University of Alberta Library

0 1620 3416176 8

A
MICROFAUNAL STUDY
OF THE
BASAL LLOYDMINSTER SHALE

For Reference

NOT TO BE TAKEN FROM THIS ROOM

D. B. BULLOCK

Ex LIBRIS
UNIVERSITATIS
ALBERTAENSIS

Journal of the

Board of Directors

of the

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....
.....
.....
.....

THE UNIVERSITY OF ALBERTA

A MICROFAUNAL STUDY OF THE
BASAL LLOYDMINSTER SHALE

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

FACULTY OF ARTS AND SCIENCE

by

D. B. BULLOCK

EDMONTON, ALBERTA,

APRIL, 1950.

TABLE OF CONTENTS

	<u>Page</u>
Title	
Abstract	
Chapter I <u>Introduction</u>	1
Introductory Statement	1
Collection and Preparation of Samples	1
Method of Mounting Microfossils	4
Scope of Thesis and Method of Treatment	5
Acknowledgements	6
Chapter II <u>Statistical Analysis of Microfauna</u>	8
Microfaunal Observations	8
Charts and Explanations of Charts	
Generic Occurrence Graphs Figures I-IV	
Explanation of	19
Percentage Population Graph Figure V	
Explanation of	21
Specific Occurrence Graphs Figure VI-XII	
Explanation of	23
Plate showing well-section Figure XIII	
Summary	18
Chapter III <u>Palaeo-ecology</u>	25
Palaeo-ecological Significance of the	
Microfauna of the Basal Lloydminster	
Formation	25
Summary	33

	<u>Page</u>
Chapter IV <u>Correlations</u>	35
Microfaunal Correlations	35
Stratigraphic Conclusions	43
Summary Table Figure XIV	
Appendix	
Statistical record of Faunal analysis	
Bibliography

Digitized by the Internet Archive
in 2018 with funding from
University of Alberta Libraries

<https://archive.org/details/microfaunalstudy00bull>

ABSTRACT

Statistical analyses of microfauna from the Lower Cretaceous, lower Lloydminster shales from the Eldorena #1 well of the Edmonton area, Alberta, indicates continuous deposition without important stratigraphic interruptions throughout, superjacent to, and subjacent to the Viking sand member.

An Ammobaculoides microfauna, older than any previously described from the Lloydminster shale, is reported from the base of the formation.

Parts of the lower Lloydminster shale are correlated with the upper 200 feet of the Buckinghorse formation of north-eastern B.C.; the lower 80 feet of the Shaftesbury formation of Peace River area, Alberta; the Joli Fou - Pelican sandstone basal Labiche shale of the Athabaska River area, Alberta; and with the lower Lloydminster shale of the Vermilion area, Alberta.

Statistical data is presented in convenient histogram charts.

CHAPTER I

INTRODUCTION

Introductory Statement

This thesis is an analytical microfaunal inventory of the basal Lloydminster shale. The analysis was selected to embrace the Viking sand member of the Lloydminster shale.

The results of this study indicated that no distinct or abrupt faunal change occurred during the deposition of the Viking sand, immediately preceding it or immediately following, within the Eldorena area and therefore the Viking sand represents sandy facies of the early Lloydminster flooding and in this area does not indicate a stratigraphic hiatus.

Collection & Preparation of Samples

The samples, from which the microfauna were obtained, were collected by Mr. C.R. Stelck from drilled cores of Eldorena #1 Well, taken by Imperial Oil Ltd. in 1949.

1. Introduction

2. Background

2.1. Problem Statement

The problem of finding the shortest path between two points in a graph is a classic problem in computer science. This problem is often solved using algorithms such as Dijkstra's algorithm or the A* algorithm. The A* algorithm is a heuristic search algorithm that uses a priority queue to select the next node to visit. It is more efficient than Dijkstra's algorithm because it uses a heuristic to estimate the cost of the path from the current node to the goal node.

In this paper, we propose a new algorithm for finding the shortest path between two points in a graph. Our algorithm is based on the A* algorithm, but it uses a different heuristic function. We show that our algorithm is more efficient than the A* algorithm in terms of the number of nodes visited and the time taken to find the shortest path. We also show that our algorithm is more robust than the A* algorithm in terms of its ability to handle graphs with large numbers of nodes and edges.

2.2. Related Work

There have been many previous attempts to solve the shortest path problem. Some of the most well-known algorithms are Dijkstra's algorithm, the A* algorithm, and the Bellman-Ford algorithm. Dijkstra's algorithm is a greedy algorithm that finds the shortest path from a source node to all other nodes in the graph. The A* algorithm is a heuristic search algorithm that finds the shortest path from a source node to a goal node. The Bellman-Ford algorithm is a dynamic programming algorithm that finds the shortest path from a source node to all other nodes in the graph.

The samples were collected continuously and irregularly, along the cores, the footage being determined by convenient length interval where no lithological change was involved, and by selective picking of shale intervals where sandy breaks provided lithological markers. This method permits an unmixed evaluation of fauna from individual shale tongues. The samples range from 1934 feet to 2128 feet (drilling depth), i.e. from the top of the Mannville formation to about 50 feet above the Viking sandstone.

The samples were placed in postal cotton bags and forwarded to the University of Alberta.

The writer divided the samples into two parts, breaking the fragments by hand to minimize the amount of crushing and consequent damage to any microfossils contained. One half of each sample is placed in a pint sealer for immediate use, and the remaining half retained in the sample bag and is filed in the Department of Geology of the University of Alberta. Each pint sealer is filled approximately three fourths full with ordinary tap water and sealed.

When the samples have softened sufficiently they are shaken vigorously to allow as much of the shale as possible, to become suspended in the water. The contents of the sealer are emptied into a prepared set of Tyler screens. These screens consist of the following suite: 28 mesh, 48 mesh, 80 mesh, 100 mesh, 150 mesh and a pan. A small stream of water from a rubber tube connected to the water tap reduces the residue on the 28 mesh screen. The residue is worked with the fingers and the remaining residue is collected to one side of the screen by means of a fine jet of water from the underside of the 28 mesh screen, and washed into a white porcelain saucer. The excess water is then poured out of the saucer and the residue allowed to dry.

This procedure is carried out with each screen size. A small stream of water is allowed to run into the pan and float off all shaly particles, leaving the microfossils and sand grains, etc. behind. This sample is also transferred to a porcelain saucer.

When the sample is dried, each mesh size is placed in a small screw-topped vial and appropriately labelled.

Method of Mounting Microfossils

The residues in the screw-topped vials contain the microfossils. The residue is scattered thinly over the surface of a "picking" plate - a small buff-colored plastic plate. The picking is done under a Bausch and Lomb binocular microscope at 30X magnification, using a blue light. The picking plate has a sectioned field, and the percentage of the sample picked is readily determined.

The microfossils are picked up on the tip of a moistened paint brush (00). The fossils are placed, and roughly grouped as to genus, on a clean, white card. Where sufficient numbers of fossils have been collected and the percentage of the sample is determined, the residue is returned to the vial. The fossils are then transferred to a mounting slide. Some of these slides contain one large rectangular cell in which case the different mesh sizes of each

sample are marked off along the sides of the cell; other slides contain 10 small, circular cells arranged in two rows of 5 cells, along the length of the slide, in which case each mesh size is confined to one cell and each sample to a row of 5 cells (i.e. - two samples of 5 cells each, per slide).

The cells of the mounting slides, have a black background which is covered with gum tragacanth, which, when touched by the moistened brush holding the fossil, becomes gummy and holds the fossil securely. The fossils are arranged in horizontal rows within the cells.

The slides of the collection, are filed in the Department of Geology, University of Alberta.

Scope of Thesis and Method of Treatment

This dissertation is a statistical evaluation of the microfauna of the Basal Lloyminster shale as represented in cores from the Imperial Eldorena well (LSD 4, Section 27, Township 57, Range 20, West of 4th Meridian). Specifically, it is an attempt by the

writer to analyze the fauna above, below and within the Viking sand with respect to continuity of fauna across the sand.

The method employed was to make statistical counts, both generic and specific, of the faunas. These counts were then studied by the use of check lists and histogram representation, to arrive at the conclusion stated.

Note -- The "species" as set up by the writer were selected as morphologic types and followed through as such, each new morphologic type receiving the specific notation of successive letters of the alphabet.

Acknowledgements

The writer wishes to express his deep appreciation to all members of the Department of Geology, University of Alberta, for their cooperation and encouragement. The writer wishes especially to express his appreciation for the assistance and advice of Mr. C.R. Stelck under whose direct supervision this thesis was written. Mr. Stelck collected the material for the study and suggested the preliminary methods of approach to the problem.

 

the first of these is the fact that the

The writer has had access to unpublished works by C.R. Stelck, A.R. Nielsen and W.G. Bahan, on applied phases of this study.

CHAPTER II

STATISTICAL ANALYSIS OF MICROFAUNA

MICROFAUNAL OBSERVATIONS

The following observations on the microfauna of the Lower Lloyminster formation, apply only to the shaly lithofacies and take no cognizance of the faunas that might be present in sandy zones.

The development of the microfauna is best shown by a consideration of each major genus. The discussion of the genera is based on the Generic Occurrence graphs (Figures I - IV), the Percentage Population graph (Figure V), the Specific Occurrence graphs (Figures VI - XII) and the writer's specific evaluation of the fauna.

Haplophragmoides (see Figures I, V and VI) is strongly represented in the lowest shale above the Mannville and is continuously present throughout the section

1. Introduction

The purpose of this study is to investigate the effect of the

2. Methodology

The study was conducted using a quantitative research design. Data was collected from 100 participants through a series of questionnaires. The questionnaires were designed to measure the variables of interest. The data was then analyzed using statistical methods to determine the relationships between the variables.

The results of the study indicate that there is a significant positive correlation between the variables. This suggests that as the independent variable increases, the dependent variable also tends to increase. The findings are consistent with previous research in this area, which has also found a positive relationship between the variables.

In conclusion, the study has shown that the variables are positively correlated. This has important implications for the field of study, as it provides evidence for the relationship between the variables. Further research is needed to explore the underlying mechanisms of this relationship.

covered by this thesis. The maximum development both generically and specifically occurs in the shale between the Eldorena sand member (1) and the base of the Viking sand. At this horizon the genus Haplophragmoides represents from 50 to 70 percent of the total population (see Figure V). The minimum development occurs immediately above the shale zone within the Viking sand where only 2 percent of the total fossil population is made up of this genus. The decrease in the percentage representation of Haplophragmoides at this horizon, is taken up mainly by spores.

In species, the same generalizations are true. (see Figure VI) There are 3 species strongly developed in the lowest shale above the Mannville formation and 6 more developed below the Eldorena sand member. Of all 9 species that are present below the Eldorena sand member, only 1 species does not continue

- (1) The writer proposes the name Eldorena sand member for the sandy horizon between the Joli Fou (basal Lloydminster) shale and the Basal Member of the Lloydminster shale, (see Figure XIII), at a depth of 2086 feet to 2105 feet in the Eldorena well.

above. There are 13 species present in the shales below the base of the Viking sand -- only 2 of these are represented within the Viking sand and none of them recur above the Viking sand! Of the 3 new species that first develop within the Viking sand only 1 is represented above the Viking and this one only poorly so. (It should be noted at this point that the writer found it impossible to differentiate with certainty, any species contained in the finer screen sizes, viz: 100 and 150 mesh and pan sample). The well known index fossil Haplophragmoides gigas Cushman, occurs in the Basal Lloydminster shale just above the Eldorena sand member and is restricted to that zone.

It may be concluded that with respect to the genus Haplophragmoides, the Viking sand does represent a definite break in specific continuity.

Ammobaculites (see Figures I, V and VII) is represented in the first sample above the Mannville formation. The over all generic development is at no horizon very strong but is consistent throughout the section with the exception of one sample, just above the shale zone

within the Viking sand, where it is absent. There are two maxima of development: one just below the Eldorena sand member of the Basal Lloydminster shale and the other embracing the base of the Viking sand.

Sandy phases do not seem to eliminate Ammobaculites from the section generically or specifically. There are 10 species developed below the Eldorena sand member and 4 of these continue (3 strongly) above the Eldorena sand member (see Figure VII). Of these 4 species, 3 continue for a short way into the base of the Viking and reappear above the Viking sand. One species, not continuous across the Eldorena sand member, reappears above the Viking sand. There are 4 species which have their initial development within the base of the Viking but only 1 of these is represented at all above the Viking. There are 4 species which first develop above the Viking but are only poorly represented within the section considered.

Continuity of Ammobaculites species is interrupted by the sand and sandy phases of the section but some species return with the advent of shale.

Shallow water environment, muddy but marginal to the sandy phases is favored by the genus Ammobaculites. The evidence from the Ammobaculites faunas, shows no hiatus or break present in the section from below the Viking to above the Viking.

Ammobaculoides (see Figures I and V) is a very short ranging genus, strongly represented in the shales up to the base of the Eldorena sand member and thereafter not present. As this genus disappears, the percentage of Haplophragmoides expands to make up the deficit.

The disappearance of the Ammobaculoides implies some important ecological change at the time of the laying down of the Eldorena sand member.

Proteonina (see Figures III, V and VIII) is represented throughout the section except immediately below the base of the Viking. Except for the shale below the Eldorena sand member, there is no great development of this genus. In the percentage population it makes up for decreases in the numbers of Haplophragmoides, Ammobaculites and Ammobaculoides.

The species, generally, are short ranging.

There are 6 strongly developed species represented in the shale below the Eldorena sand member, only one of these survives this sand. However 3 of these species recur very briefly above the Viking. Five species develop within the basal part of the Viking and 4 of these recur above the Viking. The basal suite of species is quite distinctive from the rest of the section.

The evidence from a study of the Proteonina shows no break in section over the Viking interval but some disruption over the Eldorena sand interval.

Reophax (see Figures III, V and IX) is only represented in the Basal Lloydminster by a very few, poor specimens. The first strong development is within the Second Viking sand and all of these are again represented above the Viking sand. Three additional species develop above the Viking sand.

The environment of the Basal Lloydminster shale was not favorable to Reophax suggesting fairly deep water at this time. The evidence of the

... ..

... ..

... ..

... ..

... ..

Reophax indicates no dissruption in continuous deposition from the Viking to the overlying shales.

Gaudryina (see Figures III, V and X) is strongly developed in the shales of the pre-Eldorena sand member, is fairly strongly represented within the Second Viking sand and again above the Viking sand. Generically it is continuously represented throughout the section.

There are 12 species developed in the shale immediately above the Mannville formation. Gaudryina canadensis and G. cf canadensis are among the 8 of the above species which are confined to this basal horizon. Only 4 of the original and 2 new species appear briefly above the Viking sand. It should be noted here, as in the case of Haplophragmoides, that the writer did not attempt to differentiate specifically those forms found in the finer screen sizes.

Gaudryina are continuous across the Viking sand but evidently the continuity of major species was very badly disrupted by the more sandy environ-

ments. The long range of the Gaudryina species seems to indicate that a fairly short time interval was involved in the deposition of the basal Lloydminster section in this area.

Verneuillina (see Figures III, V and XI), as is to be expected, has a development similar to that of Gaudryina, but is more erratic. The genus Verneuillina is absent at 6 irregularly spaced horizons throughout the section.

There are 2 species present below the Eldorena sand member of the Basal Lloydminster shale, that do not reappear until some 15 feet above the Viking where they occur quite strongly. Two species, one of which is Verneuillina canadensis, develop above the Viking sand.

Generally speaking, the sandy environments have the same affect on the species of Verneuillina as on the species of Gaudryina. The evidence from this corroborates the evidence supporting a short time interval of deposition suggested by the genus Gaudryina.

Miliammina (see Figures I, V and XII) is not present below the Eldorena sand member but first develops in the shale just below the base of the Viking sand. It is quite strongly represented within the Second Viking sand and the shale zone above but is nearly absent throughout the Viking sand proper. It is again strongly represented above the Viking.

The 3 species that develop immediately below the base of the Viking, continue strongly through the Second Viking and return again in the shales above the Viking. The 3 additional species that initially develop within the Second Viking and the shale zone above it are represented above the Viking. There are 2 species which are very poor in numbers, that are initiated above the Viking.

The genus Miliammina is a shallow water form and the generic and specific evidence of the genus in this suite corroborate the previous evidence that the shale above the Viking represents a relatively shallow water environment. There is no disruption of the specific continuity across the Viking interval.

Hyperammina (see Figures I, V and XII) has a distribution very similar to that of Miliammina. It is present, generically, throughout the entire section.

One species develops immediately below the Second Viking and continues through the shale zone above the Second Viking. It reappears above the Viking where there are 7 new species strongly developed, 2 of which had their initial development within the Second Viking and the others in the post-Viking shale.

The evidence of Hyperammina further corroborates that afforded by Miliammina and others. The Viking sand facies was ecologically unfavorable to this genus. There is apparently no disruption of specific continuity through the sand, reaffirming the absence of any important stratigraphic hiatus within the Viking sand section.

Summary

Evidence from the above analyses of the micro-fauna indicates that there is no major stratigraphic hiatus involved in the Viking sand interval, also that there is no pronounced stratigraphic break immediately above or immediately below the Viking sand. Further, it shows that the time interval involved in the deposition of the Viking sand was not long. The shales below the Eldorena sand represent the initial phase of a transgressive sea which had local embayments of shallow water with deposition during Eldorena sand time. There is nearly continuous deposition through the deep water Haplophragmoides gigas zone.

All genera except the genus Haplophragmoides that are present in the initial shales of the section are represented in the post Viking Shales. Specifically there are faunal ties between pre-Eldorena shales and post-Eldorena shales and between H. gigas zone shales and post-Viking shales indicating that the different faunas represent biofacies changes in the Basal Lloydminster sea and that there is no break in deposition although there are different environments of deposition and varied sediments laid down.

Explanation of Generic Occurrence Graphs

A statistical count is made for genera and graphs compiled (see Figures I - IV). These graphs show the relative development of each genus against the lithology and stratigraphic sequence of the enclosing sediments.

The horizontal component of each graph is a logarithmic progression (i.e. - it is divided into 4 logarithmic divisions, viz: 0 - 10; 10 - 100; 100 - 1000; 1000 - 10,000), the units representing the number of fossils present. The vertical component corresponds to the drilling depth from which the samples were collected.

The writer has chosen to distinguish between count-values under 10 and those over 10 by shading that portion of the graph over 10. This was done to emphasize horizons favorable to the development or preservation of each genus.

CONSTITUTIONAL HISTORY OF THE UNITED STATES

The Constitution of the United States is the supreme law of the land. It is the framework of government under which the people live. The Constitution is a living document, and it has been amended many times since it was first written. The original Constitution was signed on September 17, 1787, in Philadelphia. It was then sent to the states for ratification. By September 28, 1789, eleven states had ratified it, and it became the law of the land. The Constitution is divided into seven articles. The first three articles deal with the executive, legislative, and judicial branches of government. The last four articles deal with the states, the federal government, and the rights of the people. The Constitution is a masterpiece of American law and government. It has shaped the nation's history and continues to shape its future. The Constitution is the foundation of our democracy, and it is the source of our rights and freedoms. We must always remember that the Constitution is not just a piece of paper, but a living document that we all have a responsibility to protect and uphold.

Graphs have been drawn up on the following genera: Haplophragmoides, Ammobaculites, Ammobauloides, Reophax, Proteonina, Gaudryina, Verneuillina, Hyperammina, Miliammina, Glomospira, Trochammina, Bothysiphon and Leptodermella. In addition, graphs for the following non-Foraminiferal elements have been drawn up: Spores, Fucoidal Elements and Collophane Spheres.

Explanation of Percentage Population Graphs

The statistical generic count is used to compute the Percentage Population Table (see Table I). This is done by analyzing each sample with respect to the percent of the total population that each individual genus represents. Both Foraminifera and non-Foraminiferal elements are used to give a more complete picture of the Thanatocoenosis of each horizon. The following entities are used: Haplophragmoides, Ammobaculites, Ammobaculoides, Reophax, Hyperammina, Proteonina, Leptodermella, Spores, Gaudryina, Verneuilina, Trochammina, Miliammina and others. The term "Others" includes the following: Collophane Spheres, Bathysiphon, Glomospira, Fucoidal Elements, Tritaxia, Nodosinella, Spiroplectammina, Eoguttulina, Globigerina and Ammodiscus.

The figures are transferred from the table to a graph. The vertical axis of the graph represents the section of the Basal Lloydminster shale dealt with in this thesis and the units represent the drilling

depth at which each sample was collected. The horizontal axis represents the percentage and the units are 10% (viz: 10%, 20% 100%). The percentage of the total population that each genus represents is plotted on the graph. The points are joined by curved lines.

Explanation of Specific Occurrence Graphs

A statistical count is made for each sample, of species populations of each major genus. Graphs are compiled for each genus (see Figures VI - XII). These graphs show the relative development of each species against the lithology and stratigraphic sequence of the enclosing sediments.

The horizontal axis represents the relative numbers of each species present. It is divided into 4 units: a single line representing from 0 to 5 fossils present; a unit bar representing from 6 to 20 fossils present; a 2 unit bar representing from 21 to 100 fossils present; a 3 unit cusp representing from 101 to 1,000 fossils present. The vertical axis corresponds to the drilling depth from which the samples were collected.

In cases where successive samples contain the same species, the continuity is shown by dotted lines. In such cases above the Viking sand where sampling was continuous, the graphic expression is

THEORY OF THE EARTH AND ITS HISTORY

The theory of the earth and its history is a branch of geology which deals with the origin and development of the earth and its various parts. It is a science which seeks to explain the processes which have shaped the earth and its features, and to determine the sequence of events which have taken place since the earth was first formed. The theory of the earth and its history is based on the study of the rocks and fossils which are found in the earth, and on the principles of geology which govern their formation and distribution. It is a science which is constantly developing, as new discoveries are made and new theories are proposed. The theory of the earth and its history is one of the most important branches of geology, and it is one which has a wide range of applications. It is a science which is essential for the understanding of the earth and its history, and it is one which is of great importance to the human race.

not broken but is also shown continuously. In samples which are only separated by moderate distances and which contain the same species, the continuity of the species is assumed and indicated by the use of dotted lines.

The following genera are included in the Specific Occurrence Graphs: Haplophragmoides, Ammobaculites, Reophax, Proteonina, Miliammina, Gaudryina, Verneuilina, Hyperammina and Glomospira.

GENERIC OCCURRENCE
of
HAPLOPHRAGMOIDES, AMMOBACULITES, AMMOBACULOIDES and HYPERAMMINA

Figure 1

GENERIC OCCURRENCE
of
MILIAMMINA, GLOMOSPIRA, TROCHAMMINA and BATHYSIPHON

Figure II

GENERIC OCCURRENCE
of
REOPHAX, PROTEONINA, GAUDRYINA and VERNEUILINA

Figure III

"GENERIC" OCCURRENCE
of

SPORES, COLLOPHANE SPHERES, LEPTODERMELLA and FUCOIDAL ELEMENTS

Figure IV

PERCENTAGE POPULATION
of
GENERA

Figure V

SPECIFIC OCCURRENCE
of
HAPLOPHRAGMOIDES

Figure VI

SPECIFIC OCCURRENCE
of the genus
ATMOBACULITES

Figure VII

SPECIFIC OCCURRENCE
of
PROTEONINA

Figure VIII

SPECIFIC OCCURRENCE
of
REOPHAX

Figure IX

SPECIFIC OCCURRENCE
of
GAUDRYTINA

Figure X

SPECIFIC OCCURRENCE
of
GLOMOSPIRA and VERNEUILINA

Figure XI

SPECIFIC OCCURRENCE
of
MILIAMMINA and HYPERAMMINA

Figure XII

WELL-SECTION

Figure XIII

CHAPTER III

Palaeo-ecological Significance of the Microfauna of the Basal Lloydminster Formation

The environments of deposition within the section can best be determined from a study of the ecology of the suites of fossils found at various horizons. These interpretations are based on an analysis of the specific fauna and the lithology of the stratigraphic horizon containing that fauna.

The presence of old soils and residual zones at the top of the Mannville formation, indicates the existence of a land area at the end of Mannville time. Within the time of deposition of the section being considered, this land mass was flooded by a sea that laid down the Basal Lloydminster shale. The earliest flooding is represented by shale which contains well-developed species of Gaudryina and Haplophragmoides, a few species of Ammobaculites and Glomospira, and a great number of Ammobaculoides. This assemblage indicates probable shallow water conditions, which is to be expected in the early stages of the advancement of the sea.

The fauna rapidly alters within a short vertical range, with the addition of several new, strongly developed species of Gaudryina, a few new species of Haplophragmoides and Ammobaculites, the complete disappearance of Ammobaculoides and the strong development of Proteonina. These changes are facies change due to a moderate deepening of the sea as it continued to flood over the land, although the appearance of Proteonina suggests brackish intervals.

Immediately below the Eldorena sand member the fauna changes considerably. All the species of Gaudryina dwindle to insignificance and subsequently disappear; all the species of Proteonina abruptly disappear; all species of Haplophragmoides show a marked decrease in numbers; and Ammobaculoides return very strongly. The subsequent deposition of the Eldorena sand indicates that at least locally the sea shallowed and is near shore at this horizon.

The Eldorena sand is glauconitic and therefore represents shallow marine deposition. The presence of a few poorly preserved Spores in the samples from immediately below and above this sand,

suggest near-shore phase of a deltaic environment.

The restricted vertical range of the genus Ammobaculoides to pre-Eldorena shales, indicates an early, local, shallow embayment into the late Mannville land area. It is known that the Eldorena sand facies is restricted in areal distribution.

When the source of the sand was cut off, probably by a deepening of the sea over the land area to the south, Joli Fou shales were laid down. These initial shales above the Eldorena sand member contain a different fauna to those shales immediately below the Eldorena sand member. The species of Haplophragmoides that were present below the sand are still present with the exception of 1 species, and 2 new species, including Haplophragmoides gigas appear. No species of Gaudryina or Ammobaculoides are present; only 1 species of Ammobaculites is present in these initial shales; and only 1 species of Proteonina is present. This indicates that the sea of post-Eldorena member time was fairly deep in this locality and too deep for the genus Ammobaculoides.

The index fossil Haplophragmoides gigas

Cushman, has been reported from widespread localities throughout Alberta and Saskatchewan. It has been found in the Joli Fou shales of the Athabaska River (1), in Cretaceous sections of Southern Saskatchewan and Manitoba (2), in the Lloydminster shale at Lloydminster, Alberta (3), in Cretaceous shales of the section recovered from the Imperial Paddle River well (4) and in the Cretaceous shales of Southern Alberta near Taber (5). This indicates that the shore line of the H. gigas sea was at least 200 miles removed from the Eldorena location.

- (1) Wickenden, R.T.D., 1949
"Some Cretaceous Sections along the Athabaska River etc." G.S.C. Preliminary Paper 49-15.

Bahan, W.G., 1950, Personal communication.
- (2) Wickenden, R.T.D., 1945.
"Mesozoic Stratigraphy of the Eastern Plains, Manitoba and Saskatchewan". G.S.C. Memoir 239.
- (3) Nauss, A.W., 1947.
"Cretaceous Micro-fossils of the Vermilion area, Alberta". Jour. Paleo. Vol. 21 #4.
- (4) Stelck, C.R., 1950, Personal communication.
- (5) Stelck, C.R., 1950, Personal communication.

The fauna of the shales immediately below the base of the Viking sand indicates a shallowing of the sea and in view of the subsequent deposition of the Viking sand, this is not unreasonable. This pre-Viking fauna contains 5 of the shallow water species of Haplophragmoides that appeared in the shales immediately above the Eldorena sand but not as strongly represented. The deeper water species Haplophragmoides gigas is gone. Four of the shallow water species of Ammobaculites that were present below the Eldorena sand member, reappear. Two new species of Proteonina are strongly developed here that, along with the genus Miliammina, first developed at this horizon with 3 very strong species, indicates brackish tendencies. The genus Hyperammina, initially develops here. This fauna represents a shallow, brackish water fauna and it is obvious that the deep sea aspect of the Haplophragmoides gigas Cushman is gone.

The shaly portions of the Second Viking sand contain the remnants of the pre-Viking fauna and a new fauna as well. One species of Haplophragmoides

The first of these is the fact that the
 
the hundredth is the fact that the

is present that had pre-Viking affiliations and only one new species developed. Of the previous species of Ammobaculites there are three represented in the Second Viking sand and three new species developed. All pre-Viking sand species of Miliammina are present along with one new species. The one species of Hyperammina is still present. One new species of Verneuilina develops in the Second Viking sand (the 2 earlier species were restricted to the shales immediately below the Eldorena sand member). The two species of Proteonina that developed immediately below the base of the Viking, continue within the Second Viking and in addition, two new species are developed. There are four species of Reophax developed in this horizon only one of which is a continuation of an initial development in the shales immediately below the base of the Viking. "Spores" make their initial major appearance in this horizon. The evidence presented by an analysis of this fauna serves to indicate that the Second Viking sand represents a shallow near-shore facies of the earlier sea.

The shale zone immediately above the Second Viking sand carries a fauna which is very similar to the fauna of the Second Viking sand. The differences lie in the development of a few new species of Reophax, Proteonina, Miliammina, Hyperammina and Haplophragmoides replacing some of the species of the Viking sand. Little environmental change is indicated except the change from sand to shale bottom. The environment remained near-shore shown by the abundance of "Spores" present in this shale.

"Spores" dominate the organic life represented in the upper Viking sand. There are a few species of Ammobaculites represented near the top of the Viking sand, which had earlier affiliations within the section at the base of the Eldorena sand. Haplophragmoides is represented at the top of the Viking by two species, one of which was initiated in the shale zone above the Second Viking. Miliammina is represented by two species at the top of the Viking, which initiated within the Second Viking. There are five species of Hyperammina present at the top of the Viking, three of which were present earlier. Verneuilina is represented by the

one species that developed immediately below the base of the Viking. There are only two poorly represented species of Proteonina present at the top of the Viking, and one of these is a representation of a species which had its initial development immediately below the base of the Viking. Reophax and Gaudryina are represented by one poorly developed species each, the former being a continuation of a species initiated within the Second Viking and the latter a new species which is not represented above the Viking within the section studied. This indicates continuity of environment throughout the Viking sand with no major disruption in the index species of that environment of near-shore, slightly brackish, shallow water.

 

Summary:

The ecology of the faunas of the different horizons shows that the section essentially represents local fluctuations of a shallow, and at times, slightly brackish, transgressive sea in pre-Viking time and a static, shallow-water sea in post-Viking time. The continuity of the faunas through the Eldorena sand interval indicates that the latter represents local deposition in a local embayment. The widespread occurrence of the H. gigas fauna indicates that the deposition in this area during this time was deep water facies and over 200 miles from the shore in all directions.

The interval of the Viking sand probably represents a shallowing of the sea in the western part due to minor uplifts of the old source areas of the Blairmore-Kootenay series to the west. This uplift area also contributed detritus to the sands of the Viking. The presence of chert pebbles and chert grains in the Viking sand and the fact that there is no Viking sand developed in the Lloydminster area or in

1944

 

1944 James Monroe

Saskatchewan, tend to support this hypothesis. The fact that the Viking sand thickens to the west also affords credence to this tenet.

CHAPTER IV

CORRELATIONS

Microfaunal Correlations

The fauna of the Basal Lloydminster formation has been dated by C.R. Stelck (1) and J.H. Wall, Upper Albian age.

The writer finds that certain faunal assemblages contained within this section have been noted from other localities. Where possible, comparisons are made with these fossils and correlations indicated. That refinement of correlation may not be lost, the writer treats the correlations on the following stratigraphic breakdown.

(1) Stelck, C.R., 1950, Personal communication.

1870

1871

1872

1873

1874

1875

1876

1877

1878

1879

1880

1881

1882

1883

1884

1885

1886

1887

1888

1889

1890

1891

1892

1893

1894

1895

1896

1897

1898

1899

1900

The suite of fossils from the pre-Eldorena member strata has been described from the Sikanni Chief River area (1) and from the Athabaska River area (2). The species listed by the writer as:

Haplophragmoides "E" found in Stelck's collection 299 feet below the top of the 1st Sikanni sandstone.

Haplophragmoides "B" found in Stelck's collection 167 feet below the Gastroplites zone in the upper Fort St. John shales.

Proteonina "C" found in Stelck's collection 148 feet below the top of the 1st Sikanni sandstone.

Ammobaculites "J" found in Stelck's collection 150 feet above the base of the Gastroplites zone. This fossil was also found in Bahan's collection 12 feet above the Grand Rapids sandstone in the Joli Fou shale.

- (1) Stelck, C.R., 1950, "Cenomanian-Albian Foraminifera of Western Canada" unpublished Ph.D. thesis.
- (2) Bahan, W.G., 1950, "Microfauna and Correlation of the Joli Fou formation" unpublished report.

Ammobaculoides sp. a few similar forms found in Bahan's collection 7 feet above the Grand Rapids sandstone in the Joli Fou shale.

This basal suite was not found by Nauss in the Lloydminster area. It is only partially represented in Bahan's collection from the Athabaska River. The suite is well represented in Stelck's collection from north eastern B.C. This indicates that the initial Basal Lloydminster sea was only present in the western portion of the basin and the stratigraphic position of this fauna seems to indicate uppermost Middle Albian or earliest Upper Albian age.

The post-Eldorena - pre-Viking shales contain the H. gigas fauna. Bahan and Wickenden (1) have reported this fauna in the Joli Fou shale. The writer has had access to and has examined carefully, the microfauna collected by Bahan from the Joli Fou

(1) Wickenden, R.T.D., 1949, "Some Cretaceous Sections along the Athabaska River, etc." G.S.C. Prelim. Paper 49-15.

Bahan, W.G., 1950, "Microfauna and Correlation of the Joli Fou formation" unpublished report.

... ..

... ..

...

... ..

... ..

... ..

... ..

shales of the Athabaska River and has found that those faunal assemblages that are developed throughout this section at the Eldorena location and those collected by Bahan are identical in nearly every respect. Some diagnostic fossils that were noted from both localities are the species listed by the writer as:

Glomospira "B" found in Bahan's collection 17 feet above the top of the Grand Rapids sandstone.

Haplophragmoides gigas found in Bahan's collection 17 feet above the top of the Grand Rapids sandstone.

Haplophragmoides "D" found in Bahan's collection 17 feet above the top of the Grand Rapids sandstone.

Ammobaculites "H" found in Bahan's collection 17 feet above the top of the Grand Rapids sandstone.

Haplophragmoides "I" found in Bahan's collection 22 feet above the top of the Grand Rapids sandstone.

 

Gaudryina canadensis found in Bahan's collection 22 feet above the top of the Grand Rapids sandstone.

Miliammina "C" was found in Bahan's collection 65 feet above the top of the Grand Rapids sandstone.

"Spores" the same forms were found in Bahan's collection 100 feet above the top of the Grand Rapids sandstone or 10 feet below the top of the Joli Fou shale.

In addition to those diagnostic species listed above, numerous other minor forms not treated statistically by the writer, are found to be present in both the section below the Viking in the Eldorena well and below the Pelican sandstone in outcrop.

The presence of these nearly identical faunas in both sections allows a direct correlation of the two sections with the exception of the fauna of the initial shales of the Eldorena well section which is only partly represented in the initial Joli Fou shales.

The post-Viking shales within the section, contain a fauna that has been noted by the writer in

the collections of microfossils from the Upper Buckinghorse formation in the Sikanni Chief River area (1), the lower Shaftesbury formation on the Peace River near Peace River town (2), the Labiche shale immediately above the Pelican sand on the Athabaska River (3), and from the Lloydminster shale in wells near Lloydminster, Alberta (4). The following specific identities were established:

Trochammina sp. (a) found in Stelck's collections 284 feet below the top of the 1st Sikanni sandstone, in the upper Buckinghorse formation.

- (1) Stelck, C.R., 1950, "Cenomanian-Albian Foraminifera of Western Canada" unpublished Ph.D. thesis.
- (2) Nielsen, A.R., 1950, "A Microfaunal Study of the Shaftesbury formation" unpublished M.Sc. Thesis.
- (3) Bahan, W.G., 1950, "Microfauna and Correlation of the Joli Fou formation" (unpublished).
- (4) Nauss, A.W., 1947, "Cretaceous Microfossils of the Vermilion area, Alberta" Jour.Pal. Vol.21#4, pp.329-343.

 

(b) found in Nielsen's collection 274 feet below the Fish Scale sand in the lower Shaftesbury formation.

(c) found in Bahan's collection 17 feet above the top of the Pelican sandstone in the Labiche shale.

Verneuilina canadensis (a) found in Bahan's collection 30 feet above the Pelican sandstone in the Labiche shale.

(b) a form very similar found in Nielsen's collection 211 feet below the Fish-Scale sand in the lower Shaftesbury formation.

(c) a form very similar found in Stelck's collection 266 feet below the top of the 1st Sikanni sandstone in the upper Buckinghorse formation.

Verneuilina "D" (a) found in Stelck's collection 304 feet below the top of the 1st Sikanni sandstone in the upper Buckinghorse formation.

 

(b) found in Nielsen's collection 258 feet below the Fish-Scale sand in the lower Shaftesbury formation.

Reophax "J"

(a) found in Stelck's collection 130 feet below the top of the First Sikanni sandstone in the upper Buckinghorse formation.

(b) found in Nielsen's collection 241 feet below the Fish-Scale sand in the lower Shaftesbury formation.

Hyperammina "E"

(a) found in Nielsen's collection 280 feet below the Fish-Scale sand in the lower Shaftesbury formation.

(b) found in Bahan's collection 33 feet below the top of the Pelican sandstone.

Nodosinella sp.

(a) found in Nielsen's collection 290 feet below the Fish-Scale sand in the lower Shaftesbury formation.

... ..
... ..

... ..
... ..
... ..

... ..

... ..
... ..
... ..

... ..

... ..
... ..
... ..

... ..

... ..

Tritaxia "A" (a) found in Nielsen's collection 274 feet below the Fish-Scale sand in the lower Shaftesbury formation.

There are several other species in Nielsen's collection that the writer found to be correlative with species in the Eldorena section but which for the sake of brevity have been omitted from this thesis.

Stratigraphic Conclusions

The faunas of the Eldorena section and those collected by Bahan from the Athabaska River are almost identical in all respects. This permits direct correlation between the Basal Lloydminster shales below the Viking sand and the Joli Fou shale; between the Viking sand and the Pelican sand; and between the Lloydminster shale immediately above the Viking sand and the lower Labiche shale immediately above the Pelican sand. The basal fauna below the Eldorena member was incompletely present in the Joli Fou shale on the Athabaska River suggesting that the earliest

Basal Lloydminster sea was only beginning to spread over the Athabaska River area at that time. Only a portion of this basal fauna of the Eldorena well-section is developed in the former area as the proper shaly environmental conditions were represented on the Lower Athabaska River by either sand facies of the uppermost Grand Rapids formation or actual sub-aerial conditions.

The Lloydminster shale at Lloydminster, Alberta and the Basal Lloydminster shales of the Eldorena well section are correlative except for the basal member and this correlation is substantiated by the microfauna developed therein. The faunas developed through the Viking interval in the Eldorena well-section are found to be laterally continuous into the Lloydminster area. The additional thickness of shale found in the Lloydminster area between the post-Viking - pre-Viking fauna indicates that the Lloydminster shale in the Lloydminster area has a shale facies representing the Viking sand interval of the Eldorena area without loss of stratigraphic section.

The pre-Eldorena member fauna is directly correlative with a fauna collected by Stelck from the upper Buckinghorse formation but the post-Eldorena member H. gigas fauna is missing from the upper Buckinghorse formation at that horizon. The post-Viking fauna of the Eldorena well-section however, is present in the upper Buckinghorse formation immediately superjacent to the pre-Eldorena faunal correlatives. This strongly suggests that there is a stratigraphic hiatus present in the upper part of the Buckinghorse formation in the Sikanni Chief River area of B.C.

The essential correlations developed or supported by this study are shown in the following table.

The faunal similarities outlined above indicate that the upper 200 feet of the Buckinghorse formation of north eastern B.C., the lower Shaftesbury formation (from 211 feet below the Fish-Scale sand to 290 feet below the Fish-Scale sand)

of the Peace River town area, and the lower Labiche shale immediately above the Pelican sand of the Athabaska River area, are correlative stratigraphically and ecologically similar to the Lloydminster shale immediately above the Viking sand in the Eldorena well-section.

SUMMARY TABLE

EIDORENA WELL	LOWER ATHABASCA R.	PEACE RIVER ALBERTA	SIKANNI CHIEF RIVER B.C.	LLOYDMINSTER ALBERTA
Late Post-Viking fauna		X Shaftesbury sh	X Sikanni ss	X sh Lloydminster
Post-Viking fauna	X Labiche sh	X sh Shaftesbury	X sh Buckinghamhorse	X sh Lloydminster
Upper Viking fauna	X Pelican ss			
Viking shale fauna				
Second Viking fauna	X Pelican ss			
Late Joli Fou fauna	X Joli Fou sh			X sh Lloydminster
H. gigas fauna	X Joli Fou sh			X sh Lloydminster
Pre-H. gigas fauna	X Joli Fou sh			X sh Lloydminster
Ammobaculoides fauna			X sh Buckinghamhorse	

BIBLIOGRAPHY

- Andrichuk, J.M., 1949, "Stratigraphy of the Area including Majeau Lake #1 Well Edmonton area." Unpublished M.Sc. thesis, University of Alberta.
- Bahan, W.G., 1950, "Microfauna and Correlation of the Joli Fou formation." Unpublished report.
- Cushman, J.A., 1927, "Some Foraminifera from the Cretaceous of Canada" Royal Soc. Can. Proc. and Trans., Vol.21, Sec.4, pp. 127-132.
- _____, 1946, "Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and Adjacent Areas." U.S.G.S. Professional Paper 206.
- _____, 1948, "Foraminifera, Their Classification and Economic Use." Harvard University Press.
- Glaessner, M.F., 1948, "Principles of Micropalaeontology" John Wiley and Sons.
- Layer, D.B., Et. Al., 1940, "Leduc Oil Field, Alberta, A Devonian Coral-Reef Discovery" Bull. A.A.P.G. Vol. 33, #4, pp.572-602.
- Nauss, A.W., 1947, "Cretaceous Microfossils of the Vermilion area, Alberta." Jour. Pal. Vol. 21, #4, pp.329-343.
- Nielsen, A.R., 1950, "Microfaunal Study of the Shaftesbury Formation" unpublished M.Sc. thesis, University of Alberta.
- Stelck, C.R., 1950, "Cenomanian-Albian Foraminifera of Western Canada" unpublished Ph.D. thesis, Stanford University.

Wickenden, R.T.D., 1932, "Notes on Some Deep Wells in
in Saskatchewan" Royal Soc. Canada
Proc. and Trans., Vol.26, Sec.4.

_____, 1941, "Cretaceous Marine Formations
Penetrated in Wells near Lloydminster,
Saskatchewan." Royal Can. Inst.
Trans., Vol.23, pp.147-155.

_____, 1945, "Mesozoic Stratigraphy of the
Eastern Plains, Manitoba and
Saskatchewan" G.S.C. Memoir 239.

_____, 1949, "Some Cretaceous Sections
along the Athabaska River" G.S.C.
Prelim. Paper 49-15.

SAMPLE	CORRECTION FACTOR	MESH SIZE	HAPLOPHRAGMOIDES	AMMOBACULITES	AMMOBACULOIDES	REOPHAX	GAUDRYINA	VERNEUILINA	BATHYSIPHON	HYPERAMMINA	MILIAMMINA	GLOMOSPIRA	AMMODISCUS	TRITAXIA	PROTEONINA	EOGUTTULINA	GLOBIGERINA	COLLOPHANE	SPHERES	TROCHAMMINA	LEPTODERMELLA	FUCOIDAL ELEMENTS	SPORES	NODOSINELLA
1934	x 1 48	x 1 80	1	8	14	3	0	0	1	8	4	1	1	0	1	3	1	3	1	8	5	1	0	0
	x 1 100	x 1 150	0	0	5	6	0	0	15	18	20	20	2	0	1	8	8	8	5	0	0	0	0	
	x 12 150	Totals	0	83	0	75	0	0	2	239	249	10	0	0	12	0	0	0	30	61	0	0	0	
1944	x 1 48	x 1 80	3	20	87	1	0	0	42	18	2	1	1	0	1	16	1	0	0	3	2	0	0	0
	x 1 100	x 1 150	10	87	19	4	1	0	18	28	1	1	1	1	1	12	1	0	16	1	0	0	0	
	x 3 150	Totals	46	164	0	0	13	0	0	38	116	9	0	1	1	0	0	0	55	6	0	0	0	
1954	x 1 48	x 2 80	3	26	11	5	6	11	8	11	8	1	1	3	1	2	7	0	6	2	1	4	3	
	x 2 100	x 5 150	10	11	4	12	6	1	8	22	5	39	15	11	2	2	0	0	0	0	3	52	3	
	x 5 150	Totals	76	94	0	114	47	12	128	151	81	19	2	7	29	0	0	0	12	21	540	1	12	
1964	x 1 28	x 1 48	5	19	64	14	17	5	7	53	3	15	11	17	8	17	27	1	4	17	27	1	4	
	x 20 80	x 20 100	7	29	7	16	7	18	1	39	15	11	11	11	8	11	13	13	2	2	1	4	0	
	x 35 150	Totals	1268	857	0	2149	750	832	122	2507	1120	0	0	0	784	0	0	0	1309	246	113	0	0	
1974	x 1 48	x 1 80	6	29	13	1	1	2	3	1	5	1	1	1	2	5	0	0	4	2	0	9	5	
	x 1 100	x 2 150	4	13	2	3	10	1	2	3	4	1	1	1	2	5	0	0	0	8	2	0	9	
	x 2 150	Totals	12	50	0	10	33	3	13	10	21	3	0	1	8	0	0	0	0	8	0	0	9	
1984	x 1 48	x 1 80	6	4	22	1	2	1	3	2	9	3	3	2	2	1	1	2	2	0	0	16	24	
	x 1 100	x 2 100	7	10	8	10	3	4	1	9	14	9	3	0	1	1	0	0	2	2	2	36	24	
	x 8 150	Totals	109	86	0	1	24	17	0	135	72	24	0	0	20	0	0	0	20	0	0	16	176	
2007	x 1 48	x 6 80	1	0	0	2	2	2	2	1	0	1	0	0	1	2	2	2	1	1	2	15	23	
	x 4 100	x 4 100	6	0	0	14	20	0	12	0	6	0	0	0	4	0	6	1	26	16	0	353	0	
	x 6 150	Totals	6	0	0	14	20	0	12	0	6	0	0	0	4	0	6	1	26	16	0	353	0	
2026	x 5/3 48	x 4 80	22	16	22	3	5	5	1	3	4	8	18	2	1	18	2	1	2	2	1	27	63	
	x 4 100	x 4 100	32	22	19	3	23	1	0	4	6	2	4	0	8	2	0	0	1	4	4	2	17	
	x 20 150	Totals	596	312	0	72	480	40	0	84	56	84	0	0	114	0	0	100	8	80	28	321	0	
2036	x 1 28	x 5/3 80	2	8	2	1	1	1	8	4	4	1	2	2	5	8	4	13	4	1	3	1	54	
	x 6 100	x 6 150	23	2	4	9	2	4	9	6	1	1	6	6	2	6	13	4	1	3	1	14	8	
	x 6 150	Totals	316	49	0	95	36	26	0	127	49	20	0	0	58	0	0	85	0	26	6	351	55	
2046	x 1 28	x 1 48	9	14	49	2	3	3	4	3	3	2	2	2	2	8	13	2	2	2	13	4	2	
	x 20 80	x 12 100	26	40	30	20	1	21	0	4	2	10	13	1	1	1	1	1	1	1	1	2	4	
	x 6 150	Totals	905	1414	0	592	132	372	0	64	144	0	0	0	324	6	0	18	52	12	0	149	0	
2056	x 1 28	x 1 48	12	11	68	1	6	3	6	2	1	1	1	1	5	8	4	1	1	1	1	13	2	
	x 1 80	x 6 100	65	59	5	1	3	1	1	3	12	0	0	0	1	1	0	0	2	5	4	0	0	
	x 6 150	Totals	2162	1225	0	88	74	42	16	96	156	0	0	0	59	0	0	0	30	0	0	0	0	
2064	x 1 48	x 4 80	12	6	71	35	1	1	4	2	2	1	1	1	1	1	1	1	1	1	1	1	1	
	x 4 100	x 5/2 150	58	16	70	1	9	0	1	10	14	2	2	0	0	0	0	2	1	5	4	0	0	
	x 5/2 150	Totals	703	202	0	0	27	0	2	74	119	20	0	0	0	0	0	0	1	5	4	0	0	
2076	x 1 48	x 6 80	3	1	92	4	15	1	2	2	1	2	2	1	1	2	3	1	1	2	2	2	2	
	x 6 100	x 10 150	92	17	56	6	17	4	8	8	3	5	5	1	1	1	1	1	1	1	2	2	2	
	x 10 150	Totals	1775	187	0	0	302	46	0	80	36	42	0	0	31	0	0	22	0	0	24	0	0	
2105	x 1 28	x 1 48	1	12	25	2	12	1	45	0	0	0	0	0	20	0	0	10	0	0	24	0	0	
	x 1 80	x 5 100	7	32	44	29	40	3	1	4	1	3	2	2	1	1	1	1	1	1	1	1	2	
	x 5 150	Totals	898	587	505	20	36	105	1	45	0	25	0	0	698	0	0	10	0	0	24	0	0	
2108	x 1 28	x 5/2 48	1	20	21	5	22	1	2	2	2	1	2	17	17	28	7	0	1	1	1	4	4	
	x 20 80	x 5 100	30	28	25	28	26	1	4	4	0	0	0	0	0	0	0	0	0	1	1	4	4	
	x 5 150	Totals	1479	1875	358	5	790	65	0	60	0	25	0	0	698	0	0	0	0	25	0	95	0	
2113	x 1 28	x 1 48	1	25	13	2	9	2	2	5	3	1	8	57	48	57	48	4	1	1	1	1	1	
	x 1 80	x 5 100	28	35	44	15	22	2	5	5	3	6	4	4	4	4	4	4	4	4	4	4	4	
	x 5 150	Totals	769	260	115	55	382	20	0	82	0	75	0	0	858	0	0	0	0	5	0	10	0	
2118	x 1 28	x 1 48	1	18	14	1	23	1	2	2	13	44	25	13	44	25	13	44	25	13	44	25	13	
	x 1 80	x 5 100	14	29	55	27	36	2	2	2	9	1	1	1	1	1	1	1	1	1	1	1	1	
	x 5/2 100	x 10 150	42	10	42	2	42	2	2	2	9	9	6	6	6	6	6	6	6	6	6	6	6	
	Totals		718	416	0	0	626	20	0	30	0	93	0	0	356	0	0	0	0	0	0	0	0	
2125	x 1 28	x 1 48	4	6	9	59*	20	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
	x 1 80	x 5 100	24	41	22	90	34	1	1	3	3	2	2	2	2	2	2	2	2	2	2	2	2	
	x 5 150	Totals	1022	524	2298	0	996	5	5	91	0	21	0	0	2	0	0	1	0	0	0	73	0	

STATISTICAL SPECIFIC RECORD
OF THE GENUS
HAPLOPHRAGMOIDES

Sam- ple	Mesh Size	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Gigas
1964	80														1				
	Totals														20				
1974	80														3				
	Totals														3				
1984 to 1996	48 80																6 2 1 2 7		
	Totals																		
2026	80				3										11 44	3 12			
	Totals				12														
2036	48 80				1										8 13				
	Totals				1														
2046	48 80			1 3											9 12				
	Totals			61											249				
2056 to 2064	48 80		1	2	5		1		1	2	14	3	1	3					
	Totals		10	20	5		1		21		140	31	30						
2064 to 2073	48 80			2	10		12		2	2	2	5							1
	Totals			8	10		48		8	8	8	20							4
2076 to 2086	48 80	5	3	17	21		7		1	3	9								3
	Totals	30	18	102	126		42		6	18	54								18

HAPLOPHRAGMOIDES
Continued

[illegible]

STATISTICAL SPECIFIC RECORD
OF THE GENUS
AMMOBACULITES

Sample	Mesh Size	A	E	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1934	80					1													5
	Totals					1													5
1944	80			1		2												1	14
	Totals			1		2												1	14
1954	80			4		10			1								5	2	
	Totals			8		20			2								10	4	
1964	48			1		3											1		
	80			17		1			3								4	1	
	Totals			341		20			60								81	20	
1974	48					2										1			
	80			13		12											3		
	Totals			13		14											1	3	
1984	48					2										1			
	80			10		7										1	4		
	Totals			10		9										1	4		
2026	80					11								4					
	Totals					44								16					
2036	80					5										1			
	Totals					8										2			
2046	48					7								3					
	80				1	38			3				1	11		6			
	Totals				20	760			60				20	223		120			
2056	48					2		1	1			2							
	80					14			7				30						
	Totals					140			71			2	300						

5084	60175	150	1	3	300
5085	60176	14	18	1	33
5086	60177	1	1	1	1
5087	60178	10	150	20	50
5088	60179	1	18	1	11
5089	60180	1	1	1	180
5090	60181	1	1	1	1
5091	60182	1	1	1	1
5092	60183	1	1	1	1
5093	60184	1	1	1	1
5094	60185	1	1	1	1
5095	60186	1	1	1	1
5096	60187	1	1	1	1
5097	60188	1	1	1	1
5098	60189	1	1	1	1
5099	60190	1	1	1	1
5100	60191	1	1	1	1
5101	60192	1	1	1	1
5102	60193	1	1	1	1
5103	60194	1	1	1	1
5104	60195	1	1	1	1
5105	60196	1	1	1	1
5106	60197	1	1	1	1
5107	60198	1	1	1	1
5108	60199	1	1	1	1
5109	60200	1	1	1	1
5110	60201	1	1	1	1
5111	60202	1	1	1	1
5112	60203	1	1	1	1
5113	60204	1	1	1	1
5114	60205	1	1	1	1
5115	60206	1	1	1	1
5116	60207	1	1	1	1
5117	60208	1	1	1	1
5118	60209	1	1	1	1
5119	60210	1	1	1	1
5120	60211	1	1	1	1
5121	60212	1	1	1	1
5122	60213	1	1	1	1
5123	60214	1	1	1	1
5124	60215	1	1	1	1
5125	60216	1	1	1	1
5126	60217	1	1	1	1
5127	60218	1	1	1	1
5128	60219	1	1	1	1
5129	60220	1	1	1	1
5130	60221	1	1	1	1
5131	60222	1	1	1	1
5132	60223	1	1	1	1
5133	60224	1	1	1	1
5134	60225	1	1	1	1
5135	60226	1	1	1	1
5136	60227	1	1	1	1
5137	60228	1	1	1	1
5138	60229	1	1	1	1
5139	60230	1	1	1	1
5140	60231	1	1	1	1
5141	60232	1	1	1	1
5142	60233	1	1	1	1
5143	60234	1	1	1	1
5144	60235	1	1	1	1
5145	60236	1	1	1	1
5146	60237	1	1	1	1
5147	60238	1	1	1	1
5148	60239	1	1	1	1
5149	60240	1	1	1	1
5150	60241	1	1	1	1
5151	60242	1	1	1	1
5152	60243	1	1	1	1
5153	60244	1	1	1	1
5154	60245	1	1	1	1
5155	60246	1	1	1	1
5156	60247	1	1	1	1
5157	60248	1	1	1	1
5158	60249	1	1	1	1
5159	60250	1	1	1	1
5160	60251	1	1	1	1
5161	60252	1	1	1	1
5162	60253	1	1	1	1
5163	60254	1	1	1	1
5164	60255	1	1	1	1
5165	60256	1	1	1	1
5166	60257	1	1	1	1
5167	60258	1	1	1	1
5168	60259	1	1	1	1
5169	60260	1	1	1	1
5170	60261	1	1	1	1
5171	60262	1	1	1	1
5172	60263	1	1	1	1
5173	60264	1	1	1	1
5174	60265	1	1	1	1
5175	60266	1	1	1	1
5176	60267	1	1	1	1
5177	60268	1	1	1	1
5178	60269	1	1	1	1
5179	60270	1	1	1	1
5180	60271	1	1	1	1
5181	60272	1	1	1	1
5182	60273	1	1	1	1
5183	60274	1	1	1	1
5184	60275	1	1	1	1
5185	60276	1	1	1	1
5186	60277	1	1	1	1
5187	60278	1	1	1	1
5188	60279	1	1	1	1
5189	60280	1	1	1	1
5190	60281	1	1	1	1
5191	60282	1	1	1	1
5192	60283	1	1	1	1
5193	60284	1	1	1	1
5194	60285	1	1	1	1
5195	60286	1	1	1	1
5196	60287	1	1	1	1
5197	60288	1	1	1	1
5198	60289	1	1	1	1
5199	60290	1	1	1	1
5200	60291	1	1	1	1
5201	60292	1	1	1	1
5202	60293	1	1	1	1
5203	60294	1	1	1	1
5204	60295	1	1	1	1
5205	60296	1	1	1	1
5206	60297	1	1	1	1
5207	60298	1	1	1	1
5208	60299	1	1	1	1
5209	60300	1	1	1	1
5210	60301	1	1	1	1
5211	60302	1	1	1	1
5212	60303	1	1	1	1
5213	60304	1	1	1	1
5214	60305	1	1	1	1
5215	60306	1	1	1	1
5216	60307	1	1	1	1
5217	60308	1	1	1	1
5218	60309	1	1	1	1
5219	60310	1	1	1	1
5220	60311	1	1	1	1
5221	60312	1	1	1	1
5222	60313	1	1	1	1
5223	60314	1	1	1	1
5224	60315	1	1	1	1
5225	60316	1	1	1	1
5226	60317	1	1	1	1
5227	60318	1	1	1	1
5228	60319	1	1	1	1
5229	60320	1	1	1	1
5230	60321	1	1	1	1
5231	60322	1	1	1	1
5232	60323	1	1	1	1
5233	60324	1	1	1	1
5234	60325	1	1	1	1
5235	60326	1	1	1	1
5236	60327	1	1	1	1
5237	60328	1	1	1	1
5238	60329	1	1	1	1
5239	60330	1	1	1	1
5240	60331	1	1	1	1
5241	60332	1	1	1	1
5242	60333	1	1	1	1
5243	60334	1	1	1	1
5244	60335	1	1	1	1
5245	60336	1	1	1	1
5246	60337	1	1	1	1
5247	60338	1	1	1	1
5248	60339	1	1	1	1
5249	60340	1	1	1	1
5250	60341	1	1	1	1
5251	60342	1	1	1	1
5252	60343	1	1	1	1
5253	60344	1	1	1	1
5254	60345	1	1	1	1
5255	60346	1	1	1	1
5256	60347	1	1	1	1
5257	60348	1	1	1	1
5258	60349	1	1	1	1
5259	60350	1	1	1	1
5260	60351	1	1	1	1
5261	60352	1	1	1	1
5262	60353	1	1	1	1
5263	60354	1	1	1	1
5264	60355	1	1	1	1
5265	60356	1	1	1	1
5266	60357	1	1	1	1
5267	60358	1	1	1	1
5268	60359	1	1	1	1
5269	60360	1	1	1	1
5270	60361	1	1	1	1
5271	60362	1	1	1	1
5272	60363	1	1	1	1
5273	60364	1	1	1	1
5274	60365	1	1	1	1
5275	60366	1	1	1	1
5276	60367	1	1	1	1
5277	60368	1	1	1	1
5278	60369	1	1	1	1
5279	60370	1	1	1	1
5280	60371	1	1	1	1
5281	60372	1	1	1	1
5282	60373	1	1	1	1
5283	60374	1	1	1	1
5284	60375	1	1	1	1
5285	60376	1	1	1	1
5286	60377	1	1	1	1
5287	60378	1	1	1	1
5288	60379	1	1	1	1
5289	60380	1	1	1	1
5290	60381	1	1	1	1
5291	60382	1	1	1	1
5292	60383	1	1	1	1
5293	60384	1	1	1	1
5294	60385	1	1	1	1
5295	60386	1	1	1	1
5296	60387	1	1	1	1
5297	60388	1	1	1	1
5298	60389	1	1	1	1
5299	60390	1	1	1	1
5300	60391	1	1	1	1
5301	60392	1	1	1	1
5302	60393	1	1	1	1
5303	60394	1	1	1	1
5304	60395	1	1	1	1
5305	60396	1	1	1	1
5306	60397	1	1	1	1
5307	60398	1	1	1	1
5308	60399	1	1	1	1
5309	60400	1	1	1	1
5310	60401	1	1	1	1
5311	60402	1	1	1	1
5312	60403	1	1	1	1
5313	60404	1	1	1	1
5314	60405	1	1	1	1
5315	60406	1	1	1	1
5316	60407	1	1	1	1
5317	60408	1	1	1	1
5318	60409	1	1	1	1
5319	60410	1	1	1	1
5320	60411	1	1	1	1
5321	60412	1	1	1	1
5322	60413	1	1	1	1
5323	60414	1	1	1	1
5324	60415	1	1	1	1
5325	60416	1	1	1	1
5326	60417	1	1	1	1
5327	60418	1	1	1	1
5328	60419	1	1	1	1
5329	60420	1	1	1	1
5330	60421	1	1	1	1
5331	60422	1	1	1	1
5332	60423	1	1	1	1
5333	60424	1	1	1	1
5334	60425	1	1	1	1
5335	60426	1	1	1	

OF THE GENUS
AMMOBACULITES
Continued

[illegible]

OF THE GENUS PROTEONINA

Sample	Mesh Size	A	B	C	D	E	F	G	H	I	J	K	L	M
1954	80					1								
Totals						2								
1964	80			1	1									
Totals				20	20									
1974	80 100 150							1		1	2			1
Totals								1	1	2	3	4		1
1984 to 1996	80								1	1			1	1
Totals									1	1			1	1
2026	48 80								3				1	
Totals									12				2	
2036	80 100							1	3	1	1	1		
Totals								2	1	2	3	3		
2046	48 80							14	11	14	20			
Totals								1	1	3	1			
2056 to 2064	100							6	4					
Totals								36	66	15	5			
2076 to 2086	80			1										
Totals				6						36	24			

OF THE GENUS

[illegible]

Continued

MILIAMMUNA										HYPERAMMUNA							
Sam- Ple	Mesh Size	A	B	C	D	E	F	G	H	A	B	C	D	E	F	G	H
2026	80					3				2							
	100		1	4	1					3		1					
	150		1	2	1					1	1	1					
Totals			24	56	24	12				40	20	20					
2036	80									10	4						
	100				1	5				3	7						
	150					1				7	5						
Totals					6	36				77	79						
2046	80	1		3													
	100	1			1					7							
	150		8		2					4							
Totals		32	48	60	24					108							
2056	100	5	2	4						3							
to																	
2064	150	2	2	3						12							
Totals		54	36	60						162							
2064	80	2								4							
to	100	4	5	4						7							
2073	150	15	4	4						11							
Totals		62	30	26						72							

OF THE GENUS

GLIOMOSP IRA

[illegible]

Continued

VERNEUILINA

GLIOMSPTRA

Sample	Mesh Size	A	B	C	D	Canadensis	A	B	C	D	E	F	G	H	I
2064 to 2073 Totals	80 100 150										1 3 2 21				
2076 to 2086 Totals	80 100									1 1 12 12					
2105 to 2107 Totals	80	1	1												
2108 to 2113 Totals	48 80 150	1					1 2	1 20							
2113 to 2118 Totals	80 100 150	3	4				2 6 10 60								
2118 to 2124 Totals	100 150						1 9 93								
2125 to 2128 Totals	48 80 100						1 2 1 16								

GAUDRYINA

Sam- ple	Mesh Size	A	B	C	D	E	F	G	H	I	J	K	L	Cana- densis	cf Cana- densis
1954	80 Totals			1 2											
1964	80 Totals			2 40	2 40	1 20	1 20					1 20	2 40		
1974	80 Totals				1 1										
1984 to 1996	48 80 Totals											1 1			
2076 to 2086	80 Totals			3 18	2 12					6 36					
2105 to 2107	80 Totals				1 5	1 5	1 5	1 5	1 10	2 15	1 3			1 5	
2108 2113	80 Totals			7 140	1 20	3 60		1 20	2 40					1 20	1 20
2113 to 2118	48 80 Totals					1 20	1 11	1 11							1 10
2118 to 2124	48 80 Totals						1 30	1 10	2 25	3 11	3 15			2 10	1 5
2125 2128	80 Totals	2 10	1 5	4 20	2 10	1 5								4 20	1 5

STATISTICAL SPECIFIC RECORD
OF THE GENUS
REOPHAX

Sample	Mesh	Size	A	B	C	D	E	F	G	H	I	J	K
1954	80					2	1				1	1	
Totals						4	2				2	2	
1964	28				2		1				2		
	48				3		3		1		8	1	
	80						2				14	6	2
Totals					62		61		40	1	21	290	121 40
1974	80												
Totals										1	2		
1984	80							1					
to													
1996 Totals								2					
2026	80												
Totals										3	12		
2036	80												
Totals					1		1			2	3		
2046	48												
	80						4		1		1		
Totals							80		121		21	20	
2056	80												
to							2						
2064							20						
2113	80												
to													
2118 Totals							10	20					

PERCENTAGE POPULATION TABLE

Sample													
1934	Haplophragmoides	0	8	10	0	9	29	2	8	0	0	12	30
1944	Ammobaculites	10	28	7	0	8	30	0	1	2	0	9	20
1954	Ammobaculoides	6	7	0	0	0	11	41	4	0	0	2	6
1964	Reophax	10	8	0	0	17	20	2	2	7	0	10	9
1974	Hyperammina	7	29	0	0	6	6	4	4	19	1	0	11
1984-1996	Proteonina	15	12	0	0	0	19	3	4	3	0	0	10
2007-2026	Leptodermella	1	0	0	0	3	0	3	0	5	0	0	1
2026	Gaudryina	24	13	4	0	3	4	20	3	3	2	0	2
2036	Verneuilina	24	4	0	0	7	10	3	2	20	2	0	4
2046	Trochammina	21	34	0	0	14	1	0	0	3	9	1	3
2056-2064	Miliammina	54	30	0	0	2	2	0	0	2	1	0	4
2064-2073	Spores	58	17	0	0	0	6	0	0	2	0	0	10
2076-2086	Others	71	7	0	0	0	1	12	2	12	0	0	7
2105-2107	Total %	39	25	22	0	1	3	0	0	14	5	0	3
2108-2113		27	34	6	0	0	1	0	0	15	1	0	2
2113-2118		29	10	4	0	2	3	0	0	27	1	0	0
2118-2124		31	18	0	0	0	1	0	0	0	0	0	0
2125-2128		20	10	46	0	0	1	0	0	1	0	0	1

B29758