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THE NEOCOMIAN PARSONS GROUP, NORTHERN YUKON AND ADJACENT NORTHWEST TERRITORIES

J. Dixon

1991

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PREFACE

The Lower Cretaceous Parsons Group of the northern Yukon and adjacent Northwest Territories is a major clastic succession of interest both for its economic potential as a hydrocarbon reservoir in the Mackenzie Delta area and because a proper understanding of this group can help unravel the tectono-stratigraphic history of the adjacent Canada Basin. The basic stratigraphic correlations and descriptions presented in this report elucidate the significance of the Parsons Group succession. The data obtained during this study are used to interpret depositional regimes represented by the strata and an interpretation of genetic stratigraphy is attempted. The relationship between tectonics and sedimentation is outlined and a summary of the economic potential is presented.

Elkanah A. Babcock
Assistant Deputy Minister
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PRÉFACE

Le Groupe de Parsons (Crétacé inférieur), dans le nord du Yukon, et dans les régions adjacentes des Territoires du Nord-Ouest, est une importante succession clastique, intéressante à la fois du point de vue de son potentiel économique en tant que réservoir d'hydrocarbures dans le secteur de delta du Mackenzie, et du fait qu'une bonne interprétation de ce groupe peut aider les chercherus à déchiffrer l'évolution tectono-stratigraphique du bassin Canada adjacent. Les corrélations stratigraphiques fondamentales et les descriptions présentées dans ce rapport permettent de comprendre l'importance de la succession du Groupe de Parsons. Les données fournies par cette étude servent à interpréter les régimes sédimentaires représentés par les strates et servent en outre à une tentative d'interprétation de la stratigraphie génétique. On expose les grandes lignes de la relation entre le diastrophisme et la sédimentation, et l'on présente un résumé du potentiel économique.

Elkanah A. Babcock
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THE NEOCOMIAN PARSONS GROUP, NORTHERN YUKON AND ADJACENT NORTHWEST TERRITORIES

Abstract

The Neocomian Parsons Group comprises, from base to top, the Martin Creek, McGuire and Kamik formations. All three formations are exposed in the northern Richardson Mountains, on the flanks of the British Mountains, and in the northern Ogilvie Mountains, and are present in the subsurface of Mackenzie Delta and southwestern Tuktoyaktuk Peninsula.

The upper Berriasian Martin Creek succession is mostly sandstone under Mackenzie Delta and the east flank of the Richardson Mountains, but westward and in the Ogilvie Mountains contains two to four coarsening-upward cycles. The presence of marine macro- and microfossils, and the assemblage of sedimentary structures point to its predominantly marine character.

The lower to middle Valanginian McGuire Formation is a shale-dominant succession that grades upward into silty and sandy shale, and finally into sandstones of the Kamik Formation. McGuire strata represent marine shelf sediments, as evidenced by the presence of marine fossils, and bioturbation and hummocky cross-stratification in interbedded sandstones.

Upper Valanginian to upper Hauterivian Kamik strata gradationally overlie McGuire beds throughout most of the study area, although locally the contact can be abrupt. They are abruptly to erosionally overlain by the Mount Goodenough Formation. The bulk of the Kamik Formation contains marine strata, with inner shelf and shoreline sandstones to southeast grading northwestward into middle and outer shelf deposits. Local nonmarine, probably deltaic, strata are present in the lower member under Mackenzie Delta and Tuktoyaktuk Peninsula.

Parsons Group strata were deposited as part of three, major transgressive-regressive cycles, or depositional sequences. The oldest cycle includes the underlying upper Husky Formation and Martin Creek Formation, the second comprises the McGuire Formation to lower member of the Kamik Formation, and the third the upper member of the Kamik Formation.

Résumé

Le Groupe de Parsons, d'âge néocomien, comprend, de la base au sommet, les formations de Martin Creek, de McGuire et de Kamik. Ces trois formations affleurent dans le nord des monts Richardson, sur les flancs des monts British et dans le nord des monts Ogilvie, et existent dans la subsurface du delta du Mackenzie et dans le sud-ouest de la péninsule de Tuktoyaktuk.

La succession de Martin Creek, située dans la partie supérieure du Berriasien, se compose principalement de grès au-dessous du delta du Mackenzie et du flanc est des monts Richardson, mais vers l'ouest et dans les monts Ogilvie, contient deux à quatre cycles à granoclassement inverse. La présence de macrofossiles et de microfossiles marins et l'assemblage de structures sédimentaires témoignent de son caractère principalement marin.

La Formation de McGuire, située dans la partie inférieure à moyenne du Valanginien, est une succession principalement composée de shale, qui passe progressivement vers le haut à un shale silteux et sableux, et finalement aux grès de la Formation de Kamik. Les strates de McGuire représentent des sédiments marins de plate-forme, comme l'indiquent la présence de fossiles marins, et la bioturbation et la stratification oblique bosselée qui apparaît dans les interstrates de grès.

Les strates de la Formation de Kamik qui s'échelonnent de la partie supérieure du Valanginien à la partie supérieure du Hauterivien, recouvrent graduellement les couches de McGuire dans la majeure partie de la région à l'étude, mais par endroits, le contact peut être abrupt. Ces strates sont recouvertes abruptement ou en contact d'érosion par la Formation de Mount Goodenough. La Formation de Kamik se compose en majeure partie de strates marines, et également de grès de plate-forme interne et de lignes de rivage au sud-est qui passent progressivement vers le nord-ouest à des dépôts de plate-forme intermédiaire et de plate-forme externe. Des strates locales de caractère non marin, probablement deltaïque, se manifestent dans le membre inférieure au-dessous du delta du Mackenzie et de la péninsule de Tuktoyaktuk.

Des strates du Groupe de Parsons se sont accumulées dans le cadre de trois grands cycles transgressifs-régressifs, ou de séquences sédimentaires. Le cycle le plus ancien comprend la partie supérieure de la Formation de Husky et la Formation de Martin Creek sous-jacentes, la succession allant de la Formation de McGuire jusqu'au membre inférieur de la Formation de Kamik constitue le second cycle, et le membre supérieur de la Formation de Kamik représente la troisième séquence.

Summary

The upper Berriasian to middle Hauterivian Parsons Group contains three formations, which are, from oldest to youngest, the Martin Creek, McGuire and Kamik. The Martin Creek and Kamik formations are sandstone-dominant, whereas the McGuire is predominantly shale. All three formations are present throughout the northern Yukon and adjacent Northwest Territories, and are well exposed in the northern Richardson, northern Ogilvie and parts of the British mountains. Parsons Group strata also occur in the subsurface, under southern Mackenzie Delta and the southwestern part of Tuktoyaktuk Peninsula.

Martin Creek strata are mostly sandstone in the southeast but become progressively shalier to the northwest and west. The lower contact with shales of the Husky Formation is generally gradational, whereas the upper contact with McGuire shales is abrupt to erosional. The Martin Creek Formation is about 100 to 200 m thick. Several coarsening-upward cycles are present on the northwest flank of the northern Richardson Mountains and in the northern Ogilvie Mountains. Northwest of the Blow River area, Martin Creek strata are only locally identifiable as a result of a northwesterly shale-out. Hummocky cross-stratification, swaley cross-stratification, wave and current ripples, and bioturbated beds are the most common sedimentary structures. Bivalves are common, and, together with the sedimentary structures, attest to the marine character of the formation. In general, the southeastern outcrops consist of nearshore and shoreline sediments, whereas those in the west and northwest consists of more open shelf sediments.

The McGuire Formation consists mostly of shale, with gradually increasing amounts of sandstone and siltstone in the upper part of the formation. It is highly variable in thickness, ranging from 8 m to about 260 m. South of McDougall Pass, in the northern Richardson Mountains, and in parts of the northern Ogilvie Mountains, the McGuire Formation rests erosionally on older strata; elsewhere the contact with Martin Creek beds is abrupt. The upper contact with Kamik strata is generally gradational, although locally it can be abrupt. West of Blow River, where Martin Creek strata usually cannot be identified as a separate formation, McGuire-equivalent strata become part of the shale-rich, Jurassic to Valanginian Kingak Formation. The association of marine fossils with bioturbated, ripple laminated or hummocky cross-stratified sandstone beds attests to the marine shelf depositional environment of the formation.

The Kamik Formation may be up to 800 m in thickness and, as such, is the thickest unit in the Parsons Group. It is a sandstone-dominant succession that is divisible into two members. The lower member makes up about 20 to 30 per cent of the formation and consists of thick, commonly cliff-forming sandstone beds with rare interbedded shale. In contrast, the upper member contains much more shale and commonly displays coarsening-upward cycles. The lower member consists of deltaic, lagoonal and shoreline deposits under Mackenzie Delta, but becomes more marine to the west and southwest. Shoreface and shelf deposits are present in the upper member. Kamik strata are erosionally to abruptly overlain by the Mount Goodenough Formation. Erosion at the upper contact is highly variable, being more pronounced on and adjacent to tectonic uplifts.

The Parsons Group and the upper part of the underlying Husky Formation make up three depositional or stratigraphic sequences. The sequences are identified on the basis of bounding unconformities and/or flooding surfaces. The Martin Creek Formation, along with the upper beds of the underlying Husky Formation, composes the oldest sequence. The next sequence consists of the McGuire Formation and the lower member of the Kamik Formation. The upper member of the Kamik Formation comprises the youngest of the three sequences. All three sequences were supplied with sediment from the cratonic areas to the east and southeast. The dominance of quartz arenites indicates a mature source terrane, consistent with the paleogeographic interpretation of a cratonic source. Parsons strata were deposited during a period dominated by extensional tectonics.

Oil and gas have been recovered from Parsons Group strata under the southern Mackenzie Delta and along parts of Tuktoyaktuk Peninsula. The most significant discovery to date is the Parsons Gas Field, with contains about 51.7 x $10^9 m^3$ of gas. The potential for additional reserves in the Parsons Group has not been fully tested, but the limited area of preservation of Parsons strata in the subsurface is a critical factor in any future drilling activity.

Sommaire

Le Groupe de Parsons qui s'échelonne de la partie supérieure du Berriasien à la partie moyenne du Hauterivien, contient trois formations qui, de la plus ancienne à la plus récente, sont les formations de Martin Creek, de McGuire et de Kamik. Les formations de Martin Creek et de Kamik sont principalement composées de grès, tandis que la Formation de McGuire se compose principalement de shale. Les trois formatins existent toutes dans l'ensemble du nord du Yukon et dans les régions adjacentes des Territories du Nord-Ouest, et forment des affleurements bien visibles dans le nord des monts Richardson, le nord des monts Ogilvie et certaines parties des monts British. Les strates du Groupe de Parrons existent aussi en subsurface, au-dessous du sud du delta du Mackenzie et dans la partie sud-ouest de la péninsule de Tuktoyaktuk.

Les strates de la Formation de Martin Creek se composent principalement de grès au sud-est, mais prennent progressivement le caractère de shales au nord-ouest et à l'ouest. Le contact inférieur avec les shales de la Formation de Husky est généralement graduel, tandis que le contact supérieur avec les shales de McGuire est abrupt ou consiste en un contact d'érosion. La Formation de Martin Creek a environ 100 à 200 m d'épaisseur. Plusieurs cycles à granoclassement inverse se présentent sur le flanc nord-ouest du nord des monts Richardson et dans le nord des monts Ogilvie. Au nord-ouest de la région de la rivière Blow, les strates de la Formation de Martin Creek ne sont reconnaissables qu'à certains endroits, parce qu'elles forment un piège de faciès vers le nord-ouest. Une stratification oblique bosselée, une stratification oblique onduleuse, des rides de vagues d'oscillation et des rides de courant, et enfin des lits bioturbés constituent les structures sédimentaires que l'on rencontre le plus fréquemment. Les bivalves sont abondants, et en même temps que les structures sédimentaires, témoignent du caractère marin de la formation. En général, les affleurements sud- est se composent de sédiments infralittoraux et littoraux, tandis que ceux situés à l'ouest et au nord-ouest se composent de sédiments de plate-forme plus ouverte.

La Formation de McGuire se compose principalement de shale, et de quantités progressivement plus importantes de grès et de siltstone dans la partie supérieure de la formation. Elle est d'épaisseur extrêmement variable, soit entre 8 m et environ 260 m. Au sud du col McDougall, dans le nord des monts Richardson, et dans certaines parties du nord des monts Ogilvie, la Formation de McGuire repose en discordance d'érosion sur des strates plus anciennes; ailleurs, le contact avec les lits de Marin Creek est abrupt. Le contact supérieur avec les strates de Kamik est généralement graduel, mais peut également être abrupt par endroits. À l'ouest de la rivière Blow, où l'on ne parvient plus habituellement à reconnaître les strates de Martin Creek comme faisant partie d'une formation distincte, les strates équivalentes à la Formation de McGuire deviennent une partie de la Formation de Kingak, riche en shale, dont l'âge s'échelonne du Jurassique au Valanginien. L'association de fossiles marins avec des couches de grès bioturbés, à stratification croisée de rides ou à stratification entrecroisée bosselée, témoignent du milieu sédimentaire de plate-forme marine dans lequel la formation a pris naissance.

La Formation de Kamik peut atteindre 800 m d'épaisseur, et de ce fait, elle est l'unité la plus épaisse du Groupe de Parsons. Il s'agit d'une succession composée principalement de grès qui se laisse subdiviser en deux membres. Le membre inférieur constitue environ 20 à 30 % de la formation et se compose d'épais lits de grès formant souvent des falaises, et contenant de très rares interstrates de shale. Par contre, le membre supérieur contient beaucoup plus de shale, et présente souvent des cycles à granoclassement inverse. Le membre inférieur se compose de dépôts deltaïques, lagunaires et littoraux au-dessous de delta du Mackenzie, mais prend un caractère plus marin à l'ouest et au sud-ouest. Il existe dans le membre supérieur des dépôts de zone infratidale et de plate-forme. Les strates de la Formation de Kamik sont recouvertes en discordance d'érosion ou abruptement par la Formation de Mount Goodenough. Au niveau du contact supérieur, l'érosion est très variable, et devient plus prononcée à l'emplacement et à proximité de soulèvements tectoniques.

Le Groupe de Parsons et la partie supérieure de la Formation de Husky sous-jacente forment trois séquences sédimentaires ou stratigraphiques. Les séquences sont identifiées en fonction des discordances qui les limitent ou des surface d'ennoyage, ou les deux. La Formation de Martin Creek, de même que les lits supérieurs de la Formation de Husky sous-jacente, constitue la séquence la plus ancienne. La séquence suivante se compose de la Formation de McGuire et du membre inférieur de la Formation de Kamik. Le membre supérieur de la Formation de Kamik englobe la plus récente des trois séquences. Les trois séquences ont toutes été approvisionnées en sédiments provenant des régions cratoniques situées à l'est et au sud-est. La prédominance des quarzites sédimentaires indique l'existence d'un terrane source de caractère mature, en conformité avec l'interprétation paléogéographique selon laquelle il existerait une source cratonique de sédiments. Les strates du Groupe de Parsons se sont accumulées durant une période dominée par la tectonique d'extension des phénomènes diastrophiques de distension.

Du pétrole et du gaz ont été récupérés dans les strates du Groupe de Parsons, au-dessous de la région sud du delta du Mackenzie et dans des parties de la péninsule de Tuktoyaktuk. Jusqu'à présent, la découverte la plus importante est celle du champ gazéifère de Parsons, qui contient environ 51,7 x 10^9 m^3 de gaz. On n'a pas entièrement exploré la possibilité que le Groupe de Parsons contienne des réserves additionnelles, mais la superficie limitée dans laquelle les strates de Parsons ont été conservées dans la subsurface est un facteur essentiel à considérer lors des futurs travaux de forage.

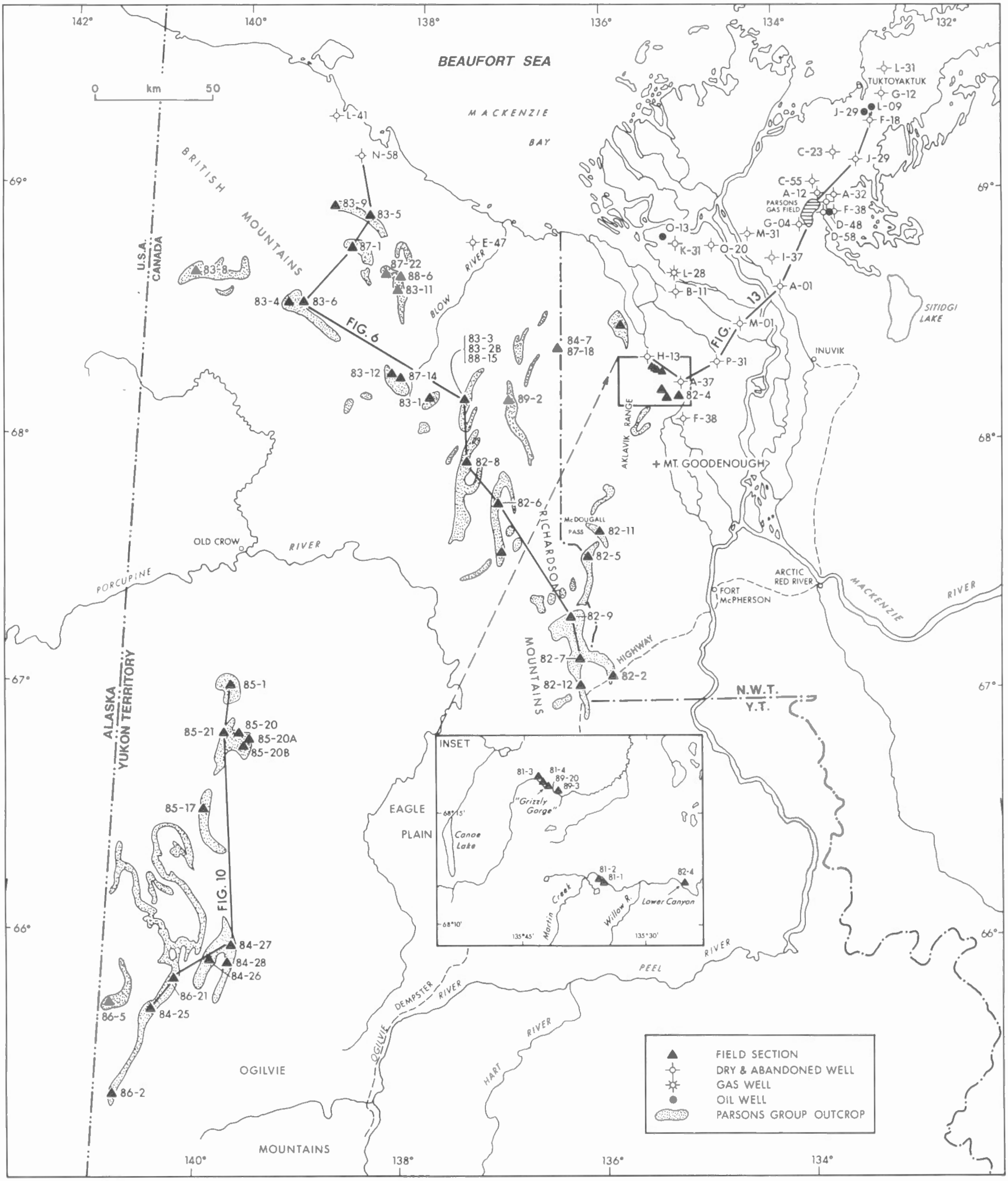

Figure 1. Location map of study area, showing field sections, exploratory wells, cross-sections, and outcrop areas of Parsons strata.

INTRODUCTION

The Neocomian Parsons Group is a Berriasian to Hauterivian succession, the thickest and most widespread coarse clastic interval in the clastic-dominant Jurassic and Lower Cretaceous succession of the northern Yukon and adjacent Northwest Territories. It is an important unit because it contains hydrocarbons in the Mackenzie Delta area, and because it records major syntectonic sedimentation associated with rifting.

The Parsons Group is present north of latitude 65 degrees, in the northern Ogilvie Mountains, the northern Richardson Mountains and on the flanks of the Barn and British mountains (Fig. 1). Subsurface occurrences of the Parsons Group are known in the southern Mackenzie Delta and southwestern Tuktoyaktuk Peninsula, and are presumed to be present between the Richardson and British mountains. Whether or not the Parsons Group occurs under the continental shelf off northern Yukon is unknown; a thick (14-16 km) cover of Upper Cretaceous and Tertiary strata masks the deeper stratigraphic levels that have not yet been drilled. Offshore from Tuktoyaktuk Peninsula, large areas of the inner shelf have no Neocomian and Jurassic strata, either because of post-Hauterivian and Tertiary erosion, or nondeposition (Dixon, 1982a).

The present study is based on outcrop and subsurface data, the latter including petroleum exploration and development wells, and some reflection seismic profiles. Subsurface data are available mostly from the southern Mackenzie Delta and southwestern Tuktoyaktuk Peninsula, with only two relevant wells on the Yukon coastal plain (Roland Bay L-41 and Spring River N-58, Fig. 1). The author's field notes are stored at the Geological Survey of Canada (Institute of Sedimentary and Petroleum Geology), Calgary, where they are available for public viewing. Well cuttings, cores and drilling information from exploratory wells in the Northwest and Yukon territories also can be viewed at the Calgary office of the Geological Survey of Canada. The objectives of this report are to discuss the stratigraphy and distribution of the Parsons Group, to identify and interpret the sedimentary facies, to reconstruct paleogeographic conditions, and to discuss the tectonic significance of the Parsons Group.

PREVIOUS WORK

Dixon (1982a) first proposed the name Parsons Group to include, in ascending stratigraphic order, the Martin Creek, McGuire and Kamik formations. Of the three formations only the Kamik was formally defined (Dixon, 1982a); the other two were to be named by J.A. Jeletzky who was preparing a manuscript. Based on the assumption that the names were to be defined shortly, Norris (1981a-g, 1982, 1985) used them on his maps of the northern Yukon and adjacent Northwest Territories, and the names were subsequently used in reports by Dixon (1982a, b; 1986a). The untimely death of J.A. Jeletzky in 1988 left some of the Lower Cretaceous stratigraphic names not formally defined, although their common usage had created a *de facto* state of recognition. A posthumously co-authored publication (Dixon and Jeletzky, in press) aims to remedy the lack of formality. In it, most of the stratigraphic units proposed by J.A. Jeletzky are defined.

Prior to formal names being applied, Jeletzky (1958, 1960) had used the informal name Lower sandstone division for strata in the Aklavik Range of the northern Richardson Mountains, identifying two internal units, the older Buff sandstone member (equivalent to the Martin Creek Formation), and the overlying White sandstone member (equivalent to part of the Kamik Formation) (Fig. 2). Jeletzky (op. cit.) did not recognize the Bluish-grey shale division (equivalent to the McGuire Formation) between these two units until later (Jeletzky, 1961). In 1960, Jeletzky identified the Coal-bearing division (also equivalent, in part, to the Kamik Formation) above the White sandstone member. The following year Jeletzky (1961) introduced new informal terms for Parsons strata on the west flank of the northern Richardson Mountains: the Lower sandstone division (Martin Creek Formation), the Bluish-grey shale division (McGuire Formation), and the White quartzite and Coaly quartzite divisions (Kamik Formation) (Fig. 2). In the same publication Jeletzky (1961, p. 14) recognized that a thin shale unit between the White and Buff sandstone members on the east flank of the Richardson Mountains was equivalent to the Bluish-grey shale division (McGuire Formation). Equivalents of the White and Coaly quartzite divisions were recognized in the Ogilvie Mountains by Jeletzky (1971a).

Since Jeletzky's initial reconnaissance, much of the work on the Parsons Group has focused on its occurrence in the subsurface of Mackenzie Delta, and to a lesser extent on its character in the northern Richardson Mountains (Young 1972, 1973a, 1974). Lerand (1973) and Young (1973b) briefly reviewed Neocomian stratigraphy and paleogeography in their summaries of the geology of the Beaufort-Mackenzie and northern Yukon areas. Cote et al. (1975), in their discussion of the geology of the Parsons Gas Field, introduced the informal term Parsons sandstone and compared the subsurface stratigraphy with that on the eastern flank of northern Richardson Mountains. Myhr and Young (1975) discussed the sedimentology of the Parsons strata in the subsurface of Mackenzie Delta-Tuktoyaktuk Peninsula. Additional subsurface data for specific wells has been presented by Myhr (1974), Myhr and Gunther (1974), and Brideaux and Myhr (1976). Young et al. (1976) reviewed the Parsons succession on a more regional basis, from the Mackenzie Delta westward across the northernmost part of the Yukon. Palynological studies that have included Parsons strata have been published by Pocock (1976), Brideaux and Fisher (1976), and McIntyre and Brideaux (1980).

Pocock (1976, Fig. 3) introduced some formation names for Lower Cretaceous strata in the northern Richardson Mountains, including Parsons-equivalent rocks. Brideaux et al. (1977) refuted the introduction of Pocock's terminology because of the lack of formal definition within Pocock's text. Pocock (1977) responded by accepting some of the criticisms, indicating he had not intended the names to be formal. The name Martin Creek Formation was introduced by Pocock (1976) for Parsons-equivalent strata, and although the name has been used subsequently, it is not used in the same manner as in Pocock's paper.

Young's (1978) field guide to the Mackenzie Delta and northern Richardson Mountains included a description of some Parsons-equivalent outcrops. Dixon (1982a) reported on Jurassic-Lower Cretaceous stratigraphy in the Mackenzie Delta area, and discussed Parsons strata. Brief mention of Parsons strata with respect to their setting in an Arctic-wide context can be found in Balkwill et al. (1983).

Dixon (1982a) formalized the name Parsons Group and introduced the Kamik Formation as a new formation of the group. Detailed descriptions and sedimentological interpretations of the Parsons strata were also presented (op. cit. and 1982b). In the same papers, stratigraphic correlation charts indicated that the Kamik Formation was equivalent to two formations in the Richardson Mountains, the Fault Creek and Lower Canyon, that

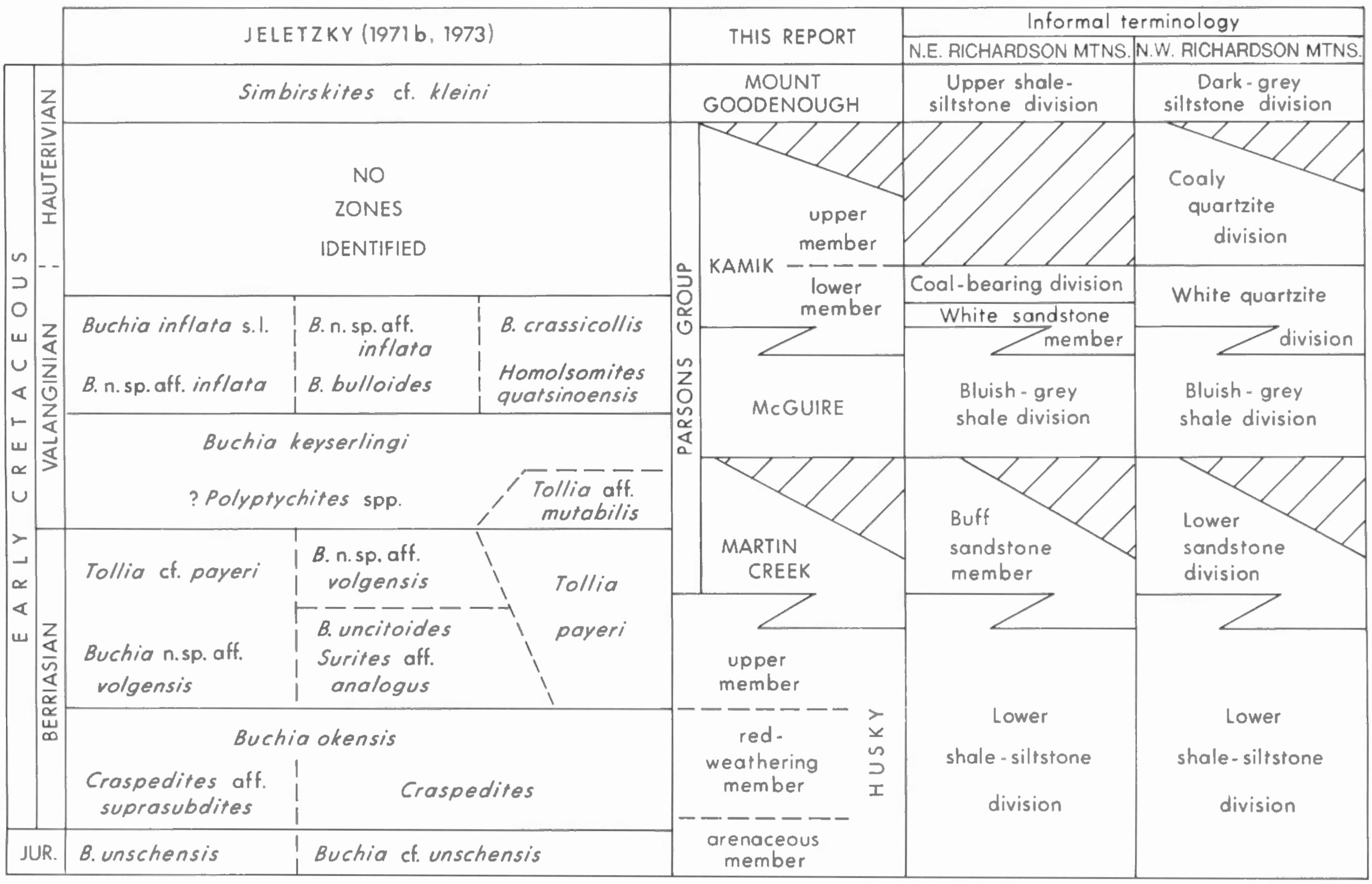

Figure 2. Table of formations; comparison of Jeletzky's (1958, 1960, 1961) informal terminology and biostratigraphic zonation with terminology used in this report.

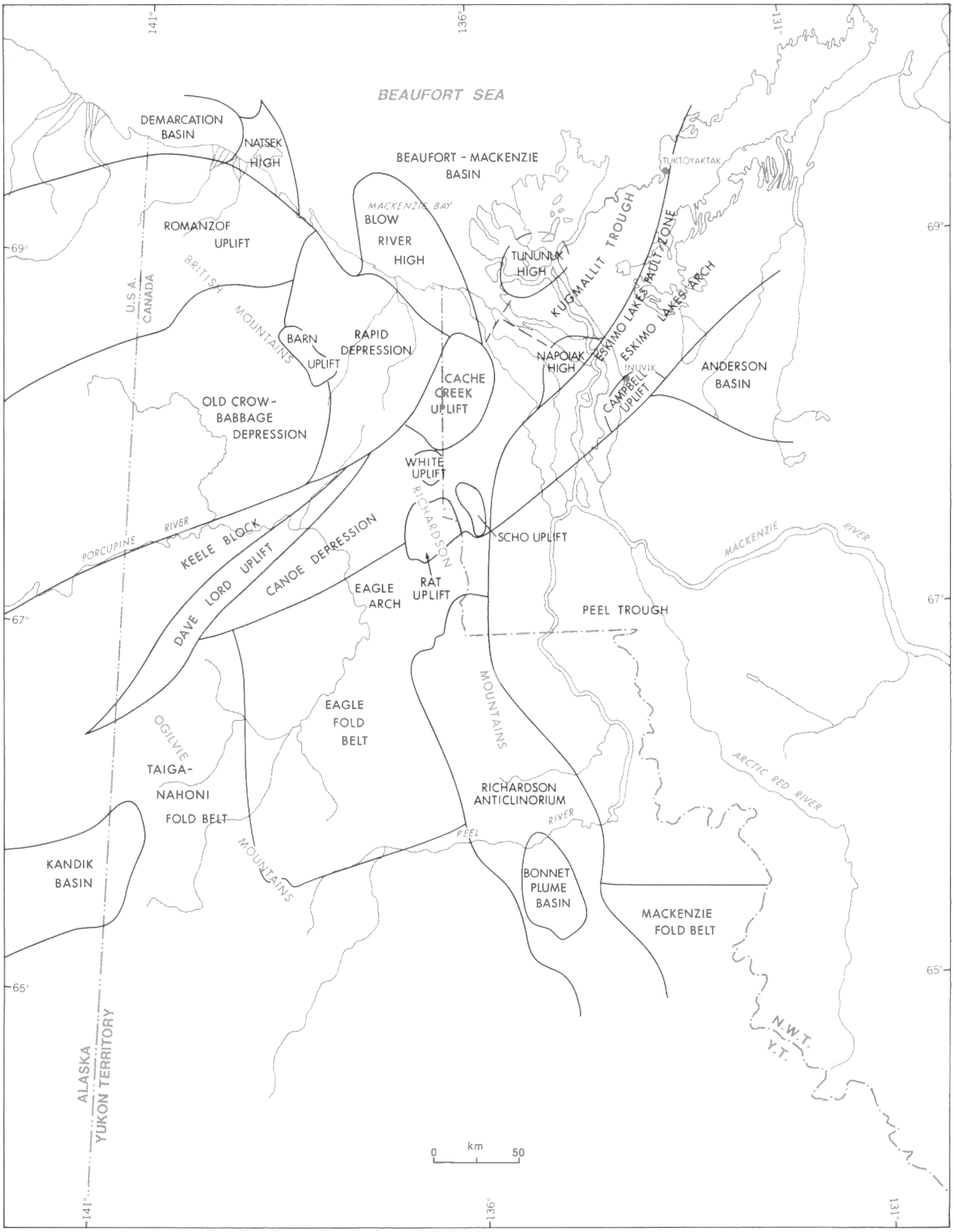

Figure 3. Regional tectonic elements (modified after Norris, 1983; Yorath and Cook, 1981; Dixon et al., 1985).

were to be proposed by J.A. Jeletzky. Unfortunately, the death of J.A. Jeletzky before the formations were formally defined negates their validity. Also, the present author's work in the outcrop belts of the Parsons Group suggests that the Kamik Formation is correlatable throughout the northern Yukon (Dixon, 1986a). Brief descriptions of the Parsons Group were presented in Dixon et al. (1985), and Dixon (1986a) reviewed the regional character of Parson strata in a paper on Cretaceous-Tertiary geology of the northern Yukon and adjacent Northwest Territories. The paleogeography during deposition of the Parsons Group has been illustrated by Dixon (1987).

Discovered and potential hydrocarbons in Parsons strata have been discussed by Langhus (1980), Dixon (1983) and Dixon et al. (1985, 1988).

PALEOGEOGRAPHIC MODELS

Although it has long been recognized that Jurassic and Lower Cretaceous strata in the northern Yukon and adjacent Northwest Territories are part of a common tectono-stratigraphic assemblage (e.g., Balkwill et al., 1983) there are two opposing viewpoints on Jurassic to Early Cretaceous paleogeographic reconstructions. Jeletzky (1971a, 1972, 1974, 1975) interpreted the presence of a depositional and bathymetric trough, the north-south oriented Porcupine Plains-Richardson Mountains Trough, which extended from the Rapid Depression (Fig. 3), located between the present-day Richardson and Barn mountains, southward through Eagle Plain. This trough separated an eastern source terrane, called the "Peel Landmass" from a western source, known as the "Old Crow-Keele Landmass". Lerand (1973) reiterated these conclusions, which he based on Jeletzky's work.

In contrast, Young (1975), Young et al. (1976), Poulton (1982, 1984) and Dixon (1986a) identified a Jurassic and Early Cretaceous, southwest trending shoreline that extended from Tuktoyaktuk Peninsula through northern Eagle Plain and then turned toward the south at the northern end of the Ogilvie Mountains. Their paleogeographic reconstruction does not include a bathymetric trough through the Eagle Plain area and, for the most part, a western source terrane was not identified. However, Young et al. (op. cit.) did include the Old Crow-Keele Landmass in some of their reconstructions. Poulton (1982) paid particular attention to the Early to Middle Jurassic paleogeography of the northern Yukon and adjacent Northwest Territories and argued in detail against the premises used by Jeletzky to account for the Porcupine Plains-Richardson Mountains Trough. In the present report, the southwest-trending-shoreline paleogeographic reconstruction is preferred. The evidence for the Old Crow-Keele Landmass is still without firm stratigraphic and sedimentological foundations.

PARSONS GROUP

The Parsons Group consists of three formations, which are, from oldest to youngest, the Martin Creek, McGuire and Kamik (Fig. 2). The Martin Creek and Kamik formations are mostly sandstone, with variable amounts of interbedded shale, whereas the McGuire Formation is predominantly shale with subordinate amounts of sandstone. East of the Blow River area, the Martin Creek Formation laterally grades into shale and siltstone of the Kingak Formation. In the Kandik River area, in the northern Ogilvie Mountains, and south of McDougall Pass (Fig. 1), Martin Creek strata have been eroded. In these areas the Parsons Group cannot be mapped as a stratigraphic unit because of the absence of Martin Creek strata. However, Kamik strata are generally present, and, although Valanginian ages in underlying shales are identifiable, the McGuire Formation commonly cannot be separated physically from underlying Jurassic (and possibly older) shale.

Martin Creek Formation

Distribution

Jeletzky (1958, 1960) identified Martin Creek-equivalent strata in the Aklavik Range and informally named them the Buff sandstone member of the Lower sandstone division. In 1961, Jeletzky limited the name Lower sandstone division to Martin Creek-equivalent strata on the western flanks of the northern Richardson Mountain. It was Jeletzky's intent to name these strata the Martin Creek Formation, after Martin Creek (sections DFA81-1 and 2), an east-flowing river in the northern Richardson Mountains (Fig. 1). There, the Martin Creek Formation is well exposed in Martin Creek canyon. The formal definition and type section of the Martin Creek Formation is introduced by Dixon and Jeletzky (in press). At Martin Creek the formation is about 100 m thick and consists almost entirely of very fine to fine grained sandstone, with minor thin shale interbeds. The contact with the underlying Husky Formation is abrupt (Fig. 4), and is chosen at the base of the first vertically persistent sandstone. Uppermost strata of the Husky Formation consist of thin interbeds of shale and sandstone, indicating that the contact with the Martin Creek Formation is sedimentologically transitional (Fig. 4). In other areas the transition between Martin Creek and

Figure 4. Contact between Husky and Martin Creek strata (arrow), Martin Creek (section DFA81-2). ISPG photograph 1895-1.

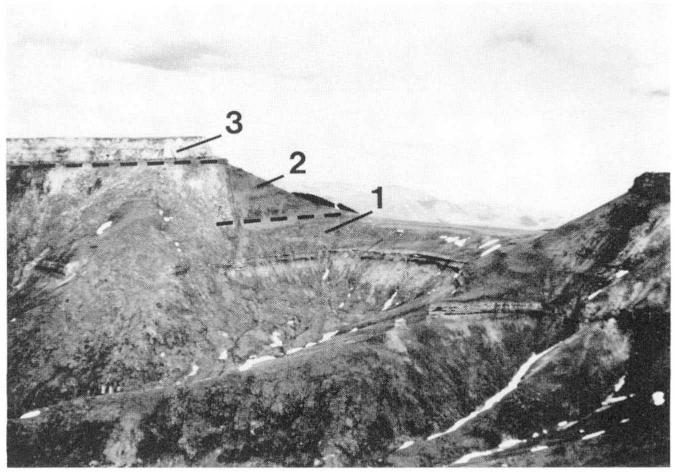

Figure 5. McGuire Formation (2) unconformably overlying upper Husky strata (1). Kamik Formation (3). Headwaters of Sheep Creek, Richardson Mountains (section DFA82-5). View is to the northeast. ISPG photograph 1858-7.

underlying strata is more gradual. In the subsurface of the southwestern end of Tuktoyaktuk Peninsula the transition is from bioturbated mudstone of the Husky Formation into thoroughly bioturbated, argillaceous sandstone and finally into cross-stratified sandstone of the Martin Creek Formation (Parson N-10 core, Dixon, 1982b). On the west flank of the northern Richardson Mountains and in the northern Ogilvie Mountains, the transitional strata generally consist of interbedded shale and sandstone, in which there is a gradual upward decline in the number and thickness of shale interbeds and a corresponding increase in the thickness of sandstone beds.

The upper contact with McGuire shale is abrupt. South of McDougall Pass, in the northern Richardson Mountains (Jeletzky, 1980), and south of latitude 65 degrees 50 minutes in the Ogilvie Mountains, Martin Creek strata have been eroded and McGuire shale rests unconformably on older strata, either the Husky or Kingak formations (Figs. 5, 6).

West of Blow River, in northwesternmost Yukon, Martin Creek sandstones pass laterally into shales of the Kingak Formation. However, within the Kingak Formation there are intervals of shale with interbeds of silty, bioturbated, argillaceous sandstone, some of which are age-equivalent to the Martin Creek Formation and are sufficiently distinct to be mapped as Martin Creek Formation (e.g., at section DFA83-6, on the north flank of Canoe Syncline; Fig. 6). Norris (1981a) mapped Martin Creek Formation in the vicinity of the Trout and Babbage rivers, although the succession in these areas is mostly shale with intervals of very thin siltstone and sandstone beds, more typical of the Kingak Formation.

Martin Creek or age-equivalent strata appear to have been eroded from the east flank of the Barn Mountains (Young, 1974, Fig. 3; section DFA87-17), under a pre-Albian unconformity. In the vicinity of two prominent peaks known as The Twins, on the east flank of Barn Mountains, Jurassic-Lower Cretaceous strata underlying the Albian rocks consist of black shale with scattered interbeds of sandstone. Young (op. cit.) recorded the presence of *Buchia okensis*, a lower Berriasian bivalve, from a sandstone unit on the southwest flank of The Twins. This bivalve is typically found in the Husky Formation (the red-weathering member of Jeletzky, 1967), which underlies the Martin Creek succession. Foraminifera recovered from the shale succession at The Twins generally include long-ranging

Neocomian forms, although from some samples a "Kamik-like" assemblage was recovered (S. Fowler, pers. comm. 1988). These ambiguous foraminiferal data need further refinement before any reliable correlations can be made. The pre-Albian succession at The Twins is not typical of the Kamik and it seems probable that the Mount Goodenough, Kamik, McGuire and Martin Creek formations have been eroded. Local structure in the vicinity of The Twins is complex and it is possible that unidentified small thrust faults cut through the Jurassic-Lower Cretaceous shale-dominant interval, which would make local stratigraphy complex and not easily resolved. However, 17 km to the north-northwest of The Twins, on Anker Creek (section DFA83-11A, Fig. 1), Albian strata rest on Kingak shales with no apparent fault between, lending additional support to the interpretation of an unconformity at the base of the Albian succession on the east and northeast flank of Barn Uplift and the erosion of the Martin Creek Formation.

Two erosional events, which resulted in the pre-McGuire and pre-Mount Goodenough unconformities, have had the most effect on the distribution of Martin Creek strata. Other erosional events, such as that which occurred in the late Aptian-early Albian, are locally important. Pre-McGuire erosion is seen in the northern Richardson Mountains (Jeletzky, 1980) and in parts of the Ogilvie Mountains (Figs. 5-7). Most of the strata mapped by Norris (1981d, e) as Martin Creek Formation south of McDougall Pass in the Richardson Mountains were misidentified and are now known to be mostly Kamik-equivalent, and in some of the more southerly occurrences may include strata of the Upper Jurassic to Berriasian North Branch Formation (Jeletzky, 1967). Pre-Mount Goodenough erosion is far more extensive and accounts for the absence of Martin Creek strata over much of Eskimo Lakes Arch, over the Cache Creek Uplift, and Eagle Arch. Evidence for Martin Creek strata being deposited in these areas is found in the presence of erosional remnants of Middle and Upper Jurassic, and even lowest Berriasian strata, commonly erosionally overlain by Mount Goodenough or younger beds. These erosional trends are part of long-lived positive elements that were intermittently reactivated during the Cretaceous. This is especially well illustrated along Eskimo Lakes Arch, where Martin Creek strata are preserved on the northwestern, downthrown side of the arch, but are absent on the arch.

Thickness

Measured thicknesses vary between 0 and 150 m, although Dixon (1982b, Fig. 3) projected a 200 m thickness in the subsurface under Mackenzie Delta-Tuktoyaktuk Peninsula. Strata thin west of the Richardson Mountains, because of a facies change to shale. The facies change occurs over a short distance. At section DFA88-15, east of Bonnet Lake (Fig. 1), there are four coarsening-upward cycles in a 150 m thick succession; 26 km to the west, near Flask Lake (section DFA83-12, Fig. 1), the Martin Creek Formation consists of centimetre to metre thick beds of sandstone interbedded with shale units of similar or greater thickness (Fig. 10). A few kilometres farther west, around parts of the Canoe Syncline, there is only a thin interval of sandstone and shale.

The Martin Creek Formation also thins to the east and southeast of the Richardson Mountains through a combination of erosion and depositional thinning.

Lithology

In the subsurface of Tuktoyaktuk Peninsula, geophysical logs and well cuttings indicate that the Martin Creek Formation is predominantly sandstone with minor amounts of interbedded shale. In those areas of the subsurface where pre-McGuire erosion has been minimal, the upper 1 to 10 m of the Martin Creek Formation consists of thinly interbedded sandstone and shale, with locally occurring, centimetre thick carbonaceous shale beds and coal seams (Dixon, 1982b, Fig. 8). On the east flank of the northern Richardson Mountains, the Martin Creek Formation consists mainly of sandstone with minor amounts of interbedded siltstone and shale. At Martin Creek (sections DFA81- and 2, Fig. 1), "Grizzly Gorge"

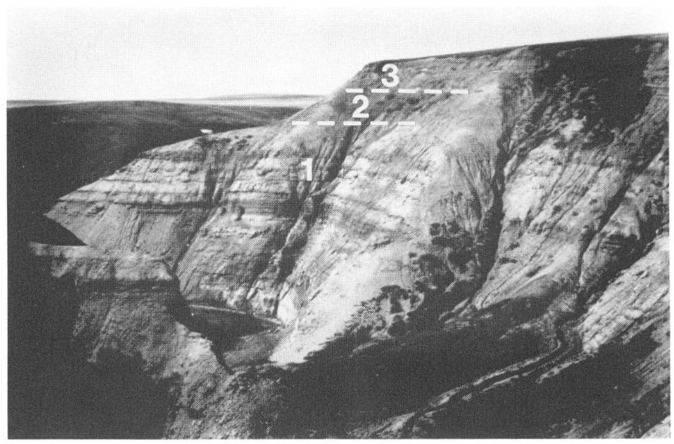

Figure 8. Martin Creek Formation (1) at "Grizzly Gorge" overlain by McGuire Formation (2), and truncated Kamik Formation and basal sandstones of the Mount Goodenough Formation (3). Northwestern Richardson Mountains. ISPG photograph 1673-18.

Figure 9. Coarsening-upward cycles in the Martin Creek Formation (1; foreground). McGuire Formation (2) and Kamik Formation (3). Western flank of Richardson Mountains (section DFA88-15). ISPG photograph 3081-7.

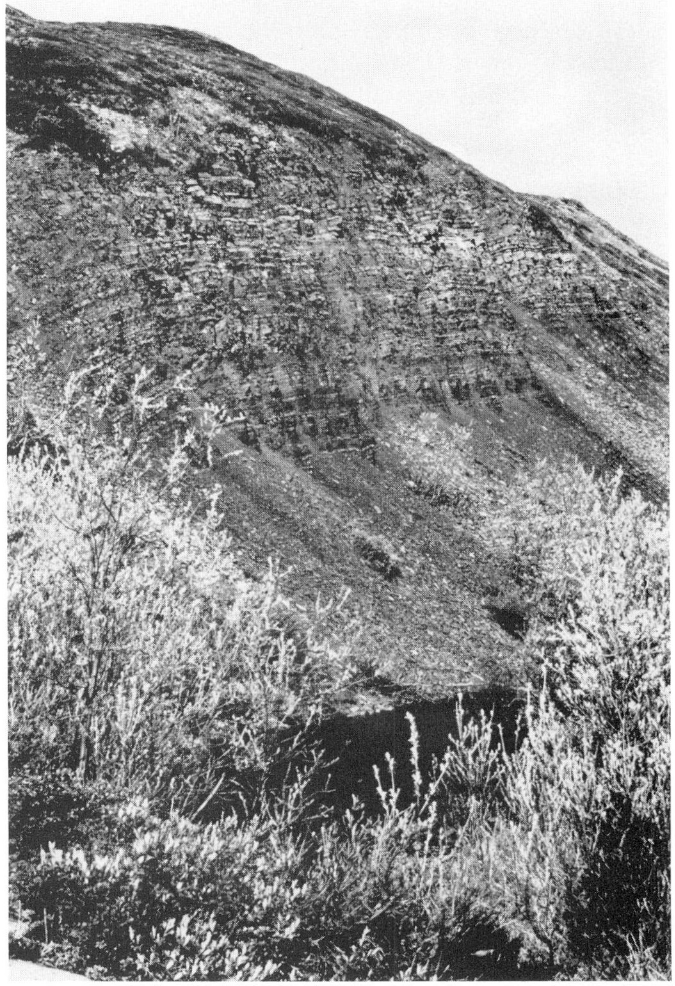

Figure 10. Martin Creek Formation near Flask Lake, Section DFA83-12. ISPG photograph 2584-6.

(section DFA81-4, Fig. 1) and throughout the Aklavik Range, the succession consists of 95 to 100 per cent sandstone (Fig. 8). On the west flank of the northern Richardson Mountains and in the northern Ogilvie Mountains, the Martin Creek succession contains abundant shale intercalations and consists of several coarsening-upward cycles (Fig. 9). The number of cycles varies geographically; on the west flank of the northern Richardson Mountains five cycles have been recognized at field section DFA88-15, east of Bonnet Lake (Fig. 1), whereas near Mount McGuire (section DFA82-8, Fig. 1), 45 km to the south, there are only two cycles. In the northern Oglivie Mountains two cycles are present. Where these cycles have been recognized, the upper Husky forms the shale facies of the lowest Martin Creek cycle.

At all localities the sandstones are very fine to fine grained; nowhere have coarser sands been noted as making up a significant part of the succession. Martin Creek sandstones generally are quartz arenites, and silica cement is ubiquitous, except in the Aklavik Range where deep weathering tends to produce very friable Martin Creek sandstones.

Sedimentology

Sedimentary structures within the Martin Creek Formation are usually readily seen, although west of the Richardson Mountains and in the northern Ogilvie Mountains sedimentary structures are masked in much of the succession. The most abundant sedimentary structure found in Martin Creek strata and present in most sections visited, is low-angle intersecting laminae sets. In places these laminae sets pass laterally into low-amplitude hummocky cross-stratification (HCS) (Fig. 11A). In outcrops, HCS is generally readily recognized but in the subsurface, definitive criteria are not always present. In the Parsons N-10 well, the Martin Creek Formation was continuously cored and the upper part of the formation was found to contain multiple beds of laminated sandstone. Dixon (1982a, b) did not recognize these beds in the core as possible HCS, but their physical attributes — low-angle laminae commonly with low-angle intersecting laminae-sets, basal scour surfaces commonly overlain by shell debris, and beds 15 to 60 cm thick — are typical of hummocky cross-stratified sandstones seen in outcrops in the nearby Richardson Mountains. In the interbedded sandstone and shale facies present in the uppermost beds of the formation's subsurface occurrence, ripple and plane laminae are the known prevalent structures. Other sedimentary structures present in the Martin Creek Formation include wave ripples, wave-modified current ripples, climbing ripples, swaley cross-stratification, bioturbated beds, horizontally laminated beds, and undulatory laminated beds (Fig. 11).

In the northernmost part of the study area there is a general east-to-west increase in the proportion of interbedded shale, an increase in the amount of bioturbated beds and a decrease in the amplitude of hummocks. In the Aklavik Range, northern Richardson Mountains, Martin Creek strata contain abundant large-amplitude HCS, swaley stratification and very little interbedded shale (e.g., at Martin Creek and "Grizzly Gorge", sections DFA81-1, 2 and 4, Fig. 1). Although the Aklavik Range successions are dominated by hummocky cross-stratified beds there are some variations; for example, the Martin Creek and "Grizzly Gorge" successions have a banded appearance (Fig. 8), which is due to the alternation of intervals containing large-scale

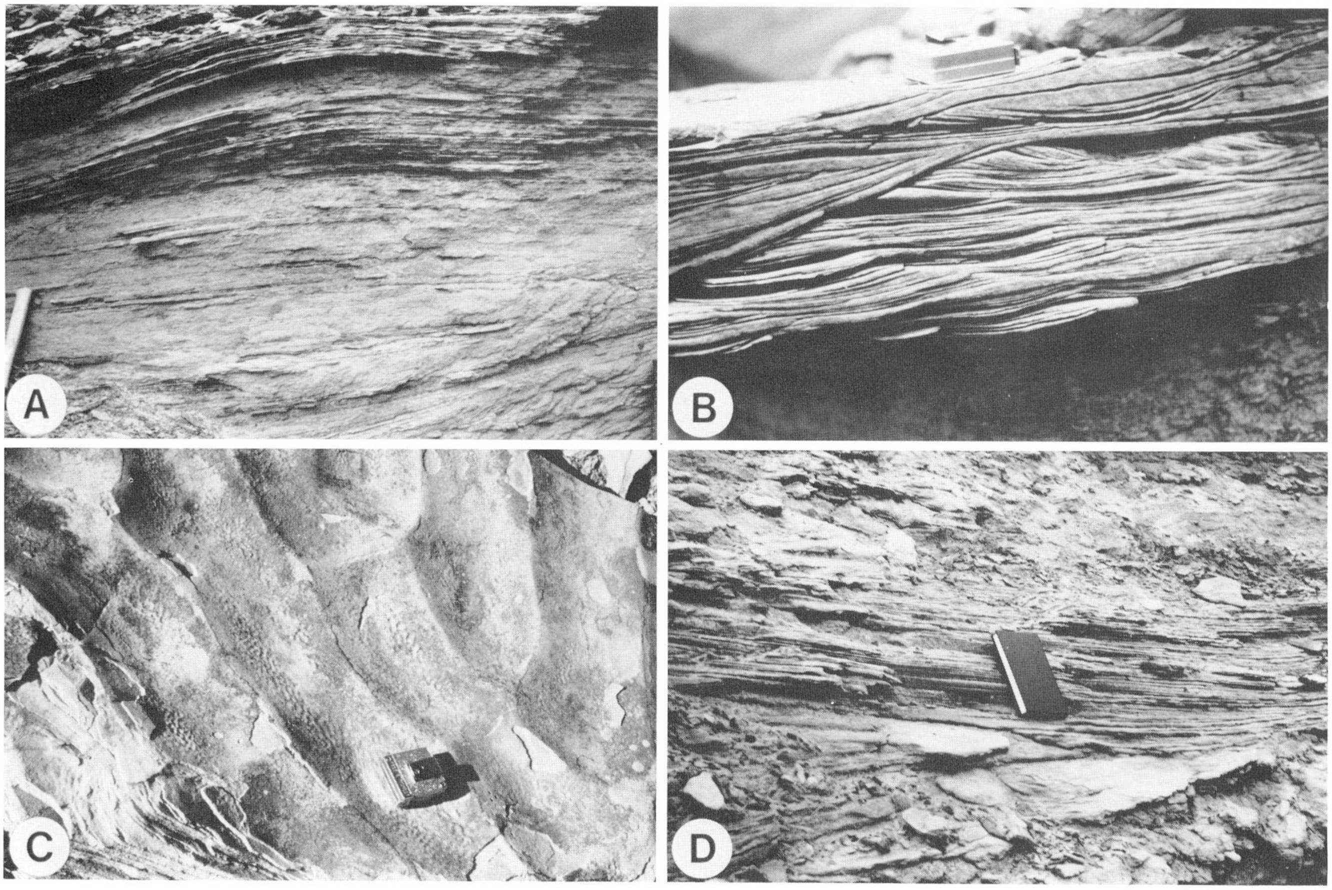

Figure 11. Sedimentary structures in the Martin Creek Formation. A, hummocky cross-stratification from Martin Creek (section DFA81-1), ISPG photograph 1673-11; B, wave-modified current ripples on the flanks of the hummocks illustrated in Figure 11A, ISPG photograph 1673-16; C, plan view of ripples illustrated in Figure 11B, ISPG photograph 1673-17; D, swaley cross-stratification from "Grizzly Gorge" (section DFA81-4), ISPG photograph 2584-8.

HCS and swaley cross-stratification with intervals containing thinner beds with smaller scale HCS and more ripple laminated sandstone. These bands are a few metres to 18 m thick, although most are 3 to 5 m thick.

Westward, on the west flank of the Richardson Mountains, in the area of Bonnet Lake, and in the northern Ogilvie Mountains, HCS becomes less prominent, the hummocks tend to be low amplitude, and extremely low-angle to subhorizontal laminae become more prevalent. The percentage of bioturbated beds increases, as does the amount of interbedded shale. Also, the succession in these areas contains two to five coarsening-upward cycles. In each cycle the first few metres consist of dark grey to black shale, which may contain some ironstone concretions, resting abruptly on the preceding cycle. There is a gradual upward increase in the occurrence of thin (mm to a few cm thick) beds of siltstone and very fine grained sandstone. The siltstone-sandstone beds are lenticular or laterally extensive and are either finely laminated (horizontal or ripple laminated) or bioturbated. The number and thickness of sandstone beds increase upward, and sedimentary structures become dominated by low-amplitude HCS or subhorizontal laminae. The upper part of each cycle is sandstone-dominant, consisting of 15 to 80 cm thick beds of amalgamated HCS, or beds that may be separated by millimetre thick shaly partings.

The prevalence of HCS and subparallel laminae is typical of storm-dominated shelves and beaches (Hunter and Clifton, 1982; Duke, 1985), and the east-to-west change from sandstone-dominant to shale-rich in the northwestern Yukon, along with the accompanying change in style and relative abundance of types of sedimentary structures indicates an eastern shoreline and sediment source area. Although large areas of Martin Creek strata have been removed in the southeast part of the study area, the preserved facies trends suggest a southwest oriented shoreline extending from the Mackenzie Delta area across the northern Yukon (Fig. 12). Cote et al. (1975) and Dixon (1982a, b) interpreted the Martin Creek succession under Mackenzie Delta-Tuktoyaktuk Peninsula as predominantly shoreface deposits with locally preserved lagoonal sediments. They, along with other workers (Myhr and Young, 1975), also suggested that the Martin Creek may represent barrier island deposits. However, the lack of preserved, or known, beach facies and the limited indication of lagoonal sediments preclude a definitive interpretation as a barrier system, as opposed to a shore-attached beach.

Jeletzky (1960, p. 6; 1967, section 72, p. 114; 1975) and Myhr and Young (1975, p. 249) described nonmarine strata from the area of "Treeless Creek", south of Mount Goodenough (Fig. 1). Dixon (1982a) questioned Jeletzky's correlation of the anomalously thin sandstone succession, suggesting that it was more likely to be the basal sandstone of the Mount Goodenough Formation. Bardoux (1984) mapped the Aklavik Range in some detail but did not recognize Martin Creek Formation at the outcrops in the vicinity of "Treeless Creek". Bardoux (op. cit.) suggested that Jeletzky may have mistakenly identified the coarse clastics of the arenaceous member, Husky Formation, as Martin Creek strata. At the Myhr and Young (op. cit.) location, which is located on Bardoux's informally named "Gypsum Creek", Bardoux (op. cit.) identified only the Mount Goodenough and Rat River formations. The author has visited the "Treeless Creek" area on several occasions and has failed to see the stratigraphic relationships suggested by Jeletzky. Furthermore, along the length of the Aklavik Range there is a north-to-south truncation of the Parsons Group beneath the sub-Mount Goodenough unconformity. On the east flank of the Mount Goodenough massif, Mount Goodenough Formation rests erosionally on thinly interbedded shale and sandstone containing *Buchia* n. sp. aff. *B. volgensis* (Jeletzky, 1958), fossils that occur in the upper Husky and lower Martin Creek formations. Comparison of the strata under the Mount Goodenough Formation with the type section of Martin Creek Formation suggests that the strata are comparable to the upper Husky Formation. "Treeless Creek" is an additional 6 km to the south of Mount Goodenough; therefore it seems unlikely that Martin Creek strata are present. Other areas of earlier identified nonmarine Martin Creek Formation south of McDougall Pass in the Richardson Mountains (Jeletzky, 1975, Fig. 11), are now known to have been incorrectly identified and were later reassigned to younger units (Jeletzky, 1980).

"Outer marine to (?)upper bathyal" sediments were interpreted by Jeletzky (1975, p. 21, Fig. 11) to be present in the area of Bonnet Lake and the nearby westernmost ranges of the adjacent Richardson Mountains. His interpretation is based on the observations of the Martin Creek succession at his section G2 (op. cit., Fig. 8) and at Bonnet Lake (Jeletzky, 1961, p. 39). Both of these sections have been re-examined. They display abundant hummocky cross-stratification, subhorizontal laminae, burrowed beds, wave and current ripples, and contain bivalves and some scarce ammonite fragments. The sedimentary structures and fossils are more typical of inner shelf storm-deposits than those of "outer marine to upper bathyal" environments.

Jeletzky (1975, Fig. 11) also identified bathyal deposits in the Kandik River area of the northern Ogilvie Mountains (Fig. 1). This interpretation was based on the premise that Martin Creek sandstones shale out in this

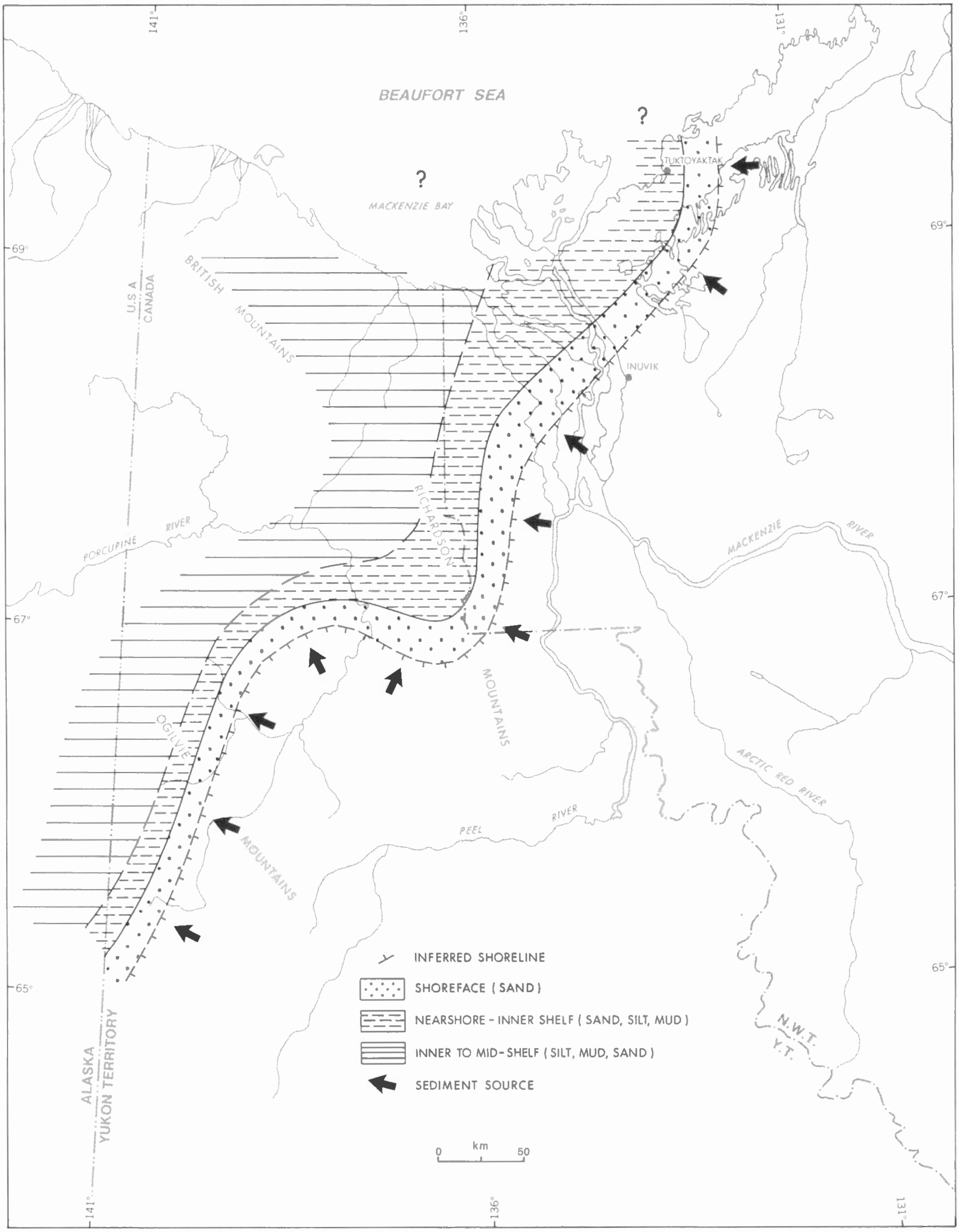

Figure 12. *Interpretation of late Berriasian paleogeography (approximate time of deposition of the Martin Creek Formation). No palinspastic reconstruction has been attempted to account for Early Cretaceous plate motions and early Tertiary compression.*

area, and that equivalent rocks are part of the shale-dominant Kingak Formation. New biostratigraphic data show that within the Kingak Formation in this area, there is a major unconformity between Valanginian and Triassic or upper Paleozoic shales (D.J. McIntyre, pers. comm., 1987; Fig. 7) and that there is no record of Berriasian strata remaining. Consequently, Jeletzky's conclusions are no longer valid.

In the northern Richardson Mountains, the sandstone-dominant facies of the Martin Creek Formation is approximately 100 km wide, extending from near Aklavik northwestward to the Bonnet Lake area, approximately perpendicular to the interpreted shoreline. Although the sandstone units may not have been contiguous, it is apparent that a wide zone of sand-rich sediment was typical of the Berriasian shelf. The Berriasian shelf may have been considerably wider, because age-equivalent shelf shales are present in the Babbage River area, an additional 100 km to the northwest of Bonnet Lake. The Berriasian shelf must have been at least 200 km wide but probably was wider. The shoreline and the shelf-edge have not been positively identified, and crustal shortening in the folded areas of the northern Yukon has not been incorporated into the estimate.

The variability in the number of coarsening-upward cycles within the Martin Creek Formation probably reflects local variations in sediment supply, at least in part. However, the fact that there are two cycles recognized at Mount McGuire and in the northern Ogilvie Mountains, 250 km to the southeast, could indicate that at least two cycles are responses to basin-wide changes in relative sea level. These possible basin-wide and local changes are not readily seen in the succession east of the Richardson Mountains, where a single prograding succession appears to be the norm. However, the alternation of types of sedimentary structures seen at Martin Creek and "Grizzly Gorge" suggest that depositional energy was variable through time, although there is no obvious pattern that can be related to the coarsening-upward cycles seen to the west. Pre-McGuire erosion has removed some Martin Creek strata at the basin margins, which could account for the lack of preserved cyclicity. However, the facies and thickness trends tend to suggest that erosion does not account for all the changes seen. Subsurface correlations of Martin Creek strata, based on log character (Fig. 13), indicate the possibility of subtle character changes that could be interpreted as coarsening-upward cycles. In the continuously cored Martin Creek Formation at Parsons N-10, it is difficult to correlate the log character change with any specific change in the rock character.

Age

The Martin Creek Formation contains foraminifera and palynomorphs, locally abundant marine bivalves, and locally occurring ammonites. The abundance of foraminifera and palynomorphs varies according to the amount of shale in the succession. The bivalves have been recovered mainly from the late Berriasian *Buchia* n. sp. *volgensis* and *Tollia* cf. *payeri* zones, but locally may be from the slightly older, but still Berriasian, *B. uncitoides* Zone, and the younger, early Valanginian *B. keyserlingi* Zone (Fig. 2; Jeletzky, 1958, 1961, 1971a, b, 1973). Jeletzky (op. cit.) was able to compare his macrofossil zonation to Boreal and Tethyan zonations in Europe. The local variations in the oldest and youngest ages are consistent with the lower contact being a facies boundary and the upper contact being an unconformity at the basin margins. Jeletzky (1958, 1960) created some confusion with regard to the amount of diachroneity at the top of the Martin Creek Formation by indicating that the Buff sandstone (Martin Creek Formation) could be as young as the *Buchia crassicolis* Zone (referred to in 1958 and 1960 as the *Aucella crassicollis* and *Buchia crassa* zones, respectively; Fig. 2). However, at that time the Bluish-grey shale division (McGuire Formation) had not been identified between the Buff (Martin Creek) and White (Kamik) sandstones, and the stratigraphic level from which the younger fossils were collected must remain doubtful.

Many of the contained foraminifera and palynomorphs are long-ranging Neocomian species (S. Fowler, pers. comm., 1988; Brideaux, 1976). There are sufficient numbers of distinct forms to identify a Berriasian age, but they are not sufficiently distinct to separate Martin Creek strata from the underlying upper Husky Formation.

Fensome (1987) used schizaealean spores to erect a zonation across Jurassic-Cretaceous boundary beds in the Aklavik Range, and included Martin Creek strata in his *Pilosporites delicatus* Subzone. He dated these beds as Ryazanian to early Valanginian (i.e., Berriasian to early Valanginian), consistent with the ages determined from the bivalves.

Brideaux and Myhr (1976) identified a number of informal dinoflagellate zones in the Parsons N-10 well, and placed the Martin Creek Formation in their zone IVf. A Berriasian age was assigned to the IVf zone. They noted that dinoflagellates were uncommon in the cored interval, whereas the well cuttings from the same interval contained more dinoflagellates. They attributed this increase to an abundance of caved material. Palynomorphs and dinoflagellates become less useful west of the Richardson Mountains where strata have been subjected to high thermal alteration, blackening the organic matter.

McGuire Formation

Distribution

McGuire Formation is the name J.A. Jeletzky intended to use in place of the informal, Bluish-grey shale division of Valanginian age (Jeletzky, 1961). The shale-dominant McGuire Formation is formally defined by Dixon and Jeletzky (in press). The type section is on the east side of a prominent north-northeast trending ridge about 5 km north of Mount McGuire, on the west flank of the northern Richardson Mountains (Figs. 6, 7, 14; section DFA82-8).

Jeletzky (1961) identified a thin equivalent of the McGuire Formation on the east flank of the Richardson Mountains, in the Martin Creek area, prior to which it was considered an undifferentiated part of Jeletzky's (1958, 1960) Lower sandstone division. Cote et al. (1975) correlated the Bluish-grey shale (McGuire Formation) at Martin Creek with a "shale marker" in the Parsons sandstone in the wells of the Parson Gas Field. Norris (1981a-g, 1982) was the first to use the name McGuire Formation on geological maps. He was followed by Dixon (1982a) who applied the name to equivalent rocks in the subsurface of Mackenzie Delta and Tuktoyaktuk Peninsula, and later used it on a more regional basis (Dixon, 1986a).

Figure 14. *Parsons Group, a few kilometres north of Mount McGuire, Richardson Mountains (section DFA82-8). **1**, Husky Formation; **2**, Martin Creek Formation; **3**, McGuire Formation; **4**, Kamik Formation; **4a**, lower member; **4b**, upper member. ISPG photograph 1858-3.*

Mappable McGuire strata tend to be confined to the northernmost Ogilvie Mountains and northern Richardson Mountains, and can be identified in the subsurface of the south Mackenzie Delta and the southwestern part of Tuktoyaktuk Peninsula. In all areas the succession is shale-dominant, with variable numbers of thin, very fine grained sandstone interbeds. Sandstone beds become more common and thicker in the upper part of the succession. Ironstone concretions are locally abundant, especially in the lower part of the succession. The lower contact with the Martin Creek Formation is everywhere abrupt. The upper contact with overlying Kamik sandstone is generally gradational, although locally, a more abrupt contact may be present, such as on parts of the east flank of the Richardson Mountains and in the subsurface under Mackenzie Delta and Tuktoyaktuk Peninsula (Dixon, 1982a).

McGuire strata can only be mapped as a separate unit wherever a shale succession between sandstones of the Martin Creek and Kamik formations are present. Where the Jurassic to Valanginian succession is mostly shale, such as on the flanks of the British Mountains, the whole interval is part of the Kingak Formation (Babbage River and Philip Creek sections, Fig. 6). South of McDougall Pass, in the northern Richardson Mountains (Figs. 5, 6), and in parts of the Ogilvie Mountains (Figs. 7, 15), Martin Creek strata have been eroded at a pre-McGuire unconformity resulting in the juxtaposition of McGuire-equivalent shale against lithologically similar Jurassic and Triassic or upper Paleozoic shales. In such locations, the physical separation of McGuire shale from older shale units is impossible without biostratigraphic control.

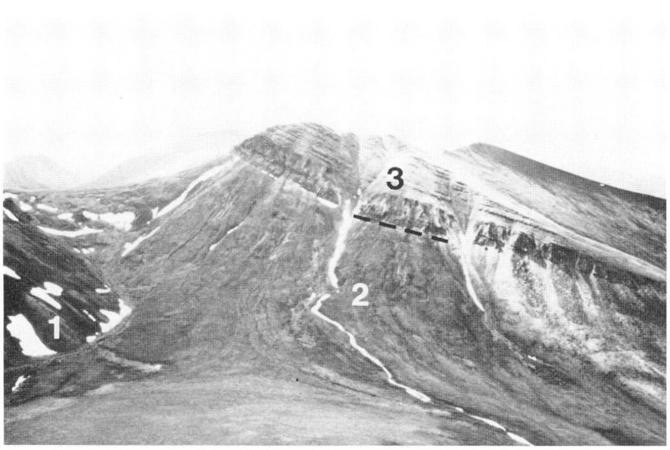

Figure 15. Shale (2) resting abruptly on Permian limestone (1) and overlain by Kamik Formation (3) (section DFA86-21). Shale contains (?)Permo-Triassic and McGuire-equivalent strata. Eastern rim of Kandik Basin, northern Ogilvie Mountains. ISPG photograph 2654-1.

Thickness

Formation thicknesses are highly variable, even over short distances. At the type section, near Mount McGuire, it is about 260 m thick, yet 22 km to the south-southeast it is only 65 m thick (section DFA82-6, Fig. 1). In the Aklavik Range it is 9 to 17 m thick, thickening eastward, in the subsurface, to about 50 m. Thicknesses in the northern Ogilvie Mountains vary between 40 and 100 m. In general, thicknesses decrease to the east and southeast, as the basin margin is approached.

Lithology

The McGuire Formation is predominantly shale, especially in the lower to middle third of the formation, with gradually increasing amounts of interbedded siltstone and very fine grained sandstone in the upper third. McGuire shales tend to be well indurated, fissile to blocky weathering, and dark grey to bluish black or bluish grey. A distinct variation of these characteristics is present in the Aklavik Range, where the McGuire shale tends to be soft and friable, almost soot-like in character and colour.

Where McGuire shales unconformably overlie Martin Creek or older strata there is no obvious erosion surface or distinct bed(s) in most of the sections examined. However, in the Parsons N-10 well, where McGuire strata rest on Martin Creek Formation, there is a pebble-lag layer at the base of the McGuire Formation, resting on an erosion surface that is pyritized. This is the only known occurrence where a distinct lithology is associated with the unconformity. Elsewhere, the contact between Martin Creek and McGuire strata is a very abrupt change from sandstone to shale, along a planar surface (at the outcrop scale). In a few locations, the underlying Martin Creek sandstones may weather a rusty colour to a depth of a few centimetres, possibly due to the oxidation of pyrite.

Sedimentology

Although shale-dominant, in the middle to upper part of the formation sandstone beds become more common, first appearing as thin interbeds that are generally argillaceous, silty and bioturbated. A few beds may contain remnant laminae that are either subhorizontal or low amplitude current-ripple laminae. The sandstone interbeds gradually become thicker and more common upsection. Most of the thick sandstone beds are bioturbated, although some ripple laminae and hummocky cross-stratification may be preserved locally. In the subsurface of Mackenzie Delta, thin small-scale

(3-5 m thick), coarsening-upward cycles have been identified in core and from the log character (Dixon, 1982a). These cycles consist of thin, wavy to lenticular beds of very fine to fine grained, bioturbated or laminated sandstone interbedded with shale (Fig. 16). Dixon (1982a) reported the local occurrence of carbonaceous material in the Kipnik O-13 well.

Bivalves, ammonites, belemnites, foraminifera and dinoflagellates are present in the succession, attesting to the marine nature of the strata. The sedimentary characteristics and the contained fossils indicate a shelf deposit, probably outer or middle shelf, grading up into inner shelf sediments. However, under Mackenzie Delta and Tuktoyaktuk Peninsula, McGuire strata become thinner and more sandy in character, probably reflecting a more basin-margin setting and proximity to a shoreline. McGuire strata represent the oldest beds of a progradational succession that includes the overlying lower Kamik; consequently it is to be expected that they should represent the more basinward deposits of the progradational cycle.

Age

McGuire strata contain bivalves of the early Valanginian *Buchia keyserlingi* Zone and locally from the slightly younger, *Buchia inflata* s.l.n. sp. aff. *B. inflata* Zone (Fig. 2; Jeletzky, 1961, 1973). Foraminifera in McGuire strata tend to consist of many long-ranging Neocomian species; however, the formation contains enough distinct species to be useful for regional correlations (S. Fowler, pers. comm., 1987). Palynomorphs and dinoflagellates have been recovered, but are useful only from areas that have not undergone thermal alteration (McIntyre and Brideaux, 1980), regions limited to the eastern slopes of Richardson Mountains and under the Mackenzie Delta-Tuktoyaktuk Peninsula. The miospores and dinoflagellates contain Valanginian species.

Dating of McGuire strata from Mackenzie Delta wells is ambiguous. Myhr and Gunther (1974), using palynomorphs, suggested that McGuire-equivalent strata were Hauterivian or Barremian, and attributed the age difference between the subsurface and outcrops to be a result of diachroneity of the formation. Such a large diachroneity would be extremely unlikely. The use of long-ranging palynomorphs indicates poor age resolution. Brideaux and Myhr (1976) included the McGuire interval in their IVe and IVf palynomorph zones, which span the Berriasian to Hauterivian. The poorly constrained ages determined from subsurface material suggest that outcrop data reflect the age span more accurately.

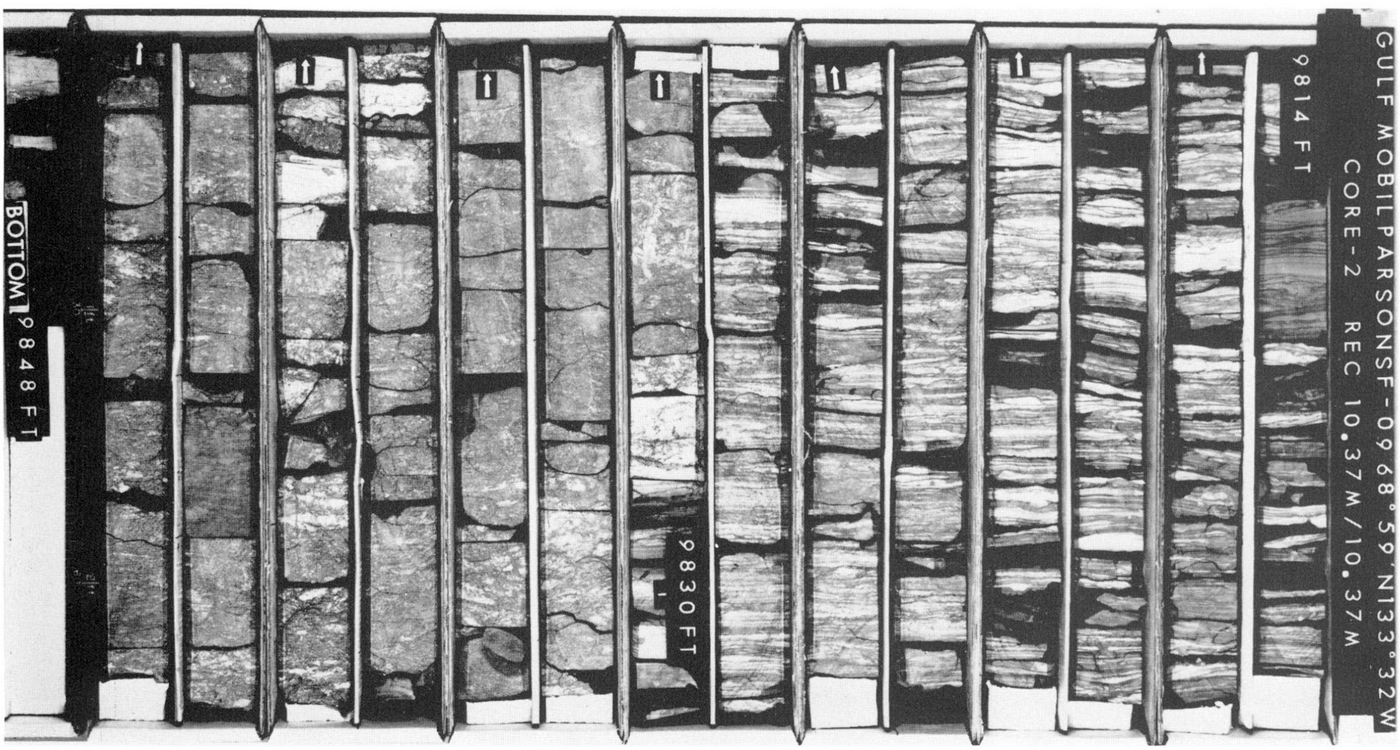

Figure 16. Lower beds of a thin, coarsening-upward cycle in the McGuire Formation from the Parsons F-09 well (core 2, 9814-9848 ft.; 2991.3-3001.7 m). ISPG photograph 554-1.

Kamik Formation

Distribution

Dixon (1982a) used the name Kamik Formation to describe a sandstone and shale unit between shale-rich successions of the underlying McGuire and overlying Siku shale. Dixon et al. (1989) later relegated the Siku Formation to being a member of the Mount Goodenough Formation. The type section of the Kamik Formation is in the Gulf Mobil Kamik F-38 well, between log depths 3006.5 and 3236.4 m (9864-10618 ft.).

Although defined as a subsurface unit, Dixon (1986a) extended the use of the name into the outcrop belts of northern Yukon and adjacent Northwest Territories, to replace the informal names White sandstone member, Coal-bearing division, and White quartzite and Coaly quartzite divisions, previously used by Jeletzky (1958, 1960, 1961) (Fig. 2). Dixon (1982a, b) also indicated that J.A. Jeletzky had intended to name the White sandstone member and Coal-bearing division of the Aklavik Range, the Fault Creek and Lower Canyon formations, respectively. These names have never been formally defined and the author's work in the outcrop belts indicates that it is unnecessary to create another set of names. The term Kamik is applicable to equivalent strata, although local units can be distinguished. Dixon (1982a, b) indicated that Jeletzky's two proposed formations were equivalent to the lower and upper parts of the subsurface Kamik Formation, based on the similar vertical successions and their contained lithofacies. However, correlations from the area of the Parsons Gas Field under the southwestern end of Tuktoyaktuk Peninsula to the northeastern edge of the northern Richardson Mountains clearly show truncation of the upper Kamik at the base of the Mount Goodenough Formation (Fig. 13). In the Aklavik Range and immediately adjacent subsurface, most of the preserved Kamik consists of the lower part of the formation. Consequently, the local twofold division of Kamik strata recognized by Jeletzky (op. cit.) in the Aklavik Range reflects local facies variations within the lower Kamik Formation.

Kamik strata have been identified in the subsurface of the Mackenzie Delta-Tuktoyaktuk Peninsula, in outcrop in the northern Richardson Mountains, on the perimeter of the British and Barn mountains and in the northern Ogilvie Mountains. The distribution has been severely modified by late Hauterivian erosion at the pre-Mount Goodenough unconformity. For example, in the subsurface of parts of the Tuktoyaktuk Peninsula, remnants of Upper Jurassic Husky strata under the Barremian Mount Goodenough Formation suggest that Kamik strata may have extended onto the Eskimo Lakes Arch. Likewise, on the northeastern edge of Eagle Plain (Fig. 1), Mount Goodenough strata progressively truncate Lower Cretaceous rocks to the southwest and south and rest on Jurassic beds of the Eagle Arch (Young, 1975; Norris, 1981d; Dixon, in press a). On the northeast flank of the British Mountains, in the Spring River N-58 and Roland Bay L-41 wells (Fig. 1), Barremian strata also rest unconformably on Jurassic beds (Fig. 6), the Neocomian beds having been eroded. South of Spring River N-58, on Philip Creek (section DFA83-5; Fig. 6), the Mount Goodenough Formation rests on truncated Kamik Formation. About 10 km to the south of Philip Creek, on Babbage River, there is a thick Kamik succession (section DFA87-1). Although section DFA87-1 may contain small thrust repeats, the Kamik succession there is more complete than the section at Philip Creek. Also, section DFA87-1 is within a large thrust sheet (Norris, 1981a) which has had some northward translation. Since there is little evidence to indicate major amounts of thrust displacement, however, the local stratigraphic relationships clearly point to a northward truncation of Neocomian strata onto what must have been a significant (unnamed) uplift during the Hauterivian.

Another erosional event that affected the distribution of Kamik strata, but on a more local scale, was one during the late Aptian-early Albian. This erosional event removed considerable pre-Albian strata from Eagle Plain (Dixon, in press a), and probably removed some Kamik strata, at least on the northern edge. On the east and northeast flank of Barn Uplift, Albian strata apparently rest on truncated Jurassic-Lower Cretaceous rocks and the Kamik Formation is absent. For example, at The Twins, a prominent double peak (Fig. 17), some Valanginian to Barremian strata appear to have been eroded (Young, 1974), yet not too far to the north and south the Kamik Formation is present.

Thickness

Complete, well exposed and accessible sections of Kamik strata are difficult to find and reliable thickness values are difficult to obtain. In the Babbage River area (section DFA87-1) approximately 800 m of Kamik strata were measured. However, this area is locally complex and it is possible there may be some minor thrust repeats in the section. At Canoe Syncline (section DFA83-6, Fig. 1), about 29 km south of DFA87-1, there are about 450 m of Kamik strata that do not appear to contain thrust faults. The almost doubling of thickness in the 29 km between these two sections could reflect the suspected thrust repeat(s) in section DFA87-1.

Figure 17. Albian conglomerates (Albian Flysch) (2) apparently resting unconformably on Jurassic to Neocomian shale and sandstone (1). The Twins, eastern Barn Mountains (section DFA87-17). ISPG photograph 3081-1.

On the west flank of the northern Richardson Mountains, access problems have precluded obtaining a complete measured section. However, up to 500 m of incomplete Kamik strata have been measured, and an estimated total thickness of 700 m would seem to be in order.

In the northernmost Ogilvie Mountains (section DFA85-1, Fig. 1) up to 1800 m of Kamik strata have been measured, but again this is from a local, structurally complex area and thrust repeats may be present. Jeletzky (1975, section D1, Fig. 5) visited the same section but included some of the upper strata within the Upper shale-siltstone division (Mount Goodenough Formation) and Upper sandstone division (Rat River Formation). His correlations do not appear to be based on any convincing biostratigraphic evidence, and Dixon (1986b) has shown that in this part of the Oglivie Mountains and northern Eagle Plain, the previously mapped Rat River Formation (Norris, 1981c, f) is absent. Those strata mapped as Rat River Formation in the northern Ogilvie Mountains and northern Eagle Plain (Norris, 1981c, f) consist mainly of the Albian Sharp Mount Formation, and in some instances, are ridge-forming sandstone intervals within the upper member of the Kamik Formation. Samples from the upper part of the succession at section DFA85-1 were barren of foraminifera, an unusual feature if the strata were the Barremian Mount Goodenough Formation, because elsewhere, Barremian strata generally yield a good foraminiferal assemblage (S. Fowler, pers. comm., 1987).

At the southwesternmost exposures of the Kamik Formation, in the central Ogilvie Mountains, incomplete thicknesses up to 500 m have been measured (sections DFA84-27, DFA84-25 and DFA86-21; Fig. 1) and the total thickness was estimated to be about 700 m. Once again Jeletzky correlated some of these strata with the Upper shale-siltstone division (Mount Goodenough Formation) (Jeletzky, 1971a, p.219; 1975, section A1, Fig. 2) based on a single occurrence of the belemnite *Acroteuthis* ex. gr. *panderiana*, which he dated as late Barremian. In close proximity to section DFA84-25 (Fig. 1), the author measured and sampled a shale succession (section DFA86-20, Fig. 1) above what he identified as Kamik Formation, which contains a typical Mount Goodenough foraminiferal assemblage. This suggests that there is a typical shale-dominant succession of the Mount Goodenough Formation present within this area, and that the underlying sandstone-bearing succession is part of the Kamik Formation.

Each member is also highly variable in thickness. Under Mackenzie Delta the lower member is 100 to 200 m thick, and the upper member up to 700 m thick, although in some locations the upper member can be considerably less due to pre-Mount Goodenough erosion. In outcrop the lower and upper members are similar in thickness to those observed in the subsurface, although the lower member can be as thin as 30 m.

In the subsurface of Mackenzie Delta and Tuktoyaktuk Peninsula, Kamik strata are up to 800 m thick (Dixon, 1982a, Fig. 12), thinning depositionally and by truncation to the south and west, toward the Eskimo Lakes Arch and Cache Creek Uplift, respectively (Fig. 13). An example of possible local truncation of Kamik strata within the Eskimo Lakes Fault Zone is illustrated by the Kamik D-48 well (Fig. 18), where Mount Goodenough strata erosionally overlie a much truncated Kamik succession, yet in the nearby Kamik D-58 and F-38 wells, there is an apparently full Kamik succession. Alternatively, Kamik strata in the D-48 well may be thin due to faulting.

The contact between the Kamik Formation and the overlying Mount Goodenough Formation is a regional unconformity, and the magnitude of erosion varies according to basin position and proximity to tectonic highs. In the depocentres, which generally coincide with tectonic depressions, erosion is minimal to undetectable. Such areas are the Kugmallit Trough, Rapid Depression and Kandik Basin (Fig. 3). On the tectonic highs, such as the Cache Creek Uplift, Eskimo Lakes Arch, Eagle Arch and Romanzof Uplift (Fig. 3), Kamik strata have been thinned or removed by pre-Mount Goodenough erosion. One of the best places to see these relationships is on, and adjacent to, the Cache Creek Uplift (Figs. 8, 13). Westward from Mackenzie Delta, the Kamik Formation

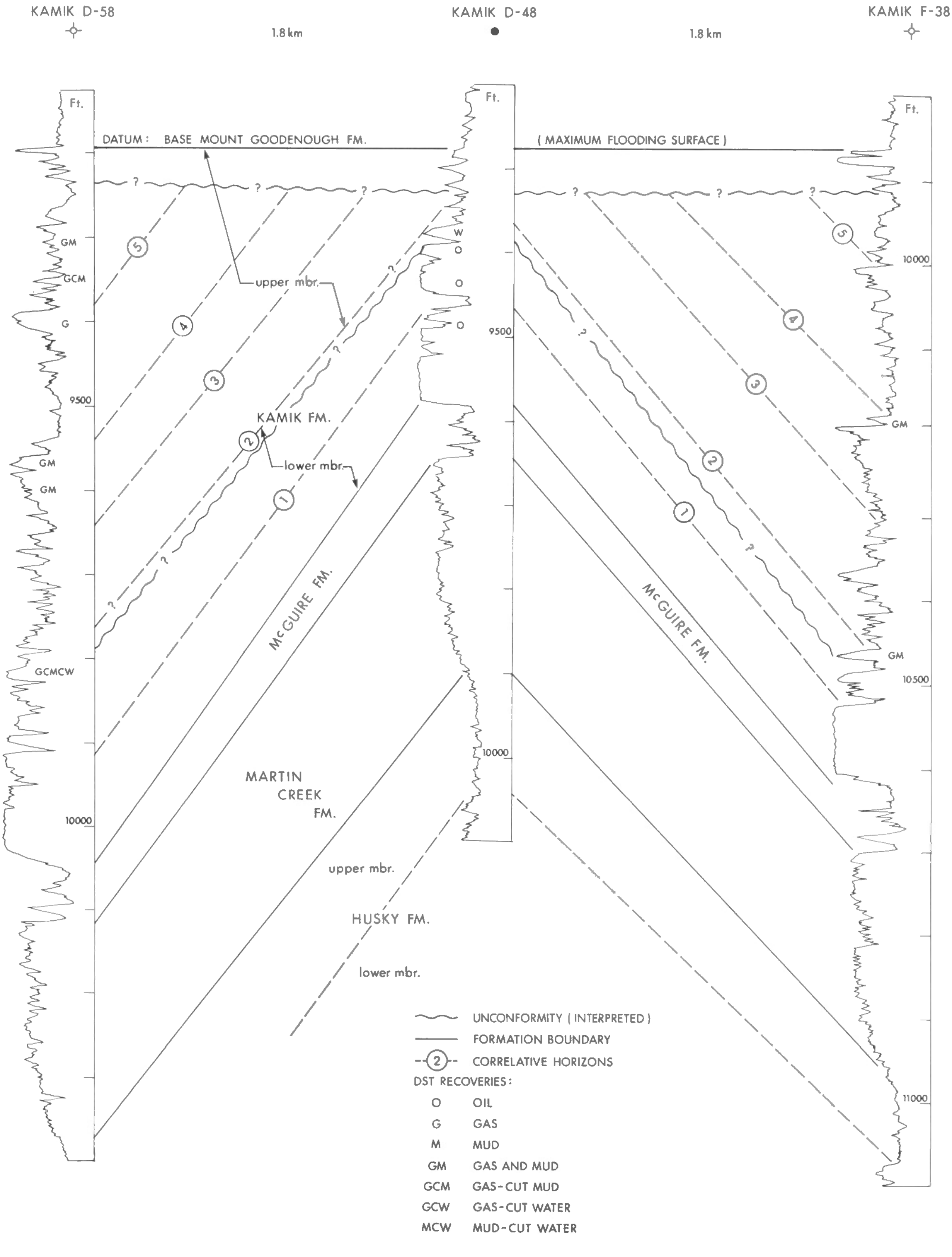

Figure 18. *Interpreted log correlations between the Kamik D-58, D-48 and F-38 wells.*

is progressively truncated, such that in the core of the Cache Creek Uplift, on Fish River (Fig. 19, section DFA87-18), Kamik, McGuire and much of the Martin Creek Formation have been eroded. On the west flank of the uplift, the truncation appears to be less gradual, and a full Kamik succession is rapidly attained. In "Grizzly Gorge", a truncated Kamik is well exposed, and the eastward thickening under the Mount Goodenough Formation is readily seen (Figs. 20, 22). A cored example of the unconformity is present in the Tuk L-09 well (Figs. 13, 23), where a thin, transgressive interval comprises thinly interbedded sandstone and mudstone (millimetre to 40 cm thick beds) with a 3 to 4 cm thick pebble layer at its base. The sandstone beds contain fine, subhorizontal, wave and current laminae, burrows, and burrow mottled beds.

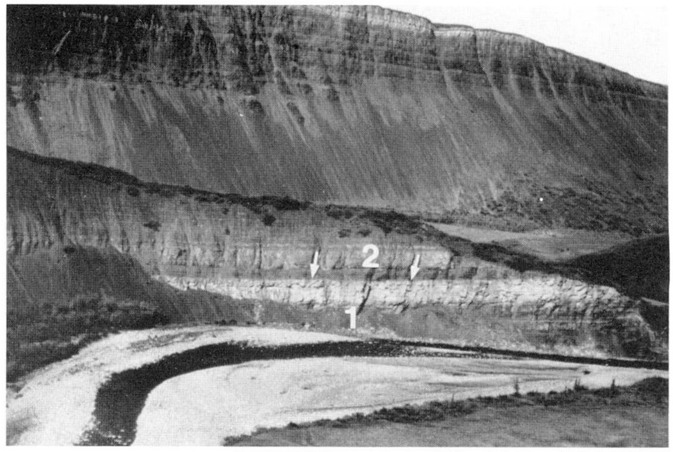

Figure 19. *Mount Goodenough Formation (2) resting unconfomrably on truncated Martin Creek Formation (1). Fish River, northern Richardson Mountains (section DFA87-18). ISPG photograph 2236-8.*

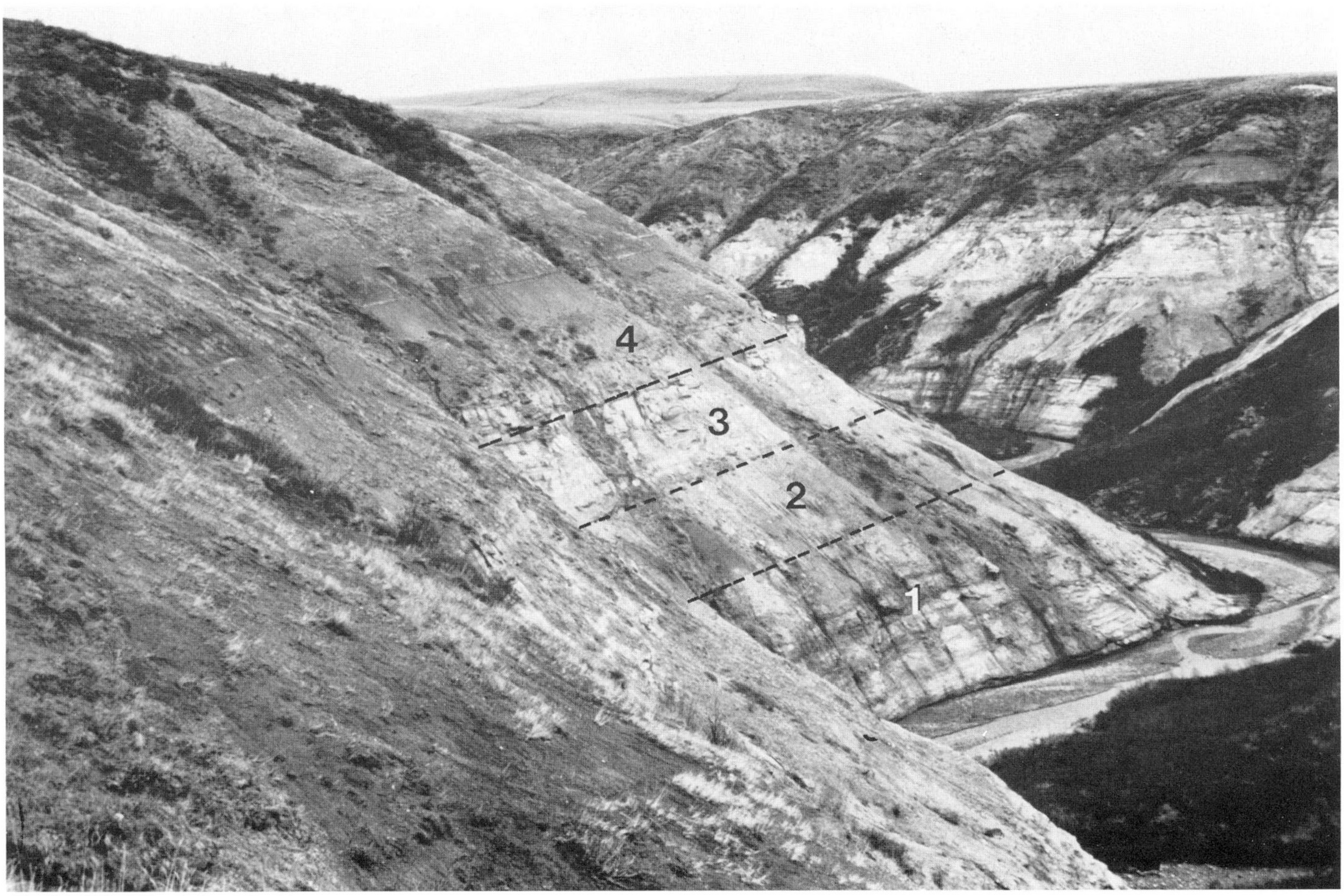

Figure 20. *Lower member, Kamik Formation (3), erosionally overlain by Mount Goodenough strata (4). Martin Creek (1) and McGuire (2) formations. View looking toward the east in "Grizzly Gorge". ISPG photograph 2057-4.*

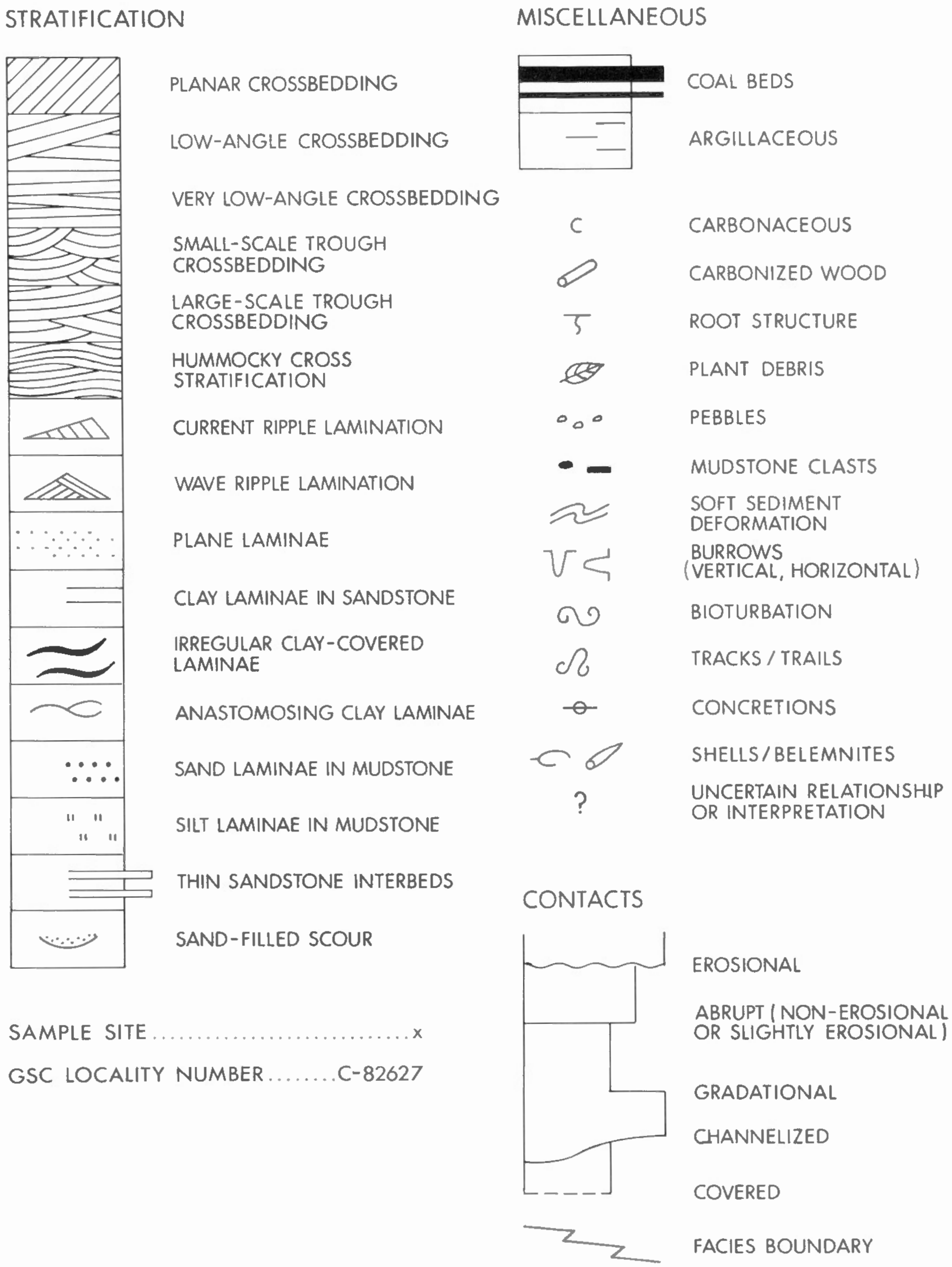

***Figure 21.** Legend for Figures 22 to 25, 28, 30, and 34.*

Lithology

Throughout its area of occurrence, the Kamik succession has a basic twofold division: a lower, sandstone-dominant interval, and an upper interval of interbedded sandstone and shale. These two intervals are informally designated the lower and upper members.

The lower member makes up approximately one third of the succession and in outcrop commonly forms cliffs (Fig. 14). In the subsurface the lower member displays a blocky log trace, which reflects the dominance of sandstone (Fig. 13). Shale is a minor component of the lower member, generally comprising less than 20 per cent of the succession. In the subsurface of the southwestern

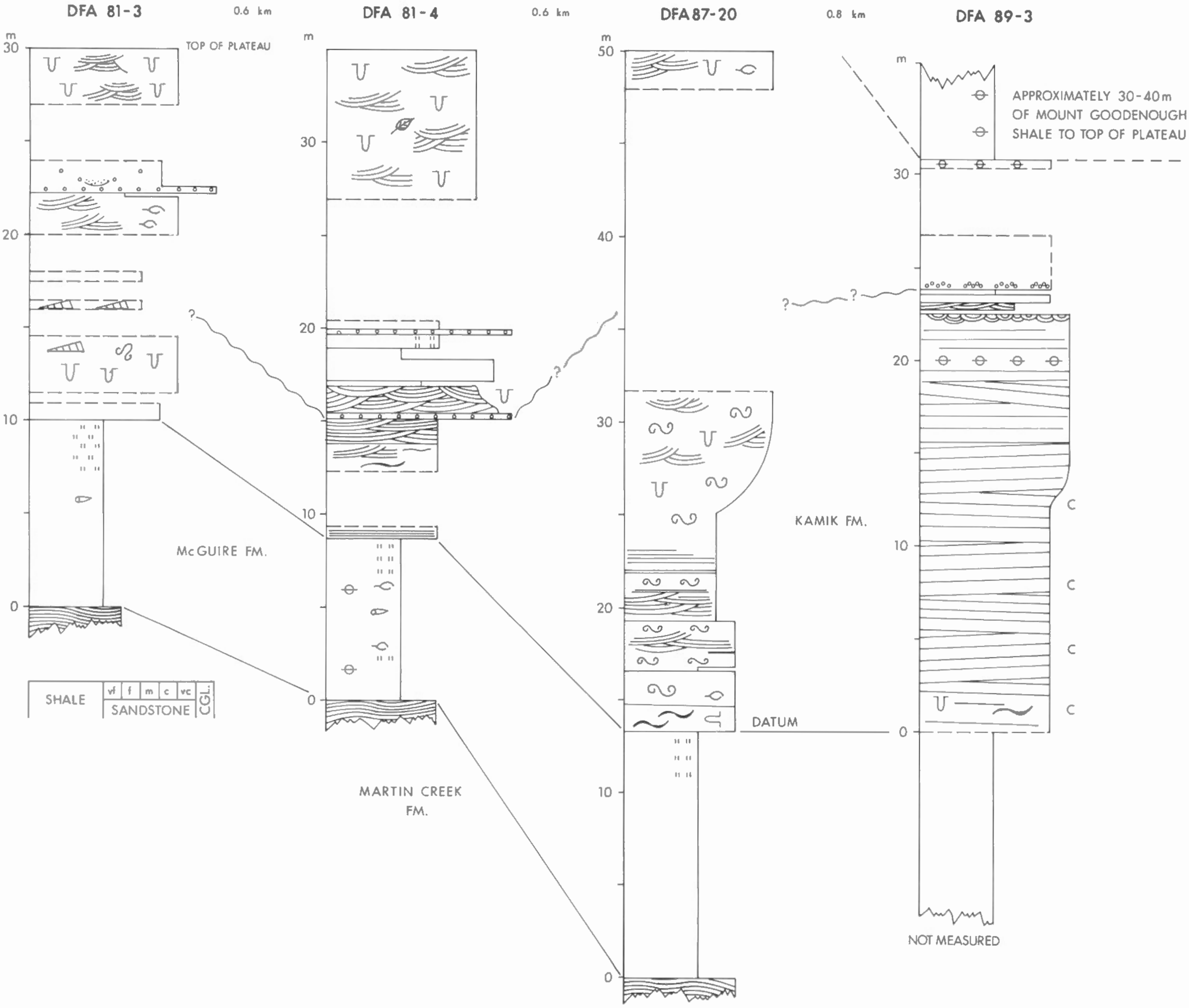

Figure 22. Graphic representation of four sections from "Grizzly Gorge", northeastern Richardson Mountains, illustrating the eastward thickening of lower Kamik beds because of truncation at a sub-Mount Goodenough unconformity.

end of Tuktoyaktuk Peninsula, centimetre thick seams of coal are present in the lower member (Dixon, 1982a, b). A few minor coal seams are also present in outcrops of the lower member along the lower reaches of Willow River (section DFA82-4, Fig. 1). Grain size in the sandstones ranges from very fine to conglomeratic. Quartz arenites are the principal sandstone type.

The upper member is characterized by alternations of sandstone and shale, commonly arranged in coarsening-upward cycles that range in thickness from a few metres to about 150 m (Figs. 13, 14). In outcrop the alternating lithotypes are commonly reflected as ridge and col topography. In the subsurface the log trace tends to be ragged. The amount of shale and sandstone varies geographically; in the eastern areas of occurrence the sandstone content is between 40 and 60 per cent, but westward and southwestward the sandstone content decreases to between 20 and 30 per cent. In the northwesternmost outcrops, on the flanks of the British and Barn mountains, the upper member contains considerably more shale than to the east and south, and immediately above the lower member there is a locally mappable shale unit (map unit Kwc2 of Norris, 1981a) (Fig. 6). Sandstones in the upper member are mostly very fine to fine grained, quartz arenites.

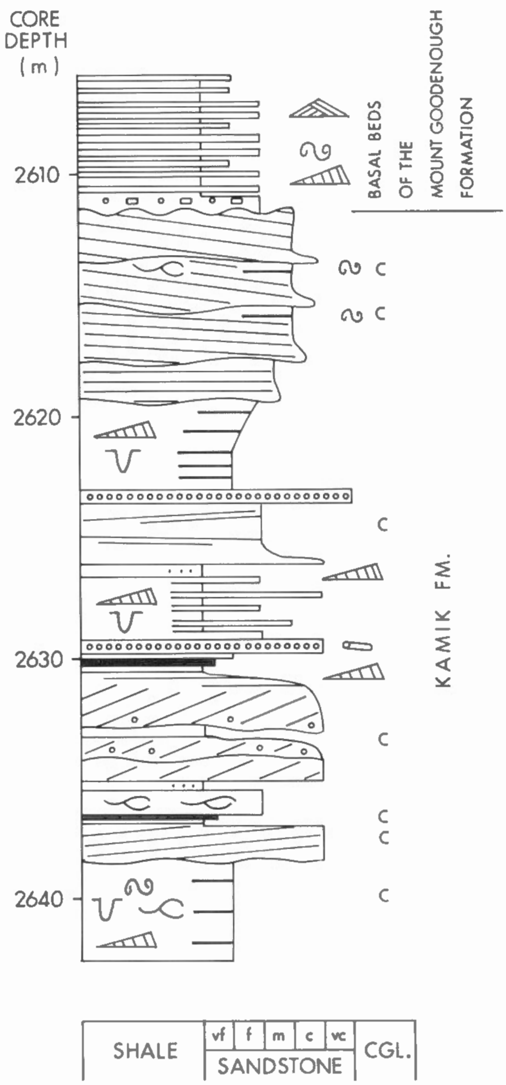

Figure 23. Graphic representation of cored material from the Tuk L-09 well, central Tuktoyaktuk Peninsula. Cores 1 and 2, 2606.7 to 2642.8 m. The erosional contact between Kamik and Mount Goodenough strata is illustrated.

Sedimentology

Lower member

Dixon (1982a, b) described in detail the facies from the subsurface occurrences of Kamik Formation in the Mackenzie Delta-Tuktoyaktuk Peninsula area. These descriptions will not be repeated. Dixon (op. cit.) concluded that a large percentage of the lower member consists of fluvial channel and overbank deposits (Fig. 24), with some marginal marine beds in the upper part of the member. For most of the lower member a deltaic setting, which was terminated by a marine transgression prior to deposition of the upper member, was interpreted. In the upper member, coarsening-upward cycles were interpreted as containing barrier bar, tidal inlet and lagoonal deposits (Fig. 25). At least three cycles were identified and correlated in wells from the Parsons Lake area, but in thicker successions, more cycles can be discerned.

The lower member gradationally overlies the McGuire shale and in the western areas, the transition beds may be up to 10 m thick (Fig. 26). In the Aklavik Range of northern Richardson Mountains and under Mackenzie Delta-Tuktoyaktuk Peninsula, the contact can be abrupt or transitional over a very short vertical distance. Where the contact is transitional, there is a gradual upward increase in the percentage of sandstone and a decrease in interbedded shale. In such transitional successions bioturbation is ubiquitous and primary sedimentary structures, such as ripple and horizontal laminae, are only locally preserved. The transitional facies represents a vertical change from offshore muddy deposits into sandier inner shelf and shoreface deposits. In the Mackenzie Delta-Tuktoyaktuk Peninsula areas the transitional facies are interpreted as delta-front deposits. Abrupt contacts tend to be more common in the eastern occurrences of the Kamik Formation, closer to the interpreted paleoshoreline, and can be attributed to local erosion (such as at "Grizzly Gorge", in the Aklavik Range, sections DFA81-3, 4 and DFA87-20; Fig. 1).

Beds above the transitional interval vary in character according to basin-position. As previously stated, under Mackenzie Delta deltaic beds, consisting of delta-front, distributary mouth-bar, fluvial channel, overbank and interdistributary bay deposits, are prevalent. In the northeastern Richardson Mountains, equivalent strata are well exposed in Martin Creek, "Grizzly Gorge", in the Lower Canyon of Willow River (ex-Donna River) and the Aklavik Range. At Martin Creek the beds immediately above the McGuire shale are poorly exposed and consist of about 4 m of indistinctly bedded, rust coloured, fine grained sandstone that contains pods of bioturbated sandstone. Immediately above these lowermost sandstone beds are about 18 m of white-weathering, friable, very fine to fine grained sandstone that contains very long, extremely low-angle crosslaminae (Fig. 27). Sparse, poorly preserved bivalves are present on some laminae. This prominent sandstone is the White sandstone member of Jeletzky (1958, 1960). Erosionally overlying the laminated sandstone are 1 to 4 m thick beds of pebbly to conglomeratic, coarse grained sandstone (Fig. 28). Each pebbly sandstone bed has an erosional base overlain by a pebbly layer or pebble-rich sandstone, succeeded in turn

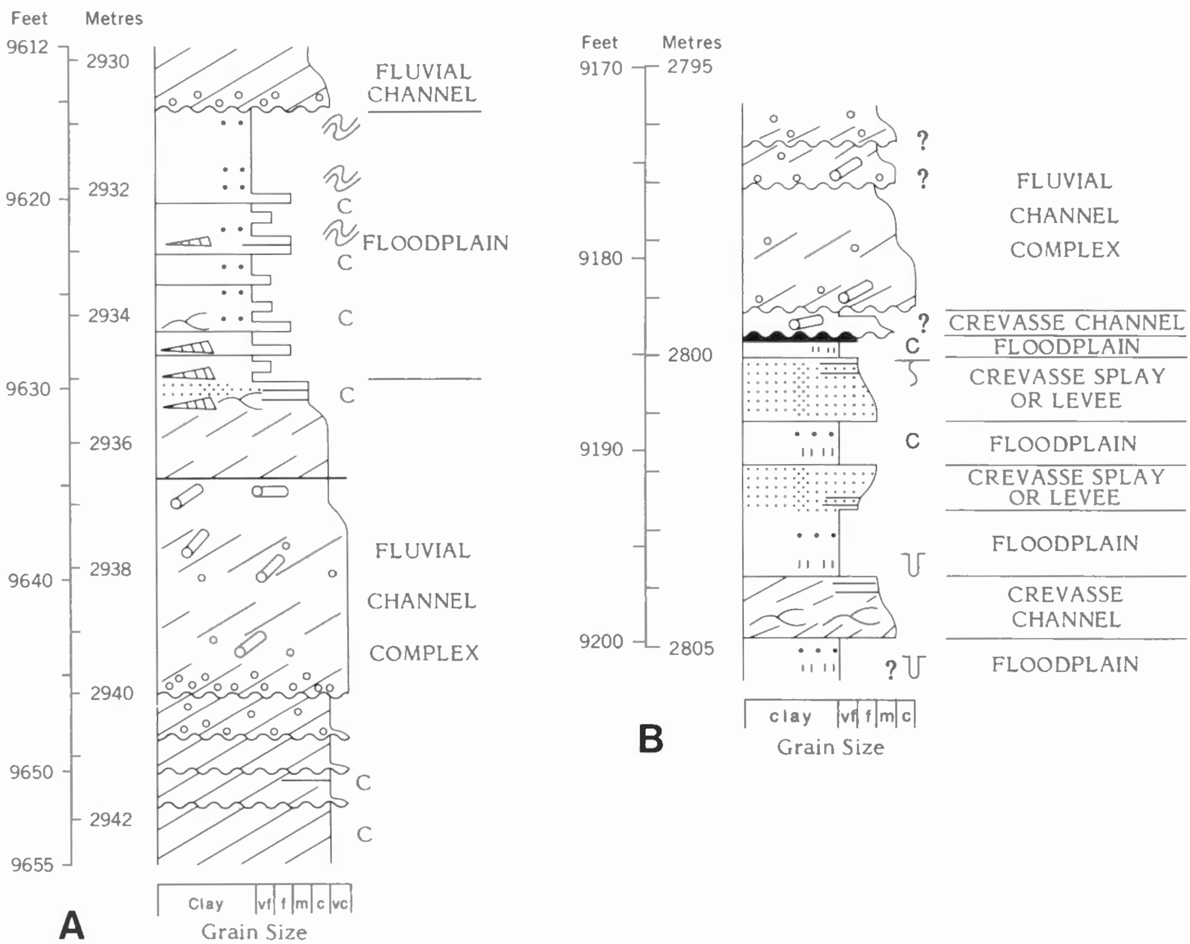

Figure 24. Graphic representation of cores from the lower member, Kamik Formation, and their depositional interpretation (from Dixon, 1982a). Core from Parsons L-43 (A) and Parsons N-10 (B).

by medium to coarse grained sandstone with some beds containing scattered granules or small pebbles. Low-angle cross-stratification and a few, isolated, small troughs are present in the pebbly beds. Strata above the pebbly beds are poorly exposed. The unconformity at the base of the Mount Goodenough Formation truncates a large amount of Kamik strata in the Martin Creek section.

Only 9 km to the north of Martin Creek, in "Grizzly Gorge", a thin wedge of eastward thickening, lowermost Kamik sandstone is preserved under the pre-Mount Goodenough unconformity (Figs. 20, 22). The Kamik sandstones are white with streaks of rusty brown and yellow. The Kamik strata at "Grizzly Gorge" differ in some respects from those at Martin Creek, in that the lowest beds consist of bioturbated fine to medium grained sandstone with remnants of low-angle crosslaminae. These lowest beds are gradationally overlain by medium to coarse grained sandstone, in which patches of trough or low-angle cross-stratification are preserved (Fig. 22). A sparse fauna of *Buchia* bivalves has been collected from the lowermost sandstone beds at "Grizzly Gorge". The prominent, thick, extremely low-angle cross-stratified sandstone facies seen at Martin Creek is not present in the western sections at "Grizzly Gorge" but is restricted to the thicker eastern measured section (section DFA89-3, Fig. 22).

About 7 km east of the Martin Creek sections, in the Lower Canyon of Willow River, there is a cliff exposure of the lower member, Kamik Formation (section DFA82-4, Figs. 29, 30). Jeletzky (1960) identified this outcrop as containing the White sandstone member at its base, overlain by the Coal-bearing division. Local and regional stratigraphic correlations suggest that the lowest beds in the Lower Canyon exposure are part of the lower member, Kamik Formation (Fig. 13). The lower contact is not exposed, consequently the relative position of the

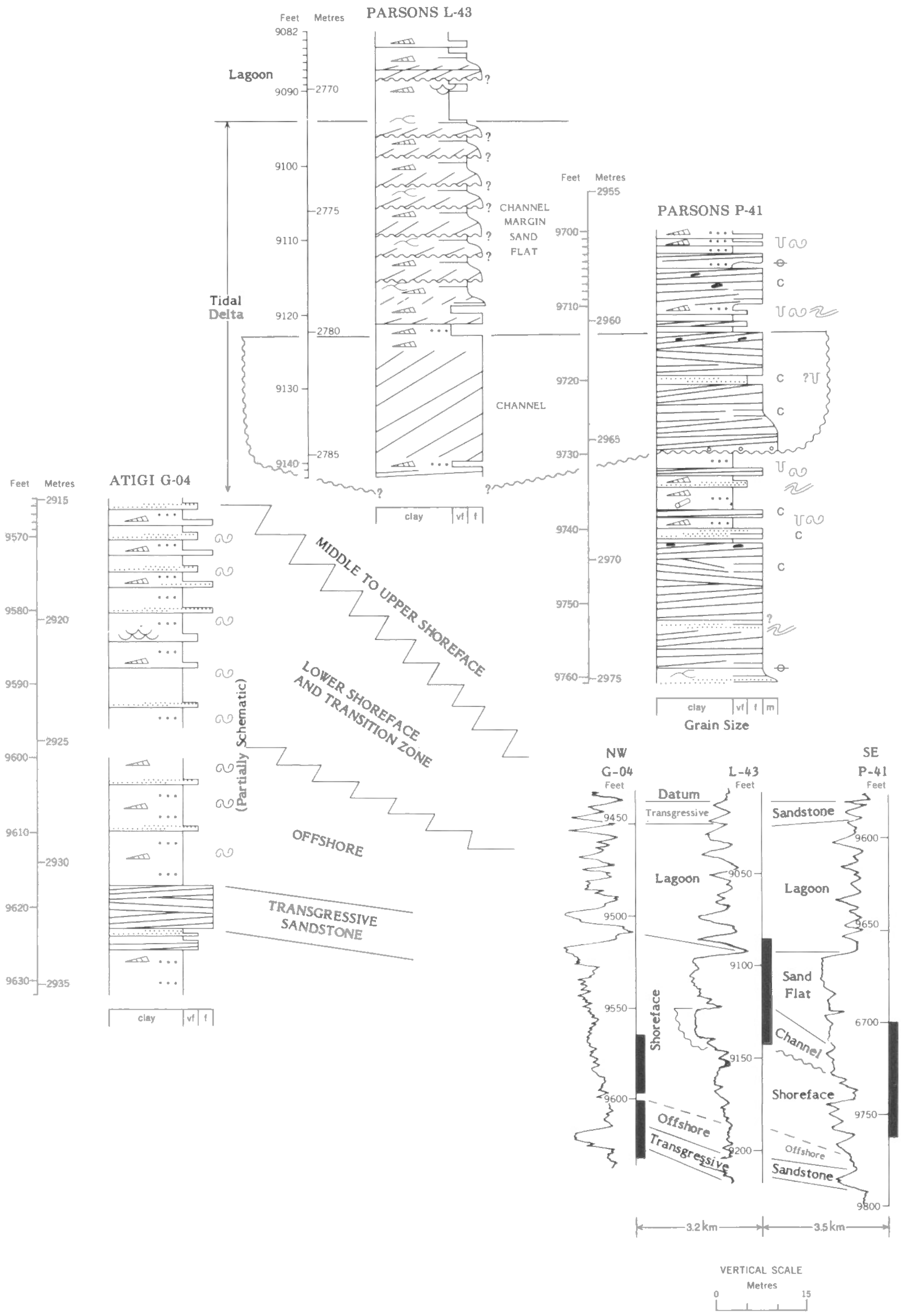

Figure 25. Graphic representation of cored material from the upper member, Kamik Formation, and its depositional interpretation (from Dixon, 1982b). From the area of Parsons Lake Gas Field, southwestern Tuktoyaktuk.

Lower Canyon section with respect to the sections at Martin Creek and "Grizzly Gorge" are not known in detail. The lowest 17 m of the exposed strata consist of medium to coarse grained, pebbly sandstone with medium- to large-scale trough cross-stratification in most of the interval (Fig. 31A, B), although beds of planar cross-stratified sandstone separated by thin, horizontally laminated beds are present near the base of the section (Fig. 30). These lowest beds form a resistant weathering cliff and may be equivalent to the "White sandstone" seen at Martin Creek and "Grizzly Gorge". Above these lower beds the facies are more varied and beds become thinner. The upper interval consists of interbedded sandstone and shale with several thin coal horizons. Most of the sandstone beds contain either wave and current ripple laminae (Fig. 31B) or low-angle crosslaminae. Many of the current ripples have been wave-modified (Fig. 31C). Some of the ripples are straight crested to branching. Individual sandstone units tend to be a few tens of centimetres to 3 m thick. One of the thicker sandstone units is readily seen to be a shallow channel-fill (Figs. 29, 30). The shale intervals commonly contain lenticular beds of very fine to fine grained, ripple laminated (mostly wave ripples) sandstone. The coal beds are about 30 cm thick, generally occur on top of a shale interval and are not laterally extensive. The coal-bearing intervals grade up from shale to carbonaceous shale to argillaceous coal. Feeding traces have been seen on bedding planes of some sandstone beds and marine foraminifera have been recovered from the shales. Jeletzky (1960) apparently recovered macrofossils from this exposure of the lower member.

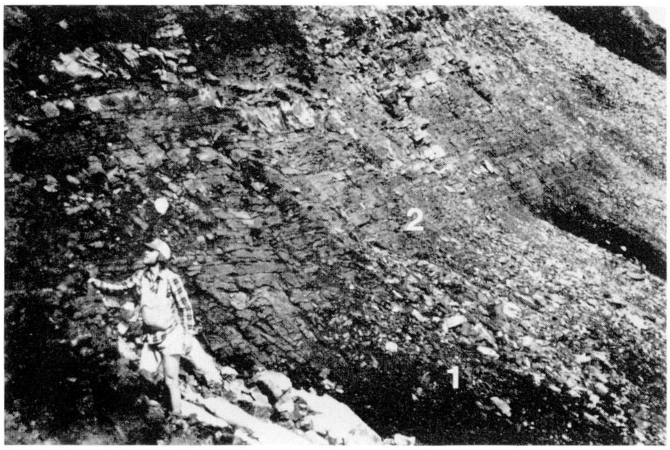

Figure 26. Transitional strata between McGuire (1) and Kamik (2) formations, near Mount McGuire, Richardson Mountains (section DFA82-8). ISPG photograph 1858-19.

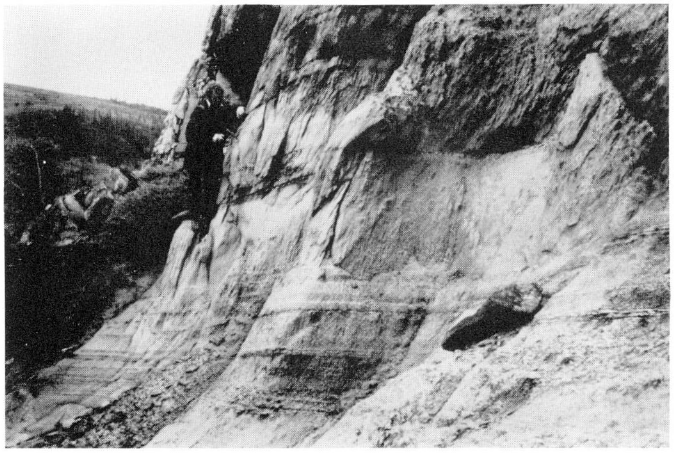

Figure 27. Long, extremely low-angle cross-stratification in beds from the lower member, Kamik Formation, Martin Creek, Richardson Mountains (section DFA82-8). ISPG photograph 1895-5.

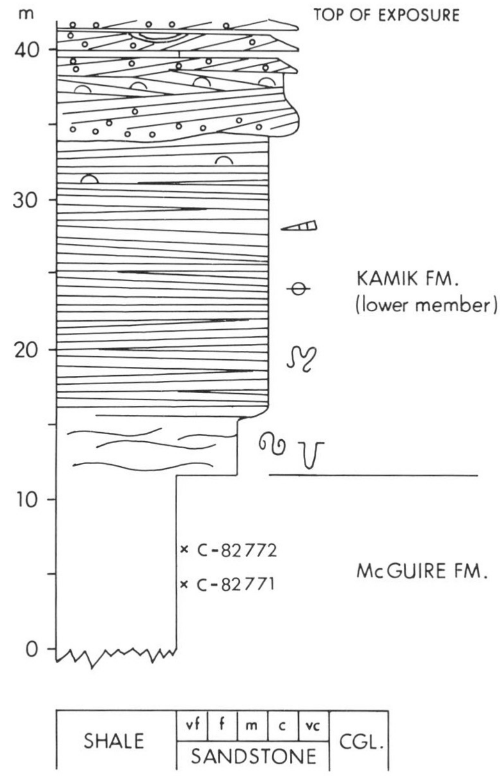

Figure 28. Graphic representation of the lower member, Kamik Formation, from section DFA81-1, Martin Creek.

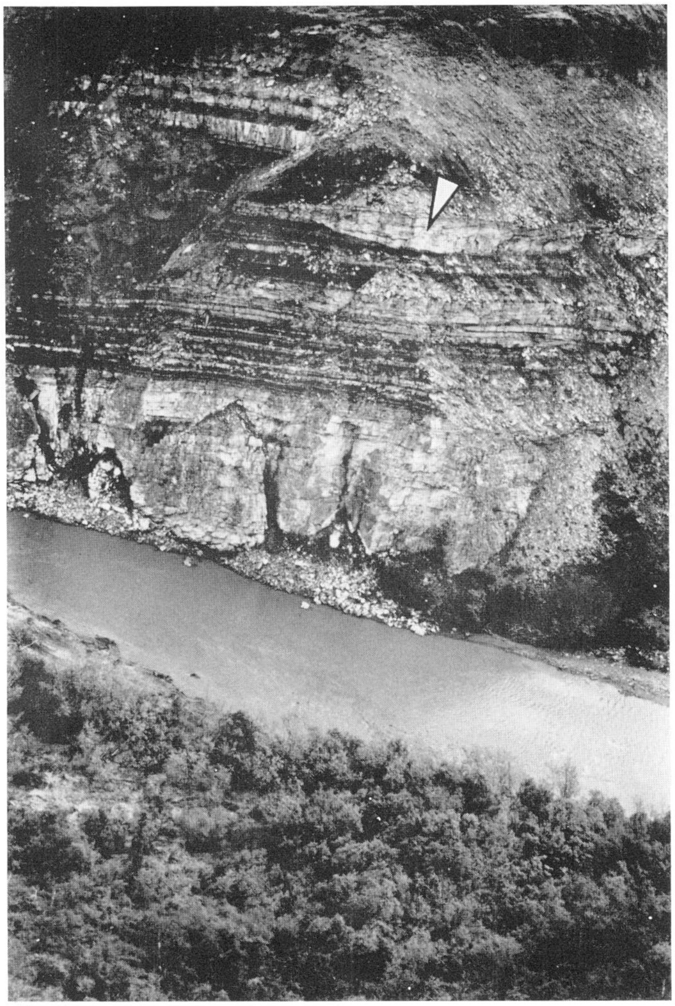

Figure 29. Lower member, Kamik Formation, at Lower Canyon, Willow River (section DFA82-4). Note the small channel-fill sandstone (arrow). The shale-rich beds in the upper part of the succession are equivalent to Jeletzky's (1960) Coal-bearing division. ISPG photograph 3081-2.

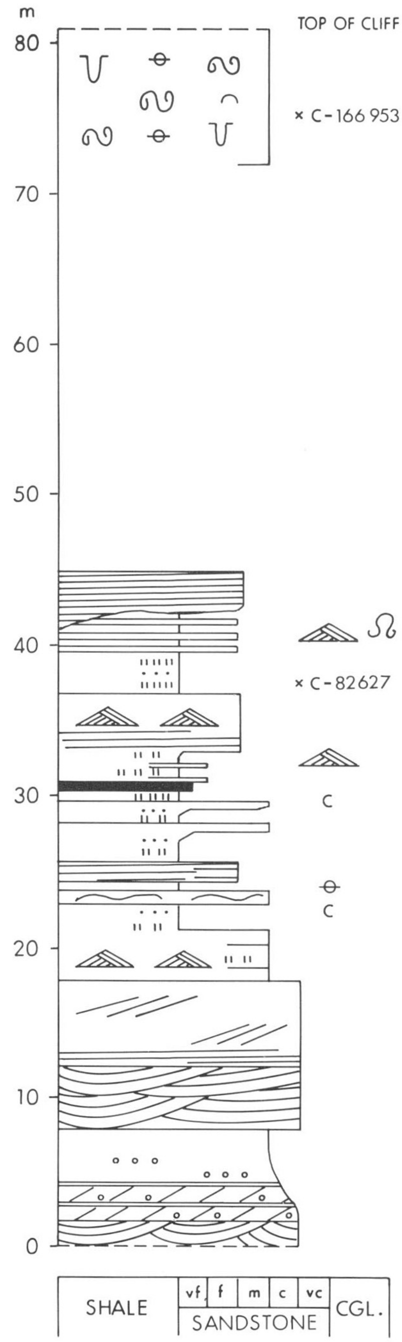

Figure 30. Graphic representation of the Kamik succession at Lower Canyon, Willow River (section DFA82-4).

The three localities in the Aklavik Range have been described in detail because they illustrate an assemblage of facies within the lower member that are transitional between the deltaic beds seen to the east, under Mackenzie Delta, and the more open marine succession to the west, which will be described later. The marine character of these lower member beds in the Aklavik Range is apparent from the assemblage of sedimentary structures and contained fossils, but the presence of coaly beds indicates some local, nonmarine conditions. Conditions that would meet these two requirements would be found in a marginal marine setting with beach and lagoonal deposits, and possibly with tidal inlets/channels. The long, low-angle crosslaminae seen at Martin Creek and in the eastern section at "Grizzly Gorge" are reminiscent of swash and backwash beach laminae. At the Willow River locality, the lowermost sandstones indicate formation by strong, unidirectional currents and could have been deposited in either a tidal delta or a tidal inlet setting. The overlying beds are probably lagoonal in origin, which would account for the rapid alternation of generally thin beds, the abundance of wave and current ripples, the presence of small channels, and the coal and carbonaceous beds.

South of the Aklavik Range, in the vicinity of McDougall Pass and Mount Sittichinli (sections DFA82-5 and 11, DFA82-7, respectively, Fig. 1) the lower member locally contains thin planar crossbed sets, some of which occur in coarse grained to granular sandstone (Fig. 32) and locally contain vertical or U-shaped burrows. These beds overlie bioturbated and hummocky cross-stratified beds at DFA82-5, but are interbedded with such facies at the other two localities. These strata along with the presence of high-energy, unidirectional sedimentary structures in close vertical association with storm-generated structures, suggest proximity to the beach.

On the west flank of the Richardson Mountains and in the northern Ogilvie Mountains, the lower member is entirely marine and is characterized by an abundance of subhorizontally laminated, hummocky cross-stratified and bioturbated beds of very fine to fine grained sandstone. Local interbeds of planar crossbedded, commonly medium to coarse grained sandstone are present in some outcrops on the west flank of the northern Richardson Mountains. Bivalves are present in the two areas but generally are not very common. The percentage of bioturbated strata in the lower member increases west and northwest of the Richardson Mountains, such that in the British Mountains, bioturbation is a prominent sedimentary feature of the lower member. The facies in the western Richardson Mountains and Ogilvie Mountains areas are interpreted as nearshore, storm-dominated sediments, which become progressively more offshore to the northwest, in the British Mountains.

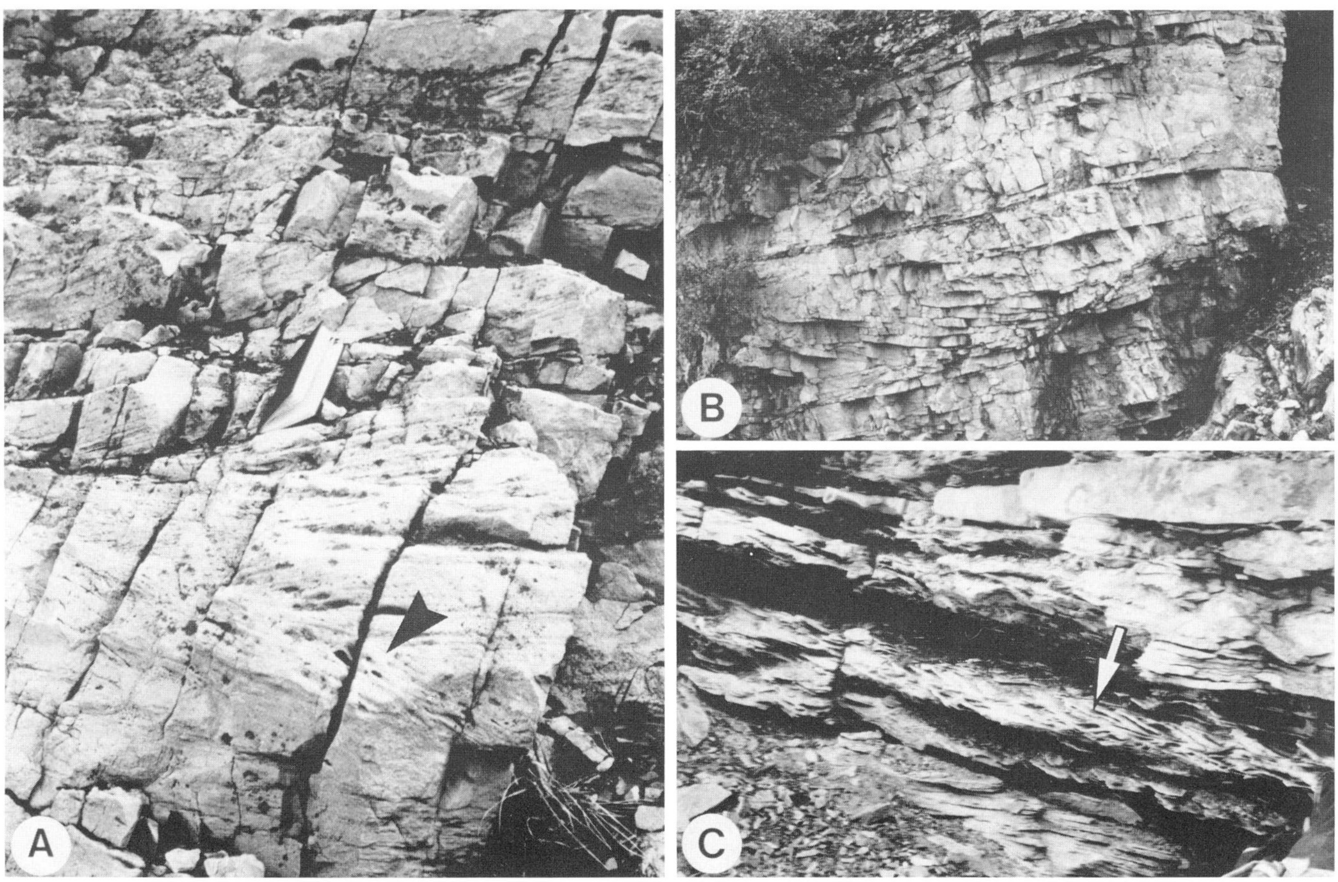

Figure 31. Sedimentary structures in Kamik strata at Lower Canyon, Willow River (section DFA82-4): A, large-scale trough crossbeds. A false impression of opposing planar crossbedding is apparent in the photograph (arrow) because only one side of the trough can be seen. Long dimension of book is 17.5 cm. ISPG photograph 1858-11. B, large-scale trough crossbed set in same unit as shown in Figure 31A. Approximate thickness of crossbed set is 1 to 1.5 m. ISPG photograph 3201.1. C, Wave-modified current-ripple crosslaminae (arrow). ISPG photograph 1858-16.

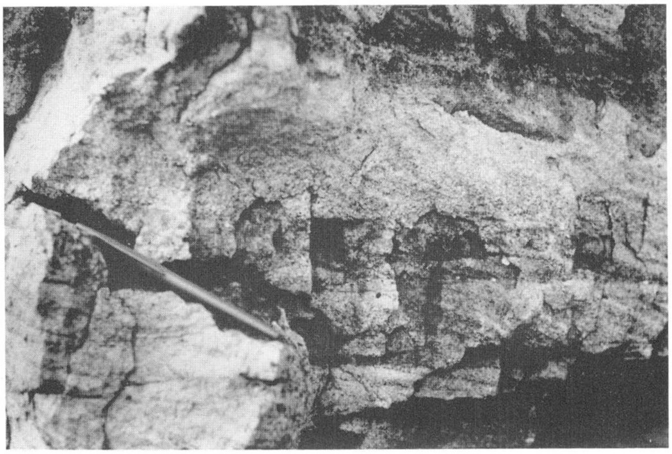

Figure 32. Small-scale planar cross-stratification in coarse grained to granular sandstone; lower member, Kamik Formation (section DFA82-5). Pen is approximately 15 cm long. ISPG photograph 1858-15.

During deposition of the lower member (approximately late Valanginian) the basin margin extended southwest from the Tuktoyaktuk Peninsula area, through the northern Richardson Mountains, across the northern edge of Eagle Plain and then appears to have swung south in the northern Ogilvie Mountains (Fig. 33). A major delta formed in the Tuktoyaktuk Peninsula-south Mackenzie Delta area (Myhr and Young, 1975; Young et al., 1976) and acted as a major source of coarse clastic sediment. The large volume of available sediment allowed for the progradation and aggradation of a thick sandstone succession across a large part of the shelf. The marine margin of the delta can be seen in the facies of the Aklavik Range. West and southwest of the Aklavik Range, marine shelf sediments dominate the lower member. The abundance of storm-produced structures such as hummocky cross-stratification in the shelf strata implies that the delta was wave-dominated (Galloway, 1975). The coal-bearing strata at section DFA86-21 (Fig. 7), which immediately overlie the lower member sandstone in the Ogilvie Mountains, may be genetically part of the lower member depositional sequence (see later section on sequence stratigraphy). If it is part of the same depositional sequence, then this would be possible evidence of a barrier setting along the basin margin.

Upper member

In the subsurface of Mackenzie Delta and Tuktoyaktuk Peninsula the upper member of the Kamik Formation is characterized by a series of coarsening-upward cycles of barrier bar, tidal inlet and lagoonal origin (Dixon, 1982a, b). Coarsening-upward cycles occur throughout the upper member in the Richardson and Ogilvie mountains, although the scale of the cycles can vary from a few metres to about 150 m. The thick cycles possibly reflect basin-scale sedimentation controls, although the author has only been able to correlate cycles on a local scale. Smaller scale cycles probably reflect local sedimentation controls, such as sediment supply and local switching of depositional regimes. The cyclicity becomes less apparent in the British and northernmost Ogilvie mountains. Here, the upper member is predominantly shale with sandstone-rich intervals scattered throughout the sections (Figs. 6, 7). However, even in these locations, the sandstone-rich intervals could be a reflection of the more obvious cyclicity seen in sections to the east and south.

The cycles on the west flank of the Richardson Mountains and the central parts of the Ogilvie Mountains generally contain more sandstone than shale (Fig. 34). In these areas, the cycles consist of a basal shale or thin bedded, thoroughly bioturbated argillaceous sandstone beds separated by shale partings, resting abruptly on the preceding cycle. The basal beds grade up into thinly interbedded sandstone and shale. Usually, these interbedded strata are bioturbated, although remnant patches of ripple and subhorizontal laminae can occur. The uppermost part of the cycles consists of amalgamated beds of very fine to fine grained sandstone with hummocky cross-stratification and fine, subhorizontal laminae. Locally, interbedded bioturbated layers can be common to abundant. This vertical association of facies is typical of all scales of cyclicity, although there are local variations. In general, the more westerly cycles are shalier and the sandstone component contains more bioturbated strata and fewer preserved sedimentary structures than those in the east. The eastern occurrences of the larger scale cycles are interpreted as representing progradation and aggradation of nearshore, perhaps even shore-attached, sandbars, that show an east-to-west change from nearshore to inner or middle shelf character.

A significant variation on the nearshore to shelf origin for the cycles is seen in some of the strata at section DFA86-21, in the Ogilvie Mountains. Here, the lowermost beds of the upper member consist of relatively thin cycles, varying from a few metres to about 15 m thick. The bulk of each cycle consists of a 4 to 12 m thick shale interval containing thin sandstone interbeds that are either bioturbated or ripple laminated. Carbonaceous material is a common component of the shale and in at least one cycle, a thin coal seam is interbedded with the shale. The shale-dominant interval of each cycle is capped by a sandstone unit that is generally only 1 to 5 m thick. Wave-ripple and wave-modified current-ripple laminae are the most prevalent sedimentary structures in the

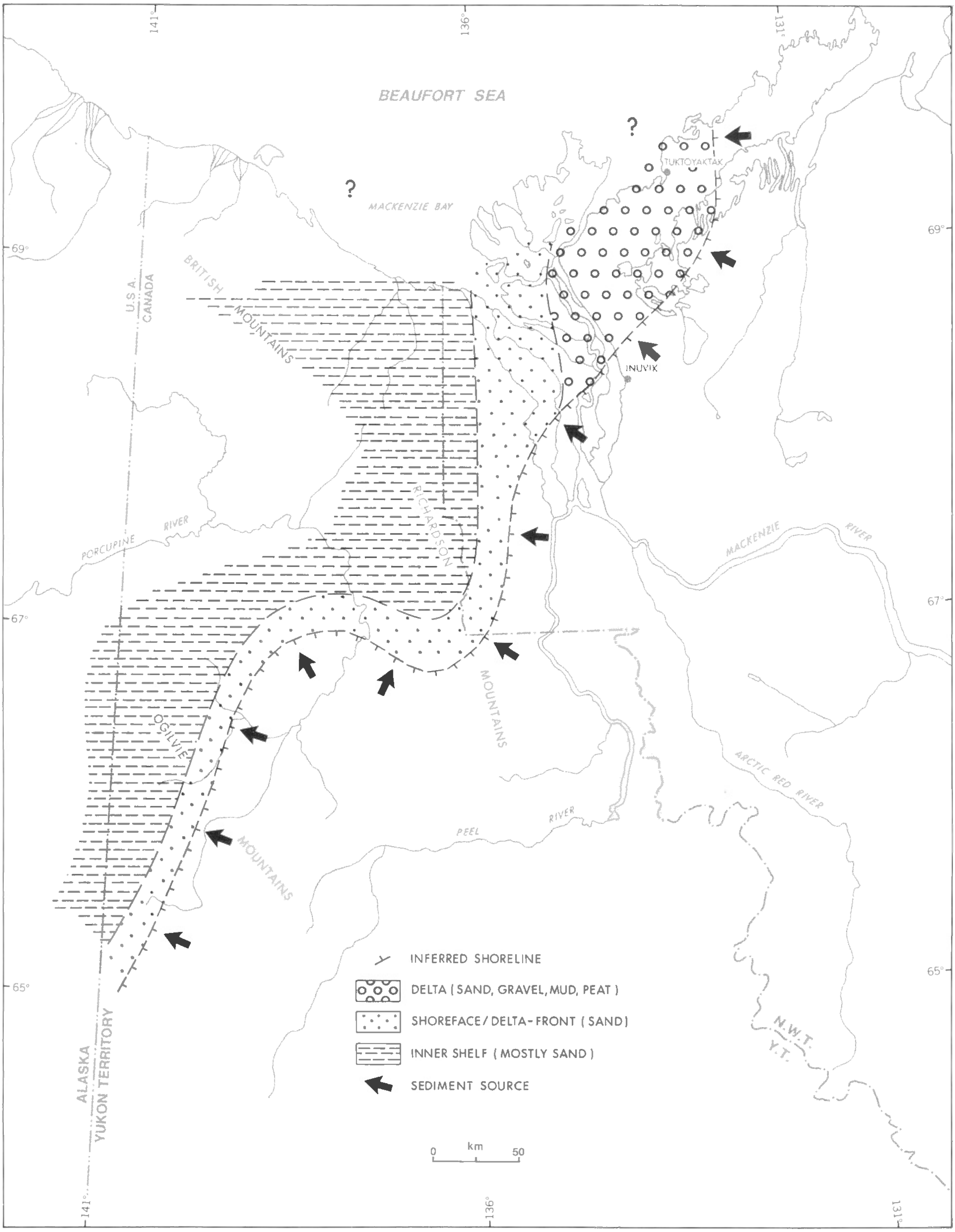

Figure 33. *Interpretation of late Valanginian paleogeography (approximate time of deposition of the lower member, Kamik Formation). No palinspastic reconstruction is attempted to account for Early Cretaceous plate motions and early Tertiary compression.*

sandstones. Other, less common sedimentary structures include small-scale trough crossbeds, small lense-shaped scours filled with planar crossbeds, and vertical burrows.

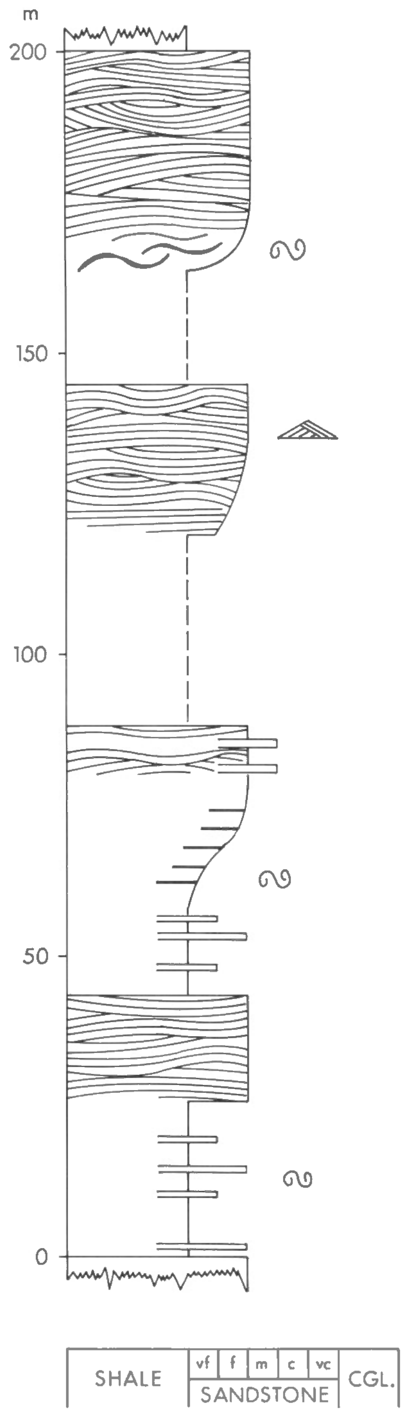

Figure 34. *Graphic representation of coarsening-upward cycles in the upper member, Kamik Formation from the west flank of the northern Richardson Mountains (section DFA83-2B).*

The association of a thin coal bed and carbonaceous shale with strata containing structures suggestive of marine influences favours the interpretation of a lagoonal setting for deposition of these cycles. Also, as previously stated, these beds may be genetically part of the succession that includes the underlying sandstones of the lower member, the lagoonal sediments being part of a prograding shoreline. Jeletzky (1971, p. 218, 219; 1975, section A1, Fig. 2) visited the same section and concluded that the succession was "predominantly nonmarine", an interpretation not supported by the author's observations, which indicate a marine sucession with some marginal marine deposits near the base of the upper member.

North of section DFA86-21, at section DFA84-27 (Fig. 1), the upper member appears to be entirely marine, and even farther north, at section DFA85-1, in the northermost Ogilvie Mountains (Fig. 1), the upper member is shale-dominant, with some sandstone-rich intervals (Fig. 7). Jeletzky (1975, section D1, Fig. 5) also visited the latter section, but produced a totally different local stratigraphy (see earlier discussion in section "Thickness of the Kamik Formation") and depositional interpretation. The facies associations the author has observed in the Kamik Formation at DFA85-1—an abundance of shale, wave and current ripple laminae, subhorizontal laminae, some hummocky cross-stratification, bioturbation and the presence of foraminifera in the lower part of the succession—indicate marine depositional conditions throughout the Kamik-equivalent succession. The south-to-north facies changes, from the Kandik area to the northern Ogilvie Mountains, are consistent with a more marine setting to the north.

Paleogeographic conditions during deposition of the upper member (middle to late Hauterivian) were similar, in general trends, to those during deposition of the lower member: a southwest trending basin margin extending to the northwestern edge of Eagle Plain and then an apparent switch to a southerly trend through the Ogilvie Mountains (Fig. 35). However, unlike the late Valanginian paleogeography there is no record of a major deltaic source. The examined sections are marine in character, with no record of fluvial or deltaic sediments. This could be a preservational phenomenon rather than reflection of an actual situation. There was a significant transgression at the end of deposition of the lower member, and if there had been a deltaic source area, it could have been located beyond the preservational margins. Another dissimilarity is the increased shaliness of the upper succession. This increased shaliness could be due to one or more situations, such as a reduction in the supply of coarse sediment, or a reflection of a more distal setting from the basin-margin, or more rapid subsidence

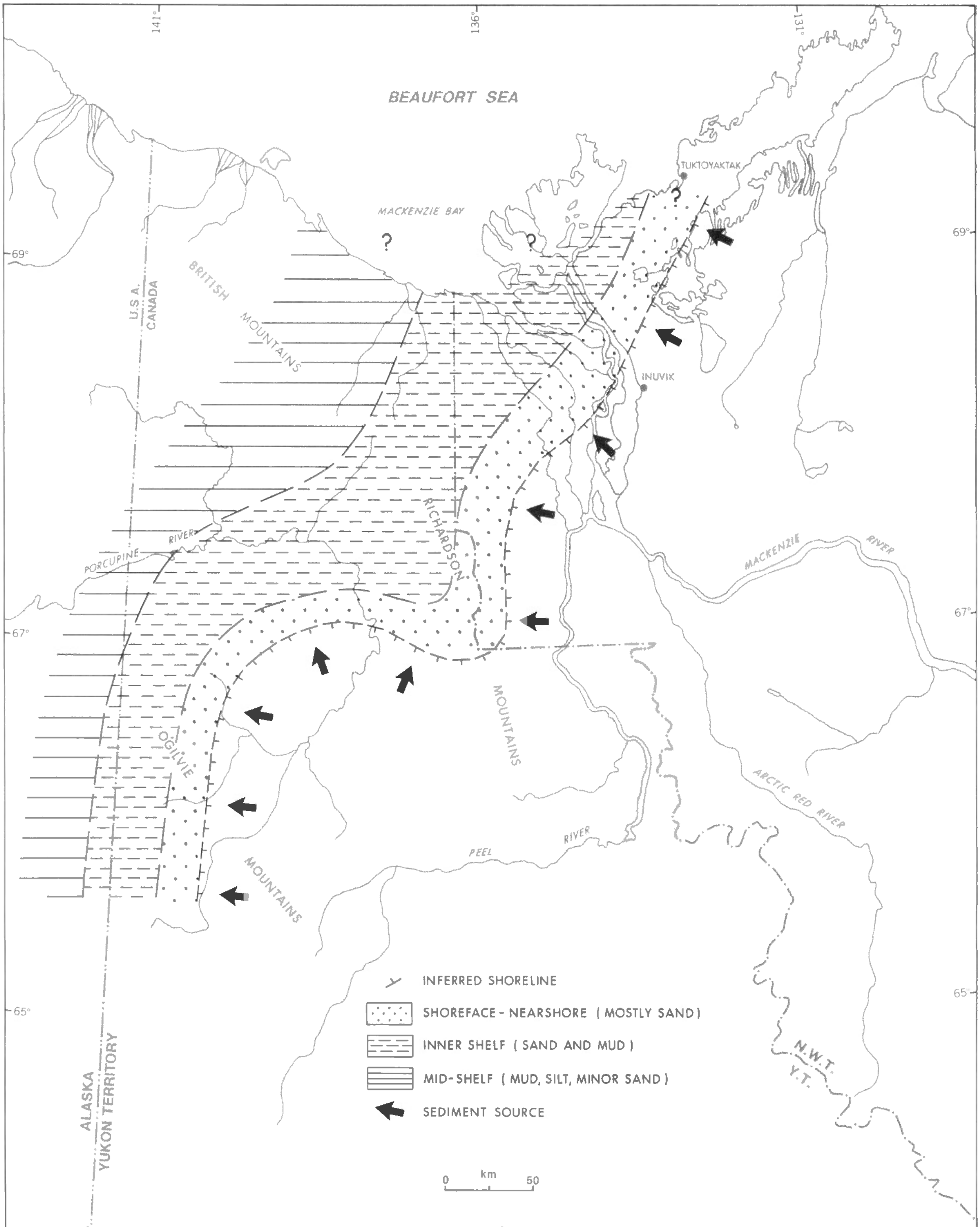

Figure 35. Interpretation of mid-Hauterivian paleogeography (approximate time of deposition of the upper member, Kamik Formation). No palinspastic reconstruction has been attempted to account for Early Cretaceous plate motions and early Tertiary compression.

compared with the lower member. As in the case of the lower member, the marine sandstones are dominated by storm-produced sedimentary structures, such as hummocky cross-stratification and low-angle cross-lamination, in the inner shelf and nearshore successions.

Age

Macrofossils within the Kamik succession are not common. Locally, the lowermost part of the lower member contains bivalves from the *Buchia* sp. aff. *inflata* Zone (Fig. 2; Jeletzky, 1958, 1960, 1961, 1975) that is dated as late early to early late Valanginian. Other bivalves within the Kamik Formation are long-ranging types, such as *Astarte*. Foraminifera can be abundant within Kamik strata, especially in the shale-rich upper member, but tend to consist of long-ranging, non-age-diagnostic forms. Many of the foraminiferal species also occur in either the underlying McGuire Formation or the overlying Mount Goodenough Formation. However, there are a sufficient number of distinct species to make the assemblage useful for local and regional identification of Kamik-equivalent strata (S. Fowler, pers. comm., 1988).

Brideaux and Myhr (1976) included Kamik strata in their dinoflagellate zone IVe in the Parsons N-10 well, which they dated as "Valanginian?-Hauterivian". Palynomorphs and dinoflagellates have been of limited use in much of the outcrop belt because of the high levels of thermal alteration.

The youngest age of the Kamik Formation has to be derived from the age of the immediately overlying Mount Goodenough Formation, which is mostly Barremian, but could be as old as late Hauterivian (Jeletzky, 1958, 1960, 1961). Consequently the age of the Kamik Formation may extend from the mid-Valanginian to late Hauterivian, but may be only as young as mid-Hauterivian.

GENETIC STRATIGRAPHIC/DEPOSITIONAL SEQUENCES IN THE PARSONS GROUP

The Exxon team of Vail and co-workers and their initial publication of the seismic/depositional sequence concept in Memoir 26 of the American Association of Petroleum Geologists (Payton, 1977) spurred a renewed interest in stratigraphy, which has led to a better understanding of basin architecture and controls on sedimentation. Subsequent workers have refined the concept, especially with regards to the internal character of a depositional sequence (see Wilgus et al., 1988). Exxon's work, however, has not been without criticism, and Galloway (1989a) has eloquently expressed some of the concerns and problems. Galloway (op. cit.) also revitalized another approach to genetic stratigraphy, first proposed by Frazier (1974), that of the depositional complex, but which Galloway (op. cit.) renamed a genetic stratigraphic sequence.

Depositional sequences are unconformity bounded successions that record the relative rise and fall of sea level (Mitchum et al., 1977). In clastic successions, sequences result from an initial transgression followed by progradation and regression. The resulting deposits have been subdivided into depositional tracts (Fig. 36; Haq et al., 1987). A number of important depositional and erosional surfaces can be recognised within a depositional sequence, the most important of which are the bounding unconformities. A ravinement surface (Nummendal and Swift, 1987) will form during transgression and generally occurs just above the unconformity, although in some instances it may merge with the unconformity. An abrupt to rapid gradation from transgressive beds into a shale-dominant succession indicates a maximum flooding surface (also called a hiatal surface by Frazier, 1974). Embry and Podruski (1988) pointed out that there may be some submarine erosion associated with the maximum flooding surface, due to bottom-current scouring in an environment of minimal sedimentation. The beds immediately overlying the maximum flooding surface represent the condensed section of the depositional sequence and commonly consist of one, or a combination, of the following facies: silt-poor clay-shale, organic-rich shale, concretion-rich shale, and phosphatic and/or glauconite-rich beds. Above the condensed section are beds deposited during progradation and aggradation. The character of the progradational beds will vary according to basin position and sediment supply. In a simple situation they will consist of a single coarsening-upward succession. However, varying rates of subsidence and sediment supply generally result in a more complex vertical association of facies, and several cycles (parasequences) may be present in some parts of the sequence.

Bounding unconformities generally are more readily recognised at basin margins, but the equivalent conformable surfaces into which they theoretically pass can be difficult, if not impossible, to identify in the rock record. The most readily recognised surface is the maximum flooding surface, which has been used by some authors as the bounding horizon for genetic stratigraphic sequences (e.g., Frazier, 1974; Galloway 1989a, b). Dixon and Dietrich (1988) discussed some of the practical problems associated with trying to identify the various surfaces, especially when using remote sensing tools, such as geophysical logs. Also, it is not uncommon for the unconformity, ravinement and maximum flooding surfaces to merge into one surface, or to be separated by such thin sediment layers that, for practical purposes, they are one feature.

Dixon (1982a, 1986a) divided the Jurassic and Lower Cretaceous succession of the northern Yukon and adjacent Northwest Territories into a number of depositional complexes (sensu Frazier, 1974/genetic stratigraphic sequences, sensu Galloway 1989a), two of which were identified in the Parsons Group: the upper Husky to Martin Creek successions in the lower one, and the McGuire and Kamik in the upper. Subsequent work has refined the original divisions and an additional transgressive event within the Parsons Group has been identified. Although Dixon's original work emphasized the depositional complex approach to genetic stratigraphy, it is possible to apply the depositional sequence concept, with similar results.

The Parsons Group is interpreted as containing three identifiable, basin-wide depositional sequences. The lowest consists of the upper Husky Formation and the overlying Martin Creek Formation; the middle sequence consists of the McGuire Formation and the lower member (for the most part) of the Kamik Formation, and the youngest is essentially the upper member of the Kamik Formation. The bounding unconformity between the middle and upper sequences is entirely interpretational, based on the fact that there appears to have been a transgressive event between the two members. The bounding erosional unconformities at the base of the McGuire Formation and at the top of the Kamik Formation have been well documented and are regional basin-margin erosional events. The bounding unconformity at the base of the oldest sequence is within the uppermost beds of the arenaceous member of the Husky Formation. It is not a major regional erosional event but is recognized as a significant regional transgression.

Martin Creek sedimentation was the culmination of a major prograding sequence that began in the latest Tithonian or earliest Berriasian. This succession consists of the upper member of the Husky Formation (sensu Dixon, 1982a), the red-weathering and upper members of the Husky Formation (sensu Jeletzky, 1967) and the Martin Creek Formation. Sedimentation began with a transgression, which in some areas of the northern Richardson Mountains can be recognized in the uppermost beds of the arenaceous member of the Husky Formation. In these beds there is a locally distinct, crossbedded, coarse grained sandstone that rests abruptly and erosionally on bioturbated, argillaceous to silty sandstone (Fig. 37). These beds are interpreted as transgressive deposits (transgressive systems tract) resting

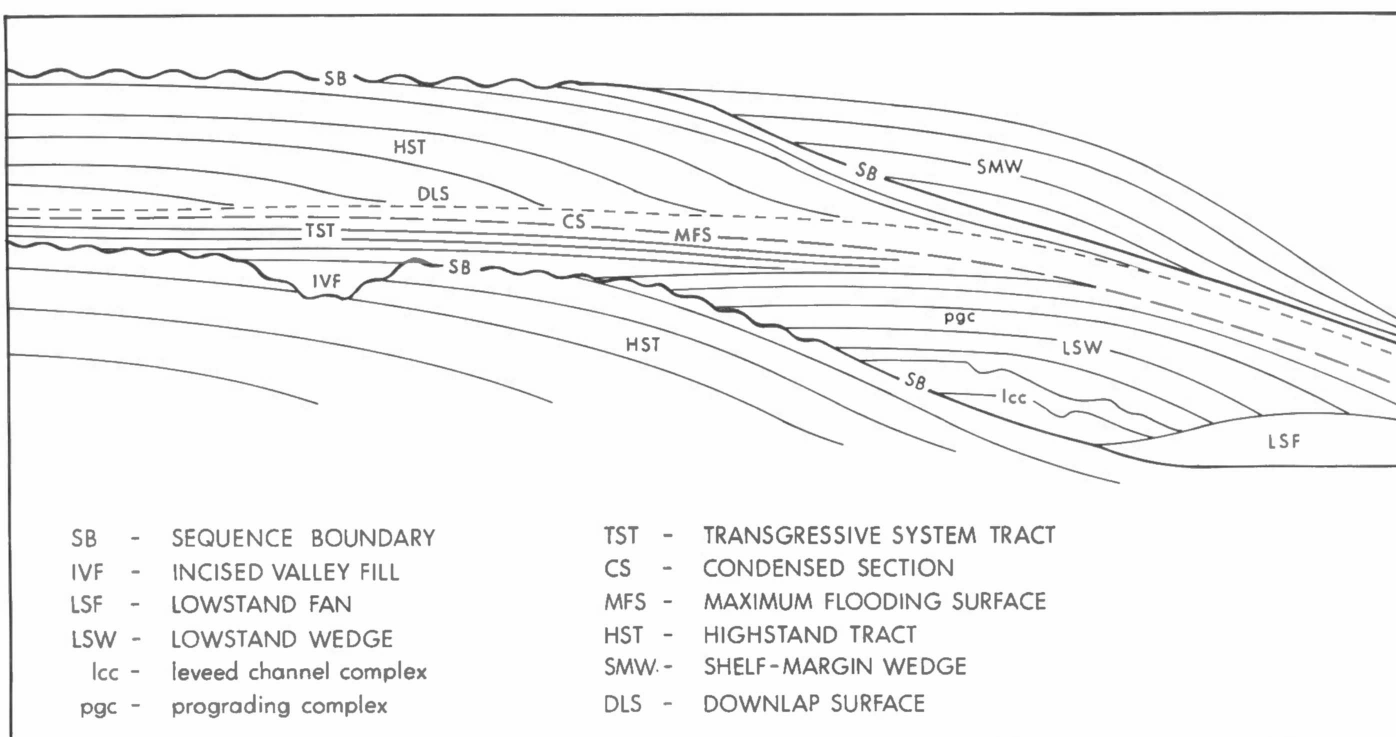

Figure 36. *Theoretical model of depositional sequences (modified after Haq et al., 1987).*

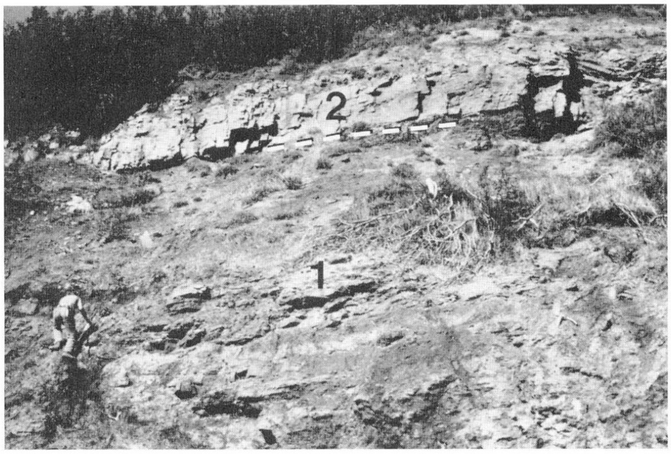

Figure 37. Medium to coarse grained transgressive sandstone beds (2) at the top of the arenaceous member, Husky Formation, erosionally overlying bioturbated, argillaceous to silty sandstones (1) of the same member. "Treeless Creek", northern Richardson Mountains (section DFA82-10). ISPG photograph 1858-2.

on an unconformity. The transgressive beds of the arenaceous member are abruptly overlain by shales (the contact between the arenaceous and red-weathering members being a maximum flooding surface), the lowermost of which are commonly replete in ironstone concretions. These ironstone-rich beds are interpreted as a condensed section, deposited during the time of maximum transgression when the supply of coarse clastic sediment to the offshore areas was minimal. Progradation became the norm after maximum transgression, and is reflected in the upward increase in abundance of coarse clastic beds within the upper Husky Formation, finally culminating in the sandstone-dominant Martin Creek Formation, which is the highstand deposit of the sequence. The presence of several coarsening-upward successions within some sections of the Martin Creek Formation could reflect either local parasequences or some subtle basin-wide control on relative sea level changes. The latter is difficult to prove because the cycles have not been correlated throughout the basin.

A major unconformity separates Martin Creek from McGuire strata at the basin margins, but basinward the surface that separates the formations appears to be a maximum flooding surface with no obvious erosional event within the uppermost Martin Creek beds. This poses a major problem when applying the depositional sequence concept, because the conformable sequence boundary cannot be identified with any degree of certainty. The difficulty in identifying the correlative conformable surface makes it almost impossible to identify a shelf margin wedge or transgressive systems tract within the upper Martin Creek or lower McGuire formations. Also, there are no distinct facies that can be used to distinguish between the highstand deposits and those of the shelf-margin wedge or transgressive beds. In a core from the Parsons N-10 (core 3) well (Fig. 1), the unconformity surface, transgressive beds and maximum flooding surface are closely juxtaposed. The unconformity is a pyritized erosional surface overlain by a thin (a few cm) pebble-lag layer, interpreted as the transgressive beds. The pebble layer is abruptly overlain by silty, bioturbated shale. A condensed section above the pebble lag does not appear to be well developed in the McGuire Formation at Parson N-10, possibly because it was close to the paleoshoreline.

The bounding unconformities of the lower sequence do not appear to have resulted in lowstand fan or wedge deposits within the adjacent basinal succession (Kingak Formation); therefore, according to the sequence concept, shelf-margin wedges must have been deposited. If this were the case, then deposits of the shelf-margin wedge associated with the lower bounding unconformity must be in part of the upper Porcupine River Formation (Jeletzky, 1977), and those of the upper bounding unconformity in the upper part of the Martin Creek Formation. However, as previously mentioned, such deposits are difficult to identify and separate from the highstand deposits.

The middle sequence, consisting of the McGuire Formation and the lower member of the Kamik Formation, has a major, basin-margin erosional unconformity at is base, but even in areas where there is significant erosion, no strata can be identified as part of a transgressive systems tract. The apparent absence of significant transgressive beds could reflect a rapid transgression and a low supply of sediment. No major erosional truncation can be documented at the upper bounding unconformity. In fact, the presence of an unconformity is based on the identification of a basin-wide transgression at the top of the lower member of the Kamik Formation, evident in the change from deltaic to marine and marginal marine sedimentation under Mackenzie Delta and the prominent lithological change from sandstone to an abruptly overlying shale in the British Mountains. The horizon at which the lithological changes occur is identified as a maximum flooding surface, therefore the bounding sequence unconformity or equivalent conformity must underlie the flooding surface. In Figure 13 the upper bounding unconformity is interpreted; nowhere has it been positively identified. Within the uppermost sequence there are many coarsening-upward cycles that, for the present, are interpreted as parasequences. The upper bounding unconformity is a readily recognized basin-margin erosional event. In more basinward positions, the contact between the Kamik Formation and overlying Mount Goodenough Formation probably represents a maximum flooding surface, and the basinward equivalent of the basin margin unconformity is not apparent in the underlying Kamik Formation.

The upper Tithonian/lower Berriasian unconformity does not appear to be associated with any tectonism. Haq et al. (1987, Fig. 3) have indicated that there was a "global" sea level fall at about the same time, the inference being that the unconformity was the result of a eustatic event. On the other hand, the unconformity at the base of the McGuire is associated with a tectonic event and on and adjacent to tectonic highs, such as the Rat Uplift, is much exaggerated. Haq et al. (op. cit.) record a eustatic sea level fall at about the end of Berriasian/early Valanginian, approximately the same time the pre-McGuire unconformity developed. The inferred unconformity between the middle and upper sequence is poorly dated, but based on relative position may have occurred at the end of the Valanginian, beginning of the Hauterivian or within the early Hauterivian. No obvious tectonism is associated with this event. Haq et al. (op. cit.) indicate several sea level falls within the late Valanginian and early Hauterivian, the most prominent being at 126 Ma, within the late Valanginian. Any of the events recognized by Haq et al. (op. cit.) could correlate with the unconformity in the Parsons succession. A lack of biostratigraphic precision precludes any accurate correlation. The youngest unconformity at the top of the Parsons Group is a major erosional event associated with tectonism. It is dated as late Hauterivian and could correspond to the unconformity identified by Haq et al. (op. cit.) at 116 Ma.

Several conclusions can be garnered from this brief discussion of depositional sequences in the Parsons Group and adjacent formations. First, the depositional sequences can be recognized, for the most part, although some problems of identifying some unconformities and their equivalent conformities are apparent. Second, the sequences cannot be directly correlated to Haq et al.'s (1987, Fig. 3) Cretaceous cycles, because of a lack of biostratigraphic precision. Approximate "fits" to Haq et al.'s data can be attempted but this is not a true test of the global attribute that Haq et al. believe led to the formation of depositional sequences. Third, the most recognizable surface in marine successions is the maximum flooding surface, which, as Frazier (1974) and Galloway (1989a) have emphasized, generally is a more practical mapping surface than the unconformities and their equivalent conformities. Finally, of the four sequence boundaries associated with the Parsons succession, two strongly reflect tectonic activity.

TECTONICS AND SEDIMENTATION

The northern Yukon and adjacent Northwest Territories are part of the North American craton, and contain no exotic, or far-travelled, terranes. During the Jurassic and Early Cretaceous the area was under the influence of extensional tectonics (Dixon, in press b) related to the opening of what was to become Canada Basin. The extensional regime is readily seen in reflection seismic across the Eskimo Lakes Fault Zone (Fig. 3), an area unaffected by younger compressional overprint (Cook et al., 1987a, b). Normal faults along the northwestern margin of the Eskimo Lakes Arch (part of the Aklavik Arch Complex: Yorath and Norris, 1975) separate relatively thin Neocomian sediments on the arch from the thicker succession in the adjacent troughs and depressions (Fig. 38). Outboard from the arch complex are a few smaller tectonic uplifts, such as the Cache Creek Uplift and Tununuk High (Figs. 3, 38), which also were active during the Early Cretaceous. The northeastern part of the Aklavik Arch Complex (Eskimo Lakes Arch, Figs. 3, 38) became the faulted continental margin when Canada Basin opened. Along the Eskimo Lakes Arch the extensional faults appear to have been reactivated older "layering" within the Proterozoic succession (Cook et al., 1987a, b).

Depositional thinning toward the structural highs, the common merging of unconformities on the highs, and local thinning and truncation within fault blocks strongly indicate that there was syndepositional growth along major fault zones during deposition of the Parsons Group. The most important unconformity associated with the Parsons Group is at the top of the succession, between the Kamik and overlying Mount Goodenough formations. This erosional event proceeded as the major structural highs were uplifted, probably acting as local sources of sediment to the adjacent structural/depositional depressions.

A feature that has not been well documented in the past, and which is related to the development of the pre-Mount Goodenough unconformity, is the northward truncation of Hauterivian and Jurassic strata in the British Mountains. Although it could be assumed that the continuation of the northern Alaska Barrow Arch (Grantz et al., 1979) into northern Yukon is expressed as the Romanzof Uplift (Fig. 3), evidence for such a correlation has not been convincing to date. The Barrow Arch has its strongest expression in Jurassic and Lower Cretaceous strata, which thin and are truncated northward onto the arch (Bird, 1985). These types of relationships are not as apparent in the British Mountains in Jurassic to lower Hauterivian strata. Furthermore, the Romanzof Uplift, as presently expressed, is a result of

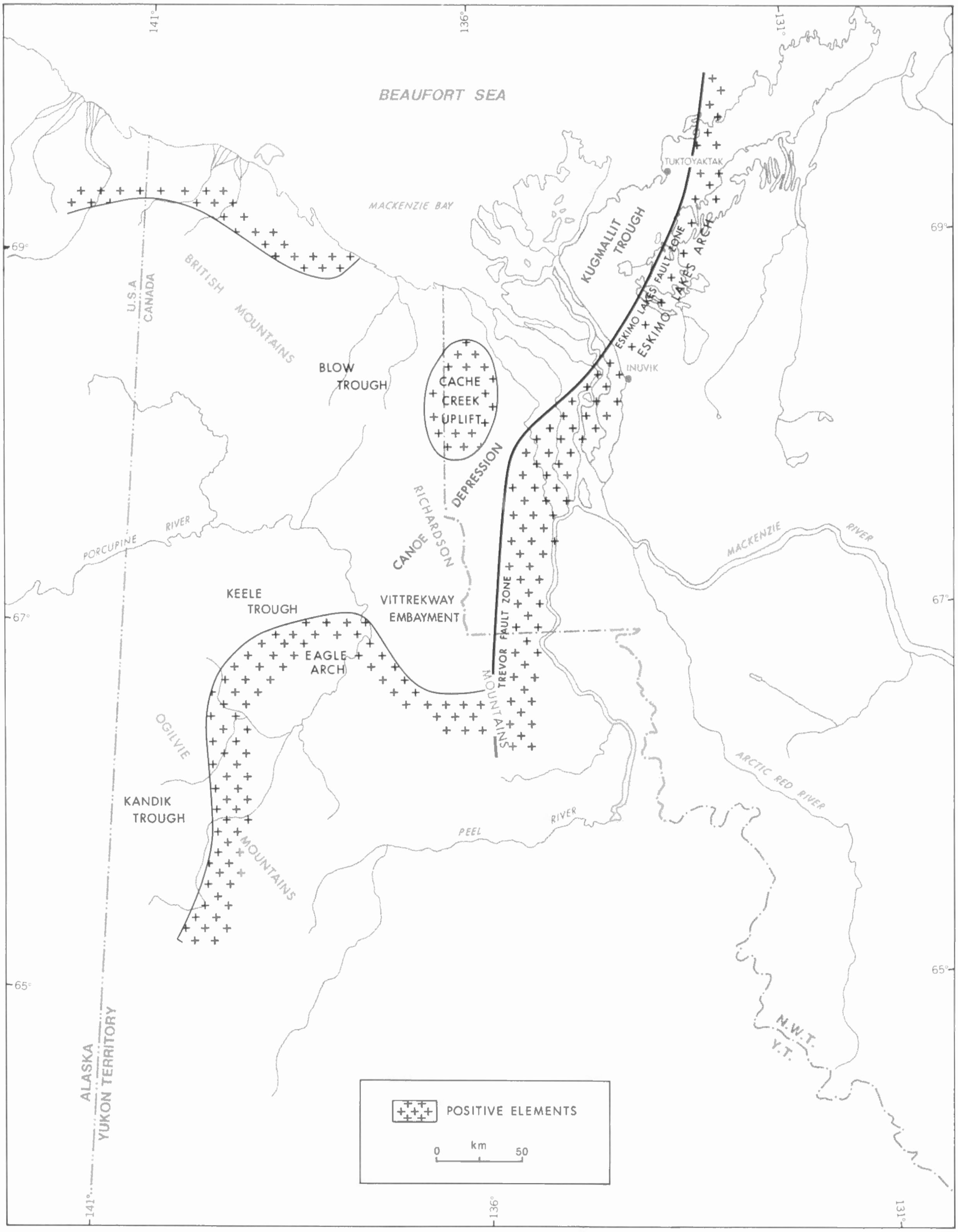

Figure 38. *Neocomian tectonic elements, expressed as relative highs and lows, and based on depositional and erosional thinning/thickening trends (modified after Young et al., 1976, Figure 2).*

Tertiary deformation and uplift, although it has had a long history of previous activity, especially in the late Paleozoic. It is not until the late Hauterivian that a northward truncation of pre-Mount Goodenough strata occurred, indicating a northern uplifted element. This northward truncation is the only evidence for a northern uplift during the Hauterivian that could be compared to the Barrow Arch. A similar stratigraphic setting is seen in the adjacent northeastern Brooks Range, where the Barremian Kemik Formation and Pebble Shale rest on progressively older strata from south to north (Molenaar et al., 1987; Mull, 1987). However, the relatively thin Kemik sandstone and its limited distribution suggest that the uplift was not a major source of clastic sediment. The uplift apparently was not long-lived, because the basal sandstone is overlain by thick, Barremian marine shales, indicating that it was rapidly inundated.

During deposition of the Parsons Group the dominant sediment source terrane was to the east and southeast, from the cratonic areas underlain by Paleozoic and Proterozoic sediments. The cratonic source is also reflected in the general composition of the sandstones, which are dominated by quartz arenites. The composition indicates a mature source terrane and the probable presence of multicyclic grains. No direct influence of Cordilleran tectonics can be documented for the Neocomian, such as the presence of texturally and mineralogically immature sediments, or the formation of foreland basins.

A number of authors have suggested that Canada Basin originated as a result of the southward movement of an Alaskan "microplate" along a strike-slip fault system that paralleled the continental margin of the Arctic Islands and continued into northern Yukon through what is now the Rapid Depression and the Keele Block, to join the Kaltag Fault in Alaska (e.g., Hubbard et al., 1987). There are a number of premises in this reconstruction that do not stand scrutiny. First, there is no evidence to support a strike-slip fault boundary along the continental margin of the Arctic Islands and offshore Tuktoyaktuk Peninsula. In fact, the evidence strongly favours a normal extensional margin (Cook et al., 1987a, b; Dietrich et al., 1989). Second, the continuation of the Alaskan Kaltag Fault into northern Yukon, as a discrete fault, or narrow fault zone, is not well established. Although Norris (1981a, c) has mapped the Kaltag Fault into northern Yukon, it is mapped principally as an uncertain and poorly constrained fault trace, with areas between control points masked by Quaternary sediments. A similar situation is apparent in the Yukon Flats of Alaska, through which the Kaltag Fault would have to be mapped to link it with Yukon geology. Also, the named Kaltag Fault occurs in northern Yukon within a very broad zone of folding and faulting, part of which is known as the Rapid Fault Array (Yorath and Norris, 1975). Most of the faults are thrusts or oblique-slip faults (Lane, 1988), associated with compressional folds. Finally, the strike-slip model requires that northern Alaska and northwestern Yukon be displaced hundreds of kilometres northeast of their present positions during the Jurassic and Early Cretaceous. This seems highly unlikely because it would require displacement of Jurassic and Lower Cretaceous stratigraphic units that are contiguous across the presumed strike-slip zone, especially the Kamik Formation. The continuity of stratigraphic units across the Rapid Fault Array and the lack of structural or stratigraphic evidence for substantial strike-slip motion indicate that any plate tectonic model for the opening of Canada Basin has to account for these constraints and not displace northern Alaska from northern Yukon by any large amounts.

ECONOMIC GEOLOGY

The Parsons Group has no known mineral showings and only a few thin coal beds at Lower Canyon, Willow River and in parts of the Ogilvie Mountains. Consequently, its economic mineral and coal potential must be considered minimal. Several oil and gas discoveries under Mackenzie Delta and the southeastern and central Tuktoyaktuk Peninsula indicate good reservoir potential for Parsons sandstones. These discoveries include the large Parsons Gas Field, with reserves in the order of 51.7 x $10^9 m^3$ of gas, and the oil discoveries at Kugpik O-13, Kamik D-48 and Tuk L-09 (Fig. 1).

Although the source for the gas has not been positively identified using geochemical methods, Langhus (1980) suggested that the Husky Formation was a probable source. Husky strata are dominated by terrestrial-type organic matter, a typical source material for gas. Thermal maturation levels in the Husky vary according to its present burial depths (Dixon et al., 1985, Fig. 49A), but are mature in the Kugmallit Trough (Fig. 3) adjacent to the Parsons Lake structure. Potential oil source rocks in the Mackenzie Delta area are present in shales of the Albian Arctic Red Formation and Upper Cretaceous Boundary Creek and Smoking Hills formations (Snowdon and Powell, 1979; Snowdon, 1980, Dixon et al., 1985). The oil trapped in Tuk L-09 and Kugpik O-13 appears to have been derived from the Upper Cretaceous shales (Snowdon and Powell, 1979; Snowdon, pers. comm. 1989). The oil in Kamik D-48 appears to have been derived from the same rock(s) as the condensates found in the Parsons Gas Field (Snowdon, *in* Dixon et al., 1985, p. 56) but no source rock has been identified to date.

The subsurface occurrence of Parsons strata in the southern Mackenzie Delta and Tuktoyaktuk Peninsula constitutes the most promising exploration area. In this area the geological conditions favourable to hydrocarbon generation and trapping are optimal. There are a number of identified or potential source rocks in the Jurassic to Upper Cretaceous succession that are thermally immature to mature, with only the most deeply buried parts of the Kugmallit Trough attaining overmature status. The area has been subjected to Jurassic and Early Cretaceous extensional faulting resulting in associated roll-over anticlines, and has not been overprinted by Tertiary deformation to any substantial degree. Porosity in the Parsons sandstones has been maintained by secondary porosity formation and values up to 25 per cent have been recorded, although 10 to 15 per cent is more normal.

Although the Tuktoyaktuk Peninsula and southern Mackenzie Delta are the most promising exploration areas, there are some aspects of the geology that limit the area of exploration. The most important limiting attribute is the truncation of Kamik strata by several unconformities, the most important of which is one at the base of the Mount Goodenough Formation. A second truncation level that has affected the distribution of Parsons strata is a late Albian to early Cenomanian unconformity. The erosion that produced these two unconformities, in association with Jurassic to Albian

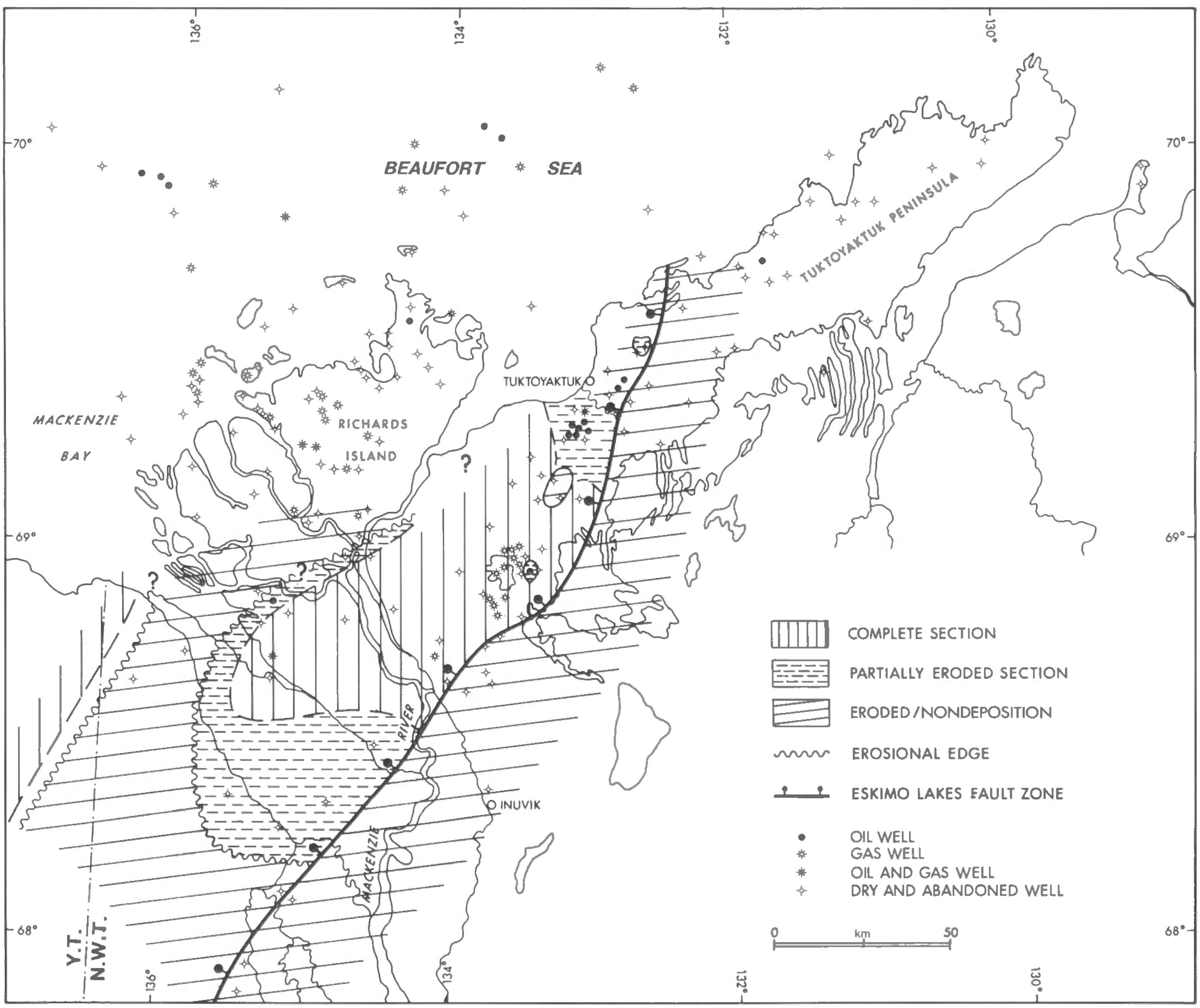

Figure 39. Distribution of the Parsons Group in the subsurface of Mackenzie Delta and Tuktoyaktuk Peninsula.

faulting, has removed much of the Parsons Group and younger strata from the Eskimo Lakes Arch, Tununuk High and Cache Creek Uplift (Figs. 3, 39). Partial sections of Parsons strata are present on the flanks of these uplifts (Fig. 39). Interpretation of a deep-reflection seimic line that extends from near the southwestern end of Sitidgi Lake northwestward to the outer Mackenzie Delta, suggests that Parsons strata are truncated northward, under the Mount Goodenough Formation, and are unlikely to occur under Richards Island (Cook et al., 1987b). Perhaps this interpretation can be extrapolated to areas under Kugmallit Bay (Fig. 1).

West of the Richardson Mountains and in the Ogilvie Mountains, the Parsons Group is less prospective. Thermal maturation of potential source rocks is very high, with vitrinite relectance values in Lower Cretaceous strata in the Blow River E-47, Roland Bay L-41 and Spring River N-58 wells (Fig. 1) indicating overmature levels near the surface (Majorowicz and Dietrich, 1989). The high levels of thermal alteration of palynomorphs recovered from Parsons strata in the Ogilvie and British mountains indicate that these sediments are organically mature to overmature. A second detracting feature is the ubiquitous silica cementation in Parsons strata of the Richardson, British and Ogilvie mountains, which reduces porosity to very low values. Finally, early Tertiary deformation has overprinted older structures, which could have breached pre-existing traps. New traps could have formed, but the high thermal maturation levels suggest that any oil or gas production from Jurassic and Lower Cretaceous strata probably occurred prior to Tertiary deformation.

CONCLUSIONS

The Berriasian to Hauterivian Parsons Group contains three formations, which are, from base to top: the Martin Creek, McGuire and Kamik. The Martin Creek and Kamik formations are characterized by the prevalence of sandstone, although shale interbeds are commonly present. The McGuire Formation is mostly shale with subordinate amounts of sandstone. The preserved record indicates that all three formations contain mostly marine, shoreline to shelf strata. A local nonmarine, probably deltaic component in the lower member of the Kamik Formation is present in the south Mackenzie Delta and Tuktoyaktuk Peninsula areas. Low-angle crosslaminae, hummocky cross-stratification and bioturbation are the prevalent preserved structures in marine sandstones of the three formations.

Parsons Group strata comprise three depositional sequences. The oldest sequence consists of the upper beds of the Husky Formation and the Martin Creek Formation. McGuire strata and the lower member of the Kamik Formation make up the middle sequence, and strata of the upper member of the Kamik Formation compose the third and youngest sequence. Two of the bounding unconformities are associated with regional tectonism and uplift of local tectonic elements; these are the unconformities at the base of the McGuire and Mount Goodenough formations. The other two bounding unconformities appear to be associated with regional transgressive events with no obvious associated tectonic activity. Correlation with specific "global" unconformities identified by Haq et al. (1987) is difficult because of a lack of biostratigraphic precision, although there are a number of possible correlative events.

Parsons Group strata were deposited during a time of extensional tectonics prior to the formation of Canada Basin. Evidence of strike-slip activity during the Neocomian, such as that required by a number of plate tectonic models, is lacking, and the continuity of stratigraphy across the Rapid Fault Array negates any major Neocomian or younger strike-slip motion in this area.

Gas and oil have been recovered from Parsons strata under Mackenzie Delta and the southwestern end of Tuktoyaktuk Peninsula, making the succession a prospective exploration target.

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APPENDIX 1

Locations of measured sections (examined by J. Dixon)

The letters DFA are Dixon's unique Geological Survey of Canada code, followed by the year the section was measured (e.g., DFA82), in turn followed by the section number (e.g., DFA82-2; sections re-examined in later years still retain the original designation). Samples collected from a section are given a third number (e.g., DFA82-2-3). Cataloguing of samples in the Geological Survey involves assigning a curation number ("C" number; see Figures 6 and 7 for examples). Full descriptions of the field sections are in Dixon's field notes and are available for viewing at the Institute of Sedimentary and Petroleum Geology, Calgary.

Section locations are more accurately plotted using UTM grid values; the curvatures of the lines of latitude and longitude may introduce errors.

1. DFA81-1. Martin Creek, Richardson Mountains, NWT
   NTS 107 B/4 (1:50 000); UTM grid ML759652
   Latitude: 68°11′56″N Longitude: 135°34′58″W
   Strata examined: Martin Creek, McGuire and Kamik (lower member) formations

2. DFA81-2. Martin Creek, Richardson Mountains, NWT
   NTS 107 B/4 (1:50 000); UTM grid ML753657
   Latitude: 68°12′13″N Longitude: 135°35′52″W
   Strata examined: Husky and Martin Creek formations

3. DFA8-3. "Grizzly Gorge", Richardson Mountains, NWT
   NTS 107 B/5W (1:50 000); UTM grid ML701738
   Latitude: 68°16′40″N Longitude: 135°43′13″W
   Strata examined: Martin Creek and McGuire formations, lowermost beds of the Kamik Formation and basal beds of the Mount Goodenough Formation

4. DFA81-4. "Grizzly Gorge", Richardson Mountains, NWT
   NTS 107 B/5W (1:50 000); UTM grid ML734704
   Latitude: 68°16′4″N Longitude: 135°42′38″W
   Strata examined: Martin Creek, McGuire, Kamik and Mount Goodenough formations

5. DFA82-1. South side of Dempster Highway, west of Fort McPherson, NWT
   NTS 106 M (1:250 000); UTM grid MK6952
   Latitude: 67°11′N Longitude: 135°43′W
   Strata examined: mapped by Norris (1981e) as North Branch Formation but probably Kamik Formation

6. DFA8-2. Roadside quarry on Dempster Highway, east of Fort McPherson, NWT
   NTS 106 M (1:250 000); UTM grid MK6452
   Latitude: 67°11′30″N Longitude: 135°49′W
   Strata examined: mapped as North Branch Formation by Norris (1981e) but probably Kamik Formation

7. DFA82-4. Lower Canyon, Willow River, Richardson Mountains, NWT (revisited 1988 and 1989)
   NTS 107 B (1:250 000); UTM grid ML8266
   Latitude: 68°12′N Longitude: 135°26′W
   Strata examined: Kamik Formation

8. DFA82-5. Headwaters of Sheep Creek, on the YT-NWT boundary, Richardson Mountains
   NTS 116 P (1:250 000); UTM grid MK4898
   Latitude: 67°36′N Longitude: 136°13′30″W
   Strata examined: Husky, McGuire and Kamik formations

9. DFA82-6. Approximately 4 km south of Anne Creek and 2 km east of trigonometric point 4728 ft. (1441 m), Richardson Mountains, YT
   NTS 116 P (1:250 000); UTM grid ML1322
   Latitude: 67°48′N Longitude: 137°3′W
   Strata examined: Martin Creek, McGuire and Kamik formations

10. DFA82-7. Mount Sittichinli, Richardson Mountains, YT-NWT boundary
    NTS 116 P (1:250 000); UTM grid MK4650
    Latitude: 67°10′N Longitude: 136°14′W
    Strata examined: North Branch, Husky, McGuire and Kamik formations

11. DFA82-8. 4 km NNE of Mount McGuire, Richardson Mountains, YT
NTS 116 P (1:250 000); UTM grid ML0341
Latitude: 67°58′N Longitude: 137°20′W
Strata examined: Husky, McGuire and Kamik formations

12. DFA82-9. La Chute River, Richardson Mountains, YT
NTS 116 P (1:250 000); UTM grid MK4172
Latitude: 67°21′30″N Longitude: 136°22′W
Strata examined: Kamik Formation

13. DFA82-11. 7.5 km ESE of Symmetry Mountain, Richardson Mountains, NWT
NTS 116 P (1:250 000); UTM grid ML5708
Latitude: 67°41′N Longitude: 136°3′W
Strata examined: Permian, Husky, McGuire and Kamik formations

14. DFA82-12. Approximately 2 km north of the Dempster Highway at the YT-NWT boundary
NTS 116 P (1:250 000); UTM grid MK4741
Latitude: 67°4′30″N Longitude: 136°13′W
Strata examined: Kamik Formation

15. DFA83-1. 3 km NNE of Bonnet Lake, YT
NTS 117 A (1:250 000); UTM grid LL8169
Latitude: 68°13′10″N Longitude: 137°51′30″W
Strata examined: Martin Creek Formation

16. DFA83-2 and 2A. 16 km east of Bonnet Lake, YT
NTS 117 A (1:250 000); UTM grid LL9766 and 9865
Latitude: 68°11′30″N Longitude: 137°29′W
Strata examined: McGuire and Kamik formations

17. DFA83-2B. 17 km east of Bonnet Lake, YT
NTS 117 A (1:250 000); UTM grid LL9867
Latitude: 68°12′30″N Longitude: 137°26′W
Strata examined: Kamik and Mount Goodenough formations

18. DFA83-4. Prominent valley cut through the west end of Canoe Syncline, Barn Mountains, YT
NTS 117 A (1:250 000); UTM grid EG7807
Latitude: 68°34′N Longitude: 139°3′W
Strata examined: (?)McGuire/Kingak and Kamik formations

19. DFA83-5. Philip Creek (tributary of Babbage River), YT (revisited in 1987)
NTS 117 A (1:250 000); UTM grid EG9244
Latitude: 68°53′30″N Longitude: 138°40′W
Strata examined: Kingak, Kamik and Mount Goodenough formations

20. DFA83-6. North limb of Canoe Syncline, Barn Mountains, YT (revisited in 1987)
NTS 117 A (1:250 000); UTM grid EG9305
Latitude: 68°32′30″N Longitude: 138°45′W
Strata examined: Martin Creek, McGuire and Kamik formations

21. DFA83-7. Trail River, YT
NTS 117 A (1:250 000); UTM grid EG8851
Latitude: 68°56′30″N Longitude: 138°47′W
Strata examined: Kamik Formation

22. DFA83-8. Headwaters of Timber Creek, YT
NTS 117 B (1:250 000); UTM grid EG2708
Latitude: 68°35′10″N Longitude: 140°21′W
Strata examined: probably Kamik Formation

23. DFA83-9. Trail River, YT
NTS 117 A (1:250 000); UTM grid EG8952
Latitude: 68°57′30″N Longitude: 138°46′W
Strata examined: Kamik Formation

24. DFA83-11. Anker Creek, YT (revisited 1988)
NTS 117 A (1:250 000); UTM grid FG1316
Latitude: 68°37′30″N Longitude: 138°12′W
Strata examined: McGuire/Kingak and Kamik formations thrust over Albian Flysch

25. DFA83-12. 6 km NNE of Flask Lake, 20 km NW of Bonnet Lake, YT
NTS 117 A (1:250 000); UTM grid FF1482
Latitude: 68°19′30″N Longitude: 138°15′W
Strata examined: probably Martin Creek Formation

26. DFA84-7. Fish River, YT
NTS 117 A (1:250 000); UTM grid ML3792
Latitude: 68°26′30″N Longitude: 136°32′W
Strata examined: Martin Creek Formation unconformably overlain by Mount Goodenough Formation

27. DFA84-25. 7 km NW of Mount Bragg, northern Ogilvie Mountains, YT (same section as F14 on Norris' GSC map 1526A; revisited in 1986)
NTS 116 G and 116 F (east half) (1:250 000); UTM grid EC2588
Latitude: 65°43′30″W Longitude: 140°25′W
Strata examined: Permian, possibly Triassic, Kingak and Kamik formations

28. DFA84-26. 11 km east of Mount Tagish Charlie, northern Ogilvie Mountains, YT
NTS 116 G and 116 F (east half) (1:250 000); UTM grid ED4408
Latitude: 65°54′N Longitude: 140°2′30″W

Strata examined: mapped by Norris (1982) as Rat River Formation but probably Kamik Formation

29. DFA84-27. 11 km NNW of Mount Tagish Charlie, north of Fishing Creek, north Ogilvie Mountains, YT (revisited in 1986)
NTS 116 G and 116 F (east half) (1:250 000); UTM grid ED5218
Latitude: 65°59′W Longitude: 139°50′W
Strata examined: Permian, possibly Triassic, Kingak, Martin Creek, McGuire and Kamik formations

30. DFA84-28. 3 km west of Mount Tagish Charlie, northern Ogilvie Mountain, YT
NTS 116 G and 116 F (east half) (1:250 000); UTM grid ED5108
Latitude: 65°53′N Longitude: 140°53′W
Strata examined: Kamik Formation

31. DFA85-1. Headwaters of Bluefish River, Keele Range, YT
NTS 116 O and 116 N (east half) (1:250 000); UTM grid EE4733
Latitude: 67°1′10″N Longitude: 139°54′W
Strata examined: Kamik Formation

32. DFA85-17. East of Salmon Fork River, 1.5 km NNW of trigonometric point 4841 ft. (1476 m), northern Ogilvie Mountains, YT
NTS 116 J and 116 K (east half) (1:250 000); UTM grid ED3473
Latitude: 66°29′N Longitude: 140°12′W
Strata examined: Porcupine River, Husky, Martin Creek, McGurie and Kamik formations

33. DFA85-20. 20A and 20B. Headwaters Salmon Fork River and of a northern branch of Fishing Branch River, Keele Range, YT
NTS 116 J and 116 K (east half) (1:250 000); UTM grid EE5322 (#20); EE5716 (#20A); and EE5413 (#20B)
Latitude: the three sites are located between 66°50′10″N and 66°54′30″N
Longitude: the three sites are located between 139°42′10″W and 139°47′30″W
Strata examined: mapped by Norris (1981f) as Rat River Formation but probably Kamik Formation

34. DFA85-21. Headwaters of Salmon Fork River, Keele Range, YT
NTS 116 J and 116 K (east half) (1:250 000); UTM grid EE4615
Latitude: 66°51′N Longitude: 139°54′W
Strata examined: Porcupine River, Husky, Martin Creek, McGuire and Kamik formations

35. DFA85-23. Southern tributary of Beaverhouse Creek, Richardson Mountains, NWT
NTS 107 B (1:250 000); UTM grid ML7583
Latitude: 68°21′45″N Longitude: 135°35′W
Strata examined: mapped as Rat River Formation by Norris (1981b) but probably Kamik Formation

36. DFA86-1. 6 km NE of Mallard wellsite, headwaters of Fishing Creek, northern Ogilvie Mountains, YT
NTS 116 G and 116 F (east half) (1:250 000); UTM grid ED3801
Latitude: 65°49′40″N Longitude: 140°10′30″W
Strata examined: Kamik Formation

37. DFA86-2. Ridge between Jungle and Ettrain creeks, northern Ogilvie Mountains, YT.
NTS 116 F and 116 G (east half) (1:250 000); UTM grid EC1252
Latitude: 65°23′30″N Longitude: 140°44′W
Strata examined: mapped as Kathul Formation by Norris (1982) but probably Kamik Formation

38. DFA86-5. 6.5 km west of Mount Osborne, northern Ogilvie Mountains, YT
NTS 116 G and 116 F (east half) (1:250 000); UTM grid EC0289
Latitude: 65°43′30″N Longitude: 140°14′W
Strata examined: Kamik Formation

39. DFA86-21. Headwaters of Orange Creek, northern Ogilvie Mountains, YT
NTS 116 G and 116 F (east half) (1:250 000); UTM grid ED2900
Latitude: 65°49′30″N Longitude: 140°21′W
Strata examined: Permian, possibly Triassic, McGuire/Kingak and Kamik formations

40. DFA87-1. Babbage River, British Mountains, YT
NTS 117 A (1:250 000); UTM grid EG8833
Latitude: 68°47′30″N Longitude: 138°47′W
Strata examined: Kingak and Kamik formations

41. DFA87-14. 4 km NNE of Flask Lake and 1.5 km south of section DFA85-12, YT
NTS 117 A (1:250 000); UTM grid FF1480
Latitude: 68°19′N Longitude: 138°16′W
Strata examined: (?)Husky, McGuire and Kamik formations

42. DFA87-20. "Grizzly Gorge", Richardson Mountains, NWT
NTS 107 B (1:250 000); UTM grid ML7173
Latitude: 68°16′10″N Longitude: 135°44′W
Strata examined: McGuire, Kamik and Mount Goodenough formations

43. DFA87-21A. Near Cache Creek, Richardson Mountains, NWT
NTS 107 B (1:250 000); UTM grid ML7097
Latitude: 68°29′30″N Longitude: 135°44′W
Strata examined: possibly Kamik Formation

44. DFA88-6. 2 km SE of Sleepy Mountain, Barn Mountains, YT
NTS 117 A (1:250 000); UTM grid FG1219
Latitude: 68°42′40″N Longitude: 138°17′W
Strata examined: Kingak and Kamik formations

45. DFA88-7. Babbage River (ridge immediately west of end of section 87-1), British Mountains, YT
NTS 117 A (1:250 000); UTM grid EG8733
Latitude: 68°47′N Longitude: 138°50′W
Strata examined: Kamik Formation

46. DFA88-15. 18 km east of Bonnet Lake and about 2 km north of section 83-2B, Richardson Mountains, YT
NTS 117 A (1:250 000); UTM grid LL9869
Latitude: 68°13′30″N Longitude: 137°27″W
Strata examined: Husky, Martin Creek, McGuire and Kamik formations

47. DFA89-3. "Grizzly Gorge", northwestern Richardson Mountains, NWT
NTS 107 B/5W (1:250 000); UTM grid ML718728
Latitude: 68°16′30″N Longitude: 135°41′W

APPENDIX 2

Wells containing Parson Group strata, and list of cored intervals

Well name	Formations	Log depths	
		feet	metres
Aklavik A-37	*Kamik*	3000	914.4
	McGuire	3169	965.9
	Martin Creek	3268	996.1
	Husky	3612	1100.9
Aklavik F-38	*Kamik*	3916	1193.6
	McGuire	4010	1222.2
	Martin Creek	4056	1236.3
	Husky	4193	1278.9
Atertak L-31	*Martin Creek*		2815.0
	Husky		2886.0
Atigi G-04	*Kamik*	9208	2806.6
(ex-East	*McGuire*	10634	3241.2
Reindeer G-04)	*Martin Creek*	10708	3263.8
	Husky	11054	3369.3
Core 4: 9580-9611 ft. (2920-2929.4 m), *Kamik Fm.*			
Core 5: 9615-9647 ft. (2930.7-2940.4 m), *Kamik Fm.*			
Beaverhouse	*Kamik*	1160	353.6
Creek H-13	*McGuire*	1323	403.3
	Martin Creek	1420	432.8
	Husky	1650	502.9
Ikhil A-01	*Kamik*	6824	2080.0
(ex-East	*McGuire*	8220	2505.5
Reindeer A-01)	*Martin Creek*	8300	2529.8
	Husky	8425	2567.9
Core 1: 7544-7579 ft. (2299.4-2310.1 m), *Kamik Fm.*			
Ikhil I-37	*Kamik*	10410	3173.0
	McGuire	13025	3970.0
	Martin Creek	13242	4036.0
	Husky	14000	4267.2
Core 1: 12824-12839 ft. (3908.8-3913.3 m), *Kamik Fm.*			
Imnak J-29	*Kamik*	9570	2916.9
	McGuire	10048	3062.6
	Martin Creek	10072	3069.9
	Husky	10272	3130.9
Kamik D-48	*Kamik*	9275	2827.0
	McGuire	9580	2920.0
	Martin Creek	9642	2938.9
	Husky	9900	3017.5

Well name	Formations	Log depths	
		feet	metres
Kamik D-58	*Kamik*	9192	2801.7
	McGuire	10050	3063.2
	Martin Creek	10112	3082.1
	Husky	10370	3160.8
Kamik F-38	*Kamik*	9864	3006.5
	McGuire	10618	3236.4
	Martin Creek	10700	3261.4
	Husky	10955	3339.1
Kamik L-60	*Kamik*	9692	2954.1
Kipnik O-20	*Kamik*	7012	2137.3
	McGuire	10080	3072.4
	Martin Creek	10385	3165.3
	Husky	10850	3307.1
Kugpik O-13	*Kamik*	7130	2173.2
	McGuire	7785	2372.9
	Martin Creek	7992	2436.0
	Husky	8310	2532.9
Core 1: 7270-7279 ft. (2215.9-2218.6 m), *Kamik Fm.*			
Mayogiak G-12	*Martin Creek*		2470.0
	Husky		2557.0
Core 1: 2474-2492 m, *Martin Ck. Fm.*			
Napartok M-31	*Kamik*		1320.0
	McGuire		1448.0
	Martin Creek		1458.0
	Husky		1548.0
Napoiak F-31	*Kamik*	2652	808.3
	McGuire	2762	841.9
	Martin Creek	2842	866.2
	Husky	3048	929.0
Nuna A-32	*Parsons Group* 10620 ft./3237 m (unable to separate the formations)		
	Husky	11140	3395.5
Ogruknang M-31	*Parsons Group* 10750 ft./3276.6 m (unable to separate the formations)		
	Husky	13330	4063.0
Core 1: 13216-13246 ft (4028.2-4037.4 m), *Kamik Fm.*			

Well name	Formations	Log depths	
		feet	metres
Parson A-44	*Kamik*	9530	2904.7
	McGuire	10490	3197.4
	Martin Creek	10550	3215.6
	Husky	10765	3281.2
Parsons D-20	*Kamik*	8963	2731.9
	McGuire	9698	2956.0
	Martin Creek	9780	2980.9
	Husky	10050	3063.2
Parson F-09	*Kamik*	8852	2698.1
	McGuire	9780	2980.9
	Martin Creek	9858	3004.7
	Husky	10110	3081.5

Core 1: 9337-9397 ft. (2845.9-2864.2 m), *Kamik Fm.*
Core 2: 9814-9848 ft. (2991.3-3001.7 m), *McGuire Fm.*

Well name	Formations	feet	metres
Parsons L-37	*Kamik*	8890	2709.7
	McGuire	10020	3054.1
	Martin Creek	10082	3073.0
	Husky	10320	3145.5
Parsons L-43	*Kamik*	8898	2712.1
	McGuire	9905	3019.0
	Martin Creek	9962	3036.4
	Husky	10265	3128.1

Core 1: 9096-9156 ft. (2772.5-2790.7 m), *Kamik Fm.*
Core 2: 9348-9378 ft. (2849.3-2858.4 m), *Kamik Fm.*
Core 3: 9622-9665 ft. (2932.8-2945.9 m); *Kamik Fm.*

Well name	Formations	feet	metres
Parsons N-10	*Kamik*	8590	2618.2
	McGuire	9276	2827.3
	Martin Creek	9346	2848.7
	Husky	9491	2892.9

Core 1: 9025-9072 ft. (2750.8-2765.1 m), *Kamik Fm.*
Core 2: 9172-9202 ft. (2795.5-2804.8 m), *Kamik Fm.*
Core 3: 9325-9341 ft. (2842.3-2847.1 m), *McGuire Fm.*
Core 4: 9341.5-9361 ft. (2847.3-2853.2 m); *McGuire and Martin Ck. fms.*
Core 5: 9361-9375 ft. (2853.2-2857.5 m), *Martin Ck. Fm.*
Core 6: 9375-9398.5 ft. (2857.5-2864.7 m), *Martin Ck. Fm.*
Core 7: 9398.5-9431.5 ft. (2864.7-2874.7 m), *Martin Ck. Fm.*
Core 8: 9431.5-9437 ft. (2874.7-2876.4 m), *Martin Ck. Fm.*
Core 9: 9437-9466 ft. (2876.4-2885.2 m), *Martin Ck. Fm.*
Core 10: 9466-9480 ft. (2885.2-2889.5 m), *Martin Ck. Fm.*

Well name	Formations	Log depths	
		feet	metres

Core 11: 9480-9512 ft. (2889.5-2899.3 m), *Martin Ck. and Husky fms.*

Well name	Formations	feet	metres
Parsons N-17	*Kamik*	9570	2916.9
	McGuire	10625	3238.5
	Martin Creek	10715	3265.8
Parsons O-27	*Kamik*	9702	2957.2
	fault		
	Husky	10022	3054.7
Parsons P-41	*Kamik*	9430	2874.3
	McGuire	10554	3216.9
	Martin Creek	10602	3231.5
	Husky	10892	3319.9

Core 1: 9716-9776 ft. (2961-2979.7 m), *Kamik Fm.*

Well name	Formations	feet	metres
Parsons P-53	*Kamik*	9372	2856.6
	fault		
	Husky	10060	3066.3
Siku A-12	*Kamik*	8722	2658.5
	McGuire	9750	2971.8
	Martin Creek	9816	2991.9
	Husky	10060	3066.3

Core 1: 8901-8964 ft. (2713-2732.2 m), *Kamik Fm.*
Core 2: 9200-9262 ft. (2804.2-2823.1 m), *Kamik Fm.*

Well name	Formations	feet	metres
Siku C-11	*Kamik*	9158	2791.4
	McGuire	9894	3015.7
	Martin Creek	9966	3037.6
	Husky	10080	3072.4
Siku C-55	*Kamik*	13600	4145.3
Siku E-21	*Kamik*	9175	2796.5
	McGuire	10322	3146.1
	Martin Creek	10400	3169.9
	Husky	10588	3227.2

Core 1: 9401-9408 ft. (2865.4-2867.6 m), *Kamik Fm.*
Core 2: 9690-9750 ft. (2953.5-2971.8 m), *Kamik Fm.*
Core 3: 9990-10026 ft. (3045-3055.9 m), *Kamik Fm.*

Well name	Formations	feet	metres
Tuk F-18	*Kamik*	9902	3018.1
	McGuire	10241	3121.5
	Martin Creek	10300	3139.4

Core 11: 9920-9953 ft. (3023.6-3033.7 m), *Kamik Fm.*
Core 12: 10061-10072 ft. (3066.6-3069.9 m), *Kamik Fm.*

Well name	Formations	Log depths	
		feet	metres
Tuk J-29	*Kamik*		2905.0
	McGuire		2917.0
	Martin Creek		2974.0
	Husky		3005.0
Core 2: 2999.5-3003.5 m, *Martin Ck. Fm.*			
Tuk L-09	*Kamik*		2612.0
	McGuire		2679.0
	Martin Creek		2703.0
	Husky		2738.0
Core 1: 2607.7-2625.2 m, *Mount Goodenough and Kamik fms.*			
Core 2: 2625.2-2642.8 m, *Kamik and McGuire fms.*			
Tullugak K-31	*Martin Creek*	6515	1985.8
	Husky	6780	2066.5
Core 1: 6594-6618 ft. (2009.9-2017.2 m), *Martin Ck. Fm.*			
Core 2: 6618-6649 ft. (2017.2-2026.6 m), *Martin Ck. Fm.*			

Well name	Formations	Log depths	
		feet	metres
Unak B-11	*Kamik*	4345	1324.4
	McGuire	5275	1607.8
	Martin Creek	5480	1670.3
	Husky	5966	1818.4
Core 2: 4390-4412 ft. (1338.1-1344.8 m), *Kamik Fm.*			
Unak L-28	*Kamik*		2040.0
	McGuire		2277.0
	Martin Creek		2287.0
	Husky		2360.0
Wagnark C-23	*Kamik*	12284	3744.2
	McGuire	12840	3913.6
	Martin Creek	12918	3937.4
	Husky	13082	3987.4
Core 1: 12404-12434 ft. (3780.7-3789.9 m), *Kamik Fm.*			
Core 2: 12613-12627 ft. (3844.4-3848.7 m), *Kamik Fm.*			

APPENDIX 3

List of internal Geological Survey of Canada paleontological reports relevant to the Parsons Group study. These reports are on file at the Institute of Sedimentary and Petroleum Geology, Calgary.

Reports by J.A. Jeletzky (macrofossils)

1. Km-2-1983-JAJ
2. Km-3-1984-JAJ
3. Km-13-1985-JAJ
4. Km-3-1986-JAJ
5. Km-8-1986-JAJ
6. Km-2-1988-JAJ

Reports by D.H. McNeil (microfossils)

1. 8-DHM-1982

Reports by S.P. Fowler (microfossils)

1. 1-SPF-1983
2. 1-SPF-1984
3. 1-SPF-1985
4. 1-SPF-1986
5. 2-SPF-1988

Reports by D.J. McIntrye
(palynomorphs and dinoflagellates)

1. 15-DJM-1983
2. 9-DJM-1984
3. 4-DJM1987 (report of possible Triassic in section DFA86-21)