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ANALYSIS OF RESERVOIR HETEROGENEITIES DUE TO SHALLOWING-UPWARD CYCLES IN CARBONATE ROCKS OF THE PENNSYLVANIAN WAHOO LIMESTONE OF NORTHEASTERN ALASKA

Annual Report for the Period
September 1989-September 1990

By
Keith F. Watts

September 1992

Performed Under Contract No. AC22-89BC14471

University of Alaska
Fairbanks, Alaska

Bartlesville Project Office
U. S. DEPARTMENT OF ENERGY
Bartlesville, Oklahoma

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Prepared for
U.S. Department of Energy
Assistant Secretary for Fossil Energy

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Abstract

The primary objective of this project is to develop an integrated database to characterize reservoir heterogeneities resulting from numerous small-scale shallowing-upward cycles (parasequences) comprising the Pennsylvanian Wahoo Limestone. The Wahoo Limestone is the upper part of an extensive carbonate platform sequence of the Carboniferous Lisburne Group that is widely exposed in the Brooks Range and is a widespread hydrocarbon reservoir unit in the subsurface of the North Slope of Alaska. A major goal is to determine lateral and vertical variations in the complex mosaic of carbonate facies comprising the Wahoo Limestone.

This report presents the preliminary results of research accomplished by a team of specialists in carbonate petrology, biostratigraphy, and diagenesis during the 1989-1990 fiscal year. It includes a summary of some of the petrographic data which has been entered into a computerized database; a discussion of biostratigraphic data, particularly conodont biofacies analyses; an overview of diagenetic studies; and a section of the regional geological framework studies. The database is allowing us to test which parameters, such as ooids, can be used to recognize and understand the carbonate petrology of the shallowing-upward cycles. The cycles have been interpreted in terms of depositional environments and sea-level fluctuations and used to develop detailed facies models. Conodont biostratigraphy is providing an independent means of correlation and age dating. Conodont biofacies analyses are being related to paleoenvironments as determined by carbonate facies analysis. Analyses of diagenesis have allowed recognition of a number of subaerial exposure surfaces that are another important means of correlation and will figure importantly in developing sea level curves. Regional studies provide an understanding of lateral facies relationships and how position on a southward-facing carbonate ramp affects the nature of carbonate shallowing-upward cycles. In order to understand the overall basin history and its relationship to the stratigraphic and structural framework, our research also considers aspects of rock units adjacent to the Wahoo Limestone, the underlying Alapah Formation and overlying Echooka Formation.

Our correlation scheme, using distinct marker beds and cyclic stratigraphy, will allow us to interpret the depositional history and paleogeographic evolution of the region and to develop predictive facies models and paleogeographic maps. Our detailed analysis of the Wahoo Limestone will provide a basis for interpreting correlative rocks in the adjacent subsurface of the coastal plain of ANWR, a potential hydrocarbon lease-sale area. In a broader sense, our work will provide an excellent generic example of carbonate shallowing-upward cycles which typify carbonate sediments. If the cyclicity resulted from global (eustatic) sea-level fluctuations, our sea level curves may be applicable to Pennsylvanian rocks elsewhere.

Executive Summary / Introduction

The primary objective of the project is to develop an integrated database to characterize reservoir heterogeneities resulting from numerous small-scale shallowing-upward cycles comprising the Pennsylvanian Wahoo Limestone. The Wahoo Limestone is the upper part of an extensive carbonate platform sequence of the Carboniferous Lisburne Group that is widely exposed in the Brooks Range and is a widespread hydrocarbon reservoir unit in the subsurface of the North Slope of Alaska (Figs. 1 & 2).

The project involves a number of carbonate researchers from four institutions (Table 1). A computerized database system is being developed to accommodate information on carbonate petrology, diagenesis and biostratigraphy derived from our analyses of thousands of samples systematically collected from over 25 stratigraphic sections in the Arctic National Wildlife Refuge (Fig. 3, Table 2). The objective is to determine lateral and vertical variations in the complex mosaic of carbonate facies comprising the Wahoo Limestone.

Our correlation scheme, using distinct marker beds and cyclic stratigraphy, will allow us to interpret the depositional history and paleogeographic evolution of the region and to develop predictive facies models and paleogeographic maps. Biostratigraphic data, provided by Dr. Bernard Mamet (University of Montreal; algae and foraminifera) and Dr. Anita Harris (U.S. Geological Survey; conodonts), will serve as independent means of correlation (Table 1). Exposure surfaces and associated variations in cement stratigraphy analyzed by Dr. Robert Goldstein and Randall Carlson (University of Kansas) will figure importantly in refining our correlations.

The ultimate goal is to construct sea level curves modeling the carbonate cycles and to determine our ability to use cyclic stratigraphy as a means of correlation. In the later stages of the project, we will examine the relationship between cyclic stratigraphy and reservoir properties in correlative rocks at the Lisburne field, in addition to testing our ability to use cyclic stratigraphy for regional correlations. Our detailed analysis of the Wahoo Limestone will provide a basis for interpreting correlative rocks in the adjacent subsurface of the coastal plain of ANWR, a potential hydrocarbon lease-sale area. In a broader sense, our work will provide an excellent example of carbonate shallowing-upward cycles which typify carbonate sediments. If the cyclicity resulted from global (eustatic) sea-level fluctuations, our sea level curves may be applicable to Pennsylvanian rocks elsewhere.

This report presents the results of research accomplished during the 1989-1990 fiscal year and supplements the four quarterly DOE technical reports completed during this period (Watts, 1990 a-d). It includes a summary of some of the petrographic data that has been entered into a computerized database; a discussion of biostratigraphic data, particularly conodont biofacies analyses; an overview of diagenetic studies; and a section of the regional geological framework studies. As such, this progress report summarizes some of the major advances made on our integrated stratigraphic studies on carbonate shallowing-upward cycles supported by the Department of Energy contract and a consortium of oil industry sponsors.

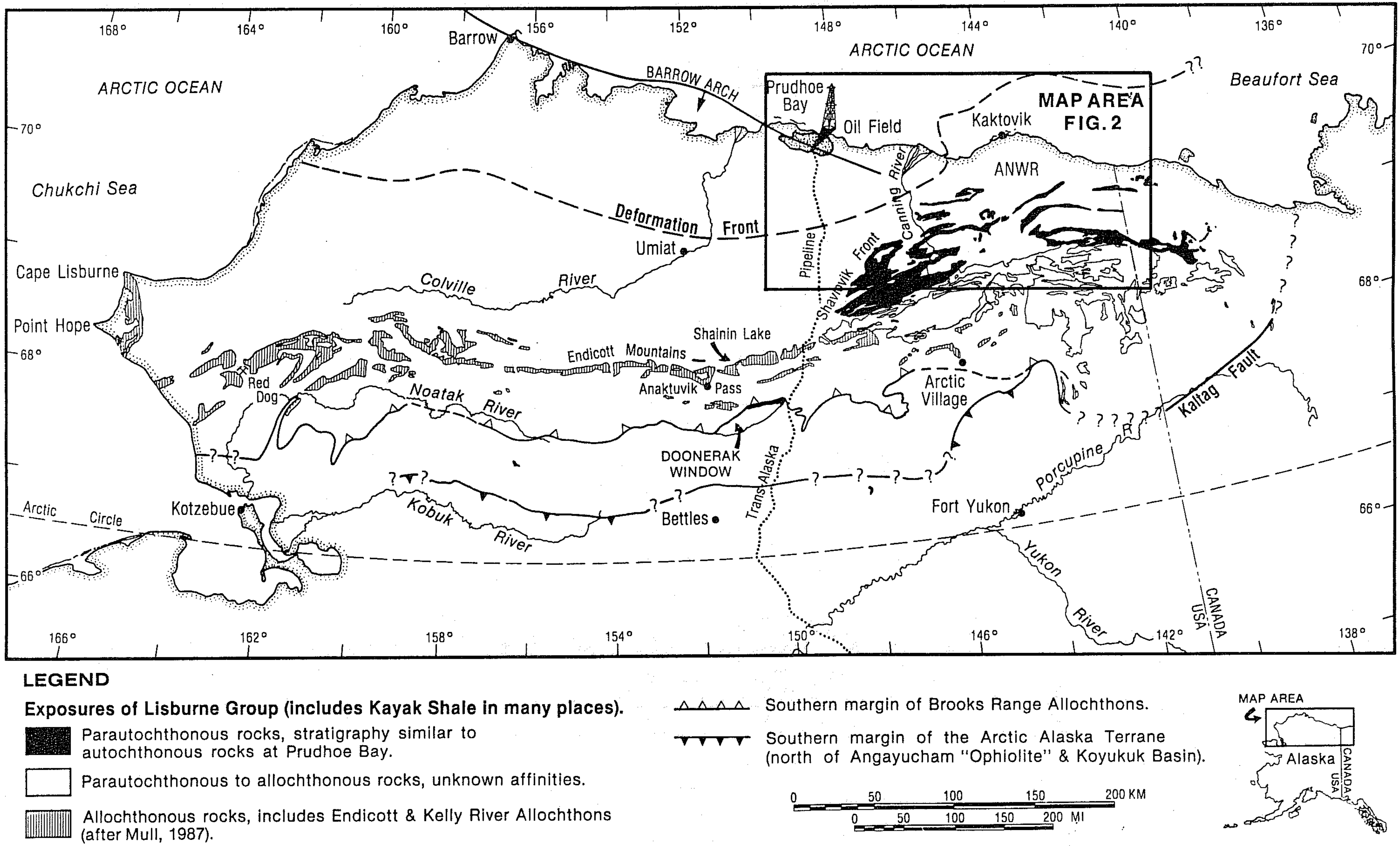


Figure 1- Geologic map showing the distribution and tectonic affinities of the Lisburne Group exposed in the Brooks Range. Compiled from Grybeck et al., 1977 (Alaska Lisburne Group), Norris, 1982 (Canada Lisburne Group), Craig et al., 1985 (Barrow Arch and deformation front), Mull et al., 1987 (allochthons), and Wesley Wallace, pers comm. (parautochthon vs. allochthon).

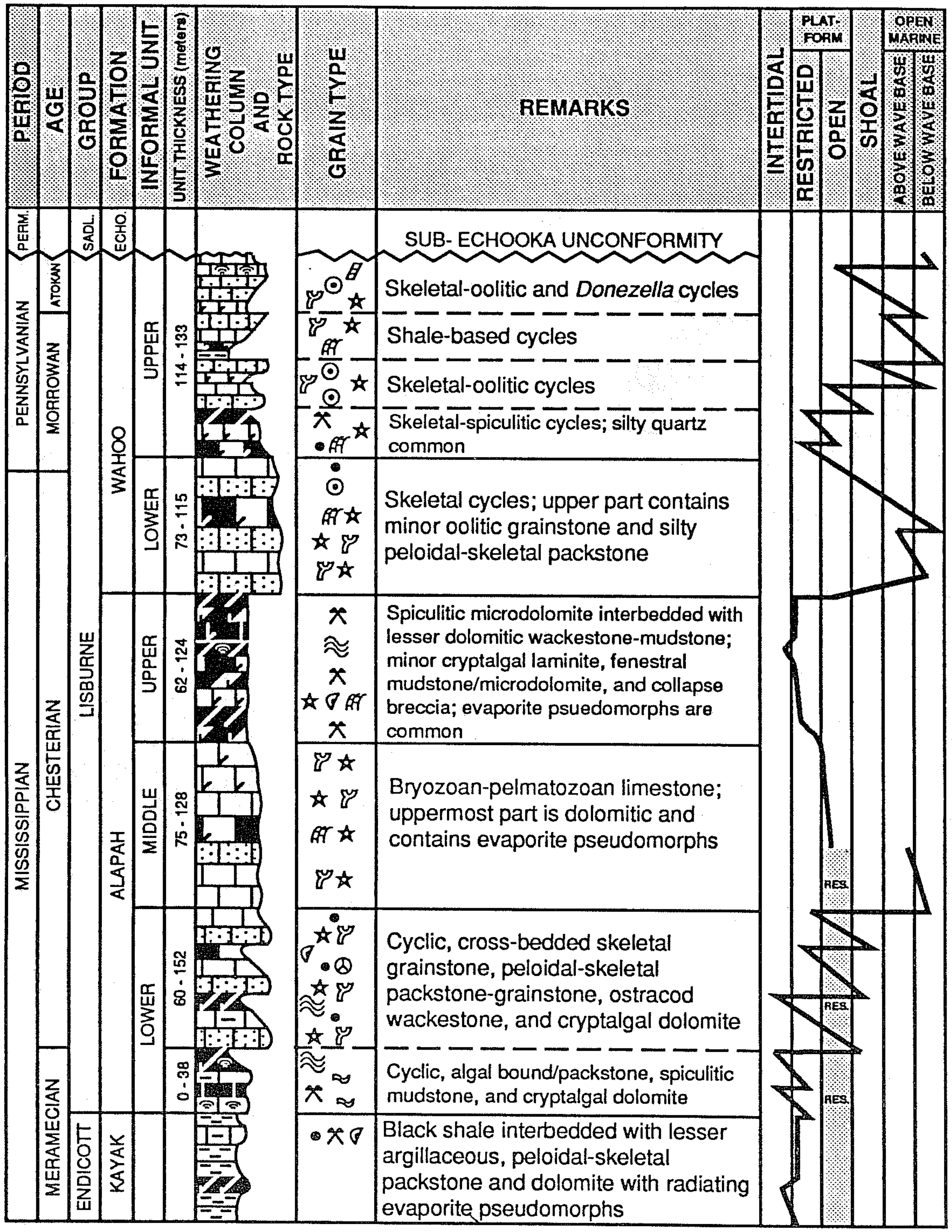


Figure 2 Schematic stratigraphic column shows the general stratigraphic framework for the Lisburne Group.

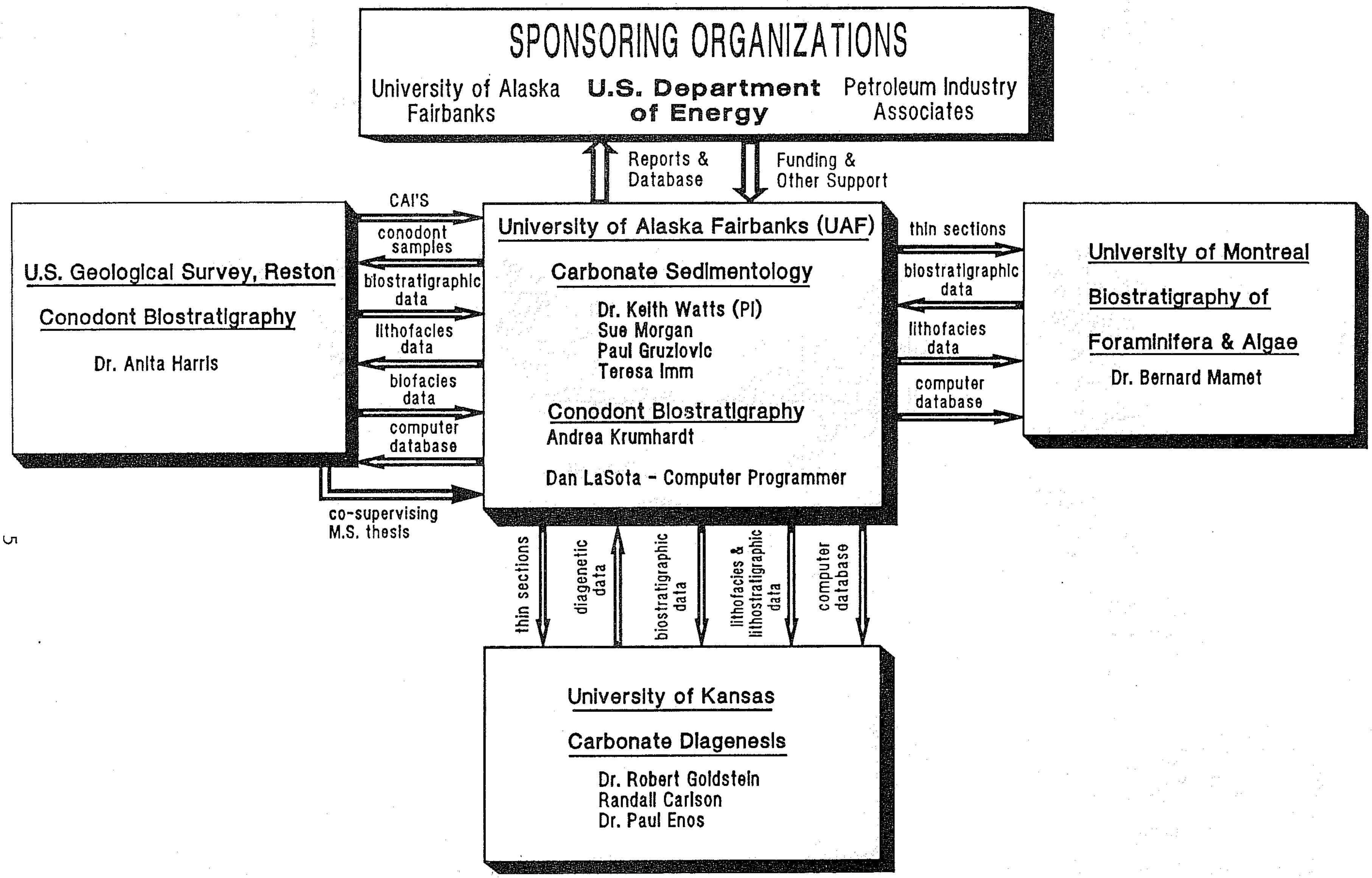


Table 1 - Organizational chart summarizes the relationships between different researchers and organizations involved in the Wahoo research program.
* Industrial sponsors in 1990 include ARCO Alaska, BP Alaska, Chevron, Conoco, Elf, Exxon, Japan National Oil Corporation, Mobil, Murphy, Phillips, Shell, Texaco, and Unocal.

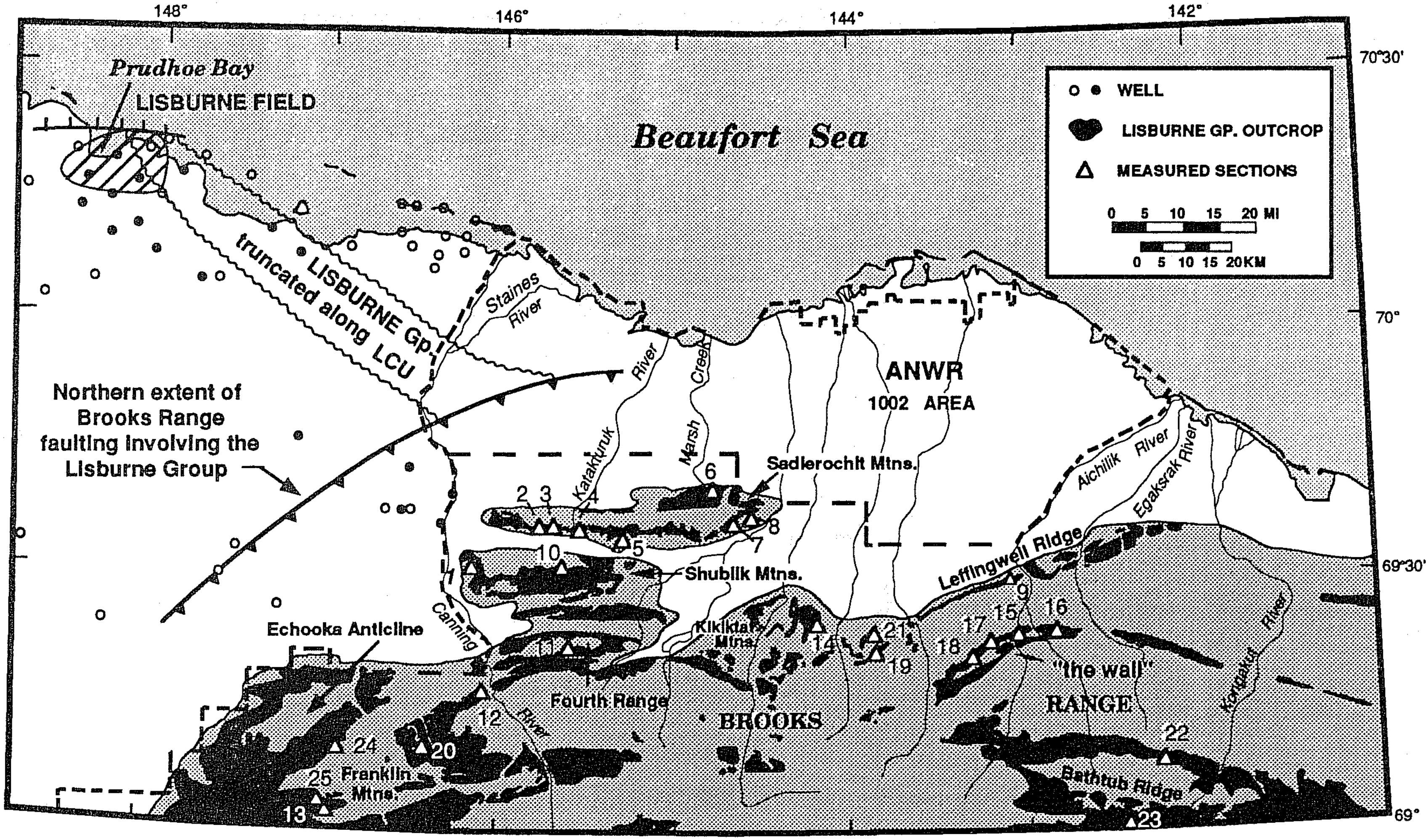


Figure 3 Map shows location of Lisburne Group exposures and stratigraphic sections measured by UAF researchers.

TABLE 2 - LISBURNE GROUP STRATIGRAPHIC SECTIONS

Number on map	Location name	Section number	Museum number	Map coordinates: Map.	Township.	Range.	Section [4]
1	Western Shublik Mountains [1]	section 86 O&P	AK- -M	MM C-4	T2N	R24E	Sec 11 [7]
2	Western Sadlerochit Mountains [1]	section 86 M	AK- -M	MM C-3	T3N	R26E	Sec 19
3	Western Sadlerochit Mountains [1]	section 86 N	AK- -M	MM C-3	T3N	R26E	Sec 21
4	Katakturuk Canyon [1]	section 86 I-L	AK- -M	MM C-3	T3N	R26E	Sec 24
5	Central Sadlerochit Mountains [2]	section 86 Z	AK- 97-M	MM C-3	T3N	R28E	Sec 30
6	Marsh Creek [3]	section 86 D	AK-4-M	MM C-2	T4N	R30E	Sec 30
7	Ledge Creek [3]	section 86 C	AK-3, 7-M	MM C-2	T3N	R30E	Sec 12
8	Sunset Pass [3]	section 86 A	AK-1, 2, 9-M	MM C-1	T3N	R31E	Sec 5
"	" [5]	section 88 A	AK-22-M	MM C-1	T3N	R31E	Sec 7
9	Leffingwell Ridge [6]	section 86 X&Y, 87V	AK-95, 96, 17-M	DP B-4	T2N	R37E	Sec 31 & 36 [8]
10	Central Shublik Mountains [4]	section 87 A-C	AK-10, 11, 12-M	MM C-3	T2N	R26E	Sec 22 & 23
11	Fourth Range [4]	section 87 D&E	AK-13, 14-M	MM B-3	T1S	R27E	Sec 20 & 21
12	Plunge Creek [4]	section 87 F&G	AK-15, 16-M	MM B-4	T2S	R25E	Sec 19
13	Wahoo Lake type section [2, 1]	section 87 Z&Y	AK-19,20-M	MM A-1	T5S	R22E	Sec 8
14	Old Man Creek [2]	section 87 W	AK-18-M	MM B-1	T1N	R32E	Sec 23
15	Aichilik River (Wahoo section) [2]	section 88 F	AK-71-M	DP B-4	T1S	R38E	Sec 6
16	Egaksrak River [2]	section 88 C	AK-21-M	DP B-4	T1N	R38E	Sec 32
17	Aichilik River (Itkilyariak section) [2]	section 88 D	AK-23-M	DP B-4	T1S	R37E	Sec 2
18	Upper Aichilik River [2]	section 88 E	AK-24-M	DP B-5	T1S	R36E	Sec 33
19	Okpilak batholith [2]	section 88KW7	AK-98-M	MM B-5	T1S	R34E	Sec 22
20	Pogopuk Creek [2,4]	section 89 A-C	AK-72, 73, 74-M	MM A-5	T3S	R23E	Sec 24
21	North Okpilak batholith [2,4]	section 89 D&E	AK-76, 99-M	DP B-5	T1S	R34E	Sec 9
22	North Bathtub Ridge (Cottonwood Cr.) [6]	section 89 F	AK-75-M	DP A-3	T3S	R41E	Sec 31
23	South Bathtub Ridge [6]	section 89 G	AK-100-M	DP A-3	T5S	R40E	Sec 14 & 23
24	Echooka Anticline [2]	section 90 A	AK-80-M	MM A-5	T3S	R21E	Sec 25
25	near Wahoo type section [6]	sections 90B-E	AK-81. 82, 83, 84-M	SG A-1	T5S	R21E	Sec 2 & 11 [9]

1 - sections measured by Teresa Imm
2 - " " " Keith Watts
3 - " " " Randall Carlson
4 - " " " Paul Gruzlovic
5 - " " " Andrea Krumhardt
6 - " " " Keith Watts and Jullie Dumoulin
7 - MM = Mt. Michelson quadrangle
8 - DP = Demarcation Point quadrangle
9 - SG = Sagavanirktok quadrangle

Table 2 - List of stratigraphic sections measured by University of Alaska researchers. Numbers refer to localities shown on Fig. 2.

Significant Accomplishments in 1989-1990

1. Completion of computerized petrographic database system for the Wahoo Limestone and input of data from over 1000 petrographic analyses.

2. Determination of the position of the Mississippian-Pennsylvanian boundary in an important reference section using conodont biostratigraphy.

3. Completion of a successful program of geological field studies in the Brooks Range of northern Alaska obtaining samples and field data on biostratigraphy, diagenesis, lithostratigraphy and regional geology.

4. Completion of detailed petrographic analysis of samples from three stratigraphic sections illustrating lateral facies changes in the Lisburne Group.

5. Presentation of several papers at international conferences (Watts et al., 1990; Krumhardt and Harris, 1990; Carlson, 1990; Imm, 1990).

6. Initiation of research project on cyclicity in the Lisburne Group by a new Ph.D. student, supported by a DOE-funded Research Assistantship.

Significance for EOR Research Plan

Our research on cyclicity addresses a number of issues which are important to DOE's fossil energy program as outlined in the Program Research and Development Announcement for this contract (DE-RA22-88BC1420). Our research will provide "generic cross-cutting descriptions of formations to permit design of cost-effective and environmentally acceptable production methods." In documenting the three-dimensional anatomy of the Wahoo Limestone (both primary and diagenetic characteristics), we will define the spatial variability in reservoir rocks that can affect movement of fluids (oil and gas, etc.). The regional scope of the research will allow integration of reservoir heterogeneity studies within a regional structural and stratigraphic framework. Excellent rock exposures in the Brooks Range allow us to map continuous outcrops of rocks equivalent to reservoir rocks. Our analyses permit us to determine depositional environments and to relate primary heterogeneities to sedimentary processes for predictive purposes and develop models required to characterize reservoir heterogeneity. In particular, we are formulating predictive geological and microfacies models which can provide a scientific basis for predicting well spacing and enhanced oil/gas recovery potential in poorly known fields.

In addition, our work meets a number of needs outlined in the report -- "Research needs for hydrocarbon fuels" (CONF-8705179; DE87014555), sponsored by the U.S. Department of Energy. Our research provides a 3-D analysis of reservoir rocks, focusing on sequence analysis and rock properties, facies analysis, and diagenesis. Although the research applies to a known reservoir (the Lisburne field), it also pertains to frontier areas (Alaska's North Slope in ANWR), providing information on regional unconformities, and tectonic and paleoenvironmental controls on basin evolution. By involving a number of carbonate specialists and biostratigraphers, this project takes an integrated approach for basin analysis and will provide conceptual facies models, paleogeographic maps, analyses of depositional systems and history, geochemistry of cements, thermal history (CAI), and diagenetic history. In the final phase of the project, analyses of well(s) from the Lisburne field will allow us to compare 3-D rock characteristics and reservoir properties and performance. Education and training of graduate students involved in the project will help to supply a continuing supply of professional geologists to implement industrial and governmental programs for satisfying the nation's future energy needs. Furthermore, our research program is an excellent example of how cooperative DOE/industry support of projects significant to industry and DOE missions can improve the research base existent in our universities, and further develop and utilize the academic manpower resource for basic research on energy problems.

Computerized Database

Significant progress was made in developing a computerized database system for petrographic and biostratigraphic data from the Lisburne Group. Using 4th Dimension database program on a MAC IIx computer, we have established menu-driven data-input structure which allows easy input of data obtained from previous and ongoing research (Figs 4 & 5). An advantage of 4th Dimension is its ability to have multiple data entry modes (even in different languages), allowing it to accommodate a variety of datasheets used by different researchers.

The strength of the computerized database is its ability to search for selected characteristics and illustrate variations in lithology or composition in a stratigraphic sequence (Fig. 6). For example, the parasequences (shallowing-upward cycles) which characterize the upper Wahoo Limestone are dramatically illustrated by the graph which shows variations in content of ooids and peloids in the Plunge Creek stratigraphic section (Fig. 8). The cycles indicate the repeated southward progradation of ooid shoals and peloidal lagoons following rapid northward transgression at the base of each parasequence. The relative abundance of ooids in different stratigraphic sections is also useful in illustrating and understanding lateral facies changes occurring down depositional dip (Fig. 9).

Petrographic analyses from more than 1000 samples have been entered into the database. Appendix 1 is a compilation of several parameters contained in the database including lithology, major and minor grain types, and interpretation of depositional environments. In addition to this essential data, the database also contains information on texture, diagenesis, and other features important for understanding facies relationships and related reservoir characteristics.

Additional programing is presently underway to develop database systems for conodont biostratigraphy. In the future, the database will be expanded to accommodate information on localities, stratigraphy, and diagenesis. At this point, our efforts have been directed at database development and data input. We have only begun to utilize this powerful research tool that will allow us to semi-quantitatively analyze and compare a variety of parameters (including petrographic, biostratigraphic, and diagenetic data) in order to develop a more complete understanding of shallowing-upward cycles.

PETROGRAPHIC DESCRIPTION

Sample

Researcher(s)

Depositional Environment

Rock Types

Carb Types

Date of Last Entry

Comments

Follow Up

Skeletal Grain Types

- Bryozoans
- fenestrate
- ramose
- Echinoderms
- columnules
- plates
- Brachiopods
- Bivalves
- Gastropods
- Foraminifera
- Ostracodes
- Trilobites
- BioClasts
- OTHER
- Algae
- Asphaltina
- Archaeolithophyllum
- Donezella
- Osagia
- Oncolites
- Cyanobacterial Mats
- Calcispheres
- Sponge Spicules
- Corals
- fragments
- solitary
- colonial
- Radiolaria
- Conodonts

Components

Components

- grains
- matrix
- cement

Carbonate Grain Types

- Skeletal (Total)
- Ooid
- Superficial Ooid
- Peloid
- Limeclast
- Lump (Grapestone)
- Pisoid

Non-carbonate material

- detrital quartz
- glauconite
- phosphate
- anhydrite
- gypsum
- pyrite
- hematite
- fluorite

Texture

Grain size (Udden-Wentworth scale)

Present

cly slt vf f m c vc gr peb cob bld

Mean

Maximum

Grain recrystallization

○ none ○ weak ○ moderate ○ strong

Grain size sorting

○ very poorly ○ poorly ○ moderately ○ well ○ very well

Grain abrasion

○ none ○ weak ○ moderate ○ strong

Packing

Compaction

Grain packing

- matrix supported
- point contacts
- straight contacts
- concavoconvex
- sutured contacts
- collapsed micritic grains
- strained grains
- calcitic twins - strain lamelli

A C M R 0 - Abundant (>50%), Common (10-50%), Minor (1-10%), Rare (<1%), 0 (none), E (Exact number from point count)

Figure 4 Data entry form for Wahoo petrographic database, second side.

Sample: [ ]

Diagenetic Feautures

Dolomite

Content [ ]
Xstal Size Min: [ ] µm
Xstal Size Mean: [ ] µm
Xstal Size Max: [ ] µm
Xstal Shape:
Replacement Fabric:
Type [(non)ferroan]:
Distribution:

Chert Replacement

Content [ ]
Concentration: [ ]

Clay Material

Content [ ]
Concentration: [ ]

- [ ] veins
- [ ] fractures
- [ ] chert nodules
- [ ] calcareous nodules
- [ ] evaporite nodules
- [ ] evaporite molds
- [ ] collapse breccias
- [ ] geopetal structures
- [ ] styolites
- [ ] oil stain (bitumen)

Biogenic structures

- [ ] corals in growth position
- [ ] articulated crinoid stems
- [ ] full-frond fenestrate bryozoans
- [ ] " " " in growth position
- [ ] articulated brachiopods
- [ ] algae in growth position
- [ ] organically bound
- [ ] vertical burrows
- [ ] horizontal trace fossils
- [ ] general bioturbation
- [ ] mottling
- [ ] massive structureless bedding
- [ ] stromatolites
- [ ] cryptalgal mats
- [ ] rootlets
- [ ] plant debris
- [ ] OTHER

Cements

- [ ] syntaxial overgrowths
- [ ] equant blocky spar
- [ ] drusy spar
- [ ] isopachous rims
- [ ] neomorphic microspar
- [ ] blocky void filling spar
- [ ] micritic cement

Micritization of grains

- [ ] micritic rim
- [ ] micritization

Sedimentary Structures

- [ ] even parallel laminae (<3mm)
- [ ] even parallel laminae (>3mm)
- [ ] coarse-grained parallel laminae
- [ ] low-angle cross-laminae
- [ ] low-angle truncations
- [ ] indistinct laminae
- [ ] wavy laminae
- [ ] current ripples
- [ ] wave ripples
- [ ] small-scale cross laminae (<5cm)
- [ ] large-scale cross laminae (>5cm)
- [ ] graded bedding
- [ ] inverse grading
- [ ] scoured surfaces
- [ ] hardground/bored surfaces
- [ ] fenestral fabric
- [ ] desiccation cracks
- [ ] shale partings
- [ ] soil horizon
- [ ] intraclastic conglomerate
- [ ] imbricated clasts
- [ ] thin bed of debris (lag deposit)
- [ ] deformed bedding
- [ ] convolute lamination
- [ ] load casts
- [ ] flute casts & other sole markings
- [ ] OTHER

Porosity

- [ ] vuggy
- [ ] moldic
- [ ] intercrystalline
- [ ] intraparticle
- [ ] interparticle
- [ ] fracture

Moldic Type

[ ]

Bed Descriptions

Color [ ]

Bed thickness [ ]

A C M R 0 - Abundant (>50%), Common (10-50%), Minor (1-10%), Rare (<1%), 0 (none), E (Exact number from point count)

Sample	AK11M121.5
Researcher(s)	Paul Gruzlovic
Rock Types	limestone
Carb Types	Grainstone

SKELETAL GRAINS

C	Bryozoans		Coral (solitary)
C	Pelmatazoans		Coral (colonial)
C	Ostracods		Algae (undiff.)
	Brachiopods		Donezella
	Sponge Spicules		Asphaltina
M	Foraminifera		Bioclasts (undiff.)
M	Calcispheres		Fenestrate
	Gastropods		ramose
	Bivalves		OTHER
	Trilobites		

NON-SKELETAL GRAINS

	Ooid		Glauconite
	Superficial ooids		Pyrite
C	Peloids		Phosphate grains
	Intraclasts		Grapestone
	Oncolites		Hematite
	Qtz sand or silt		Diagenetic quartz

MEAN GRAIN SIZE

☐ vf ☒ f ☐ m ☐ c ☐ vc

PRESERVATION OF GRAINS

Recrystalization of grains

◉ none ○ slightly ○ moderate ○ well

Grain Borings:

○ none ○ slightly ◉ moderate ○ well

Micritic Envelope Development:
partial complete

○ none ○ slightly ◉ moderate ○ well

Grain Roundness

◉ well ○ moderate ○ poorly

GRAIN SORTING

◉ well ○ moderate ○ poorly

DOLOMITE

Content:

Xstal Size Min: 0 µm

Xstal Size Mean: 0 µm

Xstal Size Max: 0 µm

Xstal Shape:

Replacement Fabric:

CLAY MATERIAL

Content:

Concentration:

CHERT REPLACEMENT

Content:

Concentration:

OIL STAIN

○ high ○ moderate ○ low ◉ none

SEDIMENTARY STRUCTURES

	Parallel laminae
	Small-scale X-laminae
	Wavy laminae
	Graded bedding
	Bioturbation
	Geopetal structures
	Stromatolite
	Fenestrae
	Birdseyes
	Breccia
	Evaporite repl. nods.
	articulated crinoid stems
	vertical burrows
	Scoured surfaces
	Imbricated clasts
	OTHER

CEMENTS

	Syntaxial overgrowths
C	Equant blocky spar
	Drusy blocky spar
	Isopachous rims
	Neomorphic microspar
	Blocky spar cavity fills
	Micritic

POROSITY

	Vuggy
	Moldic
	Intercrystalline
	Intraparticle
	Interparticle
	Fracture

COMPACTION: well-moderate

	Sutured grains
	Broken rims or coats
	Strained grains
	Bent twins
	Styolites
	Fractures

Depositional Environment: lagoonal

Comments
little room for cement

Date of Last Entry 5/4/90

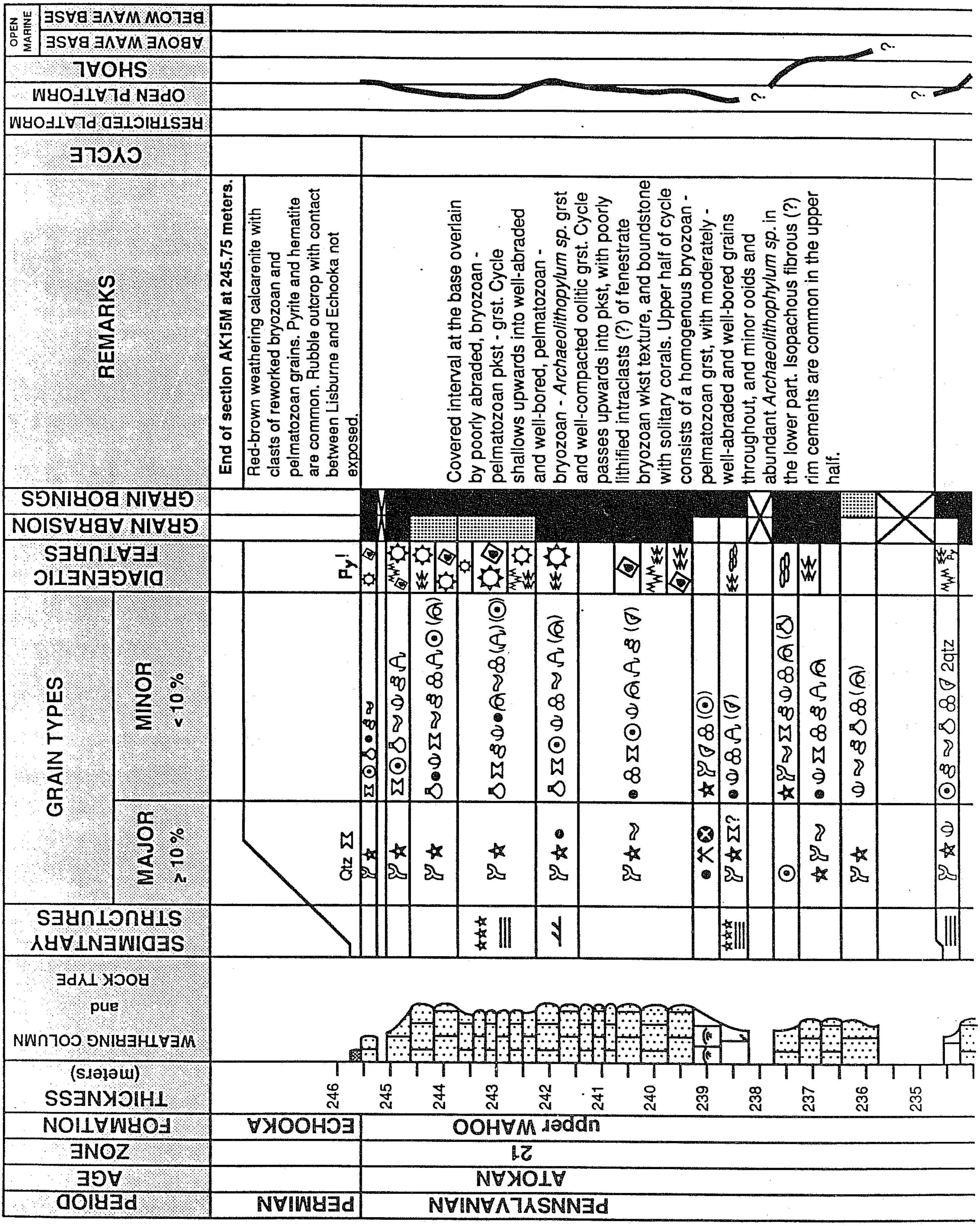


Figure 6 Example of detailed stratigraphic column.

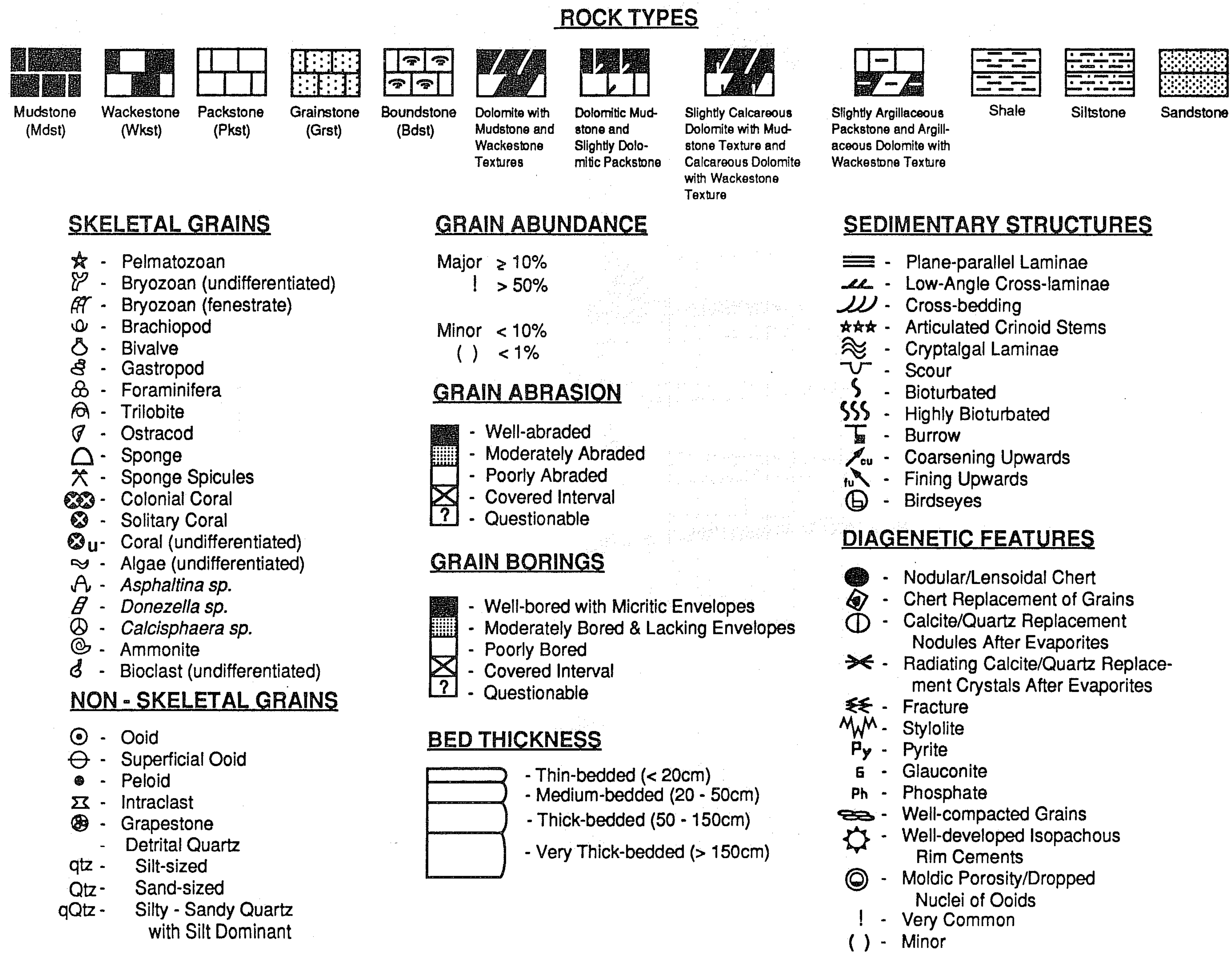
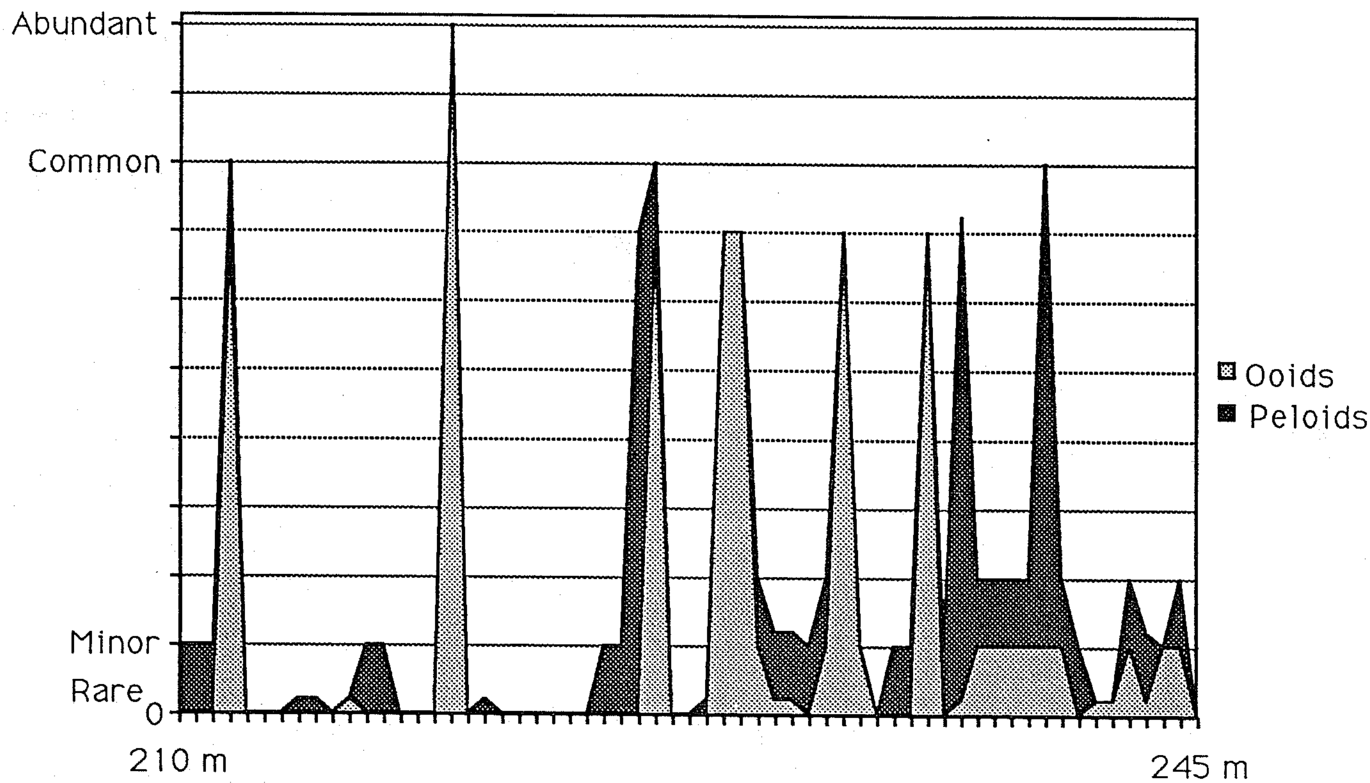


Figure 7 Key to symbols used in stratigraphic columns.



Plunge Creek section - Cyclicity in ooids and peloids in the Atokan part of the upper Wahoo Limestone

Figure 8 Graph generated by the 4th Dimension Wahoo database illustrates repeated lithologic cycles as shown by the distribution and relative abundance of ooids and peloids in the upper part of Wahoo Limestone at Plunge Creek (locality 11 on Fig. 2). Horizontal scale indicates meters above base of section.

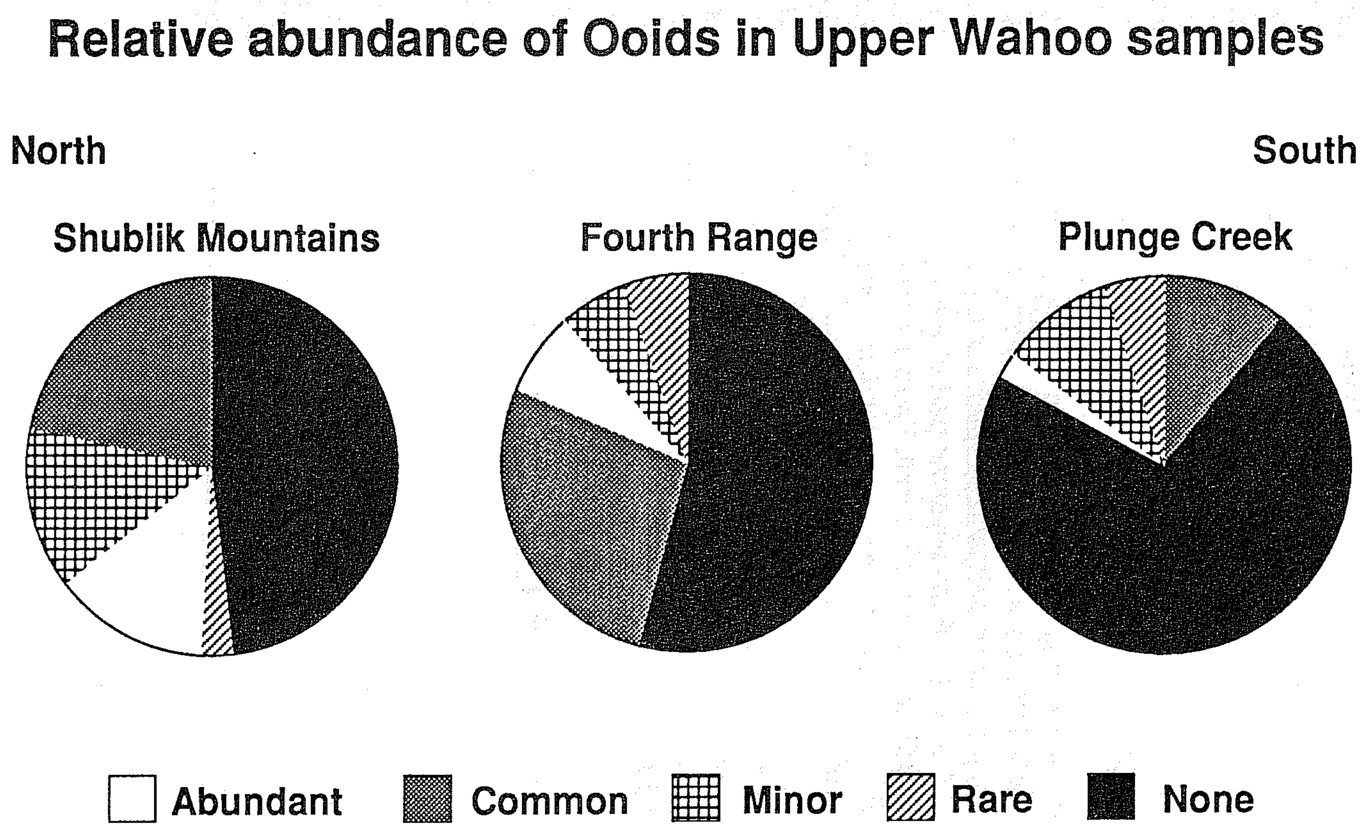


Figure 9 Pie diagrams show the relative abundance of ooids between three stratigraphic sections on a north-south transect down depositional dip. The diagrams illustrate the reduction in ooids to the south (basinward) of ooid shoals.

Biostratigraphic Studies

Biostratigraphic studies of conodonts have been particularly useful in defining the position of the Mississippian-Pennsylvania boundary in the Wahoo Formation (Fig. 10; Krumhardt and Harris, 1990). The Mississippian-Pennsylvanian boundary, now defined by the International Carboniferous Boundary Commission as the first appearance of the *noduliferus-primus* Zone, is located approximately 15m below the contact of the informal lower and upper subunits of the Wahoo Formation. Because conodont biostratigraphy is independent of lithostratigraphy and the biostratigraphy of foraminifera and algae, the conodont results allowed us to resolve inconsistencies in stratigraphic nomenclature and age determinations (Fig. 11).

At section AK88-A, the Wahoo Formation is informally subdivided into lower and upper subunits (Fig. 10). The lower Wahoo, which contains the Mississippian-Pennsylvanian boundary, consists of predominantly bryozoan-pelmatozoan packstone with lesser grainstone/packstone. An increase in grainstones in the Pennsylvanian part of the lower Wahoo indicate a general shallowing-upward trend toward the top of the unit. The base of the Pennsylvanian upper Wahoo begins with silty, dolomitized skeletal and cryptalgal wackestone and packstone and passes upwards into ooid grainstone, ooid and *Donezella* packstone and grainstone, and is capped by *Osagia*-bearing peloidal and spiculitic wackestone and packstone. Although numerous lithofacies comprise the parasequences in the upper Wahoo, this small-scale parasequence cyclicity is superimposed on a larger scale transgressive-regressive trend from cryptalgal intertidal conditions deepening upward into ooid shoals then shallowing into restricted platform (lagoonal deposits at the top of the unit).

Paleoenvironments and Conodont Biofacies

Lower Wahoo

The lower Wahoo is interpreted to have formed on an open-marine, shallow platform of normal salinity as indicated by the abundance of bryozoan and pelmatozoan grains. The abundance of packstone plus the high conodont diversity indicate that a low-energy, nonrestricted, open-marine environment dominated during the lower Wahoo. The Mississippian-Pennsylvanian boundary occurs in the upper part of the lower Wahoo.

Lower Wahoo - Mississippian

Packstone and lesser wackestone which formed in low-energy environments produced 6.5 generically identifiable conodonts per kilogram and are dominated by *Cavusgnathus*.

WAHOO FORMATION
SUNSET PASS - SECTION AK88A
SADLEROCHIT MOUNTAINS

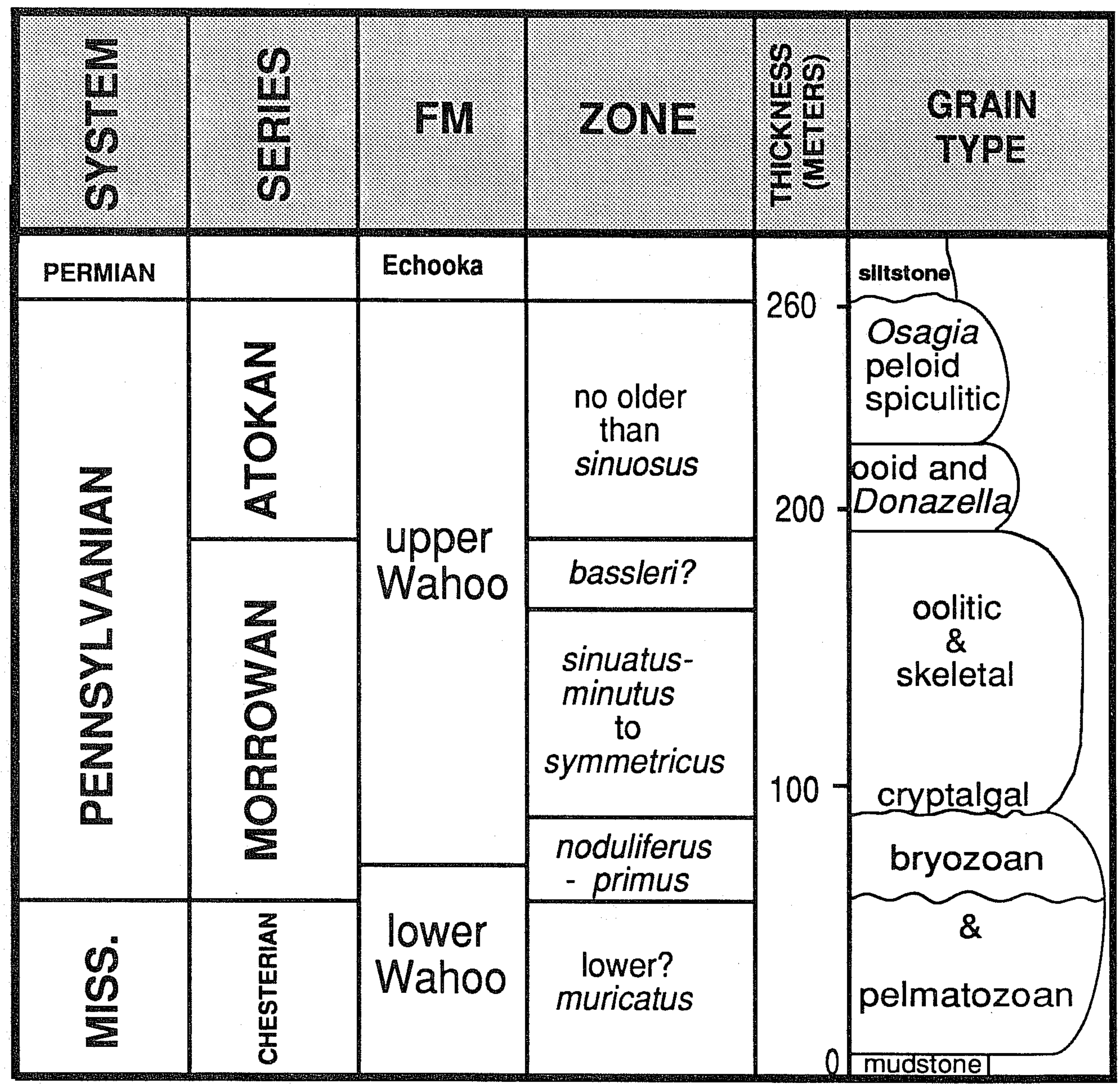


Figure 10 Conodont biostratigraphy for the Wahoo Limestone. See Appendix 2 for sample data.

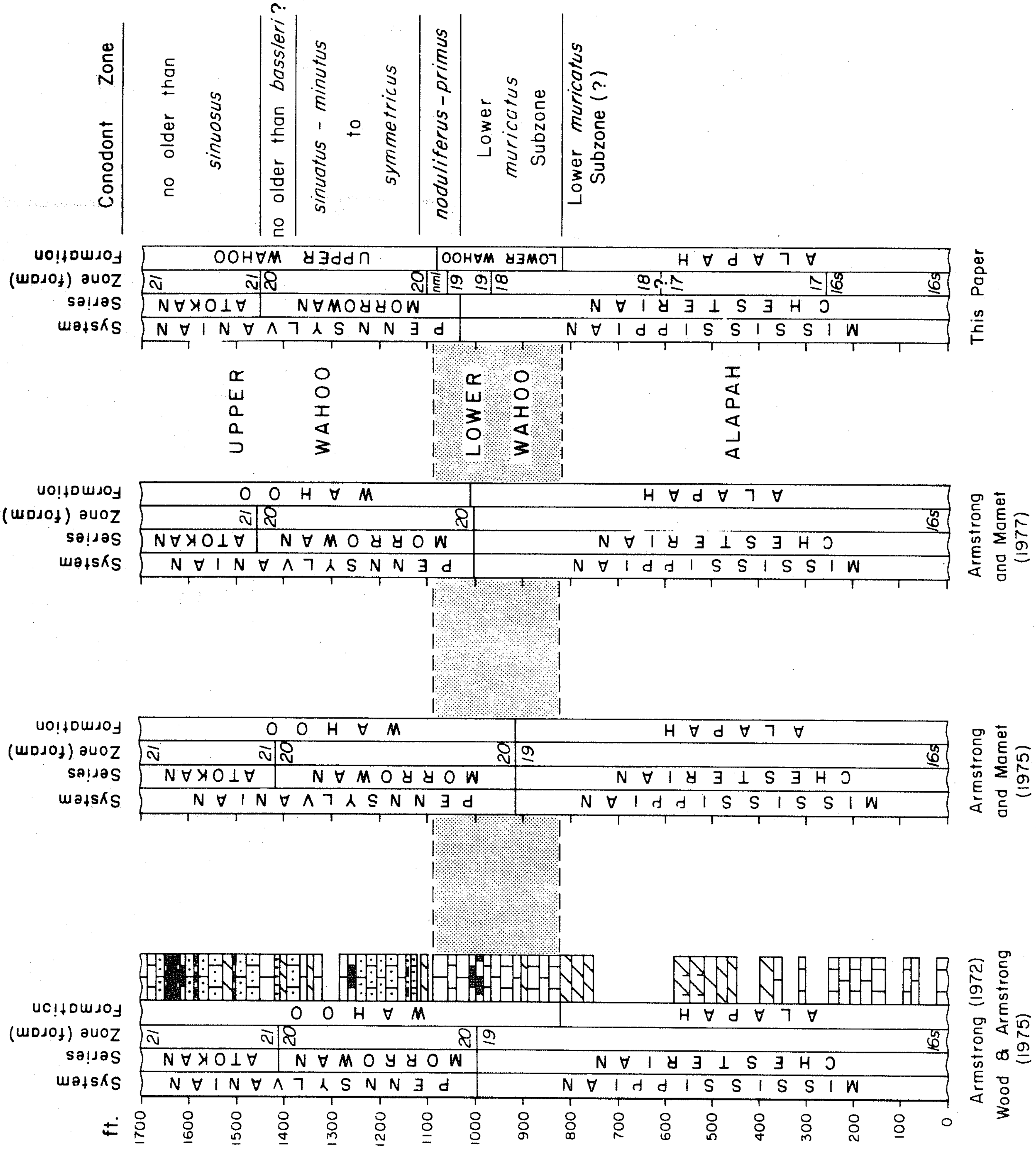


Figure 11 Problems with stratigraphic nomenclature and biostratigraphic ages for the Lisburne Group.

Cavusgnathus is typically found in shallow, open-marine environments. The moderate- to high-energy open-marine environments, represented by packstone/grainstone, yield 9.5 conodonts per kilogram and are also dominated by *Cavusgnathus* (Fig. 12). The associations are as follows:

Low Energy		Moderate to High Energy	
51%	*Cavusgnathus*	68%	*Cavusgnathus*
18%	*Gnathodus*	13%	*Adetognathus*
16%	*Adetognathus*	7%	*Gnathodus*
8%	*Hindeodus*	5%	or less of
3%	or less of		Vogelgnathus
	Rhachistognathus		*Rhachistognathus*
	Adetognathus		*Hindeodus*
	dioprioniodus		

Lower Wahoo - Pennsylvanian

In the Pennsylvanian, *Cavusgnathus* is replaced by *Adetognathus* and the index fossil for the Pennsylvanian, *Declinognathodus,* appears. Species of *Rhachistognathus* also increase (Fig. 12). The low-energy facies yield 3.6 conodonts per kilogram. The moderate- to high-energy packstone/grainstone and grainstone are more abundant in the Pennsylvanian part of the lower Wahoo and yield 27 conodonts per kilogram. The associations are as follows:

Low Energy		Moderate to High Energy	
42%	*Adetognathus*	57%	*Adetognathus*
22%	*Declinognathodus*	34%	*Declinognathodus*
18%	*Hindeodus*	8%	*Rhachistognathus*
16%	*Rhachistognathus*	1%	*Hindeodus*
2%	*Idioprioniodus*		

Upper Wahoo

The upper Wahoo is composed of numerous parasequences having small-scale cyclical changes in lithology that indicate shallowing-upward cycles. These lithologies formed in a variety of carbonate depositional environments including intertidal, restricted lagoon, open lagoon, tidal channel, shoal, moderate to high-energy open-marine, and low-energy open-marine (Fig. 12).

Intertidal cryptalgal laminites are limited stratigraphically to the lowermost upper Wahoo. These rocks produced only one conodont per kilogram, most of which were generically indeterminate elements. While conodonts can tolerate a wide variety of marine conditions, they do not withstand silty conditions or extreme salinities. The conodonts present in this environment are the result of postmortem transport.

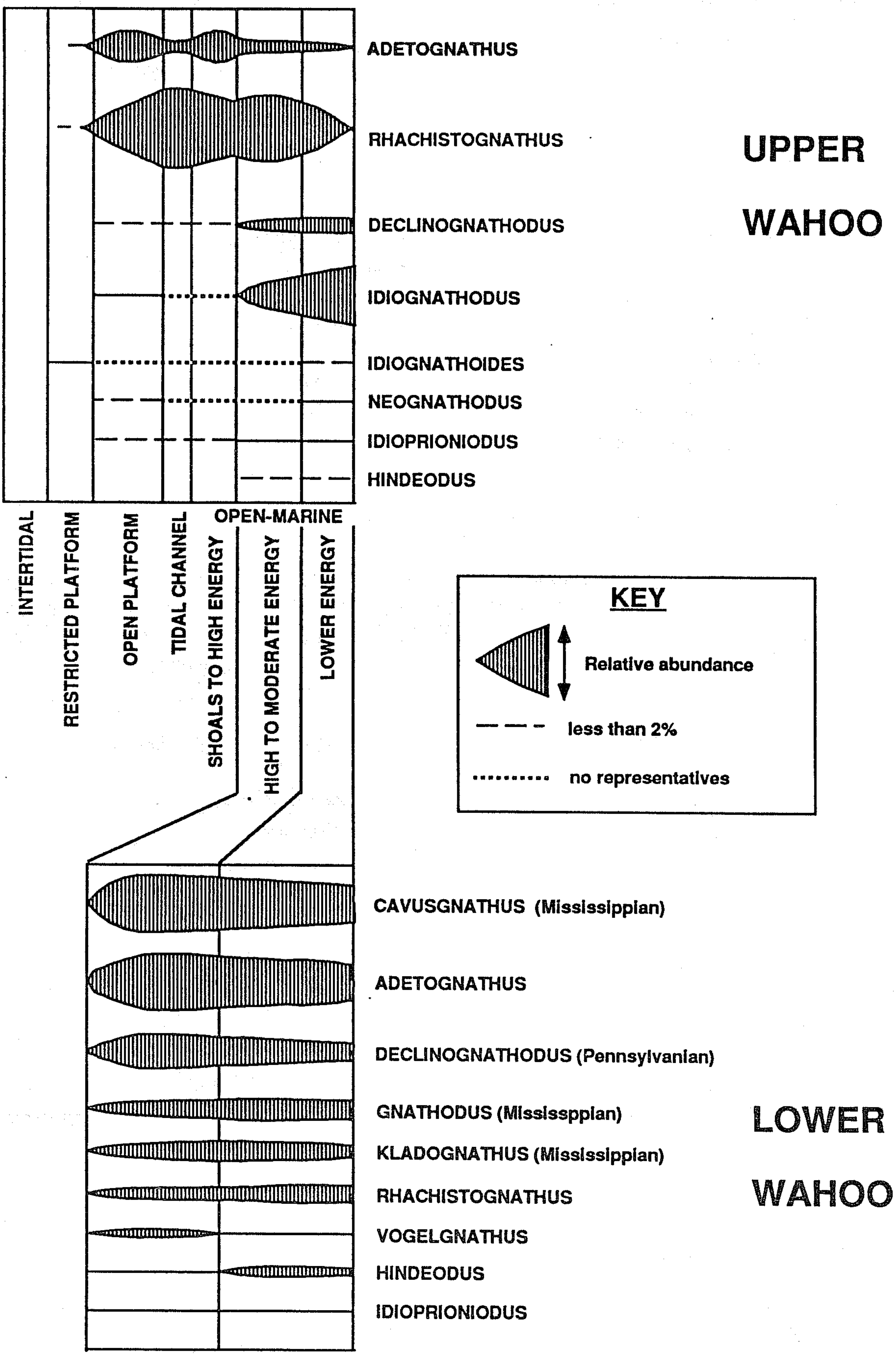


Figure 12 Conodont biofacies and interpretations of paleoenvironments.

The restricted platform (lagoonal) depositional environments are represented by oncolitic grainstone, peloidal oolitic, and spiculitic packstone/grainstone and spiculitic mudstone. These rocks produced 0.8 conodonts per kilogram. Interestingly, most of the conodonts are juveniles. All other conodonts are attributed to postmortem transport.

The lithologies of the open platform are represented by oolitic to oncolitic packstone/grainstones, peloidal grainstone/packstone, and rarer oncolitic bryozoan/pelmatozoan packstone/wackestone. These rocks produced 9 conodonts per kilogram. The associations suggest that *Rhachistognathus* and *Adetognathus* lived in the lagoon to the virtual exclusion of all other conodonts. With the possible exception of *Idiognathodus*, the other conodonts probably represent postmortem transport. The oolitic and oncolitic rocks produced the least conodonts. The associations of the open platform are as follows:

62% *Rhachistognathus*
30% *Adetognathus*
2% *Idiognathodus*
Less than 1% of *Idioprioniodus*, *Declinognathodus*, and *Neognathodus*

The tidal channels and high-energy, marine environments of the platform (possibly tidal deltas and storm washovers) include skeletal, peloid/bryozoan, and peloid/foraminifera grainstones. These samples yielded the highest numbers of *Rhachistognathus*. All other conodonts are considered postmortem transport. These rocks yield 20 conodonts per kilogram with the following association:

83% *Rhachistognathus*
16% *Adetognathus*.

The highest energy environments are represented by oolitic and oolitic/skeletal grainstones. These rocks produce only 4 conodonts per kilogram. *Adetognathus* in the upper Wahoo is at its highest relative abundance in these high-energy environments. This is in contrast to the lower Wahoo in which *Adetognathus* appears to prefer lower energy, open-marine conditions. The association is:

59% *Rhachistognathus*
38% *Adetognathus*.

The moderate- to high-energy open marine environments are represented by poorly washed skeletal grainstone and pelmatozoan/bryozoan grainstone/packstone to grainstone, some of which are silty. These rocks produce 16 conodonts per kilogram. This slightly more diverse biofacies indicates a more stable marine environment. The association consists of:

69% *Rhachistognathus*
12% *Idiognathodus*
10% *Declinognathodus*
9% *Adetognathus*.

The deepest open-marine environment represented in the upper Wahoo includes pelmatozoan/bryozoan packstone and packstone/wackestone. These rocks were deposited below, but close to, wave base. Many were dolomitized. These rocks produce the most diverse associations as well as the greatest number of conodont fragments. The latter were undoubtedly winnowed from nearby higher energy regimes. The yield is 10 conodonts per kilogram. This facies is either at or beyond the environmental preference of *Rhachistognathus* and *Adetognathus*. Thus, most of their elements probably represent hydraulic admixture. *Idiognathodus* and *Declinognathodus* probably inhabited this normal-marine, low-energy environment. The association includes:

50% *Idiognathodus*
23% *Declinognathodus*
16% *Rhachistognathus*
6% *Adetognathus*,
3% or less of *Neognathodus*, 2% *Idioprioniodus*, *Hindeodus*, and *Idiognathoides*.

Conodont Color Alteration Indices

Conodonts are initially pale yellow and composed of apatite and lesser organic matter. With progressive heating, the organic carbon trapped in the internal structure of the conodont element first gets progressively darker brown, then jet black, then becomes lighter grey, opaque white, and finally transparent. This color change has been quantified, termed CAI (Color Alteration Indices), with numeric values ranging between 1 to 8, with 1 representing pale yellow, and 8 signifying transparent. This process is irreversible and thus records the highest temperature attained by the host rock. CAI values of 1.5 to 2 fall within the oil window (~65 - 135 °C).

The CAI's of the conodonts in Section AK88-A ranged from 2.5 to 6. Interestingly, no conodonts had a value of 5 (black) and most samples were dominated by a CAI of 6 (grey). In addition, all conodont elements had a sugary texture rather than the normally hyaline surface texture of conodonts. The wide range of CAI values obtained from individual samples along with the altered surface texture indicate hydrothermal alteration.

Interestingly, samples from the uppermost Alapah Formation are much more altered that those from the lowest Wahoo Limestone, suggesting that the hydrothermal activity affected the Alapah more strongly. The presence of cavernous porosity at the Alapah-Wahoo boundary, now filled by coarse spar, may have promoted the flow of hydrothermal fluids through the relatively porous dolostones of the uppermost Alapah, whereas the more tightly cemented limestones of the Wahoo were less affected by hydrothermal alteration.

Diagenetic Studies

University of Kansas researchers have made significant progress in their studies of cement stratigraphy. Using cathodoluminescence and other advanced techniques for analyzing diagenesis, several possible exposure surfaces have been recognized, as indicated by variations in cementation histories (Fig. 13; Carlson, 1990). Limestones below the exposure surfaces are characterized by extensive early diagenetic, nonferroan, calcite cements having numerous cathodoluminescent zones. In contrast, above the exposure surfaces, early cements are uncommon and late diagenetic, ferroan, calcite cements generally have very dull cathodoluminescence.

During June and July of 1990, field studies of the Lisburne Group were undertaken in the Sadlerochit and Shublik Mountains and the Fourth Range (localities 8, 10, and 11 on Fig. 3). The major goal of the field work was to find surfaces of subaerial exposure within the unit and find cross-cutting relationships that would allow dating of different generations of calcite cement within the Lisburne Group. These study areas represent a cross-section traversing the Lisburne carbonate platform southward down depositional dip. A major goal was to assess the relationship between diagenesis and paleogeographic setting on the Lisburne carbonate platform.

A major regional unconformity surface truncates the top of the Lisburne Group beneath the Permian Echooka Formation (Figs. 2 and 14). In the Sadlerochit Mountains (locality 8 on Fig. 3), the basal Echooka Formation has conglomerates which contain rounded clasts of limestone derived from the underlying Lisburne. In the Shublik Mountains (locality 10 on Fig. 3), the basal Echooka conglomerate contains abundant clasts from the Lisburne and also has an iron-rich horizon with possible root casts that may represent a paleosol that developed along the unconformity surface. A variety of conglomerates and karst breccias occur above the unconformity in the Fourth Range (locality 11 on Fig. 3). Comparison of the stratigraphic sections along this transect shows that pre-Echooka erosion cut deeper in the south, possibly removing an additional 100 meters of Lisburne strata in the Fourth Range compared to the Sadlerochit Mountains (Fig. 14).

A number of less well-developed subaerial exposure surfaces occur within the Lisburne Group. Subaerial exposure surfaces recognized in our field studies are more abundant in the north than in the south, with 11 surfaces in the Sadlerochit Mountains, 10 surfaces in the Shublik Mountains, and 9 surfaces in the Fourth Range. The nature and interrelationships of the exposure surfaces are summarized below.

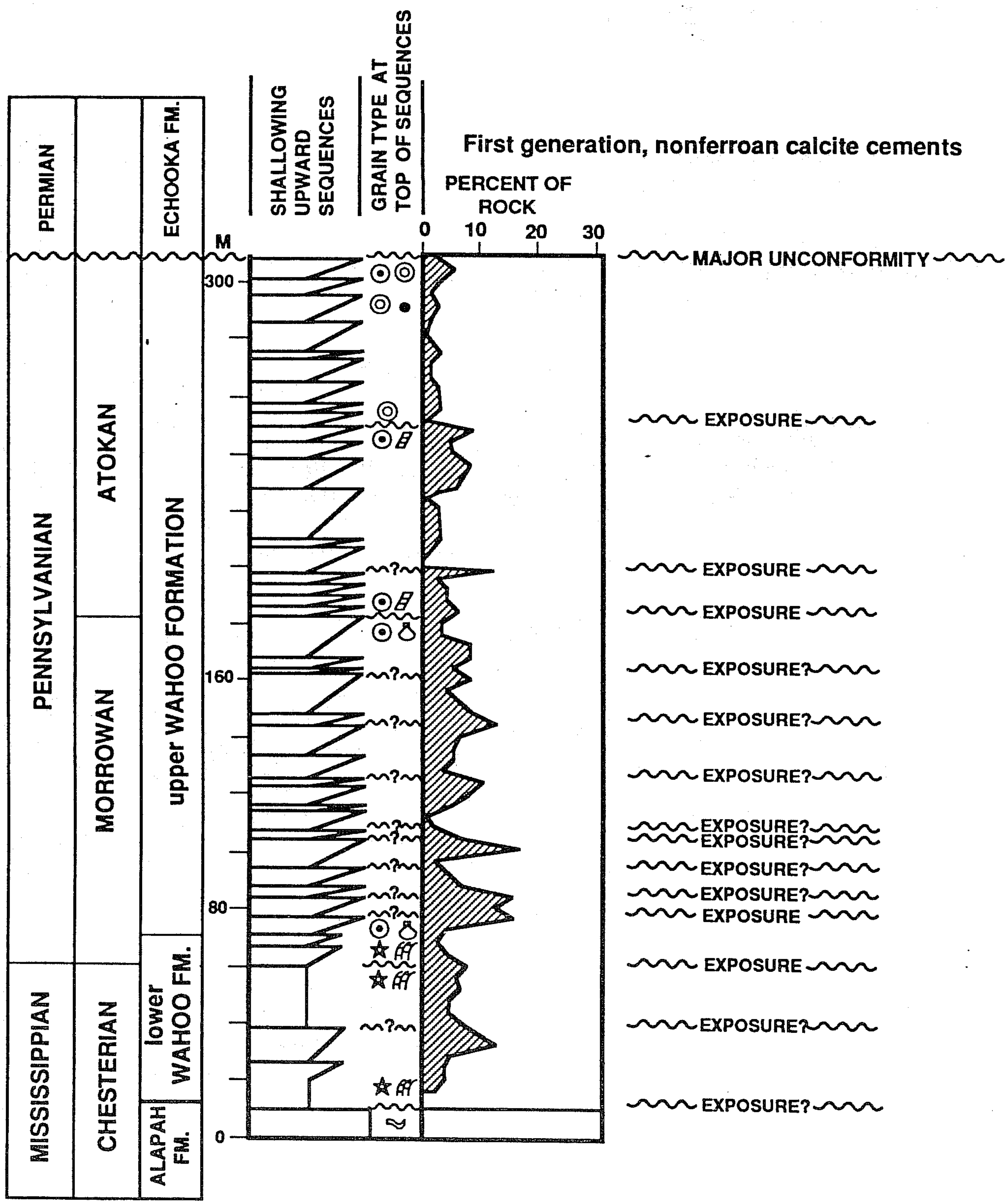


Figure 13 Position of possible exposure surfaces in the Lisburne Group in the eastern Sadlerochit Mountains.

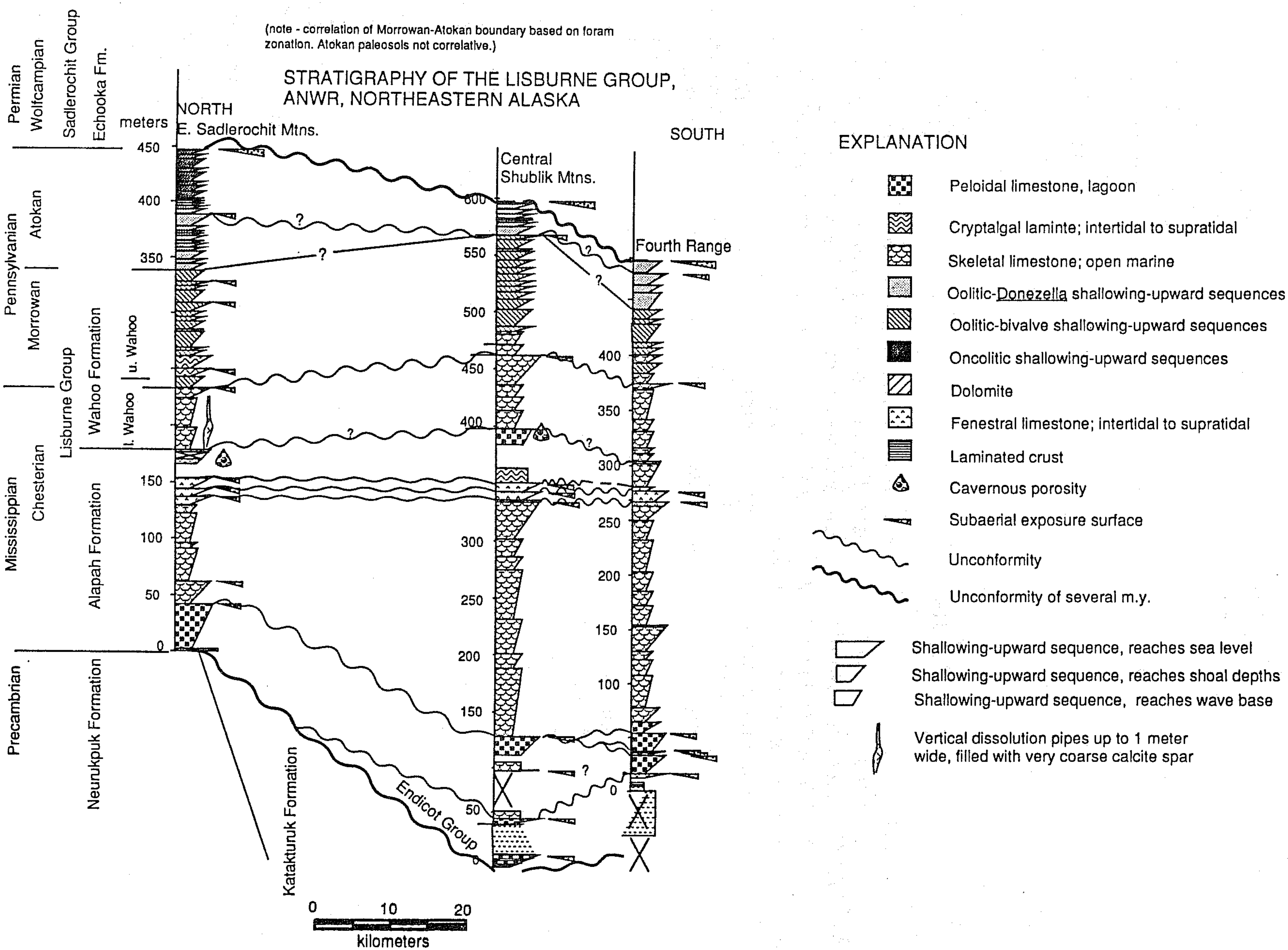


Figure 14 Correlation diagram shows position of exposure surfaces in sections analyzed during the 1990 field season (see Fig. 3 for locations).

Exposure Surfaces in the Basal Alapah

The lowermost exposure surface in the Lisburne Group occurs near the base of the Alapah Formation (Fig. 14). The exposure surface has a laminated crust, solution collapse breccia and fractures showing evidence of later compaction. This surface occurs in the Shublik Mountains and Fourth Range but apparently laps out northward and is not present in the Sadlerochit Mountains. *In situ* brecciation in the Itkilyariak Formation (sandy limestones which locally occur immediately beneath the Lisburne Group) may indicate subaerial exposure in the Sadlerochit Mountains. However, previous foraminifera zonation data indicate that the base of the Lisburne is older in the Shublik Mountains and Fourth Range (as old as Zone 13) than in the Sadlerochit Mountains (Zone 16), so these exposure events may not correlate.

Exposure Surfaces Approximately 40 Meters Above Base of Alapah

A well-developed exposure surface occurs approximately 40 meters above the base of the Alapah Formation in all three study areas (Fig. 14). In the Sadlerochit Mountains, a well developed laminated crust is present and root features extend five, perhaps ten, meters below the horizon. This surface in the Shublik Mountains is also marked by a laminated crust and laterally extensive *in situ* brecciation. In the Fourth Range, this horizon has three closely spaced subaerial exposure surfaces marked by cryptalgal laminated mudstones and *in situ* breccias that cap thin sequences of lime mudstone, peloidal packstone, and fenestral dolomite. Above the three surfaces, 15 meters of peloidal packstone are capped by fenestral dolomite that has early cracks and root molds filled with calcite spar. The most direct correlation is that the lowermost surface in the Fourth Range correlates with the exposure surfaces at this level in the Shublik and Sadlerochit localities and that the three sequences between the other subaerial exposure surfaces in the Fourth Range lap out northward before reaching the Shublik Mountains. Alternatively, the highest exposure surface in the Fourth Range may correlate and the underlying exposure surfaces may have been lost due to erosion and merging of unconformities in the northern areas. However, the well-developed paleosol and lack of erosional features in the Sadlerochit Mountains suggest prolonged exposure during the repeated onlapping carbonate sequences in the Fourth Range.

Package of Three Exposure Surfaces in the Upper Alapah

The above noted exposure surfaces are overlain by a thick section (varying from 100 to 200 meters thick) of echinoderm-bryozoan packstone and grainstone that form several subtidal shallowing-upward sequences. This thick interval of open-marine carbonates is capped by a series of three, closely spaced, subaerial exposure surfaces in the Sadlerochit and Shublik Mountains that can be traced to two similar surfaces in the Fourth Range (Fig. 14). The thin sequences associated with these exposure surfaces are composed of burrowed peloidal packstone that are capped by lime mudstone with *in situ* breccia, root molds and minor pisolith. The stratigraphic correlation diagram (Fig. 14) is hung on this interval because this extensive tidal flat environment may represent a correlative, generally horizontal datum. This datum may provide a picture of the paleotopography at the base of the Lisburne and/or relative subsidence across this Mississippian carbonate platform.

Exposure Surfaces at the Alapah-Wahoo Contact

The uppermost beds of the Alapah Formation in all three sections have interbedded stromatolites and finely crystalline dolostone. Stromatolites are most abundant in the Sadlerochit and Shublik Mountains and are less well developed in the Fourth Range section. Early cracks and disruption of algal textures are present in the stromatolitic beds, indicating supratidal to possible subaerial exposure conditions in the uppermost Alapah before the major transgression that resulted in the deposition of open-marine limestones of the overlying Wahoo Limestone.

The Wahoo-Alapah boundary in the Sadlerochit and Shublik Mountains is marked by cavernous porosity filled mostly by very coarse calcite spar and contains lesser down-dropped blocks, clasts of limestone, quartz silt and sand, and angular chert fragments. The cave formation involves the lowest Wahoo Limestone so it must postdate the possible subaerial exposure of the uppermost Alapah Formation.

Exposure Surfaces at the Mississippian-Pennsylvanian Boundary

An exposure surface occurs immediately below the Mississippian boundary (as determined by conodont at the Sadlerochit Mountains section, see above), approximately 50 to 60 meters above the base of the Wahoo Limestone (Fig. 14). In the Sadlerochit Mountains, erosional topography ranging from a meter to a few centimeters is present less than one meter below the first occurrence of Pennsylvanian conodonts. A sample from immediately below this irregular surface has banded caliche that is offset by stylolites. This constrains the formation of the caliche to preburial conditions and indicates that it most likely formed during subaerial exposure of the Mississippian strata. In the Shublik Mountains, samples collected from beneath the Mississippian-Pennsylvanian boundary have ribbon spar filling fine fractures that meander around grains. Ribbon spar and early cracks are associated with meteoric-vadose conditions. In the Fourth Range, *in situ* brecciation and tegmatic fractures occur less than ten meters below the first Pennsylvanian foraminifera. Conodont biostratigraphy in the Sadlerochit Mountains has moved the Mississippian-Pennsylvanian boundary 10 meters lower than indicated by foraminiferal zonation so the Fourth Range exposure surface may correlate. Conodont analyses of the Fourth Range section are presently underway and will allow us to test this correlation.

Morrowan Exposure Surfaces in the Sadlerochit Mountains

Three exposure surfaces have been recognized in Morrowan age (lower Pennsylvanian) limestones in the Sadlerochit Mountains (Fig. 14). These exposure surfaces were not found in the Shublik Mountains and Fourth Range, suggesting that these paraconformities pass southward into relatively conformable successions. The lowermost surface occurs at the top of the first shallowing-upward cycle in the upper Wahoo Limestone (Fig. 14), and is marked by small expansion-dissolution fissures (1-2 cm wide) filled with chalcedony and minor calcite cement predating laminated clays lining the sides of the fissures. The next two surfaces occur at 130 and 150 meters above the base of the Wahoo Limestone and have *in situ* brecciation developed in finely crystalline, green dolostone that caps a shallowing-upward cycle. Porosity in these breccias is infilled by dark-brown lime mud and echinoderm and bryozoan grains that infiltrated during the deposition of the overlying marine limestones.

Morrowan-Atokan Boundary in the Shublik Mountains

In the Shublik Mountains, a subaerial exposure surface occurs at the Morrowan-Atokan boundary (Mamet, pers. comm.). This boundary is a few meters above first Atokan foraminifera recognized by Gruzlovic (in prep.). Ribbon spar was observed and *Paleomicrocodium*, a perforating algae indicating subaerial exposure, was previously recognized at this horizon. Subaerial exposure features were not found at the Morrowan-Atokan boundary in the Sadlerochit Mountains and Fourth Range (Fig. 14). A single subaerial exposure surface was found, however, in the lower part of Atokan strata in the Sadlerochit Mountains and in the Fourth Range. The surface in the Sadlerochit Mountains is 210 meters above the base of the Wahoo and is expressed by small dissolutional pockets in an oolitic grainstone that are filled with dolomitic mud from the overlying cycle. In the Fourth Range, black shale infiltrated into partially cemented oolitic grainstone along early-developed fractures. If Mamet's biostratigraphic correlations are correct, it is possible that additional exposure surfaces exist in each study area but were not recognize (Fig. 14). Alternatively, if the exposure surfaces correlate between the sections, then biostratigraphic correlation may need revision.

Regional Stratigraphic Framework

Petrographic analyses have been completed on a suite of more than 1000 samples from three stratigraphic sections and provide a detailed understanding of the anatomy of down-dip profile of the Lisburne carbonate platform. Paul Gruzlovic (in prep.) is nearing completion of this master's thesis that will provide a detailed analysis of the cyclicity evident in these rocks and illustrates how lateral facies changes affect the nature of shallowing-upward cycles.

Field studies on regional geology of the Lisburne Group in 1990 focused on:

1. determining the nature of the stratigraphy of the type section of the Wahoo Limestone and lateral facies changes between the type locality and the cyclical Wahoo farther to the northeast (Fig 3; localities 24 & 25);
2. determining the difference between parautochthonous (relatively less deformed) and allochthonous (thrust-faulted and tectonically transported) rocks of the Lisburne Group near the Trans-Alaska Pipeline (Fig. 1);
3. examining the type localities of the Wachsmuth and Alapah Formations (the lower parts of the Lisburne Group) at Shainin Lake (Fig. 1) to determine their stratigraphy and depositional history.

The general field relationships of these areas together with ongoing petrographic, biostratigraphic, and diagenetic studies will yield valuable information on lithofacies, biofacies, and ages which are critical to understanding the regional stratigraphic framework. In addition to refining our knowledge of stratigraphic relationships and constraining paleogeographic models, the results will also contribute to regional structural syntheses.

Down-dip Profile of the Lisburne Carbonate Platform

A north-south series of stratigraphic sections, representing cross-section across the south-dipping carbonate ramp upon which the Wahoo Limestone formed, have been analyzed to determine the nature of lateral facies changes (Fig. 15; Gruzlovic, in prep.). The cyclic stratigraphy characterizing these rocks provides a means of detailed correlation that is more precise than allowed by biostratigraphy alone. These correlations indicate lateral facies changes from shallower water paleoenvironments in the north and deeper water areas in the south. Overall, the upper Wahoo Limestone is transgressive then regressive, with the deepest water facies in the middle part. Smaller-scale parasequences (shallowing-upward cycles) are superimposed on these overall trends. Thus, we are able to illustrate differences in the nature of shallowing-upward cycles that formed in shallow versus deeper marine conditions. For example, parasequences in the lowest part of the upper Wahoo show significant lateral facies changes with ooid shoal deposits in the south and open and restricted platform (lagoonal)

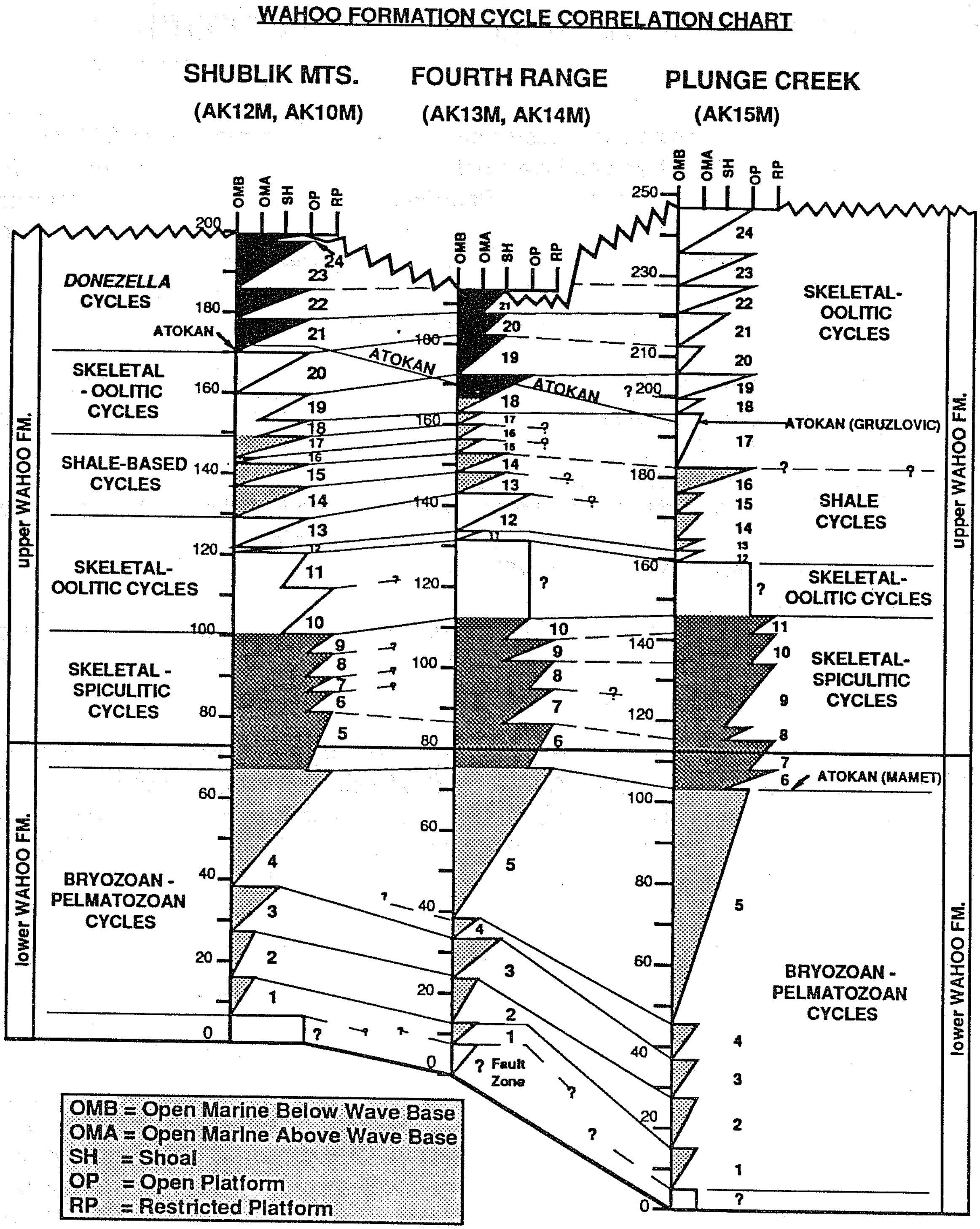
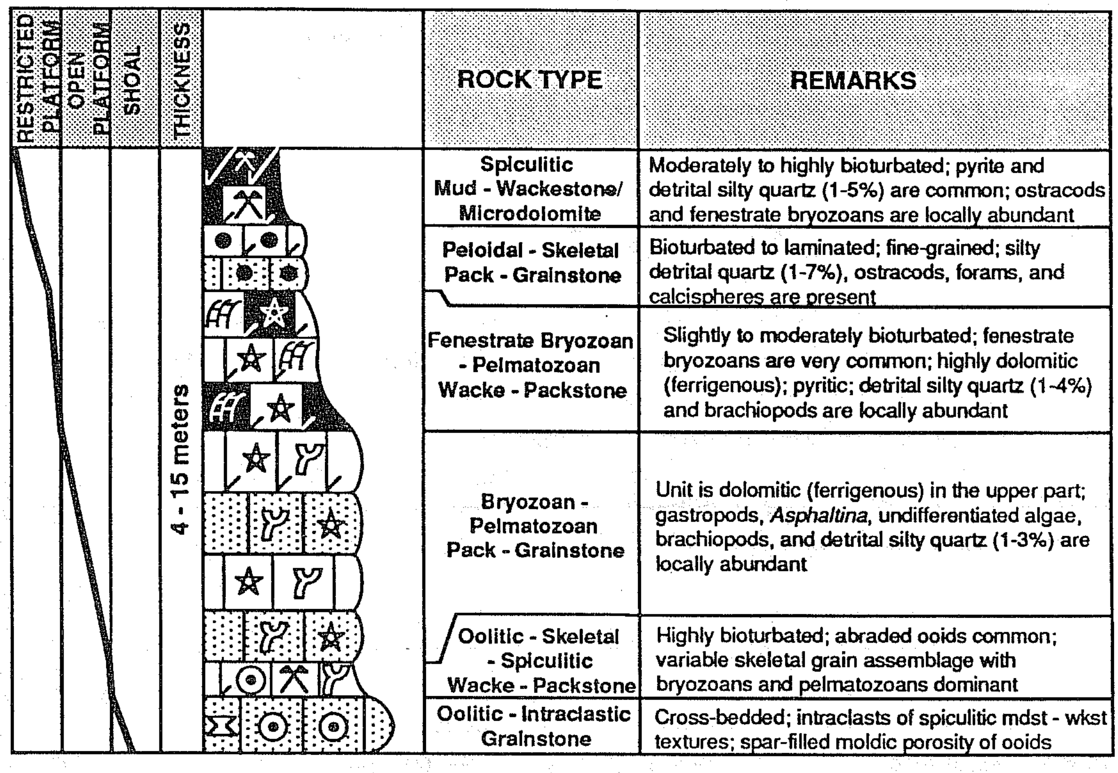
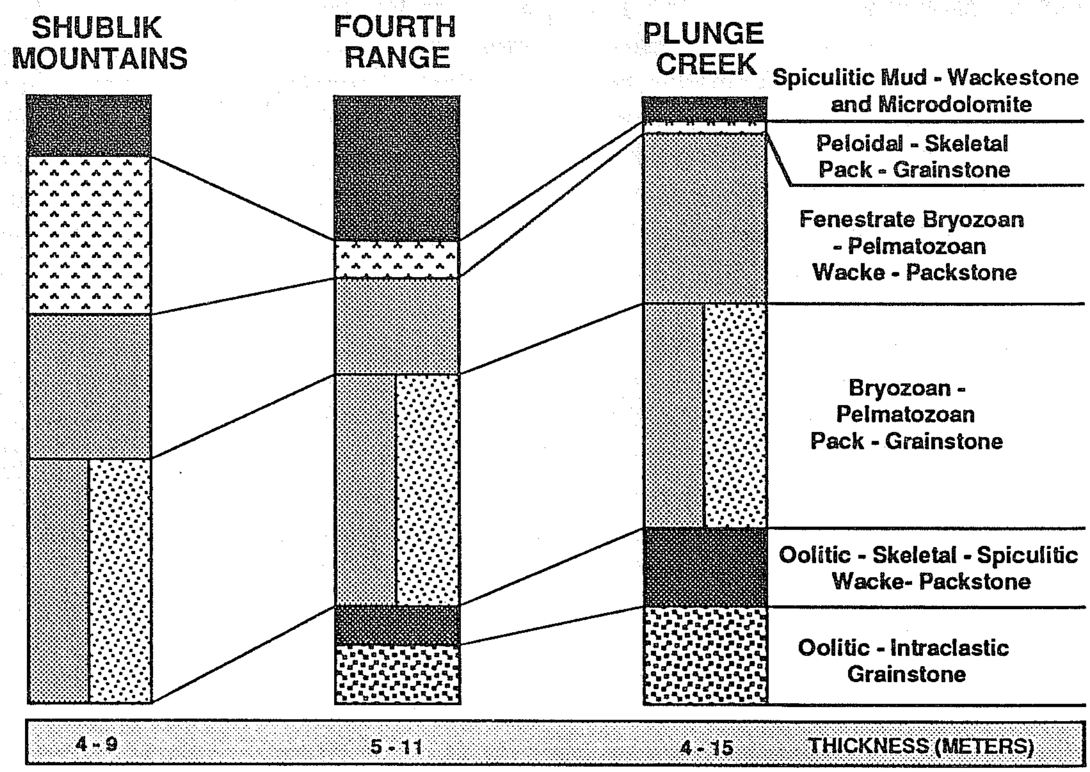


Figure 15 Correlation chart for the Lisburne Group sections along a transect extending down depositional dip (see Fig. 3 for locations; Gruzlovic, in review).

Figure 16 a) Typical shallowing-upward cycle in the lower part of the Wahoo Formation at Plunge Creek (see Fig. 15; from Gruzlovic, in review).

SKELETAL - SPICULITIC IDEAL SHALLOWING UPWARD CYCLE





b) Comparison between shallowing-upward cycles in the lower part of the Wahoo Formation (from Gruzlovic, in review).

deposits to the north (Fig. 16). In the middle part of the upper Wahoo, southern deeper-water areas have well-developed calcareous shales in the lower part of the cycles that represent incipient platform drowning events in which carbonate production rates were low. In the upper part of the upper Wahoo, *Donezella* algae occurs in oolitic-skeletal cycles in the north, but is lacking in correlative deeper-water cycles to the south. Facies associations within parasequences of the upper Wahoo have allowed Gruzlovic (in prep.) to develop detailed facies models (Fig. 17).

Basinward Facies Changes Near Wahoo Lake

Previous studies indicate that the upper 50 meters of the Wahoo Limestone at the Wahoo Lake type-locality are mostly argillaceous spiculitic limestones that formed in a basinal environment (location 13 on Fig. 3; Watts et al., 1989). Thus, significant facies changes exist between this area and shallow-marine limestones in other localities studied farther to the northeast. The goal of our 1990 studies was to examine the nature of the facies changes and determine whether the platform-to-basin transition represents continued southward deepening on a homoclinal carbonate ramp or a more abrupt distally steepened carbonate ramp (cf. Read, 1984).

Deep-water limestone and argillaceous shale in the uppermost Wahoo, such as previously documented at the type locality (section 13 on Fig. 3; Watts et al., 1989), were not recognized farther to the north (sections 24 and 25 on Fig. 3). On the south flank of the Echooka anticline (section 24 on Fig. 3), the upper part of the Wahoo consists primarily of bryozoan-pelmatozoan wackestone that apparently formed below wave-base on a southward-facing carbonate ramp. The deeper marine, basinal limestones seem to be restricted to an outcrop belt along the south flank of a major anticlinal structure at the type locality and presumably also occurs in areas farther to the south. If the rocks in the study areas are the same age (biostratigraphic studies in progress) and correlative rocks have not been lost due to erosion along the unconformity at the top of the Lisburne, the lack of slope breccias suggests that the Wahoo platform was a southward sloping ramp.

Several partial stratigraphic sections of the Lisburne Group were measured and sampled near the type section of the Wahoo Limestone. Much of the Wahoo Limestone is composed of massive, cliff-forming, fossiliferous, crinoidal limestone. Unfortunately, structural deformation caused these limestones to be highly strained and somewhat sheared, obscuring the original lithologies. However, bedded limestone and dolomite in the underlying Alapah Formation were deformed by smaller-scale folding, lack penetrative shearing, and have well-preserved primary and secondary fabrics. Of particular interest, collapse breccias, cave sediments, and speleothem cements near the top of the Alapah Formation may correlate with possible exposure surfaces recognized in diagenetic studies in the Sadlerochit and Shublik Mountains and Fourth Range (see above; localities 8, 10 & 11 on Fig. 3).

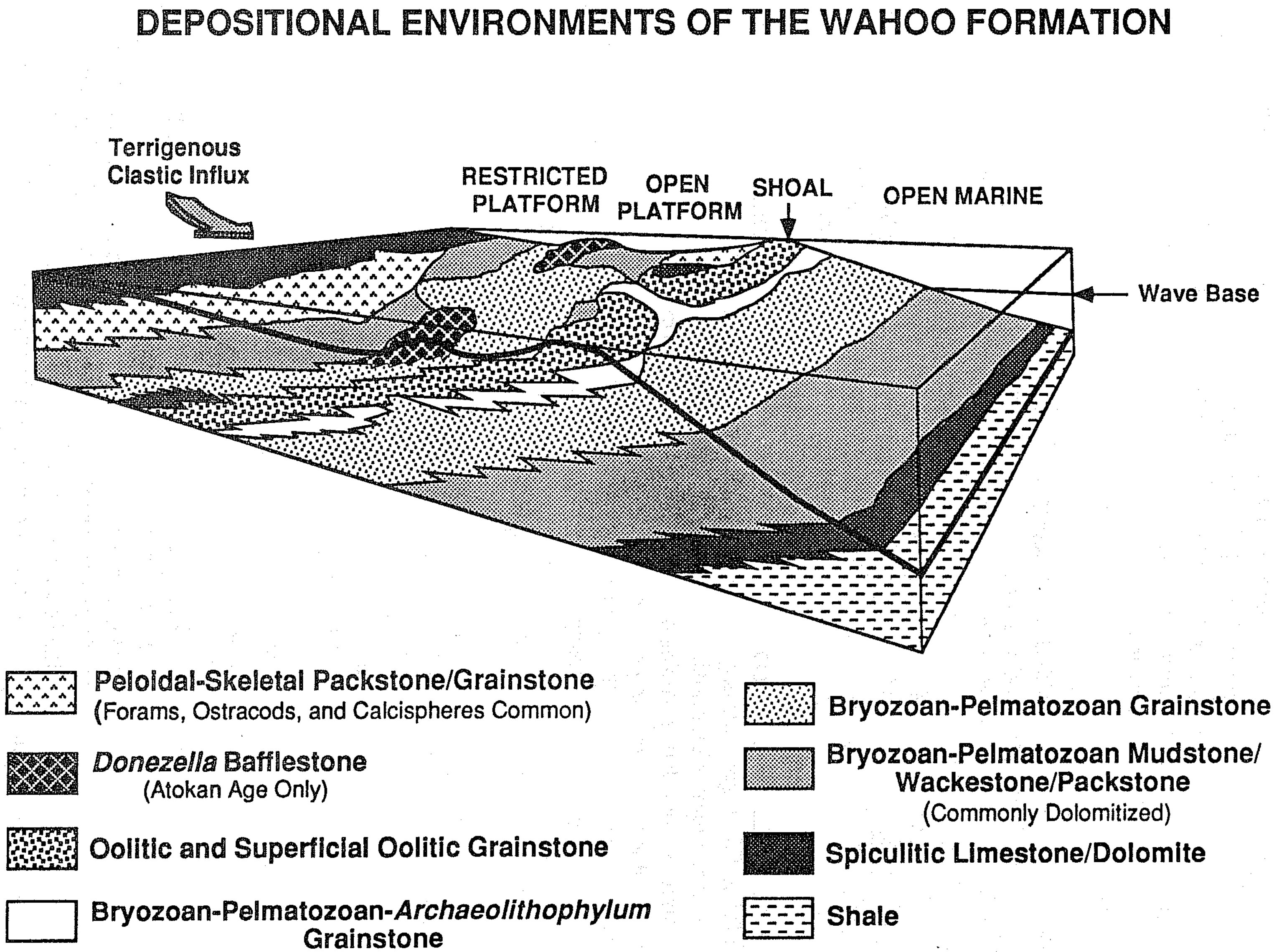


Figure 17 Facies model for the upper Wahoo Limestone (from Gruzlovic, in prep.).

Parautochthonous Versus Allochthonous Lisburne

The boundary between parautochthonous rocks of the northeastern Brooks Range in northern ANWR and allochthonous rocks farther to the south extends eastward from the northern margin of the central Brooks Range toward Canada (Mull et al., 1987b). Stratigraphic relationships across this structural boundary may help to constrain estimates of tectonic transport and are critical to constructing regional paleogeographic reconstructions for the Lisburne Group.

Working in conjunction with U.S. Geological Survey geologists involved in studies along the Trans-Alaska Pipeline, several stratigraphic sections of the Lisburne Group were measured in the northernmost exposures of the Endicott Allochthon. The Lisburne Group is extremely thick (perhaps 2500 meters or more) but gradational boundaries between different rock types makes subdivision into thinner mappable stratigraphic units difficult. A five-meter-thick interval of orange-weathering limestone in the middle of the underlying Kayak Shale is a distinct marker that is useful in mapping studies and for stratigraphic correlation. The lower part of the Lisburne Group consists of dark-colored, ledge- and slope-forming limestone and dolostone and may represent the Alapah Limestone. The upper part of the Lisburne Group consists of light-colored, cliff-forming, crinoidal limestone that may correlate with the Wahoo Limestone. The boundary between these two major units is gradational and poorly defined. Between these two units, a several hundred meter thick transitional interval alternates between the light and dark lithologies. Numerous conodont samples were collected from the uppermost Lisburne Group to determine whether these fossiliferous limestones are Mississippian or Pennsylvanian in age. Unfortunately, reconnaissance flights east and northeast of the Trans-Alaska Pipeline were unable to locate an intact, accessible, and well-exposed section of the southernmost parautochthonous Lisburne Group. However, the stratigraphy of the Lisburne Group can be compared with our detailed studies of parautochthonous rocks in northeastern ANWR.

Type Sections of the Alapah and Wachsmuth Formations

The Alapah and Wachsmuth Formations (the lower part of the Lisburne Group) were originally described near Shainin Lake (Bowsher and Dutro, 1962) in what has become recognized as part of the Endicott Mountains allochthon (Figure 1; Mull et. al, 1987b). These formation names were then extended to parautochthonous rocks of the northeastern Brooks Range (Brosge' et al., 1962; Armstrong, 1972; Mamet and Armstrong, 1972; Armstrong and Mamet, 1975, 1977; Wood and Armstrong, 1975). The present distance between the Shainin Lake section and the nearest measured section of parautochthonous rocks in the northeastern Brooks Range is 115 km (71 miles) to the northeast (Wahoo Lake section, locality 13 on Fig. 3). At least, an additional 88 km (55 miles) of separation is required to account for the northward tectonic transport of the Endicott Mountains allochthon (Mull et al., 1987a). To determine whether this stratigraphic nomenclature was overextended and whether rocks in these widely separated areas are truly correlative, we measured and sampled the type sections of the Alapah and Wachsmuth Formations and will compare the results with our work on supposedly correlative rocks in ANWR.

Interestingly, the Wachsmuth Limestone has several intervals of massive, coarse-crystalline dolostone with considerable intercrystalline, moldic and vuggy porosity which contain possible bitumen. Many of the molds are after crinoid ossicles, suggesting that these calcitic grains were later dissolved from the dolomite matrix. These thick-bedded, light-colored dolostones have relict textures suggestive of pelmatozoan packstone/grainstone and occur in several thick intervals that cyclically alternate with dark-colored, argillaceous, fine-grained limestone and dolomite with chert nodules.

Numerous corals occur in the lower part of the Alapah Limestone. Snowstorms and low visibility in late July 1990 interfered with measuring the Alapah section. This work will be completed during the 1991 field season.

Future Research Plans

Work on the computerized database will continue with additional data input, programming, and analysis. Programming will focus on developing database systems for biostratigraphy of foraminifera and algae, for information derived from detailed studies of diagenisis, and for stratigraphic and locality information. Existing thin sections lacking detailed petrographic descriptions will be analyzed using our standardized format and added to the database system. These data will then be analyzed using a number of different statistical techniques.

Conodont samples collected during the 1990 field season are being processed and analyzed and will yield valuable biostratigraphic information. Following petrographic analyses, thin sections will be given to Dr. Mamet who will complete biostratigraphic analyses of foraminifera and algae.

Detailed studies of diagenesis will continue, focusing on samples collected during the 1990 field season and existing suites of thin sections previously collected in the study areas.

Regional studies will continue, completing analyses of samples collected during the 1990 season, examining the nature of southward facies changes in the Lisburne Group and the relationship between stratigraphy and structural geology. In future years, similar work will be conducted in the eastern part of ANWR toward the Canadian border.

In late 1991 and 1992, our analyses of the Lisburne Group will extend westward to the Lisburne field and test our ability to use cyclicity as a means of correlation and for relating lithologic changes to reservoir characteristics.

Summary

Our integrated geological studies are providing a detailed understanding of the depositional and diagenetic history of the Lisburne Group that will serve as an excellent model for reservoir heterogeneities resulting from carbonate shallowing-upward cycles. Detailed petrographic analyses are allowing us to develop a graphic understanding of the origin and nature of a variety of shallowing-upward cycles. These detailed analyses, together with regional framework studies, will provide a better understanding of the paleogeography and history of sea-level fluctuations. Analyses of conodonts are yielding a variety of biostratigraphic information, including biofacies interpretations tied to petrographic analyses, and color alteration indices (thermal history indicator). Diagenetic studies have provided information on cement stratigraphy and have located a number of subaerial exposure surfaces that can be used for stratigraphic correlation and in constructing sea level curves. Together, this spectrum of analyses will allow us to develop a precise correlation scheme to elucidate factors influencing and defining reservoir heterogeneities resulting from shallowing-upward cycles that typify carbonate rocks.

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Appendix 1

Petrographic data from the Wahoo database

Table summarizes some of the information contained in the Wahoo database. The sample number is in two parts: the first AK-#-M part is the University of Alaska Museum number and refers to stratigraphic section (see Fig. 3 and Table 2 for locations); the second part of the number is in meters above the base of the section. A key to the symbols used under grain types is given below and correspond to the symbols used in stratigraphic sections (Figs. 6 & 7). The carbonate lithology column provides textural information using Dunham's (1962) classification. Paleoenvironmental interpretations are based on grain types and lithology together with the position within parasequence and relationship to adjacent lithologies.

Key for Location of Measured Sections

Central Shublik Mountains

Section AK-10-M, uppermost lower Wahoo Limestone and upper Wahoo Limestone
Section AK-11-M, Alapah Formation
Section AK-12-M, lower Wahoo Limestone and lowermost upper Wahoo Limestone

Fourth Range

Section AK-13-M, Alapah Formation, lower Wahoo Limestone, and lowermost upper Wahoo Limestone
Section AK-14-M, upper Wahoo Limestone

Plunge Creek

Section AK-15-M, lower Wahoo Limestone and upper Wahoo Limestone
Section AK-16-M, upper Alapah Formation

SKELETAL GRAINS

- Pelmatozoan
- Bryozoan (undifferentiated)
- Bryozoan (fenestrate)
- Brachiopod
- Bivalve
- Gastropod
- Foraminifera
- Trilobite
- Ostracod
- Sponge
- Sponge Spicules
- Colonial Coral
- Solitary Coral
- u - Coral (undifferentiated)
- Algae (undifferentiated)
- *Asphaltina sp.*
- *Donezella sp.*
- *Calcisphaera sp.*
- Ammonite
- 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

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK10M0	[illegible]	[illegible]	Packstone	open platform
AK10M0.5	[illegible]	[illegible]	Packstone	open platform
AK10M1	[illegible]	[illegible]	Grainstone	open platform
AK10M1.5	[illegible]	[illegible]	Packstone	restricted platform
AK10M2	[illegible]	[illegible]	Grainstone	open platform
AK10M2.5	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK10M3	[illegible]	[illegible]	Packstone	restricted platform
AK10M3.5	[illegible]	[illegible]	Packstone	restricted platform
AK10M4	[illegible]	[illegible]	Packstone	open platform
AK10M4.5	[illegible]	[illegible]	Packstone	restricted platform
AK10M5	[illegible]	[illegible]	Wackestone	restricted platform
AK10M6	[illegible]	[illegible]	Wackestone	restricted platform
AK10M6.5	[illegible]	[illegible]	Packstone	open platform
AK10M7	[illegible]	[illegible]	Packstone	open platform
AK10M7.5	[illegible]	[illegible]	Wackestone	restricted platform
AK10M8	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK10M8.5	[illegible]	[illegible]	Wackestone	restricted platform
AK10M9	[illegible]	[illegible]	Packstone	restricted platform
AK10M9.5	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK10M10	[illegible]	[illegible]	Grainstone	open platform
AK10M11	[illegible]	[illegible]	Grainstone	open platform
AK10M11.5	[illegible]	[illegible]	Boundstone	open platform
AK10M12	[illegible]	[illegible]	Packstone	restricted platform
AK10M12.5	[illegible]	[illegible]	Packstone	open platform
AK10M13	[illegible]	[illegible]	Packstone	restricted platform
AK10M13.5	[illegible]	[illegible]	Packstone	restricted platform
AK10M14	[illegible]	[illegible]	Packstone	restricted platform
AK10M14.5	[illegible]	[illegible]	Packstone	restricted platform
AK10M15	[illegible]	[illegible]	Packstone	open platform
AK10M15.5	[illegible]	[illegible]	Packstone	open platform
AK10M15.75	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK10M16	[illegible]	[illegible]	Packstone	restricted platform
AK10M16.5	[illegible]	[illegible]	Packstone	restricted platform
AK10M17	[illegible]	[illegible]	Packstone	open platform
AK10M17.5	[illegible]	[illegible]	Packstone	restricted platform
AK10M18	[illegible]	[illegible]	Packstone	restricted platform
AK10M18.5	[illegible]	[illegible]	Packstone, Wackeston	lagoonal

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK10M19	[illegible]	[illegible]		restricted platform
AK10M19.5	[illegible]	[illegible]	Packstone, Wackeston	open platform
AK10M20	[illegible]	[illegible]	Wackestone	restricted platform
AK10M20.5	[illegible]	[illegible]	Packstone	open platform
AK10M21	[illegible]	[illegible]	Packstone	open platform
AK10M21.5	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK10M22	[illegible]	[illegible]	Wackestone	restricted platform
AK10M22.5	[illegible]	[illegible]	Wackestone	restricted platform
AK10M23	[illegible]	[illegible]	Wackestone	deep
AK10M23.5	[illegible]	[illegible]		restricted platform
AK10M24		[illegible]	Mudstone	restricted platform
AK10M24.5	[illegible]	[illegible]	Packstone	open platform
AK10M25	[illegible]	[illegible]	Wackestone	restricted platform
AK10M25.5	[illegible]	[illegible]	Packstone	open platform
AK10M26	[illegible]	[illegible]	Packstone, Wackeston	open platform
AK10M26.5	[illegible]	[illegible]	Packstone	restricted platform
AK10M27		[illegible]	Mudstone	restricted platform
AK10M27.5		[illegible]		restricted platform
AK10M28			Mudstone	restricted platform
AK10M28.5	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK10M29	[illegible]			restricted platform
AK10M29.5	[illegible]	[illegible]	Grainstone	lagoonal
AK10M30	[illegible]	[illegible]	Packstone	open platform
AK10M30.5	[illegible]	[illegible]	Packstone	open platform
AK10M31	[illegible]		Packstone	open platform
AK10M31.5	[illegible]	[illegible]	Grainstone	shoal
AK10M32	[illegible]	[illegible]	Grainstone	shoal
AK10M32.5	[illegible]	[illegible]	Grainstone	shoal
AK10M33	[illegible]	[illegible]	Grainstone	shoal
AK10M33.5	[illegible]	[illegible]	Grainstone	open platform
AK10M34	[illegible]	[illegible]	Packstone	open platform
AK10M34.5	[illegible]	[illegible]	Packstone	open platform
AK10M35	[illegible]	[illegible]	Packstone	open platform
AK10M35.5	[illegible]	[illegible]	Packstone	open platform
AK10M36	[illegible]	[illegible]	Packstone	open platform
AK10M36.5	[illegible]	[illegible]	Packstone	open platform
AK10M37	[illegible]	[illegible]	Grainstone	open platform
AK10M37.5	[illegible]	[illegible]	Packstone	restricted platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK10M38	YꜲ★	Ʊ∼♣∩⌂ℓ⊙	Packstone	open platform
AK10M38.5	Y★ℓ	ꜲƱ♣●∩☮	Packstone	restricted platform
AK10M39	ƱY★	∩∼♣☮ℓ⌂	Packstone	restricted platform
AK10M39.5	Y★	∼Ʊȣ♣∩⧗⌂ℓ†	Packstone, Mudstone	restricted platform
AK10M40	★Y⧗●	♣∼⊙⌂ȣ∩	Packstone	open platform
AK10M40.5	Y★⊖	Ʊ♣⊙⧗●∼	Grainstone	shoal
AK10M41	Y★●	Ʊ♣∩⊖☮	Grainstone	shoal
AK10M41.5	Y★●	Ʊ∼♣⧗⊙ȣ☮	Grainstone	shoal
AK10M42	∼Y★	Ʊ♣ȣℓ⧗●⊙	Grainstone	shoal
AK10M42.5	∼Y★	Ʊ♣⊙⧗●ȣ	Grainstone	shoal
AK10M43	Y★	♣ȣ∼●Ʊ	Packstone	open platform
AK10M43.5	Y∼●★	Ʊ♣ℓ⧗⊖ȣ∩	Grainstone	shoal
AK10M44	Y∼●★	ℓƱ♣⊙⧗⊖ȣ∩	Grainstone	shoal
AK10M44.5	Y★	Ʊ♣ȣ∩⧗Ꜳ∼	Packstone, Wackeston	open platform
AK10M45.5	Y★	∩ℓ♣∼	Packstone	open platform
AK10M46	Y★	Ʊ∼Ꜳ∩♣⧗	Packstone	open platform
AK10M46.5	Y★	∼Ʊȣ♣⧗ℓ∩⌂	Packstone	open platform
AK10M47	ƱY★	ℓ♣●∩☮	Packstone	open platform
AK10M47.5	Y★	Ʊ♣⧗●ȣ∼⌂∩	Grainstone	open platform
AK10M48	Y★	∼♣ȣ⧗∩Ʊ	Grainstone	open platform
AK10M48.5	Y★	Ʊ♣●∩	Grainstone	open platform
AK10M49	Y★	Ʊ♣	Wackestone	open marine
AK10M49.5	Y★	∩Ʊȣ⌂ℓ	Grainstone	open marine
AK10M50	Y∼⊖★	Ʊ♣⧗⌂∩	Grainstone	shoal
AK10M50.5	YꜲ★	Ʊ	Packstone	open marine
AK10M51	Y★	∼Ʊ⧗♣⌂∩	Grainstone	open marine
AK10M51.5	Y★	∼♣ȣƱ⧗∩⌂	Grainstone	open marine
AK10M52	∼Y★	Ʊ♣ȣ⌂∩ℓ	Grainstone	open marine
AK10M53	⊖	Ʊ∼♣Y⧗⊙★	Grainstone	shoal
AK10M53.5	⊖	Ʊ∼♣Y⧗⊙★	Grainstone	shoal
AK10M54	⊖	Ʊ∼♣Y⧗⊙★	Grainstone	shoal
AK10M54.5	Y★	Ʊ♣Ꜳℓȣ∩	Packstone	open platform
AK10M55	★Y⧗⊙	♣∼⌂ȣ∩Ʊ	Grainstone	open platform
AK10M55.5	Y★⊙	∼♣ȣƱ⧗⌂∩	Packstone	open platform
AK10M56	Y★⊙	∼Ʊȣ♣∩⊗⧗ℓ⌂	Grainstone	open platform
AK10M56.5	∼ȣY⊙★	♣Ʊ⌂	Grainstone	open platform
AK10M57	∼ȣY⊙★	♣Ʊ⧗	Grainstone	open platform
AK10M57.5	Y★	Ʊ♣⊙ȣ∼∩ℓ	Grainstone	open platform
AK10M58		Ʊ★	Mudstone	open marine

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK10M59	[illegible]	[illegible]	Packstone, Wackeston	open marine
AK10M59.5	[illegible]	[illegible]	Grainstone	open marine
AK10M61	[illegible]	[illegible]	Grainstone	shoal
AK10M61.5	[illegible]	[illegible]	Grainstone	shoal
AK10M62	[illegible]	[illegible]	Grainstone	shoal
AK10M62.5	[illegible]	[illegible]	Grainstone	shoal
AK10M63	[illegible]	[illegible]	Grainstone	shoal
AK10M63.5	[illegible]	[illegible]	Grainstone	shoal
AK10M64	[illegible]	[illegible]	Grainstone	shoal
AK10M64.5	[illegible]	[illegible]	Grainstone	shoal
AK10M65	[illegible]	[illegible]	Grainstone	shoal
AK10M65.5	[illegible]	[illegible]	Wackestone	open marine
AK10M67	[illegible]	[illegible]	Grainstone	shoal
AK10M67.5	[illegible]	[illegible]	Grainstone	shoal
AK10M68	[illegible]	[illegible]	Grainstone	open platform
AK10M69	[illegible]	[illegible]	Grainstone	shoal
AK10M69.5	[illegible]	[illegible]	Grainstone	shoal
AK10M70.5	[illegible]	[illegible]	Packstone	open platform
AK10M71	[illegible]		Wackestone	open marine
AK10M71.5	[illegible]	[illegible]	Grainstone	open marine
AK10M72	[illegible]	[illegible]	Packstone	open marine
AK10M72.5		[illegible]	Mudstone	open marine
AK10M73.5	[illegible]	[illegible]	Packstone	open marine
AK10M74	[illegible]	[illegible]	Packstone	open marine
AK10M74.5	[illegible]	[illegible]	Grainstone	open marine
AK10M75	[illegible]	[illegible]	Grainstone	shoal
AK10M75.5	[illegible]	[illegible]	Grainstone	open platform
AK10M76	[illegible]	[illegible]	Grainstone	open platform
AK10M76.5	[illegible]	[illegible]	Grainstone	open platform
AK10M77	[illegible]	[illegible]	Grainstone	open platform
AK10M77.5	[illegible]	[illegible]	Grainstone	shoal
AK10M78	[illegible]	[illegible]	Grainstone	open marine
AK10M78.5	[illegible]	[illegible]	Grainstone	open marine
AK10M79	[illegible]	[illegible]	Grainstone	open marine
AK10M79.5	[illegible]	[illegible]	Grainstone	open marine
AK10M80	[illegible]	[illegible]	Grainstone	open marine
AK10M80.5	[illegible]	[illegible]	Grainstone	shoal
AK10M81	[illegible]	[illegible]	Packstone	open platform
AK10M81.5	[illegible]	[illegible]	Grainstone	open marine
AK10M82	[illegible]	[illegible]	Grainstone	open marine

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK10M82.5	[illegible]	[illegible]	Grainstone	open marine
AK10M83	[illegible]	[illegible]	Grainstone	open marine
AK10M83.5	[illegible]	[illegible]	Grainstone	shoal
AK10M84	[illegible]	[illegible]	Grainstone	shoal
AK10M84.5	[illegible]	[illegible]	Grainstone	shoal
AK10M85	[illegible]	[illegible]	Grainstone	open platform
AK10M85.5	[illegible]	[illegible]	Grainstone	open platform
AK10M86	[illegible]	[illegible]	Packstone	open platform
AK10M86.5	[illegible]	[illegible]	Grainstone	shoal
AK10M87	[illegible]	[illegible]	Grainstone	shoal
AK10M87.5	[illegible]	[illegible]	Grainstone	open marine
AK10M88	[illegible]	[illegible]	Grainstone	open marine
AK10M88.3	[illegible]	[illegible]	Grainstone, Packston	open marine
AK10M88.5		[illegible]	Mudstone	open marine
AK10M89	[illegible]	[illegible]	Wackestone	open marine
AK10M89.5	[illegible]	[illegible]	Grainstone	open marine
AK10M90	[illegible]	[illegible]	Grainstone, Packston	open marine
AK10M90.5	[illegible]	[illegible]	Grainstone	open marine
AK10M91	[illegible]	[illegible]	Packstone	open marine
AK10M91.5	[illegible]	[illegible]	Packstone	open marine
AK10M92	[illegible]	[illegible]	Grainstone	open marine
AK10M92.5	[illegible]	[illegible]	Grainstone	open marine
AK10M93	[illegible]	[illegible]	Grainstone	open marine
AK10M93.5	[illegible]	[illegible]	Grainstone	open marine
AK10M94	[illegible]	[illegible]	Grainstone	open marine
AK10M94.5	[illegible]	[illegible]	Grainstone	open marine
AK10M95	[illegible]	[illegible]	Grainstone	shoal
AK10M95.5	[illegible]	[illegible]	Packstone	open platform
AK10M96	[illegible]	[illegible]	Packstone	open platform
AK10M96.5	[illegible]	[illegible]	Grainstone	shoal
AK10M97	[illegible]	[illegible]	Grainstone	shoal
AK10M97.5	[illegible]	[illegible]	Grainstone	shoal
AK10M98	[illegible]	[illegible]	Grainstone	shoal
AK10M98.5	[illegible]	[illegible]	Grainstone	shoal
AK10M99	[illegible]	[illegible]	Grainstone	open marine
AK10M99.35	[illegible]	[illegible]	Packstone	open marine
AK10M99.5	[illegible]	[illegible]	Packstone	open marine
AK10M100	[illegible]	[illegible]	Grainstone	open marine
AK10M100.51	[illegible]	[illegible]	Packstone	open marine
AK10M100.52	[illegible]	[illegible]	Packstone	open marine

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK10M101	Y★	ѴℳΛ♣	Grainstone	open marine
AK10M101.5	Y★	Ѵℳ♣~Λ	Grainstone, Packston	open marine
AK10M102	Yℳ★	Ѵ♣Λ	Grainstone, Packston	open marine
AK10M102.5	Y~⊙★	Ѵ♣8⧖ⒶΛ	Grainstone	shoal
AK10M103	Y~★⧖⊙	♣8ΛѴ	Grainstone	shoal
AK10M103.5	Y~★⧖⊙	♣8ѴΛⒶ	Grainstone	shoal
AK10M104	★Y⧖⊙	~♣8ΛѴⒶ	Grainstone	shoal
AK10M104.5	Y★	Ѵ♣8⧖ⒶΛ	Grainstone	open platform
AK10M105	Y★	♣8~ѴⒶ	Packstone	open platform
AK10M105.5	Y★	ΛѴ♣•⧖8☮ℳ	Grainstone, Packston	open platform
AK10M106	⊙	Y♣⊖Ѵ☮★	Grainstone	shoal
AK10M106.5	⊙⧖	Y♣⊖★	Grainstone	shoal
AK10M107	⊙	⊖⧖~Y	Grainstone	shoal
AK10M107.5	Y★	ℳ	Packstone	open marine
AK10M107.9	Y★	Ѵℳ♣Λ	Grainstone	open marine
AK10M108.5	Y★	♣Ѵ⧖8	Grainstone	open marine
AK10M109	★Y⊙⊖	~♣⧖Ѵ	Grainstone	shoal
AK10M109.5	Y~⊙★	Ѵ♣8Λ⧖⊖Ⓐ	Grainstone	shoal
AK10M110	𝔅⊙	~Y8♣⧖★☮ѴΛ	Bafflestone	open platform
AK10M110.5	⊙	⊖~♣Y⧖★	Grainstone	shoal
AK10M111	⊙	★Y⧖⊗	Grainstone	shoal
AK10M111.5	~Y★	♣8⧖ⒶΛ	Grainstone, Packston	open platform
AK10M112	Y★	♣8Ѵ⧖Λ~	Grainstone	open platform
AK10M112.5	★Y⊙⊖	~♣8⧖𝔅Ѵ	Grainstone	shoal
AK10M113	Y~⧖★	Ⓐ♣8⊙•𝔅ℓΛ	Grainstone	open platform
AK10M113.5	Y★⧖	♣~8⊙𝔅ѴⒶℓΛ	Grainstone	open platform
AK10M114	⊙	⊖⧖8	Grainstone	shoal
AK10M114.5	Y★	Ѵ~♣Ⓐℳ	Grainstone	open marine
AK10M115	Y★	Ѵ♣8⧖ℳⒶ	Packstone	open marine
AK10M115.5	Y★⊙	♣~8⧖𝔅ⒶΛ	Grainstone	shoal
AK10M115.7	𝔅	★Y♣☮ℓ~ⒶѴ	Bafflestone	open platform
AK10M116	𝔅	Y~♣★•☮ℓ	Bafflestone	open platform
AK10M116.5	𝔅♣	★•~Ѵ⧖Ⓐ	Grainstone	open platform
AK10M117	𝔅♣	★Y~⊗•⧖☮Ⓐ	Bafflestone	open platform
AK10M117.5	♣⊗𝔅	Y~★•☮	Boundstone	open platform
AK10M118	⊙	⊖⧖♣Y★	Grainstone	shoal
AK10M118.5	Y★	ⒶѴ♣⧖⊙☮	Grainstone	open platform
AK10M119	~♣★⊙⊖	8Y⧖𝔅⊗	Grainstone	shoal

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK10M119.5			Grainstone	open platform
AK10M120			Grainstone	shoal
AK10M120.5			Grainstone, Packston	open platform
AK10M121			Grainstone	open platform
AK10M121.5			Bafflestone	open platform
AK10M122			Grainstone	shoal
AK10M122.5			Grainstone	open platform
AK10M123			Grainstone	open platform
AK10M123.5			Grainstone	shoal
AK10M124			Bafflestone	open platform
AK10M124.5			Grainstone	open platform
AK10M125			Grainstone	shoal
AK10M125.5			Grainstone	shoal
AK10M126			Grainstone	shoal
AK10M126.5			Grainstone, Packston	open marine
AK10M127			Grainstone	shoal
AK10M127.5			Grainstone	open platform
AK10M128			Packstone	open platform
AK10M128.5				
AK11M0				intertidal
AK11M0.5				intertidal
AK11M4.5			Packstone	lagoonal
AK11M5.7			Packstone	lagoonal
AK11M6.5			Packstone	lagoonal
AK11M10				intertidal
AK11M40.5			Grainstone, Packston	lagoonal
AK11M46.56			Packstone	lagoonal
AK11M50			Packstone	lagoonal
AK11M55.7			Grainstone	shoal
AK11M60			Wackestone	lagoonal
AK11M67.5			Grainstone	shoal
AK11M71.5			Wackestone	lagoonal
AK11M90			Grainstone	shoal
AK11M97			Wackestone	lagoonal
AK11M104			Grainstone	shoal
AK11M110			Grainstone	shoal
AK11M115			Packstone	lagoonal
AK11M121.5			Grainstone	lagoonal
AK11M121.52			Grainstone	lagoonal

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK11M125	Y★⊖	~♣Ѵ⊙Ⓐ	Grainstone	shoal
AK11M131	Y★⊙	Ѵ~♣●⊖Ⓐ	Grainstone	shoal
AK11M134	★Y⊙⊖	♣~Ѵ	Grainstone	shoal
AK11M141	Y★	Ѵℓ	Packstone	lagoonal
AK11M145	★Y●ℓ	♣	Packstone	lagoonal
AK11M145.02				
AK11M150	★Y●ℓ	~♣☮Ѵ	Packstone	lagoonal
AK11M157	★Y●ℓ	~♣ѴⒶ	Packstone	lagoonal
AK11M160.5	★Y●ℓ	Ѵ♣⧗☮	Packstone	lagoonal
AK11M163				intertidal
AK11M166	Y★●	ℓѴ♣⧗☮Ⓐ	Grainstone	shoal
AK11M170	Y★	⧗	Grainstone	shoal
AK11M180	Y★		Wackestone	lagoonal
AK11M180.02	Y★		Wackestone	lagoonal
AK11M185	Y★●	Ѵ♣☮ℓ	Packstone	lagoonal
AK11M190	★Y●⊖	ℓ♣☮⧗⊙Ѵ	Grainstone, Packston	shoal
AK11M195	YѴℓ★	~♣☮Ⓐ	Packstone	lagoonal
AK11M200	Ѵ~♣●★Y	Ⓐ	Packstone, Bafflesto	lagoonal
AK11M205	~♣8Ѵ⧗★Y	ℳⒶ	Packstone	open platform
AK11M210	Y★	Ѵ♣ℳⒶ	Grainstone, Packston	open platform
AK11M216	★Y●⊖	Ѵ♣⧗ℓ	Grainstone	shoal
AK11M216.02				
AK11M220.5	Y★●	~♣Ѵ⧗☮	Grainstone	shoal
AK11M223	★	ℳ	Wackestone	open platform
AK11M229	Y★	Ѵ♣	Packstone	open platform
AK11M234.5	Yℳ★	ѴⒶ♣~	Packstone	open platform
AK11M241	Yℳ★	Ѵℓ↟	Packstone	open platform
AK11M247.5	Yℳ★	♣Ѵ	Packstone, Wackeston	open platform
AK11M250	Y★	ℳ~	Packstone	open platform
AK11M254.4	Yℳ★	ѴⒶ	Packstone	open platform
AK11M261	Y★	Ѵ~Λℓ♣Ⓐ	Grainstone	open platform
AK11M264	Y★	Ѵ♣ℓ●~☮	Grainstone	open platform
AK11M270	Y★	Ѵ8ℳΛ♣	Packstone	open platform
AK11M274.5	Y★⧗	Ѵ	Grainstone	open platform
AK11M279.5	Y★↟		Packstone, Wackeston	open platform
AK11M285	★Y	Λ8⧗ℓ♣	Grainstone	open platform
AK11M290	Y★	Ѵℓ	Grainstone, Packston	open platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK11M297			Packstone	open platform
AK11M312			Packstone	open platform
AK11M315.5			Packstone	open platform
AK11M320			Packstone	restricted platform
AK11M325.5			Packstone	restricted platform
AK11M335				restricted platform
AK11M345.5				restricted platform
AK11M351				restricted platform
AK11M374.5			Wackestone	restricted platform
AK11M375			Packstone	restricted platform
AK11M380			Mudstone	restricted platform
AK11M383			Wackestone	restricted platform
AK11M389			Grainstone	open platform
AK12M3				restricted platform
AK12M4.5			Grainstone	open platform
AK12M6			Grainstone	shoal
AK12M8.5			Grainstone	shoal
AK12M12			Grainstone, Packston	open marine
AK12M14			Grainstone	open marine
AK12M16			Grainstone	open marine
AK12M20			Grainstone	open marine
AK12M22			Packstone	open marine
AK12M24			Wackestone	open marine
AK12M26			Wackestone	open marine
AK12M28			Packstone	open marine
AK12M30			Packstone	open marine
AK12M32			Grainstone	open marine
AK12M33			Packstone	open marine
AK12M36			Packstone	open marine
AK12M38			Grainstone	open marine
AK12M40			Grainstone	shoal
AK12M42			Grainstone	shoal
AK12M44			Grainstone, Packston	open marine
AK12M46			Packstone	open marine
AK12M50			Packstone, Wackeston	open marine
AK12M54			Packstone, Wackeston	open marine
AK12M56			Grainstone, Packston	open marine

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK12M58	★Y	8∩&	Grainstone	open marine
AK12M60	★Y	Ѵ8∩ℋ	Grainstone	open marine
AK12M62	ℋ★	8Y∩~	Grainstone	open marine
AK12M64	8ℋ★	∩YⒶℓ	Grainstone	open marine
AK12M66	Y★	∩8ℓⒶ~Ѵ	Grainstone	open marine
AK12M68	⊖	Y~&★⧗●⊙8	Grainstone	shoal
AK12M69	ѴY★	&Ⓐ	Packstone	open platform
AK12M70	Y★●	Ѵ&ℓ☮~Ⓐ	Packstone	restricted platform
AK12M72	Y★	~&Ѵ⧗∩8	Grainstone	open platform
AK12M74	8Y★	~&ѴⒶ∩	Packstone	open platform
AK12M76	Y★	&8Ѵ⧗Ⓐ	Grainstone	open platform
AK12M77	ѴY★	ℋ&8∩Ⓐℓ☮	Packstone	open platform
AK12M77.5	ℋY●★	∩ℓ&Ѵ	Packstone	restricted platform
AK12M79	★Y●ℓ	~&ѴⒶ∩	Packstone	restricted platform
AK12M81	Yℋ★	Ѵℓ	Packstone, Wackeston	open platform
AK12M83	★Y●↟	ℋℓ&☮∩	Packstone	restricted platform
AK13M0	↟●	~&★☮ℓ	Packstone	lagoonal
AK13M3	★~↟ℓ	Y	Packstone, Boundston	lagoonal
AK13M5	★↟●	Y~&ℓ⊗⊗ℋ	Packstone	lagoonal
AK13M12	~&ℓ★	↟●	Boundstone	lagoonal
AK13M14.5	~&●★	ℓѴ↟Ⓐ	Boundstone	lagoonal
AK13M16.5		ℓ↟	Mudstone	lagoonal
AK13M19		ℓ↟	Mudstone	lagoonal
AK13M21.5	~&●★	Ѵ☮Ⓐ⊗	Boundstone	lagoonal
AK13M22.5	~●	★&☮ℓ	Boundstone	lagoonal
AK13M26		↟Ⓐ		lagoonal
AK13M40.01	↟●			lagoonal
AK13M40.02		↟		intertidal
AK13M41.1	~↟●	&ℓ	Packstone	lagoonal
AK13M41.8	~↟●	&ℓ	Packstone	lagoonal
AK13M42.1	↟			intertidal
AK13M42.75			Boundstone	intertidal
AK13M43.5	↟			lagoonal
AK13M45				intertidal
AK13M46.4			Boundstone	intertidal
AK13M46.6		~	Mudstone	intertidal
AK13M50.5	★~⧗ℓ	&☮Y	Boundstone	lagoonal
AK13M59.5	~★●	Y&ℓⒶ	Packstone	lagoonal
AK13M62.5				intertidal
AK13M65	Y★●	Ѵ&⧗ℓ	Grainstone	shoal

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK13M70.5	ϒ★	Ʊ♣ℓ⊗⊗	Packstone	lagoonal
AK13M77.5			Boundstone	intertidal
AK13M84				intertidal
AK13M89	ϒ★●		Packstone	lagoonal
AK13M92	★ϒ●⊙	ℓ♣⧗☮ᕱ	Grainstone	shoal
AK13M97.5	ϒ★●	♣⧗	Grainstone	lagoonal
AK13M102	ϒ★●	♣ᕱ☮	Grainstone	shoal
AK13M107	ϒ★●	Ʊ♣⧗⊙	Grainstone	shoal
AK13M111	ϒ★			lagoonal
AK13M116	ϒ★	Ʊ	Grainstone, Packston	lagoonal
AK13M121	ϒ★⧗	Ʊ●𝒮♣ᕱ	Grainstone	shoal
AK13M124	𝓜★	ϒℓ⸙♣	Wackestone	lagoonal
AK13M128.5	ϒ★●	ℓƱ⧗⊙♣	Grainstone	shoal
AK13M134.5	ϒ★	ℓƱ●ᕱ	Wackestone	lagoonal
AK13M138.5	ϒ★●	Ʊ♣⧗ℓ	Packstone	lagoonal
AK13M143.5	ϒ★●	ℓ♣	Grainstone	lagoonal
AK13M149.5		★		open platform
AK13M155.5	ϒ★	Ʊ♣ℓ⧗●	Grainstone	open platform
AK13M160.5	ϒ★	ℓƱ⸙ᕱ	Packstone	open platform
AK13M166	ϒ★	Ʊℓ♣ᕱ	Packstone	open platform
AK13M171.5	ϒ★	Ʊ		open platform
AK13M174	𝓜★	ℓƱ⸙𝒮♣ᕱ	Wackestone	open platform
AK13M179	ϒ★	Ʊ𝓜	Packstone	open platform
AK13M184	★ϒ	⧗	Grainstone	open platform
AK13M200.5	𝓜★	ϒ⸙		restricted platform
AK13M202.3	ϒ★	Ʊ	Grainstone	restricted platform
AK13M202.8	ϒ★	Ʊ⸙ᘏ	Packstone	restricted platform
AK13M203.5		⸙		restricted platform
AK13M204.4		⸙	Mudstone	restricted platform
AK13M204.7	𝒮ϒ★	Ʊᘏ♣~⧗ℓ⊙☮	Packstone	restricted platform
AK13M208	⸙	Ʊϒ★		restricted platform
AK13M218	⸙	★		restricted platform
AK13M226	𝓜ϒ●★	ℓƱ⧗⸙	Packstone	restricted platform
AK13M231.5	ϒ★	Ʊᘏℓ♣	Grainstone, Packston	restricted platform
AK13M236			Boundstone	intertidal
AK13M240.5	⸙●			restricted platform
AK13M245	⸙			restricted platform
AK13M249.5	★ϒ	♣ℓ⧗⊗⊗	Grainstone	restricted platform
AK13M250.5	ϒ★	Ʊ●	Packstone, Wackeston	restricted platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK13M252	Y★	Ʊʃ ●	Packstone, Wackeston	restricted platform
AK13M257	Y★	ℳƱʃ ● ↑	Wackestone	restricted platform
AK13M262	↑			restricted platform
AK13M268.5				intertidal
AK13M274	Y★	Ʊʃ♣	Wackestone, Mudstone	restricted platform
AK13M278	Y★	♣∩Ⓐ	Grainstone, Packston	restricted platform
AK13M279	↑		Wackestone	restricted platform
AK13M280	Y★	∩Ʊ♣⧗Ⓐʃ	Grainstone, Packston	restricted platform
AK13M285	ℳ★	Y↑●	Packstone, Wackeston	restricted platform
AK13M286	↑			restricted platform
AK13M288	●	↑		restricted platform
AK13M290	ℳ	Y★↑Ʊ	Wackestone	restricted platform
AK13M292	Yℳ★		Wackestone	restricted platform
AK13M294	↑			restricted platform
AK13M296		↑	Mudstone	restricted platform
AK13M298.5	↑	●	Wackestone	restricted platform
AK13M300.5	↑			restricted platform
AK13M302.5		↑		restricted platform
AK13M304.5	ℳ★	Y↑	Packstone, Wackeston	open marine
AK13M307	Y★	ℳƱ∩♣Ⓐ	Grainstone, Packston	open marine
AK13M310	Y★		Grainstone	open marine
AK13M312	Y★↑		Wackestone	open marine
AK13M314	Y★	∼ƱⒶ♣	Packstone	open marine
AK13M316	Y★	ß∩⧗♣	Grainstone	open marine
AK13M318	Y★	∩↑♣	Packstone	open marine
AK13M320	Y★	ℳƱ∩⧗	Packstone	open marine
AK13M322	Y★	♣∩	Grainstone, Packston	open marine
AK13M324	Y★	Ʊ∩ß♣⧗	Grainstone	shoal
AK13M326	Y★	ℳß∩ʃ	Grainstone, Packston	open platform
AK13M327.5	Y★●	∼♣ℳ☮ʃ	Packstone	open platform
AK13M330	Y★	♣Ⓐ	Grainstone	open marine
AK13M332	Y★	♣Ʊℳ	Packstone	open marine
AK13M334	Y★	♣ß⧗∩	Grainstone	open marine
AK13M336	Y★	∩♣⊙ʃ	Grainstone	shoal

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK13M337.8	Y ℳ ★	Ʊ & ℓ ⧗ ☮	Packstone, Wackeston	open platform
AK13M340	ℰ Y ★	∼ & Ʊ ⧗ Λ	Grainstone	open platform
AK13M342	Y ★	Ʊ ℳ	Packstone	open marine
AK13M344	Ʊ Y ★	& Λ	Packstone	open marine
AK13M346	Y ★	Ʊ ⧗	Packstone	open marine
AK13M348	Y ★	ℳ ℓ &	Packstone	open marine
AK13M350	Y ★	& ℳ ∼ Ʊ	Packstone	open marine
AK13M352	Y ★	∼ Ʊ ℳ &	Packstone	open marine
AK13M354	Y ★	∼ ℳ & Λ	Packstone	open marine
AK13M355.3	Y ★	Ʊ ∼ Λ	Packstone	open marine
AK13M356.5	Y ★			open marine
AK13M358	Y ★			open marine
AK13M363.5	Y ★	Ʊ ℰ Λ ℳ	Packstone	open marine
AK13M365	Y ★		Packstone	open marine
AK13M366	Y ★	Λ Ⓐ	Grainstone	shoal
AK13M367	Y ★	Λ ℰ ⧗ Ⓐ	Grainstone, Packston	shoal
AK13M369	Y ★	Ʊ Λ Ⓐ	Packstone	open platform
AK13M371	Y ★	Ʊ &	Packstone	open platform
AK13M373	Y ★	Λ ℳ Ⓐ	Packstone	open platform
AK13M375	Y ℳ ★	Ʊ Ⓐ	Wackestone	restricted platform
AK13M375.9	ᛘ	★		restricted platform
AK13M378		ℳ ᛘ		restricted platform
AK13M380	Y ★	ℳ ⧗	Packstone, Wackeston	open platform
AK13M381.5	Y ★	Λ Ʊ & ⧗ Ⓐ	Packstone	open platform
AK13M383	Y ★	Ʊ & ⧗ Ⓐ ℰ	Packstone	open platform
AK13M384	Y ℳ ★	Ʊ	Wackestone	open platform
AK13M384.5	Y ★	ℳ Ʊ Ⓐ Λ ℰ	Packstone	open platform
AK13M385	Y ★	Λ & ● ℓ	Packstone	open platform
AK13M385.3	Y ★	Λ Ʊ & ● ℓ Ⓐ	Packstone	open platform
AK13M385.9	ᛘ			restricted platform
AK13M387.7	ᛘ	ℳ		restricted platform
AK13M388.1	★ ℰ Y	Λ Ⓐ	Packstone	restricted platform
AK14M0	Y ★	& ℰ Λ Ʊ	Grainstone	open platform
AK14M0.5	Y ℳ ★	ℓ ᛘ &	Wackestone	restricted platform
AK14M1	ℳ Y Λ ★	ℓ ᛘ	Wackestone	restricted platform
AK14M1.5	Y ★	Ʊ ∼ ℰ Λ ⧗ Ⓐ ℓ	Packstone	open platform
AK14M2	ℳ ★ ᛘ	Y Ʊ Ⓐ ℓ	Wackestone	restricted platform
AK14M2.5	ᛘ			restricted platform
AK14M3		ᛘ		restricted platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK14M3.5	↟			restricted platform
AK14M4	↟			restricted platform
AK14M4.5	↟	ℋ Y		restricted platform
AK14M5		↟ℋ	Mudstone	restricted platform
AK14M5.5	↟			restricted platform
AK14M6	↟			restricted platform
AK14M6.5	↟			restricted platform
AK14M7	Y★↟	ℓ	Wackestone	restricted platform
AK14M7.5	⊙•⧖	Y8⊖★∼	Grainstone	shoal
AK14M8	⊙•⧖	Y★⊖8	Grainstone	shoal
AK14M8.5	⊙•⧖	Y8⊖★	Grainstone	shoal
AK14M9	⊙•⧖	Y★⊖	Grainstone	shoal
AK14M9.5	Yℋ★	∩♡ℓ↟Ⓐ	Packstone, Wackeston	open platform
AK14M10	Y★⊙	ℋℓ↟	Wackestone	open platform
AK14M10.5	★Y⊙↟	∼ℋℓ⧖♣Ⓐ∩	Wackestone	open platform
AK14M11	Y★	♣8ℓ↟Ⓐ	Wackestone	open platform
AK14M11.5	Y★	8♣↟ℓ∩	Packstone	open platform
AK14M12				restricted platform
AK14M12.5		↟		restricted platform
AK14M13		ℋ↟		restricted platform
AK14M13.5	Yℋ★	♣ℓ⊗∩	Packstone	open platform
AK14M14	Yℋ★	∩♣8⧖ℓⒶ	Grainstone	open platform
AK14M14.5		↟		restricted platform
AK14M15	Yℋ★	♡∩8♣ℓ↟⧖Ⓐ⊗	Packstone, Wackeston	restricted platform
AK14M15.5	Yℋ★	∼♡8♣⧖ℓ∩Ⓐ	Packstone	restricted platform
AK14M16	Y★⧖	∼♣8♡ℓ∩Ⓐ	Grainstone	open platform
AK14M16.5	Y★⧖	∼♣8♡Ⓐℓ∩	Grainstone	open platform
AK14M17.01	ℋ★	YⒶ	Wackestone	restricted platform
AK14M17.5	★Y↟ℓ	♡♣	Packstone, Wackeston	restricted platform
AK14M18	∼Y★	♡♣8⧖ℓⒶ	Grainstone	open platform
AK14M18.5	Y★ℓ	∼♡8♣ℋ↟Ⓐ∩⊗	Wackestone	restricted platform
AK14M19	Yℓ	★↟♣♡		restricted platform
AK14M19.5	ℓ	Y★↟		restricted platform
AK14M20		↟		restricted platform
AK14M20.5	ℋ★ℓ	Y♡↟∩	Wackestone	restricted platform
AK14M21	ℋ↟	Y★ℓ	Wackestone	restricted platform
AK14M21.5	↟	★Yℓ		restricted platform
AK14M22	★Y•ℓ	♡∼♣⊗Ⓐ∩	Packstone	restricted platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK14M22.3	ℋ★†	YƱ∼ⓐℓ⧖	Packstone, Wackeston	restricted platform
AK14M22.5	★Y⧖⊙	∼Ʊ8♣ℋⓐ⊖∩ℓ	Grainstone, Packston	shoal
AK14M23	⊙⧖	Y♣★ⓐ	Grainstone	shoal
AK14M23.5	Y★⊙	⧖8∼ⓐ	Packstone	open platform
AK14M24	ℋY†★	Ʊ∼♣∩⧖⊙ℓ	Packstone, Wackeston	open platform
AK14M24.5	Y★⧖	Ʊ∩♣∼⊖⊙ℓⓐ	Packstone	open platform
AK14M25	Y★	∼Ʊ8♣⧖∩ⓐℓ	Grainstone	open platform
AK14M25.5	Y★●	∼♣Ʊⓐℓ	Grainstone	open platform
AK14M26	Yℋ★	Ʊ∩♣∼ℓ†⊗ⓐ⧖	Packstone	restricted platform
AK14M26.3				
AK14M26.5	Y★●	∼♣Ʊ⧖ℓ8	Packstone	restricted platform
AK14M26.75	★Y●ℓ	♣Ʊ⊗	Grainstone	restricted platform
AK14M27	∼Y★	8∩⧖♣Ʊ	Grainstone	open platform
AK14M27.5		★Y†ℓ	Mudstone	restricted platform
AK14M28	⊙Y★	♣8⧖Ʊ	Grainstone	shoal
AK14M28.5	Y∼●★	Ʊ♣8⧖⊙∩	Grainstone	open platform
AK14M29	Yℋ★	∼Ʊ8♣⧖∩⊙ⓐ	Grainstone	open platform
AK14M29.5	Y★	Ʊ∼●∩♣	Grainstone	open platform
AK14M30	Y★	Ʊ∼ℓ∩8	Packstone, Wackeston	open platform
AK14M30.3	Y★	∼Ʊ8♣ℓ⧖ℋ∩	Packstone	open platform
AK14M31	ℋ★	Ʊ8∩ⓐℓ	Wackestone	open platform
AK14M31.5	∼Y★	Ʊ∩8♣ℓ●⧖ⓐ⊙	Grainstone	open platform
AK14M32	ƱY★	∩♣ℓ⧖⊗	Packstone	open platform
AK14M32.5	Y★⧖	∩Ʊℓ⊙	Packstone	open platform
AK14M33	Y★	∩Ʊℓ⧖ⓐ	Packstone	open platform
AK14M33.5	Y★∩	∼Ʊⓐ	Grainstone	shoal
AK14M34	Y★	Ʊ8∩⧖●∼	Grainstone	shoal
AK14M34.5	ℋ★	∼8Ʊ⧖∩	Grainstone	shoal
AK14M35.1	Y★	Ʊ8∩⧖ⓐ	Grainstone	shoal
AK14M35.5	Y★	∩8⧖ⓐ	Grainstone	shoal
AK14M36	8Y★	∩Ʊ⧖⊙	Grainstone	open marine
AK14M36.5	ƱY★	∼♣8∩⧖●ℓ	Grainstone	open marine
AK14M37	∼Y★	Ʊ8⧖∩♣	Grainstone	open marine
AK14M37.5	8Y★	Ʊ∼ℓ∩	Grainstone, Packston	open marine
AK14M38	Y★	♣8Ʊⓐ∩	Grainstone	open marine
AK14M38.5	∼8Y⧖★	♣∩ℓ	Grainstone	shoal
AK14M39	∼8Y⧖★	∩ℓ♣	Grainstone	shoal

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK14M39.5	∼&8⧗★Y	∩ℓ	Grainstone	shoal
AK14M40	∼8Y⧗★	&ℓ∩	Grainstone	shoal
AK14M40.5	Y★	&8Ѵ∩Ⓐ	Grainstone	open marine
AK14M41.5	∼8★Y	∩Ⓐ⊙	Grainstone	open marine
AK14M42	∼8★Y	Ѵ∩⊙	Grainstone	open marine
AK14M42.5	∼8★Y	∩&⊙	Grainstone	open marine
AK14M43	∼&★Y	∩Ѵℓ⧗8⊙	Grainstone, Packston	open marine
AK14M43.5	ℋ★	∼8Y∩⊙Ѵ	Grainstone	open marine
AK14M44	⊖⊙	Ѵ∼&Y⧗ℓ★	Grainstone	shoal
AK14M44.5	⊖⊙	Ѵ∼&Y⧗ℓ★8	Grainstone	shoal
AK14M45	⊖⊙	ѴY&∼⧗ℓ★Ⓐ	Grainstone	shoal
AK14M45.5	∼8★Y	&∩Ѵ⧗⊙Ⓐℓ	Grainstone	open marine
AK14M46	Y★	Ѵ∼8∩⧗⊙ℓ	Grainstone	open marine
AK14M46.5	Y∼∩★	Ѵ&8⧗⊙Ⓐ	Grainstone	open marine
AK14M47	∼Y★	&∩ѴⒶ⧗●8⊙ℓ	Grainstone	open marine
AK14M47.5	∼Y★	8∩●	Grainstone	open marine
AK14M48	∼Y★	Ѵ&8ℓ∩Ⓐ	Grainstone	open marine
AK14M48.5	Y∼★⧗⊖	Ѵ&8●Ⓐ∩	Grainstone	shoal
AK14M49	Y★	Ѵ∩8&ℓ●⧗Ⓐ⊙∼	Grainstone	open platform
AK14M49.5	Y★	∩Ѵ&ℓ●⧗Ⓐ∼ℋ	Packstone	open platform
AK14M50	∼&Y●★	Ѵ8∩⧗ℓ	Packstone	open platform
AK14M50.5	Y∼●★	Ѵℓ&⧗⊖∩☮Ⓐ	Grainstone	shoal
AK14M51	∼Y★	ℋ∩Ѵ8&⧗●ℓ⊖⊙	Grainstone, Packston	shoal
AK14M51.52	∼Y★	ℋℓ&Ѵ●⧗⊖Ⓐ∩	Grainstone	shoal
AK14M52	Y∼⊖★	ℓѴ&Ⓐ●⧗⊙∩	Grainstone	shoal
AK14M52.15	ℋ★	ѴY	Wackestone	open marine
AK14M52.25	Y★	Ѵ⊗∩Ⓐ	Grainstone	open marine
AK14M52.5	Y★	Ѵℋ⧗	Packstone	open marine
AK14M53	Y★	Ѵ∼&∩⧗8Ⓐ☮	Grainstone	open marine
AK14M53.5	Y★	8ѴⒶ&	Grainstone	open marine
AK14M54	∼Y★	Ѵ&8ℋ⊙ℓ	Grainstone	open marine
AK14M54.5	★Y⧗⊙	8∼Ⓐ	Grainstone	lagoonal
AK14M55	Y★	∼&8Ⓐ∩Ѵ	Packstone	open marine
AK14M55.5	Y★	ѴⒶ	Packstone	open marine
AK14M56	∼Y★	∩&8⧗●Ⓐ	Grainstone	open marine
AK14M56.3	Y★			
AK14M57	⊖∼⧗⊙	Y★●&⊗Ⓐℓ	Grainstone	shoal
AK14M57.5	Y∼★⊙⊖	&●⧗8ⒶѴ	Grainstone	shoal
AK14M58	Y★⊖	&Ѵ∼⧗●⊙Ⓐ	Grainstone	shoal
AK14M58.5	★Y⊙⊖	&∼⧗●Ⓐ	Grainstone	shoal

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK14M59	★Y⊙⊖	∼&⧗●ℰ	Grainstone	shoal
AK14M59.5	Y★⊙	∼&Ⓐ⧗●Ѵ	Grainstone	shoal
AK14M60	Y★	∩ѴⒶ⧗●ℰ	Grainstone	open platform
AK14M60.5	Y★⊖	ℰ&∼⧗●⊙ⒶℓѴ	Grainstone	shoal
AK14M61	Y★	ℳѴℰ∩⧗&∼Ⓐ⊙	Grainstone	open platform
AK14M61.5	Y★	Ѵ∩Ⓐℰ&∼	Grainstone	open platform
AK14M62	Y★	Ѵℳ&⧗●∼⊙☮Ⓐ	Packstone	open platform
AK14M62.5	Yℳ★	Ѵ∩●∼Ⓐℓ	Packstone	open platform
AK14M63	Yℳ★	Ѵ&ℰℓ●↟Ⓐ	Packstone	open platform
AK14M63.5	★Y⧗⊙	∼Ѵℰ&⊖●∩Ⓐ	Grainstone	lagoonal
AK14M64	ѴY★	∩&ℓ⧗Ⓐ	Packstone	open marine
AK14M64.5	Y★	ℳⒶ●ℰѴ∩	Grainstone	open marine
AK14M65	ѴY★	Ⓐℳ⧗●&∩	Packstone	open marine
AK14M65.5	Yℳ★		Packstone	open marine
AK14M66	Y★	∩⧗Ⓐ●	Grainstone	open marine
AK14M66.5	Y★	∩Ѵ&●⊗∼☮	Grainstone	open marine
AK14M67	Y★	Ѵ⧗∩Ⓐ	Grainstone	open marine
AK14M67.5	Y★	∼Ѵ●&Ⓐ∩	Grainstone	open marine
AK14M68	Y★	Ѵ∼Ⓐ∩	Grainstone	open marine
AK14M68.5	⊖	★Y∼⧗⊙ℰⒶ	Grainstone	shoal
AK14M69				open marine
AK14M70	Y★	ℳѴⒶ∩	Grainstone, Packston	open marine
AK14M70.5	Y★	Ѵℳℰ	Grainstone, Packston	open marine
AK14M71	Y★	ѴℳⒶ	Grainstone, Packston	open marine
AK14M71.5	Y★	ℳ∩Ѵ●	Grainstone	open marine
AK14M72	Y★	ℳѴℰ∩Ⓐℓ⧗&∼	Grainstone	open marine
AK14M72.5	Y★	ℳѴⒶ⊗∼⧗	Grainstone	open marine
AK14M73	Y∼⧗★	ℰѴ&●⊙⊖∩	Grainstone	shoal
AK14M73.5	ℳY↟★	ѴⒶ	Packstone	open marine
AK14M74.15	ℳ★↟	Yℓ	Packstone	open marine
AK14M74.5	Y★	ѴℰℳⒶ∩	Grainstone	open marine
AK14M75	Y★	ℳѴ∩Ⓐ	Packstone	open marine
AK14M75.5	Y★	ℳⒶℰ●	Packstone	open marine
AK14M76	Y★	Ѵ&∩Ⓐℓ	Packstone	open marine
AK14M76.5	Y★	∩ℳѴ●⧗&ℰⒶℓ	Grainstone, Packston	open marine
AK14M77		YⒶ		open marine
AK14M77.45	Y★	Ѵℳℰ&∩	Grainstone	open marine
AK14M77.65	ℳ★↟	YⒶ	Wackestone	open marine

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK14M78	Yℋ★	ѴΛⒶ	Packstone	open marine
AK14M78.5	Yℋ★	Ѵ♣ⒶΛ	Packstone	open marine
AK14M79	Y★	Ѵ⧗8	Grainstone	open marine
AK14M79.5	Y~⧗★	♣8●Ѵ	Grainstone	open marine
AK14M80	Y~⧗★	♣8●∕Ѵ	Grainstone	open marine
AK14M80.5	~Y★	Ѵ⧗↟	Packstone	open marine
AK14M81	Y★	∕Ѵ●Λ↟	Packstone	open marine
AK14M81.5	ℋ★↟	Y	Packstone, Wackeston	open marine
AK14M82	Y★	ℋѴΛ●8Ⓐ	Grainstone	open marine
AK14M82.5	Y★	Ѵℋ8♣Ⓐ	Grainstone	open marine
AK14M83	~Y★	♣Ѵ⧗Ⓐ8∕	Grainstone, Packston	open marine
AK14M83.5	★Y⧗⊙	♣~●8☮Ѵ	Grainstone	lagoonal
AK14M87	Yℋ★	ѴΛ●Ⓐ	Packstone	open platform
AK14M87.5	Y★	ℋѴ♣●Λ8Ⓐ	Grainstone	open platform
AK14M88	Y★	ѴΛ⧗♣☮Ⓐ	Grainstone	open platform
AK14M88.5	Y★	∕ΛѴ⧗●8Ⓐ	Grainstone	open platform
AK14M89	~Y★	Ѵ♣8Λ⧗●Ⓐ	Grainstone	open platform
AK14M89.5	⊗♣●8̸	★Y~∕⧗☮⊖	Bafflestone	open platform
AK14M90	●	♣☮		restricted platform
AK14M90.5	⊖⊙●	Y♣8̸★	Grainstone	shoal
AK14M91	⊙●	★Y⊖⧗	Grainstone	shoal
AK14M91.5	⊙●	Y~⊖★8	Grainstone	shoal
AK14M92	Y★	⊗ΛѴ⊙⧗8♣☮Ⓐ	Grainstone	open platform
AK14M92.5	Y★	Ѵℋ8♣Λ●☮Ⓐ	Grainstone	open platform
AK14M93	Yℋ★	ѴⒶ♣●Λ	Packstone	open marine
AK14M94	Y★	ℋѴ↟Λ8	Packstone	open marine
AK14M94.5	Y★	~Ѵ8♣Λ⧗∕☮Ⓐ	Grainstone	open marine
AK14M95	Y★	Ѵ♣8ℋ●ΛⒶ	Grainstone	open marine
AK14M95.5	Y★⧗	~♣ѴⒶ	Grainstone	open marine
AK14M96	Y★⊖	Ѵ~●⊙♣ⒶΛ	Grainstone	shoal
AK14M96.5	⊙	Y~★⧗●	Grainstone	shoal
AK14M97.5	⊖⊙	Y~★⧗∕	Grainstone	shoal
AK14M98	Y↟⊙	ℋѴ♣∕Λ★	Packstone, Wackeston	open platform
AK14M98.5	⊙	~♣Y⧗★	Grainstone	shoal
AK14M99	⊙Y★⧗	♣~●8☮Ⓐ	Grainstone	shoal
AK14M100	⊖⊙	♣★	Grainstone	shoal
AK14M101	⊙	★Y♣●⊖8̸8	Grainstone	shoal
AK14M101.5	⊙⊖	★Y♣⧗☮8̸~	Grainstone	shoal
AK14M102.25	⊖⊙	~♣Y⧗★	Grainstone	shoal

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK14M102.5	⊙⊖	Y♣▱★	Grainstone	shoal
AK14M103	YℋⅩ★	Ʋ♣	Grainstone	open marine
AK14M104	★Y⊙⊖	∼♣▱⧖●	Grainstone	shoal
AK14M104.5	★Y⊙⊖	∼♣▱⧖●	Grainstone	shoal
AK14M105	★Y⊙⊖	∼♣▱⧖●Ʋ	Grainstone	shoal
AK14M105.5	⊖⊙	★Y∼♣⧖●▱Ʌ	Grainstone	shoal
AK14M106	⊖⊙	★Y∼♣⧖●▱Ⓐ	Grainstone	shoal
AK14M106.5	⊖⊙	Y∼♣★⧖●▱8	Grainstone	shoal
AK14M107	⊖⊙	★Y▱⧖●ℓ	Grainstone	shoal
AK14M107.5	⊖⊙	Y∼♣★⧖●▱	Grainstone	shoal
AK14M108	⊖⊙	Y∼♣★⧖●▱	Grainstone	shoal
AK14M108.5	★Y⧖⊙	∼♣8●⊖Ⓐ	Grainstone	lagoonal
AK14M109.5	⊖⊙⧖	∼♣8▱★Y	Grainstone	shoal
AK14M111	∼⊖⊙	Y♣⧖★	Grainstone	shoal
AK14M111.5	⊖⊙	Y♣⧖★	Grainstone	shoal
AK14M112	⊖⊙	★⧖	Grainstone	shoal
AK14M112.5	⊖⊙	Y★⧖	Grainstone	shoal
AK14M113	♣⊖⊙	Y★⧖	Grainstone	shoal
AK14M113.5	⊖⊙	Y♣⧖★	Grainstone	shoal
AK14M114	⊖⊙	Y♣⧖★	Grainstone	shoal
AK14M114.03	⊖⊙	★♣⧖ℓ	Grainstone	shoal
AK15M0	Y★	ɅⒶ⧖	Grainstone	open marine
AK15M4	Y★	ƲɅ⧖●Ⓐ	Grainstone	open marine
AK15M5	Y★Ʌ	ƲℋⒶ	Packstone	open marine
AK15M8	Y★	♣Ʋ↟ℓɅ	Packstone	open marine
AK15M10	Y★	ƲɅ♣	Grainstone	open marine
AK15M12	Y★	Ʌ⧖	Grainstone	open marine
AK15M14	Y★	ƲⒶ	Grainstone	open marine
AK15M15	Y★	ƲℋɅ♣	Packstone	open marine
AK15M16.5	Y★	Ʌ8	Packstone	open marine
AK15M18	Y★	Ʌ		
AK15M20.02	↟	Yℋ★	Wackestone	
AK15M20.1	↟	Yℋ	Wackestone	
AK15M24	Yℋ★	ƲɅ♣	Packstone	open marine
AK15M26	★Y	Ⓐ	Grainstone	open marine
AK15M28	Y★	Ʋ♣ℋ⊗	Packstone	open marine
AK15M30	Yℋ★	ƲɅ♣Ⓐ	Packstone, Wackeston	open marine
AK15M32	Y★	ɅƲ	Packstone	open marine
AK15M32.8	Y★	ɅƲ	Packstone	open marine
AK15M34	Y★	Ʋ♣ℋɅⒶ	Packstone	open marine

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK15M36	[illegible]	[illegible]	Grainstone	open marine
AK15M38.4	[illegible]	[illegible]	Packstone	
AK15M40	[illegible]	[illegible]	Packstone	open marine
AK15M42	[illegible]	[illegible]	Packstone	open marine
AK15M44	[illegible]	[illegible]	Grainstone	open marine
AK15M46	[illegible]	[illegible]	Packstone	open marine
AK15M48	[illegible]	[illegible]	Packstone	open marine
AK15M50	[illegible]	[illegible]	Packstone	open marine
AK15M52	[illegible]	[illegible]	Packstone	open marine
AK15M54	[illegible]	[illegible]	Packstone	open marine
AK15M56	[illegible]	[illegible]	Packstone	open marine
AK15M59	[illegible]	[illegible]	Packstone	
AK15M62	[illegible]	[illegible]	Wackestone	open marine
AK15M64.5	[illegible]	[illegible]	Packstone	open marine
AK15M66	[illegible]	[illegible]	Wackestone	open marine
AK15M68	[illegible]	[illegible]	Packstone	open marine
AK15M70	[illegible]	[illegible]	Wackestone	open marine
AK15M72	[illegible]	[illegible]	Packstone	open marine
AK15M74	[illegible]	[illegible]	Grainstone	open marine
AK15M75.6	[illegible]	[illegible]	Grainstone	open marine
AK15M78	[illegible]	[illegible]	Packstone	open platform
AK15M80	[illegible]	[illegible]	Grainstone	open platform
AK15M82	[illegible]	[illegible]	Packstone	open platform
AK15M84.5	[illegible]	[illegible]	Grainstone	open platform
AK15M89	[illegible]	[illegible]	Grainstone	open platform
AK15M93	[illegible]	[illegible]	Packstone	open platform
AK15M95	[illegible]	[illegible]	Packstone	open platform
AK15M98	[illegible]	[illegible]	Grainstone	open platform
AK15M100	[illegible]	[illegible]	Wackestone	open platform
AK15M103	[illegible]	[illegible]	Grainstone	shoal
AK15M105	[illegible]	[illegible]	Grainstone	open platform
AK15M107	[illegible]	[illegible]		restricted platform
AK15M109	[illegible]	[illegible]	Grainstone	open platform
AK15M112	[illegible]	[illegible]	Packstone	open platform
AK15M112.5	[illegible]	[illegible]		restricted platform
AK15M113	[illegible]	[illegible]	Packstone	restricted platform
AK15M113.5	[illegible]	[illegible]	Packstone	restricted platform
AK15M114	[illegible]	[illegible]	Packstone	restricted platform
AK15M114.5	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK15M115	[illegible]	[illegible]	Packstone	open platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK15M115.5	[illegible]	[illegible]	Grainstone, Packston	open platform
AK15M116	[illegible]	[illegible]	Grainstone	shoal
AK15M116.5	[illegible]	[illegible]	Packstone	open platform
AK15M117	[illegible]	[illegible]	Packstone	open platform
AK15M117.5	[illegible]	[illegible]	Packstone	open platform
AK15M118	[illegible]	[illegible]	Grainstone	shoal
AK15M118.5	[illegible]	[illegible]	Grainstone	shoal
AK15M119	[illegible]	[illegible]	Grainstone	shoal
AK15M119.5	[illegible]	[illegible]	Grainstone	shoal
AK15M120	[illegible]	[illegible]	Packstone	open platform
AK15M120.5	[illegible]	[illegible]	Packstone	open platform
AK15M120.8	[illegible]	[illegible]	Packstone	open platform
AK15M121.5	[illegible]	[illegible]	Grainstone	shoal
AK15M122	[illegible]	[illegible]	Grainstone	shoal
AK15M122.5	[illegible]	[illegible]	Grainstone	shoal
AK15M123	[illegible]	[illegible]	Grainstone	shoal
AK15M123.5	[illegible]	[illegible]	Grainstone	shoal
AK15M124	[illegible]	[illegible]	Grainstone	shoal
AK15M124.5	[illegible]	[illegible]	Grainstone	shoal
AK15M125	[illegible]	[illegible]	Grainstone	open platform
AK15M125.5	[illegible]	[illegible]	Grainstone	open platform
AK15M126	[illegible]	[illegible]	Grainstone	open platform
AK15M126.5	[illegible]	[illegible]	Packstone	open platform
AK15M127	[illegible]	[illegible]	Grainstone	open marine
AK15M127.5	[illegible]	[illegible]	Packstone	open platform
AK15M128	[illegible]	[illegible]	Grainstone	open platform
AK15M128.5	[illegible]	[illegible]	Grainstone	open platform
AK15M129	[illegible]	[illegible]	Packstone	restricted platform
AK15M129.5	[illegible]	[illegible]	Packstone	restricted platform
AK15M130	[illegible]	[illegible]	Packstone	restricted platform
AK15M130.5	[illegible]	[illegible]	Packstone	restricted platform
AK15M131	[illegible]	[illegible]	Wackestone	restricted platform
AK15M131.5	[illegible]	[illegible]	Packstone	restricted platform
AK15M132	[illegible]	[illegible]	Packstone	restricted platform
AK15M132.5	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK15M133.5	[illegible]	[illegible]	Grainstone	open platform
AK15M134	[illegible]	[illegible]	Grainstone	open platform
AK15M134.5	[illegible]	[illegible]	Grainstone	open platform
AK15M135	[illegible]	[illegible]	Grainstone	open platform
AK15M135.5	[illegible]	[illegible]	Packstone	restricted platform

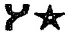
Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK15M136	[illegible]	[illegible]	Packstone	restricted platform
AK15M136.5	[illegible]	[illegible]	Wackestone	restricted platform
AK15M137	[illegible]	[illegible]	Wackestone	restricted platform
AK15M137.5	[illegible]	[illegible]	Wackestone	restricted platform
AK15M138	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK15M138.5	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK15M139	[illegible]	[illegible]	Wackestone	restricted platform
AK15M139.5	[illegible]	[illegible]	Packstone, Wackeston	restricted platform
AK15M140	[illegible]	[illegible]	Wackestone	restricted platform
AK15M140.5	[illegible]	[illegible]	Packstone	restricted platform
AK15M141	[illegible]	[illegible]	Grainstone	lagoonal
AK15M141.5	[illegible]	[illegible]	Wackestone	open platform
AK15M142	[illegible]	[illegible]	Packstone	open platform
AK15M142.5	[illegible]	[illegible]	Grainstone	open platform
AK15M143	[illegible]	[illegible]	Grainstone	open platform
AK15M143.5	[illegible]	[illegible]	Grainstone	open platform
AK15M144	[illegible]	[illegible]	Grainstone	open platform
AK15M144.5	[illegible]	[illegible]	Wackestone	restricted platform
AK15M145.5	[illegible]	[illegible]	Packstone	open platform
AK15M146	[illegible]	[illegible]	Packstone	open platform
AK15M146.5	[illegible]	[illegible]	Grainstone	open platform
AK15M147	[illegible]	[illegible]	Grainstone	open platform
AK15M147.5	[illegible]	[illegible]	Packstone	open platform
AK15M148	[illegible]	[illegible]	Packstone	open platform
AK15M148.5	[illegible]	[illegible]	Packstone	open platform
AK15M149.01	[illegible]	[illegible]	Packstone	open platform
AK15M149.02	[illegible]	[illegible]	Packstone	open platform
AK15M152	[illegible]	[illegible]	Packstone	open platform
AK15M152.51	[illegible]	[illegible]	Packstone	open platform
AK15M153	[illegible]	[illegible]	Packstone	open platform
AK15M153.5	[illegible]	[illegible]	Packstone	open platform
AK15M154	[illegible]	[illegible]	Packstone	open platform
AK15M154.5	[illegible]	[illegible]	Packstone, Wackeston	open platform
AK15M155	[illegible]	[illegible]	Grainstone	shoal
AK15M155.5	[illegible]	[illegible]	Grainstone	shoal
AK15M156	[illegible]	[illegible]	Packstone	open platform
AK15M157	[illegible]	[illegible]	Grainstone	open platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK15M157.5	Y★●	♣8Ѵ⧗⊙~	Grainstone	open platform
AK15M158	★Y●	Ѵ8⧗∩~	Grainstone	open platform
AK15M158.5	Y★	Ѵ♣∩●⊙	Grainstone	open marine
AK15M159	Y★	Ѵ∩	Grainstone	open marine
AK15M159.5	Y★	8Ѵ⧗●	Grainstone, Wackesto	open marine
AK15M160	Y★	Ѵ8ℓ∩♣	Wackestone	open marine
AK15M160.5	Y★	Ѵ∩8♣⧗	Grainstone	open marine
AK15M161.2	Y★	Ѵℓ♣∩	Packstone	open marine
AK15M161.5	Y★	Ѵ∩8♣⧗	Grainstone	open marine
AK15M162	Y★	~Ѵ∩8	Grainstone	open marine
AK15M162.5	ѴY★	♣8●ℓ	Packstone	open marine
AK15M163	Y★	∩♣ℓ⧗	Grainstone	open marine
AK15M163.5	Y★	Ѵ♣⧗∩	Grainstone	open marine
AK15M169	ѴY★	♣	Packstone	open marine
AK15M169.5	Y★	Ѵ∩8♣	Grainstone	open marine
AK15M170.4	Y★	Ѵ8∩ℓ♣	Packstone	open marine
AK15M172	Y★	Ѵℓ♣●⧗☮	Packstone	open marine
AK15M172.5	ѴY★	♣ℓ8●~	Grainstone	open marine
AK15M173	8Y★	Ѵℓ♣Ⓐ	Packstone	open marine
AK15M173.5	Y★	Ѵ~∩8Ⓐ	Grainstone	open marine
AK15M174	Y★	∩Ѵ~●Ⓐ	Grainstone	open marine
AK15M174.5	Y★	8Ѵ∩♣	Grainstone	open marine
AK15M175	Y★	Ѵ∩●♣~	Grainstone	open marine
AK15M175.5	ѴY★	∩8Ⓐ⧗♣	Packstone	open marine
AK15M176	ѴY★	∩8⧗ℓ	Grainstone	open marine
AK15M176.5	Y★	♣8∩Ѵ	Packstone	open marine
AK15M177	Y★	Ѵ∩	Packstone	open marine
AK15M178.5	Y★	Ѵ∩8♣	Grainstone	open marine
AK15M179	~Y★	♣8Ѵ⧗	Grainstone	shoal
AK15M179.5	Y♣●★	∩Ѵ~ℓⒶ⧗☮	Packstone	open platform
AK15M180	Y♣●★	ℓ∩Ѵ✱Ⓐ☮	Packstone	open platform
AK15M180.5	Y★⊙	~♣8Ѵ⧗∩Ⓐ	Grainstone	shoal
AK15M181	★⊖⊙	ѴY8♣⧗⊗∩Ⓐ	Grainstone	shoal
AK15M181.5	Y★⊙	Ѵ~♣8⧗●⊖ℓ	Grainstone	lagoonal
AK15M182	Y★	Ѵ8	Packstone	open marine
AK15M182.5	Y★	Ѵ~♣∩Ⓐ⊙ℓ	Packstone	open marine
AK15M184	Y★	~8ѴⒶ∩♣	Grainstone	open marine
AK15M184.25	Y★	Ѵ8Ⓐ∩	Grainstone	open marine
AK15M186	8Y★	~♣ⒶѴ	Grainstone	open marine
AK15M186.5	Y★	Ѵ8Ⓐ∩♣	Grainstone	open marine

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK15M187.5	Y★	Ѵ∩8	Grainstone	open marine
AK15M188	Y★	~8Ѵ⧗♣ℓ	Grainstone	open marine
AK15M188.5	Y★	8∩⧗	Grainstone	open marine
AK15M189.2	Y★	Ѵ∩ℓ	Grainstone	open marine
AK15M190	Y★	8Ѵ~	Grainstone	open marine
AK15M190.5	Y★⧗	~8∩Ѵ♣	Grainstone	shoal
AK15M191	Y★	Ѵ~♣⧗⋒∩	Grainstone	open marine
AK15M191.5	Y★	Ѵ•⧗⋒	Grainstone	open marine
AK15M192	ѴY★	∩♣8⋒ℓ⊙	Packstone	open marine
AK15M192.5	Y★	♣∩Ѵ⧗•8Θ⋒	Grainstone	open marine
AK15M193	Y★	Ѵ♣8∩⧗ℓ⋒~	Grainstone	open marine
AK15M193.5	Y★	♣8⊗Ѵ	Grainstone	open marine
AK15M194	Y★	Ѵ∩	Grainstone	open marine
AK15M194.5	Y★	Ѵ⋒⧗	Grainstone	open marine
AK15M195	★	Y		open marine
AK15M195.5	Y★	Ѵ♣•∩	Grainstone	open marine
AK15M196	Y★	Ѵ♣∩⧗8⋒	Packstone	open marine
AK15M196.5	★8Y	Ѵ~♣⧗•∩	Grainstone	open marine
AK15M197.25	ѴY★	♣8	Packstone	open marine
AK15M198	Y★	♣•⧗Ѵ⋒ℓ	Packstone	open marine
AK15M198.5	Y★			open marine
AK15M199.1	Y★	Ѵ∩•♣⋒ℓ	Grainstone	open marine
AK15M199.5	Y★	∩Ѵ8⧗•♣⋒ℓ	Grainstone	open marine
AK15M200	★	↟		open marine
AK15M200.1		↟		open marine
AK15M200.5	Y★	Ѵ♣8∩•⋒ℓ~	Grainstone	open marine
AK15M201	Y★	~Ѵ8♣∩⧗⋒ℓ	Grainstone	shoal
AK15M201.5	Y★	Ѵ~♣∩⧗•⋒	Grainstone	shoal
AK15M202	★Y•ℓ	Ѵ♣∩☮⋒	Packstone	open platform
AK15M202.5	Y★	~Ѵ8♣∩•⧗ℓ⋒	Grainstone	shoal
AK15M203	Y★•	Ѵ~♣∩⧗ℓ☮	Grainstone	shoal
AK15M203.5	Y★•	Ѵ♣∩⧗ℓ	Grainstone	shoal
AK15M204	Y★•	Ѵ∩♣~Θ⧗ℓ⊗	Grainstone	open platform
AK15M204.5	Y★•	♣8~⧗Ѵ	Grainstone	open platform
AK15M205.5	Y★	Ѵ⧗	Packstone	open marine
AK15M206	Y★	Ѵ♣•⋒	Packstone	open marine
AK15M206.5	Y★	Ѵ•⧗∩	Grainstone	open marine
AK15M207	Y★	Ѵ~♣⧗•∩8	Grainstone, Packston	open marine
AK15M208	Y★	♣Ѵ∩	Packstone	open marine
AK15M208.5	Y★	Ѵ•∩	Packstone	open marine

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK15M209.5	Y★	&Ѵ∼⧗●8Ⓐℓ	Grainstone	open marine
AK15M210	Y★	∼&Ѵ●Λ	Grainstone	open marine
AK15M210.5	Y★	Ѵ∼&●ΛⒶ	Grainstone	open marine
AK15M211	Y★	Ѵ∼Λ●&Ⓐ	Grainstone	open marine
AK15M211.5	★Y⧗⊙	∼&8Ѵ●ΛⒶ	Grainstone	lagoonal
AK15M212*	Y★	ѴΛⒶ8	Grainstone	open marine
AK15M213.3	Y★	Ѵ&Ⓐ	Grainstone	open marine
AK15M214	Y★	Ѵ	Packstone	open marine
AK15M214.5	Y★	ѴⒶ●	Packstone	open marine
AK15M215	Y★	ΛѴ●Ⓐ	Packstone	open marine
AK15M216	Y★	Ѵ8Λ⧗Ⓐ	Grainstone	open marine
AK15M216.5	Y★	∼&8Ѵ⧗⊙Ⓐ	Grainstone	shoal
AK15M217	Y★	∼Ѵ8&●⧗ΛⒶ	Grainstone	open marine
AK15M217.5	Y★	&ΛѴ⧗●Ⓐℓ	Grainstone	open marine
AK15M218	Y★	&8Ѵ∼	Grainstone	open marine
AK15M218.5	Y★	∼&8⧗ⒶѴ	Grainstone	open marine
AK15M219	Y★	∼&8Ѵ⧗Ⓐℓ	Grainstone	open marine
AK15M219.5	⊙	∼&8Y⊖★Λ	Grainstone	shoal
AK15M220	Y★	ΛѴ&∼⧗ℓⒶ	Grainstone	open platform
AK15M220.5	Y★	Ѵ⧗8●Ⓐ	Grainstone	open marine
AK15M222	Y★	ѴⒶΛ	Grainstone	open marine
AK15M222.5	Y★	Ѵℓ&⧗	Grainstone, Packston	open marine
AK15M223	Y8⧗★	Ѵ∼Ⓐ	Grainstone	open marine
AK15M223.5	Y★	Ѵ∼&⧗Ⓐℓ	Grainstone	open marine
AK15M224	Y★	Ѵ∼⧗Ⓐ&	Grainstone	open marine
AK15M224.5	Y★	∼8⧗Ⓐ	Grainstone	shoal
AK15M225	Y★	Ѵ&8Ⓐ●✝⧗ℓ	Packstone	open platform
AK15M225.5				open platform
AK15M225.5	Y&ℓ★	∼8●Ѵ	Grainstone	open platform
AK15M226	Y★●	∼&Ѵ⧗ℓ	Grainstone	open platform
AK15M226.5	⊖★⧗⊙	∼Ѵ8&Ⓐ●YΛ	Grainstone	lagoonal
AK15M227	Y★	ѴΛⒶ	Packstone	open marine
AK15M228.5	Y★	ѴΛ&Ⓐ	Grainstone	open marine
AK15M229	Y★	Ѵℓ⧗●	Grainstone	open marine
AK15M229.5	Y★⊙	∼8Ѵ⧗&ℓ	Grainstone	shoal
AK15M230	★⊙	Ѵ∼&⧗YⒶ	Grainstone	shoal
AK15M230.5	∼Y★	&ℓѴ⧗●⊙Ⓐ	Grainstone	shoal
AK15M231	Y★	∼Ѵ8&●⧗ℓ⊙	Grainstone	open platform
AK15M231.5	Y★	∼ѴΛ⧗●&⊙Ⓐℓ	Grainstone	open platform
AK15M232	Y★	&Ѵ∼ℓ⧗●8⊘Λ	Grainstone	open platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK15M232.5	Y★	∼Ʊ8&ℓ ●⧗Ⓐ⊙	Grainstone	open platform
AK15M234	⊖⊙⧗	8∼★YƱ	Grainstone	shoal
AK15M234.5	ƱY★	&8∼⊙ℓ	Packstone	open platform
AK15M236	Y★	&8∼ƱⒶ	Grainstone	open marine
AK15M236.5	∼Y★	&Ʊ⧗●Λ	Grainstone	open marine
AK15M237	∼Y★	Ʊ&8Λ⧗●Ⓐ	Grainstone	open marine
AK15M237.5	⊙	∼Ʊ8&Ⓐ⧗Y★	Grainstone	shoal
AK15M238.5	Y★⧗	Ʊ&Λ●ℓ	Packstone	open platform
AK15M239	⊗↟●	Y&★ℓ⊙	Boundstone	open platform
AK15M239.5	∼Y★	Ʊ&8Ⓐ●⧗⊙Λ	Grainstone	open platform
AK15M240	∼Y★	ΛƱ&Ⓐ⧗●⊙	Grainstone	open platform
AK15M240.5	∼Y★	ΛƱ&Ⓐ⧗●⊙	Grainstone	open platform
AK15M241	∼Y★	Λ8&Ʊ●⧗Ⓐ⊙ℓ	Grainstone	open platform
AK15M241.5	Y★●	∼&Ʊ⊙Λ	Grainstone	shoal
AK15M242	∼Y★	⊙Ʊ⧗●Ⓐ	Grainstone	shoal
AK15M242.5	Y★	Ʊ∼&⧗●Ⓐ	Grainstone	open platform
AK15M243	Y★	Ʊ8Ⓐ⧗⊙	Grainstone	open platform
AK15M243.5	Y★	Ʊ∼8⧗&Ⓐ⊙	Grainstone	open platform
AK15M244	Y★	8Ʊ&⧗●⊙Ⓐ	Grainstone	open platform
AK15M244.5	Y★	∼ΛƱ⧗●8⊙Ⓐ	Grainstone	open platform
AK15M245	Y★	Ʊ∼8⧗⊙Λ	Grainstone	open platform
AK15M245.5	Y★	∼8⊙⧗●	Grainstone	open platform
AK15M245.75	⧗			
AK16M0.01	↟	ꟿ★	Wackestone	restricted platform
AK16M3	Y★	Ʊℓ●&ꟿ	Packstone	open platform
AK16M6	Yꟿ★	Ʊℓ●	Wackestone	open platform
AK16M9	Y★↟	ꟿℓ	Packstone	open platform
AK16M12	ꟿYΛ★	Ʊℓ∼Ⓐ	Packstone, Wackeston	open platform
AK16M14	Y★	8⧗&	Grainstone	open platform
AK16M15	Y★	8Λ⧗Ʊ	Grainstone	open platform
AK16M17	Y★	8Λℓ⧗●	Grainstone	open platform
AK16M18	Y★↟			restricted platform
AK16M21.6	Y★	ΛƱ8●⧗&ℓ∼	Packstone	open platform
AK16M24	Y★	8●⧗ƱⒶℓ	Grainstone	open platform
AK16M27	Y★	Ʊ●⧗&Ⓐℓ	Grainstone	open platform
AK16M30	ꟿ↟	Y★		restricted platform
AK16M32.8	Y★●	&8Λ⧗ℓ	Packstone	open platform
AK16M33	Y★	∼Ʊ8&Λ●⧗ℓⒶ	Grainstone	open platform
AK16M33.1	Y★	∼Ʊ8&Λ●⧗ℓⒶ	Grainstone	open platform
AK16M36	Y★	Ʊ&Λ●ℓ	Packstone	open platform

Sample Number	Grains > 10%	Grains < 10%	Carb Lithology	Paleoenvironment
AK16M39.5			Packstone	open platform
AK16M41			Grainstone	open platform
AK16M42.5			Grainstone	open platform

Appendix 2

Conodont Biostratigraphy of the Wahoo Limestone

Table shows data on conodonts collected from the eastern Sadlerochit Mountains (locality 8 on Fig. 3).

USGS Collection Number		30745	30746	30747	30748	30749	30750	30751	30752	30753	30754	30755	30756	30757	30758	30759	30760	30761	30762	30763
Meters Above Base of Wahoo Fm		0.4	6	7	13.2	17.1	22	27	32	37	42	47	50.5	53	56	59	62	65	69	74
Sample Weight (kg)		6.7	6.9	7.2	6.7	7.4	7.3	7	8.4	7.4	8.7	7.9	8.6	8.6	10.1	6.4	5.8	5.9	7	6.2
Adetognathus sp. indet.	Pa															61	8	4	9	
	Pb														1?				2	
Adetognathus complexus	Pa						1	3				1	4		7	37	2	2	8	1
Adetognathus lautus	Pa																			
A. spathus	Pa																			
Cavusgnathoids	Pa	25	85	79	15		41	12	33	22	11	29	12		10					
Cavusgnathus sp.	Pa					5	45	2	18	4	5	27	5	1						
C. altus	Pa			1	10		2													
C. naviculus	Pa						1						1							
C. unicornis	Pa	75	80	82	45	4	21	5	35	4	16	36	10							
	Pb	9	1	1																
	M	18		4	4															
	Sc	6																		
Declinognathodus sp.	Pa																			
D. noduliferous sp.	Pa																1	1	1	
D. noduliferus japonicus	Pa														8	52	7			
D. noduliferus noduliferus	Pa															7	5			
Gnathodus sp.	Pa	3												1						1? R
	M													1						
Gnathodus bilineatus	Pa				2															
G. bilineatus bilineatus	Pa	1		2						3				5					1 R	
G. girtyi girtyi	Pa	64	17	12				5	4	3				22					12 R	1 R
G. girtyi simplex	Pa			1					1	1				37						
G. girtyi trans. *D. noduliferus*	Pa													3						
Hindeodus sp.	Pa									3										
H. minutus	Pa										1	3		16		1			10	
	Pb							1						7					2	
	M							1						7		1			3	
	Sa								1					2						
	Sb										1								1	
	Sc																		2	
Idiognathodus delicatus	Pa																			
Idiognathodus cf. *I. klapperi*	Pa																			
Idiognathoides cf. *I. ouachitensis*	Pa																			
Idiognathoides sulcatus	Pa																			
Idioprioniodus sp.	Pa																			
	Pb																			
	M																			
	Sa																			
	Sb	1	1																	
	?																			
I. conjunctus	Pb													1						
	M													1						
	Sa													1						
	Sb													1	2					
	Sc																			
	?																			
Kladognathus sp.	P	24	12	15	1			3	1	1	1	2								
	M	15	8	14	4			3	1	1	1	1		3						
	Sa	2		1				1			1									
	Sb	8			1					1										
	Sc	48	10	16	2			3	7	5	1	11	1	2		1 R	1R		4 R	
Lochreia commutatus	Pa	1	1	1	1															
Neognathodus sp.	Pa																			
Neognathodus polynodosus	Pa																			
Neognathodus roundyi	Pa																			
Rhachistognathus sp.	Pa		2	2												6			1	
R. minutus	Pa																			
R. minutus declinatus	Pa																			
R. minutus havlenai	Pa																			
R. minutus minutus	Pa																			
R. muricatus	Pa		9	13	8										6	7			8	
R. muricatus trans. *R. primus*	Pa																			
R. muricatus trans. *R. websteri*	Pa		1																	
R. prolixus	Pa		2																	
R. websteri	Pa															1			1	
Vogelgnathus cf. n. sp.	Pa	2			10									2	1					
Indet. Pa element																				
Indet. Pb element		7		3			2	5			1	3		7		7	1	1	3	
Indet. M element		8	3		1		1		2				1	2	1	1	1			
Indet. Sa element		8	2	1											1					
Indet. Sb element			1	2	2											1				
Indet. Sc element		3						1		1			1	3		2	1			
Elements per kilogram		49	34	35	16	1	16	6	12	7	4	14	4	15	4	29	5	1	8	<1
Indet. bar, blade, and platform fragments		561	100	126	271	2	11	95	91	43	16	44	20	107	41	133	38	12	147	5
CAI		4 6	3 4 6	4 6	3 4 6	3 4 6	4 6	3 4 6	4 6	4 6	3 4	4 6	3 4 6	3 4 6	3 6	4 6	3 4 6	4 6	4	4
System		Mississippian													Pennsylvanian					
Series		Chesterian													Morrowan					
Formation		lower Wahoo																		
Conodont Zone		Lower? *muricatus*													*noduliferus - primus*					

R = Radepoelt

Conodont abundance for AK88-A0.4 - 74 meters above base of Wahoo Fm.

USGS Collection Number		30764	30765	30766	30767	30768	30769	30770	30771	30772	30773	30774	30775	30776	30777	30778	30779	30780	30781	30782	30783
Meters Above Base of Wahoo Fm		76.5	76.8	80.8	84	85	88	91	95	97	102	107	113	118	122	133.5	142	152	157	162	167
Sample Weight (kg)		6.3	6	7.8	7.7	7	9.2	8.8	9.6	9.2	9.3	8.3	8.9	9	9	7.8	7.1	8.6	7.5	8.4	9
Adetognathus sp. indet.	Pa		1		11	10		4	3	7	13	10	19	5	11	17	12		11	13	1
	Pb																				
Adetognathus complexus	Pa	1			1	2		3				3	11	1	1						
Adetognathus lautus	Pa				15	14		18	14		17	23	35	5	22	7	4		8	23	
A. spathus	Pa												2			12	5	1	10	8	
Cavusgnathoide	Pa																				
Cavusgnathus sp.	Pa																				
C. altus	Pa																				
C. naviculus	Pa																				
C. unicornis	Pa																				
	Pb																				
	M																				
	Sc																				
Declinognathodus sp.	Pa														1						1?
D. noduliferous sp.	Pa																				
D. noduliferus japonicus	Pa																			10	
D. noduliferus noduliferus	Pa					2		1					2	1	7	24	15	34		31	
Gnathodus sp.	Pa																				
	M																				
Gnathodus bilineatus	Pa																				
G. bilineatus bilineatus	Pa																				
G. girtyi girtyi	Pa																				
G. girtyi simplex	Pa																				
G. girtyi trans. *D. noduliferus*	Pa																				
Hindeodus sp.	Pa												7								
H. minutus	Pa															3					
	Pb																				
	M	1																			
	Sa																				
	Sb																				
	Sc																				
Idiognathodus delicatus	Pa																				
Idiognathodus cf. *I. klapperi*	Pa																				
Idiognathoides cf. *I. ouachitensis*	Pa																				
Idiognathoides sulcatus	Pa																				
Idioprioniodus sp.	Pa															1 ?					
	Pb															1 ?					
	M										1	1?				2	2				
	Sa							2								1		1	1		1
	Sb										1				1						
	?										1										
I. conjunctus	P																			3	
	M																		1		
	Sa																			1	
	Sb																			2	
	Sc																				
	?																				
Kladognathus sp.	P																				
	M																				
	Sa																				
	Sb																				
	Sc											2 R									
Lochreia commutatus	Pa																				
Neognathodus sp.	Pa																				
Neognathodus polymodosus	Pa					4					3										
Neognathodus roundyi	Pa																				
Rhachistognathus sp.	Pa			9	14	57			9	6	48	53	41	3	34	51	19		4	16	3
R. minutus	Pa											7									
R. minutus declinatus	Pa								3		5	34	2	1	8	21			21	16	2
R. minutus havlenai	Pa					1	1		2		7	28	18	3	37	48	10		5	25	
R. minutus minutus	Pa				2	11	7	11		4	22	15	56	2	74	55	3		3	3	2
R. muricatus	Pa				14	33	4	174	16		5	2	3		22	5					
R. muricatus trans. *R. primus*	Pa					1			3												
R. muricatus trans. *R. websteri*	Pa																				
R. prolixus	Pa																		1 ?		
R. websteri	Pa					14	1	60	8	8	43	8	22	2	5	12	1			1	
Vogelgnathus cf. n. sp.	Pa	1																			
Indet. Pa elements		2		9			4				1		17					10		19	
Indet. Pb elements						5		25	1		9	10	28		7	3	1	1	3	4	
Indet. M elements						2		7	1		7			1	2	2	2			2	
Indet. Sa elements				1		1		4					2	1		1			1	3	
Indet. Sb elements								1					1							1	
Indet. Sc elements		1				2		11	1			2	3		2	3	1		1	4	
Elements per Kilogram		1	<1	2	7	23	2	36	6	3	20	24	30	3	26	34	11	5	9	22	1
Indet. bar, blade, and platform fragments		1	1	18	28			153	19	21	170	62	240	21	70	162	97	28	47	156	4
CAI		2.5	4	4	4	4	4	4	4 6	4	3 4 6	4	4	4	4	4	4 6	4	3.5	4 6	4
System		Pennsylvanian																			
Series		Morrowan																			
Formation		upper Wahoo																			
Conodont Zone		*noduliferus - primus*			*sinuatus - minutus* to *symmetricus*																↑ *basseleri ?*

Conodont abundance for AK88-A76.5 - 167 meters above base of Wahoo Fm.

*U.S.GPO:1992-661-026/60048

USGS Collection Number		30784	30785	30786	30787	30788	30789	30790	30791	30792	30793	30794	30795	30796	30797	30798	30799	30800	30801	Total Elements
Meters Above Base of Wahoo Fm		173	177	187	191.5	197.5	207	217.5	222	227	232	241	246	250	253	257.5	260.5	261.5	262.5	
Sample Weight (kg)		7.3	9.3	7.5	9.3	8.7	8.8	8.5	9.7	7.8	8.6	8.5	9.2	7.9	6.9	7.4	7.8	8.4	8.1	
Adetognathus sp. indet.	Pa	2		7	7					2	3		2			3				256
	Pb																			2
Adetognathus complexus	Pa			1	3								6			1				100
Adetognathus lautus	Pa	1	1	1	1					3		10	17				8	15		262
A. spathus	Pa			1	1					1	5	3	1			3				53
Cavusgnathoids	Pa																			374
Cavusgnathus sp.	Pa																			112
C. altus	Pa																			13
C. naviculus	Pa																			2
C. unicornis	Pa																			413
	Pb																			11
	M																			26
	Sc																			6
Declinognathodus sp.	Pa						4													5
D. noduliferous sp.	Pa																			3
D. noduliferus japonicus	Pa																			77
D. noduliferus noduliferus	Pa	1	23	33		23	24	34						1						268
Gnathodus sp.	Pa																			5
	M																			1
Gnathodus bilineatus	Pa																			2
G. bilineatus bilineatus	Pa																			11
G. girtyi girtyi	Pa																			128
G. girtyi simplex	Pa																			40
G. girtyi trans. *D. noduliferus*	Pa																			3
Hindeodus sp.	Pa		1								1									12
H. minutus	Pa					3		2						1	1					41
	Pb																			10
	M					1														14
	Sa																			3
	Sb																			2
	Sc																			2
Idiognathodus delicatus	Pa			11		4	16	69			14	6	8	2		1				131
Idiognathodus cf. *I. klapperi*	Pa							1												1
Idiognathoides cf. *I. ouachitensis*	Pa							3												3
Idiognathoides sulcatus	Pa											2								2
Idioprioniodus sp.	Pa																			1
	Pb			1																2
	M																			5
	Sa																			6
	Sb		1																	5
	Sc						2													3
I. conjunctus	Pb						2	1?						1						7
	M						1	2			2									7
	Sa						1?	2								1				5
	Sb							2				1		1		1				10
	Sc							3						2		1				6
	?							2				2								4
Kladognathus sp.	P																			60
	M																			51
	Sa																			5
	Sb																			10
	Sc																			114
Lochreia commutatus	Pa																			4
Neognathodus sp.	Pa															1				1
Neognathodus polymodosus	Pa											1								8
Neognathodus roundyi	Pa						2				6	2		16						26
Rhachistognathus sp.	Pa	4				1				1	2									386
R. minutus	Pa												9				6			22
R. minutus declinatus	Pa	1	19	276	4	7	2				30	9	4			16	1	4		486
R. minutus havlenai	Pa		1								5	2	6		2	4	1	2		208
R. minutus minutus	Pa				1								4		2?	6	1	12		294
R. muricatus	Pa																			330
R. muricatus trans. *R. primus*	Pa																			4
R. muricatus trans. *R. websteri*	Pa																			1
R. prolixus	Pa																			3
R. websteri	Pa																			187
Vogelgnathus cf. n. sp.	Pa																			16
Indet. Pa elements			20	40	2	3	2	5		3	22		5		7	8	1	9		189
Indet. Pb elements					3	2	5	9			2		12		1		3	6		180
Indet. M elements				1				4									2	5		59
Indet. Sa elements			1	1			1						3	2			2			36
Indet. Sb elements													1					1		11
Indet. Sc elements		1		3									1				2	1		51
																			Grand Total	5197
Elements per Kilogram		1	7	50	2	5	7	16	<1	1	11	4	9	3	2	6	3	7	0	
Indet. bar, blade, and platform fragments		22	45	200	12	99	121	181	3	3	81	36	97	15	35	21	54	112	1	4299
CAI		4 6	4 6	4 6	4 6	4 6	4 6	4 6			6 4	4 6	4	4 6	4	4	4	4	4	
System		Pennsylvanian																	Permian	
Series		Morrowan		Atokan																
Formation		upper Wahoo																	Echooka	
Conodont Zone		*baesleri* ?		no older than *sinuosus*																

Conodont abundance for AK88-A, 173 to 262.5 meters above base of Wahoo Fm.