UPPER CRETACEOUS STRATIGRAPHY, YUKON COASTAL PLAIN and NORTHWESTERN MACKENZIE DELTA

by

F. G. YOUNG.

GSC Bulletin Ms.

Dec. 24, 1973

COPY 2.
(OPEN FILE COPY)

CONTENTS

ILLUSTRATIONS

ABSTRACT

Upper Cretaceous and older Mesozoic sedimentary rocks were studied for three field seasons by the writer on Yukon Coastal Plain and regions to the south. These studies, combined with those made in the office and laboratory, including the close examinations of the I.O.L. Ellice O-14 and I.O.L. Blow River YT E-47 boreholes form the basis for this report.

Upper Cretaceous strata comprise the youngest rocks of Yukon Coastal Plain and consist predominantly of shale, sandstone and conglomerate. Comparatively rare are coal, carbonate rocks and pyroclastic volcanics. These rocks are economically important for their potential reserves of coal and petroleum. The Upper Cretaceous sequence of formations consists of the Boundary Creek Formation at the base, followed upwards by the Fish River Group, which includes the Tent Island and Moose Channel formations, and the Reindeer Formation.

The Boundary Creek Formation is mainly bituminous, marine shale which was apparently deposited during a considerable portion of middle Late Cretaceous time. It is preserved only east of Blow River where it unconformably overlies Lower Cretaceous strata, and is commonly 500 to 1,000 feet thick. This unit is characterized by its brightly coloured sulphate encrus-

tations, bentonite beds and hematite bands, and its tendency to deform into complex, disharmonic folds.

The Fish River Group is a molassoid terrigenous clastic wedge, approximately 6,000 ~~to 7,000~~ feet thick, consisting of grey mudstone, siltstone, quartz-chert-lithic sandstone, conglomerate and rare coal seams. It is extensively preserved on the coastal plain, in the subsurface of lower Mackenzie Delta, and probably beneath the continental shelf under Mackenzie Bay.

The Tent Island Formation consists mainly of soft mudstone approximately 3,000 feet thick immediately west of Mackenzie Delta, and possibly twice as thick farther west in the area of Deep Creek. A basal sandstone and conglomerate unit, here named the Cuesta Creek Member, occurs sporadically at the base of the formation. This coarse clastic unit is a potential reservoir for hydrocarbons because of its lenticular nature and position between two thick marine shale formations. Although macrofossils are extremely rare, microfossils are relatively common in the Tent Island, and include foraminifers, dinoflagellates, pollen and spores. These assemblages indicate the formation is Campanian-Maastrichtian in age.

The Moose Channel Formation is subdivided into two ~~three~~ members, which, ~~from bottom to top~~ include the basal sandstone member, and

Ministicoog Member. The basal sandstone member consists of sandstone, conglomerate, and mudstone, interpreted to represent alluvial, deltaic and littoral depositional sites. The Ministicoog is dominated by mudstone, but contains sandstone beds as well, and is believed to represent tidal-flat to shallow marine environments.

The Reindeer Formation (Aklak Member) is exposed in a few small outcrops west of Mackenzie Delta where it conformably overlies the Moose Channel Formation. A delta-plain facies prevails in these exposures as well as in the I.O.E. Ellice C-14 borehole, and consists of sandstone, conglomerate, mudstone and coal.

Fossils in the Moose Channel and Reindeer formations include wood fragments, leaf and fruit impressions, pollen and spores, and minor foraminifers. They indicate a latest Cretaceous (Maastrichtian) age, extending into earliest Tertiary in the subsurface sections of the Reindeer Formation.

Sandstones of the Fish River Group and Reindeer Formation are mainly immature, chert litharenites. Emphasis in this study was placed on attempting to define stratigraphic and areal trends in sandstone composition in order to assist in the identification of members. The greatest variations occur among the proportions of chert, plagioclase and volcanic rock fragments, the latter two being roughly inversely proportional to chert. The Cuesta Creek Member sandstones are relatively high in chert content (average 34%) compared with stratigraphically higher sandstones (basal Moose Channel 21%; Aklak 24%). Plagioclase and volcanic fragments are particularly enriched in the basal sandstone member of the Moose Channel.

Paleocurrents, dispersal trends and petrography of clastic particles indicate that in general the source of sediment and heads of drainage systems lay west and south of the present coastal plain, and that the Moose Channel Formation was not deposited by a proto-Mackenzie River. Deltaic sedimentation and the location of depocentres appear to be concentrated in the lower coastal plain and subsurface of the present Mackenzie Delta. Evidence from palynomorph discoloration, coal reflectance, and mineral stabilities indicate that these areas are highly favourable sites for petroleum generation and entrapment.

UPPER CRETACEOUS STRATIGRAPHY, YUKON COASTAL PLAIN AND NORTHWESTERN MACKENZIE DELTA

INTRODUCTION

Upper Cretaceous strata comprise the youngest rocks of Yukon Coastal Plain and are preserved in synclinal cores and downfaulted blocks such that they form approximately one half of the bedrock surface-area. These rocks plunge gently seaward, and are overlain by Tertiary sediments beneath the continental shelf and Mackenzie Delta. The Upper Cretaceous sequence consists of the Boundary Creek Formation at the base, followed upwards by the Fish River Group, which includes the Tent Island and Moose Channel formations, and the Reindeer Formation. Stratigraphic units comprising this sequence, except for the previously described Moose Channel and Reindeer Formations (Mountjoy, 1967), are named and defined in this report.

Discussions of sedimentology, paleogeography, paleontology, structural geology, and economic geology are based on detailed bedrock studies undertaken in the eastern coastal plain area (see geological map), reconnaissance geology of the rest of the coastal plain, and studies of samples and well-logs of several wells, notably the I.O.E. Ellice O-14 borehole located in northwestern Mackenzie Delta.

The rocks described here are predominantly terrigenous clastic sedimentary rocks. The small remainder include coal, carbonate rocks, and pyroclastic ~~we~~ volcanics. The Boundary Creek Formation is mainly bituminous, marine shale, and appears to represent a considerable portion of early to middle Late Cretaceous time. The Fish River Group and Reindeer Formation is a molasse-like clastic wedge, about 7,000 feet thick and consisting of grey mudstone, siltstone, quartz-chert-lithic sandstone, conglomerate, and rare coal seams.

GEOGRAPHIC SETTING

Upper Cretaceous rocks are largely absent in the mountainous parts of the north-draining region of northern Yukon Territory, and occur primarily within Yukon Coastal Plain, a strip of land of low relief about 15 miles wide between Porcupine Plateau and Beaufort Sea. The coastal plain rises abruptly several hundred feet above the Mackenzie deltaic plain along a straight scarp that trends N 52°W ~~in this area~~. The tundra-covered land surface gradually increases in elevation towards the southwest, in the form of a dissected, ~~x~~uplifted pediplain. Outcrops occur primarily in stream-banks and gorges,

and in a weathered and highly fractured ~~form~~ condition along rare cuestas. There are no permanent roads or settlements on the coastal plain west of Mackenzie Delta except for the Distant Early Warning (DEW) establishment at Shingle Point, a few miles north west of the ~~study~~ map-area. In summer the ~~area~~ coastal plain may be reached only by aircraft or boa~~x~~t from the towns of Aklavik and Inuvik, 48 and 70 miles distant to the southeast, respectively.

In most years geological field work can be started at the beginning of June in this area, although late snowfalls can cause delays lasting until mid-June. The coastal plain is very prone to dense fog and moderate winds borne off the ice-pack and open leads of the adjacent Beaufort Sea. Base-camps established inland in higher terrain take advantage of warmer air and probably experience less "down-time" due to inclement weather than those set up on the coastal plain.

~~Previous Work~~ PREVIOUS WORK

The earliest geological observations of the immediate study-area were made by O'Neill (1915, 1924) during a three-year stint with the Canadian Arctic Expedition. He traversed the Yukon Coastal Plain several times, where he was duly impressed by the thick, well exposed Pleistocene deposits along the Arctic coast.

Latour (1956) made a brief visit in 1955 to Moose River coal mine at Coal Mine Lake, where the coal yielded pollen and spores dated by MacGregor (1961) as upper half of the Upper Cretaceous. During Operation Porcupine of the Geological Survey in 1962 Mountjoy made observations of the Upper Cretaceous rocks on and near Big Fish River, and reported on them subsequently (1967a). In that report he named and discussed the Moose Channel Formation. Norris revisited the study-area several times in follow-up studies to Operation Porcupine, and reported briefly on thicknesses and some of the sedimentological properties of the Fish River Group (Norris, 1970).

During the last two decades several geological reconnaissance missions were sent into this area by petroleum companies, but none of this work has yet been published. Holmes (1972) based his Master of Science thesis about the Moose Channel Formation on data and samples gathered while working for the Atlantic Richfield Company. A concise version of this research (Holmes and Oliver, 1973) was presented to the Canadian Arctic Symposium in Saskatoon.

Chamney (1971) erected 7 physical stratigraphic divisions and 23 biostratigraphic subdivisions based upon microfossil recovery from cuttings and cores of the Reindeer D-27 borehole, the first well drilled on Mackenzie Delta. An attempt is made in this report to correlate his informal divisions to units recognized in the Ellice O-14 borehole, located 30 miles west, and to the surface stratigraphy discussed here.

~~Present Studies~~ PRESENT STUDY

With the advent of active exploration for oil and gas in the Mackenzie Delta area in the late 1960's, the need for more ~~stratigr~~ surface and subsurface stratigraphic control from the coastal plain and northern Richardson Mountains was immediately realized. Very little information had been published on rocks younger than the Aptian upper sandstone division of Jeletzky (1958, 1960), and the writer's present project was designed to fill these knowledge gaps.

The present study was launched in the summer of 1970 when the writer shared a camp and a helicopter, supplied by Liftair International Limited, with Drs. D. K. Norris and J. A. Jeletzky of the Geological Survey. Stratigraphic information on the Fish River Group was obtained during the course of a two-week ~~down-stream~~ traverse by inflateable boat down Little Fish (Cache) Creek and Big Fish River (Young, 1971). This method allowed the writer to visit nearly all outcrops along the riverbanks at a slow pace, except for running the rapids in Fish River canyon near the confluence of Little Fish (Cache) Creek. During this traverse the writer was amiably assisted by Mr D. Loney.

In June and July of 1971 a base camp was maintained at Coal Mine Lake in the heart of the ~~study~~ map-area (Figure 1). With the excellent

assistance of Mr D. H. McNeil and a helicopter chartered from Shirley Helicopters Limited, nearly all stream-cuts and ridge outcrops in the ~~study~~ map-area were examined (Young, 1972). Foot traverses were made along ~~the entire lengths of~~ Boundary, Eagle, Hornet, Aklak, and "Bushy" Creeks, starting from their first headward outcrops.

During the field seasons of 1970, 1971 and 1972 reconnaissance stops, foot traverses, and measured sections in Upper Cretaceous rocks were described at various locations on the coastal plain (Figure 2). Drill cuttings and cores from the entire I.O.E. Ellice C-14 borehole, and the upper half of the I.O.E. Blow River YT E-47 borehole were examined and logged in detail by the writer.

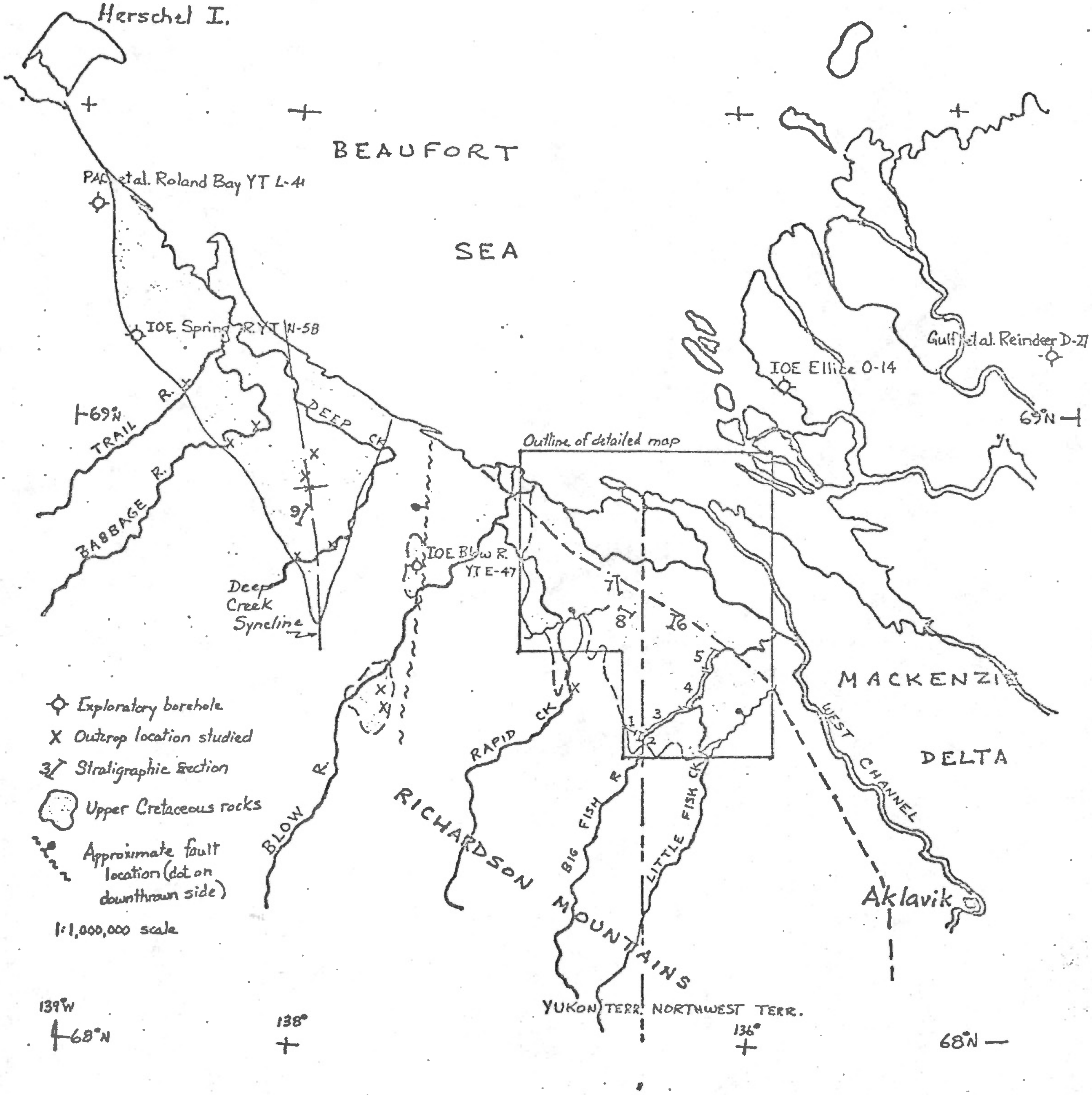


Figure 2. Location Map with Simplified Geological Outline.

ACKNOWLEDGMENTS

The writer wishes to thank Drs. D. K. Norris, J. A. Jeletzky, C. J. Yorath, D. F. Stott, and Mr. T. P. Chamney, all of whom are officers of the Geological Survey, for their advice during the initial steps of this project and for many useful discussions.

Discussions on outcrop occurrences, stratigraphy, and sedimentological problems with Mr. D. Holmes of Atlantic Richfield Canada Limited were most useful and stimulating. The field assistance offered by Mr. D. Loney in 1970 and Messrs. D. H. McNeil, Z. Hadnagy, D. Gardner, and J. Irish is gratefully acknowledged.

Foraminiferal identifications were made by T. P. Chamney, and palynological determinations by Dr. W. W. Brideaux, both of the Survey. Plant remains were identified by Dr. C. J. Smiley of the University of Idaho. Clay mineral analyses were made by Dr. A. E. Foscolos of the Geological Survey. C. J. Yorath kindly donated his sample-description log of the Reindeer D-27 borehole for incorporation in this report.

The helpful comments of A.W. Norris and D.K. Norris, who critically read this manuscript are gratefully acknowledged. Other suggestions for improvement of the text were kindly provided by , D.W. Myhr, and numerous other geologists familiar with the geology of the area.

GEOGRAPHIC NAMES

no underline.

With the recent increased interest in the economic potential of Mackenzie Delta and surrounding area the need for more geographic names is evident. Also, vague references to various unnamed streams along which important geological outcrops occur ~~by unofficial names is~~ are undesirable in the long run. Accordingly, several names were submitted to the Canadian Permanent Committee on Geographic Names, and ~~were~~ approved by them.

The names important to the report include the following:

Eagle Creek- a northward flowing stream whose course lies just west of the Yukon-Northwest Territories Boundary and which drains into newly named Scow Lake in northwestern Mackenzie Delta.

Hornet Creek- a major southwestern tributary of Eagle Creek, which it enters at Lat. 68° 44' 20" North, Long. 136 35'00" West.

Aklak Creek- the largest stream debouching into Coal Mine Lake of northwestern Mackenzie Delta. This is the name ~~is~~ used by the local Indians for this creek and means "bear" in the~~ir~~ Loucheux language.

Boundary Creek- a major western tributary of Big Fish River, whose junction with the latter almost coincides with the point where Big Fish River crosses the Yukon-Northwest Territories boundary at Lat. 68°30' 15" North.

Cuesta Creek- a northward flowing tributary of Rapid Creek which it meets at Lat. 68°45'00" North, Long. 136°53'30" West, and which cuts through a prominent, north-south trending, unnamed cuesta.

A ruling was obtained from the Committee regarding the present ambiguities in the names for the major river flowing into northwestern Mackenzie Delta. That is, Big Fish River is the correct name, and not Fish River as printed on the Blow River, 117A map-sheet, Edition 1, published by the Surveys and Mapping Branch. Also, the large tributary of Big Fish River labelled Cache Creek on the same map-edition should be called Little Fish Creek. To avoid confusion in the report, the latter is referred to as Little Fish (Cache) Creek.

GEOLOGICAL SETTING

The geological history of the northern Yukon Territory since Precambrian time is relatively complex, consisting of numerous periods of sedimentation of various styles, punctuated by tectonic activity and a few major orogenic episodes. General reviews of this history have been published by Martin (1959), Jeletzky (1961, 1962), Norris et al.(1963), Douglas et al.(1970), ~~and~~ Norris (~~in press~~ 1973), and Miall (1973).

Mountain-building occurred during the late Precambrian Era in the Racklan Orogeny (Gabrielse,1967) which was followed by a long period of sedimentation resulting in the Neruokpuk Formation of northern Yukon. In late Devonian and early Mississippian time these rocks were compressed and deformed during the Ellesmerian Orogeny. Areas uplifted by this diastrophism include British Mountains, Aklavik Arch and Richardson Mountains. Further depositional intervals interrupted by periods of uplift are recorded from the Mississippian, Pennsylvanian, Permian, and Triassic Periods.

In early Jurassic time ~~a marine trough developed which~~ the seaway inundated northern Yukon and resulted in ~~the~~ a thick black shale deposit (Kingak Formation) extending from Eagle Plain through the coastal plain into Alaska.

Quartz sand was deposited mainly on the southeast margin of this seaway and in several northwest-projecting tongues well into Early Cretaceous time. This sequence has been well documented by Jeletzky (1958, 1960, 1961, 1971) in areas south of the coastal plain.

In the late Early Cretaceous (Aptian) the Upper sandstone division (Jeletzky, 1958) marks the beginning of a major tectonic episode because its sandstone is richer in chert and limestone fragments than earlier deposits. It grades upwards into a very thick, shaly, flyschoid succession which was deposited in a north-trending trough running through Blow River valley (Young, 1974). The flyshhoid sequence rapidly thins toward the east in the region of Big Fish River, where phosphatic iron carbonate rock and shale accumulated on a restricted shelf. In late Albian and possibly earliest Late Cretaceous time subsidence of this trough gradually ceased, and its sediments were subjected to tectonic stresses and, in part, raised above sea level. Following a brief period of emergence the Upper Cretaceous depositional intervals were initiated, whose sediments are described in this report.

STRATIGRAPHY

The Upper Cretaceous sequence of the Yukon Coastal Plain includes, in ascending order, the Boundary Creek, Tent Island and Moose Channel formations, the latter two comprising the Fish River Group, and the Reindeer Formation. The ages, thickness ranges, and gross lithologic aspects are summarized in the Table of Formations. Except for the Moose Channel and Reindeer Formation, all stratigraphic names ~~used in this report~~ shown in Table I. are new.

Table I. Table of Formations (Yukon Coastal Plain)

Series	Stage	Formation and thickness (ft)	Lithology
? Tertiary	? Paleocene	Reindeer (1,900±)	Non-marine sandstone, coal, siltstone, conglomerate (Aklak Mbr.)
		Conformable	contact
Upper Cretaceous	Maastrichtian	Fish River Group: Moose Channel (2000 - 3000)	Silty mudstone (Ministicoog Mbr.); sandstone, in part pebbly, coarse-grained, minor shale, conglomerate, coal.
	Maastrichtian – Campanian	Fish River Group: Tent Island 2400-5000±	Mudstone, light grey to bluish grey, in part lilty, sandy, or pebbly; conglomerate and sandstone at base (Cuesta Creek Member)
	Disconformity		
	Santonian - (?) Cenomanien	Boundary Creek 0 - 3600+	Shale, dark grey, bituminous, soft, yellow- to red-weathering, bentonite, rare limestone and siltstone.
?Angular Unconformity			
Lower Cretaceous	Albian	unnamed shale, phosphatic ironstone	

The Boundary Creek Formation is preserved between two unconformities only in the eastern coastal plain near Mackenzie Delta, and is a structurally incompetent shale unit containing bentonite and limestone beds. The Fish River Group commences with the Tent Island Formation, a thick, recessive-weathering grey mudstone unit with minor sandstone bands and beds. At its base is a locally occurring sandstone and conglomerate here called the Cuesta Creek Member. Owing to the imprecise definition of the Moose Channel Formation (Mountjoy, 1967) this name has been applied by some workers (personal commun.) to the entire Fish River Group. However, the original intent (E. Mountjoy and D.K. Norris, personal commun.) and usage in the Geological Survey and elsewhere restricts the Moose Channel to the upper sandstone formation only, a practice followed here. At the type section on Big Fish River the Moose Channel consists of a 1,900-foot-thick sandstone member, overlain by a poorly exposed, 975-foot-thick mudstone unit, here called the Ministicoog Member. The conglomeratic and coal-bearing Aklak Member was also included in the Moose Channel Formation (Mountjoy, 1967; Young, 1972), but is now included in the Reindeer Formation as a result of regional subsurface correlations.

The organization of the stratigraphy and sedimentology descriptions is as follows: the Boundary Creek Formation is completely discussed in the usual format in this chapter; similar accounts of units in the Fish River Group and the Reindeer Formation, with abridged lithologic descriptions, are also found in this chapter. Detailed sedimentological descriptions and interpretations of the Fish River Group and Reindeer Formation are reserved for a separate chapter, as is a general and comparative description of sandstone petrography. The problems of correlating stratigraphic sections within the study-area, as well as interregional correlations are discussed in a separate chapter as well.

BOUNDARY CREEK FORMATION

Name and Distribution

The name Boundary Creek Formation is here proposed for a distinctive Upper Cretaceous shale unit outcropping in eastern Yukon Coastal Plain. It is well exposed in the high northern bank of the lower course of Boundary Creek after which the formation is named. The composite section available at this site is also designated the type section (Section 1, appendix).

Because of its soft, recessive-weathering nature, the Boundary Creek Formation outcrops only in active, stream-cut gullies and gorges. Nevertheless, even taking into account this limitation, the formation is not extensively preserved. Its main outcrop area lies in the environs of Fish River, Little Fish (Cache) Creek, and lower Rapid Creek (~~Map Figure~~ Figure 1). It was not recognized in outcrops west of Blow River, but possibly occurs in the depth-interval 3,370 to 3,990 feet in the I.O.E. Blow River YT E-47 borehole. The Upper Cretaceous Shale Division described by Jeletzky (1960) is believed to be a limited occurrence of the Boundary Creek Formation in eastern Aklavik Range.

→ add over page.

Add.
This is substantiated by the great similarity in lithology at each location, by the similarity in paleontological age assignments (see below), and by the occurrences of fish and bird bone beds both at Trulsen Creek and in the Bituminous Shale Zone of Anderson Plain (Chamney, 1973a), with which the Boundary Creek Formation correlates.

The Boundary Creek Formation is approximately 800 feet thick at its type section, 540 feet thick a few miles to the south on Big Fish River, and at least 750 feet thick on Little Fish (Cache)

Creek (Lat. 68°28'N; Long. 136°12'W). Owing to its tendency to be tectonically deformed and to slump in outcrops, these thicknesses are only approximations. The supposed equivalent strata in the Blow River E-47 borehole amount to about 600 feet in thickness, taking into account bedding dips. The Treeless Creek section in eastern Aklavik Range was estimated by Jeletzky (1960) to be 900 to 1,000 feet thick. A section twice measured near Cuesta Creek, a tributary entering lower Rapid Creek, was determined to be in the order of 3,600 feet thick, this amount being stratigraphically above an ~~unexposed~~ unlocated basal contact. A few observed faults within the section may cause stratigraphic repetitions, but probably do not account for the majority of the measured thickness. Seven miles to the east on Hornet Creek the formation wedges out to completely below the Fish River Group.

Lithology

The Boundary Creek Formation is reasonably constant in lithologic character throughout its thickness, and cannot be subdivided into mappable members. The formation consists mainly of dark grey to black, soft shale, which is oxidized to various colours including yellow, red, and mahogany brown, but predominantly light to medium grey (Fig. 3). Thin beds and bands of yellow-weathering, putty-like, greyish white bentonite occur throughout the unit, and are concentrated in certain zones. High in the section bentonitic seams attain thicknesses of about one foot.

Thin carbonate beds and lentils comprise a minor part of the lower half of the formation, and include argillaceous or sandy limestones in the type section, bedded sideritic ironstones on Fish River and Rapid Creek, and argillaceous dolostones in the Cuesta Creek section. Calcareous and sideritic concretions are common in the medial third of the formation, and large septarian nodules up to five feet wide are found about 200 feet below the top at the type section. Similar nodules observed at the Treeless Creek section contain veins of amorphous, resinous material.

Arenaceous terrigenous clastics are notably rare in the Boundary Creek Formation. Thin-bedded siltstone is present in rare amounts in all studied localities, but only at Little Fish (Cache) Creek were sandy siltstone beds observed, and these displayed flute-casts and groove-casts.

An outstanding feature of this formation are the colourful weathering encrustations formed largely of sulphate minerals and iron oxides. Gypsum (selenite) and jarosite are common weathering products of the shales, and barite was observed rarely as veins. Some of these minerals may have resulted from spontaneous combustion of pyritic, bituminous shale, such as that occurring in the "bodannes" of the correlative "Bituminous Shale

Zone" on Anderson Plain (Yorath, et al., 1969). The more common ochrous and selenitic encrustations formed particularly on slightly calcareous, hard mudstone beds, however, seem more likely to be products of leaching and hydration in a semi-arid to arid climate.

A preliminary analysis of the clay mineralogy of these shales was undertaken by A. E. Foscolos at the Institute of Sedimentary and Petroleum Geology, and the semi-quantitative results of X-ray diffraction patterns are given in Table 2 .

Sample	Dolom.	Siderite	Pyrite	Qtz	Felds.	Kaolin.	Illite.	Chlor.	Montm.	Gypsum
19YAb-17	—	—	10	59	9	—	12	10	—	—
19YAb-20	—	4	8	55	7	—	15	11	—	—
19YAb-6	11	—	—	46	9	—	6	4	—	24
20YAb-1	—	—	—	70	13	—	—	3	10	4
20YAb-4	3	—	—	65	14	—	2	3	13	—
20YAb-7	—	—	—	68	13	—	16	3	—	—
57YA-2*	3	—	—	59	14	—	14	10	—	—
Averages	2.5	0.5	2.5	60	11	—	9	6	3	4

*sample from Cuesta Creek section; the others from type section.

Table 2 . Composition of shale samples, Boundary Creek Formation.

The montmorillonite present in two samples taken from a yellow-banded shale unit verifies the presence of bentonite, and suggests a volcanic source for some of the clays. Other evidence of volcanic activity during deposition of the muds include the presence of small andesitic lapilli in digested micropaleontological samples from beds associated with concentrations of bentonite seams (T. P. Chamney, personal commun.).

The presence of limestone beds in this formation is practically unique among the Mesozoic formations of this region. A thin section of one of these beds indicates a fairly pure calcarenite composed of monocrystalline plates and fragments, suggesting echinoderm debris. Some limestone samples contain quartz sand grains of similar size (ca. .20 mm diam.) as the carbonate particles. Other limy beds apparently consist entirely of fine spicular fragments.

Structural Relations

The Boundary Creek Formation is one of the most structurally incompetent Mesozoic units in the coastal plain area as indicated by its tendency to deform into disharmonic folds. X Its relative plasticity contrasts with the relative brittle nature of subjacent and overlying units, which are commonly faulted in association with folded Boundary Creek. This characteristic is well exemplified on Little Fish Creek where brittle Albian shale and turbidites are deformed into variously dipping, fault-bounded panels, but the overlying Boundary Creek shale is disharmonically folded. Faults occur higher stratigraphically in the Tent Island Formation without associated folding. Similar observations were made along the lower course of Rapid Creek. The possibility of this plastic shale contributing to shale diapirs in the offshore subsurface therefore deserves serious consideration.

The lower contact of the Boundary Creek was observed in the banks of Big Fish River and Rapid Creek, where a basal, red-weathering shale unit lies in sharp, concordant contact above bedded iron-stone and shale of Albian age. Ferruginous beds greatly resembling the Albian ironstones occur within the basal red-weathering shale, and masquerade as a continuous, transitional facies between the Albian strata and Upper Cretaceous shales. However, this contact is probably disconformable in the Big Fish River area, because a considerable thickness of Albian turbiditic sandstone and shale occurs between the bedded ironstone and Boundary Creek Formation on nearby Little Fish (Cache) Creek.

In the Blow River E-47 borehole the dipmeter log indicates a large angular discordance at a depth of 3,990 feet. Overlying beds interpreted to represent the Boundary Creek Formation dip about 20° to the southeast, but the underlying Albian shales dip 20 to 30° northwestward. This contact can alternatively be interpreted as a fault plane.

The upper contact is rarely exposed, but from mapping patterns is inferred to be locally unconformable. On Hornet Creek the basal conglomerates of the Fish River Group rests with slight angular discordance on brittle, hard shales of probable Albian age.

However, on Boundary Creek and Big Fish River the basal beds (Cuesta Creek Member) consist of platy siltstones and shales which overlie the non-arenaceous Boundary Creek shale apparently concordantly, and possibly conformably.

Depositional Environment

No detailed sedimentological analysis of the Boundary Creek Formation was undertaken, but much about its environment of deposition can be inferred simply from gross lithology and biotic characteristics. The vertical homogeneity of the bituminous, pyritic mudstones, which represent a long span of Upper Cretaceus time (see below), indicates that a fairly continuous, slow rain of clay-sized particles were deposited onto a quiet, practically stagnant basin floor. This basin contained marine waters as evidenced by such marine life-forms as echinoderms, ammonites, radiolarians, and foraminifers.

The abundance of bitumen in the shales, and the presence of pyrite attest to anaerobic, reducing conditions which were long maintained on the sea-floor. Although it was previously suggested (Young, 1973) that this formation represented hypersaline conditions on the basis of the contained sulphate minerals, it is now believed that the latter are products of late diagenesis and weathering, and do not reflect salinity of the original seawater.

The lack of arenaceous influxes and the vertical continuity of the euxinic shale facies reflects the stability of the basin in this area. However, the frequent occurrences of bentonite layers in the section attest to volcanicity and therefore instability within the region. This deposit represents a metastable tectonic period established between an earlier flyschoid phase in the late Early Cretaceous, and a later molassoid phase (Young, 1973), represented by the Fish River Group.

Age

The Treeless Creek outcrops of the Boundary Creek Formation (Upper Cretaceous Shale Division) contain various pelecypods and ammonites which indicate that the beds there are Cenomanian to Turonian in age (Jeletzky, 1960, p.22). No macrofossils have been recovered from the formation in the (Big) Fish River area, and microfossils are relatively sparse. Those that have been recovered are confined largely to the upper half of the formation, and consist of radiolarians and foraminifers dated as possibly Turonian and Santonian in age by Chamney (1972; personal commun.). Pollen and spore recoveries to date have consisted mainly of recycled debris.

The three members of the formation at the Treeless Creek section can be correlated on lithologic grounds to similar units at the Boundary Creek and (Big) Fish River sections. The "orange-

weathering member" and the underlying "dark grey shale member" both lie below the section sampled and studied by Chamney (1972), and permit a tentative Cenomanian-Turonian age assignment to the lowest part of the formation.

Thus the Boundary Creek Formation seems to represent fairly constant sedimentary conditions throughout the larger part of Late Cretaceous time, including Cenomanian to late Santonian stages. Much more paleontological work is required to refine this range in ages and to determine whether or not hiatuses may in fact exist within the formation.

S-2

FISH RIVER GROUP

The Fish River Group derives its name from Big Fish River (referred to as simply "Fish River" by virtually everyone conversant with the area) along whose banks the group is exposed over most of its entire thickness. The composite section exposed as gently northeast dipping strata over a distance of 14 miles is designated the type section of the group, despite the unfortunate presence of minor faults and the poor exposure of mudstone units. The total thickness of section on Big Fish River is approximately 6,000 feet, as determined from direct field measurements and graphic calculations over covered intervals. The Fish River Group is also entirely represented along the course of Eagle Creek, although one major fault and several minor ones disrupt the stratigraphic continuity along the stream's course. By summing the measured stratigraphic thicknesses and restoring the formations into their proper sequence, the total thickness of the group here is also approximately 6,000 feet.

The Fish River Group occurs in the Blow River Valley within a probable downfaulted block, and is poorly exposed immediately south of the mouth of Fitton Creek (Fig. 2). It is dominantly mudstone here (Tent Island Formation probably) but also includes two, widely separated, ridge-forming sandy units, each displaying non-marine characteristics. The higher one is 380 feet thick and probably represents the Moose Channel Formation. It is approximately 1,500 feet stratigraphically above the lower sandstone and mudstone unit, which was measured to be 750 feet thick, and can be referred to the Cuesta Creek

Member of the Tent Island Formation. Downstream from this outcrop-area in the I.O.E. Blow River YT E-47 borehole, the uppermost 4,000 feet of section was identified as the Fish River Group with the aid of foraminiferal remains (T. P. Chamney, pers. com.).

West of Blow River the Fish River Group again outcrops in the core of Deep Creek Syncline (Figure 2, Sec. 9), where it is poorly exposed, and the thickness of the Tent Island Formation is not well established, although it appears to be considerably thicker here (10,000 feet according to Norris, 1972a, p.97) than it is to the east.

TENT ISLAND FORMATION

The dominantly pelitic unit referred to previously as the "Upper Cretaceous unnamed shale unit" (Young, 1971; Chamney, 1972), and erroneously as the "Upper Cretaceous shale division" (Young, 1972), is here named Tent Island Formation. The name refers to Tent Island in Shoalwater Bay, and the name of the map-area (NTS 117A/16) in which most of the studied outcrops of the formation are located. The type section (Sections 2 & 3, Appendix) is incompletely exposed on the northwest bank of Big Fish River from its confluence with Boundary Creek at the Northwest Territories-Yukon boundary (Fig. 4) to its junction with Little Fish (Cache) Creek. Most of the upper half of the formation consists of soft clay-shale, thus fresh outcrops are rare. On Big Fish River this part of the formation forms a long, high bank characterized by slumped, bluish grey mud.

Occurring sporadically at the base of the formation is a resistant sandstone and conglomerate unit with mudstone beds. This unit is here named the Cuesta Creek Member after the creek which cuts through a prominent cuesta formed by resistant strata of this unit west of lower Rapid Creek. Previously it was referred to as the "basal chert conglomerate and sandstone division" (Young, 1972). Except for the lower contact the formation is completely exposed on Big Fish River where it crosses the Yukon-Northwest Territories boundary, and this is selected as the type section (Section 2; Fig. 4).

A previously published stratigraphic section of Little Fish (Cache) Creek (Young, 1971) reported the Tent Island Formation as 1,100 feet thick. At this locality, however, the unit is truncated at its base by a fault, and its true thickness is not represented. At its type section the Tent Island Formation is about 3,125 feet thick, and on Eagle Creek its thickness is about 2,800 feet. In the Reindeer D-27 borehole, Chamney (1972) expressed the opinion that it was represented in the depth-interval 6,960 to 10,720 feet, or 3,760 feet of section.

West of Mackenzie Delta the Tent Island Formation has been recognized in sporadic outcrops along the lower coastal plain between West Channel and Rapid Creek. The formation apparently thickens towards lower Rapid Creek in consonance with the shale-out of the basal Cuesta Creek Member. These trends and the possible northwestward disappearance of the unconformity separating the Fish River Group from the underlying shale sequence may result in the replacement of the Tent Island Formation by a much thicker shale formation encompassing the older Boundary Creek Formation.

In the Fish River area the Cuesta Creek Member ~~Formation~~ rests unconformably on the Boundary Creek Formation ~~yellow-weathering shale~~ division ~~unit~~, which is largely equivalent to the Bituminous Shale Zone of the Anderson Plain (Chamney, 1972). At the type section this contact is not exposed, but is believed to underlie a 100-foot-thick succession of graded sandstone and interbedded mudstone beds assigned to the Cuesta Creek Member ~~Formation~~ (Section 2, Appendix). This succession in turn is scoured and its upper beds truncated by conglomerate and coarse sandstone beds, and this striking contact seems at first glance to represent the unconformity. However, it probably represents channel-scouring of pro-deltaic and delta-front beds by the seaward advance of a delta distributary, because laterally the lower succession is preserved and grades ~~passes~~ vertically ~~by gradations~~ into a sandstone member.

Elsewhere, as on lower Rapid Creek, the conglomerate rests directly on eroded mudstone of the Boundary Creek Formation ~~yellow-weathering shale unit~~ division (Fig. 5 ~~Photo 71-3-15~~). Here the local rate of angular discordance is one foot in 25, (2.5°) with downcutting northward. However, only 4 miles northwest of this locality, where the continuation of the cuesta-forming outcrop belt meets the south bank of Rapid Creek, the Cuesta Creek Member ~~Formation~~ is a mere ~~only~~ 15 feet thick, and

barely recognizeable. Here it is almost entirely replaced by sandy mudstone and shale, and no sharp contact with the underlying Boundary Creek Formation ~~yellow-weathering shale unit~~ division is discernible. Thus, the unconformity may be replaced northward by a continuous sedimentary sequence, in conjunction with the disappearance of the Cuesta Creek Member ~~Formation~~.

The upper contact of the Tent Island Formation with the Moose Channel Formation is selected at the base of the relatively continuous succession of coarse clastics sediments of that formation, and is generally distinct. (See discussion of this contact on p. 84 ff. & Figure 16).

Cuesta Creek Member

At the type section the Cuesta Creek Member is 325 feet thick (Section 2), and at Eagle Creek 355 feet thick. It is present in isolated outcrops in the valley of lower Rapid Creek, but the only available thickness in this area is from the prominent cuesta, where it is 280 feet thick. The member has not been recognized southeast of Big Fish River, and seems to be absent in Reindeer D-27 borehole. This member is also locally present in the Deep Creek area where it is easily confused with the Moose Channel Formation. One section measured on Deep Creek at Lat. 68°47'N, Long. 138°01'W was faulted, but approximately 450 feet of interbedded conglomerate, sandstone and mudstone are indicated. Here the member forms a low ridge trending northwest, immediately east of Hidden Lake. Farther northwest, good exposures of the Cuesta Creek Member are present in the banks of Trail River (Lat. 69°02'N, Long. 138°34'W), where it is about 140 feet thick.

The upper contact of the Cuesta Creek Member is sharp in some places but gradational in others. It is chosen at the top of the highest, relatively resistant sandstone or conglomerate bed of the Cuesta Creek Member. Pebbly mudstones commonly encountered above the resistant underlying sandstones are included with the unnamed shale member of the Tent Island Formation.

At the type section the member consists of four units (Fig. 6), which in ascending order include (i) a basal sandstone and shale unit, (ii) a lower sandstone and conglomerate unit, (iii) a mudstone unit, and (iv) an upper sandstone and conglomerate unit. Only the upper three units are visible at the prominent cuesta west of Rapid Creek.

The coarse clastic units commonly weather to a characteristic deep red-orange colour. Fresh surfaces are mainly medium to dark grey due to the high content of dark chert and slate fragments. The largest phenoclast was observed at Hornet Creek and measured 3 by 2 feet in two visible dimensions.

The abundant conglomerate at the type section displays clasts up to one foot in maximum dimension. At Eagle Creek conglomerate is almost absent, and the ~~formation~~ member here is mostly sandstone and friable argillaceous sand, with minor coal streaks and seams.

The mudstone ~~member~~ unit consists of silty, dark grey-brown brittle shale, which is in part sandy and carbonaceous, and locally contains dark brown limy beds and concretions.

Mudstone Member

The rocks of the Tent Island Formation are generally soft, easily eroded, and exhibit a muddy aspect in the field, especially near Big Fish River and eastward. Wherever it is nearly flat-lying the formation causes high-density drainage patterns to develop. Towards lower Rapid Creek the mudstones become harder and darker grey, and lose their clayey appearance.

Near the base of the formation pebbly mudstone units are common, and are in part graded and interbedded with stratified non-pebbly mudstone (Fig. 7). Also common in the basal half are interbedded sandstone and siltstone beds. On Eagle Creek and Big Fish River sandstone is practically absent, however thin-bedded, laminated and cross-laminated calcareous siltstone is common. Cone-in-cone structure is frequently developed on the undersides of siltstone and rare argillaceous limestone beds, both in the Big Fish River and Deep Creek areas: This structure is apparently a hall-mark of the formation in this region.

The upper half is very recessive, and consists of medium grey mudstone and shale mainly. In places the mudstone contains nodular to lenticular pods of silt, sand, and rarely, gravel. A few intervals are enriched in sandstone, sand, silt, and pebble conglomerate interbeds ~~and bands~~. Such interbeds are normally very thin and exhibit bright yellow, orange and olive-green weathering colours. Carbonaceous particles are abundant in these coarser interbeds.

X-ray analyses of "clay" mineralogy for five mudstone samples, two from Little Fish ~~(Cache)~~ Creek and three from Eagle Creek revealed illite and chlorite as the only clay minerals, and quartz is the major clay-size component (A.E. Foscolos, internal report). The average composition of the five samples is:

Quartz	43.0%
Feldspar	10.8%
Illite	22.8%
Chlorite	21.6%
Carbonate	1.8%

Microscopic examination of several sandstone and siltstone samples revealed the universal presence of calcite cement and a constant particulate composition dominated by quartz, chert, and metasedimentary rock fragments. Minor components include potash feldspar, plagioclase, andesitic rock fragments, carbonaceous flakes and shards, and mica. All samples are well compacted and non-porous. Sand grains are mainly angular to subangular, very fine-grained to fine-grained, and moderately to well sorted. Incipient replacement of feldspar and labile grains by calcite has occurred in samples where the latter is abundant.

Paleontology and Age of Tent Island Formation

In its type area the Tent Island overlies disconformably the Boundary Creek Formation, dated by Chamney (1972) as questionable Turonian to Santonian in age, and biostratigraphically equivalent to the Bituminous Shale Zone of Anderson Plain. Although no macrofossils were recovered from the basal Cuesta Creek Member, palynological samples from this unit at Eagle Creek yielded poor to mediocre indigenous palynomorphs (GSC loc. C-11376) identified by W. W. Brideaux of the Geological Survey as:

- *Cicatricosisporites* sp.
- *Inaperturopollenites hiatus* (Potonié) Thomson and Pflug
- *Aquilapollenites* sp.
- fragmented plant debris

Brideaux considered this assemblage to be probably Campanian or Maastrichtian in age. Hence, in the eastern outcrop area, the basal Tent Island Formation appears to be no older than Campanian in age.

Higher up in the same section, but still within the basal half of the formation, the following palynomorphs were recovered and identified by Brideaux (GSC locs. C-11380 and C-11399):

- *Triatriopollenites* sp.
- *Triporopollenites* sp. cf. *T. rugatus* Newman
- *Betulaceoipollenites* sp. cf. *B. infrequens* (Stanley) Norton and Hall
- *Inaperturopollenites hiatus* (Potonié) Thomson and Pflug

Stereisporites antiquasporites (Wilson & Webster) Dettmann

Cleistosphaeridium sp.

Aquilapollenites sp. A

unidentifiable bisaccates

This assemblage was dated as Upper Cretaceous, probably Maastrichtian in age.

No macrofossils or diagnostic microfossils have yet been recovered from the type section on Big Fish River, but on nearby Little Fish (Cache) Creek, five miles east, the formation has yielded abundant foraminifers, dinoflagellates, pollen and spores, and the only macrofossil from the entire Fish River Group. This was identified by J. A. Jeletzky as a pelecypod, possibly of the génus Acila.

A rich microfauna along with a mixed indigenous and recycled microflora were recovered from a 200-foot thick interval beginning about 900 feet below the Moose Channel Formation. T. P. Chamney of the Geological Survey examined the microfauna and reported the following species (GSC locs. C-6059 and C-6067) of foraminifers:

Cyclammina sp. 1A

Trochamminoides sp. 9B

Haplophragmoides sp. 66

H. var. sp. 87

H. ex. gr. H. gigas minor Nauss

?Gaudryina sp.

Verneuilinoides fischeri Tappan

Saccammina sp.

Marsonella (Dorothia) sp. 13B

Ammodiscus cf. A. planus Loeblich

Trochammina sp. G 132

T. sp. G 138

?Arenobulimina sp. 8

A. ex. gr. A. paynei Tappan

Bathysiphon sp. 13

Hippocrepina (Hyperammonoides) sp. 22

?Globorotalia sp.

Reophax sp.

Praebulimina venusae Nauss

Gyroidina (Serovaina) sp.

The same samples yielded the following palynomorphs, identified by W. W. Brideaux:

Deflandrea spectabilis Alberti

D. magnifica Stanley

Astrocysta cretacea Pocock ex Davey

Hystrichosphaeridium? sp.

recycled Paleozoic, Triassic and Lower Cretaceous miospores

probable Maastrichtian dinoflagellates

According to Chamney, the foraminifers comprise the Cyclammina sp. 1A Zone Assemblage which he reported in the Reindeer D-27 borehole

(Chamney, 1971) in the depth-interval 9,200 to 9,560 feet. This assemblage is biostratigraphically equivalent to the Schrader Bluff Formation of northern Alaska, and is now considered to be Maastrichtian in age (Chamney, 1973). Brideaux noted that the presence of Deflandrea magnifica Stanley, if indigenous, "can mean only that the sample is no older than Maastrichtian or no younger than Early Paleocene". Hence the upper half of the Tent Island Formation in the Big Fish River area is reasonably well dated as Maastrichtian in age.

Far to the northwest on Trail River, a 150-foot thick arenaceous ~~the Cuesta Creek~~ ~~Member~~ section containing coaly shale lentils was described and interpreted to be basal Moose Channel Formation ~~from which palynological samples were collected~~ by D. K. Norris (1974, p. 348, 349). Brideaux found ~~these to be~~ the coaly shale impoverished in pollen and spores, but containing ~~a~~ an unnamed species of the marine dinoflagellate ~~species of~~ Deflandrea, indicating a probable ~~Santonian-Campanian~~ Senonian age. This age supports the writer's preference that the section is basal Tent Island Formation, or Cuesta Creek Member.

In the area of Deep Creek, D. K. Norris collected shale samples for microfossil analysis from the Tent Island Formation. These samples (GSC locs. C-9784 to C-9788) were examined and reported on by T. P. Chamney, who found a sparse microfauna consisting of:

Haplophragmoides n. sp.

H. sp. 88

?H. sp.

?Trochammina sp.

Hippocrepina sp.

H. (Pelosina) sp. 6

Bathysiphon sp.

Saccammina sp. 2

This assemblage of foraminifers was dated as Senonian (probably Santonian-Campanian) by Chamney.

Thus, west of Blow River, where it is much thicker than it is in the type area, Tent Island Formation may be as old as Santonian. If this be true, the Cuesta Creek Member is not the same age everywhere, but is younger in the Big Fish River area than in the area northwest of Blow River.

Moose Channel Formation

The Moose Channel Formation was established by Mountjoy (1967, p. 8) for "about 1,200 feet of non-marine, loosely consolidated sandstones occurring along the Arctic Coast in a belt extending for about 10 miles on either side of the mouth of Fish River". He designated the exposures along Big Fish River the type section, although no detailed measurements and descriptions were made because of lack of time during the 1962 field season. Also included in the original description of the Moose Channel Formation were coaly beds outcropping in the banks of Aklak Creek, stratigraphically higher than the rocks on Big Fish River. These beds are here designated the Aklak Member, ~~the youngest subdivision of the Moose Channel Formation~~ and assigned to the Reindeer Formation.

Lying stratigraphically below the Aklak Member is a mudstone-dominated unit, here termed the Ministicoog Member, which is partly exposed in the lowest reaches of Big Fish River. The basal sandstone member which forms the steep-walled gorge at the confluence of Little Fish Creek and Big Fish River is left unnamed. The type section of the Moose Channel Formation is approximately 3,000 feet thick.

Besides outcropping in the vicinity of Big Fish River the Moose Channel also appears on the banks of Eagle Creek, whose mouth is located 14 miles northwest of the mouth of Big Fish River (Fig. 1). Approximately ~~3,000~~ 2,400 feet were measured on Eagle Creek (Sections 7, 8) and assigned to the Moose Channel Formation.

The Moose Channel Formation also occurs in Deep Creek Syncline about 50 miles west-northwest of the mouth of Big Fish River on the coastal plain (Fig. 2). The formation's resistant sandstone beds distinctly outline the syncline and cause the outcrop area to be somewhat elevated above the surrounding plain. Outcrops here are rare, however, because extensive physical weathering has reduced the rock to a thick fragmental mantle. Graphic measurements were made from vertical air photographs and structural data obtained from three ground traverses. A total thickness approximating ~~3,000~~ 2,250 feet is indicated for the Moose Channel Formation in this area (Section 9).

The Moose Channel Formation underlies the lower Mackenzie Delta where it is probably extensively preserved, judging from the few boreholes drilled there. In the I.O.E. Ellice 0-14 well strata assigned to the Moose Channel occur in the interval ~~3900~~ 5,610 to 9,160 feet of depth. ~~The top of this interval is merely an estimate, however, because of the uniform nature of the vertical succession of facies.~~ Sandstones occurring at the bottom of the hole just below 9,160 feet, may also in fact belong to the Moose Channel Formation. Nevertheless, the indicated thickness of the Moose Channel here does seem relatively greater than those of outcrop sections, although sandstones are relatively attenuated by the abundance of mudstone.

In the Reindeer D-27 well the Moose Channel is represented by only 1,480 feet of section in the depth-interval 5,010 to 6,220 feet.

An isopach map (Fig. 8) drawn of the combined basal sandstone and Ministicoog members indicates a lenticular sedimentary packet that thickens seaward and is thickest offshore in line with the Yukon-Northwest Territories boundary. This thickness maximum coincides approximately with the high negative gravimetric anomaly (*Sobczak*, et al., 1973) which is centered over the mouth of Shallow Bay.

The lower contact of the Moose Channel Formation is taken at the base of a relatively continuous sequence of sandstone and conglomerate beds. This is distinct and sharp (Fig. 9) in the outcrop area, and may even be somewhat erosional in places. The lower contact in the Ellice 0-14 borehole is gradational above Tent Island mudstones, and in the Reindeer D-27 well is also gradational at a depth of approximately 6,220 feet.

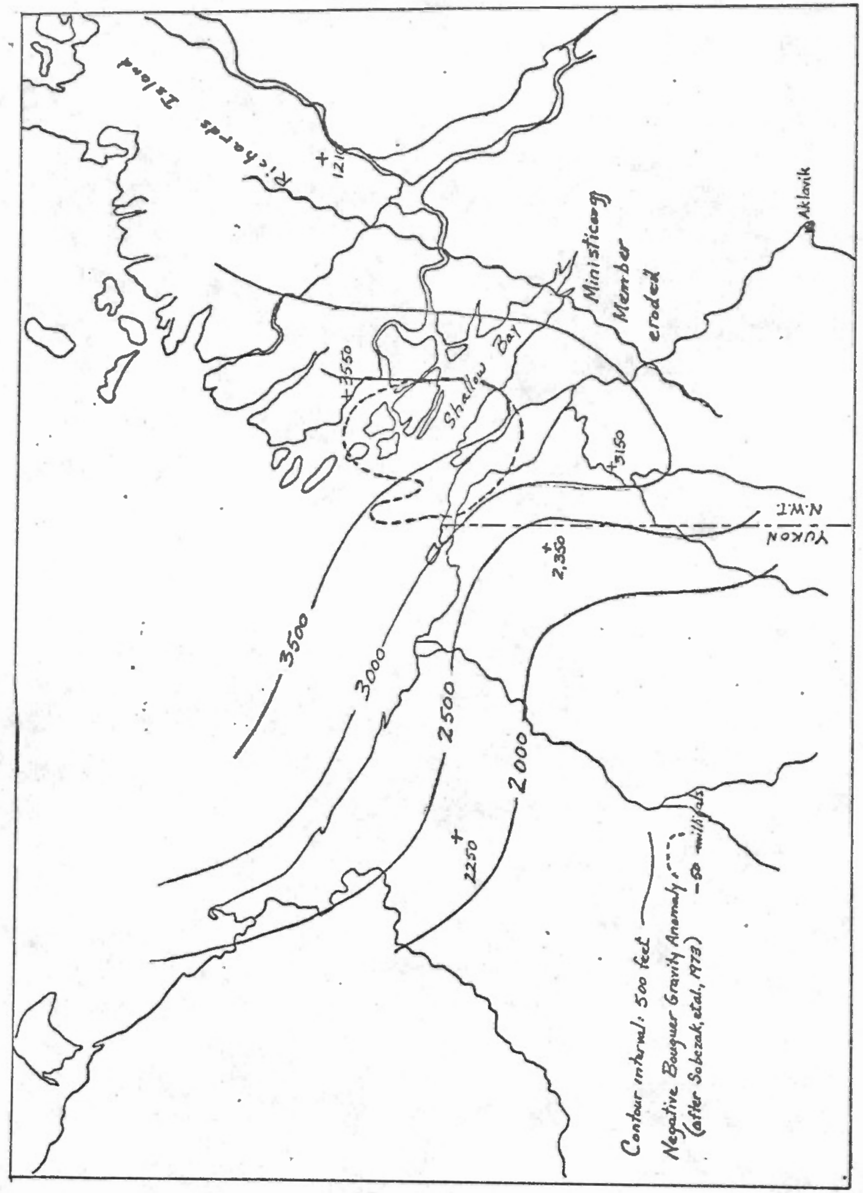


Figure 8. Isopach map of combined Basal sandstone and Ministicoog Members, Moose Channel Formation.

Basal sandstone member

In the vicinity of lower Big Fish River the basal sandstone member forms resistant ridges and steep-walled gorges because of its great amount of durable sandstone. Sandstone comprises over 85% of the 1,950-foot thickness exposed on Big Fish River (Section 4), whilst the remainder consists of grey shale, mainly as thin interbeds. Towards the northwest the basal member becomes less sandy and resistant, and thins to only 1,250 feet on Eagle Creek (Section 7). Here the basal member is nearly all sandstone in the top 460 feet, but consists of alternating beds of mudstone, sandstone, conglomerate, and rare coal in the lower part.

In the subsurface section of the Ellice O-14 borehole, the basal sandstone member is 2,375 feet thick (depth-interval 6,785-9,160 feet), but may be only 1,~~340~~ 210 feet thick (depth-interval ~~4,330~~ 5,010-6,220 feet) in the Reindeer D-27 well. In both instances the member consists of alternating sandstone-dominated and mudstone-dominated units, and consists of approximately 40% sandstone.

In outcrops the basal sandstone member is characterized by light grey, fine- to coarse-grained sandstone which is rich in lithic fragments of various kinds, quartz, chert, and feldspar. Scattered pebbles and pebble-lenses are common features

~~Basal Sandstone member~~

in the sandstone beds. These sandstones react to weathering processes in various ways, including the formation of irregular flags or slabs, development of friable, non-bedded sand, and the retention of very thick to massive, unfractured beds. Detailed descriptions of the sedimentary features associated with this member are discussed in the chapter on Sedimentology.

In the Ellice O-14 borehole section the ~~basal~~ lower half of the ~~Moose Channel~~ basal member contains far more sandstone and conglomerate than the upper half, which is practically devoid of conglomerate. Sandstone is mainly fine- to medium-grained, moderately to well sorted, grey, black-speckled, and rarely visibly porous. Argillaceous, silty, carbonaceous, and very fine-grained sandstones are also present, commonly interbedded with coarser varieties. The basal half contains chert-pebble conglomerate beds, silty and sandy, dark brownish grey mudstone, and rare coal seams. The upper half is dominantly siltstone and silty mudstone, commonly with abundant carbonaceous particles. Calcareous and glauconitic sandstones are present in this interval.

Ministicoog Member

The interbedded grey mudstone and siltstone unit (Fig. 10) that overlies the basal sandstone member, and was previously referred to as "the coaly mudstone member" (Young, 1971), is herein formally defined as the Ministicoog Member. The type section is located at the lower end of Big Fish River (Section 5) where it is neither completely exposed nor is the uppermost 250 feet present. To accommodate these shortcomings other cutbanks in the vicinity of Big Fish River are designated as part of the type area, and the I.O.E. Ellice 0-14 borehole section in the depth-interval 5,610-6,780 feet is selected as the reference subsurface section. The member is named after Ministicoog Channel which flows a few miles northeast of the type section.

The thickness of the Ministicoog Member in the type area is approximately 1,200 feet of which the lower 940 feet can be studied in the banks of Big Fish River near its mouth (Section 5, Appendix). It is 1,170 feet thick in the Ellice 0-14 borehole, 1,100 feet on Eagle Creek, and 1,000±50 feet at Deep Creek Syncline, 50 miles west-northwest of the type area. In the Reindeer D-27 borehole it may be represented by only 210 feet in the depth-interval 4,740 to 4,950 feet, or alternatively, it may be completely absent as indicated on the correlation diagram. In either case, this marked thinning is probably due to erosion prior to deposition of the overlying Reindeer Formation.

The contact with the underlying basal sandstone member is gradational and picked at the top of the well-bedded or massive sandstones. At the type section this contact is distinctive. However, to the northwest at Eagle Creek, the contact is difficult to pick because of the high content of sandstone in the Ministicoog there.

The upper contact of the Ministicoog is generally abrupt and marked by a distinct change in lithology from mudstone to sandstone or conglomerate of the overlying Reindeer Formation. This abruptness is well displayed at the Eagle Creek section where resistant conglomerate and sandstone directly overlie recessive coal and mudstone. The coarse clastic beds are convoluted just above the contact, indicating that the underlying muds were still soft and water-saturated when the coarse clastics were superimposed on them. A similar phenomenon was observed on Aklak Creek. Thus, fairly continuous sedimentation from the Ministicoog into the Reindeer Formation is evident at these sections.

Paleontology and Age of the Moose Channel Formation

Except for their traces, no fossilized macrofauna have yet been found in the Moose Channel Formation. However, fossil plant remains, pollen and spores, and microfauna have been collected and studied by numerous paleontologists, and their identifications form the basis of the following discussion of ages of the various members of the Moose Channel.

Basal sandstone member: - The sandy character of the basal sandstone member has resulted in poor microfossil preservation, and no samples from the type area have yielded material suitable for age assignments.

A few plant leaves were recovered from coaly shale in the basal sandstone member on Eagle Creek near its junction with Mackenzie Delta. These were identified by C. J. Smiley of Univ. of Idaho as *Metasequoia cuneata*, which he reports is a late Cretaceous to early Tertiary species in North America. Another collection from a different fault-block on Eagle Creek (GSC loc. C-11283) yielded *Equisetites* sp., also found in the Aklak Member.

Strata in the I.O.E. Ellice O-14 borehole, believed to be correlative with the basal sandstone member have been somewhat more productive in pollen and spores. Samples of cores at depths of 8,873', 9,485', and 9,520' contained dark brown plant debris from which Brideaux was unable to determine an age. However, samples from core #9 in the depth-interval 7,870-7,920 feet (GSC locations C-12667, C-12669, C-12675) yielded the following assemblage of palynomorphs:

Triporopollenites sp. AA = *T.* sp. cf. *T. rugatus* Newman

Taxodiaceaepollenites sp.

Betulaceoipollenites sp. AA = *B.* sp. cf. *B. infrequens* (Stanley) Norton & Hall

Diconodinium sp.

Cleistosphaeridium sp.

Podocarpidites sp.

Aquilapollenites sp.

Brideaux assigned a late Cretaceous, Maastrichtian age, to this assemblage. Higher strata contained material of inconclusive character, but which suggested a pre-Paleocene age.

On the basis of the above identifications the basal sandstone member is latest Cretaceous (Maastrichtian) in age.

~~Paleontology~~ - Ministicoog Member: -

Many samples from lower Big Fish ~~Creek~~ River and Aklak Creek were prepared for palynological analysis but were reported by Brideaux to be either barren or "full of" recycled and non-diagnostic pollen and spores. A single sample from lower Eagle Creek (G.S.C. loc. C-11272) contained the following forms:

~~reworked~~ derived Lower Cretaceous trilete spores.

Sphagnumsporites (Sterisporites) australis parva (Cookson) Potonié

Inaperturopollenites hiatus (Potonié) Thomson & Pflug

Stereisporites psilatus (Ross) Pflug

S. antiquasporites (Wilson & Webster) Dettmann

Triporopollenites sp. cf. T. costatus Norton

Betulaceoipollenites sp. cf. B. infrequens (Stanley) Norton Hall

Brideaux assigned this assemblage to the Upper Cretaceous, probably Maastrichtian age, based on the occurrence of T. cf. T. costata and B. cf. B. infrequens ~~on the basis of the last fossil in the list~~.

At the top of the member on Aklak Creek (G.S.C. loc. C-11298) shale samples yielded recycled Lower Paleozoic spores, recycled Lower Cretaceous pollen and spores, and Triporopollenites sp. cf. T. costatus Norton. This was dated as Upper Cretaceous, probably post-Senonian in age by Brideaux.

In the I.O.E. Ellice O-14 borehole, core #7 is believed to be from the Ministicoog Member, and samples analysed for palynology by Brideaux yielded the following forms (G.S.C. loc. C12662, depths 6280-6284 feet):

derived Cretaceous and ~~Late~~ Upper Permian-~~early~~ Lower Triassic species

Aquilapollenites spp.

Sequoiapollenites spp.

Stereisporites sp.

Taxodiaceaepollenites sp.

rare trilete spores

This assemblage was dated by Brideaux as Maastrichtian or possibly Campanian in age. Slightly lower in the core (6304-6308 feet) another sample (G.S.C. loc. C-12664) yielded:

derived Lower Cretaceous and older spores

Spiniferites ramosus (Ehrenberg) Mantell.
~~*Hystrichosphaera ramosa* (White) Davey and Williams~~

Aquilapollenites spp.

Lycopodiumsporites sp.

Cr undacidites sp.

Taxodiaceaepollenites sp.

This sample cannot be precisely dated, but is considered by Brideaux to be pre-Paleocene in age.

Detailed sampling for micropaleontological analysis was carried out by Chamney on lower Big Fish River. A cursory examination of the material indicates the presence of numerous new foraminiferal assemblages (Chamney, 1972) which will require careful study, but tentatively, he assigned the formation to the upper part of the Upper Cretaceous, ~~and the upper part to the Cretaceous~~ or possibly Tertiary. (written communication, 1972).

In view of the above reconnaissance micropaleontological studies, the Ministicoog Member is likely Maastrichtian in age.

Reindeer Formation

On Yukon Coastal Plain the Aklak Member is generally the uppermost ~~youngest~~ stratigraphic unit, except for Pleistocene deposits, and its top is everywhere eroded. The Aklak Member was referred to previously (Young, 1972) as the "coal-bearing member" of the Moose Channel Formation, and was included in that formation in the original discussion by Mountjoy (1967). This assignment is amended here in the light of subsurface correlations beneath Mackenzie Delta, and is now considered to be a basal member of the Reindeer Formation.

Mountjoy (1967) proposed the Reindeer Formation to describe about 550 feet of poorly consolidated non-marine clastic sediments and lignites exposed in the Caribou Hills east of Mackenzie Delta. These rocks contain indigenous Paleocene pollen and spores (ibid.; W. Brideaux, written commun.) which are distinctly somewhat younger than palynomorph assemblages from the type Aklak Member. However, several borehole sections penetrate over four thousand feet of Reindeer Formation, which ranges in age from Maastrichtian to Eocene or Oligocene (Brideaux, 1973), and indicate the incomplete nature of the surface sections.

The Aklak Member has been observed at three localities west of Mackenzie Delta. These include the type section on Aklak Creek, which flows into the southern end of Coal Mine Lake, Eagle Creek (at Lat. 68°42'00"N, Long. 136°32'00"W), and the axial part of Deep Creek Syncline.

The type section lacks an upper contact, but was selected because of the characteristic diverse lithology, good fossil recovery, and ease of access. The Aklak Member is exposed in the banks of Aklak Creek for about 2 miles above its mouth, and attains a thickness of approximately 1,900 feet. On air photograph A 14361-44, its top is at X=-4.05, Y=+2.70 cm., and base at X=-5.40, Y=+0.98 cm. This section (Section 6) lies within an outcrop zone about two miles wide marginal to the western side of Mackenzie Delta and marked by brilliant red cutbanks of ancient bocannes, or hematitic sintered mudstone.

A few miles to the northwest at Eagle Creek the basal 685 feet of the member ~~section possibly~~ is exposed, and consists of resistant sandstone and conglomerate beds. This section is abruptly overlain by a recessive and covered interval, suggesting a vertical stratigraphic change to mudstones. Similarly, further west at Deep Creek Syncline ~~the sandstone unit interpreted as~~ the Aklak equivalent is about 600 feet thick, and is overlain abruptly by recessive, non-outcropping rocks.

The basal contact of the Reindeer Formation is distinct in all sections studied, and as discussed ~~below-~~ above, is conformable in the N Yukon Coastal Plain area. This also appears to be true for the Ellice Island area because the contact in the I.O.E. Ellice O-14 borehole-section is slightly gradational and conformable. However, on the eastern side of Mackenzie E Delta the basal contact is unconformable, as exemplified by angular discordance at the contact at 5,010-foot depth in the Reindeer D-27 borehole.

The Aklak Member is characterised by alternating units of conglomerate, sandstone, siltstone, shale and coal, suggesting a fluvial and delta-plain facies. Its areal and upper limits are defined by changes in facies to those dominated by mudstone or by marine characteristics, and probably occur at various levels above the base from place to place. No upper contact of the Aklak Member in the Ellice O-14 section is suggested because of the almost continuous succession of non-marine depositional cycles from the base to the top of the Reindeer Formation at the 1,160-feet depth.

Sandstone predominates in the member, and varies from friable to well consolidated in both outcrop and subsurface.

Sandstones of the Aklak Member appear to be paler and more speckled than those of the Moose Channel Formation, which commonly displays sandstones with tones of yellow, orange, green or red. Feldspar content is about 5% or less, which is about one-half that of the Moose Channel, and chert content about twice as much as the latter (see Ch. 4). The Aklak sandstones are commonly conglomeratic with phenoclasts up to 3 cm maximum diameter, and interbedded with pebble- and cobble-conglomerate.

Red siltstone and shale with leaf impressions are associated with bright red bocannes in the type section. The hematite content of these rocks is probably due to the heating induced during the combustion of the nearby bocannes. The latter are partly brecciated and appear as red to dark brown cinders in outcrop. No smouldering bedrock occurs in this area today.

The Aklak Member is economically important for its coal seams, one of which was mined at Coal Mine Lake for many years to supply fuel for the village of Aklavik. The coal content of the Aklak is much greater than that of the Moose Channel Formation, despite the similarity in lithotopes.

Paleontology and age of the Aklak Member

The Aklak Member contains a relatively rich flora and microflora, but an impoverished fauna, due largely to its dominantyly non-marine, delta-plain depositional setting. Leaf fossils were collected on Aklak Creek during Operation Porcupine and identified by W. A. Bell of the Geological Survey of Canada (Mountjoy, 1967). Bell reported the following taxa in the collections (GSC loc. 6613 to 6615):

Trochodendroides (Cercidiphyllum?) arctica (Heer) Berry forma *richardsoni*

Equisetum sp.

Taxodium gracile Heer

Commenting on the age indications of this collection, Bell stated that "*T. arctica* is . . . common in the Paleocene"

Two plant fossil collections were recently made from the same locality and were examined by C. J. Smiley of University of Idaho. In the first collection he reported (GSC loc. C-11280) "mostly 'coalified' stems and plant debris, with a few fragmentary and poorly preserved specimens resembling the following taxa:

?Cyperacites sp.

?Potamogeton sp.

?Nelumbites sp.

?Paratazodium or *?Metasequoia* (isolated needles only..)

?Equisetites sp.

Smiley comments that this collection affords a "good correlation with floral records from non-marine units that interbed with the top of the marine Schrader Bluff Fm. (the Sentinel Hill Member) along the Chandler and Colville Rivers. [The collection] correlates with lower part of Kogosukruk Tongue of the Prince Creek Formation, between two marine units that contain Inoceramus patootensis and I. steenstrupi. [It is] apparently near the boundary between my Zones V1 and V11, from available floral records". Smiley's Zones V1 and V11 lie within the Santonian to Maastrichtian Stages of the Upper Cretaceous (Smiley, 1969, fig. 3) and the boundary between the zone is approximately the Campanian-Maastrichtian boundary.

Palynological studies on the Aklak ~~Fm.~~ Member were first made by D.C. McGregor who examined spores and pollen in coal samples supplied by B.A. Latour from Moose River Mines on Coal ~~Mine~~ Mine Lake (Mountjoy, 1967). He reported that the assemblage had a pre-Tertiary aspect, and "an age within the upper half of the Upper Cretaceous is considered most likely".

Recently a more complete reconnaissance examination of the palynology of the Aklak Member was undertaken by W.W. Brideaux. An assemblage from a coaly sample collected about 100 feet above the base of the type section on Aklak Creek consists of (G.S.C. loc. C-11299):

Stereisporites antiquasporites (Wilson & Webster) Dettmann

Sphagnum (Stereisporites) regium Drozhastichich in Samoilovitch *et al.*

Inaperturopollenites hiatus (Potonié) Thomson & Pflug

Laricoidites magnus (Potonié) Potonié, Thomson & Thiergart

Sequoiapollenites paleocenicus Stanley

Sequoiapollenites sp. A.

Sequoiapollenites sp. B.

Triatriopollenites sp. cf. T. costatus Norton

Betulaceoipollenites sp. cf. B. infrequens (Stanley) Norton & Hall = B. sp AA

Triporopollenites sp. cf. T. rugatus Newman = T. sp. AA

~~age: Maastrichtian to (?) Early Paleocene~~

Brideaux refers this assemblage to the Maastrichtian or possibly the lower Paleocene and comments that it "resembles most those described from uppermost Cretaceous or lowest Paleocene deposits of the western interior United States and adjacent Western Canadian plains and foothills."

An almost identical pollen assemblage was discovered by Brideaux in the I.O.E. Ellice C-14 borehole at a depth of 4,850 ft. (G.S.C. loc. C-12661). In this suite he includes the following:

Sequoiapollenites sp. A.

Sequoiapollenites sp. B.

Sphagnum (Stereisporites) regnium Drozh. in Samoilovich, et al.

Laevigatosporites ovatus Wilson & Webster

Triporopollenites sp. AA. = T. cf. T. rugatus Newman

Betulaceoipollenites sp. AA. = B. cf. B. infrequens (Stanley) Norton & Hall

Taxodiaceaepollenites sp.

various bisaccate pollen

derived Lower Cretaceous species

This assemblage allows direct correlation between a subsurface section and a key surface section. (Fig. 8).

Stratigraphically higher in the type section Brideaux found pollen and spore assemblages very similar to the one near the base of the member. The youngest beds sampled at the type section, approximately 1,500 feet above the base yielded the following forms (G.S.C. loc. C-19561):

Triporopollenites sp. AA.

Betulaceoipollenites sp. AA.

Cranwellia striata Srivastava

Lycopodiumsporites sp.

Triporites spp.

Alnipollenites? sp.

recycled Carboniferous and Lower Cretaceous species

This was dated by Brideaux as Maastrichtian or possibly early Paleocene stage.

Interestingly, a coaly sample collected by D. K. Norris (1972a, p. 97) from a structurally discordant outcrop in the Deep Creek Syncline (Lat. 68°53'N, Long. 138°02'W) yielded a pollen assemblage identified by Brideaux as follows (GSC loc. C-11263):

Deltoidospora spp.

Osmundacidites spp.

Cycadopites spp.

unidentified bisaccate pollen (Abietineaceous types)

Inaperturopollenites hiatus (Pontonié) Thomson & Pflug

Betulaceoipollenites sp. cf. *B. infrequens* (Stanley) Norton and Hall = *B.* sp. AA

Tricolpites sp.

Triporopollenites sp.AA = *T.* sp. cf. *T. nugatus* Newman

This assemblage is indistinguishable in age from those of the type Aklak Member, according to Brideaux (pers. com., 1973). Palynological research by Brideaux on both the type Aklak and type Reindeer Formation of Caribou Hills shows that the type Reindeer is definitely younger. He comments that "the pollen species from the Caribou Hills (Reindeer Formation) location represent a more modern parent flora than do those from sections on Aklak Creek. Although sections at Aklak Creek may be in part of Paleocene age, they are likely very early Paleocene and are definitely older than the Paleocene material from the Reindeer Formation at Caribou Hills. The occurrence in some samples from Aklak Creek of *Aquilapollenites* spp. and *Cranwellia striata*, generally taken to indicate Maastrichtian or at most very early Paleocene age, support this view".

In summary, the fossil flora support a latest Cretaceous age for the Aklak Member in outcrop occurrences on Yukon Coastal Plain. A lower limit is suggested by leaves and stems which are similar to those found in the Lower Kogosukruk Tongue of Alaska's north slope. This unit intertongues with marine shale

containing *Inoceramus patootensis* and *I. steerstrupi*, dated as Santonian to lowest Maastrichtian.

On the other hand, a younger age is suggested by Bell who examined similar flora and found it containing elements of both Upper Cretaceous and early Tertiary floras. The palynology of the formation indicates a Maastrichtian to very early Paleocene age, and the possibility exists that the Cretaceous-Tertiary boundary lies within the unit at the type section.

Insofar as the Aklak Member comprises the entire Reindeer Formation in the I.O.E. Ellice O-14 borehole (depth-interval 1,160-5,610 feet), the age of the Aklak ranges up into the Eocene and possibly the Oligocene according to Brideaux (1973, GSC locs. C-12656 to C-12660).

SEDIMENTOLOGY OF THE FISH RIVER GROUP

TENT ISLAND FORMATION

The Tent Island Formation is dominated by mudstone and siltstone. In its basal part pebbly mudstone and interbedded sandstone and mudstone are also common. The basal Cuesta Creek Member consists of minor amounts of all the above, as well as sandstone and a mixed conglomerate-and-sandstone facies. These facies are apparently closely related in a paleogeographic sense because any two may occur in vertical contiguity. This characteristic is well demonstrated by the facies-succession at the type section on Big Fish River (Figure 6).

Description of Lithofacies

Conglomerate-sandstone facies: This facies was observed in the Cuesta Creek Member on Big Fish River, Hornet Creek, and near the head of Deep Creek. Conglomerate and sandstone beds commonly form the basal few feet of the formation where the Cuesta Creek Member is dominantly sandstone.

In the type section on Big Fish River conglomerate and sandstone comprise 30 feet near the middle of the Cuesta Creek Member, and the entire 67 feet of its uppermost unit. Across the river a distance of 2,000 feet, conglomerate and sandstone comprise 63 feet of the lower unit, partly in the form of a channel-fill sequence.

Where the scour is deepest the infilled clastics form a fining-upwards sequence of sediments. The basal 13 feet is a single bed of coarse pebble conglomerate which has a coarse-grained sand matrix. The upper two feet of this lens grades laterally into conglomeratic sandstone with flat mud-clasts up to 300 mm wide. On top of this beds is an 11-foot thick sandstone which is medium-grained and contains abundant mud-clasts. Even, parallel laminations are present in its top 4 feet. Above this is 3 feet of weak, shale-parted sandstone with ripple-laminations. Such a sequence of sediments and associated structures is typical of fluvial deposition (Allen, 1965), in which a gradual upward decrease in flow regime is exhibited.

Overlying this sequence the coarse sediments are more typical of the fadies elsewhere. In this respect the typical facies consists of lenticular, interleaved beds of conglomerate, pebbly sandstone, sandstone, and rarely shale. Rapid lateral gradations from conglomerate to sandstone are common, and in places sandstone beds split up into several extensive thin beds, each divided by a lens of conglomerate or shale (Figure 12). Phenoclasts exhibit a wide range in sizes at a given locality and commonly have maximum diameters between 1 and 3 feet. Mudstone clasts of local derivation are common. Imbrication of phenoclasts is sometimes discernible, but more generally longest diameters are roughly aligned parallel to bedding.

Coarse, poorly sorted clastic beds which grade rapidly in texture laterally are characteristic of braided stream depostion (Smith, 1970). Because of the limited areal extent of this facies within the formation the streams must have been relatively small, but were occasionally imbued with high discharges in order to have transported boulder-size clasts.

<u>Sandstone facies</u>: - Uniform sandstone members dominate the formation in the Rapid Creek-Hornet Creek area in contrast to the conglomerates predominating in the type area. Beds of sandstone range in thickness from a few inches to about 3 feet, and are commonly pebbly in the basal 1-2 inches. These beds are generally uniform in appearance or faintly parallel-banded, with rare shallow, tabular cross-stratification and current lineations. Coaly and carbonaceous plant debris is rare in this facies. Grain-size modes range from about fine-grained (0.25 mm diameter) to granular (4.0 mm), and the sands are generally well sorted, tightly packed and lack detrital matrix.

These textural and structural properties probably resulted from deposition in the littoral zone where wave activity and longshore currents reworked the sands. The lack of trace fossils or bioturbation usually associated with shoreface sands is puzzling, but not inconsistent with the generally abiotic nature of the underlying and overlying marine mudstones (see Chamney, 1972). Foreset orientations of cross-bedding sets at Cuesta Creek show a bimodal distribution, typical of littoral sand deposits (Klein, 1967). This interpretation is also supported by the gradual shale-out northward along the cuesta formed by the sandstones. Thus the sandstone facies grades laterally and vertically into sandstone-shale facies of the basin's shallow marginal zone.

<u>Sandstone-mudstone facies</u>: - This facies forms the basal ~~member~~ unit of the formation in the type area, but is not present to the northwest where sandstone and conglomerate lie directly on the ~~Yellow-weathering shale division~~ Boundary Creek Formation. Only on lower Rapid Creek where the entire ~~formation~~ Cuesta Creek Member shales out does this facies reappear. It also forms the basal unit of the overlying unnamed member of the Tent Island Formation along with pebbly mudstones,

These beds appear to be inclined at a small angle with respect to the upper conglomerate beds of the Cuesta Creek Formation (Figure 11).

Mudstone is the dominant rock-type of the facies and is typically brownish grey, silty and brittle. Siltstone and sandstone comprise thin beds which range up to one foot in thickness. These beds exhibit sharp basal contacts along which current-formed structures such as current lineations, flute-casts and groove-casts are present. The beds are commonly parallel-laminated with abundant carbonaceous debris on preferred planes of splitting, and grade upwards into finer textured ~~rock~~ sediments. Ripple-laminations and climbing ripples were occasionally observed.

A single lenticular channel, filled with conglomerate and sandstone, was observed within the ~~lithosome~~ facies on the southeastern bank of Big Fish River opposite the type section. This channel is 12 feet thick at its axis, at least 100 feet wide, and filled by conglomerate which grades laterally and upwards into sandstone. At the same locality the top of this ~~lithosome~~ unit is scoured to a depth of 32 feet by a major channel which is also filled by conglomerate and sandstone.

The intermittent sandstone beds possess current-structures formed by traction-load carpets and turbidity currents. Because the basal unit is scoured and overlain by coarse detritus it is reasonable to conclude that sedimentation occurred on the foreslope of a prograding delta, whose topset deposits are the conglomerate and sandstone beds. Elsewhere, this facies is relatively thin and interfingers with the sandstone facies. In these cases it may represent sublittoral deposition in a non-deltaic situation.

Pebbly mudstone facies: In the type area pebbly mudstones, and paraconglomerates ("tilloid" of Young, 1971) are common just above the Cuesta Creek Member (Figure 7). On Little Fish (Cache) Creek this lithology grades upwards into, or alternates with, sandy mudstone and shale. Small scours are sometimes present on the sharp bases of paraconglomerate beds. Burrow-structures are common in the sandy mudstone beds. These features indicate sedimentation from muddy slurries charged with pebbles and sand which flowed downslope partly as gravity flows, and partly as turbidity currents. The large scours referred to below also indicate that slumping occurred on unstable depositional slopes, giving rise to various gravity-induced deposits.

Scour Structures:—

Near the base of the formation in association with turbidite sandstone beds are pebbly mudstone beds, slump structures, and large-scale scours. A scour on Little Fish ~~(Cache)~~ Creek is steep-sided, at least 50 feet deep, truncates sandstone beds dispersed in a mudstone unit, and is filled with uniform dark grey mudstone. On Hornet Creek, a two-stage scour ~~and~~ is preserved (Figure 13 ~~Ph-71-7-35~~). The lower one is truncated and overstepped by the upper one; both are filled by alternating sandstone and shale beds. In both localities some sandstone beds truncated by the scours are ~~commonly~~ convoluted, suggesting contemporaneous soft-sediment flowage when hydrostatic pressure was locally lowered by the sudden truncation of the beds.

Mudstone-siltstone facies:—

The dominant lithofacies of the Tenxt Island Formation consists of ~~is~~ mudstone with scattered thin siltstone beds present in varying proportions up to 25% (Figure ~~Ph~~ 14). These beds have much the same characteristics throughout the formation. The siltstone is commonly very fine-grained sandy and calcareous, and weathers to a dull orange-brown colour. Carbonaceous and micaceous flakes are typically concentrated in horizontal laminae. Parallel laminations, small-scale cross-laminations, and low-amplitude ripple-marks are characteristic of these beds, which vary in thickness from 1 to 10 inches. In places beds are markedly lenticular, but generally reasonably persistent laterally.

These structures were evidently produced by a low-energy traction carpet, probably developed at the distal ends of turbidity currents (Walker, 1967). Storm-induced suspensions (Reineck and Singh, 1972) may have caused some of the beds, but the cross-laminations and ripples in the upper parts of beds attest to the presence of bottom-currents at the time of deposition.

A peculiar variant ~~microfacies~~ of this lithofacies ~~formation~~ occurs in the ~~its~~ upper part of the formation in association with uniform soft mudstone. It consists of alternating bands or very thin beds and lentils of poorly consolidated sand, brittle brown silty mudstone, and soft grey clay mainly ~~[illegible]~~). Such units have a variegated appearance, weathering to yellow, orange, ~~cream~~ light grey, brown, and olive-green. Laminae rich in black, coaly or carbonaceous particles are abundant and occasional coal laminations are present. Thin, lenticular beds of pebbly

mudstone, conglomerate and argillaceous sandstone are present in minor amounts. Rarely, sulphur- and sulphate-cemented conglomerate or sandstone is observed. Cross-laminations and burrows are rare. The frequent, small-scale alternation of sediment-types reflects highly variable conditions of clastic supply. This may be due to one or more rivers supplying sediment to the basin under conditions of widely varying discharge. A stormy coastline could also ~~supply~~ result in intermittent coarse suspension deposits, but the plant debris strongly supports a nearby fluvial source for the sediment. Bottom currents were evidently almost absent except for sporadic gravity-flows which introduced coarse material in the forms of pebbly mudstones and lenticular sandstones ~~beds~~.

General Interpretation

The widespread areal extent and the generally pelitic character of the Tent Island Formation, as well as its indigenous foraminiferal and dinoflagellate microfauna, indicate a shallow marine environment with relatively open circulation. Common carbonaceous and arenaceous matter in the sediments suggest deposition occurred relatively close to shore. However, a formation of this extent and thickness could not have been deposited close to shore all at the same time. Hence a strong possibility exists that the formation was built up by a stacking of laterally prograding pelitic wedges. Support for this hypothesis is offered by the existence of conglomeratic and sandy beds in the midst of the mudstones, as on Little Fish (Cache) Creek, and by the presence of pebbly mudstones with large scour-structures at various levels within the formation.

Initially, sedimentation was partly non-marine, in which Cuesta Creek Member conglomerate and sandstone were deposited in valleys and low areas on the erosional surface. Small deltaic wedges of sediment, represented by the sandstone and mudstone facies and associated littoral and fluvial coarse clastics, were locally deposited at the mouths of relatively small rivers. Continued deepening of the marine waters occurred such that the present coastal plain area was inundated. Subsidence of this area more or less kept pace with sedimentation, because a thick blanket of marine muds ~~were~~ was laid down apparently without a break in ~~the~~ sedimentation.

Moose Channel Formation

This discussion is based upon well exposed surface sections and traverses in the mapped area near Big Fish River, and one subsurface section (I.O.E. Ellice O-14). Only the major sedimentary environments are described here, with one or two good examples of each used for illustration. The main bases used here for interpreting lithofacies are sedimentary structures, visible textures, and vertical sedimentary sequences; no grain size analyses were attempted.

The major lithotopes recognized in the Moose Channel include alluvial, progradational deltaic, littoral, and marine basinal environments. The latter are confined mainly to the Ministicoog Member, but shallow marine sediments may also be present in the basal member in the Ellice O-14 well. Similar depositional environments are interpreted in the Aklak Member of the Reindeer Formation, which also contains aggradational alluvial deposits.

Basal Sandstone Member

Alluvial Lithotope: The alluvial sedimentary environment can be subdivided into two distinct facies, the diversified alluvial ~~vertical accretion~~ and coarse sandstone ~~lateral accretion~~ facies respectively. The former denotes a facies whose diverse lithology reflects gradual upward accumulating sediment (vertical accretion) under a variety of conditions; the latter is a dominantly sandstone facies which accumulated by the lateral migration ~~sweeping~~ of fluvial point-bars and braided channels (lateral accretion).

(i) Diversified ~~Vertical Accretion~~ Alluvial Facies: The main characteristics of this facies are its diverse lithology and lack of uniformity in both the vertical and lateral senses. Rock types include cobble conglomerate, coarse- and fine-grained sandstone, siltstone, mudstone, and carbonaceous shale. ~~and sulphurous mud~~. Several types of sedimentary units recur in a measured section through this facies, and are described below.

The first type is a highly diverse sediment succession, in which each succeeding bed is lithologically different. For example in the interval 760 to 790 feet of the Eagle

Creek section (Section ~~Fig~~ 7) the following sequence was observed: black, carbonaceous shale with leaf impressions and an overlying unit of interbedded sandstone and mudstone are locally eroded and overlain by very poorly sorted, mélange-like, cobble conglomerate. This in turn is overlain by grey shale with thin fine-grained sandstone beds and thicker, very fine-grained, cross-stratified sandstone beds. Such vicissitudes in lithology reflect ever-changing physical and chemical conditions, such as those expected near a river with a wide range of discharge rates. During maximum flow periods channel-avulsion ~~crevassing~~ occurs and temporary channels are formed on the floodplain, leaving sand and gravel deposits; subsequent periods of ~~later~~ low discharge ~~periods~~ result in the accumulation of mud and organic debris.

A second type is rich in mudstone, with very thin laminations of sand, silt and coaly fragments. Thin, graded beds of fine sandstone with ripples and parallel laminations occur. The mud is sulphurous in places. This type of sedimentary unit is interpreted as resulting from a floodplain lake, in which periodic influxes of coarser clastics appeared from overflowing nearby fluvial or distributary channels.

The final important type of sequence consists mainly of sandstone ~~and is~~ commonly 10 to 25 feet thick. The upwards succession above is: (i) a basal scoured contact ~~are~~ pebbly coarse-grained sandstone; (ii) medium- to coarse-grained sandstone containing mud-clasts; (iii) fine- to medium-grained, parallel-laminated sandstone with lenses of limonitic shale-clasts; and (iv) unconsolidated, limonitc sand. The sequence is overlain by mudstone with minor thin sandstone beds.

Such a generally fining-upwards sequence, in association with other fluvial and floodplain deposits, has been ascribed to the lateral migration of a meandering stream (Fig. 28, 3A) (Bernard and Major, 1963; Allen, 1965). The lowest, coarse clastics were deposited in the stream channel or thalweg, the sandstones were built up on the sides of a laterally accreting point-bar, and the uppermost fine beds represent levee (with iron-enriched soil zones) and floodplain muds.

(ii) Coarse sandstone facies:- A large portion of the Moose Channel Formation on Big Fish River consists of thick units of coarse-grained sandstone with minor amounts of pebble conglomerate and argillaceous sandstone. Good examples of this facies are the intervals 450-605 feet, 750-1120 feet, and 1675-1825 feet above the base of the formation in Section 4.

The sandstone is generally coarse-grained and moderately sorted, but fine- to very coarse-grained bands and beds also occur. Structures common in these sandstones include tabular cross-stratification in laterally extensive sets from 0.5 to 5.0 feet thick, scour-and-fill structure exhibiting local erosion up to 10 feet deep, associated festoon cross-stratification, and carbonized wood fragments ranging in size from arenaceous particles to parts of logs several feet in diameter. This type of sandstone tends to split on weathered cliffs into thin, irregular slabs; massive sandstone beds are rare.

The characteristic pebble beds are tightly packed, usually about 1 foot thick, and have sharp, eroded, basal contacts and ~~x~~ distinct upper contacts. In part, these beds form the bases of thin, fining-upwards rhythms. Pebbles are well rounded in both the conglomeratic beds and sandstone beds where as phenoclasts they range up to boulder size.

Near the top of the formation on Big Fish River a repetitive series of thin, fining-upwards rhythms ~~(Photo)~~ occurs within the facies (Fig. 15). A typical rhythm from the base upwards consists of: (i) conglomerate or pebbly, coarse-grained sandstone with shallow cross-stratification, in sharp contact with underlying sediments, which grades up into (ii) fine- to medium-grained sandstone, overlain by (iii) shaly siltstone with ripple-marks and interbedded friable sandstone with plane laminations and minor pebbles. The rhythms vary in thickness from 1.5 to 5.0 feet.

Similar thin sedimentation rhythms occur in the Shawangunk Conglomerate of the Appalachian Mountains and have been interpreted by Smith (1970) as being deposited from braided streams. The irregular bedding, cut-and-fill structures, and rapidly varying grain-sizes ~~fe~~ reflect highly fluctuating flow conditions associated with unconfined, braided channels.

The more generally sandy parts of this facies are also interpreted as being deposited in non-cohesive fluvial channels, probably mainly of the braided type, in which longitudinal and transverse sand-bars comprise the dominant bed-form (Ore, 1965). These bars accrete mainly by lateral deposition on foreset slopes, resulting in planar cross-stratification similar to that commonly observed in the Moose Channel Formation. The frequent abandonment, migration, and re-occupation of fluvial channels in sandy alluvial plains result in the formation of scour-and-fill structures and lag~~x~~ gravels in channels. Very minor overbank muds are preserved due in part to the constant lateral migration of channels. The presence of festoon cross-bedding supports unidirectional flow (McKee, 1966; Visher, 1972) such as that ~~found~~ associated with fluvial channels.

Deltaic Lithotope:

Subenvironments within this lithotope include the prodelta, delta fringe, distributary and interdistributary depositional sites. For a typical prograding delta lobe, these sites occur as listed in ~~a~~ upward stratigraphic sequence. This lithotope is best developed in surface sections at the base of the Moose Channel Formation where the Tent Island Formation grades upwards by virtue of a progradational deltaic phase, and by the depth-intervals 7,750-8,075 and 8,925-9,375 feet in the I.O.E. Ellice O-14 borehole.

These intervals are characterized by a vertical profile in which prodeltaic muds become increasingly interbedded with silt and sand beds as the delta advances basinward. At the tops of the intervals the interbedded sediments grade into or ~~bee~~ are sharply overlain by sandstone beds, which represent distributary mouth and delta-front deposits. Further upward, these sandstones may grade into alluvial or delta-plain sediments. This vertical profile is expressed

on electric logs of boreholes by a gradually upwards increasing S.P. response, commonly accompanied by gradually increasing resistivity (Pirson, 1970, p.36 ff; Fisher, 1969, Fig. 7), a phenomenon well illustrated in the Ellice O-14 well at the intervals noted above.

Good riverbank exposures of this lithotope are present in the canyon of Little Fish (Cache) Creek and Big Fish River. The three stratigraphic sections examined in this area are correlated and shown diagrammatically in Fig. 16. At the southeast end of the exposures a complex of distributary channels and bar-finger sands overlie the prodeltaic muds, but to the northwest the sandstone is more homogeneous and better sorted, suggesting a delta-fringe facies. The contact of the upper sandstone is sharp in the middle section (~~in 70-7-12~~ Fig. 9), but becomes interfingering a short distance to the southeast. The sandstone in the middle section shows plane-laminations, shallow cross-stratification, grain-size banding, large spherical flow-rolls, and conglomerate beds up to 1 foot thick. This is interpreted as the axial part of a distributary channel where fluctuating bottom-currents

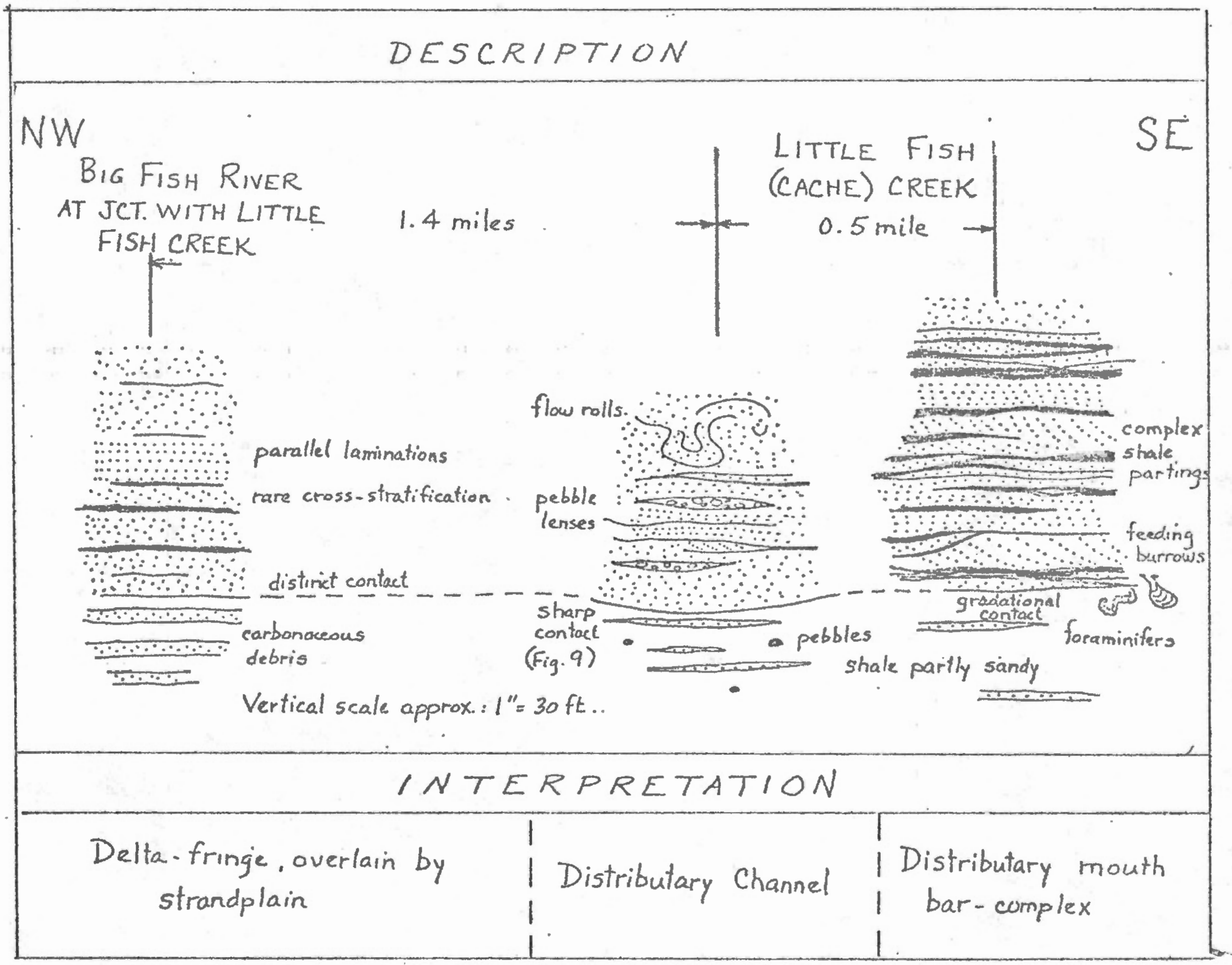


Figure 16. Comparison and interpretation of three closely spaced sections across Tent Island – Moose Channel contact, Big Fish River canyon.

existed. A short distance upstream on Little Fish (Cache) Creek the contact becomes a complex array of irregular and lenticular interbedded shale and sandstone. The sandstone lenses exhibit large-scale tabular foresets, and contain foraging burrows of the <u>Teichichnus</u> and <u>Rhizocorallium</u> types. The shale contains sparse foraminifers (T.P. Chamney, pers. commun.). The biogenic features indicate a shallow marine environment (Howard, 1972) adjacent to the distributary mouth where sand-bars were intermittently established. At the north-western section the prodeltaic, very thin-bedded carbonaceous muds grade upwards into delta-front sand and shale containing abundant macerated carbonaceous debris. These beds grade upwards into dominantly thick-bedded sandstone that shows plane-laminations, shallow cross-stratification, and rare pebbly lenses, ~~but~~ and is generally homogeneous, medium-grained. This facies is interpreted as a marginal strand-plain and delta-fringe, influenced mainly by wave-generated longshore currents.

Progradational cycles in the Ellice O-14 borehole consist of basal silty mudstone with carbonaceous and very fine sand laminae, which grade upwards into interbedded mudstone, siltstone, and medium-grained sandstone. Core #9 of the well penetrates this stage, and reveals convolutions (Fig. 17), graded beds, burrows, and bioturbated layers (Fig. 18) typical of delta-front environment (Coleman and Gagliano, 1965). This gradational sequence is followed by well sorted, medium-grained sandstone, probably of littoral origin. Capping each of the two cycles are thin beds of coal and silty mudstone which indicate lagoonal or marshy conditions. The submarine parts of these cycles were probably deltaic in origin, but were capped by barrier islands and strand-plains where coarse clastics issuing from the distributary were reworked.

Littoral Litho~~ne~~tope : –

This lithotope is present in ~~xxxix~~ small portions of all sections studied ~~(e.g. Fig. , left side)~~, and is best represented by ~~constitutes~~ a 500-foot thick ~~member~~ unit at the top of the basal member ~~Moose Channel Formation~~ on lower Eagle Creek (Section 7). Its distinguishing features are (i) dominance of uniform, well sorted, fine- to medium-grained sandstone, and (ii) presence of foraging and feeding burrows. The latter are not common, but present throughout the member, and include a multiple type of *Rhizocorallium* (?*Gyrophyllites*), and a type of *Asterosoma*.

Sedimentation structures include low-angle and high-angle tabular cross-stratification, in places with shallow basal scours, current lineations, plane-laminations with associated small shale-clasts, oscillation ripples, and thin pebble lenses and layers. Large coalified wood fragments and oxidized clayey-limonitic layers are also present. Cross-stratification dips indicate a dominant paleocurrent flow towards the east-southeast, but are widely dispersed, and show a ~~wak~~ weak bimodality.

Coarse alluvial sandstones form tongues within this ~~member~~ unit, and it is underlain by diverse deltaic plain deposits and overlain ~~by~~ gradationally by coastal basin muds of the ~~Ellice Island Formation~~ Ministicoog Member. These stratigraphic relationships and the associated structures and textures suggest deposition in a beach environment. Because there is no upward gradation from marine shale, these deposits were probably not of the barrier island type (Davies, Ethridge and Berg, 1971). Rather, the setting is suggestive of a beach-ridge strand-plain system, such as those described from the Rhone Delta (Oomkens, 1970) and the Senegal Delta (Wright and Coleman, 1972).

The amount, and in places the thickness, of littoral ~~x~~ sands in the ~~Moose Channel Formation~~ basal member indicate that wave-power was nearly ~~an~~ as important influence on sedimentation as riverine currents. Hence, the morphology and distribution of sand-bodies of the delta system of the eastern ~~Moose Channel Formation~~ basal sandstone member ~~was~~ were probably similar to those of the modern Niger or Nile Deltas (op. cit.), but on a smaller scale.

Ministicoog Member

The Ministicoog is characteristically a mudstone unit with minor amounts of siltstone and sandstone, but in one section on Eagle Creek, the amount of sandstone interbeds increases to about one-half the volume of rock. This interbedded sandstone and shale facies, as well as an associated sandstone facies, are described and interpreted below, and integrated with the interpretation and distribution of the mudstone facies in the chapter on Provenance and Paleogeography.

Mudstone facies: - At its type section on Big Fish River the Ministicoog Member is dominantly brown-grey mudstone and shale, with varying amounts of siltstone (Fig. 10).

The latter is thin- to medium-bedded, generally parallel laminated or cross-laminated, and commonly occurs concentrated in thin units as interbeds with mudstone. The mudstone is generally soft and chunky fracturing on weathered banks, and is less commonly shaly fracturing or very thin-bedded. In parts of the member it contains abundant macerated carbonaceous debris. Three tongues of sandstone, all less than 100 feet thick, appear in the member of Big Fish River. These sandstones are fine- to coarse-grained chert litharenites, partly pebbly, and greatly resemble those of the basal sandstone member.

The Ministicoog retains the characteristics described above in cutbank exposures examined northwest of Big Fish River as far as the area of Coal Mine Lake. In the stream-cut section immediately southeast of Big Fish River, the siltstone interbeds tend towards very fine-grained, slightly calcareous sandstone, with shallow-dipping cross-stratification.

Westward about 35 miles at Deep Creek Syncline the recessive interval suspected to represent the Ministicoog Member is largely covered everywhere and presents very few opportunities for examination. Only a few resistant units of sandstone and conglomerate outcrop and appear to be markedly lenticular. These units display graded beds, large-scale tabular cross-stratification, and rounded cobbles of quartzite up to 20 cm long. Because these units are apparently enclosed within marine shale, they may represent some type of submarine channel or fan deposit. Most of the interval is probably mudstone, with minor beds of very fine-grained sandstone and conglomerate in its upper one-third.

In the I.O.E. Ellice 0-14 borehole the Ministicoog is dominantly greyish brown mudstone, in part silty, as at the type section. Minor interbeds of siltstone and fine-grained sandstone are present, especially in the central part in the depth-interval 6,000-6,170 feet. Parallel laminations, carbonaceous debris, and tiny burrows were observed in cuttings; the single core exhibits convolutions and bioturbation structures.

The large volume of mud and silt comprising this facies indicates a relatively quiet sedimentary environment, and its widespread distribution and preserved foraminifers strongly suggest a marine shelf. The abundance of macerated carbonaceous debris and the presence of burrows and rootlets suggest relatively shallow and nearshore settings in the case of the coastal plain surface exposures. This is further supported by the apparent rapid lateral facies change to the interbedded sandstone and mudstone facies described next.

Interbedded sandstone and mudstone facies: - The Ministicoog contains considerably more sandstone interbeds on Eagle Creek about four miles above its mouth (Section 8) than at any other studied location. The trend towards a sandstone facies in a southwesterly direction in this area may explain why the basal sandstone member appears so thick in the bluffs immediately east of upper Eagle Creek.

The typical lithologic sequence at Eagle Creek consists of alternating resistant sandstone beds and recessive mudstone-rich intervals in about equal proportions (Fig. 19). ~~The latt~~ The muddy ~~interbeds~~ intervals of this facies are recessive-weathering, yellow- and grey-banded, and contain thin, uneven lenses of semi-consolidated medium- to coarse-grained sand, which have sharp basal contacts and graded upper contacts. Reed-like carbonaceous plant fragments occur on splitting surfaces. Current and oscillation ripples, rootlets, and clay drapes or coatings are common in the upper parts of the sand interbeds. Burrows and load-casts are less commonly exposed on their undersurfaces.

The thick bedded sandstone ~~beds~~ is fine- to coarse-grained, pebbly, ~~faintly laminated~~ and shares many structures in common with the thin sandstone interbeds described above, and, in addition, ~~ms~~ exhibits star-shaped feeding traces (Asterosoma), large coalified wood fragments, large convolutions, alternating fine-and coarse-grained bands, internal shaly intercalations with burrows, and streaky lamination.

The sand-rich units and thick sandstone beds are interpreted as being deposited in the channels and point-bars of meandering tidal creeks (Van Straaten, 1961; Klein, 1967). The muddy intervals represent vertically accumulated sediments from the high tidal flats proper (Häntzschel, 1939) over which low sand-bars and tributary creeks migrated, resulting in lenticular sandstone beds.

Present-day tidal flat sediments, or "tidalites" (Klein, 1971), are currently being carefully studied by sedimentologists (R. Ginsburg, written commun., 1972). Wünderlich (1970) compared the German Devonian "Nellenköpfchen beds" to the modern coastal environment of the German Bay, and illustrated interbedded coarse and fine clastics on various scales ("tidal bedding") that are similar in form to those observed in the Ministicoog ~~Aklak Formation~~. Sedimentary structures associated with the German Devonian tidal sediments include horizontal and vertical burrows, trails, bioturbated layers, slumpings, oscillation and current ripples, clay drapes on ripples, dune cross-stratification, channel-fill beds, flaser and streaky lamination in mudstone, load-casts, flute-casts and others. Most of these structures were also observed in interbedded sandstone-shale facies of the Ministicoog ~~Aklak~~.

Sandstone facies:— Near the base and the top of the above facies are two 80-foot thick sandstone units which are fairly uniform in character and consist mainly of well sorted, fine- to medium-grained, and in part glauconitic sandstone. Because of their close stratigraphic relationship with the tidalites, their well sorted nature, and the presence of glauconite, they are interpreted as bay-mouth bars or barrier island complexes.

REINDEER FORMATION

Aklak Member

The Aklak Member can be subdivided into three main lithofacies, including (a) a sandstone-mudstone-coal facies, (b) a sandstone-conglomerate facies, and (c) a carbonaceous siltstone facies. The first facies is the most common, and comprises the basal half of the type section on Aklak Creek as well as the basal part of the Aklak Member in the Ellice O-14 borehole. The second facies was recognized only at the base of the member on Eagle Creek, where it forms a resistant sandstone unit 685 feet thick. The carbonaceous siltstone facies is characteristic of the upper half of the member on Aklak Creek and in the Ellice O-14 borehole, and may constitute most of the recessive and covered interval above the resistant sandstones on Eagle Creek.

The first two facies were discussed earlier under the heading Basal Sandstone Member, Moose Channel Formation in the section on the Alluvial Lithotope, and only the important differences need be amplified here. One major difference is the more abundant coal and plant remains in the Aklak Member compared with the Moose ~~basal~~ Channel Formation ~~sandstone member~~. This may be partly due to a wetter climate which supported a more luxuriant flora at the time the younger member was deposited. Similar trends have been noted elsewhere in North America in rocks of this age (Rouse and Srivastava, 1972; Leffingwell, 1971). As well, the predominance of the delta-plain facies in the Aklak sections compared with the fluvial and littoral facies observed in the Moose Channel probably partly accounts for seemingly greater quantities of coal in the Aklak Member.

Sandstone-mudstone-coal facies:

Vertical profiles ~~The alluvial-cycles~~ of this facies ~~the Aklak~~ show a typical upward succession of lithologies and structures (Fig. 20). At the base in sharp contact with underlying mudstones is pebbly to cobbly conglomerate, pebbly sandstone, or non-pebbly, fine- to medium-grained sandstone. Tabular cross-stratification and homogeneous beds occur in the basal part of the coarse clastic unit, and are succeeded by cross-lamination, ripple-marks and climbing ripples. In places, another set of tabular cross-stratified beds occurs at the top. This unit ~~is~~ varies greatly in thickness from a few feet to about 50 feet from one cycle to the next. Commonly overlying the coarse clastics are ~~is~~ coal and coaly mudstone, in units up to 20 feet thick. This grades abruptly upwards into coaly shale and finally silty, micaceous mudstone with abundant carbonaceous debris and lenticles. The mudstone units are in part, or entirely, oxidized to red colours with associated ancient bocanne (cinder and clinker beds).

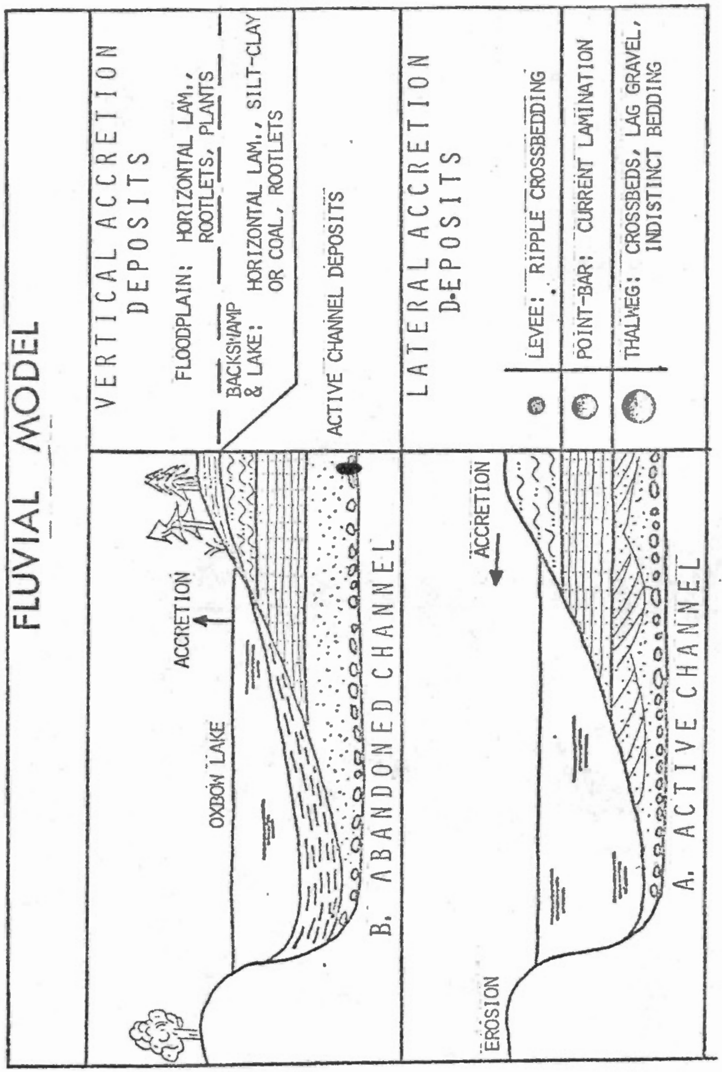


Figure 21. Fluvial Models of Sedimentation (after Visher, 1965). A. Lateral accretion model, B. Vertical accretion model.

The coarse clastic phases of these cycles probably represent fluvial channel and point-bar depsoits (Visher, 1965). Wherever these are abuptly terminated at the top and overlain by coaly dediments the process of channel avulsion may have occurred with the attendant abrupt change from high energy to low energy sedimentation (Fig. 21, B). As the meander loops and swales were filled in with organic muck, they tended to merge with the surrounding backswamp or floodplain, and fine clastics gradually replaced the organic sediments ~~near the tops~~ in the upper parts of the cycles. Alluvial cycles with a high proportion of overbank deposits have been described from a variety of ancient complexes (Allen, 1965), and have been interpreted (Allen and Friend, 1968; Beerbower, 1964) as being formed by meandering, well-channelized streams whose sediment load was dominantly silt and clay.

Sandstone-conglomerate facies: - This is essentially the same facies as the "coarse sandstone facies" of the basal sandstone member, except that the Aklak representative consists mainly of finer grained sandstone and contains thicker conglomerate units than the basal member. Similarities in sedimentary structures include conglomerate-filled scours ~~(Pl. 71-10-9)~~, coarse sand- and pebble-lenses (Fig. 22), and cross-stratification. Therefore, as in the case of the coarse sandstone facies, this facies is interpreted as resulting from deposition by braided streams.

Carbonaceous siltstone facies: — Approximately 600 feet above the base of the section ~~The base of the middle member~~ on Aklak Creek ~~consists~~ is an interval ~~of~~ at least 250 feet thick consisting of relatively uniform, poorly exposed red-weathering siltstone and silty mudstone. In the middle of this unit is a thin sequence consisting of 2 feet of fine-grained sandstone at the base, overlain by 2 feet of unconsolidated seatearth-like mud (~~Fh 72-1-22~~ ~~Fig. 23~~), and capped by 0.5 feet of friable coal. Scoria-like ancient bocanne appears in slope debris throughout the unit. Orange-weathering limestone, silty and micritic, occurs rarely at the top of the unit. Rootlets are common in the siltstone, and faint leaf impressions are rare.

Other similar thick siltstone and mudstone units occur in the top of the Aklak at the type section, and can be reasonably assigned to the same depositional setting. The redness, due to the presence of oxidized ferrous minerals, is probably due to ~~late diagenetic~~ chemical changes associated with spontaneous combustion and weathering, because many samples are internally grey when freshly broken.

Although ~~lacking~~ it lacks any ancient bocannes, as ~~befits~~ would be expected in a deeply buried subsurface section, the depth-interval 3,900 to 4,500 feet in the Ellice O-14 borehole consists of siltstone, bituminous shale, fine-grained argillaceous sandstone, and coal, similar to the surface sections. In both sections this facies overlies the alluvial sandstone-mudstone-coal facies.

This facies, with its evidence of quiet sedimentary conditions and subaerial vegetation, is characteristic of the delta-plain, in which swamps, lakes, crevasse-splays, levees, and coastal embayments form an interwoven complex. This facies and its electric log expression in the Ellice O-14 borehole are strikingly similar to the delta-plain facies described by Fisher (1969) from the Lower Wilcox Group of the Gulf Coast. He attributed thick accumulations of this facies to high constructive deltas, in which riverine forces and their resulting deposits far exceed those of marine influence.

SANDSTONE PETROGRAPHY

Sandstones of the Fish River Group and Reindeer Formation display a general similarity in textures and compositions, and can be classified as immature, chert litharenites (Folk, 1968). In this study emphasis was placed on defining compositional trends, in a stratigraphic sense and an areal sense, in the hope that members could be differentiated on the basis of sandstone compositions. This undertaking met with limited success and is discussed below. Modal analyses were performed on 33 thin sections, with over 500 points counted per section (Griffiths, 1967, p. 191), and results summarized in Table III.

TEXTURES

Textural characteristics common to nearly all sandstones sampled from the Fish River Group and Reindeer Formation include angularity of arenaceous particles, and very tight packing (Figures 23 - 25). The sandstones display a complete range of modal grain-sizes, varying from silt to pebble sizes, as visually estimated. Fine- to coarse-grained sandstone is probably most common; very coarse-grained sandstone and granular conglomerate (1.0 to 4.0 mm grain-diameters) the least common.

Matrix. Interstitial matrix comprises only a minor part of these sandstones, but is less than 5% of the rock in only ¼ of the samples analysed. However, some of the material included as matrix is probably crushed labile particles and ~~in part~~ diagenetic precipitates. Hence the amount of original detrital matrix is probably somewhat less than that measured. The average matrix content of all samples is 10.0%; that of the seven samples from the Ellice 0-14 borehole is 14.9%.

The matrix generally consists of admixtures of clay, sericite and quartz. Bituminous matter comprises the matrix of some alluvial sandstones.

Interstitial pores occur in many sandstones in which secondary cements are lacking, but this porosity may be due in part to leaching of calcite at the outcrop. Patchy calcite cement is present in many samples from all parts of the group and from all areas studied. Quartz overgrowth cement is also commonly present in small amounts, even in samples containing calcite pore-fillings.

Rounding. The low degree of rounding of sand-size particles is a striking feature of these sandstones (Fig. 24). Quartz and chert grains up to 1 mm in greatest diameter are mostly subangular (Powers, 1953), with angular and subrounded grains less abundant. By visual estimates sandstones from the Big Fish River area seem to display greater angularity than those of the Deep Creek area. In all areas and formations particles greater than 2 mm in diameter are subrounded to well rounded. Such particles tend to be dominantly chert in composition, showing that "maturity" in texture and durability is attained much faster in rudaceous populations than in arenaceous ones (Pettijohn, 1957).

Grain-sizes and Sorting. No formal size analyses were performed on thin sections or ~~dies~~ disaggregated rock samples. From measurements of projected grain diameters viewed through a microscope and estimating the ranges of sizes within individual thin sections (Folk, 1968), it is evident that most of the sandstones examined are moderately sorted. Many examples of poorly sorted and well sorted sandstones are also present.

Packing. Sandstones of the Fish River Group are typically highly compacted (Fig. 23) and display fabrics which attest to high post-depositional pressures. The most notable evidence of high compaction is the overly close grain-to-grain relationship in which most sand-grains touch neighbouring grains along straight contacts (Griffiths, 1969) in thin sections (Fig. 25). Embayed or sutured contacts are present in samples from the Ellice 0-14 borehole as well as from surface material. The suturing was probably aided by the process of pressure solution (Thompson, 1959), which in turn provided silica for cement as continuous overgrowths and microcrystalline pore-fillings in areas of lesser pressure. In one pebbly sandstone a sand grain was observed to be impacted three-quarters of its diameter into the side of a chert pebble. The only way this could have occurred without fracturing either particle is via ~~partial or~~ pressure solution.

Bent, twisted and crushed grains of muscovite, phyllite, microschist, limestone and others also bear evidence of high compacting pressures. Many long grain-to-grain contacts were achieved by the physical deformation of relatively soft granular materials.

The high compressional forces which caused these compactional textures may have been either tectonic or geostatic in origin, or possibly both.

~~Composition~~ COMPOSITION

Quartz, chert, metamorphic, ~~and~~ sedimentary, ~~rock fragments,~~ and volcanic rock fragments, and feldspars are the main constituents of the Rish River Group and Reindeer sandstones, in the order of decreasing abundance. Variations in the relative amounts of different consistuents were found to exist among certain outcrop areas, and among the different formations. These variations reflect the localized nature of the source-areas of this detrital material, as would result from the drainage of a heterogeneous upland by relatively short streams.

Types of Particles

Quartz: - Quartz is the most abundant component (average proportion of ~~granular~~ particulate fraction: ~~43%~~ 42%) of the sandstones, and consists mainly of ordinary plutonic and vein quartz. Polycrystalline quartz from metaquartzite and recrystallized chert is also common. Volcanic quartz was not recognized, despite the abundance of volcanic rock fragments.

Chert: - Many varieties of chert were deposited in these sandstones, including the following main types:

(i) colourless, microcrystalline quartz (< 20 microns)

(ii) brown, nearly opaque, (?) phosphatic chert;

(iii) pale brown, chalcedonic, nearly isotropic chert; and

(iv) spherulitic (radiolarian?) chert.

All gradations of chert into slate, or chert into altered tuff are present; hence, chert is here placed with lithic components for classification purposes (Folk, 1968; Chen, 1968) instead of the quartz fraction.

Sedimentary and Metamorphic Rock Fragments: - Large amounts of slate, phyllite, quartz-mica schist are present in the sandstones; the conglomerates commonly contain phenoclasts of very fine-grained siliceous sandstones, in part chertiferous. Locally there are enrichments of crystalline limestone fragments (usually single detrital crystals) and bituminous slate or microschist.

Igneous Rock Fragments: - Fragments of plutonic igneous rocks are very rare; only the occasional granitoid fragment was recognized. However, extrusive igneous rock detritus ~~was~~ is generally common in surface samples, and includes spilitic and andesitic basalts and various kinds of tuff. Volcanic fragments are absent to rare in the Blow River E-47 and Reindeer D-27 boreholes.

Feldspars: - Feldspar grains consist of two main types: potash feldspar and plagioclase. The potash feldspar is mainly orthoclase or sanidine; microcline and perthite are very rare. Plagioclase occurs mainly as angular, fresh, arenaceous grains, and commonly shows polysynthetic twinning. Measurements of extinction angles of paired twins by the Michel-Leyy technique indicate compositions of the range An_{20-30} (andesine). Lesser amounts of untwinned, vacuolized plagioclase are present. The proportion of potash feldspar in these sandstones is relatively constant (average 4%) ~~± standard deviation ———~~), but the amount of plagioclase varies greatly, generally in direct proportion to the abundance of volcanic detritus.

Variations in Sandstone Composition

Compositional analyses by point-counting thin sections of sandstones were run in order to determine compositional characteristics of the various formations and localities. Only fine- and medium-grained sandstones were analysed because coarser varieties tend to be enriched in chert and lithic fragments, and finer ones enriched in quartz. The analysed proportions of each component are given in Table III according to the member from which the samples were derived. Only samples from the base (Cuesta Creek Member) of the Tent Island Formation were analysed, because it is otherwise generally lacking in sandstone.

Differences in proportions of main constituents of sandstones among the formations are subtle, and vary according to locality as well. Although a given formation may display considerable variation in composition from place to place, compositional changes from the base to the top of the group tend to be similar in all localities. Also, certain accessory materials, such as detrital carbonate, appear in limited parts of the section. These trends are useful in identifying stratigraphic units in the subsurface where fossil control is imprecise or unavailable.

Strat. Unit	Field No.	Est'd mean† grn-size	%Vol	Qtz	Cht	Lith	Volc	K-Fp	Plag	Oth	Void	Cem	Det	Qtz/Cht	Fsp/RF	V+P	V+P/Cht
			Particulates (recalculated to 100%)								Matrix			Ratios			
CUESTA CREEK MEMBER	58 YA-3	mg	83	33	57	1	–	tr	–	tr	—	12	6	0.6	0	0	0
	21YAb-15	mg	77	47	23	23	2	1	1	4	2	6	4	2.0	0.03	2	0.09
	176YA-5	cg	65	30	29	13	15	6	4	11	—	8	7	1.4	0.19	18	0.62
	33cYAb-4	mg	79	46	31	15	1	1	2	5	19	–	2	1.5	0.06	3	0.10
	E-47-5	mg	84	31	31	30	–	1	1	4	—	15	5	1.0	0.04	1	0.03
	MEAN VALUES			37	34	16	4	2	2	5				1.3	0.07	5	0.17
	STANDARD DEVIATIONS			7.5	11.8	9.8	5.7	2.1	1.4	3.5				0.55	0.07	6.7	0.26
MOOSE CHANNEL FM. "Basal Sandstone" Member	34YA-6	fg	61	32	21	15	9	7	5	10	11	6	22	2.1	0.30	15	0.71
	35YA-2	mg	79	35	20	2	29	2	9	3	14	1	6	2.0	0.22	38	1.90
	37YA-1	fg	71	56	13	12	7	6	4	3	24	–	5	4.3	0.33	11	0.85
	38YA-3	mg	78	51	15	11	7	6	8	3	7	9	7	3.5	0.41	15	1.0
	40YA-3	fg	85	45	16	16	9	4	6	7	8	–	7	2.9	0.25	15	0.94
	124bYA-1	fg	80	37	16	11	8	3	14	12	–	4	16	2.3	0.48	22	1.37
	122YA-8	mg	84	32	27	8	14	4	11	4	6	1	9	1.2	0.29	25	0.93
	2YA-T	fg	71	60	25	2	–	8	tr	5	18	6	5	2.4	0.28	tr	0
	E-47-1	fg	72	45	23	25	–	3	2	3	–	16	12	2.0	0.10	2	0.09
	0-14-11	fg	82	41	22	20	5	4	2	6	3	–	16	1.9	0.14	7	0.32
	0-14-20	mg	75	46	26	14	2	5	5	2	–	–	24	1.8	0.25	8	0.31
	0-14-21	mg	74	44	22	20	6	3	4	3	1	4	21	2.0	0.15	10	0.46
	0-14-27	fg	78	54	25	8	3	3	2	4	–	5	16	2.2	0.16	5	0.20
	D-27-26	fg	73	42	20	18	tr	4	4	12	–	4	23	2.1	0.18	8	0.40
	D-27-34	mg	68	29	24	23	1	2	5	16	–	1	31	1.2	0.14	6	0.40
	MEAN VALUES			43	21	14	7	4	5	6				2.3	0.25	12	0.70
	STANDARD DEVIATIONS			9.0	4.2	6.7	7.2	1.7	3.6	4.2				0.77	0.10	9.5	0.50

TABLE III a. Compositional Analyses of Fish River Group Sandstones.

Strat. Unit	Sample No.	Est'd mean grn-size	%Vol	Qtz	Cht	Lith	Volc	K-Fp	Plag	Oth	Void	Cem	Det	Qtz/Cht	Fsp/RF	V+P	V+P/Cht
			Particulates (recalculated to 100%)								Matrix			Ratios			
MINISTICOOG MBR. MOOSE CHANNEL FM.	42YA-4	mg	92	47	17	25	5	5	7	4	3	1	4	2.5	0.11	6	0.32
	10YAb-6	fg	87	54	10	15	1	3	4	14	2	tr	11	5.5	0.22	4	0.40
	143YA-6	mg	83	43	25	13	7	2	12	3	8	–	7	1.7	0.32	20	0.80
	140YA-11	mg	84	35	20	10	14	2	17	3	5	7	4	1.7	0.44	31	1.55
	0-14-9	fg	87	42	26	22	–	2	1	7	–	–	13	1.6	0.06	2	0.08
	MEAN VALUES			44	20	17	5	3	7	6				2.6	0.23	13	0.63
	STANDARD DEVIATIONS			6.2	5.7	5.6	5.0	1.2	6.4	4.2				1.5	0.14	11.2	0.58
AKLAK MEMBER REINDEER FORMATION	30fYAb-1	fg	81*	61	26	8	1	1	2	1	(15)	12	8	2.4	0.11	3	0.12
	169bYA-1	mg	97*	32	39	7	1	1	–	3	(20)	2	2	0.8	0.03	1	0.03
	13YAb-5	fg	92	30	35	19	1	3	1	4	3	–	6	0.8	0.09	2	0.06
	33aYAb-10	mg	77	50	24	10	3	4	5	5	–	13	10	2.1	0.24	7	0.29
	0-14-4	mg	85	35	46	8	7	3	tr	2	9	4	2	0.8	0.06	7	0.15
	0-14-7	fg	88	38	24	19	8	3	2	6	(14)	–	12	1.6	0.09	10	0.42
	MEAN VALUES			41	32	12	4	3	2	4				1.4	0.10	5	0.18
	STANDARD DEVIATIONS			11.0	8.3	5.1	2.9	1.1	1.7	1.7				0.66	0.07	3.2	0.15

TABLE III b. Compositional Analyses of Fish River Group and Reindeer Sandstones.

Explanation: † - Wentworth grade scale; ( ) void due to plucking during slide preparation.
%Vol = pctg. volume occupied by particulates
Lith = lithic fragments; K-Fp = potash feldspar; Plag = plagioclase feldspar
Det = detrital matrix; Fsp/RF = feldspar/rock fragments (incl. chert)
V+P = volcanics + plagioclase

Of the main constituents, quartz, potassium feldspar, and sedimentary plus metamorphic rock fragments display relatively constant proportions in sandstones throughout the succession. The average amount of quartz in the particulate fraction is 42%, of potassium feldspar 3%, and of rock fragments 15%. The particle types exhibiting variable proportions among the several stratigraphic members are chert, volcanic rock fragments, and plagioclase. These components are thus the most useful in differentiating stratigraphic units and studying areal composition trends.

Chert is greatest in abundance in the Cuesta Creek sandstones, where it averages 34%. It is considerably lower in abundance in the basal sandstone and Ministicoog members of the overlying Moose Channel Formation, where it averages 21 and 20% respectively. However, it rises slightly in abundance in the younger Aklak regressive phase, where it averages 24% in six samples. Because of the relatively constant proportion of quartz, the quartz/chert ratio varies mainly due to changes in chert content. The ratio averages 1.3 in value in the Cuesta Creek Member, rises to 2.3 and 2.6 in the ~~lower two members of the~~ Moose Channel Formation, then falls back to an average of 1.4 in the Aklak Member (Fig. 26). This trend is far more pronounced in individual sections, such as at Aklak Creek, where the quartz/chert ratio increases to a maximum of 5.5 towards the top of

the Ministicoog Member, then decreases sharply in the overlying Aklak Member to 0.8.

Plagioclase abundances vary roughly inversely to chert contents from one member to the next. That is, in the Cuesta Creek Member for example, where chert is relatively abundant, plagioclase is relatively rare (average amount: 2%). In the eastern outcrop area the Cuesta Creek Member is depleted in both types of feldspar (average total feldspar content: 1.6%). Feldspars, and in particular plagioclase, increase to a maximum proportion in the ~~basal sandstone and Ministicoog members of~~ the Moose Channel Formation. In the Aklak Member of the Reindeer Formation plagioclase is a very minor component (average amount: 2%), as it is in the Cuesta Creek Member of the Tent Island Formation.

The amount of volcanic rock fragments varies in a similar way to that of plagioclase, suggesting that either the two were derived from common sources, or they were degraded during sediment transport in similar ways. Volcanic detritus is rarest in the Cuesta Creek Member, except for its occurrences in the western coastal plain, and greatest in the basal sandstone member of the Moose Channel Formation (average amount: 7%).

Because of their inverse relationship, the proportions of volcanic rock fragments plus plagioclase (V + P in Table III) versus those of chert can be used to enhance petrographic differences and trends among the various sandstone members ~~of the Fish River Group~~ (Fig. 27). The average value of the ratio V + P / chert is 0.17 in samples of the Cuesta Creek Member, 0.70 in the basal sandstone and Ministicoog members of the Moose Channel, and only 0.18 in the Aklak Member. The t-statistic, which compares the means and standard deviations of two separate sample-groups and tests them for equality was applied to ratio-values of the Aklak Member versus those of the lower Moose Channel, and the test indicates that real differences in the values of this ratio indeed exist at the 95% confidence level.

Notable variations of a given component occur among different sections or localities also. These variations are also dominant among chert, plagioclase, and volcanic rock fragments (Table IV). The combined amounts of volcanics plus plagioclase in sandstones of the Eagle Creek area are about <u>twice</u> as great as those of the Big Fish River area, and <u>three times</u> ~~as~~ greater than those in the Moose Channel of the Ellice 0-14 well. These marked areal differences in composition must partly be a result of local derivation of clastic materials.

Area :	Deep Creek	Eagle Creek	Big Fish River	IOE Ellice 0-14
No. of samples:	2	5	9	7
Chert	25	22	21	27
Volcanic RFs	1	9	8	4
Plagioclase	1	12	4	2
Volc. + Plagio.	2	21	12	7

TABLE IV. Areal compositional differences in Moose Channel Formation sandstones.

Summary:-

Tent Island Formation, Cuesta Creek Member:

(i) high chert content; over-all average: 34%.

(ii) very low feldspar content in eastern outcrop area; average: 2%.

(iii) very rare volcanic rock fragments in eastern area (< 2%), but common in Deep Creek area (15%).

(iv) low values for ratios of quartz/chert: 1.3, feldspar/rock fragments: 0.07, and V+P/chert: 0.17 .

Moose Channel Formation

Basal sandstone member:

(i) low chert content; over-all average: 21%.

(ii) high feldspar content (generally > 5%), plagioclase particularly enriched (average: 5%).

(iii) high volcanic rock fragments content; over-all average: 7%.

(iv) high values for ratios of quartz/chert: 2.3, feldspar/rock fragments: 0.25, and V+P/chert: 0.70 .

Ministicoog Member:

(i) similar petrographic characteristics to basal sandstone member; feldspar generally less abundant.

(ii) presence of minor clastic carbonate a characteristic in eastern area and I.O.E. Ellice 0-14 borehole.

Reindeer Formation

Aklak Member:

(i) high chert content (exceeds 24% generally).

(ii) very low plagioclase content (generally 2% or less).

(iii) low values of ratios, but not so low as those of Cuesta Creek Member; quartz/chert: 1.4, feldspar/rock fragments: 0.10, V+P/chert: 0.18 .

STRATIGRAPHIC CORRELATIONS

LOCAL CORRELATIONS

Due to a lack of regional marker beds and the localized nature of deltaic sedimentation lithostratigraphic correlations of surface and subsurface sections are difficult and of gross nature. Paleontological control for correlating is restricted to various microfossil groups and plant fossils, which are confined to the upper part of the group. Many of the correlations presented here (Fig. 28) are tentative and subject to revision as detailed micropaleontological studies are conducted and their results brought to bear on the problem of correlating.

The types of data used to make the correlations include, in the approximate order of decreasing reliablity:

(i) similar fossil assemblages and diagnostic species;

(ii) lithologic markers and petrographic peculiarities in association with homotaxial stratigraphic sequences; and

(iii) geological age assignments based on different fossil groups.

Much reliance is placed on the concept that the thick marine shale formations represent regional transgressions generally contemporaneous over large areas, and that thick coarse alluvial units represent intervals when uplands were shedding off debris over large areas. Hence, the homotaxiality of stratigraphic sequences

is regarded as a reasonable first approximation for gross correlations, and becomes increasingly reliable as more independent paleontological support is obtained.

Correlations in the Big Fish River-Eagle Creek areas

From the type section on Big Fish River to nearby creeks towards the southeast and northwest correlations can be made by almost direct tracing of markers and larger stratigraphic units. The Eagle Creek section, which is in a different structural element from the above, contains faults and is pieced together and correlated with the type section on the basis of thickness and lithologic similarities of individual formations and fossil assemblages.

Type area to the I.O.E. Blow River borehole

The Upper Cretaceous age of the uppermost 4,000 feet of the I.O.E. Blow River YT E-47 borehole was not recognized until comparatively recently, when T. P. Chamney quickly examined foraminiferal remains from well-cuttings over this interval. There are no hints of such an age from the poorly exposed surface geology near the wellsite, which is located within a wide belt of deformed, late Lower Cretaceous, pelitic sediments. Samples from the depth-interval 1,700 to 1,800 feet contain microfossils typical of the "*Cyclammina*" sp. 1A assemblage zone which occurs in the Tent Island Formation. The sandstones present above the 1,350-foot depth are probably Moose Channel Formation, and those from about 3,100 to 3,370 feet belong to the Cuesta Creek Member. The shales immediately below but above the angular discontinuity (as established from dipmeter logs) at 3,990 feet are tentatively assigned to the Boundary Creek Formation. Microfaunal remains below this horizon, interpreted to be an angular unconformity, suggest a Lower Cretaceous, mainly Albian age.

Type area to Deep Creek area

The correlation of the members present in the Deep Creek area with those of the type Fish River Group are tentative, being based primarily on the homotaxiality of the two successions. The two outcrop areas are discontinuous, being separated by a north-trending zone of deformed ~~Albian~~ Lower Cretaceous shales. In both areas the group has a fluviatile conglomerate and coarse sandstone unit (Cuesta Creek Member) at its base, characteristically only locally preserved, overlain by a thick mudstone unit identified in both areas as the Tent Island Formation. It appears to be considerably thicker in the western outcrop area, where Foraminifera ~~may range down into the Santonian Stage~~ appear to be Senonian in age (Chamney, ~~Paleont. Rept. 4-Mes-TPC1972~~ internal report on collections by D.K. Norris). Hence, the basal conglomerate may be older in the Deep Creek area than in the type area, and may even be of quite different ages from one occurrence to the next.

A dominantly sandstone formation occurs above the Tent Island Formation, homotaxial with the Moose Channel Formation. An intermediate mudstone unit is similar in lithology and thickness to the Ministicoog Member on Big Fish River, and is overlain by another sandstone unit tentatively correlated with the Aklak Member. Coaly material collected by D. K. Norris from

an outcrop believed to be near the contact of the two upper units yielded pollen of Maastrichtian or possibly Paleocene age (Brideaux, Paleont. Rept. K6-WWB-1971), which agrees with palynological datings of ~~the Moose Channel Formation in its~~ rocks near this contact in the type area.

Type area to I.O.E. Ellice O-14 borehole

The ~~upper part of the Fish River Group~~ Aklak Member is correlated between the type area and the I.O.E. Ellice O-14 borehole with greater confidence than the ~~lower part~~ Moose Channel Formation. The Aklak Member consists of similar nonmarine rocks in both sections, and, according to Brideaux (Paleont. Rept. WWB-2-1972), contains nearly identical pollen assemblages (cf. GSC loc. C-11299 with C-12661). The underlying Ministicoog mudstone is similar in thickness and lithology in both sections, and contains sandstone with small amounts of carbonate detritus. The basal member of the Moose Channel Formation is much shalier in the Ellice O-14 well than at the type section, but contains sandstone with relatively high amounts of feldspar as at the type section. The suspected basal contact with the Tent Island Formation is gradational and obscured by faulting, consisting of a coarsening-upwards sequence similar to that observed at the type section (Fig. 16). This cycle may, however, be underlain by more cycles with sufficient arenaceous beds to justify placement in the Moose Channel Formation.

Type area and Ellice well to Reindeer D-27 borehole

Because the biostratigraphy of the B.A.-Shell-I.O.E. Reindeer D-27 borehole has been published (Chamney, 1971, 1973), it seems appropriate to attempt to relate that work to the present study. The correlations presented in Fig. 28 are based on the similarities of microfaunal assemblages between the Reindeer D-27 well and surface sections of the type area of the Fish River Group, especially at the level of the Tent Island Formation. Chamney (1972) reported that his "Cyclammina" sp. 1A foraminiferal assemblage zone (Division 11) of the Reindeer D-27 borehole also occurs in the lower condensed section on Little Fish Creek (Cache Creek). Ages assigned by him to the overlying divisions up to a depth of 4,740 feet in the Reindeer D-27 well, where he depicts a major unconformity, correspond with those of the type Moose Channel Formation. In this study the unconformity is placed lower in the section at a depth of 4,990 feet, on the basis of dipmeter logs which show an abrupt change in bedding attitude at this level. A conglomeratic unit occurs directly above this discontinuity, lending support to the concept of an angular unconformity, and agreeing in lithologic character with deposits above this level. Above the unconformity the poorly dated conglomerates and sandstones are apparently younger than the type Aklak Member, and are probably correlative with the Reindeer Formation of the nearby Caribou Hills, which contains a Paleocene microflora (Brideaux, Paleont. Rept. K5-WWB-1972).

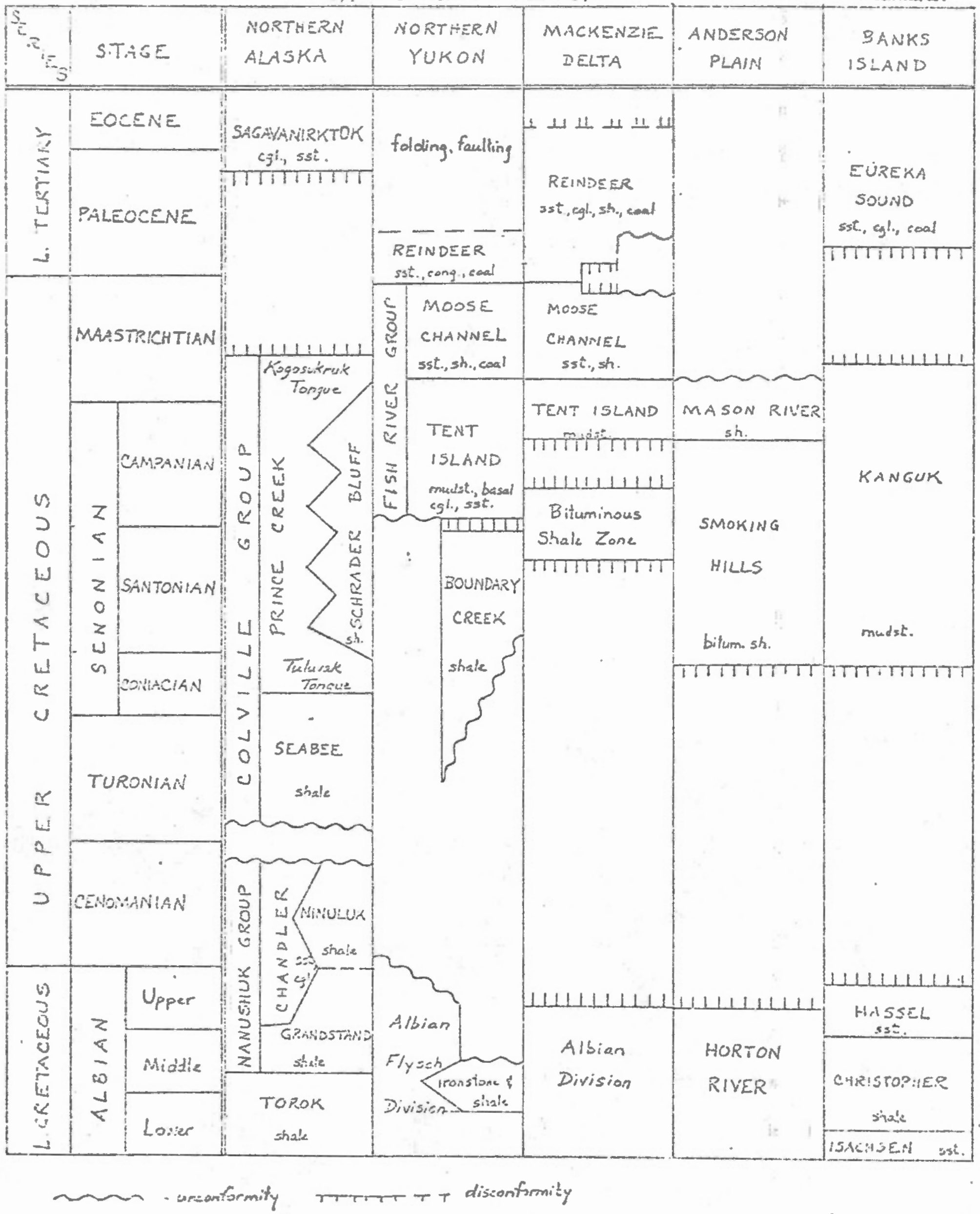
A discrepancy in age assignments based on micropaleontological research by various workers exists in the lower half of the Reindeer D-27 borehole (various personal communications). Considerably younger ages are attributed by some to the thick shale formation in the interval between 7,000 and 11,000 feet, as evidenced by the published work on Foraminifera by Petracca (1972). He assigned an Eocene to Oligocene age to cuttings from depths between 9,000 and 10,000 feet, and core-samples between 9,573 and 9,598 feet. This discrepancy is discussed by Chamney (1973b, p. 177), and until such time as the specialists have resolved their differences, the correlations shown here (Figure 28) are based on Chamney's

extensive micropaleontological work on the Reindeer D-27 well and the consistent lithostratigraphic framework which supports these correlations.

REGIONAL CORRELATIONS

Correlations of Late Cretaceous and Early Tertiary stratigraphic units in northern Yukon Territory and northwestern District of Mackenzie were discussed by Mountjoy (1967), and were slightly modified and tabulated in "Geology and Economic Minerals of Canada" (Douglas, 1970, Chart III). Further modifications to these correlations are necessary in the light of recent paleontological research (Table V) and are discussed below according to geologic province.

Table V. Correlation of Upper Cretaceous formations, northern Alaska and northwestern Canada.



(a) North-central Yukon Territory

In Eagle Plain the lower shale member of the Eagle Plain Formation ranges up into the Campanian Stage according to Chamney (1971b), who examined microfauna in cuttings from the Soc. Mob.-W.Min. Molar YT P-34 borehole, and hence it is correlative with the Tent Island Formation of the Fish River Group. Because at least 2,500 feet of sandstone and shale of the Eagle Plain Formation lie above the spud-in stratigraphic level of the Molar P-34 well to the west of it, the formation probably ranges as young as Maastrichtian and is equivalent to the Moose Channel Formation.

Southwest of Eagle Plain in western Ogilvie Mountains is the Monster Formation which was assigned a late Upper Cretaceous age by Mountjoy (1967) on the basis of leaf fossils identified by W. A. Bell. Green (1972) described a new section of this unit and submitted new fossil plant collections to F. M. Hueber for identification, but no further precision in age determinations was possible from these. The writer has measured two sections of this formation and submitted material to W. Brideaux for palynological analysis, but the samples proved to be barren. Hence, the Monster Formation, and similar strata westward in Alaska (Mertie, 1937), are generally equivalent in age to the Fish River Group and the upper part of the Eagle Plain Formation.

The Bonnet Plume Formation of Bonnet Plume Basin was the subject of detailed palynological research by Rouse and Srivastava (1972), who documented the Maastrichtian to Paleocene age of this largely non-marine formation. Their paleoecological interpretations and regional correlations are ~~useful-al~~ relevant to the correlative Fish River Group.

~~(e)~~ Norman Wells-Great Bear Plain areas

The non-marine, upper part of the Little Bear Formation at its type section on the foreland flank of Mackenzie Mountains near Norman Wells has yielded pollen assemblages which have been

dated as Campanian to possibly early Maastrichtian (Brideaux, 1971). These assemblages necessitated radical revisions to the stratigraphic correlations previously attributed to the Little Bear and overlying East Fork Formations (e.g. see Yorath, in Aitken and Cook, in press). Recent unpublished research by Brideaux (Paleont. Rept. K5 WWB 1973) shows that the type section of the East Fork Formation is Campanian in age, and the medial, marine facies of the Little Bear Formation contains Santonian microplanktonic fossils. Hence, the upper part of the Little Bear Formation is correlative with the Boundary Creek Formation, and the East Fork Formation, which may lie unconformably above the Little Bear (C.J. Yorath, personal commun.), is equivalent to the Tent Island Formation.

Other outcrops in this region have yielded younger microfloral assemblages similar to those of the Aklak Member ~~upper Moose Channel Formation~~. These include one of late Maastrichtian to early Paleocene age on Police Island in the Mackenzie River (GSC loc. C-16889 to C-16892, Paleont. Rept. K7 WWB 1972), and a similar dated assemblage from Grizzly Bear Mountain on the west side of Great Bear Lake (GSC loc. C-4301, reported in Balkwill, 1971, p.22).

(e) Anderson-Horton Plains

The "Pale Shale Zone" (Mason River Formation of Yorath, et al., in press) of Anderson and Horton Plains is tentatively dated as late Campanian in age from sparse microfauna recovered by Chamney (in Yorath and Balkwill, 1970). Thus the Pale Shale is probably correlative with the Tent Island Formation.

The "Bituminous Shale Zone" (Smoking Hills Formation ~~of, ibid~~ of Yorath, et al., in press) consists of black shale with beds of jarosite and hematite similar to the Boundary Creek Formation, although the latter is perhaps not so bituminous. The correlation of these units is documented by the similarity of microfossil residues (Chamney, 1972), including radiolarians, foraminifers, fish scales and vertebrate bones found in both units.

(f) Arctic Islands

According to Plauchut (1971) the shaly Kanguk Formation is Santonian to Maastrichtian in age and is preserved over a large part of the Sverdrup Basin, including Banks Island. Micropaleontological work on samples from recently drilled wells on Banks Island by W.V. Sliter indicates a time-range of Cenomanian to Campanian for the Kanguk (in Miall, 1974). Palynological studies of the same unit in the Elf et al. Storkerson Bay A-15 borehole by W.S. Hopkins suggest an age more restricted to the Senonian (Paleont. Rept. K-10-WSH-1973 ~~WVS-LT-10WSH-1973~~). In either case the Kanguk is correlative with the Boundary Creek and Tent Island Formations.

It is interesting to note the similarity in age and lithology, including the peculiar 'cone-in-cone limestone beds (A. D. Miall, 1974 ~~pers. commun.~~), between the Kanguk and the equivalent Tent Island Formation of northern Yukon.

The Eureka Sound Formation, a largely arenaceous, non-marine unit which overlies the Kanguk in much of the Arctic Islands, is generally Early Tertiary in age (Plauchut, 1971), and therefore correlative with the Reindeer Formation ~~is younger than the Fish River Group~~. ~~However,~~ In places where continuous sedimentation above the Kanguk shale has occurred,

(H. Balkwill, pers. commun.), the Eureka Sound extends down into the Maastrichtian Stage (W. S. Hopkins, Paleont. Rept. K-22-WSH-1972). Thus, its oldest members are probably equivalent in age to the Aklak ~~Formation~~ Member of the Reindeer Formation. Future detailed studies of the Eureka Sound may reveal ~~sever~~ a complex tectonic-sedimentary history (K. Roy, pers. commun.), similar to the stratigraphic record of the ~~upper~~ Fish River Group and overlying Reindeer Formation.

(e) Alaska North Slope

Plant fossils were submitted to C. J. Smiley, University of Idaho, who has had considerable experience with the Mesozoic stratigraphy of northern Alaska (Smiley, 1967, 1969a, 1969b). Commenting on the similarities of florules between the upper Fish River Group and those of ~~x~~ northern Alaska, he said ~~in a written report~~ (Paleont. Rept. Misc. 1-CJS-1972):

> "...the Moose Channel Formation ~~(sic)~~ seems definitely to correlate with the Kogosukruk Tongue of the non-marine Prince Creek Formation in northern Alaska, and most likely with the lower part of the tongue that interbeds with the marine Sentinel Hill Member of the Schrader Bluff Formation."

Thus, the marine Tent Island Formation which underlies the non-marine deposits from which the above florules were collected probably correlates with the marine Schrader Bluff Formation of northern Alaska, which is dated as Santonian-Campanian in age. This correlation is confirmed by the similarity of foraminiferal assemblages (T. P. Chamney, Paleont. Rept. 17Gen-TPC-72) in the two formations.

These regional stratigraphic correlations reveal a marked similarity in the stratigraphic sequence of lithologic units in northern North America. The upper Santonian and Campanian Stages are represented by a widespread marine transgression over this region, which resulted in thick deposits of grey mudstone with minor limestone and siltstone (Tent Island, Schrader Bluff, Kanguk, etc. Formations). By contrast, Maastrichtian time is notable for regressive, non-marine sedimentation, reflecting Laramide tectonic activity with associated uplifted terrains in northern Alaska, northern and central Yukon, the Arctic Islands, and northern Mackenzie Mountains.

Provenance and Paleogeography

Several independent sources of information have bearing on the nature and location of source-areas, the directions of dispersal of detritus, and the main paleogeographic elements at various instants in time. These data include mineralogy of detritus, ages of recycled pollen and spores, clastic grain-size trends, paleocurrent measurements from sedimentary structures, and facies trends. An integration of these features, plus a knowledge of regional stratigraphic and tectonic features, provide an overall geologic framework in which to view the Fish River Group.

Composition and Origins of Clastic Detritus

As previously discussed under the section on sandstone petrography the arenites of the Fish River Group and Reindeer Formation contain abundant quartz, chert, and various sedimentary, metamorphic, and volcanic lithoclasts. These components directly reflect the diverse lithologies of the source-areas. Conglomerates of the ~~group~~ sequence tend to be far more enriched in chert than the sandstones, and, as suggested by D. K. Norris (1971), indicate derivation from "uplifted Neruokpuk and Road River terranes". The abundance of chert in Lower Paleozoic strata in Barn Mountains is clearly depicted in a cross-sectional diagram by Lenz and Perry (1972). As well, the Carboniferous Lisburne Group contains much chert and cherty carbonate rock (Bamber and Waterhouse, 1971) in Barn and British Mountains. Green chert fragments, easily mistaken for glauconite, can be traced to ~~Neruokpuk~~ Devonian outcrops (Norris, 1970) like those southeast of Bonnet Lake.

Schistose and metaquartzite fragments were probably derived from metamorphic terranes of the Neruokpuk Formation such as that of British Mountains, and from deformed Lower Paleozoic strata in Barn Mountains.

The feldspar contents of the sandstones generally vary in proportion to the abundances of igneous rock fragments, a relationship that suggests the feldspars ~~are~~ were derived ~~from~~ directly from igneous rocks. In particular, plagioclase feldspar is typically common where volcanic lithoclasts are abundant, and potash feldspar is high were granitic phenoclasts occur in associated conglomerates. The latter phenomenon is especially true for the basal Moose Channel Formation at ~~its type section~~ Big Fish River. Hence, plagioclase was probably derived mainly from igneous terranes rich in volcanic rocks, and potash feldspar was derived mainly from exposed granitic stocks. In support of this it should be noted that older sandstones and carbonate rocks, ~~including~~ as well as metamorphosed varieties in the surrounding region contain very little feldspar, thereby precluding these rocks as major sources of feldspar.

The origin of these igneous rock fragments and feldspars is somewhat of a mystery because of the remoteness, scarcity, and diminutive sizes of igneous terranes exposed today. Speculating on the origin of andesitic phenoclasts in Moose Channel conglomerates, Norris (1970) suggested they were derived from Alaska. In the Brooks Range of northern Alaska, immediately west of the Canadian border, the Neruokpuk Formation contains volcanic rocks (Dutro, et al., 1972), and basalt, gabbro and quartz diorite dated as Jurassic in age occur in the Porcupine River area in eastern Alaska (Imlay and Detterman, 1973).

Norris (1972) indicates the existence of volcanics in the Cambrian Neruokpuk of British Mountains, but other occurrences of volcanics in northern Yukon are rare; Dyke (1972) noted some in the Proterozoic section in the White Mountains of the northern Richardson Range.

The distribution of volcanic detritus and feldspars by area and stratigraphic level in the Fish River Group is instructive for determining source-areas. These materials are relatively common in the basal part of the group (Cuesta Creek Member) in the western outcrop area, but are rare in the Big Fish River area at similar stratigraphic levels. This distribution suggests detritus was derived from the volcanic rocks of the Brooks Range, and deposited in the Deep Creek area, but did not reach the area farther east. A reversal in abundances occurs, however, in the basal and medial Moose Channel Formation, in which volcanics and feldspars are much more common in the eastern outcrop area and in the

Ellice O-14 borehole than in the western outcrop area. The proportion of volcanics plus plagioclase in analysed sandstones of the Moose Channel Formation reaches a maximum of 38% in a sample from Big Fish River, but is on the average most abundant at Eagle Creek (Table IV) in all three members. Strangely enough, sandstones analysed from the type Aklak Member on Aklak Creek are impoverished in volcanic lithoclasts (approximately 1%) relative to the amounts in similar rocks from Eagle Creek (3%) and the Ellice O-14 borehole (7%). The erratic distribution of volcanic lithoclasts among closely spaced localities indicates very poor blending of detritus by the drainage system, and suggests a closer source of detritus than the Brooks Range. Also, the higher amounts of volcanic detritus in the upper Fish River Group in the Delta area suggests the presence of a large volcanic terrane not too far away. This terrane is not presently evident, and requires speculation regarding its location. One possibility is that the volcanics are now totally eroded away, but at one time may have been associated with granitic stocks such as those of Barn Mountains. Another possibility is that the volcanics were derived from presently submerged rocks beneath the Beaufort Sea, or from presently mantled outcrops on the lower coastal plain.

Grain-Size Trends

As a guiding principle it can be assumed that the mean size and largest size of clastic fragments decrease downstream from their point of derivation due to the action of abrasion and fracturing during transport (Sternberg, 1874). The maximum diameters of the largest phenoclasts were measured in the field at most localities in order to aid in the determination of paleodispersal trends.

The basal unit, the Cuesta Creek Member of the Tent Island Formation, contains the largest phenoclasts on the average as well as the very largest in particular. A boulder of chert arenite, one meter in largest dimension, was observed ~~mx~~ above the unconformity on Hornet Creek, and on Trail River blocks of sandstone up to 3 meters on a side are present. Clasts this size must be very close to their sources, perhaps in the order of only a few miles.

A map showing maximum ~~pen~~ phenoclast sizes (Fig. 29) indicates a general northward trend of fining of fragments in the area east of Blow River. This trend is interrupted by major projections of very coarse material on Hornet and Eagle Creeks, suggesting that transport energy was concentrated here probably as a stream channel directed towards the northeast. Maximum sizes decrease rapidly to the northwest and indicate slack-water

conditions near a shoreline close to the mouth of present-day Rapid Creek.

A similar map with more control points can be drawn for the basal sandstone member of the Moose Channel Formation in the eastern outcrop area (Fig. 30). In this case there is a fairly regular north- and northeastward decrease in the maximum diameters of phenoclasts, ranging from a maximum of 300 mm at Little Fish Creek (Cache Creek), to a minimum of 40 mm in the Ellice O-14 borehole. This trend closely parallels the dispersal directions indicated by measurements of current-formed structures. The maximum value (110 mm) observed from the Deep Creek outcrop area suggests that this site is not so close to the source-area as the entire eastern outcrop area, although other factors, such as relative relief in the source-areas, could also account for these differences.

Too few data points are available to plot maps for the Tent Island Formation and Ministicoog and Aklak Members ~~of the Moose Channel Formation~~. However, the maximum sizes observed in the Aklak Member on Aklak Creek and Eagle Creek (300 mm and 400 mm, respectively) greatly exceed the respective values of the ~~older basal sandstone member~~ Moose Channel Formation. This, as well as the highly nonmarine character of the Aklak compared to the ~~basal sandstone~~ Moose Channel, suggests the source-area of the Aklak was closer to the present outcrops than that of the ~~basal sandstone member~~ Moose Channel Formation.

Ages of Recycled Microfossils

Palynological samples from various localities and stratigraphic levels in the Fish River Group and Reindeer Formation have commonly yielded abundant recycled pollen and spores (W. W. Brideaux, internal rept.'s). This material is useful in determining the provenance of clastic detritus because it can be accurately dated. All members of the sequence contain about the same assemblage of recycled palynomorphs, the dominant ones being Lower Cretaceous forms. Less common are Lower Paleozoic, Carboniferous, Permian and Triassic spores. Sedimentary rocks of these ages outcrop today in northern Richardson Mountains, Barn Mountains and Porcupine Plateau. Triassic rocks are restricted to northern Barn Mountains and eastern British Mountains (Mountjoy, 1967), and possibly eastern Richardson Mountains (Jeletzky, 1967). Hence, detritus in the Fish River Group and Reindeer Formation must have been derived from some or all of the above localities, as well as much of the present large areas to the southwest where Lower Cretaceous strata are exposed. These areas also include large tracts of Jurassic outcrops, and it is puzzling why Jurassic palynomorphs are not recognized in the recycled assemblages. Possibly many of the Jurassic palynomorphs are long-ranging varieties which cannot be differentiated from the Lower Cretaceous forms.

Paleocurrent Measurements

Sedimentary structures used to determine paleocurrents include cross-stratification, scour-axes, ripple-marks, and current lineations. The latter two provide only orientations, and independent evidence is required to determine the directions of paleocurrents. The 184 readings are grouped into 17 stations, each of which generally includes readings from numerous different beds scattered throughout an entire member.

Directional data recorded in the field were corrected for simple tectonic tilting by means of a stereonet, using the method explained by Potter and Pettijohn (1963). Corrected data were grouped into 30-degree sectors. The percentages of readings falling into each sector were plotted as circular histograms (Figures 29, 30). Resultant vectors were calculated and plotted on the maps only if the vector strengths indicated statistical significance at a confidence level greater than 95% (Curray, 1956, Fig. 4).

Paleocurrent measurements in the Cuesta Creek Member are concentrated in the eastern outcrop area (Fig. 29), where four different stations show no single, consistent trend. At Big Fish River climbing ripples indicate the general direction of current flow which produced the measured current lineations was north-northwest. At the other three stations the paleocurrent

Figure. 29. Palæocurrents and Phenoclast Maxima in Cuesta Creek Member.

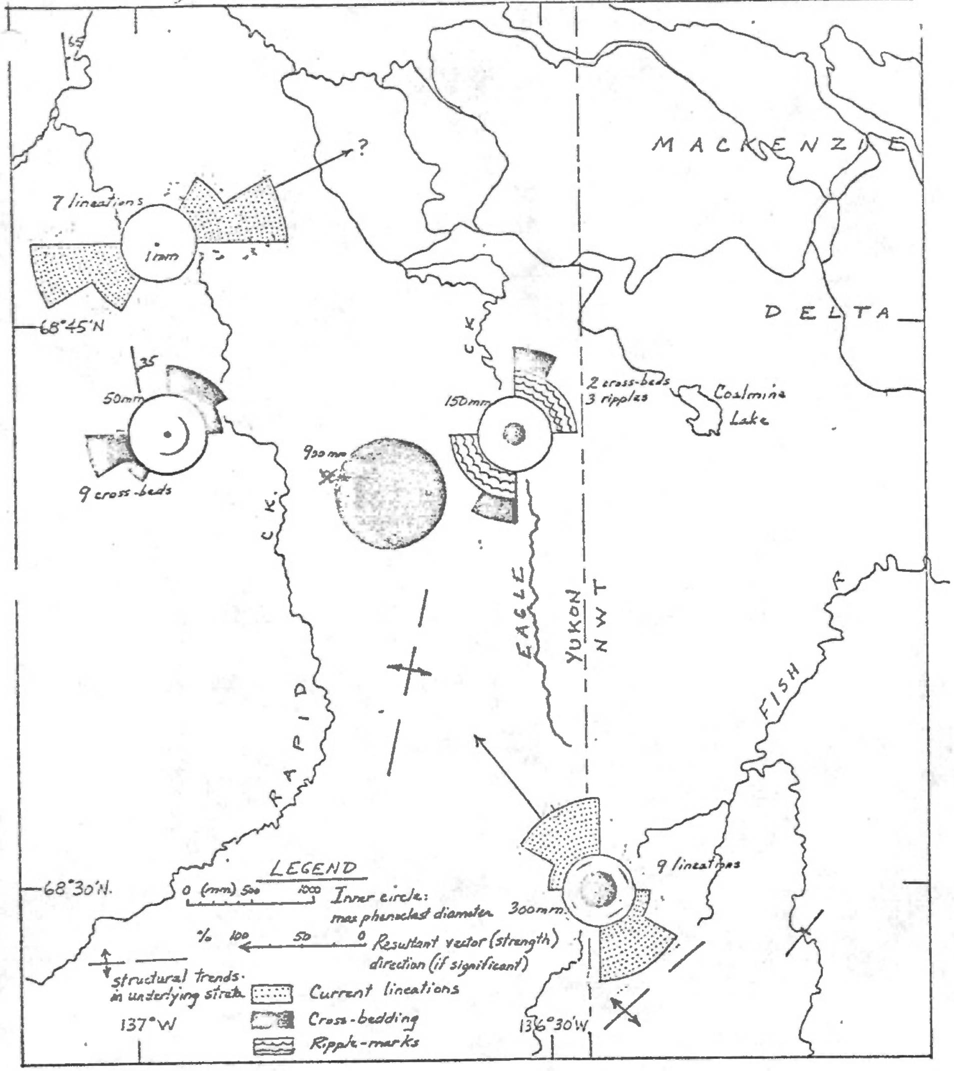
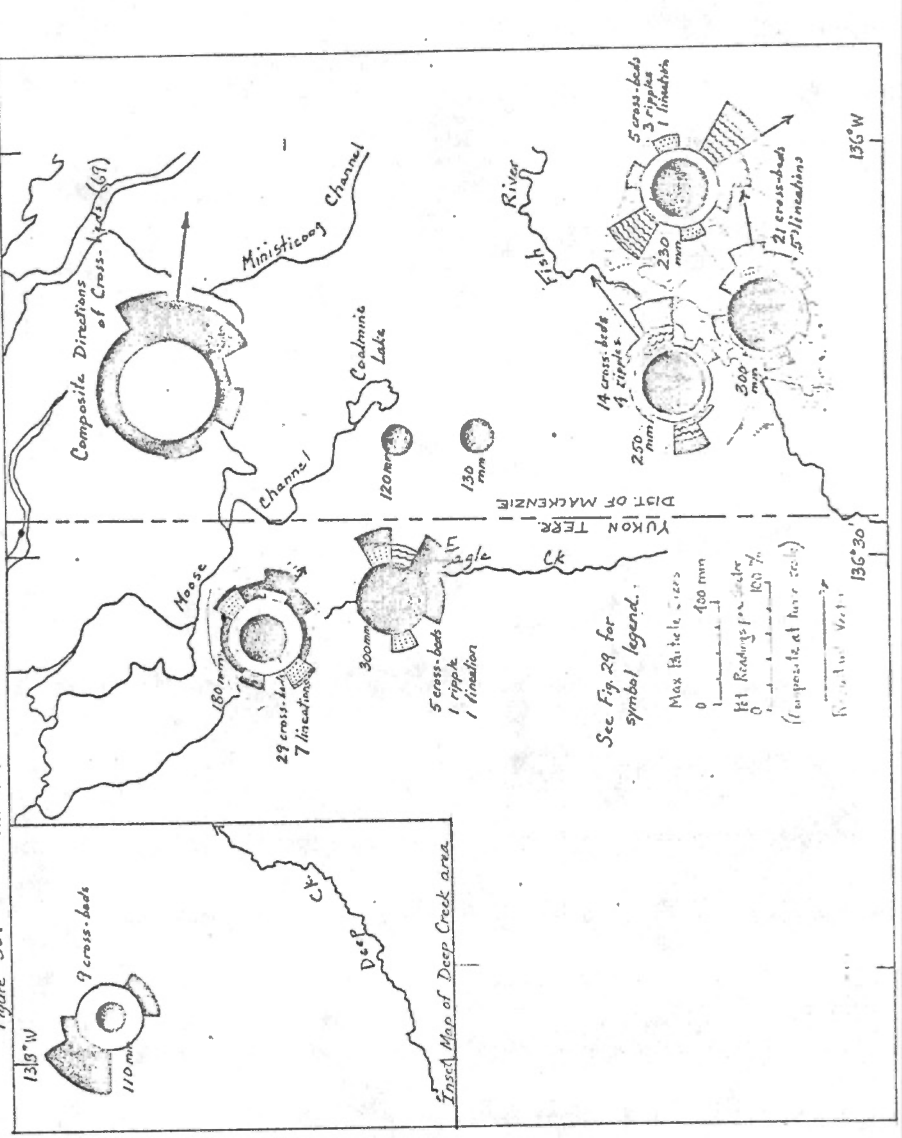


Figure 30. Palaeocurrents and Phenoclast Maxima in the Basal Sandstone Member, Moose Channel Formation



distributions are bimodal, with modes diametrically opposed. Such distributions are typical of strand-line and tidal flat deposits (Klein, 1967) where wave- and tide-generated currents run both towards and away from the shore. From other data, such as grain-size trends, it is reasonable to assume that the land lay southwest of these ~~stations~~ locations.

The dispersal pattern thus outlined by these few stations indicate an interesting relationship to the present structural and outcrop trends, ~~in that~~ by which the paleocurrents at each station are roughly orthogonal to the outcrop trends. This relationship supports an hypothesis suggested to the writer by J. S. Bell of Shell Canada Limited, who believes ~~s~~ that ~~antielin~~ structurally elevated areas in the underlying Lower Cretaceous and older rocks may have been topographically high during Upper Cretaceous sedimentation, and that folds in the latter sequence developed along much the same lines as did the underlying folds. Thus, dispersal directions in the basal Fish River Group would naturally be perpendicular to the flanks of structural highs in the underlying rocks.

In the basal Moose Channel Formation paleocurrent trends are less well defined, partly because of the higher variance in directional values at each station. In the eastern outcrop

area the dominant paleocurrent trends appear to be in an easterly direction (Fig. 30), ~~although the dispersion of values at each station does not permit much confidence in a statistical sense~~. If the cross-bedding dip-directions of all four stations are grouped (69 readings) the resultant vector gives a direction of S83E, with a 99.9% chance that this value is not due to random causes.

A collection of readings from the Moose Channel ~~and Minis-ticoog Formations~~ Formation in the Deep Creek area indicates strongly a northwestward dipping paleoslope. The inlier of suspected Upper Cretaceous strata in Blow River valley provided paleocurrent orientations aligned roughly north-south.

Paleocurrent directions in the Ministicoog ~~Formation~~ Member are highly variable in both the western and eastern outcrop areas (Fig. 31), typical of sediments dispersed in shallow marine waters (Klein, 1967; Dott and Roshardt, 1972). The tidalite facies on Eagle Creek shows consistent north-northeast to south-southwest paleocurrent orientations, as well as northeast-deirected current ripples. These orientations are consistent with facies trends in the member, in which tidal flat sediments grade laterally towards the north and east into a shallow-neritic-zone mud facies, as expressed on lower Eagle Creek, Aklak Creek, and Big Fish River.

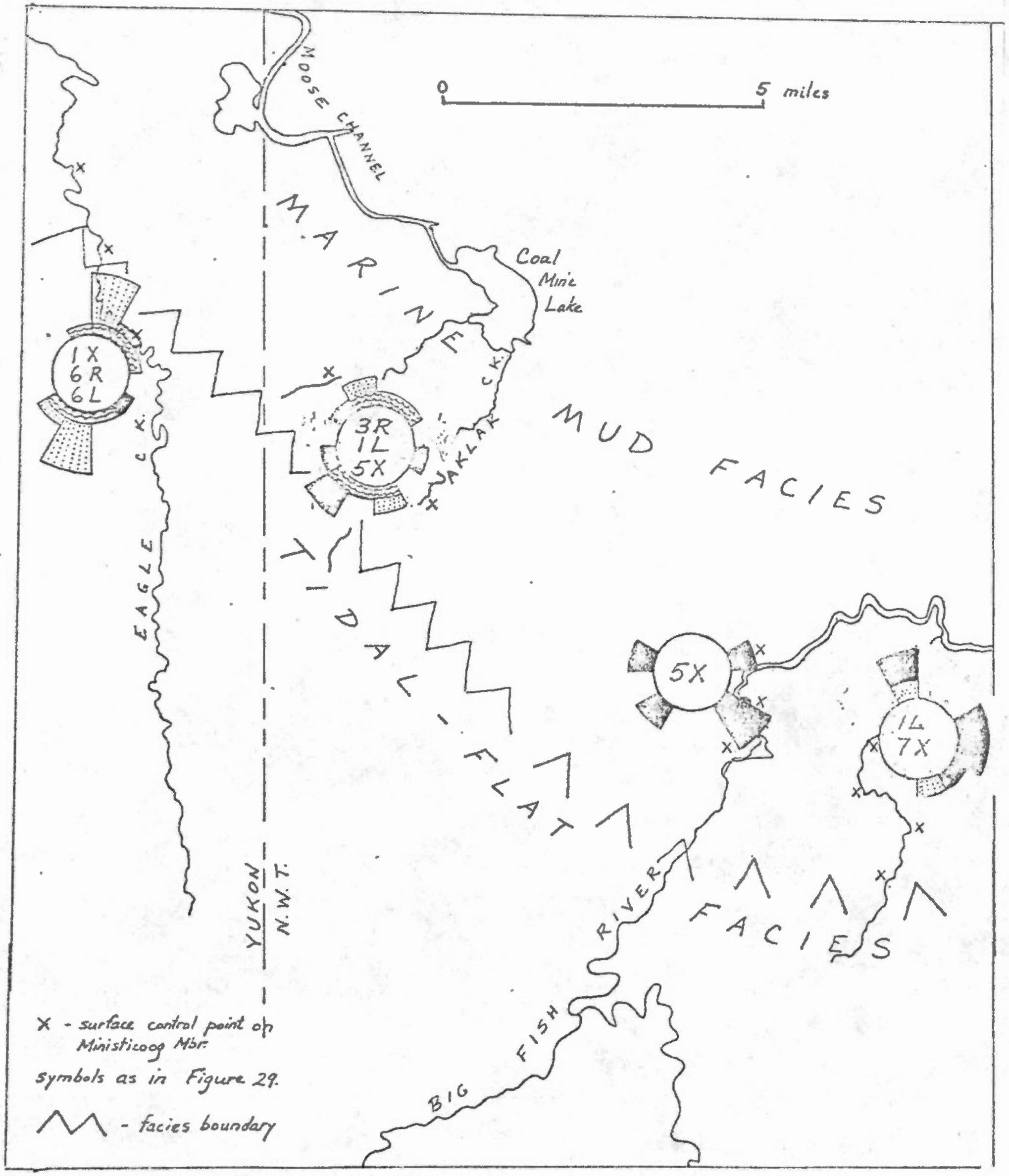


Figure 31. Paleocurrents and facies trends in the Ministicoog Member, Moose Channel Formation.

The Aklak Member at Aklak Creek shows an essentially uni-modal paleocurrent pattern from 15 cross-bedding dips whose resultant vector points at North 80° East. A few miles west on Eagle Creek the highly sandy Aklak contains cross-beds directed easterly, ripple-marks oriented northeast-southwest, and scour-axes directed towards the southeast.

Paleogeographic Summary

Dispersal trends and the petrography of clastic particles indicate that in general the source of sediment and heads of dispersal systems lay to the west and south of the present coastal plain, and that receiving basins for sedimentation lay beneath Yukon Coastal Plain, Beaufort Sea shelf, and Mackenzie Delta. A quick examination of any columnar stratigraphic section of the Fish River Group, however, reveals that both large- and small-scale fluctuations in sedimentary facies and shoreline position occurred. Large-scale vertical stratigraphic changes, from base to top include: (1) alluviation (Cuesta Creek Member), (2) marine inundation (Tent Island Formation), (3) deltaic and alluvial progradation (Moose Channel Formation, basal member), (4) marine inundation (Ministicoog Member), (5) deltaic and alluvial progradation (Aklak Member, Reindeer Formation). At a single location these vacillations are manifest to varying degrees, and small-scale reversals are typical within the large-scale trends. This type of cyclicity is commonly conceived in terms of transgressive and regressive phases of sedimentation with respect to shifts in shoreline position. That is, during the marine inundation represented by the Tent Island Formation for example, the shoreline transgressed landward and was probably stationed well into the upland areas. Subsequently, during progradation and upbuilding of coarse clastic wedges, the shoreline necessarily regressed seaward, and was located somewhere near the present coastline or farther north. During the regressive phases a coastal plain sedimentary wedge became established which could be considered ancestral to the present-day Yukon Coastal Plain.

Paleodispersal trends show clearly that the Fish River Group was not deposited from a proto-Mackenzie River. Rather, the locally derived detritus and eastwardly directed paleocurrents indicate the existence of a highland which formed a drainage divide between the coastal plain area and Eagle Plain to the south, similar to present physiography. The presence of a south-bounding highland together with eastward dispersal suggests the existence of a major eastward-flowing river which headed in Brooks Range, and followed structurally controlled topographic alignments. The north-south structural trend in the lower Blow River area may have formed a northwards projecting topographic salient, which deflected the hypothetical river north onto the present Beaufort Sea shelf, from whence it curved back towards Mackenzie Delta (Fig.32). Variable paleocurrent directions in the Cuesta Creek Member support this possibility, at least at the commencement of sedimentation of this sequence.

Deltaic sedimentation and the loci of depocentres appear to have been concentrated in the lower coastal plain and subsurface of the present Mackenzie Delta. Marine shale tongues and deltic facies are far more common in the I.O.E. Ellice O-14 section than in any surface sections to the southwest. In the eastern outcrop area during regressive episodes, shoreline and coastal plain environments were most common.

The Fish River Group, embracing a mixture of non-marine, transitional and marine sedimentary rocks composed of immature, recycled detritus, can be interpreted as a molasse-like suite. This is best appreciated when it is reviewed along with the entire Mesozoic history of sedimentation and tectonics of the area (Young, ~~1973~~ in press). But even from a close viewpoint, certain features of the Fish River Group are surprisingly similar to analogous features in the Subalpine Molasse of central Europe. (pers. commun., F. B. Van Houten). For example, the immature polymictic sandstones, lenticular conglomerates, and freshwater carbonates and coals are all features common to each series. Also the Tonmergel ~~of~~ forming the Lower Marine Molasse at the base of of the Subalpine Molasse is strikingly similar in lithology and stratigrahic setting to the bluish grey, thin-bedded mudstones with calcareous interbeds comprising the Tent Island Formation.

STRUCTURAL GEOLOGY

The dominant structural grain in Upper Cretaceous strata of Yukon Coastal Plain is north-south, expressed also in the axial trends of broad, upright folds and in the strikes of high-angle normal faults. Smaller areas, mainly in the vicinities of Big Fish and Babbage Rivers, display a northwest-southeast structural alignment. A set of normal faults, but no fold-axes, strike east-west to northeast-southwest, and strata within two miles of the Cache Creek Uplift in the southeast corner of the map-area (Fig. 1) strike northeast-southwest, parallel to the uplift.

The Boundary Creek Formation is commonly complexly deformed, but displays fold axes sub-parallel to the structural grain of underlying Albian strata and overlying Fish River Group. Bedding dips in the Boundary Creek generally exceed slightly those of the overlying rocks, suggesting that tilting occurred prior to Fish River Group sedimentation.

Strata of the Fish River Group in the map-area and Deep Creek Syncline are gently to moderately tilted and transected by high-angle normal faults (Norris, 1972a). Mountjoy (1967) stated that the Moose Channel Formation has a northwest-southeast strke in contrast to the north-south structural grain of the Richardson Mountains which border the map-area on the south. This is largely true near Big Fish River, but farther west a north-south strike prevails, parallel with that of underlying strata.

On Big Fish River the strata dip northeast at low dips ranging from 3 to 7 degrees. On most other creek exposures in that area, however, dips are somewhat higher in the range of 10 to 25 degrees. On Eagle Creek, ~~Fish River Group~~ Moose Channel and Reindeer strata dip eastward at angles ranging from 25 to 50 degrees.

On the southwest shore of Coalmine Lake a vertical bed of Aklak conglomerate forms a prominent outcrop, and coal beds mined adjacent to it are also vertically oriented. This unusual structural configuration is possibly due to either drag-folding adjacent a major fault, or rotation of a small wedge caught between two fault splays. In either case, the lateral extent of the vertical beds would be quite limited.

Folding and tilting of strata of the Fish River Group appears to have occurred along the same rotational axes as that in the underlying Albian shales and ~~Yellow... weathering shale division~~ Boundary Creek Formation. For example, the north-trending cuesta formed by the Cuesta Creek Member

strikes in the same orientation as the underlying Albian and younger shales, but the dips of the Cuesta Creek beds are only 10-15 degrees east while the dips of the older rocks range between 35 to 60 degrees east. Similarly, in the Deep Creek Syncline the Fish River Group strata comprise the youngest rocks in the axial part of the fold and are inclined at dips generally less than 25° to horizontal in the axial part of the fold. However, dark gray Albian shales which underlie the Fish River Group dip 40 to 60 degrees in the western limb of the syncline. The gradual decrease in dip towards the fold-axis indicates a ~~concentric~~ cylindrical type of folding during the final tectonic phase. The same type of co-axial folding occurs in the subsurface of the continental shelf to the north according to continuous seismic profiles (Yorath, 1973, fig. 5).

Folding about north-south axes appears to have occurred prior to most of the faulting, because the folds are truncated in various ways, or appear as simple monoclines between two sub-parallel faults. In the eastern coastal plain (Fig. 1) the northeast-trending faults are generally truncated by the north-trending faults, suggesting that the latter are the younger features. The north side is generally down-dropped with respect to the south block across most of the northeast-trending faults, indicating a genetic relationship to the similarly trending, fault-bounded Cache Creek Uplift (Norris, 1973). Accordingly, this feature must have formed after the Fish River Group was deposited, probably in early Tertiary time.

Faults which offset large blocks of Fish River strata also extend into the Albian and older rocks of the adjacent northern Richardson Mountains and comprise the major faults in that region. However, the older rocks contain more ~~closely~~ closely spaced faults and tighter folds, oriented mainly along north-south or northeast-southwest axes, and were probably deformed prior to Upper Cretaceous sedimentation. This, plus the fact that Fish River Group sediments onlap structures in the slightly older shales as suggested by Mountjoy (1967a), indicate that tectonism occurred in early to mid-Late Cretaceous time. As well, a postdepositional tectonic episode must have affected the Upper Cretaceous sediments, and may have caused as much mountainous relief as the earlier episode. The thick wedges of Eocene and younger coarse clastics in the subsurface of Mackenzie Delta were probably derived from such Laramide uplifts.

ECONOMIC GEOLOGY

The Fish River Group and Reindeer Formation are ~~is~~ important economically because of their ~~its~~ coal deposits and probable ~~potential~~ petroleum and natural gas reserves.

~~Coal~~ COAL

Coal seams are thin and rare in the basal sandstone member of the Moose Channel Formation but relatively thick and numerous in the Aklak Member. Coal was mined at Moose River Mine on the western bank of Mackenzie Delta from a vertically inclined series of beds in the Aklak. This mine operated successfully for many years, supplying coal for domestic use in the Aklavik area until 1956 when the mine was abandoned. ~~to fuel the electrical power plant at Aklavik. In 19__ fuel oil replaced coal to generate power, the coal mining was discontinued.~~ Coal samples from this mine submitted to the Mines Branch by B.A. Latour for analysis were classified as sub-bituminous "A" to high volatile "C" bituminous in rank, and determined to have a calorific value of 11,080 B.T.U. per pound. (Mines Branch, Fuel Research Lab Report 2926-55).

On Aklak Creek which flows into Coal Mine Lake where the mine was located, two coal beds outcrop, the lower being about 23 feet thick, and the higher, some 250 feet stratigraphically above, being 12 feet thick. Both units contain about 30% coaly mudstone interbeds. Faults cause difficulties in determining the areal extent of these seams, including the ones mined, but at least 6800 acres (2750 hectares ~~acres~~) must be underlain by substantial coal seams less than 1500 fe below the surface. Coal seams up to 3 feet thick are also noted on Eagle Creek, and were reported by D.K. Norris (1972) from the Deep Creek area (Lat 68°53' N., Long. 138°02' W.).

Coal samples from various outcrop localities and the I.O.E. Ellice O-14 and Gulf et al. Reindeer D-27 boreholes were analysed for vitrinite reflectance by P. Gunther of the Geological Survey (Table VI). As determined from empirical curves relating proportions of volatile matter to reflectance values, the comparable A.S.T.M. coal ranks range from high-volatile bituminous-A to -C. Note that coal from Eagle Creek is of slightly higher rank than that of the Big Fish River area. This trend reflects the gradual increase in paleotemperatures and tectonic deformation from east to west towards Blow River. Coal samples of the Reindeer D-27 borehole are lower in rank than those of the Ellice O-14 well or the outcrop samples. The Trail River sample is comparable in rank to the coals of Big Fish River and the Ellice borehole.

PETROLEUM GEOLOGY

Prospective Formations

Sandstone units in the Fish River Group and overlying Reindeer Formation are highly prospective for petroleum and natural gas in the subsurface of northwestern Mackenzie Delta and adjacent Beaufort Sea shelf (Lerand, 1973). Intertonguing deltaic and marine shale facies, such as those exhibited by these rocks, constitute zones of prolific petroleum production in many areas, including the Gulf Coast of southern U.S.A. (Lowman, 1949; Rainwater, 1963). Substantial gas reserves are already indicated in transition-zone facies of the Reindeer Formation in the Taglu field under northern Mackenzie Delta.

Marine to non-marine transition zones in the Moose Channel and Reindeer Formations, and isolated thick developments of the Cuesta Creek Member comprise the main prospective parts of the Upper Cretaceous-Lower Tertiary sequence.

In the Moose Channel Formation the delta-plain facies is transitional with marine mudstones in the I.O.E. Ellice O-14 borehole (Fig. 32), which probably lies within a northwest-southeast trending zone which passes through Ellice and Langley Islands marking the area most favourable for finding trapped hydrocarbons in this formation. The delta-plain facies (Aklak Member) of the lower Reindeer Formation apparently extended farther to the northeast than that of the Moose Channel Formation , as evidenced by its presence in the Ellice O-14 borehole, onshore paleocurrent trends, and its transition-zone character in the Taglu G-33 borehole. This prospective zone includes the Taglu field and probably trends northwest-southeast under southwestern Richards Island and the northern part of the Mackenzie Delta Plain.

The largest reservoirs appear to be formed in rollover and domical anticlines associated with growth faults (Lerand, 1973, p.332). These structures can be located by seismic and gravity surveying (Sirrine, G. K., reported in Oilweek, Nov. 19, 1973), and result in stacked sandstone reservoirs having large net pay thicknesses.

The Cuesta Creek Member of the Tent Island Formation is an important potential reservoir for hydrocarbons, particularly in the vicinity of anticlines beneath the coastal plain and Beaufort Sea shelf . This sandstone and conglomerate unit has the advantages of being lenticular in nature (Silver, 1973), and being sandwiched between two thick marine shale formations. Factors which detract from its prospectiveness include the presence of fresh water within the unit, breaching of most mapped anticlines on the coastal plain to stratigraphic

levels below the Cuesta Creek, and tectonic disturbance in the areas of Rapid Creek and Blow River.

The Cuesta Creek Member was tested in the I.O.E. Blow River E-47 borehole in the depth-interval 3,260-3,403 feet. Excellent permeability of the tested conglomeratic sandstone is indicated by the 3,050 feet of fresh water recovered. Because the sample-cuttings appear non-porous, the good permeability may in part be due to open fractures in the rock. Fractures occur in a core cut just above the tested interval, and appear as slickensided surfaces and open tension gashes. Quartz veins and fault-brecciation are also present.

Some Factors Affecting Petroleum Potential

Tectonic deformation and its timing relative to deposition and sediment burial, the quality of porosity, and geothermal history all have a bearing on petroleum potential. Following are some findings on these factors which resulted from this research.

As discussed in the previous chapter the Fish River Group and Aklak Member of the Reindeer Formation west of Mackenzie Delta were folded and faulted during a late Laramide tectonic episode. The north-south aligned folds and faults become more closely spaced in the vicinity of lower Rapid Creek (Fig.1), commensurate with increased brittleness of shales, quartz veining, and other signs of intensified deformation westward. This tectonism probably resulted in flushing of hydrocarbons by groundwater or hydrothermal waters, reduction of porosity, greater heat flow and a great reduction in petroleum potential in the Blow River area. West of Blow River the intensity of deformation lessens, and the petroleum potential in turn probably increases.

Porosity of surface sandstones is low due to their high degree of compaction and the presence of calcite cement. Similar textures were visually noted in cores of correlative rocks in the I.O.E. Ellice O-14 borehole. However, core analyses in Ellice O-14 indicate effective porosities of 10 to 30% at depths down to about one mile. This is reflected in the fact that 4,350 feet of salt water were recovered during a drill-stem test of the interval 4,866 - 4,916 feet. Porosity gradually decreases downhole to ineffective values according to porosity analyses of cores. A sandstone core from 7,900 feet depth showed porosities in the range of only 1 - 10%.

Associated with deep burial is the increase in temperature due to the outward flow of geothermal heat through the earth's crust. Because increased temperature has an important bearing on petroleum genesis and preservation (Philippi, 1965), a brief review of thermal indicators in the Reindeer Formation, Fish River Group and the underlying Albian flyschoid sediments follows.

Indicators of thermal history include the color of sedimentary organic matter, coal ranks, and the presence of certain authigenic ~~and hydrothermal~~ minerals. These features provide an estimate of maximum temperatures because of their irreversible nature.

The pale yellow and brown colours of spores, pollen and other plant debris recovered from outcrop samples of Fish River Group rocks in the eastern outcrop area indicate low degrees of thermal alteration (Staplin, 1969). Analcime was reported by Holmes (1972) in a recrystallized tuff from the Moose Channel Formation on Aklak Creek. In the presence of quartz, analcime becomes unstable at temperatures greater than 200°C. and at pressures less than 2000 bars (Liou, 1971), and converts into albite and water. Hence, its presence indicates that temperatures in the host-rock have never exceeded 200°C.

In the I.O.E. Ellice O-14 borehole, thermal metamorphism of organic materials apparently increases with depth, as Brideaux noted that "[plant] material becomes progressively more carbonized downhole until a dark brown color is reached in cores 10 to 12" (8,873 feet to 9,523 feet). The dark brown color would fall into Staplin's (1969) thermal index 2.5 to 3, and would correspond to the temperatures at which both light and heavy hydrocarbons would be generated.

TABLE VI Results of coal reflectance measurements, Moose Channel and Reindeer Formations

Locality or Borehole	Fm.	Sample No. or depth in well	Coal Reflectance Average %Ro	Std. Dev.	% VM of Vitrinite (from Kötter's curve)	Comparable ASTM rank
Big Fish River	MC	29 YA	0.70	.038	39	High volatile bituminous -A
	MC	34 YA-4	0.63	.041	41	HVB-B
	MC	34 YA-8	0.66	.060	41	HVB-B
	MC	141b YA-1	0.61	.018	42	HVB-B
Aklak Creek	R	13 YAb-1	0.63	.041	41	HVB-B
	R	14 YAb-2	0.63	.049	41	HVB-B
Eagle Creek	R	33a YAb-2	0.71	.039	38	HVB-A
	MC	140 YA-2	0.76	.030	37	HVB-A
Caribou Hills	R	198 YA-7	0.25	.071	>56	Lignite
Trail River	MC	180 YA-4	0.62	.015	42	HVB-B
I.O.E. Ellice O-14	R	4270-4280	0.62	.056	41	HVB-B
	R	5000-5010	0.59	.043	42	HVB-B
	R	5500-5510	0.62	.046	41	HVB-B
	R	5580-5590	0.65	.039	40	HVB-B
	MC	8590-8600	0.68	.080	39	HVB-A
	MC	8920-8930	0.74	.046	37	HVB-A
Gulf-Shell-IOE Reindeer D-27	R	3697--3705'	0.55	.018	44	High Volatile Bituminous-C
	R	4763'	0.48	.075	46	H.V.B.-C
	MC	5310' } separate samples	0.58	.028	42	H.V.B.-C
	MC	5310' } separate samples	0.52	.031	45	H.V.B.-C
	MC	6100'	0.55	.038	44	H.V.B.-C

The ranks of coals gradually increase downsection in the I.O.E. Ellice O-14 borehole (Table VI), paralleling the gradual occlusion of porosity and permeability of sandstones, and the increase in brown coloration of palynomorphs. According to some unpublished data relating coal reflectance to temperature the paleotemperatures in the Ellice O-14 borehole between the depths 4,270 and 8,930 feet were approximately 85° and 103°C. (Gunther, Internal Rept. CP73-R3). Hence paleotemperatures in the Reindeer D-27 well were probably somewhat less than 85°C.

According to Philippi (1965) temperatures of about 150°C. were required to generate oil in the young sediments of the Los Angeles Basin, but in the Paris Basin of France, a temperature of only 60°C. at a depth of approximately 5,000 feet was sufficient to generate oil from kerogen (Tissot et al. 1971). Possibly a time-factor plays a role in the generation of oil, because the Paris Basin sediments enriched in petroleum are Jurassic in age. Nevertheless, because the Upper Cretaceous rocks considered here lie within the depth- and temperature-ranges deemed to be productive of immature gas and oil, they are highly prospective in the subsurface of Mackenzie Delta and offshore coastal areas.

REFERENCES

Allen, J.R.L.
1965: Fining-upwards cycles in alluvial successions; Geol. Jour., v. 4, p. 229-246.

Allen, J.R.L. and Friend, P.F.
1968: Deposition of the Catskill Facies, Appalachian region: with notes on some other Old Red Sandstone basins; Geol. Soc. Am., Special Paper 106, p. 21-74.

Balkwill, H.R.
1971: Reconnaissance geology, southern Great Bear Plain, District of Mackenzie; Geol. Surv. Can., Paper 71-11.

Bamber, E.W. and Waterhouse, J.B.
1971: Carboniferous and Permian stratigraphy and Paleontology, northern Yukon Territory, Canada; Bull. Can. Petrol. Geol., v. 19, p. 29-251.

Beerbower, J.R.
1964: Cyclothems and cyclic depositional mechanisms in alluvial plain sedimentation; Kans. Geol. Surv. Bull., Merriam, D. F. ed., p. 31-42.

Bernard, H.A. and Major, C.J.
1963: Recent meander belt deposits of the Brazos River: an alluvial "sand" model; (Abstr.) Bull. Am. Assoc. Petrol. Geologists, v. 47, p. 350.

Brideaux, W.W.
1971: Palynologic evidence for a very late Cretaceous age of Little Bear and East Fork Formations, District of Mackenzie; in Report of Activities, Part B: November 1970 to March 1971, Blackadar, R.G. ed., Geol. Surv. Can., Paper 71-1, Part B, p. 86-91.

1973: Cretaceous and Tertiary assemblages (palynomorphs), I.O.E. Ellice O-14; in Biostratigraphic determinations of fossils from the subsurface of the Yukon Territory and the Districts of Franklin, Keewatin and Mackenzie, B.S. Norford et al., Geol. Surv. Can., Paper 72-38, p. 2-5.

Chamney, T.P.
1972: Biostratigraphic contributions from the Arctic Coastal Plain west of the Mackenzie River Delta; in Report of Activities, May to October, 1971, Blackadar, R.G. ed., Geol. Surv. Can., Paper 72-1, Part A, p. 202-203.

Chamney, T.P.
1973a: Tertiary and Mesozoic micropaleontology sampling, west flank of the Mackenzie River Delta, District of Mackenzie; in Report of Activities, April to October, 1972, Blackadar, R.G. ed. Geol. Surv. Can., Paper 71-1A, p. 253.

1973b: Tuktoyaktuk Peninsula Tertiary and Mesozoic biostratigraphy correlations; in Report of Activities, November 1972 to March 1973, Blackadar, R.G. ed., Geol. Surv. Can., Paper 73-1, Part B, p. 171-178.

Chen, Pei-Yuan
1968: A modification of sandstone classification; J. Sediment Petrol., v. 38, p. 54-60.

Coleman, J.M., and Gagliano, S.M.
1965: Sedimentary structures: Mississippi River deltaic plain; Soc. Econ. Paleontologists and Mineralogists, Spec. Publ. no. 12, p. 133-148.

Coleman, J.M. and Wright, L.D.
1971: Analysis of major river systems and their deltas; procedure and rationale, with two examples; Louisiana State University, Central Studies Institute, Technical Report no. 95.

Davies, D.K., Ethridge, F.G. and Berg, R.R.
1971: Recognition of barrier environments; Bull. Am. Assoc. Petrol. Geologists, v. 55, p. 550-565.

Dott Jr., R.H., and Roshardt, M.A.
1972: Analysis of cross-stratification orientation in the St. Peter Sandstone in southwestern Wisconsin; Bull. Geol. Soc. Am., v. 83, p. 2589-2596.

Douglas, R.J.W., ed.
1970: Geology and Economic Minerals of Canada; Econ. Geol. Rept. No. 1, Geol. Surv. Can., 838 p.

Dutro, J.T., Jr., Brosgé, W.P. and Reiser, H.N.
1972: Significance of recently discovered Cambrian fossils and reinterpretation of Neruokpuk Formation, northeastern Alaska; Bull. Am. Assoc. Petrol. Geologists, v. 56, p. 808-815.

Dyke, L.D.
1971: Structural investigations in the White Uplift, northern Yukon Territory; in Report of Activities, April to October 1971, Geol. Surv. Can., Paper 72-1, Part A, p. 204-207.

Fisher, W.L.
1969: Facies characterization of Gulf Coast basin delta systems, with some Holocene anologues; Trans. Gulf Coast Assoc., Geol. Societies, XIX, p. 239-261.

Folk, R.L.
1968: Bimodal supermature sandstones, product of the desert floor; 23rd. Intern. Geol. Congr., Proc. Sect. 8, p. 9-32.

Gabrielse, H.
1967: Tectonic evolution of the northern Canadian Cordillera; Can. J. Earth Sci., v. 4, p. 271-298.

Green, L.H.
1972: Geology of Nash Creek, Larsen Creek, and Dawson map-areas, Yukon Territory; Geol. Surv. Can., Mem. 364, 157 p.

Griffiths, J.C.
1967: Scientific method in analysis of sediments; The McGraw-Hill Book Co., New York, 508 p.

Häntzschel, W.
1939: Tidal flat deposits; in Recent Marine Sediments; Trask, P.D., ed., Soc. Econ. Paleontologists and Mineralogists. p. 195-209.

Holmes, D.W.
1972: Moose Channel clastics of the Fish River area, Northwest Territories; unpubl. M.Sc. Thesis, Univ. of Calgary, 104 p.

Holmes, D.W., and Oliver, T.A.
1973: Source and depositional environments of the Moose Channel Formation, Northwest Territories (Abstr.); Symposium on the Geology of the Canadian Arctic, Saskatoon, Sask., May 1973, Program and Abstracts, p. 12.

OMIT

Hornal, R.W., Sobczak, L.W., Burke, W.E.F. and Stephens, L.E.
1970: Preliminary results of gravity surveys over the Mackenzie Basin and Beaufort Sea; Dept. Energy, Mines and Resources, Ottawa, Canada, Earth Physics Branch, Gravity Map Series Nos. 117, 118 119.

OMIT

Howard, J.D.
1972: Trace fossils as criteria for recognizing shorelines in the stratigraphic record; in Recognition of Ancient Sedimentary Environments, Rigby, J.K. and Hamblin, W.K. eds., Soc. Econ. Paleontologists and Mineralogists, Spec. Publ. 16, p. 215-225.

Klein, G. de V.
1957: Comparisons of recent and ancient tidal flat and estuarine sediments; in Estuaries, Am. Assoc. Adv. Science, p. 207-218.

Imlay, R.W. and Detterman, R.L.
1973: Jurassic paleobiogeography of Alaska; U.S. Geol. Surv., Prof. Paper 801.

Klein, G. de V.
1971: Environmental model for some sedimentary quartzites; (Abstr.) Bull. Am. Assoc. Petrol. Geologists, v. 55, p. 347.

Jeletšky, J.A.
1958: Uppermost Jurassic and Cretaceous rocks of Aklavik Range, northeastern Richardson Mountains, Northwest Territories; Geol. Surv. Can., Paper 58-2.

1960: Uppermost Jurassic and Cretaceous rocks, east flank of Richardson Mountains between Stony Creek and lower Donna River, Northwest Territories; Geol. Surv. Can., Paper 59-14.

1961: Upper Jurassic and Lower Cretaceous rocks, west flank of Richardson Mountains between the headwaters of Blow River and Bell River, Yukon Territory, Geol. Surv. Can., Paper 61-9.

1962: Pre-Cretaceous Richardson Mountains Trough; its place in the tectonic framework of Arctic Canada and its bearing on some geosynclinal concepts; Trans. Roy. Soc. Can., v. 54, p. 55-83.

1967: Jurassic and (?) Triassic rocks of the eastern slope of Richardson Mountains, northwestern District of Mackenzie; Geol. Surv. Can., Paper 66-50.

1970: Marine Cretaceous biotic provinces and paleogeography of western and Arctic Canada: illustrated by a detailed study of ammonites; Geol. Surv. Can., Paper 70-22.

1971: Stratigraphy, facies and paleogeography of Mesozoic rocks of northern and west-central Yukon; in Report of Activities, April to October 1970, Blackadar, R.G. ed., Geol. Surv. Can., Paper 71-1, Part A, p.203-221.

Leffingwell, E. de K.
1919: The Canning River region, northern Alaska; U.S. Geol. Surv., Prof. Paper 109.

Lenz, A.C.
1972: Ordovician to Devonian history of northern Yukon and adjacent districts of Mackenzie; Bull. Can. Petrol. Geol., v. 20, p. 321-362.

Lenz, A.C. and Perry, D.G.
1972: The Neruokpuk Formation of the Barn Mountains and Driftwood Hills, northern Yukon, its age and graptolite fauna; Can. J. Earth Sci., v. 9, p. 1129-1138.

Liou, J.G.
1971: Analcime equilibria; Lithos v. 4, p. 389-402.

Lerand, M.
1973: Beaufort Sea; in Future Petroleum Provinces of Canada — their geology and potential, McCrossan, R.G., ed., Can. Soc. Petrol. Geologists, Mem. 1, p.315-386.

Lowman, S.W.
1949: Sedimentary facies in Gulf Coast; Bull. Am. Assoc. Petrol. Geologists, v. 33, p. 1939-1997.

Martin, L.J.
1959: Stratigraphy and depositional tectonics of the north Yukon-lower Mackenzie area, Canada; Bull. Am. Assoc. Petrol. Geologists, v. 43, p. 2399-2455.

McKee, E.D.
1966: Structures of dunes at White Sands National Monument, New Mexico (and a comparison with structures of dunes from other areas); Sedimentology, v. 7, p. 3-69.

Mertie, J.B., Jr.
1937: The Yukon-Tanana Region, Alaska; U.S. Geol. Surv., Bull. 872.

Miall, A.D.,
1974: Stratigraphy of the Elf et al. Storkerson Bay A-15 well; in Report of Activities, May to October, 1973, Blackadar, R.G. ed., Geol. Surv. Can., Paper 74-1, Part A.

Mountjoy, E.W.
1967a: Upper Cretaceous and Tertiary stratigraphy, northern Yukon, and northwestern District of Mackenzie; Geol. Surv. Can., Paper 66-16.

1967b: Triassic stratigraphy of northern Yukon Territory; Geol. Surv. Can., Paper 66-19.

Norris, D.K.
1970: Structural and stratigraphic studies, Blow River area, Yukon Territory and western District of Mackenzie; in Report of Activities, Part A: April to October, 1969, Blackadar, R.G. ed., Geol. Surv. Can., Paper 70-1, Part A, p. 230-235.

1971: Tectonic complex, northern Yukon and western District of Mackenzie, Canada; (Abstr.) in Program of 24th Ann. Mtg., Rocky Mountain Section, Geol. Soc. Am., p. 398-399.

1972b: En echelon folding in the northern Cordillera of Canada; Bull. Can. Petrol. Geol., v. 20, p. 634-642.

1973: Tectonic styles of northern Yukon Territory and northwestern District of Mackenzie, Canada; in Arctic Geology, Pitcher, M.G. ed., Am. Assoc. Petrol. Geologists., Memoir 19, p. 23-40.

1974: Structural and stratigraphic studies in the northern Canadian Cordillera; in Report of Activities, Part A: April to October 1973, Blackadar, R.G. ed., Geol. Surv. Can., Paper 74-1, Pt. A, p.343-349.

1972a: Structural and stratigraphic studies in the Tectonic Complex of northern Yukon Territory, north of Porcupine River; in Report of Activities, Part B: November 1971 to March 1972, Blackadar, R.G., ed., Geol. Surv. Can., Paper 72-1, Pt. B, p. 91-99.

Norris, D.K. and Price, R.A.
1963: Geology of northern Yukon Territory and northwestern District of Mackenzie; Geol. Surv. Can., Map 10-1963.

O'Neill, J.J.
1915: Canadian Arctic Expidition; Geol. Surv. Can., Summ. Rept. for 1914, p. 112-115.

1924: Report of the Canadian Arctic Expedition, 1913-1918, v. 11: Geology and Geography; Part A: The Geology of the Arctic Coast of Canada, west of the Kent Peninsula, p. 1A-107A. Government Printer, Ottawa.

Oomkens, E.
1970: Depositional sequences and sand distribution in the Post-glacial Rhône delta complex; in Deltaic Sedimentation, Modern and Ancient, Morgan, J.P. ed., Soc. Econ. Paleontologists and Mineralogists, Spec. Publ. 15, p. 198-212.

Ore H.T.
1965: Characteristics of rapidly aggrading streams; in Wyoming Geol. Assoc. Guidebook, 19th Field Conf., Sedimentation of Late Cretaceous and Tertiary Outcrops, p. 195-201.

Pettijohn, S.J.
1957: Sedimentary Rocks; Harper and Bros., New York, N.Y., 2nd ed., 718 p.

Philippi, G.T.
1965: On the depth, time and mechanism of petroleum generation; Geochim. et Cosmochim. Acta, v. 29, p. 1021-1049.

Pirson, S.J.
1970: Geologic well log analysis; Gulf Publishing Co., Houston, Texas, 370 p.

Plauchut, B.P.
1971: Geology of the Sverdrup Basin; Bull. Can. Petrol. Geol., v. 19, p. 659-679.

Potter, P.E. and Pettijohn, F.J.
1963: Paleocurrents and basin analysis; Acad. Press Inc., Publ., New York, N.Y., 296 p.

Powers, M.C.
1953: Comparison chart for visual estimation of roundness; J. Sediment. Petrol., v. 23, p. 117-119.

Reineck, H.E. and Singh, I.B.
1972: Genesis of laminated sand and graded rhythmites in storm-sand layers of shelf mud; Sedimentology, v. 18, p. 123-128.

Rainwater, E.H.
1963: The environmental control of oil and gas occurrence in terrigenous clastic rocks; Gulf Coast Assoc. Geol. Soc., Trans., v. 13, p. 79-94.

Rouse, G.E. and Srivastava, S.K.
1972: Palynological zonation of Cretaceous and early Tertiary rocks of the Bonnet Plume Formation, northeastern Yukon, Canada; Can. J. Earth Sci., v. 9, p. 1163-1179.

Russell, D.A.
1967: Cretaceous vertebrates from the Anderson River, N.W.T.; Can. J. Earth Sci., v. 4, p. 21-39.

→ Silver, 1973 (see below)

Smiley, C.J.
1967: Paleoclimatic interpretations of some Mesozoic floral sequences; Bull. Am. Assoc. Petrol. Geologists., v. 51, p. 849-863.

1969a: Cretaceous floras of Chandler-Colville region, Alaska: Stratigraphy and preliminary floristics; Bull. Am. Assoc. Petrol. Geologists, v. 53, p. 482-502.

1969b: Floral zones and correlations of Cretaceous Kukpowruk and Corwin Formations, northwestern Alaska; Bull. Am. Assoc. Petrol. Geologists, v. 53, p. 2079-2093.

Smith, N.D.
1970: The braided stream depositional environment: comparison of the Platte River with some Silurian clastic rocks, north-central Appalachians; Bull. Geol. Soc. Am., v. 81, p. 2992-3014.

→ Sobczak, et al.

Staplin, F.L.
1969: Sedimentary organic matter, organic metamorphism, and oil and gas occurrence; Bull. Can. Petrol. Geol., v. 17, p. 47-66.

Sternberg, H.
1875: Untersuchungen uber langen-und guerprofil geschiebefuhrende Flusse; Z. Bauwesen, v. 25, p. 483-506.

Thomson, A.
1959: Pressure solution and porosity; in Silica in sediments; Soc. Econ. Paleontologists and Mineralogists, Spec. Publ. 7, p. 92-110.

Van Straaten, L.M.J.U.
1961: Sedimentation in tidal flat areas; J. Alberta Soc. Petrol. Geologists, v. 9, p. 203-226.

Tissot, B., Califet-Debyser, Y., Deroo, G., and Oudin, F.L.
1971: Origin and evolution of hydrocarbons in Early Toarcian shales, Paris Basin, France; Bull. Am. Assoc. Petrol. Geologists, v. 55, p. 2177-2193.

Sobczak, L.W., Stephens, L.E., Winter, P.J., and Hearty, D.B.
1973: Gravity measurements over the Beaufort Sea, Banks Island and Mackenzie Delta; Gravity Map Series of the Earth Physics Branch, Dept. of Energy, Mines and Resources, Canada, 16 pp.

Silver, C.
1973: Entrapment of petroleum in isolated porous bodies; Bull. Am. Assoc. Petrol. Geologists, v. 57, p. 726-740.

Visher, G.S.
1965a: Use of vertical profile in environmental reconstruction; Bull. Am. Assoc. Petrol. Geologists, v. 49, p. 41-61.

1965b: Fluvial processes as interpreted from ancient and recent fluvial deposits; Soc. Econ. Paleontologists and Mineralogists, Spec. Publ. 12, p. 116-132.

1972: Physical characteristics of fluvial deposits; in Recognition of Ancient Sedimentary environments, J.K. Rigby and W.K. Hamblin, eds., Soc. Econ. Paleontologists and Mineralogists, Spec. Publ. No. 16, p. 84-97.

Walker, T.R.
1967: Formation of red beds in modern and ancient deserts; Bull. Geol. Soc. Am., v. 78, p. 353-368.

Wright, L.D. and Coleman, J.M.
1972: River delta morphology: wave climate and the role of the sub-aqueous profile; Science 176, p. 282-283.

Wünderlich, F.
1970: Genesis and environment of the "Nellenkopfschenschichten" (Lower Emsian, Rheinian Devonian) at locus typicus in comparison with modern coastal environments; J. Sediment. Petrol. v. 40, p. 102-130.

Yorath C.J. 1973:
1973: Geology of Beaufort-Mackenzie Basin and eastern part of northern Interior Plains; Am. Assoc. Petrol. Geologists, Mem. 19, Pitcher, M.G. ed., p. 41-47.

Yorath, C.J. and Balkwill, H.R.
1970: Stanton map-area, Northwest Territories (107D); Geol. Surv. Can., Paper 69-9.

Yorath, C.J., Balkwill, H.R., and Klassen, R.W.
in press: Franklin Bay (97C) and Malloch Hill (97F) map-areas, District of Mackenzie; Geol. Surv. Can., Paper

Young, F.G.
1971: Mesozoic stratigraphic studies, northern Yukon Territory and northwestern District of Mackenzie; in Report of Activities, Part A: April to October, 1970, Blackadar, R.G. ed., Geol. Surv. Can., Paper 71-1, Part A., p. 245-247.

1972: Cretaceous stratigraphy between Blow and Fish Rivers, Yukon Territory; in Report of Activities, May to October 1971, Blackadar, R.G., ed., Geol. Surv. Can., Paper 72-1, Part A, p. 229-235.

in press: Mesozoic epicontinental, flyschoid and molassoid depositional phases of Yukon's north slope; in Symposium on the Geology of the Canadian Arctic, J.D. Aitken, ed.

APPENDIX A

DESCRIPTIONS OF STRATIGRAPHIC SECTIONS

Section 1

Type section of Boundary Creek Formation, Boundary Creek, Y.T., on northern bank immediately upstream from confluence with Big Fish River at Lat. 68°30'30"N, Long. 136°23'50"W. Measured partly by D.H. McNeil and partly by T.P. Chamney, June 1971. *Air photo A14361-26, top of section at X= ~~-3.4~~ +0.90 cm, Y=1.25 cm.; base at X= -3.40 cm., Y= +2.00 cm.*

Unit	Description	Thickness (feet)	Distance Above Base
	Overlying interbedded mudstone and sandstone of Cuesta Creek Member, Tent Island Formation. *Contact is covered here, but believed to be disconformable.*		
	Boundary Creek Formation (794 ± 40 feet)		
22	Covered interval	20	794
21	Shale, poorly exposed, interbedded pale grey and pale yellow varieties, the latter probably bentonitic, wavy bedding characteristic, selenite crystals common in scree	80	774
20	Shale, dark grey to black, flaky to papery, in part soft and plastic; 2- to 4-inch bentonite beds common, pale yellow-brown; large septarian nodules up to 5 feet in diameter; selenite encrustations on many bedding planes	46	694
19	Shale, dark grey, papery, with very thin-bedded white bentonite; pale yellow coatings common	27	648
18	Silty mudstone, orange-brown to burgundy red marker bed, variegated purplish weathered surfaces	3	621
17	Shale, medium to dark grey, fissile, recessive-weathering, orange- and yellow-weathering; common yellow bentonite layers	30	618
16	Shale, as above, with few clay ironstone concretions, in part papery, darker grey, possible fish scale and bone impressions	30	588
15	Shale, grey, soft, fissile in part, white to yellow bentonite bands becoming more common towards top; minor ironstone concretions	85	558
14	Bentonite marker bed, yellowish white, very soft, homogeneous	1	473
13	Shale, mahogany-brown-weathering, relatively resistant, grey; silty lime mudstone beds at top and base, minor hard, flaggy, pale yellow claystone beds	25	472
12	Mudstone, calcareous, dark brown, laminated, irregular bottom surface, even upper surface	1	447

Unit	Description	Thickness (feet)	Distance Above Base
11	Shale, black, grey-black-weathering, flaky, petroliferous odour, bentonite seams very common, selenite crystals common, calcareous concretions 1 to 6 inches across	74	446
10	Shale, brown-black, flaky, weathers grey to rusty brown, soft, clayey, recessive-weathering, poorly exposed	28	372
9	Limestone, bioclastic and quartz sandy, medium to dark grey, fine-grained, light and dark laminae, cross-laminated, thin-bedded, interbedded with shale, 50%, grey-black	18	344
8	Shale, soft, poorly exposed, rare thin beds of calcareous mudstone	40	326
7	Covered interval	55	286
6	Shale, brown-black, clayey, very soft, selenite crystals common, H_2S-odour when struck, two limestone beds, echinodermal calcarenite, rusty weathering, dark grey, fine-grained, beds 0.5-foot thick	13	231
5	Shale, as above, with thin bentonite seams very common (1 to 5 feet apart); very thin beds of calcareous mudstone minor	26	218
4	Interbedded rusty-weathering and black shales	6	192
3	Interbedded rusty and grey shales, capped by hard calcareous mudstone bed, 0.5 to 1.0 foot thick, possible fine bone impressions; rusty, highly weathered basal bed, 1.5 feet thick	13	186
2	Shale, grey-black, grey-weathering, clayey, soft, fine chippy, light grey and yellow bentonitic bands, 5% calcareous mudstone beds, rusty and hackly weathering; selenite crystals common	45	173
1	Alternating types of shale, including soft, grey-black, pyritic, flaky shale with bentonite bands, and rusty-weathering, brown-black shale, moderately hard, chippy; all brick-red weathering, hematitic locally; sharp contact at base	128	128
	Bedded ironstone and shale unit (Lower Cretaceous).		

Section 2

Type-section of Cuesta Creek ~~Formation~~ Member, located on northwest bank of Big Fish River just downstream from confluence with Boundary Creek at Lat. 68°30'30"N., Long. 136°23'50"W. Measured by D.H. McNeil, June 1971. Air photo A14361-26; top of section at X=+1.15cm., Y=+1.80cm.; base of section at X=+0.90cm., Y=+1.26cm.

Unit	Description	Thickness (feet)	Distance Above Base (feet)
	Overlying silty ~~shale~~ mudstone of Tent Island Formation		
	Cuesta Creek ~~Formation~~ Member, Tent Island Formation		
10	Conglomerate (60%) and interbedded sandstone (40%). Conglomerate is rusty grey-weathering, pebbly, medium- to thick-bedded, contains well rounded phenoclasts of chert and mudstone and medium-grained sand matrix; sandstone is medium grey, weathering grey to rust, medium-grained, quartz-chert arenite, very hard, resistant to erosion, medium-to thick-bedded. Sharp contact with Unit 9.	68	326
9	Mudstone, shaly, dark brown, grey-weathering, silty, chunky fracturing, weathers into brittle chips and flakes. Sharp contact with Unit 8.	59	258
8	Sandstone, brown-weathering, light grey-brown, medium-grained, slightly porous, quartz-chert lithic arenite, medium-bedded, resistant to erosion, fractures into angular slabs. Gradational contact with Unit 7.	7	199
7	Conglomerate (70%) and interlensed sandstone (30%). Conglomerate, rusty grey, mainly pebbly but phenoclasts up to one foot wide, lithic sand matrix, thick-bedded to massive, very resistant; sandstone, medium grey, orange-weathering in part, medium-grained, poorly sorted, subangular quartz and black chert and lithic grains, slightly porous, medium- to thick-bedded, beds visibly lenticular, very hard and resistant to erosion. Contact with Unit 6 sharp and even.	31	192
6	Shale, silty, dark brown, brown-grey weathering, hard, chippy-weathering; sandy concretions 3" to 1' wide, up to 6" thick. Laminated sandstone beds at base about 1 foot thick, contain plant-stem fragments. Sharp basal contact.	14	161

Unit	Description	Thickness (feet)	Distance Above Base (feet)
5	Sandstone, medium grey, light grey-weathering, rusty coloured in places, fine- to medium-grained, quartzose with 30% rusty and black grains, porous, very hard, medium- to thick-bedded; pebbly layers common near base, contain shale-clasts.	22	147
4	Shale, silty, brown, brownish grey-weathering, weathers into brittle chips and flakes.	9	125
3	Covered interval. Slope debris suggests mudstone and minor sandstone.	66	116
2	Silty shale (80%) and sandstone (20%) interbedded; shale is brownish black, brownish grey-weathering, silty, contains abundant brown-coloured matter, weathers to brittle chips and flakes; sandstone is fine-grained, micaceous, laminated, in very thin, discontinuous beds up to 1" thick. Gradational contact with Unit 1.	11	50
1	Mudstone, silty (60%) and interbedded sandstone (40%); mudstone is dark brown, grey-weathering, massive, chunky, recessive relative to sandstone beds which are irregular in part, graded in part, and up to 1' thick; sandstone is fine-grained, micaceous, quartzose, lithic, argillaceous, laminated.	39	39

l/c Contact with ~~Yellow-weathering Shale Division~~ Boundary Creek Formation not exposed in covered interval which is about 20 feet thick.

165

Section 3

Type section of Tent Island Formation, located on steep bluffs of Big Fish River along a 5-mile stretch between the confluences of Boundary and Little Fish (Cache) Creeks. Composite section consists of several partial sections measured by T.P. Chamney and F.G. Young. Stratigraphic separations between partial sections determined graphically from field measurements, photographs, and maps. Top on air photo A14361-47 at X=1.45cm. Y=+1.30cm.
Base of section at top of Section 2.

Unit	Description	Thickness (feet)	Height above Base (feet)
	Overlying sandstone of Moose Channel Formation		
	Tent Island Formation, Mudstone member (2,803 feet ±140)		
37	Sandstone (50%) and interbedded shale (50%), poorly exposed, inaccessible, medium-bedded; shale is dark red-brown-weathering, medium grey; sandstone contains abundant carbonaceous particles on bedding surfaces	42	2,803
36	Shaly mudstone, poorly exposed in part, covered in part, forms recessive slopes; coal lenticles up to 1/2" thick commonly intercalated with yellow sandy clay and grey clay; upper 5' contain sandstone beds and carbonaceous shale	78± 5	2,761
35	Sandstone (50%) and interbedded shale (50%) in beds 0.1 to 1.5' thick, alternating, with sharp basal contacts; sandstone is greenish grey, medium-grained, quartzose and lithic, with scattered chert pebbles, laminated with coarse-grained and carbonaceous plant-debris layers; minor calcareous concretions and pebble-conglomerate lenses	57	2,683
34	Conglomerate, pebbly, sandy matrix, largest phenoclast approximately 50 mm in diameter; sharp, eroded contact on underlying beds	0.6	2,626
33	Sandstone and interbedded shale, minor, brown, thin- to medium-bedded; sandstone is greenish grey, medium-grained	2.2	2,625.4
32	Conglomerate, pebbly to cobbly; sand matrix is very coarse-grained, chert-lithic; phenoclasts include fragments of quartz, porcellaneous chert, jasperoid, and green granodiorite. Largest clast 210 mm in longest diameter	0.5	2,623.2
31	Sandstone, greenish grey, pale greenish grey-weathering, fine- to medium-grained with rare pebbles and lenses of pebbly conglomerate; one massive bed, laminated, sharp basal and upper contacts	5.0	2,622.7
30	Marlstone, medium brown-grey, orange-weathering, cryptocrystalline; one bed which grades laterally into interbedded shale and marlstone in one direction, and into limy, concretionary sandstone with coaly mudstone lentils in the opposite direction	1.5	2,617.7
29	Sandstone, medium yellow-grey-weathering, fine- to medium-grained mainly, with coarse-grained bands and pebbly conglomerate layers, the latter containing carbonized wood fragments; bedding planes show oscillation ripples and mud-cracks	5.2	2,616.2
28	Interval not examined, appears to be mainly light brown-weathering mudstone from a distance; visual and graphic estimates of thickness agree	100± 10	2,611
27	Mudstone, medium grey, soft, forms top of large eroded bank on northwest side of Fish River	60	2,511
26	Mudstone, medium grey, with yellow sulphurous bands and minor sand laminae, fine-grained; small lens of weakly consolidated pebble-conglomerate near top, cemented by jarosite and/or sulphur	30	2,451
25	Mudstone, light grey-weathering, poorly stratified, contains thin laminations of coal and sand, lenticular, yellowish grey-weathering	120	2,421

Unit	Description	Thickness (feet)	Height Above Base (feet)
24	Lower slope of bank covered by fine chips of orange-weathering mudstone	140	2,301
23	Covered interval. Calculated stratigraphic interval to top of next exposure downsection	350± 35	2,161
22	Claystone, shaly, medium grey, with thin beds of sand in basal 2 feet	13	1,811
21	Siltstone, pale yellow-weathering, dark grey, laminated, one lenticular bed	1	1,798
20	Alternating claystone and sand interbeds, very thin- to thin-bedded, claystone is brittle in part, with fragmental plant debris laminae, olive-yellow weathering. Lower contact gradational	28	1,797
19	Claystone (60%) and interbedded sand (40%); claystone is light grey in part, and in part brittle, ferruginous, brown-grey; beds less than 1" thick; sand is yellow-grey-weathering, fine- to medium-grained, parallel-laminated, in part cemented, in beds up to 8" thick, some carbonaceous plant debris laminae; unit has variegated and banded appearance	10	1,769
18	Shale, light grey, clayey, soft, stratified, orange-banded; 20% sand interbeds, parallel-laminated, 1-2" thick, fine- to coarse-grained, quartz-chert arenite, contain carbonaceous laminae	42	1,759
17	Covered interval. Partial section below measured one mile upstream. Calculated thickness of missing section	120± 12	1,717
16	Shale, medium grey, with rare limy beds, pale orange-grey-weathering, up to 0.5' thick, and silty, very fine-grained sandstone beds, thin- to medium-bedded, lenticular in basal 10 feet	76	1,597
15	Shale, medium grey, poorly stratified, brittle, flaky, with minor argillaceous silty limestone beds, less than 1" thick, commonly displaying cone-in-cone structures	64	1,521

Unit	Description	Thickness (feet)	Height Above Base (feet)
14	Shale, purplish brown-grey, semi-brittle, platy to flaky, with rare sandy siltstone beds, banded, and thin calcareous siltstone beds, commonly displaying cone-in-cone, shallow load-casts, and grooves	110	1,457
13	Mudstone, medium grey, thin-bedded, chunky fracturing; rare siltstone beds, soft; poorly exposed	120	1,347
12	Largely covered interval; thickness determined by graphic means; underlying section measured and described by T.P. Chamney (CR6A-71)	500± 50	1,227
11	Shale, green-grey, silty, non-calcareous, with minor siltstone beds, 3-6" thick at the top, displaying cone-in-cone structure	10	727
10	Mudstone, rusty brown-weathering, grading into green-grey at top; common 2-inch thick siltstone beds spaced about 5 feet apart, cone-in-cone structure common on bases of siltstone beds	30	717
9	Shale, grey, hard, silty, with common 2- to 3-inch flinty, calcareous siltstone beds spaced 5 to 10 feet apart and displaying cone-in-cone structure	240	687
8	Shale, grey, hard, sharp platy fracture, cliff-former, inaccessible	30	447
7	Shale, grey, hard, silty, with scattered 2-inch thick siltstone beds	100	417
6	Shale, grey, relatively less indurated and silty, with 2-inch siltstone beds spaced about 5 feet apart	40	317
5	Shale, grey, hard, silty, flinty fracture	20	277
4	Shale, grey to pale brown, indurated, alternating with softer, crumbly shale; indurated shale contains 3-inch thick concretionary lenses; minor 3-inch calcareous siltstone beds present near base and top	100	257

Unit	Description	Thickness (feet)	Height Above Base (feet)
3	Covered interval. Visual estimate	30± 6	157
2	Shale, medium grey, grey-brown-weathering, contains scattered chert pebbles. Visual estimate	100± 20	127
1	Shaly mudstone, dark brown, silty, chunky, with thin, discontinuous sand lenses (5%), dark grey, fine-grained, laminated, 1-inch thick	27	27

Top of Cuesta Creek ~~Formation~~ Member

Section 4

Type Section: Moose Channel Formation, Big Fish River, N.W.T., downstream from confluence with Little Fish (Cache) Creek at Lat. 68°33'01"N, Long. 136°15'30"W. Measured by F.G. Young during high-water runoff stage in June 1970. Air photo A 14361-46, top of section at X= +4.30 cm., Y= +1.20 cm.; base at X= -1.73 cm., Y= -5.11 cm.

Unit	Description	Thickness (feet)	Distance ~~Below Top~~ Above Base (feet)
	Overlying siltstone and shale of ~~Ellice Formation~~ Ministicoog Member.		
	Moose Channel Foramtion, Basal sandstone member (1,959 ± 100 feet)		
52	Sandstone, very fine-grained, silty, orange-brown-weathering, flaggy, poorly exposed; uneven shaly intercalations, ripple-marks	40	1,959 ~~1,934~~
51	Sandstone, fine- to coarse-grained, thick-bedded variety interbedded with thinly bedded, friable, shaly, fine-grained sandstone in about equal proportions; light brown-grey pebbly layers and pebble conglomerate beds, 1' - 2' thick; common shallow-dipping medium-scale cross-stratification	58	1,919 ~~1,894~~
50	Sandstone, pale brown-grey, medium- to coarse-grained slightly pebbly, beds 4" - 3'; minor shaly sandstone interbedded; rare pebble conglomerate beds with phenoclasts of maximum diameter 170 mm.; series of thin fining-upwards cycles, 2' - 5' thick, with sharp basal contacts	82	1,861 ~~1,836~~
	Moved upstream about one-half mile. Approximately continuous partial sections from graphic calculations.		
49	Sandstone, fine- to medium-grained, interbedded with laminated siltstone and friable, shaly sandstone, medium-grained; rare pebble layers; ripple-marks common; poorly exposed	30 ± 10	1,779 ~~1,754~~ ± 10
48	Sandstone, fine- to medium-grained, light brown-grey; beds 1' - 5', lenticular; 20% conglomerate in pod-like beds and interfingering with sandstone, in part scour-fillings in scours up to 10 feet deep	35	1,749 ~~1,724~~
47	Covered	40	1,714 ~~1,689~~

Unit	Description	Thickness (feet)	Distance ~~Below Top~~ Above Base (feet)
46	Sandstone, fine- to medium-grained mainly, rare pebbles, becomes partly coarse-grained in upper 3 feet with shallow cross-stratification in various orientations; interbedded friable, platy sandstone common; minor ripple-marks and small worm-burrows; poorly exposed	58	1,674 ~~1,649~~
45	Sandstone, medium-grained, moderately sorted, coarse- to very coarse-grained bands, pebbly in part, light brown-grey; feldspathic quartz-chert-slate litharenite; shallow-cross-stratification with gently scoured basal surfaces	57	1,616 ~~1,591~~
44	Covered, not measured directly (approx.)	25	1,559
43	Sandstone, medium- to coarse-grained, pebbly, thick-bedded; interbedded with recessive, covered rock, possibly mudstone in part	20.5	1,534
42	Conglomerate, pebbly, mostly less than 50 mm. diameter, in very coarse sand matrix, well consolidated; sharp basal contact, upper contact covered.	1.5	1,513.5
41	Sandstone, pale grey, fine-grained, scattered pebbles and cobbles; minor shallow cross-stratification, uniform	20	1,512
40	Covered, recessive slope	38	1,492
39	Sandstone, pale grey, pale greenish grey weathering, medium-grained, pebbly; interbedded brown shale in upper 5 feet; feldspathic quartz-chert-slate litharenite; load-casts with current lineations and burrows on undersurfaces of beds	21	1,454
38	Covered, recessive slope	26	1,433
37	Sandstone, fine- to medium-grained, uniform, thin- to medium-bedded, flaggy weathering habit; minor cross-stratification	7	1,407
36	Mainly covered, recessive, probably mostly shale. Basal conglomerate about 1 foot thick rests with erosional contact on resistant sandstone bed at top of Unit 35	10	1,400

Unit	Description	Thickness (feet)	Distance ~~Below Top~~ Above base (feet)
35	Sandstone, pale brown-grey, medium-grained with scattered very coarse grains and pebbles, laminated, massive, irregularly fractured; minor orange-weathering pebble conglomerate beds, 0.5'-1.0' thick in upper half, forming basal parts of medium- to large-scale cross-stratified sandstone beds.	66	1,390
34	Sandstone, light grey, fine- to coarse-grained, pebbly, thick-bedded; minor intercalated sandy, soft shale, whitish-grey, coal seamlets, and pebble conglomerate; woody plant fragments and comminuted carbonaceous plant debris on bedding surfaces.	15	1,324
33	Covered	6	1,309
32	Sandstone, medium-grained, resistant, ripple-marks at top, cross-stratified; base is bioturbated; 2' - 4' beds	10	1,303
31	Shale, dark grey, very recessive, 60%, 1' - 3' beds, interbedded with sandstone, as below.	15	1,293
30	Sandstone, medium-grained, poorly sorted, pebbly to cobbly layers, shale-coated bedding planes with rootlets; recessive, thin-bedded, minor friable sand layers and conglomerate	12	1,278
29	Sandstone and interbedded shale, 1" - 1' beds, conglomerate layers near top with maximum phenoclast diameters 250 mm.	12	1,266
28	Conglomerate, compact, poorly sorted, dominated by quartzite and chert phenoclasts; sharp basal contact without obvious scouring; maximum diameter of clasts 130 mm.	1	1,254
27	Sandstone, pale brown-grey, very fine- to medium-grained, thin-bedded, laminated, carbonaceous streaks minor, soft-sediment slumped; minor conglomerate and scattered pebbles in sandstone.	65	1,253
26	Shale and sandstone interbedded, recessive, mainly covered; shale, medium grey, interlaminated with siltstone, platy, medium brown; sandstone, medium-grained, yellow, thin-bedded; numerous rootlets	19	1,188

Unit	Description	Thickness (feet)	Distance ~~Below Top~~ Above Base (feet)
25	Sandstone, greenish-grey weathering, light grey, fine- to coarse-grained, with scattered pebbles and pebble layers up to 1 foot thick; common tabular cross-stratification, medium-scale, in part comprising laterally accreted beds; upper 10 feet consists of soft medium- t0 coarse-grained sandstone with plant fragments overlain by a massive, resistant sandstone bed; sandstone is feldspathic (10%) quartz-chert-slate litharenite.	111	1,169
24	Covered, recessive interval, not measured directly	55	1,058
23	Sandstone, pale grey, medium- to coarse-grained, pebbly, relatively resistant, medium- to thick-bedded; minor 1-foot beds of compact pebble conglomerate, rusty weathering; in part cross-stratified, contains large coalified masses	90	1,003
22	Mudstone, medium grey, chunky fracturing, recessive	15	913
21	Sandstone, light greenish grey, orange-weathering, coarse- to very coarse-grained, pebbly, minor medium-grained, slightly calcareous; thick-bedded to massive, resistant; medium-scale cross-stratification, carbonized woody impressions	50	898
20	Sandstone, green, fine-grained, irregularly fractured, slabby, relatively recessive; minor mudstone, medium grey, dark red-brown weathering in beds to 1 foot thick; minor conglomerate, pebbly to cobbly, 6" beds	20	848
19	Sandstone, pale grey, fine- to coarse-grained, moderately sorted, thick-bedded to massive, resistant; poorly preserved leaf impressions and carbonized films common, minor flow-rolls up to 2 feet in diameter; minor compact pebble conglomerate in 1-foot beds; cemented burrows at base; above 1-foot thick basal conglomerate	70	828
18	Shale, mainly covered, recessive	10	758
17	Sandstone, medium grey, coarse-grained, granular to pebbly, massive, resistant; tabular cross-stratification in sets up to 6 feet thick and in reversed orientations; small-scale trough cross-stratification at tops of beds; rare beds of conglomerate and mudstone	83	748

Unit	Description	Thickness (feet)	Distance ~~Below Top~~ Above Base (feet)
16	Recessive, mainly covered interval. Probably shale, sandstone, and unconsolidated sand interbeds	10	665
15	Sandstone, pale brown-grey, medium- to coarse-grained, granular to pebbly, thick-bedded to massive, minor sandy shale intercalations; common tabular cross-stratification	25	655
14	Mainly covered interval, recessive; partly platy fracturing fine-grained sandstone	22	630
13	Sandstone, light yellowish grey-weathering, medium- to coarse-grained, massive, resistant, rare cobbles and scattered pebbles within sandstone; cross-stratified in part; feldspathic quartz-volcanilithic-chert litharenite	74	608
12	Sandstone, orange-weathering, medium-grained, and minor conglomerate; clay-films on bedding surfaces	3	534
11	Sandstone, pale green-grey, pebbly, moderately sorted, alternating fine- and coarse-grained bands, minor thin conglomerate beds; thick-bedded to massive, medium-scale tabular cross-stratification forming beds of lateral accretion; coalified tree stumps and woody fragments; numerous shallow scour- and-fill structures	33	531
10	Covered by talus	30	498
9	Sandstone, pale green, medium-grained, thick-bedded to massive, irregular slabby fracturing; occasional pebble conglomerate beds	20	468
	Moved upstream about one-half mile; base of above partial section approximately same stratigraphic level as top of underlying partial section		
8	Sandstone, medium yellow-weathering, largely inaccessible, thick-bedded, fairly uniform-appearing, minor shale and conglomerate interbeds	88	448
7	Mudstone, medium grey, and interbedded sandstone (40%), pale yellow-grey weathering, thin-bedded mainly	17	360

175

Unit	Description	Thickness (feet)	Distance ~~Below Top~~ Above Base (feet)
6	Sandstone, pale green-grey weathering, thick- and even-bedded, becomes increasingly resistant upsection; conglomerate beds up to 2 feet thick minor	15	343
5	Interbedded sandstone and shale, relatively recessive, inaccessible, grades laterally into dominantly sandstone	10	328
4	Sandstone, fine-grained(?), granular, apparently uniform texture throughout, medium- to thick-bedded, inaccessible at close range	45	318
3	Interbedded sandstone and shale, about equal proportions, sandstone pale green-grey weathering, medium-bedded to massive, inaccessible	25	273
2	Sandstone, light grey, medium- to coarse-grained, thick-bedded; tabular cross-stratification common; coaly fragments common up to 1 foot long	40	248
1	Sandstone, green-grey-weathering, medium-grained mainly, with minor coarse- and very coarse-grained bands; minor 6-inch shale beds in basal 15 feet; medium- to thick-bedded, rare shallow cross-stratification; scattered pebbles and rare pebble conglomerate lenses and beds; feldspathic quartz-chert-lithic arenite	208	208

Tent Island Formation

Section 5

Type section of Ministicoog ~~Formation~~ Member on Big Fish River, N.W.T., immediately west of Mackenzie Delta. Uppermost ~~part~~ 250 feet of formation not present. Top of section located at Lat. 68°37'50"N, Long. 136°08'20"W. Measured by F.G. Young, June 1970, with addenda supplied by T.P. Chamney who measured and sampled section in 1971.
Air photo A14361-46, top of section at X=+6.68, Y=+7.10cm; base at X=+4.30cm, Y=+1.20 cm.

Unit	Description	Thickness (feet)	Height Above Base (feet)
	Pleistocene (?) sand, fine-medium grained, ripple-laminated, and cobbly gravel, approximately 40 feet thick		
	Moose Channel Formation		
	MINISTICOOG ~~FORMATION~~ Member ~~Moose Channel Formation~~ (973 ± 45 feet)		
29	Sandstone, silty shale, and shale, thinly interbedded with rare 2-foot beds of sandstone and pebbly conglomerate. Sandstone, fine-grained, orange-weathering, in part convoluted, cross-laminated, carbonaceous; quartzose chert litharenite; shale, medium grey, about 50% by volume	86	973
28	Mudstone, medium grey, recessive, with minor medium- to coarse-grained sandstone beds, cross-stratified	28	887
27	Mudstone and interbedded siltstone (40%), thin- to medium-bedded, ripple-laminated; unit capped by thick bed of cross-stratified sandstone, flaggy fracturing, yellow-grey weathering	45	859
26	Shaly mudstone and minor siltstone, brown, thin-bedded; poorly exposed, abundant slope debris	50	814
25	Covered	10	764
24	Small scattered outcrops of shale with thin interbeds of siltstone and silt laminations	20	754
23	Covered, recessive and slumped slopes	70	734

Unit	Description	Thickness (feet)	Height Above Base (feet)
	Moved one mile south to high, east bank of river.		
22	Mudstone, yellow-grey, light yellow-grey weathering, very thin- to medium-bedded; minor siltstone, thin-bedded, in part carbonaceous fragmental	76	664
21	Sandstone, medium-grained, lenticular, rare pebbles and coaly wood fragments, common sets of climbing ripples, common thin interbeds of shaly sand, recessive	10	588
20	Sandstone, pale yellow-grey-weathering, medium- to coarse-grained, moderately sorted, thick-bedded, festoon cross-stratification; irregular shaly interbeds uncommon; unit appears to thicken northwest-ward; sharp lower contact	19	578
19	Shale (80%) and platy siltstone interbeds (20%), brown-grey weathering, recessive	23	559
18	Sandstone, brown-grey weathering, very fine-grained, deformed into ball-and-pillow structures, and shale (50%), yellow-grey	6	536
17	Siltstone and shale, 50% each, interbedded, medium-bedded; rare lenticular beds of sandstone up to 1.5 feet thick, contorted, laminated, fine-grained	5	530
16	Siltstone (80%), brown-weathering, argillaceous, micaceous, irregularly splitting, current lineations and sole-marks; and interbedded mudstone, brown-grey, rare yellow and grey claystone with nodular coal	18	525
15	Shale, medium grey, rare siltstone bands; white efflorescent marker horizon 2 feet above base	13	507
14	Siltstone (50%) and interbedded shale (50%)	15	494

Unit	Description	Thickness (feet)	Height Above Base (feet)
13	Shaly mudstone, very thin- to thin-bedded	15	479
12	Shaly siltstone (50%) interbedded with and in part grading into silty shale (50%) dark grey, soft; macerated carbonaceous debris common on bedding surfaces. Base of unit ties in approximately with top of pyramid-like hill one mile southwest	10 ± 10	464
11	Mudstone, grey, with thin interbeds of siltstone, evenly laminated, burrowed, load-casts, in part olive to orange weathering; chunky mudstone predominates	110	454
10	Siltstone, medium-grey, thin- medium-bedded, parallel and cross-laminated; minor interbedded clay, yellow and grey	12	344
9	Mudstone, dark grey, chunky fracturing, minor siltstone interbeds	10	332
8	Covered	70 ± 10	322
7	Interbedded soft friable sandstone and hard sandstone; minor soft shale; brown silty friable sandstone up to 5 feet thick in one bed near base; overlying beds thin- to medium-bedded; occasional pebbly layer	15	252
6	Sandstone, brown-grey-weathering, medium- to thick-bedded, lenticular shale partings common; sandstone mainly fine-grained, lithic, laminated, moderately sorted; erosive, sharp basal contact	10	237
5	Silty sandstone, light grey, very fine-grained, thin- to medium-bedded, laminated; approximately 20% soft shale interbeds, grey; some very lenticular, cross-stratified sandstone beds	15	227

Unit	Description	Thickness (feet)	Height Above Base (feet)
4	Sandstone, single resistant bed, conglomeratic along basal contact, fine- to medium-grained, laminated, medium-scale cross-stratification; minor discontinuous, thin ferruginous mudstone layers	4	212
3	Interbedded sandstone (60%), very fine-grained, and mudstone, thin-bedded, light grey; sandstone is evenly laminated and cross-laminated with rare coarse-grained and pebbly layers	5	208
2	Covered, recessive; calculated thickness. Moved south one mile to east bank at top of type section of Moose Channel Formation	75 ± 25	203
1	Mudstone, medium grey, silty in part; rare siltstone and silty very fine-grained sandstone beds, evenly laminated, micaceous	128	128

Top of Basal sandstone member (Section 4) ~~Moose Channel Formation~~

Section 6

Type section of Aklak Member, Reindeer ~~Moose Channel~~ Formation

~~Section~~ measured on lower course of Aklak Creek which discharges into the southern end of Coal Mine Lake, northwestern Mackenzie Delta. Strata are only locally exposed on 200 - foot high bluffs, and extensive covered or semi-exposed stratigraphic intervals were measured graphically using air photographs and 1:50,000-scale map. Base of section is at Lat. 68°40'06"N., Long. 136°21'00"W., highest exposed beds are located at Lat. 68°40'51"N., Long. 136°19'00"W. Lower half of section measured by D.H. McNeil and T.P. Chamney in 1971, upper half by F.G. Young in 1972.

Air photo A14361-44
top at X = -4.05 cm. Y = +2.70
base at X = -5.72 cm Y = +0.15

Unit	Description	Thickness (feet)	Distance Above Base
	Reindeer ~~MOOSE CHANNEL~~ FORMATION		
	Aklak Member (top not exposed) 1800±60 feet thick.		
51	Broken debris only - shale, black, in part dark grey, leaf impressions, carbonaceous, flaky.	15	1798
50	Covered; scree slopes suggest mainly brown-grey silty mudstone.	40	1783
49	Sandstone, light bluish grey, medium-grained, argillaceous, semi-friable, chert litharenite; mainly broken, flaggy debris; broken clay-ironstone nodules near top.	45	1743
48	Vegetated and covered interval.	92	1698
47	Mudstone, light red, hematitic, abundant plant impressions, chippy, hard debris mainly; in part scoriaceous, dark bluish grey cinder debris; dark grey mudstone at top with leaf impressions.	13	1606
46	Vegetated and debris-covered, recessive slope.	90±5	1593
45	Sandstone, medium grey, medium- to coarse-grained chert litharenite, pebbly in part, thin- to thick-bedded; in part tabular cross-stratification.	15	1503
44	Covered interval.	20	1488
43	Mudstone, dark brown-grey to black, carbonaceous to coaly, abundant leaf and stem impressions, coal laminae (5%) common in basal 20 feet; thin- to medium-bedded; chippy to flaky weathering.	40	1468
42	Sandstone, yellowish grey-weathering, medium- to coarse-grained, rippled surfaces, mainly broken slabs.	10	1428

Unit	Distance	Thickness (feet)	Distance Above Base
41	Covered interval; fragmental sandstone debris common.	20	1418
40	Sandstone, orange-weathering, medium-grained feldspathic chert litharenite, parallel-laminated, dark grey bands, ripple-laminated in part, fairly well sorted. Grades into Unit .	8	1398
39	Conglomerate, friable, sandy, poorly exposed.	2	1390
38	Interbedded siltstone and silty mudstone with minor thin coal seams; siltstone is partly yellow, partly red, contains leaf, stem, and fruit fossils, beds are 1-3" thick; mudstone is oxidized to yellow, red, and black tones, becoming scoriaceous and cindery towards top (ancient bocanne)	72	1388
37	Interbedded clay, mudstone, ochrous marlstone, and coal; mud is soft, yellowish grey; coal is shaly, 2" thick; very easily eroded.	7	1316
36	Conglomerate, pebbly to granular, slightly friable in basal 2', overlain by 5-foot bed of pebbly "grit" with sand lenses, rich in chert and white quartz. Sharp upper contact.	8	1309
35	Covered by scree; probably mainly coaly mudstone.	60	1301
34	Sandstone, , pebbly-layers, thick-bedded, with 6-inch tabular cross-stratification sets dipping northeast; becomes thin-bedded and flaggy towards top. Base not exposed.	15	1241
33	Interval largely poorly exposed, apparently underlain mainly by sandstone, medium-grained to granular, pebbly in part, chert litharenite.	300±30	1226
32	Covered interval, recessive slope-former; debris indicates grey shale mainly.	75±5	926
31	Siltstone, silty shale, and rare silty limestone interbedded, mostly orange-grey to red; broken outcrops on grassy, recessive slope.	45	851
30	Interbedded red siltstone and silty mudstone, rootlet and leaf impressions present; poorly exposed, broken debris mainly.	75	806

Unit	Description	Thickness (feet)	Distance Above Base
29	Fragmental debris of light red, orange, and bluish black siltstone and mudstone, in part coaly, some of which is sintered to cindery or scoriaceous material, in part brecciated (ancient bocanne)	23	731
28	Seatearth, unlithified, brownish grey, overlain by 6-inch coal seam, friable.	2	708
27	Sandstone, grey, fine-grained, well sorted, irregularly fractured.	2	706
26	Sandy siltstone and mudstone, interbanded, brown-grey, poorly exposed.	33	704
25	Broken outcrop of red-weathered and oxidized siltstone, mudstone and silty sandstone; fresh surfaces light to dark grey; scoriaceous and cindery fragments common.	20	671
24	Sandstone, medium-grained, laminated, rusty banded by silt and coalified plant-fragment debris.	1	651
23	Covered by comminuted rock fragments. Possibly underlain by medium brown silty mudstone.	39	650
22	Scree-covered mainly; black shale and coal present under debris.	25	611
21	Covered, recessive slope; burrow-tailings reveal abundant black shale and coal; possible sandstone bed in middle, very fine- to fine-grained, parallel-laminated, coal fragmental.	25	586
20	Interbedded conglomerate and sandstone, soft and friable, thin-bedded, poorly exposed.	6	561
19	Sandstone, medium- to very coarse-grained, granular to pebbly in part, vaguely laminated, coal fragmental laminae abundant; becomes increasingly softer upwards.	6	555
18	Conglomerate, pebbly to cobbly, very poorly sorted, coarse sand to pebble matrix, and sandstone, coarse-grained, coal fragmental, as lenses and interbeds which grade rapidly laterally into conglomerate; phenoclasts rounded, heterogeneous composition, maximum diameter of 300 mm.	8	549

Unit	Description	Thickness (feet)	Distance Above Base
17	Conglomeratic sandstone, massive, resistant, conglomerate layers and lenses (10%).	29	541
16	Alternating conglomerate and sandstone beds, 0.5 to 1.0 feet thick; conglomerate is grey, pebbly to cobbly, polymictic, with medium- to coarse-grained sand matrix, and grades rapidly laterally into sandstone; sandstone is speckled grey, in part rusty-weathering, medium-grained, poorly sorted, pebbly, chert-quartz arenite, in part cross-stratified.	9	512
15	Partly covered interval with broken outcrops of red-weathered siltstone, silty sandstone and silty shale, grey to light red; ripple cross-laminations and parallel laminations common; well preserved leaf impressions on some bedding surfaces.	55	503
14	Siltstone, rusty grey, bright red-weathering, quartzose, abundant rusty grains, laminated and cross-laminated, platy weathering.	12	448
13	Covered, recessive slope.	20	436
12	Sandstone, medium brown-grey, light orange-grey-weathering, fine-grained, micaceous quartz-chert arenite, carbonaceous debris, root burrows, thin-bedded, ripple cross-laminated in part; minor mudstone interbeds, 1-3" thick.	11	416
11	Mudstone, brown, weathers greyish brown, massive, weathers into angular, hard chunks.	19	405
10	Coal, black, varies from dusty & ?argillaceous to shiny and brittle, sub-bituminous, yellow- to black-weathering; moderately resistant, thin- to medium-bedded. Sharp contact on sandstone.	12	386
9	Sandstone, medium grey, weathers light brown-grey, fine-grained, subangular quartz, chert, and lithic grains, laminated, thin-bedded; base not exposed.	8	374

Unit	Description	Thickness (feet)	Distance Above Base
8	Covered interval	170±20	366
7	Sandstone, dark grey, medium-grained, beds 1-3 feet thick, tabular cross-stratification, ripples on some bedding planes.	11	196
6	Sandstone, medium grey, weathers rusty grey, fine-grained, porous, almost friable, quartz-chert arenite, climbing ripple-laminations, splits into 1-3" slabs.	37	185
5	Sandstone, dark grey, weathers medium grey to rusty, medium-grained, poorly sorted, subangular, slightly porous, quartz-chert-carbon-lithic arenite, slightly micaceous; large cross-stratification sets, low- to high-angle, in beds 2-3 feet thick; pebble conglomerate at base sharply overlies mudstone below.	7.5	148
4	Mudstone, brownish-black, grey-brown-weathering, silty, micaceous, carbonaceous, with rare 2-inch siltstone beds, laminated; becomes shale downwards, dark brown, dark grey-weathering, soft, fissile.	29.5	140.5
3	Coal, black, weathers rusty brown, black, and greenish black, lignitic, hard, contains plant fragments, top 4 feet are flaky; indurated lenses of coaly claystone, brownish black, relatively soft, about 25% of unit, forms "eyes" and lenses up to 10 feet long; base not exposed; GSC loc. C-11299 pollen and spore assemblage suggests Maestrichtian or ?Early Paleocene age (W.W. Brideaux)	23	111
2	Pebbly sandstone, medium grey, weathers rusty to light brown-grey, medium-grained, poorly sorted, subangular, quartz-chert-lithic arenite, resistant to weathering, beds 4" to 2' thick.	6	88
1	Sandstone, rusty grey, fine- to medium-grained, black- and rust-speckled, tight, hard, laminated, thin-bedded, low-angle cross-stratification common, convoluted beds near base, ripples present.	82	82

Unit	Description	Thickness (feet)	Distance Above Base
	Ministicoog ~~Formation~~ Member		
18	Covered interval.	29	392
17	Mudstone, brownish black, silty, hard, 80%, and interbedded siltstone and rare laminated sandstone, in part lenticular, maximum bed-thickness 3 feet.	20.5	363
16	Siltstone (70%) and interbedded mudstone (30%); medium-scale low-angle cross-stratification set, truncated at top.	2.5	342.5
15	Mudstone (70%), brownish black, and interbedded sandstone (30%), greyish black, leaden grey-weathering, fine-grained, quartz-chert arenite, minor pebbles and cobbles, lenticular beds.	6	340
14	Sandy siltstone, medium grey, weathers light brown-grey, silt to fine-grained, quartzose, black minerals 15%, cross-laminated beds alternate with parallel laminated beds about 1 foot thick.	4	334
13	Mudstone (70%) and sandy siltstone (30%) interbedded; mudstone is brownish black, weathers medium brown-grey, silty, hard, beds 3" to 3' thick.	15	330
12	Sandstone, medium grey, black- and white-speckled, weathers light brown, fine- to medium-grained, grains subangular to subround, porous, hard, laminated, thin- to medium-bedded, small-scale cross-stratification, ripples, resistant to weathering.	10	315
11	Covered interval.	150±15	305
10	Sandstone, speckled, weathers light orange-grey, quartz-chert arenite, medium- to coarse-grained with pebbles at top (coarsens upwards), poorly sorted; appears massive, unstratified.	15.5	155.5
9	Covered interval.	23.5	140
8	Sandstone, medium grey, fine- to medium-grained, pebbly, quartz-chert arenite, poorly sorted, cross-stratified, parallel-laminated, contains conglomeratic lenses up to 5" thick, quartzite and chert pebbles and cobbles, well rounded.	2.5	116.5
7	Covered interval.	7	114
6	Sandstone, rusty medium grey, speckled, porous, hard, rippled, low-angle cross-stratified, laminated, thin-bedded, resistant.	5	107
5	Mudstone (60%) and interbedded sandstone (40%); mudstone, chippy to chunky fracturing, as below; sandstone, medium to dark grey, weathers brown-grey, quartz-chert arenite, very fine- to fine-grained, laminated and cross-laminated, sharp bedding contacts.	5	102
4	Covered interval; probably underlain by shale.	22	97
3	Shale, brownish black, dark brownish grey-weathering, fissile, with minor (10%) siltstone beds, lenticular, discontinuous, thin, dark grey, compact.	20.7	75
2	Pebbly mudstone, unconsolidated, leaden grey, polymictic, unsorted, pebbles and cobbles to 6" diameter randomly disposed in clay matrix, sharp contact on underlying unit.	0.3	54.3
1	Siltstone (50%) and interbedded mudstone (50%), evenly alternating; siltstone is dark grey, hard, non-porous, laminated, in beds up to 1 foot thick, with some low-amplitude ripples; mudstone is brownish black, silty, hard, chunky, relatively easily eroded.	54	54

Formation is exposed ~~infrequently~~ sporadically in short intervals below here; basal contact and stratigraphic thickness uncertain.

Section 7

Partial section of Moose Channel Formation measured near mouth of Eagle Creek, northern Yukon Territory, in right (east) bank where beds are reasonably well exposed and strike northward, dipping 30 to 50° easterly. Air Photo A15462-23; Lat. 68°45'N, Long. 136°34'W. Measured by F. G. Young in June, 1971.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Top of section not exposed; possible fault between here and next partial section upstream.		
	Moose Channel Formation, Ministicoog Member (235 ft.+)		
51	Mudstone, grey, mainly silty, brittle; minor silt laminae, bands, and very thin beds (5-10%); siltstone is light grey, orange weathering, laminated, micro-cross-laminated in part	106	1,515
50	Silty shale, medium to dark grey, with rare thin beds of argillaceous siltstone, laterally continuous	10	1,409
49	Mudstone, light to medium grey, chunky, poorly stratified, occasional yellow nodules and rare pebbles and carbonaceous fragments; minor graded beds of sandstone up to 1 foot thick, sharp basal contacts with current lineations	40	1,399
48	Mudstone, light grey, 75%, and interbedded medium-bedded siltstone, 25%, laminated, plant debris on bedding surfaces, rootlets	18	1,359
47	Mudstone, light grey, chunky, soft, with rare, scattered pebbles and small cobbles of chert and quartzite; almost unstratified; rare gypsiferous (weathered pyrite?) nodules	34.5	1,341

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
46	Interbedded soft shaly sandstone, sand, and light grey mudstone, recessive; sand is light brown, fine grained, carbon fragmental, in part ripple laminated. Sharp basal contact	5	1,306.5
45	Interbedded sandstone and shale; sandstone is fine to medium grained, in part granular to pebbly, crudely parallel laminated, slightly feldspathic chert-quartz arenite; shale contains abundant carbonaceous fragments, dark grey, in part sandy, evenly laminated	4.5	1,301.5
44	Silty and sandy mudstone, chunky, recessive, poorly consolidated, medium grey; rare black chert pebbles; minor sandy beds, parallel laminated, rich in carbonaceous debris	14	1,297
43	Sandstone, very argillaceous, fine to medium grained, medium to dark grey; uneven, medium bedded; bioturbated, minor chert granules and pebbles, comminuted plant debris in concentrated laminae	3	1,283
	Basal Sandstone Member (1,280 ± 100 feet)		
42	Conglomerate, pebbly-cobbly, medium- to coarse-grained sandy matrix, grades laterally into sandstone, medium-grained, chert-quartz arenite, ripple-and-dune structures, small fan-like feeding burrow on upper surface	4	1,280
41	Partly covered. Sandstone, light grey, very fine to fine grained, shale-clasts common, minor pebble layers; thin to thick bedded; probable argillaceous sand interbeds	39	1,276

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
40	Sand, no solid outcrop, orange to grey, fine grained, argillaceous, minor coarse pebbles	7	1,237
39	Scree-covered slope. Scree fragments of very argillaceous, very fine-grained sandstone, friable, chunky	3	1,230
38	Sandstone, light grey, mostly very fine grained, very thin to medium bedded, chert-quartz arenite	6	1,227
37	Sandstone, orange-brown weathering, very fine to fine grained, slightly argillaceous, chert-quartz arenite, medium to thick bedded, uniform. Thin bed of pebble conglomerate 2 feet below top	24	1,221
36	Partly talus-covered, recessive interval. Sandstone, shaly to platy fracturing, light grey, fine grained, parallel laminated, contains small shale chips	16	1,197
35	Sandstone, fine grained, relatively resistant, well bedded, with small lenses of conglomerate	22	1,181
34	Sandstone, fine grained, thick bedded, parallel laminated, carbonaceous fragments, small shale-clasts, interbedded platy, friable sandstone	15	1,159
33	Sandstone, fine grained, medium to thick bedded, resistant, carbonaceous debris in parallel laminae, minor current lineations and cross-stratification, in part platy- to shaly-weathering interbeds	20	1,144
32	Sandstone, fine grained, medium to thick bedded, banded, slabby splitting in part, planar cross-stratification, minor ripple-laminated beds; a few surfaces exhibit simple and branching burrows	10	1,134

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
31	Sandstone, fine grained, resistant, less than 10% shaly sandstone interbeds; occasional pebbly beds containing granitoid clasts up to 140 mm wide	30	1,124
30	Sandstone, fine grained, slightly argillaceous, poorly to moderately sorted, lenses of conglomerate with phenoclasts up to 130 mm diameter; minor shaly sandstone with foraging burrows and pebbles	20	1,094
29	Sandstone, fine grained, light grey, moderately to poorly sorted, interbedded shaly and friable sandstone, fine-grained, carbonaceous debris; minor shale partings; rare shale-chip conglomerate layers, ripple-drift and planar cross-stratification, burrows in shaly sandstone, rare ball and pillar structure	55	1,074
28	Sandstone, fine grained and minor sand interbeds, platy and slabby, sandstone medium to thick bedded; ripple laminated in part, burrowed in part, *Rhizocorallium* feeding burrows, festoon cross-stratification in part	125 ± 15	1,019
	Uncertain contact relations; moved downstream to point near confluence of Hornet Creek entering on left side		
27	Conglomerate, pebbly sandstone, mudstone, coal, thin to very thin interbeds, mostly oxidized. Sharp basal contact	2	894
26	Sandstone and sand interbedded, scattered pebbles and cobbles in thick beds; fine-grained, chert-quartz arenite, parallel-laminated, low-angle planar cross-stratification; rare lenses of pebble conglomerate up to 1.5 feet thick; rare limonitic oxidized beds of sand	65	892

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
25	Interbedded sandstone, siltstone and mudstone, recessive; sandstone in part cross-stratified	10	827
24	Sandstone, light grey, very fine grained; thin to medium bedded, planar cross-stratification, mild scours	3	817
23	Poorly exposed grey shaly mudstone with interbedded fine-grained sandstone. Sharp basal contact	4	814
22	Conglomerate, pebbly with minor cobbles, poorly sorted, no visible imbrication. Erosional contact	5	810
21	Coaly shale, black, papery and flaky, contains leaf impressions including ~~Equisetites sp~~. (GSC loc. C-11269) Metasequoia cuneata	2	805
20	Sandstone, light yellowish grey weathering, fine grained, chert-quartz arenite, carbonaceous fragments, medium to thick bedded, grades at top into unconsolidated sand with mud intercalations	15	803
19	Recessive, poorly exposed interval. Mudstone, clayey, medium grey, yellow stained, dark reddish brown weathering, minor pebbles and sandy bands and thin beds; minor olive-green argillaceous siltstone and dark grey bituminous bands	29	788
18	Sandstone, fine to medium grained, rare chert and quartz pebbles, moderately sorted, medium to thick bedded	7	759
17	Covered and recessive interval	10	752
16	Sandstone, fine to coarse grained, in part pebbly; parallel laminated and ripple laminated; contains sand and mudstone beds up to 1 foot thick	11	742

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
15	Poorly exposed mudstone with minor medium-bedded sandstone	10	731
14	Sandstone, very fine to fine grained, in part unconsolidated, parallel laminated, poorly exposed	5	721
13	Mudstone, recessive, mostly covered; minor sandstone	9	716
12	Sandstone, medium- and coarse-grained bands, conglomeratic layers and lenses with chert cobbles and orange-weathering rip-up clasts, parallel laminations; basal conglomerate 0.5 feet thick; sharp basal contact	23	707
11	Mudstone, silty, grading to siltstone, laminated, with coaly fragments	4	684
10	Sandstone bed, fine to medium grained, crudely laminated, feldspathic chert-quartz arenite	5	680
9	Mudstone, medium grey, thin bedded, with sandy bands and rare coal stringers; recessive; sharp basal contact	20	675
8	Sandstone, medium grained, granular to pebbly layers at bases of thick beds, faint laminations, minor sandy mud and medium-grey mudstone interbeds; abundant shale clasts, in part cross-stratified. Sharp, even, basal contact	25	655
7	Mudstone, light grey, bedded, sandy layers, poorly exposed	19.5	630
6	Sandstone, shaly partings at base, becoming more resistant upwards; basal beds are pebbly, and contain shale clasts and large plant fragments; parallel laminations and minor planar cross-stratifications	4.5	610.5

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
5	Interbedded mudstone and sandstone, thin bedded, recessive	2	606
4	Sandstone, light grey, fine grained, slightly feldspathic chert-quartz arenite; thin to medium bedded; current lineations common, parallel laminated, carbonaceous debris laminae	8	604
3	Interbedded sandstone, argillaceous sand, and dark grey shale, thin to medium bedded; thicker beds of sandstone display ripple-drift cross-lamination sets, planar cross-stratification, and parallel lamination, and contain mud-clasts and plant-stem fragments	26	596
2	No lower strata on east bank of creek. Calculated thickness of strata covered by creek bed to exposures on west bank	530 ± 50	570
1	Sandstone, fine grained, in part convoluted, ripple laminated; 5% conglomerate, minor ironstone concretions. Contact covered.	40	40
	<u>Tent Island Formation</u>		
	Mudstone with 10% interbedded siltstone	250	
	Base of section exposed on lower Eagle Creek		

Section 8

Eagle Creek, Yukon Territory

This composite section of the middle part of the Moose Channel Formation and basal ~~and upper parts of the Moose Channel~~ Reindeer Formation was ~~consolidated~~ summarized from several shorter sections measured and described from bank exposures on the right side of Eagle Creek, Yukon Territory, at approximately Lat. 68°42'N, Long. 136°32'W.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Top not exposed - thick recessive interval		
	<u>~~Moose Channel~~ Reindeer Formation, Aklak Member</u> (664+ feet)		
80	Interbedded sandstone and conglomerate, some conglomerate beds graded, others not, bedding contacts sharp, basal contact sharp and erosional	31	2246.5
79	Covered interval	4	2213.5
78	Sandstone, medium grained, lithic chert-quartz arenite, thick bedded, bedding contacts sharp, occasional 1-foot thick conglomerate beds	13	2209.5
77	Conglomerate, pebbly, with sandstone lenses common; sharp, uneven lower contact	12	2196.5
76	Sandstone, as in Unit 78	10	2184.5
75	Conglomerate, pebbles and cobbles in sandy matrix, maximum phenoclast diameter 20 cm., clasts well rounded; sandstone lenses about 1 x 20 feet; contain clasts of similar lithic sandstone, possibly of internal derivation; unit appears homogeneous except for indistinct horizontal orientation of pebbles	28	2174.5
74	Covered interval	40	2146.5

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
73	Sandstone, light grey, rusty grey-weathering, medium grained, very poorly sorted, no visible porosity, quartz-chert-feldspar-muscovite composition; medium bedded, irregularly fractured, cross-bedded in part; pebbly horizons common, minor scour structures filled with pebbles	108	2106.5
72	Covered interval	8	1998.5
71	Sandstone, medium to dark grey, fine grained, moderately sorted, porous, pebble layers common, thin- to medium-bedded, irregularly fractured; carbonaceous debris common on bedding planes; ripple-marks	67	1990.5
70	Sandstone, as in Unit 69 but contains in addition few 1-foot beds of muddy, micaceous siltstone; coalified plant fragments and shale-clasts common	7	1923.5
69	Sandstone, medium grey, fine to medium grained, poorly sorted, minor porosity, hard, grains subangular to subrounded, quartz-chert arenite, pebbly bands common, coaly fragments common; thin- to medium-bedded, minor small and medium scale cross-stratification	63	1916.5
68	Covered interval	50	1853.5
67	Sandstone, light to medium grey, medium grained, very poorly sorted, subangular to subrounded, nearly fraible, quartz-chert-feldspar arenite; thin- to medium-bedded, moderately resistant; large sets of cross-stratification in some beds, pebbly horizons common	90	1803.5
66	Sandstone, medium to coarse grained, banded, minor pebble conglomerate and scattered pebbles; medium-bedded with occasional thick bed	57.5	1713.5
65	Conglomerate, cobbly, maximum clast-diameter 8 inches (21 cm.)	1.5	1656

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
64	Sandstone, medium to coarse grained, banded, with 10% conglomerate beds and pebbly sandstone beds, lenticular, up to 1 foot thick	27	1654.5
63	Coal, black, bituminous	1	1627.5
62	Sandstone, light grey, medium grained, poorly sorted, with minor conglomerate; thick-bedded	30	1626.5
61	Sandstone, light grey, rusty grey-weathering, medium grained, poorly sorted, quartz and variously coloured chert, granular and pebbly, with 20% conglomerate beds, relatively continuous, 0.5-1.0 feet thick; medium- to thick-bedded; resistant; cobbles and coaly debris at base of unit which is partly convoluted; small and medium scale cross-bedding up to 3 feet thick per set	14	1596.5
	Moose Channel Formation, Ministicoog Member (1,080 feet)		
60	Mudstone, medium grey, recessive, coal laminae, silty and sandy in uppermost 1 foot, poorly stratified	11.5	1582.5
59	Shale, black, papery, coaly, rare coal lenses, yellow-weathering; leaf impressions common	3	1571
58	Mudstone, medium grey, in part silty, with small clay ironstone concretions. GSC loc. C-11285 (palynological analysis by W. Brideaux) yielded recycled Lower Cretaceous spores and pollen, Lower Paleozoic recycled spores, Stereisporites antiquasporites (Wilson & Webster) Dettmann, Inaperturopollenites hiatus (Potonié) Thompson & Pflug, Betulacoeoipollenites sp. cf. B. infrequens (Stanley) Norton & Hall. Age: Upper Cretaceous, probably Maastrichtian	17.5	1568

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
57	Sandstone, pale green-grey, orange-weathering mud-clasts, fine grained, laminated, macerated coaly plant debris, in part outline current lineations on parting planes; thick-bedded	22	1550.5
56	Interbedded sandstone and mudstone; sandstone dark green-grey, very fine to fine grained, even splitting, poorly consolidated, medium-bedded; mudstone, chunky, irregular fracturing, medium grey, in beds up to 1 foot thick; recessive	12.5	1528.5
55	Sandstone, fine grained, very evenly laminated, ripple-laminated in part, abundant carbonaceous fragments, some large coalified wood fragments	7	1516
54	Covered by vegetation on both banks of stream	100±10	1509
53	Very poorly exposed sandstone, slabby, ripple-marked, with recessive interbeds of mudstone	100±10	1409
52	Interbedded mudstone, grey, sandstone, partly pebbly, and pebble conglomerate, well cemented; sandstone bedding soles display load casts, fine crawling trails and pocket burrows	4	1309
51	Conglomerate, bright yellow to orange, cobbly, with interbedded sand, olive green, coarse-grained, and sandstone, yellow-weathering, fine-grained; thin- to medium-bedded	4	1305
50	Sandstone, yellowish grey-weathering, coarse grained, pebbly, feldspathic quartz-chert arenite, carbonaceous laminae and coalified wood fragments, in part cross-stratified; thick bedded; pebbles consist of chert, chert-grit sandstone, ironstone	11	1301
49	Recessive, mainly covered interval; in part shale, medium grey, coaly in part. Sharp basal contact	14	1290

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
48	Sandstone, medium grained, well sorted, hematitic at top, pebbly to cobbly near base, with mixed conglomerate and sandstone filling 3-foot deep scour, sharp, eroded basal contact; resistant, massive	28	1276
47	Sandstone, orangish grey-weathering, medium grained, sparse pebbles, uniform character, in part nearly friable; massive, irregularly fractured	56	1248
46	Interbedded sandstone and mudstone, with sandstone dominant in uppermost 20 feet, but about 50-50 ~~proportions~~ ratio below; sandstone, medium grained, faintly laminated, resistant, orange-weathering, pebbly layers; medium- to thick-bedded; mudstone, recessive, contains thin sandstone beds with pebbles and cobbles, ripple-laminated in part, macerated carbonaceous debris common	102	1192
45	Poorly exposed interval, probably thin sandstone and mudstone interbeds as below	13	1090
44	Interbedded sandstone, thin-bedded, and mudstone, approx. 50-50 ~~proportions~~ ratio; sandstone, fine to medium grained, pebbly at bases of beds, laminated, burrowed, rootlets; mudstone, light grey, sandy streaks, rootlets	25	1077
43	Mudstone with thin coal seams	2	1052
42	Interbedded sandstone and sandy mudstone; sandstone, fine to medium grained, moderately sorted, laminated, ripple-marked, clay drapes on ripple beds, burrows, rare pebble layers, carbonaceous debris common; mudstone-rich beds commonly about 2 feet thick, contain thin beds and laminae of sandstone; mudstone is clayey, soft, grey	32	1050

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Moved downstream 1/4-mile to equivalent stratigraphic level		
41	Sandstone, orange-weathering, fine grained, in part calcareous, scattered pebbles, fairly uniform, flat shale-clasts abundant on bedding soles, rare star-shaped feeding burrows, ripple-marks; minor shaly intercalations and thin interbeds	40	1018
40	Interbedded sandstone and sandy mudstone, thin-bedded, both evenly laminated; sandstone, orange- and grey-banded, fine to medium grained, minor pebbles and cobbles, abundant carbonaceous fragments, oscillation-ripples common, mudstone contains sandy bands	33	978
39	Sandstone, fine grained, vaguely laminated, some coarse-grained and pebbly bands, partly calcareous; forms large flow rolls, 5 feet high at base of unit	20	945
38	Interbedded sandstone and mudstone, each approx. 2 feet thick; sandstone coarse grained commonly, medium- to thick-bedded, except thin-bedded within mudstone intervals; pebbles and small cobbles common, especially at bases of mudstone beds, shale-clasts common	22	925
37	Sandstone, generally fine grained, pebbly and coarse to very coarse grained near tops of beds, minor mudstone interbeds, orange-grey, up to 0.5 feet thick; load casts, burrows and tool-marks on bedding soles; thin- to thick-bedded, resistant, sharp basal contact	11	903
36	Interbedded sandstone and mudstone, thin-bedded, sharp bedding contacts common; sandstone, fine grained, conglomeratic at bases of beds, laminated, mudstone, medium grey, contains 20% lenses of sandstone with reedy carbonized plant fragments abundant	14.5	892

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
35	Sandstone, fine to coarse grained, banded, shale partings, thin- to medium-splitting, rootlets, lenticular	2.5	877.5
34	Interbedded grey mudstone, medium- to coarse-grained sand, and minor pebbly sandstone, fine grained, lenticular; recessive	8	875
33	Sandstone, light orange-grey-weathering, laminated in part, pebble lenses, shale-clast lenses, minor mudstone interbeds, plant rootlets at tops of many beds; medium- to thick-bedded, sharp basal contact	8	867
32	Underlying interbedded sandstone and mudstone inaccessible, measured only	130±15	859
31	Sandstone, light grey, fine grained, uniform; thick-bedded to massive, numerous black partings in upper half, friable in part in top 25 feet; sharp basal contact	80	729
30	Mudstone, medium grey, chunky, recessive	2.5	649
29	Sandstone and sand, 40-60% proportions, very fine to fine grained, laminated, even splitting	8.5	646.5
28	Mudstone, chunky, thin siltstone interbeds, common plant-fragment layers; very recessive	35	638
27	Sandstone and shale interbedded, 50% of each; sandstone, medium to coarse grained, bands rich in shale-clasts, some small burrows	27	603
26	Conglomerate, pebbly, with rare shale lenses; irregular thickness	1	576
25	Sandstone, pale orange-weathering, fine to coarse-grained, scattered pebbles, parallel-laminations, cross-stratification in nearly planar sets, in part ripple-marked; minor coaly stringers and unconsolidated sand	11	575

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
24	Mudstone, coaly with minor yellowish sandy layers, medium to coarse grained in uppermost 15 feet; interbedded coaly and ochrous varieties below, the latter silty with plant debris, very soft; very recessive	60	564
23	Coal, black, banded, one blocky-fracturing bed	2	504
	Basal Sandstone Member (502+ feet)		
22	Sand and sandstone, fine grained, slightly argillaceous, mostly evenly laminated, medium grey, macerated coaly plant debris common, irregular coaly stringers in 3-inch bed 20 feet below top; rare mudstone beds, dark grey; scour-and-fill structures, cross-stratification, current lineations	67	502
21	Interbedded sandstone, siltstone and shale; sandstone, very fine to medium grained, in part parallel-laminated, commonly burrowed; shale, grey, sandy and pebbly bands and thin beds; siltstone beds in top 15 feet, associated with carbonaceous laminae containing abundant plant fragments. GSC loc. C-11283, plant remains identified by C. J. Smiley, Univ. of Idaho, as Equisetites sp. (Upper Cretaceous)	57	435
20	Sandstone, fine to coarse grained, banded, ripple-marked, clay laminae, planar and festoon cross-stratification, scattered pebbles, thick-bedded; basal few feet contain lenses and beds of marlstone	13	378
19	Conglomerate, granular to bouldery, very poorly sorted, lithified, mainly chert clasts, maximum diameter 400 mm	1	365

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
18	Sand and sandstone, light grey, very fine to fine grained, scattered pebbles and cobbles, pyrite nodules; mostly massive, fairly resistant; conglomerate lenses up to 0.5 feet thick in upper half; cross-stratification and scouring common in top 20 feet	83	364
17	Sand, ochrous, fine to medium grained, very limonitic, very recessive, grades into overlying unit	1.5	281
16	Sandstone, orange-weathering, fine and coarse grained bands, wavy laminations, carbonaceous plant debris, minor shale partings, limonitic crust on top 1-inch layer	0.5	279.5
15	Conglomerate, pebbly to cobbly, slightly limonitic	0.5	279
14	Marlstone, orange-weathering, lithographic, light grey, contains minute plant fragments	0.5	278.5
13	Interbedded sandstone, sandy, coal-fragmental mudstone, and conglomerate, cobbly; sandstone, medium grey, in thin uneven beds, with abundant wood-fragments, coalified, ripple-marks, parallel-laminations; sharp basal contact	3	278
12	Sandstone, fine to coarse grained, crudely laminated, cross-stratified at base, minor friable layers	7.3	275
11	Conglomerate, pebbly, sandy, friable, limonitic in part, grades up into coarse-grained sandstone, coal-fragmental, and capped by shale layer	0.7	267.7
10	Sand, slightly lithified, light grey, medium grained, laminated, poor to fair sorted; recessive	8	267
9	Coal, black, partly laminated, shaly in part, very recessive	4	259

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
8	Sandstone, fine and medium grained bands, sparse chert pebbles and pyrite nodules, low-angle cross-stratification; mainly massive, resistant	19	255
7	Sandstone, fine to coarse grained, pebble-layers, slightly calcareous, quartz-chert-lithic arenite, parallel-laminated, cross-stratified in part, in part covered or poorly exposed	47	236
6	Interbedded sandstone and mixed mudstone-sandstone beds, 1 to 2 feet thick; recessive, poorly exposed; sandstone beds thick, slabby fracturing	22	189
5	Sandstone, basal parts of beds coarse grained and pebbly, upper parts fine grained, parallel-laminated, poorly consolidated, medium- to thick-bedded; mudstone interbeds in basal 10 feet; bedding soles show burrows, scratch marks, and groove-casts	25	167
4	Mudstone, medium grey, chunky fracturing, with minor thin-bedded sandstone, fine grained laminated, burrowed, in part lenticular; scoured, sharp basal contact	14	142
3	Sandstone, light grey, fine grained, moderately sorted, slightly calcareous, in part porous; parallel laminated and planar cross-stratified, shale-clast bands common, burrowed shaly laminae near top; medium- to thick-bedded	13	128
2	Covered by stream alluvium of valley floor	100	115
1	Interbedded conglomerate, sandstone, and mudstone in 1- to 2-foot beds; conglomerate is channelled, with clay drapes, and overlain by sandstone or conglomerate beds; sandstone and mudstone occur as thin interbeds in 3-foot subunits; some sandstone shows planar cross-stratification	15	15

Section poorly exposed in axial part of Deep Creek Syncline on Yukon Coastal Plain in vicinity of Lat. 68°51'N, Long. 137°58'W. Stratigraphic units and their thicknesses are based largely on three ground traverses and air photo interpretations. High-level (A 14406-58, 59) and recently flown, low-level, high-resolution, vertical air photographs were used and integrated with lithologic and structural control obtained on the ground.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Reindeer ~~Moose Channel~~ Formation (top not exposed; highest beds in synclinal axis) 3035 ± 150 feet thick		
19	Covered, recessive interval, probably mudstone of uncertain thickness.	170 ± 20	3,035
18	Sandstone, light rusty grey, fine-grained, compact, in part poorly sorted, platy fracturing, 10% chert; minor red sandstone, fine-grained micaceous, thin-bedded.	170 ± 15	2,865
17	Mudstone, uniform, dark air-photo unit.	45	2,695
16	Sandstone, light grey, fine-grained with coarse sand and granules present, moderate to poor sorted, quartzose, 15% chert and dark fragments, platy and thin-bedded, porous in part.	115	2,650
15	Mudstone, uniform, dark air-photo unit.	85	2,535
14	Sandstone, very fine to fine-grained, chert granules common, rusty specks very abundant, compact, subangular to subrounded grains; very thin-bedded.	200 ± 10	2,450
	Moose Channel Formation		
13	Mudstone, uniform in upper 50 feet; interbedded with sandstone below with pebble horizons; possibly contains coal beds; sandstone, rusty grey, very fine to very coarse-grained beds moderate to poor sorted, in part porous, rare low-angle cross-bedding; pebbly beds fill scour-structures in part, contain phenoclasts up to 90 mm in diameter, composed of black chert and white quartzite. Sharp basal and upper contacts.	380 ± 35	2,250

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
12	Covered recessive interval traceable throughout area, probably underlain by mudstone; thickness seems much greater in north than south.	250 ± 25	1,870
11	Conglomerate and sandstone, forming a lenticular, resistant unit, possibly not at same stratigraphic level everywhere in outcrop area; conglomerate consists of chert pebbles and coarse sand mainly, minor shale rip-up clasts; sandstone is fine- to coarse-grained, argillaceous, poorly sorted, with some large scale cross-stratification.	70 ± 10	1,620
10	Covered, recessive interval everywhere, probably mudstone.	300 ± 10	1,550
9	Sandstone, light to medium grey, fine- to medium-grained; poor to moderate sorting, in part argillaceous, in part chert-pebbly; in part hard and non-porous, in part porous; irregular to even bedded; current lineations, carbonaceous debris, coaly fragments, bedding-plane trails, ripple-laminae; quartz-lithic-chert grain components.	360 ± 20	1,250
8	Covered, recessive unit, probably mudstone	140	890
7	Sandstone, light grey, fine-grained mainly, thin-bedded; quartz with 25% chert, minor potash feldspar, thin, irregular bedding; 1- to 2- foot graded sets at base, changing laterally into pebble conglomerate with sand lentils.	100	750
6	Covered, recessive unit, no exposures.	100 ± 10	650
5	Very poorly exposed unit interpreted as interbedded sandstone and mudstone from air photographs.	85	550
4	Covered, recessive unit, probably mudstone	50	465
3	Sandstone, light grey, fine-grained, moderately sorted, trace porosity; thinly bedded probably.	95	415
2	Covered, recessive unit, probably mudstone.	90	320
1	Sandstone, mainly fine-grained, coarse-grained beds common, quartz-chert-feldspar composition, pebbly layers minor, moderately sorted; resistant at top and bottom but not in middle portion, possibly due to shaly interbeds.	230	230

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Tent Island Formation (upper part only)		
4	Covered, recessive unit, appears uniform.	110 ± 10	610
3	Mudstone, not exposed, with minor sandstone beds, fine-grained, poorly to moderately sorted, 25% chert, rare coarse-grained sand and pebbly beds, in part porous.	250 ± 25	500
2	Mudstone, brown-black, carbonaceous to coaly, silty, chunky; rare sandstone, dark grey, fine-grained, poorly sorted, carbonaceous debris, micaceous, homogeneous fabric.	150	250
1	Not exposed, recessive, probably mudstone for considerable thickness below.	100+	100

Figure 26. Diagram showing quartz versus chert contents, Fish River Group sandstones.

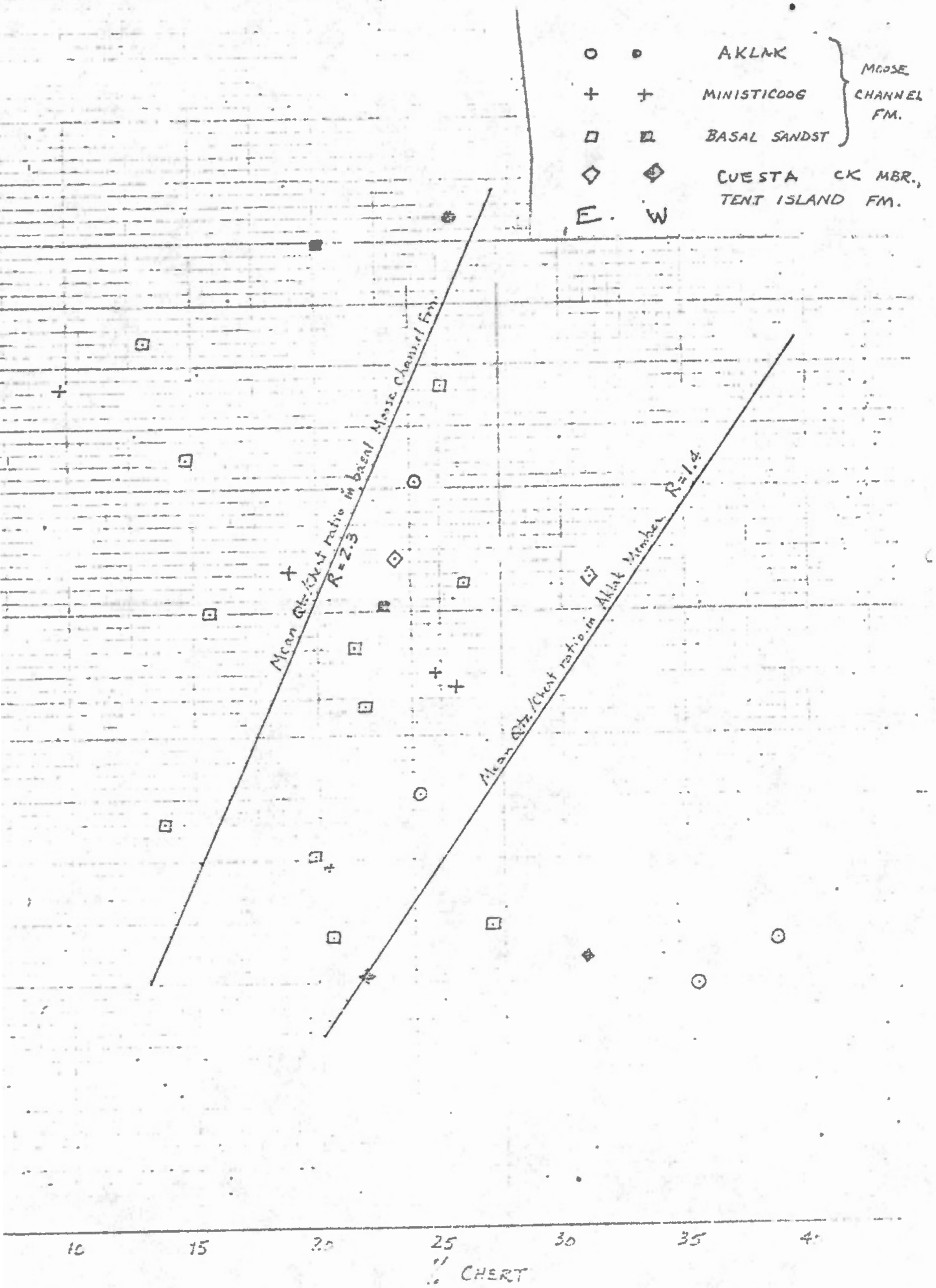
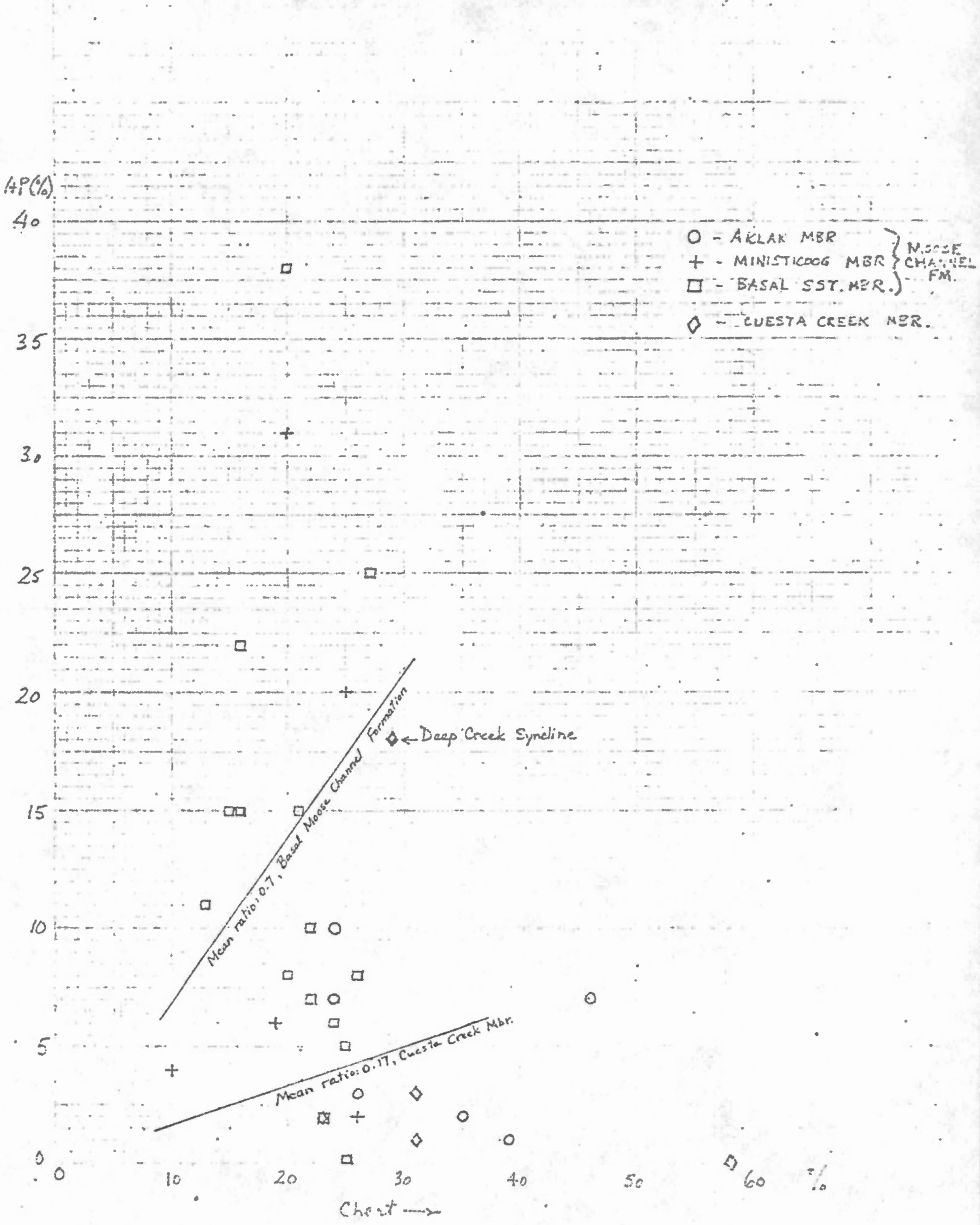


Figure 27. Diagram showing volcanics plus plagioclase versus chert contents, Fish River Group sandstones.



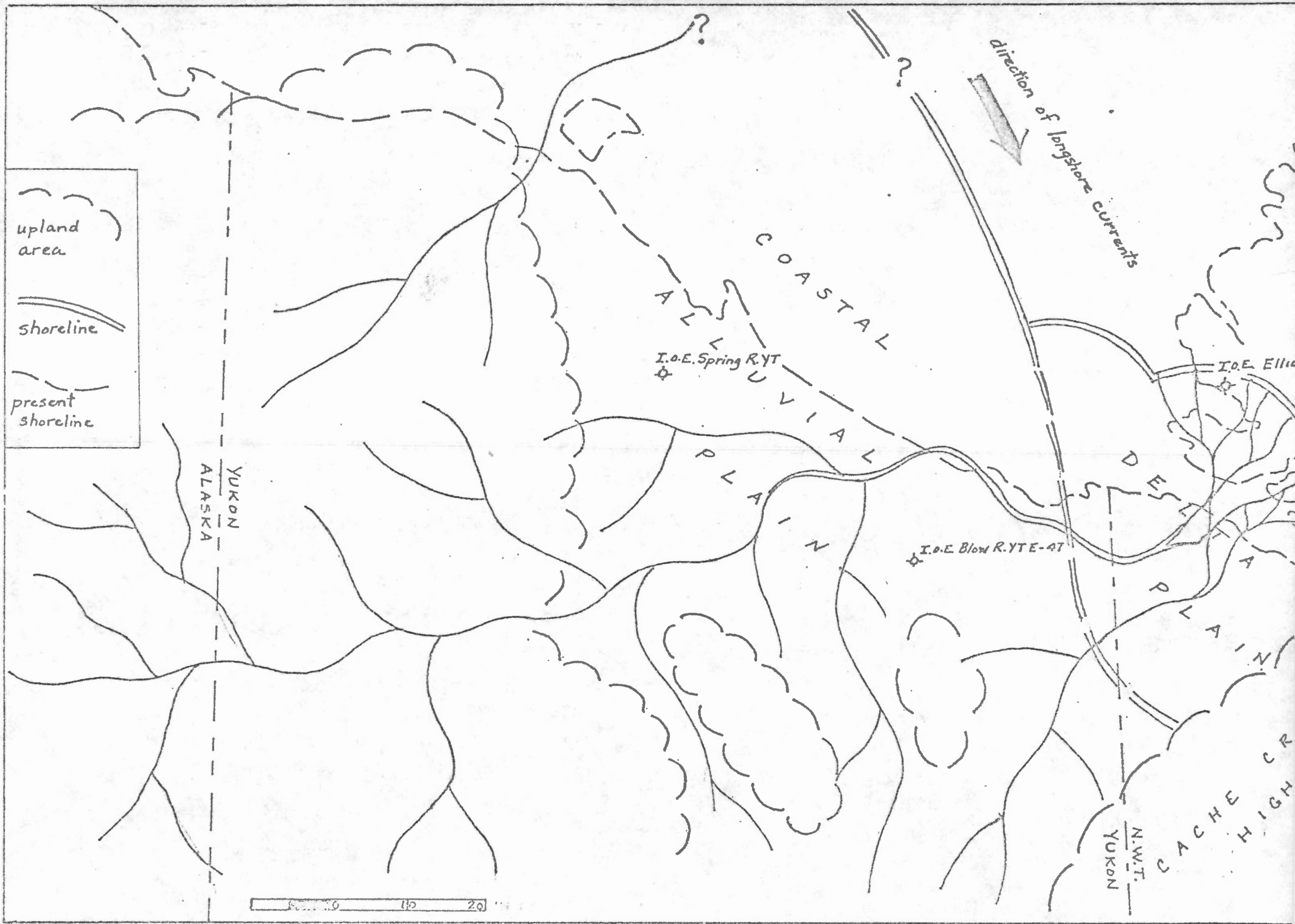


Figure 32. Paleogeographic Reconstruction of Northern Yukon During Deposition of basal Moose Channel Formation.