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Upper Cretaceous and Tertiary Stratigraphy on the Tuktoyaktuk Peninsula, Northwest Territories.

James Dixon and David H. McNeil

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UPPER CRETACEOUS AND TERTIARY STRATIGRAPHY ON THE TUKTOYAKTUK PENINSULA, NORTHWEST TERRITORIES

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CONTENTS

LIST OF FIGURES

ABSTRACT

Improved biostratigraphy and a better understanding of the regional geology of the Beaufort-Mackenzie Basin allows for an improved understanding of the Upper Cretaceous to Tertiary geology of the Tuktoyaktuk Peninsula. Early work tended to group large packages of sedimentary rock into undivided units, although some units, such as the Smoking Hills Formation, were commonly identified. Physical correlations from 90 wells integrated with biostratigraphic data from 32 wells has led to the identification of the following transgressive-regressive sequences and associated foraminiferal biozones: Boundary Creek (barren of foraminifera), Smoking Hills (*Spiroplectammina spirocompressa* Zone), Mason River (*Haplophragmoides bilobatus* Zone), Fish River (*Convallina caverna* Zone), Aklak (*Reticulophragmium boreale* Zone and an informal upper Aklak assemblage zone), and Iperk (unzoned terrestrial and reworked microfossils). Boundary Creek strata are identified primarily by physical correlations, but with some confirmation from limited palynological data. Iperk strata include some Quaternary beds due to the difficulty of separating these units in subsurface data.

The upper Paleocene to lowest Eocene Aklak Sequence is the most widespread unit and it rests erosionally on a variety of older units. Aklak strata contain the only hydrocarbons found in Upper Cretaceous and Tertiary strata of the Tuktoyaktuk Peninsula – in delta-front sandstones of the middle to upper part of the Aklak Sequence. Boundary Creek and Smoking Hills strata are organic-rich and are known source rocks for some of the oil discoveries on the Tuktoyaktuk Peninsula and Mackenzie Delta.

INTRODUCTION

Tuktoyaktuk Peninsula lies to the east of Mackenzie Delta, along the southeast margin of the Beaufort Sea. It extends northeast for a distance of approximately 230 km (Fig. 1). The highest relief is along the Caribou and Storm Hills, adjacent to the East Channel on Mackenzie Delta, where elevations of just over 200 m are

attained. The land slopes gently northeastward and much of the peninsula is only a few to a few tens of metres above sea-level. The Beaufort Sea borders its northwestern side and along the southeast are the Eskimo Lakes and Liverpool Bay. The community of Tuktoyaktuk is located approximately midway along the peninsula, on the coastline of Kugmallit Bay. Ninety wells have been drilled in the area (Fig. 2), three of which are located just a few kilometres offshore (West Atkinson L-17, Kannerk G-42 and Angasak L-03). Most of the hydrocarbons found in the Tuktoyaktuk Peninsula have been in Cretaceous strata (Parsons gas field, Atkinson oil field) but some oil and gas has been recovered from Tertiary sandstone reservoirs in the Tuk field (Morrell, 1996).

Early studies of the Upper Cretaceous and Tertiary succession of Tuktoyaktuk Peninsula were hampered by a lack of biostratigraphic data, poor quality reflection seismic and few outcrop control points. Consequently much of this interval of rock was grouped together as an undivided succession in many of the wells drilled on the peninsula (Dixon, 1990). Improved foraminiferal biostratigraphy (Fig. 3) and a better understanding of the regional geology has allowed us to attempt a more refined stratigraphic analysis of the 90 wells on the Tuktoyaktuk Peninsula (Appendices 1, 2).

Only a few cores were cut in Upper Cretaceous and Tertiary strata of the Tuktoyaktuk Peninsula, the majority being cut in the Smoking Hills Sequence and a few in the Tertiary Aklak Sequence (Dixon, 2002). The latter cores tend to be in weakly cemented to unconsolidated sediment and are poorly preserved.

STRATIGRAPHY

Previous Work

The first geological publication relevant to the Tuktoyaktuk Peninsula was by Mountjoy (1967), who described the strata of Caribou Hills as a succession of interbedded sandstone, shale and coal, with gravels at the top of the section. He

designated this succession as the type section for the Tertiary Reindeer Formation. Doerenkamp et al. (1976) reported on the palynomorphs from Caribou Hills, as well as Anderson Plains to the southeast of Tuktoyaktuk Peninsula. Some of the Upper Cretaceous units on Anderson Plains extend under Tuktoyaktuk Peninsula and the work of Plauchut and Jutard (1976), Yorath et al. (1975) and Yorath and Cook (1981) are relevant to the study area.

Young et al. (1976) restricted Mountjoy's (1967) Reindeer Formation at Caribou Hills to beds below the upper succession of gravels and sands, the latter being considered Neogene and tentatively identified as Beaufort Formation. Price et al. (1980) and Ioannides and McIntyre (1980) revised the stratigraphy of the Caribou Hills sections and presented more biostratigraphic data. It was noted that a prominent white clay interval contains possible Oligocene palynomorphs, resting on a predominantly Paleocene to Eocene succession and that the two intervals are probably separated by an unconformity. However, they continued to place the overlying gravels in the Beaufort Formation. Also, biostratigraphic data from the basal part of the coal-earing succession indicated that this part of the succession correlates with the Ministicoog Member of Moose Channel Formation. The rationale used by Ioannides and McIntyre (1980) for assigning an Oligocene age to the white clay unit was based on correlation with the microfloras of the central British Columbia Australian Creek Formation (lower part) and was justified at that time. The age of the lower Australian Creek Formation, however, has since been revised and is now considered to be Late Eocene (Long and Sweet, 1994).

Dixon et al. (1992) pointed out some of the nomenclature problems with the Caribou Hills succession, noting that the "white clay unit" and the "Beaufort Formation" are probably part of the same succession and considered them to be part of the Oligocene Kugmallit Sequence. However, as stated above, the biostratigraphic data now indicate an Eocene age which would place the "white clay unit" in the Richards Sequence. They also noted that in the nearby Storm

Hills, a succession of gravels rest unconformably on the Caribou Hills succession and most probably is part of the Pliocene Iperk Sequence. Also noted, was the need to abandon the term “Beaufort Formation” in this basin.

The first attempt to correlate Upper Cretaceous strata in the subsurface of Tuktoyaktuk Peninsula was by Myhr (1975) who used prominent gamma-ray log-markers. A similar use of the gamma-ray log-markers was by Dixon et al. (1985, fig. 28B;1992, fig. 40). Morrell (1996) described the Tuk hydrocarbon discovery and illustrated correlations on a reflection seismic line and a geological cross section.

Stratigraphic Nomenclature

Some of the early work in the area introduced lithostratigraphic nomenclature for the Beaufort-Mackenzie Basin (Mountjoy, 1967; Young et al., 1976), based largely on outcrop and wells at the margin of the basin. When examining the whole basin a conventional lithostratigraphic approach was found to be inadequate and a sequence stratigraphic nomenclature was proposed by Dietrich et al. (1985), later modified and expanded by Dixon et al. (1992). Sequences are bounded by subaerial unconformities and/or transgressive surfaces of erosion and are not limited to any particular facies.

Under Tuktoyaktuk Peninsula the Upper Cretaceous to Tertiary succession can be divided into a number of transgressive-regressive sequences (Fig. 3), some of which are also equivalent to formations (e.g., Boundary Creek, Smoking Hills, Mason River). The white-clay unit and overlying gravels at the Caribou Hills, now considered to be part of the Richards Sequence, do not appear to extend northeast along the Tuktoyaktuk Peninsula. In some earlier publications the Mason River Formation was considered to be equivalent to the Tent Island Formation (i.e., equivalent to the lower part of the Fish River Sequence) but the ages of these two units suggest they are separate entities. Mason River strata are

late Campanian to early or middle Maastrichtian in age (Doerenkamp et al., 1976), whereas Tent Island strata are late Maastrichtian to possibly earliest Paleocene (Sweet, 1978). These disparate age ranges strongly support the notion that the two units are not correlative. Foraminifera also suggest they are non-correlative units, each characterized by a different and successive assemblage (see section on Biostratigraphy).

Strata at Caribou Hills, identified as Moose Channel and Reindeer formations by Price et al. (1980), are part of the Aklak sequence. The white clay unit and overlying gravels are tentatively identified as Richards Sequence and the gravels at Storm Hills are part of the Iperk Sequence

BIOSTRATIGRAPHY

Previous Work

Preliminary foraminiferal zonations for the Upper Cretaceous and Tertiary of the Mackenzie-Beaufort area were published by McNeil (1989, 1996a,b,c), and a formal zonation scheme was established by McNeil (1997) based on the stratigraphic "tops" of benthic foraminifera. McNeil (1997) presented foraminiferal data for two Tuktoyaktuk Peninsula wells, Wagnark G-12 and Tuk F-18, in which four zones were well developed: the Santonian-Campanian *Glaphyrammina spirocompressa* Zone, the latest Campanian-Early Maastrichtian *Haplophragmoides bilobatus* Zone, the Late Maastrichtian *Convallina caverna* Zone, and the early Late Paleocene *Reticulophragmium boreale* Zone. An additional Late Paleocene informal zone is recognized in this study above the *R. boreale* Zone and is referred to as the "upper Aklak assemblage zone." The stratigraphic position of the foraminiferal zones is indicated on Figure 3.

CORRELATIONS AND DESCRIPTION OF SEQUENCES

Correlations of Upper Cretaceous and Tertiary strata are illustrated in Figures 4 to 7; along a strike-oriented cross section (Fig. 4), two short dip-oriented cross-

sections (Figs. 5 and 6) and a cross section through the Tuk oil and gas field (Fig. 7). In parts of the peninsula the Smoking Hills, Mason River, Tent Island and lower Aklak sequences are predominantly shale and siltstone, making it difficult to separate them based on lithological characteristics. Consequently biostratigraphic data was used to locate the approximate position of the sequence boundaries in several wells and these wells were used as reference points for correlation into wells with no biostratigraphic data. Thin sandy or silty beds close to where the biostratigraphic data indicated a faunal change were commonly picked as the base of sequences – interpreted to be transgressive beds above the bounding unconformity of a sequence.

As previously indicated, the Smoking Hills Sequence contains a number of distinct gamma-ray log-markers that can be correlated over large areas of the northeastern part of Tuktoyaktuk Peninsula. Myhr (1975) identified 5 log markers in Upper Cretaceous strata (markers A to E) and one in the Albian Horton River Formation (marker F; Horton River strata are equivalent to the Arctic Red Formation, the name more commonly used in recent literature). Myhr (1975, fig. 3) considered markers A, B, and C to be within the Mason River Formation, and marker D to be the contact with the underlying Smoking Hills Formation. Dixon et al. (1992, fig. 40) placed the equivalent strata containing markers A to E as part of the Smoking Hills Sequence/Formation and strata between markers E and F as Boundary Creek Sequence/Formation. Physical correlations and biostratigraphic data indicate that beds containing markers A to E are part of the Smoking Hills Sequence and marker F is in Albian strata (Figs. 4 to 6). The presence of Boundary Creek strata is less clear. Only in a few wells is there a thin succession between the base of the Smoking Hills Sequence and Arctic Red strata that could be possible Boundary Creek beds. This differs from earlier stratigraphic choices where Boundary Creek strata were reported in more wells (Dixon, 1990).

Biostratigraphic data indicate beds equivalent to the Mason River and Fish River sequences are locally present, but pre-Aklak erosion limits their distribution (Figs. 4 to 6).

Boundary Creek Formation/Sequence

In its type area (Young, 1975), west of the Mackenzie Delta, the Boundary Creek Formation consists of light-grey weathering shale with very thin to thin interbeds of bentonite and is organic-rich. It overlies Albian strata unconformably and in turn is erosionally overlain by the Tent Island Formation (lower part of the Fish River Sequence). A late Cenomanian to Turonian age has been assigned to Boundary Creek beds. Because it is bounded by unconformities the formation is, by definition, also a transgressive-regressive sequence.

Correlation of Boundary Creek beds eastward has been difficult due to erosion by younger events but a few remnants are indicated to be present under Tuktoyaktuk Peninsula. A thin interval of shale and silty shale has been noted in a few wells to lie between the basal unit of the Smoking Hills succession and Albian beds – these are tentatively identified as Boundary Creek Formation/Sequence (Imnak J-29, Kannerk G-42, Kamik D-48, Kamik D-58, Parsons F-09 and Russell H-23) .

Microfossil recovery is generally poor in the Boundary Creek Formation in the Mackenzie Delta area and is limited to dwarfed, low- diversity assemblages of agglutinated foraminifera, algal cysts, radiolarians, and fish fragments. The *Trochammina superstes* Zone has been documented in the Boundary Creek Formation (McNeil, 1997) in the Mackenzie Delta subsurface, but the limited sections of Boundary Creek strata in the Tuktoyaktuk Peninsula did not yield any evidence of this zone. Dinoflagellate cysts are typically abundant and diagnostic in Boundary Creek strata. Unfortunately, published reports on the palynology of the Boundary Creek are few in number for the Tuktoyaktuk area, but Loranger (1975) and Brideaux and Myhr (1976) have noted evidence of Cenomanian-

Turonian palynomorphs, presumably Boundary Creek strata, in the Parsons F-09 and N-10 wells. Unpublished information in GSC files indicates Cenomanian-Turonian palynomorphs occur in the Imnak J-29, Russell H-23. and Kannerk G-42 wells, consistent with Boundary Creek strata identified here.

Smoking Hills Formation/Sequence

The type section of the Smoking Hills Formation is in Anderson Plain, southeast and east of Tuktoyaktuk Peninsula (Yorath et al., 1975), where it consists of medium to dark grey shale and interbedded bentonite, and it is also organic-rich. It has been dated as Santonian to Early Campanian (McIntyre, 1974; Yorath et al., 1975; Doerenkamp et al., 1976). It rests unconformably on the Albian Horton River Formation and is unconformably overlain by the Mason River Formation. Like the Boundary Creek succession, the Smoking Hills Formation can also be classified as a transgressive-regressive sequence.

In the subsurface of Tuktoyaktuk Peninsula the Smoking Hills Formation/Sequence is a distinct succession characterized by intervals of “normal” gamma-ray response interbedded with intervals of higher or rapidly variable gamma-ray response. This characteristic has been noted by previous authors (Myhr, 1975; Dixon et al. 1992) but with differing stratigraphic interpretations. In the present report up to eight informal subdivisions are recognized in some wells (e.g. Kanguk I-24; Fig. 4). However, facies change, onlap and possible internal truncations reduce the number of recognizable subdivisions in many wells (Fig. 4). The most complete succession is present under the north-western part of the Tuktoyaktuk Peninsula, becoming thinner to the southwest due to a combination of onlap on to a positive element in the north-central part of the peninsula and younger erosional events (Fig. 4). The lower beds of the Smoking Hills Sequence are very distinct, consisting of a thin basal interval that has a high gamma-ray response, overlain by an interval of variable gamma-ray response, in turn overlain by a thick interval of high gamma-ray response (Fig. 4). These three intervals can

be correlated over large areas of the Tuktoyaktuk Peninsula (Figs.4 to 6). Above these lower beds the Smoking Hills strata tend to be less radioactive, although with sufficient variation to allow several more widespread subdivisions to be recognized. Smoking Hills beds are commonly overlain erosionally by the Aklak Sequence but in places remnants of the Mason River Sequence overlie Smoking Hills strata (Fig. 4).

Smoking Hills strata have been identified as the source beds for some oil discoveries, e.g., Atkinson Point (Snowdon and Powell, 1979).

Foraminifera of the *Glaphyrammina spirocompressa* Zone occur commonly in the Smoking Hills strata. Two biofacies within this zone can be recognized in the Tuktoyaktuk Peninsula (McNeil, 1997). The biofacies are probably controlled by variations in substrate oxygenation. In the southwestern area, from outcrops south of the Caribou Hills at Douglas Creek northwards in wells such as Parsons F-09, Wagnark G-12 and Tuk F-18 the benthic foraminifera assemblage is more diverse and robust and has been referred to as the *Recurvoides tununukensis* biofacies by McNeil (1997). Representative species include *Bathysiphon vitta*, *Saccammina* spp., *Ammodiscus tenuissimus*, *A*. *cretaceus*, *A*. *thomsi*, *Reophax* sp., *Haplophragmoides bilobatus*, *H*. sp., *G*. *spirocompressa*, and *Recurvoides tununkensis*. Northwards, substrate oxygenation appears to have been lower and organic content of the substrate probably higher as the benthic foraminifera are typically very fine grained and of lower diversity. The low oxygen substrate assemblages are referred to as the *Balticammina*? *neosuperstes* biofacies and typical species include *Bathysiphon vitta*, *Saccammina* sp., *Ammodiscus cretaceus*, *Haplophragmoides* sp., and *Balticammina*? *neosuperstes*. In the type section of the Smoking Hills Formation to the east of Tuktoyaktuk Peninsula benthic foraminifera are absent due to organic-rich, anoxic substrates. Palynomorphs and diatoms occur abundantly in the Horton River sections and

these have been described by McIntyre (1974) and Tapia and Hardwood (2002), assigning ages of Santonian to Early Campanian.

Mason River Formation/Sequence

The type section of the Mason River Formation was described by Yorath et al. (1975) from Anderson Plain, southeast and east of Tuktoyaktuk Peninsula. The formation consists of light-grey weathering shale with some distinct rust-coloured beds. It is late Campanian to early or middle Maastrichtian in age and unconformably overlies Smoking Hills strata and is overlain unconformably by Tertiary gravels. Like the Boundary Creek and Smoking Hills succession, the Mason River Formation also can be classified as a transgressive-regressive sequence.

In the subsurface of Tuktoyaktuk Peninsula, shales identified as Mason River strata are not particularly distinct from under- and overlying shales of adjacent units, consequently much of the strata identified as Mason River is based on paleontological data from a few wells and then physical correlations into wells with no biostratigraphic data. In most wells it is underlain by Smoking Hills strata, except in a few wells, e.g., Tuk L-09, where biostratigraphic data and/or correlations indicates Mason River strata rest on Albian beds. Where preserved, the Fish River Sequence overlies Mason River beds, but in many places the Aklak Sequence rests directly on Mason River Sequence (Figs. 4 and 6).

The Mason River Sequence reaches its thickest development in the area of the Wagnark C-23 and Nuna A-10 wells (Fig. 4). Correspondingly, the biostratigraphic record is also well-developed in this area. McNeil (1997) chose the Wagnark G-12 well as the stratotype for the foraminiferal *Haplophragmoides bilobatus* Zone, which is widespread in the lower part of the Mason River Sequence in the Tuktoyaktuk Peninsula area. McNeil (1997) assigned an early Maastrichtian age to the Mason River, based largely on palynological interpretations (McIntyre, 1974,

1992 pers. comm.) The benthic foraminifera recovered suggest Early Maastrichtian also, but many of the species from the assemblage occur in the Campanian as well. Species that are largely confined to the zone include agglutinated species *Bathysiphon strombotulare*, *Saccammina grzybowskii*, *Saccammina* sp., *Haplophragragmoides* sp. and *Verneuilina macintyrei*. Calcareous benthic foraminifera occur in fewer numbers represented by *Praebulimina carseyae*, *Eoeponidella linki*, and *Gavelinella* sp. The calcareous microfauna is widespread in Arctic and Western Interior North America in Campanian and Lower Maastrichtian rocks (McDougall, 1987; McNeil, 1997, McNeil and Caldwell, 1981, and Wall, 1983).

Fish River Sequence

Fish River Sequence is an unconformity-bounded succession of late Maastrichtian to early Paleocene age first defined by Dietrich et al. (1985) and expanded upon by Dixon et al. (1992). In outcrop of the northernmost Richardson Mountains, along Fish River, it was recognized that the sequence contains the Tent Island Formation and the overlying sandstone unit of the Moose Channel Formation. Under Tuktoyaktuk Peninsula the Fish River Sequence has been recognized primarily from biostratigraphic data, lacking any distinct lithological features that separate it from under- and overlying shale-rich successions. It has a very limited distribution due to extensive erosion at the base-Aklak unconformity (Figs. 4 and 6).

The Fish River Sequence contains the *Convallina caverna* Zone defined from the 2164-2359 m-interval in the Tuk F-18 well (McNeil, 1997). The zone is defined as the stratigraphic interval between the top of the range of *C*. *caverna* and the top of *H*. *bilobatus*. Typical species in the zone include *Saccammina* sp., *Bathysiphon vitta*, *Haplophragmoides* spp., *Ammobaculoides* sp., *Convallina caverna*, *Trochammina tukensis*, and *Verneuilinoides* sp. The zone is considered to be Late Maastrichtian based on extrapolation of palynological interpretations of equivalent strata from the Big Fish River area (Sweet, 1978) and from the Horton River area

(D.J. McIntyre, pers. comm.). *Convallina caverna* is a distinctive foraminiferal index that is easily recognized. As mentioned above, a regional unconformity truncates the Fish River Sequence through much of the Tuktoyaktuk Peninsula area. Remnants of the Fish River Sequence containing the *C*. *caverna* Zone can be recognized in several wells illustrated on figures 5 and 6 (Tuk H-30, Tuk J-29, Tuk L-09, Tuktu O-19, and Wagnark C-23).

Aklak Sequence

Aklak Sequence is an upper Paleocene to basal Eocene unconformity-bounded succession, first defined by Dietrich et al. (1989), with additional data supplied by Dixon et al. (1992). The sequence contains strata equivalent to the Ministicoog Member of the Moose Channel Formation and the Aklak Member of the Reindeer Formation. It is overlain unconformably by the Taglu Sequence. The Ministicoog Member (i.e., lower Aklak Sequence) contains a distinct assemblage of foraminifera (*Reticulophragmium boreale* assemblage) that is traceable throughout the Mackenzie Delta and Tuktoyaktuk Peninsula, whether it is in a shale or sandstone-shale successions. At Caribou Hills the Aklak Sequence, which includes Price et al.'s (1980) Moose Channel and Reindeer formations, consists of interbedded sandstone, shale and coal with the *Reticulophragmium boreale* assemblage present in the basal beds. Here, Aklak beds rest erosionally on Smoking Hills strata; Mason River and Fish River strata having been eroded.

The sandy character of the Aklak Sequence continues northeastward into the Parsons Lake area but the lowermost beds become shalier. The trend to a shalier succession continues to the northeast, and in the Nuna area, and wells to the northeast, the lower Aklak Sequence is predominantly shale with some thin sandstone beds (Fig. 4). Only the upper part of the Aklak Sequence remains sandy but even this part of the sequence is shalier than that to the southwest (Fig. 4).

Few horizons within the Aklak Sequence can be traced over large areas with any degree of confidence, although between closely spaced wells correlations are reasonably accurate. The main producing sandstones in the Tuk discovery can be correlated with confidence outside of the Tuk area (Fig. 4) - these are the group II sandstones described by Morrell (1996). Morrell (op. cit.) illustrated the Tuk discovery with a reflection seismic line and a stratigraphic cross section, in which he interpreted the presence of a significant amount of Fish River strata and internal truncations within the Aklak Sequence. Correlations presented here (Fig. 7) do not support Morrell's (op. cit.) stratigraphy - there is very little Fish River strata and the Aklak Sequence does not appear to have any significant internal truncation surfaces.

Preservation of strata below the basal Aklak unconformity shows a general synformal pattern (Fig. 8) along the length of the peninsula. The youngest succession (Fish River Sequence) is preserved in the central part of the peninsula, in the Wagnark wells and some of the Tuk wells. Northeast and southwest of this area the preserved strata are progressively older (Fig. 8). In the southern Mackenzie Delta Aklak strata rest directly on Lower Cretaceous beds (Fig. 8), on a tectonic feature that appears to be an expanded Napoiak-Tununuk High. Two other area where Aklak rests on Lower Cretaceous beds are present in the central Tuktoyaktuk Peninsula, at the Kimik D-29 and West Atkinson L-17 wells (Fig. 8).

The Aklak Sequence contains two foraminiferal zones that are preserved in a variety of depositional settings across much of the Beaufort-Mackenzie Basin. The lower Aklak contains the *Reticulophragmium boreale* Zone, which has a wide geographic distribution across the Beaufort-Mackenzie Basin. The zone was defined from the Yukon Coastal Plain (McNeil, 1989) and is a reliable marker of the lower part of the Aklak Sequence as documented through the Mackenzie Delta subsurface to the Caribou Hills (McNeil, 1997). The precise age of the *R. boreale* Zone is difficult to determine because most of its species are endemic to the

Arctic, but palynological studies indicate that it occurs within the Paleocene (Ioannides and McIntyre, 1980; Parsons and Norris, 1999). McNeil (1997) considered the zone to be early Late Paleocene.

Along the Tuktoyaktuk Peninsula, the *R*. *boreale* Zone is developed in two distinct biofacies, a shallow-water, marginal marine biofacies dominated by *R*. *boreale*, and a more diverse offshore shelf biofacies containing agglutinated and calcareous benthic foraminifera. Typical agglutinated species of the offshore assemblage include *Saccammina placenta*, *Psammosphaera fusca*, *Bathysiphon* sp., *Hyperammina* sp., *Ammodiscus tenuissiumus*, *Haplophragmoides reindeerensis*, *Labrospira turpiculus*, *Reticulophragmium boreale*, *Recurvoides caribouensis*, *Trochammina* sp., and *Verneuilinoides durus*. Typical calcareous benthic foraminifera present include *Cyclogyra involvens*, *Pseudonodosaria* sp., *Miliolinella circularis*, *Praebulimina corpulenta*, and *Parrelloides walli*. The taxonomy and biostratigraphy of most these species have been documented by McNeil (1997).

The boundary between the marginal marine and the offshore biofacies of the *R*. *boreale* Zone can be mapped (Fig. 9) and extends southwest/northeast following a linear trend between the Eskimo Lakes fault zone on the east and the Kugmallit Trough to the west. The upper part of the Aklak Sequence along the Tuktoyaktuk Peninsula is dominated by terrestrial sediment and marine units that do occur are difficult to correlate. The presence of marine beds are indicated by sporadic occurrences of a low-diversity benthic foraminiferal assemblage that is informally referred to here as the upper Aklak assemblage zone. This assemblage zone is partially correlative to the *Portatrochammina aklakensis* Zone that McNeil (1997) recognized in the upper Aklak Sequence in outcrops and subsurface of the Beaufort-Mackenzie Basin to the west. *P*. *aklakensis* occurs questionably in the Ogruknang O-31 well, but has not be recognized in sections farther east. The upper Aklak assemblage is variable in its composition along the Tuktoyaktuk

Peninsula, but commonly occurring species include the calcareous benthic *Nonion* sp. and agglutinated foraminifera such as *Placentammina* sp., *Portatrochammina tagluensis*, and *Caronia gallagheri*. *Caronia gallagheri* is a conspicuous species in the Lower Eocene Ellice shale in northwestern part of the basin, but has been found to range into the upper part of the Aklak Sequence as well.

Iperk Sequence

Iperk strata are Pliocene in age and were first defined as a lithostratigraphic group by Jones et al. (1980), later identified as a sequence by Dietrich et al. (1985), with more details added by Dixon et al. (1992). The base of the Iperk Sequence is a major unconformity and tectono-stratigraphic boundary (Dixon et al., 1992; Lane and Dietrich. 1995; McNeil et al., 2001) – it marks the end of major tectonism in the Beaufort-Mackenzie Basin. Although separated from Quaternary strata by a major unconformity it is commonly difficult to separate the two successions in well data, consequently units identified as Iperk Sequence may contain Quaternary beds. No biostratigraphic interpretations have been made for Iperk strata in Tuktoyaktuk wells. Microfossil recovery from the Iperk Sequence in this area is dominated by reworked Mesozoic foraminifera, radiolaria, and inoceramid prismatic calcite. Terrestrial microfossils such as seeds, plant and insect fragments, microgastropods, microbivalves, and ostracods occur commonly.

Iperk strata under Tuktoyaktuk Peninsula are dominated by fine to coarse grained sandstone, gravel and some interbedded shale. Many beds are weakly consolidated and recovery of cuttings during drilling can be poor. Gamma-ray log signatures are characterized by a blocky log response. In a number of wells the base of the Iperk Sequence is behind casing and accurate depths are not always possible.

CONCLUSIONS

Upper Cretaceous and Tertiary stratigraphic units under Tuktoyaktuk Peninsula

are more readily identified than in previous years due to improved biostratigraphy and a better understanding of the regional geology. Strata include representatives of the following sequences: Boundary Creek, Smoking Hills, Mason River, Fish River, Aklak, and Iperk. However, the Boundary Creek Sequence is identified only tentatively. The Aklak Sequence is the most prominent stratigraphic unit, being present throughout the peninsula and truncating many of the older units. The Aklak Sequence contains oil and gas in the Tuk-Tuktuk discovery wells, with hydrocarbons occurring in several sandstone horizons, the most prolific and widespread reservoirs being the informally designated group II sandstones (Morrell, 1996).

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