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MANGAQTAAQ FORMATION LACUSTRINE(?) DEPOSITS IN THE ENDICOTT GROUP HEADWATERS OF THE KONGAKUT RIVER, EASTERN BROOKS RANGE, ALASKA

by

A. V. Anderson and K. F. Watts

Tectonics and Sedimentation Research Group
Geophysical Institute and
Department of Geology and Geophysics
University of Alaska Fairbanks

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794 University Avenue, Suite 200
Fairbanks, Alaska 99709-3645

INTRODUCTION

A distinctive section of black argillaceous limestone and shale with interbedded sandstone crops out locally along the headwaters of the upper Kongakut River (fig. 1). Large oncolites on bedding plane dip slopes of limestone are the most distinctive characteristic. This unit is here informally named the Mangaqtaaq Formation. It has not been recognized within the Devonian to Mississippian succession elsewhere in the Brooks Range. We favor a lacustrine interpretation based on the lack of definitive marine fauna, limited lateral extent, and interfingering nonmarine fluvial deposits, but the formation could also be interpreted as a restricted shallow marine deposit. The formation is as much as 200 meters thick and has an east to west lateral outcrop extent of 10 kilometers. The lower half of the formation consists of cyclic alternations of black limestone and mudstone (fig. 2). In the east the upper half is rhythmically interbedded black mudstone and siltstone, whereas to the west coarse terrigenous clastic deposits interfinger with black limestone and siltstone-mudstone. Plant fossils in the lower 100 meters are dated as Late Devonian to Early Mississippian (S. Mamay, personal communication, 1989).

The formation is here informally named the Mangaqtaaq Formation; its type section is in a small west-flowing tributary of the upper Kongakut River on the south side of Mangaqtaaq Ridge (new, informal name) in the W 1/2 of Section 9, T. 5 S., R. 38 E., Demarcation Point (A-4) quadrangle (69° 1.4', 143° 6.4') (Fig. 1). Mangaqtaaq is an Inupiaq Eskimo word meaning "black color" (J. Nageak, personal communication), which describes these rocks. The succession unconformably overlies the Middle to Late(?) Devonian Ulungarat Formation at a sharp contact with low angle discordance. At the type section, the base of the section is not exposed. Approximately 75 to 100 meters of

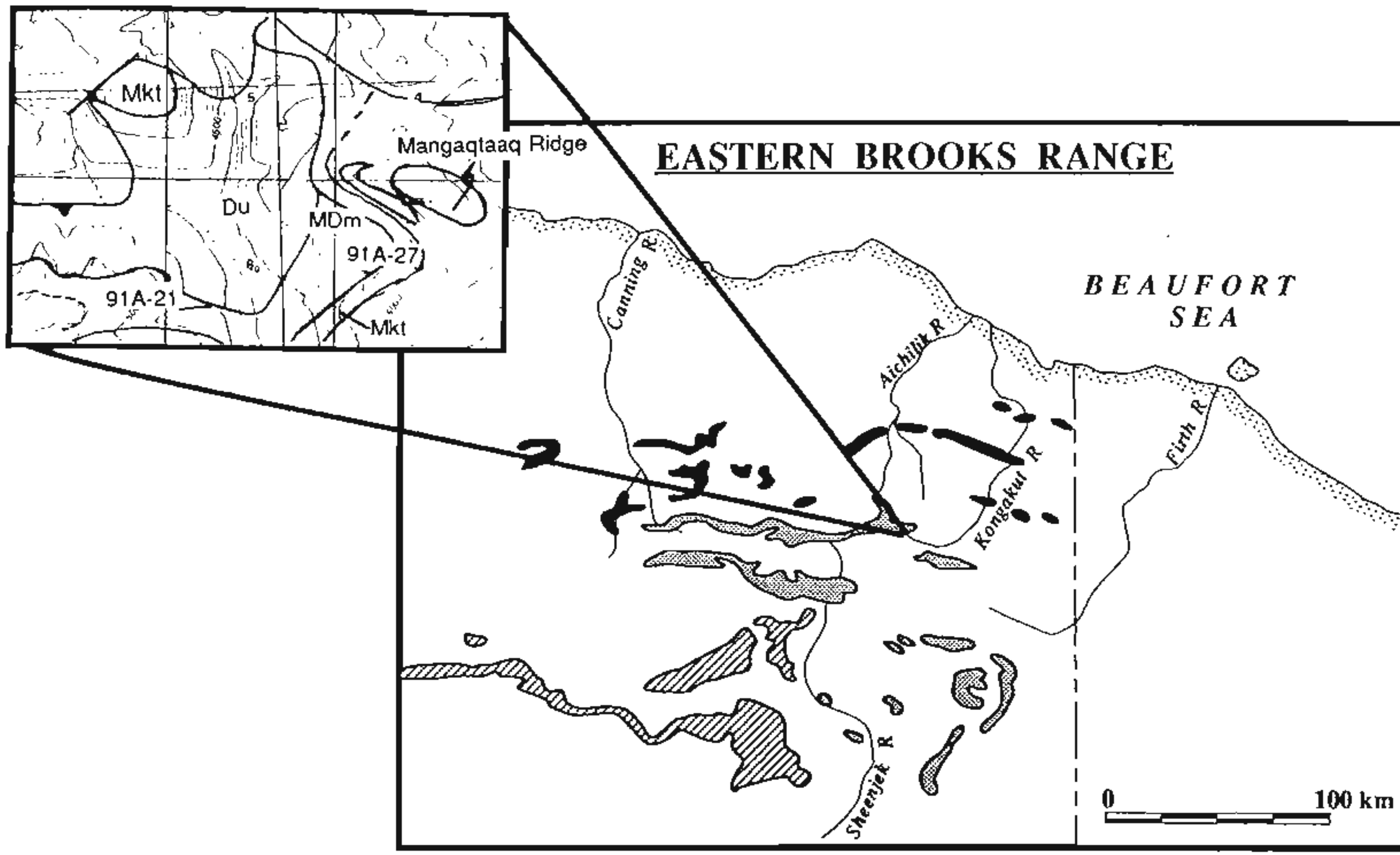


Figure 1. Location of Reference section, Mangaqtaaq Formation (91A-27), 69° 1.4', 143° 6.4' in the Demarcation Point (A-4) quadrange, Alaska. Map shows contacts of Mangaqtaaq Formation (MDm) with Ulungarat Formation (Du) and Kekiktuk Conglomerate (Mkt).

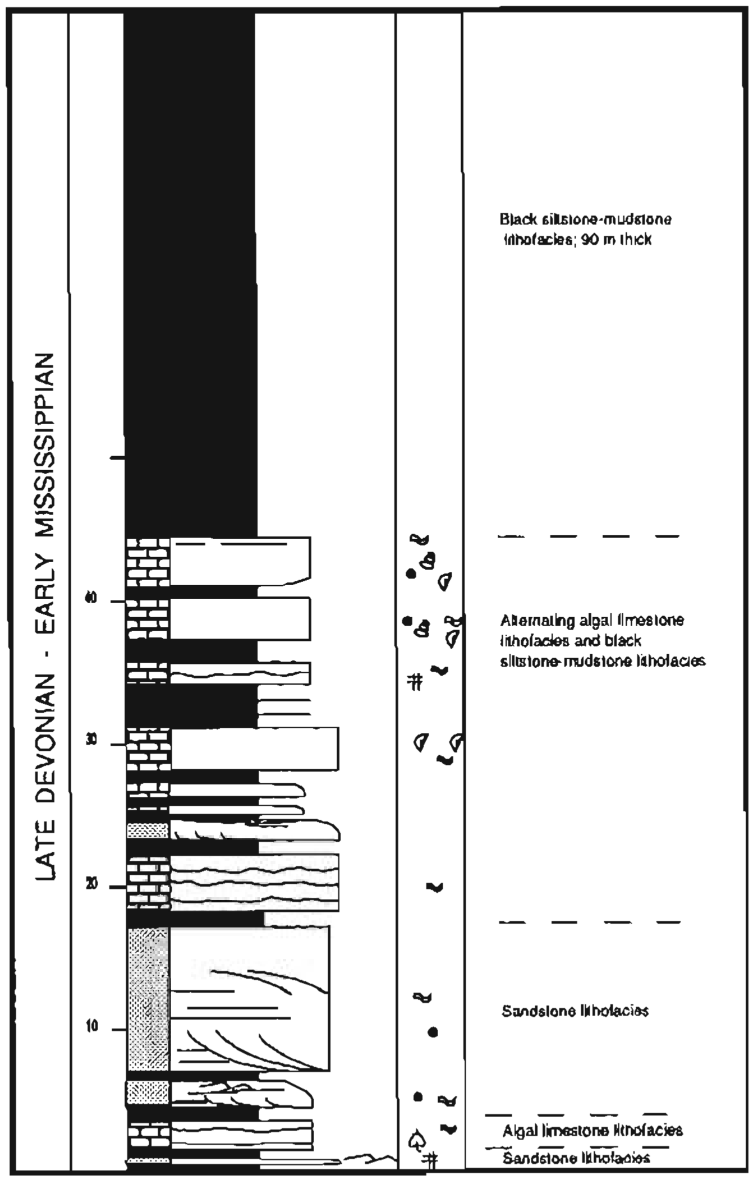


Figure 2. Reference section for the Mangaqtaaq Formation Showing lithofacies and grain type. For complete description see measured section 91A-27.

covered section is estimated to the north. Better exposures of the basal contact are seen in outcrops located 1.5 kilometers to the west. The upper contact is a low-angle unconformity overlain by chert-quartz pebble conglomerate and sandstone of the Kekiktuk Conglomerate.

DESCRIPTION OF LITHOFACIES

Three lithofacies are recognized in the Mangaqtaaq Formation. They consist of an algal limestone lithofacies and a sandstone lithofacies deposited in shallow water environments, and a black siltstone-mudstone lithofacies that records an abrupt change in the depositional system.

Algal limestone lithofacies

A black algal packstone to grainstone (in places boundstone) which includes calcareous algae, peloids, gastropods, ostracods, black intraclasts, and micritic mud forms the dominate lithofacies. The major component is calcareous algae with associated pyrite and dead oil. The blue-green algae, *Girvanella* and *Ortonella* can be recognized. Some beds have low linked hemispheroid to domal structures interpreted to be stromatolites. One large, 30 centimeter , algal structure is directly overlain by mudstone with mud cracks. Blue-green algae occur as both oncolites and stromatolites. Microfabrics of algae include: 1) dense algal areas without apparent structure (spongiostrome of Nickel, 1983), 2) algae growing perpendicular to alga mass centers with elongate fenestrate between the algae growths, and 3) unlaminated algal masses with irregular fenestrate. The only invertebrate fossils are ostracods and gastropods associated with the algae. Petrographic study shows a history of early carbonate cementation followed by some hydrocarbon filling of moldic porosity.

Large oncolites, commonly varying in size from less than 1 to 8 centimeters, are the most prominent feature. The oncolites are free lying and of irregular spheroidal to ellipsoidal shape; possibly deformed by compaction. Both spongiostrome (without visible structure) and porostroms (with visible structure) (Nickel, 1983) are present. Most show vague internal structure of concentric irregular layering of alternating porous and dense layers. Some show concentric growth rings, others a clotted fabric, or a less common radial fabric. Most oncolites have 2 to 3 growth rings separated by dark rims, but oncolites without growth rings are common. Nuclei include shells, peloids, dense algal balls, and an oolite. Size, morphology, and surface structure can be used to classify oncolites and relate them to depositional environment (Nickel, 1983). The large size, rough surface structures, and internal morphology of the Mangaqtaaq oncolites suggests an environment with fluctuating energy conditions. Periodically there was enough energy to move the oncolites, but movement was not frequent enough to smooth the oncolite surface.

Peloids are micritic, elongate to subround, 1 to 2 millimeters long grains without recognizable structure. The shapes suggest that some are probably micritized bioclasts; others may be pellets or algal fragments. Dark brown or black rims of indeterminate origin are visible on some grains. Peloids are intermixed with the algae.

Grit-size black intraclasts are visible in hand sample and are common throughout the lithofacies. Petrographic study shows these grains to be opaque black, angular to subrounded, sometimes long and thin in shape. Many grains include ostracod and gastropod skeletal remains. These are interpreted to be intrabasinal rip-up clasts derived from erosion within the unit. In as much as these grains are common in both the limestone and sandstone lithofacies, the factor that controlled erosion occurred frequently.

The algal limestone lithofacies records a low-energy, warm, shallow water environment periodically interrupted by erosion, possibly by storm events. Under these conditions $CaCO_3$ precipitation is induced by CO_2 removed by photosynthesis. The limited fauna - blue-green algae, ostracods, gastropods - indicates a restricted environment. Thick algal growths could prevent oxygen from reaching the substrata thus creating the anoxic conditions suggested by the black color and preserved plant material.

Sandstone Lithofacies

The sandstone lithofacies is a mixture of lithic and carbonate sands. The lithic grains consist of angular to subrounded chert and intrabasinal clasts with minor quartz. In addition to the black intraclasts described above, intrabasinal clasts include pebbles of argillite clasts in chert cement, chert breccia in argillite, and chert breccia cemented with chert. These grains are interpreted to be eroded from the underlying Ulungarat Formation. The intrabasinal carbonate clasts include broken oncolites and algal limestone, disarticulated ostracods, and gastropod shell fragments. Ooids and coated grains with as many as 4 asymmetrical layers are present. These grains are often deformed and their origin is unclear.

The sandstone lithofacies deposits vary in thickness from a few centimeters to 2.5 meters, usually show erosional bases, ripple cross-stratification, and often fine upward to horizontal laminated black siltstone-mudstone containing plant fossils. The fossils are preserved as molds, as thin films of plant material, and a few intact plant stems which are still green. Sporangia, reminiscent of Tetrasylopteris has been identified by Sergius

Mamay (personal communication, 1989), indicating a possible Late Devonian-Early Mississippian age range.

The sandstone lithofacies was deposited by a system with sufficient energy to transport terrigenous sands into the area, to erode and abrade intrabasinal grains, and to mix these components. A lower-energy environment is indicated by thin beds (1-2 cm) of fine-grained sandstone with ripple cross-stratification and intercalated mudstone and by low angle cross-sets with mud drapes. Both symmetrical and asymmetrical ripples are found. A higher energy system is indicated by a channel 2.5 meters deep overlain by lateral accretion sandstone deposits. The erosional energy of this system is reflected in the mixed provenance of the component grains. Sands and small pebbles derived from the underlying Ulungarat Formation are mixed with broken and abraded intrabasinal carbonate grains and "black grains" eroded from earlier deposits of the Mangaqtaaq Formation. Mud draped, thin ripple cross-stratified sandstones and seldom turned oncolite structures may be the product of infrequent storms. The sandstones are interpreted to have been deposited in a lake margin environment.

Black siltstone-mudstone lithofacies

In the lower half of the formation, black, finely laminated siltstone-mudstone varies in thickness from a few centimeters to 3 meters, has sharp contacts, and occurs at random intervals between the sandstone lithofacies and/or algal limestone lithofacies. In the upper 90 meters of the type section, black finely-laminated siltstone and mudstone are interbedded on the scale of 2 to 4 centimeters. The contact with the underlying algal limestone lithofacies is sharp and planar. No plant fossils have been recovered from this interval. One and one-half kilometers west these siltstones interfinger with coarse terrigenous clastic deposits.

Abrupt changes in the depositional environment are indicated by the sharp contacts of the black siltstone-mudstone lithofacies. The sharp transition upward into unfossiliferous deposits represents the drowning of a restricted carbonate system, possibly to depths below the photic zone where algae could not exist or terrigenous clastic detritus created an unfavorable environment for the algae.

The repetitive pattern of algal limestone and black siltstone-mudstone lithofacies reflects fluctuations in water level, rate of sedimentation, and/or basin subsidence below the photic zone. The 90 meters thick black siltstone-mudstone lithofacies at the top of the unit in the east represents the sudden onset of a changed depositional environment.

STACKING OF LITHOFACIES AND LATERAL VARIABILITY

At the type locality, the lower half of the formation is an aggregational combination of the algal limestone and sandstone lithofacies (fig. 2, measured section 91A-27). This succession is interrupted at irregular intervals by the abrupt deposition of the black siltstone-mudstone lithofacies. Eleven separate cycles of black siltstone-mudstone lithofacies alternating with algal limestones are recognized in the lower 44.5 meters of the measured type section. The cyclic nature of these deposits suggests a periodic cause, perhaps fluctuations induced by climate. An abrupt long term change is recorded by the 90 m of black siltstone and mudstone at the top of the formation.

One and one-half kilometers west of the type section, the algal limestone lithofacies is interbedded with and overlain by sandstone and conglomerate (fig 3, measured section 91A-21). These coarse terrigenous clastic deposits are interpreted to interfinger with the 90 meters thick interval of siltstones and mudstones in the upper part of the type section. Five and one-half kilometers further southwest the algal limestone lithofacies is the dominate lithology of the formation, and is interrupted twice by the deposition of 3 meter thick sandstone intervals. One of these sandstones is composed entirely of pure white chert grains. Three and one-half kilometers northwest pure white chert occurs within the Romanzof Cherts (OCcp) and is the probable source of these sands. Major terrigenous clastic influx is not present in this area which appears to have remained a shallow shoreline, more distal from major terrigenous clastic deposition, throughout Mangaqtaaq time.

These deposits are interpreted to be on a structurally higher thrust sheet that was tectonically transported northward.

ENVIRONMENT OF DEPOSITION

The environment of deposition of the Mangaqtaaq Formation can be interpreted as either lacustrine or shallow marine. The limited fauna and anoxic conditions indicate a restricted depositional environment. Lenticular bedding and cross-bedding in sandstone lithofacies, abundant plant detritus, absence of conodonts or any definitive marine fauna, blue-green algae characteristic of both lacustrine and very shallow restricted marine conditions are characteristic of beds in the formation.

The association of lithofacies document a low energy, warm, shallow water environment characterized by abundant algal growth and populated by a restricted fauna of grazing organisms. Thin ripple cross-stratified sandstones

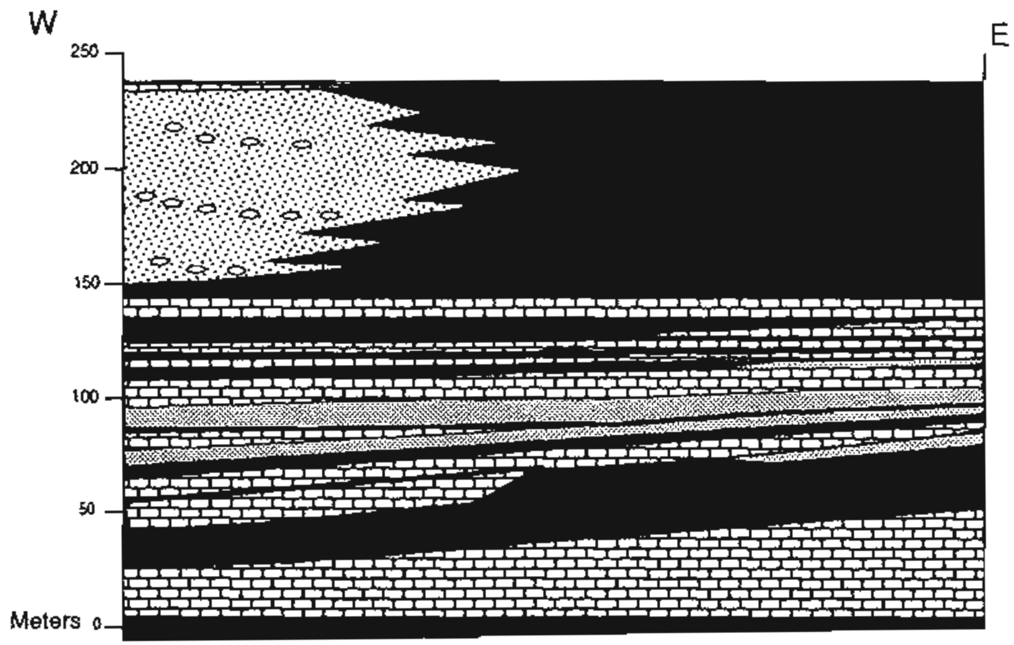


Figure 3. Generalized stratigraphic cross-section, Mangaqtaaq Formation.

Algal limestone lithofacies
Black siltstone - mudstone lithofacies
Sandstone lithofacies
Coarse terrigenous clastic deposits

with mud drapes mark storm or flood events while higher energy streams (or sheet floods) migrated across the shore zone eroding the shore and depositing a mixed load of terrigenous and carbonate sands. The sandstone composition indicates derivation from the underlying Ulungarat Formation combined with intraformational carbonate clasts. Periodically this regime was abruptly interrupted by deposition of black siltstone and mudstone.

The repetitive nature of the algal limestone and black siltstone-mudstone lithofacies may be explained by tectonic and/or climatic controls. The 3 to 10 meter thick limestone cycles may be a response to changing water depth, basin subsidence, and/or rate and amount of terrigenous clastic depositon. Periods of increased rainfall would both increase the rate of erosion from surrounding highlands and raise the water level of a lake, possibly placing existing algal areas below the photic zone. Alternatively, or concurrently, faulting related to basin subsidence could be the source of the terrigenous clastic detritus.

These characteristics, combined with its limited lateral extent, and stratigraphic position between and interfingering with nonmarine fluvial environments could be interpreted as either a very restricted shallow marine or lacustrine environment. We favor a lacustrine interpretation based on the lack of definitive marine fauna, limited lateral extent, and interfingering nonmarine fluvial deposits. These deposits are part of a Middle Devonian to Early Mississippian clastic succession interpreted to have been deposited along a rift-basin margin (Anderson and Wallace, 1991). The Mangaqtaaq Formation is interpreted to have been deposited on down dropped fault blocks with interbedded terrigenous clastic detritus derived from the Ulungarat Formation on uplifted fault-blocks.

KEY TO SYMBOLS

Grain Type

	Gastropod
	Ostracod
	Algae
	Intraclasts
•	Peloid
qtz	Silt
Ch	Chert
#	Unidentified fossil fragments
	Plants

Rock Type

- Limestone
- Sandstone
- Siltstone
- Mudstone

Carbonate Classification

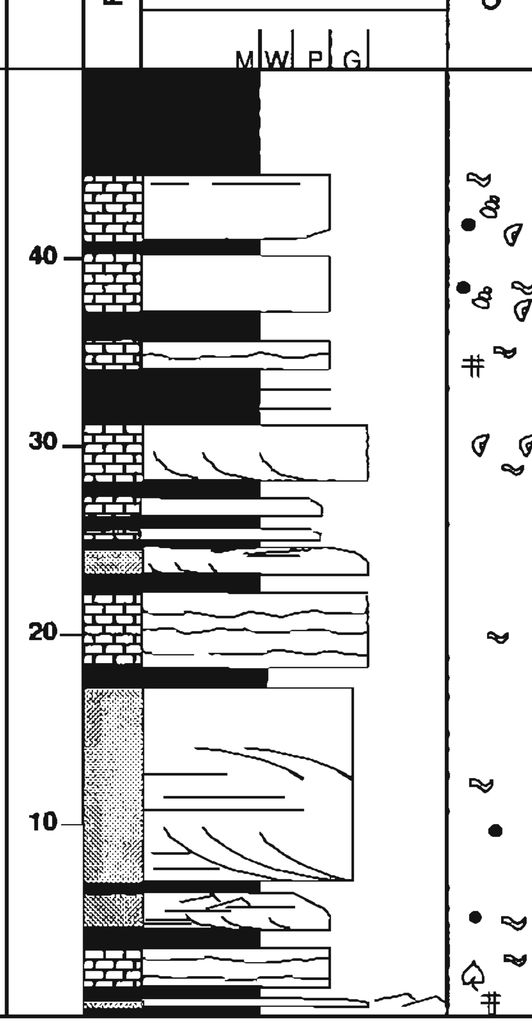
G	Grainstone
P	Packstone
W	Wackestone
M	Mudstone

Sedimentary Structures

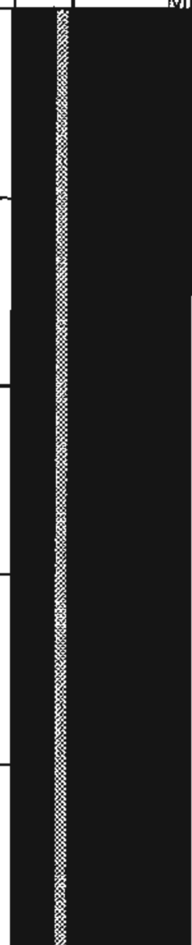
- Trough Cross-stratification
- Horizontal Cross-stratification
- Low-angle Cross-stratification
- Ripple Cross-stratification
- Wavy Lamination

Section 91A-27 Type section of Mangaqtaaq Formation
W 1/2, Sec. 9, T. 5 S., R. 38 E, Demarcation Point (A-4) quadrangle
A. Anderson

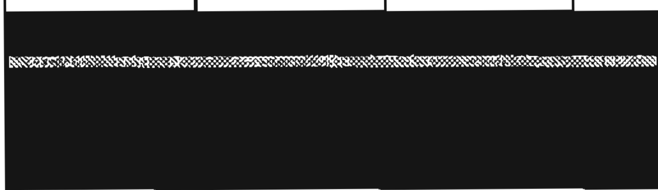
PERIOD	EPOCH	FORMATION	MEMBER	METERS	ROCK TYPE	GRAPHIC COLUMN	GRAIN TYPE	DESCRIPTION	ENVIRONMENT OF DEPOSITION
LATE DEVONIAN - EARLY MISSISSIPPIAN		MANGAQTAAQ						(37 - 44.5 m) Algal packstone with peloidal packstone between algal areas; ostracods, gastropods.	Alternating shallow water and either below photic zone or turbid conditions
								(23 - 37 m) Argillaceous skeletal algal packstone in places oncolitic; Forms ledges.	
								(1 - 4.5 m) & (19 - 23 m) Skeletal algal grainstone - packstone in places peloidal; ostracods, gastropods; sharp contacts with mudstone-siltstone interbeds; oncolites prominate below 4 m; 1 large (30 cm across) algal structure draped with mud; mudcrackes; 3 cm thick ostracod horizon. Forms ledges.	Alternating algal limestone lithofacies and black siltstone-mudstone lithofacies
								(4.5 - 19 m) Sandstone: calcarenite and chert arenite with significant variation in proportion of carbonate to chert grains. Skeletal algal grainstone to pack-stone; oolites. in places trough cross-stratified with erosional bases to 1.5 m depth; episalon, low-angle, and ripple cross stratification. Forms ledges.	Sandstone lithofacies
								(0 - 1 m) Sandstone & interbedded mudstone: chert arenite with skeletal fragments & carbonate grains; beds 1 - 2 cm thick; low-angle cross-stratification with mud drapes; interbedded siltstone-mudstone with abundant plant fossils.	Algal limestone lithofacies
								Measured section underlain by black siltstone with abundant plant fossils. Lower contact is covered.	Sandstone lithofacies



Section 91A-27 Type section of Mangaqtaaq Formation
W 1/2, Sec. 9, T. 5 S., R. 38 E., Demarcation Point (A-4) quadrangle
A. Anderson Page 2 of 3

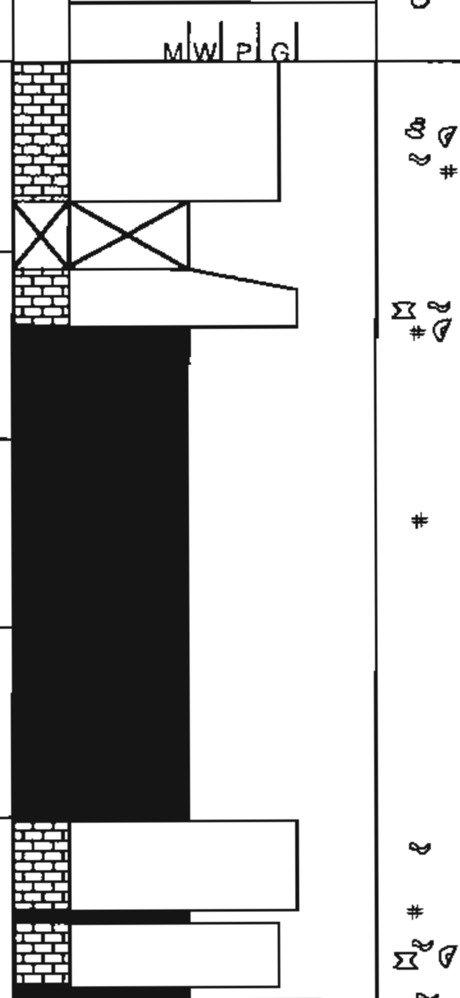
PERIOD	EPOCH	FORMATION	MEMBER	METERS	ROCK TYPE	GRAPHIC COLUMN (M W P G)	GRAIN TYPE	DESCRIPTION	ENVIRONMENT OF DEPOSITION
LATE DEVONIAN - EARLY MISSISSIPPIAN		MANGAQTAAQ		90 80 70 60				(44.5 - 128 M) Mudstone-siltstone: Black, calcareous, fissile; interbedded on scale of 2-4 cms. Sharp basal contact; upper contact covered.	Turbid water or below photic zone Black siltstone-mudstone lithofacies

LATE DEVONIAN - EARLY MISSISSIPPIAN	PERIOD
	EPOCH
MANGAQTAAQ	FORMATION
	MEMBER
110 120 130 140	METERS
	ROCK TYPE
	GRAPHIC COLUMN (M W P G)
	GRAIN TYPE
Upper contact is covered by approximately 20 m of vegetation and loose talus from overlying conglomerate and sandstone beds.	DESCRIPTION
	ENVIRONMENT OF DEPOSITION



Section 91A-27 Type section for Mangaqtaaq Formation
W. 1/2, Sec. 9, T. 5 S., R. 38 E., Demarcation Point (A-4) quadrangle, Alaska
A. Anderson Page 3 of 3

Section 91A-21
SW 1/4, Sec. 8, T. 5 S., R. 38 E., Demarcation (A-4) quadrangle
A. Anderson

PERIOD	EPOCH	FORMATION	MEMBER	METERS	ROCK TYPE / GRAPHIC COLUMN / GRAIN TYPES	DESCRIPTION	ENVIRONMENT OF DEPOSITION
LATE DEVONIAN - EARLY MISSISSIPPIAN		MANGAQTAAQ		40 30 20 10		(36 - 54 m) Skeletal algal grainstone-packstone: Ostracod & gastropod fragments, black intraclasts; faint cross-stratification(?); weathers black and orange-black; forms ledges.	Shallow water Algal limestone lithofacies
						(10 - 36 m) Mudstone & wackestone with minor skeletal debries.	Below photic zone or turbid water Black siltstone-mudstone lithofacies
						(0 - 10 m) Algal packstone-grainstone overlain by mudstone with minor skeletal debries in 3 intervals: Basal 0.5 m is algal boundstone. Algae, ostracods, black intraclasts. Oncolites from <0.5 cm - 7 cm across; bedding(?) 4-10 cm thick; sharp, irregular contacts; mudstone between some beds; black cubic areas at center of several "clotted" algae; forms ledges. Below measured section: Black shale with thin limestone beds (<2 cm thick); Micrite with black intraclasts & < 20% skeletal fragments; some faint cross-stratification.	Shallow water Algal limestone lithofacies

Section 91A-21
SW 1/4, Sec. 8, T. 5 S., R. 38 E, Demarcation Point (A-4) quadrangle
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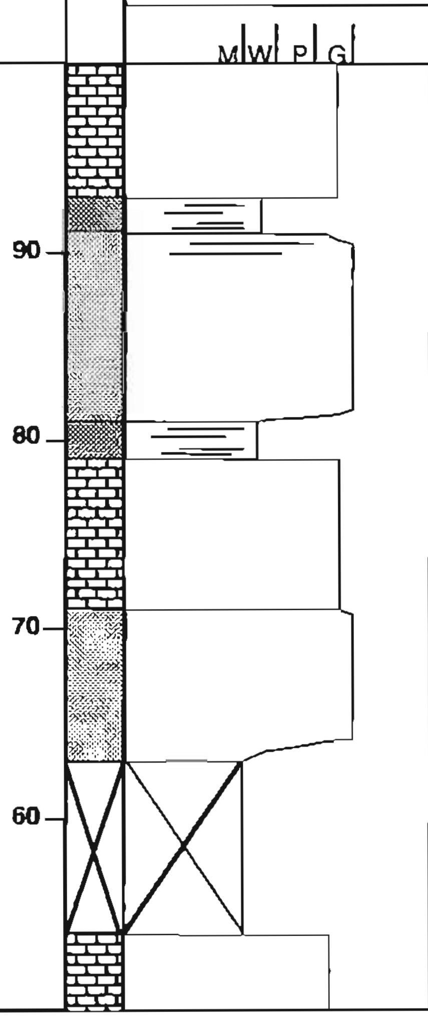
PERIOD: LATE DEVONIAN - EARLY MISSISSIPPIAN

EPOCH:

FORMATION: MANGAQTAAQ

MEMBER:

METERS: 60–93



GRAIN TYPE: qtz, Ch, Ch, qtz

DESCRIPTION

(63 - 71 m) and (79 - 93 m)
Sandstone & siltstone: chert arenite with minor algal intraclasts; weathers medium-gray and orange-brown. Sedimentary structures obscured by weathered surface. Float with planear tabular cross-stratificatrion. Forms ledges. Black, platy siltstone; recessive weathering.

(71 - 79 m)
Algal grainstone-packstone: prominate oncolites on many surfaces. Weathers black and orange-black. Forms ledges.

ENVIRONMENT OF DEPOSITION

Shallow water

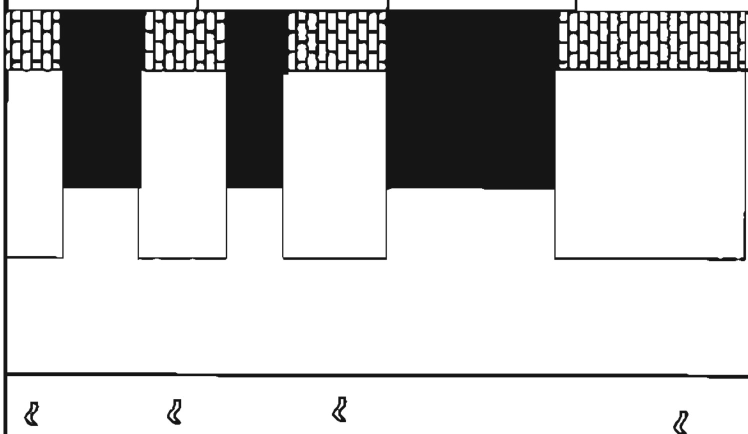
Sandstone lithofacies

Algal limestone lithofacies

Sandstone lithofacies

PERIOD	LATE DEVONIAN - EARLY MISSISSIPPIAN
EPOCH	
FORMATION	MANGAQTA AQ
MEMBER	
METERS	110 · 120 · 130 · 140

ROCK TYPE / GRAPHIC COLUMN (M W P G)



GRAIN TYPE

Section 91A-21
SW 1/4, Sec. 8, T. 5 S., R. 38 E, Demarcation Point (A-4) quadrangle
A. Anderson Page 3 of 3

DESCRIPTION

Above measured section: ledges of sandstone and small pebble conglomerate. Float includes some algal limestone indicating small interbeds of limestone.

(93-139 m)
Algal grainstone-packstone: resistant outcrops 3 - 4 m thick, laterally and vertically separated by loose slope (micrite(?)). Weathers black and orange-brown.

ENVIRONMENT OF DEPOSITION

Shallow water
Algal limestone lithofacies

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