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TURBIDITE DEPOSITIONAL ENVIRONMENTS OF THE UPPER CRETACEOUS TO TERTIARY CANNING FORMATION, ARCTIC NATIONAL WILDLIFE REFUGE (ANWR), ALASKA

By

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ABSTRACT

The Upper Cretaceous to Lower Tertiary Canning Formation, in ANWR, contains significant turbidite successions which are important in reconstructing the depositional and tectonic history of this region. The turbidite facies crop out around the Sadlerochit Mountains, and are characterized by sandstone- and shale-dominant sequences which we interpret as submarine fan channel, channel levee complex, and interchannel deposits (mid-fan facies association). This sequence is locally overlain by shallow marine deposits of the Sagavanirktok Formation, which we interpret as lower delta plain sediment.

Two contrasting types of channelized sandstone bodies are developed in the Canning Formation. The first type of channel-fill is composed of massive, fine- to medium-grained, lens shaped sandstone bodies which overlie a conspicuous erosional scour. These sediments were deposited during the same event which produced the erosional scour. The second type of channel-fill consists of fining-upward, thick- to thin-bedded sandstone. The sandstone beds thin and pinchout at the edges of the channel scour. These sandstone successions were deposited during later depositional episodes unrelated to the event which produced the erosional scour.

Associated with the channels are sand-rich turbidite deposits. The sandstone beds are often laterally discontinuous, and contain soft sediment folds. Small scale slumps are seen in some of these deposits. These levee complex deposits are made up of channel levees and overbank deposits in close proximity to the channels.

In many outcrops, intercalations of very fine- to fine-grained sandstone, siltstone, and shale dominate the succession. The sandstone and siltstone beds are laterally discontinuous, and the shale often contains flaser and lenticular bedded fine-grained sandstone. These deposits are interpreted as interchannel deposits.

We interpret the turbidite facies of the Canning Formation to have been deposited during times of fluctuating sea level. The system was fed by debris flows that originated at the seaward edge of an east to northeast prograding delta. Deposition during relative high stands of sea level was characterized by mud-rich deposits containing lenticular bedded fine-grained sandstone and siltstone turbidites. During relative low stands, sand-rich turbidite deposits were the result of slumping and resedimentation of deltaic deposits.

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INTRODUCTION

During the 1985 summer field season, we visited 27 locations where the Canning Formation turbidite facies cropped out in the Arctic National Wildlife Refuge. Seven stratigraphic sections were measured and three traverses sketched. Figure 1 shows the locations of the outcrops listed in table 1. This report contains preliminary stratigraphic and depositional environment data for the turbidite facies.

REGIONAL GEOLOGIC SETTING

The stratigraphy of the Arctic Slope consists of three unconformity bound depositional sequences: the Franklinian, Ellesmerian, and Brookian sequences (Lerand, 1973). The Proterozoic to Middle Devonian Franklinian sequence consists of marine and nonmarine miogeoclinal and eugeoclinal sedimentary rocks (Grantz and May, 1983). During Late Devonian and Early Mississippian time, the Ellesmerian orogeny structurally deformed the Franklinian rocks. Stable continental shelf clastic and carbonate rocks of the Ellesmerian sequence overlie a major angular unconformity created by the deformation and subsequent erosion. The Ellesmerian rocks were derived from a northern source area and, are Early Mississippian to Early Cretaceous in age. Beginning during Jurassic time, uplift and deformation formed the Brooks Range (Grantz and May, 1983). The southerly-derived Brookian sequence unconformably overlies the Ellesmerian sequence. The Brookian sequence is the dominant filler of the Colville basin, and consists of Cretaceous and Tertiary clastic rocks that were being shed from the newly uplifted Brooks Range.

The Colville basin is a laterally restricted, east-west trending, elongate foredeep. The basin is asymmetric, with the deepest portion occuring along its southern margin, and gradually shallowing towards the north.

TABLE I

No.	OUTCROP	LOCATION
1.	#85MV010	LAT. 69°33'24" N. LONG. 145°49'48" W.
2.	*85MV012	LAT. 69°33'46" N. LONG. 145°48'45" W.
3	*85MV014	LAT. 69°42'53" N. LONG. 145°35'19" W.
4.	*85MV015	LAT. 69°41'59" N. LONG. 145°36'15" W.
5.	*85MV016	LAT. 69°34'05" N. LONG. 145°37'53" W.
6.	85MV017	LAT. 69°33'41" N. LONG. 145°42'53" W.
7.	85MV018	LAT. 69°33'34" N. LONG. 145°42'42" W.
8.	*85MV019	LAT. 69°39'35" N. LONG. 145°39' W.
9.	85MV020	LAT. 69°39'39" N. LONG. 145°39'16" W.
10.	85MV027	LAT. 69°41'41" N. LONG. 144°59'48" W.
11.	85MV028	LAT. 69°41'48" N. LONG. 144°59'57" W.
12.	85MV029	LAT. 69°41'55" N. LONG. 145°0'0" W.
13.	85MV030	LAT. 69°42'6" N. LONG. 145°0'1" W.
14.	85MV031	LAT. 69°42'8" N. LONG. 144°59'49" W.
15.	85MV032	LAT. 69°42'12" N. LONG. 144°59'54" W.
16.	85MV033	LAT. 69°42'19" N. LONG. 145°0'12" W.
17.	85MV034	LAT. 69°42'32" N. LONG. 145°0'22" W.
18.	85MV036	LAT. 69°42'47" N. LONG. 145°0'20" W.
19.	85MV037	LAT. 69°43'7" N. LONG. 145°0'12" W.
20.	85MV038	LAT. 69°43'15" N. LONG. 145°0'20" W.
21.	*85MV039	LAT. 69°42'54" N. LONG. 145°26' W.
22.	85MV041	LAT. 69°42'59" N. LONG. 145°16'28" W.
23.	85MV042	LAT. 69°43'14" N. LONG. 145°19'13" W.
24.	#85MV043	LAT. 69°43'20" N. LONG. 145°20'04" W.
25.	*85MV049	LAT. 69°34'35" N. LONG. 146°18'20" W.
26.	#85MV051	LAT. 69°39'35" N. LONG. 146°14'08" W.
27.	85MV052	LAT. 69°37'34" N. LONG. 146°17'33" W.

* denotes measured sections

# denotes traverses

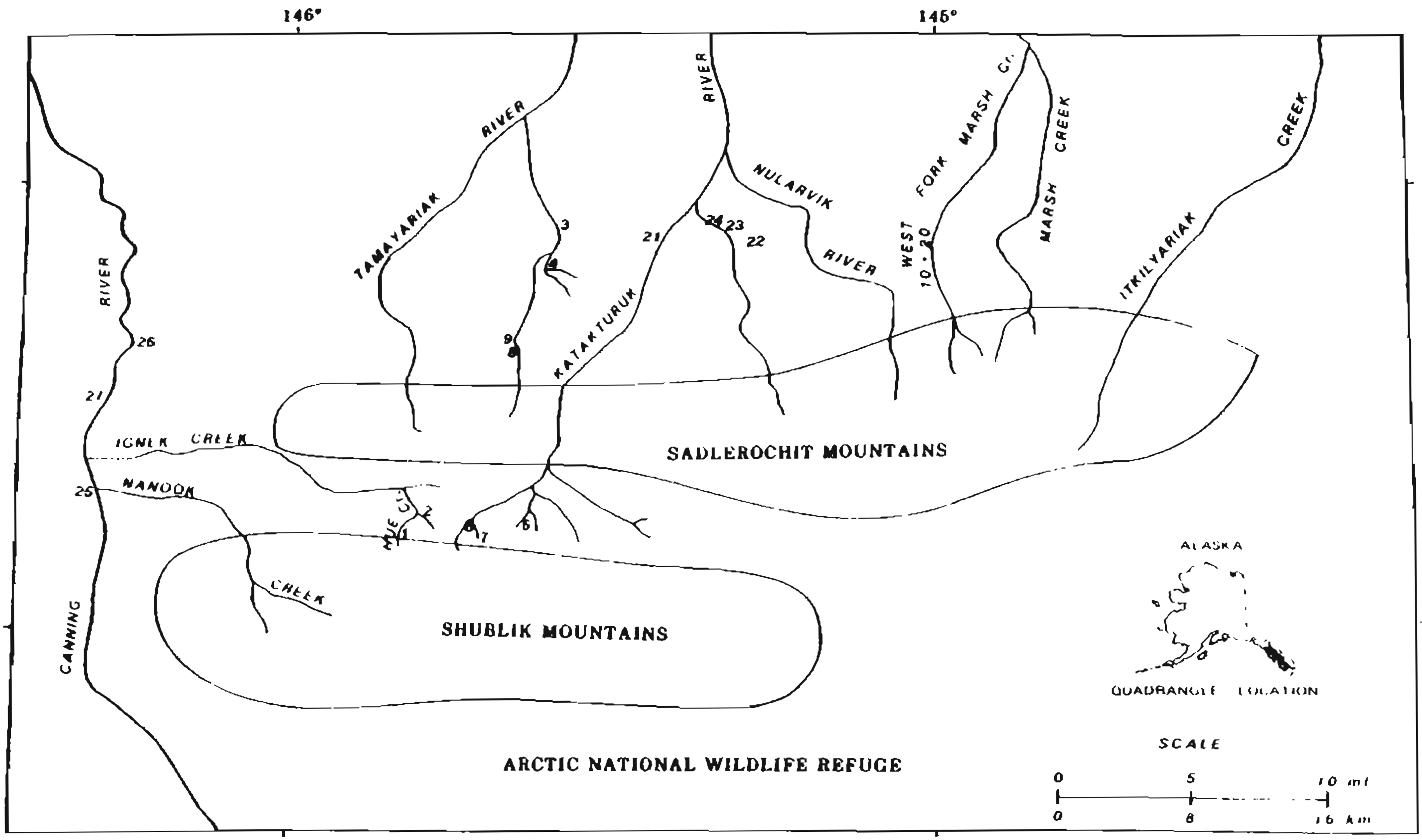

Fig. 1 Outcrop location map

The southern margin is paralleled by the Brooks Range and the northern margin is bound by the Barrow Arch, a topographic high produced by rifting of Alaska's northern margin.

The infilling of the Colville basin began in western Alaska during Jurassic or Earliest Cretaceous time. By Albian time, the western and central portions of the basin where being filled by post orogenic deposits. The Albian in my study area, if present is unrecognizable. The Albian is overlain by the organic-rich Hue shale. Deposition of the Hue Shale, which is interbedded with tuff and bentonite material, continued at least into the Coniacian. The first clastic deposits introduced into this part of the basin are recorded by the turbidite facies of the Canning Formation.

GENERAL LITHOLOGY

The turbidite facies of the Canning Formation is composed of sandstone and siltstone turbidites interbedded with shale. The sandstone is a gray to brown, moderately well sorted, very fine to medium-grained lithic arenite. It is very thin to thick-bedded. The Bouma sequence can be identified in most beds, and sole marks are often found on their bases. Sandstone to shale ratios vary from outcrop to outcrop.

AGE

A total of 19 shale samples were submitted for age determination to Micropaleo Consultants, Inc. 18 of these samples were found to contain foraminifera and/or palymnomorphs that were identifiable and dateable. These samples ranged in age from Late Cretaceous to early Tertiary. More specifically from Santonian to Eocene (?). Table 2 is a listing of the age calls for the 18 samples. For a detailed listing of the microfossils identified, refer to Vandergon, (1986).

TABLE 2

FORAMINIFERA

Sample Number	Age
85MV012E	Possible Late Cretaceous to Tertiary. Santonian to Paleocene
85MV012M	Possible Late Cretaceous to Tertiary. Santonian or Younger.
85MV012S	Possible Late Cretaceous to Tertiary. Santonian or Younger.
85MV014J	Late Cretaceous. Santonian to Maestrichtian.
85MV017C	Late Cretaceous to Tertiary. Santonian to Paleocene.
85MV021D	Late Cretaceous to Tertiary. Santonian to Paleocene.
85MV039 (85JD126B)	Late Cretaceous to Tertiary. Santonian to Paleocene.
85MV046B	Indeterminate
85MV051A	Late Cretaceous to Tertiary. Santonian to Paleocene.
85MV052B	Late Cretaceous to Tertiary. Santonian to Paleocene.

PALYNOMORPHS

Sample Number	Age
85MV010D	Late Cretaceous. Senonian
85MV012E	Possible Mesozoic.
85MV012M	Late Cretaceous. Probable Senonian
85MV012S	Late Cretaceous. Probable Senonian
85MV014J	Late Cretaceous. Campanian.
85MV015A	Indeterminate.
85MV017C	Indeterminate.
85MV018A	Probable Cretaceous. Undifferentiated.
85MV021D	Probable Paleogene. Probable Paleocene.
85MV025L	Late Cretaceous. Maestrichtian.
85MV039 (85JD126B)	Possible Late Cretaceous. Possible Maestrichtian.
85MV039 (85JD126C)	Tertiary.
85MV039 (85JD126D)	Indeterminate.
85MV039 (85JD126F)	Tertiary. Possible Eocene.
85MV046B	Tertiary. Undifferentiated.
85MV049D	Probable Late Cretaceous. Probable Campanian - Maestrichtian.
85MV051A	Indeterminate.
85MV052B	Late Cretaceous. Senonian. Possible Maestrichtian.

TERMINOLOGY

The turbidite systems and facies nomenclature used in this report are from Mutti (1985), and Mutti and Ricci Lucchi (1972).

A turbidite system, according to Mutti, 1985, is "a body of rocks where channel-fill deposits are replaced by nonchannelized sediments in a downcurrent direction." Turbidite systems vary in size, overall geometry, types of facies and facies associations, and distribution and geometry of sandstone bodies. The primary variables that lead to differences in the growth patterns of turbidite systems are sediment grain size and the volume of gravity flows feeding them. The size of gravity flows is mainly a function of fluctuations in relative sea level. Mutti has developed three types of turbidite systems for ancient sea level dominated turbidite deposits by determining where sand is deposited in the system. A fluctuation of sea level during the deposition of a turbidite system will form a composite system made up of alternating system types. The Canning Formation turbidite facies can be considered a composite system made up of alternating type II and III deposits. Some of the distinguishing characteristics of types II and III deposits are listed below.

Type II deposits form channelized bodies that grade down-current into non channelized sandstone lobes. The depositional lobe and channelized deposits are physically attached by transitional facies. A type II system dominated by finer grained sediment tends to develop depositional lobes, while coarser grained material produces systems dominated by channelized deposits. Medium- to small-volume, sand-rich turbidity currents are responsible for the growth pattern of type II systems. This system is thought to be produced primarily during times of relative lowstand of sea level.

Type III turbidite systems are produced by medium- to small-volume mud-rich turbidity currents. These currents are produced during relative highstands of sea level by slumping of the seaward edge of an actively prograding delta. The deposits are characterized by small sandstone filled channels that are surrounded by thin-bedded mudstone, siltstone and fine-grained sandstone overbank deposits. The channel and overbank deposits grade laterally and basinward into basinal mudstone deposits.

Mutti and Ricci Lucchi, 1972, produced a turbidite facies classification based on sediment characteristics such as sand shale ratios and grain size variations. Table 3 lists the turbidite facies recognized in the Canning Formation turbidite facies.

TABLE 3

Facies B	Medium-fine to course-grained sandstone Massive beds which are lenticular Inferred product of both grain flows and high-velocity turbidity currents
Facies C	Medium- to fine-grained sandstone A complete Ta-e Bouma sequence Product of "classical" turbidity currents
Facies D	Fine- and very-fine-grained sandstones and siltstones Sandstone beds have marked lateral continuity Bouma sequence begins with Tb or Tc.
Facies E	Has a higher sand:shale ratio than facies D Sandstone beds are discontinuous with wedging and lensing
Facies F	Chaotic deposits (slumps, mudflows, etc.)
Facies G	Pelagic and hemipelagic shales

STRATIGRAPHY

General

The Canning Formation turbidite facies can be divided into three types of deposits, channel, channel levee complex, and interchannel deposits. These types of deposits are typical of the middle fan facies association of Mutti and Ricci Lucchi, (1972). The Canning Formation conformably overlies the Hue Shale. This contact is exposed along Hue Creek in Ignek Valley (Sheet 2). The base of the Canning Formation turbidite facies is picked at the first appearance of sandstone or siltstone turbidites within the shale.

The outcrops visited represent isolated parts of the entire section. There are no identifiable marker beds to tie one outcrop into another. The biostratigraphic resolution of the microfossils identified is likewise inadequate for correlation of outcrops. This made it impossible to measure the total thickness of the turbidite facies. However, wells west of ANWR containing the turbidite facies have thicknesses ranging from 300 to 900 meters (Molenaar, in press). The upper contact of the turbidite facies with the Sagavanirktok Formation is covered. However, Molenaar, in press, concludes that the main part of the Sagavanirktok Formation disconformably overlies the Canning Formation in the type well.

The following are stratigraphic descriptions for ten outcrops, seven of which were measured with a Jacob staff and Brunton (Sheet 1). The remaining three outcrops were drafted as traverse cross sections to record lateral relationships (Sheet 2). These ten outcrops contain the stratigraphic and sedimentologic data for which I base my interpretations.

MEASURED SECTIONS

85MV012

This 44 meter section is composed of an overall fining upward sequence of interbedded sandstone and siltstone turbidites and shale. The sandstone is a fine- to medium-grained lithic arenite. The sandstone beds have a maximum thickness of 37 cm, but they average 6 cm. The beds have sharp, flat bases and either a sharp rippled top or a gradational top. The sandstone beds seem to be laterally continuous across the outcrop which extends only a few tens of meters. Most beds begin with Bouma Tb or Tc intervals, with the Tc interval being dominant. Convolute bedding, flame structures, and various sole marks are associated with the sandstone beds. These sedimentary structures decrease in abundance upward in the section.

The sandstone beds are interpreted as facies C or D deposits (Mutti and Ricci Lucchi, 1972). However, the shale dominant upper portion of the section is made up of Facies G hemipelagic and pelagic shale interbedded with Facies D turbidites. The facies association indicates deposition on the mid-fan as channel levee complex and interchannel deposits. The overall fining and thinning upward sequence is recording a relative rise in sea level. The sand-rich type II deposits at the base of the section grade upward into type III mud-rich deposits.

85MV014

This section is located along a tributary of the Tamayariak River. It is 81 meters thick and is characterized by thinly interbedded sandstone, siltstone, and shale, with minor bentonites. The finer-grained sediments are dominant at this outcrop. The sandstone is a very fine-grained lithic arenite. The beds vary in thickness from a few millimeters to 15 cm, with an average thickness of 6 cm. Sandstone beds are laterally continuous across the outcrop. Many layers are massive and structureless. Bouma sequences are hard to distinguish.

The strata is interpreted as facies D deposits. They represent interchannel deposition on the mid-fan.

85MV015

Like outcrop 85MV014, fine-grained material dominates this section. This 12 meter section contains interbedded sandstone, siltstone and shale. The sandstone is very fine- to medium-grained. The beds are ripple-topped, and are laterally continuous across the outcrop. The Bouma sequence is dominated by the Tc interval.

This outcrop is made up of facies D deposits, and represents a mid-fan interchannel environment.

85MV016

This outcrop is 39 meters thick and is made up of an upward coarsening sequence of interbedded siltstone, shale, bentonite, and fine-grained sandstone. The siltstone is thin-bedded, has no internal structures and is highly fractured. The siltstones are highly cemented and may in part be concretionary. The sandstone and bentonite show an inverse relationship in that the sandstone increases up section, while the bentonite decreases.

We interpret this outcrop to represent facies D interchannel deposits.

85MV019

This outcrop is a 39 meter section of thinly interbedded fine- to medium-grained lithic sandstone, and dark-gray shale that contains lenticular bedded siltstone and sandstone. The sandstone beds contain laminae of organic material interspersed throughout them. The sandstone beds are laterally continuous throughout the outcrop. However, a close look at the finer grained interval shows a pinching and swelling of thin lenticular beds. Starved sandstone ripples are also present. The sandstone beds are dominated by the Tcde interval of the Bouma Sequence. The tops of most sandstone beds are gradational. The lower half of the outcrop consists primarily of a coarsening upward sequence, while the upper half is dominated by a fining upward sequence.

This outcrop is dominated by sandstone. The lower coarsening upward cycle represents deposition in an interchannel area. The upward fining sequence most likely represents a channel-fill deposit. A channel scour below the channel-fill deposits is not readily apparent, but the limited lateral exent of the outcrop would hinder the recognition of a broad low relief scour. The channel-fill deposits are unrelated to the flow that scoured the channel.

The section is dominated by Facies D deposits. This outcrop is made up of overbank deposits, which in part may fill in an abandoned channel. The sand-rich nature of the deposits suggests deposition during a relative lowstand of sealevel. These deposits are type II turbidite system deposits.

85MV039

This 74 meter section is made up of three individual sand-rich intervals. The lower two sandy intervals are separated by a chaotic zone. The upper sandy interval is separated from the lower intervals by 35 meters of shale that contains lenticular bedded sandstone and siltstone turbidites.

The sandstones are fine- to medium-grained and lithic. The Bouma sequence is variable. The thickest beds contain complete Tabcde sequence. However, the most common Bouma sequences recognized are those missing the basal Ta or Tab intervals. The sandstone beds are thin- to thick-bedded. The beds often have rippled tops, and the bases are sharp. Sole marks are present on many beds.

The upper sandy interval has an erosional channel scour at its base. The sandstone beds that fill this scour lapout against it. The channel-fill is unrelated to the event or events that eroded the broad low relief channel. The lower two sandy intervals may represent the same relationship, but not enough section is exposed to see this relationship.

This outcrop is made up of mid-fan channel-fill, overbank and interchannel deposits. The sand-rich intervals are characterized by facies C and D deposits. They were deposited during relative lowstands of sea level, and are type II deposits. The 35 meters of shale separating the sandy intervals represents deposition during a relative highstand of sea level. The interval is made up of facies G hemipelagic and pelagic shale interbedded with facies D turbidite deposits, and is classified as a type III deposit.

<u>85MV049</u>

This 265 meter composite section is made up of two sections with an undetermined amount of section missing between them. The section is composed of thinly interbedded medium-grained lithic sandstone, siltstone and silty shale. The sandstones have sharp, flat bases with numerous sole marks. Upper surfaces are rippled with organic concentrations filling ripple lows. The sandstone beds vary in lateral continuity.

This outcrop extends several hundred meters along the west bank of the Canning River. It has a number of sandier intervals within the section. These are interpreted to be the result of either shifting source areas, or relative fluctuations in sea-level.

This outcrop is made up of facies C and D deposits. They record deposition as channel-fill, overbank, and interchannel deposits. The upper fifteen meters of the section exposes facies D channel-fill deposits overlying a channel scour. The channel-fill is unrelated to the event which produced the scour. The sand-rich nature of this outcrop suggests a deposition during a relative lowstand of sea level, and are considered a type II deposit.

TRAVERSES

85MV010

This outcrop along Hue Creek exposes the contact between the Hue Shale and the Canning Formation turbidite facies. This contact is made at the first appearance of sandstone or siltstone turbidites within the shale sequence.

There are several sandstone intervals near the top of the exposed section along Hue Creek. These sandstone intervals consist of several meters of sandstone rubble. Sole marks can be found on pieces of float. The sandstone is a fine-grained lithic arenite. The sandstone appears to be massive. The rubble crops are separated by tens of meters of shale with interbedded bentonite layers.

We interpret these outcrops to be either thick massive channel fill deposits, or they could be depositional lobe deposits.

85MV043

This outcrop is located along a tributary of the Katakturuk River. It is a sequence of interstacked sandstone-filled channels surrounded by thin-bedded turbidites. The sandstone is fine- to medium-grained, mainly massive with some plane parallel laminae near the tops of beds. The channelized sandstone beds average slightly less than a meter in thickness, and begin to pinchout over a distance of 20 meters. The tops of beds are slightly wavy, but sharp, and the bases are usually planar and sharp. Some of the lower bedding surfaces contain load casts, and other sole marks. Within the sandstone beds there are layers of shale rip ups, but the rest of the outcrop contains very little shale.

Adjacent to the thick channelized sandstones there are thinner sandstone beds that contain large quantities of organic material such as woody fragments. A variety of Bouma sequences are found in these thinner sandstone beds. The sequences are lacking the basal Ta or Tab intervals. These beds also contain a variety of sole markings. A soft sediment fold is preserved in these thinner sandstone beds.

The rocks at this outcrop are catagorized as facies B channel-fill, and facies D and E levee and overbank deposits. The deposits record deposition during a relative lowstand of sea level. These deposits can be classified as type II deposits.

85MV051

The lower part of this outcrop consists of interbedded sandstone, siltstone, and shale. The sandstone is very fine-grained, and beds range from less than 1 cm to 40 cm thick. Most sandstone beds have plane bases and rippled tops, although some beds are wavy. The beds pinch out along the outcrop. Some beds seem to be small channel-fills. The lower part of the outcrop contains many chaotic zones. In these zones there are scattered clumps of pebbles which were ussually assocciated with bentonite. Following bedding laterally across the outcrop is hindered by these scattered chaotic zones.

The upper portion of the section is characterized by many interstacked channels. These channels scour into the underlying thin-bedded turbidite deposits. The channel-fill consists of fine- to medium-grained, mostly massive sandstone, with a pebble to boulder conglomerate and organic rich sandtone lag deposit at the base. The channels are a few meters thick and tens of meters wide.

This outcrop contains facies B channel deposits, and facies D and E levee and overbank deposits in the lower portion of the section. Deposition took place during a relative lowstand of sealevel. These deposits are considered type II deposits.

PETROLOGY

Sandstone modal analysis was completed on 10 thin sections from various outcrops of the Canning Formation turbidite facies. In general, the sandstones studied have similar textures and compositions. Samples averaged 52.35% quartz, 3.07% feldspars, 42.18% rock fragments, and 2.40% other detrital fragments. Of the rock fragments, sedimentary rock fragments made up the majority with 36.79%. The sandstone samples are classified as lithic arenites. According to Dickenson and Suczek (1979) triangular diagrams, the turbidite facies had a recycled orogen provenance.

PALEOCURRENT DATA

The orientation of a variety of sole marks and current ripples were measured to determine the paleocurrent direction during the deposition of the turbidite facies. These measurements were corrected for tectonic tilt by the stereonet correction method. The measurements were then lumped together into 15° sectors and plotted on a rose diagram (Fig. 2). Flute casts were considered the only paleocurrent indicator that showed a true direction of flow. All other measurements were treated as lineations and were plotted as such on the rose diagram (hence the double headed nature of the diagram). The mean vector trend for the paleocurrents is ENE (60-75° sector). Sediment was being supplied to the basin from the southwest.

THERMAL ALTERATION INDEX

One of the most commonly used parameters for measuring thermal maturity of kerogens is thermal alteration index (TAI). Staplin (1979), defined the TAI as a measure of color on a scale ranging from 1 to 5. The higher numbers indicate a greater maturity of the kerogen. Although the exclusive use of TAI as a maturity indicator can at times be subjective, it is still considered to be valid when used by itself. The numerical value indicating the oil-generative zone varies from laboratory to laboratory. TAI values of

PALEOCURRENT ANALYSIS

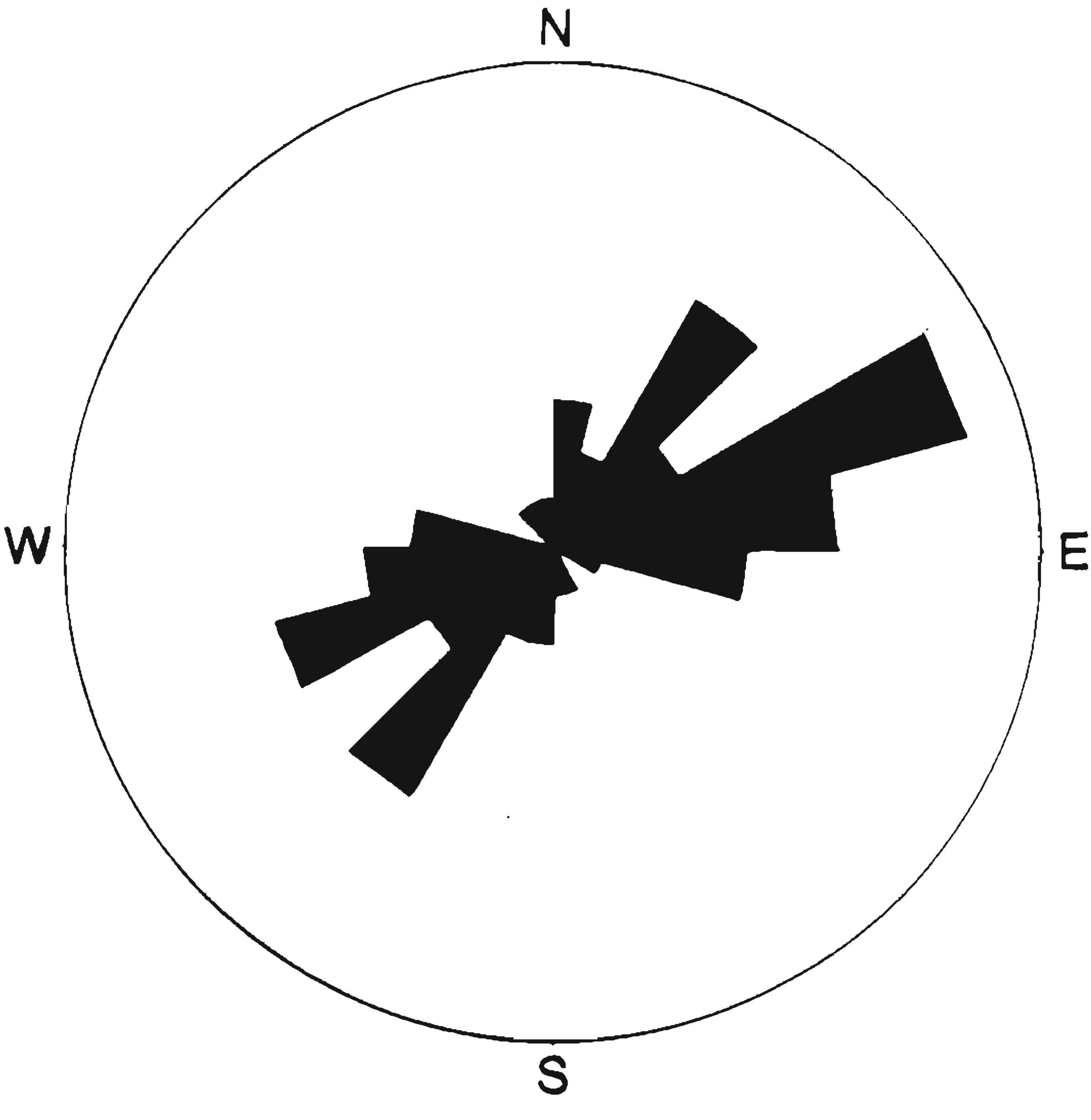

Fig. 2 Paleocurrent rose diagram

oil-generative zones used by Waples (1981), are approximately in the range of 2.6 to 3.2. Table 4 lists TAI values for shales collected at various outcrops.

TABLE 4

SAMPLE	TAI	KEROGEN TYPE (%)		
		A	H	W-F
85MV010C	2.8	30?	10	60
85MV010D	2.8	60	30	10
85MV012E	2.8		10	90
85MV012M	2.5-2.8		10	90
85MV012S	2.5-2.8		40	60
85MV014J	2.5		20	80
85MV015A	2.5		30	70
85MV017C	2.5		20	80
85MV018A	2.5		20	80
85MV021D	2.5		40	60
85MV025L	2.3	80	20	T
85MV046B	2.3		5	95
85MV049D	2.3	T	10	90
85MV051A	2.3-2.5		5	95
85MV052B	2.3-2.5		10	90

A = amorphous, H = herbaceous (includes palynomorphs), W-F = woody-fusinitic

The TAI for two-thirds of the samples indicates that the organic material is still immature. One-third of the samples have reached the hydrocarbon generation zone of maturity. Two of the mature samples were collected from the Hue Shale (85MV010C and 85MV010D), which is considered a potential hydrocarbon source rock in ANWR.

DEPOSITIONAL HISTORY

During Albian to Cenomanian time, shallow marine to nonmarine deltaic deposits of the Nanushuk group were being deposited in the western and central Colville basin. During this same period of time, in the area of study, the basin underwent a period of nondeposition or is possibly recorded by a condensed section of shale. Further to the east the Bathtub Graywacke and the Arctic Creek facies turbidites were being deposited.

Deposition of the Hue Shale, which coincides with a global rise in sea level at the end of Cenomanian time (Vail et al., 1977b), blankets the central and eastern Colville basin with organic-rich shales. Shale deposition continued into at least the Coniacian.

A lowering of sea level during Latest Cretaceous time resulted in major slumping and resedimentation of the deltaic deposits. Debris flows created by the slumps evolved into turbidity currents that carried sediment into the basin, which until this time had been dominated by the deposition of the organic-rich Hue Shale. As time progressed the delta prograded over the turbidite deposits, and the filling of the Colville basin was essentially completed.

Based on the lithofacies identified, the deposits in the study area can be characterized as part of the middle fan facies association, as established by Mutti and Ricci Lucchi, (1972). With limited outcrop exposure of the different associated facies, it is hard to model the overall fan morphology. However, since the basin is elongate, and paleocurrent measurements indicate flow paralleling the axis of the basin, it could be assumed that the morphology of the fan is also elongate.

The presence of abandoned channel scours suggests that further along the transport direction the material transported by the currents that produced these scours will be found, possibly as overlapping depositional lobes.

The volume of the turbidity currents and whether or not they were sand- or mud-rich, was dependent on relative fluctuations in sea level. Gravity flows that developed during relative low stands of sea level developed into sand-rich turbidity currents down slope. These high density turbidity currents were responsible for producing the sandstone filled channels, the abandoned channel scours and the relatively sand-rich deposits in the interchannel areas. These deposits are type II turbidite system deposits.

Mud-rich turbidity currents were produced during periods of relative highstand of sea level. The turbidity currents were produced at the seaward edge of the actively prograding delta due to slumping. This slumping is the result of normal sediment instability due to rapid sedimentation rates. These deposits are considered type III turbidite system deposits.

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