species of the **dehiscens** Zone (Fahraeus, 1971; Klapper, 1977a, p. 41-42).



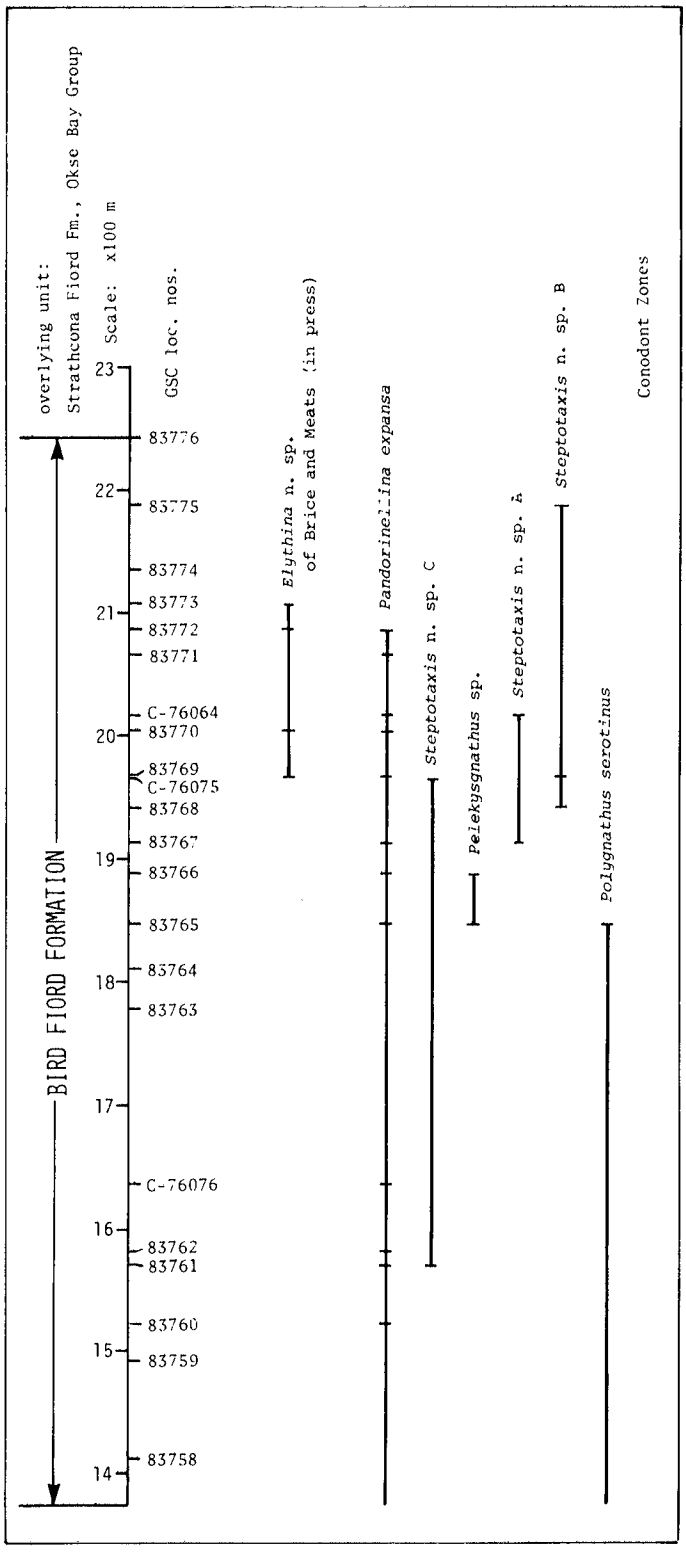


Figure 8.2. *Conodont distribution and zonation of the Blue Fiord Formation exposed along creeks located 2.5 km east of the type section, and of the Bird Fiord Formation at its type section.*

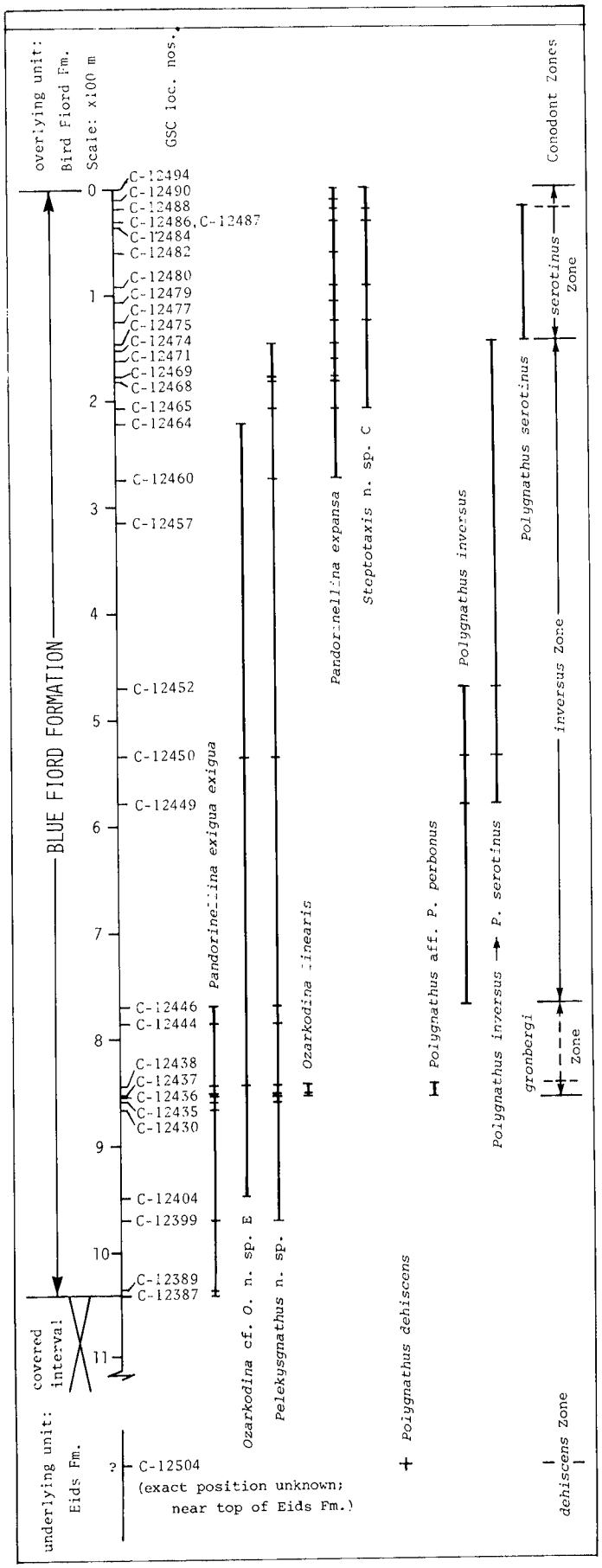


Figure 8.3. *Conodont distribution and zonation of the Blue Fiord Formation at the Sor Fiord section.*

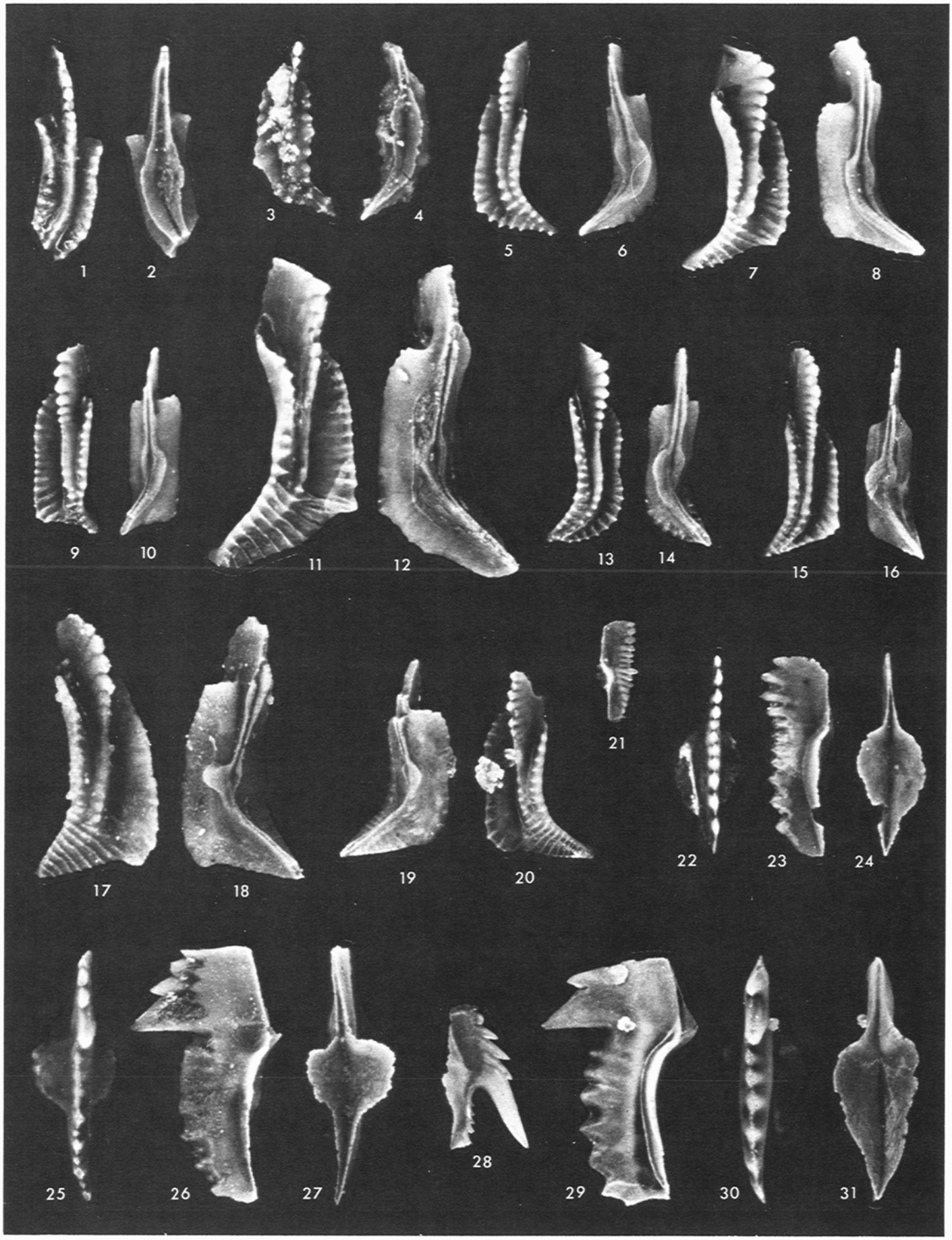
The species ranges as high as the lower part of the **gronbergi** Zone in Nevada, Alaska, and in the Khodzha-Kurgan section in the Zeravshan Range, central Asia (Klapper and Johnson, 1980, Table 5).

Polygnathus aff. **P. perbonus** (Pl. 8.1, fig. 5, 6; Pl. 8.3, fig. 11, 12) ranges in the type area of the lower member of the Blue Fiord Formation from 267 to 539 m above the base of the formation, and at Sor Fiord from 846 to 852 m below the top of the formation. It is tentatively identified herein in the lower member of the Blue Fiord Formation at southeast of Eids Fiord (Weyant, 1975, Pl. 1, fig. 39, 41; section 3 of Fig. 8.1 herein). **Polygnathus** aff. **P. perbonus** occurs within the **gronbergi** Zone in Nevada (Klapper, 1977a, p. 42), but within the **inversus** Zone in the type Cranswick Formation, northern Yukon Territory (Pedder and Klapper, 1977, p. 231). The range of **P.** aff. **P. perbonus** is entirely below the first occurrence of **P. inversus** at Sor Fiord, and at the type area, the two species have a common occurrence in two samples, at the levels of 393 and 495 m above the base of the Blue Fiord Formation (GSC loc. 83732, 83734). This suggests that the levels of **P.** aff. **P. perbonus** below the first occurrence of **P. inversus** at these sections may represent the **gronbergi** Zone by inference of stratigraphic position. The **gronbergi** Zone, on evidence of the zonally-restricted nominal species, has been identified in the upper Zlichovian Chýnice Limestone in the Barrandian area (Klapper, 1977b). **Polygnathus gronbergi** occurs with the tantaculite **Nowakia barrandei** Bouček and Prantl in the Harz Mountains (Klapper and Johnson, 1975, p. 71) and in the Schönau Limestone of the Kellerwald, Germany (Weddige and Ziegler, 1977, p. 71).

As noted earlier, there is some overlap in the ranges of **Polygnathus** aff. **P. perbonus** and **P. inversus** in the Blue Fiord Formation at the type area. **P. inversus** (see Pl. 8.1, fig. 7-12; Pl. 8.3, fig. 6, 13) is joined by a morphologically transitional form between **P. inversus** and **P. serotinus** (referred to as **P. inversus → P. serotinus** in the stratigraphic part of the paper, as for example, on Figures 8.2 and 8.3, but as **"P. inversus,** transitional to **P. serotinus"** in the Systematics and on explanations to Pl. 8.1, fig. 13-16, Pl. 8.3, fig. 4, 5) at 574 m above the base of the Blue Fiord (GSC loc. 83736) and the overlap continues to the 939-m level (GSC loc. 83748). The transitional form continues upward to the 966-m level (GSC loc. 83749). At Sor Fiord, **Polygnathus inversus** and **P. inversus → P. serotinus** range from 770 to 469 m and from 579 to 147 m below the top of the Blue Fiord Formation, respectively. **Polygnathus inversus** is the nominal species of the inversus Zone (Klapper, 1977a, p. 42) and ranges as high as the lowest part of the **serotinus** Zone.

The **inversus** Zone is equivalent to strata that, in central Europe, contain the **laticostatus** Zone (or Fauna; see Weddige and Ziegler, 1977, p. 71-73; Klapper, 1977a, p. 35). **Polygnathus laticostatus** and **P. inversus** occur jointly in Nevada and in the Harz Mountains, Germany, in a sample with the tentaculite, **Nowakia cancellata** (Richter) (Klapper and Johnson, 1975, p. 71). The **laticostatus** Zone occurs in the Barrandian area of Czechoslovakia in the lower part of the Suchomasty Limestone at levels with **Nowakia elegans** (Barrande) and higher with **N. cancellata** (Klapper et al., 1978, p. 105, Fig. 1, 2). The Zlichovian-Dalejan boundary is drawn at the **elegans-cancellata** zonal boundary, according to the proposal of Chlupáč (1976a, Fig. 1; 1976b, p. 180, 182), and this falls within the **laticostatus** Zone.

Polygnathus inversus occurs elsewhere in the Canadian Arctic Archipelago in the Disappointment Bay Formation at Sutherland River, Devon Island (Klapper, 1969, Pl. 6, fig. 19-30; also in undescribed collections of Uyeno, see Uyeno and McGregor, 1970, section 4), in the Blue Fiord Formation at Weatherall Bay, northeastern Melville Island (undescribed collections of Uyeno, see McGregor and Uyeno, 1969, section 2), and on the larger of the princess Royal Islands (Uyeno in Mayr et al., 1980, Pl. 32.1, fig. 53, 54).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The species has its other occurrences in the Stuart Bay Formation at Young Inlet, northeastern Bathurst Island (Uyeno in McGregor and Uyeno, 1972, Pl. 5, figs. 13, 14), and Twilight Creek, northern Bathurst Island (undescribed collections made by Ormiston in 1962 and by Uyeno in 1969).

Polygnathus serotinus Telford (Pl. 8.1, fig. 17-20) occurs in two collections in the Blue Fiord Formation near the type section (at 1104 and 1144 m above the base of the formation, GSC loc. 83753 and 83754), and in a third collection from about midway in the Bird Fiord Formation at 469 m above the base of the formation (GSC loc. 83765). At Sor Fiord the species occurs at 147 m and 18 m below the top of the Blue Fiord Formation (GSC loc. C-12475 and C-12488). **P. serotinus** is the nominal species of the **serotinus** Zone, but ranges as high as the **costatus costatus** Zone. The Sor Fiord specimens appear to represent early phyletic forms of the species, however, because the anterior outer margin is relatively low for **P. serotinus.** Furthermore, in the collection at 147 m, **P. serotinus** is accompanied by **P. inversus → P. serotinus,** the latter also occurring in the **inversus** Zone in Nevada (Klapper and Johnson, 1975, p. 73, Pl. 3, fig. 19-22, 24-31). Thus, this evidence suggests that the collections at 147 m and 18 m below the top of the Blue Fiord Formation at Sor Fiord are within the **serotinus** Zone. Although the upper range of **P. inversus → P. serotinus** is below the first occurrence of **P. serotinus** at the Blue Fiord type area, it is very probable, too, that the upper part of the upper member of the Blue Fiord Formation is similarly within the **serotinus** Zone. **P. serotinus** has been reported previously from the Blue Fiord Formation from the subsurface on Cameron Island (Uyeno and Mayr, 1979, Pl. 38.1, fig. 47, 48).

The **serotinus** Zone is identified in the Barrandian area in the Suchomasty and Třebotov limestones (Dalejan) at levels within the **Nowakia richteri** Zone and in the lowest part of the **N. holynensis** Zone (Klapper, 1977b; Klapper et al., 1978, Fig. 1, 2).

In the absence of indicators of the overlying zones, the occurrence of **Polygnathus serotinus** in the Bird Fiord Formation is difficult to assess. As noted earlier, the species ranges elsewhere into the overlying **patulus** and **costatus costatus** zones. That this occurrence is possibly of Eifelian age is suggested by the presence higher in the section, between 591 to 732 m above the base of the formation (GSC loc. 83769 to 83773, Fig. 8.2) of **Elythina** n. sp. of Brice (name in press, and carried here in open nomenclature; identified by A.W. Norris). According to Norris (personal communication), **Elythina** n. sp. "...is placed by Brice [and Meats] (in press) within the **Warrenella kirki** Zone. In Nevada the **W. kirki** Zone occurs within Johnson's (1977, fig. 2) Interval 17 which is within the conodont **kockelianus** Zone of Eifelian, early Middle Devonian age". The Emsian-Eifelian boundary cannot be placed accurately here, but may fall near the base of the Bird Fiord Formation at its type section.

To summarize the conodont evidence, the entire Blue Fiord Formation, at the section immediately east of the type section and at Sor Fiord, and the lower member of the formation just south of Eids Fiord, all on southwestern Ellesmere Island, and the formation outcropping on the larger of the Princess Royal Islands, are late Early Devonian in age (**dehiscens** to **serotinus** zones, approximately Pragian-Zlichovian boundary to Dalejan). The lower 125 m of the Disappointment Bay Formation at Sutherland River on Devon Island is of similar age (**inversus** Zone) (Klapper, 1969, Fig. 4; revised figure based on undescribed collections of Uyeno, see Uyeno and McGregor, 1970, section 4). The Blue Fiord Formation in the subsurface of Cameron and Vanier islands (located northwest of Bathurst Island) ranges in age from late Early to early Middle Devonian (**gronbergi-inversus** zones through the **patulus** and/or **costatus costatus** zones). In contrast, the formation on the east side of Young Inlet and at Twilight Creek, northern Bathurst Island, and the upper part of the formation at Grove Lake, Grinnell Peninsula, Devon Island, and at Rookery Creek, west-central Cornwallis Island, are early Middle Devonian (Eifelian), confirming the original dating of McLaren (in Fortier et al., 1963, p. 612) and Ormiston (1967) on the basis of brachiopods and trilobites.

The Bird Fiord Formation at its type section on southwestern Ellesmere Island is probably of late Early to early Middle Devonian age (Dalejan? to Eifelian). The formation outcropping on the east side of Young Inlet, northern Bathurst Island, is entirely within the Middle Devonian, probably Eifelian to Givetian age, thus again confirming McLaren's (in Fortier et al., 1963, p. 615) and Ormiston's (1967) original dating.

Plate 8.1

All figures x50. Unless otherwise noted, all specimens from the Blue Fiord Formation, from section located 2.5 km east of the type section.

Figures 1-4. **Polygnathus dehiscens** Philip and Jackson.
1,2, GSC 64481, upper and lower views of Pa element, GSC loc. 83722;
3,4. GSC 64482, upper and lower views of Pa element, GSC loc. 83726.

Figures 5,6. **Polygnathus** aff. **P. perbonus** (Philip).
GSC 64483, upper and lower views of Pa element, GSC loc. 83729.

Figures 7-12. **Polygnathus inversus** Klapper and Johnson.
7-10, GSC 64484 and 64485, upper and lower views of two Pa elements, GSC loc. 83736;
11,12. GSC 64486, upper and lower views of Pa element, GSC loc. 83737.

Figures 13-16. **Polygnathus inversus** Klapper and Johnson, transitional to **P. serotinus** Telford.
13,14, GSC 64487, upper and lower views of Pa element, GSC loc. 83743;
15,16. GSC 64488, upper and lower views of Pa element, GSC loc. 83749.

Figures 17-20. **Polygnathus serotinus** Telford.
17,18, GSC 64489, upper and lower views of Pa element, GSC loc. 83754;
19,20. GSC 64490, lower and upper views of Pa element, Bird Fiord Formation, type section, GSC loc. 83765.

Figure 21. **Pandorinellina** sp.
GSC 64491, lateral view of Pa element, GSC loc. 83742.

Figures 22-24. **Ozarkodina linearis** (Philip).
GSC 64492, upper, lateral, and lower views of Pa element, GSC loc. 83729.

Figures 25-27. **Pandorinellina exigua exigua** (Philip).
GSC 64493, upper, lateral, and lower views of Pa element, GSC loc. 83722.

Figures 28-31. **Pandorinellina expansa** Uyeno and Mason.
28, GSC 64494, lateral view of Pb element, GSC loc. 83746;
29,31. GSC 64495, lateral, upper, and lower views of Pa element, Bird Fiord Formation, type section, GSC loc. 83765.

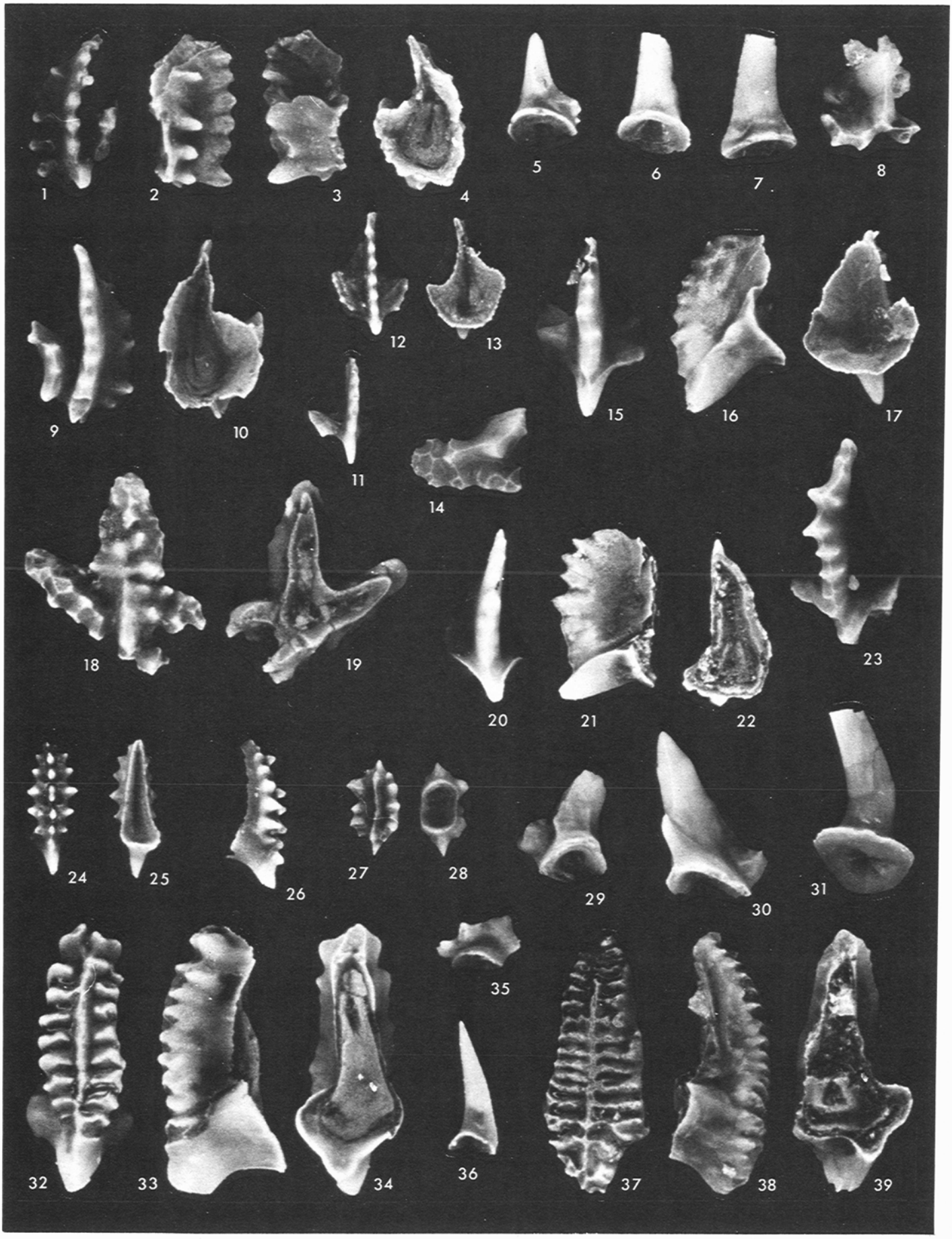
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Plate 8.2

All figures x50. Unless otherwise noted, all specimens from the Bird Fiord Formation. (All Bird Fiord collections from the type section, except Figures 1-7, 9, 10, 14, 18, and 19).

Figures 1-11. **Steptotaxis** n. sp. A.
- 1-4, GSC 64496, upper, outer lateral, inner lateral, and lower views of I element, GSC loc. C-76074;
- 5, GSC 64497, lateral view of S_{2b} element, GSC loc. C-76074;
- 6, GSC 64498, lateral view of M_2 element, GSC loc. C-76074;
- 7, GSC 64499, lateral view of S_{2a} element, GSC loc. C-76074;
- 8, GSC 64500, upper view of S_{2c} element, GSC loc. 83767;
- 9,10, GSC 64501, upper and lower views of I element, GSC loc. C-76074;
- 11. GSC 64502, upper view of I element, GSC loc. 83767.

Figures 12,13. **Steptotaxis glanisteri** (Klapper)
GSC 64503, upper and lower views of I element, Blue Fiord Fm., section 2.5 km east of the type section, GSC loc. 83754.

Figures 14,18,19. **Steptotaxis** n. sp. C.
- 14, GSC 64504, upper view of S_{2c} element, GSC loc. C-76075;
- 18,19. GSC 64505, upper and lower views of I element, GSC loc. C-76075.

Figures 15-17. **Pelekysgnathus** sp.
GSC 64506, upper, lateral, and lower views of I element, GSC loc. 83767.

Figures 20-23. **Pelekysgnathus** n. sp.
- 20-22, GSC 64507, upper, lateral, and lower views of I element, Blue Fiord Fm., section at 2.5 km east of the type section, GSC loc. 83722;
- 23. GSC 64508, upper view of I element, Blue Fiord Fm., section at 2.5 km east of the type section, GSC loc. 83737.

Figures 24-39. **Steptotaxis** n. sp. B.
(all from GSC loc. 83769 unless otherwise noted)
- 24,25, GSC 64509, upper and lower views of I element;
- 26, GSC 64510, lateral view of I element;
- 27,28, GSC 64511, upper and lower views of S_{2c} element;
- 29, GSC 64512, lateral view of S_{2b} element;
- 30, GSC 64513, lateral view of S_{2b} element;
- 31, GSC 64514, lateral view of M_2 element;
- 32-34, GSC 64515, upper, lateral, and lower views of I element, GSC loc. 83768;
- 35, GSC 64516, lateral view of S_{2c} element;
- 36, GSC 64517, lateral view of S_{2a} element;
- 37-39. GSC 64518, upper, lateral, and lower views of I element, GSC loc. 83775.

Systematic Paleontology

Genus **Polygnathus** Hinde, 1879

Type species: **Polygnathus dubius** Hinde, 1879

Polygnathus inversus Klapper and Johnson

Plate 8.1, figures 7-16; Plate 8.3, figures 4-6, 13

Polygnathus inversus Klapper and D.B. Johnson, 1975, p. 73, Pl. 3, figs. 15-39
[synonymy through 1974]

Polygnathus inversus Klapper and Johnson, in Klapper and J.G. Johnson, 1980, p. 453
[synonymy through 1979]

Remarks. In the original description of **Polygnathus inversus** from Nevada, a transition between that species and **P. serotinus** Telford (= **P.** sp. nov. D of Klapper and Johnson, 1975, p. 73 and explanation of Pl. 8.3) was suggested on the evidence of a substantial number of specimens with lower surface features of intermediate aspect. Such specimens (e.g., Klapper and Johnson, 1975, Pl. 3, fig. 19-22, 24-31, as well as several hundred unfigured Nevada specimens; Pl. 8.1, fig. 13-16, Pl. 8.3, fig. 4, 5 herein) have an incipient development of a shelf-like protuberance on the outer side of the pit, but the protuberance characteristic of **P. serotinus** is more distinctly demarcated and smaller (e.g. Pl. 8.1, fig. 17-20). Futhermore, the pit itself in **P. serotinus** is smaller than in the transitional form. In the lower stratigraphic range of the transitional form in the Blue Fiord sections of this paper (e.g., GSC loc. 83743, Fig. 8.2; GSC loc. C-12449, C-12450, C-12452, Fig. 8.3) the anterior outer margin is about at the same height as the inner margin, as in the transitional forms from Nevada and in agreement with the diagnosis of **P. inversus.** In the higher stratigraphic range of the transitional form in the Blue Fiord sections (e.g., GSC loc. 83749, Fig. 8.2; GSC loc. C-12475, Fig. 8.3) the anterior outer margin is somewhat higher than the inner margin, but not so markedly higher as is characteristic of **P. serotinus.** These higher transitional forms thus compare with **P. declinatus** Wang (1979, p. 401-402, Pl. 1, fig. 12-20), but as the Blue Fiord Formation shows a sequence of transitional forms between **P. inversus** and **P. serotinus,** we do not favour formal designation of individual morphotypes within the sequence. Rather, we prefer to express the observed transition by designating the specimens as **"P. inversus,** transitional to **P. serotinus"** or, as has been done in the stratigraphic part of this paper, simply as **"P. inversus → P. serotinus".**

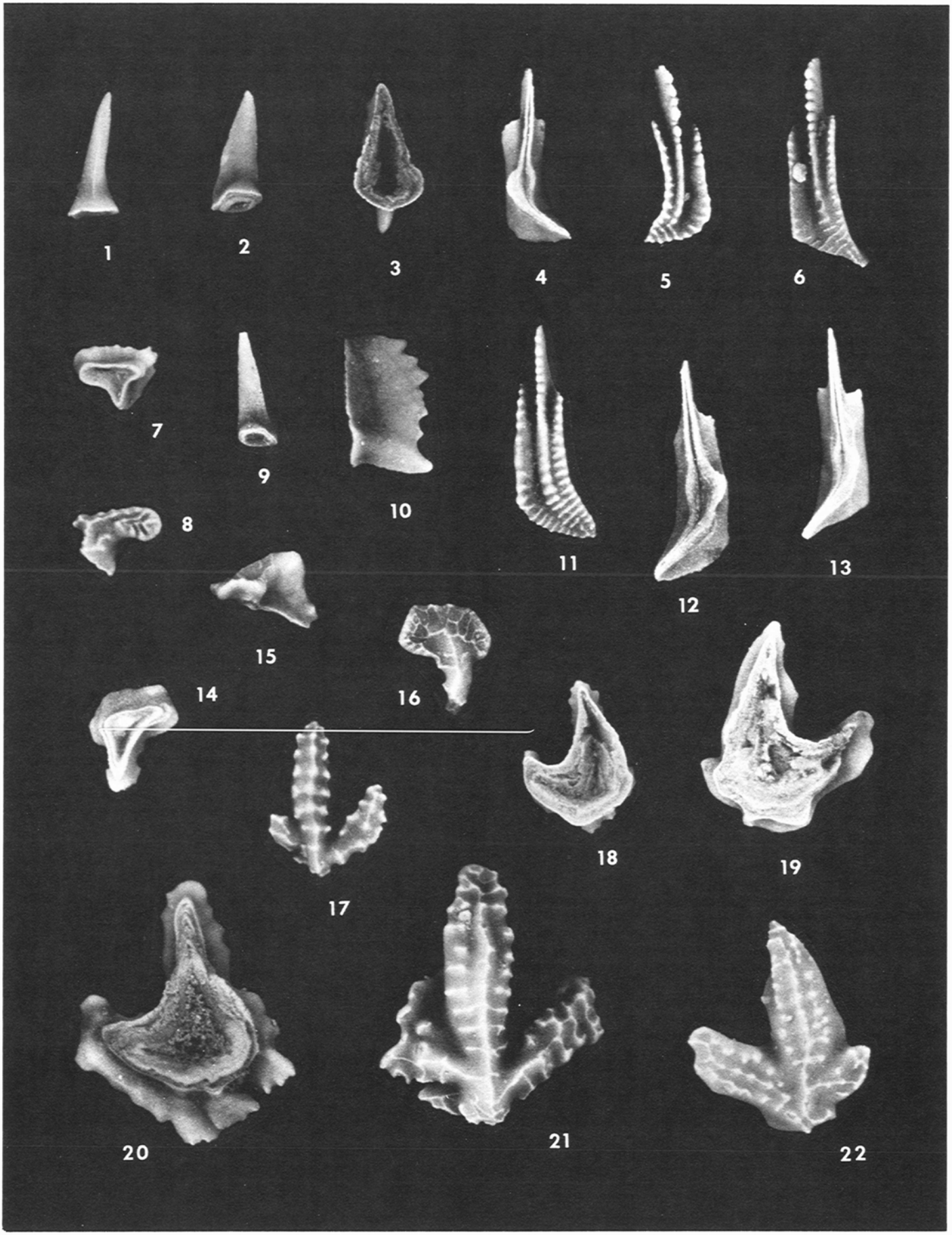
Genus **Steptotaxis** new genus

Type species. **Pelekysgnathus pedderi** Uyeno and Mason, 1975

Derivation of name. steptos, Gr. = crowned, taxis, Gr. = arrangement, for the diagnostic coronellan element of the apparatus.

Diagnosis. Multielement conodont genus in which the composition of the apparatus is like that of **Pelekysgnathus,** except that a coronellan element is present in the S_2 position in addition to acodinan elements.

Remarks. The multielement genus **Pelekysgnathus** Thomas (1949) is characterized by an apparatus consisting basically of three kinds of skeletal elements: pelekysgnathan in the I position, acodinan in the S_2 position, and a weakly costate or unornamented cone, the base of which is circular to elliptical in cross section, in the M_2 position (Klapper and Philip, 1972, p. 101-102). In contrast, all species assigned with certainty to the genus **Steptotaxis** include coronellan, as well as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acodinan elements in the S_2 position. Thus, we revise **Pelekysgnathus** herein to exclude those species represented by apparatuses which include coronellan elements and refer the following instead to **Steptotaxis: Pelekysgnathus pedderi** Uyeno and Mason (1975), **P. uyenoi** Chatterton (1979), and **P. glenisteri** Klapper (1969). The coronellan element was illustrated when the first two were originally described, whereas the apparatus of **P. glenisteri** was illustrated by Klapper and Philip (1972). In addition, **Steptotaxis** includes the three species cited in open nomenclature and illustrated in the present paper (Pl. 8.2, 8.3).

Besides the presence of the distinctive coronellan element, **Steptotaxis** may be distinguished from **Pelekysgnathus** in that the main process of the I element in all but one of the species is characterized by icriodontan denticulation. The principal exception is **Steptotaxis** n. sp. A, in which the denticulation of the main process is a single row of nodes, but some specimens of **S. uyenoi** also show this development in common with I elements of **Pelekysgnathus.** Furthermore, in contrast with **Pelekysgnathus,** I elements of **Steptotaxis** characteristically have two well-developed lateral processes directed anteriorly, which have denticulation like that of the main process. Again there is one exception, namely **Steptotaxis** n. sp. B, which lacks such processes.

Plate 8.3

All figures x40. All specimens from the Blue Fiord Formation, from the Sor Fiord section.

Figures 1,2,7-9,14-22. **Steptotaxis** n. sp. C.

- 1, GSC 53495, lateral view of M_2 element, GSC loc. C-12487;
- 2, GSC 53496, lateral view of S_{2a} element, basal funnel preserved, GSC loc. C-12487;
- 7,8, GSC 53499, lower and upper views of S_{2c} element, posterior toward the bottom, GSC loc. C-12465;
- 9, GSC 53497, lateral view of S_{2a} element, GSC loc. C-12488;
- 14-16, GSC 56150, lower, lateral, and upper views of S_{2c} element, posterior toward the bottom in figs. 14, 16, anterior platform to left and posterior cusp to right in fig. 15, basal plate preserved (fig. 14), GSC loc. C-12487;
- 17,18, GSC 56149, upper and lower views of I element, basal plate preserved, GSC loc. C-12465;
- 19,22, GSC 56152, lower and upper views of I element, basal plate preserved, GSC loc. C-12465;
- 20,21, GSC 56154, lower and upper views of I element, basal plate preserved, GSC loc. C-12487.

Figures 3,10. **Pelekysgnathus** n. sp.
GSC 56160, lower and lateral views of I element, basal plate preserved, GSC loc. C-12438.

Figures 4,5. **Polygnathus inversus** Klapper and Johnson, transitional to **P. serotinus** Telford.
GSC 53489, lower and upper views of Pa element, GSC loc. C-12452.

Figures 6,13. **Polygnathus inversus** Klapper and Johnson.
GSC 53493, upper and lower views of Pa element, GSC loc. C-12450.

Figures 11,12. **Polygnathus** aff. **P. perbonus** (Philip).
GSC 53494, upper and lower views of Pa element, GSC loc. C-12437.

Some I elements of **Steptotaxis** species (e.g., **S. pedderi, S.** n. sp. C) resemble those of **Pedavis** Klapper and Philip, but the latter genus has a modified sagittodontan S_2 element and a strongly costate M_2 element.

Sannemannia was proposed by Al-Rawi (1977, p. 58-59) with **S. pesanseris** Al-Rawi as the designated type species. **Sannemannia** included **Pelekysgnathus glenisteri** and **P. furnishi** Klapper (1969) in Al-Rawi's proposal. The genus was diagnosed strictly in terms of morphology of the I element, with no account taken of the then indicated multielement taxonomy of **Pelekysgnathus glenisteri** and **P. furnishi,** discussed by Klapper and Philip (1972, p. 102). The multielement association of the type species of **Sannemannia** is unclear, because **S. pesanseris** was originally based on a single specimen of an I element. Subsequently, Hans P. Schönlaub recovered well-preserved I elements of **S. pesanseris** from the type stratum at the type locality in the Frankenwald, Germany; included in Schönlaub's collections is one S_{2c} element that differs radically from coronellan elements of **Steptotaxis** (we are grateful to Dr. Schönlaub for sharing these data and to Dr. W. Ziegler for providing SEM pictures of Schönlaub's specimens of **S. pesanseris).** Furthermore, the I element of **S. pesanseris** has a single row of nodes on the main process and shows no trace of the icriodontan denticulation that is characteristic of all but one of the species of **Steptotaxis.** Thus, we restrict **Sannemannia** herein to the type species and do not include the species listed under the genus by Klapper (in Klapper and Johnson, 1980, p. 455), but which are instead referred to **Steptotaxis,** as discussed above.

There remains the problem of the generic assignment of **Pelekysgnathus furnishi.** As yet, we have not found a coronellan element in the apparatus of this species, but the denticulation of the main process of the I element is incipiently icriodontan (Klapper and Philip, 1972, p. 102) and thus may be transitional with that of **Steptotaxis glenisteri.** At present, we can only assign **P. furnishi** to **Steptotaxis** with question.

Range. As presently understood, **Steptotaxis** ranges from the **dehiscens** Zone (in an undescribed collection from the Eids Formation at Vendom Fiord, southwestern Ellesmere Island) to at least as high as the **pedderi** faunal unit in Canada (i.e., approximately **australis** Zone).

Appendix

Included in this study are three collections from the Bird Fiord Formation near its type section, made by R. Thorsteinsson in 1979. These are:

C-76076 = UTM Zone 16X, 515,600 mE, 8,571,625 mN;

C-76075 = UTM Zone 16X, 515,500 mE, 8,570,000 mN; and

C-76074 = UTM Zone 16X, 513,500 mE, 8,569,375 mN.

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