GEOLOGICAL SURVEY OF CANADA
PAPER 89-15

BARREMIAN TO ALBIAN STRATIGRAPHY, TUKTOYAKTUK PENINSULA AND SOUTH MACKENZIE DELTA, NORTHWEST TERRITORIES

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1989

Available in Canada through

authorized bookstore agents and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Ottawa, Canada K1A 0S9

and from

Geological Survey of Canada offices:

601 Booth Street
Ottawa, Canada K1A 0E8

3303-33rd Street N.W.,
Calgary, Alberta T2L 2A7

A deposit copy of this publication is also available for reference
in public libraries across Canada

Cat. No. M44-89/15E
ISBN 0-660-13272-9

Critical readers

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Original manuscript submitted: 88.03.09
Approved for publication: 89.04.23

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BARREMIAN TO ALBIAN STRATIGRAPHY, TUKTOYAKTUK PENINSULA AND SOUTH MACKENZIE DELTA, NORTHWEST TERRITORIES

Abstract

Barremian to Albian strata of the Parsons Lake and south Mackenzie Delta areas have distinct seismic stratigraphic expression, geophysical log responses and foraminiferal assemblages. Data from these sources have led to the revision of formational boundaries, such that a much thicker, Albian, Arctic Red Formation and a thinner Mount Goodenough Formation are now recognized.

The Mount Goodenough succession contains a distinctive assemblage of Barremian agglutinated and calcareous benthic foraminifers, readily differentiated from Albian forms. Mount Goodenough strata can be correlated with the whole of the Atkinson Point Formation, not just the upper part, as was previously concluded. Also, the Siku Formation is reduced in rank to a member of the Mount Goodenough Formation.

Arctic Red strata are divisible into three informal members, lower, middle and upper, corresponding to three seismic facies; downlapping bottomset, foreset clinoforms, and onlapping reflections respectively. The boundaries between each member and between the Arctic Red and the underlying formation also have distinct log responses, usually abrupt changes in gamma-ray count and/or sonic transit time.

The Arctic Red succession also contains three distinct foraminiferal assemblages: a lower unnamed assemblage (the Lower member assemblage), a middle *Quadrimorphina albertensis* assemblage, and an upper assemblage tentatively assigned to the *Verneuilinoides borealis* assemblage. The middle and upper assemblages indicate an Early Albian age for that part of the Arctic Red Formation. The lower assemblage is not age-diagnostic.

Résumé

Les strates d'âge barrémien à albien, situées dans les régions du lac Parsons et du sud du delta de Mackenzie, se caractérisent par une expression stratigraphique et sismique distinctive, des réponses distinctives sur les diagrammes géophysiques, et par des assemblages particuliers de foraminifères. Les données provenant de ces sources nous ont amenés à réviser les limites des formations, de sorte que l'on identifie maintenant une formation beaucoup plus épaisse d'âge albien, la Formation d'Arctic Red, et une formation plus mince, à savoir la Formation de Mount Goodenough.

La succession de Mount Goodenough contient un assemblage distinctif de foraminifères benthiques agglutinés, calcaires, d'âge barrémien, qui se laissent facilement distinguer des formes albiennes. Il est possible de corréler les strates de Mount Goodenough avec l'ensemble de la Formation d'Atkinson Point, et non seulement avec sa partie supérieure, contrairement aux conclusions antérieures. En outre, le rang de la Formation de Siku a été réduit à celui de membre de la Formation de Mount Goodenough.

Les strates d'Arctic Red se laissent subdiviser en trois membres informels, inférieur, moyen et supérieur, qui correspondent à trois faciès sismiques; les faciès des couches deltaïques de fond à recouvrement progressif descendant, les lits deltaïques frontaux en forme de talus, et les couches réflectrices transgressives. Les limites entre chaque membre et entre la Formation d'Arctic Red et la formation sous-jacente se caractérisent aussi par des réponses distinctives sur les diagraphies, en général des variations abruptes du compte des émissions de rayons gamma et/ou de temps de propagation des ondes sonores.

La succession d'Arctic Red contient aussi trois assemblages distinctifs de foraminifères : un assemblage inférieur non dénommé (assemblage du membre inférieur), un assemblage intermédiaire de *Quadrimorphina albertensis*, et un assemblage supérieur provisoirement placé dans l'assemblage de *Verneuilinoides borealis*. Les assemblages moyen et supérieur indiquent que cette partie de la Formation d'Arctic Red est d'âge albien inférieur. L'assemblage inférieur n'indique pas d'âge précis.

INTRODUCTION

Barremian to Albian strata in the subsurface of Tuktoyaktuk Peninsula and south Mackenzie Delta consist of the Mount Goodenough, Rat River, Atkinson Point and Arctic Red formations (Dixon, 1982). In the nearby outcrops of northern Richardson Mountains (Fig. 1) the Mount Goodenough, Rat River and Arctic Red (or equivalent Albian strata) formations are readily identified and mapped (Jeletzky, 1958, 1960, 1961; Norris, 1981) on the basis of lithology, fossils and stratigraphic position. Lithology and stratigraphic position were the prime criteria for Dixon's (1982) subsurface correlations, as only limited, and commonly ambiguous, biostratigraphic data were available. Subsequent work has involved the use of reflection seismic and better biostratigraphic data, resulting in the need to revise Dixon's correlations of Barremian to Albian strata. The revisions include:

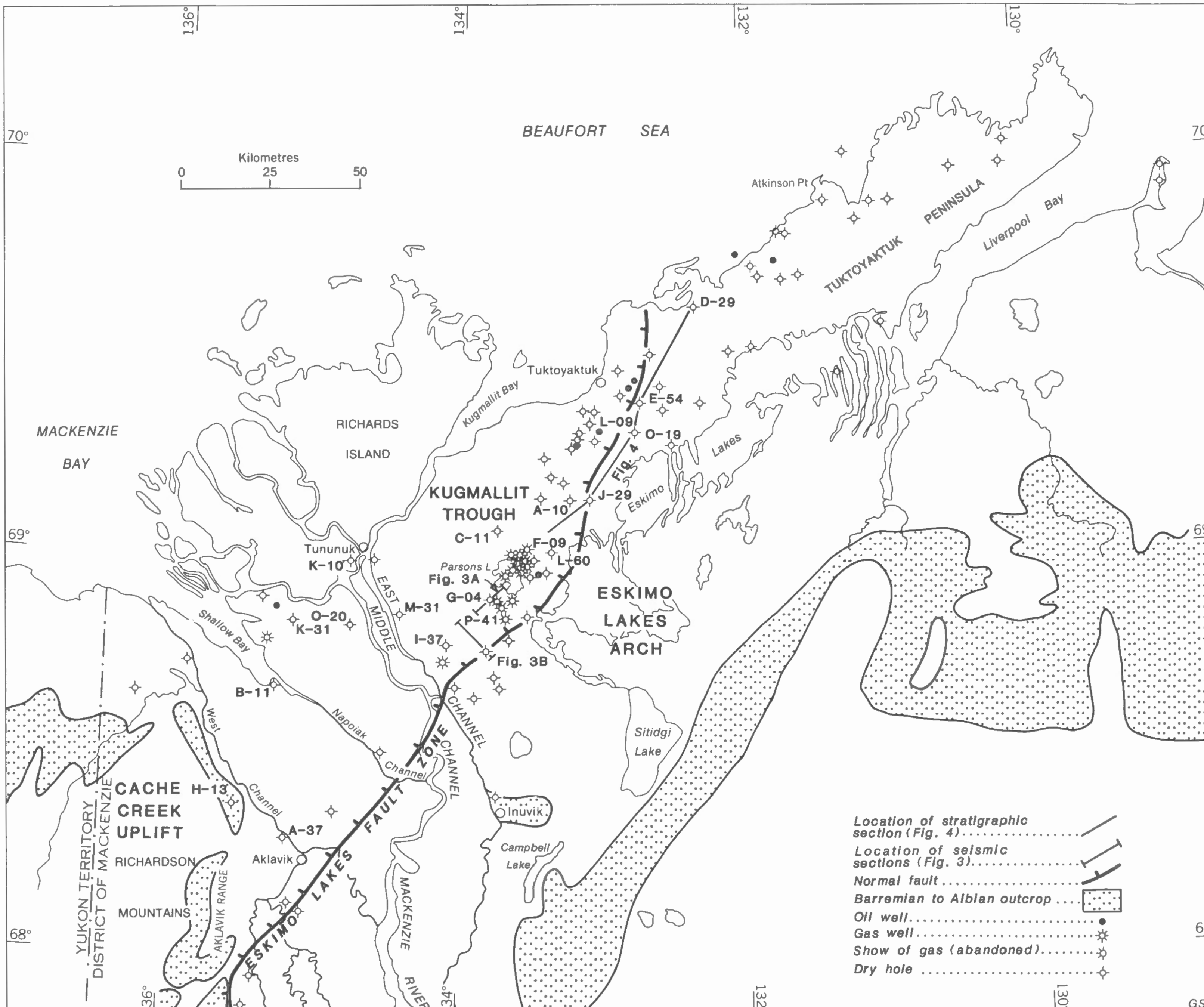


Figure 1. *Location map of wells, cross-section, seismic lines, and exposures of Barremian to Albian strata.*

1. Identification of a thicker Arctic Red succession, some of which had been included in the Mount Goodenough Formation

2. Identification of a threefold division within Arctic Red strata of the Kugmallit Trough

3. Inclusion of the Siku Formation as a member of the Mount Goodenough Formation

4. Limiting the identification of the Rat River Formation to fewer wells than previously indicated (Dixon, 1982).

Previous correlation

Dixon (1982, Fig. 4) identified a shale unit, the Siku Formation [the type section of this formation is in the Gulf Mobil Siku A-12 well, between log depths 2575.6-2657.9 m (8450-8720 ft); Dixon, 1982], between the Kamik sandstone succession below and the overlying Mount Goodenough silty shale strata. The Siku shales were thought to be separated from the Mount Goodenough shales by a regional unconformity, identified in the Pikiolik E-54 well and correlated through the Tuktu O-19 to Imnak J-29 wells.

Dixon (1982, Figs. 3, 4) used a prominent gamma-ray log marker to separate Mount Goodenough from Arctic Red strata, identifying the marker as a hiatal surface [log depth 1927.9 m (6325 ft) on Fig. 2]. Strata above the log marker are shale-dominant, although silty and sandy units are present, and were identified as Arctic Red Formation. Strata immediately below the marker are commonly sandy or silty and this is reflected in the gamma-ray response as a leftward deflection of the log trace. However, the bulk of the strata below the log marker also are shale-dominant and were identified as Mount Goodenough Formation. Within Dixon's (op. cit.) Mount Goodenough succession there is a prominent interval containing several low-velocity shales, the top of which was identified as a "sonic marker" by Dixon (op. cit.) and the base as a hiatal surface. The base of the Mount Goodenough Formation is an unconformity, commonly overlain by a sandstone interval. Dixon (1982/Appendix 1) identified Rat River strata in the Kipnik O-20, Ogruknang M-31, Tullugak K-31, Tununuk K-10, and Unak B-11 wells. The identification of this formation in these wells is now known to be incorrect (see Geological Survey of Canada Open File 1590 for new formation tops).

The Atkinson Point Formation (Dixon, 1979, 1982) was correlated with the Rat River Formation and uppermost Mount Goodenough Formation, based on the apparent lateral continuity of these strata. A late Barremian to Aptian age was suggested.

SEISMIC STRATIGRAPHY

The analysis of four multifold seismic reflection lines from the southern part of the Parsons Lake area (Fig. 1) has revealed a Barremian to Albian stratigraphy different from that described by Dixon (1982). The seismic profiles have been tied to the geology of the East Reindeer G-04 and Parsons P-41 wells. Two of the profiles (one dip oriented and one strike oriented) are reproduced in Figure 3. On both seismic sections the base of the Upper Cretaceous and top of the Husky Formation have been identified and correlated from the two wells. Within the intervening Lower Cretaceous section the base of the Mount Goodenough Formation (as determined from well data) appears seismically as a low to moderate amplitude, discontinuous reflection (Fig. 3). There are subtle indications on the seismic line of local truncation below the reflection, and onlap above, which

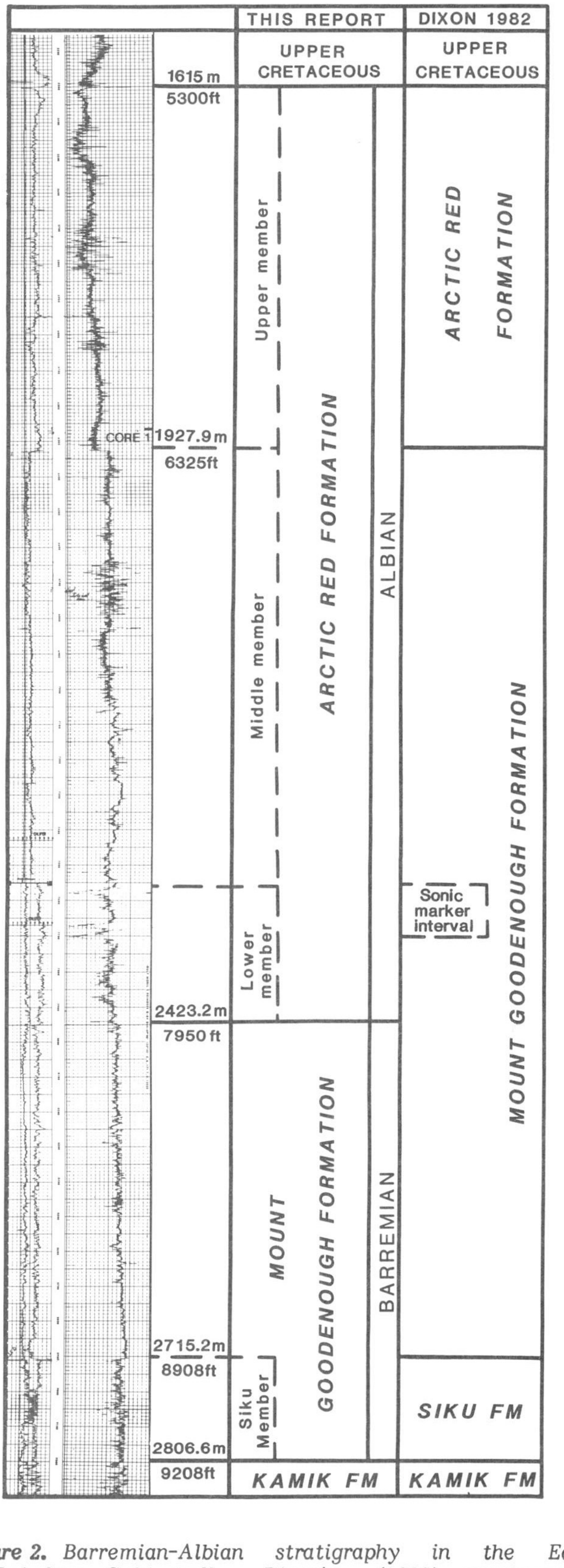


Figure 2. *Barremian-Albian stratigraphy in the East Reindeer G-04 well. Dixon's (1982) stratigraphic divisions and current revisions are indicated. Sonic and gamma-ray logs.*

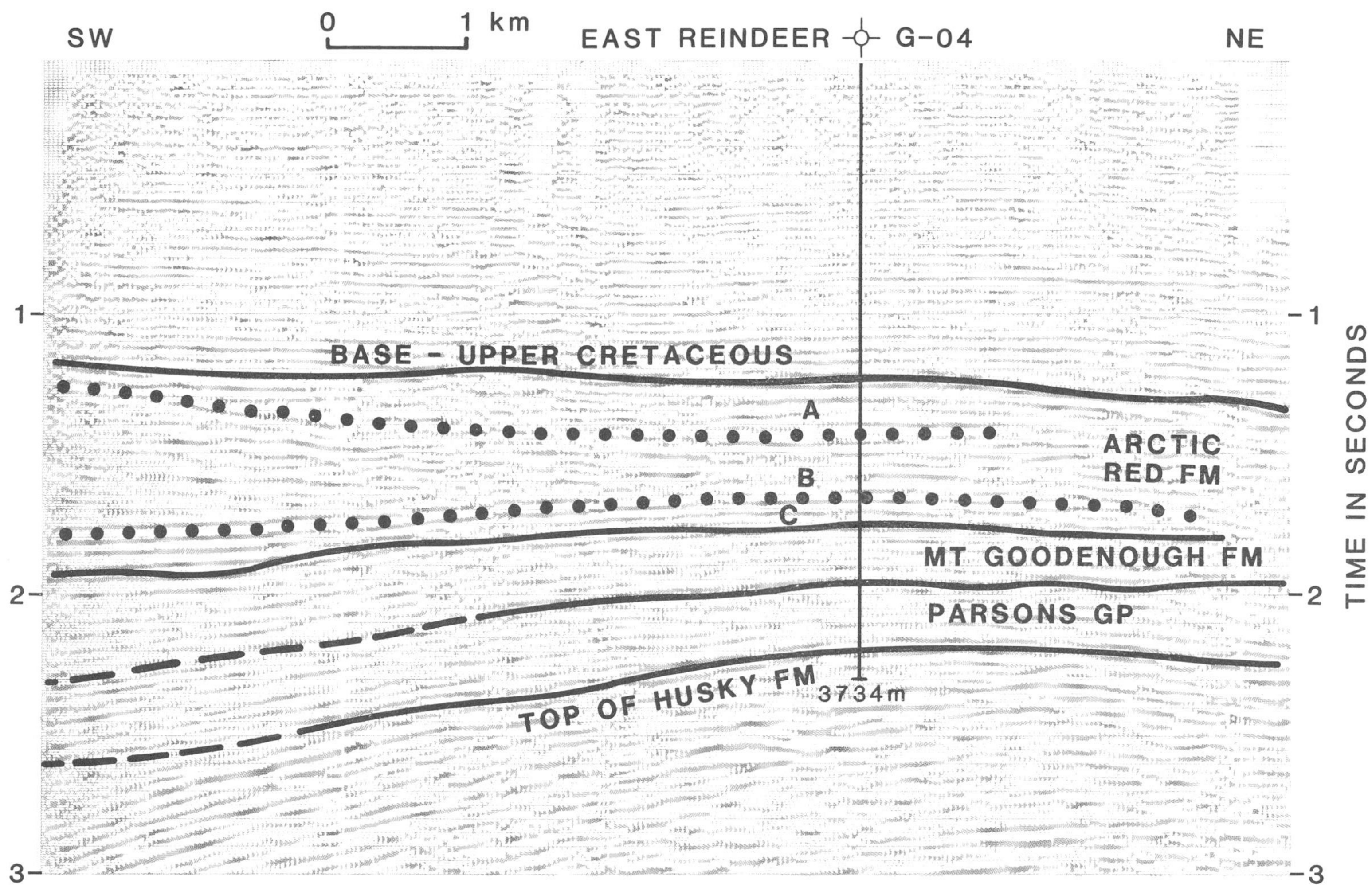


Figure 3a. *Reflection seismic through the Reindeer G-04 well.*

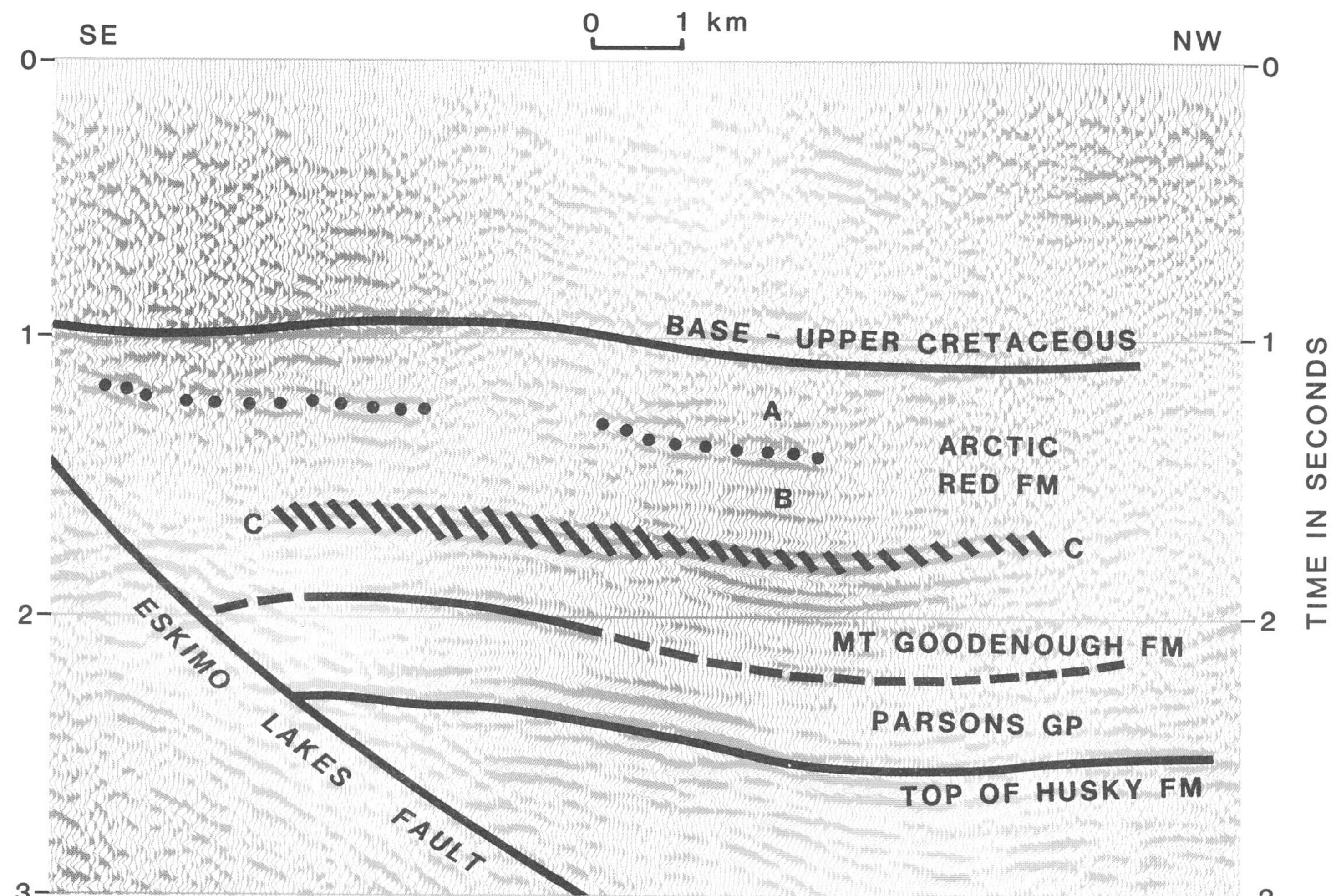


Figure 3b. Reflection seismic through the Parsons P-41 well.

are consistent with the known regional character of the Mount Goodenough basal unconformity. The section above the base-Mount Goodenough unconformity contains variable seismic patterns. The most distinctive zone is a band of high amplitude, near continuous reflections that appear on all four reflection profiles. At the Reindeer G-04 well this high amplitude zone (Unit C in Figure 3) occurs at reflection times of 1.67 to 1.75 seconds. This seismic zone ties to a stratigraphic interval in the G-04 well containing low-velocity shale, the top of which had been identified as a "sonic marker" by Dixon (1982). The low-velocity shale zone [log depths 2304.3-2423.2 m (7560-7950 ft) in the G-04 well] was interpreted as an intra-Mount Goodenough unit by Dixon (op. cit.). On the seismic profile the base of the low-velocity zone appears to be an unconformity, locally truncating underlying reflections. The top of the low-velocity shale zone corresponds with the uppermost reflection of the high amplitude unit (C). Overlying and downlapping the high amplitude zone is a thick succession of strata characterized by low amplitude, discontinuous reflections with locally divergent to hummocky geometry. The complex stratal patterns and low-angle clinoforms within this succession are characteristic of slope deposition. This seismic sequence, extending to the unconformity below the Upper Cretaceous, can be further subdivided into two units (A and B in Figure 3). The boundary between Units A and B corresponds to a moderate amplitude, discontinuous reflection that is locally onlapped by overlying reflections. This subtle seismic discontinuity can be tied to prominent log markers in the G-04 [depth 1927.9 m (6325 ft)] and P-41 [depth 1798.3 m (5900 ft)] wells. In the East Reindeer G-04 well the distinct sonic and gamma-ray marker at 1927.9 m (6325 ft) was interpeted by Dixon (op. cit.) as the boundary between the Mount Goodenough and Arctic Red formations.

The seismic analysis described above led to the re-evaluation of available biostratigraphic data and the analysis of foraminifera in six additional wells (see later discussion of biostratigraphy). Foraminifers in the low-velocity zone are not age-diagnostic, but could be Early Albian (see later discussion), whereas strata immediately below contain Hauterivian to Barremian microfossils. Palynomorphs from the Parsons N-10 well tend to indicate similar ages for the intervals under discussion (Brideaux and Myhr, 1976). These results necessitate some revisions to the subsurface correlations of Dixon (1982). Strata of the low-velocity shale zone and above are reassigned to the Arctic Red Formation. Mount Goodenough, and locally Rat River, strata are limited to those below the low-velocity shale zone. The sonic and gamma-ray log marker, previously identified as the base of the Arctic Red Formation (Dixon, op. cit.), is now interpreted as an intra-Albian marker.

LITHOSTRATIGRAPHY

The seismic boundaries are readily correlatable with distinct log markers that have already been identified by Dixon (1982) and correlated throughout the south Mackenzie Delta and southwestern end of Tuktoyaktuk Peninsula. However, the slope clinoforms identified in the seismic sections were not recognized by Dixon, who placed the clinoform-containing interval within the Mount Goodenough Formation. The seismic units and their seismic facies clearly indicate that the unit with slope clinoforms is a distinct unit separated from the underlying seismic unit by a major, regionally extensive boundary. The Gulf Mobil East Reindeer G-04 well (Lat. 68°53'15.9"N, Long. 133°46'03.3"W) will be used as a subsurface reference section for the identification of the log markers used as formation and member boundaries (Fig. 2).

Mount Goodenough Formation

Mount Goodenough strata consist of a locally developed basal sandstone of highly variable thickness, overlain by a shale-dominant succession. The basal sandstone is generally only a few metres thick and tends to be argillaceous and silty, although 'cleaner' sandstones are present locally.

The bulk of the Mount Goodenough Formation consists of medium to dark grey, very silty shale interbedded with siltstone. In outcrops of the Aklavik Range, Jeletzky (1958) divided the formation into a shale-dominant Lower member, and an Upper member of shale with interbedded siltstone and sandstone. In many of the wells, the silty/sandy beds occur in 15 to 30 m thick, coarsening-upward units. Many of these cycles can be correlated between closely spaced wells. Some have considerable lateral extent and serve as useful intraformational correlation markers. In some wells the silty/sandy shales of the Mount Goodenough Formation are gradationally succeeded by shale-to-sandstone, coarsening-upward cycles of the Rat River Formation.

Siku shales originally were separated from the Mount Goodenough as a different formation but recent studies indicate that this unit is part of the Mount Goodenough succession. The correlation of strata in the Tuktu O-19 and Imnak J-29 wells (Dixon, 1982, Fig. 4), which formed the basis for the original conclusions, is open to a different interpretation (Fig. 4). The so-called basal sandstone in J-29 is actually a higher stratigraphic unit within the succession, and the basal unconformity is in fact a conformity, or an unidentifiable unconformity at, or near, the top of the Kamik succession in the J-29 well. The foraminiferal assemblage within the Siku strata is typical of the Mount Goodenough Formation, adding further support to the stratigraphic link between these two shale successions. Also, at the Tuk M-09 and Kamik D-48 wells there is a much thinned Kamik succession overlain by Mount Goodenough shale. This situation is believed to be due to sub-Mount Goodenough erosion which, at these two localities, would be at the base of the shale succession, not within it. The inclusion of the Siku shale within the Mount Goodenough Formation would be consistent with the lithological succession seen in the Aklavik Range (Jeletzky, 1958); therefore, it is proposed that the Siku shale become a member of the Mount Goodenough Formation (the type section and descriptions remain as Dixon, 1982, stipulated).

Thickness of the Mount Goodenough strata (inclusive of Siku and Rat River equivalents in the Kugmallit Trough) ranges up to 700 m (Fig. 5).

Rat River Formation

Rat River strata are not always readily separated from underlying Mount Goodenough strata using log signatures, even though sandy beds may be present. Consequently, Rat River strata have not been identified in some wells, although equivalent beds may be present. Where identified, the formation thickness is in the order of 100 m or less and its strata form coarsening-upward cycles. The cycles consist of silty shales at the base, grading up into interbedded shale, siltstone and sandstone, capped by very fine to fine grained sandstone. The contact with overlying Arctic Red strata is abrupt. Some pre-Arctic Red erosion may have occurred, which also would account for the absence of Rat River strata in some areas. However, it appears that the presence or absence of Rat River strata is due mainly to facies variations.

Atkinson Point Formation

The Atkinson Point Formation was originally defined as a succession of conglomerate and sandstone occurring between overlying Arctic Red shale and a basal unconformity, below which rocks as old as Proterozoic occur (Dixon, 1979). The coarse clastics grade laterally into shale and siltstone and the sandstone-to-shale facies boundary climbs upsection (Fig. 4; Dixon, 1982). The sandstones become progressively siltier in the Kugmallit Trough, so that, away from the type area, it becomes progressively more difficult to distinguish an Atkinson Point unit (Fig. 4).

Correlation of the Atkinson Point Formation with the Rat River Formation and uppermost Mount Goodenough Formation was suggested by Dixon (1979), based principally on stratigraphic position and physical correlations, some of which are now known to be incorrect. Physical correlations, using the restrictions imposed by the new stratigraphic data, are indicated in Figure 4. The log correlations suggest that the Atkinson Point Formation, at its type area, is equivalent to all of the the Mount Goodenough and Rat River interval. If this is correct, then its age possibly extends from the late Hauterivian into the Aptian.

Thickness and facies types within the Atkinson Point and equivalent strata change significantly from the Eskimo Lakes Arch across the Eskimo Lakes Fault Zone into the Kugmallit Trough. On the arch, Atkinson Point strata are entirely sandstone and/or conglomerate whereas, across the fault zone, facies within the equivalent stratigraphic interval become shalier. The thickness of the interval between the basal unconformity and the base of the Arctic Red Formation approximately doubles westward, across the fault zone (Fig. 5).

Arctic Red Formation

Arctic Red strata can be divided into three informal members based on seismic stratigraphy and log signature. The Lower member (Unit C in Figure 3) forms a relatively thin but seismically distinctive unit that corresponds with a low-velocity shale interval, the top of which was identified as a "sonic marker" by Dixon (1982). This interval consists of brownish grey, commonly waxy-appearing shale, containing locally abundant carbonaceous material. Its thickness is generally in the order of 100 m. In its upper half there are at least three thin shale intervals with very low sonic transit times, separated by "normal" shales. These very low-velocity shales are distinct log-markers. In the Kugmallit Trough, strata of the Lower member consist of bottomset beds of prograding slope clinoforms and, therefore, represent deep water, basinal marine beds.

The Middle member (Unit B in Figure 3) consists of a thick succession of dark grey, usually silty, shale between the top of the low-velocity shale interval and a prominent sonic and gamma-ray marker [at depth 1927.9 m (6325 ft) in the G-04 well]. Seismic unit B (Fig. 3), containing slope clinoforms, corresponds to the Middle member. The Middle member also contains thin interbeds of siltstone and very fine grained sandstone, commonly in coarsening-upward cycles (Fig. 2). Many of these cycles are readily correlated between closely spaced wells and some are regional in extent. A prominent coarsening-upward cycle is commonly present immediately below the Upper member. In places the Middle member is unconformably overlain by Late Cretaceous or younger strata, the Upper member having been eroded. Strata of the Middle member reflect an overall basinward progradation of slope to shelf-margin deposits.

The Upper member equates with the onlapping seismic unit (Unit A in Figure 3). Medium to dark grey shales are the dominant lithology in the Upper member, and shelly and carbonaceous debris is present throughout. Thin interbeds of siltstone and very fine grained sandstone are present but are not as common as in the Lower member. Carbonate concretions are scattered throughout the Upper member. Upper Cretaceous or lower Tertiary strata unconformably overlie the Upper member. The Upper member appears to be a complex succession of slope and basinal deposits, the base of which may be an intra-Albian submarine unconformity.

The Arctic Red succession has a number of log markers (sonic, gamma and resistivity) that can be correlated between many of the wells within the Kugmallit Trough, but generally are not traceable into the formation on the Eskimo Lakes Arch. Erosion and thinning of Albian strata on the arch make it impossible to correlate the three members from the trough onto the arch, neither on the reflection seismic nor by using log markers. However, at the southwest end of the arch, the log-marker-defined members can be traced from the Aklavik A-37 and F-38 wells across the Treeless Creek Fault into the Aklavik F-17 and Rat Pass K-35 wells. The thickness of Arctic Red strata is rapidly reduced between the F-38 and F-17 wells; the Middle member is almost halved in thickness.

Arctic Red strata thicken rapidly across the Eskimo Lakes Fault Zone, from a few tens of metres to over 1000 m in the vicinity of the Ikhil I-37 well (Fig. 6). Thickness of the combined Lower and Middle members is up to about 600 m, whereas the Upper member is usually thinner due to Late Cretaceous and early Tertiary erosion, although preserved thicknesses of up to 600 m are known at Ikhil I-37. On the Eskimo Lakes Arch, Arctic Red strata are generally less than 200 m thick at the northeast end, thickening to over 400 m at the southwest end (Fig. 6).

BIOSTRATIGRAPHY

Introduction

Barremian to Albian strata in the subsurface of the Mackenzie Delta yield assemblages of predominantly agglutinated foraminifers. Calcareous benthonic foraminifers are present to a lesser degree. Four assemblage zones have been delineated in the six wells examined, two of which, the Aklavik A-37 and the Parsons F-09, are illustrated in Figure 7. The other wells include Ogeoqeoq J-06, Ogruknang M-31, Parsons A-44, and Siku A-12 (see Appendix 2). The occurrences of selected species are provided in Appendix 2 in order to substantiate biostratigraphic correlations, but no attempt has been made to document the entire foraminiferal assemblage. An assessment of the corresponding stratigraphy and log signatures permits the biostratigraphic information to be extrapolated through the other wells considered in this report.

The assemblages can be correlated with foraminiferal faunas, from nearby outcrops of the northern Richardson Mountains, previously documented by Chamney (1969, 1978) and Fowler (1985). Longer-range correlations with microfaunas of the Sverdrup Basin (Sliter, 1981; Wall, 1983) and the North Slope of Alaska (Tappan, 1962; Bergquist, 1966) permit regional recognition of two of the assemblage zones.

Microfossil slides for the Shell Aklavik A-37 (GSC locality no. C-30197), Gulf Ogruknang M-31 (C-82855), and Gulf Parsons F-09 (C-33937) wells are stored at the Institute of Sedimentary and Petroleum Geology in Calgary. Microslides of samples from the Gulf Parsons A-44 and Gulf Siku A-12 wells were obtained on loan from Gulf Canada

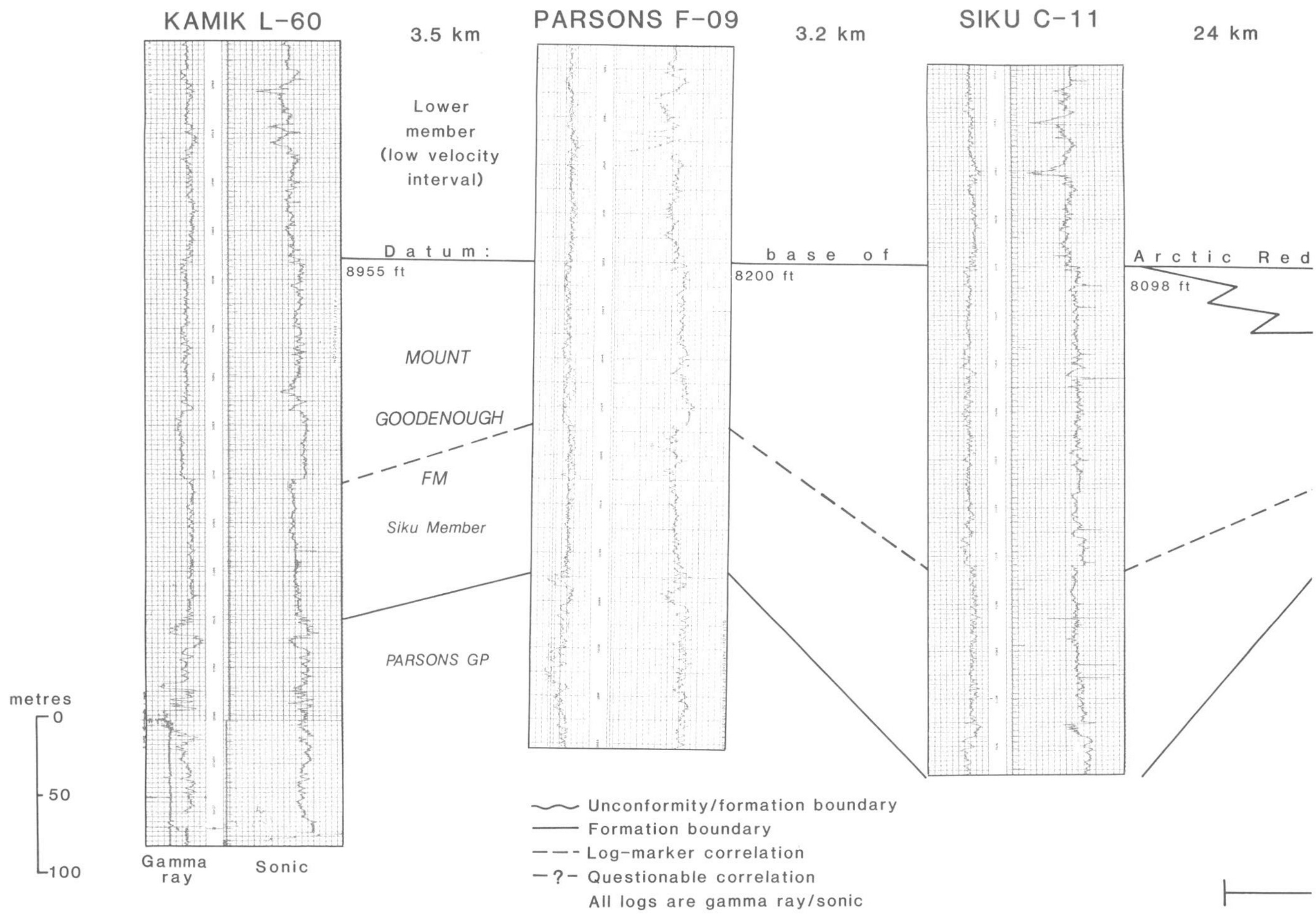


Figure 4. *Correlation of Atkinson Point and Mount Goodenough strata, central Tuktoyaktuk Peninsula. Sonic and gamma ray logs.*

Corporation, and microslides for Gulf Ogeoqeoq J-06 were obtained from Shell Canada Resources Limited. For all six wells, the microslides were prepared from well cuttings.

Mount Goodenough Formation

Foraminiferal assemblage

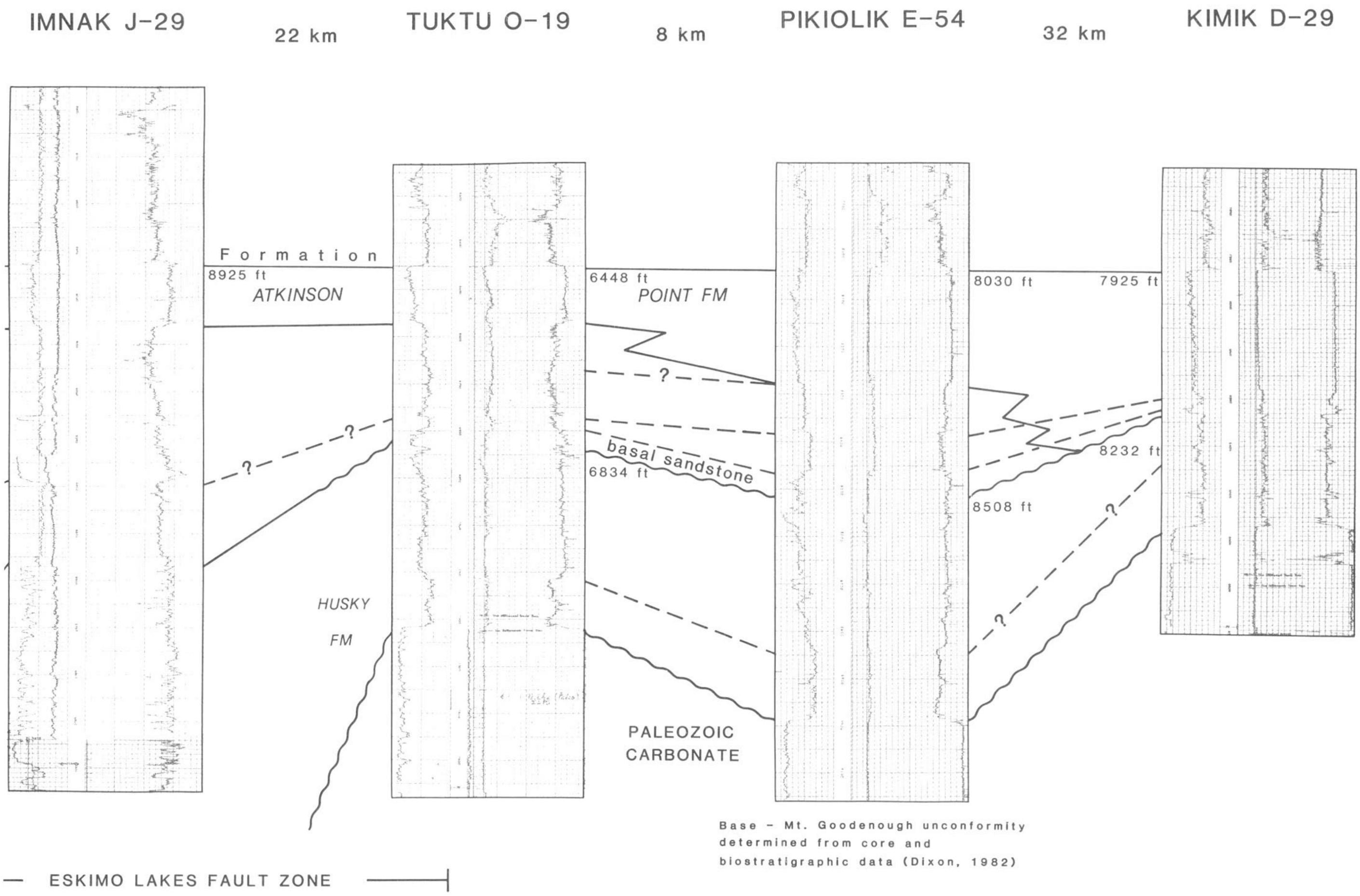
Foraminifers from the Mount Goodenough Formation in the Aklavik Range of the Richardson Mountains were studied by Chamney (1969), who reported on an agglutinated assemblage from the lower part of the "upper shale siltstone division" (Mt. Goodenough Formation). Fowler (1985), in a more extensive study of Early Cretaceous microfaunas from the Richardson Mountains area, described a rich foraminiferal assemblage of agglutinated and calcareous benthic foraminifers from the Mount Goodenough Formation exposures on Martin Creek, Mount Goodenough, and Mount Goodenough Creek.

The Mount Goodenough Formation is dated as late Hauterivian to possibly Aptian in its uppermost beds (Dixon, 1982). This age assignment was derived from paleontological determinations, on molluscs, by Jeletzky (1958, 1960, 1961), and on palynomorphs, by Brideaux and Myhr (1976).

The Mount Goodenough foraminiferal assemblage is well developed in the Aklavik A-37 [603.5-975.4 m (1980-3200 ft)] and Parsons F-09 [2529.8-2697.5 m (8300-8850 ft)] wells. Abundant occurrences of agglutinated foraminifers, associated with rare calcareous benthonic specimens, characterize the assemblage. For the purposes of this study, only a small portion of the the foraminifers of this assemblage zone are identified to species level. The species recognized include *Ammobaculites* cf. *A. coprolithiformis* (Parker and Jones), *Arenobulimina* sp. 14, *Gaudryina tailleuri* (Tappan), *Haplophragmoides concavus* (Chapman), *H.* sp., *Labrospira goodenoughensis* (Chamney), *Lenticulina macrodiscus* (Reuss), *L.* sp. (with raised sutures), *Lituotuba* sp. 116, *Praebulimina* sp. 69, and *Verneuilinoides neocomiensis* (Myatliuk) [species numbers after Fowler, 1985].

Arenobulimina sp. 14 is a characteristic index fossil of the Mount Goodenough Formation assemblage, with its first downhole occurrence (in well cuttings) at 30.5 or 61 m (100 or 200 ft) below the top of the formation. Similarly, it occurs in the lower member of the Mount Goodenough Formation in the Richardson Mountains (Fowler, 1985).

The lowest extent of the Mount Goodenough assemblage cannot be determined reliably using well cuttings. The fauna occurs in the cutting samples well below the lower contact



with the Kamik Formation, but more detailed studies, preferably based on cores, will be required to discriminate the foraminiferal assemblages immediately underlying the Mount Goodenough Formation.

Arctic Red Formation

Foraminiferal assemblages

Beds assigned to the Arctic Red Formation in the Aklavik A-37 and Parsons F-09 wells yielded three foraminiferal assemblages: a lower unnamed assemblage, the *Quadrimorphina albertensis* assemblage, and a tentatively recognized *Verneuilinoides borealis* assemblage. The lower unnamed assemblage, which is informally referred to here as the "Lower member assemblage", has not been previously recognized in the North American Arctic. The *Q. albertensis* and *V. borealis* assemblages, however, are both well known in the Arctic Islands and in equivalent strata in the North Slope of Alaska.

"Lower member assemblage"

The Lower member is defined as a low-velocity zone on sonic logs and is seismically interpreted as the basinal downlap facies of slope sediments (Middle member of the Arctic Red Formation).

This basinal lithofacies yields a low diversity, but distinctive, assemblage of agglutinated foraminifers in the Aklavik A-37 well. The assemblage is informally referred to as the "Lower member assemblage" and is recognized also, but with less assurance, in the Parsons F-09 well, where rare specimens of the assemblage occur in cutting samples just below the Lower member of the Arctic Red Formation. The limited recovery and the possibility of the specimens being caved render the assemblage recognition tentative. The microfauna consists of small-sized, very finely agglutinated specimens of *Ammodiscus*, *Reophax*, *Trochamminoides*, and *Trochammina*, none of which are specifically identified here. The distinctive, "dwarfed", thin-walled character of specimens from this assemblage is interpreted as signifying a low-oxygen substrate paleoenvironment with little clastic terrigenous input (i.e. starved basin) in relatively deep water.

The age of the Lower member cannot be determined directly from its foraminiferal content, but can be deduced from its stratigraphic relationships. As discussed previously, geological interpretation of seismic data suggests that the Lower member is a downlap facies-equivalent of the Middle member. Since the Middle member carries the Early Albian *Quadrimorphina albertensis* assemblage, a similar age probably applies to the Lower member.

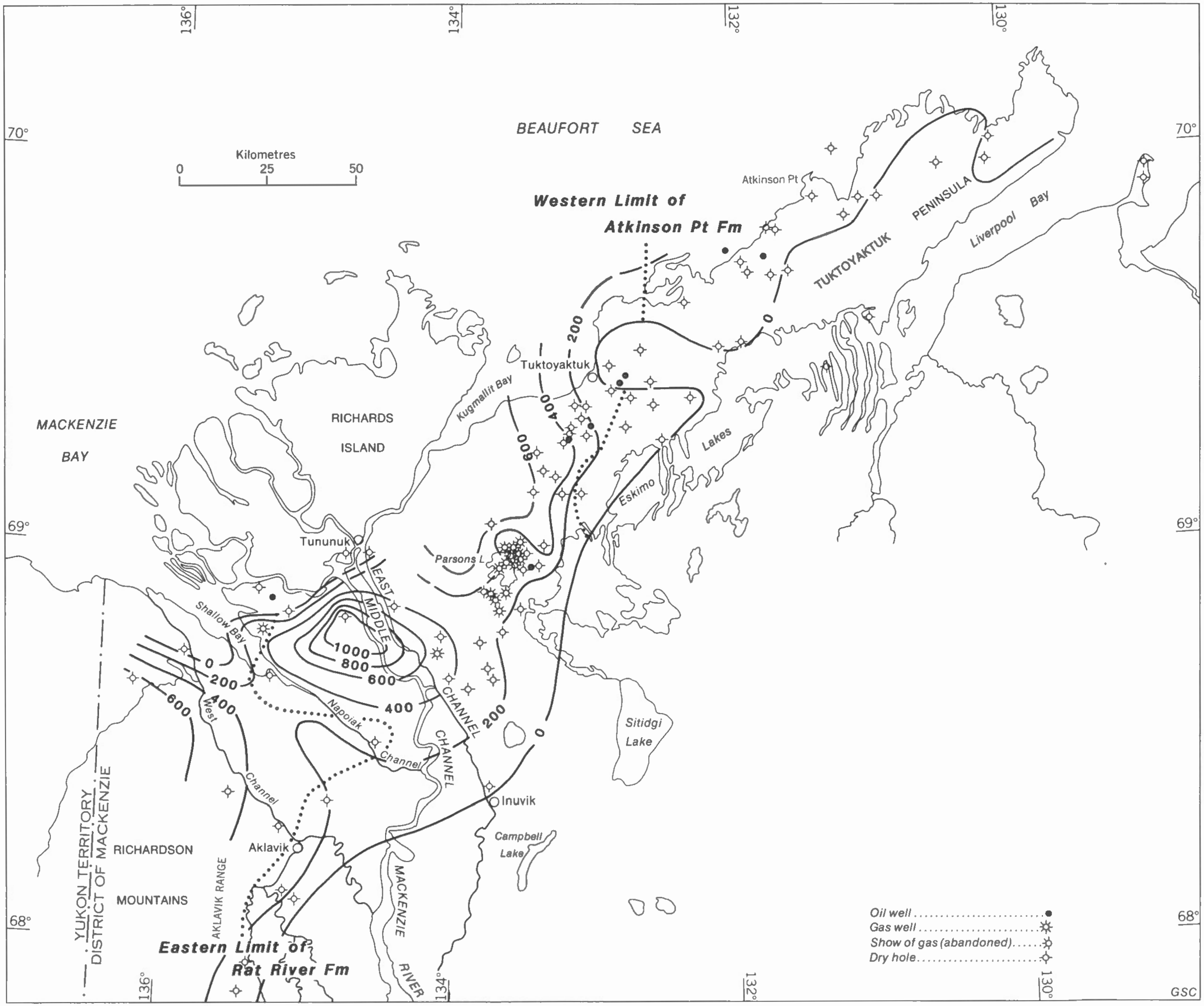


Figure 5. *Isopach map of the Mount Goodenough, Rat River and Atkinson Point stratigraphic interval. Approximate limits of identifiable Rat River and Atkinson Point formations are indicated. Contours in metres.*

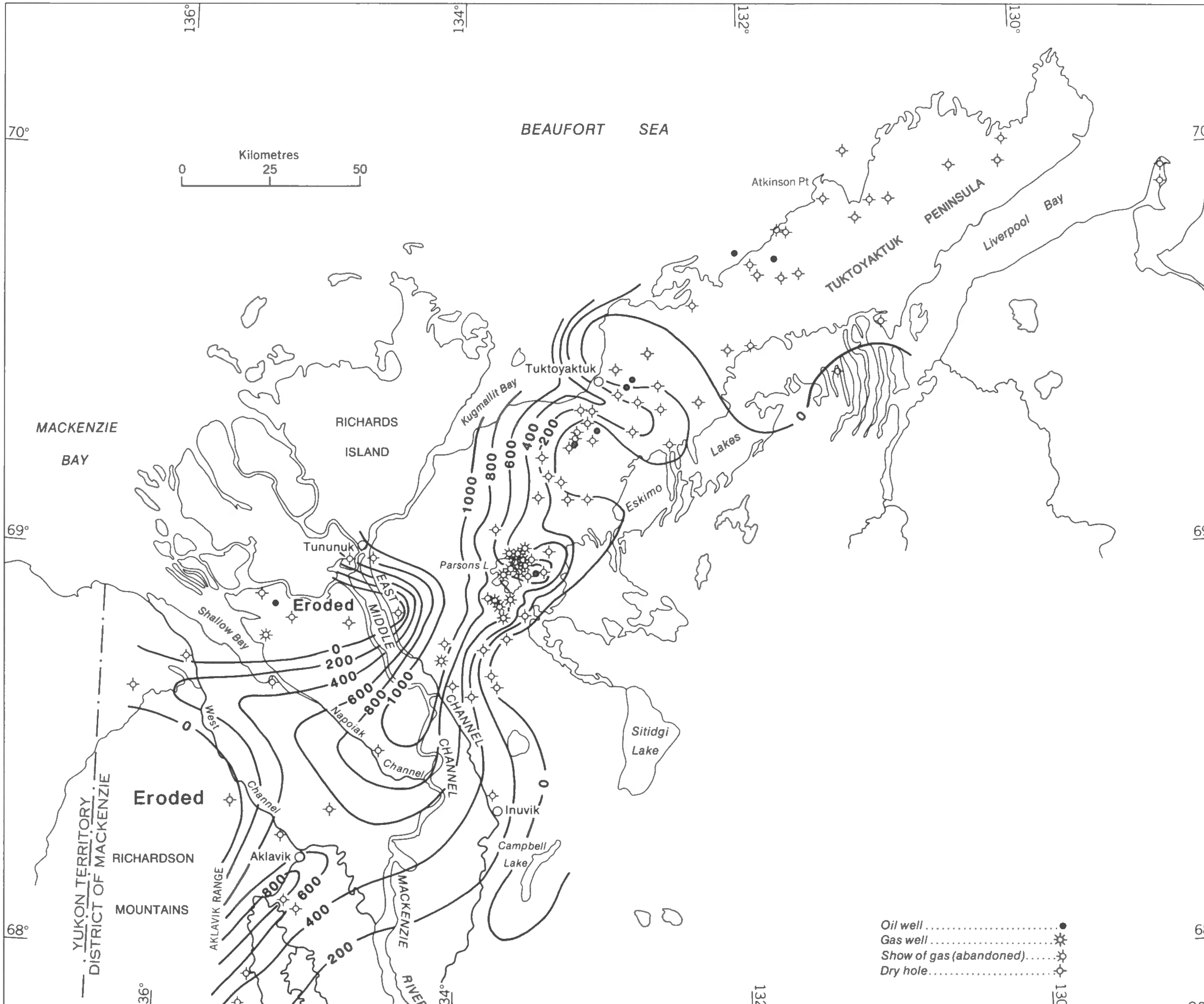


Figure 6. *Isopach map of the Albian, Arctic Red Formation. Contours in metres.*

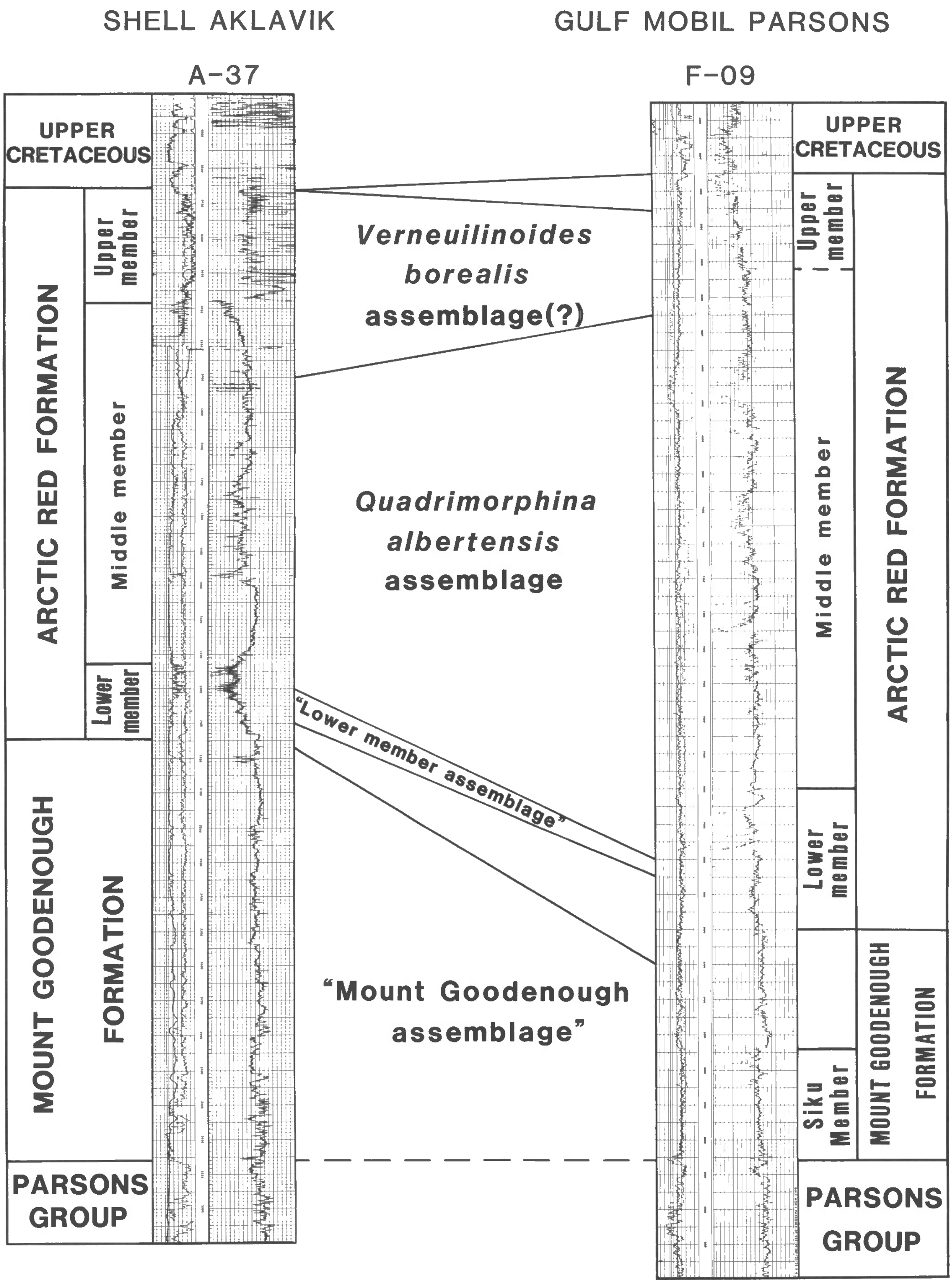


Figure 7. Foraminiferal assemblages in the Aklavik A-37 and Parsons F-09 wells.

Quadrimorphina albertensis assemblage

The Middle member of the Arctic Red Formation contains the Early Albian *Quadrimorphina albertensis* Zone. This zone is widespread in the Arctic, occurring in the Mackenzie Delta area, the Sverdrup Basin, and the North Slope of Alaska. In Yukon, the *Saracenaria trollepei* through to *Valvulineria loetterlei-Trochammina stelcki* zones recognized by Chamney (1978) comprise equivalent assemblages. In the North Slope of Alaska, the assemblage occurs in the *Gaudryina tailleuri* zone of Tappan (1962) and Bergquist (1966).

Wall (1983) and Sliter (1981) have given thorough accounts of the *Quadrimorphina albertensis* assemblage in Sverdrup Basin, and have indicated its age as Early Albian and its environmental setting as normal marine neritic. Seismic data from the current study indicate that the fauna extends into the bathyal environment as well. The assemblage is recognized in the Aklavik A-37 well between 274.3 and 518.2 m (900 and 1700 ft) and in the Parsons F-09 well between 1966 and 2407.9 m (6450 and 7900 ft). In both wells, it occurs below the upper contact of the Middle member.

The *Q. albertensis* microfauna is well developed in both the Aklavik A-37 and Parsons F-09 wells. Characteristic agglutinated species include *Ammobaculites fragmentarius* Cushman, *Gaudryina subcretacea* Cushman, *G. tailleuri* (Tappan), *Glomospirella gaultina* (Berthelin), *Haplophragmoides topagorukensis* Tappan, *Pseudobolivina rayi* (Tappan), and *Uvigerinammina athabascensis* (Mellon and Wall). Characteristic calcareous benthic species include *Conorboides umiatensis* (Tappan), *Gavelinella stictata* (Tappan), *Saracenaria trollopei* Mellon and Wall, *Serovaina loetterlei* (Tappan), and *Quadrimorphina albertensis* Mellon and Wall.

The lowest occurrence of the assemblage is difficult to determine from data based on well cuttings, but in the wells studied the characteristic fauna occurs abundantly down to the base of the Middle member and is sporadic or absent in lower samples, clearly suggesting a lower limit near the base of the Middle member.

Verneuilinoides borealis assemblage(?)

The Upper member in the Aklavik A-37 and Parsons F-09 wells yields a poorly developed agglutinated foraminiferal assemblage. Many of the species apparently range down into strata yielding the *Q. albertensis* assemblage. None of the species are identified here to the species level, but genera present include: *Ammobaculites, Bathysiphon, Glomospira, Gravellina, Haplophragmoides, Saccammina, Trochammina,* and *Verneuilinoides.* The assemblage is tentatively considered indicative of the *Verneuilinoides borealis* assemblage of the Sverdrup Basin (Sliter, 1981; Wall, 1983), based on general compositional similarity to that assemblage's microfauna, and based on homotaxial comparison between the two regions. Wall's age determination for the *V. borealis* assemblage indicated a potential span from latest Early Albian to Late Albian.

Macrofossils and microflora

Brideaux and Jeletzky (1974, p. 6, 7) and Jeletzky and Stelck (1981, p. 12) identified the ammonite *Pachygrycia canadensis* (ex-*Sonneratia*) in Core 1 from the Upper member, Arctic Red Formation, in the East Reindeer G-04 well. This ammonite is considered to indicate an earliest Albian age (op. cit.). However, in the Arctic Islands, this ammonite is generally associated with the *Quadrimorphina albertensis* assemblage (Wall, 1983). Its occurrence in the Upper member of the Arctic Red Formation, in beds that should lie above the *Q. albertensis* Zone, is anomalous.

Material from the core was sampled for foraminifers and palynomorphs. The cored interval appears to be barren of foraminifers but yielded a rich microflora of dinoflagellates and conifer pollen. The dinoflagellate assemblage includes *Pseudoceratium polymorphum* (Eisenback) Bint, *Odontochitina operculata* (O. Wetzel) Deflandre and Cookson, *O. singhii* Morgan, *Oligosphaeridium complex* (White) Davey and Williams, *O. totum* Brideaux, *Laciniadinium arcticum* (Manum and Cookson) Lentin and Williams, *Luxadinium propatulum* Brideaux and McIntyre, and *Chichaouadinium vestitum* (Brideaux) Bujak and Davies. Angiosperm pollen include specimens of *Tricolpites sagax* Norris, *Retitricolpites vulgaris* Pierce, and a more coarsely reticulate species of *Retitricolpites.*

The dinoflagellate and pollen flora indicate that the cored interval is of late Middle Albian or Late Albian age. *Chichaouadinium vestitum* first occurs in late Middle Albian strata of Alberta but *Luxadinium propatulum* does not appear until the early Late Albian in the same area (Brideaux, 1971; Singh, 1971). However, Doerenkamp et al. (1976) recorded *L. propatulum* in the top part of their Early to Middle Albian CIIb zone from strata on Banks Island, and Brideaux (1975) noted the appearance, in the Middle Albian, of cysts similar to some species of *L. propatulum.* Neither species occurs in the Middle Albian Horton River Formation that outcrops to the east of the Mackenzie Delta (Brideaux and McIntyre, 1975). *Odontochitina singhii* has not been recorded in strata older than Late Albian in Western Canada (Singh, 1983) but occurs throughout the Albian in Australia. The evidence of the abundant *Lacinidinium arcticum* is inconclusive, but this species has not yet been recorded from Middle Albian strata. Morphologically primitive angiosperm pollen, including *Tricolpites sagax* and *Retitricolpites vulgaris,* both of which are present in the core material, first appear in the late Middle Albian of Alberta (Brideaux, 1971; Singh 1971) and are common in the Late Albian. Similar types occur in the Middle Albian Horton River Formation (Brideaux and McIntyre, 1975). The palynological evidence from the occurrence of dinoflagellate and angiosperm pollen species conclusively shows that the cored interval is not older than late Middle Albian, but does not completely eliminate the possibility of a Late Albian age. The species discussed above also occur in the Cenomanian, but distinctive Cenomanian pollen and dinoflagellates do not occur in the microfloral assemblage from the core.

SUMMARY

Integration of data from reflection seismic, borehole geophysical logs, lithology, and foraminiferal biostratigraphy revealed the need to revise previous stratigraphic correlations of Barremian to Albian strata in the subsurface of the south Mackenzie Delta and in the vicinity of Parsons Lake. Albian strata of the Arctic Red Formation are extended downward, with the consequence that the vertical extent of underlying Mount Goodenough strata is reduced. Previously identified occurrences of Rat River Formation in the Kipnik O-20, Ogruknang M-31, Tullugak K-31, Tununuk K-10, and Unak B-11 wells are now known to be incorrect and the strata have been reassigned to younger units. Revised correlations between the Atkinson Point and Mount Goodenough formations suggest that the former may encompass a late Hauterivian to Aptian age, rather than just Aptian (Dixon, 1979). The Siku Formation is reduced in rank to a member of the Mount Goodenough Formation.

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APPENDIX 1

Formation and member tops in Barremian-Albian strata for selected wells
(Measurements refer to depth below Kelly Bushing)

Formations/ members	feet	metres
Aklavik A-37		
Arctic Red Formation	430	131.1
Upper member	eroded	
Middle member	430	131.1
Lower member	674	205.4
Mount Goodenough Formation[1]	1930	588.3
Siku Member	2804	854.7
McGuire Formation	3169	965.9
Aklavik F-17		
Arctic Red Formation	510	155.4
Upper member	510	155.4
Middle member	721	219.8
Lower member	1870	570.0
Mount Goodenough Formation	2063	628.8
Siku Member	2398	730.9
Paleozoic	2530	771.1
Akalvik F-38		
Arctic Red Formation	510	155.4
Upper member	510	155.4
Middle member	770	234.7
Mount Goodenough Formation	3200	975.4
Siku Member	3780	1152.1
(?) Kamik Formation[2]	3916	1193.6
East Reindeer G-04 (new name: Atigi G-04)		
Arctic Red Formation	5300	1615.0
Upper member	5300	1615.0
Middle member	6325	1927.9
Lower member	7560	2304.3
Mount Goodenough Formation	7950	2423.2
Siku Member	8908	2715.2
Ikhil A-01 (formerly East Reindeer A-01)		
Arctic Red Formation	2580	786.4
Upper member	eroded	
Middle member	2580	786.4
Lower member	5025	1531.6
Mount Goodenough Formation	5502	1677.0
Siku Member	6498	1980.6
Imnak J-29		
Arctic Red Formation	8465	2580.1
Atkinson Point Formation	8925	2720.3
Mount Goodenough Formation	9062	2762.1
Siku Member	9390	2862.1
Kamik I-60		
Arctic Red Formation	7152	2179.9
Upper member	eroded	
Middle member	7152	2179.9
Lower member	8590	2618.2
Mount Goodenough Formation	8955	2729.5
Siku Member	9410	2868.2

Formations/ members	feet	metres
Ogeoqeoq J-06		
Arctic Red Formation	3978	1212.5
Upper member	3978	1212.5
Middle member	4440	1353.3
Lower member	4660	1420.4
Mount Goodenough Formation	4788	1459.4
Husky Formation	5510	1679.4
Ogruknang M-31		
Mount Goodenough Formation	9400	2865.1
Siku Member	9600	2926.1
Parsons A-44		
Arctic Red Formation	5860	1786.1
Upper member	5860	1786.1
Middle member	6930	2112.3
Lower member	7905	2409.4
Mount Goodenough Formation	8325	2537.5
Siku Member	9108	2776.1
Parsons F-09		
Arctic Red Formation	6065	1848.6
Upper member	6065	1848.6
Middle member	(?)6320	(?)1926.3
Lower member	7850	2392.7
Mount Goodenough Formation	8202	2500.0
Siku Member	8535	2601.5
Parsons P-41		
Arctic Red Formation	5490	1673.4
Upper member	5490	1673.4
Middle member	5862	1786.7
Lower member	7682	2341.5
Mount Goodenough Formation	8178	2492.7
Siku Member	9004	2744.4
Rat Pass K-35		
Arctic Red Formation	20	6.1
Upper member	20	6.1
Middle member	500	152.4
Lower member	1460	445.0
Mount Goodenough Formation	1620	493.8
Siku Member	1770	539.5
Paleozoic	1940	591.3
Siku C-11		
Arctic Red Formation	6395	1949.2
Upper member	6395	1949.2
Middle member	6985	2192.0
Lower member	7725	2354.6
Mount Goodenough Formation	8098	2468.2
Siku Member	8720	2657.9

[1] May include some eroded Kamik Fm. in the basal sandstone.
[2] May include some basal sandstone of the Mount Goodenough Formation.

APPENDIX 2

Distribution of foraminiferal assemblages in six Mackenzie Delta wells
(Measurements refer to depth below Kelly Bushing)

Refer to Figure 7 for biostratigraphic distribution of the zones. Lower limits of zones approximate, since data are based on well cuttings. Bracketed footages indicate that the assemblage is poorly documented in that part of the well.

Aklavik A-37

Verneuilinoides borealis assemblage (?)
360-900 ft — 110-274 m

Quadrimorphina albertensis assemblage
900-1700 ft — 274-518 m

"Lower member assemblage"
1800-1900 ft — 549-579 m

"Mount Goodenough assemblage"
1980-3200 ft — 604-975 m
(3200-3700 ft) — (975-1128 m)

Ogruknang M-31

Verneuilinoides borealis assemblage (?)
- absent by unconformity

Quadrimorphina albertensis assemblage
- absent by unconformity

"Lower member assemblage"
- absent by unconformity

"Mount Goodenough assemblage"
9400-10 750 ft — 2865-3277 m
(11 300-12 200 ft) — (3444-3719 m)

Ogeoqeoq J-06

Verneuilinoides borealis assemblage (?)
- absent

Quadrimorphina albertensis assemblage
4400-4500 ft — 1341-1372 m

"Lower member assemblage"
- absent

"Mount Goodenough assemblage"
4900-5600 ft — 1494-1707 m
(5600-6034 ft) — (1707-1839 m)

Parsons A-44

Verneuilinoides borealis assemblage (?)
- absent

Quadrimorphina albertensis assemblage
7200-7900 ft — 2195-2408 m

"Lower member assemblage"
- absent

"Mount Goodenough assemblage"
8300-9500 ft — 2530-2896 m
(9500-10 500 ft) — (2896-3200 m)

Parsons F-09

Verneuilinoides borealis assemblage (?)
6150-6450 ft — 1875-1966 m

Quadrimorphina albertensis assemblage
6450-7900 ft — 1966-2408 m

"Lower member assemblage"
8000-8050 ft — 2438-2454 m

"Mount Goodenough assemblage"
8300-8850 ft — 2530-2697 m
(8850-9800 ft) — (2697-2987 m)

Siku A-12

Verneuilinoides borealis assemblage (?)
- absent

Quadrimorphina albertensis assemblage
7150-7900 ft — 2179-2408 m

"Lower member assemblage"
- absent — 549-579 m

"Mount Goodenough assemblage"
8000-9100 ft — 2438-2774 m