Conodont Biostratigraphy Of The Chazy Group (lower Middle-ordovician), Champlain Valley, New York And Vermont.

73-4276

RARING, Andrew Michael, 1945-
CONODONT BIOSTRATIGRAPHY OF THE CHAZY GROUP (LOWER MIDDLE ORDOVICIAN), CHAMPLAIN VALLEY, NEW YORK AND VERMONT.

Lehigh University, Ph.D., 1972
Paleontology

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CONODONT BIOSTRATIGRAPHY OF THE CHAZY GROUP (LOWER MIDDLE ORDOVICIAN), CHAMPLAIN VALLEY, NEW YORK AND VERMONT

by
Andrew Michael Raring

A Dissertation

Presented to the Graduate Committee

of Lehigh University

in Candidacy for the Degree of

Doctor of Philosophy

in

Department of Geological Sciences

Lehigh University

1972

Sept. 19, 1972
(date)

James M. Parker
Professor in Charge

Accepted Sept. 19, 1972
(date)

Special committee directing the doctoral work of Mr. Andrew Michael Raring

James M. Parker
Chairman

J. Donald Ryan

Philip R. Berger

Charles Bohlen

ACKNOWLEDGMENTS

The project was undertaken upon the instigation of Dr. T.J.M. Schopf, now at the University of Chicago. He was instrumental in providing inspiration and guidance as well as obtaining funding.

Later the project was directed at Lehigh by Dr. James Parks. His guidance through the labyrinth of university regulations and effort in obtaining funding were steadying. Drs. Ryan, Sclar, and Pritchard enthusiastically served on the special and examining committees as well.

Professor Stig M. Bergström of The Ohio State University served as primary advisor. The time spent with Dr. Bergström in discussion of Ordovician conodont biostratigraphy and his kindness in providing extensive Middle Ordovician conodont collections for comparison were invaluable to my progress in evaluation of the Chazy collection. Similar, though less extensive, assistance was rendered by Dr. Walter Sweet and students Jack Carnes and Joe Fetzer of The Ohio State University.

Mr. Doug Bush is responsible for photographs taken on Lehigh's electron microprobe with scanning microscopy attachment. Mr. Thomas Usselman kindly directed the conventional microscope photography.

I am also grateful for the encouragement and technical assistance, particularly in the final stages of preparation

of the manuscript, which was given by my wife, Sue Ann Stewart Raring.

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ABSTRACT

Biostratigraphic zonation of the Chazy Group (lower Middle Ordovician) with macrofossils has been unsuccessful due to the benthonic life habit of these taxa and the consequent lithologic control of their distribution. Conodonts from the type locality of the Chazy Group, near Chazy, New York, and from associated outcrops in the Champlain Valley of New York and Vermont, provide the basis for a zonation within the Chazy and an improved correlation to other Middle Ordovician strata.

The majority of Chazy conodont elements belong to species associated with the North American Midcontinent Province. The multielement species *Phragmodus tortus* Sweet and *Plectodina palaris* Raring, n. sp., predominate. Genera representative of the North Atlantic Province are also present, including *Eoplacognathus* and *Polyplacognathus*. Other genera present in the Chazy have an interprovincial distribution, including the new genus *Thrincodus* and *Belodella*, *Appalachignathus*, and *Multioistodus*.

The Chazy Group can be divided into four zones based on conodonts. The lower zone, equivalent to the Day Point Formation excluding the middle and upper Fleury Member, is characterized by the presence of *Eoplacognathus* n. sp.. The middle zone encompasses the range of *Polyplacognathus*

friendsvillensis. The third zone extends from the upper Crown Point through medial Valcour, marked by Polyplacognathus sweeti. The uppermost zone, the upper Valcour Formation, is distinguished by the presence of Plectodina aculeata and Cardiodella tumudus.

Chazy equivalents include the Lenoir and lower Arline Formations of Friendsville, Tennessee, Cooper's Marmor Stage and an unnamed interval above; the Dutchtown and possibly Joachim Formations of Missouri; the McLish and Tulip Creek Formations of Oklahoma; the Youngman Formation of Vermont; the St. Hyacinthe Limestone of Quebec; and the Laval Group of the Montreal area.

INTRODUCTION

The Chazy Group is one of the oldest described sequences of Middle Ordovidian rock in North America. The strata are predominantly limestones with interbedded sandstones, dolomites, and shales which are exposed in scattered outcrops in the central and northern Champlain Valley of New York and Vermont. Emmons (1842) was the first to describe the beds and apply the name Chazy limestone. Both he and James Hall (1847) noted that the Chazy fauna was unique.

Subsequently three formations were established within the sequence and the Chazy was elevated to Group rank. In actuality the three formations cannot be traced throughout the Chazy outcrop area. The basal strata are typically interbedded sandstones and shales but include varying amounts of limestones, magnesian limestones, and dolomites. Fine-grained argillaceous limestone is predominant throughout the remainder on the Chazy section although calcarenites and calcilutites associated with biohermal development are locally significant.

The Chazy Group was proposed by both Ulrich (1911) and Grabau (1909) as the reference section for the Chazy Stage. The time interval represented by the Chazy Stage was envisioned as being post-Canadian (Lower Ordovidian) and pre-Black Riveran (middle Middle Ordovician), the entire span of lower Middle Ordovician time. The type section of the Chazy Group at the village of Chazy, New York, became the type section of the new stage as well. Neither the bottom nor the top of the Chazy Group is exposed at the type section and exposures elsewhere are rare. Further, the base of the Middle Ordovician section in eastern North America in most places is unconformable to underlying rocks and the type section of the overlying Black River beds crop out hundreds of miles from the Champlain Valley. These stratigraphic problems aside, the Chazy has proven a durable and useful Stage over the years.

Definition of the boundaries of the Chazy Stage has been difficult to achieve with precision. One problem has been that the shelly faunas in the Chazy Group are largely of shallow water, benthonic taxa whose distribution was greatly affected by environmental changes and therefore limited geographically. Another problem has been that many of the Chazy taxa were newly evolved and not found in the older generally unfossiliferous Canadian series, making comparison difficult. As a result of these problems previous studies of other groups of fossils have failed to define with precision the upper and lower boundaries of Chazy time. However, the succession of conodont faunas in Middle Ordovician time has been thoroughly described from several regions, notably Sweden (Bergström, 1971a) and the

North American Midcontinent (Sweet and others, 1971a). Definitive studies of Chazyan brachiopods (Cooper, 1956) and trilobites (Shaw, 1968), among others have discussed the provincialism of the Chazyan shelly fauna and its lack of evolutionary development within Chazy time.

Conodonts are microfossils common in rocks of the Paleozoic era which have proved useful for zonation and correlation of sedimentary rock strata. Their size ranges from less than one to more than five mm and they are composed of calcium phosphate. We have little idea of the nature of the animal that possessed these hard parts, which in general appearance resemble fish teeth or worm jaws. Until recently the method of classification was to assign each distinct morphologic plan a separate generic name and use finer morphologic distinctions to define individual species. In many cases mirror image forms were described as separate species or even genera. Finding small whole number ratios between several species belonging to separate genera as well as similar numbers of left and right-handed forms in large collections of conodonts has led to the now prevalent view that assemblages of different forms having bilateral symmetry occurred in the conodont-bearing animal. Consequently, every form species in the assemblage belongs to only one biologic or natural species. Some form genera evolved rapidly; thus a conodont of particular morphology may represent a limited span of geologic time.

Due to their presence in rocks of varied lithology, it has been assumed that conodonts belonged to planktonic organisms. Further, the rapid evolution of some lineages has allowed establishment of zones or faunas of short duration. Research on the conodont fauna of the Chazy was undertaken with the intent of providing a closer delimitation of the boundaries of Chazy time. Correlation of the Chazy fauna within the recently established zones and subzones of the Swedish succession (Bergström, 1971a) and the succession of conodont faunas (Sweet, Ethington, and Barnes, 1970) has provided a revision of Chazy time.

A major result of the study of Chazyan conodonts has been a more thorough understanding of the time-stratigraphic relationship of the Chazy Group to the many Middle Ordovician formations in the southern Appalachians. In that region, the Chazy Group is correlated to the Marmor Stage as Cooper (1956) indicated when he proposed that the Marmor replace the Chazy. The upper portion of the Chazy represents a time interval not included in rocks of Cooper's type Stages, however. The top of the Chazy Group appears to be older than the beginning of the Ashby Stage on the basis of conodont fauna while it appears that earliest Porterfield time may overlap with youngest Chazy time. Conodont faunas indicate that the Ashby is not older than the Porterfield, as Cooper (1956) assumed when he established the southern Appalachian Stages for the Middle

Ordovician (Bergström, 1971a).

The conodont fauna of the Chazy Group is dominated by the multielement species Phragmodus tortus Sweet, ms., and Plectodina palaris Raring, n. sp., and by simple cone types such as Panderodus and Drepanoistodus. These forms characterize the Midcontinent fauna of North America. They are indicative of faunas 5 and 6 of Sweet, Ethington, and Barnes (1970). The sequence of faunas described in the above report were not intended to be interpreted as zones; neither were faunas 5 and 6 completely described.

The Chazy conodont fauna also contains some elements with affinities to the North Atlantic Province (Bergström, 1971a) and these are more useful in defining the age of the Chazy Group. In this category are the genera Polyplacognathus, Eoplacognathus, and Periodon. They allow a comparison to faunas from southern Appalachian sections in easternmost outcrop belts, which contain a greater admixture of species found in the Middle Ordovician sequence of the Baltic region. These sections in turn can be assigned to intervals within the zones of the Baltic Shield previously established by Bergström. The Chazy Group represents an interval comprising the Pygodus serrus and lower Pygodus anserinus zones.

A curious feature of the Chazy conodont fauna is the presence in scattered samples of conodonts representative of the "Australian fauna" (Bergström, 1970) as yet undescribed in the literature. Also present are a variety of "fibrous" conodont forms, typical of Midcontinent Province faunas. Finally, several as yet unreported genera are present, including Appalachignathus Votaw, unpub. Ph.D. dissertation (Bergstrom, and others, in press) and the new genera *Thrincodus* and *Pseudophragmodus*.

THE CHAZY GROUP

Outcrop Area

The Chazy Limestone crops out in the Lake Champlain lowlands of northeastern New York State and Vermont. To the east, metamorphic rocks abut the lowland across Logan's Line, a thrust fault which marks the edge of the allochthonous sequence. To the west, the Precambrian Adirondack Mountains limit the Chazy outcrop area. Pleistocene glacial deposits cover the Chazy rock north of the Canadian border area, while to the south the Chazy is both stratigraphically thinned and structurally pinched out between the Taconic Allochthon and the Precambrian. Figure 1 indicates the localities of the major collection sites within the Champlain Valley.

The Champlain lowland area is one of low relief and scattered outcrops. The Chazy Limestone is gently folded, with low angles of dip, and the sequence is cut by numerous high angle faults. As a result, outcrop belts are discontinuous and only infrequently follow the north-

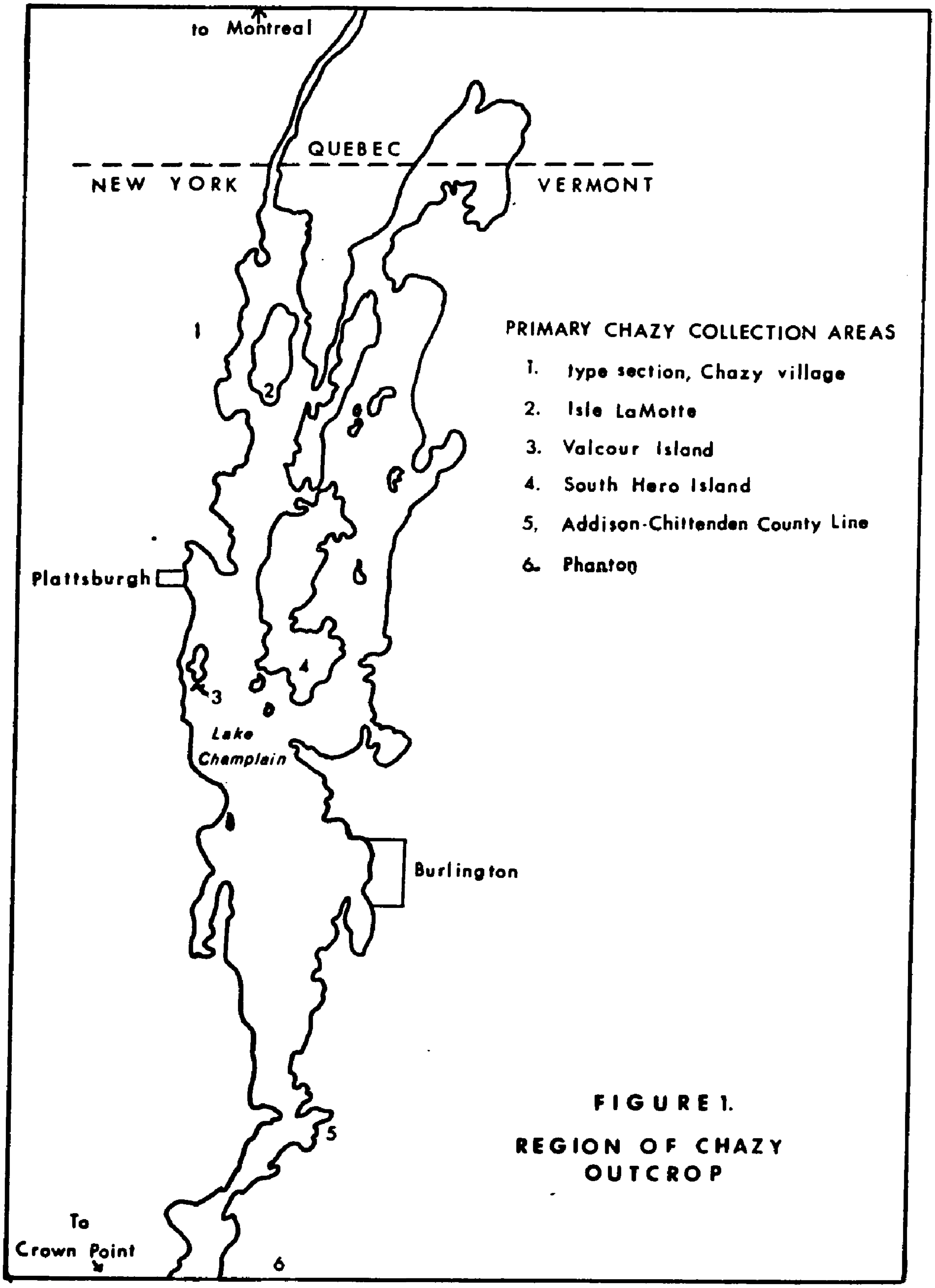


FIGURE 1.

REGION OF CHAZY OUTCROP

south structural trend of the region. There are two roughly east-west trending outcrop belts in the northern portion of the lowland. The type section at the Village of Chazy, New York, is located in the northernmost of the two belts. In the southern portion of the lowland a north-south trending outcrop belt is found to the east of the lake in Vermont with a parallel belt badly broken by faulting present just west of Logan's Line. Isolated outcrop areas are also found on both sides of Lake Champlain.

Chazy equivalents are missing below limestones of the Black River Group where Middle Ordovician rock reappears along the southern flank of the Adirondacks. The Black River Stage represents an interval of time thought to immediately follow that of the Chazy Stage. The Chazy Limestone of the type area extends north below Pleistocene cover to the Montreal area, where it again crops out. In the city of Montreal, the sequence is termed the Laval Group (Hofmann, 1963) and contains a greater percentage of sandstone and shale than does the Chazy Group of the type area. The outcrop belt extends further to the northeast in the St. Lawrence Valley, beyond to the Mignan Islands, and finally to the northwestern coast of Newfoundland. There is also a tongue of Chazy equivalent rock extending from Montreal to the west, in the Ottawa Valley. A narrow allochthonous thrust slide parallel and just east of Logan's Line contains the Youngman Formation and St. Hyacinthe

Limestone of Vermont and Quebec.

Stratigraphic Sequence

The Chazy is divisible in its type section at the village of Chazy, New York, into three lithologic units. The Day Point Formation is at the base, overlain successively by the Crown Point and Valcour Formations. Elsewhere in the Champlain Lowland area these three units of the type section cannot always be recognized, although their names have been applied. Beyond the Champlain Valley, Chazy equivalent rocks bear local stratigraphic names. (Figure 2)

The Chazy Group in its type area is underlain by Cambro-Ordovician carbonates. The Beekmantown Group which is immediately below is divided into five formations, The Chazy rest upon the uppermost of these formations, the Providence Island, or Bridport, dolomite. The contact, in the few places it can be observed, appears to be conformable, although Oxley and Kay (1959) considered it to be a disconformity. Good exposures of the basal contact can be seen at the southern end of Isle LaMotte, Vermont and at the shore of Lake Champlain on the line between Chittenden and Addison Counties, Vermont. The first section was described by Oxley and Kay (1959) and the second by Welby (1961). The contact is marked by the appearance of interbedded sandstone and shale above dolomite having varying amounts of interbedded shale. Due to the similarity of the shales above and below the lowest sandstone, the contact

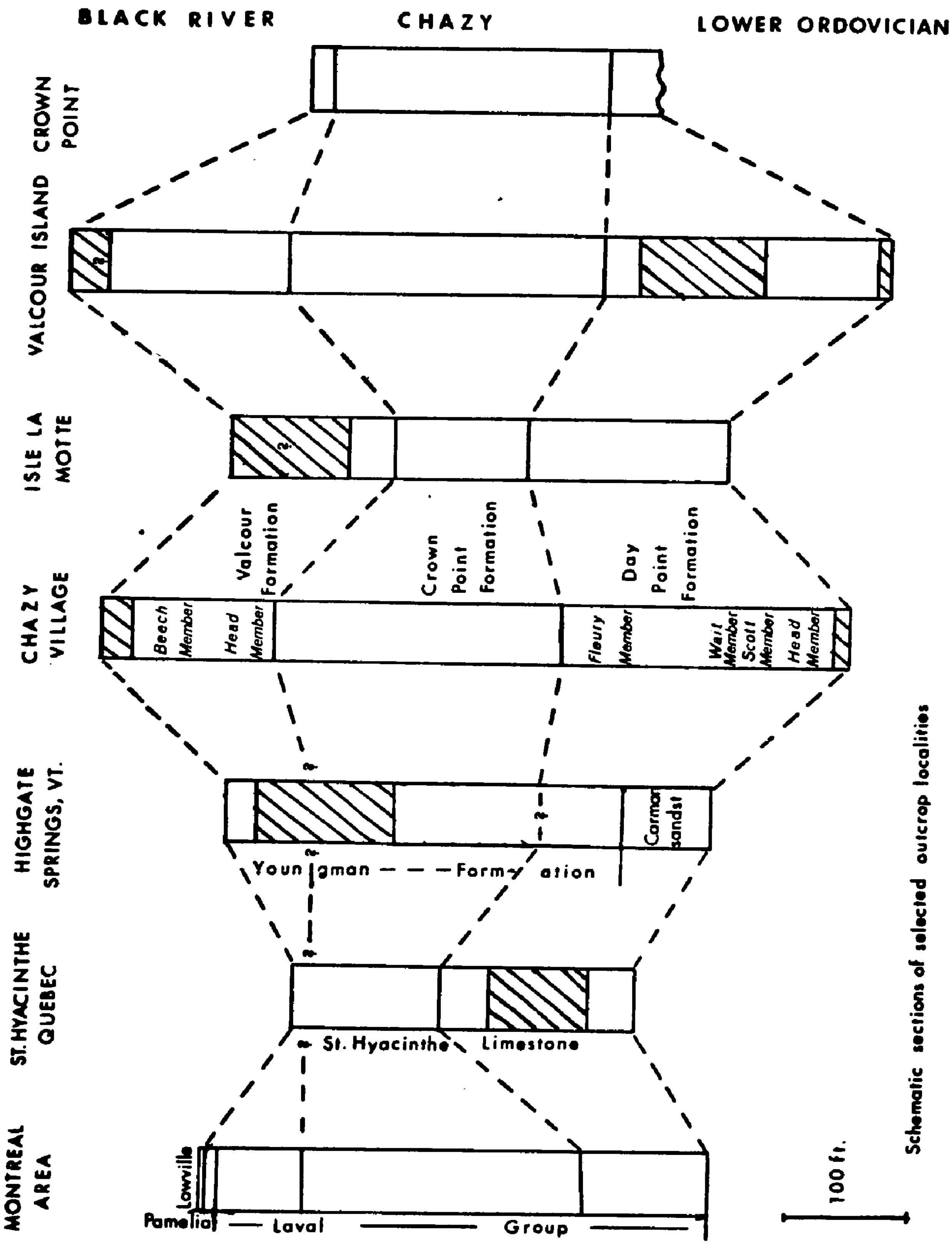


FIGURE 2.
REGIONAL STATIGRAPHY

has a gradational appearance, as described by Welby (1961) in the southern portion of the Central Champlain Valley.

The Day Point Formation contains prominent sandstones toward the base and calcarenites toward the top. Dolomite and shale are also found within the Day Point Formation, generally toward the base. In the type section, there are two intervals of sandstone separated by magnesian limestone with a thick accumulation of limestones of various lithologies above. These are the Head Sandstone, Scott Limestone, Wait Sandstone, and Fleury Limestone members (Oxley and Kay, 1959). To the south, in Vermont, Welby (1961) did not find these members developed but found significant amounts of interbedded shale and a variety of sandy and dolomitic limestones with little or none of the upper calcarenites found in the type area.

The Crown Point Limestone at Chazy is a gnarly-weathering, argillaceous calcisiltite, with only minor calcarenite. Elsewhere in the Champlain Lowland it is considerably thinner than at Chazy (250 ft.) and in some areas there are extensive fossil reefs. The fine-grained facies has irregular dolomitic stringers and is always developed at the base of the formation. Both calcarenites and calcilutite are found in and around the biohermal mounds (Toomey and Finks, 1969). The presence of the large coiled gastropod, Maclurites magnus Leseur, was used to define the Crown Point by early investigators (Brainard and

Seely, 1888).

The Valcour is more poorly exposed than the lower two Chazy formations and therefore is the least well defined. Its lower portion is predominantly fine-grained argillaceous limestone little different from the typical Crown Point lithology but in the type section it is distinguished by the presence of calcilutite and dolomite beds in the lower portion. Elsewhere, the Hero member may be largely a biohermal calcarenite, as on Isle LaMotte (Toomy and Finks, 1969), or an argillaceous fine-grained limestone. Where biohermal limestones predominate in the Hero member, the upper Crown Point also displays biohermal development. Thus, regardless of which facies is developed in the Hero member locally, it is usually not possible to distinguish it from the Crown Point on the basis of lithology.

The upper Valcour Beech member (Oxley and Kay, 1959) also contains a variety of limestone types. Dolomitic limestone, dolomite, shale, and sandstone are also found. The Beech member is characterized by the presence of the brachiopod Rostricellula plena (Hall), which was used by Raymond (1906) to define the highest of three faunal divisions of the Chazy limestone. Valcour limestones contain quartz silt and fine sand in greater abundance than those of the Crown Point.

Above the Valcour are found limestone beds of several lithologies which have traditionally been assigned to the Black River Stage. The Pamelia is the lowest unit above the Cambro-Ordovician in the type area of the Black River Group, on the southwest flank of the Adirondacks. It is predominantly a dolomite, with minor shales and sandstones. Above the Pamelia is the Lowville, or "birdseye" limestone, which is succeeded by several younger limestone units. The thin calcilutite overlying the Chazy Group in some areas of the Champlain Lowland has been considered equivalent to the Lowville. Above these beds, and resting on the Chazy where the calcilutite is absent, are beds of massive, dark, and fine-grained limestone, the Isle LaMotte. Welby (1961) placed both the calcilutite and overlying limestone of the Central Champlain Valley of Vermont in the Orwell Formation.

The beds stratigraphically equivalent to the Pamelia, if present in the Champlain Lowland area, are the magnesian limestones and dolomites of the uppermost Valcour. Fisher (1968) described this interval in a now-flooded quarry southeast of Chazy Village. The Chazy equivalent Laval Group of the Montreal area is overlain by beds assigned to the Pamelia Formation but considered by Hofmann (1963) to be largely of Chazy age.

Depositional History

The thickness of the Chazy Limestone is extremely variable. It is over 700 feet thick at the type section at

Chazy village while only two miles away, a nearly complete section is only 300 feet thick. Where the middle interval of the Chazy, upper Day Point through lower Valcour, has extensive reef development, the total section is thinner than at those places where only minor reef development is present. It is only in sections such as that at Chazy village, where the Crown Point is a homogenous calcisiltite, that a three-fold division of the Chazy can be unambiguously made on the basis of lithology.

Sections to the south in the Champlain Valley reveal a thinning of the Day Point and Valcour. The base of the Chazy is thought to be time-transgressive, with the reduction of Day Point thickness to the south being produced by nondeposition in lowest Chazy time. Similarly, the thinning of the Valcour southward may be due to non-deposition in uppermost Chazy time in that direction. While at Chazy village the Valcour and younger limestone lithologies are interbedded (Fisher, 1968), to the south a hiatus between the age of the top Valcour beds and the overlying limestone is suggested by distinct contact (Welby, 1961). Finally, a shore section near the southern end of Chazy outcrop at Crown Point, New York, displays only the Crown Point lithology above basal sandstones (Raymond, 1902). Here, Valcour equivalent beds may be present but indistinguishable due to lack of calcarenites.

The Chazy sea is assumed to have deepened to the east

(Kay, 1958). Greater amounts of sand in the Day Point to the west and north indicate a sediment source in that direction whereas thinning of the Chazy southward in the Champlain Valley suggests that the Chazy sea advanced to the south and later retreated to the north (Oxley and Kay, 1969). While it is certain that a hiatus exists at the base of the Chazy Group its magnitude is unknown due to lack of fossils in the lowermost Day Point and underlying beds. It is possible that deposition was continuous from the Valcour into Isle LaMotte - Orwell. If the Black River age assigned to those units is correct, no major disconformity exists between the Chazy Group and overlying beds.

A significant section is exposed at Highgate Springs, Vermont, immediately south of the international border at the shore of Lake Champlain. Here, the Youngman Formation is found above the Cambro-Ordovician sequence. The argillaceous limestone and argillite of the Youngman has been correlated with the Chazy Group (Kay, 1958). The Youngman rests on a thrust sheet and represents a more eastern facies of the Chazy. There are no shallow water biohermal calcarenites in the section and the macrofossils are so unlike those of the Chazy that Black River-Trenton age had been proposed for the Youngman (Cooper, 1956). The St. Hyacinthe Limestone lies along strike with the Youngman to the north in Quebec and also is correlable to the Chazy.

Farther to the south and east the metamorphozed

Middlebury Limestone at Middlebury, Vermont, is thought also to be correlative to the Chazy Group. However, relationships remain unclear.

Isopach maps for the Chazy of the Champlain Lowland were presented by Oxley and Kay (1959); Hofmann (1963) prepared isopach maps for the St. Lawrence Lowland to the north.

THE CHAZY STAGE

History of Stratigraphic Nomenclature

The importance of the Chazy Group to Ordovician stratigraphy is due to the attention paid these stata at an early date. Emmons (1942), in the final report of the first Geological Survey of New York, described the sequence and named it the Chazy Limestone. It was noted that there were no equivalent beds elsewhere in the state. A few years later, Hall (1847) described the fauna of the Chazy briefly. Since that time the Chazy has had time-stratigraphic significance; strata of supposed similar age have been compared to the Chazy. Early examples were regional reports in Canada (Ells, 1891) and Vermont (Hitchcock, 1861).

In the last decade of the nineteenth century Brainard (1890) and Brainard and Seely (1888, 1896) gave thorough descriptions of the stratigraphy and paleontology of the Chazy and detailed maps of the better exposures. They divided the Chazy into three divisions, designated A, B, and C, based primarily on stratigraphy in the type area around the village of Chazy, New York. Shortly thereafter, Percy Raymond redescribed several outcrop localities and more completely recorded the Chazy faunas in a series of papers (1902, 1905a&b, 1906, 1911a). The three faunal zones he established did not correspond exactly to the divisions of Brainard and Seely.

The present formational names were first applied by Cushing (1905). His Day Point, Crown Point, and Valcour "substages" were based on Brainard and Seely's A, B, and C divisions. The localities used as reference sections are scattered within the Champlain Lowland. However, the type section for the Chazy Group, and as a result, all three formations, is properly at Chazy, New York, where it was first described in 1888 by Brainard and Seely. Later, Hudson (1931) described the most completely exposed section of Chazy Limestone, found at the south end of Valcour Island, New York.

With the accumulation of abundant stratigraphic and paleontologic descriptions of the Chazy, it was proposed by both Grabau (1909) and Ulrich (1911) that the Chazy be assigned the time-stratigraphic rank of Stage, representative of all Post-Canadian, pre-Black River time, that is, the lower Middle Ordovician interval. The Chazy Stage was readily accepted although relationship of the Chazy and Black River beds could not be conclusively demonstrated due to geographic separation. At that time, there were no sections known in North America having a clearly unbroken Lower to Middle Ordovician sequence.

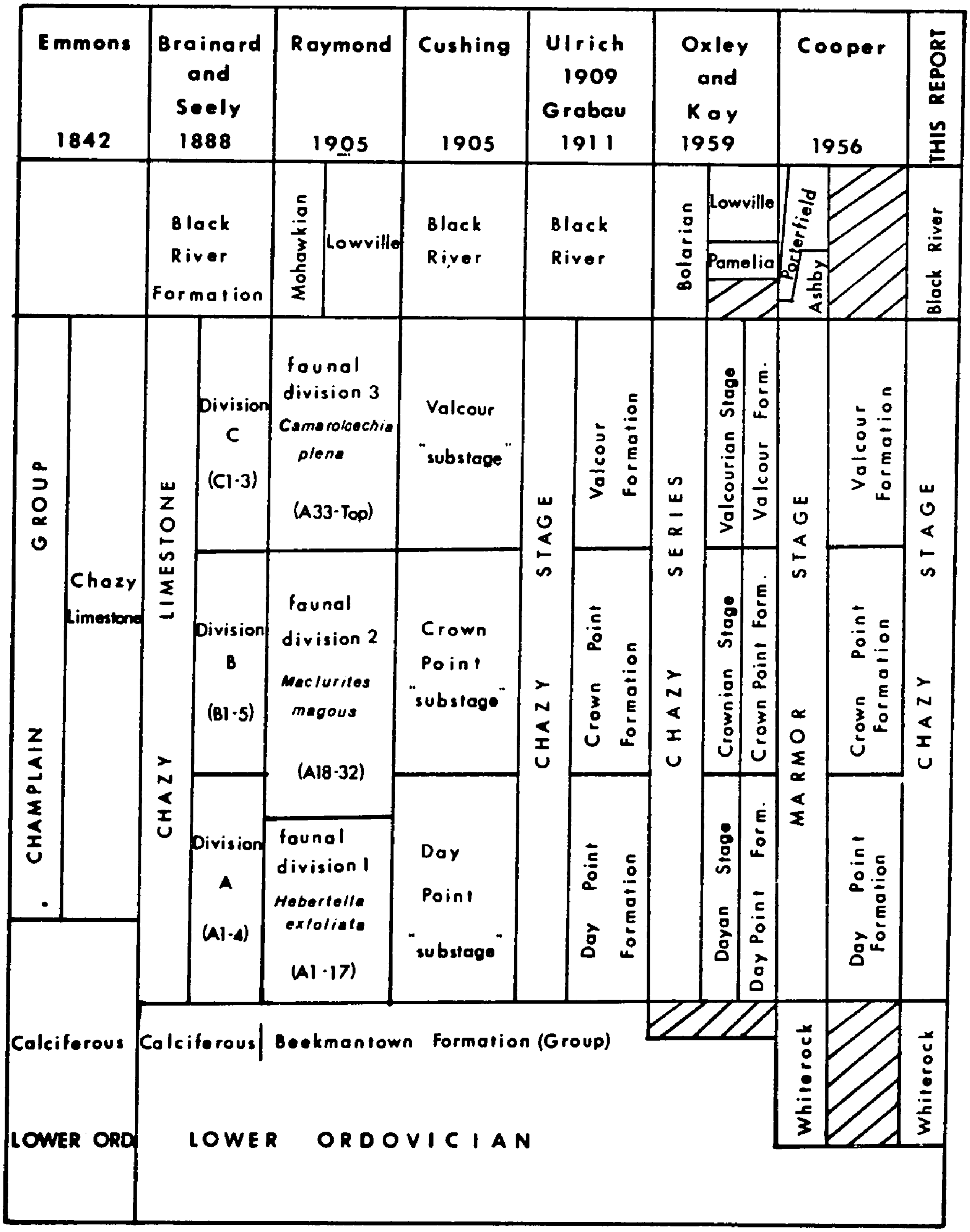
A further refinement of Chazy stratigraphy was attempted in 1959 by Oxley and Kay, who raised the Chazy to Series rank and established three Stages based on the formations of the Chazy Group. These were the Dayan, Crown Pointean, and Valcourean Stages. The proposal has not been accepted in subsequent investigations dealing with the Chazy (Shaw, 1969). The formations become indistinguishable within a short distance of the northern Champlain Valley immediate to Chazy village and it is improbable that formation boundaries are time lines even in that area. Figure 3 charts the development of Chazyan stratigraphic nomenclature.

History of Paleontologic Record

The fauna of the Chazy Limestone was one of the earliest studied in North America. Both Emmons (1842) and Hall (1847) discussed the fauna of the Chazy Limestone in early reports of the New York State Geological Survey. A Canadian report appeared shortly thereafter (Billings, 1859). Further discussion of Chazyan fossils followed with the report of Walcott (1879) and later, those of Hudson (1904, 1907).

The definitive compilation of the fossil content of

FIGURE 3.
DEVELOPMENT OF STRATIGRAPHIC NOMENCLATURE



the Chazy Limestone was presented by Percy Raymond in a series of reports (1905a&b; 1906; 1910a,b,&c; 1911b; 1916a &b). The stratigraphy at the most complete exposures of the Chazy Limestone was discussed and the sections were broken into faunal zones. Later reports dealt specifically with the trilobite, braciopod, pelecypod, and ostracode content of the Chazy.

Little descriptive paleontology was done on the Chazy fauna after the studies of Raymond until the last few decades. Renewed interest in the lower Middle Ordovician, spurred by doubt concerning Chazy correlative strata in the southern Appalachians, has resulted in a number of studies on the Chazy fauna. Flower (1952, 1955, 1958) described the nautiloids. J. P. Ross (1963a,b,&c; 1964a&b) described the bryozoans. The ostracodes were described by Swain (1957, 1962) while the conularids had been previously described by Sinclair (1942).

An important memoir, "Chazyan and related brachiopods," was published by G. A. Cooper (1956) who proposed in this volume new stages for the Middle Ordovician. A correlation chart for the Middle Ordovician of North America was also presented.

Shaw (1968) later studied the Chazyan trilobites. He described a diverse fauna in which the presence of many species was controlled by facies. However, he was unable to establish zones within the Chazy Group on the basis of his trilobite collections. Shaw therefore stated that the elevation of the Chazy to series rank, and the Day Point, Crown Point, and Valcour Formations to Stage rank, as proposed by Oxley and Kay (1959), could not be validated on the basis of trilobites.

Faunal lists for the Chazy Group in the Champlain Valley were presented by Oxley and Kay (1959) in their reexamination of Chazyan stratigraphy. Hofmann (1963) describes the stratigraphy for the Chazy equivalent Laval Group of the Montreal area. Faunal lists were presented for his proposed members of the Laval as well as for the Pamelia. The fauna of all but the upper Pamelia was considered to be Chazyan.

The Chazy contains some of the oldest bioherms known in the geologic record. Coral reefs have long been known to exist in the Chazy and were discussed by Raymond (1924). Chazyan stromatoporoids were discussed by Galloway and St. Jean (1961). Fossil communities, as well as spatial relationships of the reefs and associated facies, were described by Pitcher (1964) and Finks and Toomy (1969). The bioherms are mound-like, with dimensions to tens of feet in diameter and height, and usually clustered and cut by channels.

Macrofossil Zonation of the Chazy

It has been previously mentioned (p. 19) that in 1905 Raymond divided what was then called the Chazy Formation into three faunal zones and that these zones did not exactly correspond to the three lithologic divisions of the Chazy established by Brainard and Seely in 1888. Raymond felt that the zones he defined were valid throughout the Champlain Valley. The lowest was called the Hebertella exfoliata division, which approximately corresponds to the Day Point Formation. Brachiopods predominate in this zone, with trilobites and gastropods common as well.

The Maclurites magnus division of Raymond is approximately equivalent to the Crown Point Formation. The gastropod for which the division was named was long thought to be a guide fossil to rocks similar in age to the Crown Point, as it was found neither above nor below the middle division of the Chazy Group. However, when limestones from other areas containing this fossil which had as a result been correlated with the Chazy, proved by other evidence to be younger, dissatisfaction with the Chazy as a Stage was fostered. The use of Maclurites magnus in correlation was complicated by the fact that several other species of Maclurites are almost indistinguishable from M. mangus but have different ranges. The Crown Point is also notable for the presence of large nautiloids and a variety of pelecypods, ostracodes, and other gastropods.

The third faunal zone described by Raymond was the Camarotoechia plena division. The brachiopod for which the division was named, now Rostricellula plena, is found throughout but becomes common only in the middle of the division and is greatly predominant among the fauna of the upper portion of the division. The upper faunal zone corresponds to the present Valcour Formation. However, only the upper Valcour contains the Rostricellula plena beds, generally distinguishable from the limestones below.

It has become evident as study of the Chazy Group advanced that fossil distribution is more dependent on facies than stratigraphic position within the Group (Shaw, 1969). The fossils of each of Raymond's three divisions in many places are present in the other divisions if the proper lithology is developed. The few macrofossil species that remain limited to one or two of the three divisions are associated with facies not present elsewhere in the Chazy Group and are untrustworthy for time-stratigraphic correlation.

No consistent zoning of the Chazy has been possible on the basis of brachiopods (Cooper, 1956), bryozoans (Ross, 1963, 1964), or trilobites (Shaw, 1968). However, the fauna of the Chazy is diverse and many fossils and groups of fossils make their first appearance in the Chazy. These groups include the corals, stromatoporoids, pelecypods, and possibly the bryozoans (Shaw, 1969). As a result, the Chazy fauna is unlike those of the underlying Lower Ordovician strata.

Both the abundance and diversity of the fauna vary from bottom to top of the sequence. The lower Day Point contains few fossils and little faunal diversity. Upward in the Valcour, the fauna becomes less diverse than that of the Crown Point. The faunal diversity and abundance of fossils are at a maximum in the medial Chazy, from the upper Day Point through the lower Valcour Formations, largely due to the presence of bioherms in this interval. Coral, bryozoa, sponges, stromatoporoids, and algae all occur in these structures.

Lower Middle Ordovician in the Southern Appalachians

Subsequent to the proposals by Grabau (1909) and Ulrich (1911) of the Chazy Stage, it was discovered that the southern folded Appalachians contained numerous outcrop belts of Middle Ordovician limestones. Ages had to be assigned to these formations by comparison of faunas to the type sections of the Middle Ordovician stages in New York State. The problem was further complicated by rapid facies changes within the Middle Ordovician of these southern Appalachian strata and the inability of workers to trace units across the structural trend of the Valley and Ridge Province. The difficulties raised by facies change and structural complications led to attempts at simplification, such as those of Reudemann (1929) and Ulrich (1935), which proved inadequate and misleading as field relations became better appreciated.

Many local formations were correlated with the Chazy on weak stratigraphic and paleontologic evidence in ensuing geologic reports, such as that by Butts (1941). However, lithologic similarity proved to have little correlative value when thrust faults were crossed, so that "formations" which had been considered key horizons for sorting-out sections scattered throughout the Appalachians were seen to be merely similar facies at varying stratigraphic positions (B. N. Cooper, 1945, 1946). Thus, a unit's position relative to the "Lenoir" or "Athens" Formations, for example, had no time significance, as these formation names had been incorrectly overextended across outcrop belts and along strike. As it became evident through continued mapping efforts that many earlier correlations were incorrect, the number of Chazy equivalents dwindled.

The turmoil of rapid revisions in the Middle Ordovician section of the southern Appalachians preceded a suggestion made by John Rogers (in Twenhofel, 1954) that a new stage name based on a southern Appalachian locality replace the Chazy. The facts that the Chazy type section was remote from other Middle Ordovician outcrop areas and that its fauna seemed provincian were considered to be important objections to having this section serve as the type section of a stage. The first objection was an artifact of American geological history; the Chazy limestone was the first lower Middle Ordovician to be described. The second stemmed from inability to find whole faunas from the southern Appalachians with close affinities to the type Chazy, though many mutual presences were noted.

A new set of stages were proposed for the Middle Ordovician in 1956 by G. A. Cooper after extensive study of the silicified brachiopods (and associated macrofossil faunas) of this interval across North America. His stages are the Whiterock, Marmor, Ashby, Porterfield, and Wilderness. All but the Whiterock, based on a locality in Nevada, have their type sections in the folded Appalachians of Virginia and Tennessee. The Marmor Stage, based on a section north of Friendsville, Tennessee, was the supposed equivalent of the Chazy Group.

The Whiterock Stage was created for strata of the interval deposited prior to Chazy, or Marmor time, but post-lower Ordovician. Considerable paleontologic evidence compiled since has borne out the premise that pre-Chazy Middle Ordovician rock is found, notably at Table Head, Newfoundland, and in Nevada and Oklahoma (Whittington, 1963, 1965; Berry, 1960, 1960a). The Chazy was supposed by Ulrich (1911) and Raymond (1906, 1916, 1925) to include the entire lower Middle Ordovician interval and Kay (1958, 1962) has favored the retention of the Chazy Stage for this entire span of time despite the incomplete type section. The concept of a Whiterock Stage has found acceptance in most quarters.

The post-Whiterock Stages of Cooper do not satisfactorily answer the objections that were raised to the Chazy Stage. While the Chazy is isolated from the bulk of Middle Ordovician outcrop, the type sections of the new stages are not located on the same thrust sheets. Sections can be traced along strike belts to their end, but not across the belts. As a result, the stratigraphic relationships of the Marmor, Ashby, Porterfield, and Wilderness Stages can be demonstrated no better than the relationship of the Chazy and Black River Groups.

It also appears that faunas in the southern Appalachians are facies-controlled. These faunas are largely benthonic and their distribution is subject to the strong influence of paleo-environment at the site of deposition. This creates a "provincialism" that affects the southern Appalachian type sections as much as the area of Chazy outcrop. An example is the well known Christiania fauna (Ulrich, 1911; Butts, 1926) which is found in the type section of the Porterfield Stage. This fauna apparently transgressed from the southeast to northwest (Bergström, per. com.) and cannot be considered to represent the same range of time at all localities.

Several geologists feel that the incomplete improvement represented by Cooper's Stages (1956) over the preexisting Chazy Stage does not justify overturning established nomenclature (Flower, 1957; Shaw, 1968). Presently, the two sets of Middle Ordovician Stage names, from New

York and the southern Appalachians, may be considered provincial with neither having a clear advantage. It is my opinion that in this situation the Chazy Stage should not be dropped from the nomenclature by reason of its priority.

CONODONT BIOSTRATIGRAPHY OF THE CHAZY

The Fauna

Previous studies of Middle Ordovidian conodont faunas from North America and Europe have shown the presence of two distinct provincial faunas (Bergström, 1971a; Sweet, Ethington, and Barnes, 1971). One fauna, foung throughout most of North America, is referred to as the Midcontinent fauna (Bergström, 1971a). The second fauna is found in the Scandanavian area, Great Britian, and the southeastern most outcrop belts of the folded Appalachians. It is referred to by Bergström (1971a) as the North Atlantic fauna. There is little area where significant mixing of the two faunas occurs. Bergström (1971a) notes that collections from extreme southeastern outcrop belts of the Appalachians may be correlated with precision to the succession of conodont zones established by him in Sweden; however, these same collections cannot be correlated with conodont collections from Middle Ordovician outcrop belts a short distance to the northwest. There are only a few conodont genera that are common to both faunas.

Conodonts collected from the type Chazy Group belong largely to the Midcontinent fauna. Found in greatest abundance is the multielement species *Phragmodus tortus*. Other important constituents of the Chazy collections belonging to the Midcontinent fauna are *Plectodina* n. sp., *Belodina compressa*, and a variety of "fibrous" conodont form genera. The conodont fauna is listed below, with indication of form as opposed to multielement species and relative abundance of the species within the Chazy.

TABLE 1

Conodont species from the Chazy Group of the Champlain Valley and the equivalent Laval Group and St. Hyacinthe Limestone of Quebec.

	F.S.	M.S.	Freq.
Acodus sp.	X		N
Acontiodus sp. A	X		R
Acontiodus sp. B	X		R
Appalachignathus delicatulus Votaw (unpub. Ph.D. dissertation)		X	R
Belodella cf. *B. niger* (Serpagli)		X	C
Belodina compressa (Branson & Mehl)		X	C
Cardiodella tumudus (Branson & Mehl)	X		R
Cardiodella sp.	X		N
Chirognathus n. sp. A	X		R
Chirognathus n. sp. B	X		N
Curtognathus? sp. A	X		N
Curtognathus? sp. B	X		N
Curtognathus typa Branson & Mehl	X		N
Coelocerodontus digonius Sweet & Bergström	X		R
Distacodus n. sp. A	X		N
Distacodus n. sp. B	X		N
Drepanoistodus suberectus Votaw (unpub. Ph.D. dissertation)		X	C
Eoplacognathus lindstroemi (Hamar)		X	N
Eoplacognathus n. sp.		X	R
Erismodus radicans (Hinde)		X	R

TABLE 1 (cont'd)

Species	F.S.	M.S.	Freq.
Multioistodus cryptodens (Mound)		X	R
Multioistodus subdentatus Cullison		X	R
New genus, new species		X	R
Oistodus aff. *O. angulatus* Bradshaw	X		
Ozarkodina ctenulata Youngquist & Cullison	X		N
Ozarkodina sp.	X		N
Panderodus gracilis (Branson & Mehl)		X	A
Panderodus panderi (Stauffer)	X		R
Phragmodus inflexus Stauffer		X	-
Phragmodus tortus Sweet		X	A
Periodon aff. *P. aculeatus* Hadding		X	N
Plectodina aculeata (Stauffer)		X	C
Plectodina pristina Raring, n. sp.		X	A
Polyplacognathus friendsvillensis Bergström		X	C
Polyplacognathus sweeti Bergström		X	C
Pseudophragmodus champainensis Raring, new genus, n. sp.	X		N
Scandodus n. sp.	X		N
Scolopodus quadraplicatus Branson & Mehl	X		N
Thrincodus palaris Raring,	X		R
new genus, n. sp.	X		R
Trucherognathus? sp.	X		N

F.S. = form species
M.S. = multielement species
Freq.: A = abundant; C = common; R = rare; N = negligible

The Chazy Group also contains conodonts belonging to the North Atlantic faunal province. Notable are platform elements of the genera *Polyplacognathus* and *Eoplacognathus*. They are found in only a small number of Chazy samples but when present, may be a significant component of the fauna. In a few samples, elements doubtfully assignable to the multielement genus Periodon were found, but due to the rarity of elements the species could not be determined.

There are several genera of conodonts which are to a large degree restricted to areas transitional between the two major faunal provinces. One such area is now represented by outcrop belts in the folded Appalachians that lie neither in the northwest nor in the southeasternmost extremity of the structural province. Belodella and Appalachignathus are represented in the Chazy and also found in Appalachian outcrop belts. Previous reports of their distribution indicate they are not restricted to the centers of the Midcontinent or North Atlantic faunal provinces.

A few forms belonging to what Bergström (1971a) has termed the "australian" fauna also are present in the Chazy collection. These conodonts have long delicate denticles carried on two or three processes and may easily be distinguished from the bulk of Chazy conodonts by general appearance alone. Conodont elements of this nature are reported to be the dominating components of the few Middle Ordovician rocks of Australia so far examined (Bergström, per. com.).

It became apparent during this study that conodont distribution was to some degree ordered, and, further, that certain components of the fauna were limited to only a few horizons within the sequence. Within the Day Point Formation of the northern Champlain Valley a zone in the lower

Fluery Limestone Member was found consistently to yield platform conodont elements. The Fleury Member is the uppermost of the four Day Point members but also by far the thickest, so the zone bearing platform conodonts is roughly in the middle of the formations. Lower in the section samples from the base of the Scott Limestone, the second of the four members, produced large Midcontinent faunas. A horizon within the upper Fleury Member also was found to contain abundant Midcontinent forms. The lower Crown Point Formation consistently was unproductive of conodonts. The upper Crown Point was variably productive, with two horizons at Valcour Island yielding platform conodonts. The Valcour Formation was also variably productive, with all samples that proved at least moderately productive coming from the middle and upper, but not uppermost, portions of the section. These comments on conodont distribution within the Chazy must be tempered by the fact that less than ten sections collected are continuous through one formation and there are only three reasonably complete sections in the type area.

CONODONT ZONATION OF THE CHAZY

The conodont collected in this study allow recognition of four zones within the Chazy of the Champlain Lowland and the nearby Laval Group of the Montreal area; each is based on the presence of one or two species. The lowest zone corresponds to the range of *Eoplacognathus* n. sp. and is succeeded by the *Polyplacognathus friendsvillensis* and *P. sweeti* zones. The uppermost zone is less well defined but seems marked by a fibrous fauna having *Cardiodella tumudus*, no platform conodont elements, and *Plectodina aculeatus* as well as *P. pristina*. Strata within the Chazy Group which are unproductive of these guide fossils include the lowermost Day Point Formation and the lower through middle Crown Point Formation.

The zone of *Eoplacognathus* n. sp. includes the lower, but not lowermost, Day Point Formation and ranges through the lower portion of the Fleury Member. Its upper limit excludes the upper portion of the Day Point, as the Fleury Limestone is by far the thickest of the four members. *Eoplacognathus* n. sp. has not previously been reported in the literature.

The zone of *Polyplacognathus friendsvillensis* includes the upper Day Point Formation, the middle and upper Fleury Limestone Member, and an indeterminable portion of the lower and middle Crown Point Formation. *Polyplacognathus friendsvillensis* has a distinctive ambalodiform element that allows the species to be separated from *Eoplacognathus* n. sp. which possesses a similar polyplacognathiform element. At Friendsville, Tennessee, the type section of the Marmor Stage, *P. friendsvillensis* ranges through all but the lower Lenoir Limestone and into the overlying Arline Formation.

The presence of *Polyplacognathus sweeti* defines a third zone which encompasses the upper Crown Point through middle Valcour strata. *P. sweeti* is easily distinguishable from *P. friendsvillensis* and has been reported to succeed the range of P. friendsvillensis in the southern Appalachians as well (Bergström, 1971a).

The upper Valcour Formation does not contain platform conodont elements. Faunal diversity decreases in this interval. This is true for macrofossil taxa as well. The conodont fauna contains *Plectodina pristina* n. sp. as does the entire Chazy Group but also contains *Plectodina aculeata*. Further, it appears that the "fibrous" conodont form species *Cardiodella tumudus* is limited to the upper Valcour. A higher proportion of "fibrous" elements is found in the upper Valcour beds than in the bulk of the Chazy Group.

The four zones listed above are applicable only to those samples from portions of the sections containing the guide fossils. Many Chazy samples did not yield the species needed to determine placement within the group on the basis of conodont content alone. As has been mentioned, beds productive of a diverse and abundant conodont collection are limited to a few horizons within the Chazy. The zone best defined is that of *Polyplacognathus sweeti* which is often present in samples taken throughout the range of that species in the Chazy Group. The uppermost, Cardiodella tumudus, zone, being partially based on the negative quality of not containing platform conodont elements, is the least satisfactorily defined. Many samples from the Day Point Formation as well as all samples from the lower and middle Crown Point Formation do not contain the platform elements needed for assignation of those strata to one of the conodont zones.

Age of the Chazy

Two standards are available for reference in assigning an age to Middle Ordovician strata on the basis of the contained conodonts. A sequence of faunas occurring within the Midcontinent Province has been described by Sweet, Ethington, and Barnes (1971); while Bergström (1971a) has defined zones within the Middle Ordovician sequence of Sweden, applicable to collections from the North Atlantic Province. As yet, a means of correlating the Midcontinent conodont faunas to the conodont zones of the North Atlantic Province has not been established. Only a few nondiagnostic conodont types occur in both faunal provinces and no sections which contain a significant number of mutual occurrences are known.

The conodont fauna of the Chazy Group is predominantly of Midcontinent aspect. It can be correlated to faunas five and six of Sweet, Ethington, and Barnes (1971). This correlation is based on the presence throughout the Chazy

Group of the multielement species *Phragmodus tortus* Sweet, ms. Both faunas five and six are described as containing this species; while fauna seven is characterized by the presence of a direct descendant, *Phragmodus inflexus* Votaw. However, from inspection of extensive collections of Middle Ordovician conodonts at The Ohio State University, it appears that the *Phragmodus* present in fauna six is distinguishable from *P. tortus* of the Chazy and fauna five. The phragmodiform element from collections of the type Llandeilo of Wales and the type Porterfield of Virginia appears to be more delicate and less contorted than the phragmodiform element of *Phragmodus tortus* from the McLish Formation of Oklahoma or from the Chazy. Consequently, it is suggested that the Chazy fauna is correlative to fauna five and an indeterminable lower portion of fauna six. It must be noted that in the summary of Middle Ordovician conodont biostratigraphy of North America it was stated that the components of both faunas six and, particularly, five were still largely undescribed (Sweet and others, 1971).

The few species of *Polyplacognathus* and *Eoplacognathus* that are present in the Chazy Group allow its correlation to the Swedish succession of conodont zones established by Bergström (1971a). The Chazy falls within the *Pygodus serrus* and lower *Pygodus anserinus* zones. Although neither of the species for which the zones were named are present in Chazy collections, their mutual presence with the platform types present in the Chazy has been described from several localities in the southern Appalachaisn (Bergström, 1971a).

The two most common platform conodont species found in the Chazy are Polyplacognathus friendsvillensis and P. sweeti. The former is found in the lower portion of the Chazy Group while the latter is found in the upper portion, and is a direct descendant of P. friendsvillensis. In previous studies P. friendsvillensis has been limited to the Pygodus serrus zone and P. sweeti has been confined to the Pygodus anserinus zone. The zonal boundary falls somewhere within the lower or middle Crown Point formation. The lack of platform conodonts in that interval prevents a more precise assignment of the zonal boundary within the Chazy.

There are two lines of evidence for determining the lower age limit of the Chazy. The first is the presence in the Day Point formation of a transitional series of forms of Polyplacognathus friendsvillensis similar to the one found in the Lenoir Limestone at Friendsville, Tennessee, described by Bergström (per. com.). At that locality, the type section of the Marmor Stage, Eoplacognathus foliaceus is found in the upper portion of the Lenoir well above the lowest occurrence of P. friendsvillensis. This indicates that the range of P. friendsvillensis extends to the bottom of the Pygodus serrus, as Eoplacognathus foliaceus defines the lowest subzone (Bergström, 1971). By analogy, the lower Chazy would include the entire *Pygodus serrus* zone.

The second line of evidence bearing on the lower age limit of the Chazy is the direct occurrence of species of the genus *Eoplacognathus* within the lower Chazy. The species of this genus define four subzones of the *Pygodus serrus* zone. At the St. Hyacinthe, Quebec, road cut (Kay, 1958; Hofman, 1963) platform conodonts similar to *Eoplacognathus foliaceus* are found toward the base of the section. These strata, comprising the St. Dominique Limestone, have long been considered to be Chazy equivalents. However, the few *Eoplacognathus* elements recovered from the Day Point in the type area of the Chazy resemble younger species. *E. lindstroemi*, guide to the uppermost of the four subzones of the *Pygodus serrus* zone, has previously been reported from the Upper Day Point (Raring, *et.al*, 1969). Forms resembling *E.* n. sp. A. Bergström (1971a) have been found in the middle Day Point. This species is limited to the third, or *E. robustus*, subzone in the Swedish sections. The specimens of *Eoplacognathus* bearing a resemblance to *E. foliaceus* probably represent a new species.

The presence of the primitive form of *Polyplacognathus friendsvillensis* in the type section of the Chazy and the presence of forms similar to *Eoplacognathus foliaceus* in the Chazyan St. Dominique Limestone

FIGURE 4

(Following page)

Conodont zonation of the North Atlantic Province and its relation to Swedish formational units, British graptolite zones, and North American Stages in the Middle Ordovician

(After Bergström, 1971)

BRITISH SERIES	GRAPTOLITE ZONES	SWEDISH STAGES	SWEDISH FORMATIONAL UNITS		CONODONT ZONES	SUBZONE	NORTH AMERICA STAGES N. Y.	NORTH AMERICA STAGES S. APPAL.
							TRENTON	TRENTON
CARADOCIAN	*Diplograptus multidens*	IDAUERAN	DALBY LS		*Amorphognathus tvaerensis*	*Prioniodus alobatus*	BLACK RIVER	WILDERNESS
						Prioniodus gerdi		
	Nemagraptus gracilis	KUKRUSEAN				*Prioniodus variabilis*		PORTERFIELD
LLANDEILIAN					*Pygodus anserinus*	upper	?	ASHBY
	Glyptograptus teretiusculus	UHAKUAN	FURUDAL LS	RYD LS		lower	CHAZY	?
LLANVIRNIAN				GULHÖGAN FORMATION	*Pygodus serrus*	*Eoplacognathus lindstroemi*		UNNAMED
						Eoplac. robustus		
	?	LASNAMÄGIAN	FOLKESLUNDA LS	SKÖVDE LS		*Eoplac. reclinatus*		MARMOR
			SEBY LS			*Eoplac. foliaceus*		
	Didymograptus murchisoni	ASERIAN	SKÄRLÖV LS					WHITE-ROCK
			SEGERSTAD LS			*Eoplac. suecicus*		

approximately 60 miles to the northnortheast are considered evidence that the Chazy encompasses the entire Pygodus serrus zone. However, this correlation is not considered to be unequivocal because of the doubt about the time relationship of Eoplacognathus n. sp. from the lower Chazy to E. foliaceus identified from the Lenoir Limestone at Friendsville, Tennessee and guide fossil to the E. foliaceus subzone of the Pygodus serrus zone.

There is only one line of evidence that allows correlation of the upper limit of the Chazy Stage to the North Atlantic zonation of Bergström (1970). In the middle and lower Valcour Formation Polyplacognathus sweeti is present in a form thought to be more primitive than previously described specimens of P. sweeti, which were limited in distribution to the lower portion of the upper subzone of the Pygodus anserinus zone. This suggests that the upper limit of the Chazy is equivalent to the boundary between the lower and upper subzones of the Pygodus anserinus zone. However, neither of the conodont species used to separate the lower and upper subzones of the Pygodus anserinus zone are present in the Chazy and no Polyplacognathus sweeti is present in the uppermost Valcour beds.

Chazy Correlative Strata: Southern Appalachians and Elsewhere

The Maromor Stage, proposed by G. A. Cooper (1956) as a replacement for the Chazy Stage, was based on a section of Lenoir Limestone at Friendsville, Tennessee. Results of the study of Chazy conodonts indicate that the Marmor Stage only represents the lower portion of the Chazy stage. Study of conodont collections from the type Marmor and other sections of Lenoir Limestone and super-adjacent strata in Tennessee at The Ohio State University confirms the conclusion of previous investigators (Shaw, 1968; Bergström, 1971a) that there is no unconformity between the Lenoir and Arline Limestones in the Marmor type section, as Cooper had stated. Instead, the Arline represents an interval of time that was undefined in Cooper's sequence of Stages. This interval is included in the upper portion of the Chazy Stage.

The Ashby Stage has its type section at Hogskin Valley, Tennessee, and according to Cooper (1956), immediately follows the Marmor Stage. However, conodonts collected from the nearby Thorn Hill section by Mr. Jack Carnes of The Ohio State University indicate that the lower Ashby belongs to the upper _Pygodus anserinus_ subzone (per. com.). The same conclusion was reported by Bergstrom (1971a) based on conodonts collected by Dr. Perry Wigley from strata in Virginia which were assigned by Cooper (1956) to the lower Ashby Stage. From this evidence it appears that the Ashby follows the Chazy without significant break or overlap. However, conodont elements assigned to _Amorphognathus traerensis_?, a younger taxon, are reported from beds below the type Ashby (Bergström, per. com.). A small gap or overlap in time between the Chazy and Ashby must be allowed due to the great geographic separation of the type sections of the two stages and lack of sufficient numbers of conodonts diagnostic to the North Atlantic faunal zonation. A gap of much longer duration exists between the two stages if the presence of Amorphognathus tvaerensis below the type section of the Ashby Stage is confirmed.

The Porterfield Stage was defined by Cooper (1956) as representing post-Ashby pre-Wilderness time and was based on a section in a quarry at Porterfield, Virginia. Examination of conodont collections from this section at The Ohio State University suggests that the lower Porterfield Stage somewhat overlaps the upper Chazy Stage or follows immediately upon the Chazy. Bergström (1971a) assigned the Porterfield to the upper subzone of the Pygodus anserinus zone and the lower portion of the succeeding zone. Specimens of Polyplacognathus sweeti collected from the base of the section at Porterfield appear to represent a later stage of development than specimens of P. sweeti collected from the Chazy. Similarly, the phragmodiform elements of Phragmodus tortus in the Porterfield collection appear to represent a younger stage of development than analogous elements of P. tortus in the Chazy collection.

The lower, and perhaps entire, Ashby and Porterfield Stages represent the same interval of time on the basis of conodont biostratigraphy. Also, an undefined interval of time exists between the Marmor and Ashby-Porterfield Stages. The Chazy represents at least most and probably all of the Marmor and the entire interval above the Marmor and below the Ashby and Porterfield Stages. The retention of the Chazy Stage would serve to completely define the post-Whiterock pre-Ashby-Porterfield interval. As less attractive alternatives, the Marmor could be redefined to include the majority of the Arline Formation in the type section or a new stage could be designated. The Chazy Stage has priority over the Marmor Stage and does not require redefinition.

The McLish and Tulip Creek Formations of the Simpson Group in the Arbuckle Mountains of Oklahoma contain _Phragmodus tortus_, placing those units in faunas five and six of the Midcontinent Province. Although there are several genera in the McLish and Tulip Creek faunas that are not found in the Chazy, the similarity of the faunas to the Chazy fauna is marked. The lower Simpson Group Joins and Oil Creek Formations contain a fauna dissimilar to that of the Chazy but said to characterize the Mid-continent faunas one, two, and three found elsewhere in North America from rock of supposed Whiterock age (Sweet, Ethington, and Barnes; 1971). Similar conodont faunas have been found elsewhere; Nevada and Newfoundland are two reported locations (Sweet, Ethington, and Barnes, 1971; Fahreus, 1970). However, these faunas are not yet considered zones as their relation to the succeeding midcontinent fauna five is still not clear.

Strata of Chazy age are apparently present in Missouri. There, the Dutchtown Formation overlies the St. Peter Sandstone and contains Phragmodus tortus. The genus Multioistodus is abundantly represented in the Dutchtown and is also present in the McLish and Tulip Creek Formations of Oklahoma. The Chazy Group contains M. subdendatus, found in the Dutchtown, and M. cryptodens, found in the McLish and Tulip Creek. Above the Dutchtown, the Joachim Dolomite contains a fauna comprised almost exclusively of fibrous conodont elements, many of which are present in the Chazy Group as minor components of the fauna.

By reference to the succession of formational units from which Bergström (1971a) defined his Swedish conodont zonation it is possible to list those units equivalent to the Chazy Group. They are the uppermost Skarlov Limestone, Seby Limestone, Folkeslunda Limestone, and Furudal Limestone. These units include the four upper subzones of the Pygodus serrus zone and the lower subzone of the Pygodus anserinus zone of the 1971 report. The lowest of the five subzones was later excluded from the P. serrus

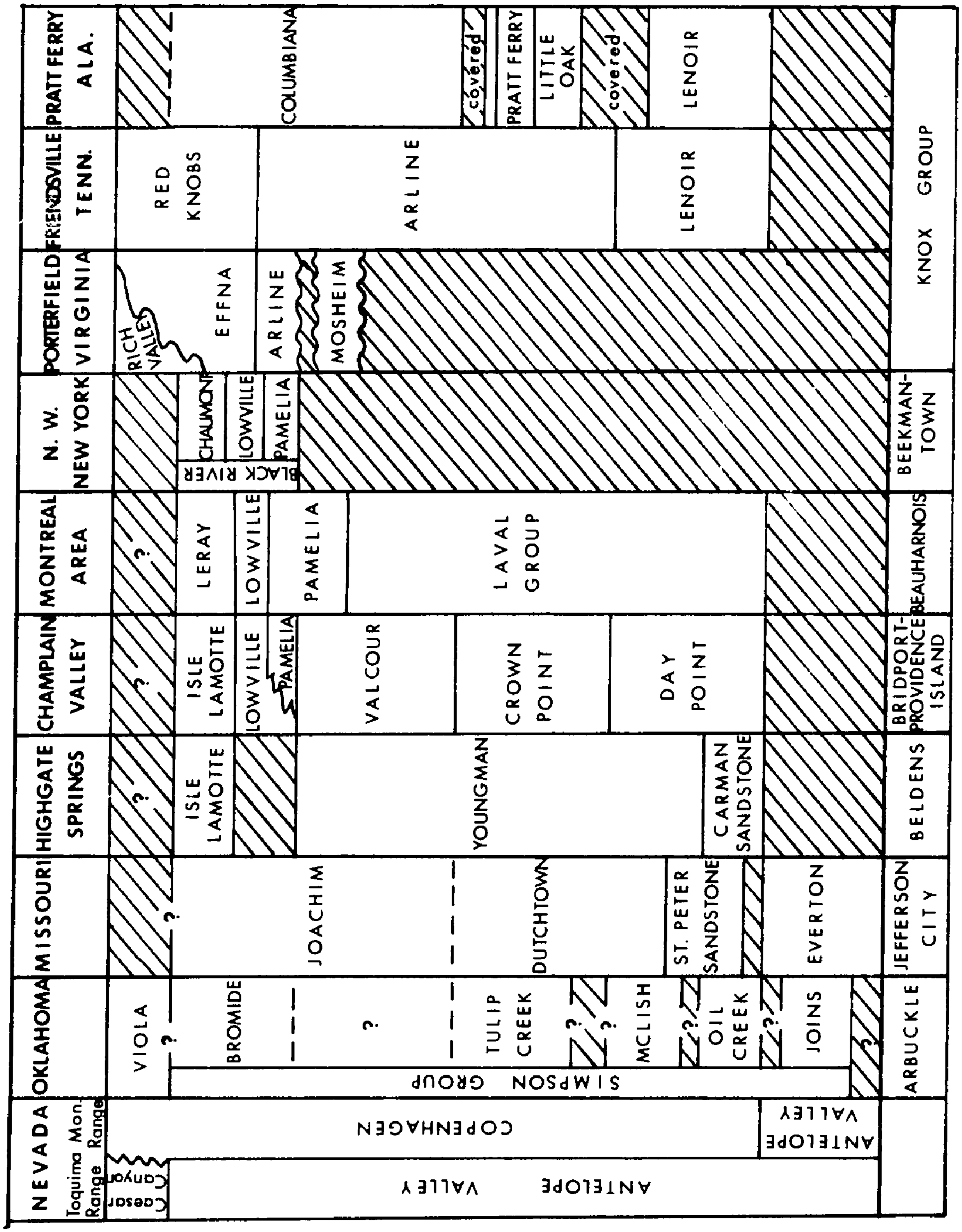


FIGURE 5

CORRELATION CHART

zone (Bergström, 1971b), making the Chazy equivalent beds representative of the entire zone.

SUMMARY OF CONCLUSIONS

Four major conclusions have been reached during study of conodonts from the Chazy Group. They are listed and briefly discussed below.

1. The Chazy Group of the Champlain Valley and the equivalent Laval Group of the Montreal area may be divided into four zones on the basis of conodonts. These are the lowest *Eoplacognathus* n. sp. zone, corresponding to the Day Point Formation exclusive of the lowermost beds and the middle and upper Fleury Member; the *Polyplacognathus friendsvillensis* zone, corresponding to the middle and upper Fleury Member of the Day Point; the *Polyplacognathus sweeti* zone, corresponding to the upper Crown Point through medial Valcour Formations; and an uppermost zone representing upper Valcour strata and marked by the presence of *Cardiodella tumudus* and *Plectodina aculeata*. An interval including lower and middle Crown Point strata could not be zoned.

2. Other Middle Ordovician strata correlative to the Chazy include the Laval Group and Lower Pamelia Formation of the Montreal area, the St. Hyacinthe Limestone of Quebec, and the Youngman Formation of Vermont. Corre-

lative strata more distant from the Chazy include the Lenoir Limestone and lower Arline Formation at Friendsville, Tennessee; the Lenoir, Little Oak, Pratt Ferry, and lower Columbiana beds at Pratt Ferry, Alabama; the Dutchtown and perhaps the Joachim Formations of Missouri; and the McLish and Tulip Creek Formations of Oklahoma.

3. The age of the Chazy Group is best measured in terms of the conodont zonation of the Middle Ordovician established by Bergström (1970) for the Swedish sequence. The lower Chazy represents the upper portion of the *Pygodus serrus* zone and probably represents the lower portion of that zone as well. The upper Chazy represents the lower subzone of the *Pygodus anserinus* zone and perhaps a portion of the upper subzone.

In terms of the Midcontinent faunas described by Sweet, Ethington, and Barnes (1970) the Chazy is equivalent to fauna 5 and at least the lower portion of fauna 6. These faunas are not formalized to zones however.

The Chazy Stage is equivalent to the Marmor Stage and a younger interval of time undescribed in the sequence of southern Appalachian Stages. The uppermost Chazy may be equivalent to the lowest portion of the Porterfield Stage.

4. The Chazy Stage should be retained as representative of the post-lowest Middle Ordovician (Whiterock), pre-middle Middle Ordovician (Porterfield, Black River,

Bolarian) interval. The type section for the stage remains at Chazy village, New York.

SYSTEMATIC PALEONTOLOGY

Genus ACODUS Pander, 1856

Type species: *A. erectus* Pander, 1856

ACODUS sp.

Pl. 4, fig. 22

Description: Several Chazy specimens fit the general morphologic plan of the genus *Acodus*, being simple asymmetric cone units having longitudinal costae on only one lateral face. The unit is mildly compressed laterally with rounded anterior and posterior margins. The anterior margin is deflected to one lateral side, producing a longitudinal costa on that side. The lateral faces are smooth.

The base is continuous with the cusp and increases in height posteriorly to the basal opening. The outline of the basal cavity is obscured by the blackened condition of the few specimens.

Occurrence: The several specimens found are from the Day Point and Crown Point Formations.

Genus ACONTIODUS Pander, 1856

Type species: *A.* erectus Pander, 1856

ACONTIODUS sp. A.

Pl. 4, figs. 3, 23

Description: Simple, recurved cones, symmetric to subsymmetric in plan. The few speciments in the Chazy collections are small and compact in appearance. The base is continuous with the cusp. The basal cavity is obscured by the dark color of the speciments but apparently is fairly deep and conical. The cusp recurves through 90° at one half its length above the base. The anterior margin of the cusp is broadly convex. A longitudinal costa divides the two lateral faces of the cusp. The postero-lateral surfaces are concave and terminate posteriorly at two sharp-edged postero-lateral costae. These are joined by a v-shaped shallow despression on the posterior surface of the cusp. The distal portion of the cusp is missing in all specimens.

Remarks: *Acontiodus* sp. A resembles *A. alveolaris* Stauffer in general plan but the latter species has the lateral costa developed to flange-like ridges while the former species has gently rounded and subdued lateral costa, reflecting a lack of compression in the anterior-posterior direction. *Acontiodus cooperi* Sweet and Bergström also is similar in plan but shows slight lateral compression while *Acontiodus* sp. A is not compressed along either horizontal axis. In *Acontiodus cooperi* the antero-lateral faces are flat and join in a rounded anterior keel while *A*. sp. A is smoothly convex across the anterior region of the cusp. Also, the lateral costa is developed into a posteriorly directed ridge and has a deep groove posterior to it in *A. cooperi* while *A*. sp. A has only shallow, smoothly rounded lateral topograpy.

Occurrence: Acontiodus sp. A apparently ranges throughout the Chazy Group but is negligible in the lower Day Point Formation and rare in the upper Day Point, Crown Point and Valcour Formations.

ACONTIODUS sp. B

Pl. 4, fig. 9

Description: Simple suberect cone elements with several blunt costae in asymmetric placement are placed in Acontiodus sp. B. The oral edge is continuously curved through more than 90° becoming the posterior margin of the cusp. Basally, two postero-lateral costae border a flat posterior face with a second longitudinal costa just anterior of the cusp's median axis on each lateral face. Distally these four costae migrate in position to become asymmetrically disposed. One lateral costa migrates anteriorly and becomes better developed distally. The cusp is flexed slightly to the side of this large antero-lateral costa.

The base can only arbitrarily be differentianted from the cusp. It is narrow and marked with a rounded lisp of material within the basal cavity beyond the basal margin.

The basal cavity appears conical but its depth can not be determined.

Remarks: The few specimens in the Chazy collection display a variability of form but all have the rounded lip of basal filling. They are small in size and have their distal extremities broken.

Occurrence: Upper Day Point through Valcour Formations.

Genus APPALACHIGNATHUS Votaw, 1971

Type species: *Appalachignathus delicatulus* Votaw, 1971

The multielement genus *Appalachignathus* was defined by Votaw (1971) as including three elements in a symmetry transition series and a falodiform element. The first three elements are small forms assignable in general plan only to eoligonodiniform, zygognathiform and trichonodilliform morphologies. The falodiform element, on the other hand, is both robust and more frequently recovered. All four are unmistakably unique from previously described Middle Ordovician forms. Elements assigned to the new genus *Appalachignathus* are found in the folded Appalachians and the Basin and Range Province of Nevada in negligible numbers.

The genus Appalachignathus will soon be formally introduced in the literature by Bergström and others in a joint publication.

APPALACHIGNATHUS DELICATULUS Votaw

Pl. 2, figs. 4, 7, 10, 11.

Coleodus n. sp. ETHINGTON & SCHUMACHER, p. 458, Pl. 69. fig. 6

New Genus B. ETHINGTON & SCHUMACHER, p. 479, Pl. 67, fig. 18, Text.-fig. 4H.
Oepicodus aff. O. copenhagenensis, n. sp. ETHINGTON AND SCHUMACHER p. 465, Pl. 68, fig. 14, Text.-fig. 4I

Description: The coleodiform element has short, reclined, and laterally fused denticles of equal size on a tall anterior blade process which is compressed and curved laterally and has a narrow basal slit excavated along its length. In the posterior region the denticles decrease in size rapidly the last being recurved and taken to represent the cusp of the element. Beneath the cusp the basal sheath extends aborally a greater distance on the outer lateral side while the aboral margin on the inner lateral side forms a lip-like longitudinal ridge. Proceeding anteriorly this inner lateral ridge declines aborally until both the inner and outer aboral margins are at the same level.

The three types of elements of the symmetry transition series are small and have two processes bearing delicate laterally confluent denticles. The first type is trichonodelliform in plan but does not have lateral processes diverging from the central axis of the cusp. Instead, the lateral process on each side inclines aborally and is confluent with the basal continuation of the cusp, which itself is little larger than the vertically oriented denticles of the processes and poorly distinguishable from them. The one trichodelliform element recovered was lost while attempting to obtain a photograph.

The other two elements are symmetrical units of modified zygognathiform and eoligonodiniform plans. In both cases the slender denticles are laterally confluent through most of their length making delicate blade-like compressed processes dissimilar to typical zygognathiform and eoligonodiniform elements. These processes give the elements a fan-like appearance. Both elements have the more posterior of the two lateral processes more prominently developed with the trend toward one dominant and close to posterior process culminated in the eoligonodiniform elements while the two processes are subequally developed and still lateral in the zygognathiform elements.

Occurrence: Elements of Appalachignathus delicatulus are found in the Upper Crown Point and Valcour Formations.

Genus BELODELLA (Ethington), 1959

Type species: Belodus devonicus Stauffer, 1940

BELODELLA cf. B. NIGER (Serpagli)

Pl. 1, fig. 10; Pl. 2, figs. 13,14,17; Pl. 4, figs. 16,17, 19,20

Oistodus niger SERPAGLI, 1967, p. 79, 80, Pl. 20, figs. 1a-7d.
Oistodus sp. LINDSTRÖM, 1959, p. 440, 441, Pl. 3, fig. 13.
Oistodus sp. SERPAGLI & GRECO, 1965, p. 203, Pl. 35, figs. 7,8.
Oistodus breviconus Branson & Mehl, HAMAR, 1966, p. 63, Pl. 1, fig. 19
Belodella erecta (Rhodes & Dineley) SERPAGLI, 1967, p. 54, p. 611, figs. 1a-6c.
Oepikodus copenhagenensis ETHINGTON & SCHUMACHER, 1964, p. 465, Pl. 68, figs. 5,9, Text-fig. 46.
Oistodus nevadensis ETHINGTON & SCHUMACHER, 1969, p. 467, 468, Pl. 68, figs. 5,9, Text-fig. 46.

New Genus A., ETHINGTON & SCHUMACHER, 1969, p. 478, 479, Pl. 668, fig. 12, Text-fig. 4J.
"Eoligonodina" sp., ETHINGTON & SCHUMACHER, 1969, p. 480, Pl. 68, fig. 17.
Belodella sp. A. FAHRAEUS, 1970.
Belodella n. sp. A, BERGSTRÖM, 1970, p. 118.
Belodella n. sp. B, BERGSTRÖM, 1970, p. 118.
Belodella niger (Serpagli) VOTAW, 1971, p. 61-65, Pl. 3, figs. 7-11, Text-fig. 6a-d.

Description: The four form species which comprise the multielement species Belodella niger have been described by Votaw (1971) and will only be mentioned briefly below. Three elements are belodelliform in plan and form a symmetry transition series. The remaining element is oistodiform in plan. The Chazy elements are small, similarly preserved, and stratigraphically associated. The Chazy forms appear indistinguishable from specimens of B. niger in Votaw's collection yet both Chazy and Black River elements may eventually prove to be species separate from Belodella niger Serpagli.

The oistodiform element is asymmetric, having a recurved laterally compressed cusp both twisted and bent toward the inner lateral direction. The anterior margin of the cusp and base forms a smooth curve. The base is extended posteriorly, has sinuous aboral margins, and a smoothly curved posterior oral margin intersecting the sharp-edged posterior margin of the cusp at a 30 degree angle.

The three belodelliform elements describe a symmetry transition series which ranges from an asymmetric element with indistinct denticulation to a symmetric unit having discrete vertically oriented denticles on the oral margin of the base. The intermediate form is clearly denticulated but with an asymmetrically developed base. All have cusps to some degree proclined from the oral margin of the base.

The base of the asymmetric form has one planar lateral face while on the other lateral face a longitudinal costa runs parallel and close to the aboral margin. The basal cavity opens posteriorly and extends anteriorly a short distance into the proclined cusp. Denticles on the oral surface of the base are confluent through much of their length and compressed, forming a flange-like structure continuous with the posterior margin of the cusp. This flange is opaque in Chazy specimens, obscuring the denticulate structure.

The intermediate form has a costa on each of the aboral lateral margins but one is more pronounced than the other. Vertically oriented peg-like denticles are more discrete than the first form but are also limited to the oral margin of the base. The cusp is twisted slightly with regard to the base and is proclined.

The symmetric element has the two longitudinal aboral-lateral costae equally developed and has a more proclined cusp bearing denticles on the posterior margin continuous with those on the base. The unit is not flexed along its axis.

Remarks: Votaw (1971) credits the grouping of the four form species into the multielement species to Dr. Stig Bergström, who has found these elements in extensive collections from the Middle Ordovician in the Appalachians. However, Bergström (1971a) reported the presence of two new species of *Belodella* in the Lenoir Limestone of Tennessee. The other findings of elements of *Belodella niger* listed by Votaw were from Middle Ordovician rock of Black River age and younger. All four types of elements are common in the Chazy Group but perhaps due to poor state of preservation could not be differentiated from the Black River specimens of Votaw or the Marmor specimens of Bergström. It appears that *Belodella niger* was a long ranging species but may have undergone gradual evolution from Marmor to Black River time. It may prove possible through further study to describe at least two species as Bergström has indicated with mention of *Belodella* n. sp A and n. sp. B from the Lenoir at Friends Church, Tennessee. For the present the elements from the Chazy Group are assigned to *Belodella* cf. *B. niger* for lack of any clean distinctions from Votaw's Black River specimens.

Occurrence: Elements belonging to *Belodella* cf. *B. niger* are present in modderate abundance throughout the Chazy.

Forms assignable to *Belodella*, but divisible by Bergström (1970) into two species are present throughout the type section of the Marmor Stage. Belodella niger is present in rock younger than the Chazy from several locations, including Tennessee (Votaw, 1971) and Nevada (Ethington and Schumacher, 1969).

Genus BELODINA Ethington, 1959

Type species: B. compressa (Branson & Mehl), 1933

BELODINA COMPRESSA (Branson & Mehl)

Pl. 4, figs. 1,2.

Belodus compressus BRANSON & MEHL, 1933, p. 114, Pl. 9, figs. 15,16.

Belodina compressa (Branson and Mehl) BERGSTRÖM & SWEET, 1966, p. 312-315, Pl. 31, figs. 12-19 (includes synonymy through 1966): VOTAW, 1971, p. 64-66, Pl. 3, figs. 36,40,41 (includes synonymy 1966-1971).

Remarks: Where the form species Belodina compressus is present in Chazy samples in sufficient abundance, the form species Eobelodina fornicala is also present in smaller numbers. The similar size and general appearance of these two forms and their mutual presence in similar ratios is strong support for the concept of the multielement species Belodina compressa. However, previous reports (Schopf, 1966: Webers, 1966; Bergström & Sweet, 1966) have listed different ratios between the two forms, though the belodiniform element has always been found to predominate. As there is little question about the identity of these form species, it can be safely reported that 206 belodiniform and 62 eobelodiniform elements are present in the Chazy collection.

Occurrence: Belodina compressa is a long ranging species. However, its presence throughout all but the lowest Chazy Group is the oldest recorded. In distribution these elements are limited to the Midcontinent region and the northwestern outcrop belts in the Appalachians.

Genus CARDIODELLA Branson & Mehl, 1944

Type species: Cardiodus tumudus Branson & Mehl, 1933

CARDIODELLA TUMUDUS Branson & Mehl

Pl. 1, fig. 18

Cardiodus tumudus BRANSON & MEHL, 1933, p. 81, Pl. 6, fig. 19, Pl. 7, fig. 2; BRANSON, 1944, p. 69, Pl. 10, figs. 5,21-23.

Cardiodella timudus BRANSON & MEHL, 1944, in SHIMER AND SCHROCK, p. 239, Pl. 93, figs. 17,18; HASS, 1962, p. 56, fig. 34-2a,2b; Pl. 112, fig. 12, Pl. 114, figs. 1,2,6

Description: Compound subsymmetric conodont elements consisting of a short, broad bar, both arched and bent to some degree, bearing several large central denticles with one to several smaller denticles on either side. The discrete divergent denticles have round profiles and are erect to anteriorly inclined. The basal cavities are broad and moderately shallow and continue to the distal extremities of the bar.

Specimens exhibit variation of form. The bar may be close to flat or arched up to 90° from horizontal. The bar may also be bent out of a common vertical plane through a smooth shallow curve or sharply bent at up to a 90°

angle. Centrally, one large denticle may predominate and serve as the cusp or the several large denticles may be equal in size. Distally, the bar may or may not be equally developed on either side. In sum, however, elements of *Cardiodella tumudus*, are distinguished by their compact heart or arrow-shaped plan, noted originally by Branson and Mehl (1933).

Remarks: When *Cardiodella* was first described (Branson and Mehl, 1933) from the Joachim Dolomite of Missouri a number of species were established although the authors noted the transitional nature of the forms both among themselves and into forms of their genus Curtognathus. In a later study of Joachim conodonts Andrews (1967) included all of Branson and Mehl's original species in their type species, *Cardiodella tumudus*. There are too few specimens of *Cardiodella* in the Chazy collection to determine if all of the Joachim forms belong in a single symmetry transition series or if several discrete morphologic groups do exist. On the basis of the Chazy specimens however, it appears that the forms of *Cardiodella* that are present would be best treated as one species possessing a range of morphologic variation.

Cardiodella was assigned to the redefined multielement genus *Curtognathus* by Votaw (1969) on the basis of his Black River conodont collection. The forms of *Cardiodella* thought by Votaw to be associated with other "fibrous" form species in multielement natural species of *Curtognathus* are not found in the Chazy collection. If the Chazy representatives of the form genus *Cardiodella* belong to a multielement assemblage this cannot be demonstrated from present collection. The one sample yielding abundant *Cardiodella*, 24 specimens, reveals no possible associated forms. It was therefore necessary to discuss *Cardiodella tumudus* as a form species.

Occurrence: Upper Laval Limestone from the Montreal area, equivalent to the upper Valcour Formation.

CARDIODELLA sp.

unfigured

Remarks: One specimen in the Chazy collection represents a new form of *Cardiodella*. It is a symmetrical bar unit whose central portion consists of a straight row of five spike-like denticles which have rounded profiles, have a pointed distal extremity, and are inclined anteriorly. At each end of this straight central segment the bar bends posteriorly, the remaining length of the bar at each end being equal to the length of the central portion. The two distal segments durve gradually along their length toward the lateral, taper to a distal point, and bear rows of denticles similar to those on the central bar segment but having a vertical to posteriorly inclined orientation. The denticles are confluent in their basal region througoug the entire length of the unit. The basal cavity is wide and shallow and in a horizontal plane.

The one specimen was lost while attempting to photograph it.

Occurrence: The one specimen was recovered from the Valcour Formation at the section at South Hero Station, Vermont.

Genus CHIROGNATHUS Branson & Mehl, 1933

Type species: *C. duodactyla* Branson & Mehl, 1933

CHIROGNATHUS n. sp. A

Pl. 1, fig. 17

"*Cordylodus*" sp. SWEET & BERGSTROM, 1962, p. 1250, Pl. 169, figs. 1, 16.

Description: Asymmetrical laterally compressed compound conodont elements with short posterior precesses bearing suberect sharp edged denticles confluent through all but their distal extremities are considered to belong to *Chirognathus* n. sp. A. In general morphology the Chazy specimens resemble the genus *Cyrtoniodus* yet they have the appearance of "fibrous" conodont elements.

The entire unit is mildly warped along both the vertical and horizontal axis, producing distinct inner and outer lateral surfaces. The erect cusp, while considerably larger than the denticles, is also thin, with sharp anterior and posterior edges, and flexes inward distally. The posterior process bears two or three slightly diverging denticles which decrease in size posteriorly and are joined basally by thin web-like ridges.

The base is mildly flared on the inner lateral side and broadly convex on the outer lateral side. The sharp-edged anterior margin of the base flexes inward aborally and terminates against the aboral margin beneath the cusp at the aboral extremity of the base. Posteriorly, the sinuous aboral margin inclines to the posterior edge of the process. The basal cavity has pointed anterior and posterior terminations, obtains a moderate width centrally, and has a shallow V profile.

Remarks: Sweet and Bergström (1962) illustrated two specimens, one resembling the Chazy material, the other bearing a long denticulated posterior process. The Chazy specimens may all be broken but they appear to have lacked any long posterior process. With only a short posterior posterior process and laterally compressed asymmetric plan these elements are morphologically similar to the genus *Cyrtoniodus*. Sweet and Bergström (1962) noted the "fibrous" appearance of the Pratt Ferry specimens and decided that all originally bore the long posterior process seen on one, giving a "*Cordylodus*" morphology to the elements.

Neither the original definition of *Chirognathus* provided by Branson & Mehl (1933) nor the later definition by Linström (1964) encompass the morphology of the Chazy specimens in detail. However, Lindström stressed the laterally compressed, sharp-edged denticulation while Branson & Mehl emphasized the hand-shaped arched nature of the units, characteristics possessed by the Chazy specimens. It is considered advisable to place the elements in question in the genus Chirognathus rather than create a new genus for a small number of specimens whose affinities are unknown.

Occurrence: Chirognathus n. sp. A is limited to the Day Point Formation and equivalent strata in the Montreal area.

CHIROGNATHUS n. sp. B

Pl. 1, Fig. 15

Description: Conodont elements of a "fibrous" nature having a long, greatly compressed, and U-shaped bar process bent at the two corners of the U through an angle greater than 90 degrees are assigned to Chirognathus n. sp. B. The erect denticles on the central portion of the U are tall and wide, with sharp lateral edges, but are extremely thin and are laterally confluent at their bases. The few denticles on one distal wing of the bar are reduced in height and have more rounded profiles while the other distal wing of the bar carries a typically tall and compressed denticle at its end. The central portion of the U-shaped bar is longer than the distal wings while the two tallest denticles occur at the corners of the U.

The narrow base lies approximately on a horizontal plane. A shallow slit occupies the aboral surface of the base.

Remarks: This strange form is represented by only four specimens from one sample. The illustrated element is the more nearly complete, yet may have one distal extremity broken. The general claw-shaped and compressed morphology is best assigned to the genus *Chirognathus*. However, in general morphology the specimens resemble those conodonts belonging to the "Australian fauna" and assigned to an unnamed new genus herein. More specimens are needed to clarify the features and classification of this form species.

Occurrence: The few representatives of *Chirognathus* n. sp. B are found only in sample 69R-VI-69 from the upper Crown Point Formation.

Genus CURTOGNATHUS Branson & Mehl, 1933

Type species: *Curtognathus typus* BRANSON & MEHL, 1933, p. 87.

The genus Curtognathus was created to include "fibrous" conodont elements having a variably arched bar bearing a row of subequal denticles in a vertical plane. Branson and Mehl noted that there were similarities to their form genera Polycaulodus, Trucherognathus, and Cardiodus. Recently, Votaw (1971) has grouped the four form genera in the multielement genus Curtognathus and described two species. The few elements assignable to the form genus Curtognathus do not permit verification of Votaw's premise that a symmetry transition series exists between Branson and Mehl's four form genera and that they belong in a multielement genus. Consequently the several morphologic types found in the Chazy are treated as form species. Larger collections are required to clarify the relationship of the several forms.

CURTOGNATHUS? sp. A

Pl. 1, fig. 13

Remarks: Several specimens from the Chazy consist of a denticulate, arched and somewhat curved bar having a nearly flat aboral surface. The cusp is subcentrally located on the unit at the apex of the arch. The cusp and denticles to either side are discrete and mildly compressed. A boss extends aborally beneath the cusp on the anterior face of the unit.

These elements bear a resemblance to the cardiodelliform element of the multielement species Curtognathus typus defined and illustrated by Votaw (1971) but are not identical. It is possible the Chazy specimens belong to an older multielement species from which C. typus descended but larger collections are necessary to evaluate this hypothesis.

Occurrence: The few elements fitting the plan described above were recovered from the upper Crown Point.

CURTOGNATHUS? sp. B

Pl. 1, fig. 16

Remarks: One conodont element in the Chazy collection is similar to Curtognathus? sp. A and found in the same sample. This specimen, referred to as Curtognathus? sp. B, was lost after photography. It differs from Curtognathus? sp. A in having the apex of the arch farther removed from the center of the unit and in having the two lateral segments of the bar bent farther from a common vertical plane. The somewhat compressed denticles do not lie in a common plane, being varyingly inclined posteriorly and anteriorly along the length of the longer bar segment.

This element may well belong to a multielement species of Curtognathus and thus is tentatively assigned to that genus. However, the relationship of Curtognathus? sp. A and C.? sp. B to the remainder of the "fibrous" conodont fauna of the Chazy remains unclear.

Occurrence: The one specimen was recovered from the upper Crown Point Formation on Valcour Island, New York.

CURTOGNATHUS TYPA Branson & Mehl

Pl. 1, fig. 9

Curtognathus typa BRANSON & MEHL, 1933, p. 88, Pl. 5, fig. 28; ANDREWS, 1967, p. 887-888, Pl. 113, figs. 1, 4, 21, Pl. 114, fig. 22 (includes synonymy through 1967)

?Curtognathus typus (Branson & Mehl) VOTAW, 1971, p. 76-85, Pl. 1, figs. 16, 20-26, Text-fig. 9A-K (includes synonymy of multielement Curtognathus typus defined by Votaw).

Remarks: The few forms assigned to *Curtognathus typa* have in common an arched bar with denticles on the oral surface symmetrically disposed about the crest of the arch. The denticles have rounded profiles, are subequal in size, and are in a common vertical plane. The base is rather wide with a flat to shallowly concave basal cavity opening aborally and somewhat posteriorly. Chazy specimens agree well with the description and illustration of Branson and Mehl (1933).

It is not possible to conclude as did Andrews (1967) that several of Branson and Mehl's form species belong in a symmetry transition series on the basis of the few Chazy representatives. Neither is it considered wise to assign the Chazy specimens to the multielement species *Curtognathus typus* defined by Votaw (1971), as the other elements of that assemblage are not found in the Chazy collection.

Occurrence: *Curtognathus typus* Branson & Mehl is found from all three formations of the Chazy Group.

Genus COELOCERODONTUS Ethington, 1959

Type species: *C. trigonius* Ethington, 1959

COELOCERODONTUS DIGONIUS Sweet & Bergström

Pl. 3, fig. 11

Coelocerodontus digonius SWEET & BERGSTRÖM, 1962, p. 1224, Pl. 168, fig. 1; Text-fig. 1F.
?*Coelocerodontus* sp. BRADSHAW, 1969, p. 1148, Pl. 132, fig. 15.

Remarks: Slender, gently-curved, simple conodont units having blunt anterior and posterior keels and faint longitudinal striae in the basal region are considered representative of Coelocerodontus digonius Sweet and Bergström. The basal cavity is presumed to extend to the apex of the cusp. The lateral faces of the cusp are convex and infrequently bear a weakly developed longitudinal depression extending from the basal margin a short distance up the cusp. This last feature is diagnostic of the genus Panderodus yet occurs in a minority of specimens.

Occurrence: Specimens assigned to Coelocerodontus digonius occur in upper Crown Point and Valcour strata.

Genus DISTACODUS Hinde, 1879

Type species: Machairodus incurvus Pander, 1856

DISTACODUS n. sp. A

unfigured

Description: Symmetrical simple conodont units bearing a median costa on each lateral face and sharp-edged posterior and anterior margins are considered to represent a new, unnamed, species of Distacodus. The unit is recurved gradually through 90° above the base with the distal portion of the cusp apparently straight but missing in the few specimens available. Mild lateral compression characterizes both base and cusp. The base is continuous with the cusp and is not flared. As with the great majority of Chazy conodonts, the opaque condition of the specimens prevents description of the basal cavity. However, the basal cavity appears to be rather deep. The lateral costae continue to the aboral margin of the unit. The costae are thin and drawn out to sharp edges, as are the anterior and posterior keels. One costa is in a median position on its lateral face throughout the length of the cusp while the other seems to maintain a position somewhat posterior of the median line and is posteriorly directed.

Remarks: No previously described Distacodus from the Middle Ordovician of North America matches the plan of Distacodus n. sp. A. However, with only a few specimens available it is impossible to observe a range of variation and gain a basis for meaningful comparison of forms.

Occurrence: Distacodus n. sp. A occurs throughout the Chazy but is represented by only twelve specimens.

DISTACODUS n. sp. B

Pl. 4, fig. 13

Description: Conodont elements whose cusp has a sharp posterior margin, two asymmetricly situated lateral costae, and a rounded anterior surface. Slight lateral compression is seen in cusp cross section. The cusp recurves quickly through 80-90° just above the base with which it is continuous. The thin, sharp-edged posterior margin of the cusp continues to the aboral edge of the base. One lateral costa is located just anterior to the median axis of the cusp throughout its length from basal margin to broken distal end. It is of high relief, comes to a sharp edge having a slight posterior inclination, and demarks a well developed groove in its posterior lee. The other side of the element is marked with a similarly developed costa which at the basal margin is slightly posterior of the anterior margin. However, this costa overlaps the anterior margin distally beyond the point of greatest cusp curvature. It is a flange-like ridge with its sharp edge directed antero-laterally. A groove formed in the posterior lee of the flange is more open than the groove associated with the lateral costa on the other side of the unit. Distally, a faint costa marks the median lateral face posterior to the antero-lateral flange. Basally the anterior margin of the unit is smoothly convex while distally this margin becomes indistinguishable on the antero-lateral surface. The anterior margin in lateral view shows a concave region centered on the junction of base and cusp. The few elements at hand are black, preventing description of the basal cavity.

Remarks: With only several specimens of Distacodus n. sp. B in the Chazy collection it is not possible to obtain a reliable description of its form. The assignment to the genus Distacodus itself is tentative.

Occurrence: Too few specimens are available to draw any conclusions about the distribution of this taxon within the Chazy Group. Specimens were found in the Crown

Point and Valcour Formations.

Genus DREPANOISTODUS Lindström, 1971

Drepanoistodus LINDSTRÖM, 1971, p. 42
Drepanoistodus VOTAW, 1971, p. 87, Pl. 1, figs. 6-9.

Type species: *Oistodus forceps* Lindström, 1955

DREPANOISTODUS SUBERECTUS (Branson and Mehl)

Pl. 3, figs. 13,14,15; Pl. 4, fig. 28

Drepanoistodus suberectus VOTAW, 1971, p. 87, Pl. 1, figs. 6-8 (includes synonymy through 1971).

Description: Conodont elements assignable to the form species *Drepanodus homocurvatus*, *Drepanodus suberectus*, and *Oistodus inconatus* belong in a multielement species which Votaw (1971) placed in the newly created genus *Drepanoistodus* Lindstrom (1971). These three forms are ubiquitously associated with one another in Middle Ordovician limestones of the Midcontinent conodont faunal province.

All three forms are simple conodont elements of robust size and possessing flared bases. *Drepanodus homocurvatus* and *D. suberectus* are symmetrical forms whose bases flare equally on both sides and open in the plane of the cusp. On the other hand, the basal cavity of *Oistodus inclinatus* does not open in the plane of the cusp, which is inclined over the inner lateral side. *D. homocurvatus* has a long tapering cusp which is gracefully recurved and has a rounded to compressed profile while *D. suberectus* and *O. inclinatus* have straight, laterally compressed cusps having sharp anterior and posterior edges. The cusp of D. suberectus is slightly reclined while that of O. inclinatus is moderately reclined.

Remarks: Various ratios between the three form species have been reported in previous studies of Middle Ordovician limestones of North America (Schopf, 1966; Webers, 1966; Bergström and Sweet, 1966). However, D. homocurvatus has always been found to predominate. The number of specimens of Drepanoistodus suberectus found in the Chazy Group is too small to propose a small whole number ratio between the three form species but is adequate to show that Drepanodus homocurvatus greatly predominates. The two less abundant form species are not found in samples not containing D. homocuravatus.

Occurrence: Elements of the three form species comprising Drepanoistodus suberectus are found throughout the Chazy Group.

Genus EOPLACOGNATHUS Hamar, 1966

Type species: Ambalodus lindstroemi Hamar

Remarks: Eoplacognathus was redefined by Bergström (1971a) to include both the ambalodiform elements originally assigned to Eoplacognathus by Hamar and polyplacognathiform elements which were found to be in association with them in the lower Middle Ordovician section of Sweden. The resulting multielement genus is similar in plan to Polyplacognathus. Eoplacognathus may be differentiated by possession of sinistral and dextral ambalodiform elements of different morphology; while sinistral and dextral ambalodiform elements of Polyplacognathus are mirror images of one another. The same distinction holds for polyplacognathiform elements of the two groups.

The lower Middle Ordovician sequence in Sweden contains a succession of five species of Eoplacognathus. These were established as guide fossils to the subzones of the Pygodus serrus zone established by Bergström (1971a). Later, the lowest of the five subzones was removed from the Pygodus serrus zone (Bergström, 1971b). Eoplacognathus is present in the North Atlantic faunal province, which includes the easternmost outcrop belts of the Appalachian Mountains (Bergström, 1971a). It is also found in central Nevada (Ethington & Schumacher, 1969).

The presence of a number of platform elements similar to described species of Eoplacognathus, along with numerous conodonts of the Midcontinent faunal province, in the Chazy Group suggests that the Chazy sea occupied a position intermediate between the North Atlantic and Midcontinent faunal provinces. However, most of the material is fragmental and the majority of whole specimens that do exist are not identical to any described species of Eoplacognathus. In a progress report (Raring, Bergström, and Schopf; 1969), E. lindtroemi was identified from the uppermost Day Point Formation. The remaining Eoplacognathus specimens are referred to a new species.

EOPLACOGNATHUS LINDSTROEMI (Hamar)

unfigured

Eoplacognathus lindstroemi (Hamar); BERGSTRÖM, 1970, Geol. Soc. Amer. Memoir 127, p. 139, Pl. 2, figs. 15,16,17, 18 (includes synonomy through 1970).

Remarks: One ambalodiform element was reported earlier (Raring, Bergström, and Schopf: 1969) from the upper Day Point Formation as belonging to Eoplacognathus lindstroemi. Bergström made the identification and illustrated the specimen, which has since been lost. As there are no specimens remaining in the Chazy collection no description of the species is made.

The presence of E. lindstroemi near the top of the Day Point Formation allows correlation of that interval to the uppermost subzone of the Pygodus serrus zone or lowest subzone of the Pygodus anserinus zone.

Occurrence: The one specimen is from the uppermost Day Point Formation of the type section at Chazy, New York.

EOPLACOGNATHUS n. sp.

Pl. 2, figs. 1-3

Description: Eoplacognathus n. sp. is a multielement species containing dissimilar dextral and sinistral ambalodiform elements and closely similar dextral and sinistral polyplacognathiform elements. All elements are platforms bearing centrally located rows of denticles on the oral surfaces of platform processes. Platform margins are smooth. Aboral surfaces are flat and bear keels opposite denticle rows on the oral surfaces. The keels have thin grooves along their crests which widen centrally to form a shallow basal cavity outlined by high lips continuous with the more distal keels.

The dextral ambalodiform element is Y-shaped. When oriented to the left the anterior process is straight distally but shallowly convex downward proximally and inclines at a 60 degree angle upward several denticles anterior to the junction of posterior and lateral processes. The straight posterior process is shorter and is continuous with the proximal few denticles on the anterior process. The lateral process diverges downward and posteriorly, is the shortest of the three processes, and makes an angle of about 100 degrees with the posterior process. The platform margins are relatively straight and smooth on the anterior and posterior processes but the lateral process has rounded projections on its margin both distally on the posterior edge and at mid-length on the anterior edge, the latter being less distinct. The denticle where the three processes join is larger than the rest.

The sinistral ambalodiform element is similar in plan to the dextral element but the anterior and posterior processes make an angle of 85 degrees, giving the element more a T than a Y shape. As in the dextral ambalodiform element the platform tapers to a point distally on the anterior process but has a rounded distal extremity on the posterior and lateral processes.

The polyplacognathiform element is comprised of four processes. The anterior process is slightly arched, narrow, and bears high denticles while the posterior process is flat and more broad, bearing a slightly curved row of stubby denticles. The postero-lateral process is lobelike, moderately long, and bears a straight row of denticles, the process being inclined posteriorly. The antero-lateral process diverges from the anterior process proximally and at a right angle but bifurcates several denticles distally into two lobes. The long, narrow posterior lobe is posteriorly directed proximally but bends laterally while the anterior lobe is short, narrow, and anteriorly directed.

Remarks: Polyplacognathiform elements of *Eoplacognathus* n. sp. resemble those of *Polyplacognathus friendsvillensis* but the ambalodiform elements of *Eoplacognathus* n. sp. are distinctive and unpaired. *E.* n. sp. is found stratigraphically below *P. friendsvillensis* and may represent a species transitional to *Polyplacognathus* from *Eoplacognathus* stock. However, the species of *Eoplacognathus* most resembling *E.* n. sp. is *E. foliaceus*, which is found above the lowest occurrence of *P. friendsvillensis* in the Lenoir Limestone at Friends Church, Tennessee (Bergström, 1971a) and is the oldest of the four species of *Eoplacognathus* used as guides to the subzones of the *Pygodus serrus* zone of the lower Middle Ordovician of Sweden (Bergström, 1971b). The most reasonable explanation for the resemblance of *Eoplacognathus* n. sp. to both *E.* *foliaceus* and *Polyplacognathus* *friendsvillensis* would be to assume these species are both younger and evolved from *E.* no. sp. This hypothesis cannot be evaluated until stratigraphic relationships between these three species are clarified through work in other regions.

Occureence: *Eoplacognathus* n. sp. is found both in the lower Day Point Formation of the northern Champlain Valley and in the St. Hyacinthe Limestone of Quebec below the lowest occurrence of *Polyplacognathus* *friendsvillensis*.

Genus ERISMODUS Branson & Mehl, 1933

Type species: *Erismodus* *typus* BRANSON & MEHL, 1933

The genus *Erismodus* was redefined by Votaw (1971) as a multielement genus consisting of a symmetry transition series "Between elements of the form geners *Erismodus*, *Microcoelodus*, and *Ptiloconus* (or *Pteroconus*). "Fibrous" conodonts, while not abundant in the Chazy Group, display great diversity of form. The one morphological feature common to elements assigned to *Erismodus* is a boss extending aborally beneath the cusp. In erismodiform and microcoelodiform elements two processes of unequal length diverge from the cusp and bear a varying number of rounded, discrete denticles. The orientation of these processes varies from a symmetrical trichonodelliform plan to an eolingonodiniform plan. All the form varients are robust in appearance with stubby denticles somewhat compressed laterally and wide shallowly excavated basal cavities. The features noted above are those which Branson and Mehl (1933) cited for elements from the Harding Sandstone of Colorado that they placed in the form genus *Erismodus*.

ERISMODUS RADICANS (Hinde), 1879

Pl. 1, fig. 12; Pl. 3, figs. 2,3,7; Pl. 4, fig. 27?

Prioniodus radicans HINDE, 1879, p. 356-357, Pl. 15, figs. 1-5.

Erismodus radicans BRANSON & MEHL, 1933, p. 156, Pl. 12, figs. 14,18,19; VOTAW, 1971, p. 89-95, Pl. 1, fig. 5, Pl. 3, figs. 42-45 (includes synonymy through 1971).

Discussion: *Erismodus radicans* is a multielement species consisting of three types of elements defining a symmetry transition series as well as at least one further morphologic type. The first three forms can be described as trichonodelliform, zygognathiform, and eoligonodiniform. Elements not belonging to the symmetry transition series are ozarkodiniform and ptiloconiform in plan.

Trichonodelliform elements have a laterally compressed recurved cusp with sharp anterior and posterior edges and smooth lateral faces. Lateral processes leave the antero-lateral margins of the cusp directed laterally and down-ward at a 45 degree angle. They are both flexed poster-iorly and curved aborally along their length and bear three to five denticles on their oral edges. The denticles are discrete, directed orally at 90 degrees to the bar processes, and are compressed in juvenile specimens but have rounded profiles in larger specimens. The posterior edge of the cusp is continuous with the oral edge of a posteriorly directed basalkeel, which may be weakly denticulated. The anterior margin of the base is extended aborally beneath the cusp as well but does not protrude anteriorly. The basal cavity is wide and shallow under the cusp and posterior keel and continues as a slit beneath the lateral processes.

Zygognathiform elements are similar to trichonodelliform elements but are no longer bilaterally symmetrical. One lateral process is swept posteriorly while the other is inclined anteriorly and the cusp has a broad shallow furrow on the lateral face having the anteriorly directed process.

Ozarkodiniform elements of *Erismodus radicans* are robust and have broad shallow basal cavities and two denticulated processes situated at about 160 degrees to one another. The central cusp is rounded in cross section while the process bars and denticles are mildly compressed. The smoothly convex anterior and posterior faces of the cusp continue on the base and extend aborally producing adapically directed bosses. The processes are not in a horizontal plane; rather, the unit is broadly arched. In oral view one process is seen to be laterally directed while the second is antero-laterally and aborally directed. The denticles are fused basally but discrete through most of their height and are subevenly spaced. The basal cavity is broad beneath the cusp and tapers evenly to its pointed lateral termination under the distal regions of the process.

The ptiloconiform elements (Pl. 4, fig. 27) are simple cones bearing a flange-like longitudinal costa on each lateral face and having anterior and posterior bosses extending aborally from the base.

Remarks: The trichonodelliform, zygognathiform, and eoligonodiniform elements and intermediate forms which are found define a symmetry transition series. However, the Ozarkodiniform elements lack a compressed cusp and do not fit in the scheme of variation from trichonodelliform to eoligonodiniform plans. They are included in *Erismodus radicans* because of their resemblance both in size and morphology to the symmetry transition series and because of the stratigraphic association of these forms.

Ptiloconiform elements are rare in the Chazy collection yet Votaw (1971) reported that they are the most abundant element in *Erismodus radicans*. The few ptiloconiform elements found do not show clear association to other *E. radicans* elements. Furthermore, they differ from ptiloconiform elements described by Votaw. Therefore the Chazy ptiloconiform elements are doubtfully included in *E. radicans* at this time.

Occurrence: *Erismodus radicans* is found throughout the Chazy Group and is locally abundant in the Day Point Formation.

Genus MULTIOISTODUS Cullison, 1938

type species: Multioistodus subdentatus Cullison, 1938

MULTIOISTODUS CRYPTODENS (Mound)

Pl. 1, figs. 2,6,7; Pl. 3, fig. 4; Pl. 4, fig. 6.

Eoneoprioniodus cryptodens MOUND, 1965, p. 197-198, Pl. 1, 1, 2, text.-fig. 1, figs. 12, 13.
Multioistodus cryptodens (Mound) SWEET, ETHINGTON, AND BARNES, 1970, p. 167-168, Pl. 2, figs. 17a, b, & c.

Description: Conodont elements are found in the Chazy Group which resembles Multioistodus cryptodens (Mound) as illustrated by Sweet, Ethington, and Barnes (1971). These cone elements are marked by one or more longitudinal costae which are exaggerated to flanges and project as undenticulated processes from the base of the units. Three morphologic types, described as acodiform, acontiodiform, and neoprioniodiform in plan, were illustrated by Sweet, Ethington, and Barnes. The Chazy specimens are robust in size but invariably have the distal portion of the cusp severed.

Chazy specimens represent three morphologic types, with the first two apparently representing ends of a symmetry transition series. The first plan has three longitudinal flange-like costae, one situated posteriorly and the other two symmetrically disposed on the lateral faces. All three project from the cusp as short undenticulated blade processes basally. The two lateral costae are inclined in a posterolateral direction, while the basal blade processes also sweep aborally. The cusp has a triangular cross section, a smoothly convex anterior face, and concave postero-lateral faces.

The second plan is similar but four sided due to the addition of a costa on the anterior margin. This fourth costa is also sharp-edged and basally flared to a flange-like process yet is less developed than the other three.

The cusp in both types of element is slightly and gradually recurved. The concave faces between the costae terminated at the junction with the base in deep recessions. These depressions are less deep and less angular in appearance in the triangular elements. The basal cavity does not appear to continue as far into the unit in the quadrangular forms.

Elements are found which are asymmetric and have three sharp-edged costae with well developed processes at the base of the unit and a fourth costa with a more retarded flange. These forms are transitional between the first two and where assigned to the quandrangular plan for convenience.

The third, asymmetric, morphologic scheme is acodiform, the cusp having only one well developed lateral costa along with the posterior costa. The cusp in these units is suberect becoming gently recurved distally, and triangular in cross section. The base flares both posteriorly and beneath the aborally extended blade-like basal continuation of the lateral costa.

Remarks: The general plan of the first two morphologic types and specimens intermediate in form resembles somewhat the acodiform, zygognathiform, and trichonodelliform elements described by Votaw (1971) for the multielement species Scandodus superbus. However, inspection of Votaw's holotypes reveals that none of the elements described as belonging to S. superbus possesses lateral costae which are developed to the degree displayed by the lateral flanges on the Chazy specimen ; further, the cusps of elements of S. superbus are proclined to erect and in none of the forms have a smoothly convex anterior face. Votaw also described drepanodiform and oistodiform elements as belonging in the Scandodus superbus assemblage. It does not appear that comparable units are present in the Chazy fauna.

Occurrence: Elements assigned to Multioistodus cryptodens are found throughout the Chazy Group and equivalent strata in the Montreal area although in few samples and never in abundance. They are also present in samples from the type sections of the Ashby Stage at Hogskin Valley, Tennessee and the Marmor stage at Friendsville, Tennessee (in the collections of Dr. S. M. Bergström and Mr. Jack Carnes, at The Ohio State University). They have been seen in collections from the McLish Formation of the Simpson Group in Oklahoma as well.

Previously, distribution of these elements was thought to be limited to Faunas two through four in North America (Sweet, Ethington, and Barnes; 1970), in strata from the Basin and Range province and of implied Whiterock age. If the identification of the above mentioned specimens from the Chazy Group and elsewhere is correct, the range of Multioistodus cryptodens is expanded upward. However, the noteable provincialism of early Middle Ordovician conodont faunas (Bergström, 1971a) should be kept in mind.

MULTIOISTODUS SUBDENTATUS Cullison

Pl. 1, figs. 1, 5.

Multioistodus subdentatus CULLISON, 1938, Jour. Paleo., v. 12, p. 226, Pl. 29, figs. 13a, b; MOUND, 1965, Tulane Studies in Geology, v. 4, no. 1, p. 25, Pl. 3, figs. 17, 18, 20, 25 (Includes synonymy through 1965); SWEET, ETHINGTON, AND BARNES, 1970, Geol. Soc. Amer. Mem. 127, p. 174, Pl. 2, fig. 24.

Multioistodus tridens CULLISON. 1938, Jour. Paleo, v. 12, p. 222, 226, 227, Pl. 29, figs. 15a, b; MOUND, 1965, Tulane Studies in Geology, V. 4, no. 1, p. 26, Pl. 3, figs. 19, 24, 26 (includes synonymy through 1965).

Description: Multiostodus subdentatus is a multielement species consisting of forms ranging in a symmetry transition series from symmetric units with one posterior denticle through asymmetric units to symmetric units with one lateral denticle on each side of the cusp and one posterior denticle. The large recurved cusp has a round profile with a posterior costa extending from its distal end to the base, where it continues up the anterior margin of the posterior denticle. Similar costae mark the lateral faces of the cusp where lateral denticles are present. Intermediate forms include units with one posterior denticle on the other face one being well developed, the other only a nub.

The denticles are always considerably smaller than the cusp. The posterior denticle is straight and reclined while the lateral denticles, if present, recurve parallel to the cusp. The distal portion of the cusp is recurved to an orientation almost parallel to the posterior denticle. Where lateral denticles are present they diverge from the antero-lateral margins of the base.

The base is in continuity with the cusp and auxiliary denticles. The basal cavity is apparently broad and shallow.

Remarks: The form species _Multiostodus subdentatus_ and _M. tridens_ both included a wide variety of forms. Taken together, they are thought to represent a symmetry transition series although elements of both form species comprise a negligible portion of the Chazy conodont collection. Elements assignable to _M. subdentatus_ and _M._ tridents are strikingly alike in size and form and are stratigraphically associated.

Occurrence: Elements assigned to _Multioistodus subdentatus_ are found in all three formations of the Chazy

Group but are infrequently present and where found occur in negligible numbers.

Multioistodus subdentatus is common in the Dutchtown of Missouri and present in the Lehman formation in Nevada as well.

NEW GENUS

Representatives of what is thought to be a new multielement genus are found throughout the Chazy Group and equivalent beds in the Montreal area. The Chazy forms may represent one or several species of the new genus; they are nowhere common so assemblages can not be reconstructed. Characteristic of all specimens assigned to the New Genus are one to three laterally compressed processes each bearing a row of long delicate denticles. The various morphologies compare favorably to speciments provided by Dr. Stig Bergström from the Middle Ordovician of Australia, and assigned by him (Bergström, 1970)to the "Australian" fauna. Similar elements have been found by Dr. Bergström in limestones from the southern Appalachians and are as yet unnamed.

The several morphologic forms will be discussed under one species, although there is no assurance that they do not represent separate "form" species. Where found, however, at least several of the forms occur together, suggesting a biologic assemblage.

NEW GENUS, NEW SPECIES

Pl. 4, figs. 4, 5.

Description: Several specimens have a slender recurved cusp followed by a long compressed posterior process that is both curved aborally and flexed toward its distal end and flanked by short lateral processes, each bearing two denticles and having slight aboral curvature distally. However, the outer lateral process is inclined anteriorly and carries two tall denticles, the distal denticle subequal in size to the cusp, while the inner lateral process is directed somewhat posteriorly and carries two equally short denticles. The denticles on the posterior process are laterally compressed, sharp-edged anteriorly and posteriorly reclined and increase in height distally to the point of maximum aboral curvature, beyond which denticle height is greatly decreased, a pattern similar to the denticulation of Phragmodiform elements. The basal cavity extends as a shallow and narrow trough beneath the three processes. This morphology is illustrated on Pl. 4, fig. 4.

A second morphologic type, illustrated on Pl. 4, fig. 5, consists of a tall slender cusp, proclined to erect distally, followed by a posterior process bearing vertically oriented denticles which increase in height posteriorly and an inner lateral process which diverges from the aboral margin of the base and is directed posteriorly and aborally. The inner lateral process bears tall, compressed, erect, and delicate denticles similar to those of the posterior process. The distal portion of the posterior process is broken in the illustrated specimen. The base is exceptionally high at the point of divergance of the inner lateral process but narrows posteriorly. The basal cavity is assumed to be shallow.

A third morphologic type assigned to new genus, n. sp. is zygnognathiform in plan, with two skewed lateral processes whose distal portions are curved posteriorly and aborally but with a denticulated posterior process as well. The posteriorly directed lateral process forms an acute angle with the posterior process and is subequal in size while the other lateral process, directed anteriorly, is shorter, with the denticle proximal to the cusp subequal in size to the cusp but the remaining few denticles greatly reduced in size. The posterior process is gently curved toward the side bearing the reduced, anteriorly directed process. These elements are more compact than the two previously described, having cusp and denticles with mild lateral compression and a wide triangular and presumably deep basal cavity beneath the cusp.

A fourth morphologic form has a hand-shaped denticulated bar with a median cusp and two lateral processes bearing tall compressed denticles, and a somewhat reduced anterior process directed sharply to one side and bearing a number of vertically directed denticles. The cusp has a longitudinal costa on its anterior face which continues basally into the oral margin on the anterior process. The cusp and denticles are sharp-edged on their lateral margins. The base is narrow and moderately deep. The basal cavity cannot be seen in the few blackened specimens.

Remarks: The "Australian" fauna conodonts are recognized by their long slender denticles and generally the presence of two or three rather long processes. Or previously described form genera they most resemble Chirognathus in appearance. It is possible that the two new species assigned to Chirognathus actually are representatives of this New Genus, or represent another new genus of the "Australian" fauna. The cyrtoniodiform specimens of Chirognathus sp. are represented in the collection of Australian conodonts of Dr. Bergström. However, it was decided that possession of two or more processes would serve as a criteria for recognition of New Genus. When better collections of "Australian" fauna conodonts are available it will be possible to better assess which morphologic features are significant in classification.

Occurrence: Elements of forms A and B of New genus, m. sp. are found in the Day Point, Crown Point and Valcour Formations and their equivalents in the Montreal region. The third and forth morphologic forms are described from a sample from Australia sent by Dr. Stig Bergström. The sample has all four morphologic plans in association.

Genus OISTODUS Pander, 1856

Type species: O. lancealatus Pander, 1856

OSTODUS aff. O. ANGULATUS Bradshaw

Pl. 1, figs. 3, 4.

aff. Oistodus angulatus BRADSHAW, p. 1156, Pl. 134, figs. 8, 9.

Description: Laterally compressed oistodiform elements having thin suberect cusps with sharp-edged anterior and posterior margins and flared inner lateral basal sheathes. The cusp has an almost inperceptable inward curvature in small specimens while larger, more mature specimens are more strongly bent inward, mildly flexed along their length, and somewhat recurved distally. The distal portion of the cusp is generally broken. The base is slightly elongated in the anterior direction and moderately elongated in the posterior direction. The oral edge of the base meets the posterior edge of the cusp at an 80 to 90 degree angle. The aboral edge of the base inclines at about 45 degrees from the anterior to the posterior extremity. A smoothly convex carina on the inner lateral face of the base of robust specimens proclines at about 25 degrees from the aboral margin to the base of the cusp, where it curves sharply and continues distally as the indistinct reclined axis of the cust. The outer lateral face of both cusp and base is flat to mildly convex.

Remarks: The Chazy specimens agree in general with both the description and illustration of O. angulatus Bradshaw (1969) from the Fort Pena Formation of the Marathon Basin, Texas. More specimens would be required to lend certainty to such an assignation, however.

The majority of the few specimens from the Chazy lie nearly in a plane, are unflexed, and have aboral margins inclining at 30 degrees or less from the anterior to posterior basal extremity. However, two whole specimens, more robust than theothers, have cusps more inclined over the inner lateral side of the base and mildly flexed along their length, and bases which extend farther aborally at their anterior margins. These robust specimens agree well with Oistodus angulatus while the remaining, smaller specimens compare less favorably.

Occurrence: Found in the Day Point, upper Crown Point, and Valcour Formations of the Champlain Valley.

Genus OZARKODINA Branson and Mehl, 1933

Type species: O. typica Branson and Mehl, 1933

OZARKODINA CTENULATA Youngquist and Cullison

Pl. 1, figs. 8, 11.

Ozarkodina ctenulata YOUNGQUIST & CULLISON, 1946, 1946, p. 588, Pl. 89, fig. 3.
Ozarkodina missouriensis YOUNGQUIST & CULLISON, 1946, p. 588 Pl. 90, fig. 20.
Ozarkodina ? sp. YOUNGQUIST & CULLISON, 1946, P. 589, Pl. 90, fig. 8.
Ozarkodina Joachiminosis ANDREWS, 1967, p. 895. Pl. 113, figs. 5, 15, Pl. 114, fig. 3.

Description: Conodont elements possessing denticulated anterior and posterior bar to blade-like processes in a common vertical plane. The anterior process is more blade-like with four to sevel vertically oriented denticles discrete distally but laterally confluent toward their bases. The posterior process has less height, is inclined aborally, and bears several discrete denticles. Both processes and cusp are moderately compressed laterally. The cusp recurves posteriorly to a varying degree toward its distal end. Negligible flexure of the process relative to one another produces distinguishable inner and outer lateral surfaces. The base has a vertical but variable developed costa on the inner lateral face continuing up the cusp. The basal cavity extends as a groove under both processes and is flared beneath the cusp, more noticeably on the inner side.

Remarks: Conodonts referred to Ozarkodina ctenulata are few in number and have portions of the processes and distal ends of the cusps broken. While several may be referred to each of the previously described species of Ozarkodina from the Dutchtown and Joachim Formations it is deemed advisable to group these closely related forms in one taxonomic group. It is conceivable that a sufficiently large collection would reveal that the four form species represent growth stages or a symmetry transition series within one biologic species.

The two figured Chazy Group specimens have anterior blade processes, one with four denticles and the other with seven. Youngquist and Cullison differentiated *O. missouriensis* from *O. ctenulata* partially on the number of denticles on the anterior process. *Ozarkodina joachiminsis* of Andrews resembles both of the above mentioned form species but was said to have denticles on the anterior process varying in number from 4 to 8. Only *Ozarkodina* ? sp. has an anterior process as blade-like as the figured Chazy specimens; however, Youngquist and Cullison included it with the other two form species as closely related taxa. The Chazy specimens show the same range of variation yet also are clearly related to one another.

The forms described above are atypical representatives of *Ozarkodina*. Their resemblance to *Bryantodina* was noted by Youngquist and Cullison (1946) who decided in favor of the first described genus *Ozarkodina*. *Bryantodina* is represented in younger Middle Ordovician rock while in older rock the conodonts most closely resembling the Chazy specimens are assigned to the genus *Histiodella*. It is possible that the representatives of the genus *Histiodella* in limestone described as belonging to the Whiterock Stage from the Basin and Range area may be the evolutionary predecessors of the Chazy and Dutchtown-Joachim forms.

Occurrence: The few Chazy specimens referred to *Ozarkodina ctenulata* are found in the low Day Point Formation.

OZARKODINA sp.

Pl. 4, figs. 7, 8.

Remarks: One exceptionally large conodont element from the Chazy collection fits the morphologic plan of the genus *Ozarkodina* yet does not belong with ozarkodiniform elements in the two multielement species of *Plectodina* nor to the species *O. ctenulata*. The unit consists of a tall and broad bar whose oral surface is weathered but bears the stumps of broken denticles. The cusp position is close to one end of the bar. The shorter anterior bar segment has a gentle aboral inclination, bears three denticles, is reduced in height, and is a few degrees out of a common vertical plane with the longer and more massive posterior bar segment. The outer lateral face bears an inclined costa in the cusp region that may have continued orally as a longitudinal costa on a proclined cusp. The basal cavity is filled but appears to have been deeply excavated.

Occurrence: The one element of *Ozarkodina* sp. was recovered from the Valcour Formation.

Genus PANDERODUS Ethington, 1959

Type species: *Palodus unicostatus* Branson and Mehl, 1933.

The genus *Panderodus* was proposed by Ethington (1959) to represent simple asymmetrical conodont elements found in rocks of Middle Ordovician and younger ages of North America; otherwise fitting the definition of *Paltodus* given by Pander in 1856 but having a deep, rather than shallow, basal cavity. Characteristic of Panderous are costae or grooves on the lateral faces and longitudinal striae extending from the basal margin some distance up the cusp.

Since Panderodus was proposed a number of form species have been added to the genus. Sweet and Bergström (1962); and Bergström and Sweet (1966) have commented that a thorough revision of the genus is needed and that the great variety of forms may belong in a few multielement species. It is possible that the small morphologic distinctions between form species in some cases may represent variation within symmetry transition series. The Chazy population of Panderodids seems to fall into the three form species P. Cracilis, P. compressus, and P. panderi, the first two being particularly hard to distinguish and assigned to a multielement species, while the presence of latter is questionable due to the paucity of specimens.

PANDERODUS GRACILIS (Branson and Mehl)

Pl. 4, figs, 10, 15.

Paltodus gracilis BRANSON AND Mehl, 1933, p. 108, Pl. 8, figs. 20, 21.
Panderodus gracilis (Branson and Mehl), BERGSTRÖM AND SWEET, 1966, p. 355-359, Pl. 35, figs. 1-6 (includes synonymy through part of 1966): VOTAW, 1971, p. 106-108, Pl. 3, figs. 32, 33 (includes synonymy 1966-1971).

Remarks: The multielement species *Panderodus gracilis* is composed of the two form species *Panderodus gracilis* and *P. compressus*. The association of the two form species has been demonstrated by Bergström and Sweet (1966), Webers (1966) and Votaw (1971). These authors listed ratios between *Panderodus gracilis* and *Panderodus compressus* of 2:1, 4:1, and 2:1 respectively. In the Chazy collection the number of specimens of each species is tentatively 1222 and 150, suggesting a ratio of 8:1. However, it was my experience that separation of the two form species is an arbitrary process requiring subjective judgment and that a complete gradation of morphologies exists. It remains a valid conclusion that a higher ratio of *Panderodus gracilis* to *Panderodus compressus* exists in the Chazy collection than in previously reported collections from younger Middle Ordovician rocks.

Occurrence: *Panderodus gracilis* is found throughout the Chazy Group. Votaw, has discussed previously reported occurrences of *Panderodus gracilis*. The species has been found in middle and upper Middle Ordovician rocks. Votaw concluded from his study of conodont fauna of Black River age, that the oldest occurrence of *Panderodus gracilis* is within Fauna 6 of Sweet and others (1970). However, the Chazy is thought to represent both fauna 5 and at least the lower portion of Fauna 6, thus extending the lower range limit of the species.

PANDERODUS PANDERI (Stauffer)

Pl. 3, Fig. 8.

Paltodus panderi STAUFFER, 1940, p. 427, Pl. 60, figs. 8, 9.
Panderodus panderi (Stauffer) BERGSTROM & SWEET, 1966, p. 359-361, Pl. 35, figs. 14, 15, text-fig. 11 (includes synonymy through part of 1966); VOTAW, 1971, p. 109, Pl. 2, fig. 29 (includes synonymy 1966-1971).

Remarks: A few simple conodont elements have characteristics of the genus Panderodus but evidently do not belong to P. gracilis. They compare favorably to illustration and descriptions of P. panderi presented in Bergström & Sweet (1966) and Votaw (1971). Specimens referred to P. panderi have robust cusps curved sharply through 90 or more degrees a short distance above the basal region.

Occurrence: The presence of P. panderi in the Chazy Group is the oldest reported for the species, previously described from Middle Ordovician strata of Black River age and younger.

Genus PHRAGMODUS Branson & Mehl, 1933

Type species: P. undatus Branson & Mehl, 1933

PHRAGMODUS INFLEXUS Stauffer

Unfigured

Phragmodus inflexus (part) STAUFFER, 1935, p. 151, Pl. 11 figs. 9, 16, 20, 25, 26 (not figs. 15, 17, 19, 21, 22, 34); VOTAW, 1971, p. 113-114, Pl. 2 figs. 11-14, 17; Text-fig. 121-J (includes synonymy through 1971).

Phragmodus inflexus is a multielement species which includes phragmodiform, cyrtoniodiform, and dichognathiform elements and is characteristic of the Mid-Continent conodont province fauna 7 (Votaw, 1971). The phragmodiform elements are smaller, more strongly compressed, and have posterior processes whose distal portions, beyond the aboral flexure of the bars, are both longer and straighter than is typical of the phragmodiform elements of Phragmodus tortus. The P. inflexus assemblage also lacks the cordylo iform elements found in P. tortus.

Occurrence: Elements of Phragmodus inflexus have been found in samples of the Isle La Motte Limestone, which directly overlies the Chazy Group in the Champlain Valley. Votaw (1971) defined a "zone" of Phragmodus inflexus in Black River equivalent strata of North America. The P. inflexus "zone" corresponds to fauna 7 of Sweet, Ethington, and Barnes (1971).

PHRAGMODUS TORTUS Sweet, ms.

Pl. 3, figs. 12, 16, 17; Pl. 4, fig. 22.

Phragmodus undatus (Branson & Mehl) ETHINGTON & SCHUMACHER, 1969, p. 472, Pl. 67, fig. 15.
Cyrtoniodus flexuosus (Branson & Mehl) ETHINGTON & SCHUMACHER, 1969, p. 459, Pl. 67, fig. 11.
Phragmodus sp. MOSKALENKO, 1971, p. 81, Pl. 13, fig. 5.
Subcordylodus sinuatus Stauffer MOSKALENKO, 1971, p. 88, Pl. 13, fig. 4.
Phragmodus tortus VOTAW, 1971, p. 115-117, Pl. 2, figs. 10, 19, 20, 22, Text-fig. 12K-N.

Description: Phragmodus tortus is a multielement species containing phragmodiform, dichognathiform, cordylodiform, and crytoniodiform elements. The phragmodiform and cyrtoniodiform elements are distinctive while the dichognathiform and cordylodiform elements bear strong resemblance to similar elements in the multielement species *Plectodina pristina* Raring, n. sp.

The phragmodiform elements are distinguished by a large recurved cusp and a posterior process which is both twisted on its axis and deflected aborally. The process bears reclined denticles which achieve a size equal to, or larger than, the cusp in the region of maximum aboral deflection, about one third of its length behind the cusp. In the cusp region an antero-lateral longitudinal costa, extending aborally and posteriorly as a ridge or undenticulated process, may be present on both lateral faces, one lateral face, or be absent. These three morphologic types are members of a symmetry transition series having intermediate forms. The elements with two well developed costae are the least common and represent the most symmetrical plan. Those elements lacking a costa seem to have the greatest degree of process flexture. Immature specimens are laterally compressed while the majority of phragmodiform elements have a squat appearance.

The dichognathiform elements have erect cusps, sharp-edged anteriorly and posteriorly, and denticulated posterior and inner-lateral processes. Unlike the dichongnathiform elements of *Phragmodus inflexus* found in younger strata, the anterior margin is not serrated in its basal region.

Also, the inner-lateral process does not extend aborally to the degree of the later dichognathiform elements.

The cordylodiform elements differ from phragnodiform elements in having a posterior process that may be flexed along its axis and bent inward slightly but is not deflected below the horizontal. These elements have mildly reclined, equal-sized, discrete denticles with ellipsoidal profiles.

The cyrtoniodiform elements are laterally compressed units having slight inward flexure of the short, denticulated posterior process. The tall, erect cusp is thin and sharp-edged. The process bears similarly shaped denticles which decrease in size posteriorly. The inner lateral face of the base is flared, widening the basal cavity in that direction.

Remarks: *Phragmodus tortus* is the most abundant species in the Chazy collection and is usually found in conjunction with *Plectodina pristina* n. sp. The black, opaque preservation and broken condition of Chazy conodonts make it often difficult to distinguish cordylodiform and dichognathiform elements of these two species. If unbroken, the processes of dichognathiform elements from *Phragmodus tortus* are longer and more robust than those of *Plectodina pristina*. Cordylodiform elements of *Phragmodus tortus* have their posterior processes more sharply twisted about their axes, and have more strongly developed longitudinal costae in the cusp region. However, the phragmodiform and cyrtoniodiform elements are invariably associated in samples containing a moderate number of either element.

Phragmodus tortus may be distin uished from the younger *P. inflexus* by several characters. The posterior process of the phragmodiform element of *P. tortus* is continuously twisted along its axis and descends below the horizontal through a gradual curve. In *P. inflexus* the posterior process of the phragmodiform element bends sharply from the horizontal and is untwisted beyond that point. The entire phragmodiform element of *P. inflexus* is also smaller and more compressed.

Occurrence: *Phragmodus tortus* is present throughout the Chazy Group. Its distribution was reported by Sweet, Ethington, and Barnes (1971) to be limited to faunas 5 and 6 of the Midcontinent conodont province.

Genus PERIODON Hadding, 1913

Type species: P. aculeatus Hadding, 1913.

The genus *Periodon* is now understood to include multi-element species of compound conodont units having a posterior process whose denticles increase in size and angle of reclination posteriorly and also anterior and lateral processes variably developed. The anterior process curves laterally and is directed aborally; its denticles, if present, extending normal to the plane of cusp and posterior process. A longitudinal costa sweeping aborally and posteriorly in its basal region may ornament the two lateral faces of the base below the cusp. The basal cavity is inverted beneath the posterior process. The variable development of anterior denticulate and lateral processes results in morphologies ranging from cordilodiform through ligonodiniform and cladognathodiform to roundyaform (Lindström, 1964). Bergström and Sweet (1966) later added prioniodiniform and falodiform elements to the *Periodon* assemblage.

PERIODON aff. P. ACULEATUS Hadding

Pl. 2, figs. 5, 6.

Periodon aculeatus HADDING, 1913, Lunds Univ. Arsskr., N.F., Afd. 2, bd. 9, no. 15, p. 33, Pl. 1, fig. 14; SWEET AND BERGSTROM, 1962, p. 1235, Pl. 171, figs. 3, 9 (includes synonymy through 1962); BRADSHAW, 1969, p. 1159-1160, Pl. 137, figs. 1-6 (includes synonmy 1962-1969).

Remarks: A few poorly preserved Chazy conodonts appear to belong to an assemblage similar to those described in the multielement genus *Periodon*. They are referred to *P. aculeatus* primarily on the basis of their stratigraphic position. However, it is possible that the specimens in question are not members of a *Periodon* species and more likely that they are not members of *Periodon aculeatus*.

Bergström and Sweet (1966) listed the form species assigned to *Periodon aculeatus* as being *Periodon aculeatus* Hadding, 1913, *Loxognathus flabellata* Graves and Ellison, 1941, *Ozarkodina macrodentata* Graves and Ellison, 1941, *Oistodus prodentatus* Graves and Ellison, 1941, and *Ligonodina tortilis* Sweet and Bergström, 1962. The illustrated Chazy specimens are Periodoniform in plan.

Occurrence: Found in the upper Crown Point Formation of the Champlain Valley.

Genus PLECTODINA Stauffer, 1930

Type species: *Plectodina aculeata* (Stauffer), 1930

The genus *Plectodina* is used as defined by Bergström and Sweet (1966) to include cordylodiform, dichognathiform, ozarkodiniform, trichonodelliform, zygognathiform, and prioniodiniform elements in multielement species. Distribution of analogous elements in the Chazy collection bears out the well documented association of forms assigned to *Plectodina*. The genus is associated in distribution with the Midcontinental faunal province and is abundantly represented in the Chazy. *Plectodina* is not represented in Middle Ordovician collections from Sweden.

PLECTODINA ACULEATA (Stauffer)

Pl. 3, figs. 5, 6, 10, 18, 19.

Prioniodina aculeatus STAUFFER, 1930, p. 126, Pl. 10, fig. 12.
Prioniodus? obliquus STAUFFER, 1930, p. 123, Pl. 10, figs. 3, 4.
Plectodina aculeata (Stauffer) BERGSTRÖM AND SWEET, 1966 p. 373-377, Pl. 32, figs. 15, 16, Pl. 33, figs. 5, 6; Text.-fig. 9A-F (includes synonymy through 1966); VOTAW, 1971, p. 117-121, Pl. 3, figs. 24-28, 31; text-fig. 13Z-F (includes synonymy 1966-1971).

Description: Cordylodiform elements have large sub-erect cusps with aboral extensions swept posteriorly and posterior bar processes flexed laterally proximal to the cusp continuing straight distally and bearing discrete re-clined denticles. There is a tendency for the basal ex-tension of the cusp to flex laterally and bear a few vertical denticles. The resulting eoligonodiniform elements are grouped in symmetry transition with the more common cordylodiform elements from which they are derived.

Dichognathiform elements of *Plectodina aculeata* have a laterally compressed cusp, short denticulate posterior and inner lateral processes, and an aborally extended un-denticulate anterior margin. The oral edge of the posterior process is continuous with the sharp posterior cusp edge. The anterior margin of the cusp is also sharp-edged and is continuous with the anterior margin of the base, which is swept posteriorly and terminates in a sharp acute angle with the inclined aboral margin. The basal cavity opens toward the inner lateral side.

Ozarkodiniform elements have a laterally compressed cusp from which denticulated anterior and posterior processes of subequal length extend at about 160 degrees to each other. The aboral inclination of the anterior process results in an arched asymmetric unit whose basal cavity opens toward the inner lateral side. A basally flaring longitudinal costa marks the inner lateral face at the cusp while the outer lateral face of the unit is smooth.

Trichonodelliform and zygognathiform elements are in symmetry transition. Trichonodelliform elements have two symmetrically disposed lateral process of equal length. Zygognathiform elements have the two lateral processes rotated around the cusp axis, leaving one close to the posterior keel and reduced in length while the other is anteriorly situated on the opposite lateral face of the cusp and is larger. The zygognathiform cusp profile is asymmetric as well. Elements are found which are transitional between the two forms.

Prioniodiniform elements are similar in plan to ozarkodiniform elements but have their anterior processes directed almost 90 degrees aborally and in approximately the same vertical plane as the posterior processes. Their cusps are compressed, but sub-erect to proclined, and have a longitudinal costa on their inner lateral faces. The processes carry continuous rows of equal-sized denticles on their oral surfaces.

Remarks: The six form species of *Plectodina aculeata* are similar in size and denticulation, being robust with discrete denticles of rounded profile. All show moderate lateral compression and have basal cavities which extend beneath the processes as shallow grooves. Cordylodiform and dichognathiform elements are most abundant.

Elements of Plectodina aculeata are rare in the Chazy collection but are distinctive for the inclusion of prioniodiniform and elligonodiniform elements and their generally robust and well perserved character. Throughout all but the uppermost Chazy Group the species of Plectodina present differs from P. aculeata in having an oistodiform rather than a prioniodiniform element and being of smaller size and in more fragmented state of preservation.

Occurrence: Plectodina aculeata is found only in the middle and upper Valcour Formation and equivalent strata of the Montreal area. Votaw (1971) reported P. aculeata throughout the Black River Group and equivalent beds and placed its lowers occurrence somewhere in the North American Midcontinent fauna 6 of Sweet, Ethington, and Barnes (1971). The presence of P. aculeata in the Chazy Group substantiates Votaw's report and may represent the oldest occurrence of the species.

PLECTODINA PRISTINA Raring n. sp.

Pl. 3, figs. 1, 9; Pl. 4, figs. 11, 14.

Plectodina n. sp. VOTAW, 1971, p. 121-123, Pl. 3, figs. 12-23; Text.-fig. 12G-L.

Description: A multielement species containing cordylodiform, dichognathiform, ozarkodiniform, trichonodelliform, zygognathiform, oistodiform elements. All are somewhat laterally compressed, of moderate size, and similar preservation.

The cordylodiform element has a suberect cusp and discrete, reclined centicles on a straight to mildly bent posterior bar process which may be variably twisted along its axis. The cusp and anterior portion of the base are flexed inward relative to the posterior process. The anterior margin of the cusp is sharp-edged and sweeps posteriorly at an angle of 30 degrees or more in its basal aborally extended continuation. The base has a smoothly convex outer lateral face and an inner lateral face that is flat to mildly convex beneath the cusp with a variably developed longitudinal groove immediately adjacent to the anterior margin. The basal cavity opens somewhat posteriorly.

The dichognathiform element has a laterally compressed cusp, sharp-edged anteriorly and posteriorly, and inner lateral and posterior processes diverging at an angle of 140 to 150 degrees. The processes are short and frequently lacking denticles, possibly due to breakage. Basally, the anterior margin of the unit curves posteriorly from the vertical by 25 to 35 degrees and the inner lateral process has a 20-30 degree aboral inclination. The basal cavity opens beneath the inner lateral process and extends as a slit beneath the distal portions of the processes.

The ozarkodina element is usually broken at midsection but the remaining bar fragments are robus, with a pointed cusp and a row of somewhat smaller denticles confluent at their bases. The anterior process apparently declined at a 30 degree angle from the horizontal and was in a common plane with the posterior process.

The trichonodelliform and zygognathiform elements are also frequently broken but when whole are similar to the analogous units of Plectodina aculeata, forming a symmetry transition series from symmetrically arranged to skewed lateral processes. Trichonodelliform elements lack any development of denticles on the short posterior process as seen in P. aculeata (Pl. 3, fig. 10).

The asymmetric oistodiform element bears a tall, laterally compresses cusp whose sharp posterior edge forms an acute angle of about 70 degrees with the oral margin of the short base. The cusp is gently recurved and bent inward, the sharp anterior margin continuous with the anterior margin of the base to the aboral extremity of the unit. The aboral margin forms an acute angle with the anterior margin and inclines a sharply acute angle with the oral edge at the posterior extremity of the base.

Remarks: The multielement species Plectodina n. sp. was proposed by Votaw, 1971, to include cordylodiform, dichognathiform, ozarkodiniform, trichonodelliform, zygognathiform, and oistodiform elements found in association with one another in Black River strata of North America. The association of elements assigned to the species from the Chazy collection are similar to Votaw's type specimens, illustrations, and description. There appear to be minor morphological differences, particularly in the oistodiform elements, between Chazy and younger collections of *Plectodina pristina*. However, whether these differences will result in designation of two separate species can not be foreseen.

Elements assigned to *Plectodina pristina* are found throughout the Chazy Group usually in association with the elements of *Phragmodus tortus*. The cordylodiform and dichognathiform elements of the two species are hard to distinguish, partially due to the broken and blackened condition of most Chazy conodont elements. The oistodiform elements are also difficult to distinguish from morphologically similar simple conodont elements and broken cyrtoniodiform specimens of *Phragmodus tortus*. However, the ozarkodiniform, trichonodelliform, and zygognathiform elements are distinctive and associated with the more abundant elements of *P. pristina* in all samples containing moderate numbers of the cordylodiform, dichognathiform and oistodiform elements.

Occurrence: Elements of *Plectodina pristina* are found in the Day Point, Crown Point, and Valcour Formations of the Champlain Valley and equivalent strata of the Montreal area.

Votaw (1971) reported *Plectodina* n. sp. to be restricted to his "*Phragmodus inflexus* zone," equivalent to fauna 7 of the North American Midcontinent fauna province (Sweet and others, 1971). Either the range of *Plectodina pristina* includes faunas 5, 6, and 7, or *P. pristina* of the Chazy Group, associated with *Phragmodus tortus,* represents a taxon separate from *Plectodina* n. sp. of fauna 7. Examination of Votaw's holotypes suggests the former interpretation is correct. Elements inseparable from those of *Plectodina pristina* in the Chazy collection are also seen in samples from the Lenoir Limestone at the type section of the Marmor Stage, Friendsville, Tennessee (Bergström 1971a).

Genus POLYPLACOGNATHUS Stauffer, 1935

Type species: *P. ramosus* Stauffer, 1935

POLYPLACOGNATHUS FRIENDSVILLENSIS Bergström

Pl. 2, figs. 12, 16; Pl. 4, figs. 18, 24.

Polyplacognathus friendsvillensis BERGSTROM, 1971a, p. 142, Pl. 1, figs. 3, 4.

Description: *Polyplacognathus friendsvillensis* is a multielement species consisting of a polyplacognathiform element and mirror image dextral and sinistral ambalodiform elements. As Bergström (1971a) has given a thorough description of the species only a brief account will be presented here.

The polyplacognathiform element has a sinuous anterior-posterior denticle row on a platform that is narrow and aborally inclined anteriorly but broad and in the horizontal plane posteriorly. The bifid antero-lateral process has a short anterior lobe and a much longer posterior lobe, extending from the anterior-posterior axis at close to a 90 degree angle. They both have straight denticle rows on narrow platforms and diverge from each other a short distance from the proximal end. The postero-lateral process forms an acute angle with the posterior process and bears several low denticles on a broad platform.

The ambalodiform units have a central row of denticles bent through a ninety degree angle not far from the posterior end. In the region of the bend a second short denticle row leaves the main row on the outer lateral side. With the anterior end of the main denticle row oriented downward the unit has the shape of a distorted T.

The platform narrows from the point of flexure to a distal point posteriorly while in the anterior direction the platform is broad and terminates in a smoothly rounded lobe. The platform bearing the outer lateral denticle row is intermediate in width and has several lobes in its anterior margin.

Remarks: *Polyplacognathus friendsvillensis* is a critical component of the Chazy conodont fauna due to its biostratigraphic significance. Bergström (1971a) reported its presence in the Lenoir Limestone at Friendsville, Tenn., type section of the Marmor Stage, where *Pygodus serrus* and

Eoplacognathus foliaceus, guides to the North Atlantic conodont province zonation, also occur. This mutual presence allows correlation of the Chazy Group to the succession of Swedish conodont zones and to limestones in the southern Appalachians.

The ambalodiform elements of P. Friendsvillensis underwent evolutionary modification during deposition of the Lenoir and Arline Formations. Bergström (per.comm.) has illustrated a dequence of four forms found in the section at Friendsville, Tenn. and these forms also succeed one another in the Chazy Group. In the earliest stage of development the anterior denticle row is concave toward the outer lateral direction and bends smoothly through ninety degrees in the central region of the unit to be continued as the posterior denticle row, which is also concave toward the outer lateral side. Succeeding stages of development saw the anterior portion of the main denticle row straighten and the junction with the posterior portion of the main denticle row become progressively a sharper bend and eventually a right angle. At the point in development where it appears there are two separate denticle rows, meeting at a right angle, P. sweeti has evolved.

The oldest stage of development of the ambalodiform element is found in both the lower Lenoir limestone and the lower Day Point Formation. The correlation of the

Lenoir and lower portion of the Chazy Group has been based on this fact.

Occurrence: P. Friendsvillensis is limited to the Day Point Formation and is abundant in the uppermost of four members, the Fleury Limestone. The base of this interval represents a position in the lower half of the formation however due to the thickness of the fleury.

POLYPLACOGNATHUS SWEETI Bergström

Pl. 2, figs. 15, 18, 19.

Polyplacognathus sweeti BERGSTRÖM, 1971, p. 143, P. 1. 1, figs. 1, 2.

Description: Polyplacognathus sweeti is a multi-element species consisting of polyplacognathiform and mirror image ambalodiform elements. Polyplacognathiform elements have a straight denticle row along an anterior-posterior axis, a long, narrow antero-lateral process at right angles to the main axis which has a short, anteriorly directed bifurcation proximally, and a broad postero-lateral platform process with a few low denticles also at right angles to the main axis.

Ambalodiform elements have a broad anterior platform lobe with central denticle row and two lateral extentions, one posteriorly situated with a sharply pointed outline and central denticle row at right angles to the anterior process, the other diverging at about 130 degrees to the anterior process opposite and anterior to the first. The anterior and postero-lateral processes are of approximately equal length while the antero-lateral process is shorter, with a more rounded outline as well. The posterior axis is marked by a few denticles but no platform projection.

Remarks: Specimens of Polyplacognathus sweeti, particularly polyplacognathiform elements, are atypical of the species as described by Bergström (1971a). Antero-lateral processes are illustrated as lacking an anterior bifurcation altogether, while most Chazy specimens bear short anterior lobes reminiscent of P. friendsvillensis, although reduced in length. The postero-lateral process of Chazy specimens is also intermediate between the swept-back orientation of the process in P. friendsvillensis and the more nearly right angle configuration of typical specimens of P. sweeti. This would seem to imply that the P. sweeti of the Chazy Group are older than those described by Bergström. Correlations presented previously (p. figure 5) are based on this interpretation.

Occurrence: Upper Crown Point through upper, but not uppermost, Valcour strata are sporatically productive of Polyplacognathus sweeti. Elsewhere, P. sweeti is found in beds assigned to the Pygodus anserinus zone (Bergström, 1971a).

Genus PSEUDOPHRAGMODUS Raring, new genus

Type species: *P. champlainensis* Raring, new species

Conodont elements are found in the Chazy collection which resemble the genus *Phragmodus* in general morphology but have a "fibrous" appearance and much reduced posterior processes. These elements are apparently undescribed although Branson and Mehl (1933) described a species, *Phragmodus simplex,* from the Upper Ordovician Thebes Formation that compares favorably with the specimens at hand. In their description they noted that the species was not laterally compressed as is typical for species of *Phragmodus* and that there was no posterior bar developed. The Chazy specimens also lack lateral compression but have posterior processes, although they are greatly reduced in length.

PSEUDOPHRAGMODUS CHAMPLAIENSIS Raring, n. sp.

Pl. 1, fig. 19.

Description: Robust conodont elements having a "fibrous" appearance, the general morphologic plan of the genus *Phragmodus*, and a reduced posterior process bearing five to seven denticles are assigned to the new species *Pseudophragmodus champlainensis*. The cusp is slightly proclined to suberect and inferior in height to the second and third posterior denticles, which are moderately reclined at their bases and recurved toward their distal extremities. Two to four nub-like denticles are carried on the oral surface of the rounded, flexed, and aborally inclined posterior bar posterior to the two large denticles. The posterior bar process is robust between the cusp and second denticle but is diverted about 70 degrees below the horizontal and tapers rapidly to a pointed distal extremity posterior to the third denticle. The first denticle is moderately reclined and inferior in height to both the cusp and second denticle. The cusp displays one sharp-edged longitudinal costa of low relief on the two lateral faces but the denticles have round profiles. A bulbous appearance is characteristic of the units. The oral margin of the bar is smoothly curved between the denticles.

The base is tallest at the rounded anterior margin. The process appears unexcavated posterior to the third denticle instead having a flat aboral surface.

Remarks: The limited number of elements assigned to *Pseudophragmodus champlainensis* do not allow judgment of whether or not cospecific forms exist. While no other forms seem stratigraphically associated the sample number is too small to exclude the possibility that *P. champlainensis* is one form in a multielement species, as yet undescribed.

Occurrence: Specimens of *Pseudophragmodus champlainensis* are found throughout the Chazy Group and equivalent strata in the Montreal area but are most common in the upper Crown Point and lower Valcour Formations.

Genus SCANDODUS Lindström, 1955

Type species: *S. furnishi* Lindström, 1955

SCANDODUS n. sp.

Pl. 4, fig. 12

Description: Simple asymmetric conodont elements with a recurved cusp possessing an anterior flange which expands to an undenticulated blade-like process basally which is deflected both aborally and laterally. The cusp is slightly bent over the inner lateral side and is slightly twisted as well. The base is flared beneath the cusp on the inner lateral side and does not open in the plane of the cusp. The cusp is laterally compressed with sharp edges both anteriorly and posteriorly. Posteriorly, a narrow sharp-edged flange extends from the broadly convex outer lateral face. On the inner lateral face the convex cusp surface intersects the flat flange surface at a sharp curve creating a longitudinal groove.

The base is in continuity with the cusp but expanded anteriorly by the blade-like flange.

The narrowing basal cavity extends a distance up the cusp and has its apex anterior to the cusp's median axis. The conical basal cavity beneath the flared inner lateral aboral margin extends as a narrow slit into the anterior flange. The flange process is sharply distinguished from the inner lateral surface of the base by a trough formed by the intersection of two surfaces. Distally, the anterior process becomes a flange of diminishing width on the cusp.

Remarks: These units are falodiform in plan but with cusp and opening of basal cavity not in the same plane. Similar elements were named Oistodus concavus by Branson and Mehl (1933) but were recovered from the top of the Jefferson City Formation (Lower Ordovician) of Missouri.

Occurrence: Only found in sample 72R-SCQ-1 from the lower Laval calcarenites.

Genus SCOLOPODUS Pander, 1856

Type species: Scolopodus sublaevis Pander, 1856

SCOLOPODUS QUADRAPLICATUS Branson and Mehl, 1933

unfigured

Scolopodus quadraplicatus BRANSON AND MEHL, 1933, p. 63, Pl. 4, figs. 14,15

Description: Simple symmetrical to subsymmetrical conodont elements having broad convex anterior faces and deep grooved with U profiles along the posterior edges. The cusps are slightly recurved and bear rounded antero-lateral costae on each side followed posteriorly by flat postero-lateral faces which terminate in rounded lip-like posteriorly directed costae which border the median posterior grooves. Each element thus has four symmetrically disposed costae with convex anterior face, concave lateral faces, and deeply concave posterior trough. The costae terminate above the rounded lip-like, aboral margin.

The base is somewhat flared and continuous with the cusp. The basal cavity is broad and appears shallowly excavated.

Remarks: Chazy specimens match the description given by Branson and Mehl for *Scolopodus quadraplicatus*. Although the few specimens in the Chazy collection have their distal ends broken they are confidently assigned to this species. They mark the youngest occurrence of *S. quadraplicatus* to date, Branson and Mehl's specimens being found in clay between the Lower Ordovician Jefferson City Formation and Middle Ordovician St. Peter Sandstone of Missouri (Ethington and Clark, 1970).

Occurrence: Lower Day Point Formation.

Genus THRINCODUS Raring, n. gen.

Type species: *Thrincodus palaris* Raring, n. sp.

Description: Asymmetric elements having a blade-like lateral process bearing stubby erect denticles on its oral surface. The blade is continuous with the cusp, which is curved both posteriorly and to the opposite lateral side. The entire unit is compressed. The basal cavity flared posteriorly beneath the cusp and continues as a shallow slit beneath the process.

Remarks: Elements assigned to the new form genus *Thrincodus* may be oriented with the blade process anterior and the basal flare directed laterally. In that orientation they would resemble the blade element of the species

Appalachignathus delicatulus Votaw in plan but not in detail. Also, Appalachignathus is defined in a multi-element sense while representative elements of the new genus Thrincodus appear to lack associated from species.

THRINDOCUS PALARIS Raring, n. sp.

Pl. 2, fig. 8; Pl. 4, fig. 25

Description: Compressed, asymmetric elements distinctive for their long, gently bowed, blade processes and basal cavities dramatically flared beneath the cusp positions.

There is a shield or leaf-like region about the cusp, an outer-lateral denticulated blade process and an inner-lateral flange having several smooth corrugations on its outer edge. The unit is considered to be compressed in an anterior-posterior direction. Placed in this orientation the cusp region is recurved and flexed inwardly in a continuous curve. The basal cavity is greatly expanded posteriorly beneath the cusp but is present as a shallow slit beneath the blade.

The region of the cusp is leaf-like due to its great anterior-posterior compression, with development of a blade on one lateral margin and a wide flange on the other. The posterior surface has a gently rounded carina of low relief which marks the position of the cusp. This carina narrows and increases in relief aborally and is better developed on more mature specimens. The anterior surface is smoothly and almost imperceptibly convex but has a circular depression adjacent to the juncture of the oral edge of the base and the inner lateral edge of the cusp region.

The inner lateral flange process of the cusp begins in an acute angle with the oral edge of the inner lateral projection of the base and widens upward to its greatest extent at a position about one third of the distance to the cusp's end. The flange narrows gradually to the distal region where it bends across the top of the cusp at a right angle. Several corrugations on the outer margin of the flange produce knobs and intervening nodes in anterior or posterior view.

On the outer lateral side of the cusp a flange begins at the extreme distal portion of the cusp in continuity with the inner lateral flange. The distal margin of this structure crosses the cusp axis at right angles, bends sharply through 90 degrees, and parallels the cusp axis below its distal end to a point about one fourth of the way to the aboral margin. At that point it curves outward to become the oral edge of the blade process. Indistinct denticles begin on the flange margin paralleling the outer lateral cusp edge but become prominent where the blade divorces itself from the cusp. The denticles are laterally confluent along their short length with the exception of the blunt, vertically oriented distal ends, but become slightly inclined toward the cusp region in more mature specimens. Their height represents a small portion of the total blade height.

On the posterior face of the blade slightly above the aboral edge a depression at the point of juncture between the blade and cusp region is continued along a portion of the length of the blade as a furrow. Below the furrow a narrow flange directed posteriorly and aborally divided the posterior face from the basal slit. The anterior surface of the blade is smooth and slightly convex with a subdued flange along the aboral edge.

The base is extended in the inner lateral direction, the oral and aboral edges coming to an acutely angled point distally. From this point the aboral edge flares posteriorly beneath the conical basal sheath and continues through a smooth curve to a sharp right-angled junction with the aboral margin of the outer-lateral blade process. The entire aboral margin of the unit rests on a horizontal plane.

The basal cavity is broad and shallow beneath the thin posterior sheath of the cusp region. Beneath the blade process the basal cavity is a narrow, shallowly excavated, trough.

Remarks: Specimens of this taxon are generally large and well-preserved but have had the distal portion of the blade process broken. In no sample are they abundant yet they are common in the Chazy collection. Identical forms have been seen in samples of the Lenoir Limestone of Tennnessee collected by Dr. S.M. Bergström.

Occurrence: Found throughout the Chazy Group of the Champlain Valley and equivalent beds of the Montreal area. Samples containing *Thrincodus palaris* usually contain specimens of *Polyplacognathus* as well.

Genus TRUCHEROGNATHUS Branson & Mehl, 1933

Type species: *T. distorta* Branson & Mehl, 1933

TRUCHEROGNATHUS? sp.

Pl. 1, fig. 14

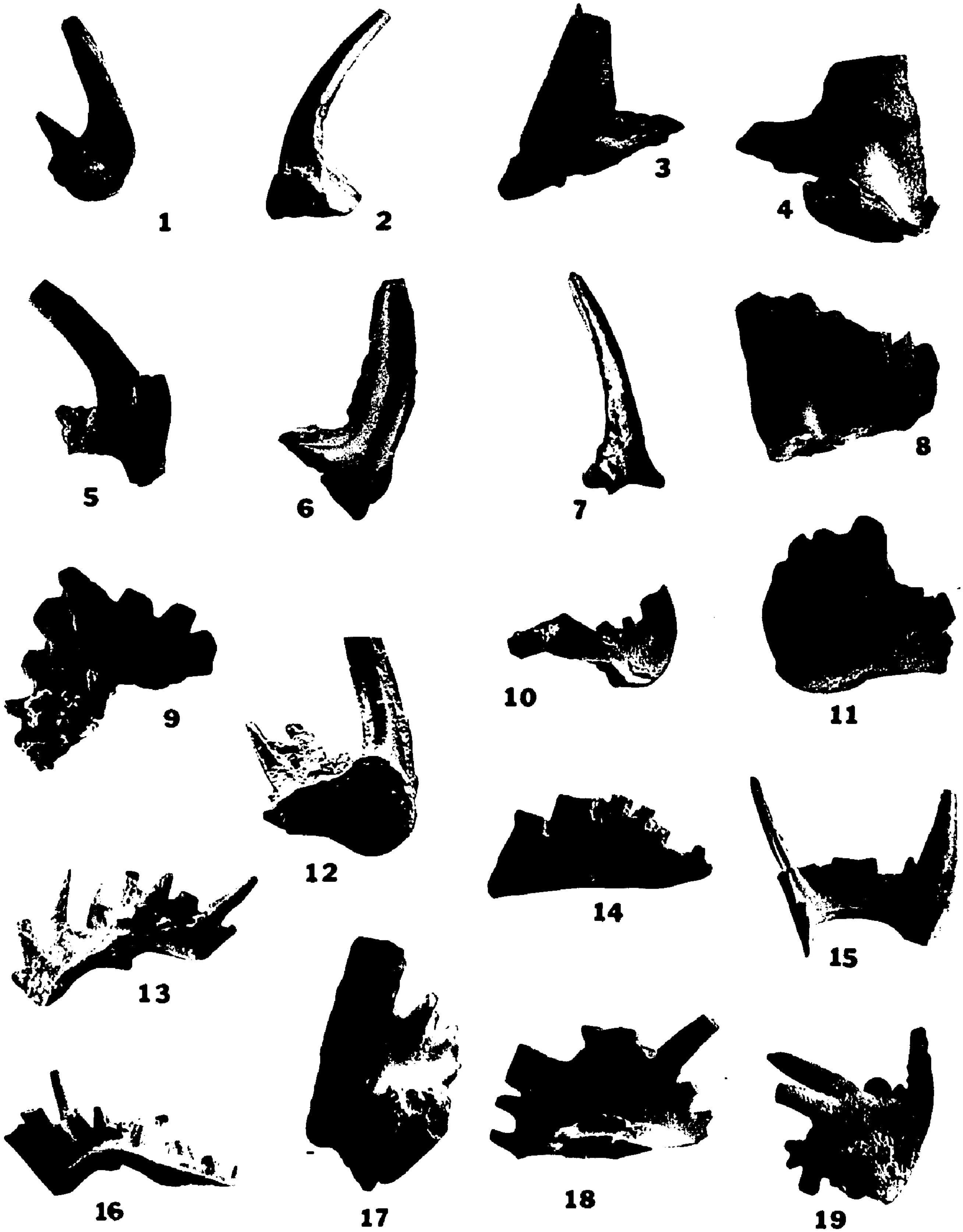
Remarks: One Chazy specimen resembles the morphologic plan of the genus *Trucherognathus* Branson and Mehl, yet is more compressed than the species described and illustrated by Branson and Mehl and is also incomplete. This broken specimen consists of a compressed and tall bar bearing laterally inclined denticles, confluent at their bases. The height of the unit decreases toward one end. The specimen has been questionably assigned to the genus *Trucherognathus*.

Occurrence: The one element is from the upper Crown Point of Valcour Island.

EXPLANATION OF PLATE 1

All figures reproduced from photographs taken on the A. R. L. Electron Microprobe with scanning microscopy attachment.

Fig. 1	Multioistodus subdentatus Cullison. Lateral view of subdentatiform element. X80.
Fig. 2	Multioistodus cryptodens (Mount). Antero-lateral view of neoprioniodiniform element. X45.
Fig. 3,4	Oistodus aff. O. angulatus Bradshaw. Inner lateral views. 3, X60; 4, X70.
Fig. 5	Multioistodus subdentatus Cullison. Lateral view of "M. tridens" form element. X70.
Fig. 6,7	Multioistodus cryptodens (Mound). Lateral and postero-lateral views of acodiform and acontiodiform elements. 6, X30; 7, X62.5.
Fig. 8	Ozarkodina Ctenulata Youngquist & Cullison. Posterior view. X30.
Fig. 9	Curtognathus typa Branson & Mehl. Posterior view. X83.
Fig. 10	Belodella cf. B. niger (Serpagli). Lateral view of intermediate belodelliform element. X83.
Fig. 11	Ozarkodina Ctenulata Youngquist & Cullison. Anterior view. X70.
Fig. 12	Erismodus radicans (Hinde). Posterior view of ptiloconiform (?) element. X45.
Fig. 13	Curtognathus? sp. A. Posterior view. X45.
Fig. 14	Trucherognathus? sp. Posterior (?) view.
Fig. 15	Chirognathus n. sp. B. Posterior view. X30.
Fig. 16	Curtognathus? sp. B. Posterior view. X45.
Fig. 17	Chirognathus n. sp. A. Posterior view. X30
Fig. 18	Cardiodella tumudus Branson & Mehl. Posterior view. X62.5.
Fig. 19	Pseudophragmodus champlainensis Raring, new genus, new species. Inner-lateral view. X45.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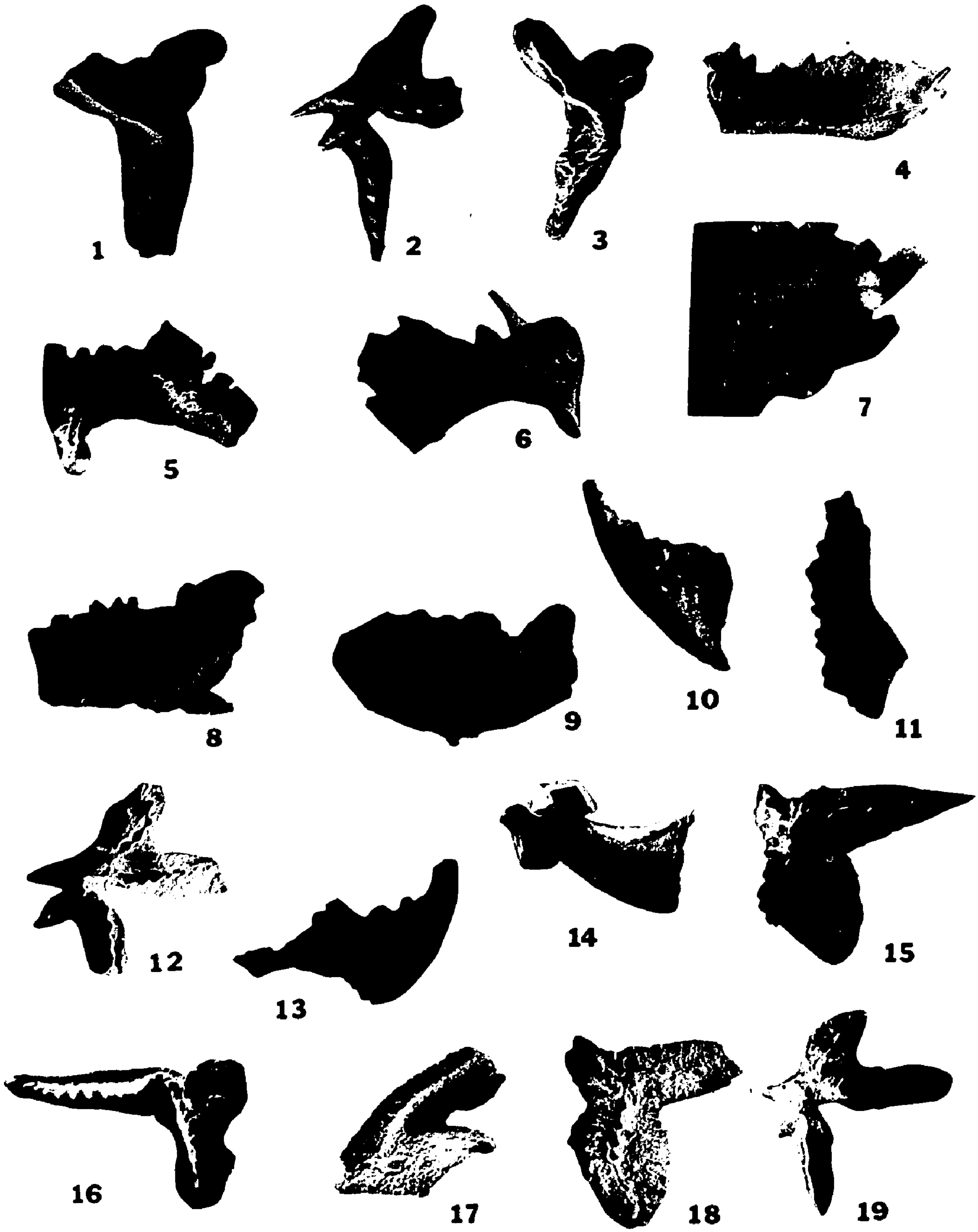
EXPLANATION OF PLATE 2

All figures reproduced from photographs taken on the A. R. L. Electron Microprobe with scanning microscopy attachment.

Fig. 1,2,3	Eoplacognathus n. sp. Superior (oral) views of sinistral ambalodiform elements (1,3) and polyplacognathiform element. 1, X50; 2, X50; 3, X50.
Fig. 4	Appalachignathus delicatulus Votaw (unpub. Ph.D. dissertation). Lateral view of falodiform (coleodiform) element. X20.
Fig. 5,6	Periodon aff. P. aculeatus Hadding. Inner lateral views of eoligonodiniform elements. 5, X60; c, X90.
Fig. 7	Appalachignathus delicatulus Votaw (unpub. Ph.D. dissertation). Close-up view of the cusp region of the lateral surface illustrated in Fig. 4. X80.
Fig. 8,9	Thrincodus palaris Raring, new genus, new species. Posterior view and posterior view of fragment from inner lateral portion of cusp. 8, X70; 9, X70.
Fig. 10, 11	Appalachignathus delicatulus Vataw (unpub. Ph.D. dissertation). Lateral view of eoligonodiniform element and postero-lateral view of zygognathiform element. 10, X50; 11, X83.
Fig. 12	Polyplacognathus friendsvillensis Bergström. Oral view of polyplacognathiform element. X60.
Fig. 13,14	Belodella cf. B. niger (Serpagli). Lateral views of symmetric and asymmetric belodelliform elements. 13, X76; 14, X80.
Fig. 15	Polyplacognathus sweeti Bergström. Oral view of ambalodiform element. X42.
Fig. 16	Polyplacognathus friendsvillensis Bergström Oral view of ambalodiform element. X70.
Fig. 17	Belodella cf. B. niger (Serpagli). Inner lateral view of oistodiform element. X80.
Fig. 18,19	Polyplacognathus sweeti Bergström. Oral views of ambalodiform and polyplacognathiform elements.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EXPLANATION OF PLATE 3

All figures reproduced from photographs taken on the A. R. L. Electron Microprobe with scanning microscopy attachment.

Fig. 1	Plectodina pristina Raring, new species. Posterior view of ozarkodiniform element. X45.
Fig. 2,3	Erismodus radicans (Hinde). Posterior and postero-lateral views of ozarkodiniform and trichonodelliform elements. 2, X50; 3, X25.
Fig. 4	Multioistodus cryptodens (Mound). Posterior view of trichonodelliform element. X33.
Fig. 5,6	Plectodina aculeata (Stauffer). Inner lateral views of cordylodiform elements showing eoligonodiniform development. 5, X40; c, X30.
Fig. 7	Erismodus radicans (Hinde). Inner lateral of eoligonodiniform element. X45.
Fig. 8	Panderodus panderi (Stauffer). Lateral view. X40.
Fig. 9	Plectodina pristina Raring, n. sp. Inner lateral view of dichognathiform element. X30.
Fig. 10	Plectodina aculeata (Stauffer). Posterior view of trichonodelliform element. X50.
Fig. 11	Coelocerodontus digonius Sweet & Bergström. Lateral view. X30.
Fig. 12	Phragmodus tortus Sweet, ms. Inner lateral view of phragmodiform element. X35.
Fig. 13,14 15	Dropanoistodus suberectus Votaw, unpub. Ph.D. dissertation. Lateral views of homocurvatiform, suberectiform, and oistodiform elements. 13, X70; 14, X85; 15, X70.
Fig. 16,17	Phragmodus tortus Sweet, ms. Inner lateral views of cyrtoniodiform and cordylodiform elements. 16, X35; 17, X35.
Fig. 18,19	Plectodina aculeata (Stauffer). Lateral views of oistodiform elements, 18 showing prioniodiniform development. 18, X35; 19, X40.


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EXPLANATION OF PLATE 4

Figures 1-9, 11, 14, and 15 reproduced from photographs taken on the A. R. L. Electron Microprobe with scanning microscopy attachment; figures 10, 12, 13, and 16-28 reproduced from photographs taken on optical microscope.

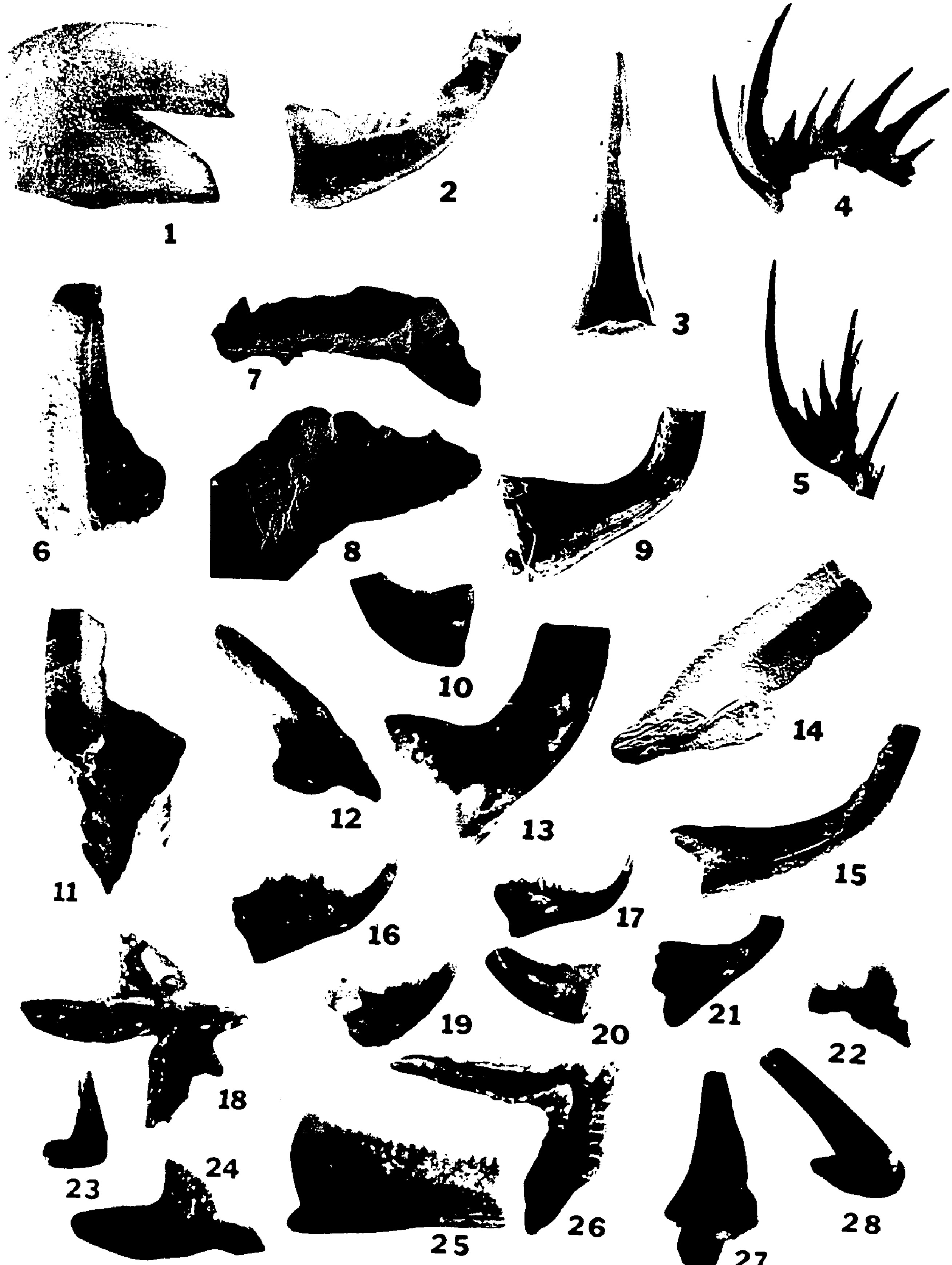
Fig. 1,2	*Belodina compressa* (Branson & Mehl). Lateral views of eobelodiniform and belodiniform elements. 1, X83; 2, X83.
Fig. 3	*Acontiodus* sp. A. Posterior view. X90.
Fig. 4,5	New genus, new species. Lateral views of forms 1 (fig. 4) and 2 (fig. 5). 4, X43; 5, X43.
Fig. 6	*Multioistodus cryptodens* (Mound). Posterior view of intermediate form of symmetry transition series. X83.
Fig. 7,8	*Ozarkodina* sp. Posterior (?) views of one element. 7, X20; 8, X55.
Fig. 9	*Acontiodus* sp. B. Lateral view. X100.
Fig. 10	*Panderodus gracilis* (Branson & Mehl). Lateral view of form species *P. compressus*. X50.
Fig. 11	*Plectodina pristina* Raring, n. sp. Inner lateral view of mature dichognathiform element. X50.
Fig. 12	*Scandodus* n. sp. Inner lateral view. X50.
Fig. 13	*Distacodus* n. sp. B. Lateral view. X50.
Fig. 14	*Plectodina pristina* Raring, n. sp. Inner lateral view of oistodiform element. X60.
Fig. 15	*Panderodus gracilis* (Branson & Mehl). Lateral view of form species *P. gracilis*. X83.
Fig. 16,17	*Belodella* cf. *B. Niger* (Serpagli). Lateral views of symmetrical belodelliform elements. 16 & 17, X50.
Fig. 18	*Polyplacognathus friendsvillensis* Bergström. oral view of polyplacognathiform element. X50.
Fig. 19,20	*Belodella* cf. *B. niger* (Serpagli). Inner lateral views of intermediate and asymmetric belodelliform elements. 19 & 20, X50.
Fig. 21	*Acodus* sp. Lateral view. X50.
Fig. 22	*Phragmodus tortus* Sweet, ms. Inner lateral view of dichognathiform element. X50.
Fig. 23	*Acontiodus* sp. A. Postero-lateral view. X50.
Fig. 24	*Polyplacognathus friendsvillensis* Bergström. oral view of broken polyplacognathiform element. X50.
Fig. 25	*Thrincodus palaris* Raring, n. gen., n. sp. Posterior view. X50.

EXPLANATION OF PLATE 4 (cont.)

Fig. 26 *Polyplacognathus friendsvillensis* Bergström. Oral view of ambalodiform element. X50.

Fig. 27 *Erismodus radicans* (Hinde). Posterior view of ptiloconiform (?) element possibly belonging to the *E. radicans* assemblage. X50.

Fig. 28 *Drepanoistodus suberectus* Votaw, unpub. Ph.D. dissertation. Outer lateral view of oistodiform element. X50.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APPENDIX 1

METHOD OF STUDY

SAMPLE COLLECTION

At the onset of the project it was expected that samples could be obtained from the type section of the Chazy Group and several relatively complete sections in uninterrupted succession from strata below the basal contact through the Chazy Group and into overlying strata. It was planned to gather samples at intervals of two or three feet. Initially every second or third sample would be processed for conodont content, with later work concentrated in zones where an abundance of conodonts or a change in the fauna was observed. This process would clearly define the succession of Chazy conodont faunas. By the referral to measure sections reported in the literature each sample could be stratigraphically located and also recollected.

The first venture into the field in June, 1968, served to dispell any illusion about the state of the Chazy outcrop. In practice it was found that scarcity of continuous outcrop, low angles of dip, and the overgrown condition of formerly well-exposed sections obscured stratigraphic relationships throughout the Champlain Valley. Brainard and Seely (1888, see p. 325) said of the type area that, "through this region the rocks crop out, in hundreds of places, though more covered by soil than the map might lead one to suppose. The ledges dip in various directions, and the explorer who runs over them for the first time is greatly perplexed to make out the stratigraphy." The demise of active farming at many of the outcrop sites makes the perplexity more acute. As the inevitable result, samples of short successions of beds from scattered exposed ledges were often the only possibility.

Samples were obtained primarily during two collecting trips, the first a week in June, 1968, and the second a two week period in August, 1969. Later samples were collected on field trips of the New York Geological Assoc. in 1969 and in April of 1972. The only continuous section of the Chazy Group is at the southern end of Valcour Island, New York, but even there the lowest Day Point and uppermost Valcour are not exposed, an interval of over one hundred feet is covered, and minor faulting of unknown displacement interrupts the section. At the Valcour locality the measure section of Shaw (1968) was found most helpful. The type section southwest of Chazy Village was collected using Oxley and Kay's (1959) section; however, the description of this locality by Brainard and Seely (1888) was invaluable. The third extensively collected and relatively complete section was compiled from exposures at the southern end of Isle LaMotte, Vermont, and the numerous 1 ledges in the southern half of the island. Erwin (1957), Fisher (1968), Shaw (1968), and others have described the area.

Field notes compiled while collecting record the stratigraphic height above a described point, generally the base of the exposed section. The starting point for each series of samples was compared to a horizon in the measured section used as reference for that section. Breif lithologic comments on the samples were made. With the notes it has been possible to closely place samples within the Chazy in most cases.

Below, Table 2 lists the collecting localities and the number of samples and their designations at the localities.

TABLE 2

COLLECTION LOCALITIES

LOCALITY 1: Type section of the Chazy Group immediately southwest of Chazy, New York, and other outcrops in the vicinity of the village.

Sample series identification	Samples	Locality
68R-CVDP	13	Type section.
CVCP	13	Type section.
NWCP	18	Outcrops north of state road 348 east and west of overpass with interstate 87, the North Way.
NWVA	4	Same as above.
CVQ	1	Quarry east of Route 9 at south end of village.
SL	4	Southeast of Chazy along Sheldon Lane in area of flooded quarry.
69R-TYCZ	23	Type section.
SL		Same as 68R-SL.

LOCALITY 2: Outcrops on the southern half of Isle LaMotte, Vermont.

68R-Hd	3	The Head, bluffs rising above Lake Champlain at the southern shore of the island.
HdDP	4	Same as above.
LMCP	5	Outcrops south of the east-west swamp on the eastern side of the island.
LMVA	1	Same as above.
69R-SLM	82	Samples from both the Head and field outcrops north to the swamp.

LOCALITY 3: The southern portion of South Hero Island, Vermont; outcrops on several fault blocks.

68R-FBA	4	Samples from fault block A of Erwin (1957).
FBB	3	Fault block B, South Hero Island.
FBC	3	Fault block C,
FBH	1	Fault block H,
FBF	1	Fault block F,
69R-SH	15	section at South Hero station.
72R-SH	3	Same as above.

LOCALITY 4: The south and southeastern shore of Valcour Island, New York, and outcrops immediately inland.

69R-VI	89	The south shore and adjacent outcrops.
VISC	5	Smuggler's Cove, southeastern shore.

LOCALITY 5: The Central Champlain Valley of Vermont; several of the stratigraphic sections reported by Welby (1961).

68R-W13	5	The shore of Lake Champlain at the Chittenden-Addison county line.
W14	4	Bluff above shore of Lake Champlain near mouth of Otter Creek.
W17	6	Outcrops along the north-south outcrop belt passing through Phanton, Vermont.
W20	4	Along the Phanton outcrop belt.
69R-WCL	23	Section collected along the Phanton outcrop belt.
WFB	21	Another locality from the Phanton outcrop belt.

LOCALITY 6: Vicinity of Rouses Point, New York

72R-RPVA	3	Field outcrops immediately southwest of the village.
RPLM	1	Same as above.

LOCALITY 7: Montreal area, Quebec.

72R-SCQ	7	Samples from upper portion of large Quarry east of St. Charles Road.
SVPQ	6	Southern end of Quarry (filled-in) in St. Vincent dePaul north of Montreal city.
IBRC	3	Road cut at hill crest along main north-south road on Isle Bizzard.

LOCALITY 8: Road cut along highway connecting St. Dominique and St. Hyacinthe, Quebec

72R-SHRC	6	See description above.

LOCALITY 9: Crown Point, New York

68R-CP	5	The Lake shore at the point.

SAMPLE PREPARATION

The first step in the process of isolating conodonts from limestone samples was to crush the rock to pebble size in a jaw crusher. Generally, a hand sample was left uncrushed for lithologic description and later reference. Five hundred grams of the 1968 samples were then dissolved in three gallon buckets containing fifteen percent acetic acid solution. When conodonts proved rare in many Chazy samples the weight of crushed rock dissolved was increased to fifteen hundred grams. Additional amounts of samples yielding an abundance of conodonts were later processed.

The acid residues were wet seived; the minus 40-mesh plus 150-mesh fractions were dried for further treatment. The next step was to perform a heavy liquid separation using tetrabromethane diluted to the desired 2.7 specific gravity by nitrobenzene. The heavy and light fractions were then rinsed with acetone and stored. The heavy fractions were examined for conodont content under a binocular microscope. The conodonts were placed in micropaleontology slides which were painted white to better display the black colored conodonts. Other small fossils found in the residues were sampled as well. Ostracodes were found to be particularly abundant in the Crown Point.

APPENDIX 2

"VITA"

Andrew Michael Raring

born: Amityville, New York; May 24, 1945

parents: Linus Michael and Cornelia Ligtermoet Raring

brother: David Ligtermoet Raring

wife: Sue Ann Stewart Raring

children: Otis Michael Raring

Education

elementary and secondary: New York and Connecticut public school systems

degrees: B.S. Washington and Lee University, June 1967

M.S. Lehigh University, October, 1969

honors: undergraduate; Lena T. Stevens honorary scholarship, Dean's List, Honor Roll.

graduate; N.S.F. graduate fellowship, N.D.E.A. graduate fellowship.

Employment

summer: 1965; Geologist's Aide, Div. of Mineral Resources, Commonwealth of Virginia.

1967; Geologist, Standard Oil Co. of Texas

full: Sept. 1968 - June 1969; Teacher, Northern Lehigh School District, Slatington, Pa.

Feb. 1970 - Feb. 1971; Shipboard Geologist, Lamont-Koherty Geol. Obs. of Columbia Univ.

present: Instructor, part-time; Muhlenburg College and Northampton County Area Community Col.

Publications

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