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STRATIGRAPHIC NOMENCLATURE OF LOWER CRETACEOUS ROCKS IN THE NORTHERN YUKON AND ADJACENT DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

J. Dixon
J.A. Jeletzky

1991

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STRATIGRAPHIC NOMENCLATURE OF LOWER CRETACEOUS ROCKS IN THE NORTHERN YUKON AND ADJACENT DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

Abstract

Previously named, but not defined, Lower Cretaceous formations in the northern Yukon and adjacent Northwest Territories are formally defined and type sections designated. The units include the upper Berriasian to lower Valanginian Martin Creek Formation, the lower to middle Valanginian McGuire Formation, the upper Hauterivian to Barremian Mount Goodenough Formation, and the upper Barremian to upper Aptian Rat River Formation. All of the type sections are found in the northern Richardson Mountains, although the formations can be mapped throughout the northern Yukon and adjacent Northwest Territories.

Martin Creek strata comprise mostly very fine to fine grained, marine sandstones that contain abundant hummocky cross-stratification and swaley stratification. They transitionally overlie the uppermost Jurassic to lowermost Berriasian Husky Formation, and are abruptly or erosionally overlain by the McGuire Formation. McGuire strata consist mostly of marine shale with thin interbeds of bioturbated and stratified sandstone in the upper third of the succession. They are gradationally overlain by Kamik sandstones. Mount Goodenough strata consist mostly of marine shale, although the upper third of the type section contains interbedded shale and sandstone. The base of the Mount Goodenough Formation is a regional unconformity, although in basinal positions the amount of erosion is minimal. In places, a locally developed basal sandstone facies overlies the unconformity, especially on or adjacent to tectonic uplifts. Although the overlying Rat River Formation abruptly overlies Mount Goodenough strata at Mount Goodenough, in most places the contact is gradational. Rat River strata consist of well stratified, very fine to fine grained, marine sandstone interbedded with variable amounts of shale. Along the eastern flanks of the northern Richardson Mountains, south of Mount Goodenough, shale and siltstone of the Martin House Formation abruptly overlie the Rat River Formation.

Résumé

Les formations du Crétacé inférieur dans le nord du Yukon et les Territoires du Nord-Ouest adjacents qui avaient été désignées mais non définies ont reçu un définition officielle et leurs stratotypes ont été choisis. Les unités comprennent la formation de Martin Creek du Berriasien supérieur au Valanginien inférieur, la formation de McGuire du Valanginien inférieur à moyen, la formation de Mount Goodenough de l'Hauterivien supérieur au Barrémien et la formation de Rat River du Barrémein supérieur à l'Aptien supérieur. Tous les stratotypes se trouvent dans le nord des monts Richardson même si les formations peuvent être cartographiées dans tout le nord du Yukon et des Territoires du Nord-Ouest adjacents.

Les couches de la formation de Martin Creek sont surtout composées de grès de très fin à fin comportant de nombreuses stratifications obliques bosselées et de stratifications à légères dépressions. Elles reposent par transition sur la formation de Husky du Jurassique terminal au Berriasien basal et sont surmontés brusquement ou par érosion par la formation de McGuire. Les couches de la formation de McGuire sont surtout composées de schistes argileux marins avec des interstratifications fines de grès bioturbé et stratifié dans le tiers supérieur de la succession. Les grès de la formation de Kamik reposent graduellement sur ces dernières. Les couches de la formation de Mount Goodenough sont surtout composées de schistes argileux marins, même si le tiers supérieur du stratotype contient des schistes argileux et du grès interstratifiés. La base de la formation de Mount Goodenough est une discordance régionale, même si dans le bassins, la quantité de sédiments érodés est minime. Par endroits, un faciès de grès basal formé localement repose sur la discordance, en particulier sur les soulèvements tectoniques ou à côté de ceux-ci. Même si la formation de Rat River sus-jacente repose brusquement sur les couches de Mount Goodenough au mont Goodenough, dans la plupart des endroits, le contact est graduel. Les couches de la formation de Rat River sont composées de grès marin bien stratifié, de très fin à fin, interstratifié avec des quantités variables de schistes argileux. Le long des versants est des monts Richardson septentrionaux, au sud du mont Goodenough, les schistes argileux et le siltstone de la formation de Martin House reposent brusquement sur la formation de Rat River.

INTRODUCTION

Although formational names have been applied to Berriasian to Aptian strata in the northern Yukon and adjacent Northwest Territories (Norris, 1981a-g, 1982; Dixon, 1982a, b, 1986a), only the Valanginian to Hauterivian Kamik Formation has been formally defined (Dixon, 1982a). Dr. J.A. Jeletzký was in the process of compiling a manuscript that would have defined the units, and described and interpreted the regional stratigraphy. He had compiled a near-complete first draft of this manuscript before his death in 1988. The present paper focuses on one of Dr. Jeletzky's objectives, the formal definition of the Martin Creek, McGuire, Mount Goodenough and Rat River formations, and is based on parts of his unpublished manuscript. It also includes a considerable amount of information from the ongoing work on the same units by J. Dixon. The type sections are described in detail, but only general comments on the regional character of each unit are given. Additional descriptions of the regional character of the units can be found in Jeletzky (1971a, 1972, 1974, 1975), Young (1972, 1973a, b), Young et al. (1976) and Dixon (1986a, in press). Jeletzky's unpublished manuscript is available for viewing at the library of the Geological Survey of Canada (Institute of Sedimentary and Petroleum Geology), Calgary, Alberta. Wherever possible the intent of his work is followed but not all of his specific data and interpretations, many of which have been superceded by more recent work or are in conflict with present ideas and data, have been incorporated.

Acknowledgments

This brief description of part of the Lower Cretaceous succession in the northern Yukon and adjacent Northwest Territories represents only a small part of many years of regional studies by both authors. Many individuals and organizations helped the authors in the field. The field assistants who helped Dr. Jeletzky are unknown to the senior author but to these anonymous individuals I would like to offer my thanks. B. Ricketts, D. McIntyre, K. Hugo, B. Edwarth, K. McIver, and R. Peach assisted or accompanied J. Dixon during many summers of fieldwork. Helicopter support from Polar Continental Shelf Project to J. Dixon is gratefully acknowledged. An especial thanks to Jim and Meredith Hodges of Sunrise Helicopters, Inuvik, for their pleasant and expert service when casual helicopter charter was used by J. Dixon. Accommodation and a logistics base in Inuvik were kindly provided by the Western Arctic Scientific Resource Centre. Part of this study was funded under the Geological Survey of Canada's (Project No. 850037) Frontier Geoscience Program (WA25-360).

Comments and criticisms by A.E. Embry and T.P. Poulton helped improve the publication. Drafting was ably undertaken by D. McGeachy and P. Neelands.

Previous work

Pocock (1976, Fig. 3) named Lower Cretaceous strata in one of his figures but failed to define them. Brideaux et al. (1977) disputed the introduction of the terminology. Pocock (1977) responded by stating that he had not intended the terminology to be formal; consequently his stratigraphic scheme did not become commonly accepted. However, some of the names introduced by Pocock were used later, although not necessarily in the same sense as by Pocock.

Prior to the presently used set of names being applied to units on several maps (Norris, 1981a-g, 1982), the Berriasian to Aptian strata had been given informal names by Jeletzky (1958, 1960, 1961) (Fig. 1). It was Dixon (1982a) who first made use of the undefined names in a textual publication, citing an "in preparation" manuscript by Jeletzky as the source of the nomenclature. The formational names Martin Creek, McGuire, Mount Goodenough, and Rat River were applied by Dixon to subsurface units in the southern part of Mackenzie Delta and the Tuktoyaktuk Peninsula. Dixon also used the name Kamik Formation to describe a sandstone-dominant unit between the McGuire and Siku shale successions (the Siku shale was later relegated to being a subsurface member of the Mount Goodenough Formation (Dixon et al., 1989). Martin Creek, McGuire and Kamik strata were combined into the Parsons Group by Dixon (1982a), a name that had been used informally by previous workers (e.g., Cote et al., 1975). Dixon (1982a, Table 1) indicated that Jeletzky intended to introduce two additional names, the Fault Creek and Lower Canyon formations, which Dixon interpreted as being equivalent to the Kamik Formation. In a subsequent paper, Dixon (1986a) used the name, Kamik Formation, on a more regional basis, in preference to the names, Fault Creek and Lower Canyon formations. Regional fieldwork by Dixon has reinforced his impression that the undefined Fault Creek and Lower Canyon units of Jeletzky (unpublished manuscript and personal communications) are local facies within the lower part of the Kamik Formation, and are restricted to the Aklavik Range of the northern Richardson Mountains. Consequently, they cannot be used as regionally significant units.

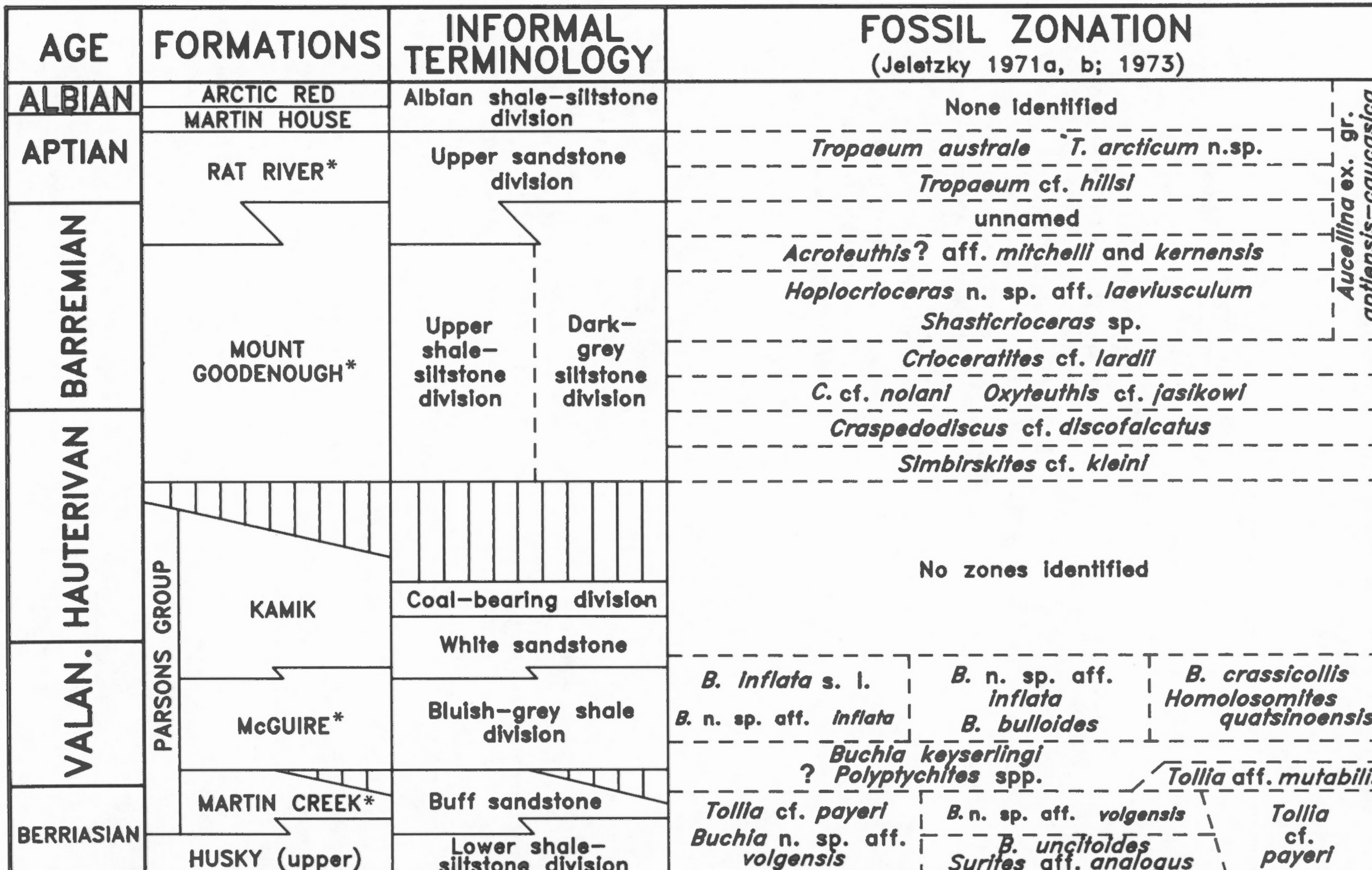


*Figure 1. Formation names and comparison with previous informal terminology. *indicates the formations defined in this report.*

All of the type sections are located in the northern Richardson Mountains (Fig. 2), three on the east flank and one on the west. The formations can be mapped throughout the northern Yukon and adjacent Northwest Territories (Norris, 1981a-e, 1982; Dixon, 1982a, in press).

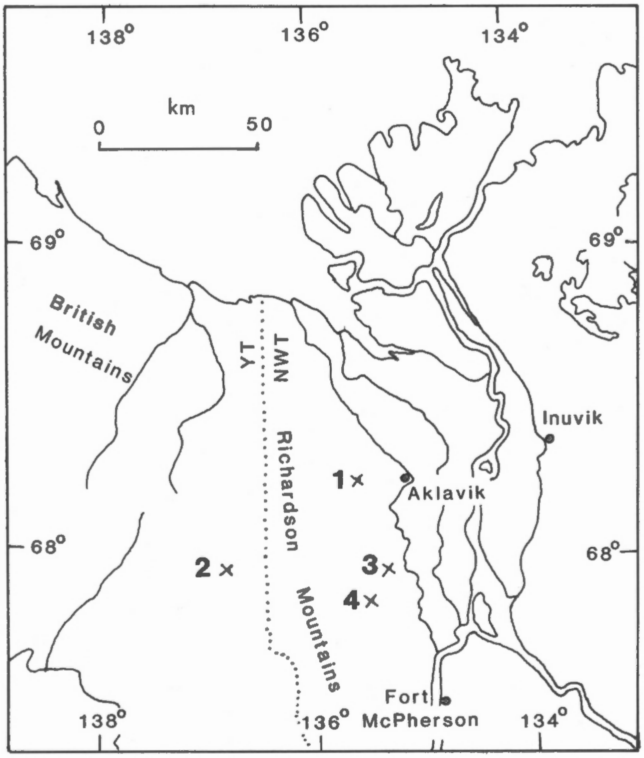
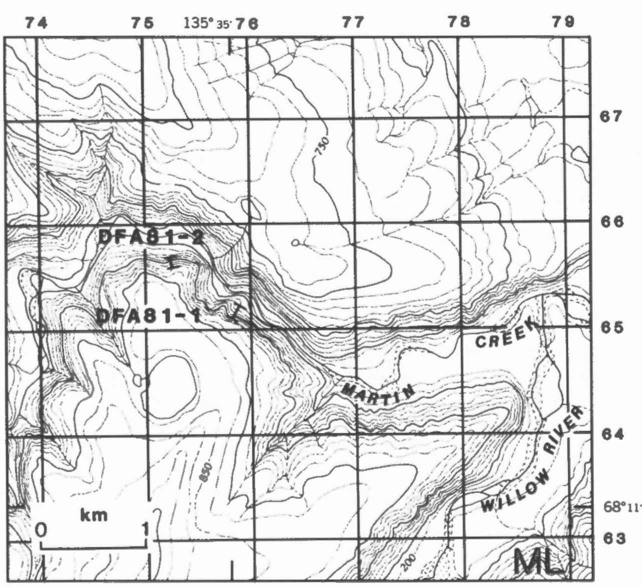


Figure 2. General geographic location of type sections. 1, Martin Creek Formation; 2, McGuire Formation; 3, Mount Goodenough Formation; 4, Rat River Formation.



MARTIN CREEK FORMATION

Description of type section

The name Martin Creek Formation is intended to replace the informal name, Buff Sandstone member, of the Lower Sandstone Division (Jeletzky, 1958, 1960; Fig. 1). In 1961, Jeletzky restricted the use of the name, Lower Sandstone Division, to only Martin Creek-equivalent strata.

The type section is located on Martin Creek, on the northeast flank of the Richardson Mountains (Fig. 3). In its upper reaches, Martin Creek flows in a northerly direction, but at about latitude 68°12′N, longitude 135°45′W, it turns abruptly east and eventually joins the distributary system of Mackenzie Delta about 17 km west of Aklavik. At the abrupt eastward bend the river enters a prominent canyon in which the Martin Creek Formation is well exposed on both valley walls. The south side is more accessible and is designated as the type section (Figs. 3, 4). The base of the formation is approximately 500 to 700 m downstream from the mouth of the canyon, at longtitude 135°35′46″W, latitude 68°12′11″N (UTM grid reference: Map 107 B/4, ML753657, 1:50 000 map scale) and the top of the section is about 800 m downstream, at latitude 135°34′55″W, longitude 68°12′53″N (UTM grid reference: Map 107 B/4, ML759651, 1:50 000 map scale). Strata dip about 10° to the northeast. Jeletzky's field section number JA-F71-7 and Dixon's sections DFA81-1 and 2 were measured along the same transect, although in different years (see Appendix 1 for complete descriptions), and are the type descriptions.

Figure 3. Detailed location map of the Martin Creek Formation type section. Numbers on the map's margins are part of the UTM grid system.

Figure 4. View of the Martin Creek Formation type section, Martin Creek canyon, looking east. 1, Husky Formation; 2, Martin Creek Formation; 3, McGuire Formation; 4, Kamik Formation. ISPG photograph 3299-9.

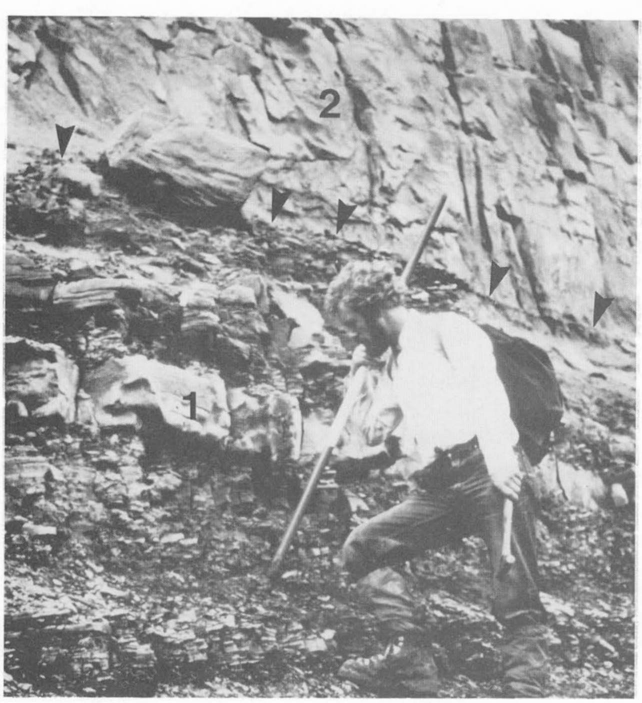


Figure 5. Contact (arrows) between Husky (1) and Martin Creek (2) strata at the type section. ISPG photograph 1895-1.

The base of the formation is placed at the base of the first occurrence of vertically persistent sandstone, above which interbedded shale is absent or very minor (Figs. 5, 6). This first thick sandstone forms a prominent cliff face on the valley wall. The lower contact with the underlying interbedded shale and

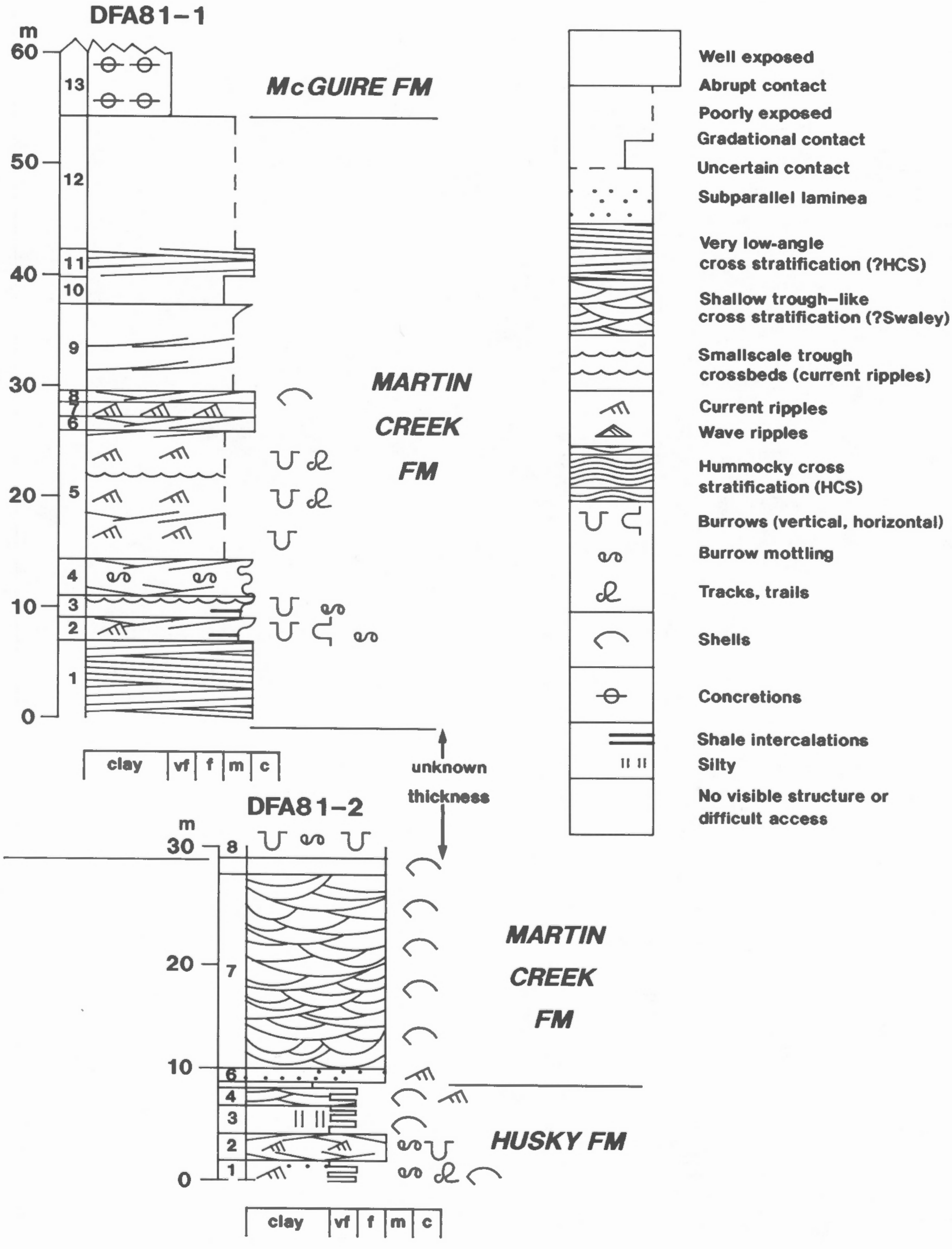


Figure 6. Graphic representation of Martin Creek strata at the type section, Martin Creek, Sections DFA82-1 and 2 (J. Dixon).

sandstone of the Husky Formation is abrupt (Figs. 5, 6). Because of the difficulty in obtaining a continuous measured section, the 121 m thickness measured by Jeletzky may be slightly in error. Dixon's two sections total 75.2 m but there is a gap of unknown thickness between the two. A thickness of about 100 m would be consistent with the known thicknesses in the nearby Beaverhouse Creek H-13 and Aklavik A-37 wells (Dixon, 1982a). Although the upper contact tends to be covered at Martin Creek, at localities close by (e.g., the next valley to the north, known informally to Geological Survey officers as "Grizzly Gorge") it is an abrupt change to the black, powdery shale of the McGuire Formation.

The type section contains very fine to fine grained sandstone, with thin laminae and intercalations of mudstone present mostly in the lowermost beds. At Martin Creek and throughout the Aklavik Range, the Martin Creek Formation weathers a very light yellow to orange, hence the original, informal designation of Buff Sandstone. Sedimentary structures within the sandstone are readily seen and consist of hummocky cross-stratification (HCS) (Fig. 7A), swaley cross-stratification (Fig. 7B), wave-modified current ripples (Fig. 7C), current ripples, burrow mottling, tracks and trails, and vertical and U-shaped burrows. Bivalves are common throughout the succession, mostly belonging to the genus *Buchia*. Shell debris is commonly present along bedding planes in the HCS and swaley beds, and may occur as local concentrations above the erosional bases of some beds. Ironstone concretions are present at a few horizons, generally in very fine grained, possibly argillaceous, sandstones, but they are not very common. The succession at Martin Creek has a banded appearance as a result of subtle colour contrasts and alternations of units with varying bed thicknesses.

General comments on regional character

Martin Creek strata have been identified throughout the northern Richardson Mountains, the northernmost Ogilvie Mountains, in the subsurface under Mackenzie Delta and in the headwaters of Blow River. Whereas sandstone is virtually the sole lithotype in the type area and adjacent Aklavik Range, shale interbeds are more common elsewhere. Also, the basal contact is not everywhere abrupt; on the west flank of the Richardson Mountains and the northern Ogilvie Mountains, the Husky to Martin Creek interval is transitional, consisting of interbedded shale and sandstone beds in which the amount of sandstone gradually increases upsection (Fig. 8). In these areas, the base of the formation is placed at the base of the first medium to thick bed of sandstone, above which sandstone is the predominant rock type (i.e., greater than 40% sandstone beds). In the Parsons N-10 well, to the east on Tuktoyaktuk Peninsula, the transition consists of a gradual increase in sand content over a zone of thoroughly bioturbated strata (Dixon, 1982a, b).

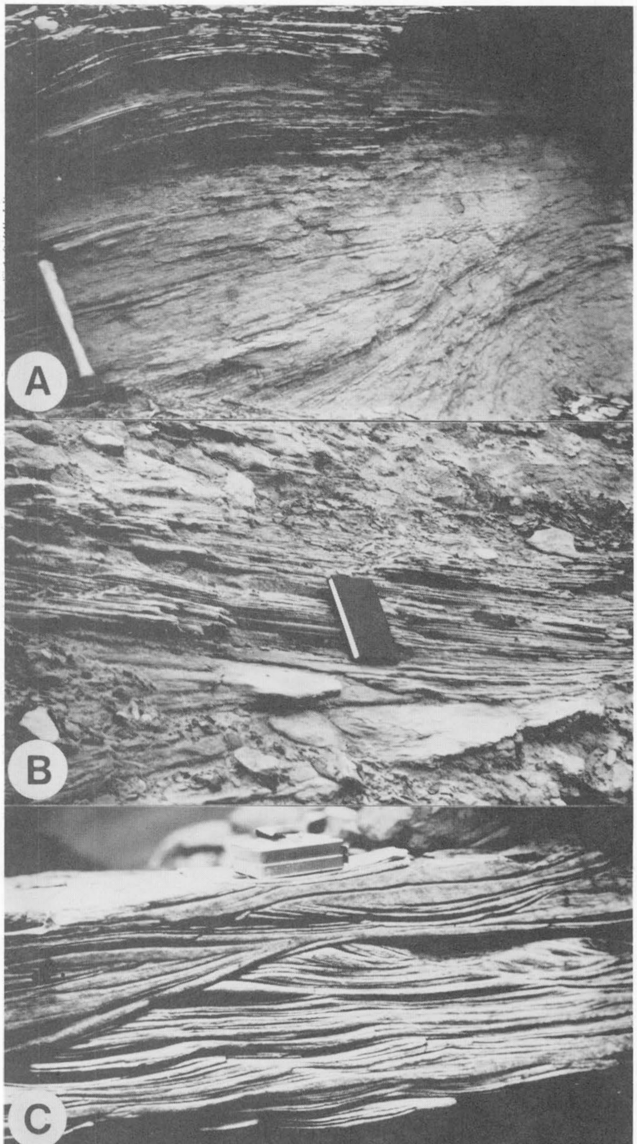


Figure 7. Typical sedimentary structures in Martin Creek strata at the type section and nearby outcrops. A, hummocky cross-stratification (HCS). Hammer length approximately 30 cm. ISPG photograph 1716-1; B, swaley cross-stratification. Book length 17 cm. ISPG photograph 2584-6; C, current-modified wave ripples. Edge of tape measure approximately 7 cm. ISPG photograph 1673-16.

The upper contact with McGuire strata is everywhere abrupt and locally unconformable.

On the west flank of the Richardson Mountains and in the northern Ogilvie Mountains, the Martin Creek succession contains thick, shaly intervals that form the basal parts of several coarsening-upward cycles (Fig. 9). This increase in shale content reflects the westward to northwestward shale-out of the Martin Creek Formation, and throughout most of the British Mountains, equivalent stata are part of the shale-dominant Kingak Formation.

Depositional setting

The prevalence of hummocky cross-stratified and swaley bedded sandstone, the common occurrence of both current and wave ripple laminae, and the abundant shell debris, within the type section and immediately adjacent areas, point to deposition in a high-energy environment subject to strong wave action. A lack of clay-size material also indicates that energy levels were consistently high, and that silt- and clay-size particles were constantly transported away from the immediate environment. Interbedded bioturbated horizons indicate that periods when low-energy conditions occurred allowed an infauna to establish itself. Such conditions are typical of the nearshore and lower shoreface environments of a wave-dominated shoreline. This interpretation is consistent with the regional setting, wherein the Martin Creek type section is believed to have been close to the paleo-shoreline (Dixon, 1982a, b, 1986a, in press).

Age

Martin Creek strata are relatively rich in bivalves, but contain few ammonites. Jeletzky identified the following macrofossils from the type section (see Appendix 1 for stratigraphic locations):

Buchia sp.
Buchia n. sp. aff. *volgensis* Jeletzky 1964
Buchia keyserlingi (Lahusen)
Buchia keyserlingi-like shells
Buchia cf. *keyserlingi* (Lahusen)

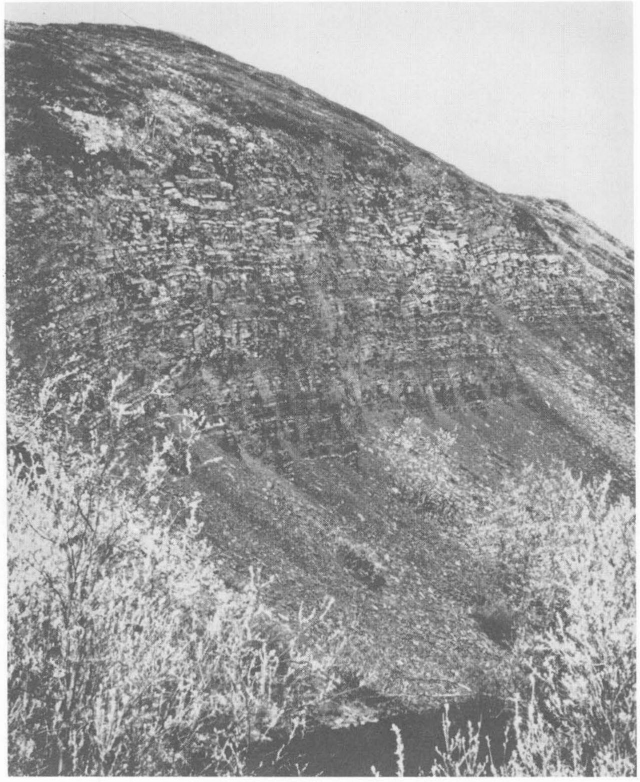


Figure 8. *Transitional nature of the Husky to Martin Creek contact west of the type area (section DFA83-12). Located about 22 km west of Bonnet Lake. ISPG photograph 1895-6.*

Figure 9. *Coarsening-upward cycles in the Martin Creek Formation. Section DFA88-15, 16.6 km east of Bonnet Lake. ISPG photograph 3081-7.*

Buchia inflata (Toula)
Pholadomya and *Pholadomya*-like shells
?*Thracia* (s.l.) sp.
Pentacrinus-like stem segments

These fossils are part of the Late Berriasian *Buchia* n. sp. aff. *volgensis* Zone and *Tollia* (*Tollia*) cf. *payeri* Zone (Jeletzky, 1958, 1960, 1961, 1971b, 1973) and the earliest Valanginian *Buchia keyserlingi* sensu stricto Zone (Jeletzky, 1961, 1973).

Some of the lower beds in the Bonnet Lake area contain fauna of the *Buchia uncitoides* sensu lato assemblage (Jeletzky, 1961, 1973), and appear to be local lateral equivalents of the *Buchia* n. sp. aff. *volgensis* Zone.

Foraminifers from the Martin Creek Formation cannot be distinguished from those in the underlying Berriasian part of the Husky Formation (S. Fowler, pers. comm.). Palynomorphs also tend to be non age-diagnostic, long-ranging Neocomian forms (Brideaux, 1976). Fensome (1987) identified schizaealean spores from the type section and included Martin Creek strata in his *Psilosporites delicatus* Subzone, which he dated as Ryazanian (Berriasian) to early Valanginian. In the Parsons N-10 well, Brideaux and Myhr (1976) included Martin Creek strata in their Berriasian dinoflagellate zone IVf.

The lower formational contact is regionally transitional, and therefore diachronous. The upper boundary is a flooding surface and locally an erosional unconformity; consequently, the uppermost beds can be expected to be of varying ages, depending upon basin position and the amount of sub-McGuire erosion.

McGUIRE FORMATION

Description of type section

The name McGuire Formation is intended to replace the informal name, Bluish-grey Shale Division of Jeletzky (1961; Fig. 1). The Bluish-grey Shale was first recognized on the west flank of the northern Richardson Mountains but a thin equivalent was also identified on the east flank (Jeletzky, 1961). Cote et al. (1975) noted its extension into the subsurface under Mackenzie Delta, and informally termed it the "shale marker".

The type section is located on the east flank of a prominent north-northeast trending ridge, 4.1 km north-northeast of Mount McGuire (Figs. 2, 10). Mount McGuire, from which the formation name is taken, is the nearest named geographic feature. Immediately below the highest point (5100 ft; 1554 m) along the ridge (Fig. 11), an accessible gully cuts through the McGuire shale and underlying strata. The co-ordinates of the base of the section are latitude 67°57′54″N, longitude 137°18′14″W (UTM grid reference: Map 116 P/14, ML031411, 1:50 000 map scale). Strata dip about 40 degrees to the west and strike at 020 degrees. Jeletzky's field section JA-F59-138 and Dixon's section DFA82-8 were measured at the same locality and are the type section descriptions (Appendix 2).

The base of the McGuire Formation is in abrupt contact with underlying sandstone of the Martin Creek Formation, whereas the upper contact is transitional into sandstones of the Kamik Formation (Figs. 12, 13). At the lower contact, the uppermost few tens of centimetres of Martin Creek sandstone are rusty-red and are thoroughly bioturbated. The first vertically persistent, and commonly cliff forming, thick unit of sandstone was chosen as the base of the overlying

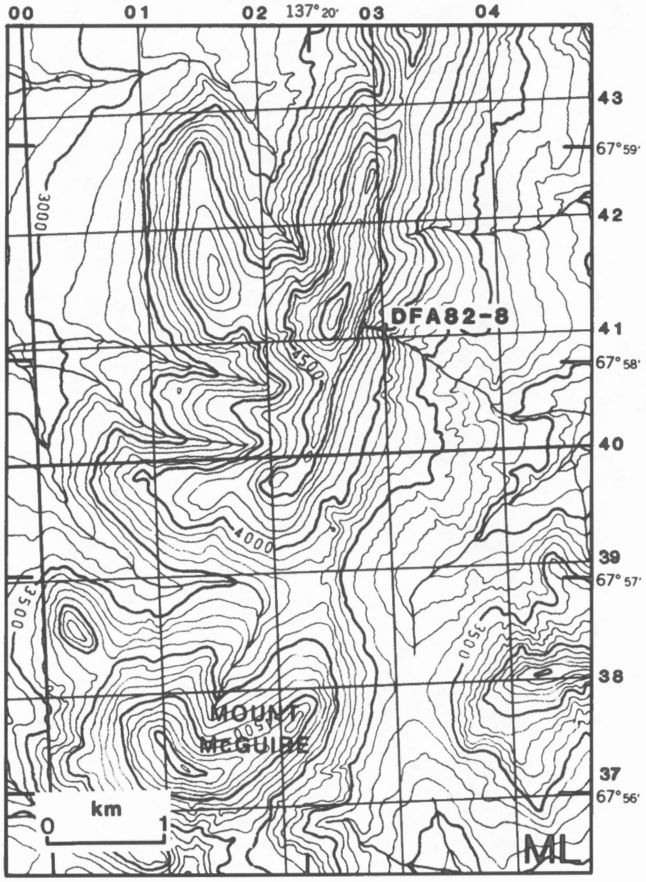


Figure 10. Detailed location map of the McGuire Formation type section. Numbers on the map's margins are part of the UTM grid system.

Kamik Formation. Above the first Kamik sandstone the amount and thickness of interbedded shale rapidly declines.

Jeletzky measured only 129 m of McGuire strata at the type section, whereas Dixon measured 264 m (the latter will be used as the probable section thickness). The lower 150 m consists of bluish grey to black, fissile shale containing numerous ironstone concretions. Bivalves are present in this lower interval. Between 150 and 200 m above the base of the formation the succession becomes siltier and the shales less fissile and more blocky weathering. Above 200 m, thin beds of silty, argillaceous sandstone are interbedded with the shale. The bulk of the sandy beds are thoroughly bioturbated, although some thicker beds contain remnant sedimentary structures—usually fine, sub-horizontal laminae, ripple laminae, or low-amplitude hummocky cross-stratification.

General comments on regional character

McGuire strata have been identified throughout the northern Richardson Mountains, northern Ogilvie Mountains and in the subsurface under southern Mackenzie Delta and the southwestern end of Tuktoyaktuk Peninsula (Dixon, 1986a, in press). The appearance and general character of McGuire strata at these other locations generally is similar to strata at the type section, although thicknesses can vary quite dramatically. In the Aklavik Range the McGuire Formation is unusually thin (6-10 m) and consists of soft, powdery, black shale. Also in the Aklavik Range, the overlying Kamik sandstone rests abruptly on McGuire shale. In the subsurface Mackenzie Delta, the McGuire Formation is again thin and tends to contain a greater proportion of thin interbeds of sandstone and siltstone than in most of its outcrop occurrences (Dixon, 1982a).

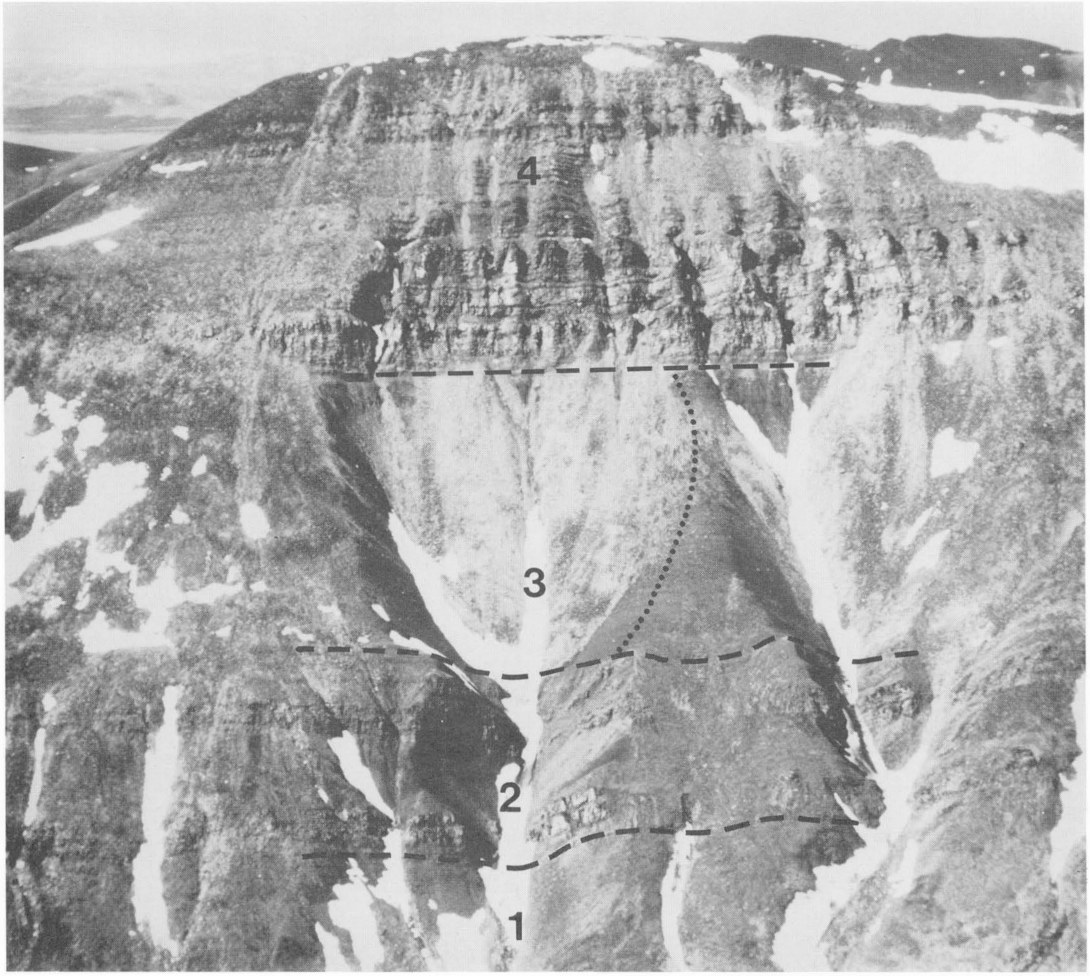


Figure 11. Aerial view of the McGuire Formation type section. Line of traverse (Dixon) indicated by dotted line. 1, Husky Formation; 2, Martin Creek Formation; 3, McGuire Formation; 4, Kamik Formation. ISPG photograph 1858-3.

South of McDougall Pass in the Richardson Mountains (Jeletzky, 1980), and south of about latitude 66°50′N in the Ogilvie Mountains (Dixon, in press), Martin Creek strata have been eroded and McGuire strata rest unconformably on older beds.

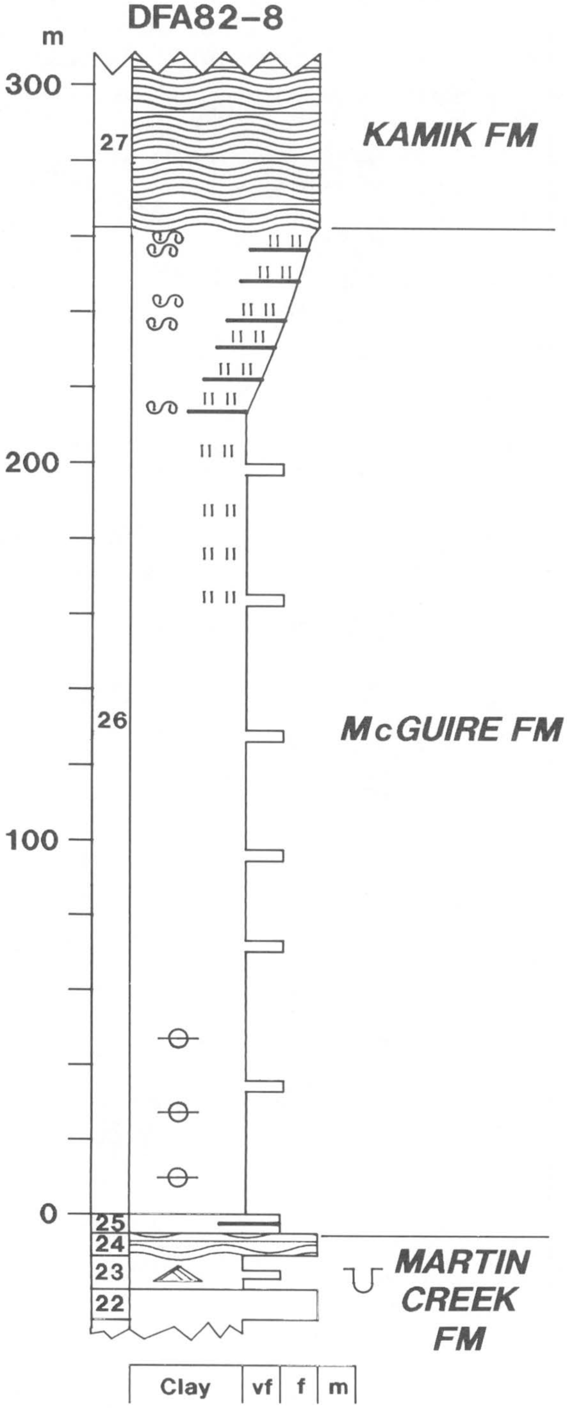


Figure 12. Graphic representation of the McGuire Formation type section. Section DFA82-8 (J. Dixon). See Figure 6 for legend.

West of the Bonnet Lake area, the whole of the Jurassic to Valanginian interval is dominated by shale of the Kingak Formation, and a separate McGuire Formation generally cannot be recognized.

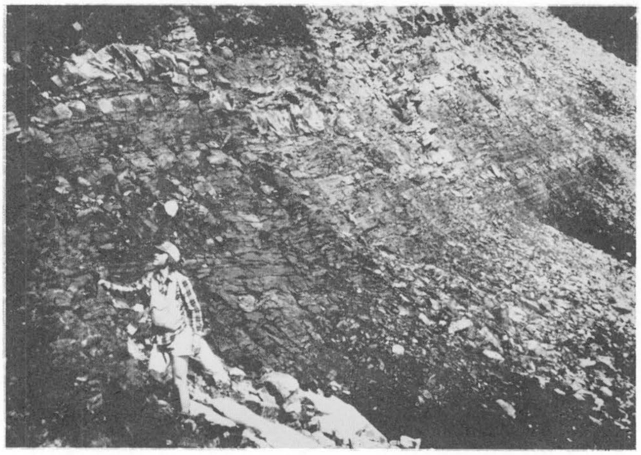


Figure 13. Transitional nature of the McGuire/Kamik contact at the type section. ISPG photograph 1858-19.

Depositional setting

The prevalence of clay- and silt-size material in the McGuire Formation indicates an overall low-energy depositional environment. However, the intermittent occurrence of sandy beds, some of which contain crosslaminae, points to periods of higher energy. A rich foraminiferal assemblage and the presence of characteristic marine bivalves indicate a marine setting. The combination of the physical and biogenic features suggests deposition on a marine shelf, generally below normal and storm wave-base, but with intermittent large storms or hurricanes bringing coarser material into the shelf environment.

McGuire strata are the basal part of an overall coarsening-upward succession into the overlying sandstone-dominant Kamik Formation, and the higher levels of the McGuire Formation contain more coarser material than the lower levels. This vertical change is interpreted as indicating aggradation, as deposition became more influenced by periodic storm activity. These changing conditions resulted in deposition of thick beds of fine grained sand that are commonly crosslaminated (commonly identifiable as low-amplitude hummocky cross-stratification). However, many of the sandstone beds are thoroughly bioturbated, indicating that deposition of sandy material was infrequent and lower-energy conditions were still prevalent.

The type section is a considerable distance from the interpreted paleoshoreline (Dixon, 1986), to the east and southeast.

Age

The lower 30 to 45 m (Jeletzky's measurements) of the type section contain fauna of the *Buchia keyserling* sensu lato Zone (Jeletzky, 1960, 1961, 1971b, 1973), which is early to middle Valanginian in age. In the middle part of the formation *Polyptychites* ex. gr. *keyserlingi* (Neumayr and Uhlig) and *Buchia* aff. *crassa* (Pavlow) are present, which Jeletzky (1973) dated as late middle Valanginian.

Foraminifers are abundant in McGuire shales and comprise a sufficently distinct assemblage to be used for regional correlations (S. Fowler, pers. comm.), although the dating of McGuire strata still relies on the macrofossil zonation. McIntyre and Brideaux (1980) identified Valanginian dinoflagellates in McGuire strata from the Aklavik Range. On the western flank of Richardson Mountains and throughout the British and Ogilvie mountains, palynomorphs generally are too poorly preserved to identify, because of high levels of thermal alteration.

MOUNT GOODENOUGH FORMATION

Description of type section

The name Mount Goodenough Formation is intended to replace the informal terms, Upper Shale-Siltstone Division (Jeletzky, 1958, 1960; Fig. 1) and Dark-Grey Siltstone Division (Jeletzky, 1961). The type section is on the east flank of the Mount Goodenough massif (from which the formation name is derived) in the Aklavik Range, northern Richardson Mountains (Figs. 2, 14, 15). Strata are well exposed, although access can be difficult in places (Fig. 16). The base of the type section begins near the base of the eastern slope at a small ephemeral stream flowing off the massif into a series of small lakes and ponds on the Mackenzie Delta plain (Dixon's field section DFA89-6; Appendix 3). The section follows the southern spur of the stream gully. Co-ordinates for the base of the section are: latitude 67°56′50″N, longitude 135°24′30″W (UTM grid reference: Map 106 M/14, ML828365, map scale 1:50 000). Jeletzky's field section for the Mount Goodenough area is number 16 (first described in Jeletzky, 1958, p. 54-67; Appendix 3). Jeletzky's co-ordinates and location description indicate that his section 16 (Jeletzky, ibid.) was located about one kilometre to the south of Dixon's type section, along a prominent, southeasterly oriented spur.

Dixon measured about 308 m of Mount Goodenough strata at the type section, of which the upper 60 m were estimated. Jeletzky measured about 481 m at his section, in which the thickness of a number of intervals was estimated. Strata on the east face of Mount Goodenough are near horizontal; consequently, the vertical relief between the top and bottom of the section should be a reasonable estimate of the section thickness. Dixon's section is estimated to have begun at about 100 m above sea level and ended at an elevation of 450 m. The elevation difference of 350 m suggests that Dixon's measurements are probably more accurate.

The base of the Mount Goodenough Formation abruptly and unconformably overlies interbedded sandstone and shale that contain fauna of the Berriasian *Buchia* n. sp. aff. *volgensis* Zone and *Tollia* (*Tollia*) cf. *payeri* Zone (Jeletzky, 1958). The fauna indicate that these strata represent upper beds of the Husky Formation, or lower beds of the Martin Creek Formation. Norris (1981e) mapped the interbedded

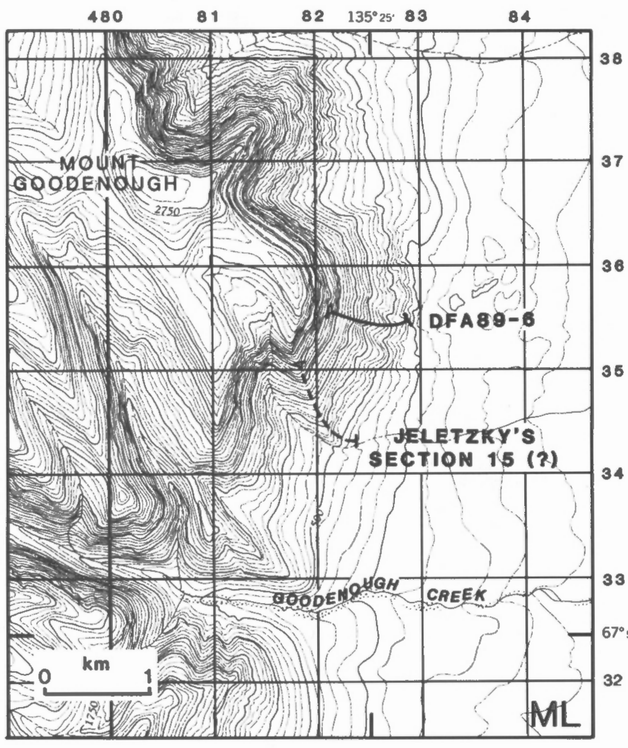


Figure 14. Detailed location map of the Mount Goodenough Formation type section. Numbers on the map's margins are part of the UTM grid system.

sandstone-shale unit as Martin Creek Formation. Comparison with the succession at the type area of the Martin Creek Formation indicates that the lower beds at Mount Goodenough are probably uppermost Husky Formation.

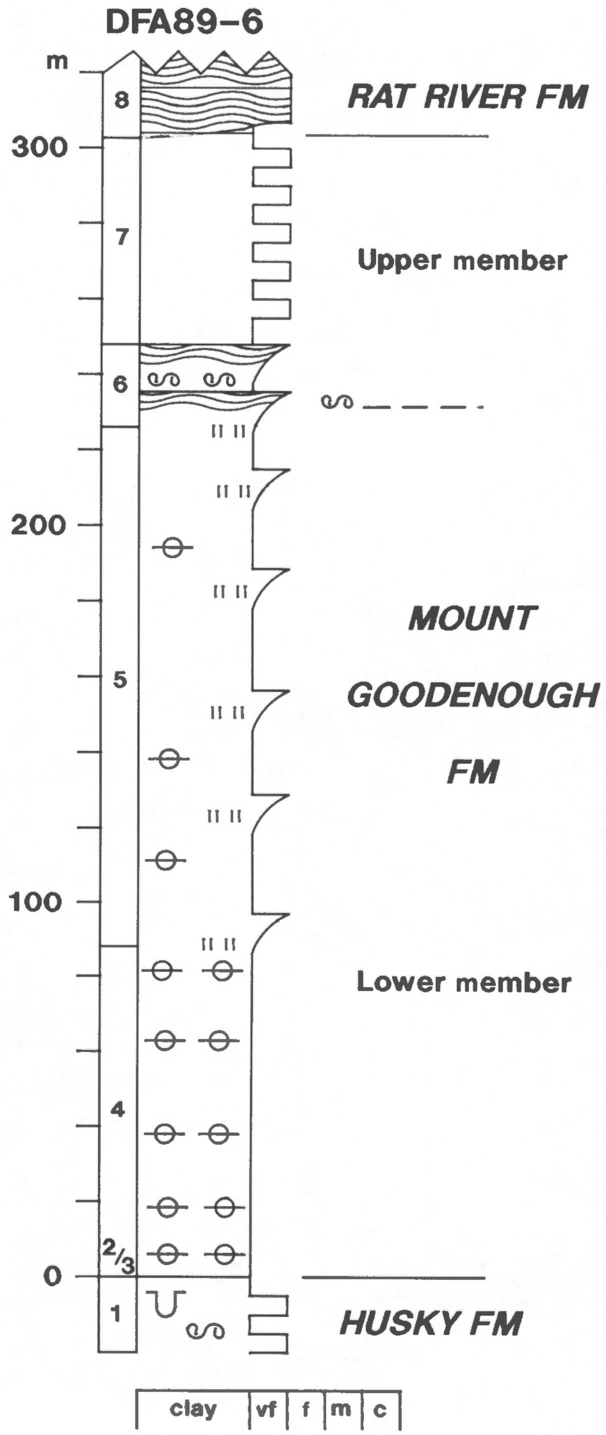


Figure 15. Graphic representation of the Mount Goodenough Formation type section. Section DFA89-6 (J. Dixon). See Figure 6 for legend.

The type section can be divided into two informal members: a lower, shale-dominant member that is about 228 m thick; and an upper member that contains interbedded shale and sandstone and is about 80 m thick (Fig. 15; thicknesses are those of Dixon). The lower member consists of black, fissile shale throughout which are numerous horizons rich in ironstone concretions. Jeletzky noted a thin (0.15 m) layer of pebbles at the base of his section, whereas Dixon did not. The first 2.2 m of Dixon's section consist of ironstone-rich shale, in which ironstone has almost completely replaced the shale. There are several thin (1-2 m) intervals of silty sandstone within the lower member, and some form minor ledges along the slope. These sandier beds generally are bioturbated,

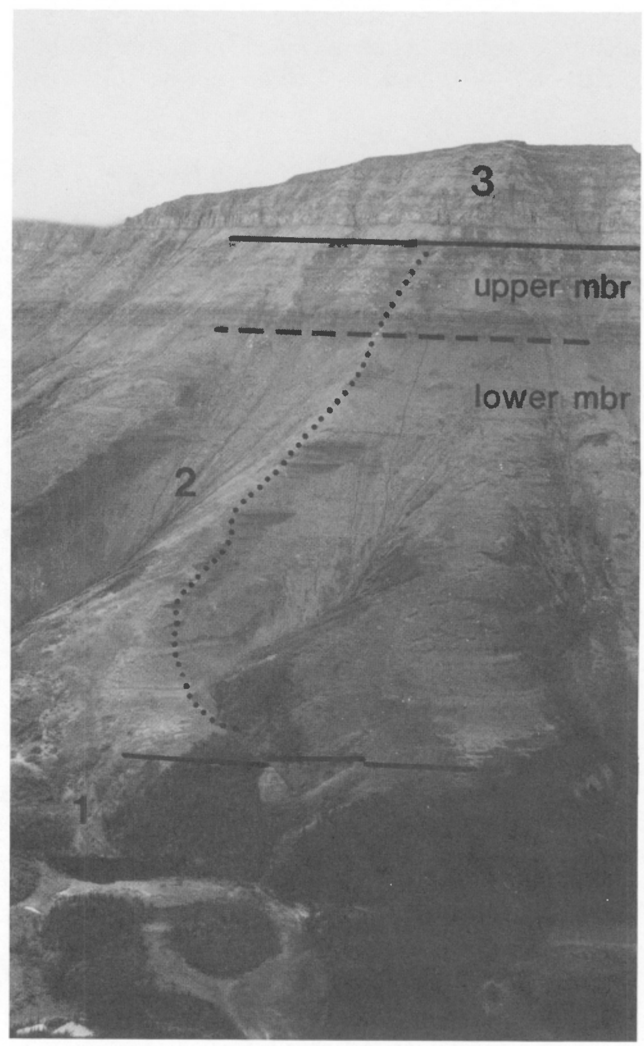


Figure 16. View of the Mount Goodenough Formation type section. Line of traverse indicated by dotted line. 1, Husky Formation; 2, Mount Goodenough Formation; 3, Rat River Formation. ISPG photograph 3299-26.

but Jeletzky noted laminae in some beds. A prominent cliff forming sandstone interval about two thirds of the way up the section (Figs. 15, 16) is the first unit of the upper member. The cliff contains two coarsening-upward cycles, the lower of which is five to six metres thick and the upper 14 to 15 m thick. Shale of the lower member grades up into interbedded sandstone and shale of the lower cycle, which is in turn abruptly overlain by about one metre of shale at the base of the second cycle. Most of the second cycle consists of very fine grained, thin to thick bedded, bioturbated or hummocky cross-stratified sandstone. The second cycle is abruptly overlain by shale, above which are about 40 to 60 m of thin to thickly interbedded shale and sandstone. Details of the character of the uppermost beds of the upper member are lacking because of difficulty of access. Along the Mount Goodenough massif the contact between Mount Goodenough strata and the cliff forming sandstones of the Rat River Formation is abrupt, and at the north end, in Jimmy Creek, the contact is a large, shallow scour (Fig. 17).

General comments on regional character

Mount Goodenough strata have been mapped throughout the northern Yukon and adjacent Northwest Territories (Norris, 1981a-g, 1982), and include beds that Norris (1981f, 1982) misidentified as the older Biederman Argillite (map unit KBI) in the Ogilvie Mountains. The twofold division seen in the Aklavik Range is not always apparent in other areas.

A basal sandstone facies is present in some areas, especially on or adjacent to tectonic highs, such as the Romanzof Uplift, Cache Creek High, and Eskimo Lakes Arch. However, in most areas, shale rests directly on older strata. Where a thick succession of

Figure 17. Erosional nature of the Mount Goodenough/Rat River contact in the Mount Goodenough area. Located at Jimmy Creek, at the north end of the Mount Goodenough massif. 1, Mount Goodenough Formation; 2, Rat River Formation. Although the discordant relationships may not be apparent on the photograph, a ground check showed that the contact is erosional. ISPG photograph 2846-4.

Kamik strata underlies the Mount Goodenough Formation, any basal sandstone present usually cannot be differentiated from the Kamik sandstone; consequently, the base of the formation is chosen at the shale-on-sandstone contact, which is generally abrupt. Although the upper contact with the Rat River Formation at Mount Goodenough is abrupt, elsewhere it is generally transitional (Fig. 18).

Depositional setting

The lower member of the type section is shale-dominant and contains marine bivalves, belemnites and ammonites, features that indicate marine shelf deposition. Only minor amounts of silt to very fine sand are present in these lower beds, suggesting that high-energy depositional conditions rarely impinged on the shelf. However, the upper member contains more numerous sandstone interbeds, the first influx of sand is marked by two very prominent coarsening-upward units. These latter units are characterized by hummocky cross-stratified beds considered to be storm-generated structures. The coarsening-upward units show no evidence of deposition within the fairweather wave zone; they are interpreted as deposits of the lowermost shoreface or offshore bars.

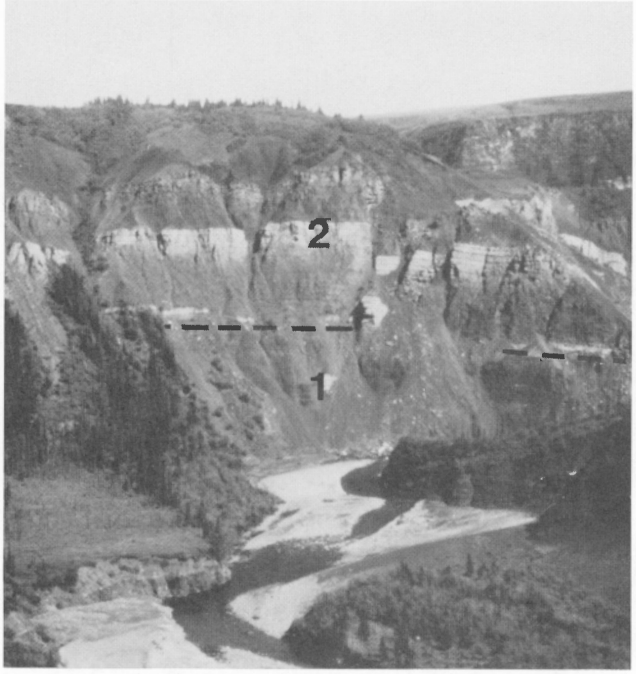


Figure 18. Coarsening-upward cycles in the Rat River Formation and a transitional contact between Mount Goodenough (1) and Rat River (2) strata. Section DFA87-19, Fish River, northern Richardson Mountains. ISPG photograph 2236-2.

The depositional setting for the type section is typical of much of the exposed Mount Goodenough Formation in the northern Richardson Mountains (Dixon, 1986). The paleoshoreline was to the southeast, possibly only a few tens of kilometres from Mount Goodenough.

Age

Macrofossils in Mount Goodenough strata are generally not very common, but foraminifers can be very abundant. Jeletzky (1958, 1960, 1961, 1971b) identified a number of assemblage zones in the Mount Goodenough Formation (see Figure 1), principally from the type area and environs, which were interpreted as indicating an age range of late Hauterivian to late Barremian for the formation. The megafossils consist mostly of ammonites and belemnites, with some bivalves. Jeletzky identified the following macrofossils from his section on Mount Goodenough (see Appendix 3):

Crioceras (*Hoplocrioceras*) cf. *remondi* (Gabb)
Crioceras (*Shasticrioceras*) sp. indet.
Crioceratites (*Emericiceras*) cf. *emerici* (Leveille 1837)
Acroteuthis-like belemnites
Acroteuthis sp. indet. (cf. *A. subquadratus* Roemer)
Oxyteuthis-like belemnites
Oxyteuthis sp. indet.
Oxyteuthis? sp. indet.
Oxyteuthis cf. *pugio* Stolley var. *rimata* Stolley
Pleuromya sp. indet.
Inoceramus sp. indet.
Dentalium
Modiolus sp. indet.
Oxyteuthis cf. *jasikowi* (Lahusen)

Fowler (1985) recognized several foraminiferal zones within the Mount Goodenough succession that have been useful for regional identification and correlation of Mount Goodenough strata, although the age designations are based on macrofossils. Pocock (1976) published some preliminary data on the palynomorphs from Mount Goodenough strata, and Brideaux and Myhr (1976) and Brideaux (1976) published information on Jurassic–Cretaceous dinoflagellates and palynomorphs from the succession in the Parsons N-10 well in the nearby subsurface of Tuktoyaktuk Peninsula.

RAT RIVER FORMATION

Description of type section

The name Rat River Formation is intended to replace the informal name, Upper Sandstone Division (Jeletzky, 1958, 1960; Fig. 1). The type section is along Rat River, on the east bank of the western reach of a prominent big bend (Figs. 19-21; Dixon's field section DFA89-9 and Jeletzky's sections JA-58-52 and JA-58-54, Appendix 4). The section is located on a river bluff approximately one kilometre north of the river bend. Strata are exposed at river level and the section was measured up a small gully to near the top of the plateau (Fig. 21; latitude 67°38′N, longitude 135°30′30″W; UTM grid reference: map 106 M/12, ML785034, map scale 1:50 000). At the type section the strata dip very gently to the northwest. Exposure is good on the cliff face but access to the best exposures is not always possible. Falling debris is a significant hazard at the base of the cliff and loosely cemented or unconsolidated sand makes climbing difficult. The section appears to be approximately the same as that measured by Jeletzky (section JA-58-52), although the uppermost beds of his section were measured slightly farther upstream in a more prominent gully (section JA-58-54).

The type section does not contain the lower contact with the underlying Mount Goodenough Formation, although 35 km to the north, in the Mount Goodenough area, the lower contact is abrupt (see previous discussion of Mount Goodenough Formation). At section DFA89-9, the overlying beds are Pleistocene gravels, but a few hundred metres farther upstream there is a section in which a thin interval of shale abruptly overlies the uppermost beds of the Rat River Formation (Jeletzky's section JA-58-54; Fig. 20). The shale is in turn overlain by Pleistocene gravel. Jeletzky (unpublished manuscript) correlated the overlying shale with the Boundary Creek Formation (Cenomanian – Turonian), based on its lithological character, but this was not supported by any paleontological data. South of Rat River, at Stony Creek, the Rat River Formation is abruptly overlain by shale and siltstone of the upper Aptian/lower Albian Martin House Formation. It seems more reasonable to assume that the shale at the Rat River locality is also part of the Martin House Formation.

Dixon measured about 105 m at the type section and Jeletzky identified another seven metres up to the base of the overlying shale unit. Very fine to fine grained sandstone is the dominant rock type, with subordinate amounts of coarser sandstone and shale. Ironstone concretions are common in both shale and sandstone units. The sandstones are generally weakly cemented with local, well cemented patches (usually in association with ironstone concretions). Three coarsening-upward cycles can be recognized at the type section (Figs. 20, 21). The basal beds of each cycle consist of either thin bedded sandstone or interbedded shale and sandstone resting abruptly on strata of the preceding cycle. These basal beds are gradationally succeeded by a sandstone-dominant interval. Bioturbation, subparallel laminae, wave and/or current ripple laminae and hummocky cross-stratification are present in the sandstone beds. Abundant fossilized wood was noted in the talus and is presumed to have eroded from Rat River strata. Bivalves are locally abundant, occurring as coquina in some beds. Some poorly preserved ammonite fragments have been observed.

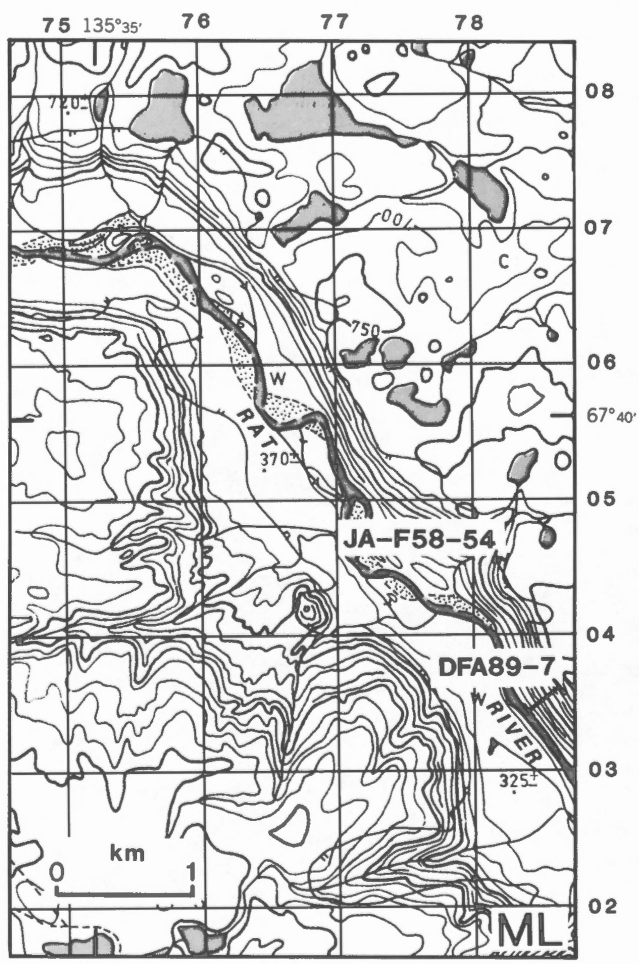


Figure 19. Detailed location map of the Rat River Formation type section. Numbers on the map's margins are part of the UTM grid system.

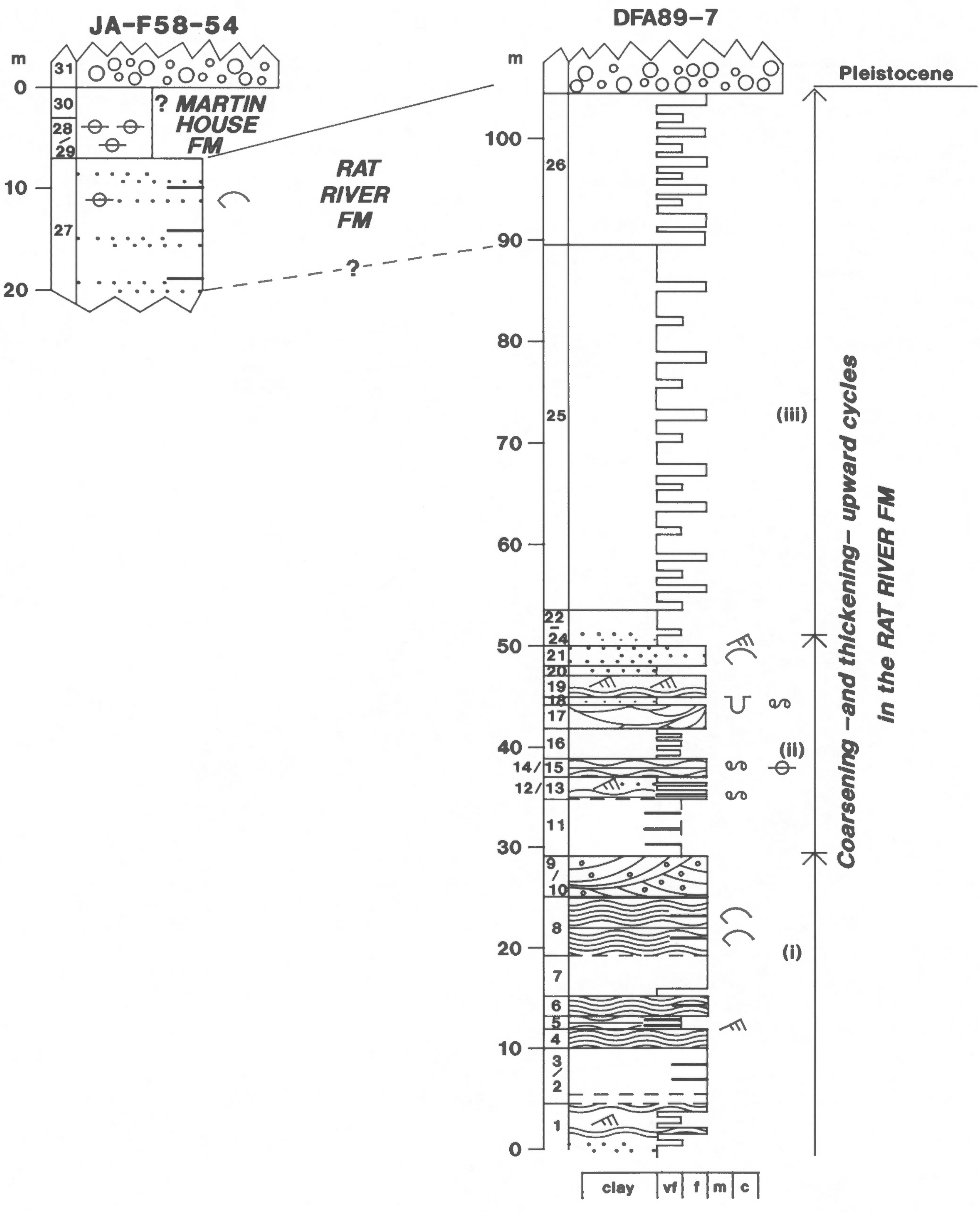


Figure 20. Graphic representation of Rat River Formation type section. Sections DFA89-7 and JA-F58-54. See Figure 6 for legend.

General comments on regional character

Rat River strata are present throughout the northern Richardson Mountains (Norris, 1981a-e) and in the subsurface of southwestern Mackenzie Delta (Dixon et al., 1989). Norris (1981c, g, 1982) mapped the unit in the northern Ogilvie Mountains and Keele Range. However, Dixon (1986b) pointed out that most of the strata mapped by Norris are, in fact, Albian Sharp Mountain Formation, although the correlation of some strata remains uncertain. Coarsening-upward cycles seen in the type area are also present in other areas but become more pronounced to the west and northwest, where the sandstone intervals in the cycles are separated by much thicker shale intervals (Fig. 18). Rat River strata have not been recognized west of Blow River, in part due to pre-Albian Flysch erosion (Young, 1974), and possibly because of a westerly shale-out trend.

With the exception of the Mount Goodenough area, the lower contact is transitional with underlying shales of the Mount Goodenough Formation. On the east flank of the northern Richardson Mountains, Rat River strata are abruptly overlain by the Martin House Formation. However, throughout most of the outcrop belt of the eastern flank of Richardson Mountains, Rat River beds are the youngest Mesozoic beds exposed. On the east flank of the Blow River valley, the uppermost beds of the Rat River Formation are mostly shale with thin sandstone interbeds, and are abruptly overlain by black shale of the Albian Flysch succession. The contrast between the two shaly units is very apparent in outcrop: Rat River shales are a dull grey and tend to weather into small blocky fragments, whereas the Albian shales are much darker, tend to weather into "pencil-shale" fragments, and have a distinct metallic blue or rusty hue.

Figure 21. Type section of the Rat River Formation (DFA89-7). Three coarsening-upward cycles are identified (i to iii). P, Pleistocene gravels. Spliced ISPG photographs 3299-28 and 29.

Depositional setting

An abundance of bivalves and a lesser number of ammonites attest to the marine origin of the Rat River strata. Sedimentary structures are dominated by hummocky cross-stratification, wave and current ripples and bioturbated horizons, features that suggest deposition in a storm-influenced setting. A lack of large-scale, unidirectional sedimentary structures and the common occurrence of interbedded shales and bioturbated beds suggest deposition below fairweather wave-base, probably on the lower shoreface. The Rat River locality was probably close to the Early Aptian paleoshoreline, a conclusion consistent with the sandstone-dominant succession at the type section. The presence of three coarsening-upward cycles within the type section indicates that there were at least three progradational phases of deposition, although there may have been more—the base of the section is not exposed.

Age

Rat River strata do not contain many age-diagnostic macrofossils, although a few ammonites, belemnites and bivalves suggest a latest Barremian to Aptian age (Jeletzky, 1958, 1960, 1961, 1971b). Jeletzky (see Appendix 4) identified the following fossils from the type area:

Tropaeum-like ammonites
Tropaeum n. sp. aff. *arcticum* (Stolley)
Tropaeum undatum Whitehouse 1926
?*Tropaeum* sp. indet.
Pecten (*Entolium*) n. sp. A
Acroteuthis cf. *kernensis* Anderson 1938
Acroteuthis mitchelli Anderson 1938
Astarte n. sp. aff. *cantabrigiensis* Wood
Aucellina cf. *caucasica* (von Buch)
Aucellina ex. gr. *caucasica* (von Buch)
Aucellina ex. gr. *aptiensis-caucasica*

In the vicinity of Vittrekwa River, an ammonite fragment collected from the upper part of the Martin House Formation was identified as either *Pachygrycia* or *Cyamhoplites* and indicates an earliest Albian age (Jeletzky, unpublished data). Mountjoy and Chamney (1969) reported a late Aptian/Early Albian age for the type section of the Martin House Formation, based on foraminifers. Palynomorphs and dinoflagellates from the Martin House Formation, although not age-definitive, favour a late Aptian to early Albian age span (H. Nohr-Hansen, pers. comm., 1989). The apparent age of the Martin House Formation restricts the youngest age of Rat River strata to the Aptian, and probably only the early Aptian.

Foraminifers from Rat River strata are similar to those of the Mount Goodenough Formation and, at present, are not considered age-diagnostic (Fowler, pers. comm.).

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APPENDICES 1-4

Description of type sections

Descriptions from both Dixon and Jeletzky are included for comparison. The descriptions of Jeletzky were obtained from his unpublished manuscript. They have been edited and modified to conform with the stratigraphic identifications set forth in this publication.

It will be apparent from the styles of description and emphasis that the two authors view the rocks from different perspectives. There are parts that appear to conflict, and these have been deliberately left in the text, allowing the reader to make his/her own judgement.

APPENDIX 1

Type section of the Martin Creek Formation

Dixon's sections DFA81-2 and -1 (base-to-top order) are successional, but the amount of physical separation was not measured because of access difficulties. The cumulative thickness of 75.2 m is incomplete—there are probably an estimated 20 to 30 m more strata between the two measured sections. Although Jeletzky's section JA-F71-7 is given as a continuous description, it was measured with a number of traverse offsets; consequently, thickness errors may have accumulated in the measurements.

SECTION DFA81-2

Location: Martin Creek canyon, northern Richardson Mountains, Northwest Territories. Measured on south side of valley, approximately 700 to 800 m east of canyon entrance.

Latitude: 68°12′13″N, longitude: 135°35′52″W
NTS: 107 B/4 UTM: ML753657 (1:50 000)
Dip: about 10° NE
Formations: Husky, Martin Creek.
Section described from base to top.

Unit	Description	Thickness (m)	Total above base (m)
	Husky Formation		
1	**Interbedded sandstone and mudstone:**		
	Mudstone: silty and sandy, carbonaceous; dark grey to bluish black; bioturbated		
	Sandstone: very fine grained, argillaceous; plane, ripple, and wavy laminae; 5-50 mm thick beds; small ripples on bedding surfaces are very common; a few bivalve shells noted; some bioturbed beds		
	Sample 81-2-1 (mudstone sample)	1.5	1.5
2	**Sandstone:** fine to medium grained; sets of low-angle, wedge-shaped cross-strata (?HCS) separated by ripple laminated argillaceous sandstone or bioturbated sandstone; stratified beds 28-45 cm thick; bioturbated/rippled sandstone beds 3-5 cm thick; a few vertical burrows present; abundant oxidized plant material; abrupt basal contact	3.0	4.5
3	**Interbedded mudstone and sandstone:**		
	Mudstone: very silty; contains bivalves		
	Sandstone: very fine to fine grained; beds a few cm thick with abrupt basal contacts and abrupt or gradational tops; unit 3 abruptly overlies unit 2		
	Sample 81-2-2 (mudstone)	2.5	7.0
4	**Interbedded sandstone and mudstone:** (gradational change from unit 3)		
	Sandstone: very fine to fine grained; 15-36 cm thick beds containing very low-angle intersecting laminae sets and ripple laminae; ripple laminae commonly argillaceous; bivalves present		
	Units 3 and 4 part of an overall coarsening- and thickening-upward cycle	1.7	8.7
5	**Mudstone:** abruptly overlies unit 4; contains very thin (<1 cm) beds of very fine grained sandstone and/or siltstone	0.3	9.0
	Martin Creek Formation		
6	**Sandstone:** very fine to fine grained; contains a few thin mudstone laminae in basal part of unit; plane, undulose and ripple laminae in lower part of unit grading up into large-scale, low-angle cross-stratification; rich in carbonaceous debris	1.0	10.0

Unit	Description	Thickness (m)	Total above base (m)
7	**Sandstone:** fine grained, cliff forming; shallow, trough-like cross-stratification that could be swaley bedding; abundant bivalve shell debris in the trough axes; most shells are convex-up		
	At several levels there are beds of finely laminated, argillaceous sandstone and thin, discontinuous mud beds that appear to fill some troughs.	18.0 (est.)	28.0
8	**Sandstone:** fine grained; rusty coloration; weathers into rubbly fragments; contains large, vertical, internally laminated burrows; some bivalves present.	2.0 (est.)	30.0

End of section.

SECTION DFA81-1

Location: Martin Creek canyon, northern Richardson Mountains, Northwest Territories. South side of valley. Approximately 600 to 700 m downstream from section DFA81-2. Access is from the valley rim through one of the few accessible gullies that lead into the canyon. Measurements begin at lowermost outcrop on valley slope. Stratigraphic separation between sections 81-1 and 81-2 not known.

Latitude: 68°11′56″N, longitude: 135°34′58″W
NTS: 107 B/4 UTM: ML759652
Dip: about 10° NE
Formations: Martin Creek, McGuire

Martin Creek Formation

Unit	Description	Thickness (m)	Total above base (m)
1	**Sandstone:** fine to medium grained; yellow to reddish orange weathering; friable to moderately well cemented; large-scale, low-angle cross-stratification	7.0	7.0
2	**Sandstone:** part of a coarsening- and thickening-upward cycle; rests abruptly on unit 1; basal part consists of 1.5 m of fine grained, argillaceous sandstone, which is, for the most part, thoroughly bioturbated with some recognizable burrows and locally preserved ripple and horizontal laminae		
	Upper 70 cm contains low-angle cross-stratification and vertical burrows (especially abundant in upper few cm)	2.2	9.2
3	**Sandstone:** coarsening- and thickening-upward cycle; rests abruptly on unit 2; basal 80 cm consists of burrowed to thoroughly bioturbated, very fine grained sandstone; gradational to abrupt change into stratified fine to medium grained sandstone; low-angle cross-strata		
	Contains a thin bed of micro-trough crosslaminae (current ripple lamination)	1.9	11.1
4	**Sandstone:** fine grained; abruptly overlies unit 3; basal 1.5 m consists of alternating beds of bioturbated and crosslaminated sandstone (10-50 cm thick beds); grades up into a 1.8 m thick, resistant, fine to medium grained sandstone that contains low-angle cross-stratification and a few subvertical burrows	3.3	14.4
5	**Sandstone:** fine grained; carbonaceous; red weathering; recessive, poorly exposed; rests abruptly on unit 4; low-angle cross-stratification; ripple laminae and one bed of medium-scale trough crossbedding about 8.4 m above base of unit; some bioturbated beds; tracks and trails common	11.6	26.0
6	**Sandstone:** fine to medium grained; planar cross-stratification in thick beds; forms a resistant ledge	1.5	27.5
7	**Sandstone:** fine grained; slightly recessive weathering; small-scale cross-stratification; ripple and plane laminae	0.8	28.3
8	**Sandstone:** fine to medium grained; low-angle, wedge-like cross-stratification (?HCS); a few, scattered bivalves; resistant weathering, ledge-forming; apparent gradational basal contact	1.2	29.5

Unit	Description	Thickness (m)	Total above base (m)
9	**Sandstone:** poorly exposed; basal few cm contain ironstone concretions; upper few metres are a ledge-forming, crossbedded (low-angle, wedge-like) sandstone; abrupt basal contact	8.0	37.5
10	**Sandstone:** poorly exposed; platy weathering	2.7	40.2
11	**Sandstone:** fine grained; hummocky cross-stratified	2.0	42.2
12	**Sandstone:** recessive weathering; rust coloured	12.0	54.2
	McGuire Formation		
13	**Shale:** black; very soft and friable; poorly exposed, upper and lower contacts covered by talus but can be dug out		
	Prominent concretions, 15 cm in diameter, occur about 4 m above base of formation.		
	Samples 81-1-3 to 6	17.5	71.7

Section continues into overlying Kamik Formation.

Comment: the wedge-like cross-stratification is most likely hummocky cross-stratification (HCS) and/or swaley cross-stratification. In other parts of the Martin Creek canyon and in "Grizzly Gorge", a few kilometres to the north, HCS and swaley beds were readily identified. Throughout the occurrence of Martin Creek strata, HCS is a very common sedimentary structure.

SECTION JA-F71-7

Location: Martin Creek canyon, northern Richardson Mountains, Northwest Territories. South side of valley. Section about 3 km west of junction with Willow River.

Latitude of base of section: 68°12′09″W
Longitude of base of section: 135°35′00″

Unit	Description	Thickness (m)	Total above base (m)
	Husky Formation		
1	**Interbedded sandstone and siltstone:** approximately 80-85% sandstone; very fine to fine grained; friable to moderately hard; buff coloured; thin beds of cross-stratified and laminated sandstone		
	Sample JA-F71-7/20: collected from 2.5-10 cm thick coquina present 30-45 cm below top of unit		
	Sample contains: *Buchia* n. sp. aff. *volgensis* Jeletzky 1964 (prevalent species)		
	B. aff. *keyserlingi (Lahusen)* *B. keyserling* var. *visiginensis* (Sokolov)	4.0	4.0
2	**Siltstone:** friable to moderately hard; locally sandy; especially in lower half of unit; dark grey; thin to medium beds (15-60 cm thick); some massive looking beds; 10-15% interbedded, very fine grained, crossbedded and laminated sandstone; gradational change from unit	3.0	7.0
3	**Interbedded sandstone and siltstone:** very fine to fine grained sandstone; buff coloured; friable to very hard; thinly bedded, laminated and crossbedded; 15-20% siltstone interbeds; gradationally overlies unit 2		
	Sample JA-F71-7/19 contains a few specimens of juvenile *Buchia* sp.		
	Traverse moved about 120 m upstream along base of cliff to a deep ravine.	4.0	11.0
	Martin Creek Formation		
4	**Sandstone:** very fine to fine grained; friable to moderately hard; dull brown to brownish grey on fresh surface, weathers buff colour; several lenticular bands of ferruginous, chocolate coloured sandstone (up to 9 m long and 7 cm to 1 m thick); mostly thick bedded (1-3 m) but with some local thin and medium beds; some crossbedding; gradational lower contact		
	About 6.5 m below the top there is a thin (2-3 cm) bivalve coquina. Other coquina layers were noted along the cliff face.	9.5	20.5

Unit	Description	Thickness (m)	Total above base (m)
5	**Sandstone:** very fine to fine grained; friable to unconsolidated; medium orange with some dark grey laminae and interbeds on fresh surface; weathers light orange to buff coloured; pods and lenses (up to 1.5 m long) of medium-brown, rust-weathering, ferruginous sandstone; basal contact abrupt and uneven	7.5	28.0
6	**Sandstone:** very fine to fine grained; somewhat friable; mottled medium and dark brown on fresh surfaces; weathers dirty white; indistinctly and irregularly bedded; lower contact viewed from distance appears to be abrupt; contains numerous carbonaceous inclusions	5.0	33.0
7	**Sandstone:** very fine to fine grained; weathers dull brown; darker brown on fresh surface; friable, recessive; gradational from underlying unit	25.5	58.5
8	**Sandstone:** very fine grained; light brownish grey when fresh, weathers light rust; resistant; large-scale crossbeds with dips of 15 to 20° to east and west; also present are indistinctly laminated, thin beds; 1-1.5 m below top of unit is a 12-15 cm thick layer containing bivalves, most of which are ***Buchia*** n. sp. aff. *volgensis* Jeletzky 1964 (sample JA-F71-7/17); same species collected from a layer in basal 15 cm of unit (sample JA-F71-7/18)	2.5	61.0
9	**Sandstone:** very fine grained; cream to whitish grey weathering; some rust coloured layers/beds; abrupt basal contact; similar to units 10 and 11; a few specimens of ***B.*** n. sp. aff. *volgensis* Jeletzky 1964 collected	9.0	70.0
10	**Sandstone:** very fine grained; quartzose; dark brown-grey on fresh surfaces, dull rust-brown weathering; thin laminae of dark rust-brown sandstone; friable; abrupt lower contact; forms depression between units 9 and 11	1.0	71.0

Unit	Description	Thickness (m)	Total above base (m)
11	**Sandstone:** very fine to fine grained; moderately well cemented; resistant; crossbedded and ripple bedded; 1.5 to 1.7 cm beds separated by thick (45 cm) beds or thin layers of friable, dull to dark brown sandstone; gradational base; ***B.*** n. sp. aff. *volgensis* Jeletzky 1964 collected 30-45 cm below top of unit	5.5	76.5
12	**Sandstone:** very fine grained; buff to whitish grey fresh surface, weathers mottled white and rust; friable; thinly bedded, crossbeds and ripple laminae; burrowed; abrupt base	2.0	78.5
13	**Sandstone:** very fine grained; brown-lavender colour on fresh surface, weathers mottled cream and pale orange, basal 30 cm dull brown and contains carbonaceous smudges; friable; irregularly bedded; contains burrows and trails	5.5	84.0
14	**Sandstone:** very fine grained; varicoloured in shades of orange, brown, rust and white; forms resistant bench; capped by a 5 to 7.5 cm ripple bedded ironstone; extensively crossbedded and ripple bedded Between 9 and 17.5 m within the unit the sandstone is less indurated and contains 5 to 15 cm thick lenticular bands and rows of flattish ironstone. Also contains 0.6-1.2 m thick interbeds of sandy siltstone Bivalves collected from intervals 4.5 m, 5.5-5.8 m, 7.5-8 m and 18-18.6 m below top of unit. Samples contain ***B.*** n. sp. aff. *volgensis* Jeletzky 1964 and ***B.*** *keyserlingi*-like shells Shells are generally disarticulated, commonly fragmented and lie parallel to bedding planes	21.5	105.5

Unit	Description	Thickness (m)	Total above base (m)
15	**Sandstone:** very fine to fine grained; dull brown, weathers whitish brown; friable to unconsolidated; in lower 60 cm contains 6 to 25 mm thick layers of chocolate coloured carbonaceous siltstone; abrupt, uneven lower contact	1.5	107.0
16	**Sandstone:** very fine to fine grained; fresh surfaces light lavender-grey to lavender-cream, weathers mottled buff and bright orange; generally haphazard degrees of cementation: very friable to moderately well cemented, although better cemented sandstone more prevalent in upper 30-90 cm; 1 to 5 cm thick beds; laminated to crossbedded (crossbeds dip to both west or east at 15-25°); ripple marks are wide, subsymmetrical and large (15-45 cm wavelength); contains a few, poorly preserved *Pholadomya*-like bivalves—no collections made; lower contact gradational	4.5	111.5
17	**Interbedded/interlaminated sandstone and siltstone:** grey, dull brown and white; recessive weathering		
	Sandstone: very fine to fine grained; friable; locally contains grit and very small pebbles; 2.5 to 30 cm thick beds containing cross-stratification and ripple marks; some burrows, locally preserved wood fragments in some sandstone beds		
	Siltstone: very sandy; fewer sandstone interbeds in lower part of unit; ironstone concretions; gradational top; base marked by a laterally impersistent ironstone band		
	Sample JA-F71-7/9, from 1.5 m below top of unit, contains poorly preserved bivalves resembling *Buchia* n. sp. aff. *volgensis* Jeletzky 1964.		
	Sample JA-F71-7/10, from 4-4.5 m below top, contains bivalves transitional between *B.* n. sp. aff. *volgensis* Jeletzky 1964 and *B. keyserlingi* (Lahusen), specimens resembling *B.* n. sp. aff. *volgensis* Jeletzky 1964, and other unidentified bivalves		
	Sample JA-F-71-7/11, from 7-7.2 m below top, contains *B.* cf. *keyserlingi*	9.0	120.5
18	**Sandstone:** very fine to fine grained; varicoloured—white, rust-brown, grey, orange; friable to unconsolidated with lenses and pods of well cemented sandstone; crossbedded and ripple bedded; local burrows; scattered ironstone concretions		
	Sample JA-F71-7/6, from 60 cm below top, contains a single right valve of *B.* cf. *keyserlingi* (d'Orbigny)		
	Sample JA-F71-7/7, from 3-3.5 m below top, contains *Camptonectes* (s. l.), *Pholadomya* sp., ?*Thracia* (s. l.), and a few specimens of *B. keyserlingi* (Lahusen)		
	Sample JA-F71-7/8, from 4.5-5 m below top, contains *B. keyserlingi* (Lahusen) and a few forms resembling *B.* n. sp. aff. *volgensis* Jeletzky 1964		
	Traverse moved about 215 m upstream	5.0	125.5
19	**Interbedded sandstone and siltstone:** brownish grey; poorly exposed; friable with local ironstone-cemented lenses and pods of sandstone/siltstone; thin bedded to laminated sandstone		
	Sample JA-F71-5A, from ironstone debris, contains *B. keyserlingi* (Lahusen) and *B. inflata* (Toula)	13.5	139.0

Unit	Description	Thickness (m)	Total above base (m)
	McGuire Formation		
20	**Shale:** silty-sandy; black when fresh; weathers dull grey to bluish black; very friable, weathers recessively; contains several intervals of ironstone concretions (0.3-1.5 m long); 5 to 5.5 m below top of formation is a gritty to pebbly, fine grained sandstone containing coaly plant material; gradational basal contact (15 cm thick sandy siltstone)		
	Sample JA-F71-/4, from the upper 3 m contains *Acroteuthis* ex. gr. *arcticum* Bluthgen, *B.* cf. *keyserlingi* (Lahusen), and other bivalves		
	Sample JA-F71-7/5, from a layer of ironstone concretions 14 m below top of formation, contains bivalves from the *B. keyserlingi* (Lahusen)—*B. inflata* (Toula) fauna.	17.5	156.5

Section continues into overlying strata.

Comment by J. Dixon: Jeletzky's observation that McGuire strata gradationally overlie Martin Creek beds is difficult to reconcile with observations at other nearby localities where the contact is everywhere abrupt. At Martin Creek the contact is commonly covered by loose sand and shale, and a clean, exposed contact is difficult to find.

APPENDIX 2

Type section of the McGuire Formation

Sections DFA82-8 and JA-F59-138 were measured in approximately the same place; however, different thicknesses were recorded by the two authors. Dixon's measurements are considered more accurate. In Jeletzky's unpublished manuscript he included a siltstone (his unit 1) in the basal beds of the McGuire Formation, which Dixon considered to be lithologically more akin to Martin Creek strata, to which he has reassigned it. Jeletzky also described the contact between the siltstone unit (unit 1) and the overlying shale (unit 2) as gradational, whereas Dixon observed an abrupt, planar contact.

SECTION DFA82-8

Location: 4 km north-northeast of Mount McGuire, Richardson Mountains, northern Yukon Territory. Section measured up a prominent gully on the east side of a north-northeast trending ridge. The section appears to be in exactly the same location as Jeletzky's section JA-F59-138.

Latitude: 67°57′N, longitude: 137°20′W
NTS: 116 P/14 UTM: ML032409
Dip: 45°W Strike: 020°
Formations: Martin Creek, McGuire and Kamik

Unit	Description	Thickness (m)	Total above base (m)
	Martin Creek Formation (strata below unit 25 are part of the Martin Creek and upper Husky formations)		
25	**Sandstone:** very fine grained; thin bedded with shaly partings; possibly bioturbated; uppermost bed iron stained	5.5	151.3
	McGuire Formation		
26	**Shale:** black, fissile in basal 150 m, gradually becoming siltier and less fissile; about 200 to 240 m above base of formation, section becomes sandier, containing beds of argillaceous, silty, rust-coloured, bioturbated, very fine grained sandstone and intercalated sandy-silty shale; uppermost 5 m consists of thin sandstone beds separated by shaly partings; these uppermost sandstone beds contain hummocky cross-stratification, swaley stratification and ripple laminae (symmetric ripples); abrupt basal contact; gradational upper contact		
	Samples (collected mostly for study of microfossils):		
	82-8-4, from immediately above lower contact		
	82-8-5, 15 to 17.5 m above base of formation		
	82-8-5A, from same as #5 but contains macrofossils identified as either *Buchia keyserlingi* (Lahusen) s. l. or *Buchia* ex. gr. *inflata-sublaevis* (fossils identified by Jeletzky, pers. comm. 1983)		
	82-8-6, 45 m above base of formation		
	82-8-7, 120 m above base of formation		
	82-8-8, 195 m above base of formation		
	82-8-9, 240 m above base of formation	264.0	415.3
	Kamik Formation		
27	**Sandstone:** very fine to fine grained in the beds immediately above the McGuire Formation.	270-300 (est.)	

End of section.

SECTION JA-F59-138

Location: middle part of the eastern slope of an approximately 1450 m high ridge 5 km north-northeast of Mount McGuire, Yukon Territory.

Latitude: 67°58′30″N, longitude: 137°18′W

Unit	Description	Thickness (m)	Total above base (m)
	Martin Creek Formation		
1	***Siltstone:** dark grey to black and bluish tinged on fresh surface; weathers brown grey; locally sandy; friable to chippy weathering; 15-25 cm thick interbeds of sandy siltstone and very fine to fine grained silty sandstone; grades down into Martin Creek strata; contains *Buchia* cf. *keyserlingi* (Lahusen) s. str., undetermined bivalve species and belemnites (*Jeletzky intended this unit to be included in the McGuire Formation, but its lithology is more akin to the Martin Creek Formation in which Dixon has placed it.)	5.0	5.0
	McGuire Formation		
2	**Shale:** dark to bluish grey and mottled on fresh surfaces; weathers brown-grey; locally silty; friable to chippy weathering, becomes more rubbly-weathering upsection; in lower 45 m there are numerous 13 to 15 cm thick bands and layers of ironstone concretions; ironstones become less common upsection; gradational lower contact Talus at 0.3 to 20 m above base include the bivalve *B.* cf. *keyserlingi* (Trautschold), and from 30.5 to 46 m above base *Polyptychites*. ex. gr. *keyserlingi* (Neaumayr and Uhlig), *B. keyserlingi* (Trautschold), *B.* aff. *crassa* (Pavlow), and other bivalves At 68 m above the base a single, in situ specimen of *B.* cf. *keyserlingi* was collected	106.0 (approx.)	111.0
3	**Sandstone:** very fine grained; silty; dark to bluish grey on fresh surfaces; weathers mottled brown-grey and rusty; grades up from sandy siltstone into interval of interbedded siltstone and 'cleaner' sandstone; indistinctly bedded except in upper 4 to 4.5 m; gradational lower contact.	18.0	129.0
	End of section.		

APPENDIX 3

Type section of the Mount Goodenough Formation

Dixon's section DFA89-9 is the chosen type section; Jeletzky's section 16 is given for comparison.

SECTION DFA89-6 (J.Dixon)

Location: east face of Mount Goodenough, Aklavik Range. Section begins in a gully that has an ephemeral stream flowing into a series of small lakes at the foot of the slope. The lakes nestle among some low mounds that have been interpreted as defunct pingos. Measured upslope along a spur on south side of gully.

Latitude: 67°56′50″N, longitude: 135°24′30″W
NTS: 106 M/14 ML828365 (base) ML822367 (top) (1:50 000)
Dip: near horizontal to slight westerly
Formations: Husky, Mount Goodenough and Rat River
Description is from base to top.

Unit	Description	Thickness (m)	Total above base (m)
Husky Formation			
1	**Interbedded shale and sandstone:** rusty reddish brown because of the presence of iron oxides; generally more shale than sandstone; sandstone in beds up to 40 cm thick, very fine to fine grained, burrowed to thoroughly bioturbated; uppermost bed is a 40 cm thick bed of bioturbated sandstone		
	Sample 89-6-1	not measured	
Mount Goodenough Formation			
2	Concretionary shale: rusty red-brown colour as a result of an abundance of ironstone concretions; shale almost completely replaced by ironstone; highly shattered appearance; rests abruptly on underlying beds		
	Sample 89-6-2 approx. 50 cm above base of unit 2	2.2	2.2
3	**Shale and concretions:** black shale with three prominent ironstone concretion layers		
	Sample 89-6-3 from about 50 cm below top of unit	1.5	3.7
4	**Shale:** black; fissile to soft; contains abundant but widely spaced layers of ironstone concretions		
	First 42 m have a brownish surface hue, whereas above this the shale is black. The brownish hue is due to presence of iron carbonate dispersed within the shale.		
	Samples 89-6-4 to 89-6-14 collected every 6 m, beginning at base of unit	86.0	89.7
5	**Shale:** black; fissile; interbedded with at least five silty to sandy shale/mudstone units that form slightly more resistant, 1-2 m thick ledges; ironstone concretions common throughout the unit		
	Samples 89-6-15 to 89-6-21 every 6 m beginning 6 m above base of unit		
	Sample 89-6-22 from 96 m above base of unit 5	138.0	227.7
6	**Interbedded shale and sandstone:** arranged in two coarsening-upward cycles, and forming a prominent lower cliff below the main cliff at the top of Mount Goodenough massif; estimated 50-60% of beds are shale, remainder sandstone; lower cycle estimated to contain 5-6 m of interbedded shale and sandstone; upper cycle has a thin, shale-dominant basal part (about 1 m), overlain gradationally by interbedded shale and sandstone and capped by predominantly sandstone with partings and thin beds of shale		
	Sandstone: thin beds up to 50 cm thick; bioturbated or finely laminated (very low angle intersecting laminae – ?HCS) and current-ripple laminae	20.0 (est.)	247.7

Unit	Description	Thickness (m)	Total above base (m)
7	**Interbedded shale and sandstone:** mostly shale with thin to thick sandstone interbeds (1-5 m thick)		
	Access was difficult to dangerous along line of section, therefore this part was only viewed from below and thickness estimated	40-60	287.7-307.7
Rat River Formation			
8	**Sandstone:** forms prominent cliff at top of slope; not observed directly at this site because of access difficulties		
	Equivalent strata examined at Jimmy Creek (see Dixon's field notebook #6, p. 6, 1984): **sandstone:** very fine to fine grained; hummocky cross-stratified; contact with underlying unit 7 is abrupt, and at Jimmy Creek can be seen to be a large, shallow scour.	not measured	

Jeletzky's (1958) Field Section #16

Location: A prominent spur on Mount Goodenough about 1.8 km north of Goodenough Creek.
Latitude: 67°56′N, longitude: 135°25′W

Unit	Description	Thickness (m)	Total above base (m)
Husky Formation			
1	**Siltstone:** sandy to very sandy; dark grey, weathers bluish grey with rusty specks; friable; locally grades into silty, fine grained sandstone; *Buchia* n. sp. aff. *volgensis* (Lahusen) collected 0.6 to 1.1 m above base of unit	1.5	1.5
2	**Siltstone:** whitish grey with rusty specks; similar to unit 1 but harder	2.1	3.6
3	**Ironstone:** weathers rusty red; gradational lower contact	0.15 (approx.)	3.75
Mount Goodenough Formation			
4	**Conglomerate:** fine to coarse pebbles; mostly chert; large pebbles poorly rounded, smaller ones better rounded; sizes range from 0.3 to 30 cm (most are 0.6 to 7.5 cm); matrix of rust to buff, medium to coarse grained sand or grit, and silt and clay; lower contact is an uneven erosional surface	0.15	3.9
5	**Shale:** locally silty to sandy; dark to blackish grey; soft, poorly exposed; contains ironstone concretions up to 1.5 m in diameter; first 9 m relatively poor in concretions, upper 6 m rich in concretions	15.0	18.9
6	**Siltstone:** sandy; green-grey; hard; thin bedded to massive appearance; locally replaced by ironstone concretions	0.15	19.05
7	**Shale:** similar to unit 5	4.5	23.55
8	**Ironstone:** grey on fresh surface, weathers rust; laterally persistent but locally grades into siltstone	0.3	23.85
9	**Sandstone:** very fine to fine grained; silty; bluish grey, weathers rusty grey; indurated and friable layers interfinger; contains fossil wood fragments	0.5	24.35
10	**Siltstone:** very sandy; locally grades into fine grained, silty sandstone; light to medium grey; contains ironstone concretions	1.2	25.55
11	**Interbedded sandstone and siltstone:** similar to unit 10; contains ironstone concretions	0.5	26.05
12	**Sandstone:** similar to unit 9; gradational upper and lower contacts; lateral thickness variable; macrofossils include: *Oxyteuthis* cf. *jasikowi* (Lahusen) and *Pleuromya* sp indet.	0.3	26.35
13	**Interbedded siltstone and sandstone:** sandy siltstone and shale-like sandstone; dark grey; similar to units 10 and 11; contains 7.5 to 12.5 cm thick concretions	2.5	28.85
14	**Siltstone:** sandy; grey to greyish black; friable; some minor concretions	2.0	30.85
15	**Ironstone:** brownish grey on fresh surfaces; weathers bright orange	0.3	31.15

Unit	Description	Thickness (m)	Total above base (m)
16	**Shale:** locally silty; blackish grey to dark grey; at 1.6-2 m grades up into siltstone; contains 5 to 10 cm thick concretion layers, largest measured concretion 2 m in diameter; fragments of *Oxyteuthis* sp. indet. and *Acroteuthis* sp. indet	6.0 (approx.)	37.15
17	**Ironstone:** dark grey, brown to rust coloured; laterally persistent	0.2	37.35
18	**Shale:** blackish grey, commonly weathers rusty to brownish grey; soft and flaky on weathered surfaces; a few silty/sandy horizons and/or siltstone beds; numerous ironstone concretion horizons, concretions up to 1.6 m in diameter, some have septarian appearance; some small (5-20 cm) marcasitic concretions; *Acroteuthis* sp. indet, *oxyteuthis* sp. indet. and *Modiolus* sp. indet. collected from middle part of unit	15.0	52.35
19	**Shale/siltstone:** silty, sandy; numerous ironstone concretions; top of unit placed at a 15-20 cm thick laterally persistent ironstone layer; *Oxyteuthis* cf. *pugio* (Stolley) var. *rimata* Stolley found in situ in lower part; *Acroteuthis* sp. indet. (cf. *A. subquadratus* Roemer?) and *Oxyteuthis*? sp. indet found in talus	25.0	77.35
20	**Siltstone:** dull grey to blackish grey; contains a few ironstone concretions; top of unit placed at a persistent row/layer of ironstone—some are marcasitic; one in situ specimen of *Oxyteuthis*-like belemnite found	19.5 (est.)	96.85
21	**Siltstone:** sandy; dark grey and dull grey, blackish tinge; similar to unit 20 although not as sandy; contains large septarian-like concretions, some laterally fused to form continuous layers 15 cm to 1.2 m thick	19.0 (est.)	115.85
22	**Siltstone:** very sandy, commonly grades into silty, very fine to fine grained sandstone; dark to blackish grey; yellowish grey pods, lenses, and 1-5 cm thick sandstone layers; concretions and concretionary layers throughout the interval, commonly spaced every 1 to 3 m; small cannonball size (5-15 cm) and very large concretions (up to 1 m); a few belemnite fragments seen	15.0	130.85
23	**Sandstone:** very fine to fine grained; dull grey to ash-grey; laminated to thin bedded, shale-like parting; commonly grades into and is interbedded with sandy siltstone; basal 1.6 to 2 m more resistant to weathering and forms a marked bench across the slope; concretions in upper part of interval, none in lower; *Dentalium* shells and fragments of *Inoceramus* shells present	4.5	135.35
24	**Siltstone:** similar to unit 22	7.5	142.85
25	**Sandstone:** fine grained; very silty; grey; interfingers with laminae and 7.5 to 10 cm thick layers of harder, grey to yellowish grey, silty, shale-like sandstone at 12.5 to 30 cm intervals; very few concretions; forms hogsback along the slope	2.1	144.95
26	**Siltstone:** very sandy; resembles unit 25 but is more friable	3.0	147.95
27	**Sandstone:** similar to unit 25; capped by ironstone concretions (0.6 to 1.6 m long, 0.3 to 0.5 m thick)	1.5	149.45
28	**Sandstone:** very fine grained; very silty; dull grey; concretions present	12.0 (est.)	161.45
29	**Shale:** silty to sandy; dark grey; concretions	7.5	168.95
30	**Shale:** similar to unit 29 but with regular intervals of interbedded, grey, sandy siltstone and lesser amounts of silty sandstone	16.5	185.55

Unit	Description	Thickness (m)	Total above base (m)
31	**Sandstone:** very fine grained; very silty; shale-like; dull grey; resistant; interfingers with sandy siltstone; two rows of concretions; forms prominent hogsback along slope, traceable for long distance	3.0	188.55
32	**Shale:** dark grey; friable; middle part only slightly silty/sandy but in basal and upper parts contains 0.6 to 1 m thick sandy siltstone beds	22.5	210.05
33	**Sandstone:** very fine to fine grained; grey to ash-grey; forms prominent cliff along the slopes of Mount Goodenough; laminated to thinly bedded; similar to units 25, 27, 28 and 31 but harder; thin layers of light-coloured sandstone and shale-like, softer darker sandstone; beds of sandy siltstone; several 7.5 to 25 cm thick beds of ferruginous sandstone and ironstone; some bed-scale normal faults with 15 cm to 1.6 m offsets	7.5	218.55
34	**Sandstone:** similar to unit 33 but softer, with 5 to 10 cm thick harder beds; few thicker beds; large ironstone concretions near base	7.5 (est.)	226.05
35	**Sandstone:** similar to unit 34 but with round concretions up to 15 cm in diameter and loaf-like concretions up to 1 m long; grades up into unit 36	3.3	229.35
36	**Shale:** dark grey, blackish to brownish tinge; locally silty; soft and flaky; a few interbeds of siltstone and silty sandstone; zones containing few concretions alternate with concretion-rich ones; top chosen at a laterally persistent concretion bed; *Pleuromya* sp. indet. and *Aulacoteuthis*-like belemnite collected near base of unit; about 12 m above base, *Inoceramus* sp. indet., *Crioceras* (*Hoplocrioceras*) cf. *remondi* (Gabb) and *Crioceras* (*Shasticriocera*?) sp. indet., collected; about 19.5 m above base; a fragment of *Crioceratites* (*Emericiceras*) cf. *emerici* (Leveille 1837) was found	45.5	274.85
37	**Shale:** similar to unit 36 but slightly more resistant in places; laminae, beds and layers of sandy siltstone; numerous concretion horizons; concretion layer at top of unit yielded an indeterminate crioceratid ammonite and a few marine pelecypods	15.0	289.85
38	**Shale:** similar to unit 36 with fewer concretions; some juvenile bivalves found	13.6 (est.)	303.45
39	**Shale:** patchy outcrops of grey to multicoloured shale alternating with covered intervals	38.0 (est.)	341.45
40	**Siltstone:** very sandy; dull grey; friable pods and layers of very fine to fine grained sandstone; grades up into unit 41	4.5	345.95
	(N.B. Units 41 to 45 form a very prominent cliff along the upper slopes of the east Mount Goodenough massif, forming an important marker horizon).		
41	**Sandstone:** very fine to fine grained; similar to unit 33 but lighter grey, speckled; rusty weathering; scattered pyrite and marcasite concretions (2.5-7.5 cm diameter); alternating hard and soft bands of sandstone; a few, minor high-angle faults	6.5	352.45
42	**Sandstone:** similar to unit 41 but more friable; forms a bench between cliffs	3.0	355.45
43	**Sandstone:** very fine to fine grained; light grey to buff; rusty to yellow weathering; well cemented; laminated, crossbedded; 15 to 60 cm thick beds alternating with 2.5 to 30 cm thick layers of friable, grey, speckled, shale-like sandstone; abundant burrows	10.5	365.95
44	**Sandstone:** less than 20% hard sandstone; similar to friable sandstone in unit 43	6.0	371.95
45	**Sandstone:** equal amounts of hard and soft sandstone; similar to unit 43	2.5	374.45

Unit	Description	Thickness (m)	Total above base (m)
46	**Interbedded siltstone and sandstone:**		
	Siltstone: sandy to very sandy; dark grey		
	Sandstone: beds up to 1.5 m thick; poorly exposed unit	46.0 (est.)	420.45
47	**Sandstone:** fine grained; well cemented; dark grey to brownish grey, weathers buff to rusty colour; fauna includes: *Crioceras* (*Hoplocrioceras*) cf. *remondi* (Gabb) and indeterminate bivalve fragments	3.5	423.95
48	**Interbedded siltstone and sandstone:** similar to units 46 and 47; interval is mostly covered and was not studied in detail	61.0 (est.)	484.95

Unit	Description	Thickness (m)	Total above base (m)
Rat River Formation			
49	**Sandstone:** fine to medium grained; light grey to buff; weathers yellow to rusty; good porosity; apparent gradational contact with unit 48; forms cliffs at top of Mount Goodenough massif.	50.0	534.95
	End of section.		

Comment by J. Dixon: the apparent gradational contact between Mount Goodenough and Rat River strata was not noted by Dixon; rather, an abrupt and erosional contact was observed. The fact that Jeletzky did not record in detail the character of his unit 49, because of poor exposure, suggests that his conclusion regarding the contact was a supposition, and not based on direct observation.

The difference in thicknesses recorded by Dixon and Jelezky has been discussed in the main body of the text.

APPENDIX 4

Type section of the Rat River Formation

The sections of Dixon (DFA89-7) and Jeletzky (JA-F58-52) appear to have been measured in approximately the same location, although Dixon did not observe the section where Jeletzky (JA-F58-54) recorded the contact between the Rat River Formation and an overlying shale unit. Section DFA89-7 plus JA-F58-54 are designated the type descriptions for the Rat River Formation.

SECTION DFA89-7

Location: Rat River, at the southern end of the west arm of the big bend where the river approaches the Mackenzie Delta. Section begins at river level and follows a small gully up to the top of the cliff. Access is moderately difficult to difficult in places and loose material makes some parts potentially dangerous. When dry, loose sand and pebbles rain down the cliff face, producing an even more hazardous situation.

Latitude: 67°38′, longitude: 135°30′30″
NTS: 106 M/12 ML785034 (base) (1:50 000)
Dip: very gentle northwesterly
Formations: Rat River overlain by Quaternary gravel
Description is from base to top

Unit	Description	Thickness (m)	Total above base (m)
	Rat River Formation		
1	**Interbedded sandstone and shale:** thin beds of sandstone separated by partings and very thin beds of shale		
	Sandstone: very fine to fine grained; beds are a few cm to 30 cm thick and contain HCS, ripples and subhorizontal laminae		
	Sample 89-7-1	4.5	4.5
2	**Sandstone:** fine grained; light to medium grey; access difficult, unable to see internal structures	1.0	5.5
3	**Sandstone:** shale partings; weakly cemented; along line of measured section this unit is covered by talus; viewed along cliff face it is seen to consist of multiple sandstone beds up to 50 cm thick	4.5	10.0
4	**Sandstone:** very fine grained; yellow weathering; weakly cemented; large-scale swaley cross-stratification	1.5	11.5
5	**Sandstone:** very fine grained; yellow weathering; 5-10 cm thick beds separated by carbonaceous to muddy parting planes; small-scale HCS and current/wave-ripple laminae; weakly cemented	1.5	13.0
6	**Sandstone:** yellow weathering; thick beds separated by carbonaceous partings; HCS; weakly cemented	2.0	15.0
7	**Sandstone:** yellow weathering; friable to weakly cemented; at base of unit there is a shelly layer of variable thickness; poorly exposed along line of traverse	4.0	19.0
8	**Sandstone:** very fine to fine grained; lighter weathering colour than underlying units; thick to very thick bedded; slightly better cemented than adjacent units, hence tends to be more resistant to weathering; beds up to 1 m thick, separated by carbonaceous partings; beds contain very long, extremely low angle, intersecting laminae sets that define extremely low amplitude HCS; some beds contain shell debris at their bases; most beds contain scattered shell debris	6.0	25.0
9	**Sandstone:** fine to medium grained; mottled yellow and black because of intense bioturbation; black material is clay and carbonaceous debris; abrupt base and top	0.3	25.3
10	**Sandstone:** fine grained with granules scattered throughout unit; light yellow weathering; speckled appearance as a result of the presence of white sand grains that are probably chert; weakly to moderately well cemented; abrupt basal contact; broad, shallow trough crossbeds	4.0	29.3

Unit	Description	Thickness (m)	Total above base (m)
11	**Covered to inaccessible:** viewed along cliff face this interval appears to consist of thin sandstone beds separated by shale partings; apparently abruptly overlies unit 10	6.0	35.3
12	**Interbedded sandstone and mudstone:** stratified sandstone beds 5-60 cm thick separated by thinner, bioturbated, sandy mudstone or muddy sandstone beds; muddy sandstone beds have a mottled appearance		
	Stratified beds: fine laminae seen in some beds, possible swaley or HCS; generally abrupt bases/tops, although tops may be burrowed; a few vertical burrows seen	2.0	37.3
13	**Sideritized sandstone:** rusty brown colour;, forms resistant ledge	0.3	37.6
14	**Sandy mudstone/muddy sandstone:** mottled appearance as a result of bioturbation	0.5	38.1
15	**Sandstone:** fine grained; light grey; finely laminated (possibly swaley beds)	1.0	39.1
16	**Interlaminated/bedded sandstone and shale:** poorly exposed; beds are a few mm to few cm thick; shale has a brownish colour		
	Sample 89-7-2	3.0	42.1
17	**Sandstone:** very fine to fine grained; white weathering; weakly cemented; 30-50 cm thick beds separated by thin, carbonaceous shale beds; finely laminated—possibly swaley stratification	2.0	44.1
18	**Interbedded sandstone and shale:** beds a few mm to about 15 cm thick; possible small-scale HCS seen in some of the thicker sandstone beds; some of the thinner beds have a mottled appearance as a result of bioturbation	1.0	45.1
19	**Sandstone:** very fine to fine grained; generally weakly cemented, but there are large segments that are cemented by iron carbonate and these form resistant blocks; abrupt base and top; possibly multiple beds; finely laminated—possible swaley beds or HCS; wave-modified current ripples in top 20 cm of unit	2.0	47.1
20	**Interbedded/laminated sandstone and shale:** brown hue; beds are a few mm to few cm thick; sedimentary structures not readily visible	1.0	48.1
21	**Sandstone:** very fine grained; white weathering; abrupt base; top 20 cm contains thin layers of carbonaceous mud, abruptly overlain by unit 22; concretion layer 20 cm below top, just below where the mud layers begin; shell-rich in basal 20 cm, and other shell debris scattered throughout unit; finely laminated	1.7	49.8
22	**Shale:** silty to sandy; appears to be carbonaceous; dark brown to black; upper two thirds of interval contains very thin sandstone beds and at least two 5-10 cm thick, finely laminated sandstone beds (HCS and ripples)		
	Sample 89-7-3 from lower part of unit	1.7	51.5
23	**Sandstone:** very fine to fine grained; yellow weathering; variable thickness, 20-50 cm thick, due to scour-like basal contact; multiple, finely laminated beds	0.5	52.0
24	**Shale:** highly carbonaceous shale containing thin (mm to few cm thick) sandstone interbeds; interval capped by a 30 cm thick sandstone bed; large ironstone concretions scattered throughout upper 50 cm	1.7	53.7
25	**Interbedded shale and sandstone:** mostly shale with mm- to dm-thick sandstone beds; access to exposure is difficult		
	Sample 89-7-4 from base of interval	36.0	89.7

Unit	Description	Thickness (m)	Total above base (m)
26	**Interbedded sandstone and shale:** dm-thick sandstone beds (or multiple beds) separated by few cm to 50 cm thick silty shale and muddy sandstone beds; access to exposure difficult and dangerous.	15.0	104.7

End of section near top of cliff where Pleistocene gravel abruptly overlies Rat River strata.

Comment: within the talus there is an abundance of fossilized wood, presumably weathering from the Rat River Formation. However, in situ fossil wood was not seen. The general vertical successsion can be divided into three coarsening-upward cycles: units 1 to 10, 11 to 13, and 14 to 26.

SECTION JA-F58-52

Location: big bend of Rat River. A cliff on the northeastern bank about 1 km upstream from the river bend (JA-F58-52); continued approximately 1 km farther upstream (JA-F58-54).

Latitude: 67°38′49″N, longitude: 135°30′W

Rat River Formation

Unit	Description	Thickness (m)	Total above base (m)
1	**Sandstone:** fine grained, clean and quartzose; whitish grey to light grey; weathers with white, yellow and rust coloured stains; indistinctly to thickly bedded; blocky fracturing; local pipe-shaped concretions 2.5 to 3 m above in a bed of rust-coloured, coquinoid, silty sandstone that is replete with bivalve shells—sample JA-F58-52/1 contains *Aucellina* ex. gr. *caucasia* (von Buch); 2 m above coquinoid sandstone there is another brownish grey, silty sandstone; upper 2-2.5 m contains strings or layers (1-2.5 cm) of small pebbles and medium grained sandstone		
	Section traverse moved upstream about 90 m where top of unit is exposed.		
	Gradational top: 30-45 cm interval of sandstone interlaminated with carbonaceous, silty sandstone and coaly, sandy siltstone	8.5	8.5

(N.B. The coquinoid sandstone was traced 200 to 300 m downstream where a rich bivalve fauna was collected—sample JA-F59-143/2. *Aucellina* ex. gr. *aptiensis-caucasia*, *Acroteuthis* cf. *kernensis* Anderson 1938 and *A. mitchelli* Anderson 1938).

Unit	Description	Thickness (m)	Total above base (m)
2	**Sandstone:** very fine grained; silty; mottled dark to blackish grey; light yellow to orange specks and laminae; friable; lenticular to irregular thin beds; pods, lenses, laminae of less silty sandstone (mm-5 cm long, few mm thick)	2.0	10.5
3	**Sandstone:** fine grained; grey-yellow to buff; weathers light yellow; friable; thin beds and laminae	0.5	11.0
4	**Shale:** silty to sandy; dark grey to brownish grey; very friable; grades into silty and sandy clay; contains numerous laminae, pods and lenses of sandstone	1.5	12.5
5	**Sandstone:** fine grained; similar to unit 3; 2.5 to 5 cm thick layers/laminae of brownish grey clay and sandy silt	1.0	13.5
6	**Sandstone:** similar to unit 2; also includes 2-3 interbeds (up to 23 cm thick) similar to units 3 and 5; friable; grades up into unit 7	2.0	15.5
7	**Sandstone:** fine grained; alternations of 1) whitish grey to dirty white sandstone; indistinctly to thin bedded, locally laminated, 15-75 cm thick beds, and 2) brownish grey, argillaceous sandstone; laminated and speckled with type 1 sandstones; 2.5-45 cm thick layers and beds		
	Forms a near-vertical bluff.	5.0	20.5
8	**Sandstone:** fine grained; bright yellow, maroon, orange; locally sulphur stained; friable, but locally replaced by cemented sandstone and ironstone; numerous laminae, lenses and 2.5-7.5 cm layers of maroon, grey or rust coloured sandy clay; some 12.5-50 cm thick pods and layers of coaly material; unit does not appear to be laterally persistent—replaced laterally by units 7 and 9	5	21.0
9	**Sandstone:** similar to variety 2 of unit 7	1.5	22.5

Unit	Description	Thickness (m)	Total above base (m)
10	**Sandstone:** fine grained; light greenish grey to whitish grey; laminated to thin bedded; indistinctly crossbedded in upper 60 cm; some laminae and thin layers of silty sandstone; ironstone lenses	1.0	23.5
11	**Shale:** mostly medium to dark grey with brownish tinge; laminae of maroon, rust and blackish grey shale; friable; thin interbeds and laminae of sandstone, especially common in upper and lower parts of unit; gradational upper and lower contacts	3.0	26.5
12	**Sandstone:** similar to unit 10; sandstone beds separated by laminae and thin layers of silty sandstone and sandy siltstone	3.5	30.0
13	**Sandstone:** fine grained, locally gritty to pebbly; yellowish grey, weathers light yellow; lenticular beds with strong lateral lithological variations—lenses and layers of sandy siltstone and silty sandstone; lower contact is abrupt and uneven and locally overlain by pebbly, coquinoid sandstone – sample JA-F58-52/2 contains *Tropaeum*-like ammonites, *Aucellina* cf. *caucasia* (von Buch) and *Astarte* n. sp. aff. *cantabrigiensis* Woods	3.0	33.0
14	**Interbedded sandstone, shale and siltstone:** brownish grey and rust; sandstone similar to unit 13	1.5	34.5
15	**Sandstone:** fine grained; yellowish grey; weathers rusty yellow to light yellow	2.0	36.5
16	**Interbedded shale, siltstone and sandstone**		
	Shale: locally silty or sandy; chocolate brown, dark grey or rust; laminae, thin layers and beds up to 45 cm thick		
	Siltstone: sandy to very sandy; dull grey, dark grey, light grey, commonly rust weathering colour; laminae, layers and thin beds		
	Sandstone: fine grained; light to whitish grey with greenish tinge, weathers light yellow to rust; not as common as other two rock types; occurs in lenses 5-50 cm thick at intervals of 3-4.5 m		
	Coquina 8 m below top of unit contains shells and ammonite fragments; contains scattered chert pebbles; ?*Tropaeum* sp. indet. collected 15.5 m below top of unit; gradational base and top	18.5	55.0
17	**Sandstone:** fine grained; light grey, yellow-grey; weathers rust coloured in places; friable, locally cemented and contains some ironstone concretions; lenticular beds separated by silty sandstone and sandy siltstone beds (5-30 cm thick); laterally appears to grade into strata similar to unit 16		
	Sample JA-F58-52/5 contains *Tropaeum undatum* Whitehouse 1926; collected 45-53 cm above base	3.5	58.5
18	**Sandstone:** fine grained; light to brownish grey, weathers whitish grey to dirty white with greenish tinge, locally rust coloured; friable; 7.5-90 cm thick sandstone beds separated by 2.5-5 cm thick layers/beds of silty shale, sandy siltstone and silty sandstone; lateral character changes over a short distance; coquina layers in top 1.5 m; gradational base and top	11.5	70.0
19	**Sandstone:** similar to unit 18 but harder and fewer interbeds of siltstone/shale; locally well cemented; ironstone concretions; scattered small pebbles present in some beds, as well as fossil wood and macrofossil debris; sample JA-F58-52/7 contains *Tropaeum* n. sp. aff. *arcticum* (Stolley 1913) collected 30-45 cm above base of unit; impersistent coquina layer with marcasite nodules at base of unit; variable lateral thickness: 1.5 to 2.5 m; gradational top	2.5	72.5
20	**Sandstone:** similar to unit 18	4.5	77.0

Unit	Description	Thickness (m)	Total above base (m)
21	**Shale:** locally silty; green to greyish green; friable; laminae and thin beds of sandy siltstone and silty sandstone; abrupt top	1.5	78.5
22	**Sandstone:** similar to units 17 and 19, but with no ironstones and less rusty weathering; crossbedded and coquina layers; abrupt, channelized base	2.5	81.0
23	**Sandstone:** similar to units 18 and 20; crossbeds well displayed in uppermost 45-60 cm; bivalve coquina 60 cm below top; other bivalves present as scattered shells	3.5	84.5
24	**Sandstone:** light to whitish grey, weathers yellow-grey to buff with bright yellow specks; 7.5-30 cm thick beds intercalated with 2.5-25 cm thick units of dark to medium grey shale and sandy siltstone; laterally replaced in part by lithotypes seen in units 23 and 25	3.5	88.0
25	**Sandstone:** fine grained; whitish grey, weathers buff to whitish yellow; micaceous; thickness varies up to 4 m; indistinct 30-60 cm thick beds; crossbedded; some layers and lenses of ferruginous sandstone (2.5-45 cm thick) commonly found as large talus blocks at base of cliff, in which were collected specimens of *Tropaeum* n. sp. aff. *arcticum* (Stolley 1913); 7.5-17.5 cm thick layers and lenses of rusty to orange siltstone; several 2.5-7.5 cm thick coquinoid sandstones; basal 1.5 m contains scattered bivalve shells; collection JA-F58-52/8 from near base of unit contains *Astarte* n. sp. aff. *cantabrigiensis* Woods and *Pecten* (*Entolium*) n. sp. A.	2.5	90.5
26	**Sandstone:** similar to unit 24 but locally more shale and siltstone (up to 40%); lateral thickness variations between 10.5 and 12 m	12.0	102.5
27	**Sandstone:** fine grained; bright yellow, orange or rust; silty in places; friable lenses, layers and beds similar to underlying units; 12.5-25 cm thick interbeds of chocolate brown shale occurring at irregular intervals, mostly in the basal 5 m; coquinoid sandstone (2.5-15.5 cm thick) present 5.5-6 m above base of unit—sample JA-F58-52/9 includes *Aucellina caucasica* (von Buch); about 2 m higher is another fossiliferous sandstone—sample JA-F58-52/10 includes *Astarte* n. sp. aff. *cantabrigiensis* Woods; overlain by Pleistocene gravels.	15.0	117.5

End of section (continues in section JA-F58-54).

SECTION JA-F58-54

Location: about 1 km downstream from JA-F58-52. Strata at section 54 overlie those at section 52 and include the upper contact of the Rat River Formation with an overlying shale succession. Unit numbers and accumulated thicknesses have been continued from Section 52.

Unit	Description	Thickness (m)	Total above base (m)
	Rat River Formation		
27	repeat of unit 27 in Section 52		
	(?)Martin House Formation		
28	**Clay:** light bluish grey with darker specks, laminae and thin beds of silty, fine grained sandstone (more common in upper part of unit); an ironstone band present 5-12.5 cm above base; abrupt basal contact	0.5	118.0
29	**Shale:** blue-grey to blackish grey; weathers brownish to rusty grey; locally silty; 2 to 3 rows of loaf-shaped ironstone septarian concretions (0.6-1 m long, 60-90 cm thick); some contain wood-boring bivalves (sample JA-F58-54/3) preserved in fossilized wood	3.5	121.5
30	**Shale:** similar to unit 29 but no concretions; friable, grades locally into unconsolidated clay; laminae, pods and lenses of sulphur-like material; gradation with unit 29	3.0	124.5
31	**Pleistocene Gravel.**	5.0	129.5

End of section.