THE CONODONT FAUNA

OF THE STONEHOUSE FORMATION,

ARISAIG, NOVA SCOTIA

A thesis

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by

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ABSTRACT

Conodonts from the Stonehouse Formation of Arisaig, Nova Scotia, include species reported from the Silurian section of the Karnic Alps by Walliser. In particular, the *eosteinhornensis* zone is represented and the faunal list includes the following: *Ligonodina elegans* Walliser, *Lonchodina detorta* Walliser, *Lonchodina greilingi* Walliser, *Lonchodina* sp. indet., *Ozarkodina typica denckmanni* Ziegler, *Ozarkodina* cf. *jaegeri* Walliser, *Spathognathodus steinhornensis eosteinhornensis* Walliser, and *Trichonodella inconstans* Walliser. In addition, two new species of the genus *Neoprioniodus* are present together with some fish fragments.

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CHAPTER I

INTRODUCTION

Problem

The Arisaig Group exposed along the shore of Northumberland Strait near Arisaig, Nova Scotia, has been studied for over a century. The Stonehouse Formation is the youngest stratigraphic unit of the group. The prolific and varied fauna of this formation has been known for many years, but its detailed study has only recently been undertaken (see page 3).

The primary purpose of this report is to describe the Stonehouse conodont fauna and to evaluate its stratigraphic significance. A secondary purpose is to note the occurrence and type of fish fragments. These fragments have been reported by T. Ørvig (see Boucot *et al.*, 1959), but have not been previously described.

Upper Silurian-Lower Devonian conodonts are poorly known. The only study of conodonts of this age in Canada was that of the Sutherland River Formation (Walliser, in Boucot *et al.*, 1960) on Devon Island in the Canadian Arctic Archipelago. In the United States, R. Liebe (1962) has studied conodonts of the Alexandrian and Niagaran Series from the Illinois Basin, and Rexroad investigated those of the Cincinnati Arch area (Rexroad *et al.*, 1965) and the Niagara Gorge (Rexroad and Rickard, 1965). Walliser (1957, 1962, 1964) investigated sections in the Karnic Alps of Germany, and

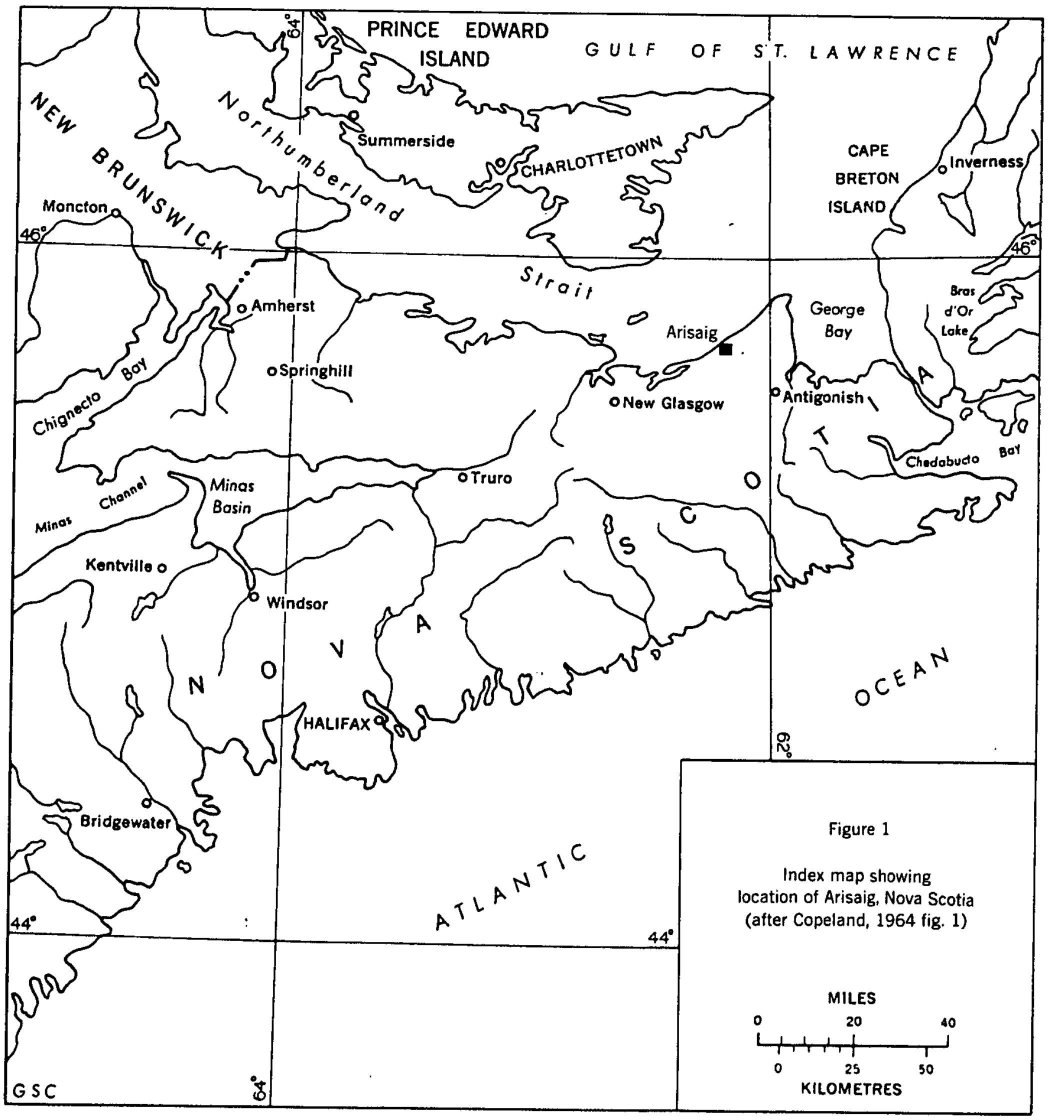

Figure 1

Index map showing location of Arisaig, Nova Scotia (after Copeland, 1964 fig. 1) produced a zonation based on conodonts covering the interval from the Valentian to the Gedinnian (Table 1). Rexroad and Rickard (op. cit.) accept the validity of Walliser's Silurian conodont zonation for the early Silurian of the Cincinnati Arch area, and have but few reservations about the application of his zonal terminology to the Niagaran (Middle Silurian) of the Niagara area. Subdivision into conodont zones of the late Silurian rocks of North America, however, has not yet been accomplished, even with Walliser's work affording a tentative frame of reference.

The age of the Stonehouse Formation is a problem of long standing. Boucot (1960) considered it to be Lower Devonian, on the basis of a study of the brachiopod fauna, but Copeland (1960) determined its age as Upper Silurian, using ostracods as index fossils. The present study of the conodonts suggests an Upper Silurian age although correlation is difficult because of the lack of comparative data from other localities.

The complete fauna was not recovered as very few rock samples were disintegrated completely by digestion with acid. Because of the variable disintegration, numerically comparable yields were unobtainable.

Previous work

Williams (1914, p. 4-24) presented a complete account of the prior history of geological work in the Arisaig area. Consequently, only a brief resume of the work done on the Stonehouse

Formation will be given in the present report.

Dawson (1845) was the first to recognize Devonian strata underlying Carboniferous rocks at McAras Brook (Figure 2). He mapped the Arisaig section, naming most of it Silurian, but later considered it Devonian (1850) and finally reverted to Silurian (1860). He divided the sequence into two units, the lower being correlative to the Upper Llandovery (lower Middle Silurian), and the upper being correlative to the Upper Silurian.

Honeyman (1864) divided the Arisaig section into five lettered subdivisions which he attempted to correlate with the Silurian type section. The uppermost unit ("D") was equated to the Upper Ludlow, a correlation with which Fletcher (1886) agreed.

The term Stonehouse was proposed by Ami (1900); he named the overlying Knoydart beds in 1901.

Rocks of the Arisaig section were divided into forty-one zones by Twenhofel (1909). Zones thirty-five to forty-one were attributed to the Stonehouse Formation which was defined as all the beds above the "Red Stratum" and below the Devonian Knoydart Formation. Zone forty-one consisted of the amygdaloidal trap which overlies the sedimentary rocks of the Stonehouse. Twenhofel concluded that the Stonehouse is Ludlovian (Upper Silurian) in age.

Williams (1914) divided the Arisaig sequence into twelve zones and renamed some of the formations that occur lower in the section. The Stonehouse included his zones eleven and twelve, distinguished on the basis of relative abundance of trilobite faunas.

A further study of the fauna led McLearn (1924) to divide the Stonehouse into four assemblage zones (a, b, c, and d) and to correlate this formation with the Ludlovian of England. This zonation remained in use until a few years ago, when detailed work on specific phyla was undertaken by several palaeontologists. The brachiopods were studied in detail by Boucot (1960) and Harper (1964) who concluded that the Stonehouse is Gedinnian and, possibly, in part Skala in age and therefore lowermost Devonian. A study of the ostracods led Copeland to conclude that this formation is uppermost Silurian, and thus to agree with Boucot in that the Stonehouse is post-Ludlovian, but to disagree in that he considered it to be pre-Devonian.

Approximately twenty miles to the southwest, in Pictou County, the uppermost fifty feet of the Stonehouse Formation contain a brachiopod fauna which is Lower Devonian according to Boucot (see Maehl, 1961, p. 29). Maehl presumes that the rocks underlying this part of the section are Upper Ludlovian in age.

Acknowledgements

The author gratefully acknowledges the help and encouragement afforded by Dr. D.L. Dineley who originally recommended a preliminary study of this subject as a graduate essay. It was at his suggestion that this project was further developed. His comments and advice were most welcome.

The assistance of Dr. M. J. Copeland of the Geological Survey of Canada was invaluable. He collected the major part of the samples which were processed, and was ever generous with data, suggestions, and assistance.

Thanks are also expressed to the Geological Survey of Canada for having granted time for work on this project as well as two weeks field work to augment the collections.

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CHAPTER II

STRATIGRAPHY AND PALAEONTOLOGY OF THE STONEHOUSE FORMATION

Stratigraphy

Location of type section

The Stonehouse Formation is exposed for approximately two thousand feet along the shore of Northumberland Strait, from Moydart Point, two miles southwest of Arisaig pier, southwest to the mouth of MacEachern Brook (Figure 2). It is also exposed along McAdam, MacDonald, Stonehouse, and MacEachern Brooks, all of which cut the shore section. Along the last-named brook, for approximately seven hundred feet upstream from the shore, two hundred and sixty feet of strata are exposed, which apparently extend the shore section by approximately one hundred and eighty feet.

Description

To the north the Stonehouse Formation conformably overlies the Moydart "Red Bed". On the shore, to the south, the Stonehouse is overlain unconformably by volcanic flows and red conglomeratic siltstones of the McAras Brook Formation of Mississippian age. A gradational contact may be present in the covered interval between the uppermost Stonehouse beds exposed along MacEachern Brook and those of the Lower Devonian Knoydart Formation along MacPherson Brook.

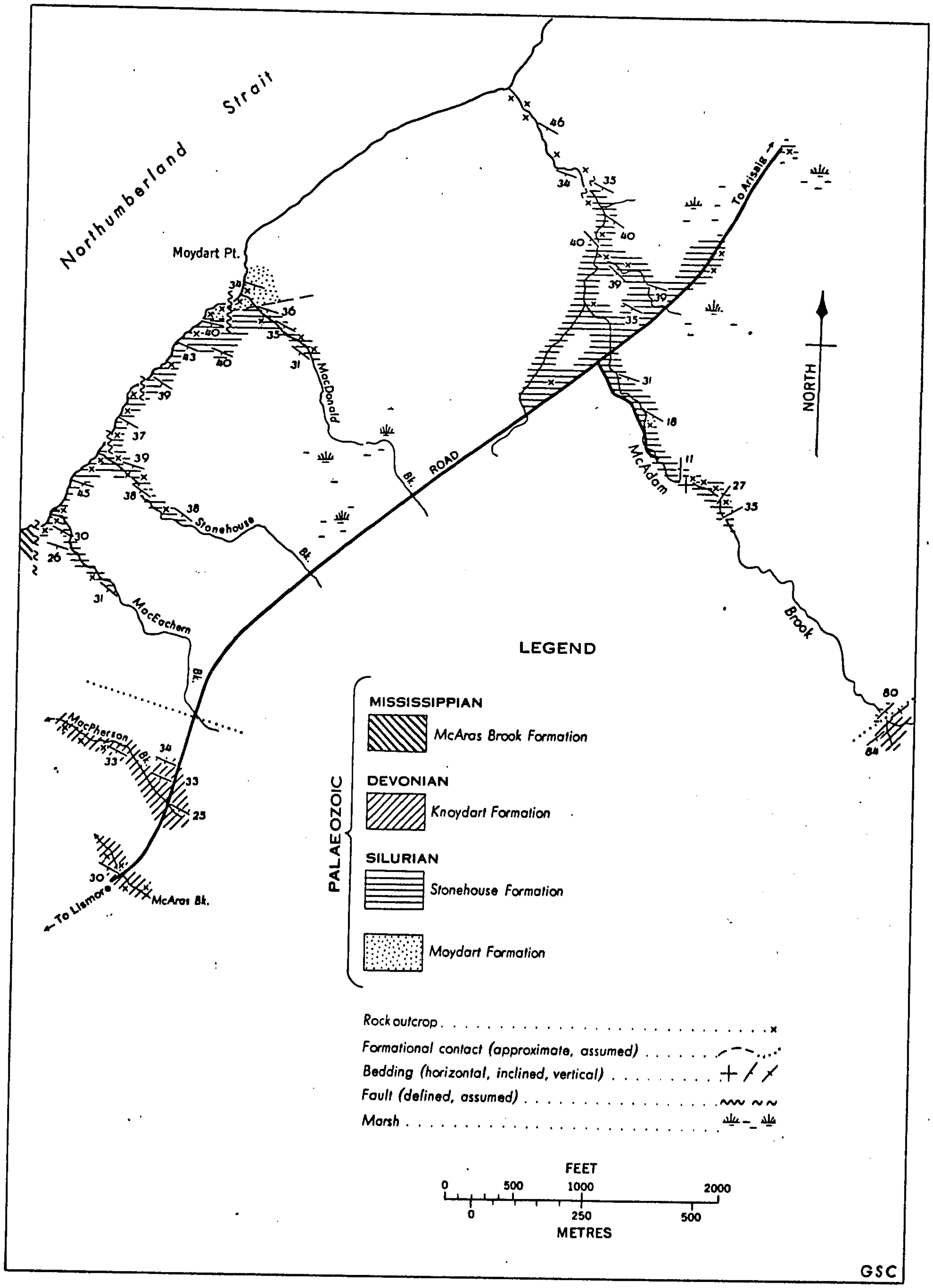

Figure 2. Geological sketch map, Stonehouse Formation, Arisaig, Nova Scotia
(after Copeland, 1964, fig. 2)
McAdam Formation at mouth of McAdam Brook

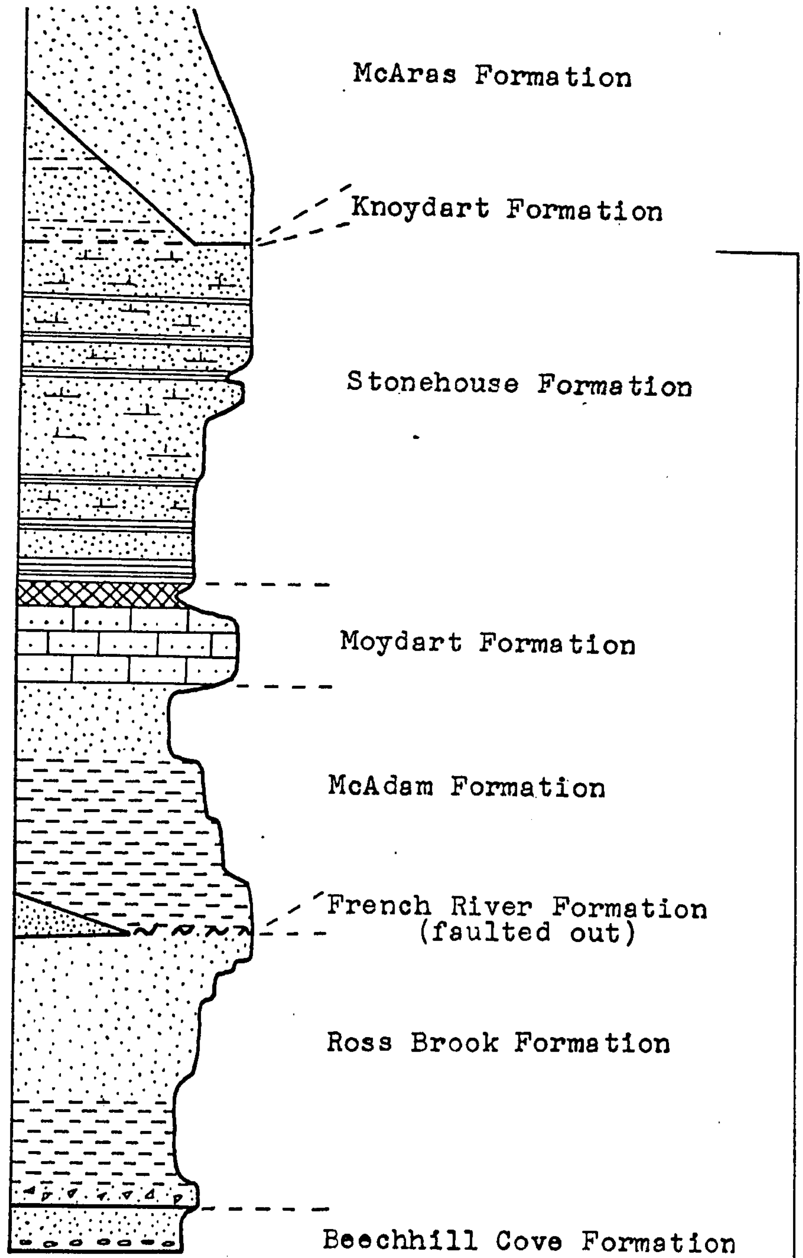

Figure 3 : Diagrammatic coastal section showing relation of Stonehouse Formation to rest of group.
(vertical scale : 1 in.=900 ft.)

In the bed of McAdam Brook, about one-half mile upstream from the main highway, vertical beds which closely resemble the Stonehouse-Knoydart rocks, are in conformable and gradational contact. The fauna from these rocks has been found to be younger than the previously known Stonehouse fauna (Copeland, 1964, p. 5; Table 1).

In general, the Stonehouse Formation consists of red siltstone, red shale and thin calcareous layers of both lithologies. There are also some greenish sandstone and shale beds. According to Copeland (1964, p. 5), there are three major lithological divisions:

> "... a lower thin, greenish grey, calcareous shale unit with minor calcareous sandstone; an intermediate unit of grey calcareous sandstone and shale; and an upper red and grey calcareous shale and sandstone unit which becomes increasingly sandy towards the exposed top of the formation on MacEachern Brook, and, as on McAdam Brook, may grade upward into red siltstones of the Knoydart Formation."

The presence of silica veins indicates secondary silicification of the rocks. The rocks are faulted, but no other effects of deformation are visible.

Significance

On the basis of its fossils, the type section of the Arisaig Group is considered to represent most of the Silurian

Period, with the exception of omissions caused by a few small unconformities. It is also conveniently and continuously exposed.

The Stonehouse, the uppermost formation of the group, contains an Upper Silurian or possibly Lower Devonian (to some workers) fauna. It is less disturbed or deformed than any other equivalent unit in the northern Appalachians. Its fauna also shows greater similarity to that of the Silurian facies of western Europe, than to those of the Gaspe Peninsula, New York, or Ontario.

Palaeontology

The Stonehouse is rich in many types of generally well-preserved fossils. McLearn (1924, p. 13) reported one hundred and three species of worms, stelleroids, brachiopods, pelecypods, gastropods, pteropods, cephalopods, trilobites, and ostracods. Thirty-nine species originated in older faunas: twenty-five in the Moydart, eleven in the McAdam (mainly pelecypods), and three in the Ross Brook Formation. Sixty-four species appear for the first time and are confined to the Stonehouse Formation.

Groups of invertebrates of this period which are not represented are corals, stromatoporoids, and bryozoans, all being forms with highly calcareous skeletons. It is possible that the waters depositing the Stonehouse sediments were either cold or deficient in carbonate. The nature of the general fauna seems to preclude the former possibility.

Age

The Stonehouse Formation has variously been placed in the Upper Silurian and in the Lower Devonian. The Siluro-Devonian problem is a complicated one because of the characters of the type sections for both systems in Europe. The type section for the Upper Silurian consists of marine rocks overlain by a bone bed, and above, in conformable sequence, the non-marine rocks of the Downtonian. The type section for the Lower Devonian consists of marine rocks. The exact position of the Downtonian in the Devonian was set arbitrarily. It was called Devonian because the top of the Silurian was originally set at the Ludlow Bone Bed. Whether the Downtonian should be called Devonian simply because it is excluded from the Silurian is a point of discussion. It seems, therefore, that to use the term Downtonian in relation to the age of a marine section is tenuous and invites unnecessary difficulties.

A semantic question arises in relation to the Stonehouse Formation, that of the meaning of the term Downtonian as interpreted by different workers. Copeland considers the ostracods of the Stonehouse as being Downtonian in age. The controversy arises in the interpretation of the term; the alternatives being 1) the Downtonian is Lower Devonian, or 2) it is uppermost Silurian. Copeland adheres to the latter while Boucot subscribes to the former. Clearly, to designate the Stonehouse Formation Downtonian is unsatisfactory.

CHAPTER III

TREATMENT OF MATERIAL

Collection

Copeland (Geological Survey of Canada), in order to study the ostracods, made an extensive collection of rock samples from the Stonehouse Formation during 1959 and 1961. The suite he gathered was representative of the whole succession; all the obviously fossiliferous beds were sampled closely and the unfossiliferous sequences sampled at intervals of six to ten feet. After removal of the ostracods, the material was made available to the author for conodont study.

In August of 1964, Dineley and the author collected additional material from the Arisaig area as members of a Geological Survey of Canada field party. Because most of the previously acquired rocks had been processed, and relative conodont contents noted, the most productive horizons were known. Only these and a few calcareous beds were sampled. The sections along the shore and along MacDonald Brook were the main objects of study. A small collection was also made from the Cape George area, immediately west of George Bay.

Preparation

The samples were broken by hammer to fragments approximately two by four inches, and then by a small jaw-crusher to finer fragments.

The crushed rocks were sieved to remove all the rock flour which consumes a great quantity of acid without producing any identifiable conodonts. The weights of the samples to be processed were recorded for comparison with the weights of the coarse residues at the end of the processing.

Dilute acetic acid (about ten to fifteen per cent) was used to digest the rocks. Formic acid was tried but was discarded because the conodont yield was smaller. The samples remained in acid for about nine weeks with acid changes twice a week until there was no further reaction. The more calcareous and argillaceous rocks broke down relatively rapidly and the others remained inert.

Following acid treatment, the samples were wet-sieved. The material retained between the twenty and the one hundred and fifty mesh sieves was kept for study and the finer material was discarded. The coarser fraction, which generally comprised the bulk of the material, was weighed to compare with the initial sample weight. It was decided to ignore the weight of the fines and clay fraction because it was negligible. A measure of the amount of breakdown of each sample was useful to determine which horizons were most calcareous. Thus the most potentially productive horizons were noted for subsequent collecting.

The retained portion was fractionated in bromoform because of the high specific gravity of conodonts and the abundance of light particles in the fines. Tetrabromethane, which is at times used, did not offer any advantages. The heavy fraction was sorted under a binocular microscope. Conodonts and fish fragments were glued to slides by a solution of gum tragacanth and water.

State of material

Most of the conodonts extracted from the Stonehouse Formation are incomplete, with bars and blades seldom whole, and denticles rarely completely preserved. All show evidence of wear by breakage, which is to be expected since the sediments are clastic. Their surfaces, however, have little or no pitting or corrosion. The conodonts are opaque, robust specimens, quite unlike the delicate material which is normally encountered. Dark grey bars and white denticles characterize the majority whereas blade-types are often medium grey. A few specimens show evidence of breakage and repair (Plate I, figure 6; Plate II, figures 3, 5, 6). Such recovery could only occur if the unit was surrounded by tissue. The fact that such incurred breakages were repaired suggests that conodonts were internal structures. Repaired units are not unique to the Stonehouse; they have been reported previously (Lindström, 1964, p. 120).

Amounts Processed

A total of 113 samples were processed. Of these, 47 were either barren of fish and conodonts, or did not break down. The sample weights ranged from 74 to 6375 grams, depending on the quantity of material available. The amount of breakdown varied from 0 to 94 per cent (this figure is obtained from the total of calcium carbonate, fine fraction, and mud, compared with the weight of what remained on the coarse sieve).

CHAPTER IV

DISCUSSION OF RECOVERED FAUNA

Conodonts

Silurian conodonts

On the whole, very little work has been done on Silurian and Lower Devonian conodonts, especially in North America. The lack of work may be attributable to the various rock types which make up the Silurian. Many are uninviting to study, being dolomitic and silicified rocks, or clastic rocks. They are difficult to digest for microfaunas and the clastic rocks are unfavourable for the preservation of such delicate fossils as conodonts. Another factor that may influence the amount of study is the fact that the Silurian is a relatively short period, with a relatively thin succession of rocks. Even if the work had been done, there would be much less to show than for rocks from a longer period.

That conodonts are present in Silurian strata of North America is shown by the work of Branson and Mehl (1933), Liebe (1962), and Rexroad (1965a,b), but the number of conodonts may have decreased during the Silurian. An evolutionary lull may have followed an acme in the Ordovician and preceded on ascent in the Middle Devonian and Mississippian. It is not known whether this lull was due only to a decrease in the number of genera and species or whether it also involved the number of individuals; that is, whether the decrease was one of genetic differentiation

SERIES	CONODONT ZONES	CONODONT 'STUFEN'
Gedinnian	woschmidti	steinhornensis
	eostein-hornensis	
	crispus	crispus/ latialatus
	latialatus	
Upper Ludlovian	siluricus	Kockelella
Middle Ludlovian	ploeckensis	
Lower Ludlovian	crassa	
	sagitta	
Wenlockian	patula	
Valentian	amorpho-gnathoides	Apsido-gnathus
	celloni	

Table 1: Conodont zones of the Silurian.
(adapted from Walliser, 1964)

or of population.

Most of the work on conodonts has been oriented toward the zoning of Ordovician, Middle and Upper Devonian, and Mississippian sections. These conodonts have proven of interest because of their wide variety and local applicability in zoning. Silurian conodonts may have been neglected as a result of this bias in emphasis.

Stonehouse conodonts

The following conodonts were recovered from the Stonehouse collections:

Ligonodina elegans Walliser 1964
Lonchodina detorta Walliser 1964
Lonchodina greilingi Walliser 1957
Lonchodina sp. indet.
Neoprioniodus n. sp. a
Neoprioniodus n. sp. b
Ozarkodina typica denckmanni Ziegler 1956
Ozarkodina cf. *jaegeri* Walliser 1964
Spathognathodus steinhornensis eosteinhornensis Walliser 1964
Trichonodella inconstans Walliser 1957

Table 3 shows the distribution of these conodonts within the Stonehouse section.

Ligonodina elegans Walliser (Plate I, figures 4-6) is the most numerous form in this collection. Four hundred positively identifiable units and fragments were recognized; the residues also contained many denticulated bars which probably were fragments of

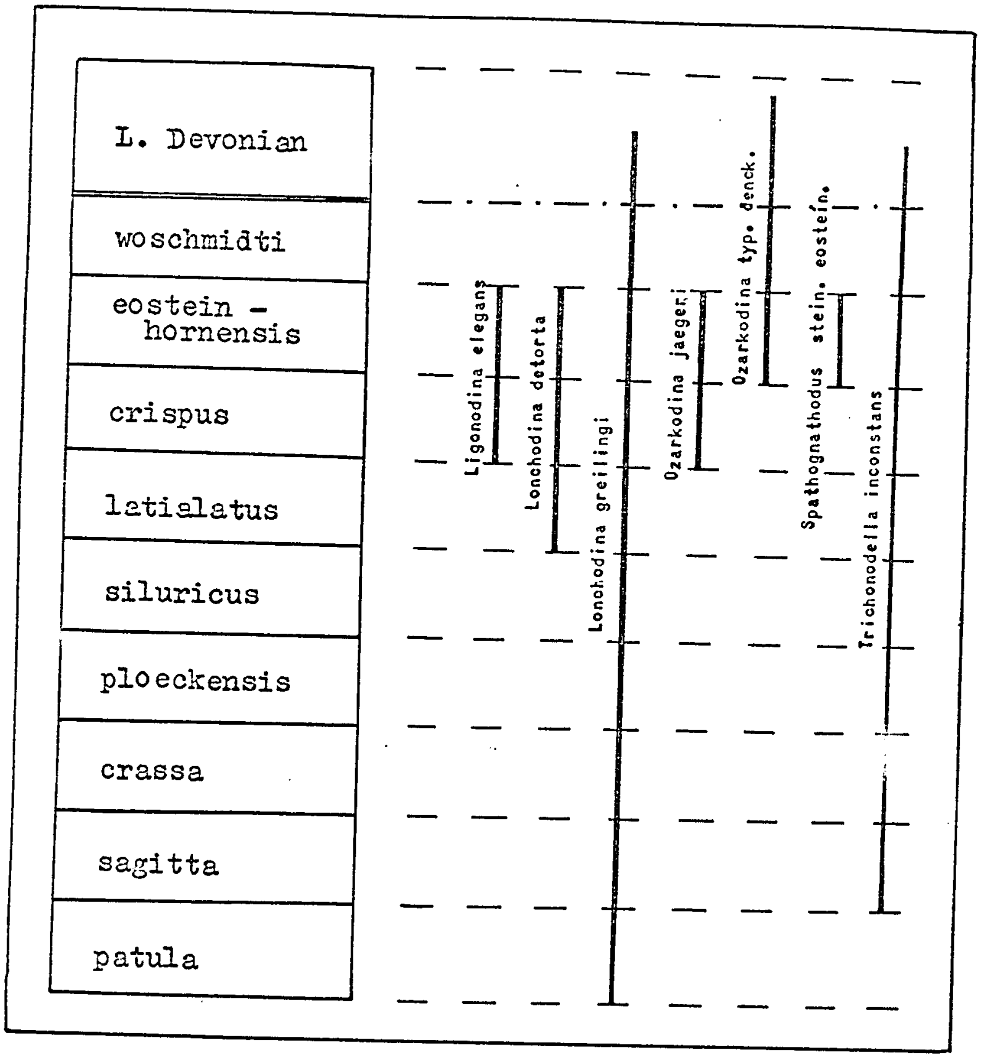

Table 2 : Stratigraphic range of Stonehouse conodonts.
Walliser's conodont zones not to scale.

units of this species. Since they could not be indisputably assigned to Ligonodina elegans, they were neither counted nor figured. This species has a relatively short time range, occurring in only two of Walliser's zones, i.e. crispus and costeinhornensis (Table 2).

Sixty-four specimens of Lonchodina detorta Walliser (Plate II, figures 1-4) were found. This species has a slightly longer range, being found in rocks of the siluricus to the costeinhornensis zones. It is a very distinctive form and cannot be confused with other species of the same genus.

Lonchodina greilingi Walliser (Plate II, figures 5, 6, 8) is about three times as numerous as Lonchodina detorta, and shows a variety of forms throughout the section. It has a rather extensive geological range, from the patula zone into the Lower Devonian. In this collection, it has little stratigraphic significance.

The discovery of thirty-two units of a form intermediate between Lonchodina greilingi and Trichonodella inconstans Walliser suggests that possibly a new species could be defined. However, not enough specimens were recovered to establish a new species. Walliser (1964, p. 51) has already proposed that a continuous transition exists linking these two species. The validity of such a series is not questioned here, but this new form is distinct from both, although it is intermediate. It should certainly be recognized as separate from them.

Two new species of Neoprioniodus (Plate III, figures 1-5) were determined. The genus is found in Middle Ordovician to Middle Triassic rocks, but the stratigraphic value of these individual species is as yet unknown. None of the species of this genus that were described by Walliser (1964) closely resemble those from the Stonehouse. These and Lonchodina sp. indet. are the only forms from the Stonehouse which are not present in Walliser's collections.

Ozarkodina typica denckmanni Ziegler (Plate II, figures 9, 10) is not abundant in this collection but enough specimens have been found to warrant the subspecific assignment. It ranges from the costeinhornensis zone into the Upper Emsian Stage.

Ozarkodina jaegeri Walliser ranges from the latialatus to the costeinhornensis zone. Only eighteen units were recovered, one of which is figured (Plate II, figure 7), which could be conspecific with it.

Many units of Spathognathodus steinhornensis eosteinhornensis Walliser (Plate I, figures 1-3) were found. This subspecies is the index for Walliser's eosteinhornensis zone and therefore the most important of the collection. It is a difficult subspecies to assign because it grades imperceptibly into the subspecies Spathognathodus steinhornensis remscheidensis Walliser. A large enough number of units of this form, three hundred and thirty-nine, was found to justify the identification. This was further substantiated by the fact that three other species from this collection are not known to extend beyond the eosteinhornensis zone.

The subspecies remscheidensis occurs in the next zone above, the wochschmidti zone.

Trichonodella inconstans Walliser (Plate I, figures 7-9) is very plentiful in the Stonehouse rocks. Stratigraphically, it is not very important because it ranges from the sagitta zone into the Lower Devonian.

All the conodonts mentioned above are found throughout the section with the single exception of Lonchodina sp. indet. It has not been recovered from any of the samples which were collected from McLearn's zone B, nor from his zone A which corresponds to Copeland's two lower zones, those characterized by the ostracods Londinia arisaigensis Copeland, and Aparchites ? sinuatus (Hall).

Detailed zoning of the Stonehouse Formation is not possible using conodonts, although the occurrence of Lonchodina sp. indet. may be broadly indicative of the stratigraphic position. It is difficult to establish a definite age for the Stonehouse Formation using conodonts, because conodonts of the Upper Silurian and Lower Devonian type sections have not been extensively studied. The only sequence which can be used for comparison at this time is that from the Karnic Alps (Walliser, 1964), which has been divided into eleven conodont zones, covering a sequence from Valentian to Gedinnian.

Using this zonation as a frame of reference, the Stonehouse Formation fits into the Upper Silurian, and corresponds entirely to Walliser's Spathognathodus steinhornensis eosteinhornensis zone, which is the second last one from the top of his zonal sequence. His topmost three zones cover an interval equivalent to the Upper Ludlovian to Gedinnian. He offers no solution to the Siluro-Devonian boundary problem. His uppermost zone contains the Devonian element Icriodus wochschmidti. The costeinhornensis zone does not contain this fossil, and no other irrefutably Devonian conodonts occur at this level of the sequence.

Fish fragments

Phosphatic fish remains in the Stonehouse Formation occur throughout the section and have been recovered in varying quantities from most of the samples processed. No relationship has been found between the occurrence and abundance of fish remains and the occurrence of conodonts.

The fish remains are either white, pinkish, green, or dark grey, and rarely colourless and transparent. Fragments of more than two colours are not often found in one sample. Deep red remains are found, but their colour is probably due to post-depositional alterations; their surface is slightly pitted in these cases. The unaltered remains generally have shiny surfaces.

On the whole, these fossils are well preserved, but some have been chipped. Because of their denser and sturdier structure, they have suffered less breakage than the conodonts.

The occurrence of fish fragments in the Stonehouse Formation carries little implication concerning the general depositional environment of the formation. The rest of the fauna, including conodonts, is marine. The disarticulated fish are thanatocoenotic, which implies only that the streams emptying into the Stonehouse sea were populated by fish, or that they were fed by lakes and streams that contained these fish.

Fragments of fish found in this formation are grouped into six categories:

Acanthoides dublinensis (Stauffer) Wells 1944
Cheiracanthoides venustus Wells 1944
Cheiracanthoides n. sp.
Onychodus
Petrodus ?
"tooth"

The last three are rare in this collection, numbering six, eight and eight respectively, but the other three are common.

The term species as used by Wells (1944), and other workers on fish remains, denotes form-species. His taxa are very clearly defined with very slight morphological differences given great importance. It is felt, for two reasons, that many of these differences could be included within the description of one form-genus. The first is the evidently wide variety in form of dermal elements of any one fish as seen on modern forms; there is no reason to believe that a similar variety did not exist in the past. The second reason is the overall resemblance between the various genera as defined by Wells, i.e. *Acanthoides*, *Cheiracanthoides* and *Helolepis*.

These three genera are defined on the basis of coronal ornamentation. In the Stonehouse collection gradations exist between ornamentation types: the smooth-surfaced forms (Plate IV, figure 1) grade into slightly indented forms (Plate IV, figures 2, 3); these into finely ribbed ones (Plate IV, figure 4), and the latter into coarsely ribbed ones (Plate IV, figures 5, 6).

The multiplication of genera and species in the case of conodonts is more acceptable because of the lack of information about the "parent" organism and the stratigraphic significance of these forms. In fish, however, the multiplication of taxa seems excessive. Nevertheless, for descriptive and comparative purposes Wells' scheme is followed in the treatment of this material.

The descriptive term "scale" is used with some reservation. The dermal elements of fish which are under consideration here are not, strictly-speaking, scales. They are small, thick phosphatic plates which formed a shagreen over the fish.

Stratigraphically, these fish remains are not very important, because they are virtually identical with forms from the Middle Devonian of the Cincinnati Arch area (Wells, 1944), the Upper Devonian of Ohio (Stauffer, 1936), and the Pennsylvanian of Missouri (Gunnell, 1933). They are of interest because similar fossils have been reported by Ørvig (see Boucot et al., 1959) from this formation. They have rarely been found elsewhere so low in the stratigraphic column.

For detailed and complete descriptions of *Acanthoides dublinensis* (Stauffer) Wells and of *Cheiracanthoides venustus* Wells, refer to the work by Wells (1944).

Table 3: Distribution of studied fauna in Stonehouse Formation

ZONATION		SAMPLES		STUDIED FAUNA										
McLEARN 1924	COPELAND 1964	G. S. C. LOCALITIES	THICKNESS FROM TOP in feet	"FISH"	Spathognathodus stein. eostein.	Ligonodina elegans	Trichonodella inconstans	Lonchodina greilingi	Lonchodina detorta	Lonchodina sp. indet.	Neoprioniodus n. sp. a	Neoprioniodus n. sp. b	Ozarkodi typ. d	
		39097		x				x						
		39071		x	x	x	x		x					
		70339	15.0	x	x	x	x	x	x		x	x		
		70341	15.0					x			x			
		70342	18.0	x	x		x				x			
		38982	39.0				x	x	x					
		38986	58.0	x	x	x	x	x					x	
		70344	61.0	x			x		x	x	x		x	
D	?	38987	62.5	x		x	x							
		70346	66.0		x	x	x				x			
		70347	70.0		x	x		x	x		x		x	
		70348	72.5	x										
		38989	80.0	x	x	x								
		70349	80.0		x			x			x			
		38992	97.5	x	x				x					
		70350	112.0			x	x	x						
		70352	126.0	x	x	x	x	x	x	x	x		x	x

ON	SAMPLES		STUDIED FAUNA										
OPELAND 1964	G. S. C. LOCALITIES	THICKNESS FROM TOP in feet	"FISH"	Spathognathodus stein. eostein.	Ligonodina elegans	Trichonodella inconstans	Lonchodina greilingi	Lonchodina detorta	Lonchodina sp. indet.	Neoprioniodus n. sp. a	Neoprioniodus n. sp. b	Ozarkodina typ. denckmanni	Ozarkodina cf. jaegeri
	39097		x				x						
	39071		x	x	x	x		x					
	70339	15.0	x	x	x	x	x	x		x	x		
	70341	15.0					x			x			
	70342	18.0	x	x		x				x			
	38982	39.0				x	x	x					
	38986	58.0	x	x	x	x	x					x	
	70344	61.0	x			x		x	x	x		x	
?	38987	62.5	x		x	x							
	70346	66.0		x	x	x				x			
	70347	70.0		x	x		x	x		x		x	
	70348	72.5	x										
	38989	80.0	x	x	x								
	70349	80.0		x			x			x			
	38992	97.5	x	x				x					
	70350	112.0			x	x	x						
	70352	126.0	x	x	x	x	x	x	x	x		x	x

ZONATION		SAMPLES		STUDIED FAUNA									
McLEARN 1924	COPELAND 1964	G. S. C. LOCALITIES	THICKNESS FROM TOP in feet	"FISH"	Spathognathodus stein. costein.	Ligonodina elegans	Trichonodella inconstans	Lonchodina greilingi	Lonchodina detorta	Lonchodina sp. indet.	Neoprioniodus n. sp. a	Neoprioniodus n. sp. b	Oz[illegible]
D	?	38996	130.5		x	x	x		x		x		x
		38999	161.5	x	x	x	x		x				
		70355	170.0	x	x	x	x		x		x		
		70356	191.0		x		x	x					
	Neobeyrichia (Nodibeyrichia) pustulosa (Hall)	39004	210.2					x					
		39008	249.2	x									
		39009	251.4			x			x		x		
		39010	263.7			x			x	x			
		39012	274.2	x	x	x	x	x			x		
		39013	284.2	x	x	x	x	x			x	x	x
		39014	294.9	x		x			x		x		
		39015	305.4	x		x	x	x	x		x		
		39016	311.4					x					
		39017	324.2	x	x								
		39019	337.2	x	x	x	x	x			x		
		39020	345.7	x		x	x	x	x		x	x	
		39021	352.9	x		x	x	x	x	x	x		

ID 64	SAMPLES: G. S. C. LOCALITIES	SAMPLES: THICKNESS FROM TOP in feet	STUDIED FAUNA: "FISH"	Spathognathodus stein. costein.	Ligonodina elegans	Trichonodella inconstans	Lonchodina greilingi	Lonchodina detoria	Lonchodina sp. indet.	Neoprioniodus n. sp. a	Neoprioniodus n. sp. b	Ozarkodina typ. denckmanni	Ozarkodina cf. jaegeri
	38996	130.5		x	x	x		x		x		x	
?	38999	161.5	x	x	x	x		x					
	70355	170.0	x	x	x	x		x		x			
	70356	191.0		x		x	x						
	39004	210.2					x						
	39008	249.2	x										
	39009	251.4			x			x		x			
	39010	263.7			x			x	x				x
	39012	274.2	x	x	x	x	x			x			
Neobeyrichia (Nodibeyrichia) pustulosa (Hall)	39013	284.2	x	x	x	x	x			x	x	x	
	39014	294.9	x		x			x		x			
	39015	305.4	x		x	x	x	x		x			
	39016	311.4					x						
	39017	324.2	x	x									
	39019	337.2	x	x	x	x	x			x			
	39020	345.7	x		x	x	x	x		x	x		
	39021	352.9	x		x	x	x	x	x	x			

ZONATION McLEARN 1924	ZONATION COPELAND 1964	SAMPLES G. S. C. LOCALITIES	SAMPLES THICKNESS FROM TOP in feet	STUDIED FAUNA "FISH"	Spathognathodus stein. eostein.	Ligonodina elegans	Trichonodella inconstans	Lonchodina greilingi	Lonchodina detorta	Lonchodina sp. indet.	Neoprioniodus n. sp. a	Neoprioniodus n. sp. b	Ozark[illegible]
D	Neobeyrichia (Nodibeyrichia) pustulosa (Hall)	39022	363.9	x		x	x		x	x	x		
		39023	382.7	x									
		39025	408.3	x			x				x		x
		39026	422.9	x				x					
		39027	436.5	x		x	x	x					
		39028	458.3	x	x	x	x						
C		39088		x	x	x	x	x			x		
		39032	545.5								x		
		39076		x	x	x	x	x	x		x	x	x
		39040	678.8	x									
		39100	678.8	x	x	x	x	x			x	x	
		39089		x	x	x		x		x	x		
B		39048	834.8		x								
		39070		x	x	x	x		x		x	x	x
		39074				x	x	x	x		x		
		39050	880.8	x	x								
		39052	920.1	x	x		x						x

ON OPELAND 1964	SAMPLES: G. S. C. LOCALITIES	SAMPLES: THICKNESS FROM TOP in feet	"FISH"	STUDIED FAUNA: Spathognathodus stein. eostein.	Ligonodina elegans	Trichonodella inconstans	Lonchodina greilingi	Lonchodina detorta	Lonchodina sp. indet.	Neoprioniodus n. sp. a	Neoprioniodus n. sp. b	Ozarkodina typ. denckmanni	Ozarkodina cf. jaegeri	
Neobeyrichia (Nodibeyrichia) pustulosa (Hall)	39022	363.9	x		x	x		x	x	x				
	39023	382.7	x											
	39025	408.3	x			x				x		x		
	39026	422.9	x				x							
	39027	436.5	x		x	x	x							
	39028	458.3	x	x	x	x								
	39088		x	x	x	x	x			x				
	39032	545.5								x				
	39076		x	x	x	x	x	x		x	x	x		
	39040	678.8	x											
	39100	678.8	x	x	x	x	x			x	x			
	39089		x	x	x		x		x	x				
	39048	834.8		x										
	39070		x	x	x	x		x		x	x	x		
	39074				x	x	x	x		x				
	39050	880.8	x	x										
	39052	920.1	x	x		x						x		

ZONATION		SAMPLES		STUDIED FAUNA									
McLEARN 1924	COPELAND 1964	G. S. C. LOCALITIES	THICKNESS FROM TOP in feet	"FISH"	Spathognathodus stein. eostein.	Ligonodina elegans	Trichonodella inconstans	Lonchodina greilingi	Lonchodina detorta	Lonchodina sp. indet.	Neoprioniodus n. sp. a	Neoprioniodus n. sp. b	Ozarko typ.
B		39055	998.9	x	x			x			x		x
A	Aparchites? sinuatus (Hall)	39056	1016.0	x	x								x
		39057	1035.8	x	x	x							x
		39060	1103.5	x	x	x	x						
	Londinia arisaigensis Copeland	39098	1407.0	x	x	x	x						x
		39096	1426.0	x									
		39094	1451.0	x	x	x	x	x			x	x	x
		39093	1457.0	x	x	x	x	x	x		x		x
		39091	1476.0	x	x	x							

ON		SAMPLES		STUDIED FAUNA										
OPELAND 1964	G. S. C. LOCALITIES	THICKNESS FROM TOP in feet	"FISH"	*Spathognathodus stein. eostein.*	*Ligonodina elegans*	*Trichonodella inconstans*	*Lonchodina greilingi*	*Lonchodina deforta*	*Lonchodina sp. indet.*	*Neoprioniodus n. sp. a*	*Neoprioniodus n. sp. b*	*Ozarkodina typ. denckmanni*	*Ozarkodina cf. jaegeri*	
	39055	998.9	x	x			x			x		x		
Aparchites? sinuatus (Hall)	39056	1016.0	x	x								x		
	39057	1035.8	x	x	x							x		
	39060	1103.5	x	x	x	x								
Londinia arisaigensis Copeland	39098	1407.0	x	x	x	x						x		
	39096	1426.0	x											
	39094	1451.0	x	x	x	x	x			x	x	x	x	
	39093	1457.0	x	x	x	x	x	x		x		x	x	
	39091	1476.0	x	x	x								x	

CHAPTER V

CONCLUSIONS

The conodont fauna from the Stonehouse Formation is sparse, but it does indicate the stratigraphic position of the formation. It is definitely indicative of Walliser's eosteinhornensis zone, because it contains that index fossil as well as a few forms that are not known to range either above or below this zone.

Assignment of the Stonehouse Formation to either the Upper Silurian or the Lower Devonian, using conodonts, cannot yet be made. Walliser offers no solution, since he omits to make a Silurian/Devonian discrimination in his zonal column. A tentative conclusion, suggesting the Upper Silurian, can be derived from the absence of exclusively Devonian forms. Although this is negative evidence, it does have some validity. Fish remains do not help solve this problem because they are indistinguishable from those in younger strata.

Division of the Stonehouse Formation into various conodont zones is not at present possible. Although the conodont fauna does not vary in any way comparable to that encountered with McLearn's macrofaunas or Copeland's ostracods, further study of this subject is certainly warranted. In the Arisaig area, valuable information might be obtained from the underlying Moydart Formation, which is marine and slightly calcareous. The overlying Knoydart Formation is not susceptible to conodont analysis, as it is non-marine and largely non-calcareous. Such a study should show whether the eosteinhornensis zone encompasses more than the Stonehouse or whether the *crispus* zone is also represented. It would also be worthwhile to extend the investigation to other correlative formations in Nova Scotia. Of paramount importance would be investigation of other Siluro-Devonian formations in eastern North America. In Gaspe, the Gaspe Limestone might break down to provide conodonts similar in age to those of the Stonehouse Formation. These two formations belong to different facies, and correlation has been difficult since there are no common useful fossils. Conodonts might help to clarify this.

The Manlius and Coeymans Limestone in New York also might prove interesting in this respect. These two formations are at the Siluro-Devonian boundary (Berdan, 1964) and their conodont content might compare with that of the Stonehouse Formation.

In southwest Ontario, the Bass Island Group may contain Upper Silurian conodonts, but because it consists of shale and dolomite, could prove difficult to study. At best, a cursory examination of the few limy beds, which might produce a small fauna, could be made.

Study of the above-mentioned formations should make comparable material available to future workers.

CHAPTER VI

SYSTEMATIC PALAEONTOLOGY

The description of forms identical with Walliser's is useful and necessary as the information is not otherwise available in English.

The samples are the property of the Geological Survey of Canada, and are deposited in its type collection, in Ottawa.

Conodonts

Ligonodina elegans Walliser 1964

(Plate I, figure 4-6)

1962	Hindeodella sp.	- Ethington and Furnish, p. 1268; Pl. 173, fig. 1.
1964	Ligonodina elegans n. sp.	- Walliser, p. 41; Pl. 9, fig. 19; Pl. 32, fig. 16-21.

Number of specimens

400

Description

Unit consists of a denticulated posterior bar and a denticulated posteriorly directed lateral process at the anterior extremity.

Posterior bar long and sturdy. Cross-section suboval, with oral edge wider than aboral edge. Aboral restriction emphasized by a slight longitudinal contraction approximately one-half to two-thirds the way down the bar. Aboral edge thin. Denticles on posterior bar discrete and posteriorly oriented at approximately fifty-five degrees to the bar. Cross-section round. Distal tapering very slight. Denticles separated by a distance about equal to their diameter. At times, first denticle posterior to cusp very small. Large cusp situated at anterior end of bar, at junction with lateral process. Cusp directed posteriorly at an angle of fifty-five degrees to bar. Cross-section circular to oval with anterior tapering. Diameter about twice that of denticles on bar. Base slightly wider than cusp, but oral tapering is slight. Denticulated lateral process directed downward and away from main bar at about fifty-five degrees. Five denticles on lateral process discrete; circular in cross-section. Inclined posteriorly with inclination decreasing away from cusp. Deep basal cavity directly beneath cusp and extending some way into it. Extends along both bars as a well-defined groove. Very little or no exterior expression of basal cavity on surface of unit.

Discussion

A complete unit has not been found in this collection. The only part that is commonly intact is the lateral process. Denticles are always broken. Sinistral and dextral forms are found.

The denticles on the posterior bar are often separated from the cusp by a wide gap, at times equal to one and one-half times the diameter of the cusp. This may be due to suppression of germ denticles. However, in some fossils the denticulation is constant up to the base of the cusp. In some specimens, the size of the denticles increases slightly to the fifth denticle and then decreases again.

Generally, the lateral process carries four or five denticles. Two cases have been found, one of which is figured (Plate I, figure 5), where it is very long and possesses at least nine denticles. A similar phenomenon has also been figured by Walliser (1964, Plate 32, figure 19).

The basal cavity has no external expression on the conodont; some specimens are found with a cone of infilling material supported by the posterior and lateral processes, and often extending to the end of the lateral process.

This species resembles very closely Ligonodina silurica Branson and Mehl, 1933. Walliser distinguishes between these two species on the basis of the length of the posterior process. One point which he fails to mention, but which has become very clear in his figures, is that in Ligonodina elegans Walliser, the lateral process is at a smaller angle to the posterior bar. In Ligonodina silurica, the angle is very close to, if not actually, ninety degrees.

Range

crispus to costeinhornensis zone

Lonchodina detorta Walliser 1964

(Plate II, figures 1-4)

1957 Lonchodina n. sp. (a) - Walliser, p. 39; Pl. 3, fig. 29, 30.

1964 Lonchodina detorta n. sp. - Walliser, p. 43; Pl. 9, fig. 20; Pl. 30, fig. 34-37.

Number of specimens

64

Description

Unit consists of two arched and considerably twisted denticulated bars. Cusp is assumed to be posterior in direction; anterior branch extends in direction of anterior extension of cusp. Posterior branch is more strongly curved.

Bars of moderate height and narrow cross-section, vertically arched at approximately ninety degrees to each other. Sigmoidally curved in oral view. Anterior bar nearly straight, bearing strong discrete denticles with oval cross-section. Denticles taper distally only very slightly, separated by approximately one-fourth their diameter, oriented posteriorly at an angle of about fifty degrees to the bar. Posterior bar twisted up to ninety degrees to anterior, convex inwardly, with maximum convexity immediately posterior to cusp after which it straightens out. Discrete denticles perpendicular to bar, up to twice as large as those on anterior bar, with flattened oval cross-sections. Cusp placed at junction of anterior and posterior bars, but mainly situated on posterior one; directed posteriorly. Approximately one and one-half to twice the diameter of denticles. Flattened oval cross-section with anterior and posterior edges. Basal cavity, situated below cusp at junction of bars, consists of a narrow, deep triangular conical excavation extending as a deep groove along the aboral edge of both bars. Expansion over basal cavity follows the trends of the bars, but extends out at one side to form the apex of the triangle. Mainly noticeable in aboral view.

Discussion

No complete specimen of this species has yet been found in the Stonehouse section. However, the strong distinct curvature of the bars places it quite definitely in Walliser's species. The amount of curvature of the posterior bar varies among the specimens: in some it is nearly straight (Plate II, figure 2), while in others it is strongly convex (Plate II, figure 1). Despite this variation, the angle between the two bars seems to remain constant. Sinistral and dextral forms are found.

Some of the variants of this species could be confused with Lonchodina walliseri Ziegler, 1960. However, the specimens from the Stonehouse Formation are without doubt more strongly arched and twisted than Lonchodina walliseri. They agree very closely with Lonchodina detorta Walliser, although a lesser range of variations than he allows is found. As in the case of Trichonodella inconstans Walliser (see page), only a restricted number of the variants reported by Walliser is found in the Stonehouse rocks.

Range

siluricus to eosteinhornensis

Lonchodina greilingi Walliser, 1957

(Plate II, figure 5, 6, 8)

1957	Lonchodina greilingi n. sp.	- Walliser, p. 38; Pl. 3, fig. 20-26.
1958	Lonchodina greilingi Walliser	- Kockel, p. 258, 259.
1960	Lonchodina greilingi Walliser	- Walliser p. 31; Pl. 8, fig. 17, 18.
1960	Lonchodina greilingi Walliser	- Ziegler, p. 188; Pl. 14, fig. 15, 16, 18, 20.
1962	Lonchodina greilingi Walliser	- Ethington and Furnish, p. 1274; Pl. 173, fig. 10.
1962	Lonchodina greilingi Walliser	- Walliser, p. 283; fig. 1, n. 22.
1964	Lonchodina greilingi Walliser	- Walliser, p. 44; Pl. 8, fig. 7; Pl. 30, fig. 7-9.

Number of specimens

150

Description

Unit consists of two greatly arched, slightly twisted denticulated lateral bars and a posteriorly oriented cusp.

Lateral bars wide, slightly twisted in relation to each other. Narrow in cross-section approaching blade configuration. In vertical plane, bars diverge from each other at an angle of approximately eighty degrees. The bar with the most posterior orientation is of lesser height than the other. Denticles coarse, discrete, asymmetrically disposed and posteriorly inclined. Cross-section varies in one unit from oval to circular. No basal thickening; distal tapering very slight. Some separated by a distance of approximately one-half their diameter and some more crowded. Large cusp, situated at junction of lateral bars, tapers distally. Cross-section circular to suboval. Strongly inclined posteriorly. Basal cavity situated beneath cusp. Outline elliptical; oriented asymmetrically with respect to bars: placed diagonally across the general trend of the bars. Does not extend into cusp, but is produced along bars as a narrow shallow groove. Basal cavity lip beneath cusp expanded on anterior surface and more so on posterior surface.

Discussion

In Walliser's original description of this species (1957) he denoted the bars as lateral. In a later description of other species of this genus (1964), he calls the bars anterior and posterior, but does not redefine the orientation of Lonchodina greilingi. Accordingly, his terminology is followed in this report.

This species shows a rather wide range of variation within the Stonehouse Formation. As these variants can be found within one sample, no stratigraphic significance can be attached to them. Sinistral and dextral forms are found.

Some bars are rounded (Plate II, figure 6), others are blade-like (Plate II, figure 5). The twisting is never great but it seems less pronounced when the bar is flat.

The cross-section of the denticles also varies with the bar shape. Where the bar is blade-like, the denticles have compressed cross-sections and sharp edges, as does the cusp. Where the bar is rounded, so are the cross-sections of the denticles and of the cusp. In some specimens each bar has denticles of about the same size; in others the size variation on any one bar is great. The amount of posterior orientation of the denticles is proportional to the amount of twisting of the bar.

A cone of basal filling is, at times, preserved, extending slightly beyond the edges of the basal cavity.

Range

patula zone to Lower Devonian

Lonchodina sp. indet.

(Plate III, figure 6-8)

Number of specimens

32

Description

Unit consists of two relatively straight, denticulated bars twisted in relation to each other, a large cusp and an expanded basal cavity.

Lateral bars set at an angle of approximately sixty degrees to each other, but slightly twisted at the apex of their junction. One bar is slightly higher and thicker in cross-section than the other. On the higher bar, denticles are discrete, wide and compressed in cross-section with their long diameter at a low angle to the bar, are separated by more than one-third their diameter and taper distally. On the smaller bar, denticles are narrower in diameter, rounder in cross-section with their long diameter parallel to bar, separated by one-half their diameter; tapering slight. Size of denticles is not constant. Cusp situated at apex of angle between lateral bars. Near base cross-section rectangular, lateral diameter about equal to that of larger bar denticles, prolonged posteriorly to form sharp edge. Antero-posterior diameter approximately twice lateral diameter at base. Cusp trends posteriorly, but with a pronounced tendency toward the lesser bar. Deep, triangular, conical basal cavity beneath cusp extends aborally along bars as a shallow and very narrow groove. Expansion for basal cavity only visible on posterior surface where it conforms to the axis of the cusp.

Discussion

This species is almost identical to Trichonodella inconstans Walliser from which it differs only in the lack of symmetry about the cusp, and in the inequality of the bars. Because of this resemblance between the present species and Lonchodina greilingi Walliser, the same orientation is maintained.

This species resembles a Trichonodella which has been squeezed laterally enough to reorient the cusp and expansion for the basal cavity in a lateral direction. In Trichonodella inconstans Walliser, the bars and denticles are unquestionably equal on both sides (Plate I, figure 7-9), but in the species described above the bars differ in height, thickness, and orientation, and the denticles differ in size and cross-section.

It was previously thought that this may be a pathological development of Trichonodella inconstans Walliser, but this species has been found over a vertical distance of about three hundred and thirty-seven feet, and thirty-two specimens were found. Repetition of a pathological case is surely rare, and is certainly not expected over such a large stratigraphical interval. That these specimens belong to a natural taxon seems to be indicated.

In his description of Lonchodina greilingi, Walliser (1957, p. 39) pointed out that this particular species is a case of twisted Trichonodella. However, in the Stonehouse collection, the Lonchodina described above seems distinct from Lonchodina greilingi Walliser, a possibly new species should be established.

It is interesting to note that in the Stonehouse section, this species does not occur in the two lower zones that McLearn determined on the basis of macrofauna (1924, p. 13-15). Lonchodina greilingi Walliser, on the other hand, occurs throughout the section.

Neoprioniodus n. sp. a

(Plate III, figure 1-3)

Number of specimens

188

Diagnosis

Pick-like conodont with greatly expanded basal cavity.

Description

Unit consists of denticulated posterior bar with an anterior cusp, anticusp, and a large basal cavity.

Wide posterior bar with compressed cross-section approaching blade configuration. Thickens slightly near aboral edge. Oriented at one hundred forty-five degrees from cusp. Outer side forms a convex curve. Subparallel, subequal denticles on posterior bar, fused or closely appressed for most of their length; tips discrete;

cross-section oval. Oriented at sixty degrees from bar, toward cusp. Terminal cusp at anterior end of bar, approximately four times wider than neighbouring denticles. Cross-section strongly compressed away from base, with sharp anterior and posterior edges. Interior curvature evident orally. Non-denticulated anticusp extends downward from cusp; forms a slightly convex line with cusp. Conical basal cavity with triangular outline situated directly beneath cusp, extends slightly into cusp, and is prolonged along bar and anticusp as a narrow deep groove. Lip of cavity flares with an upward tilt on inner side; no expression of cavity on outer side.

Discussion

This species exhibits a certain, but not extensive, range of variations. In some specimens, the denticles on the posterior bar are not fused, but are very close together. The line formed by the cusp and the anticusp may be nearly straight (Plate III, figure 2). Sinistral and dextral forms are found.

The lip of the basal cavity extends away from the cusp at an obtuse, but varying, angle. The size of the cavity and of its lip is a very distinctive feature of this species.

Neoprioniodus n. sp. b

(Plate III, figure 4, 5)

Number of specimens

32

Diagnosis

Pick-like conodont with denticulated anticusp.

Description

Unit consists of a denticulated posterior bar with anterior, denticulated anticusp and slightly expanded basal cavity.

Narrow posterior bar with compressed cross-section, oriented at one hundred and forty-five degrees from cusp; narrows posteriorly. Parallel, discrete denticles oriented orally at approximately fifty degrees from posterior bar, separated by about one-fourth their diameter. Cross-section suboval; distal tapering slight. Curved to the interior. Cusp at anterior end of posterior bar. Cross-section compressed with sharp anterior and posterior edges, approximately four times wider than other denticles. Anticusp extends aborally from cusp, bears two discrete denticles which have oval cross-sections and are directed orally, subparallel to the bar denticles. Anticusp directed at twenty-five degrees from exterior line of cusp, with a slight indentation at the base. Basal cavity situated directly beneath cusp, not extending deeply into it. Outline of cavity triangular, shape conical. No expression on outer side, but inner side is slightly expanded from base of cusp to aboral edge.

Discussion

In this collection specimens of Neoprioniodus n. sp. a are at least six times more numerous than those of Neoprioniodus n. sp. b. A total of one hundred and forty-six units of this genus were found, but in approximately twenty-six of these cases they could not be precisely assigned to either species. This was due to breakage, generally of the anticusp, making specific determinations impossible. Both species showed dextral and sinistral forms.

Neoprioniodus n. sp. b is characterized by the denticulated anticusp, a feature not present in Neoprioniodus n. sp. a. It also differs from the latter by the aboral tapering of the posterior bar and by the size of the basal cavity expansion which, in Neoprioniodus n. sp. a, has quite a wide range in size and is generally larger. In Neoprioniodus n. sp. b it does not flare as widely, but may be slightly constricted.

These species can be found in the same sample and both occur in all three of Copeland's ostracod zones (1964, p. 5). It is concluded that they hold no stratigraphic significance within the Stonehouse Formation. Until more are found at equivalent or different horizons, their importance cannot be determined.

Ozarkodina typica denckmanni Ziegler 1956

(Plate II, figure 9, 10)

1956 Ozarkodina denckmanni n. sp. - Ziegler, p. 103; Pl. 6, fig. 30, 31; Pl. 7, fig. 1, 2.

1960 Ozarkodina denckmanni Ziegler - Ziegler, p. 190; Pl. 15, fig. 13-15.

1960 Ozarkodina denckmanni Ziegler - Walliser, p. 31; Pl. 8, fig. 13, 14.

1962 Ozarkodina denckmanni Ziegler - Walliser, p. 283; fig. 1, no. 32.

1964 Ozarkodina typica denckmanni Ziegler - Walliser, p. 61; Pl. 9, fig. 14; Pl. 26, fig. 3-11.

Number of specimens

52

Description

Laterally compressed arched unit consists of denticulated anterior and posterior blades and apical denticle over basal cavity.

At mid-length, blades arched at about one hundred and fifty degrees from each other. Cross-section compressed. Height increases gradually apically; rate of increase greater for anterior blade. Barely discernible inner lateral curvature with apex of concavity near mid-length. Subparallel, subequal denticles on both blades fused basally, but free at tips. Cross-section flattened with sharp anterior and posterior edges. Denticles on anterior blade directed posteriorly at approximately sixty degrees to blade; those on posterior at approximately eight degrees. Eleven or twelve denticles on anterior; ten or more on posterior blade. Apical denticle situated at apex of arch, and directed posteriorly at about sixty degrees to anterior blade. Diameter at least twice that of denticles. Cross-section compressed with sharp anterior and posterior edges. Fused as far as tip of adjacent denticles. Small, shallow conical basal cavity located directly beneath apical denticle, prolonged along aboral edge of blades as a very narrow and shallow groove. Very slight expansion on exterior surface of blade at apex of arch.

Discussion

Because no complete specimens of this subspecies has been found in this collection, the full number of denticles has not been determined. There is very little variation between representatives of his collection. This subspecies has the most delicate units of the Stonehouse conodonts.

Range

costeinhornensis zone to Lower Emsian

Ozarkodina cf. jaegeri Walliser 1964

(Plate II, figure 7)

1964 Ozarkodina jaegeri n. sp. - Walliser, p. 57; Pl. 9, fig. 16; Pl. 25, fig. 11-18; Abb. 3n,o.

Number of specimens

18

Description

Unit consists of arched denticulated blades, with apical denticle over basal cavity at mid-point.

Blades of equal height and length arched at mid-length at about one hundred and thirty degrees to each other. Cross-section compressed but with an expansion which begins at base of denticles and tapers off about two-thirds the way down the blade. Blades taper very slightly distally. Nine equal, discrete but closely appressed denticles on anterior blade. Angle to bar decreases apically from sixty-five to fifty degrees. Cross-section compressed. Denticles on posterior blade smaller in diameter, discrete with more rounded cross-sections. Smaller, poorly developed denticles alternate with the larger ones. Oriented at about ninety degrees to blade. Apical denticle at mid-length, at least three times as wide as denticles. Cross-section compressed with sharp anterior and posterior edges. Oriented at about forty degrees to anterior bar. Last denticle on anterior bar confines the diameter of the apical denticle; no restriction on posterior side. Basal cavity shallow, conical, extends aborally along blades as a narrow shallow groove. Very slight expansion on lateral surfaces.

Discussion

The specimen figures (Plate II, figure 7) agrees in many respects with that shown by Walliser (Plate 25, fig. 17). There are, however, some differences. No discrepancy is to be found by referring to Walliser's description, but comparison of figures shows the differences.

There is a faint longitudinal ridge in Walliser's holotype; in the Stonehouse specimen it is more strongly defined. The denticles on the anterior blade of Walliser's are not at a constant angle to the blade varying from fifty to ninety degrees. In the Stonehouse *Ozarkodina* the equivalent denticles are at a constant angle to the blade. In Walliser's, the denticles on the posterior blade are equal, but in the Stonehouse specimen the size varies.

Although these are the main differences encountered, the Stonehouse specimens seem conspecific with Walliser's.

Only eighteen specimens were found and they do not occur at stratigraphically significant positions within the Stonehouse Formation. Within this collection, the specimens of this species are noticeably thicker and coarser than those of *Ozarkodina typica denckmanni* Ziegler.

Range

latialatus to *costeinhornensis* zones

Spathognathodus steinhornensis

costeinhornensis Walliser 1964

(Plate I, figure 1-3)

1964 *Spathognathodus steinhornensis costeinhornensis* n. ssp.
- Walliser, p. 85; Pl. 9, fig. 15;
Pl. 20, fig. 7-16, 19-25; Abb. 9.

Number of specimens

339

Description

Unit consists of denticulated blade with sub central cusp and basal cavity.

High blade with narrow cross-section which flares slightly near aboral edge; this flare lessens away from basal cavity. Very slight swelling about one-half way down blade. Height lessens near anterior end. In oral view, shows slight curving only at anterior end. Six or seven discrete, subequal denticles on both blade portions; cross-sections very compressed giving sharp anterior and posterior edges. Distal tapering rapid. Denticles oriented perpendicular to blades, closely pressed together, some fused near base. Subcentral to central cusp slightly larger and coarser than other denticles. Cross-section compressed with sharp anterior and posterior edges. Parallel to other denticles. Aborally, a groove extends along blade, shallowing and narrowing at anterior and posterior ends. Beneath cusp it widens slightly and deepens to form cavity which does not extend beyond the longitudinal swelling. Edges of basal cavity expansion lobe-like with unequal portions. Largest expansion of lobes posterior. Outline nearly rectangular; anterior margin nearly ninety degrees to blade, while angle of posterior margin variable. Smaller lobe on side of concavity of anterior portion of blade.

Discussion

In many of the present specimens, the basal cavity is more or less heart-shaped, but thirty-two per cent of the specimens show a rectangular outline. Denticle development is rather uniform in most specimens. There is some variation in the height of the blades, but the majority are high. There is also a large range in the denticle development; some are discrete and taper rapidly, and in other specimens they are long and fused along much of their length. In a few specimens the anterior portion of the blade tapers to about one-third the central height. Rare individuals show the cusp much the same in size as the other denticles and therefore difficult to distinguish. The number of denticles varies from four to ten per bar portion, but the great majority have six denticles (thirty-six percent have six denticles; twenty per cent have seven, with the five and eight denticled specimens at fifteen per cent each). The longitudinal swelling is not always present.

Three hundred and thirty-nine specimens of this important species have been found in the Stonehouse. They conform closely to Walliser's description of the subspecies (1964, p. 85) which is not very sharply defined. In the original description this subspecies can only be differentiated from Spathognathodus steinhornensis remscheidensis Ziegler if a large number of specimens are available. However, in remscheidensis the denticles are not equally developed nor the basal cavity as rectangular as in eosteinhornensis.

The blade height is greater and more constant in the Stonehouse specimens and Walliser's figures of eosteinhornensis (Plate 9, figure 15; Plate 20, figure 7-16, 19-25) than in remscheidensis (Plate 20, figure 26-28; Plate 21, figure 1-2).

The placing of the Stonehouse *Spathognathodus* into the *eosteinhornensis* subspecies is warranted even though the discrimination is difficult. It is felt that three hundred and thirty-nine specimens are enough material to justify the identification.

Range

eosteinhornensis zone

Trichonodella inconstans Walliser 1957

(Plate I, figure 7-9)

1957	*Trichonodella inconstans* n. sp.	- Walliser, p. 50; Pl. 3, fig. 10-17.
1960	*Trichonodella inconstans* Walliser	- Walliser, p. 35; Pl. 7, fig. 11-12.
1960	*Trichonodella inconstans* Walliser	- Ziegler, p. 197; Pl. 14, fig. 14, 17.
1962	*Trichonodella inconstans* Walliser	- Ethington and Furnish, p. 1287; Pl. 173, fig. 7.
1962	*Trichonodella inconstans* Walliser	- Reichstein, p. 538.
1962	*Trichonodella inconstans* Walliser	- Walliser, p. 283; fig. 1, no. 2.
1964	*Trichonodella inconstans* Walliser	- Walliser, p. 90; Pl. 8, fig. 8; Pl. 30, fig. 10-12.

Number of specimens

309

Description

Bilaterally symmetrical unit consists of two arched denticulated lateral bars and a strong, centrally positioned cusp.

Lateral bars of moderate height and compressed cross-section, diverge from each other by approximately eighty-five degrees. Divergence then tapers off apically to give a U-shaped aspect in posterior view. Slightly curved posteriorly away from the vertical plane. Posteriorly inclined denticles numerous, discrete, with slightly compressed oval cross-sections. Distal tapering slight; basal widening apparent. Separated from each other by a distance of about one-half their diameter, which is relatively constant. Cusp, located at point of junction of lateral bars, approximately twice the diameter of denticles. Cross-section compressed near base, but becomes square distally. Posterior curvature evident. Distal tapering not apparent. Cusp extends posteriorly to bars and forms a pillar-like process. Basal cavity triangular in outline, compressed conical in shape, extends into cusp and is prolonged along bars as narrow, shallow grooves. No expression of basal cavity on anterior face; on posterior face, lip of basal cavity extends up and along the trend of the cusp.

Discussion

This species offers a very wide range of variations. All are found at every horizon, and, therefore, no local stratigraphic significance can be derived.

The bars are generally compressed, but in some cases, they are thicker and tend to be rectangular in cross-section. The angle of the bars is relatively constant at eighty-five degrees in the Stonehouse samples; however, a wide range is permissible according to the original description of the species (Walliser, 1957, p. 50). The denticles are compressed in cross-section, but in varying amounts. Usually distal tapering is slight, but it can be very obvious in some units (Plate I, figure 9). Generally, the specimens of this species from the Stonehouse collection are more U-shaped than Walliser's samples.

The original description of this species (Walliser, op. cit.) allows a very wide range of characteristics. This seems to be realistic from the point of view of intra-specific diversity. All the variants grade into each other and with no stratigraphically delineated sequence. However, from the practical point of view, and as it is clear that with conodonts "form-species" are used, it may be more useful to split this species, at this time. Most of the Stonehouse specimens possess one set of distinguishing features and could be separated from the opposite extreme of this species. Generally, bars, even when they thicken to attain a rectangular cross-section, maintain their height and do not become rod-like. The denticles are always discrete and the basal cavity is extended as a groove under the blades. The angle between the bars is always approximately eighty-five degrees. This constitutes one end-member of the wide range of variations encompassed within this species. Because these properties are constant throughout the Stonehouse

Formation, it seems that they form a distinct group within Trichonodella inconstans Walliser.

Possibly an arbitrary division could be made on the angle of divergence of the bars. Already this difference can be seen between Trichonodella excavata (Branson and Mehl), and Trichonodella inconstans Walliser; the angle of the former being the larger.

Range

sagitta zone to Lower Devonian

Fish fragments

Acanthoides dublinensis (Stauffer) Wells, 1944

(Plate IV, figure 1)

1938	Acanthodes ? dublinensis n. sp.	- Stauffer, p. 442; Pl. 53, fig. 21-24, 31-34.
1944	Acanthoides dublinensis (Stauffer)	- Wells, p. 29; Pl. 2, fig. 42; text fig. 5h.

Discussion

This species has an ornamented coronal surface. The main point of variation between previously described specimens of this species is in the amount of convexity of the coronal surface. Generally, in this collection, this surface is quite flat, but in a few instances, a slight convexity can be detected. This is not sufficient enough to warrant putting those few specimens in the species *Acanthoides hardyi* Wells 1944.

Cheiracanthoides venustus Wells 1944

(Plate IV, figure 2-6)

1944 *Cheiracanthoides venustus* n. sp. = Wells, p. 25; Pl. 2, fig. 28-32; text fig. 4i, j.

Discussion

A very wide range of variations in ornamentation is found in these fish "scales"; it can be very strong ridges or high relief or only faint indentations on the anterior coronal edge. The outline of the coronal surface itself varies from rhombic (Plate IV, figure 20 through triangular (Plate IV, figure 3-5) to very sharply tipped (Plate IV, figure 6). The triangular shape is the most common in this collection. This species occurs throughout the Stonehouse Formation.

Cheiracanthoides n. sp.

(Plate V, figure 1; Plate VI, figure 1)

Diagnosis

"Scale" with large spatulate posterior extension to coronal surface.

Description

Smooth, convex, rhombic basal surface. Neck slightly constricted. Coronal surface strongly ornamented with five ridges converging from the anterior edge to a posterior point corresponding to the outer corner of the base. Posterior expanded as a flange from the two lateral corners. Flange more finely ornamented than anterior portion of surface, with fifteen subparallel ribs.

Discussion

This form is rare in the Stonehouse Formation. The figured specimen is a very large one; the few others in the collection more closely approximate the other dermal denticles in size. Neither are these other specimens as well ornamented.

Wells (1944) did not describe any such forms. It is felt that this specimen probably belongs in the genus Cheiracanthoides Wells 1944, but must be a new "species" at the same level as the Wells' "species".

Onychodus Newberry 1857

(Plate IV, figure 7, 8, 10)

Number of specimens

6

Description

"Scale" fragment with flat base and tubercular ornamentation. Some units have their upper surface studded with dome-like ridged tubercles, which radiate toward the margins of the fragments. Another unit is ornamented with branch-like ridges oriented in one general direction. Two of the units have light amber bases (Plate IV, figure 7, 10); the other is black (Plate IV, figure 8). All have smooth shiny surfaces. They range in size from 0.9 to 1.4 mm.

Discussion

The six units of this type were found at three localities spanning most of the stratigraphic interval of the Stonehouse Formation: at thirty-one feet from the bottom (G.S.C. loc. 39094), one hundred and twenty-six feet and approximately seventy-five feet from the top (G.S.C. loc. 70352, and 70363). This genus, which is rare in this collection, is not important zonally.

Two of the figured units (Plate IV, figure 7, 10) seem to be complete while the third (Plate IV, figure 8) appears to be fragmentary. This third specimen is directly comparable to the larger ones figured by Wells (1944, Plate 3, figure 35, 36), from the Middle Devonian Delaware Formation in Ohio. The other two are similar enough to be conspecific with the third.

Wells assigned his fragments to the species Onychodus sigmoides Newberry. However, it is felt that the Stonehouse specimens are neither complete nor numerous enough to warrant specifis designation.

Petrodus ? McCoy

(Plate III, figure 9-11)

1933 Petrodus ? - Gunnell, p. 296; Pl. 32, fig. 28.

Number of specimens

8

Description

Domed and radiate "scale" with edges flat and conically hollowed base. Five to seven straight rays extend away from central peak which has a small, hollow depression at the summit. In some cases, they bifurcate near the outer margin. These rays are high and are only joined at the bottom by a thin web-like extension of the base.

Discussion

A similar "scale" was figured by Gunnell (1933) from the Pennsylvanian Cherryvale Shale of the Kansas City Group in Missouri. In his specimen, two of the rays do not reach the center but diverge from the other rays. This is the only figure of a unit resembling the Stonehouse specimens in any way. There is little doubt that they are of the same origin. Only the wide stratigraphic separation could cause some question.

These forms are very rare in the Stonehouse Formation.

They have been found in only two samples, both within thirty-one feet of the base of the formation.

Fish "tooth"

(Plate IV, figure 9)

Description

Large conical "tooth" fragment 1.8 mm high, and 1.1 mm wide at base. Dull white surface with some red to pink colouration which may be due to post-depositional alteration. Slight ridges widely spaced along unit. Base widens. Unit broken off both at top and bottom.

Discussion

Five units which could be placed in this category were found, but they do not resemble each other very closely. The figured specimen is by far the largest. The others are approximately one-half that size. Two units are brown, two are white, and the other is greyish.

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APPENDIX

Locality index

(Numbers designating localities are from the Geological Survey of Canada series)

Unless otherwise specified, samples were collected from the shore section of the Stonehouse Formation, near Arisaig.

38982 39 feet from top of shore section.
Copeland, 1959.

38986 58 feet from top of shore section.
Copeland, 1959.

38987 62 feet 6 inches from top of shore section.
Copeland, 1959.

38989 80 feet from top of shore section.
Copeland, 1959.

38992 97 feet 6 inches from top of shore section.
Copeland, 1959.

38996 130 feet 6 inches from top of shore section.
Copeland, 1959.

38999 161 feet 7 inches from top of shore section.
Copeland, 1959.

39004 210 feet 10 inches from top of shore section.
Copeland, 1959.

39009 254 feet 5 inches from top of shore section.
Copeland, 1959.

39010 263 feet 8 inches from top of shore section.
Copeland, 1959.

39012 274 feet 2 inches from top of shore section.
Copeland, 1959.

39013 284 feet 2 inches from top of shore section.
Copeland, 1959.

39014 294 feet 10 inches from top of shore section.
Copeland, 1959.

39015 305 feet 5 inches from top of shore section.
Copeland, 1959.

39016 311 feet 5 inches from top of shore section.
Copeland, 1959.

39019 337 feet 2 inches from top of shore section.
Copeland, 1959.

39020 345 feet 8 inches from top of shore section.
Copeland, 1959.

39021 352 feet 11 inches from top of shore section.
Copeland, 1959.

39022 363 feet 11 inches from top of shore section.
Copeland, 1959.

39025 408 feet 4 inches from top of shore section.
Copeland, 1959.

39026 422 feet 10 inches from top of shore section.
Copeland, 1959.

39027 439 feet 6 inches from top of shore section.
Copeland, 1959.

39028 458 feet 4 inches from top of shore section.
Copeland, 1959.

39032 545 feet 6 inches from top of shore section.
Copeland, 1959.

39052 920 feet 1 inch from top of shore section.
Copeland, 1959.

39055 998 feet 10 inches from top of shore section.
Copeland, 1959.

39056 1016 feet from top of shore section.
Copeland, 1959.

39057 1035 feet 9 inches from top of shore section.
Copeland, 1959.

39060 1103 feet 6 inches from top of shore section.
Copeland, 1959.

39070 500 feet upstream from mouth of North Branch of McAdam Brook, where it joins McAdam Brook - on North Branch McAdam Brook.
Copeland, 1959.

39071 Stonehouse blocks from ditch near Upper Stonehouse-Knoydart contact on main highway.
Copeland, 1959.

39074 96 feet above mouth of North Branch, McAdam Brook,
Copeland, 1959.

39076 Traverse up Brook no. 1. North of old Government wharf, north of McAras Brook. 54 feet from mouth of creek (top).
Copeland, 1959.

39085 From most westerly outlier of Silurian strata on the end of Cape George; Antigonish County,
Copeland, 1959.

39086 Same locality but slightly west of G.S.C. loc. 39085.
Copeland, 1959.

39087 McAdam Brook. Just below contact with Knoydart Formation.
Copeland, 1959.

39088 McAdam Brook at falls near faults north of the Main Road.
Copeland, 1959.

39089 Blocks from ditch, north side of McAdam Brook, along highway.
Copeland, 1959.

39091 From limy bed 6 feet above Red Stratum of Moydart Formation, on shore.
Copeland, 1959.

39093 Limestone lens about 5 inches thick; 25 feet above Red Stratum of Moydart Formation.
Copeland, 1959.

39094 Limestone lens 3 inches thick; 31 feet above Red Stratum of Moydart Formation.
Copeland, 1959.

39098 Limestone lens in shaly horizon slightly above M.I.T. locality 18.
Copeland, 1959.

39100 Same as G.S.C. locality 39040.
Copeland, 1959.

70339 15 feet from top of shore section.
Legault, 1964.

PLATE I

(All figures x45)

Spathognathodus steinhornensis eosteinhornensis Walliser

Figures 1a, b	G.S.C. loc. 70360; 1a, lateral view; 1b, aboral view.
Figures 2a, b	G.S.C. loc. 70352; 2a, lateral view; 2b, oral view.
Figures 3a, b	G.S.C. loc. 70360; 3a, lateral view; 3b, aboral view.

Ligonodina elegans Walliser

Figure 4	G.S.C. loc. 39013; lateral view.
Figure 5	G.S.C. loc. 39085; lateral view; long lateral process with nine denticles.
Figure 6	G.S.C. loc. 70360; lateral view; repaired fracture from base of cusp to basal cavity.

Trichonodella inconstans Walliser

Figure 7	G.S.C. loc. 70360; posterior view.
Figure 8	G.S.C. loc. 38992; posterior view.
Figure 9	G.S.C. loc. 39022; posterior view.

PLATE I

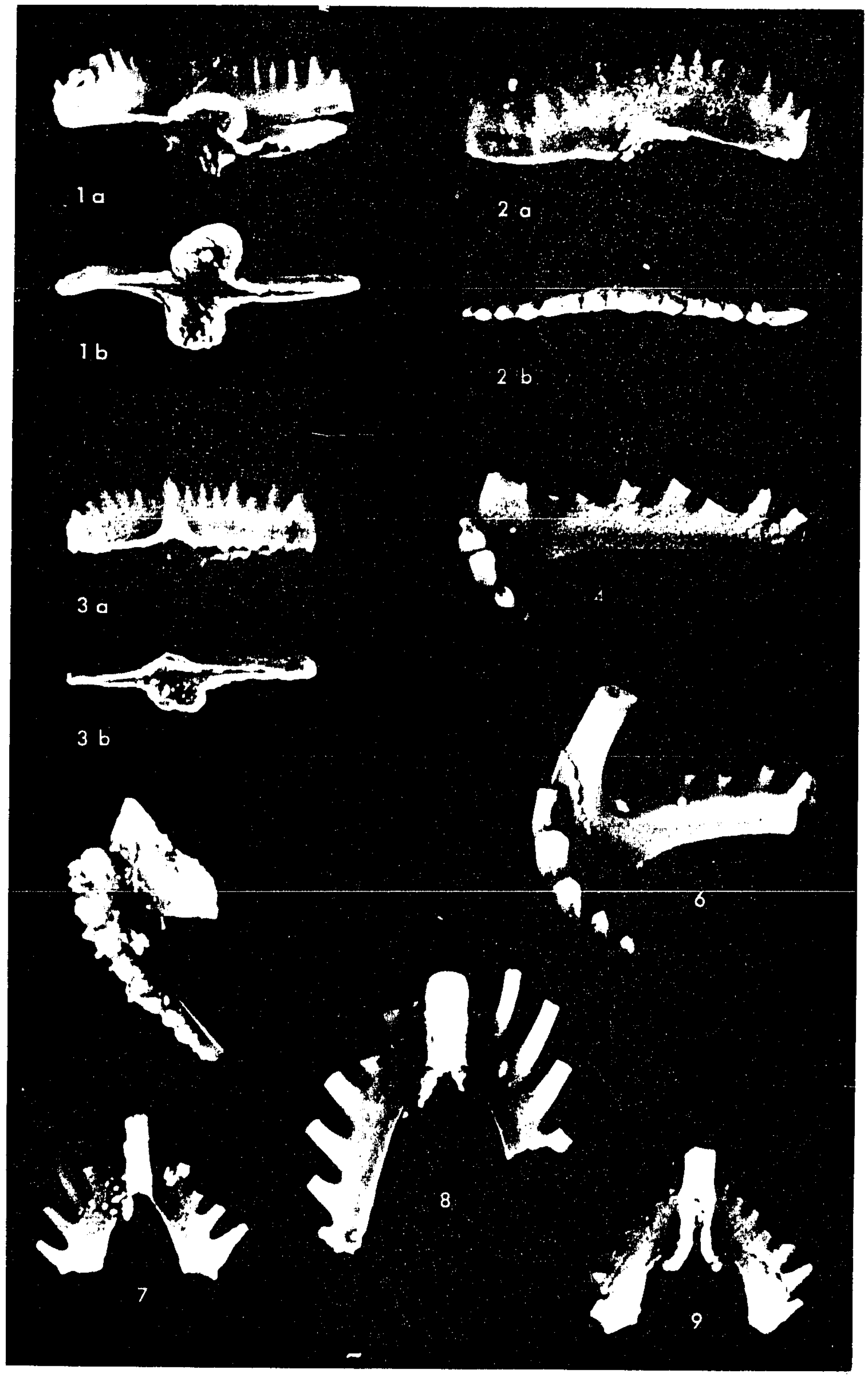

PLATE II

(All figures x45)

Lonchodina detorta Walliser

Figure 1 G.S.C. loc. 70360; lateral view.

Figure 2 G.S.C. loc. 70360; lateral view.

Figure 3 G.S.C. loc. 39019; lateral view; repaired fracture from base of cusp to second denticle of anterior bar.

Figure 4 G.S.C. loc. 70352; lateral view.

Lonchodina greilingi Walliser

Figure 5 G.S.C. loc. 70352; posterior view; repaired fracture at base of cusp and first denticle on lateral bar.

Figure 6 G.S.C. loc. 70360; posterior view; repaired fracture at base of cusp; basal filling.

Figure 8 G.S.C. loc. 70360; posterior view; basal filling.

Ozarkodina cf. *jaegeri* Walliser

Figure 7 G.S.C. loc. 39093; lateral view.

Ozarkodina typica denckmanni Ziegler

Figure 9 G.S.C. loc. 39070; lateral view.

Figure 10 G.S.C. loc. 70360; lateral view.

PLATE II

PLATE III

(All figures x45)

<u>Neoprioniodus</u> n. sp. a

Figure 1 G.S.C. loc. 70360; lateral view.

Figure 2 G.S.C. loc. 39012; lateral view.

Figure 3 G.S.C. loc. 39021; lateral view.

<u>Neoprioniodus</u> n. sp. b

Figure 4 G.S.C. loc. 70360; lateral view.

Figure 5 G.S.C. loc. 38996; lateral view.

<u>Lonchodina</u> sp. indet.

Figure 6 G.S.C. loc. 70360; posterior view.

Figure 7 G.S.C. loc. 39087; posterior view.

Figure 8 G.S.C. loc. 70360; posterior view.

<u>Petrodus</u> ?

Figure 9 G.S.C. loc. 39094; top view.

Figure 10 G.S.C. loc. 39093; top view.

Figure 11 G.S.C. loc. 39093; top view.

PLATE III

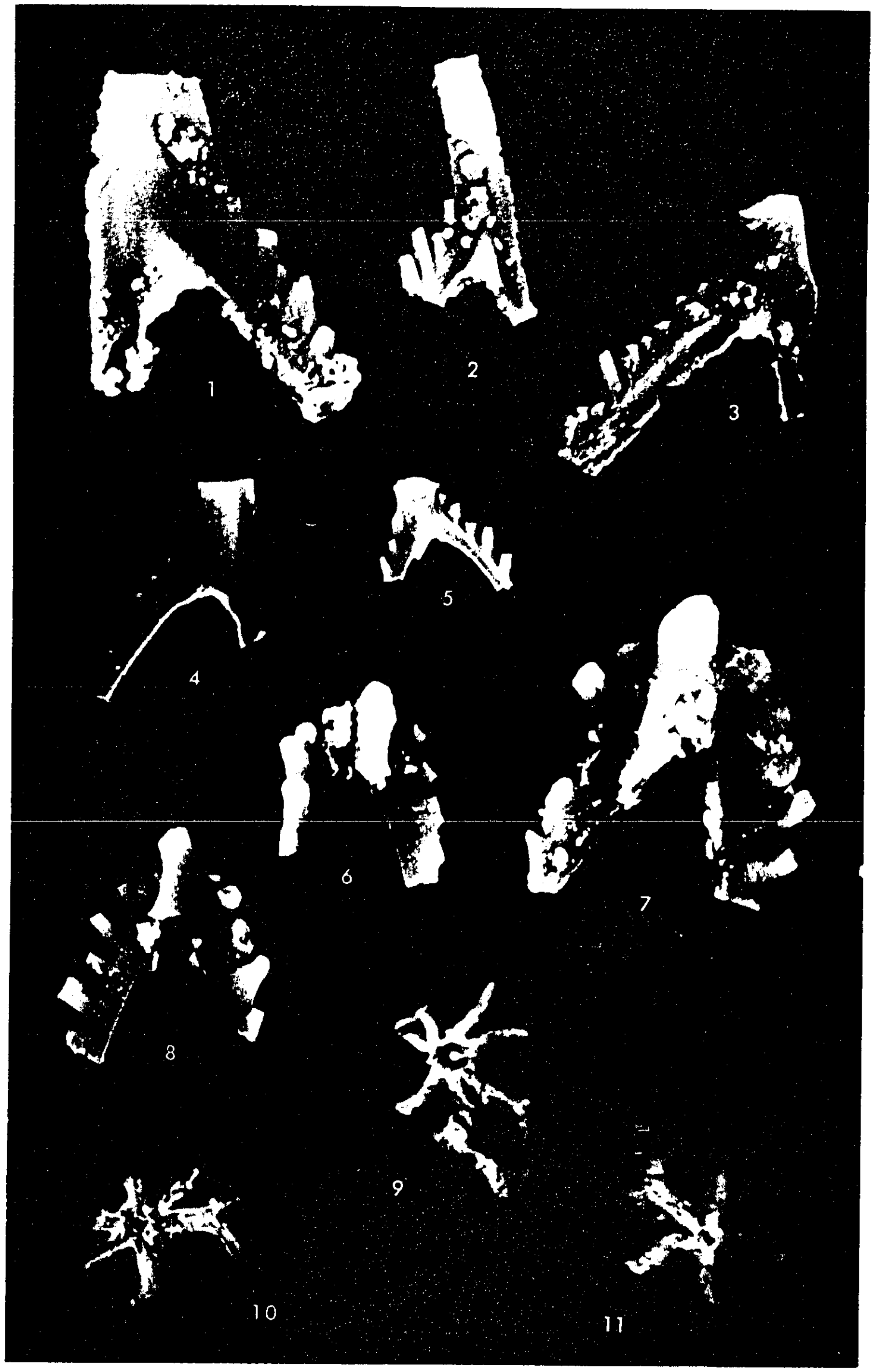

PLATE IV

(All figures x45)

Acanthoides dublinensis Wells

Figure 1 G.S.C. loc. 39014; top view.

Cheiracanthoides venustus Wells

Figure 2 G.S.C. loc. 39014; top view.

Figure 3 G.S.C. loc. 39014; top view.

Figure 4 G.S.C. loc. 39012; top view.

Figure 5 G.S.C. loc. 39014; top view.

Figure 6 G.S.C. loc. 39012; top view.

Onychodus

Figure 7 G.S.C. loc. 70352; top view.

Figure 8 G.S.C. loc. 39086; top view.

Figure 10 G.S.C. loc. 70352; top view.

Fish "tooth"

Figure 9 G.S.C. loc. 70341; lateral view.

PLATE IV

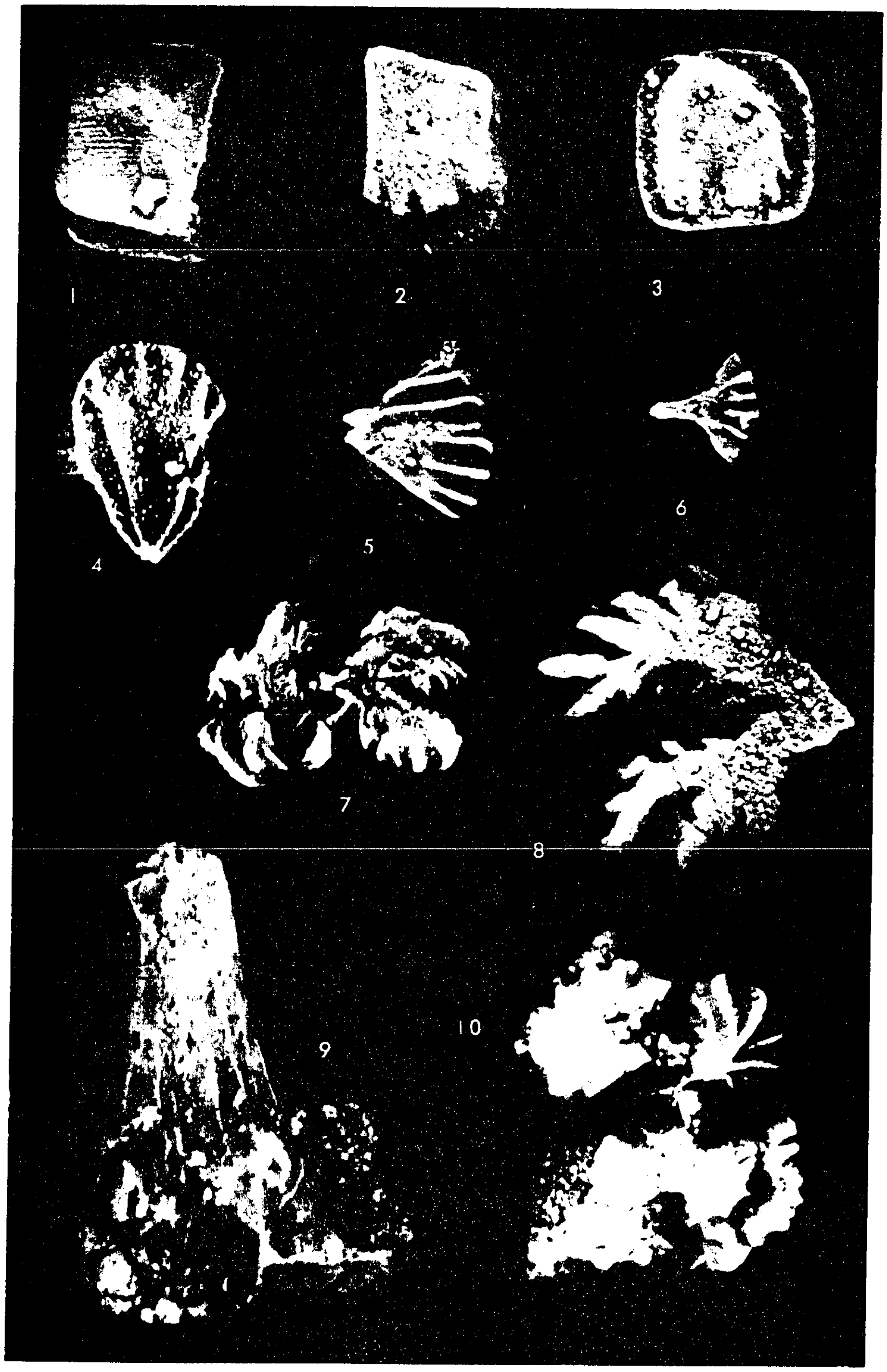

PLATE V

(x45)

Cheiracanthoides n. sp.

Figure 1   G.S.C. loc. 36999; top view.

PLATE V

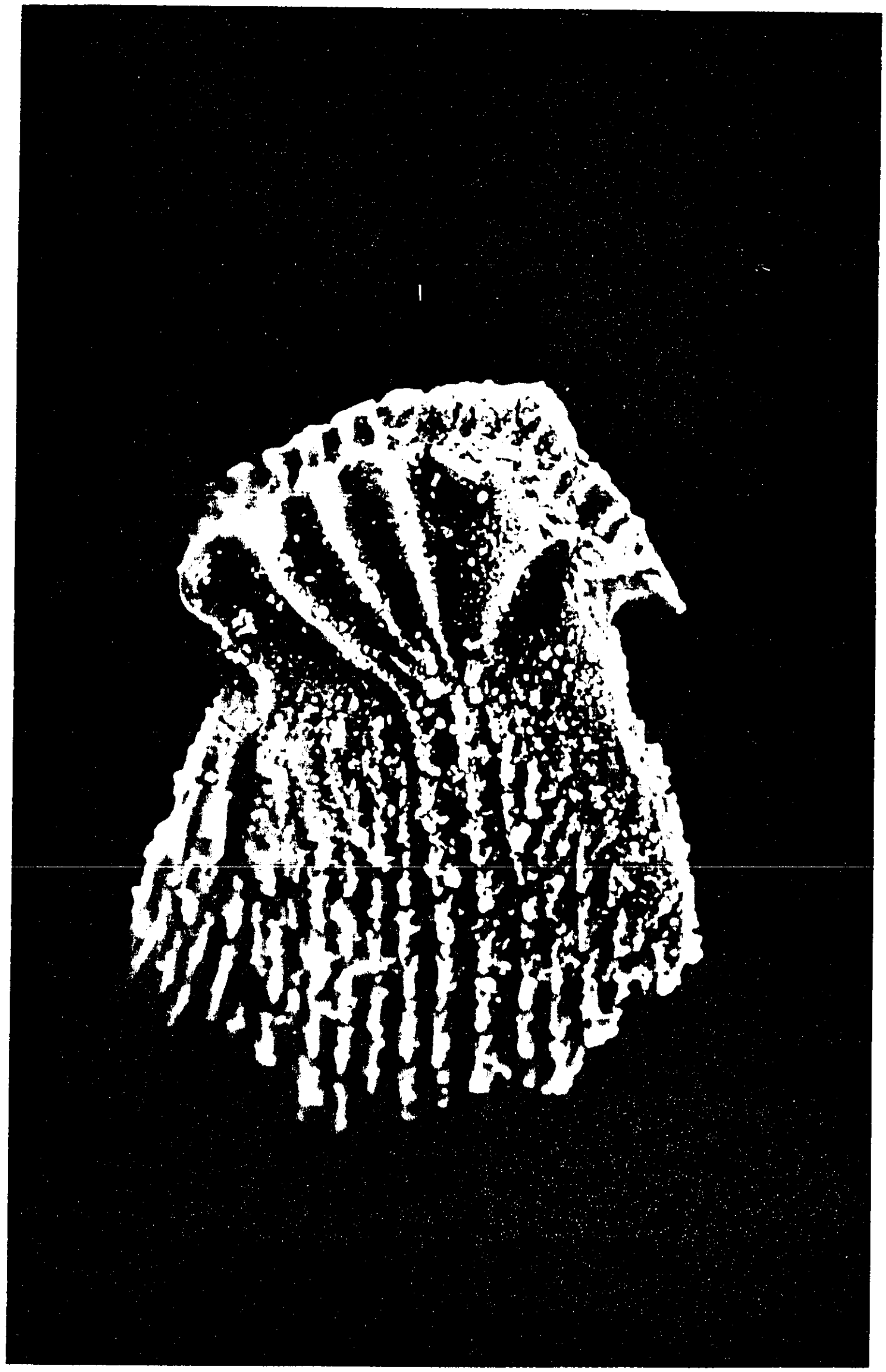

PLATE VI

(x45)

Cheiracanthoides n. sp.

Figure 1 G.S.C. loc. 38999; bottom view of same unit as in Plate V.

PLATE VI