GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

BULLETIN 345

SOME ORDOVICIAN CONODONT FAUNULES FROM THE MIRAMICHI ANTICLINORIUM, NEW BRUNSWICK

GODFREY S. NOWLAN

Canada

1981

CANADA
1842
GEOLOGICAL SURVEY – COMMISSION GÉOLOGIQUE

BULLETIN 345

SOME ORDOVICIAN CONODONT FAUNULES FROM THE MIRAMICHI ANTICLINORIUM, NEW BRUNSWICK

GODFREY S. NOWLAN

1981

Available in Canada through

authorized bookstore agents
and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Hull, Québec, Canada K1A 0S9

and from

Geological Survey of Canada
601 Booth Street
Ottawa, Canada K1A 0E8

A deposit copy of this publication is also available
for reference in public libraries across Canada

Cat. No. M42-345E Canada: $4.00
ISBN 0-660-10927-1 Other countries: $4.80

Price subject to change without notice

Critical Readers

M.J. Copeland
W.H. Poole
J.E. Repetski

Original manuscript received: 1980 - 4 - 2
Approved for publication: 1980 - 7 - 10.

Preface

The Miramichi Anticlinorium is an area underlain by complexly folded and faulted Lower Paleozoic volcanic and sedimentary rocks which are intruded by large granitic bodies. Strata of the region are host to rich zinc-lead-copper deposits, many of which are being actively mined. The stratigraphy of this complex and generally poorly exposed terrane is difficult to decipher, and fossils are extremely rare in the thick sequences. The descriptions of biostratigraphically diagnostic conodonts given in this report will aid in the understanding of stratigraphy and regional correlation of an area important to the economy of New Brunswick.

D.J. McLaren
Director General
Geological Survey of Canada

OTTAWA, July 1980

CONTENTS

Tables

Figures

SOME ORDOVICIAN CONODONT FAUNULES FROM THE MIRAMICHI ANITCLINORIUM, NEW BRUNSWICK

Abstract

Ordovician conodonts have been recovered from deformed strata at several localities within the Appalachians of New Brunswick. Samples from the upper part of the lower Tetagouche Group have yielded conodonts of middle Arenigian to early Llanvirnian age including *Microzarkodina flabellum* which is reported from North America for only the second time. The upper unit of the Tetagouche Group has yielded conodonts of Caradocian age, assignable to the *Amorphognathus tvaerensis* Zone. Species characteristic of the *Prioniodus variabilis* Subzone (earliest Caradocian) and the younger *Prioniodus alobatus* Subzone have been recovered from separate samples.

A limestone occurrence at Waterville, New Brunswick has yielded conodonts characteristic of the *Pygodus serrus-Pygodus anserinus* zonal boundary, equivalent to the Llanvirn-Llandeilo boundary. The fauna is very similar to those from the Cobbs Arm Limestone and Davidsville Group in the Newfoundland Appalachians.

The faunules are all of the North Atlantic Conodont Province affinity consistent with an original depositional site marginal to the North American craton. Correlations are made with the standard conodont zonation established in the Baltoscandian region.

Résumé

On a trouvé des conodontes de l'Ordovicien en plusieurs endroits des Appalaches du Nouveau-Brunswick, dans des strates déformées. Des échantillons provenant de la partie supérieure du groupe de Tétagouche inférieur contenaient des conodontes de l'Arenig moyen jusqu'au Llanvirn inférieur, entre autres des *Microzarkodina flabellum*, qui étaient signalés en Amérique du Nord pour la seconde fois. On a trouvé des conodontes du Caradocien attribuables à la zone *Amorphognathus tvaerensis* dans l'unité supérieure du groupe de Tétagouche. Des échantillons différents des premiers contenaient des espèces caractéristiques de la sous-zone *Prioniodus variabilis* (du tout début Caradocien) et de lą sous-zone plus récente *Prioniodus alobatus*.

On a dégagé d'une couche calcaire à Waterville (Nouveau-Brunswick) des conodontes caractéristiques de la limite zonale *Pygodus serrus-Pygodus anserinus*, équivalente à la limite Llanvirn-Llandeilo. La faune ressemble beaucoup à celle du calcaire de Cobbs Arm et du groupe de Davidsville dans les Appalaches de Terre-Neuve.

Les conodontes sont typiques de la province de l'Atlantique nord, comme on s'y attendait pour un site sédimentaire en bordure du craton nord américain. Les corrélations ont été effectuées selon la zonation des conodontes établie dans la région baltoscandienne.

INTRODUCTION

Few fossils have been reported from strata of pre-Silurian age in the Appalachians of New Brunswick, making stratigraphic interpretation of the deformed and metamorphosed sequences very difficult. Only rare, isolated occurrences of carbonate rocks suitable for extraction of conodonts and other acid-resistant microfossils are known and no major, continuous sections are available for study. This report documents the localities visited by W.H. Poole and the author during the summers of 1978 and 1979 and discusses the biostratigraphic significance and stratigraphic implications of the Ordovician conodonts recovered. In general the recovery rate was low, but some new discoveries have been made.

Only two Ordovician conodont faunas from New Brunswick have been reported. Landing et al. (1978) investigated the sequence of the St. John Group on Navy Island, Saint John, New Brunswick and recovered a few specimens of *"Prooneotodus" tenuis* (Müller) from the Tremadocian part of the sequence. Kennedy et al. (1979) reported an abundant fauna of middle Caradocian age from a single sample of the Tetagouche Group at Camel Back Mountain in northern New Brunswick; additional exposures near their locality were sampled for this study.

Several of the localities collected by the author and subsequent collections made by Poole are from the Tetagouche Group of northern and central New Brunswick. In addition, several collections were made in the west central part of the province in the Woodstock area. Each unit is discussed separately with reference to local stratigraphy and the significance of the conodonts recovered. All sampling localities, whether productive or not, are listed and described in the appendix and shown in Figures 1, 3, 4 and 5. A summary of the findings is presented and some of the conodonts are illustrated (Pl. 1-5).

NORTHEASTERN LOCALITIES

The term Tetagouche Series was first used by Young (1911) and later modified by Alcock (1935). The most recent comprehensive description and discussion of these strata and their designation as the Tetagouche Group was made by Skinner (1974). The total thickness of the group is difficult to estimate but may be as much as 10 000 m (Skinner, 1974). This thick sequence underlies much of the area termed the Miramichi Anticlinorium (Rodgers, 1970) and Zone 3 of Ruitenberg et al. (1977). The internal stratigraphy of the Tetagouche Group is poorly known because of poor outcrop and a general paucity of fossils, marker beds and sedimentary facing direction indicators. Skinner (1974) divided the group into three lithostratigraphic assemblages: a Sedimentary unit, a Metabasalt unit and a Rhyolite unit but assigned no stratigraphic interpretation to the sequence. The Tetagouche Group is generally regarded as having a distinct lower, mostly sedimentary unit and an upper, mostly volcanic unit (Poole, 1963; 1976; Helmstaedt, 1971). The lower unit includes rocks of debatable age that may range from Hadrynian to Early Ordovician. The lower part of this lower unit may correlate with the Grand Pitch Formation described from northern Maine by Neuman (1962) who assigned a tentative Cambrian age based on stratigraphic position and the presence of *Oldhamia smithia* Ruedemann, a problematic fossil that may range from late Precambrian to Ordovician age (see discussion by Neuman, 1962, p. 795, 796). The uppermost part of the lower unit is generally characterized by the presence of a calcareous unit, usually calcareous slate. It is this unit which has yielded brachiopods of Arenigian age (Neuman, 1968; 1971; Fyffe, 1976). Conodonts have now been recovered from this level. The upper part of the lower unit of the Tetagouche Group can be reasonably correlated with the Shin Pond Formation described from northern Maine by Neuman (1964; 1967); both units contain fossils of a similar age and comprise sediments interbedded with felsic volcanics. The Shin Pond Formation unconformably overlies the Grand Pitch Formation in Maine, but no evidence of such an unconformity has been found in the lower part of the Tetagouche Group in New Brunswick.

The upper unit of the Tetagouche Group consists mostly of volcanic rock but with some intercalated slate, greywacke, manganiferous chert and graphitic chert. It is from a local limestone associated with metabasalt that Kennedy et al. (1979) recovered conodonts of middle Caradocian age belonging to the *Prioniodus alobatus* Subzone of the *Amorphognathus tvaerensis* Zone Bergström (1971). Graptolites, also of Caradocian age have been recovered from the upper unit in slate associated with metabasalt (Poole, 1963; Helmstaedt, 1971; Skinner, 1974). An unusual occurrence of conodonts in siliceous slaty shale was reported by Sweet and Bergström (1966) from the Wassataquoik Chert (Neuman, 1967) of northern Maine associated with graptolites suggestive of the mid-Caradocian zone of *Diplograptus multidens*. The Wassataquoik Chert is probably correlative with parts of the upper unit of the Tetagouche Group based on lithology, geological setting and biostratigraphic information. The documented occurrence of conodonts in this type of lithology should encourage investigation within the Tetagouche Group.

Several localities within the Tetagouche Group have been sampled and the few productive samples have provided new information.

Camel Back Mountain

The Camel Back Mountain area (Fig. 1) was recollected by the author in 1978 from two adjacent localities (GSC loc. 96063, 96064). The two samples appear to differ slightly in age. Locality 96064 which is close to the locality reported by Kennedy et al. (1979)

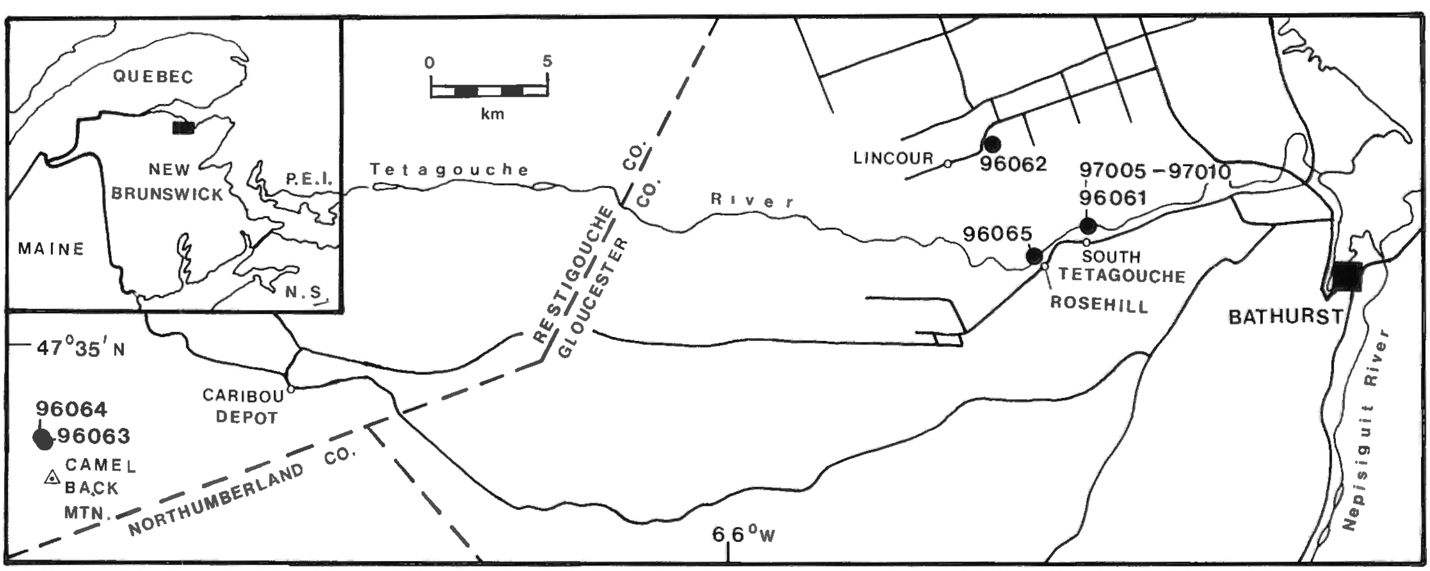


Figure 1. Sketch map showing the collecting localities at Camel Back Mountain and in the region west of Bathurst, New Brunswick. See Appendix for detailed description of localities.

yielded a fauna virtually identical to that reported by those authors (Table 1). This fauna includes the biostratigraphically diagnostic species *Prioniodus alobatus* Bergström which indicates a middle Caradocian age approximately equivalent to the Soudleyan Stage. It is representative of the *P. alobatus* Subzone of the *Amorphognathus tvaerensis* Zone of Bergström (1971)(see Fig. 2). Taxa recovered in this study not included in the faunal list of Kennedy et al. (1979, Table 1) are *Drepanoistodus* sp., *"Scolopodus" peselephantis* Lindström and *Walliserodus nakholmensis* (Hamar); none of these taxa influences the age assignment.

Trilobites have also been recovered from the Camel Back Mountain locality from which Kennedy et al. (1979) reported conodonts (Dean in Skinner, 1974; Dean, 1976, p. 237). The fauna includes the genera *Ceraurinella, Chomatopyge?, Illaenus* (s.l.) *Sphaerexochus* and an undeterminable proetid. Dean (1976) concluded that the fauna is of Caradocian age and shows affinities with southern Appalachian faunas.

Locality 96063 which is only about 40 m distant from locality 96064 yielded a different fauna. The outcrops at both localities are isolated exposures and no section is exposed between them. Some taxa common to the two samples are *Periodon aculeatus* Hadding, *Strachanognathus parvus* Rhodes and *Walliserodus nakholmensis* (Hamar)(see Tables 1, 2); however, most of the fauna from locality 96063 is different. It includes specimens probably assignable to *Prioniodus variabilis* Bergström, although none of the amorphognathiform elements is complete. Fragments of the posterior process show the prominent triangular lateral expansion of the inner side characteristic for the species (see taxonomic remarks). In addition the representatives of *Protopanderodus* Lindström in this sample are all assignable to earlier species of the genus than *P. liripipus* Kennedy et al. These include *Protopanderodus graeai* (Hamar), *P. rectus?* (Lindström) and a single specimen of *P. varicostatus?* (Sweet and Bergström). *Spinodus ramosus* (Hadding) is also present in reasonable abundance. This species is known from the Llanvirnian (e.g. Lindström, 1955b) to at least early Caradocian (e.g. Repetski and Ethington, 1977 who recovered it in association with *Prioniodus gerdae* Bergström). Four fragmentary specimens referred to *Polyplacognathus* cf. *P. ringerikensis* Hamar were also recovered from locality 96063. This species is similar to the polyplacognathiform element of *Eoplacognathus elongatus* (Hamar) a

TABLE 1

Species recovered from GSC Locality 96064 in the Tetagouche Group at Camel Back Mountain, New Brunswick.

Amorphognathus tvaerensis Bergström	
ramiform (a-d)	13
holodontiform (e)	1
ambalodiform (f)	6
amorphognathiform (g) (estimated from fragments)	3
Coelocerodontus? lacrimosus Kennedy et al. s.f.	116
Dapsilodus? similaris (Rhodes)	189
Drepanoistodus sp.	
suberectiform (p)	1
homocurvatiform (q)	16
Panderodus cf. *P. gracilis* (Branson and Mehl)	13
Periodon aculeatus Hadding	
periodontiform (a-d)	62
oistodiform (e)	62
ligonodiniform (f)	20
prioniodiniform (g)	22
Prioniodus alobatus Bergström	
cordylodiform/cladognathiform (a/b)	70
hibbardelliform (c)	41
tetraprioniodiform (d)	73
oistodiform (e)	52
prioniodiform (f)	82*
prioniodiform ("amorphognathiform")(g)	16
Protopanderodus liripipus Kennedy et al.	
protopanderodiform (costate)	310
scandodiform	102
"Scolopodus" peselephantis Lindström	12
Strachanognathus parvus Rhodes	98
Walliserodus nakholmensis (Hamar)	14
TOTAL:	1394

*This figure probably includes fragmentary g elements.

species with a restricted range from the upper part of the *Pygodus anserinus* Zone to the lower part of the *A. tvaerensis* Zone (Bergström, 1971) (late Llandeilan to early Caradocian). This fauna is indicative of the *Prioniodus variabilis* Zone (Bergström, 1971) of earliest Caradocian age and is, therefore, slightly older than that recovered from locality 96064. The close juxtaposition of these two localities of different age suggests that these low outcrops should be systematically collected to establish whether or not continuous carbonate deposition prevailed from early to middle Caradocian in the Camel Back Mountain area.

South Tetagouche

Extensive collecting from this locality on the Tetagouche River (GSC Localities 97005-97010, 96061; see Fig. 1) failed to yield biostratigraphically diagnostic forms. The samples were taken from the arenaceous limestone described by Fyffe (1976, p. 139) and yielded very few specimens, all of restricted diversity and poor preservation. *Protopanderodus rectus* Lindström (Pl. 1, fig. 6, 7) and *Drepanoistodus basiovalis* (Sergeeva) (Pl. 3, fig. 20-22) can be positively identified but the material is mostly fragmentary. *P. rectus* is a widespread species known to range from early middle Arenigian to early Llanvirnian (see Löfgren, 1978 for complete list of regional occurrences). *D. basiovalis* is known from strata of middle Arenigian to Llanvirnian (see Löfgren, 1978, for complete list of regional occurrences). Although these species are rather long-ranging, they suggest an age for this locality similar to that of presumably equivalent strata at Middle Hayden Brook.

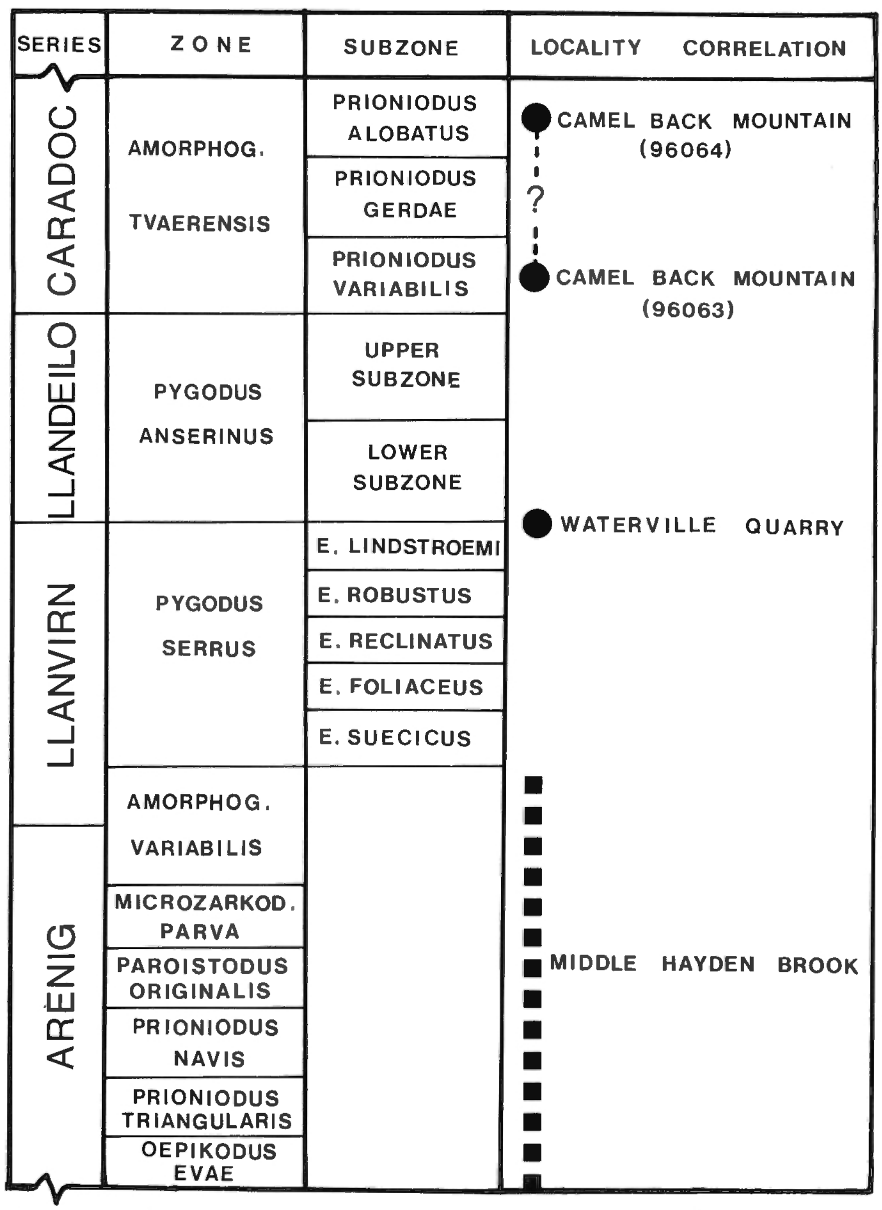


Figure 2. Correlation of the localities with the Ordovician Series, based on the conodont zonation and subzonation of Bergström (1971). Zones in the Arenig are based on Lindström (1971). Squares indicate total possible range in age for samples. Circles indicate closer correlations with specific subzones.

TABLE 2

Species recovered from GSC Locality 96063 in the Tetagouche Group at Camel Back Mountain, New Brunswick.

Drepanoistodus? cf. *D.? venustus* (Stauffer)	
homocurvatiform (q)	23
oistodiform (r)	20
Periodon aculeatus Hadding	
periodontiform (a-d)	18
oistodiform (e)	24
ligonodiniform (f)	6
prioniodiniform (g)	10
Polyplacognathus cf. *P. ringerikensis* Hamar s.f.	4
Prioniodus variabilis Bergström	
cordylodiform/cladognathiform (a/b)	35
hibbardelliform (c)	15
tetraprioniodiform (d)	25
oistodiform (e)	21
prioniodiform (f)	16
prioniodiform ("amorphognathiform") (g) (estimated from fragments)	7
Protopanderodus graeai (Hamar)	
protopanderodiform (acontiodiform, costate)	16
scandodiform	2
Protopanderodus rectus? (Lindström)	
protopanderodiform (acontiodiform, costate)	48
Protopanderodus varicostatus? (Sweet and Bergström)	
protopanderodiform (acontiodiform, costate)	2
"Scolopodus" giganteus Sweet and Bergström s.f.	1
Spinodus ramosus (Hadding)	
cordylodiform (a) spinatiform	24
cordylodiform (a) ramosiform	5
cladognathiform (b)	5
hibbardelliform (c)	1
Strachanognathus parvus Rhodes	16
Walliserodus nakholmensis (Hamar)	
scandodiform	36
distacodiform-paltodiform	24
acontiodiform-paltodiform	25
carinate	48
TOTAL:	477

CENTRAL LOCALITIES

Middle Hayden Brook

This locality (GSC loc. 96067) is on Middle Hayden Brook near its confluence with the Taxis River north of the village of Cross Creek in central New Brunswick (Fig. 3). The collection was obtained from a thin calcareous unit near the top of the lower unit of the Tetagouche Group. The fauna is listed in Table 3. The few specimens recovered are mostly broken and considerably thermally altered as shown by the presence of both grey and grey-white specimens (Colour Alteration Index 6 of Epstein et al., 1977). The fauna is numerically dominated by the biostratigraphically most diagnostic species *Microzarkodina flabellum* (Lindström). *M. flabellum* has been reported from many localities in western Europe including Scandinavia (e.g. Lindström, 1955a; van Wamel, 1974), Estonia (e.g. Viira, 1974), Poland (e.g. Dzik, 1976), Turkey (Gedik, 1977) and the Canning Basin of western Australia (McTavish and Legg, 1976) (see Löfgren, 1978, p. 62, for complete listing of occurrences). This is only the second report of the species from North America; Ethington (1979) has reported this taxon from the Juab Formation of the Ibex area.

The range of *M. flabellum sensu* Löfgren (1978) is considered to be from early middle Arenigian (late Latorpian of the Baltic area) to late middle Arenigian (Volkhovian of the Baltic area); however Löfgren (1978) has recently reported it from strata of earliest Llanvirnian age.

The remainder of the fauna from this locality is not biostratigraphically diagnostic. Thus the Middle Hayden Brook assemblage may range from early Middle Arenigian to earliest Llanvirnian. The Arenigian age indicated by brachiopods from other localities at this stratigraphic level (Neuman, 1968) is approximately confirmed.

Lower Birch Island

A sample (GSC loc. 96066) of calcareous slate at this locality (Fig. 4) in central New Brunswick yielded two simple cone elements assignable to the form genus *Oistodus* Pander. Paucity of specimens and the fragmentary nature of the material preclude specific identification This sample is from the upper part of the lower unit of the Tetagouche Group (Poole, 1963).

SOUTHWESTERN LOCALITIES

Correlation of strata of the Tetagouche Group in the north with strata of the southwestern part of the Miramichi Anticlinorium is difficult but recent mapping by Venugopal (1978a,b,c; 1979a,b) has clarified some of the relationships. He has shown that the Pocomoonshine volcanics, a unit comprising mafic and felsic volcanics interbedded with manganiferous slates and cherts, is lithologically similar to the upper unit of the Tetagouche Group. Both of these units overlie sequences of slate and metaquartzite and may be of a similar age.

The only report of fossils from Cambro-Ordovician strata in the southwestern part of the Miramichi Anticlinorium is that by Bailey (1901, p. 145) who recorded the occurrence of Lower Ordovician graptolites which Hahn (1912, p. 135) identified as *Dictyonema flabelliforme* (Eichwald) var. *sociale* (Salter). Attempts to relocate the fossiliferous exposures have failed.

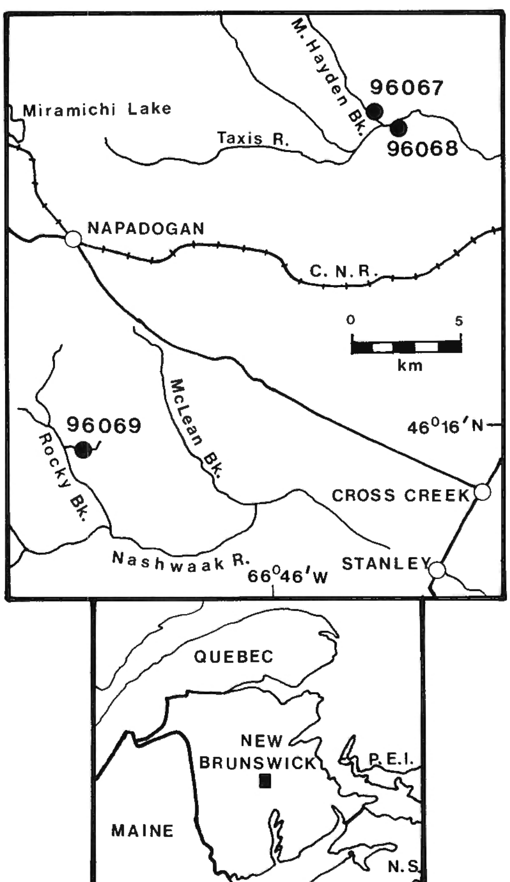


Figure 3. Sketch map showing the Middle Hayden Brook, Taxis River and Rocky Brook localities in central New Brunswick. See Appendix for detailed description of localities.

A few localities in this southwestern area expose rocks suitable for acid digestion and these were collected by the author in 1978, with additional samples supplied by Poole in 1979. The significance of the localities that yielded conodonts is discussed below.

Waterville Quarry

The Waterville limestone occurrence is located about 13 km north of the St. John River in the northwestern part of York County, New Brunswick (Fig. 5). The locality has been quarried for more than a century but it is now inactive (Hamilton, 1965; Anderson, 1968). Two samples (GSC loc. 96073, 96074) were taken from this locality by the author in July 1978 and three additional samples (GSC loc. 97012, 97013, 97014) were collected by Poole in 1979. The locality is thoroughly described in Hamilton (1965, p. 58-61) who provided a detailed map of the site and a history of quarry operation. The limestone is preserved as a series of large lenticular bodies resembling large boudins. It is a medium grained, pale grey to white marble with thin dark laminae locally preserved. Chemical analysis shows the marble to be very pure carbonate (Hamilton, 1965; Anderson, 1968). Anderson (1968) has also provided a brief description of a drilling programme undertaken in 1945 and 1946 to outline the extent of the limestone bodies.

The limestone occurrence at Waterville has generally been regarded as of Silurian age based on the presence of crinoid stems and gross lithologic similarities to known Silurian strata (Hamilton, 1965). Anderson (1968) mapped the surrounding area including the Woodstock,

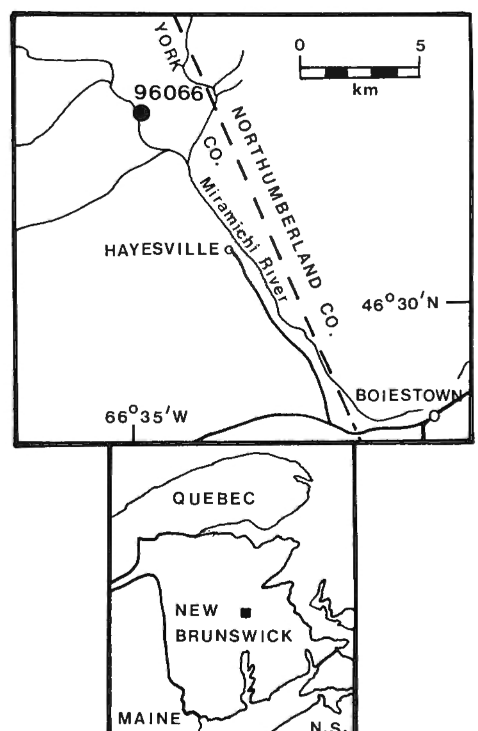


Figure 4. Sketch map showing Lower Birch Island locality on Southwest Miramichi River north of Hayesville, New Brunswick. See Appendix for detailed description of locality.

TABLE 3

Species recovered from GSC Locality 96067 in the Tetagouche Group at Middle Hayden Brook.

Drepanoistodus sp.	2
Microzarkodina flabellum (Lindström)	
cordylodiform (a)	2
zygognathiform (b)	1?
oistodiform (e)	4
ozarkodiniform (f or g?)	8
Oistodus sp.	1
Protopanderodus rectus? (Lindström)	6
Walliserodus? sp.	3
TOTAL:	27

Millville and Coldstream map areas. He discussed the Waterville limestone briefly in his discussion of map unit 5 (Anderson, 1968, p. 23) which is of Silurian age based upon graptolites collected by L. Pavlides and identified by W.B.N. Berry (Pavlides, 1966). It is clear from the new evidence provided by conodonts that the unit is older than the dated parts of map unit 5. Venugopal (1979b) included the Waterville limestone in the Belle Lake Slate Formation which apparently overlies the Pocomoonshine Volcanics.

All the samples collected yielded conodonts, resulting in a collection of over 300 specimens. The conodonts are generally poorly preserved and most are badly contorted and fractured. They are grey-black to grey-white in colour suggesting a Colour Alteration Index (CAI, Epstein et al., 1977) of about 6 or higher. Sufficiently well preserved specimens have been recovered to permit some specific identifications that allow a precise biostratigraphic age assignment. The species recovered from the Waterville samples and their abundance are listed in Table 4. The best preserved specimens were recovered from locality 96073; identification of species in several of the other samples is less certain and indicated by a question mark on Table 4.

The biostratigraphically diagnostic forms belong to the genus *Pygodus* Hadding. Species of this genus have been used for zonation of Llanvirnian and Llandeilian strata (Bergström, 1971). *Pygodus serrus* (Hadding) is generally restricted to the *P. serrus* Zone of Bergström (1971) of Late Llanvirnian age, although Bergström and Carnes (1976) indicated some overlap of the ranges of *P. serrus* and *P. anserinus*.

The specimens referred to *P.* cf. *P. serrus* Lamont and Lindström have a rudimentary fourth denticle row suggestive of the later species of *P. anserinus*. The fortunate occurrence of specimens showing transitional stages of the marked morphologic change from *P. serrus* to *P. anserinus* permits precise correlation with the *P. serrus*-*P. anserinus* zonal boundary, which is one of the most useful reference levels in the Middle Ordovician, and corresponds to the Llanvirn/Llandeilo boundary (Bergström, 1971).

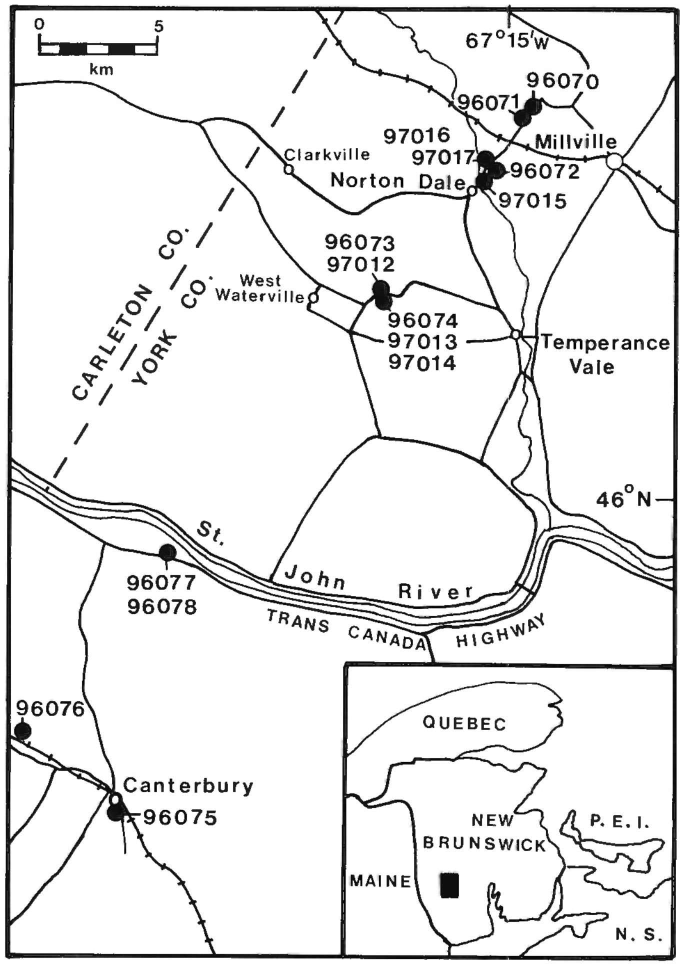


Figure 5. Sketch map of part of west central New Brunswick showing localities near Waterville, Canterbury and Millville. See Appendix for detailed description of localities.

Prioniodus prevariabilis Fåhraeus is known to range from the middle Llanvirnian to the late Llandeilian in Sweden (Löfgren, 1978). The other elements of the fauna include *Periodon aculeatus* Hadding, a relatively long-ranging form, and a number of other long-ranging taxa and fragmentary elements identifiable at the species level (see Table 4).

TABLE 4

Species recovered from limestone of the Waterville Quarry, New Brunswick.

SPECIES	SAMPLES 96073	96074	97012	97013	97014	TOTAL
Drepanoistodus? cf. *D.? venustus* (Stauffer)	5	1	-	-	-	6
Panderodus cf. *P. gracilis* (Branson and Mehl)						
compressiform	1	-	-	-	1	2
graciliform/arcuatiform	8	3	6	3	17	37
Panderodus aff. *P. serratus* Rexroad	-	-	-	-	4	4
Panderodus sp.	1	-	-	-	-	1
Panderodus? sp.	1	-	-	-	-	1
Periodon aculeatus Hadding						
periodontiform (a-d)	5	2	2	16	12	37
oistodiform (e)	2	-	-	10	10	22
ligonodiniform (f)	1	1	-	6	2	10
prioniodiniform (g)	2	-	-	5	4	11
Prioniodus prevariabilis Fåhraeus						
cordylodiform/cladognathiform (a/b)	17	-	-	?3	1	21
hibbardelliform (c)	6	-	-	?1	1	8
tetraprioniodiform (d)	8	-	-	?2	3	13
oistodiform (e)	26	-	-	?1	1	28
prioniodiform (f)	}22	-	-	-	-	}22
prioniodiform ("amorphognathiform") (g)		-	-	-	-	
Protopanderodus varicostatus? (Sweet and Bergström)	3	1	-	6	-	10
Protopanderodus sp.	6	1	-	7	6	20
Pygodus cf. *P. serrus* (Hadding)						
haddingodiform (f)	4	1	-	3	5	13
pygodiform (g)	4	-	?1	9	2	16
Strachanognathus parvus Rhodes	1	-	-	2	3	6
Walliserodus sp.	1	2	-	5	5	13
TOTALS	124	12	9	79	77	301

In 1979, W.H. Poole collected a single coral colony in the walls of a small pit about 60 m east of the main quarry. T.E. Bolton (Geological Survey of Canada) identified the specimen as *Paleoalveolites?* sp. a genus known from strata of Blackriveran age elsewhere. This occurrence seems to be somewhat older based on conodonts.

The conodont fauna recovered from the Waterville quarry is essentially identical to that of the Cobb's Arm Limestone of northern Newfoundland reported by Bergström et al. (1974). A fauna of the same age is also known from limestone near the base of the Davidsville Group in northeastern Newfoundland (Stouge, 1979; Nowlan, unpublished data). Descriptions of the units in each area are remarkably similar both in terms of lithology and structural setting. This regional occurrence of limestones of identical age is rather coincidental and may perhaps reflect local uplift or development of volcanic islands in the centre of, or along the eastern margin of the Iapetus Ocean.

The Llanvirnian/Llandeilian age for the Waterville limestone occurrence does not correlate with either of the faunal levels known from the Tetagouche Group, but is older than the faunally dated part of the upper unit and younger than the calcareous unit at the top of the lower Tetagouche Group (see Fig. 2).

Other Limestone Localities

Several other localities with calcareous rocks suitable for the extraction of microfossils were collected in the west central part of New Brunswick (Fig. 5) but with little success in terms of conodont recovery.

Two localities collected in calcareous rocks in the vicinity of Canterbury, New Brunswick (GSC loc. 96075, 96076) proved barren with the exception of a denticulated fragment in locality 96075.

Several localities near Norton Dale (Fig. 5) within Anderson's (1968) map unit 5 and Venugopal's (1979a) map unit Ss were also sampled but without result (see Appendix).

A single sample from the Scott Siding Slate (Venugopal, 1978a,b) (GSC loc. 96078) yielded a few fragmentary simple cone elements that are referrable to *Protopanderodus* Lindström. This formation is believed to be Silurian, but *Protopanderodus* is presently restricted to the Ordovician. Unfortunately, the specimens were obtained from pebbles within a lens of limestone conglomerate and thus may be derived from older strata. A sample collected from a single thin bed of calcareous siltstone (GSC loc. 96077) in the Scott Siding Slate failed to yield any conodonts. Additional collecting from this unit is needed.

REGIONAL CORRELATION

As noted above, the scarcity or absence of fossils in many successions of the Miramichi Anticlinorium of New Brunswick makes it difficult to date many units precisely. The recovery of conodonts from several previously either undated or poorly dated units has shown reasonable potential for their recovery from deformed strata in the Appalachian Orogen. Similar studies in the Newfoundland part of the Appalachian Orogen have also yielded promising results (Bergström et al., 1974, S. Stouge, 1979; 1980; Nowlan, unpublished data). The limitations imposed by rarity of suitable lithologies for acid digestions and by high metamorphic grades are undoubtedly severe, but they can be overcome by careful search in suitable areas.

All the conodonts recovered in this study are typical of the North Atlantic Faunal Province (Barnes et al., 1973) and facilitate correlation in terms of the North Atlantic conodont zonal succession (Bergström, 1971). The ability to correlate with a geographically widespread zonal scheme permits comparison with both northwestern Europe and the eastern part of the central and southern Appalachians.

Middle Arenig-earliest Llanvirn

Middle Arenig-earliest Llanvirn conodonts of North Atlantic Province affinity from the time slice represented by the occurrence of *Microzarkodina flabellum* are not known from the Appalachians, but are widespread in northwestern Europe and are known from the eastern Mediterranean area and Australia. The small fauna reported by Hibbard et al. (1977) from the Dunnage Mélange in northeastern Newfoundland is somewhat older than the Middle Hayden Brook fauna reported herein. The faunas reported by Bergström et al. (1972) from South Catcher Pond in the Lushs Bight Group (Newfoundland) and from the Hamburg Klippe, Pennsylvania are indicative of the early Arenigian *Prioniodus elegans* Zone of Lindström (1971). Dean (1970) recovered trilobites from the South Catcher Pond locality as well. Lower Ordovician brachiopods from the Tetagouche Group of central New Brunswick reported by Neuman (1968, 1971) probably are late Arenigian (Whiterockian) and thus within the range indicated by the conodonts from Middle Hayden Brook and South Tetagouche.

M. flabellum is well known from late Latorpian and Volkhovian beds of the Balto-scandic area (Lindström 1955a, 1960, 1971; van Wamel, 1974; Viira 1967, 1974; Mägi and Viira, 1976; Löfgren, 1978). Dzik (1976) recovered specimens of the species from erratic boulders of presumed Baltic origin in Poland. This species is also known from the Middle Taurus of Turkey (Gedik, 1977) and is reported from strata within the Canning Basin of Western Australia (McTavish and Legg, 1976). Unfortunately the species is not known from the British Isles or from other localities in the Appalachian region.

Llanvirn-Llandeilo

The conodont fauna recovered from the Waterville limestone occurrence is known from many localities in northwestern Europe and the Appalachians. As noted above, the fauna is essentially identical to that from the Cobbs Arm Limestone of northern Newfoundland. Bergström et al. (1974, p. 1651-1653) provided a thorough discussion of the regional correlation of the unit with units in the southern Appalachians, Champlain Valley, southern Scotland, Wales and Baltoscandia; the reader is referred to their paper for further discussion. Since the report of Bergström et al. (1974) a few additional reports of a similar fauna have come to light. Faunal elements representative of the *Pygodus serrus-P. anserinus* zonal boundary have been recovered from the Davidsville Group of northeastern Newfoundland (Blackwood, 1978; Stouge, 1979; Nowlan, unpublished data). Similar faunas have also been recovered from limestone blocks in the Sops Head and Boones Point complexes (Dean, 1978) in western Notre Dame Bay and from the Victoria Lake Group at Buchans in Newfoundland (Stouge, 1980). A fauna belonging to the younger *P. anserinus* Zone has been reported from Squid Cove on New World Island, northeastern Newfoundland (Uyeno in Dean, 1971). Löfgren (1978) has recently reported *P. serrus* from northern Sweden, but this middle Llanvirnian occurrence is probably somewhat older than the Waterville fauna.

In terms of the North American standard sequence of stages, the late Llanvirnian-early Llandeilian interval correlates approximately with the middle to upper part of the Chazyan Stage. This correlation can be effected through knowledge of the *Polyplacognathus friendsvillensis-P. sweeti* lineage in the type Chazyan (Raring, 1972) and relating these occurrences to strata in the southern Appalachians bearing both *Polyplacognathus* and *Pygodus*. The extensive work of Bergström (1971, 1973b) in the southern Appalachians has greatly increased knowledge of the stratigraphic interrelationship and distribution of representatives of these two genera.

In terms of the standard graptolite zonation, this interval corresponds to the middle part of the *Glyptograptus teretiusculus* zone in the Baltoscandian area (Bergström, 1973a).

Early to middle Caradocian

The regional correlation of this interval based on the presence of *Prioniodus variabilis* and *P. alobatus* in the Camel Back Mountain area is less extensive than the Llanvirnian-Llandeilan occurrence at Waterville quarry. Bergström (1971) reported *Prioniodus gerdae* from the Lincolnshire and Edinburgh formations of Virginia. Bergström and Carnes (1976) reported *P. variabilis* and elements of the *P. variabilis-P. gerdae* transition from the Holston Formation of eastern Tennessee. The report by Kennedy et al. (1979) of *P. alobatus* from the Camel Back Mountain area was the first report of this species from North America.

Shelly fossils of undoubted Caradoc (or Ashgill) age are poorly known from deformed strata of the Appalachian Orogen. Neuman (1968) has reported Caradocian brachiopods from New World Island, northeastern Newfoundland and several localities of probable Caradocian age in Maine.

In terms of standard North American stadial units this early to middle Caradocian interval corresponds approximately to the Blackriveran Stage, although the base of the Caradocian may be older than the base of the Blackriveran (see Sweet and Bergström, 1976). With regard to the standard graptolite zonation this interval corresponds to the upper part of the *Nemagraptus gracilis* Zone and the lower part of the *Diplograptus multidens* Zone.

BIOGEOGRAPHIC SIGNIFICANCE

Provincialism exhibited by Ordovician conodonts has been discussed in several recent papers (Barnes et al., 1973; Bergström, 1973c; Sweet and Bergström, 1974; Barnes and Fåhraeus, 1975). Two provinces can be distinguished, namely the Midcontinent Province and the North Atlantic Province. Faunas representative of the Midcontinent Province are best known from cratonic regions of North America and Siberia, and apparently reflect shallow water, low latitude seas characterized by high temperature and salinity. In contrast, faunas representative of the North Atlantic Province are known from areas of widely different tectonic history and apparently reflect "normal" marine conditions in either high or low latitudes (Barnes and Fåhraeus, 1975).

The faunules recovered from strata of the Miramichi Anticlinorium are all of North Atlantic Province affinity and thus have virtually nothing in common with faunas of the same age from the midcontinent of North America. The faunules are most similar to those of the Baltoscandian area of northwestern Europe and correlation can be readily effected between the two areas. The New Brunswick occurrences are also somewhat similar to faunas of parts of the southern Appalachian belt. A few distinctions can be drawn between faunas in the northern Appalachians region and those in the southern part. Bergström et al. (1974) pointed out that the genera *Phragmodus, Plectodina* and *Polyplacognathus* are absent from Middle Ordovician occurrences in Newfoundland whereas they are common components in faunas from the southern Appalachian region. These genera are also absent from the faunas of the Miramichi Anticlinorium. It may also be noted that *Strachanognathus* is not known from the southern Appalachian region whereas it is present in most faunas from the northern Appalachians. Thus, faunas from the southern Appalachians are of a more mixed provincial aspect than those from New Brunswick and Newfoundland.

The great similarity of conodont faunas from Baltoscandia and New Brunswick is particularly striking in view of the widely different tectonic histories of the two areas. Strata of the Miramichi Anticlinorium formed part of a volcanic island arc within, or at the margin of, the Iapetus Ocean whereas the strata of the Baltoscandian area are shallow water platformal deposits. Furthermore, plate tectonic reconstructions for the Middle Ordovician show New Brunswick at low latitude and the Baltoscandian area at high latitude, the two areas being separated by thirty to sixty degrees of latitude (Smith et al., 1973; Scotese et al., 1979).

The provincial distribution of conodonts in the Middle Ordovician of North America appears to parallel closely the boundary between cratonic (Midcontinent Province) and extra-cratonic (North Atlantic Province) sequences. The area of overlap lies on the outer shelf which, unfortunately, is seldom preserved in a tectonic region such as that of the eastern margin of North America. Conodonts of North Atlantic Province affinity occur in strata originally marginal to the North American craton in widely separated areas: the Canadian Arctic Islands (Tipnis, 1978), Nevada and southeastern California (Harris et al., 1979), Texas and Oklahoma (Bradshaw, 1969), the Ouachita Mountains (Repetski and Ethington, 1977), the southern Appalachians (e.g. Bergström, 1973b) and the northern Appalachians (Bergström et al., 1974; Fåhraeus and Nowlan, 1978). Thus conodonts typical of the North Atlantic Province occur in a circumcratonic pattern with respect to North America. As noted above, North Atlantic Province faunas also extend widely along and across the Iapetus Ocean into the Baltic area. It can also be pointed out that Middle Ordovician conodonts from strata interpreted as representing slope deposits formed on the eastern margin of Iapetus Ocean (Davidsville Group as interpreted by Currie et al., 1979) are of North Atlantic Province affinity (Stouge, 1979; Nowlan, unpublished data). As a result of this broad distribution conodonts can contribute little to discussions on the position of the Iapetus suture based on faunal provincialism (e.g. McKerrow and Cocks, 1977). Other faunal groups that show greater provinciality in this region such as trilobites (Whittington and Hughes, 1972) and brachiopods (Neuman, 1972; Williams, 1969) are more useful to such discussions.

An exception to the provincial distribution described above has recently been noted by Bergström (1979) who reported a conodont fauna of early Llanvirnian age including forms typical of Whiterockian strata of North America, from the Hølonda area of western Norway. This interpretation agrees with the affinities of brachiopods recovered from the same area (Neuman, 1979). This occurrence can be interpreted in two ways. Firstly, it can be concluded that the strata of the region were originally a part of North America (Bergström, 1979). This conclusion is not necessarily correct if one considers the variety of factors influencing provincial boundaries. For example, it is not necessary for provincial boundaries to parallel the axis of an ocean, because the provinciality is a result not only of geographic separation but also of physico-chemical factors such as salinity and ocean current patterns. It need not be entirely unexpected therefore to find representatives of the same faunal province on opposite sides of an ocean. The marked similarity of North American and Siberian cratonic faunas of the Midcontinent Province in the Middle and Upper Ordovician certainly suggests that it was possible for conodonts to cross an intervening ocean (perhaps by means of a larval stage) and to thrive in widely separate areas of suitable ecologic conditions. Similarly, there were a number of incursions of North Atlantic Province faunas onto cratonic areas during the Ordovician (Barnes et al., 1973). Therefore, all factors (faunal provinciality, stratigraphy and tectonic history) should be taken into account in the interpretation of major tectonic events or boundaries.

SUMMARY AND CONCLUSIONS

Conodont faunas of three separate ages have been recovered from strata in the Miramichi Anticlinorium.

1. Conodonts from the upper part of the lower unit of the Tetagouche Group at Middle Hayden Brook include *Microzarkodina flabellum* and indicate a middle Arenigian to earliest Llanvirnian (late Canadian to early Whiterockian) age. The samples from South Tetagouche suggest a similar age. Several other samples from this level at various localities either yielded undiagnostic forms or failed to yield any specimens.

2. Conodonts from the upper unit of the Tetagouche Group at Camel Back Mountain are suggestive of possible early and definite middle Caradocian age (Kennedy et al., 1979; this paper).

3. Conodonts from the Waterville quarry in the southern part of the Miramichi Anticlinorium represent the *Pygodus serrus-P. anserinus* zonal boundary of latest Llanvirnian to early Llandeilian age. This fauna is identical to that of the Cobbs Arm Limestone and of the lower part of the Davidsville Group in Newfoundland.

The faunas recovered are representative of the North Atlantic Province and provide few clues for the discussion of the position of Iapetus Ocean suture in the Appalachian orogen.

Results from this preliminary effort to find conodonts in deformed strata of the Appalachians of New Brunswick are encouraging and suggests that further studies are warranted in order to help elucidate the history of the relatively unfossiliferous strata of the central Appalachians.

PALEONTOLOGY

The primary aim of this study is to document the biostratigraphic significance of faunas recovered from isolated samples in New Brunswick. Accordingly, well known species or species of which only a few specimens were recovered are treated in a section entitled 'Taxonomic Remarks', which provides pertinent information on the species and the basis for its identification herein. Systematic treatments have been made for poorly known taxa that are sufficiently well represented and for those taxa to which significant taxonomic contributions can be made.

All illustrated specimens are deposited in the National Type Fossil Collection at the Geological Survey of Canada (GSC) in Ottawa.

The letter code for conodont elements proposed by Barnes et al. (1979) is used in conjunction with more traditional descriptive terms.

Taxonomic Remarks

Amorphognathus tvaerensis Bergström, 1962
Pl. 5, fig. 13, 14, 16

Only a few representative elements of this species have been recovered in this study. All amorphognathiform (g) elements are fragmentary. A single holodontiform (e) element with one of the postero-lateral processes broken off confirms the identification of this species from Camel Back Mountain. Bergström's (1971) concept of this species is adopted herein.

Types. Hypotypes, GSC 64412-64414; unfigured hypotype, GSC 64415.

Coelocerodontus? lacrimosus Kennedy, Barnes and Uyeno, 1979 s.f.
Pl. 5, fig. 12

Kennedy et al. (1979) erected this form species based on material from Camel Back Mountain. The multielement affinities of this species remain in doubt, although it is most similar to carinate (acodontiform of Cooper, 1975) elements of species of *Walliserodus*.

Types. Hypotype, GSC 64411.

Drepanoistodus? cf. *D.? venustus* (Stauffer, 1935a)
Pl. 1, fig. 13, Pl. 3, fig. 7, 17

Oistodiform elements similar to *O. venustus* Stauffer have been recovered from Waterville quarry (Table 4) and Camel Back Mountain (Table 2). These occur together with homocurvatiform elements and are tentatively assigned to the genus *Drepanoistodus*. No suberectiform elements were recovered. Löfgren (1978) has provided a recent discussion of this species.

Types. Figured specimens GSC 64325, 64359, 64360.

Drepanoistodus basiovalis (Sergeeva, 1963)
Pl. 3, fig. 20-22

Specimens assignable to this species were recovered from the South Tetagouche locality (Fig. 1) and oistodiform elements agree closely with Sergeeva's description. Löfgren (1978) has provided a recent description and discussion of this taxon and her interpretation is followed herein. No suberectiform elements were recovered.

Types. Hypotypes, GSC 64371-64373.

Drepanoistodus sp.

Elements probably belonging to this genus have been recovered from Middle Hayden Brook (Table 3) and from Camel Back Mountain (Table 1). Only homocurvatiform elements were recovered and as such do not permit specific identification. Oistodiform elements recovered elsewhere are similar to *Oistodus venustus* Stauffer and are tentatively assigned to *Drepanoistodus* (see above).

Panderodus cf. *P. gracilis* (Branson and Mehl, 1933)
Pl. 1, fig. 14, 17, 18

Representatives of this species were recovered from Camel Back Mountain (GSC Locality 96064) and also from the Waterville Quarry. At the former locality the species is represented only by graciliform (p) elements whereas at the latter two compressiform (q) elements were recovered. The material from Waterville Quarry is similar to representatives of *Panderodus* recovered by the author from the Chazyan Mingan Formation of the Mingan Islands, Quebec. The q elements have a broader lower base and differ sufficiently from typical *P. gracilis* to be possibly a separate taxon. The specimens from the Caradocian occurrence (GSC Loc. 96064) at Camel Back Mountain may be true representatives of *P. gracilis* but the lack of q elements precludes certain specific identification.

Types. Figured specimens, GSC 64326-64328.

Panderodus aff. *P. serratus* Rexroad 1967
Pl. 1, fig. 16, 19

A single sample from the Waterville Quarry (GSC Loc. 97014) yielded four specimens assignable to *Panderodus* that have serrated oral margins. The elements are strongly bowed laterally and resemble most closely the form species *P. arcuatus* (Stauffer). Similar elements have been reported from Silurian strata by Rexroad (1967) and have been subsequently included in a multielement species *P. serratus* by Cooper (1975). Nowlan and Barnes (in press) have reported elements similar to *P. serratus* from the Late Ordovician of Anticosti Island, Québec. The Waterville specimens are clearly much older and may represent a separate species.

Types. Figured specimens, GSC 64330, 64331.

Periodon aculeatus Hadding, 1913
Pl. 2, fig. 7-10, Pl. 4, fig. 1-9

The elements assigned to this species come from both the Waterville quarry (Llanvirnian-Llandeilian) and Camel Back Mountain (Caradocian). There is no appreciable difference between specimens from the two localities although the specimens from Waterville Quarry are rather poorly preserved. The variability of all elements in both occurrences precludes assignment to separate species. Kennedy et al. (1979) have discussed the variation of specimens from Camel Back Mountain and the relationship between *P. aculeatus* and *P. grandis*. Löfgren (1978) has discussed the distinction of *P. aculeatus* from older species of the genus.

Types. Hypotypes, GSC 64342-64345; 64374-64382.

Prioniodus alobatus Bergström, 1971
Pl. 5, fig. 9, 15, 17-22

The question of the relationship between *Prioniodus* and *Baltoniodus* has been discussed by Fåhraeus and Nowlan (1978) and their interpretation is followed herein for species of *Prioniodus*. *P. alobatus* was thoroughly described by Bergström (1971) and his interpretation is followed herein. It is noted that the amorphognathiform (g) element is commonly broken at the junction between the cusp and the posterior process as in other species of *Prioniodus*. Only one well preserved specimen is illustrated.

Types. Hypotypes, GSC 64402-64408.

Prioniodus prevariabilis Fåhraeus, 1966
Pl. 2, fig. 6, 11, 12, 13, 15

See remarks under *P. alobatus*. As noted under *P. variabilis* this species is distinguished by its lack of prominent ledges along the processes of ambalodiform (f) and amorphognathiform (g) elements.

Types. Figured specimens, GSC 64337-64341.

Prioniodus variabilis Bergström, 1962
Pl. 4, fig. 10-12, 14-17

See remarks under *P. alobatus*. *P. variabilis* is distinguished from *P. prevariabilis* by its prominent ledges along the processes and marked triangular lateral expansion of the inner side of the posterior processes of the amorphognathiform (g) element (see Bergström, 1971). No complete g elements have been recovered herein but the fragments of posterior processes (Pl. 4, fig. 17) suggest that *P. variabilis* is indeed present at Camel Back Mountain. The other elements of the apparatus do not differ appreciably from homologous elements in *P. alobatus* and *P. prevariabilis*.

Types. Hypotypes, GSC 64383-64389.

Pygodus cf. *P. serrus* (Hadding, 1913)
Pl. 2, fig. 14, 16-20

Bergström (1971) described and discussed the species of *Pygodus* in some detail. The pygodiform (g) element of *P. serrus* is characterized by three rows of denticles on the upper surface, distinguishing it from the later species *P. anserinus* Lamont and Lindström which has four rows of denticles. In the collections from Waterville Quarry there are forms similar to *P. serrus* but with a rudimentary fourth denticle row reminiscent of *P. anserinus*.

Types. Figured specimens, GSC 64346-64351.

"Scolopodus" giganteus Sweet and Bergström, 1962 s.f.
Pl. 3, fig. 14

A single fragment of the basal portion of a costate laterally compressed element is referred to this species. *S. giganteus* is a long ranging form species known from Lower and Middle Ordovician strata. It is thoroughly described by Sweet and Bergström (1962) and has been reported recently from the upper Deepkill Shale of New York by Landing (1976) and from the Womble Shale of Arkansas by Repetski and Ethington (1977). The most recent synonymy is that of Landing (1976).

Types. Hypotype, GSC 64366.

"Scolopodus" peselephantis Lindström, 1955a
Pl. 5, fig. 10, 11

This species was well described by Lindström (1955a) based on material from uppermost Tremadocian and lowermost Arenigian beds of Sweden. Löfgren (1978) has discussed in detail the changes noted in this species from younger strata. She did not find the differences between stratigraphically older and younger forms sufficient to separate them into two species. The specimen recovered herein are more typical of the later forms of the species. In addition they are extremely small and completely clear except for small dark areas at their base.

Types. Hypotypes, GSC 64409, 64410.

Strachanognathus parvus Rhodes, 1955
Pl. 3, fig. 18, Pl. 5, fig. 5

This species has been recovered from both Waterville quarry (Llanvirnian-Llandeilian) and Camel Back Mountain (Caradocian). This occurrence represents only the third report of this species from North America; it is also known from the Cobb's Arm Limestone, Newfoundland (Bergström et al., 1974) and from Camel Back Mountain as reported by Kennedy et al., 1979. The variation within this species has been described by Bergström (1962) and a full synonymy has recently been provided by Löfgren (1978). All of the varieties reported by Bergström (1962) are present in this material.

Types. Hypotypes, GSC 64369, 64398.

Walliserodus sp.
Pl. 1, fig. 1, 2

Elements assignable to *W. nakholmensis* from Camel Back Mountain are described under systematic paleontology. Samples from Waterville quarry have yielded a few specimens that are probably assignable to *Walliserodus* but indeterminate as to species.

Types. Figured specimens, GSC 64313, 64314.

Walliserodus? sp.
Pl. 1, fig. 3, 4

Three specimens from the Tetagouche Group at Middle Hayden Brook may be assignable to *Walliserodus*. An acontiodiform and a possible carinate element are illustrated. The acontiodiform element appears as through it had serrated or possibly denticulate lateral margins, and hence is only tentatively assigned to *Walliserodus*.

Types. Figured specimens, GSC 64315, 64316.

Systematic Paleontology

Genus *Dapsilodus* Cooper, 1976

Type species, *Distacodus obliquicostatus* Branson and Mehl, 1933.

Remarks. Cooper (1976, p. 211) erected this genus for Silurian elements with an apparatus composed of an "acodontiform element and a suite of distacodontiform (or acontiodontiform) elements that form an intergrading series of morphotypes." Cooper (1976) further speculated that representatives of the genus may occur in the Ordovician characterized by such forms as *Acodus mutatus* (Branson and Mehl). It appears from recent work on late Ordovician faunas that forms like *A. mutatus* are closely allied with oistodontiform elements (Sweet, 1979, p. G18; Nowlan and Barnes, in press). Bergström (1978) has, however, assigned such elements to *Dapsilodus mutatus* (Branson and Mehl). Clearly there is a degree of confusion about the correct generic assignment which depends on the inclusion or exclusion of an oistodiform element. In Middle Ordovician faunas this problem does not seem to arise because of a lack of abundant and closely associated oistodontiform elements with such forms as *Acodus similaris* Rhodes. Indeed the elements conform very closely to the generic description of *Dapsilodus* Cooper. Accordingly forms representative of *Acodus similaris* Rhodes are herein included tentatively in *Dapsilodus*. The only reason for this tentative assignment is the lack of an unequivocal evolutionary lineage connecting Middle Ordovician forms with Silurian forms.

Dapsilodus? similaris (Rhodes)
Pl. 5, fig. 1-4

Acodus similaris Rhodes, 1955, p. 124, 125, Pl. 10, fig. 7, 10, 14, 16, 18, 23, 26-28, 30; Lindström, 1959, p. 435, Pl. 3, fig. 6, 9; Hamar, 1964, p. 256, Pl. 1, fig. 3; Hamar, 1966, p. 48, Pl. 3, fig. 3-9, 13, text-fig. 4 (no. 5-10, 12); Serpagli, 1967, p. 42, Pl. 7, fig. 1a-10d; Igo and Koike, 1967, p. 13, Pl. 1, fig. 16-18, text-fig. 4E, Viira, 1967, p. 327, Pl. 5, fig. 8; Viira, 1974, p. 43, Pl. 9, fig. 23, 24, Pl. 12, fig. 14, 15, text-fig. 19, 20; ?Flajs and Schönlaub, 1976, Pl. 1, fig. 30, Pl. 2, fig. 16, 23; Repetski and Ethington, 1977, p. 99, Pl. 1, fig. 15; non Palmieri, 1978, p. 7, Pl. 2, fig. 14, 20, 21; Kennedy, Barnes and Uyeno, 1979, p. 542, Pl. 1, fig. 21, 22.

Remarks. The great variation in forms referred to *Acodus similaris* has been described in detail by previous authors (Hamar, 1966; Serpagli, 1967). These authors have shown that both acodiform and distacodiform elements are present within the species. The distacodiform elements are variable with respect to the situation of the lateral costae. A costa is located on each side but they may be symmetrically or asymmetrically situated. The costae may be situated medially on the lateral surface or close to the posterior edge, they are never situated on the anterior portion of the lateral face.

Elements within *D.? similaris* are geometrically similar to the form species *Acodus mutatus* and *Distacodus procerus* Ethington which occur in Upper Ordovician strata. *D.? similaris* differs in that the base is much higher and possesses a deeper basal cavity. In addition *D.? similaris* is not known to be associated with an oistodiform element.

Types. Hypotypes, GSC 64394-64397.

Genus *Microzarkodina* Lindström, 1971

Type species: *Prioniodina flabellum* Lindström, 1955a

Microzarkodina flabellum (Lindström)
Pl. 2, fig. 1-5

Prioniodina flabellum Lindström, 1955a, p. 587, Pl. 6, fig. 23-25.
Microzarkodina flabellum (Lindström). Lindström, 1971, p. 58, Pl. 1, fig. 6-11, fig. 19, 20; Löfgren, 1978, p. 61, 62, Pl. 11, fig. 27-36, fig. 27A, B. (complete synonymy through 1978).

Remarks. This species has been discussed in some detail by Löfgren (1978). She has pointed out the difficulty of separating ozarkodiniform elements of *M. flabellum* from those of *M. parva* Lindström, and based on the fragmentary material at hand the distinction is not possible here. Löfgren (1978) assigned all ozarkodiniform elements with one denticle in front of the cusp to *M. flabellum* which is the older name and her interpretation is followed herein. Dzik (1976, p. 435) may be correct in regarding *M. parva* as a subspecies of *M. flabellum* but such distinction cannot be made based on fragmentary material.

The species is represented at Middle Hayden Brook by fifteen specimens, eight of which are ozarkodiniform. No trichonodelliform elements were recovered and only a highly fragmentary zygognathiform element is present.

Types. Hypotypes, GSC 64332-64336.

Genus *Polyplacognathus* Stauffer, 1935b

Type species: *Polyplacognathus ramosus* Stauffer, 1935b

Polyplacognathus cf. *P. ringerikensis* Hamar s.f.
Pl. 4, fig. 13, 20

cf. *Polyplacognathus ringerikensis* Hamar, 1964, p. 276, 277, Pl. 6, fig. 1, 2, 11, 12, text-fig. 5 (no. 8); Hamar, 1966, Pl. 4, fig. 1.
?*Polyplacognathus* cf. *P. ringerikensis* Hamar, Viira, 1974, p. 111, text-fig. 141.
?*Eoplacognathus elongatus* (Bergström). Bergström, 1971, p. 137, 138, Pl. 2, fig. 12-14.

Remarks. One mostly complete and three fragmentary specimens are assigned to this taxon. They are clearly assignable to *Polyplacognathus* and are most closely similar to *P. ringerikensis* Hamar s.f. A number of significant differences exist however and these are detailed below based upon the most complete specimen (Pl. 4, fig. 13).

If the straight axis is taken as antero-posterior and the shorter more sharply pointed process is regarded as anterior there are four additional processes rather than the three described for *P. ringerikensis* by Hamar (1964). To the left (in Pl. 4, fig. 13) of the antero-posterior axis there is a short rounded postero-lateral process similar to that on *P. ringerikensis*. The antero-lateral process on the left side is not bifid and the processes on the right side are both distinctly separate. The right-hand antero-lateral process bears high compressed denticles, higher than those of the anterior process. These differences serve to distinguish the specimens recovered herein from *P. ringerikensis*. A new species is not erected based on this sparse material, and the specimens are compared to the closest known species.

P. ringerikensis is the polyplacognathiform (g) element of *Eoplacognathus elongatus* (Bergström, 1971); however, no eoplacognathiform (f) elements were recovered. Hence the species is regarded as a form species representative of *Polyplacognathus*.

Types. Figured specimens, GSC 64390, 64391.

Genus *Protopanderodus* Lindström, 1971

Type species. *Acontiodus rectus* Lindström, 1955a.

Remarks. Representatives of this genus are present in most of the samples from New Brunswick. Specific identification of fragmentary specimens of this genus is difficult because of the taxonomic importance of basal shape and extent of costae. A few species are definitely identifiable but others are tentatively assigned to or compared with known species.

Protopanderodus graeai (Hamar)
Pl. 3, fig. 9, 11, 13

Acodus graeai Hamar, 1966, p. 47, Pl. 3, fig. 11-14, text-fig. 3, no. 5.
Protopanderodus graeai (Hamar). Löfgren, 1978, p. 93, 94, Pl. 3, fig. 19-25, text-fig. 21K-M (includes synonymy to date).

Remarks. Löfgren (1978) reconstructed the apparatus of this species to include symmetrical and asymmetrical acontiodiform (protopanderodiform) elements and scandodiform elements. The latter bear an inner costa and were described as *Acodus graeai* by Hamar (1966) and *Acodus triangulatus* by Fåhraeus (1966). The species is distinguished from other species of *Protopanderodus* by the presence of an inner costa on scandodiform elements and by the long base and deep basal cavity of symmetrical acontiodiform elements. *P. graeai* is identified herein on the basis of long-based acontiodiform elements, and a scandodiform element with a very prominent inner lateral carina. Löfgren (1978) tentatively assigned such scandodiform elements to this species rather than to *P. robustus* which possesses elements with a more gently rounded carina. In overall morphology, this species is similar to *P. rectus* and specimens compared to *P. rectus* have been recovered from the same samples.

Types. Hypotypes, GSC 64363-64365.

Protopanderodus liripipus Kennedy, Barnes and Uyeno, 1979
Pl. 5, fig. 6-8

Protopanderodus liripipus Kennedy, Barnes and Uyeno, 1979, p. 546-550, Pl. 1, fig. 9-19 (contains synonymy to date).

Remarks. Many fairly well preserved specimens of this species have been recovered. The reader is referred to Kennedy et al. (1979) for an extensive discussion of the species and its relation to other species of *Protopanderodus*

Types. Hypotypes, GSC 64399-64401.

Protopanderodus rectus (Lindström)
Pl. 1, fig. 6, 7

Acontiodus rectus Lindström, 1955a, p. 549, Pl. 2, fig. 7-11, text-fig. 3B.
Protopanderodus rectus (Lindström). Lindström, 1971, p. 50; Löfgren, 1978, p. 90, 91, Pl. 3, fig. 1-7, 36 A, B, text-fig. 31 A-C (contains synonymy to date).

Remarks. Acontiodiform (protopanderodiform) elements with much shorter bases than those referred to *P. graeai* are assigned to *P. rectus*. Scandodiform elements typical of *P. rectus* are found only in material from the South Tetagouche locality (GSC Loc. 97009). Other occurrences of *P. rectus* can be identified with less certainty from samples at Middle Hayden Brook (Pl. 1, fig. 8, 11) and Camel Back Mountain (Pl. 3, fig. 8, 10) because of a lack of scandodiform elements. The acontiodiform (protopanderodiform) elements in these samples are closest to *P. rectus* in terms of basal outline.

Types. Hypotypes, GSC 64318, 64319.

Protopanderodus rectus? (Lindström)
Pl. 1, fig. 8, 11, Pl. 3, fig. 8, 10

?Acontiodus rectus Lindström, 1955a, p. 549, Pl. 2, fig. 7-11, text-fig. 3B.
?Protopanderodus rectus (Lindström). Lindström, 1971, p. 50; Löfgren, 1978, p. 90, 91, Pl. 3, fig. 1-7, 36 A, B, text-fig. 31 A-C (contains synonymy to date).

Remarks. Acontiodiform elements with much shorter bases than those referred to *P. graeai* are assigned here to *P. rectus?*. Scandodiform elements typical of *P. rectus* are absent. The acontiodiform elements may be less basally extended representatives of *P. graeai* but they are distinguished herein to illustrate clearly the variety of the fauna.

Types. Figured specimens, GSC 64320, 64321, 64361, 64362.

Protopanderodus varicostatus? (Sweet and Bergström)
Pl. 1, fig. 5, Pl. 3, fig. 15

?Scolopodus varicostatus Sweet and Bergström, 1962, p. 1247, Pl. 168, fig. 4-9, text-fig. 1A, C, K; Hamar, 1964, p. 284, Pl. 1, fig. 1, 2, text-fig. 4, no. 7a, b; Viira, 1967, p. 325, Pl. 4, fig. 12; Bradshaw, 1969, p. 1163, Pl. 132, fig. 10, Pl. 134, fig. 12, 13; Viira, 1974, p. 123, Pl. 5, fig. 23, 24, text-fig. 160.
?Protopanderodus varicostatus (Sweet and Bergström). Dzik, 1976, fig. 16e-g.

Remarks. A few specimens similar to *P. varicostatus* (Sweet and Bergström) were recovered from sample 96063, in which a variety of forms of *Protopanderodus* were recovered. The elements have more costae than those referred to *Protopanderodus graeai* and *P. rectus?* and have much shorter bases than those assigned to *P. liripipus*. Several specimens from Waterville Quarry are also probably assignable to *P. varicostatus*, but the paucity of material and lack of scandodiform elements precludes definite identification.

Types. Figured specimens, GSC 64317, 64367.

Genus *Spinodus* Dzik, 1976 emend. herein

Type species. *Cordylodus ramosus* Hadding, 1913.

Remarks. Hadding (1913) described two form species from the lower *Dicellograptus* shale of Scania which he termed *Cordylodus ramosus* and *Polygnathus spinatus*. Later, Lindström (1955b) redescribed the fauna and assigned both of these form species to the genus *Cordylodus*. Subsequently Lindström (1964) regarded *C. spinatus* and *C. ramosus* as conspecific and illustrated a symmetry transition series for the species including cordylodiform (a), ligonodiniform (b) and hibbardelliform (c) elements. Barnes and Poplawski (1973) concurred with Lindström (1964) and grouped the two species under *Cordylodus ramosus* which is the name appearing first in Hadding's (1913) study and therefore has priority.

More recently Dzik (1976, p. 424) erected a new genus *Spinodus* for elements "with strongly elongated branches and long denticles circular in cross section." He suggested that the apparatus had a composition such as in "primitive Prioniodontidae." Dzik however provided only a brief diagnosis of the genus and supplied no synonymy for the single species which he termed *S. spinatus*. It is not clear whether Dzik (1976) wished to exclude the form species *C. ramosus* from the concept of *Spinodus*. It is clear however from previous work that both form species co-occur in most reports (Hadding, 1913; Lindström, 1955b; Lamont and Lindström, 1957; Sweet and Bergström, 1962; Lindström, 1964 and Barnes and Poplawski, 1973). The only documented exceptions to this co-occurrence are the reports of Uyeno and Barnes (1970) and Nassedkina (1975), but in both of these studies the number of specimens recovered was very low.

From the literature and from collections in this author's possession it seems clear that *C. ramosus* s.f. and *C. spinatus* s.f. are conspecific and lie within the parameters of *Spinodus* Dzik; consequently the genus is adopted with *C. ramosus* as the type species.

Spinodus ramosus (Hadding)
Pl. 4, fig. 18, 19

Cordylodus ramosus Hadding, 1913, p. 31, Pl. 1, fig. 6; Lindström, 1955b, p. 108, 109, Pl. 22, fig. 12, 19; Lamont and Lindström, 1957, p. 61, 67; Sweet and Bergström, 1962, p. 1225, Pl. 170, fig. 15; Pl. 171, fig. 10; Lindström, 1964, fig. 27D; Barnes and Poplawski, 1973, p. 772, Pl. 4, fig. 6; Bergström, 1978, Pl. 79, fig. 20.
Polygnathus spinatus Hadding, 1913, p. 32, Pl. 1, fig. 8.
Cordylodus spinatus (Hadding). Lindström, 1955b, p. 109, Pl. 22, fig. 5, 18, 27; Lamont and Lindström, 1957, p. 61, Pl. 5, fig. 10; Sweet and Bergström, 1962, p. 1225, 1226, Pl. 170, fig. 12, Pl. 171, fig. 13; Uyeno and Barnes, 1970, p. 106, 107, Pl. 24, fig. 7-11.
"Cordylodus" spinatus (Hadding). Repetski and Ethington, 1977, p. 99, Pl. 2, fig. 20.
Cordylodus spinathus (sic)(Hadding). Nassedkina, 1975, p. 123, Pl. 4, fig. 11.

Remarks. The elements of this species have been adequately described by Lindström (1955b, 1964) and commented upon by subsequent authors notably Sweet and Bergström (1962) and Uyeno and Barnes (1970). *S. ramosus* exhibits a symmetry transition series of cordylodiform (a), cladognathiform (b) and hibbardelliform (c) elements. The a position is apparently occupied by elements without a marked anticusp (*C. spinatus* s.f.) and by elements with a pronounced aborally extended anticusp (*C. ramosus* s.f.). In addition, elements of the a position vary from symmetrical to asymmetrical in terms of the relationship of cusp and denticles. In some specimens the cusp and denticles lie in a plane and in others the denticles on the posterior process are flexed to one side or the other. Elements with a distinct anticusp are symmetrical.

The numerical ratios between the elements is impossible to assess based upon information in the literature. From the collection at hand and based on about fifty additional specimens from the Davidsville Group in Newfoundland (Nowlan, unpublished data), it appears that a elements are about evenly split between symmetrical and asymmetrical forms and that a elements without an anticusp outnumber those with an anticusp by about 7:1. Elements of the b and c positions are rare with b outnumbering c by about 3:1. The overall ratio of elements based on this relatively sparse information is about 20 a (without anticusp): 3 a (with anticusp): 3 b: 1 c.

Types. Hypotypes, GSC 64392, 64393.

Genus *Walliserodus* Serpagli, 1967

Type species. *Acodus curvatus* Branson and Branson, 1947.

Remarks. Serpagli (1967) chose *Paltodus debolti* Rexroad, 1967 as the type species of this genus. Cooper (1975) included the form species *Acodus curvatus* in the multielement species which also included *P. debolti* and hence changed the type species.

The nature of the apparatus of Silurian representatives of this genus is well known. The type species *W. curvatus* consists of a symmetry transition series of costate cones which includes acodiform (*A. curvatus* Branson and Branson s.f.) paltodiform-distacodiform (*Paltodus migratus* Rexroad s.f.) elements. In addition the apparatus also includes large, gently curved laterally compressed cones referred to as the acodontiform element (*Acodus unicostatus* Branson and Branson s.f.) by Cooper (1975, p. 995, 996). Recently a similar apparatus has been recognized in strata of Late Ordovician age (Nowlan in Bolton and Nowlan, 1979; Nowlan and Barnes, in press). In this species, referred to as *W.* cf. *W. curvatus*, there is a similar array of costate cones and an 'acodontiform' (carinate) element which is conspecific with *Drepanodus amplissimus* Serpagli, 1967. This element is similar to *Acodus unicostatus* Branson & Branson s.f. but lacks the prominent costa.

The nature of the apparatus of Early and Middle Ordovician representatives of the genus is less clear. Early Ordovician *W. australis* Serpagli has a much more variable component of costate elements and appears to lack the acodontiform (carinate) element altogether. It may be that *W. australis* is sufficiently different that it should belong in a separate genus. Such a distinction is beyond the scope of this paper. Middle Ordovician forms such as *W. ethingtoni* (Fåhraeus), *W. iniquus* (Viira) and *W. nakholmensis* (Hamar) have costate elements that are more variable than those of Late Ordovician and Silurian species but less variable than those of Early Ordovician species. An acodontiform (carinate) element has not been reported to occur in any of these Middle Ordovician species. Collections at hand and survey of the literature indicate that potentially homologous acodontiform (carinate) elements do co-occur at least with these species.

Collections of *W. nakholmensis* as interpreted below include costate cones and a carinate element that is similar to elements illustrated and described as *Scalpellodus cavus* (Webers) by Dzik (1976). Indeed, Dzik (1976, p. 444) includes *Drepanodus amplissimus* Serpagli in synonymy with *Scalpellodus cavus*. Löfgren (1978) recently illustrated and described specimens assigned to *W. iniquus*, but included only costate cones. A possibly homologous carinate element was described by her as *Scalpellodus viruensis* Löfgren. The rate of co-occurrence and relative abundance of specimens of *W. iniquus* and *S. viruensis* as shown by Löfgren (1978, fig. 39, 40, 41) is consistent with such a suggestion. Similarly, in the case of *W. ethingtoni*, Löfgren (1978) described and illustrated only costate elements belonging to the species. Some of the elements illustrated as *Paltodus? jemtlandicus* n. sp. by Löfgren (1978, particularly Pl. 4, fig. 6, 8) are possibly homologous to carinate elements in *Walliserodus*. Collections of *W. ethingtoni* from the Davidsville Group of Newfoundland (Nowlan, unpublished data) show consistent co-occurrence of such elements with typical *W. ethingtoni*. Thus, in the opinion of this author, Middle Ordovician representatives of *Walliserodus* contain an acodontiform (carinate) element homologous and very similar to that found in Late Ordovician and Silurian species.

Walliserodus nakholmensis (Hamar)
Pl. 3, fig. 1-6, 12

Paltodus n. sp. Hamar, 1964, p. 271, Pl. 1, fig. 21, 22, text-fig. 4, no. 6.

Panderodus nakholmensis Hamar, 1966, p. 66, Pl. 7, fig. 22-24, text-fig. 3, no. 3.

?Scandodus inflexus (Pander). Hamar, 1966, p. 72, 73, Pl. 3, fig. 15-17.

Walliserodus nakholmensis (Hamar). Dzik, 1976, p. 444, fig. 2, fig. 14 q-t.

?Scalpellodus cavus (Webers). Dzik, 1976, p. 444, fig. 14 a-c.

Remarks. The apparatus includes scandodiform, distacodiform-paltodiform and acontiodiform elements in a symmetry transition series and a carinate element. Hamar (1964) described an element transitional between paltodiform and acontiodiform as *Paltodus* n. sp. Later, Hamar (1966) described the acontiodiform and slightly asymmetrical acontiodiform element as *Panderodus nakholmensis*. The element described by Hamar (1966) as *Scandodus inflexus* (Pander) may be the scandodiform element of this species which is homologous to the acodiform element of other species of *Walliserodus*. In addition this species contains 'distacodiform' elements with a single costa on each side. These costae are asymmetrically situated with respect to one another. An additional element similar to those illustrated as *Scalpellodus cavus* by Dzik is present in the apparatus and is homologous to the acodontiform (carinate) elements of other species.

Types. Hypotypes, GSC 64352-64358.

Acknowledgments

Sincere thanks are due to L.R. Fyffe (New Brunswick Department of Natural Resources) and J.E. Repetski (U.S. Geological Survey) for critically reading the manuscript and offering many suggestions for its improvement. L.R. Fyffe is also acknowledged for guiding the author to many of the localities and for helpful discussions in the field. W.H. Poole (Geological Survey of Canada, Ottawa) also assisted in locating several of the collecting localities in 1978 and collected several additional samples in 1979. David Walker (Geological Survey of Canada, Ottawa) did the scanning electron micrography and his skill and competence are much appreciated.

REFERENCES

Alcock, F.J.
1935: Geology of Chaleur Bay region; Geological Survey of Canada, Memoir 183.

Anderson, F.D.
1968: Woodstock, Millville and Coldstream map-areas, Carleton and York Counties, New Brunswick; Geological Survey of Canada, Memoir 353.

Bailey, L.W.
1901: Geological correlations in New Brunswick; Transactions of the Royal Society of Canada, Series 2, Section 4, v. 7.

Barnes, C.R. and Fåhraeus, L.E.
1975: Provinces, communities, and the proposed nektobenthic habit of Ordovician conodontophorids; Lethaia, v. 8, p. 133-149.

Barnes, C.R. and Poplawski, M.L.S.
1973: Lower and Middle Ordovician conodonts from the Mystic Formation, Quebec, Canada; Journal of Paleontology, v. 47, p. 760-790.

Barnes, C.R., Rexroad, C.B. and Miller, J.F.
1973: Lower Paleozoic conodont provincialism; in F.H.T. Rhodes (ed.), Conodont paleozoology: Geological Society of America Special Paper 141, p. 157-190.

Barnes, C.R., Kennedy, D.J., McCracken, A.D., Nowlan, G.S. and Tarrant, G.A.
1979: The structure and evolution of Ordovician conodont apparatuses; Lethaia, v. 12, p. 125-151.

Bergström, S.M.
1962: Conodonts from the Ludibundus Limestone (Middle Ordovician) of the Tvären area (S.E. Sweden); Arkiv för mineralogi och geologi, v. 3, no. 1, 1961, Stockholm.

1971: Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America; Geological Society of America, Memoir 127, p. 83-162.

1973a: Correlation of the late Lasnamägian Stage (Middle Ordovician) with the graptolite succession; Geologiska Föreningens i Stockholm Förhandlingar, v. 95, p. 9-18.

1973b: Biostratigraphy and facies relations in the lower Middle Ordovician of easternmost Tennessee; American Journal of Science, v. 273-A, p. 261-293.

1973c: Ordovician conodonts; in Atlas of Palaeobiogeography, ed. A. Hallam, Elsevier Scientific Publishing Company, 1973.

1978: Middle and Upper Ordovician conodont and graptolite biostratigraphy of the Marathon, Texas graptolite zone reference standard; Paleontology, v. 21, p. 723-758.

1979: Whiterockian (Ordovician) conodonts from the Hølonda Limestone of the Trondheim region, Norwegian Caledonides; Norsk Geologisk Tiddskrift, v. 59, p. 295-307.

Bergström, S.M. and Carnes, J.B.
1976: Conodont biostratigraphy and paleo-ecology of the Holston Formation (Middle Ordovician) and associated strata in eastern Tennessee; Geological Association of Canada, Special Paper 15, p. 27-57.

Bergström, S.M., Epstein, A.G. and Epstein, J.B.
1972: Early Ordovician North Atlantic province conodonts in eastern Pennsylvania; United States Geological Survey, Professional Paper 800-D, p. D37-D44.

Bergström, S.M., Riva, J. and Kay, M.
1974: Significance of conodonts, graptolites, and shelly faunas from the Ordovician of western and north-central Newfoundland; Canadian Journal of Earth Sciences, v. 11, p. 1625-1660.

Blackwood, R.F.
1978: Northeastern Gander Zone, Newfoundland; Department of Mines and Energy, Newfoundland and Labrador, Report of Activities for 1977, Report 78-1, R.V. Gibbons (ed.), p. 72-79.

Bolton, T.E. and Nowlan, G.S.
1979: A Late Ordovician fossil assemblage from an outlier north of Aberdeen Lake, District of Keewatin; Geological Survey of Canada, Bulletin 321, p. 1-26.

Bradshaw, L.E.
1969: Conodonts from the Fort Pena Formation (Middle Ordovician), Marathon Basin, Texas; Journal of Paleontology, v. 43, p. 1137-1168.

Branson, E.B. and Branson, C.C.
1947: Lower Silurian conodonts from Kentucky; Journal of Paleontology, v. 21, p. 549-556.

Branson, E.B. and Mehl, M.G.
1933: Conodont studies; University of Missouri Studies, v. 8, Pts. 1-4.

Cooper, B.J.
1975: Multielement conodonts from the Brassfield Limestone (Silurian) of southern Ohio; Journal of Paleontology, v. 49, p. 984-1008.

1976: Multielement conodonts from the St. Clair Limestone (Silurian) of southern Illinois; Journal of Paleontology, v. 50, p. 205-217.

Currie, K.L., Pajari, G.E. and Pickerill, R.K.
1979: Tectono-stratigraphic problems in the Carmanville area, northeastern Newfoundland; in Current Research, Part A, Geological Survey of Canada Paper 79-1A, p. 71-76.

Dean, P.L.
1978: The volcanic stratigraphy and metallogeny of Notre Dame Bay, Newfoundland; Memorial University of Newfoundland, Geology Department, Report No. 7.

Dean, W.T.
1970: Lower Ordovician trilobites from the vicinity of South Catcher Pond, northeastern Newfoundland; Geological Survey of Canada, Paper 70-44.

1971: Ordovician trilobites from the central volcanic mobile belt at New World Island, northeastern Newfoundland; Geological Survey of Canada, Bulletin 210.

1976: Some aspects of Ordovician correlation and trilobite distribution in the Canadian Appalachians; in M.G. Bassett (ed.) The Ordovician System; proceedings of a Palaeontological Association symposium, Birmingham, September 1974, p. 227-250.

Dzik, J.
1976: Remarks on the evolution of Ordovician conodonts; Acta Palaeontologica Polonica, v. 21, p. 395-455.

Epstein, A.G., Epstein, J.B. and Harris, L.
1977: Conodont color alteration - an index to organic metamorphism; United States Geological Survey Professional Paper 995, p. 1-27.

Ethington, R.L.
1979: Conodonts from the pre-Eureka Ordovician of the Great Basin; Brigham Young University, Geology Studies, v. 26, pt. 3, p. 1-6.

Fåhraeus, L.E.
1966: Lower Viruan (Middle Ordovician) conodonts from the Gullhögen Quarry, southern central Sweden; Sveriges Geologiska Undersöking, Series C, no. 610, p. 1-40.

Fåhraeus, L.E. and Nowlan, G.S.
1978: Franconian (Late Cambrian) to Early Champlainian (Middle Ordovician) conodonts from the Cow Head Group, western Newfoundland; Journal of Paleontology, v. 52, no. 2, p. 444-471.

Flajs, G. and Schönlaub, H.P.
1976: Die biostratigraphische Gliedening des Altpaläozoikums am Polster bei Eisenerz (Nördliche Grauwackenzone, Osterreich); Verhandlungen der Geologischen Bundesanstalt, 1976, Part 2, p. 257-295.

Fyffe, L.R.
1976: Correlation of geology in the south-eastern and northern parts of the Miramichi Zone; in J.L. Davies, Northern New Brunswick: New Brunswick Department of Natural Resources, 139th Annual Report, p. 137-141.

Gedik, I.
1977: Orta Toroslar'da konodont biyostratigrafisi (Conodont biostratigraphy in the Middle Taurus); Türkiye Jeoloji Kurumu Bülteni, v. 20, p. 35-48.

Hadding, A.R.
1913: Undre dicellograptus-skiffern i Skåne; Lunds Universitets Årsskrift, N.F., v. 9, no. 15, p. 1-90.

Hahn, F.F.
1912: On the *Dictyonema*-fauna of Navy Island, New Brunswick; Annals of the New York Academy of Science, v. 22, p. 135.

Hamar, G.
1964: Conodonts from the Lower Middle Ordovician of Ringerike; Norsk Geologisk Tidsskrift, v. 44, p. 243-292.

1966: The Middle Ordovician of the Oslo region, Norway. 22. Preliminary report on conodonts from the Oslo-Aster and Ringerike districts; Norsk Geologisk Tidsskrift, v. 46, p. 27-28.

Hamilton, J.B.
1965: Limestone in New Brunswick; Mines Branch, Department of Lands and Mines, New Brunswick, Mineral Resource Report No. 2, 147 p.

Harris, A.G., Bergström, S.M., Ethington, R.L. and Ross, R.J., Jr.
1979: Aspects of Middle and Upper Ordovician conodont biostratigraphy of carbonate facies in Nevada and southeast California and comparison with some Appalachian successions; Brigham Young University Geology Studies, v. 26, pt. 3, p. 7-44.

Helmstaedt, H.
1971: Structural geology of Portage Lakes area, Bathurst-Newcastle district, New Brunswick; Geological Survey of Canada, Paper 70-28.

Hibbard, J.P., Stouge, S. and Skevington, D.
1977: Fossils from the Dunnage Mélange, north-central Newfoundland; Canadian Journal of Earth Sciences, v. 14, p. 1176-1178.

Igo, H. and Koike, T.
1967: Ordovician and Silurian conodonts from the Langkawi Islands, Malaya; Geology and Palaeontology of Southeast Asia, v. 3, p. 1-29.

Kennedy, D.J., Barnes, C.R. and Uyeno, T.T.
1979: A Middle Ordovician conodont faunule from the Tetagouche Group, Camel Back Mountain, New Brunswick; Canadian Journal of Earth Sciences, v. 16, p. 540-551.

Lamont, A. and Lindström, M.
1957: Arenigian and Llandeilian cherts identified in the Southern Uplands of Scotland by means of conodonts etc.; Edinburgh Geological Society Transactions, v. 17, p. 60-70.

Landing, E.
1976: Early Ordovician (Arenigian) conodont and graptolite biostratigraphy of the Taconic Allochthon, eastern New York; Journal of Paleontology, v. 50, no. 4, p. 614-646.

Landing, E., Taylor, M.E. and Erdtmann, B.-D.
1978: Correlation of the Cambro-Ordovician boundary between the Acado-Baltic and North American faunal provinces; Geology, v. 6, p. 75-78.

Lindström, M.
1955a: Conodonts from the lowermost Ordovician strata of south-central Sweden; Geologiska Föreningens i Stockholm Förhandlinger, v. 76 (1954), p. 517-604.

1955b: The conodonts described by A.R. Hadding, 1913; Journal of Paleontology, v. 29, p. 105-111.

1959: Conodonts from the Crug Limestone (Ordovician, Wales); Micropaleontology, v. 5, p. 427-452.

1960: A Lower-Middle Ordovician succession of conodont faunas; 21st International Geological Congress Reports, v. 7, p. 88-96.

1964: Conodonts; Elsevier, Amsterdam, 196 p.

1971: Lower Ordovician conodonts of Europe; Geological Society of America, Memoir 127, p. 21-61.

Löfgren, A.
1978: Arenigian and Llanvirnian conodonts from Jämtland, northern Sweden; Fossils and Strata, No. 13, Universitetsforlaget, Oslo.

Lutes, G.
1979: Canterbury-Skiff Lake, York County; Geological map, New Brunswick Department of Natural Resources, Plate 79-26.

Mägi, S. and Viira, V.
1976: On the distribution of conodonts and inarticulate brachiopods in Ceratopyge and Latorpian Stages in northern Estonia; Eesti NSV Teaduste Akadeemia Toimetised, Keemia Geoloogia, v. 25, p. 312-318.

McKerrow, W.S. and Cocks, L.R.M.
1977: The location of the Iapetus Ocean Suture in Newfoundland; Canadian Journal of Earth Sciences, v. 14, p. 488-495.

McTavish, R.A. and Legg, D.P.
1976: The Ordovician of the Canning Basin, Western Australia; In M.G. Bassett, (ed.) The Ordovician System: proceedings of a Palaeontological Association Symposium, Birmingham, September, 1974, p. 447-478.

Nassedkina, V.A.
1975: Ordovician conodonts from the western slopes of the Urals; in New miospores, foraminifera, ostracodes and conodonts from the Paleozoic and Mesozoic of the Urals, N.P. Malakhova and B.I. Chiwashov (eds.), Academy of Sciences of the USSR, Uralian Scientific Centre, Sverdlovsk (1975), p. 110-127.

Neuman, R.B.
1962: The Grand Pitch Formation: new name for the Grand Falls Formation (Cambrian?) in northeastern Maine; American Journal of Science, v. 260, p. 794-797.

1964: Fossils in Ordovician tuffs, northeastern Maine, with a section on Trilobita by H.B. Whittington; United States Geological Survey, Bulletin 1181-E.

1967: Bedrock geology of the Shin Pond and Stacyville Quadrangles Penobscot County, Maine; United States Geological Survey, Professional Paper 524-I.

1968: Paleogeographic implications of Ordovician shelly fossils in the Magog Belt of the northern Appalachian region; in Studies of Appalachian geology - northern and Maritime E-An Zen, W.S. White, J.B. Hadley and J.B. Thompson, Jr., eds.; New York, Interscience, p. 35-48.

1971: An early Middle Ordovician brachiopod occurrence from Maine, New Brunswick and northern Newfoundland; in Dutro, J.T. (ed.), Paleozoic perspectives: a paleontological tribute to G. Arthur Cooper: Smithsonian Contributions to Paleobiology, no. 3, p. 113-124.

1972: Brachipods of Early Ordovician volcanic islands; 24th International Geological Congress, Montreal, Section 7, p. 297-302.

1979: Brachiopods of the Hølonda area, western Norway; International Geological Correlation Program: Caledonide Orogen; Abstracts of meeting in Blacksburg, Virginia, September, 1979, p. A-7.

Nowlan, G.S. and Barnes, C.R.
In Press: Late Ordovician conodonts from the Vauréal Formation, Anticosti Island, Québec; Geological Survey of Canada, Bulletin.

Palmieri, V.
1978: Late Ordovician conodonts from the Fork Lagoons Beds, Emerald area, central Queensland; Queensland Department of Mines, Geological Survey of Queensland, Publication 369, Palaeontological Paper 43.

Pavlides, L.
1966: Reconnaisance map of bedrock geology of a part of northwestern New Brunswick, Canada; United States Geological Survey, Open File Report, Geological Survey of Canada, CTF 21J-1.

Poole, W.H.
1963: Map 6-1963, Geology, Hayesville, New Brunswick, Geological Survey of Canada, Preliminary Series.

1976: Plate tectonic evolution of the Canadian Appalachian region; Geological Survey of Canada, Report of Activities, Part B, Paper 76-1B, p. 113-126.

Raring, A.M.
1972: Conodont biostratigraphy of the Chazy Group (lower Middle Ordovician), Champlain Valley, New York and Vermont; Ph.D. dissertation (unpublished), Lehigh University, 1972.

Rast, N. and Stringer, P.C.
1974: Recent advances and the interpretation of geological structure of New Brunswick; Geoscience Canada, v. 1, p. 15-25.

Repetski, J.E. and Ethington, R.L.
1977: Conodonts from graptolite facies in the Ouachita Mountains, Arkansas and Oklahoma; Arkansas Geological Commission, Symposium on the geology of the Ouachita Mountains, v. 1, p. 92-106.

Rexroad, C.B.
1967: Stratigraphy and conodont paleontology of the Brassfield (Silurian) in the Cincinnati Arch area; Indiana Geological Survey Bulletin 36.

Rhodes, F.H.T.
1955: The conodont fauna of the Keisley Limestone; Quarterly Journal of the Geological Society, v. 111, p. 117-142.

Rodgers, J.
1970: The tectonics of the Appalachians; Wiley Interscience, 271 p.

Ruitenberg, A.A., Fyffe, L.R., McCutcheon, S.R., St. Peter, C.J., Irrinki, R.R. and Venugopal, D.V.
1977: Evolution of pre-Carboniferous tectonostratigraphic zones in the New Brunswick Appalachians; Geoscience Canada, v. 4, p. 171-181.

Scotese, C.R., Bambach, R.K., Barton, C., Van der Voo, R. and Ziegler, A.M.
1979: Paleozoic base maps; Journal of Geology, v. 87, p. 217-277.

Sergeeva, S.P.
1963: Konodonty iz nizhnego ordovika Leningradskoy oblasti; Akademia Nauka USSR, Paleontologicheskiy Zhurnal, 1963, p. 93-108.

Serpagli, E.
1967: I conodonti dell'Ordoviciano superiore (Ashgilliano delle Alpi Carniche; Bolletino Società Paleontologica Italiàna, v. 6, p. 30-111.

Skinner, R.
1974: Geology of Tetagouche Lakes, Bathurst and Nepisiguit Falls map-areas, New Brunswick; Geological Survey of Canada, Memoir 371.

Smith, A.G., Briden, J.C. and Drewry, G.E.
1973: Phanerozoic world maps; in Organisms and continents through time, N.F. Hughes (ed.), Special Paper of the Palaeontological Association, No. 12, p. 1-42.

Stauffer, C.R.
1935a: Conodonts of the Glenwood Beds; Geological Society of America, Bulletin, v. 46, p. 125-168.

1935b: The conodont fauna of the Decorah Shale (Ordovician); Journal of Paleontology, v. 9, p. 596-620.

Stouge, S.
1979: Conodonts from Davidsville Group of the Botwood Zone, Newfoundland; Department of Mines and Energy, Newfoundland and Labrador, Report of Activities for 1978, Report 79-1, R.V. Gibbons (ed.), p. 43.

1980: Lower and Middle Ordovician conodonts from central Newfoundland and their correlatives in western Newfoundland; Department of Mines and Energy, Newfoundland and Labrador, Current Research, Paper 80-1, p. 134-142.

Sweet, W.C.
1979: Conodonts and conodont biostratigraphy of post-Tyrone Ordovician rocks of the Cincinnati Region; United States Geological Survey, Professional Paper 1066-G.

Sweet, W.C. and Bergström, S.M.
1962: Conodonts from the Pratt Ferry Formation (Middle Ordovician) of Alabama; Journal of Paleontology, v. 36, no. 6, p. 1214-1252.

1966: Ordovician conodonts from Penobscot County, Maine; Journal of Paleontology, v. 40, p. 151-154.

1974: Provincialism exhibited by Ordovician conodont faunas; in Paleogeographic provinces and provinciality, ed. C.A. Ross, Society of Economic Paleontologists and Mineralogists, Special Publication No. 21, p. 189-202.

1976: Conodont biostratigraphy of the Middle and Upper Ordovician of the United States Midcontinent. In M.G. Bassett (ed.) The Ordovician System; proceedings of a Palaeontological Association Symposium, Birmingham, September 1974, p. 121-151.

Tipnis, R.S.
1978: Early Middle Ordovician conodonts of North Atlantic Province from northeastern Ellesmere Island, Arctic Canada; Geological Survey of Canada Paper 78-1C, p. 75-78.

Uyeno, T.T. and Barnes, C.R.
1970: Conodonts from the Lévis Formation (Zone D1) (Middle Ordovician), Lévis, Quebec; Geological Survey of Canada Bulletin 187, p. 99-123.

van Wamel, W.A.
1974: Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of northwestern Öland, southeastern Sweden; Utrecht Micropaleontological Bulletins, 10, 126 p.

Venugopal, D.V.
1978a: Geology of Meductic-Temple-lower parts Eel River, Carleton and York Counties, New Brunswick; Map, Plate 78-27, New Brunswick Department of Natural Resources.

1978b: Geology of Benton-Kirkland-Upper Eel River Bend map area G-22; Mineral Resources Branch, New Brunswick Department of Natural Resources, Map Report 78-3.

1978c: Geology of Pinder-Waterville-Temperance Vale, York County, New Brunswick; Map, Plate 78-32, New Brunswick Department of Natural Resources.

1979a: Geology of Maplewood-Nortondale-Clarkville, Carleton and York Counties; Map, Plate 79-75, New Brunswick Department of Natural Resources.

1979b: Geology of Debec Junction-Gibson Millstream-Temperance Vale-Meductic region, Map-areas G-21, H-21, I-21, and H-22; New Brunswick Department of Natural Resources, Map Report 79-5.

Viira, V.
1967: Ordovician conodont succession in the Ohesaare core; Eesti NSV Teaduste Akadeemia Toimetised, Keemia Geoloogia, v. 16, p. 319-329. (In Russian).

1974: Ordovician conodonts of the east Baltic; "Valgus", Tallinn, 142 p. (In Russian).

Whittington, H.B. and Hughes, C.P.
1972: Ordovician geography and faunal provinces deduced from trilobite distribution; Philosophical Transactions of the Royal Society, B263, p. 235-278.

Williams, A.
1969: Ordovician faunal provinces with reference to brachiopod distribution; p. 117-154, in Wood, A. (editor), The Pre-Cambrian and Lower Paleozoic rocks of Wales. Report of a symposium held at the University College of Wales, Aberystwyth in honour of Professor O.T. Jones and Sir William Pugh, University of Wales Press, Cardiff.

Young, G.A.
1911: Bathurst district, New Brunswick; Geological Survey of Canada, Memoir 18-E.

APPENDIX

Register of New Brunswick (N.B.) localities including the following information:

1. Geological unit from which sample was taken (if known).
2. Description of locality.
3. Grid reference or latitude and longitude.
4. Lithology.
5. Weight dissolved (in grams).

* Indicates barren sample.

GSC Locality No.

96061* Tetagouche Group, upper part of lower unit; cliff exposure on right bank of Tetagouche River, 0.7 km north of South Tetagouche United Church, Gloucester Co., N.B. NTS 21P/12. Latitude 47°37'25"N; Longitude 65°48'25"W.

Lithology: recrystallized calcarenite.

Weight dissolved: 1870 g.

96062* Tetagouche Group, upper unit; in the woods bordering disused pasture, 1.7 km east-northeast of the post office in Lincour, Gloucester Co., N.B. NTS 21P/12. Latitude 47°39'15"N; Longitude 65°51'45"W.

Lithology: Medium grey marble.

Weight dissolved: 2350 g.

96063 Tetagouche Group, upper unit; flat outcrop on the south side of logging road, north of Camel Back Mountain, east of Eighteenmile Brook, Restigouche Co., N.B. NTS 21O/9. Military grid reference 95796935; Latitude 47°33'03"N; Longitude 66°23'55"W.

Lithology: crinoidal calcarenite, associated with metabasalt.

Weight dissolved: 2740 g.

96064 Tetagouche Group, upper unit. Low cliff (maximum 2 m) exposure in woods about 40 m north of logging road and north of 96063, Restigouche Co., N.B. This locality is probably a few hundred metres southwest of the locality reported by Kennedy et al. (1979). This conclusion is based on the location of the fossil locality described by H. Helmstaedt in personal communication. NTS 21O/9. Military grid reference 95756941; Latitude 47°33'05"N; Longitude 66°23'58"W.

Lithology: bioclastic calcarenite.

Weight dissolved: 3145 g.

96065* Tetagouche Group, upper part of lower unit. Small outcrop 1.3 km upstream from Tetagouche Falls near Rosehill, Gloucester Co., N.B. This locality yielded the Arenigian brachiopods reported by Fyffe (1976). NTS 21P/12. Latitude 47°36'45"N; Longitude 65°50'20"W.

Lithology: cleaved, phyllitic, calcareous siltstone.

Weight dissolved: 300 g (poor breakdown of large sample).

96066 Tetagouche Group, upper part of lower unit. Lower Birch Island locality, York Co., N.B., on left bank of Southwest Miramichi River about 17 km northwest of Boiestown, N.B. NTS 21J/10. Latitude 46°34'10"N; Longitude 66°34'20"W.

Lithology: slaty calcisiltite, with brachiopods (Neuman, 1971).

Weight dissolved: 500 g (poor breakdown of large sample).

96067 Tetagouche Group, upper part of lower unit. On Middle Hayden Brook, 600 m upstream from its confluence with the Taxis River, York Co., N.B. NTS 21J/7. Latitude 46°27'25"N; Longitude 66°46'15"W.

Lithology: small pods of coarse bioclastic calcarenite in tuffaceous siltstone, with brachiopods (Neuman, 1971).

Weight dissolved: 2000 g (poor breakdown of larger sample).

96068* "Taxis River grit", Silurian(?) unit. Taxis River, 700 m downstream from its confluence with Middle Hayden Brook, York Co., N.B. NTS 21J/7. Latitude 46°27'15"N; Longitude 66°45'35"W.

Lithology: cleaved, weakly calcareous sandstone with bryozoan fragments.

Weight dissolved: 100 g (poor breakdown of large sample).

96069* Tetagouche Group, upper part of lower unit. On a small tributary to the left bank of Rocky Brook, 3.8 km north-northwest of the confluence of Rocky Brook and Nashwaak River, York Co., N.B. 8.8 km due south of Napadogan, N.B. NTS 21J/7. Latitude 46°19'55"N; Longitude 66°56'05"W.

Lithology: Thin beds of brown weathering silty limestone and calcareous slate with brachiopods (Neuman, 1971).

Weight dissolved: 900 g (poor breakdown of large sample).

96070* Map unit 5 of Anderson (1968) and map unit Ss of Venugopal (1979a). 4 km west-northwest of Millville, York Co., N.B. on highway 585 (old 274), north of the 'settlement' of Woodstock Road; 1.5 km north of railroad crossing on north side of bend in the road. This locality is 200 m northeast of 96071 and 100 m east of fossil locality shown by Anderson (1968). NTS 21J/3. Latitude 46°08'50"N; Longitude 67°14'15"W.

Lithology: Calcareous slate.

Weight dissolved: 400 g (poor breakdown of large sample).

96071* Map unit 5 of Anderson (1968) and map unit Ss of Venugopal (1979a). 4 km west-northwest of Millville, York Co., N.B. on highway 585 (old 274) north of the 'settlement' of Woodstock Road; 1.35 km north of railroad crossing on west side of road. This locality is 200 m south of fossil locality shown by Anderson (1968). NTS 21J/3. Latitude 46°08'46"N; Longitude 67°14'30"W.

Lithology: Calcareous slate.

Weight dissolved: 850 g (poor breakdown of large sample).

96072* Map unit 5 of Anderson (1968) and map unit Ss of Venugopal (1979a). Small quarry on highway 585 (old 274) at Norton Dale, York Co., N.B., east side of the road, 180 m north of old bridge over Nackawic River. NTS 21J/3. Latitude 46°07'20"N; Longitude 67°16'06"W".

Lithology: Calcareous slate.

Weight dissolved: 1700 g.

96073 Map unit 5 of Anderson (1968); map unit Ss of Venugopal (1978c) and Belle Lake Slate Formation of Venugopal (1979b). Waterville Quarry, 2 km due west of Central Waterville, York Co., N.B., north end of small pit on south side of the road. Same locality as 97014 (see below). NTS 21J/3. Latitude 46°04'45"N; Longitude 67°19'10"W.

Lithology: Pale grey marble with thin black laminae, locally crinoidal.

Weight dissolved: 3100 g.

96074 ?Map unit 5 of Anderson (1968); map unit Ss of Venugopal (1978c) and Belle Lake Slate Formation of Venugopal (1979b). Waterville Quarry, 2 km due west of Central Waterville, York Co., N.B.; northwestern extremity of main quarry, high in quarry face; north side of road. NTS 21J/3. Latitude 46°04'50"N; Longitude 67°19'10"W.

Lithology: Pale grey marble with local thin black laminae.

Weight dissolved: 2029 g.

96075 "Canterbury limestone" (Lutes, 1979). 0.7 km southeast of Canterbury, York Co., N.B. on northwest side of highway 630; southwest side of railroad where it crosses road. NTS 21G/14. Latitude 45°53'10"N; Longitude 67°27'35"W.

Lithology: Medium grey, fine sandy limestone.

Weight dissolved: 2895 g.

96076* "Canterbury limestone". 5 km west-northwest of Canterbury, York Co., N.B., north of railroad crossing. NTS 21G/13. Latitude 45°54'40"N; Longitude 67°31'00"W.

Lithology: Medium grey, fine sandy limestone.

Weight dissolved: 1974 g.

96077* Scott Siding Slate (Venugopal, 1978a, b; 1979b). 2.5 km east along new Trans Canada Highway from intersection with highway 122 from Canterbury, York Co., N.B.; large roadside exposure on north side. NTS 21G/14. Latitude 45°58'58"N; Longitude 67°26'00"W.

Lithology: Calcareous siltstone.

Weight dissolved: 600 g (poor breakdown of large sample).

96078 Scott Siding Slate (Venugopal, 1978a,b; 1979b). Locality as for 96077 above, but more westerly position in outcrop. NTS 21G/14. Latitude 45°59'00"N; Longitude 67°26'02"W.

Lithology: Lens of limestone breccia, with calcareous matrix and micrite pebbles.

Weight dissolved: 2185 g.

Note: 97005-97010 were taken in an east-west direction through about 24 m of steeply dipping strata.

97005* Tetagouche Group, upper part of lower unit. Locality as for 96061, but on left bank of Tetagouche River. NTS 21P/12. Latitude 47°37'28"N; Longitude 65°48'20"W.

Lithology: recrystallized calcarenite.

Weight dissolved: 2646 g.

97006 As for 97005.

Weight dissolved: 1995 g.

97008 As for 97005.

Weight dissolved: 3192 g.

97009 As for 97005.

Weight dissolved: 2241 g.

97010* As for 97005.

Weight dissolved: 44 g (poor breakdown of large sample).

97012 Map unit 5 of Anderson (1968); map unit Ss of Venugopal (1978c) and Belle Lake Slate Formation of Venugopal (1979b). Waterville Quarry as described for localities 96073, 96074; from small pit northeast of main pit on north side of highway 595.

Lithology: Pale grey marble with thin black laminae.

Weight dissolved: 2700 g.

97013 As for 97012, but from south end of pit on south side of road.

Weight dissolved: 2595 g.

97014 As for 97013 but from north side of pit.

Weight dissolved: 2580 g.

97015* Map unit 5 of Anderson (1968) and map unit Ss of Venugopal (1978c). Beneath old bridge near Norton Dale over the Nackawic River; 200 m south of locality 96072. NTS 21J/3. Latitude 46°07'10"N; Longitude 67°16' 07"W.

Lithology: Calcareous siltstone.

Weight dissolved: 2085 g.

97016* Map unit 5 of Anderson (1968) and map unit Ss of Venugopal (1978c). 100 m north of old bridge over Nackawic River at Norton Dale on east side of old highway 585 (old 274). NTS 21J/3.

Lithology: Calcareous siltstone.

Weight dissolved: 615 g (poor breakdown of large sample).

97017* As for 97016.

Weight dissolved: 624 g (poor breakdown of large sample).

PLATES 1 to 5

Plate 1

The specimens illustrated are from the Tetagouche Group at Middle Hayden Brook (GSC loc. 96067) and South Tetagouche (GSC loc. 97009) and from the Waterville Quarry (GSC locs. 96073, 97013, 97014).

Figures 1, 2. *Walliserodus* sp. Lateral views, figured specimens. (1) Distacodiform element, X170, GSC 64313, GSC Locality 97013. (2) Scandodiform element (homologous to acodiform element?), X110, GSC 64314, GSC Locality 97014.

Figures 3, 4. *Walliserodus?* sp. Figured specimens. (3) Posterior view, acontiodiform element, X170, GSC 64315, GSC Locality 96067. (4) Lateral view, carinate element (=acodontiform element sensu Cooper, 1975), GSC 64316, GSC Locality 96067.

Figure 5. *Protopanderodus varicostatus?* (Sweet and Bergström). Lateral view, figured specimen, acontiodiform (protopanderodiform) element, X120, GSC 64317, GSC Locality 97013.

Figures 6, 7. *Protopanderodus rectus* (Lindström). Hypotypes. (6) Outer lateral view, scandodiform element, X60, GSC 64318, GSC Locality 97009. (7) Lateral view, bicostate acontiodiform (protopanderodiform) element, X80, GSC 64319, GSC Locality 97009.

Figures 8, 11. *Protopanderodus rectus?* (Lindström). Lateral views, figured specimens. (8) Bicostate acontiodiform (protopanderodiform) element, X180, GSC 64320, GSC Locality 96067. (11) Unicostate acontiodiform (protopanderodiform) element, X66, GSC 64321, GSC Locality 96067.

Figure 9. *Panderodus?* sp. Figured specimen. Lateral view, poorly preserved compressiform-like element, GSC 64322, GSC Locality 96073.

Figure 10. *Oistodus* sp. Figured specimen. Lateral view, X90, GSC 64323, GSC Locality 96067.

Figure 12. *Protopanderodus* sp. Figured specimen. Lateral view, X180, GSC 64324, GSC Locality 97013.

Figure 13. *Drepanoistodus?* cf. *D.? venustus* (Stauffer). Figured specimen. Lateral view, oistodiform element, X120, GSC 64325, GSC Locality 96073.

Figures 14, 17, 18. *Panderodus* cf. *P. gracilis* (Branson and Mehl). Figured specimens. (14) Outer lateral view, arcuatiform element, X120, GSC 64326. (17) Lateral view, compressiform element, X120, GSC 64327. (18) Lateral view, graciliform element, X170, GSC 64328. All specimens from GSC Locality 97014.

Figure 15. *Panderodus* sp. Figured specimen. Lateral view, X120, GSC 64329, GSC Locality 96073.

Figures 16, 19. *Panderodus* aff. *P. serratus* Rexroad. Figured specimens, outer lateral views. (16) X108, GSC 64330. (19) X120, GSC 64331. Both specimens from GSC Locality 97014.

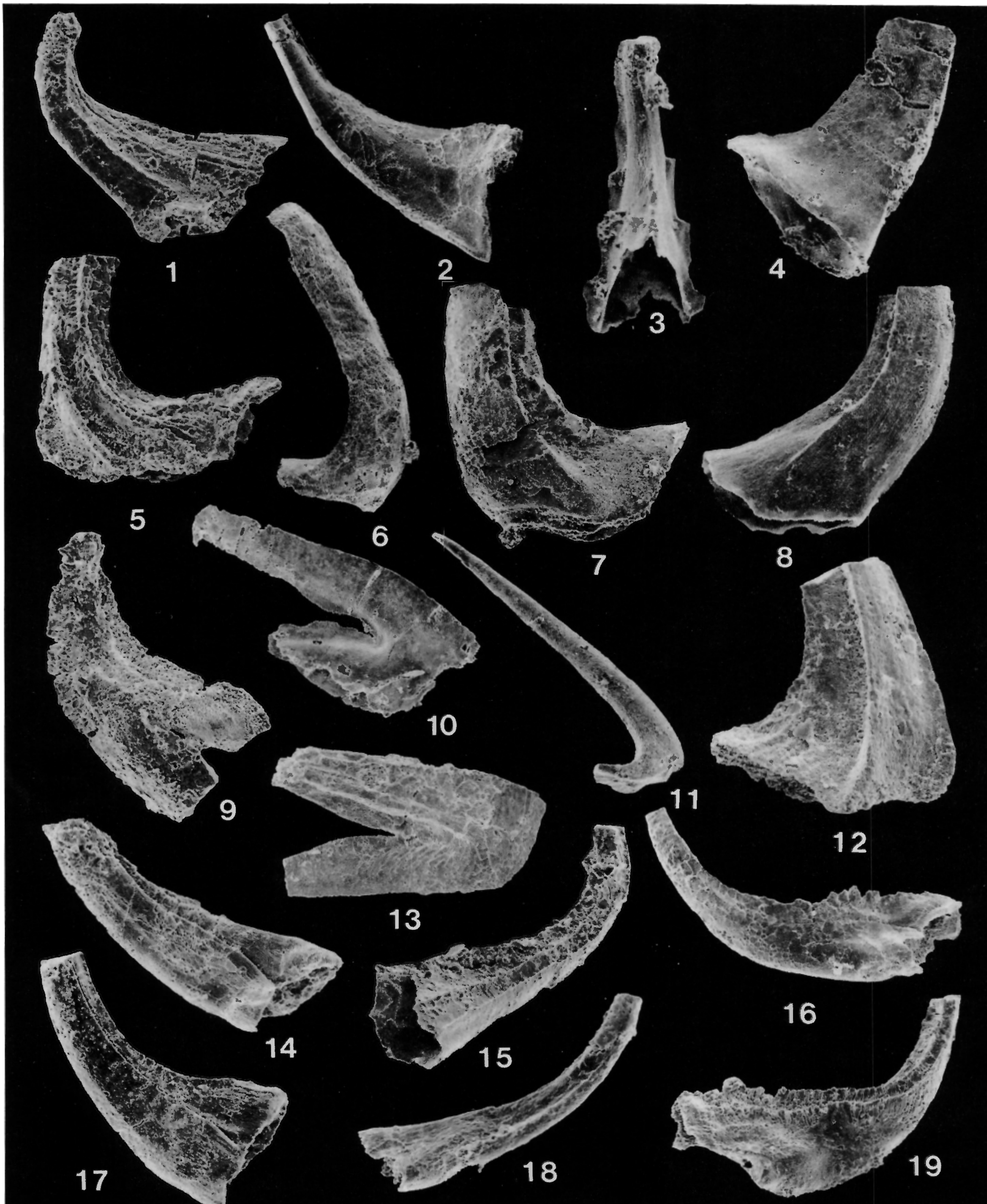

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Plate 2

Specimens are from Waterville Quarry, except Figures 1-5 which are from the Tetagouche Group at Middle Hayden Brook.

Figures 1-5. *Microzarkodina flabellum* (Lindström). Hypotypes, lateral views. (1) Ozarkodiniform (f) element, X120, GSC 64332. (2) Ozarkodiniform (f) element, X180, GSC 64333. (3) Oistodiform (e) element, X180, GSC 64334. (4) Cordylodiform (a) element, X180, GSC 64335. (5) Ozarkodiniform (f) element, X180, GSC 64336. All specimens from GSC Locality 96067.

Figures 6, 11, 12, 13, 15. *Prioniodus prevariabilis* Fåhraeus. Hypotypes. (6) Lateral view, cordylodiform (a) element, X90, GSC 64337. (11) Lateral view, prioniodiform (f) element, X120, GSC 64338. (12) Postero-lateral view, tetraprioniodiform (d) element, X120, GSC 64339. (13) Upper view, prioniodiform ("amorphognathiform")(g) element, X108, GSC 64340. (15) Lateral view, oistodiform (e) element, X90, GSC 64341. All specimens from GSC Locality 96073.

Figures 7-10. *Periodon aculeatus* Hadding. Hypotypes, lateral views. (7) Prioniodiniform (g) element, X72, structurally deformed, GSC 64342, GSC locality 97013. (8) Periodontiform (a) element, X120, GSC 64343, GSC Locality 97013. (9) Ligonodiniform (f) element, X120, GSC 64344, GSC Locality 97014. (10) Oistodiform (e) element, X102, GSC 64345, GSC Locality 97013.

Figures 14, 16-20. *Pygodus* cf. *P. serrus* (Hadding). Figured specimens. (14) Lateral view, haddingodiform (f) element of *P. serrus* type, X120, GSC 64346, GSC Locality 97014. (16) Upper view, proximal portion of fragmentary pygodiform (g) element showing surface texture, X110, GSC 64347, GSC Locality 96073. (17) Upper view, pygodiform (g) element, showing one node on rudimentary fourth denticle row, X102, GSC 64348, GSC Locality 96073. (18) Upper view, distal portion, pygodiform (g) element, X108, GSC 64349, GSC Locality 97014. (19) Upper view of slightly distorted pygodiform (g) element showing two nodes on rudimentary fourth denticle row to left of central row, X120, GSC 64350, GSC Locality 97014. (20) Outer lateral view, haddingodiform (f) element of *P. anserinus* type, X180, GSC 64351, GSC Locality 97014.

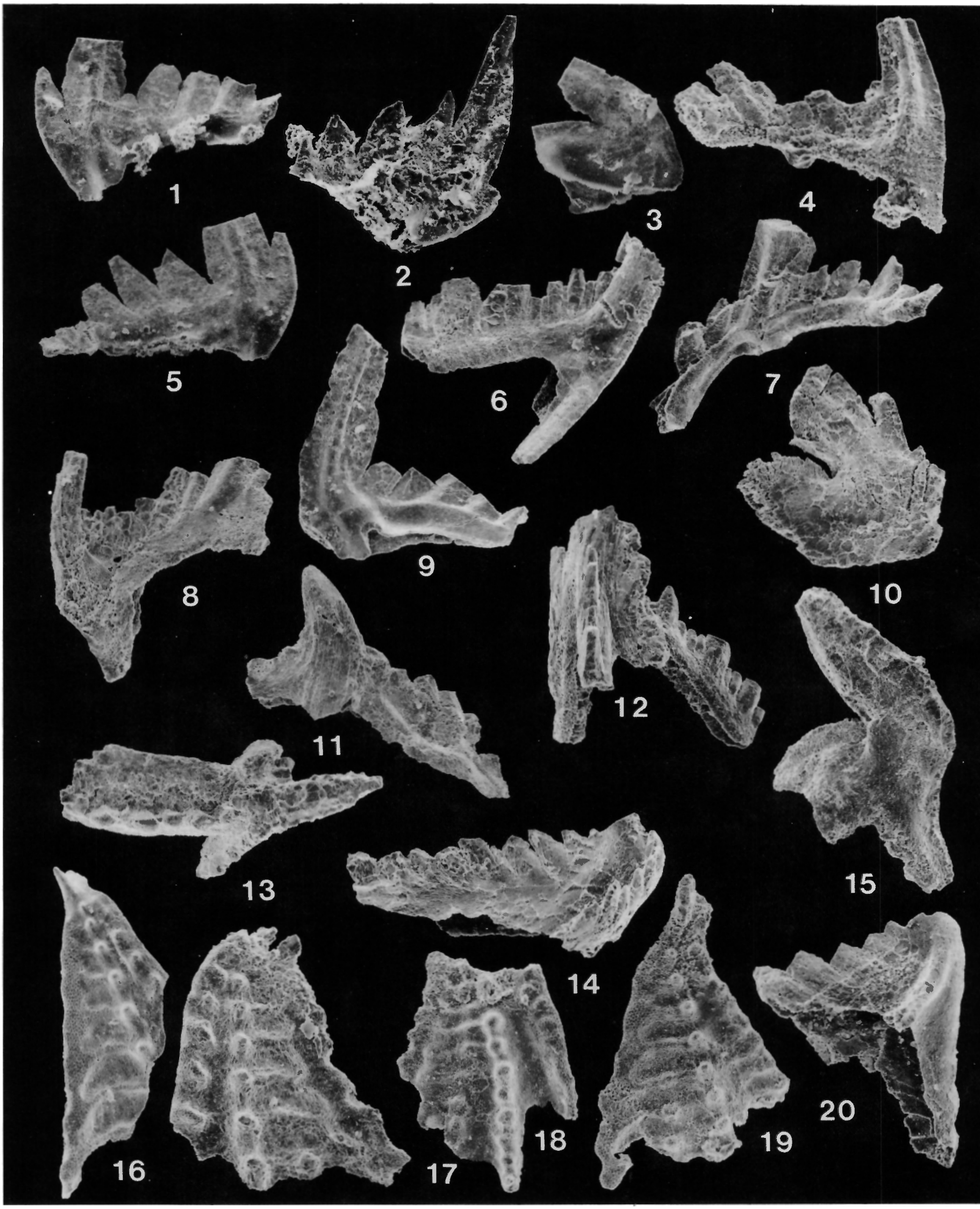

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Plate 3

The specimens illustrated are from Camel Back Mountain except Figures 16 and 19 which are from Lower Birch Island (GSC loc. 96066), Figures 20-22 which are from south Tetagouche and Figure 18 which is from Waterville Quarry.

Figures 1-6, 12. *Walliserodus nakholmensis* (Hamar). Hypotypes. (1) Lateral view, distacodiform (d) element, X114, GSC 64352. (2) Lateral view paltodiform-acontiodiform (b) element, X96, GSC 64353. (3) Posterior view, paltodiform-acontiodiform (c) element, X114, GSC 64354. (4) Inner lateral view, scandodiform (a) element, X102, GSC 64355. (5) Lateral view, carinate (e) element, X90, GSC 64356. (6) Lateral view, carinate element, X85, GSC 64357. (12) Inner lateral view, scandodiform element, X120, GSC 64358. All specimens from GSC Locality 96063.

Figures 7, 17. *Drepanoistodus?* cf. *D.? venustus* (Stauffer). Hypotypes. (7) Lateral view, homocurvatiform (q) element, X108, GSC 64359. (17) Lateral view, oistodiform (r) element, X115, GSC 64360. Both specimens from GSC Locality 96063.

Figures 8, 10. *Protopanderodus rectus?* (Lindström). Figured specimens. (8) Lateral view, bicostate acontiodiform element, X90, GSC 64361. (10) Lateral view, bicostate acontiodiform element, X55, GSC 64362. Both specimens from GSC Locality 96063.

Figures 9, 11, 13. *Protopanderodus graeai* (Hamar). Hypotypes. (9) Inner lateral view, ?scandodiform element, X50, GSC 64363. (11) Lateral view, bicostate evenly curved acontiodiform element, X42, GSC 64364. (13) Lateral view, bicostate element, X55, GSC 64365. All specimens from GSC Locality 96063.

Figure 14. *"Scolopodus" giganteus* Sweet and Bergström s.f. Hypotype. Lateral view, X48, GSC 64366, GSC Locality 96063.

Figure 15. *Protopanderodus varicostatus?* (Sweet and Bergström). Figured specimen. Lateral view, X55, GSC 64367, GSC Locality 96063.

Figure 16. *Oistodus* sp. Figured specimen, lateral view, X180, GSC 64368, GSC Locality 96066.

Figure 18. *Strachanognathus parvus* Rhodes. Hypotype, lateral view, X120, GSC 64369, GSC Locality 97014.

Figure 19. *Oistodus?* sp. Figured specimen, lateral view, X240, GSC 64370, GSC Locality 96066.

Figures 20-22. *Drepanoistodus basiovalis* (Sergeeva). Hypotypes. Lateral views. (20) Homocurvatiform (q) element, X102, GSC 64371. (21) Oistodiform (r) element, X95, GSC 64372. (22) Homocurvatiform element, X175, GSC 64373. All specimens from GSC Locality 97009.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

Plate 4

The specimens illustrated are all from Camel Back Mountain.

Figures 1-5, 8. *Periodon aculeatus* Hadding. Hypotypes, lateral views. (1) Periodontiform (a) element, X180, GSC 64374. (2) Oistodiform (e) element, X72, GSC 64375. (3) Prioniodiniform (g) element, X180, GSC 64376. (4) Periodontiform (b) element, X115, GSC 64377. (5) Ligonodiniform? (f) element, X180, GSC 64378. (8) Oistodiform (e) element, X80, GSC 64379. All specimens from GSC Locality 96064.

Figures 6, 7, 9. *Periodon aculeatus* Hadding. Hypotypes, lateral view. (6) Prioniodiniform (g) element, X90, GSC 64380. (7) Ligonodiniform (f) element, X180, GSC 64381. (9) Oistodiform (e) element, X90, GSC 64382. All specimens from GSC Locality 96063.

Figures 10-12, 14-17. *Prioniodus variabilis* Bergström. Hypotypes. (10) Lateral view, cordylodiform (a) element, X110, GSC 64383. (11) Outer lateral view, prioniodiform (g?) element, X90, GSC 64384. (12) Posterior view, tetraprioniodiform (d) element, X100, GSC 64385. (14) Outer lateral view, prioniodiform (f) element, X66, GSC 64386. (15) Lateral view, oistodiform (e) element, X96, GSC 64387. (16) Posterior view, hibbardelliform (c) element, X66, GSC 64388. (17) Upper view of posterior process of prioniodiform ("amorphognathiform")(g) element showing pronounced lateral expansion of the base, X96, GSC 64389. All specimens from GSC Locality 96063.

Figures 13, 20. *Polyplacognathus* cf. *P. ringerikensis* Hamar s.f. Figured specimens, upper (oral) views. (13) Most complete specimen, oriented with anterior process downward, X80, GSC 64390. (14) Fragmentary specimen, X96, GSC 64391. Both specimens from GSC Locality 96063.

Figures 18, 19. *Spinodus ramosus* (Hadding). Hypotypes, lateral views. (18) Cordylodiform (a) element, X90, GSC 64392. (19) Cladognathiform (b) element, X96, GSC 64393. Both specimens from GSC Locality 96063.

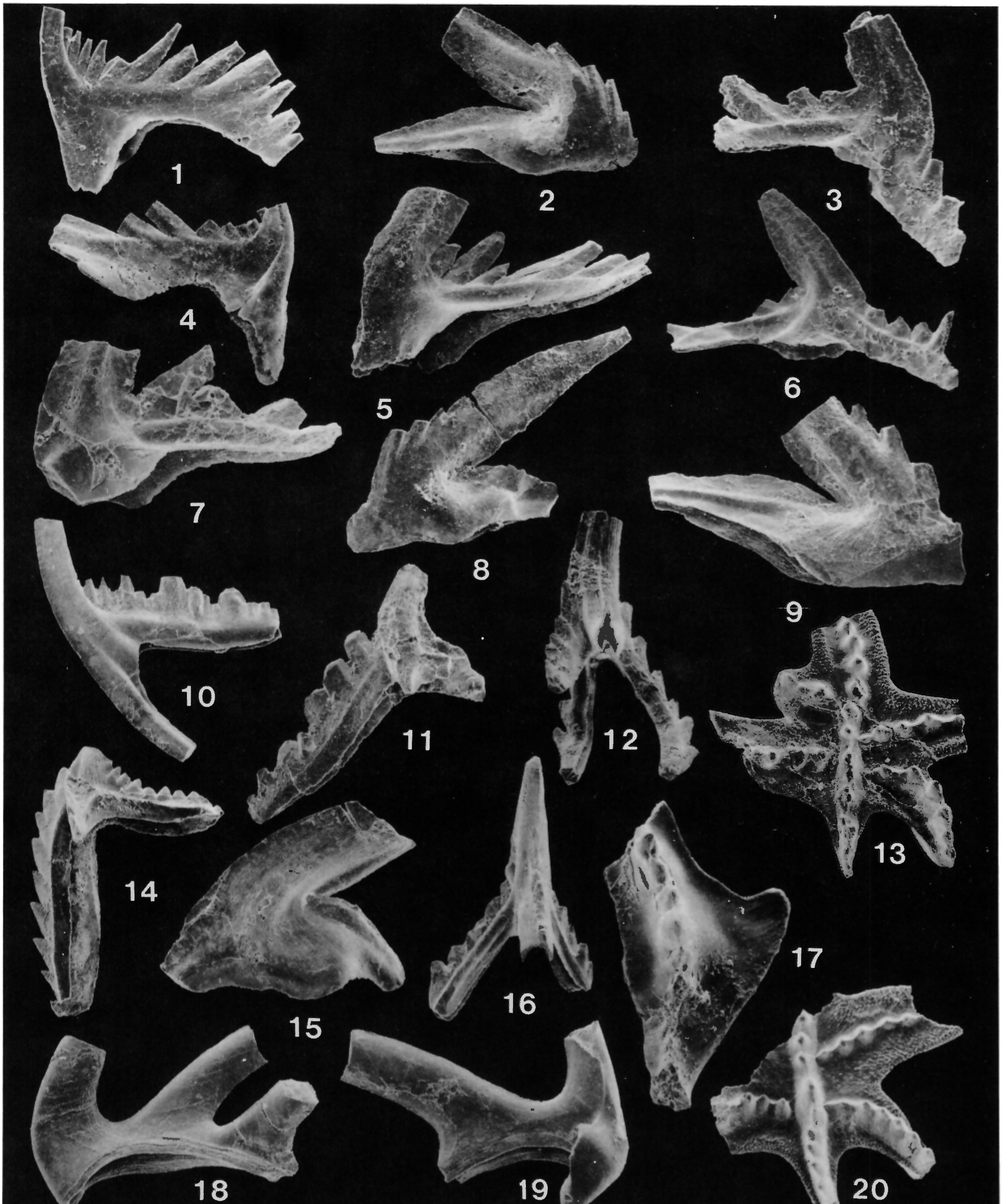

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Plate 5

All specimens from GSC Locality 96064.

Figures 1-4. *Dapsilodus? similaris* (Rhodes). Hypotypes, lateral views. (1) Distacodiform (d) element, X180, GSC 64394. (2) Acodiform (b) element, X180, GSC 64395. (3) Distacodiform element, X180, GSC 64396. (4) Distacodiform element, X180, GSC 64397.

Figure 5. *Strachanognathus parvus* Rhodes. Hypotype. Lateral view, X114, GSC 64398.

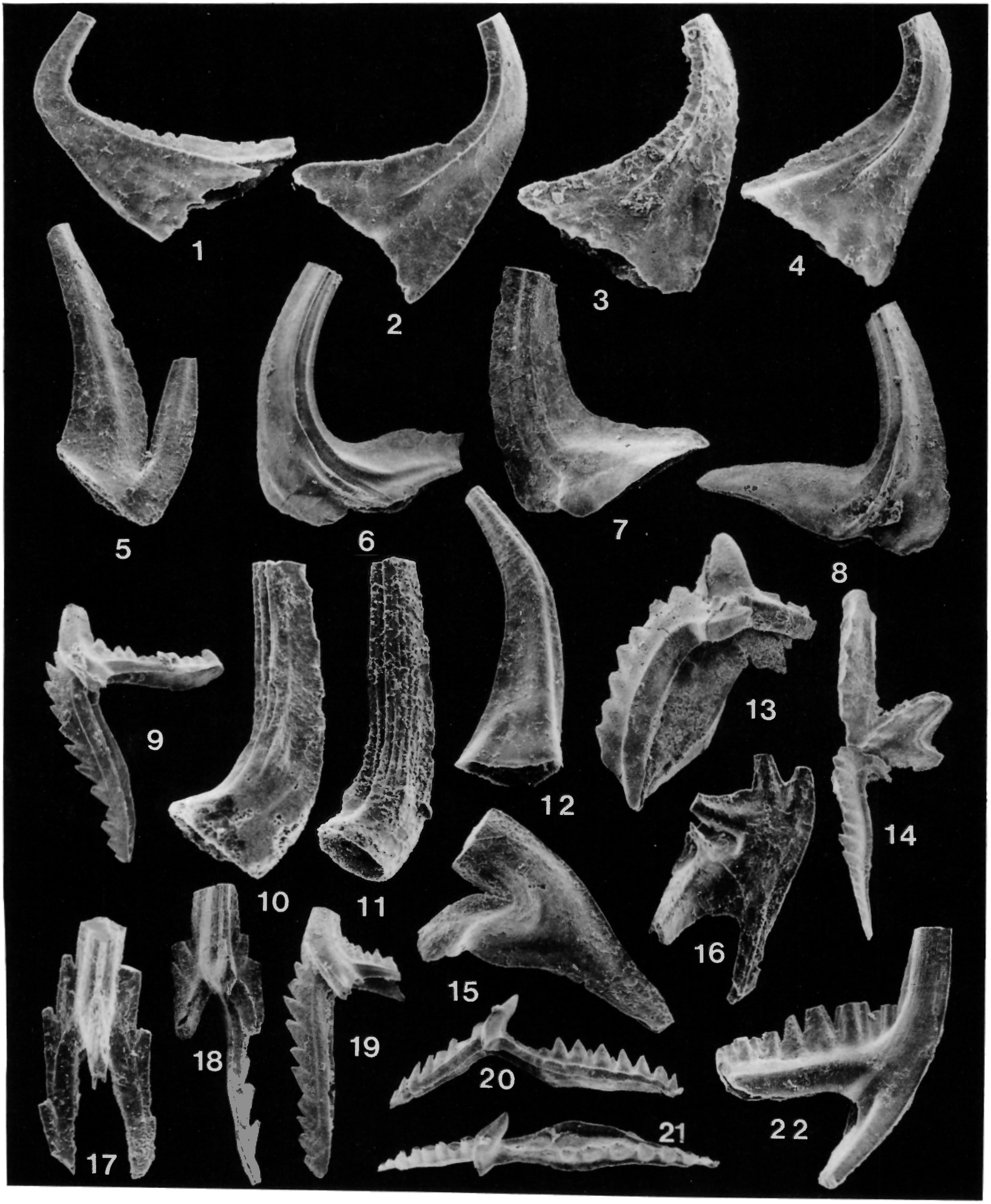
Figure 6-8. *Protopanderodus liripipus* Kennedy, Barnes and Uyeno. Hypotypes, lateral views. (6) costate element, X66, GSC 64399. (7) Scandodiform element, X84, GSC 64400. (8) Costate element, X66, GSC 64401.

Figures 9, 15, 17-22. *Prioniodus alobatus* Bergström. Hypotypes. (9) Outer lateral view, prioniodiform (f) element, X55, GSC 64402. (15) Lateral view, oistodiform (e) element, X100, GSC 64403. (17) Posterior view, hibbardelliform (c) element, X120, GSC 64404. (18) Posterior view, tetraprioniodiform (d) element, X78, GSC 64405. (19) Outer lateral view, prioniodiform (f) element, X60, GSC 64406. (20, 21) Outer lateral and oblique upper views, amorphognathiform element, X42, GSC 64407. (22) Inner lateral view cordylodiform (a) element, X108, GSC 64408.

Figures 10, 11. *"Scolopodus" peselephantis* Lindström. Hypotypes. (10) Lateral view, X180, GSC 64409. (11) Postero-lateral view, X180, GSC 64410.

Figure 12. *Coelocerodontus? lacrimosus* Kennedy, Barnes and Uyeno s.f. Hypotype. Lateral view, X90, GSC 64411.

Figures 13, 14, 16. *Amorphognathus tvaerensis* Bergström. Hypotypes. (13) Outer lateral view, ambalodiform element, X78, GSC 64412. (14) Upper view of fragmentary amorphognathiform element, X48, GSC 64413. (16) Lateral view, holodontiform element, X130, GSC 64414.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22