Division of Geological & Geophysical Surveys

PUBLIC-DATA FILE 93-42

LATERAL FACIES CHANGES IN THE CARBONIFEROUS LISBURNE GROUP ALONG THE AICHILIK TRANSECT, NORTHEASTERN ALASKA

by

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March 1993

Released by

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
Division of Geological & Geophysical Surveys
794 University Avenue, Suite 200
Fairbanks, Alaska 99709-3645

ABSTRACT

The Carboniferous Lisburne Group was formed along an extensive, south-dipping carbonate ramp in response to a marine transgression that onlapped northeastward across northern Alaska. Lateral thickness variations and facies changes within the Lisburne Group reveal a significant southward thickening and deepening trend. Detailed analysis of this trend is providing insights into the paleogeography, depositional history, and subsidence of the Lisburne carbonate platform in the Arctic National Wildlife Refuge.

Two stratigraphic sections were measured along a north-south transect (the Aichilik River transect) across the Lisburne carbonate platform in order to document changes in thickness and depositional environment. The section in the north is dominated by shallow-marine lithologies including thick successions of cross-stratified grainstones representing shoal environments, and restricted-marine lithologies such as peloidal spiculitic packstone.

The section in the south is significantly thicker than its counterpart in the north, indicating differential subsidence of the platform. Although the Southern section has not been analyzed in detail at this time, the lithologies are quite unlike those in the Northern section. The dominant lithologies were deposited in deeper water with normal marine circulation, with minor lithologies indicating intertidal, restricted-platform and shoal environments. Solitary and colonial corals in muddy lithologies are prevalent in this section, and represent open-marine conditions below wave base.

INTRODUCTION

During reconnaissance studies in 1988 and 1989, Keith Watts discovered a basinward increase in thickness and distinct lateral facies changes in the Lisburne Group from north to south along the Aichilik transect in the northeastern part of the Arctic National Wildlife Refuge (Watts 1989 and 1990). He measured two sections; a complete section near Bathtub Ridge at the southern end of the transect, and a composite section between the Egaksrak and Aichilik rivers at the northern end of the transect (Fig. 1). Since Watts' field work was of a reconnaissance nature, I analyzed the sections in more detail in 1992.

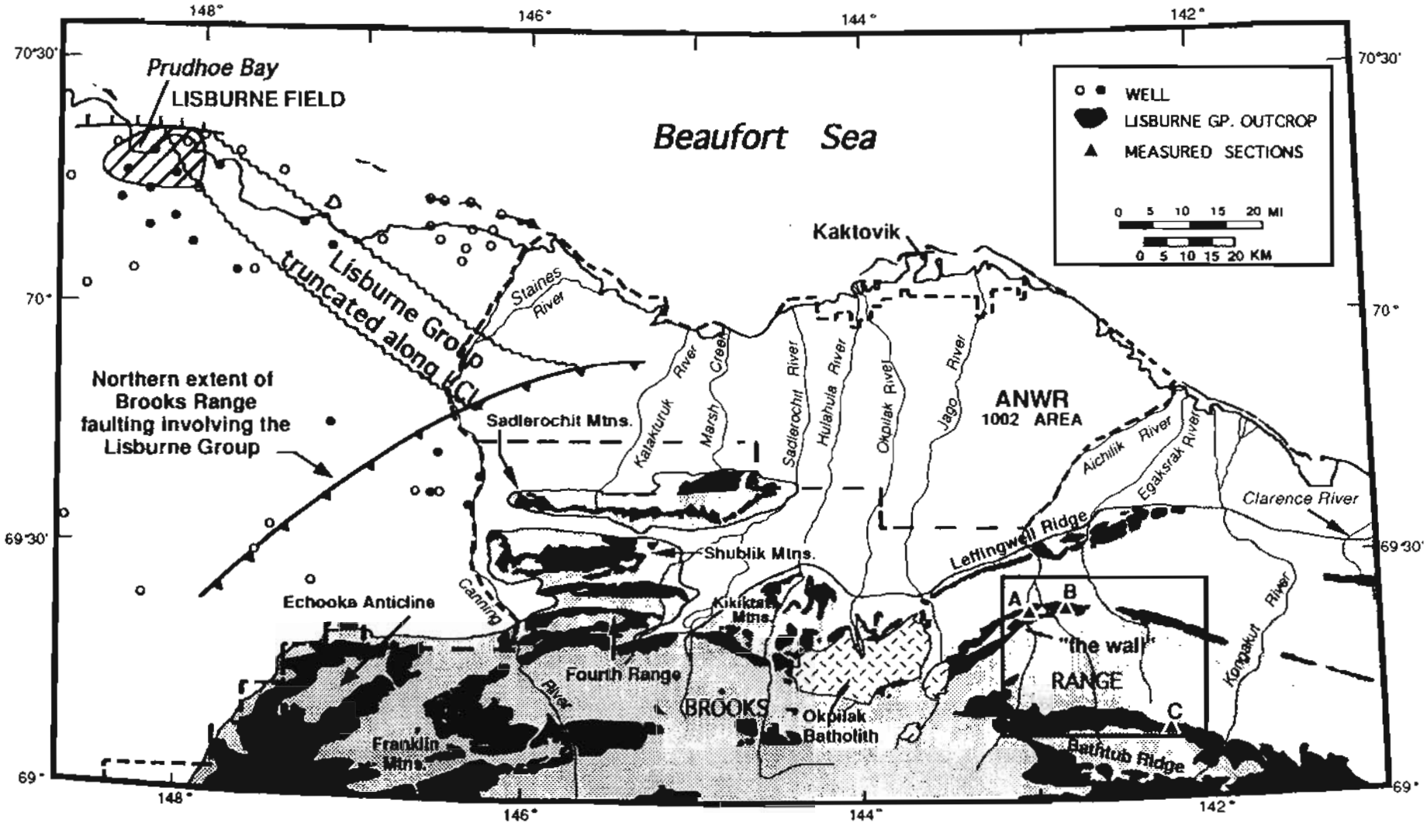


Figure 1 - Map of northeastern Alaska illustrating Lisburne Group exposures (black-colored areas), the mountains of the Brooks Rang (stippled pattern), and the 1002 region of the Arctic coastal plain in the Arctic National Wildlife Refuge. Black triangles are the locatior of measured sections. A - Aichilik section (upper part of the Northern section), B - Egaksrak section (lower part of the Northern sectio C - Southern section, modified from Watts and others (1991).

The lateral variations between the sections in this study inspire several questions. How do depositional environments change as distance from the shoreline and water depth increase? What do these paleoenvironmental changes tell us about the paleogeography of the carbonate platform? Does the basinward increase in thickness across this north-south transect represent differential subsidence and increased carbonate production rates? If so, was this differential susidence a product of passive margin subsidence? In order to resolve these questions, the objectives of this study are:

1) To use microfacies analysis to interpret depositional environments, which in turn can provide information regarding water depth, salinity, and platform geometry;

2) To determine whether measured thicknesses and biostratigraphic ages derived from this study can provide insights about differential subsidence rates and carbonate production rates, and

3) To interpret the depositional and tectonic history of the Lisburne carbonate platform.

MEASURED SECTIONS

In the northern part of the study area, two incomplete measured sections together form a composite section along "the wall", which I will refer to as the Northern section (Fig. 2). "The wall" is a distinctive ridge composed of Ellesmerian rocks located south of correlative rocks that form Leffingwell Ridge. The lower part of this composite section is located between the Egaksrak and Leffingwell Fork Rivers (Egaksrak section) (Fig. 1). The upper part of the composite section is located approximately five miles west of the Egaksrak section, along the Aichilik River (Aichilik section) (Fig. 1). The Egaksrak and Aichilik sections are part of the same synclinal structure. In the south, a section is located near Cottonwood Creek north of Bathtub Ridge, and I will refer to it as the Southern section (Fig. 1).

Samples for microfacies analysis were collected where changes in lithology were noted (approximately every few meters), and conodont samples were collected at 30-50 meter intervals. Approximately one-half of the thin sections made from these samples have been analyzed at this time; therefore the descriptions that follow are preliminary results. Common lithologies occurring

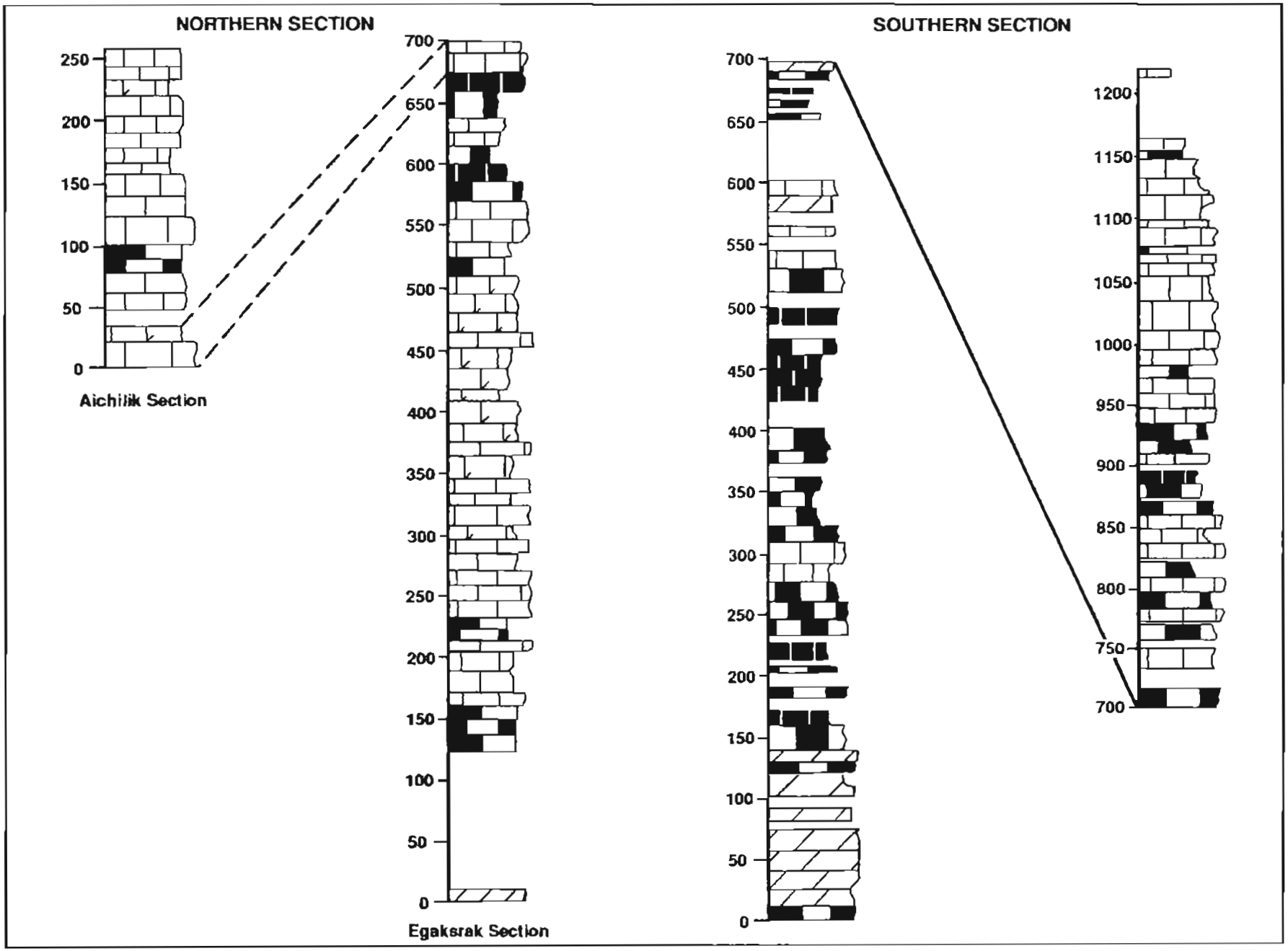


Figure 2 - Diagram showing preliminary correlation between the Aichilik and Egaksrak sections, and relative thicknesses of the Northern and Southern sections.

within the Northern and Southern sections are described in the appendix, and the corresponding lithologic names are used in the descriptions that follow.

NORTHERN SECTION

The lower part of the Northern section, the Egaksrak section, is 676 meters thick and is a well-exposed, nearly a complete section of the lower part of the Lisburne Group (Fig. 4). The lower half of the Egaksrak section is informally named the "lower cross-stratified grainstone" and occurs within the Alapah Limestone. The upper half of the Egaksrak section is informally named the "middle skeletal limestone" and consists of skeletal packstones and wackestones with lesser skeletal grainstones and mudstones.

The 256 meter thick Aichilik section is the upper part of the Northern section. (Fig. 5). The Aichilik section is a complete section of the upper Lisburne Group, but only the top portion was measured due to faulting in the lower part. Much of the Aichilik section is strained, presenting difficulties in correlation and thickness determinations. However, most grains and lithologies are recognizable for microfacies analysis.

The lower part of the Aichilik section is part of the "middle skeletal limestone" previously mentioned. As in the Egaksrak section, this unit contains skeletal wackestone and packstone with lesser skeletal grainstone and mudstone. The upper portion of the Aichilik section is characterized by oolitic grainstones within the Wahoo Limestone, and is informally named the "upper oolitic grainstone".

Lower Cross-Stratified Grainstone

The lower cross-stratified grainstone occurs within the Egaksrak section and is part of the Alapah Limestone. Dolostone, laminated peloidal packstone, wackestone and mudstone, oncolitic rudstone, interclastic packstone, and algal boundstone occur at the base of this unit and represent intertidal to restricted environments. Overlying these lithologies is a 250 meter thick succession of alternating cross-stratified skeletal grainstone and skeletal and peloidal packstones. This succession represents shoals alternating with restricted and open-platform environments.

ROCK TYPES

SKELETAL GRAINS

- Pelmatozoan
- Bryozoan (full-frond fenestrate)
- Bryozoan (undifferentiated)
- Brachiopod
- Bivalve
- Gastropod
- Foraminifera
- Trilobite
- Ostracod
- Oncolites
- Sponge Spicule
- Colonial Coral
- Solitary Coral
- Coral (undifferentiated)
- *Asphaltina sp.*
- *Donezella sp.*
- *Calcisphaera sp.*
- Algae (undifferentiated)
- Bioclast (undifferentiated)

NON - SKELETAL GRAINS

- Ooid
- Superficial Ooid
- Peloid
- Intraclast
- Grapestone
- Detrital Quartz
  - qtz - Silt-sized
  - Qtz - Sand-sized
  - qQtz - Silty - Sandy Quartz with Silt Dominant

GRAIN ABUNDANCE

Major ≥ 10%
! > 50%

Minor < 10%
( ) < 1%

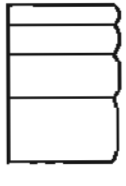
GRAIN ABRASION

- Highly Abraded
- Moderately Abraded
- Poorly Abraded
- Covered Interval
- Questionable

GRAIN MICRITIZATION

- Highly Micritized with Micritic Envelopes
- Moderately Micritized & Lacking Envelopes
- Poorly Micritized
- Covered Interval
- Questionable

BED THICKNESS



- Thin-bedded (< 20cm)
- Medium-bedded (20 - 50cm)
- Thick-bedded (50 - 150cm)
- Very Thick-bedded (> 150cm)

SEDIMENTARY STRUCTURES

- Plane-parallel Laminae
- Low-angle Cross-laminae & (or) -bedding
- High-angle Cross-bedding
- Articulated Crinoid Stems
- Cryptalgal Laminae
- Scour Structure
- Bioturbated
- Highly Bioturbated
- Burrow Structure
- Coarsening Upward
- Fining Upward
- Fenestral Fabric (Birdseye Structure)

DIAGENETIC FEATURES

- Nodular and/or Lensoidal Chert
- Chert Replacement of Grains
- Calcitized and (or) Silicified Evaporite Nodules
- Radiating, Calcitized and (or) Silicified Evaporite Crystals
- Solution Collapse Breccia
- Fracture
- Stylolite
- Py - Pyrite
- G - Glauconite
- Ph - Phosphate
- Highly Compacted Grains
- Well-developed Isopachous Rim Cement
- Spar-filled & (or) Unfilled Moldic Porosity & Dropped Nuclei of Ooids
- ! - Very Common
- ( ) - Minor

Figure 3 - Key to symbols used in stratigraphic columns.

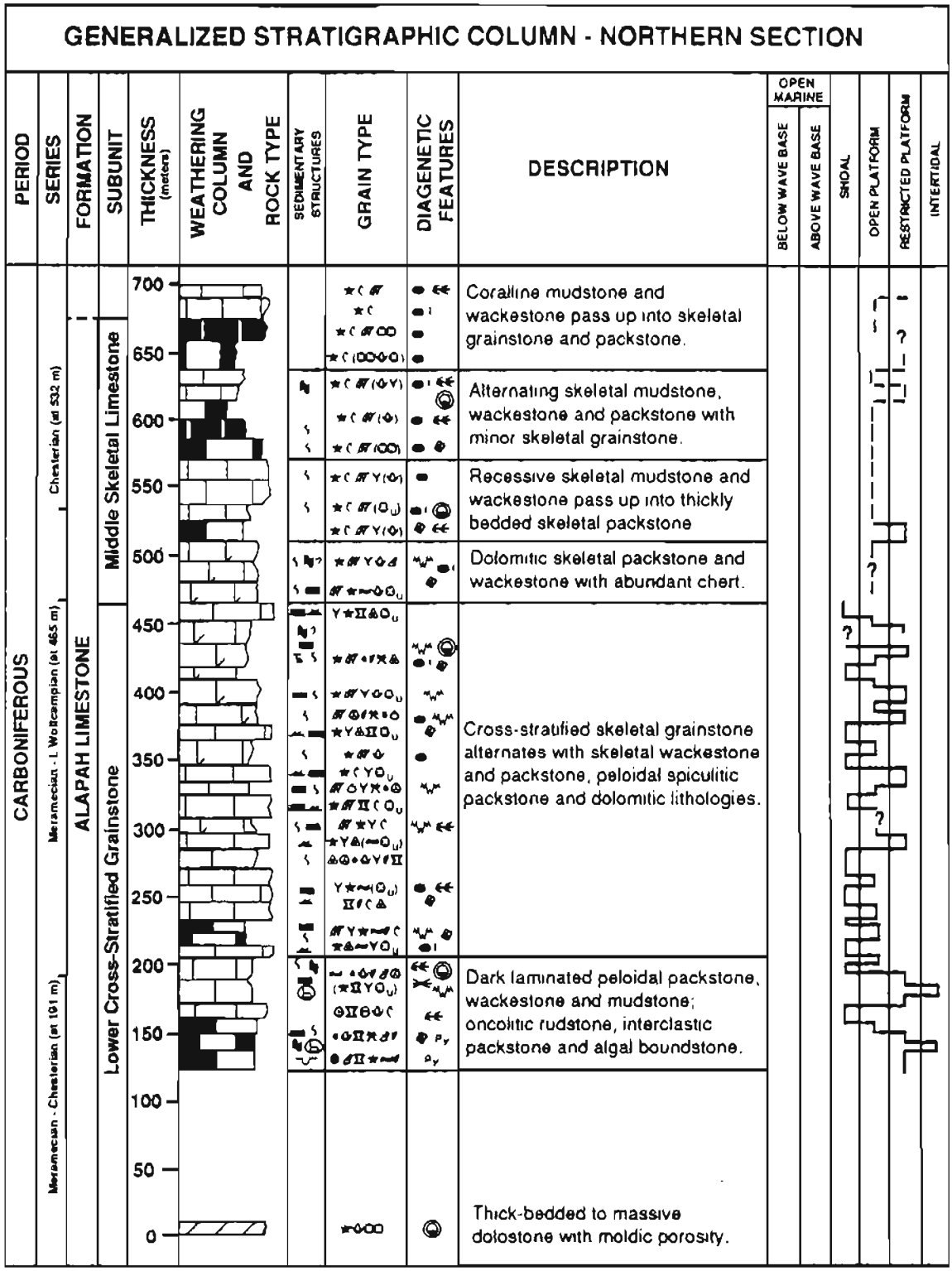


Figure 4 - The Lisburne Group of the Egaksrak section includes a succession of cross-stratified grainstones within the Alapah Limestone.

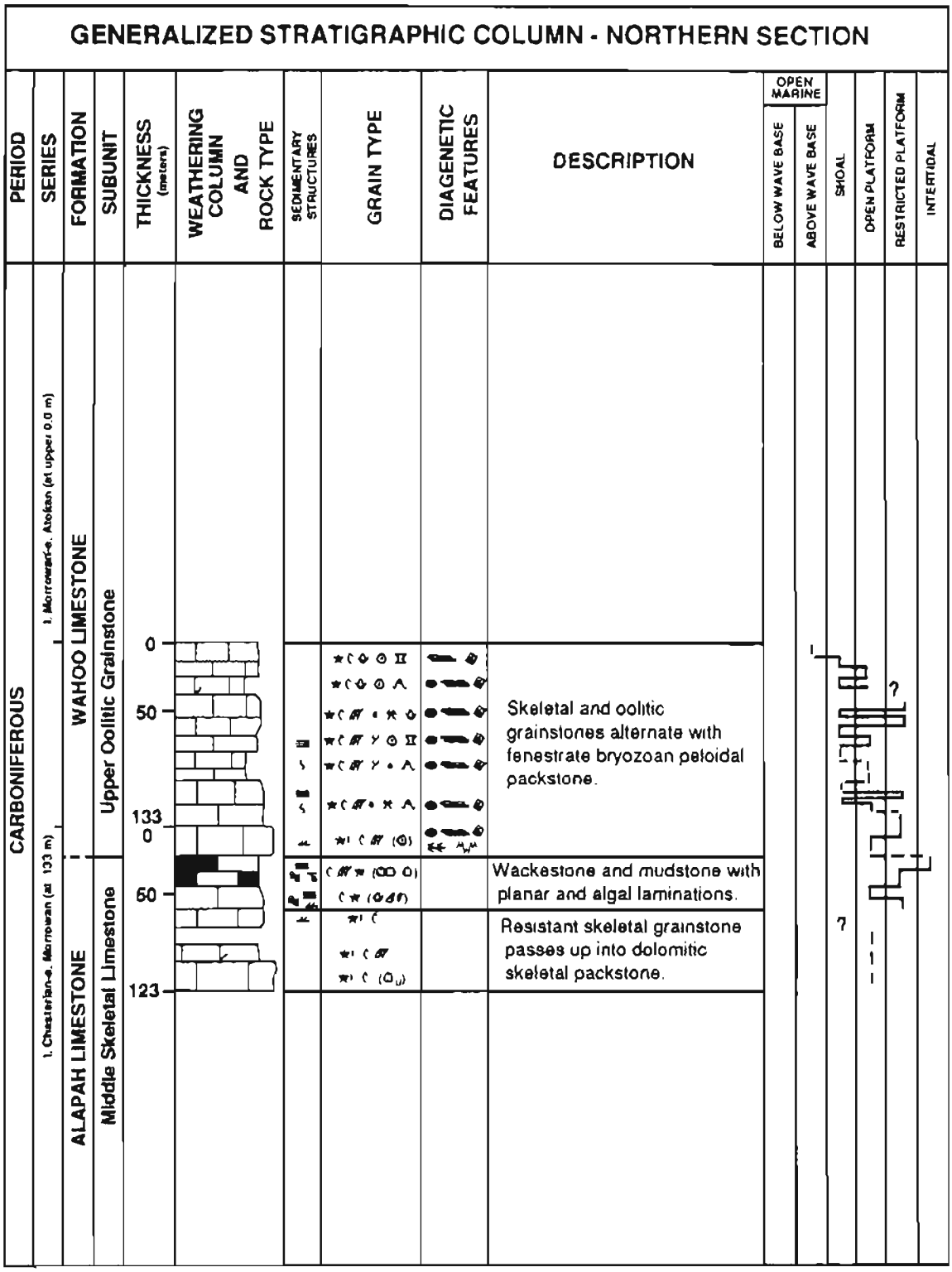


Figure 5 - The Lisburne Group of the Aichilik section was measured from the top. The upper 133 meters was measured by Keith Watts, the lower 123 meters was measured by Mary Eckstein.

Middle Skeletal Limestone

The middle skeletal limestone occurs at the top of the Egaksrak section and base of the Aichilik section. The unit is dominated by open-platform and open-marine pelmatozoan bryozoan packstones and wackstones. Coralline and skeletal mudstones, algal boundstone, and pelmatozoan grainstone occur in lesser quantities.

Upper Oolitic Grainstone

The 155 meter thick upper oolitic grainstone occurs within the Wahoo Limestone at the Aichilik section, and possibly in the uppermost portion of the Egaksrak section. Cross-stratified, oolitic and skeletal grainstones representing shoals alternate with fenestrate bryozoan peloidal packstone representing open and restricted-platform environments.

SOUTHERN SECTION

The Southern section is a thick section dominated by muddy lithologies containing abundant corals indicating more open-marine conditions than those found in the north (Figs. 6 and 7). The section is relatively complete and is 1219 meters thick. Despite several large covered intervals the section does not appear to be structurally duplicated, as indicated by the lack of strained grains in thin section. Mamet and Armstrong have measured sections of Lisburne in the Romanzoff and Franklin Mountains that have comparable thicknesses (Mamet and Armstrong, 1972). The contact between the Alapah and the Wahoo Limestones is indistinct and a fairly thick portion (several hundreds of meters) is composed of lithologies that are transitional between typical Alapah and Wahoo lithologies.

The base of the Southern section contains abundant solitary and colonial corals and is informally named the "lower coralline wackestone". A similar lithology without abundant corals lies above, and is informally named the "middle pelmatozoan bryozoan limestone. A massive, light-colored, cliff-forming limestone at the top of the Southern section contains abundant pelmatozoans and bryozoans and is informally named the "upper pelmatozoan bryozoan grainstone".

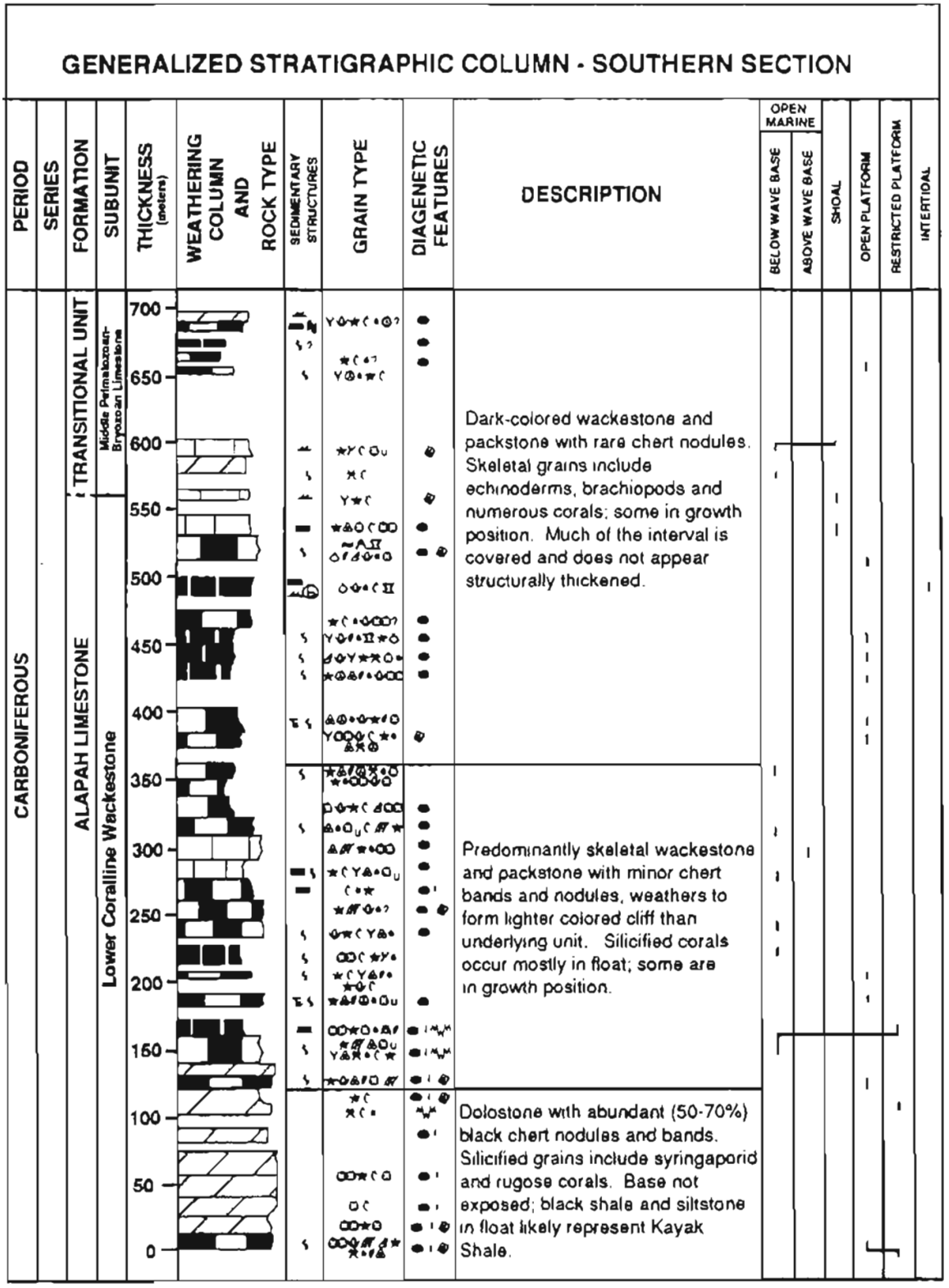


Figure 6 - The Lisburne Group in the lower portion of the Southern section contains abundant corals in muddy lithologies.

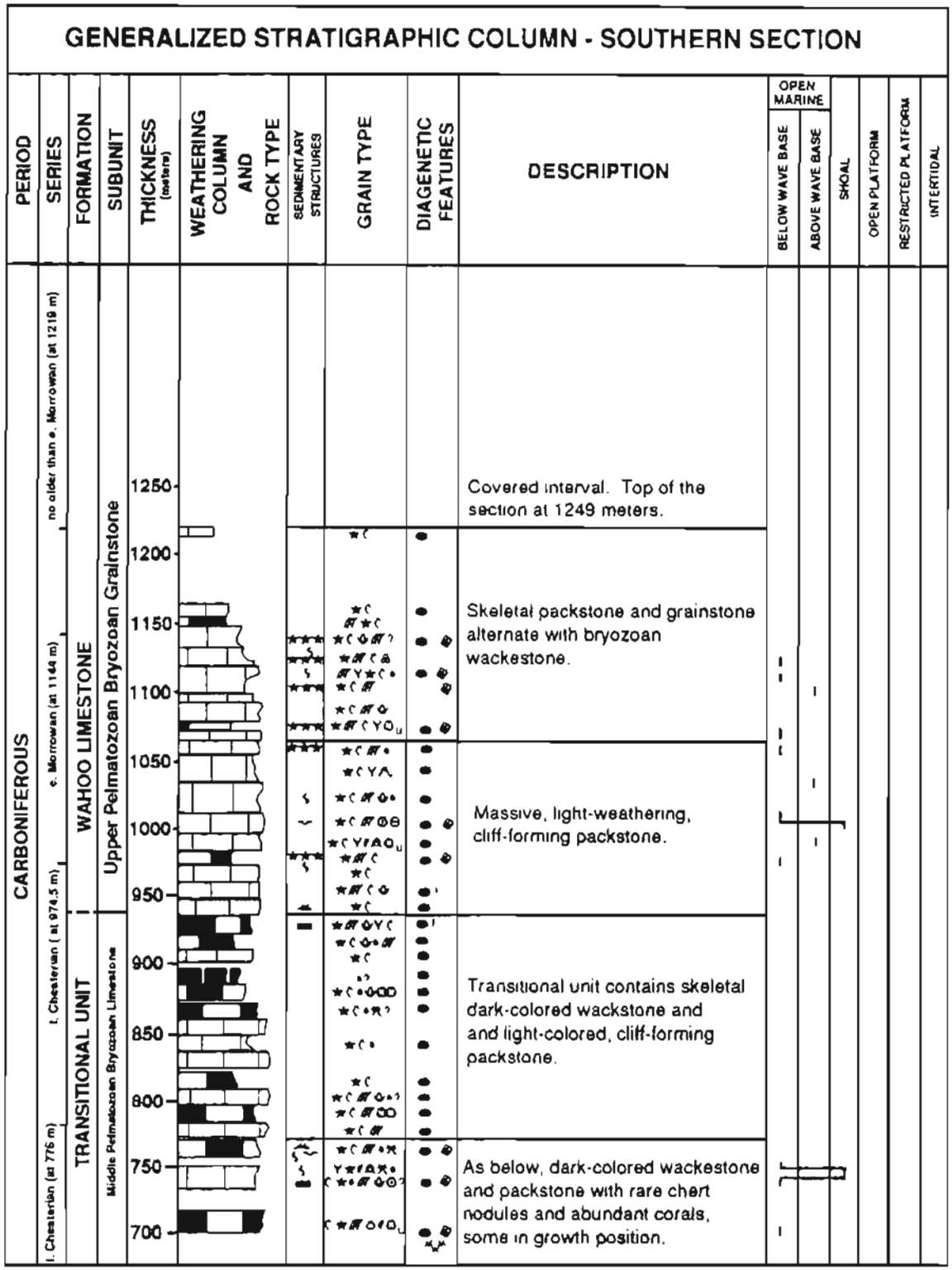


Figure 7 - The Lisburne Group in the upper portion of the Southern section contains abundant pelmatozoans and bryozoans in grainy lithologies.

Lower Coralline Wackestone

The lower coralline wackestone occurs within the Alapah Limestone. A 100 meter interval of dolostones containing abundant black chert nodules and bands occurs at the base of the unit. This lithology contains pelmatozoans, corals, peloids and sponge spicules representitive of either open-platform or open-marine environments. Skeletal wackestone and packstone 400 meters thick with abundant chert and corals occurs above this, and represents restricted-platform, open-platform, and open-marine conditions. At the top of the lower coralline wackestone unit, coral and chert become less abundant. An occurence of peloidal interclastic mudstone near the top of the lower coralline wackestone indicates a short period of subaerial exposure punctuating a long interval of open-marine conditions.

Middle Pelmatozoan Bryozoan Limestone

The middle pelmatozoan bryozoan limestone is a 375 meter thick succession of skeletal packstone, wackestone, and mudstone with lesser grainstone. Abundant pelmatozoans, bryozoans, and lesser corals in muddy lithologies represent an open-marine environment. Well-sorted and well-rounded grainstones are uncommon and represent a shoal environment

Upper Pelmatozoan Bryozoan Grainstone

Massive, light-colored, cliff-forming skeletal packstone and grainstone with minor wackestone comprise the top 200 meters of the Southern section. Articulated crinoids, pelmatozoans, and ramose and fenestrate bryozoans dominate the skeletal grains, representing an open-marine environment with lesser shoals. The upper pelmatozoan bryozoan grainstone occurs within the Wahoo Limestone.

CORRELATION

In order to meet the objectives of this project, the Egaksrak and Aichilik sections (Northern section) must be correlated and then compared to the Southern section. Since the Aichilik section is strained, correlation may not be

straightforward. However, since many of the lithologies of the Aichilik section can be identified, lithostratigraphic correlation of the Northern section is valid. Thickness determinations, however, might be difficult to determine for the Northern section due to considerable compaction and pressure solution at the Aichilik site. Preliminary correlation of the Northern section is based on the first occurence of resistant, well-sorted grainstones above the muddy lithologies of the middle skeletal limestone unit (Fig. 2). Since the thin sections from the top of the Egaksrak section and the lower part of the Aichilik section have not been analyzed yet, this correlation is tentative.

CONTINUING STUDIES

Microfacies analysis has not been completed at this time; therefore results presented in this report are tentative. Approximately 250 thin sections have been analyzed, and about the same amount remain to be examined. Conodont samples will be processed and examined by Andrea Krumhardt, (Tectonics and Sedimentation Research Group, UAF) and will provide both age control and conodont alteration indices. Well-constrained age dates and a more thorough understanding of the lithologic successions in the study areas will allow for a complete analysis of this project.

APPENDIX 1

Common Lithologies

Common Lithologies of the Northern and Southern Sections

Oncolitic Packstone and Wackestone

Oncolitic packstone and wackestone occurs only at the Northern (Egaksrak) section, and common in the lower half of ther in the lower part of the Alapah Limestone. Although not common, it is important because it indicates a restricted-platform environment. Common as a packstone or wackestone, and less common as a rudstone, this lithology contains abundant oncolites and intraclasts with lesser calcispheres, gastropods, ostracodes, brachiopods and algae.

Peloidal Packstone

Peloidal packstone is abundant in the lower 400 meters of the Northern section (Egaksrak section) and common in the lower half of the Southern section. The peloidal packstone contains abundant fecal pellets (peloids), common intraclasts and sponge spicules, with lesser fenestrate bryozoans, algae, calcispheres, gastropods, and ostracodes, and indicates formation in a restricted-platform setting. Commonly, a different peloidal packstone contains most of the grains above except sponge spicules, gastropods, and ostracodes, and includes ramose bryozoans and echinoderms. The depositional environment of this second type of peloidal packstone is interpreted to be open platform.

Skeletal Packstone and Wackestone

Skeletal packstone and wackestone is a relatively common lithology throughout the lower portion of the Northern section and most of the Southern section. Prevalent grains include echinoderms, both fenestrate and ramose bryozoans, and forams. Less abundant are ostracodes, trilobites, calcispheres, algae (including Archeolithophyllum), bivalves, corals, intraclasts, brachiopods, sponge spicules, fecal pellets, and burrows. These grains indicate open-platform or open-marine conditions.

Skeletal Grainstone

Well-sorted and strongly abraded skeletal grainstone is a prevalent lithology in the lower 100-500 meters of the Northern (Egaksrak) section and occurs in the upper half of the Southern section. In the Egaksrak section, resistant, light-colored, cross-stratified grainstone occurs in repeated intervals 5-15 meters thick and represents a shoal environment. Echinoderms, coral fragments, and bryozoans are common with numerous micritized grains. Forams, intraclasts, ooids, and algae including Asphaltina and Archeolithophyllum occur less abundantly.

Oolitic Grainstone

Oolitic grainstone is fairly common in the upper part of the Northern (Aichilik) section, and formed in a shoal environment. Abundant grains include ooids, superficial ooids, echinoderms, forams, bryozoans, and completely micritized grains. Gastropods, corals, algae, and intraclasts are less common. Although the skeletal grains are strongly abraded, the oolitic grainstone is only moderately sorted.

Pelmatozoan Grainstone

The pelmatozoan grainstone appears near the top of the Northern and Southern sections. Echinoderms, forams, ramose bryozoans, Asphaltina, and completely micritized grains are the prevalent grains. Intraclasts, ooids, algae (including Asphaltina and Archeolithophyllum), ostracodes, coral fragments, Archeolithophyllum, and trilobites are less abundant. The pelmatozoan grainstone is poorly to moderately sorted and weakly to moderately abraded, representing an open-marine environment above wave base.

Peloidal Intraclast Mudstone

Although only a singular occurrence near meter 500 of the Southern section, the peloidal intraclast mudstone is important because it may represent subaerial exposure. The prevalent grains are fecal pellets and intraclasts within

a fenestral fabric, along with calcite replacing gypsum and auto breccia. This intertidal representative is unique among the open marine lithologies of the Southern section.

Spiculitic Calcispheric Packstone

This open-platform lithology is common in the lower half of the Southern section. Sponge spicules, calcispheres, echinoderms, bryozoans, and corals are the prevalent grains with fewer gastropods, ostracodes, fecal pellets, forams, fenestrate bryozoans, brachiopods and algae. Calcispheric packstone without sponge spicules and coralline boundstone are also common and represent an open-platform environment.

ACKNOWLEDGMENTS

This project was funded by ARCO Alaska, BP Exploration, Chevron, Exxon, Japan National Oil Corporation, Phillips, Texaco, and the U.S. Department of Energy.

REFERENCES CITED

Mamet, B.L., and Armstrong, A.K.,1972, Lisburne Group, Franklin and Romanzof Mountains, northeastern Alaska, USGS Prof. Paper 800-C, pp.C127-C144.

Watts, K.F., 1989, Carboniferous Lisburne Group of the Arctic National Wildlife Refuge, Brooks Range, northeastern Alaska, progress report summarizing initial results of 1988 research: Alaska Division of Geological and Geophysical Surveys Public Data File Report 89-1G, 21 p.

Watts, K.F., 1990, Carboniferous Lisburne Group of the Arctic National Wildlife Refuge, northeastern Brooks Range, Alaska, progress report summarizing initial results of 1989 research: Alaska Division of Geological and Geophysical surveys Public Data File Report, 22 p.