

AN ABSTRACT OF THE THESIS OF

ROY EDWARD SMITH for the MASTER OF SCIENCE
(Name of student) (Degree)

in Geology presented on December 13 1972
(Major department)

Title: TAXONOMY AND ECOLOGY OF ATRYPELLA SPP. AND THE
ATRYPELLA COMMUNITY

Abstract approved: Redacted for privacy
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Two measured sections of the upper Silurian Douro Formation from Devon Island, N.W.T. were examined for their faunal content with emphasis on the paleoecology and taxonomy of the fauna. Atrypella is believed to have lived with its beaks embedded in the muddy substrate of a somewhat restricted environment. Intermittent, low velocity currents caused disarticulation within the members of the Atrypella community and resulted in members of adjacent communities being swept in. The Atrypella Community has low faunal diversity and high density; the bulk of the Community being composed of Atrypella spp., Protathyris spp., and Howell-ella sp. A crude zonation exists within Atrypella spp. from Arctic Canada, but more precise age dating, perhaps utilizing conodonts, is needed to clear up uncertainties.

From this study, Atrypella spp. was found to be restricted to the Ludlow and Pridoli stages of the Silurian System in both North America and Eurasia.

In latest Wenlock or earliest Ludlow time, two broad lineages of Atrypella evolved, possibly from Cryptatrypa. One lineage was characterized by forms similar to and including A. scheii (Holtedah1). The second lineage was characterized by forms similar to and including A. prunum (Dalman).

In late Pridoli time, conditions favourable for the existence of Atrypella spp. began to deteriorate and by the end of Pridoli time, both lineages had become extinct.

Taxonomy and Ecology of Atrypella spp.
and the Atrypella Community

by

Roy Edward Smith

A THESIS

submitted to

Oregon State University

in partial fulfillment of

the requirements for the

degree of

Master of Science

June 1973

APPROVED:

Redacted for privacy

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Date thesis is presented December 13 1972

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ACKNOWLEDGEMENTS

I would like to thank the various people who have aided in this study. Sincere appreciation is extended to Drs. A. J. Boucot and J. G. Johnson of Oregon State University for their guidance, patience and careful editing of the manuscript. I would also like to thank Dr. E. J. Dasch of Oregon State University for his careful editing of the manuscript and helpful suggestions.

Special thanks are due Dr. J. William Kerr of the Geological Survey of Canada who allowed the writer time from normal duties to collect the thesis material. I would also like to thank Mr. D. W. Morrow of the University of Texas at Austin for his help in collecting the thesis material.

Sincere appreciation is extended to Mrs. Mary Fischer who did an excellent job of drafting the figures. Mr. Lee Kristjanson of Bradley Air Services is to be commended for his able assistance in piloting the Piper Super Cub aircraft. I would also like to acknowledge the help of fellow graduate student D. M. Rohr for his many helpful suggestions.

In conclusion I would like to thank Drs. R. Thorsteinson and W. W. Nassichuk of the Geological Survey of Canada without whose help and encouragement this project would not have been attempted.

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INTRODUCTION

HISTORY OF EXPLORATION

The first European visitors may have been the Norse Greenlanders. The presence of what are believed to be Eider Duck shelters found on St. Helena Island, situated off the east coast of Colin Archer Peninsula seem to confirm this. To the writer's knowledge, the only other occurrence of these structures is in Norway, but some may be present in Greenland.

The first reported voyage to the region was by William Baffin in 1616. During that year, he found and described Jones Sound and Lancaster Sound to the north and south of Devon Island, respectively.

During a voyage in 1818, Sir John Ross noted the Cunningham Mountains situated in southeast Devon Island. In 1819, Sir Edward Parry entered Lancaster Sound and travelled along the southern coast of Devon Island. After traversing the entire length of the island, he stopped at Beechey Island off the southwest coast of Devon. Beechey Island was the wintering site of the Franklin Expedition during 1845-1846. Members of the party may have made short journeys to Devon during the spring of 1846. In 1848, Sir John Ross, in the course of searching for Franklin's party investigated several inlets including Maxwell Bay on the south coast of Devon Island.

During succeeding years, more ships entered Lancaster Sound in search of Sir John Franklin. In 1850, ships under the command of William Penny focused the search on western Devon Island. In 1852 Sir Edward Belcher wintered in Northumberland Sound off the west coast of Grinnell Peninsula. For several decades after the opening of the fisheries, whalers visited Devon Island, but since they were not on an exploratory mission, details are lacking as to their extent.

Otto Sverdrup, sailing in the Fram in 1900 passed through Cardigan Strait and proceeded westwards along the north coast of Grinnell Peninsula. In 1902, a sledge party from the Fram travelled southward from Arthur Fiord to Beechey Island and then back again.

In 1924 a Royal Canadian Mounted Police post was established at Dundas Harbour, but was moved to Craig Harbour, on the south coast of Ellesmere Island in 1951.

Since 1945, Devon Island has been the site of several scientific investigations as well as R.C.M.P. patrols travelling between Ellesmere Island and Resolute on Cornwallis Island.

PREVIOUS WORK

Early geological observations on Devon Island were conducted during the search for Sir John Franklin, who had been missing since 1846. Notable recordings on the

geology of the area are those of Belcher, 1855. Several ships returned to England with maps, charts, and fossil collections. Salter (1852) interpreted some of the geology from the aforementioned data.

During 1903-1904, Per Scheii undertook geological investigations in northern Devon Island, the results of which were summarized by Olaf Holtedahl in 1917. Since that time, numerous scientific investigations have focused attention on Devon; two are especially worthy of note. In 1955, scientists attached to Geological Survey of Canada Operation Franklin investigated large tracts of the Arctic Archipelago, including selected portions of Devon Island. Preliminary maps were made and the stratigraphy and structure were described in some detail. During the summer months of 1971 and 1972, G.S.C. Operation Grinnell under the leadership of Dr. J. William Kerr concentrated on mapping portions of western Devon Island, including Grinnell Peninsula. Mr. D. W. Morrow of the University of Texas at Austin is currently working on the sedimentology of the Lower Paleozoic sequence of the area for his Ph.D. dissertation under the direction of Dr. R. L. Folk. In addition, several workers have described species of Atrypella from the Arctic regions of the world; this subject will be dealt with in a later chapter.

LOCATION AND ACCESSIBILITY

The material for the study was collected from the Douro Range of western Devon Island, District of Franklin, Northwest Territories, Canada. One section from the Douro Formation was measured at $76^{\circ} 22''$ N Latitude and $92^{\circ} 50''$ W Longitude. The second section was measured at $76^{\circ} 17''$ N Latitude and $92^{\circ} 40''$ W Longitude.

The Douro Range extends westwards from the west shores of Jones Sound and passes between Prince Alfred Bay and the southern reaches of Arthur Fiord. The thesis area is accessible only by aircraft. Visitation is limited to the summer months owing to the severity of the weather and perpetual darkness from November to April. A commercial airliner must be taken either from Calgary or Montreal to Resolute Bay on Cornwallis Island. A smaller plane is then used to travel to Devon Island. Upon reaching Devon, a helicopter or Piper Super Cub is necessary to reach the thesis area as larger aircraft are unable to find a suitable landing place.

GEOGRAPHY

Relief in the thesis area is controlled directly by the underlying rock type and structure. The lowest elevation of the area is approximately 500 feet and the highest is approximately 1200 feet. Therefore, the relief

is approximately 700 feet. All the streams and rivers are ice free only during the period June through mid-September and flow southwesterly into Prince Alfred Bay. The most obvious factor affecting the climate of the area is the high latitude of over 76°N . The sun never rises from early November to early February and never sets from the end of April to the middle of August.

There is no weather station on Devon Island. Data from the weather station at Resolute Bay on Cornwallis Island (Thorsteinsson, 1958) shows the average summer temperature (June to August) to be 38.6°F . and the average winter temperature (December to March) to be -25.5°F . These averages were computed from data obtained for the period 1947-1954. Conditions on Devon Island are probably similar. The average yearly precipitation is approximately five to six inches.

The summer months are generally warm enough to conduct field investigations without extreme discomfort. However, high winds, fog, and snow periodically cause cancellations of all operations. The writer has seen blizzards in early August last four to five days with winds of up to fifty miles per hour.

For the greater part of its extent, the thesis area is barren of vegetation. It is underlain primarily by carbonate rocks which do not seem to form suitable soils

for plant growth in this climate. Scattered about the area are a few specimens of Icelandic Poppy, saxifrage, mountain sorrel, and a species of willow grows along the ground surface. None of these reaches a height of greater than five inches. The high winds would snap the stalks of any plants that dared venture higher than a few inches.

Rock exposure is generally good on slopes and ridges, with the best exposures in the bottoms of creek valleys. The lack of vegetation contributes to the good exposures, but snow cover is at times a hindrance. Unseasonal storms may leave up to five inches of snow on the area and make geologic work practically impossible.

REGIONAL STRATIGRAPHY

The fossils collected for the study were from the upper Silurian Douro Formation. The formation ranges from post Monograptus leintwardinensis time to pre-Pridoli (R. Thorsteinsson, 1972, pers. comm.).

The dominant lithology of the Douro Formation is limestone and argillaceous limestone, light to medium dark grey with grey-green argillaceous seams. The lithology is generally thin to medium bedded and in places discontinuous to lumpy.

The basal contact of the Douro Formation is conformable with the underlying Grinnell Formation (D. W.

Morrow, 1972, pers. comm.) which is dominantly thin- to thick bedded limestone with some dolomite interbeds. The Douro Formation begins with the first predominantly brachiopod-bearing dark grey limestone bed containing grey-green argillaceous material. The Douro Formation is overlain with sharp yet conformable contact by the Devon Island Formation which consists of about 500 feet of graptolitic bearing greyish-black calcareous shales. The age of the formation is Late Silurian.

PURPOSE AND METHODS OF INVESTIGATION

The primary objection of the study was to investigate the possibility of zonation among the various species of Atrypella and to study the paleoecology of this genus. A further objective was to study the taxonomy and paleoecology of the other brachiopods present in the Atrypella Community.

I collected the material in late August of 1971 while a member of G.S.C. Operation Grinnell under the leadership of Dr. J. William Kerr. The samples were collected from two sections of the Douro Formation situated five miles apart (Fig. 2). Section one is seen on R.C.A.F. air photo number A167-162 with the base at -3.6X, +4.1Y and the top at -2.8X, +4.8Y. Section two is seen on R.C.A.F. air photo number A16747-163 with the base at 0.7X, -1.1Y and the top

at 0.2X. These coordinates utilize the grid system developed by Dr. D. K. Norris of the Geological Survey of Canada. The sections were measured and described with the aid of a Jacob's staff, Brunton compass (for dip only), dilute hydrochloric acid, and hand lens.

As the sections were measured, large oriented slabs were collected from the various fossiliferous horizons within the formation. In places where induration was poor, the rock was gathered in small pieces. Loose specimens (talus) and those contained in a poorly indurated matrix with a high percentage of argillaceous material were separated and labelled accordingly. The purposes of collecting large slabs were: 1, to determine through orientation studies the attitude of the fossils and any effects due to currents; 2, to distinguish between life and death assemblages; 3, to determine the paleoecology and relation to substrata of the various community members; 4, to ensure a fairly representative sample at a particular horizon. The latter has great value when dealing with relative percentages of the various taxa throughout a formation. Orientation studies were performed by measuring the orientation of the long axes of the fossils as well as the angle of plunge of the plane of commissure.

After orientation data were recorded, the blocks were disaggregated and broken into small pieces to ensure



FIGURE 1

Map of the Arctic Archipelago showing thesis area.

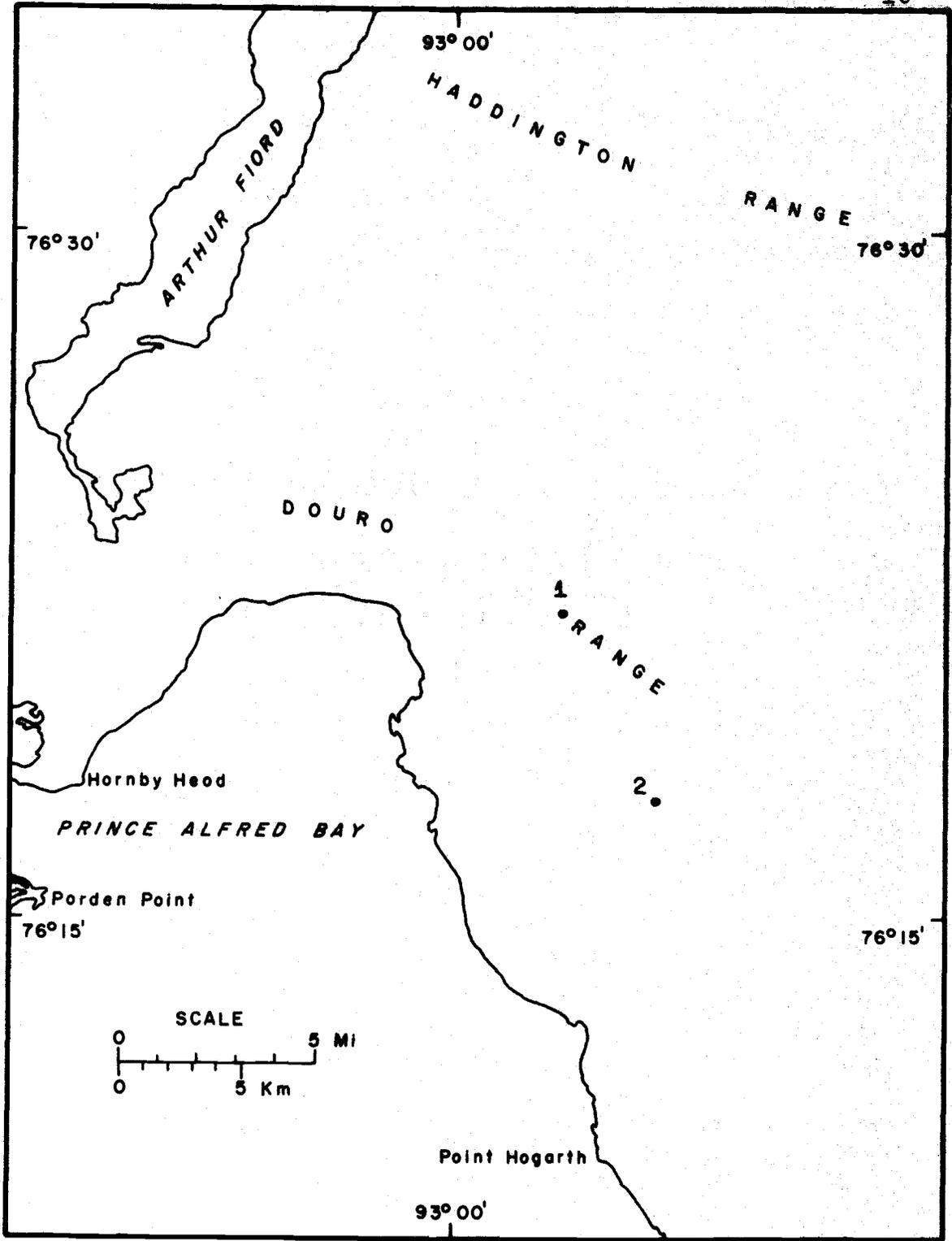


FIGURE 2
Map of thesis area showing section localities.

detection of all but the most minute specimens. Articulated as well as disarticulated specimens were retained and the remaining rock retained to be used for possible future microfossil studies. Inevitably, a certain number of specimens were destroyed during extraction, but the writer feels the number would not significantly alter relative percentages of the various taxa. For articulated specimens, loss would be, perhaps three percent. For disarticulated specimens, perhaps ten to fifteen percent.

Individual fossils were then examined using standard paleontological techniques. Some specimens were heated in a Bunsen burner flame and the calcined shell material slowly removed utilizing a bevel-edged needle. Acetate peels were made of serial sections of other specimens to determine their internal structure. Others were examined visually and measured with a pair of callipers.

In addition, thin sections of well indurated slabs were made for petrographic analysis. They were classified using Dunham's (1962) classification and an Energy Index (Plumley et al. 1962) was determined for each sample. Finally slabs cut perpendicularly to the bedding were utilized to help ascertain depositional environment.

PALEOECOLOGY

The amount of deviation of the long axis of the brachiopods from a common "north" was recorded and the resulting data plotted on a series of rose diagrams to see if there were any linear trends which would indicate current direction. It must be noted that the data were not plotted as a vector in that brachiopods of this type cannot be used in determining current direction as in sediments.

With brachiopods it can only be determined that the current flowed parallel to the long axes of the fossils.

Examination of the various rose diagrams (Appendix I), shows that the orientations are widely diverse and do not show any constancy from sample to sample. This precludes the possibility of a current which flowed in the same direction for any length of time and indicates that the currents were probably intermittent in nature.

The plunge was determined by measuring the angle between the bedding plane and a plane passing through the plane of the commissure of Atrypella. Plunges range from 0° to 90° . Some specimens plunged at 90° with the anterior end uppermost while others had the posterior end uppermost. There seems to be a correlation between relatively high plunge and a high percentage of articulated specimens. Conversely shallow plunge seems to correlate with a low percentage of articulated specimens. (Table 1).

The disarticulated samples were probably subjected to some sort of current action and it seems highly likely that the valves would settle to the bottom with the plane of commissure parallel to the sediment-water interface. Two samples, C11953b and C11956 (Table 1) are somewhat anomalous in that they exhibit a moderate plunge with a low percentage of articulated specimens. This may be a combination of current action and worm burrowing. Burrowing can shift sediment and in so doing cause some of the valves to be re-oriented.

LITHOLOGIC STUDIES

The brachiopods were encountered in two main lithologic types, arbitrarily designated types A and B. Type A is a medium to dark grey, thin to medium lumpy bedded poorly indurated limestone containing numerous grey-green argillaceous seams. The seams contain chlorite and illite (D. W. Morrow, 1972, pers. comm.).

Type B is a medium grey thin bedded, platy, dense, well indurated limestone with much less argillaceous material than type A. Type A generally contains a higher percentage of articulated brachiopods in the form of geopetals and fewer other taxa than type B. Some samples of both types contain very minor amounts of pyrite. Figures 3 and 4 show very fossiliferous slabs representing

Table 1. Atrypella orientation data from Section 1

<u>Sample</u>	<u>Number of Measurements</u>	<u>Ped. valve uppermost</u>	<u>Brach valve uppermost</u>	<u>Av. plunge</u>	<u>A/D</u>
C11951	32	12	14	23°	2.2
C11952b	22	11	7	33°	2.2
C11952c	31	15	11	17°	.25
C11953a	45	14	23	25°	8.0
C11953b	38	22	10	38°	.70
C11953c	36	19	15	17°	.16
C11954a	11	3	3	76°	4.5
C11954b	30	10	13	52°	4.0
C11955a	40	26	13	4°	0.1
C11956	34	16	12	2.7°	0.7

A refers to articulated specimens.

B refers to disarticulated specimens.

the two lithologic types.

Thin section analysis of the two types clearly shows type A to have been relatively undisturbed with articulated brachiopod shells, ostracodes, and lime mud as the main elements. Type B contains disarticulated and fragmentary brachiopod valves, ostracodes, high spired gastropods, rare crinoids, and echinoderm plates and spines, and elongate lime mud intraclasts. The differences in constituents, particularly the intraclasts, clearly demonstrate some form of current activity although it may not have been of a vigorous nature. The currents not only tore up pieces of semiconsolidated lime mud, but carried in elements from adjacent communities. (See Appendix 2 for more detail). Examination of the shell thickness and the dentition of Atrypella spp. leads the writer to believe that a very minor current would be of sufficient force to disarticulate the shells (See peels). In addition their somewhat biconvex shape would attribute to their being rolled around by a current. Therefore, the net distance the shells have travelled may be very short while total distance may be significantly greater. Figures 5 and 6 are photomicrographs which illustrate the composition and texture of types A and B lithology, respectively. The geopetal in Figure 5 is clearly visible and the contact between sparite and microspar rather well developed. The surrounding matrix

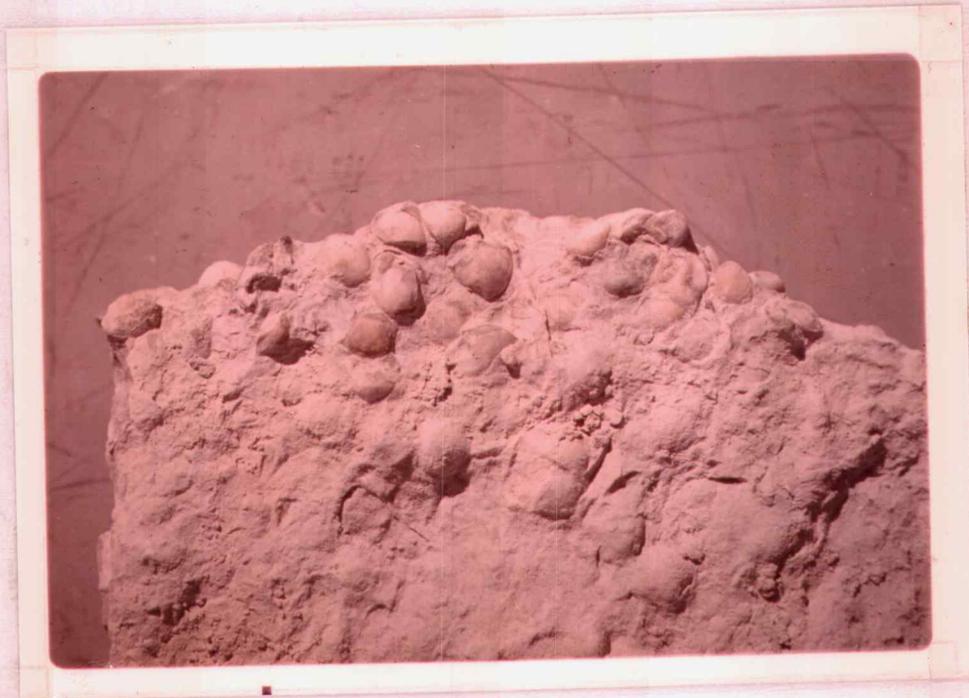


Figure 3. Type A lithology. G.S.C. Sample C11958.

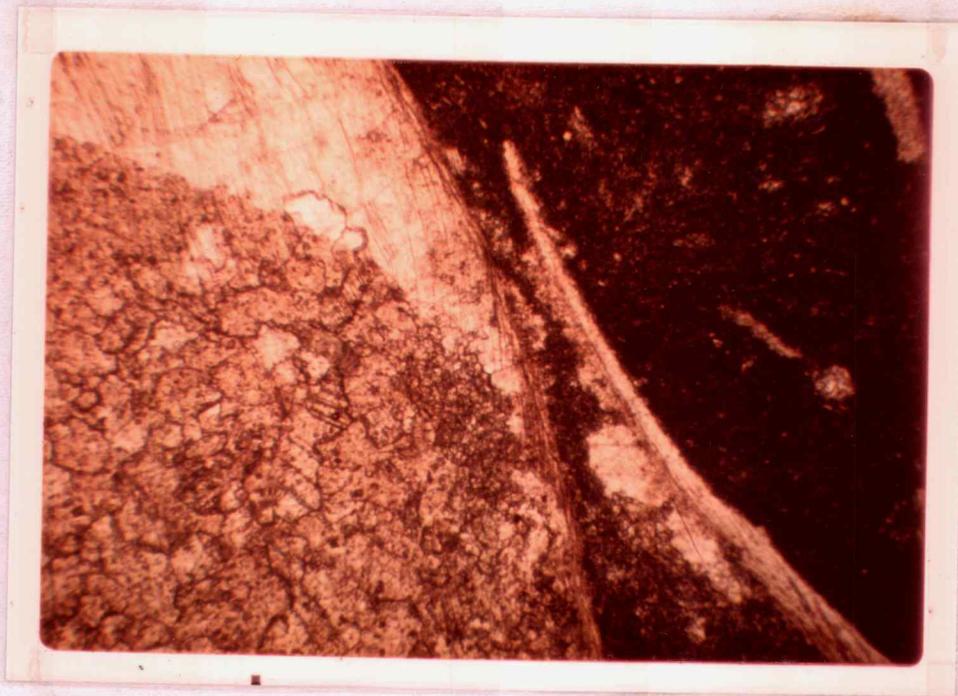


Figure 5. Photomicrograph of sample from G.S.C. Sample C11953. Field of view: two by three millimeters.



Figure 6. Photomicrograph of sample from G.S.C. Sample C11954. Field of view: 2 by 3 millimeters.

is micrite and contains very little fragmental material. In Figure 6, the texture and debris clearly differentiate it from Figure 5. Visible are fragments of a gastropod, trilobite, echinoderm spine and Brachiopods. In addition, there is an abundance of finely comminuted debris. Conspicuous by their absence are the thin argillaceous seams so well developed in Type A lithology.

Polished sections have less resolution than thin sections, but some can give a better overall picture of the depositional fabric. Figure 7 is a photograph of a slab from sample C11953a. Here, the geopetal fabric is extremely well developed. In some specimens the spiralia are easily seen. Nearly all the specimens of Atrypella are preserved as geopetals although there are a few disarticulated specimens. The matrix is approximately 90 percent lime mud, with few fragments of other organisms visible. Figure 8 is a photograph of a slab from sample C11953c, a Type B lithology. The differences between this slab and the preceding one are strikingly evident. Nearly all the valves are disarticulated. Elongate sedimentary intraclasts are evident in the lower one-third of the picture. Of particular interest is the erosional contact visible in the lower left portion of the picture. The base of the slab is essentially lime mud which is overlain by a layer of intraclasts and disarticulated brachiopod valves. The

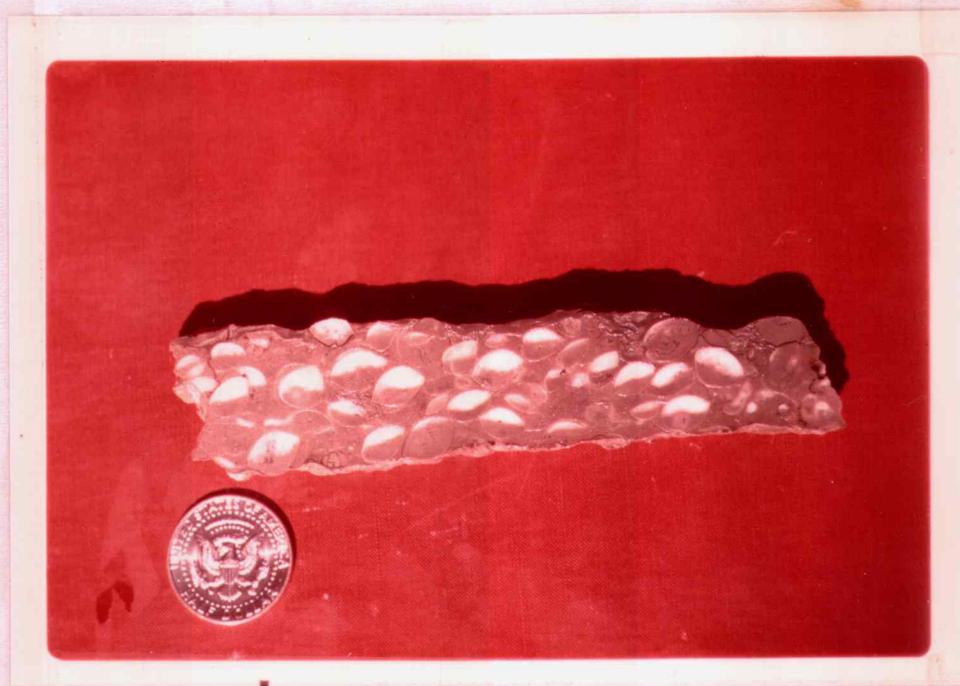


Figure 7. Slab from G.S.C. Sample C11953a
illustrating geopetal fabric.

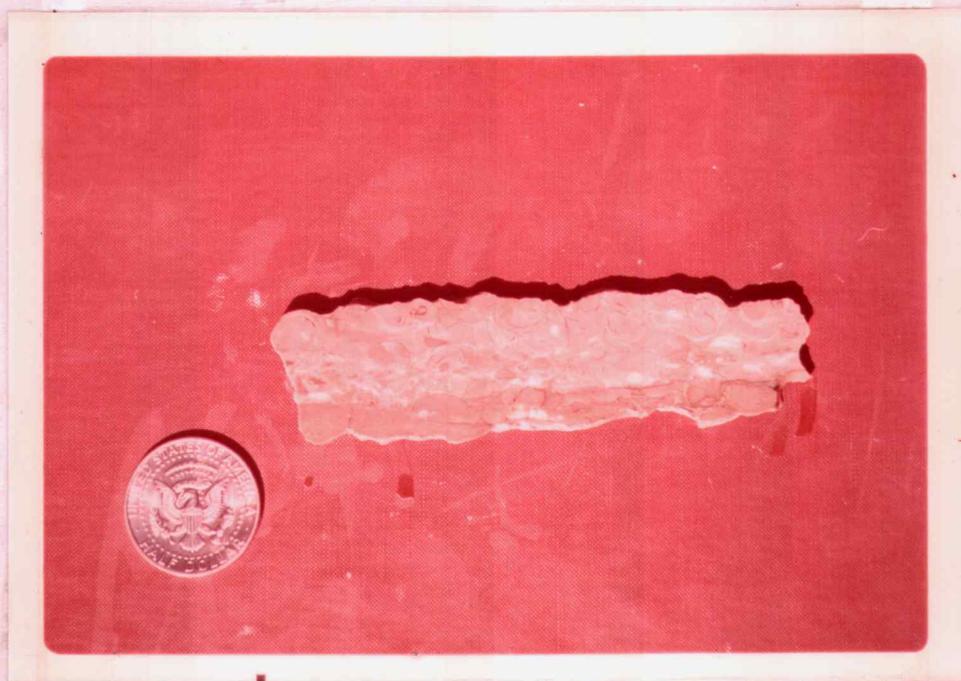


Figure 8. Slab from G.S.C. Sample C11953b
illustrating fabric.

contact between the two being somewhat undulatory. In the lower right area of the slab is a thin argillaceous seam which is truncated about midway in the slab. In the extreme lower right hand corner, the argillaceous seam appears to have been deflected downwards as a result of loading.

One of the most interesting features of the formation in outcrop is the bedding. It has been variously referred to as nodular, wavy, and lumpy. In effect, it is very undulatory and is best developed where there are numerous, grey-green argillaceous seams or partings. The writer favours the term lumpy because nodular refers to having the shape of, or being composed of, nodules. This may be misleading when applied to this lithology.

A recent explanation for this phenomenon is that it is produced by worm burrowing (John Wendte, pers. comm. 1972). The worms travelled slightly below the sediment-water interface, in a horizontal plane, ingesting the sediment and expelling fecal pellets composed of lime mud in their wake. The burrowing creates bands of more consolidated sediment. Succeeding sediment loads differentially on the areas between the burrows and produces a concave deflection in the bedding plane. The more argillaceous sediments were compacted to a greater degree than the lime mud of the burrows. Some burrows are visible on slabs cut perpendicular to bedding. This

proves that some burrowing which disrupted normal bedding planes took place. One might speculate that the worms would have concentrated in the more argillaceous layers as these may have contained a greater amount of nutrients.

LIFE AND DEATH ASSEMBLAGES

When one is engaged in a study of the paleoecology of a certain taxon or taxa, there arise several problems pertinent to arriving at meaningful conclusions.

The first problem is ascertaining whether the sample represents a life or death assemblage, because upon this depends any further deductions pertaining to life conditions of the organisms in question. Boucot (1953) has presented criteria for distinguishing between a life assemblage (undisturbed), and a current drifted assemblage. If we assume a high infant mortality rate among the organisms in question, the size/frequency curve will be rather strongly concave downward. However, this is assuming that no external forces alter the population structure before preservation. If sedimentation is rapid, the assemblage may be buried before external forces come into action. In addition, post-depositional solution may selectively remove the smaller forms owing to their higher surface/volume ratio. Human error may also produce a skewed size/frequency curve due to the difficulty of

detection and subsequent extraction of the very smallest forms from the matrix. A second important consideration is the ratio of articulated/disarticulated valves. Some brachiopods are fairly resistant to disarticulation. However, a close inspection of the shell form, thickness, and dentition should be made before any comments are made on the ease or difficulty of disarticulation of a particular taxon. A third consideration is the ratio of pedicle to brachial valves present. If a particular taxon is markedly dorsibiconvex, or vice versa, the two valves will become differentially current sorted.

In conclusion, three types of assemblages are possible. They are: 1. A life assemblage in which the shells are essentially unaltered and were buried in or very near life position, 2. A current-depleted assemblage in which the smaller, generally less biconvex, forms were removed by current action, leaving the remaining members in an unaltered state, and 3. A death assemblage, in which there are few small forms and a very low articulated/disarticulated ratio.

Sample C11952b is a good example of a life assemblage. The ratio of articulated/disarticulated specimens is 3.5 for Atrypella spp., 7.6 for Protathyris spp., 1.67 for Ferganella sp., and 0.06 for Howellella sp. The latter figure, far below the others, may indicate that the

Howellella shells were carried in from an adjacent community. Of a total of 1003 specimens counted, 73 percent are Atrypella spp., 18 percent are Protathyris spp., 1.6 percent are Howellella sp., 3 percent are Ferganella sp. Indeterminate strophomenids account for 4 percent and there is one specimen of each of the following: gastropod, coral, crinoid.

With regard to lithology, this sample falls into Type A as the matrix contains a high proportion of argillaceous material and is poorly indurated. Approximately 10 percent of all brachiopod specimens are not identifiable to the generic level. Notable here is the absence of ostracodes because they are moderately abundant in some samples.

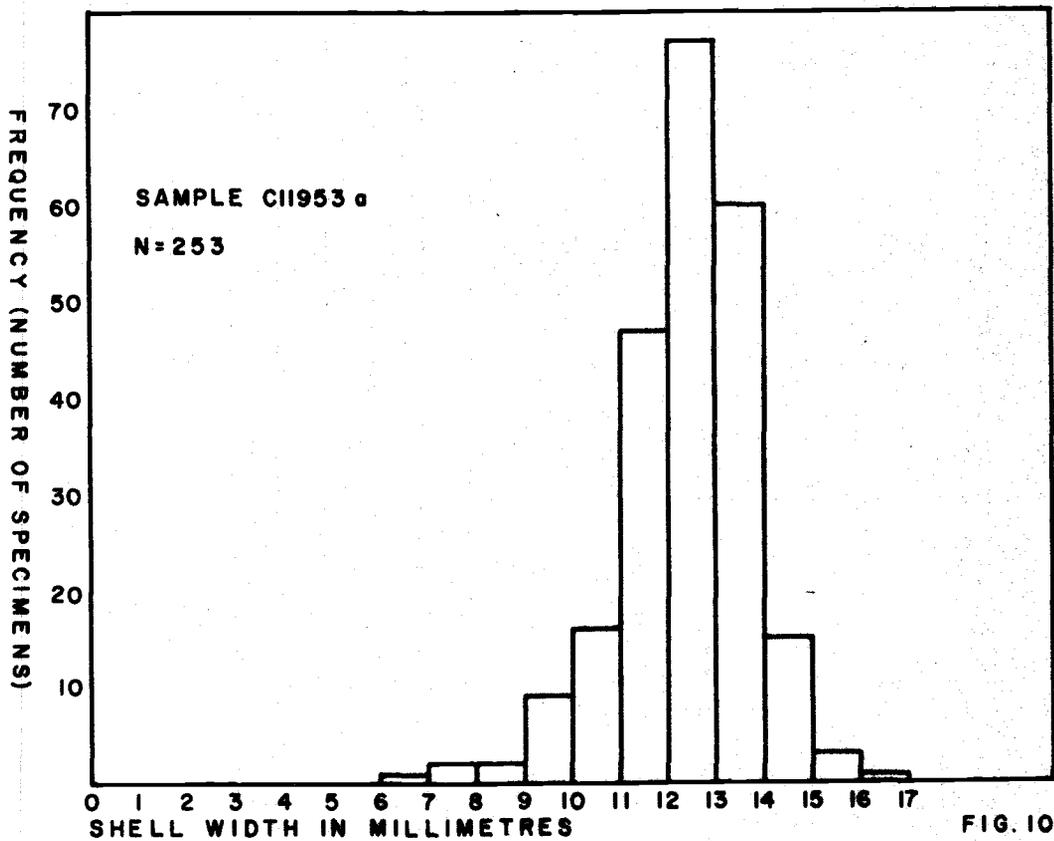
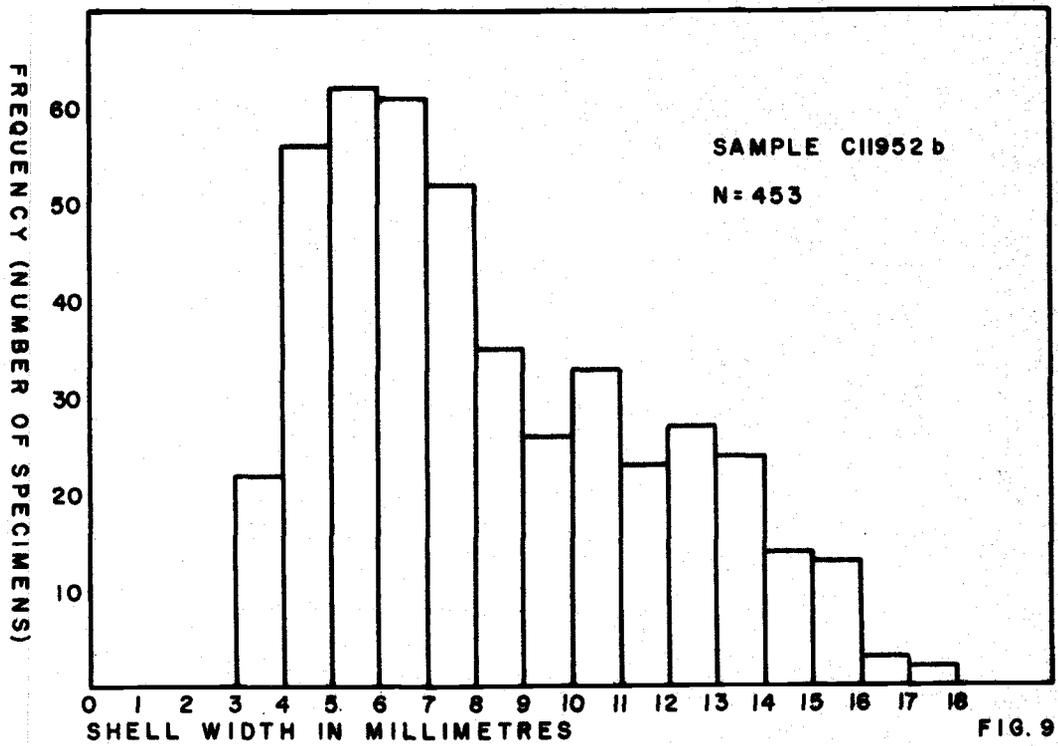
Figure 9 is a size/frequency diagram of Atrypella spp. from sample C11952b. The curve is very near to what one would expect for a normal life assemblage with a high infant mortality rate. The interval from 3 to 4 millimeters is anomalously low compared to the interval from 4 to 5 millimeters. This may be the result of either of several factors, and possibly a combination of them. The first being the difficulty in detecting and extracting specimens smaller than three millimeters in width. Predators and solution effects may have been responsible for their removal as well. Current effects cannot be

ruled out, but if present, currents would have been very low velocity. Minor decreases followed by increases may be due to the arbitrary intervals chosen. However, these fluctuations do not alter the overall shape of the curve to an appreciable degree.

Sample C11953a is an example of a current depleted assemblage as there is a definite lack of smaller forms. A low velocity current may have selectively removed them. The articulation/disarticulation ratios are: Atrypella spp., 12.1, Protathyris spp., 4.6, and Howellella sp. 0.1. As in the previous sample, the latter ratio is decidedly low as compared to the former two. This may indicate once again that Howellella sp. is not a normal constituent of the Atrypella Community. It is very likely a member of an adjacent community. Of 692 counted specimens, Atrypella sp. composed 87 percent, Protathyris sp. 7 percent, and Howellella sp. and ostracodes both 3 percent.

With regard to lithic type, the sample falls in type A, but contains less argillaceous material than the previous sample, but definitely more than a type B lithology.

Figure 10 is a size/frequency graph for sample C11953a. Upon examination of the graph it is apparent that the smaller forms are missing. The bulk of the specimens occur between the 11 and 14 millimeter range.



The smallest measured had a width of between 6 and 7 millimeters while the largest is between 16 and 17. Current action seems to be the most plausible mechanism for removal of the shells. However, it was not of sufficient force to cause widespread disarticulation among the other specimens. The hydrodynamic shape (weakly biconvex and sub-rectangular) of the immature forms probably contributed to their removal.

It is interesting to note the high density coupled with the low diversity of the two previously mentioned samples. Atrypella spp. and Protathyris spp. constitute the bulk of the faunal content of both of them. Corals, gastropods, and other organisms which are normally associated with brachiopods are very rare or absent in these samples.

Sample C11952c is an example of a typical death assemblage. The articulated/disarticulated ratios are as follows: Atrypella spp. 0.12, Protathyris spp. 0.35, Howellella sp. 0.03. Of 269 specimens counted Atrypella spp. composed 76 percent, Protathyris spp. 8 percent, Howellella sp. 11 percent, and high spired gastropods 5 percent. Other death assemblages contain minor amounts of indeterminate strophomenids, trilobites, and crinoids. This sample is a type B lithology in that it is hard, dense, and contains very little argillaceous material. An additional 58 specimens of brachiopods were too poorly preserved to be identified to generic level.

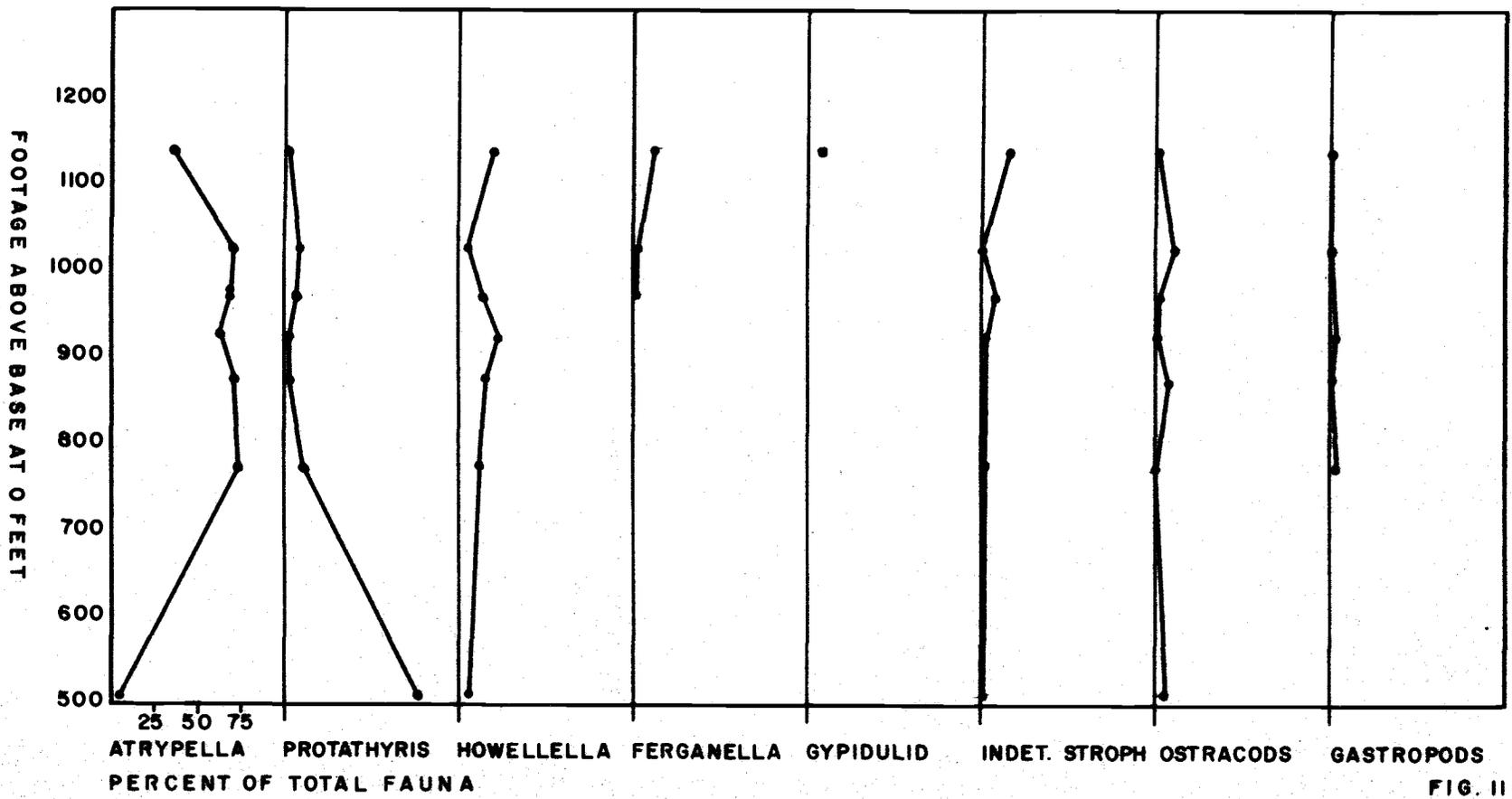


FIG. II

RELATIVE PERCENTAGES OF FAUNAL CONSTITUENTS

In order to examine the behavior of the Atrypella Community progressing up the section, total faunas were counted and percentages computed for the individual constituents. The resulting data from section 1 are represented in Figure 11. The most striking feature of the graph is the replacement of Protathyris spp. by Atrypella spp. as the dominant constituent. At a distance of 504 feet above the base of the section Protathyris spp. accounts for 76 percent of the total fauna and Atrypella spp. 6 percent. At a height of 774 feet above the base, Atrypella spp. accounts for 74 percent and Protathyris spp. 13 percent. From this point upwards Atrypella spp. are the most abundant brachiopods in the formation. Protathyris spp. are present but only in small numbers. Howellella sp. occurs in every sample examined and is a minor but noteworthy element. Ferganella sp. and Gypidula sp. are very rare and occur only near the top of the formation. Ostracodes are also a minor but persistent element. Indeterminate strophomenids are also rare as are gastropods which occur only in the upper two-thirds of the section.

At the top of the section there is a decrease of Atrypella spp., Protathyris spp. and ostracodes. This decrease is accompanied by a corresponding increase in Howellella sp., Ferganella sp., indeterminate strophomenids,

trilobites (See Appendix 2), and by the sole occurrence of Gypidula sp. This is interpreted as a shift from the low diversity quiet water Atrypella Community to a low diversity rougher water community. Howellella sp. and Ferganella sp. both possess relatively thick shells and dental plates and were probably able to withstand a greater degree of turbulence than was the thinner shelled Atrypella. This new assemblage may depict shallower water conditions than those experienced by the Atrypella Community.

The succeeding formations; Devon Island, Sutherland River, and Prince Alfred may be thought of as part of an offlap assemblage as there exists a disconformity between the Prince Alfred Formation (sandstone) and the overlying Blue Fiord Formation (limestone). Therefore, in a broad sense a gradual shallowing condition is suggested.

The prediction of shallower water conditions at the top of the formation is not consistent with a scheme proposed by Boucot (1972 unpublished manuscript). He places the Gypidula Community in a deeper zone than the Atrypella Community, in addition to designating it as a rough water community. A plausible explanation is that the boundaries between the two communities may not be as rigid as he believes and there may be some overlap between the two.

Similar data from section 2 are represented in Figure 12. As in section 1 control in the lower portion

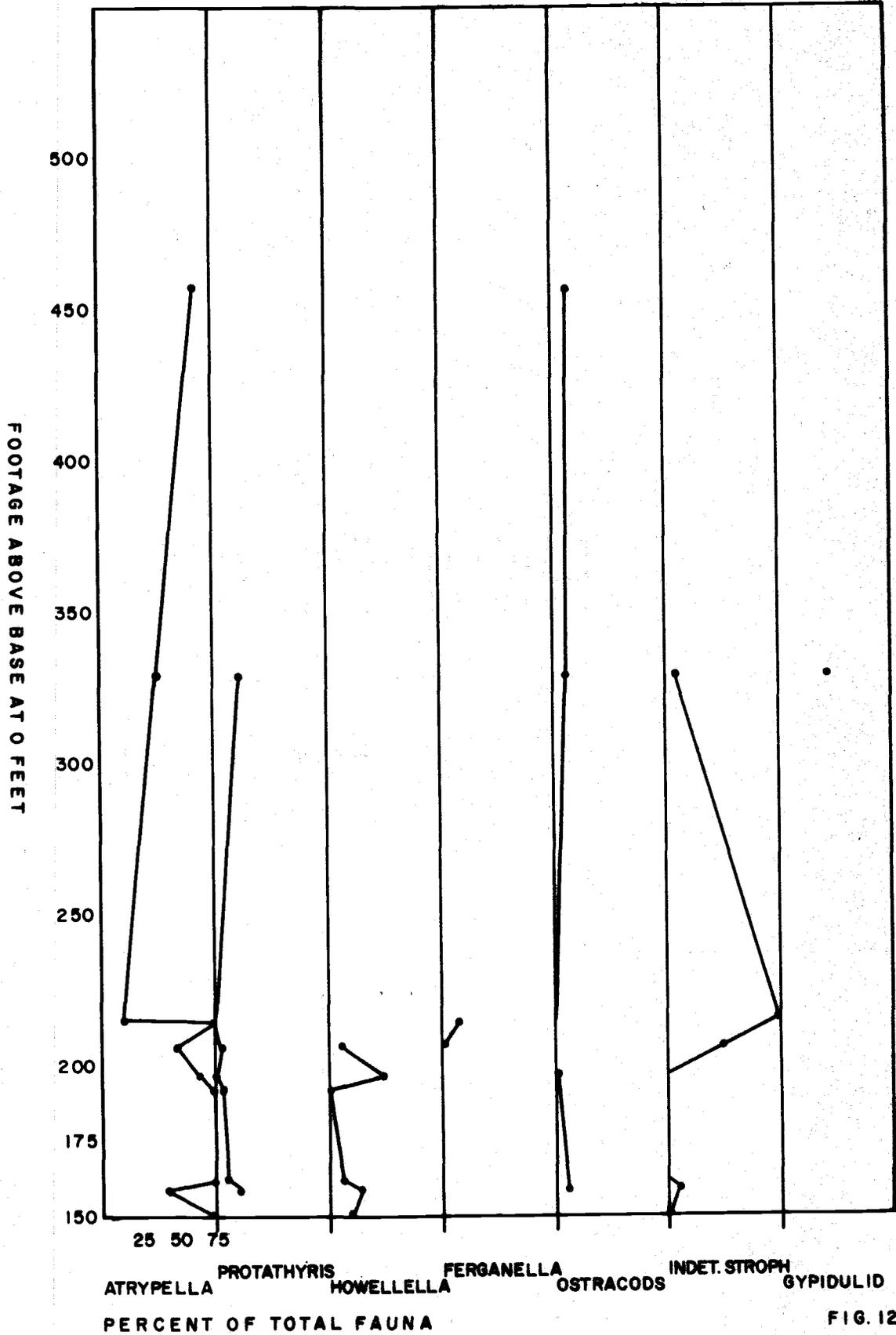


FIG. 12

of the section is very poor and sampling did not begin until a horizon 152 feet above the base. At this level, Atrypella spp. is the dominant member of the fauna and Protathyris is relegated to a subordinate position with regard to percent of total fauna. Howellella sp. and Ferganella sp. are restricted to the lower portion of the section. Ostracodes show a gradual increase from bottom to top, but the number of specimens per sample decreases upwards as well. Indeterminate strophomenids are quite rare, but at 216 feet above the base of the formation they constitute nearly 80 percent of the total fauna. This is accompanied by a corresponding decrease in Atrypella spp. to 15 percent. Gypidula sp. is present at only one level and accounts for 31 percent. Trilobites occur at the top of the formation and account for 11 percent of total fauna. However, there the total fauna is very low, 17 specimens, so the figure may be somewhat misleading. The two sections show some similarities with respect to faunal trends, but the differences are readily evident. Poor control in certain portions of the sections is undoubtedly responsible for some of these discrepancies.

Section one has a total thickness of 1179 feet while section two has 459 feet, slightly less than half of the former. In addition, section two contains a smaller total of specimens per sample than section one as well as more

pyrite. An average block is approximately eight to ten inches square and one to seven inches thick. The argillaceous matter from section two is of a darker color suggesting more carbonaceous matter. From these data it is concluded that section two represents a more euxinic basinward facies than section one.

RELATION OF ATRYPELLA SPP. TO THE SUBSTRATE

As previously mentioned, there is a direct correspondence between relatively high plunge and heavily argillaceous sediments. From burning and scraping specimens and studying valves in thin section it is evident that there is a posterior thickening of the shell material. This would tend to keep individuals' beaks downward. A slight displacement caused by a current would automatically be counteracted and the shell would return to its vertical or near vertical position. The smaller, immature specimens of Atrypella spp. are markedly less biconvex than their mature counterparts. There was sufficient room for a pedicle to have been present in the immature stages, which would have prevented their being wafted about by any current action. The mature, more convex specimens of Atrypella spp. possess such incurved beaks that there was no room for a pedicle to emerge between them. Therefore, as the specimens reached maturity, their size and weighted

umbonal regions replaced the pedicle as a means for stabilization. In conclusion, the data suggest that Atrypella spp. lived with beaks immersed in soft mud bottoms.

FOSSIL "NESTS"

The life assemblages that occur in the section were contained in heavily argillaceous sediments and occurred as clusters or "nests". Several explanations for this phenomenon have been discussed (Rudwick, 1970). One of them is the idea that the fossils were attached to a stone or similar object, presumably by their pedicles. The writer has seen no evidence for this. A second proposal is that the brachiopods were attached to some form of material, ascidians etc. that would not normally be preserved in the fossil record. The shells would fall to the bottom and be buried with no record of their attachment. This may have been the case for immature forms, but since mature forms seem to have possessed no pedicle, it is ruled out.

The writer believes that Atrypella lived in colonies in minor depressions in the sea floor. The immature forms may have attached themselves to the larger ones and thus escaped removal by current activity. An influx of sediment would fill the depression and bury the brachiopods in or near life position. The depth of overlying sediment would be sufficient enough that later, periodic currents

would not disrupt the shells.

COMMUNITY ECOLOGY

The Atrypella Community, characterized by low diversity and high density, flourished in a quiet, shallow water semi-restricted environment. It consists predominately of Atrypella spp. and Protathyris spp. and ostracodes. Howell-ella sp. is somewhat of an anomaly in that it usually occurs with a high degree of disarticulation. It may be a member of an adjacent community. The various faunal constituents were tolerant of some turbidity, but not excessive sedimentation. There seems to be no evidence that they had developed a snapping movement which would have kept them free of excessive argillaceous material. Therefore, excessive sediment would have been responsible for their death and later burial. The sediments were subjected to burrowing by soft bodied organisms, presumably worms, which probably fed on nutrients contained in the argillaceous sediments. Periodic currents of a minor nature disrupted the normal living conditions and resulted in minor erosional surfaces and a high degree of disarticulation. These currents may have been generated by storm waves. Since the two main components of the community are biconvex, they would have rolled around the sea floor under the influence of these currents. The currents were sporadic

and not always from the same direction, which would have resulted in a high degree of disarticulation without the fauna being removed too far from its original habitat. In effect, the total distance might be quite large, but net distance very low.

This type of fauna and lithology is known to occur over an area of at least 50,000 square miles in the Arctic Archipelago. According to Boucot (1970, p. 586)

"the presence of a very uniform carbonate stratigraphy over a large region, yielding almost homogeneous faunas from within each of the thin carbonate strata would suggest a region of negligible slope."

Therefore, it seems very likely that the shoreline during deposition of the Douro Formation was of a highly irregular nature. Quoting from the same page (Boucot, 1970),

"with very shallow slopes highly irregular shorelines develop and environmental and community boundaries would tend to occur, producing a complex mosaic vertically in the rock record."

Due to heavy snow cover, sampling was greatly hindered in certain parts of the sections measured, particularly the lower portions. Therefore Figures 11 and 12 are not truly representative of the various community relationships. A further detailed study encompassing numerous sections with better control could produce much valuable information

with regard to the various animal communities and their boundaries, both vertically and laterally in this formation.

SYSTEMATIC PALEONTOLOGY

Phylum Brachiopoda

Suborder Atrypoiodea

Superfamily Atrypacea Gill, 1871

Family Atrypidae Gill, 1871

Subfamily Septatrypinae Kozłowski, 1929

Genus Atrypella Kozłowski, 1929

Type species: Atrypa prunum Dalman, 1828, p. 133

Atrypella prunum (Dalman)

Pl. 1, Figs. 1-4, 5, 6, Figure 13.

Comparison: This species is the largest of all the Arctic forms examined. It is similar to A. carinata (Johnson and Reso, 1964, Pl. 20, Figs. 18-26) but is larger in all dimensions and more elongate and lenticular. In addition, A. prunum differs in the anterior commissure deflection which in some forms is developed into a tongue-like process. It is also similar to Atrypella gigas (Khodalevich, 1939, Pl. 21, Fig. 3), but gigas is larger and has a different deflection of the commissure. A specimen designated as Atrypella scheii Holtedahl, (Kirk and Amsden, 1952, Pl. 7, Figs. 12-22) is also similar, but their scheii is smaller and less lenticular than prunum.

Exterior: The shells are smooth, strongly dorsibiconvex, elongate, and commonly slightly transverse in outline. Brachial valve fold and pedicle valve sulcus are developed anteriorly. A deep and narrow deflection in the commissure of some specimens produces a tongue. The maximum width occurs at mid-length. The pedicle valve is slightly flattened anteriorly. The pedicle valve beak is strongly incurved over the brachial umbo. The ornamentation consists of very fine, concentric growth lines developed anteriorly of the umbos. Both umbos are convex, but the pedicle umbo more so than the brachial umbo as well as being more pointed. The hinge line is slightly curved and there is no interarea. The mature specimens attain a large size, one specimen measures 30.1 mm. in length, 25.2 mm. in width, and 23.3 mm. in thickness.

Interior of the pedicle valve: The hinge teeth are stout, elongate in cross section and set moderately close together. Dental lamellae are absent. When viewed in cross-section, the shell material thickens on the lateral margins. The pedicle valve umbonal cavity is set off by a well developed, slightly transverse platform. The delthyrium is low, broad, triangular, and does not appear to be closed by deltidial plates. Vascula media grooves project anteriorly from the umbo. The diductor tracks are divergent and lie on the lateral edges of a prominent trapezoidal platform.

Interior of the brachial valve: The sockets are deep and elongate. The hinge plates are discrete and diverge anteriorly. A myophragm is restricted to the umbonal region. The spiralia are dorso-medially directed and consist, in large specimens, of fourteen to fifteen whorls. The crural bases are connected to the socket ridges by a pair of outer hinge plates which are inclined in cross-section. Crural bases appear to be connected to the primary lamellae. The diductor site is non-striate.

Occurrence: Cape Philips Formation, Cape Philips, Cornwallis Island, N.W.T., U.S.N.M. loc. 12671. Collected by A. R. Ormiston, 1959.

Measurements:

Length	Width	Thickness
36.0	26.5	26.0
32.1	25.7	23.3
32.4	27.3	21.7
30.2	25.4	23.4
33.0	25.3	20.8

All measurements in millimeters.

Atrypella phoca (Salter, 1852)

Pl. 1, Figs. 7-12, Figure 14.

Comparison: This species is not as large as A. prunum, and is more pointed in the posterior portion and more globose. It resembles Atrypella vagranica (Khodalevich, 1939, Pl. 24, Fig. 1), but is more pointed and globose. Another similar form (ibid., Pl. 22, Figs. 1-4) Atrypella camelina is also less pointed and less biconvex than phoca.

A. carinata (Johnson and Reso, 1964, Pl. 20, Figs. 18-26) is larger and more lenticular as well as less globose than A. phoca.

Exterior: The shells are smooth, suboval in outline with a curved, very narrow hinge line. The specimens are markedly biconvex, in some specimens, globose. Both valves are U-shaped in cross-section with the brachial greater than the pedicle. The pedicle umbo is convex and sub-triangular in outline. The brachial valve umbo is also convex, but not as pronounced as the pedicle valve umbo. The pedicle valve beak is strongly incurved and the sulcus poorly developed in the anterior portion of the shell. The fold in the brachial valve is rarely developed, but is indicated by a sharp deflection upwards in the line of commissure. There is a median furrow present in both valves. There is no interarea. The ornament consists of fine, concentric

growth lines developed anterior to the umbos. Maximum width occurs slightly anterior to the midpoint of the shell. A mature specimen measures 22.5 mm. in length, 18.6 mm. in width, and 20.1 mm. in thickness.

Interior of the pedicle valve: The teeth are stout, elongate in cross-section and set moderately wide apart. The umbonal cavity is set off by a slightly raised platform. Vascula media grooves extend from the umbo anteriorly. Dental lamellae are absent. The delthyrium is low, broad, triangular and does not appear to be covered by deltidial plates. The diductor tracks are faintly impressed and are divergent.

Interior of the brachial valve: The hinge plates are discrete and diverge anteriorly. The sockets are very broad and shallow. A myophragm is present. The crural bases are connected to the socket ridges by outer hinge plates which are sub-horizontal in cross-section. Flabellate abductor scars are slightly impressed. The spiralia are dorso-medially directed and consist, in large specimens, of eight to nine whorls. The diductor site is nonstriate.

Occurrence: This species does not occur in the Douro Formation, but is known to occur in Member C of the Read Bay Formation on Cornwallis Island (Thorsteinsson, 1958). It also occurs in the Read Bay Formation of Prince of

Wales Island.

Measurements:

Length	Width	Thickness
22.5 mm	18.6 mm	20.1 mm
20.1	18.6	17.3
19.1	16.8	15.3
21.7	21.2	17.0
21.3	19.7	18.2

Atrypella scheii (Holtedah, 1914) Form A

Pl. 1, Figs. 13-18, Figure 15.

Comparison: This form is much less convex and more triangular in outline than A. scheii Form B or Form C. It is similar to A. scheii (Holtedah, Kirk and Amsden, 1952, Pl. 7, Figs. 12-22) but is more triangular in outline and has a broader hinge line as well as being less convex. It is similar to a specimen of Atrypella kuschvensis (Khodalevich, 1939, Pl. 23, Fig. 3a). It resembles Atrypella uralica (ibid., Pl. 21, Fig. 7) but does not possess as well developed a fold and sulcus.

Exterior: The shell is smooth and sub-triangular in outline, having a width usually greater than the length. It has no interarea, but possesses a wide, straight hinge line. The pedicle beak is small, pointed, and incurved

over the brachial umbo. The shells are slightly dorsi-biconvex. Brachial valve fold and pedicle valve sulcus are almost nonexistent. The only evidence of these features in some specimens is a slight deflection in the line of commissure. The hinge line is broad and slightly curved. The maximum width occurs slightly of midlength. The shell ornament is limited to faint, fine, concentric growth lines anterior to the umbos. Immature to mature specimens retain a similar outline as they are usually wider than longer and only moderately biconvex. A mature specimen measures 16.3 mm. in length, 16.8 mm. in width and 8.6 mm. in thickness.

Interior of the pedicle valve: The teeth are moderately stout, elongate in cross-section, and set moderately close together. The umbonal cavity is set off by a slightly raised platform. The diductor tracks were not impressed. The delthyrium is low, broad, triangular and does not appear to be covered by deltidial plates. Vascula media grooves extend anteriorly from the umbo.

Interior of the brachial valve: The sockets are moderately deep and broad. A myophragm is present in the umbonal region. The hinge plates are discrete and diverge anteriorly. The crural bases are connected to the socket ridges by outer hinge plates which are sub-horizontal in cross-section. Vascula media grooves are present. The

primary lamellae are connected to the crural bases. The spiralia are dorso-medially directed and consist of eight whorls in mature specimens. The diductor site is non-striate.

Remarks: At times, it is difficult to separate immature specimens of Form A from Form C as they are similar in shape.

Measurements:

Length	Width	Thickness
10.8	13.1	5.0
14.8	16.0	8.7
15.7	15.4	9.2
16.3	16.8	8.6
8.2	9.3	4.0

All measurements in millimeters.

Occurrence: Douro Formation Section 1 (Fig. 2), Samples C119554, C11955, Section 2, C11960, C11961, C11962.

Atrypella scheii (Holtedah1, 1914) Form B

Pl. 1, Figs. 19, 20, 22-24, Figure 16.

Comparison: This form differs from Forms A and C by its more elongate, sub-rectangular outline. It is similar to A. tenuis (Kirk and Amsden, 1952, Pl. 7, Fig. 1). It resembles Atrypella linguata (Nikiforova, 1937, Pl. 9,

Fig. 1), but is more elongate and has a broader hinge line. It also resembles A. scheii forma typica (Nikiforova, 1970, Pl. 4, Fig. 7), but A. scheii forma typica is much more convex and has a different deflection in the commissure.

Exterior: The shells are smooth, dorsibiconvex, and sub-rectangular in outline. The pedicle valve beak is small, pointed, and slightly incurved. The pedicle valve umbo is more convex than the brachial. A poorly developed, shallow pedicle valve sulcus is present in the anterior portion. A brachial valve fold is not well developed, but indicated by a deflection in the line of commissure. The greatest width occurs at a point just anterior of the hinge line. The hinge line is medium in length, curved, and there is no interarea present. The shell surface exhibits very faint, concentric growth lines which are developed anterior to outline and are always longer than wide. In cross-section, the pedicle valve has the shape of a broad "V" and the brachial valve somewhat U-shaped. A mature specimen measures 20.4 mm. in length, 17.3 mm. in width, and 12.5 mm. in thickness.

Interior of the pedicle valve: The hinge teeth are stout, elongate in cross-section and set moderately close together. The umbonal cavity is set off by a poorly developed platform. Vascula media grooves extend anteriorly from the umbos.

The diductor tracks are divergent and lie on a very low trapezoidal platform. The delthyrium is low, broad, triangular, and does not appear to be covered by deltidial plates.

Interior of brachial valve: The hinge plates are discrete and diverge anteriorly. A myophragm is present in the umbonal region. The crural bases are connected to the socket ridges by outer hinge plates which are sub-horizontal to oblique in cross-section. The crural bases are connected to the primary lamellae. The spiralia are dorso-medially directed. The adductor muscle scars are flabellate and faintly impressed. The adductor site is non-striate.

Measurements:

Length	Width	Thickness
20.4 mm.	17.3 mm.	12.5 mm.
19.4	16.4	10.8
18.1	15.0	9.6
11.5	10.1	5.9
7.8	7.2	3.6

Occurrence: Douro Fm. Fig. 2, Section 1, Samples: C11951, C11952, C11953, C11954, C11955, C11956, C11957. Section 2, Samples: C11958, C11959, C11960, C11962.

Atrypella scheii (Holtedah1, 1914) Form C

Pl. 2, Figs. 2-8, Figure 17.

Comparison: This form is more nearly square in outline and much more dorsi-biconvex than either Form A or B. It is similar to A. scheii forma typica (Nikiforova, 1970, Pl. 4, Figs. 3-7), but it possesses a less convex pedicle valve. It is very similar to A. scheii forma gibbera (ibid., Pl. 4, Fig. 12). It resembles Atrypella camelina (Khodalevich, 1939, Pl. 22, Figs. 1-5), but the latter possesses a more inflated pedicle valve. It is more convex and more nearly square in outline than A. scheii (Kirk and Amsden, 1952, Pl. 7, Figs. 12-22, non Holtedah1).

Exterior: The shells are very nearly equal in length and width and are strongly dorsi-biconvex. The pedicle valve beak is small, pointed, and strongly incurved. The pedicle valve umbo is less convex than the brachial umbo. A weakly developed sulcus is present on the anterior portion of the pedicle valve. The brachial valve fold is usually represented by an upwards deflection in the line of commissure. The specimens exhibit a curved, broad, hinge line and no interarea. Maximum width occurs at midpoint of the shell. Immature to mature stages retain a somewhat similar outline, but mature forms are more convex. The shell surface exhibits faint, concentric growth lines

anterior to the umbos. A mature specimen measures 17.9 mm. in length, 17.3 mm. in width, and 14.0 mm. in thickness. In cross-section, the ventral valve is an obtuse "V" shape and the brachial a "U" shape.

Interior of the pedicle valve: The hinge teeth are stout, elongate in cross-section and set moderately close together. The umbonal cavity is set off by a moderately transverse platform. The vascula media grooves extend anteriorly from the umbo. The diductor tracks are broadly divergent and lie on a slightly raised platform. The delthyrium is low, broad, triangular, and does not seem to be covered by deltidial plates.

Interior of the brachial valve: The sockets are moderately deep and elongate. A myophragm is present in the umbonal region. The hinge plates are discrete and diverge anteriorly. The crural bases are connected to the socket ridges by outer hinge plates which are sub-horizontal in cross-section. The spiralia are dorso-medially directed and consist of twelve whorls in large specimens. The slightly impressed adductor scars are flabellate. The diductor site is non-striate.

Measurements:

Length	Width	Thickness
17.9 mm.	17.3 mm.	14.0 mm.
18.7	18.3	16.7
21.2	19.2	17.0
19.1	17.5	16.4
16.6	16.1	15.7

Occurrence: Douro Fm. (Fig. 2), Section 1, Samples C11952, C11953; Section 2, Samples C11958, C11959, C11960, C11961, C11962, C11963, C11964.

Atrypella sp.

Pl. 1, Fig. 21, Figure 18.

Pl. 2, Figs. 9-12.

Comparison: This species is intermediate in form between A. phoca and A. scheii. It does not attain the size of convexity of the former nor the broader hinge line of the latter. It is similar to A. phoca forma media (Nikiforova, 1970, Pl. 3, Figs. 4-8), but is more convex. It is more pointed and convex than A. tenuis (Kirk and Amsden, 1952, Pl. 17, Figs. 1-11).

Exterior: The shell is smooth and suboval in outline. It is slightly dorsi-biconvex and in cross-section exhibits a broad "V" shaped pedicle valve and a "U" shaped brachial

valve. The pedicle valve beak is small, pointed and incurved over the umbo. The pedicle valve sulcus is poorly developed in the anterior portion of the shell. The brachial valve fold is slightly developed, but in some specimens it is indicated by a sharp high deflection in the line of commissure. The ornament is limited to faint, concentric growth lines developed anterior to the umbos. Maximum width occurs at mid-length. The hinge line is short, curved and there is no interarea. A mature specimen measures 19.3 mm. in length, 17.3 mm. in width, and 13.7 mm. in thickness.

Interior of pedicle valve: The teeth are moderately stout, elongate in cross-section and set moderately far apart. The umbonal cavity is set off by a slightly raised platform. Vascula media grooves extend anteriorly from the umbo. The diductor tracks are divergent and lie on a slightly raised trapezoidal platform. The delthyrium is low, broad, triangular and does not appear to be covered by deltidial plates.

Interior of brachial valve: The hinge plates are discrete and diverge anteriorly. The sockets are shallow and broad. A myophragm is restricted to the umbo. The crural bases are connected to the socket ridges by a pair of outer hinge plates, which are subhorizontal in cross-section. The crural bases are connected to the primary lamellae. The

spiralia are directed dorso-medially. Adductor scars are slightly impressed and flabellate.

Measurements:

Length	Width	Thickness
19.3	17.3	13.7
18.1	16.6	13.2
15.8	15.5	11.8
16.0	13.7	11.7
15.2	13.2	11.8

All measurements in millimeters.

Occurrence: Douro Fm. (Fig. 2) Section 1, Sample C11952.

Genus Cryptatrypa Siehl, 1962

Type species: Terebratula philomela Barrande, 1847, p. 387.

Cryptatrypa? sp.

Exterior: The shell is smooth, subequally biconvex and elongate to lenticular in outline. The pedicle sulcus is weakly developed in the anterior portion of the shell. The brachial fold is not well developed, but is represented by a deflection in the line of commissure. The pedicle beak is pointed and slightly incurved. The hinge line is short, curved, and there is no interarea. Maximum width occurs at the midpoint of the shell.

Interior of the pedicle valve: Two very thin dental lamellae are present which are confined to the umbo.

Remarks: Very few specimens were encountered and none were serial sectioned to examine the internal structure.

Occurrence: Douro Fm. (Fig. 2) Section 1, Sample C11951.

Suborder Athyridoidea

Superfamily Athyridacea M'Coy, 1844

Family Athyrididae M'Coy, 1844

Subfamily Protathyridinae Boucot, Johnson, and Staton, 1964

Genus Protathyris Kozlowski, 1929

Type species: Protathyris infantile Kozlowski, 1929, Pl. 11, Figs. 47, 47a-47d.

Protathyris aff. infantile Kozlowski, 1929, Pl. 2, Figs. 13-17, Figure 19.

Comparison: This species differs from P. "didyma" Kozlowski, 1929 non Dalman in that it is less convex, smaller, and broader. It lacks the concentric growth lines present on P. Praecursor.

Exterior: The shells are smooth, biconvex, and subcircular to suboval in outline. Mature specimens possess a shallow pedicle valve sulcus in the anterior portion. The brachial valve is nearly circular in outline. The brachial valve

fold is indicated by an upwards deflection in the line of commissure. The pedicle valve umbo is more convex than the brachial valve umbo. The pedicle valve beak is slightly incurved. The hinge line is short, curved and there is a small interarea. Maximum width occurs at mid length.

Both immature and mature forms retain a similar outline and are usually wider than long. A mature specimen measures 16.0 mm. in length, 15.0 mm. in width, and 9.8 mm. in thickness.

Interior of the pedicle valve: The hinge teeth are thin, pointed, elongate in cross-section, and widely set apart. They are supported by a pair of dental lamellae which are confined to the umbo. Muscle scars are not impressed. The spiralia are directed laterally. The delthyrium is moderately high, wide, and triangular in outline. It is partially covered by two deltidial plates which are interrupted by a subtriangular open delthyrium.

Interior of brachial valve: The sockets are moderately deep and broad. The hinge plates are divided apically by a small fissure. Anteriorly they unite, forming a cardinal plate that is convex dorsally. A myophragm is present in the umbonal region. The muscle scars are not impressed.

Measurements:

Length	Width	Thickness
16.0	15.0	9.8
11.4	11.2	6.5
8.8	9.1	5.5
8.3	8.6	4.8
9.7	9.4	5.9

All measurements in millimeters.

Occurrence: Douro Fm. (Fig. 2) Section 1. Samples: C11951, C11952, C11953, C11955, C11956, C11957. Section 2, Samples: C11959, C11960, C11962.

Protathyris didyma Kozlowski, 1929, non Dalman
1828, Pl. 6, Fig. 7

Pl. 2, Figs. 18-21, Figure 20.

Comparison: This species differs from P. praecursor in that it is larger, more convex and more pointed. It is not similar to Didymothyris didyma (Dalman) (Rubel and Modzalevskaya, II, 1967, Pl. 1, Figs. 1-13) as it lacks a pedicle support. It lacks the concentric growth lines present on P. "didyma" Kozlowski, non Dalman.

Exterior: The shells are smooth, and lenticular to subtriangular in outline. They are moderately ventri-biconvex in lateral profile. All forms exhibit a shallow

pedicle sulcus in the anterior portion of the shell. A brachial valve fold is not well developed, but is indicated by a deflection in the line of commissure. The pedicle valve umbo is convex and sharply pointed. The pedicle valve beak is slightly incurved. The hinge line is short, curved, and there is a small interarea. Maximum width occurs at a point slightly anterior to midlength. Both immature and mature specimens are longer than wide, with rare exceptions being slightly wider than long. Both umbos are convex. In mature forms, a pedicle median furrow is developed and merges with the sulcus. Some specimens attain a moderate size as one specimen measures 17.6 mm. in length, 15.0 mm. in width, and 13.2 mm. in thickness.

Interior of pedicle valve: The hinge teeth are stout, sub-ellipsoidal in cross-section and widely set apart. They are supported by a pair of well developed dental lamellae which are restricted to the umbo. The muscle scars were not impressed. The spiralia are directed laterally. The delthyrium is fairly high, moderately broad and triangular in outline. It is partially covered by two deltidial plates which are interrupted by a subtriangular open delthyrium.

Interior of the brachial valve: The sockets are moderately deep and broad. The hinge plates are divided apically by a small fissure, then unite to form a cardinal plate which is

convex dorsally throughout its entirety. A low myophragm is present and restricted to the umbo.

Measurements:

Length	Width	Thickness
14.1	12.1	10.7
15.6	13.1	11.2
15.5	12.8	11.7
17.6	15.0	13.2
16.1	14.6	12.0

Occurrence: Douro Fm. Fig. 2. Section 1, Samples C11951, C11952, C11953, C11956. Section 2, Samples C11959, C11960, C11961, C11962, C11966.

Order Rhynchonellida

Superfamily Rhynchonellacea Gray, 1848

Family Rhynchotrematidae Schuchert, 1913

Subfamily Rhynchotrematinae Schuchert, 1913

Genus Ferganella Nikiforova, 1937

Type species Ferganella turkestanica Nikiforova, 1937, p.39.

Ferganella cf. turkestanica

Pl. 2, Figs. 22-26, Figure 21.

Exterior: The shells are medium sized and subtriangular to subpentagonal in outline. In lateral profile, they are slightly dorsibiconvex. The pedicle valve sulcus is well

developed in the anterior portion of the shell and contains four or five costae. The brachial valve fold is moderately developed in the anterior portion of the brachial valve. The umbonal regions bear faint costae and the remainder of the shell is covered with well developed costae. The commissure exhibits a zigzag pattern due to the costae. The pedicle valve beak is slightly raised and not incurved. The specimens are usually wider than long, but some specimens possess nearly equal lengths and widths. The hinge line is narrow, curved, and there is no interarea. Maximum width occurs at a point slightly anterior of midlength. Thicknesses are usually greater than half the widths.

Interior of the pedicle valve: The hinge teeth are stout and set moderately far apart. They are supported by a pair of well developed dental lamellae which are restricted to the umbo. The adductor scars are paired, elongate and subelliptical in outline. They are confined to the sulcus. They are bounded by a pair of anteriorly divergent diductor tracks which are also confined to the sulcus. A pedicle callist is present.

Interior of the brachial valve: The sockets are moderately deep and broad. The notothyrial cavity is relatively large and oval in cross-section. The septalium is supported by a low myophragm.

Measurements:

Length	Width	Thickness
9.7 mm.	12.8 mm.	7.0 mm.
9.6	11.5	5.5
11.3	12.6	7.4
10.0	11.5	6.2
8.8	8.8	6.6

Occurrence: Douro Fm. (Fig. 2) Section 1, Samples: C11952, C11955, C11956, C11957; Section 2, C11963, C11964.

Suborder Spiriferidina

Superfamily Reticulariacea Waagen, 1883

Family Reticulariidae Waagen, 1883

Genus Spirinella Johnston, 1941

Type species: Spirinella caesistriata Johnston, 1941, p. 161.

Spirinella sp.

Pl. 2, Figs. 32-35.

Exterior: The shell is small, subequally biconvex, transverse, and suboval in outline. It is ventri-biconvex, but not markedly so. The shell is commonly wider than long and the thickness is approximately three quarters of the width. The pedicle valve beak is raised and slightly incurved. The brachial valve beak is much less convex than the pedicle. The hinge line is straight and approximately nine-tenths of

the width of the shell. Maximum width occurs slightly anterior of the shoulders. The pedicle sulcus and brachial fold are poorly developed in the anterior portion of the shell. The anterior commissure is sulcate, but only slightly deflected by the sulcus of the pedicle valve. The cardinal margins are submegathyrid. The surface of the shell is covered by fine, radiating striae. They are superposed on fine, concentric growth lines producing a reticulate pattern on the shell surface.

Interior of the pedicle valve: A pair of thin, lenticular dental lamellae are confined to the umbo.

Remarks: A limited number of specimens were encountered and none was serial sectioned.

Measurements:

Length	Width	Thickness
6.1	6.7	4.5

Occurrence: Douro Fm. (Fig. 2) Section 1, Sample C11951.

Superfamily Delthyridacea Phillips, 1841

Family Delthyrididae Phillips, 1841

Subfamily Delthyridinae Phillips, 1841.

Genus Howellella Kozlowski, 1946

Type species: Terebratula crispus Hisinger, 1826, Pl. 7,

Fig. 4.

Howellella sp.

Pl. 2, Figs. 27-31

Exterior: The shell is strongly biconvex, transverse, and exhibits a distinct pedicle valve sulcus and corresponding brachial valve fold. Lateral plications are few and decrease in height away from the sulcus. The pedicle beak is pointed, and larger than the brachial beak. A well developed high, triangular open delthyrium is present. Maximum width occurs slightly posterior of midlength. The hinge line is transverse and approximately two-thirds of the width of the specimens.

Interior of the pedicle valve: A pair of well developed dental lamellae are present and confined to the umbo. A median septum is not present.

Remarks: No specimen of Howellella sp. was serial sectioned, but numerous ones were prepared as internal molds.

Measurements:

Length	Width	Thickness
5.1	6.3	3.7
5.8	7.1	4.7
5.6	6.2	4.4
6.1	7.2	4.6
7.5	8.2	5.2

All measurements in millimeters.

Occurrence: Douro Fm. (Fig. 2) Section 1, Samples: C11951, C11952, C11953, C11954, C11955, C11956, C11957; Section 2, Samples: C11958, C11959, C11960, C11961, C11962, C11963.

Suborder Strophomenoidea

Superfamily Davidsoniacea

Family Chilidiopsidae Boucot, 1959

Genus Iridistrophia Havlivek, 1965

Type species: Orthis umbella Barrande, 1848

Iridistrophia sp.

Exterior: The shell is suboval in outline with a broad hinge line. The brachial valve is convex and the pedicle valve slightly concave. The delthyrium is covered by a triangular, convex pseudodeltidium. The brachial interarea does not seem to be present; nor does the chilidium. The shell is covered with costellae which radiate from the umbos.

Interior of the pedicle valve: The teeth are supported by a pair of long, divergent dental lamellae. The muscle fields are not impressed. Maximum width occurs slightly posterior of midlength.

Remarks: Only one articulated specimen was found; therefore serial sectioning was not undertaken.

Occurrence: Douro Fm. (Fig. 2) Section 1, Sample C11952.

ZONATION OF ATRYPELLA

North America:

Age Range: In previous publications (Williams, A., ed., 1965), the age range for North American Atrypella was reported as Late Silurian to Early Devonian. The oldest occurrence of Atrypella, designated Late Wenlock, was reported by Boucot (in Berry and Boucot, 1970, p. 126) to be from the east side of Black Island, Newfoundland. Subsequent examination by the writer has revealed that the specimens are not Atrypella, but a new genus of smooth, possibly related atrypacean. Nowhere in North America is Atrypella reported as occurring in the Lower Devonian. Therefore, it seems probable that North American species of Atrypella are confined to the Ludlow and Pridoli stages of the Silurian System.

Zonation: Most recorded occurrences of this genus in North America are not from measured sections, and therefore, are of little use in establishing any sort of zonation within the genus itself. However, some collections that contain abundant Atrypella from Arctic Canada are from measured sections (Thorsteinsson, 1958; this paper). In the present work on the Douro Formation of Devon Island, a crude zonation exists within the forms A, B, and C of Atrypella scheii (Holtedah1). Form A has a limited range within the sections while forms B and C have longer ranges.

The possibility of using form A for zonal purposes is hindered due to the difficulty in distinguishing between immature specimens of forms A and C. Therefore, they cannot be used with any certainty. These three forms are known to occur from post-Monograptus leintwardinensis time to pre-Pridoli (R. Thorsteinsson, 1972, pers. comm.). However, these forms may be present in the Read Bay Formation which ranges into the Pridoli. Specimens of Atrypella phoca have been reported from Member C of the Read Bay Formation of Cornwallis Island (Thorsteinsson, 1958). The age of this species is latest Ludlow or early Pridoli. To the writer's knowledge, Atrypella phoca does not occur below this horizon. Atrypella scheii Kirk and Amsden non Hortedahl, reported from locality 2689 (Kirk and Amsden, 1952, p. 53) appears to be a younger form than A. phoca. Originally reported as Upper Silurian in age, the fauna from locality 2689 is now known to be of Pridolian age based on the presence of Schizophoria (J. G. Johnson, 1972, pers. comm.). This Alaskan form is different than any forms of A. scheii encountered in the Douro Formation. In addition, specimens collected from Prince of Wales Island, N.W.T. by R. Thorsteinsson in 1972 (G.S.C. Number C8245) bear a remarkable resemblance to the Alaskan form of A. scheii. The age of the Arctic fauna is definitely post-Ludlow and probably Pridoli as indicated by the presence of Icriodus sp. (R.

Thorsteinsson, 1972, pers. comm.). However, the zone of I. woschmidti is Early Gedinne, so at present a more precise age assignment for the fauna from Prince of Wales Island is not possible. Specimens of Atrypella prunum (Dalman) collected from the Cape Phillips Formation of Cornwallis Island are of no zonal use at the present because the writer is unaware at which level or graptolite horizon within the formation the specimens were collected. Kozłowski (1929, p. 176) in describing the form from Polish Podolia states "A. prunum est tout-a-fait rare en Podolie polonaise se presentant seulement a la base des calcaires de Skala."

Therefore, an age assignment as young as Pridoli seems possible. However, A. prunum (Dalman) is also found in the Hemse Group of Gotland which is Ludlow in age. It seems probable that this species is latest Ludlow to earliest Pridoli in age, but its relationship stratigraphically to A. phoca and A. scheii Kirk and Amsden is at present unknown.

In conclusion, zonation of North American Atrypella is somewhat sketchy at the present time. More data from measured sections, coupled with precise age dates utilizing conodonts or graptolites, is needed.

Problems: When attempting to establish any zonation within the Atrypella species found in these regions, there are several problems which are not too easily solved. Some of the publications are undoubtedly out of date

(Khodalevich, 1939) as newer stratigraphical studies have assigned different ages to certain strata. Secondly, the quality of some of the photographs makes comparison of some of the forms difficult and at times nearly impossible. Thirdly, some publications do not include pictures of the internal structures of the various species. In addition, some of the earlier publications (Khodalevich, 1939, Nikiforova, 1954) incorrectly use Lissatrypa synonymously with Atrypella. Therefore, any designation of Atrypella specimens presumably incorrectly identified as Lissatrypa is from visual observations and wherever comparisons of the internal structures.

Age Range: Khodalevich (1939) figured several forms of "Lissatrypa" which he said occur in the Wenlock of the eastern slope of the Urals. "L. turjensis is Atrypella looking, but possesses a fold which is more pronounced than it is on most species of Atrypella. However, it does not show any inner hinge plates characteristic of Lissatrypa. "Lissatrypa" camelina (Buch) is also similar in external and internal characteristics to Atrypella and probably is Atrypella. Nikiforova and Obut (1965) assigned strata containing A. camelina to the Lower Ludlow. Perhaps the beds containing "L." turjensis may be of the same age. Nikiforova (1970) cites A. cf. kuschvensis as occurring in the Vaigatch Horizon which is Lower Devonian. However,

beds below the horizon of A. cf. kuschvensis have not been proven to be of Early Devonian age. Therefore the age range for this genus is probably Ludlow to Pridoli.

Zonation: The Lower Ludlow is characterized by Atrypella camelina (Buch), but this form ranges to the Pridoli. (Nikiforova and Obut, 1965). Atrypella linguata (Buch) is also found in the Ludlow (Nikiforova, 1937). Atrypella phoca occurs in the Upper Ludlow of Vaigatch in the Grebensk Horizon (Nikiforova, 1970). In the Pridoli of Vaigatch Nikiforova (1970) reports Atrypella cf. kuschvensis. Khodalevich, 1939 reports Atrypella vagranica from the Marginalis Beds of the eastern slope of the Urals. These beds are known to range into the Lower Devonian, but the writer is unaware of what horizon within the Marginalis Beds the aforementioned specimens were collected. Atrypella prunum (Dalman) occurs in the Hemse Group of Gotland, but its stratigraphical relationships with the other forms of Atrypella in these regions is not known. Atrypella gigas may be a geographic variation of A. prunum (Dalman), but where it occurs within the Marginalis Beds is not known to the writer. In addition, A. linguata (Buch) may be similar to A. scheii form B (this paper). With reference to the foregoing similarities, lack of knowledge of internal structures hinders positive correlation. Examination of type material from both areas with regard to external as

well as internal features would eliminate any problems of correlation. Once again, data from measured sections as well as age dates utilizing graptolites and conodonts would help clear up the uncertainties within the zonation of Atrypella.

In conclusion, there are some similarities as well as some differences between zonations of North American and Russian Atrypella. If the aforementioned suggestions are followed, workers will have a more clear understanding of the various forms of Atrypella and the problems involved within its zonation.

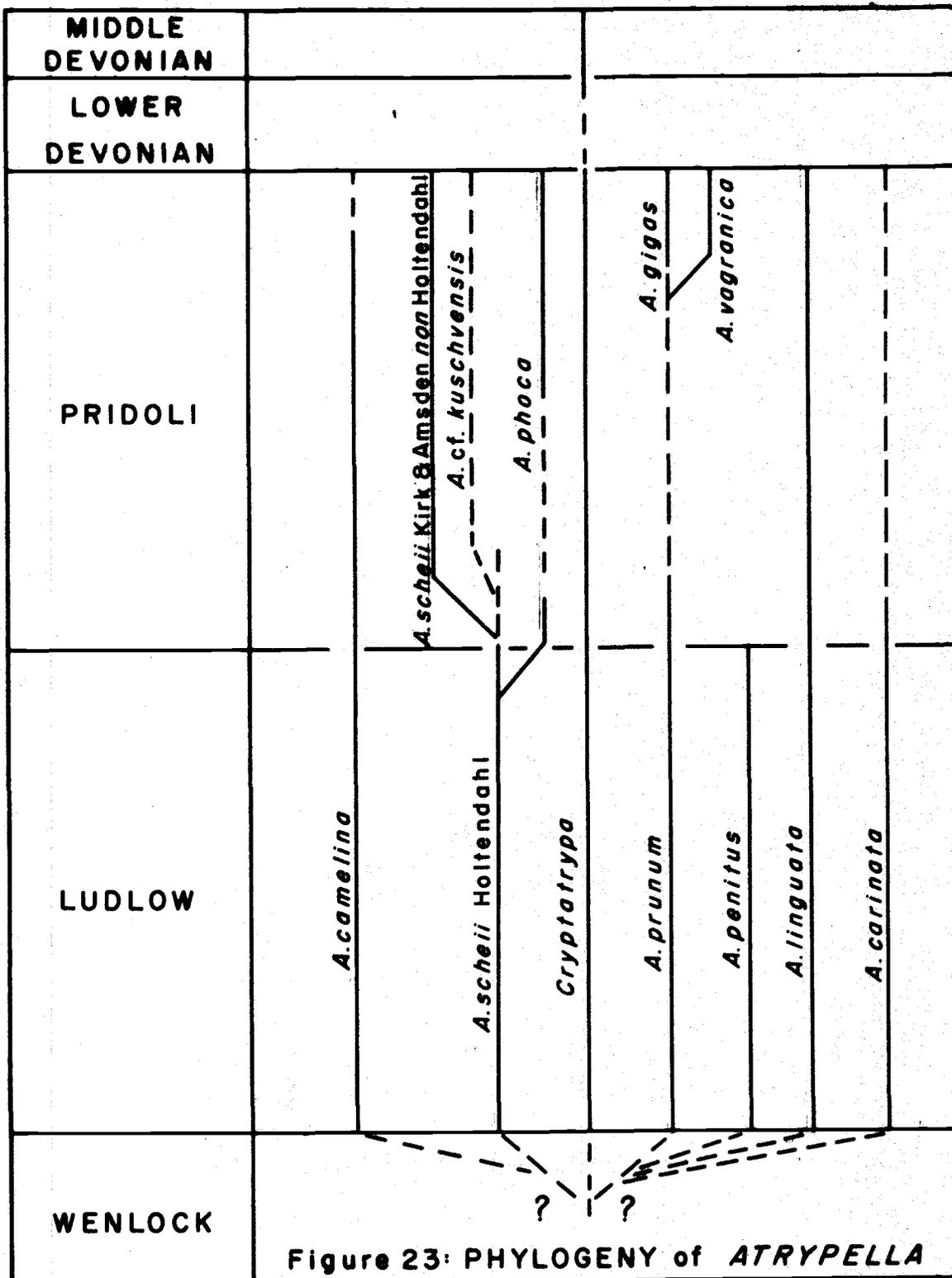
Questionable: The following forms described by Khodalevich, 1939, do not appear to be true Atrypella in the North American sense: "Lissatrypa" turjensis Khodalevich, 1939, Pl. 19, Figs. 5, 6. The fold and sulcus appear to be too well developed for Atrypella. No pictures of internal structures were illustrated. "Lissatrypa" latisinuata Khodalevich, 1939, Pl. 21, Figs. 1, 2. The sulcus seems too pronounced and the shape is somewhat different from Atrypella. No pictures of internal structures were illustrated. "Lissatrypa" Kuschvensis Khodalevich, 1939, Pl. 23, Figs. 1-7. The nature of the fold and sulcus are different from Atrypella.

PHYLOGENY OF ATRYPELLA

In considering an ancestral stock for Atrypella spp., several genera exhibit some affinities. Atrypopsis (Poulsen, 1943) is somewhat similar, but has dental lamellae and a hinge plate divided apically by a small fissure. These features may have been eliminated to evolve into the earliest forms of Atrypella. Cryptatrypa (Siehl, 1962) has short or obsolescent dental plates which are present or lacking, and discrete hinge plates as well as a smooth exterior. Loss of the dental plates would not have been too large an evolutionary step to be accomplished and, coupled with slight changes in form, could have resulted in Atrypella. Therefore, in considering the aforementioned ancestral possibilities for Atrypella, Cryptatrypa seems the most likely.

In latest Wenlock or early Ludlow times, two lineages of Atrypella seem to have emerged (Fig. 23). One lineage was characterized by forms having a wide hinge with width and length being nearly equal. The other lineage is characterized by more elongate and lenticular forms. Convexities vary within both lineages but all forms are biconvex and usually dorsi-biconvex.

The earliest representatives of the broad-hinged forms may be A. scheii (Holtedahl) and A. camelina. However, A. camelina (Buch) has some affinities with



with A. prunum (Dalman). A. phoca may have evolved from A. scheii (Holtehdahl) in latest Ludlow or early Pridoli times. The former has some affinities with the more globose forms of the latter. In Pridoli time, scheii Kirk and Amsden non Holtehdahl probably evolved from A. scheii (Holtehdahl). A. cf. kuschvensis has affinities with A. scheii (Holtehdahl) and may have arisen from it in the upper Pridoli.

In accordance with the available stratigraphic data, A. prunum and A. linguata seem to be the earliest of the lenticular forms. A. carinata and A. penitus may be slightly later forms, but no precise dating is available to confirm this. In the Late Pridoli, A. gigas may have evolved from A. prunum, or it may be a synonym of it. A. vagranica, present in the Upper Pridoli, seems to be related to A. prunum and may have evolved from it.

In conclusion, the aforementioned ideas are undoubtedly subject to errors. However, more precise age ranges of the various species are necessary before the errors can be eliminated. These ranges may help to give a clearer understanding of the phylogeny of Atrypella.

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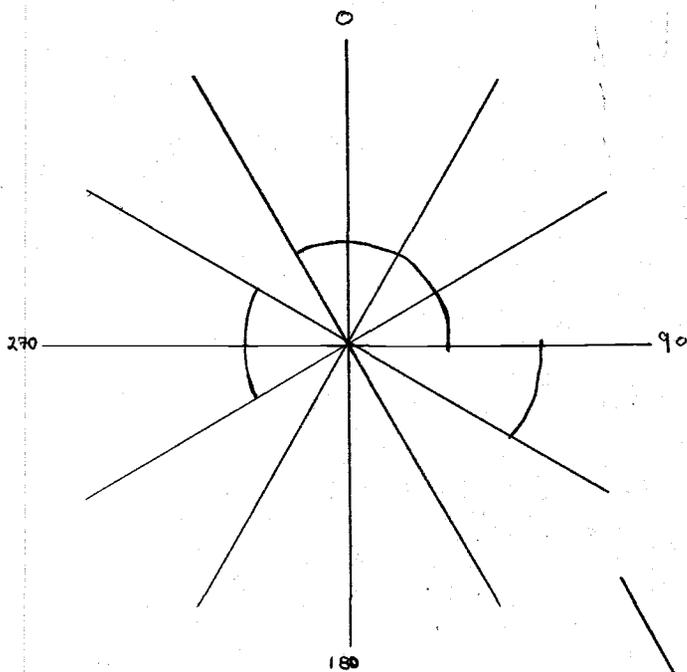
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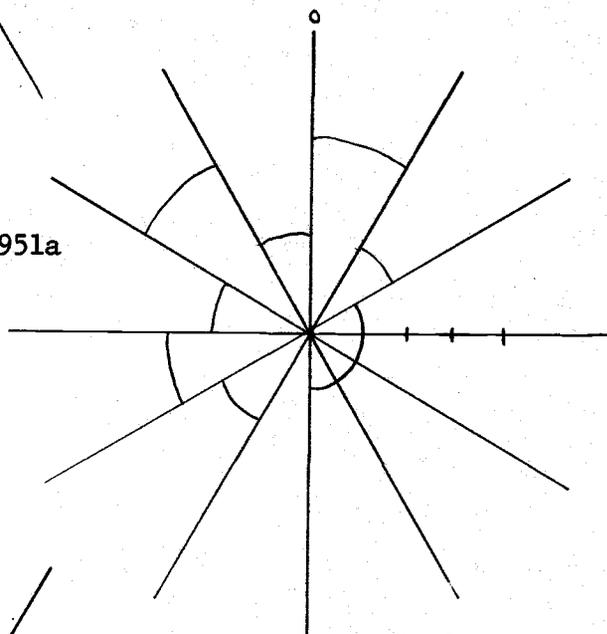
A P P E N D I C E S

APPENDIX I

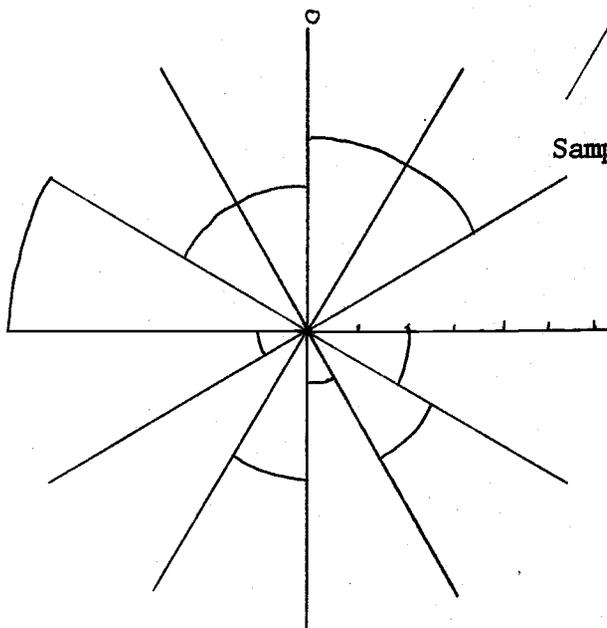
Rose diagrams showing Atrypella valve orientations.



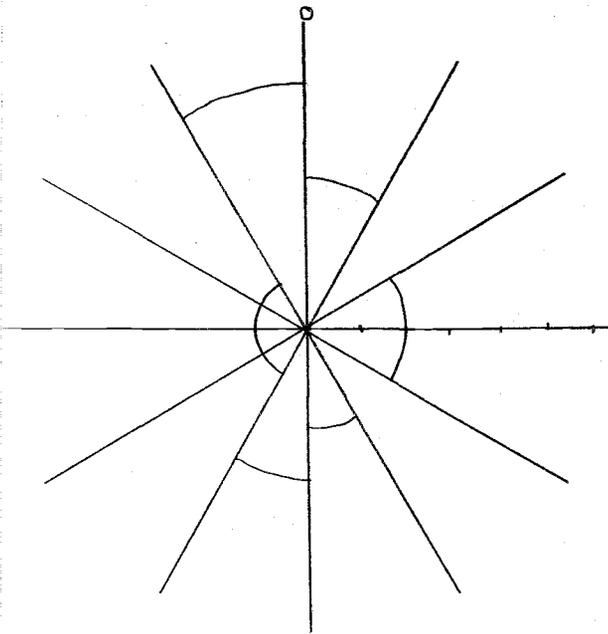
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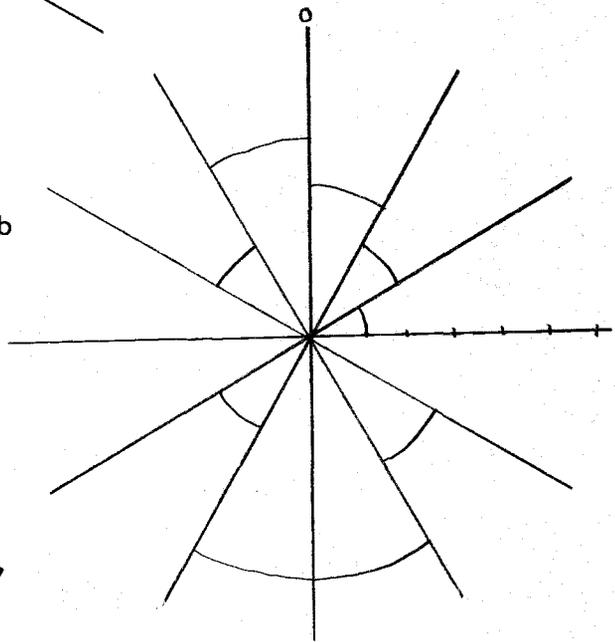
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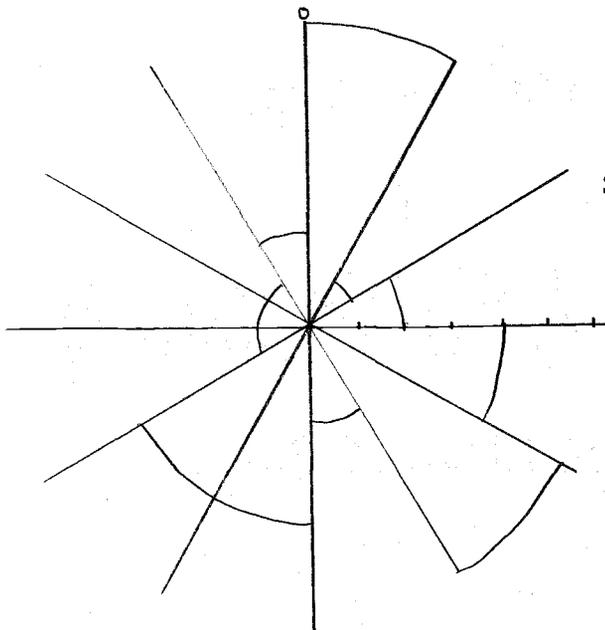
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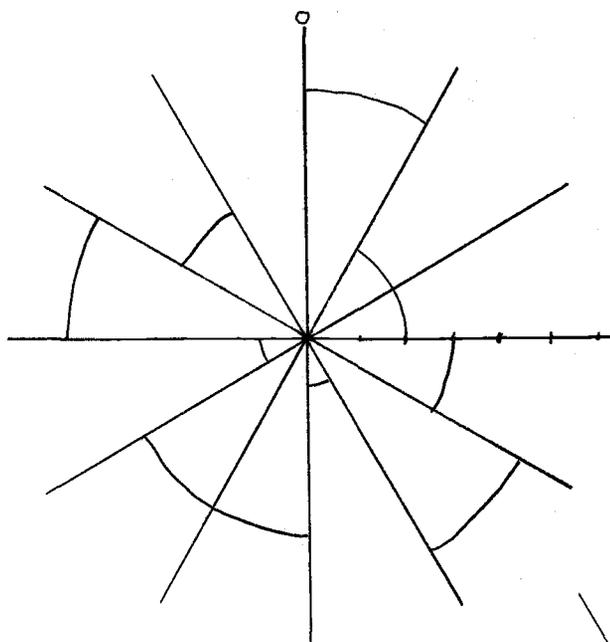
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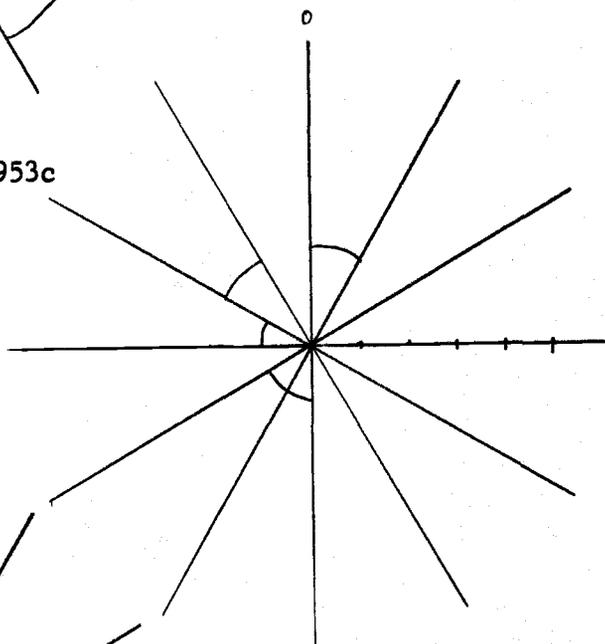
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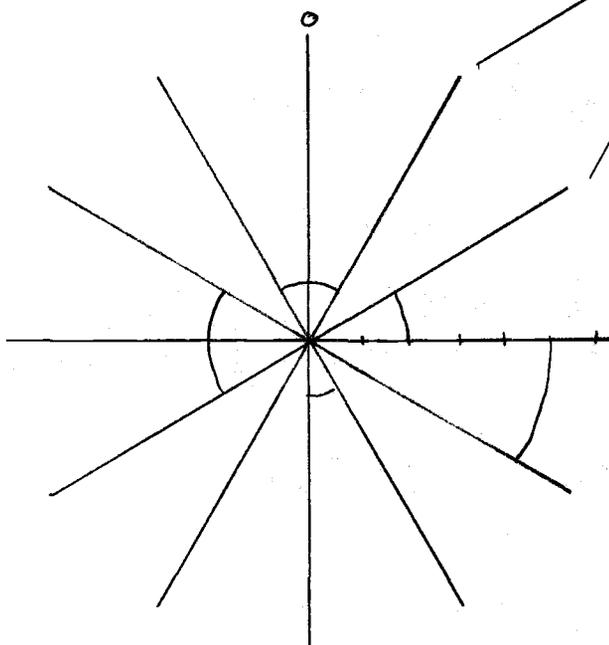
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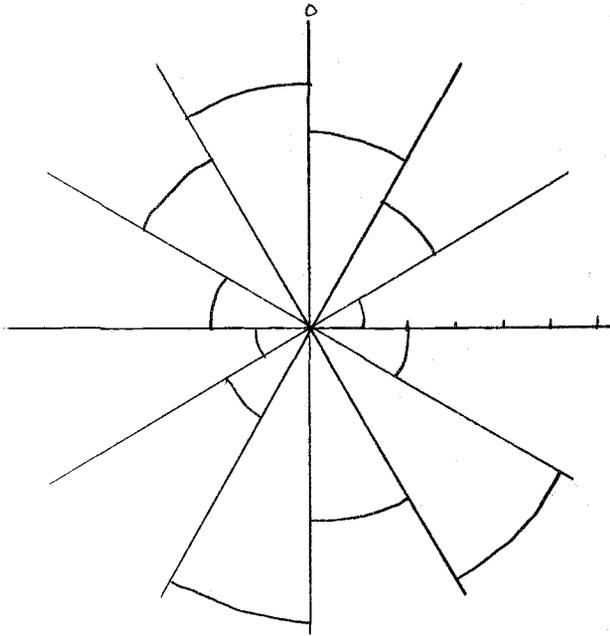
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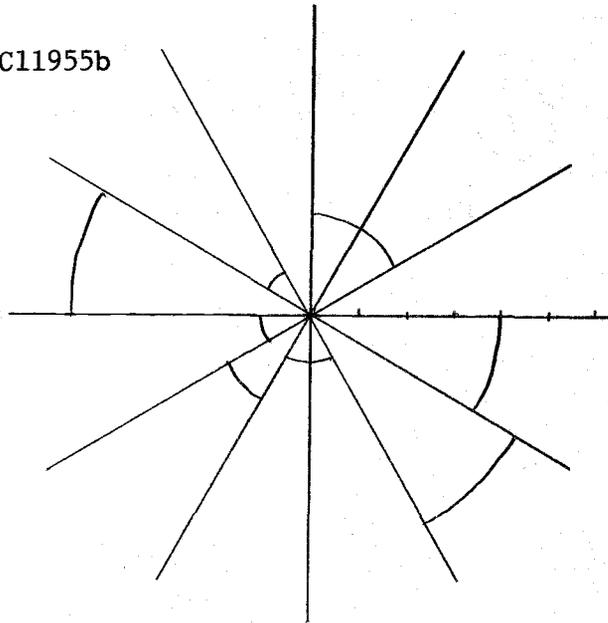
Sample Number C11954a



Sample Number C11954b



Sample Number C11955b



Sample Number C11956

APPENDIX 2

Relative distribution of the faunal constituents

Sample C11951a

	Number of specimens	A*	D*	A/D	Percentage of total fauna
<u>Atrypella</u>	11	9	2	4.5	8
<u>Howellella</u>	20	7	13	0.5	14
<u>Protathyris</u>	96	72	24	3.0	67
indet. stroph.	4	0	4	0.0	3
ostracodes	10				8

Total 143 specimens.
Indeterminate 40.

Sample C11951b

<u>Atrypella</u>	10	8	2	4.0	7
<u>Howellella</u>	2	1	1	1.0	1
<u>Protathyris</u>	115	110	5	22.0	85
ostracodes	2				1
indet. Aulopodid	2				1

Total 132 specimens.
Indeterminate 35.

Sample C11951c

<u>Atrypella</u>	10	9	1	9.0	4
<u>Howellella</u>	27	17	10	1.7	10
<u>Protathyris</u>	199	195	4	48.8	75
indet. stroph.	3				1
ostracodes	26				

Total 266 specimens.
Indeterminate 50.

Sample C11952b

	Number of specimens	A*	D*	A/D	Percentage of total fauna
<u>Atrypella</u>	730	567	163	3.5	73
<u>Howellella</u>	17	1	16	.06	1.6
<u>Protathyris</u>	181	160	21	7.6	18
<u>Iridistrophia</u>	1	1	0		0.1
indet. stroph.	39	0	39	0.0	4
<u>Ferganella</u>	32	20	12	1.7	3
gastropod	1				
coral	1				
crinoid	1				

Total 1003 specimens.
Indeterminate 127.

Sample C11952c

<u>Atrypella</u>	215	24	191	.12	76
<u>Howellella</u>	31	1	30	.03	11
<u>Protathyris</u>	23	6	17	.35	8
gastropods	13				5

Total 269 specimens.
Indeterminate 58.

Sample C11953a

<u>Atrypella</u>	603	557	46	12.1	87
<u>Howellella</u>	20	2	18	0.1	3
<u>Protathyris</u>	48	39	9	4.6	7

	Number of specimens	A*	D*	A/D	Percentage of total fauna
ostracodes	21				3

Total 692 specimens.
Indeterminate 132.

Sample C11953b

<u>Atrypella</u>	191	79	112	0.7	69
<u>Howellella</u>	40	0	40	0.0	14
<u>Protathyris</u>	8	3	5	0.6	4
ostracodes	37				13

Total 276 specimens.
Indeterminate 56.

Sample C11953c

<u>Atrypella</u>	148	42	106	0.4	61
<u>Howellella</u>	76	2	74	.03	31
<u>Protathyris</u>	3	0	3	0.0	1
ostracodes	16				6.5
gastropods	1				0.5

Total 244 specimens.
Indeterminate 51.

Sample C11954a

<u>Atrypella</u>	49	21	28	.75	44
<u>Howellella</u>	35	11	24	.46	31.5
<u>Protathyris</u>	1	0	1	0.0	1
indet. stroph.	6	0	6	0.0	5.5
ostracodes	2				1

	Number of specimens	A*	D*	A/D	Percentage of total fauna
gastropods	10				9
indet. brachs.	8	0	8	0.0	7
Total 111 specimens. Indeterminate 19.					

Sample C11954b

<u>Atrypella</u>	280	194	86	2.3	82
<u>Howellella</u>	48	32	15	2.2	14
<u>Protathyris</u>	0				
indet. stroph.	11	0	11	0.0	3
ostracodes	2				1

Total 341 specimens.
Indeterminate 45.

Sample C11955

<u>Atrypella</u>	149	46	103	.44	68
<u>Howellella</u>	30	2	28	.07	14
<u>Protathyris</u>	16	9	7	1.3	7
<u>Ferganella</u>	1	1	1	1.0	0.5
indet. stroph.	17				7.5
ostracodes	5				2

Total 218 specimens.
Indeterminate 38.

Sample C11956

	Number of specimens	A*	D*	A/D	Percentage of total fauna
<u>Atrypella</u>	291	96	195	.49	70
<u>Howellella</u>	20	0	20	0.0	5
<u>Protathyris</u>	37	13	24	.54	9
<u>Ferganella</u>	7	4	3	1.3	2
ostracodes	55				11
trilobites	2				0.5
gastropods	4				1

Total 416 specimens.
Indeterminate 180.

Sample C11957a

<u>Atrypella</u>	19	14	5	2.8	36
<u>Howellella</u>	13	0	13	0.0	24.5
<u>Protathyris</u>	0				
<u>Ferganella</u>	9	5	4	1.25	17
Gypidulid	8	0	8	0.0	15
ostracodes	1				2
trilobites	2				4
gastropods	1				2

Total 52 specimens.
Indeterminate 0.

Sample C11957b

	Number of specimens	A*	D*	A/D	Percentage of total fauna
<u>Atrypella</u>	97	56	41	1.4	36
<u>Howellella</u>	44	2	42	.05	16
<u>Protathyris</u>	6	2	4	0.5	2
<u>Ferganella</u>	16	2	14	.14	6
indet. stroph.	86	0	86	0.0	32
ostracodes	6				2
trilobites	12				4.5

Total 270 specimens.
Indeterminate 57.

Sample C11958

<u>Atrypella</u>	141	64	77	.83	83
<u>Howellella</u>	26	4	22	.18	15
indet. stroph.	3	0	3	0.0	2

Total 170 specimens.
Indeterminate 19.

Sample C11959

<u>Atrypella</u>	40	5	35	.14	44
<u>Howellella</u>	20	0	20	0.0	22
<u>Protathyris</u>	15	7	8	.88	16.5
indet. stroph.	7	0	7	0.0	8
ostracodes	9				8.5

Total 91 specimens.
Indeterminate 36.

Sample C11960

	Number of specimens	A*	D*	A/D	Percentage of total fauna
<u>Atrypella</u>	65	32	33	.97	76
<u>Howellella</u>	9	0	9	0.0	11
<u>Protathyris</u>	11	8	3	2.7	13
ostracodes	1				1

Total 85 specimens.
Indeterminate 33.

Sample C11961

<u>Atrypella</u>	41	21	20	1.0	93
<u>Howellella</u>	1	0	1	0.0	2
<u>Protathyris</u>	2	0	2	0.0	4

Total 44 specimens.
Indeterminate 36.

Sample C11962

<u>Atrypella</u>	87	32	55	.58	73
<u>Howellella</u>	20	6	14	.43	17
<u>Protathyris</u>	10	4	6	.67	9
ostracodes	2				1

Total 119 specimens.
Indeterminate 60.

Sample C11963

<u>Atrypella</u>	105	1	104	.01	50
<u>Howellella</u>	19	0	19	0.0	9
<u>Protathyris</u>	8	0	8	0.0	4

	Number of specimens	A*	D*	A/D	Percentage of total fauna
<u>Ferganella</u>	1	0	1	0.0	0.5
indet. stroph.	79	0	79	0.0	37
Total 212 specimens. Indeterminate 170.					

Sample C11964

<u>Atrypella</u>	28	25	3	8.3	88
<u>Ferganella?</u>	4	0	4	0.0	12

Total 32 specimens.
Indeterminate 9.

Sample C11965

<u>Atrypella</u>	16	0	16	0.0	15
indet. stroph.	91	0	91	0.0	85

Total 107 specimens.
Indeterminate 39.

Sample C11966

<u>Atrypella</u>	41	25	16	1.6	37
<u>Protathyris</u>	18	17	1	17.0	17
Gypidulid	33	0	33	0.0	31
indet. stroph.	6	0	6	0.0	6
ostracodes	8				8

Total 106 specimens.
Indeterminate 61.

Sample C11967

	Number of specimens	A*	D*	A/D	Percentage of total fauna
<u>Atrypella</u>	11	5	6	.83	64
ostracodes	2				11
trilobites	2				11
orthocone cephalopod	1				6

Total 17 specimens.
Indeterminate 14.

A* - Articulated

D* - Disarticulated

APPENDIX 3**Section descriptions and petrographic analyses**

SECTION DESCRIPTIONS

Section 1, R.C.A.F. Air Photo Number Al6747-162.

Section begun with base at 0 feet in the Douro Formation.

504 feet: limestone, medium grey, with greenish grey argillaceous seams, medium bedded; fresh surface, medium dark grey, bedding lumpy, abundant corals, brachiopods and crinoids, loose fossils sample C11950; slabs samples C11951a, C11951b, C11951c.

774 feet: limestone, medium grey, fresh surface medium dark grey, grey greenish argillaceous seams, thin to medium bedded, bedding lumpy and fairly continuous, abundant Atrypella. Samples C11952a (loose fossils), C11952b (pocket), C11952c (slabs).

874 feet: limestone, medium grey, fresh surface medium dark grey, grey greenish argillaceous seams, thin to medium bedded, bedding lumpy, to lenticular. Samples: slabs C11953a, C11953b, C11953c.

924 feet: limestone medium grey to slightly pinkish, fresh surface medium dark grey, medium to thick bedding, lumpy and very discontinuous, grey greenish argillaceous seams, abundant corals, gastropods, and Atrypella. Samples: slabs C11954a, C11954b.

969 feet: limestone, medium grey, fresh surface medium dark grey, thin to medium bedded, continuous lumpy and uneven, little grey greenish argillaceous material, abundant varied fauna of gastropods, cephalopods, corals and Atrypella. Samples: Slabs C11955a, C11955b.

1024 feet: this horizon the same as the preceding one, but predominantly brachiopods. Sample: C11956, (slab).

1144 feet: this horizon is the same as the preceding two, however with less Atrypella and more other brachiopods as well as corals and trilobites. Samples: C11957a, C11957b (slabs).

1179 feet: top of the Douro Formation, next unit is overlying Devon Island Formation.

Section 2, located on R.C.A.F. Air Photo Number A16747-163. Section begun with base of Douro Formation at 0 feet.

152 feet: limestone, dark grey, fresh surface medium dark grey, medium to thick discontinuous bedding, contains numerous brachiopods and a few ostracodes. Sample C11958 (slab).

159 feet: lithology same as below; Sample C11959 (slab).

161 feet: lithology same as below; Sample C11960 (slab).

190 feet: limestone, medium dark grey, fresh surface, medium dark grey, thin to medium bedded, discontinuous and lumpy, grey greenish argillaceous seams, unit very recessive, very abundant Atrypella. Sample C11961 (pocket).

194 feet: lithology same as below, Sample C11962 (slabs).

205 feet: limestone, dark grey, fresh surface medium dark grey, thin to medium bedded, slightly lumpy, rare grey greenish argillaceous seams, abundant Atrypella. Sample C11963 (slab).

213 feet: limestone, medium grey, fresh surface medium grey, thin bedded and lumpy and discontinuous, abundant grey greenish argillaceous material, abundant Atrypella. Sample C11964 (slab).

214 feet: lithology same as below, Sample C11965 (slab).

328 feet: limestone, medium grey, fresh surface light grey, medium bedded lumpy and discontinuous, very little argillaceous material, few Atrypella. Sample C11966 (slab).

459 feet: limestone, medium grey, fresh surface medium dark grey, medium to thick bedded, uneven, but fairly continuous, a sparse brachiopod and brachiopod fauna with some fish and cephalopods. Samples C11967 (slab), C11968 (slab). Overlying unit is Devon Island Formation.

THIN SECTION DESCRIPTION

Sample C11951b

Skeletal lime wackestone. Constituents: few to common brachiopod fragments, one thamnopodid fragment, ostracodes, some recrystallization of micrite to microspar around the edges of the coral, one brachiopod preserved as a geopetal, very minor detrital angular quartz, less than 5 percent, Energy Index I2 deposition in quiet water.

Sample C11951c.

Skeletal lime wackestone. Constituents: a few brachiopod fragments and rare crinoid columnals, thin argillaceous seams, rare ostracodes, sub-angular detrital quartz less than 5 percent, few fecal pellets, some alteration of micrite to microspar. Energy Index I2; deposition in quiet water, the fossils showed no signs of abrasion and there was a high percentage of articulated valves.

Sample C11952b.

Skeletal lime wackestone. Constituents: common to abundant brachiopod fragments, sub-angular detrital quartz, less than 5 percent, numerous argillaceous seams, geopetals, some recrystallization of micrite to microspar, disarticulated brachiopod valves; Energy Index I3; deposition in quiet water the sample is abundantly fossiliferous, contains ochinoderm plates, many articulated brachiopods. The disarticulated ones show no sign of abrasion and the

assemblage is one of low diversity.

Sample C11952c.

Skeletal lime wackestone. Constituents: broken brachiopod valves, echinoid spines, high spired gastropods, echinoderm plates, less than 5 percent sub-angular detrital quartz, rare argillaceous seams, crinoid columnals, isolated patches of sparry calcite probably due to solution effects, rare fecal pellets. Energy Index II 1; deposition in intermittently agitated water. The fossil material is more fragmental than the preceding samples. Gastropods are an element of the fauna which may have been swept in from an adjacent environment.

Sample C11953a

Skeletal lime wackestone to packstone. Constituents: common to abundant articulated brachiopods preserved as geopetals, some valves are disarticulated, but not broken, very minor detrital quartz, few argillaceous seams. Energy Index I 3; deposition in quiet water. The sample is abundantly fossiliferous, contains many articulated fossils and has an assemblage of low diversity.

Sample C11953b

Skeletal wackestone. Constituents: numerous disarticulated and broken brachiopod valves, gastropods, less than 5 percent detrital quartz, echinoderm plates, some recrystallization of micrite to microspar, no argillaceous seams. Energy Index II 2; deposition in intermittently

agitated water. The sample contains coarse-grained carbonate material and a high percent of broken valves.

Sample C11953c

Skeletal wackestone. Constituents: disarticulated and broken brachiopod valves, echinoid spines, sub-rounded intraclasts of lime mudstone, some recrystallization of micrite, detrital quartz is less than 5 percent, very little argillaceous material, few fecal pellets, few echinoderm plates. Energy Index II 2; deposition in intermittently agitated water. The sample contains a simple assemblage of fossils which are disarticulated and broken.

Sample C11954a

Skeletal wackestones. Constituents: disarticulated and broken brachiopod valves, colonial corals, gastropods, rare argillaceous seams, some recrystallization of micrite to microspar, numerous echinoderm spines and plates, detrital quartz is less than 5 percent, some fecal pellets, one trilobite fragment. Energy Index II 2; deposition in intermittently agitated water the sample contains a low diversity assemblage of fossils which are broken and disarticulated.

Sample C11954b

Skeletal wackestone. Constituents: common argillaceous seams, sub-angular detrital quartz is less than 5 percent, some brachiopods are articulated and some disarticulated,

gastropod, crinoid fragments, some recrystallization of micrite to microspar, numerous echinoderm plates, some pellets, one trilobite fragment. Energy Index I 3; quiet water the assemblage is of low diversity and contains a moderate amount of articulated specimens.

Sample C11955a

Skeletal wackestone. Constituents: disarticulated brachiopod valves, few argillaceous seams, gastropods, sub-angular detrital quartz less than 5 percent, fine fecal pellets, echinoderm plates, and some recrystallization of micrite into microspar. Energy Index II 1; deposition in intermittently agitated water. The assemblage is moderately fossiliferous and has a large percentage of disarticulated valves.

Sample C11955b

Skeletal wackestone. Constituents: high spired gastropods, tiny sub-rounded pellets, disarticulated and broken brachiopod valves, rare argillaceous seams, echinoderm plates, fecal pellets, and some solution effects (vugs infilled with sparry calcite). Energy Index II 2; deposition in intermittently agitated water.

Sample C11956

Skeletal wackestone. Constituents: disarticulated and broken brachiopod valves, small sub-rounded clasts, some recrystallization of micrite to microspar, fecal pellets, detrital quartz less than 5 percent, and one

echinoid spine. Energy Index II 2; deposition in intermittently agitated water.

Sample C11957a

Skeletal wackestone. Constituents: disarticulated and broken brachiopod valves, numerous lime mudstone intraclasts, ostracods, fecal pellets crinoids. Energy Index II 2; deposition in intermittently agitated water. The sample exhibits rip-up phenomenon as there are some large sub-rounded to oval lime mudstone clasts.

Sample C11957b

Skeletal wackestone, constituents: disarticulated and fragmentary brachiopod valves, gastropod, trilobite, ostracod, crinoid, echinoid spine, echinoderm plate, fecal pellets and some lime mud intraclasts as well as some recrystallization. Energy Index II 2; deposition in intermittently agitated water.

EXPLANATION OF PLATE I

All figures are 1.5X unless otherwise stated.

Figures

- 1-4 Atrypella prunum (Dalman) (USNM 12671) pedicle
brachial, lateral, and anterior views.
- 5, 6 A. prunum (Dalman) (USNM 12671) posterior and
pedicle views of interior mold.
- 7, 8, 10,
12 Atrypella phoca (Salter) Read Bay Fm. Prince of
Wales Island, N.W.T., posterior, lateral,
anterior and pedicle views.
- 9, 11 A. phoca (Salter) Read Bay Fm., Prince of Wales
Island, N.W.T., brachial and posterior views
of internal mold.
- 13-16 Atrypella scheii (Holtedah1) Form A (GSC C11954a)
pedicle, brachial, posterior and pedicle views
of internal mold. All figures XI.
- 17, 18 A. scheii (Holtedah1) Form A (GSC C11954a)
pedicle and anterior views. All figures XI.
- 19, 22 A. scheii (Holtedah1) Form B (GSC C11954a)
pedicle and lateral views.
- 21 Atrypella sp. (GSC C11952 b) brachial view of
internal mold.
- 20, 23, 24 A. scheii (Holtedah1) Form B (GSC C11954a)
pedicle, brachial, and posterior views of
internal mold.

EXPLANATION OF PLATE II

All figures are 1.5X unless otherwise stated.

Figures

- 1 A. scheii (Holstedahl) Form B (GSC C11954a)
anterior view.
- 2,3,7,8 A. scheii (Holstedahl) Form C (GSC C11961)
pedicle, posterior, anterior, and lateral views.
- 4,5,6 A. scheii (Holstedahl) Form C (GSC C11961) pedicle,
brachial, and posterior views of internal mold.
- 9, 10 Atrypella sp. (GSC C11952b) pedicle and posterior
views of internal mold.
- 11, 12 Atrypella sp. (GSC C11952b) pedicle and anterior
views.
- 13,15,17 Protathyris aff. infantile (GSC C11951c) pedicle,
anterior, and lateral views.
- 14, 16 Protathyris aff. infantile (GSC C11951c) brachial
and posterior views of internal mold.
- 18,19,20 Protathyris didyma Kozlowski non Dalman
(GSC C11952b) pedicle, brachial, and posterior
views of internal mold.
- 21 Protathyris didyma Kozlowski non Dalman (GSC
C11952b) posterior view.
- 22, 23 Ferganella cf. turkestanica (GSC C11952b)
pedicle and brachial views.
- 24,25,26 Ferganella cf. turkestanica (GSC C11952b)
brachial, pedicle, and posterior views of
internal mold. Posterior view exhibits
pedicle valve uppermost.
- 27 Howellella sp. (GSC C11954) pedicle view of
internal mold. Figure is 2.5X.

Figures

- 28, 29, 30, 31 Howellella sp. (GSC C11954) brachial,
lateral, posterior, and anterior views.
All figures are 2.5X.
- 32, 33, 34, 35 Spirinella sp. (GSC C11951b) pedicle,
brachial, posterior, and anterior views.
All figures are 2.5X.

Plate 1



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3



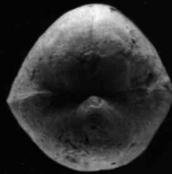
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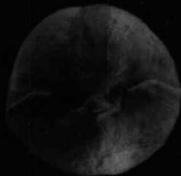
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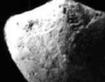
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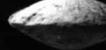
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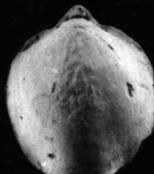
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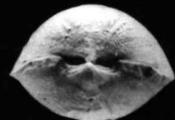
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Plate 2

