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**PORCUPINE RIVER FORMATION;
A NEW UPPER JURASSIC SANDSTONE UNIT,
NORTHERN YUKON TERRITORY**

J.A. JELETZKY



Energy, Mines and
Resources Canada

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Ressources Canada

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**PORCUPINE RIVER FORMATION:
A NEW UPPER JURASSIC SANDSTONE UNIT, NORTHERN YUKON TERRITORY**

Abstract

The formal name Porcupine River Formation is introduced for a mappable, lithologically distinctive, shallow marine to nonmarine sandstone unit outcropping on the western flank of the Late Jurassic generation of Richardson Mountain-Porcupine Plain Trough in northern and west-central Yukon. This formation outcrops from the southwestern headwaters of Blow River at the southeastern end of Barn Mountains in the north to the headwaters of Fishing Creek and Kandik River in Nahoni Range in the south. Northward and southward therefrom the Porcupine River Formation appears to pinch-out and to become replaced laterally by argillaceous rocks of the Husky Formation and its equivalents. The same happens to the east of its outcrop belt in the central zone of Richardson Mountain-Porcupine Plain Trough. In the west, the outcrop belt of the formation abuts a part of northwesternmost and west-central Yukon and of east-central Alaska where Upper Jurassic rocks are completely unknown and, presumably, were never deposited because the region was a tectonic landmass. The marine and nonmarine rocks of the Porcupine River Formation were derived from this western Keele Range-Old Crow Landmass.

The outcrop belt of Porcupine River Formation includes three eastward-convex protuberances inferred to be the deltaic lobes. From south to north these are: Southeastern Keele Range lobe, Dave Lord Ridge lobe and Barn Mountains lobe. These lobes are characterized by maximum thickness (from some 400 m or 1320 ft. to at least 777 m or 2550 ft.) and partly to predominantly nonmarine (deltaic to alluvial) facies of the Porcupine River Formation. The deltaic lobes are either separated from each other or flanked by westward-convex protuberances of strongly attenuated (i.e. from 30 m or 100 ft. to 125 m or 400 ft.), apparently exclusively marine, partly argillaceous facies of Porcupine River Formation which are interpreted as westward-directed embayments of the Porcupine Sea. These embayments are (from south to north): Kandik Embayment, Keele Embayment, and Driftwood Embayment.

The Porcupine River Formation overlies conformably and apparently gradationally the argillaceous rocks of Kingak Formation (restricted). Wherever its upper contact is preserved, the sandstone is overlain conformably and apparently gradationally by the upper tongue of the Husky Formation.

The maximum known time span of the Porcupine River Formation extends from mid- to ?late Callovian to late, but not the latest, late Tithonian. However, it is considerably shorter than that in most of its sections. The age-limits and the alternation of facies of the formation vary considerably from one deltaic lobe to another and from one marine embayment to another. This variation apparently reflects the strongly localized, semi-independent character of oscillatory Late Jurassic tectonic movements which affected the western flank of the Richardson Mountain-Porcupine Plain Trough.

Résumé

L'auteur propose le nom officiel de formation de Porcupine River pour une unité peu profonde de grès marin à non marin, qu'il est possible de représenter sur une carte, qui se distingue par sa lithologie, et qui affleure sur le flanc ouest du sillon chaîfons Richardson-plaine de Porcupine (formée au Jurassique supérieur) dans la partie nord et centre-ouest du Yukon. Cette formation affleure à partir des eaux d'amont au sud-ouest, de la rivière Blow, à l'extrémité sud-est des monts Barn (au nord), jusqu'aux eaux d'amont du ruisseau Fishing et de la rivière Kandik dans la chaîne Nahoni (au sud). En s'éloignant de ce point vers le nord et vers le sud, la formation du Porcupine River semble se retrécir pour être progressivement remplacée, des deux côtes, par des roches argileuses de la formation de Husky et de ses équivalents. La même phénomène se rencontre à l'est de sa zone d'affleurement, dans la partie centrale du sillon chaîfons Richardson-plaine de Porcupine. A l'ouest, la zone d'affleurement de la formation touche une partie de l'extrême nord-ouest et du centre-ouest du Yukon ainsi que du centre-est de l'Alaska, là où les roches du Jurassique supérieur sont tout à fait absentes et où elles n'ont probablement jamais été déposées à cause de la forte activité tectonique qui caractérise cette région. Les roches d'origine marine et non marine de la formation de Porcupine River proviennent de la masse continentale de l'ouest Keele-Old Crow.

La zone d'affleurement de la formation de Porcupine River comprend trois protubérances dont la convexité est dirigée vers l'est et qui seraient des lobes deltaïques. Du sud au nord, on trouve le lobe sud-est du chaîfon Keele, celui de l'arête Dave Lord, et celui des monts Barn. Ces lobes se caractérisent par une épaisseur maximale allant de 400 mètres ou 1320 pieds à 777 mètres ou 2550 pieds au moins et par le faciès principalement non marin (deltaïque à alluvial de la formation de Porcupine River). Les lobes deltaïques sont tantôt séparés entre eux, tantôt bordés de protubérances de convexité ouest formées par le faciès, en partie argileux, d'apparence exclusivement marine, et fortement atténué (c'est-à-dire de 30 mètres ou 100 pieds à 125 mètres ou 400 pieds) de la formation de Porcupine River; l'auteur les interprète comme des rentrants de la mer Porcupine, dirigés vers l'ouest. Ces rentrants sont, du sud au nord, le rentrant de Kandik, le rentrant de Keele et le rentrant de Driftwood.

La formation de Porcupine River recouvre, de manière concordante et apparemment graduelle, les roches argileuses de la formation de Kingak (restreinte). Partout où son contact supérieur s'est maintenu, le grès repose, de manière concordante et apparemment graduelle, sous la langue supérieure de la formation d'Husky.

La durée maximale connue de la formation de Porcupine River s'étend du Callovien moyen au (?) supérieur jusque vers la fin, mais non pas la toute fin, du Tithonien supérieur. Cependant, elle est beaucoup plus courte que dans la plupart de ses coupes. Les limites d'âges et les modifications du faciès de la formation varient énormément d'un lobe deltaïque à un autre et d'un rentrant marin à un autre. Cette variation reflète apparemment le caractère très localisé et semi-indépendant des mouvements tectoniques oscillatoires du Jurassique supérieur qui ont affecté le flanc ouest du sillon chaîrons Richardson-plaine de Porcupine.

**PORCUPINE RIVER FORMATION:
A NEW UPPER JURASSIC SANDSTONE UNIT, NORTHERN YUKON TERRITORY**

INTRODUCTION AND ACKNOWLEDGMENTS

The purpose of this paper is to describe and to name formally a lithologically distinctive, widespread, paleogeographically and stratigraphically important sandstone unit fringing the western margin of the Late Jurassic generation of the Richardson Mountain-Porcupine Plain Trough (Jeletzky, 1975a, p. 2, 3, Fig. 1). This mappable unit, for which the name Porcupine River Formation is introduced herein, was extensively discussed and paleogeographically interpreted by the author (Jeletzky, 1963, p. 80-82, Fig. 6; 1971a, p. 205, 207, 213, 214, 215, Figs. 1-3; 1972, p. 27, 28, 39-41; 1974, p. 4, 7; 1975a, p. 10, 11, etc., Figs. 2-8, 10, etc.) under the informal name of "Unnamed Upper Jurassic sandstone division".

Organizations and individuals who have facilitated the writer's research by providing camp facilities, air support and field assistance are specifically mentioned in the publications referred to above, but the writer desires to express once more his deep appreciation of this assistance and co-operation. The writing of this paper was facilitated by discussions with D.K. Norris and F.G. Young, I.S.P.G., Calgary and by the kind permission of Shell Oil Canada Limited, Calgary to publish the section KS-116P5/5-10 of sandstone named herein the Porcupine River Formation, measured by their party in 1971. T.P. Poulton, H.P. Trettin and F.G. Young critically read the manuscript and contributed a number of valuable comments.

The writer expresses his sincere thanks to all colleagues and organizations who supported his research but accepts the full responsibility for any statements and conclusions resulting therefrom, except where stated otherwise in this report.

All fossils listed in this paper have been identified and dated by the writer, except for the Callovian ammonites and accompanying fossils which were identified and dated by Hans Frebold (Geological Survey of Canada, retired).

HISTORICAL REMARKS

McConnell (1891, p. 123D-125D) was, apparently, the first to describe the Jurassic sandstone unit, herein designated the Porcupine River Formation, from its extensive outcrops on Porcupine River between the point 8.8 km (5.5 miles) below the mouth of Bell River and the point about 30.6 km (19 miles) above the mouth of Driftwood River. This unit was named informally the "Sandstone and quartzite series" by McConnell (1891, p. 123D). As mentioned by Jeletzky (1960, p. 7, 13, 17 and corr. chart), this sandstone unit and the underlying "shale series" were considered to be Cretaceous rocks by McConnell (*ibid.*) because of a misidentification of ammonites found in the latter rocks. The Late Jurassic age of the "Sandstone and quartzite series" of McConnell (1891, p. 123D) was recognized originally by Jeletzky (1960, p. 5, corr. chart) who found mid-Late Jurassic *Buchia* ex gr. *mosquensis-piochii* in the "Sandstone and quartzite series", which indicated its equivalence with McConnell's "Aucella beds" (also sandstones) containing "*Aucella mosquensis*

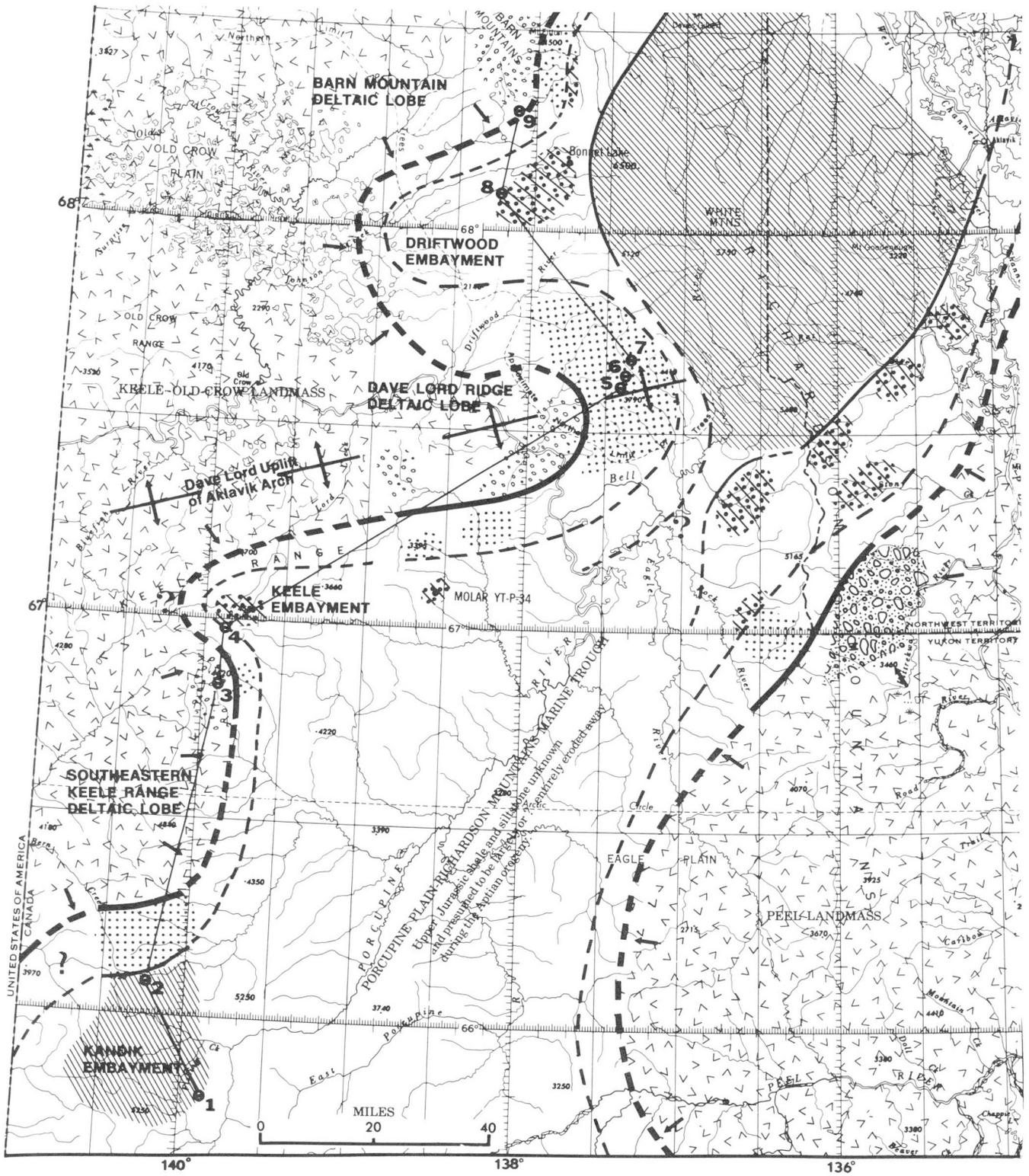
var. *concentrica*". These two sandstone units of McConnell (1891, p. 124D) accordingly were combined and correlated with the lithologically dissimilar Lower shale-siltstone division (now Husky Formation; see Jeletzky, 1967, p. 26-40) of northeastern Richardson Mountains by Jeletzky (1960, p. 5, corr. chart; 1963, p. 80-82, Fig. 6, etc.).

GEOGRAPHICAL DISTRIBUTION OF
PORCUPINE RIVER FORMATION

The principal outcrop area of the Porcupine River Formation is the continuous mountainous outcrop belt of northeastern Keele Range and Dave Lord Ridge extending from the middle course of Southern Johnson Creek at about Latitude 67°14'30"N and Longitude 138°18'W to Porcupine River Canyon at about Latitude 67°25'N and Longitude 136°45'W and thence into the headwaters of Waters River at about Latitude 67°36'N and Longitude 137°16'W. This outcrop belt, about 72.5 km (45 miles) long and from 8 to 19.3 km (5-12 miles) wide, roughly corresponds to the middle of the three eastward-directed protuberances of the Porcupine River Formation previously recognized by Jeletzky (1975a, p. 29-31, Fig. 10) and interpreted as eastward-prograding deltaic lobes derived from a western source area (Fig. 1). The area includes most of the typical, thick to very thick development of the Porcupine River Formation. Within this belt, the sections of the formation approach and locally exceed 610 m (2000 ft.) in thickness. Outside of this outcrop area, thick and typical development of the formation is known to occur in southeastern Keele Range (Jeletzky, 1971a, p. 213, Fig. 3), in the lower course of Bern Creek (Jeletzky, 1971a, p. 214, 215, Fig. 3), in the headwaters of eastern confluent waters of Waters River (Jeletzky, 1974, p. 7; 1975a, p. 11, 15, Figs. 6, 7, 10), and in the western part of the Blow Pass area (Jeletzky, 1974, p. 21, 22). To the south, east and north of these areas, the Porcupine River Formation rapidly thins out and becomes replaced laterally by predominantly or entirely argillaceous rocks of the Husky Formation and its equivalents (see Jeletzky, 1975a, p. 4-6, 8-9, 10-11, 14-15, 18-19, Figs. 2-8, 10).

This paper is concerned mainly with the geology of the Porcupine River Formation within the middle, eastward-directed salient which is designated herewith as the area of typical development of the formation, or the Dave Lord Ridge deltaic lobe (Fig. 1). Numerous sections of the formation were studied and measured within the area, but only the selected type section in Porcupine River Canyon, some other supplementary sections in the same canyon, two reference sections in the headwaters of Berry Creek and one reference section in the headwaters of Waters River are described in this report (see Fig. 2 and in the Appendix).

The geology of the Porcupine River Formation in all its other known outcrop areas will be referred to only to provide a balanced account of its stratigraphy, age, correlation and facies changes. The reader is referred to the publications mentioned above of Jeletzky (1963, 1971a, 1972, 1974 and 1975a) for further details about the geology of the formation.

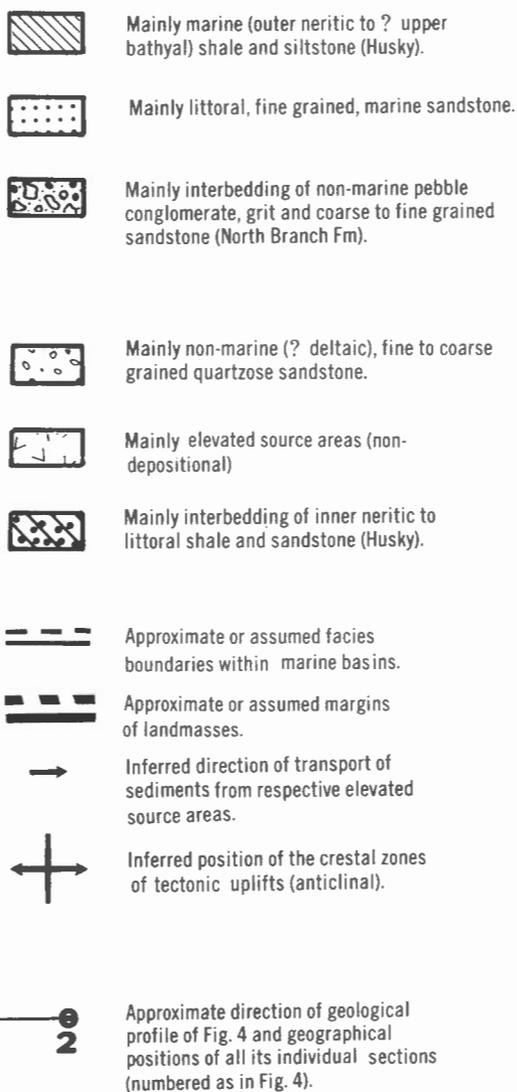


LEGEND

GEOLOGY

AREA OF TYPICAL DEVELOPMENT (DAVE LORD RIDGE DELTAIC LOBE)

Nomenclature



The Unnamed Jurassic sandstone division of previous reports is named the Porcupine River Formation, because of its extensive exposures in banks and hillsides of the so-called Porcupine River Canyon of McConnell (1891, p. 123D) situated 13 to 17 km (8-10.5 miles) below the point of confluence of Porcupine and Bell Rivers (Fig. 2). The Porcupine River Canyon thus becomes the type-area of the formation. These extensive outcrops of the formation, originally discovered by McConnell (1891, p. 123D-125D), are the only major exposures easily accessible to persons travelling by boat from Old Crow or using a small fixed wing aircraft from Old Crow or Inuvik. All other major exposures of the formation are, for all practical purposes, accessible only by helicopter.

All known sections of the Porcupine River Formation within its type area are either poorly exposed and incomplete or severely faulted and disharmonically folded, or both. One could, therefore, question the wisdom of the above choice of the type area, particularly since better sections of the Porcupine River Formation are available on the upper slopes of Dave Lord Ridge, in the eastern headwaters of Berry Creek, and on upper Waters River. However, the choice of the type area was made for the following reasons. First, the choice was made in 1959 before there was an opportunity to study any of the better but not easily accessible sections of the formation. The chosen type area and the name became widely known soon thereafter to governmental and industrial geologists working in northern Yukon. The name Porcupine sandstone has been used widely in field notes, internal reports, and verbal discussions of these geologists ever since and became firmly associated in their minds with the outcrops in Porcupine River Canyon. The name Porcupine Formation was mentioned in print (Lerand, 1973, p. 346, Fig. 24) at least once which, of course, does not represent a valid definition. Second, no other comparably representative, better exposed sections of the Porcupine River Formation occur anywhere along Porcupine River. Therefore, no alternative type area is available under the provisions of the North American Stratigraphic Code if the name is to be employed for the Unnamed Upper Jurassic sandstone division. Therefore, the writer was faced with the choice of either replacing the already well-known name Porcupine sandstone with another completely unfamiliar name (i.e. Berry Creek Formation or Waters River Formation) for the sake of a better type area and section or to formally propose the former name in spite of an inferior type area and section. The writer elects the latter alternative. The Porcupine River Canyon is designated as the type area of the Porcupine River Formation and Section 1 (see below for the description) on the western bank of the canyon (Fig. 2) is selected as its type section. At the same time the writer selects one much better and almost continuously exposed section of the Porcupine River Formation (Sec. 4, Appendix) in the eastern headwaters of Berry Creek and two other such sections (see Secs. 5 and 6, Appendix) in the headwaters of Waters River as the reference sections for the unit. All sections concerned form part of the same continuous outcrop belt of the typically developed Porcupine River Formation (Fig. 2) and contain enough diagnostic fossils

Figure 1 (opposite)

Geographic extent, paleogeography, facies, and depositional tectonics of Porcupine River Formation and its predominantly argillaceous equivalents (Husky Formation). The map amalgamates deliberately but somewhat arbitrarily the Oxfordian to Late Kimmeridgian facies and tectonic elements of Porcupine River Formation to provide a more lucid, overall picture. See text and Figure 4 for more exact ages of individual deltaic lobes and marine embayments of Porcupine Basin. Only the arenaceous and interbedded arenaceous and argillaceous rocks on the west side of the Richardson Mountain-Porcupine Plain Trough form part of Porcupine River Formation. Those on the eastern side of the trough belong to arenaceous facies of Husky Formation.

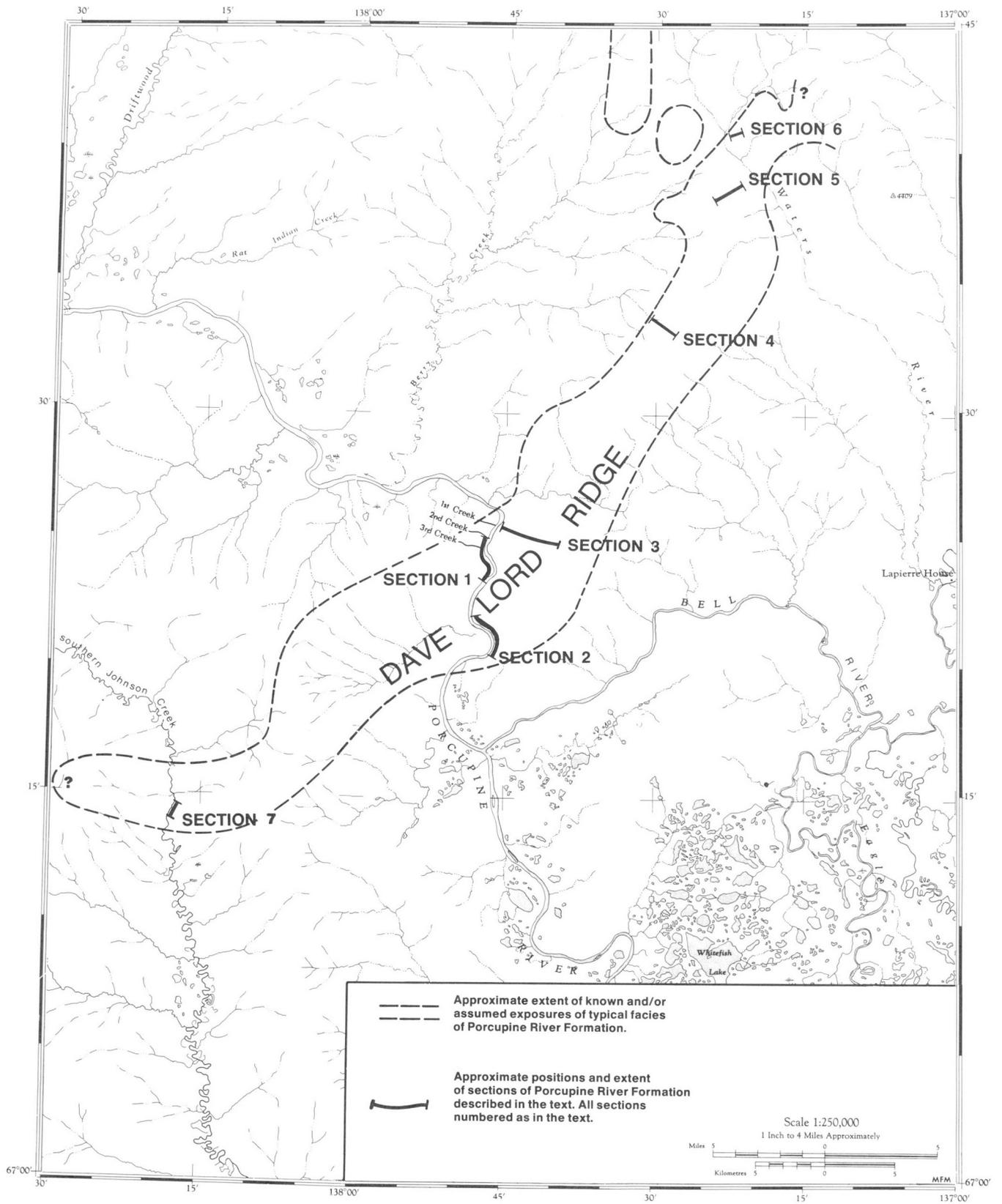


Figure 2. Index map showing approximate extent of exposures of Porcupine River Formation within Dave Lord Ridge deltaic lobe, approximate position and extent of stratigraphic sections described in the text and some of the new geographic terms used in the paper.

for their confident correlation. Therefore, the elected course of action does not entail any danger of a future misinterpretation of the Porcupine River Formation.

Subdivision and lithology of typical development

In all sections studied within the area of typical development, the Porcupine River Formation is divisible into two units on lithological and inferred genetic grounds. The lower unit is predominantly nonmarine with some intercalated marine beds; the upper unit is almost entirely marine.

Because of this interfingering of marine and non-marine strata and because of the difficulty of correlation between widely separated sections, based on the data now available, it is considered premature to give member status to these units. Therefore, they are referred to in this report as the marine facies and nonmarine facies of the formation.

The lower facies is from 168 to about 335 m (550-1100 ft.) thick and appears to be almost entirely, or predominantly, of nonmarine origin. It is designated herewith as the nonmarine facies of the typical development of Porcupine River Formation. This facies consists predominantly of dull to dark grey, light grey to dirty white weathering, invariably quartzose and mostly orthoquartzitic (with the same admixture of chert and white mineral (?kaolinized feldspar) grains as in the marine facies), carbonaceous to coaly, fine to very fine grained, in places silty sandstones. Variable, and locally major, proportions of almost entirely noncarbonaceous, buff- to orange-coloured sandstones, lithologically similar to sandstones of the marine facies (see below), may be intercalated locally with the carbonaceous to coaly varieties. Both kinds of sandstone are predominantly resistant and ridge-forming; they also are invariably noncalcareous and nonglauconitic. Numerous interbeds of dull to dark grey, mainly sandy to very sandy, hard to friable, carbonaceous to coaly siltstone commonly are intercalated with both kinds of sandstone in many sections, and tend to be concentrated in the basal part of the unit. The carbonaceous to coaly sandstone and siltstone varieties alike include at least some microlaminae, specks, and small pods of coaly matter and of impure to pure coal, frequent accumulations of carbonized or lithified plant remains (including branches, twigs, and sizable tree trunks), and numerous subvertical to vertical carbonaceous to coaly tubes up to 2.5 cm (1 in.) in diameter presumed to be plant rootlets. The noncarbonaceous sandstone varieties also may contain accumulations of lithified wood and plant remains on bedding planes. Marine fossils are entirely to almost entirely absent in all of the above-mentioned plant- and wood-bearing rock varieties, including noncarbonaceous sandstones, and some apparently nonmarine pelecypods (?unionids) have been found locally. When present at all, marine fossils are restricted to the basal and uppermost beds transitional to adjacent marine units, to exceptional sections situated on the periphery of the area of typical development of Porcupine River Formation (e.g. Sec. 6, Appendix), or to thin and restricted interbeds apparently representing short-term marine incursions into a basically nonmarine environment. This facies (units 2-6 of type section) is interpreted as an entirely to predominantly nonmarine unit (see section on depositional environment) of the formation.

Units 9 to 2 inclusive of Section 4 (Appendix) are typical of the nonmarine facies. Unit 6 of the type section of Porcupine River Formation seems to be somewhat less typical because of an apparent scarcity of dull to dark grey, nonmarine siltstones and strongly carbonaceous to coaly sandstones. However, this lithological difference may be more apparent than real as Unit 6 of the type section is rather poorly exposed. Being generally less resistant, the nonmarine siltstones and extremely carbonaceous to coaly sandstones are likely to be largely or entirely covered by talus in such poorly exposed sections.

The marine facies overlies the nonmarine facies gradationally and is usually 213 to 274 m (700-900 ft.) thick. However, as indicated by the 678 m (2225 ft.) thick (base not reached) development of the facies in Section 5 (Appendix), only the lower part is exposed in these sections. The widespread lower part, as well as the rarely preserved upper part, of the marine facies consists of prevalent white- to buff- or orange-coloured (in fresh and weathered state), resistant and ridge-forming sandstones. These sandstones are exclusively to predominantly fine to very fine grained, clean (little or no silt particles), well to fairly well sorted as to the grain size and moderately to fairly well rounded, the grains being usually subrounded to subangular. These noncarbonaceous to slightly carbonaceous sandstones are predominantly quartzose to orthoquartzites. In these varieties the content of chert grains was estimated to fluctuate from near 0 to 5 and, rarely, 8 per cent and the same is true of the content of white grains of ?kaolinized feldspar. However, less quartzose varieties, that include a total of 20 to 25 per cent (est.) of chert grains, white grains of ?kaolinized feldspar and orange limonite grains combined, may occur in considerable quantities in some unpublished sections. Such polymictic sandstones are much more common in the headwaters of Berry Creek and Waters River than in the type area of the Porcupine River Formation. Unlike sandstones of the nonmarine facies, those of the marine facies are commonly somewhat calcareous and may be slightly glauconitic. As a rule, the light to bright coloured sandstones of the marine facies include few or no interbeds and units of the more sombre coloured, plant- and rootlet-bearing carbonaceous to coaly sandstones lithologically similar to those of the nonmarine facies.

The sandstones of the marine facies contain some marine fossils throughout and are commonly rich in coquinooid interbeds replete with marine pelecypods. Bedding is either medium to thick and indistinct or altogether absent for the most part, although the facies may include, locally, a large number of thinly bedded to laminated, commonly markedly cross-bedded and ripple-marked sandstones. Other sedimentary structures, such as worm burrows, hieroglyphic markings, or bioturbation tend to be extremely rare in sandstones of the marine facies. Non-sandy to very sandy, carbonaceous to noncarbonaceous siltstones are rare to almost absent in the marine facies. Whenever present, these subordinate siltstones are at least predominantly marine on the basis of the same lithological and paleontological (especially the common presence of marine pelecypods) evidence as the enclosing sandstones. However, some of these siltstones appear to be nonmarine (e.g. Unit 11 of Sec. 4, Appendix).

The medium-grained sandstones are rare even in the westernmost sections studied and coarse-grained sandstones, as well as grits and pebble conglomerate, are all but absent.

Unit 7 of the type section (see Sec. 1, below) and Units 9, 11, 13, 15 and 17 of Section 3 (Appendix) are representative of the typical, thick-bedded to massive strata of the marine facies while Units 3 and 4 of Section 2 (Appendix) are representative of its thinly bedded to laminated, intensively cross-bedded and ripple-marked development. Units 10 to 14 of the reference Section 4 (Appendix) also are typical, in spite of the presence of numerous interbeds of more sombre to dark grey coloured, carbonaceous to coaly sandstones and siltstones which appear to be nonmarine (?paludal) in part.

Type section of Porcupine River Formation

The following section measured along the western bank of Porcupine River within the so-called Porcupine River Canyon is designated herewith as the type section of the formation. The top of the section is situated at the point about 13 km (8 miles) downstream from the confluence of Porcupine and Bell rivers and some 325 m (≈ 350 yds.) south of the upper end of the canyon (see Fig. 2) while its base is situated about 2.4 km (1.5 miles) farther downstream within the lower part of the canyon. The section is centred at Latitude 67°25'N and Longitude 136°45'W.

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
<u>Section No. 1 (Type section)</u>			
(Field No. JA-F58-106)			
<u>Porcupine River Formation</u>			
Marine facies			
(Buchia mosquensis (s. lato) and ?Buchia (Anaucella) concentrica (s. lato) zones combined).			
7	Sandstone, white, buff or light grey when fresh, weathers white with rusty specks and spots, mostly fine grained, but with some interbeds of medium-grained sandstone, clean (very little or no silt particles), quartzose to orthoquartzite with trace to 5 per cent (est.) admixture of dark grey chert grains, similar admixture (3 to 5 per cent; est.) of white ?kaolinized feldspar grains, and some dull green glauconite grains in the uppermost 76 m (250 ft.); moderately hard to friable, moderately to extremely porous; mostly indistinctly and thick bedded to massive-looking but with interbeds of thin-bedded to laminated sandstone; bedding tends to be irregular (corrugated); mainly more or less calcareous in the upper 127 to 183 m (500-600 ft.); farther down mostly non-calcareous; outcrops poor and intermittent, except in the uppermost 76 to 91 m (250-300 ft.); contains a considerable number of 2.5 to 10 cm (1-4 in.) interbeds of coquinoid sandstone in upper 137 m (450 ft.); early Portlandian (s. str.) forms (i.e. late) of Buchia mosquensis (von Buch) and other pelecypods occur in place in the topmost 0.6 m (2 ft.) of the unit (GSC loc. 35649); late to ?mid-Kimmeridgian forms of B. mosquensis (v. Buch) (including B. cf. volongensis Sokolov) and other pelecypods occur in place some 89 m (292 ft.) below the top (GSC loc. 35651); the same late to ?mid-Kimmeridgian B. mosquensis forms, Cylindroteuthis (s. lato) sp. indet., Lophidiaster-like starfish and ?Arctica (s. lato) sp. indet. occur in place some 94.5 m (310 ft.) below the top (GSC loc. 35648; see Pl. I, fig. 1); Buchia cf. mosquensis (v. Buch) s. lato was seen 137 m (450 ft.) below top (no collection made); only indeterminate pelecypods and plant remains, including fossil wood, have been seen in the extremely poorly exposed, 76 m (250 ft.) (see Pl. I, fig. 2) thick basal beds of the unit; top not exposed (concealed beneath alluvial deposits) some 325 m (350 yds.) south of the upper end of the Porcupine Canyon. Apparently grades downward into unit 6; visible.....	213.5 (700) (est.)	535 (1757)
<u>Nonmarine facies</u>			
6	Sandstone, mostly dull to light grey when fresh, weathers mottled light grey to dirty white with orange to rust specks and spots, very fine grained, quartzose to orthoquartzitic with only a trace of		

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
	argillaceous fraction (i.e. clean), contains a minor admixture (5-7% all told; est.) of white ?kaolinized feldspar grains and dark mineral (?chert) grains, noncalcareous, commonly carbonaceous to (?)coaly, fairly well sorted as to the grain size and fairly well rounded, most grains being subrounded to subangular; mostly thick 0.3 to 1.5 m (1-5 ft.) and indistinctly bedded; moderately hard and dense with fair to excellent visible interstitial porosity; resistant to weathering and breaks into large blocks or slabs; distinct cross-bedding and ripple marks are rare; no marine fossils seen but bedding planes commonly are covered by poorly preserved, carbonized or petrified plant remains (mostly pieces of wood and bark) including sizable branches and tree trunks up to 15 cm (6 in.) in diameter; twigs and tree trunks commonly are oriented subparallel to each other suggesting current (?stream) action but no good examples were found <i>in situ</i> to determine the direction of the current; the unit includes 15 cm to 1.5 m (6 in. to 5 ft.) interbeds of dark to medium grey, fine to very fine grained, generally quartzose but silty sandstone resembling that of units 1 and 2 but carbonaceous to coaly and rich in dark grey to black specks, lamellae, and thin layers of coaly matter; outcrops poor and intermittent throughout, most parts of the river bank and lower slopes being covered by large slabs and blocks of sandstone of the unit (see Pl. I, fig. 2); numerous intervals containing recessive carbonaceous to coaly sandstone and siltstone similar to units 6, 7 and 2, 3 of Section 4 may be concealed in the rubble-strewn intervals of the shoreline (see Pl. I, fig. 2); no attitude except at the level about 30.5 m (100 ft.) above visible base where the sandstone strikes 320° to 330° and dips 12° to 13°SW; rocks are strongly jointed throughout and locally are sheared and faulted on a small scale (displacements up to 45 cm (18 in.)), the above described presumably nonmarine sandstones outcrop along the shore for about 1.26 km (0.75 mile) from the point of their first appearance; base covered at the end of this interval; visible..	274 (900) (est.)	321.5 (1057)
5	Sandstone, as in unit 1; strikes 245°, dips 5 to 6°SE; base covered; visible.....	4.5 (15) (est.)	47.5 (157)
4	Almost completely covered (rubble-strewn) interval along the shore; probably underlain by recessive, carbonaceous to coaly sandstone and ?siltstone judging by small patches of bedrock; ends about 91 m (100 yds.) north-northwest of the mouth of Third Creek (see Fig. 1); corresponds to about 30.5 m (100 ft.) of section assuming the attitude as in adjacent units.....	30.5 (100)	43 (142)
3	Sandstone, as in unit 1; no fossils seen; strikes 245° and dips 5 to 6°SE; base covered; visible.....	4.5 (15) (est.)	12.5 (42)
2	Sandstone, lithologically similar to that of unit 1, except for being predominantly blackish grey and carbonaceous to coaly; a poor <i>Cylindroteuthis</i> -like belemnite was found in fresh, locally derived float; top covered; visible.....	2 (7)	8 (27)
<u>Kingak Formation (marginal facies)</u>			
1	Sandstone, mottled brown and grey, weathers rust-coloured, very fine grained, very silty, ferruginous; locally grades into superficially similar, very sandy siltstone; thinly bedded to laminated and includes numerous lamellae, pods and lenses of dirty-white to whitish grey, locally weathering buff to yellow, partly fine grained, less silty to clean, quartzose sandstones; this alternation of sandstone varieties causes an extremely mottled to speckled appearance of the rock, especially on the weathered surface; strike 040-050°, dip 9-10°SE; a <i>Modiolus</i> sp. indet. was found in place; base covered at water's edge; upper contact gradational; visible.....	6 (20)	6 (20)

An interval, almost entirely covered, about 0.4 km (0.25 mile) long, separates the base of the above type section of the Porcupine River Formation from the top of a richly fossiliferous section of the shallow water facies of the Kingak shale described by Jeletzky (in Frobald, 1961, p. 2, Footnote; see Pl. I, fig. 3, this report). This interval probably harbours a major fault (or more than one fault).

Other sections within the type area

Neither the base nor the top of the Porcupine River Formation is exposed at the type section. However, there are other sections within the designated type area exposing beds of the formation, which are younger than the topmost beds of unit 7 of the type section. One such section was measured on the undercut right (eastern) bank of Porcupine River where the southwesternmost Jurassic outcrops occur. The Jurassic outcrops begin at the upstream end of the first major, eastward-convex loop of Porcupine River at the point 9 to 10 km (5.5-6 miles) downstream (or about 6.5 km (4 miles) north) below the mouth of the Bell River (Fig. 2). The covered interval separating these Jurassic rocks from the closest outcrops of ?Upper Cretaceous rocks situated about 3.2 km (2 miles) up from the mouth of Bell River is believed to harbour a major northeast-trending fault with a downthrown southeastern side.

From the point of their first appearance, the Jurassic rocks outcrop more or less uninterruptedly for the next 2.8 to 3.2 km (1.75-2 miles) downstream in the east bank of Porcupine River within its broad and rounded, eastward concave loop (Fig. 2). These rocks are flexed into a series of minor, mostly open folds, in places faulted and locally drag-folded. The sequence of beds (Sec. 2, Appendix), worked out in the above-mentioned interval may, therefore, be inaccurate in detail.

The second section (Sec. 3, Appendix) including still younger beds of the Porcupine River Formation outcrops on the rounded, partly overgrown western slopes of a high, flat-topped Mason Hill (about 762 m (2500+ ft.)) overlooking Porcupine River from the east near the lower (i.e. northern) end of the canyon (Fig. 2).

Thickness and contact relationships

McConnell (1891, p. 123D) estimated the thickness of his "Upper sandstones" (equals Porcupine River Formation of this paper) in Porcupine River Canyon to be between 915 and 1220 m (3000 and 4000 ft.). This thickness appears to be excessive as a result of underestimation of the tectonic disturbance of these rocks. The rocks of Porcupine River Formation in the canyon are synclinally bent, strike mainly at acute angles to the river's course, are disharmonically folded, and are considerably faulted (see aerial photograph A14406-87).

By combining the measured Sections 1 to 3 (see under headings Type Section and Appendix) and by using the evidence of diagnostic *Buchia* species contained in them, the writer estimates the total thickness of the Porcupine River Formation exposed in the type area at between 610 and 670 m (2000-2200 ft.).

The reasoning is as follows: (1) The 549 m (1800 ft.) thick (est.) type section (i.e. Sec. 1), begins just above the base of the formation as defined in Sections 4 and 7 and

ends in the upper (probably uppermost) part of *Buchia mosquensis* s. lato Zone (see Jeletzky, 1967, p. 33-36 for definitions of *Buchia* zones). (2) Unit 4 of the Section 2, about 82 m (270 ft.) thick, is entirely younger than the topmost part of Section 1 since it contains *Buchia piochii* s. lato (early forms) fauna and is underlain by Unit 3 containing the same late forms of *Buchia mosquensis* (v. Buch) as those occurring at the top of Unit 7 of Section 1. (3) Unit 13 of Section 3 contains a mixed *Buchia fischeriana* s. lato-*Buchia piochii* s. str. fauna which is next younger than the *Buchia piochii* (early forms) fauna occurring in the topmost Unit 4 of Section 2. This adds at least another 44 m (145 ft.) and possibly as much as 186 m (610 ft.) to the total exposed thickness of Porcupine River Formation in the Porcupine River Canyon.

The weakest link in this somewhat crude computation is the estimated thickness of 549 m (1800 ft.) in the very poorly exposed, probably faulted, and possibly folded Section 1 (type section). This estimate could conceivably be too high by as much as 20 to 30 per cent if the amount of supplementary folding and faulting were underestimated because of poor and intermittent outcrops. However, the estimated total of 610 to 670 m (2000-2200 ft.) for the type Porcupine River Formation appears to be reasonable because it agrees well with the reliably measured thicknesses of the somewhat less typical (more marine interbeds) facies of Porcupine River Formation in the eastern headwaters of Berry Creek (Sec. 4, Appendix) and on upper Waters River (Sec. 6, Appendix) including rocks of about the same age. These sections regularly total between 451 and 549 m (1480-1800 ft.). It must be pointed out in this connection that the thickness of 1159 m (3800 ft.) of Porcupine River Formation (its marine facies only!) measured by Jeletzky (1971a, p. 211, Fig. 2) on the eastern slope of a 1067 m (3500 ft.) high, nameless mountain overlooking Waters River from the west is an overestimation caused by previously unrecognized faulting (see in description of Sec. 5, Appendix) of this section. The thickness of the marine facies in this section is nevertheless about 679.5 m (2250 ft.). As mentioned in comments on Section 5 (Appendix), this unusually great thickness of the marine facies reflects the presence there of about 396 m (1300 ft.) of *Buchia fischeriana* s. lato Zone. It is estimated that about 305 m (1000 ft.) of these rocks have been eroded away in Sections 3, 4, and 6.

The apparently erosionally disconformable contact between the typical development of Porcupine River Formation and the underlying Kingak Formation (see Sec. 7, Appendix) is believed to be the result of local channeling since the youngest known beds of the Kingak Formation (restr.) immediately underlying the largely or entirely nonmarine facies of Porcupine River Formation (e.g. Unit 1 of Sec. 4, Appendix) always carry the same early to ?mid-Callovian ammonite fauna. The same appears to be true of the lower contact of Porcupine River Formation everywhere outside the area of the typical development (unpublished sections in western and eastern headwaters of Waters River, etc.).

None of the sections studied in the central and eastern parts of the area of typical development of the formation (e.g. Secs. 1 to 6 of this paper; Jeletzky, 1971a, p. 211, Fig. 2; 1972, p. 39, 40; 1974, p. 7, 21, 22; 1975a, p. 4, 8, 11, 15, 18, 19, 46, Figs. 2-8, 18) reaches the top of the unit. The summits of the highest mountains of eastern Keele Range and those of southern and central Dave Lord

Ridge are invariably capped by sandstone of the marine facies of the formation, some undetermined part of which was obviously destroyed by erosion. The marine facies appears to represent the principal recent erosional level within the area of typical development of the Porcupine River Formation. The same apparently was true of the ancient post-Upper Jurassic periods of uplift and erosion, as the Albian and younger Cretaceous rocks of the area were found to overlie the deeply eroded surface of Porcupine River Formation (e.g. in type section of Sharp Mountain Formation; see Jeletzky, 1975b, p. 240 and in southeastern Keele Range near unnamed 1409 m (4620 ft.) high summit; see Pl. II, Fig. 1) in all personally studied fossiliferous surface sections.

By combining Section 4 with Section 5 it is possible to obtain a reliable, although approximate, estimate of total thickness of the Porcupine River Formation at least in the northern part of the area of its typical development. By adding 305 m (1000 ft.) of sandstone of the *Buchia fischeriana* s. lato Zone preserved in Section 5 to 473 m (1550 ft.) of the lower part of the formation preserved in Section 4 (see Fig. 2) a total of 777 m (2550 ft.) is obtained for the preserved part of the typical development of the formation. This estimated total is considered to be a minimum value only. This is suggested by: (1) The exposed (almost complete) thickness of the nonmarine facies in Section 6 of no less than 325 m (1065 ft.); (2) The fact that the complete thickness of the *Buchia fischeriana* s. lato Zone is not preserved in any of the sections studied; and (3) The fact that the incomplete succession of the marine facies in Section 5 is 678 m (2225 ft.) thick. These increased thicknesses may reflect a gradual northward increase of the thickness of the Porcupine River Formation connected with the less positive character of the northern part of Dave Lord Ridge deltaic lobe. If so, typical facies of the Porcupine River Formation may be more than 1067 m (3500 ft.) thick in this part of the lobe. It is equally possible, however, that the above estimate of total thickness of the formation is equally applicable to the central and western parts of the area of its typical development (i.e. Porcupine River Canyon and more westerly parts of Keele Range. Namely, the apparent thinning out of the formation in these parts of the Dave Lord Ridge deltaic lobe may be caused solely by its profound erosion there. As pointed out by Jeletzky (1974, p. 9), there is a strong tendency for the argillaceous rocks of Husky Formation overlying the biochronologically reduced (i.e. containing a relatively reduced number of *Buchia* zones) Porcupine River Formation in the eastern headwaters of Waters River to wedge out westward and to become replaced laterally by sandstones of the correspondingly expanding (in biochronological span as well as in thickness) Porcupine River Formation. It was suggested in this connection (Jeletzky, 1974, p. 9) that still farther west: "argillaceous rocks of the Husky Formation were completely replaced laterally by the arenites of the Unnamed Upper Jurassic sandstone unit in the Keele Range-Berry Creek sections, even though this cannot yet be verified because of the incompleteness of all sections known (see Jeletzky, 1971a, p. 205, 211-213, Fig. 2; 1972, p. 38-41). It is postulated that in this area, which was situated at the eastern shoreline of the Upper Jurassic Keele-Old Crow Land (Jeletzky, 1971a, Fig. 1; 1972, Fig. 1; this report, Fig. 1), this Unnamed Upper Jurassic sandstone unit merged imperceptibly into the littoral to nonmarine facies of the western equivalent of the Lower sandstone division".

This east-west replacement of Husky argillaceous rocks by Porcupine River arenites is virtually duplicated by the facies changes of these two formations observed in a north-to-south direction (see Fig. 4 and in section on age, thickness and facies changes in other outcrop areas). This is well illustrated by the strong southward attenuation of biochronological span and thickness of the Husky Formation between the headwaters of Johnson Creek (northern) and the extreme headwaters of Berry Creek (i.e. Sec. 6, Appendix; see Fig. 4) and its prevalent lateral replacement by the marine facies of Porcupine River Formation in this direction. These data confirm the suggestion of Jeletzky (1974, p. 9; and cited above) about a probable coalescence of the Porcupine River Formation and littoral to nonmarine facies of the western equivalent of the Lower sandstone division into a single unit to which the name Porcupine River Formation would have to be applied in the area of Porcupine River Canyon and parts of Keele Range adjoining this area from the west and northwest. The probable coalescence of these two arenaceous formations may have increased the cumulative thickness of the Porcupine River Formation in this area in comparison with the thickness estimated earlier in this section for the headwaters of Berry Creek and Waters River Canyon area and parts of Keele Range adjoining it from the west.

Depositional-structural environment and paleogeographic interpretation of typical facies

The depositional environment of typical facies of the Porcupine River Formation exposed in Dave Lord Ridge deltaic lobe (Fig. 2) was controlled by the regional, hinge-like, late or ?mid-Callovian to late Oxfordian uplift of the western flank of Richardson Mountain-Porcupine Plain Trough and the following early Kimmeridgian to at least mid-late Tithonian subsidence discussed elsewhere (Jeletzky, 1975a, p. 46, Fig. 18). The regional uplift resulted in the deposition of predominantly to entirely nonmarine rocks of the nonmarine facies of Porcupine River Formation over all of the northeastern Keele Range-Dave Lord Ridge area over the open marine, predominantly inner to outer neritic rocks of the uppermost (i.e. uppermost Bathonian to lower Callovian) Kingak Formation (restr.). In the area discussed here, this uplift apparently was a slowly progressing tectonic event of a relatively insignificant vertical amplitude (?several hundred feet only, judging by the nature of nonmarine to marine sediments of the typical development of Porcupine River Formation; see below). The slow tempo of the uplift is evidenced by the widespread presence of medium to thick, predominantly argillaceous, carbonaceous to coaly, plant-bearing, nonmarine units at the base of the typical development of the Porcupine River Formation (e.g. Units 2 and 3 of Sec. 4; Jeletzky, 1974, p. 7). Whenever present, these apparently lagoonal, outer deltaic or paludal deposits are replaced gradually upward by distinctly coarser grained (but nevertheless mostly fine grained!) arenaceous rocks of the middle and upper parts of the nonmarine facies. These fine arenaceous rocks apparently are predominantly upper deltaic (delta plain) to alluvial lowland deposits.

The relatively small vertical amplitude of the late or ?mid-Callovian to late Oxfordian uplift in the eastern Keele Range-Dave Lord Ridge area is indicated by the fact that, in contrast with other tectonic uplifts recorded in the Richardson Mountain-Porcupine Plain Trough

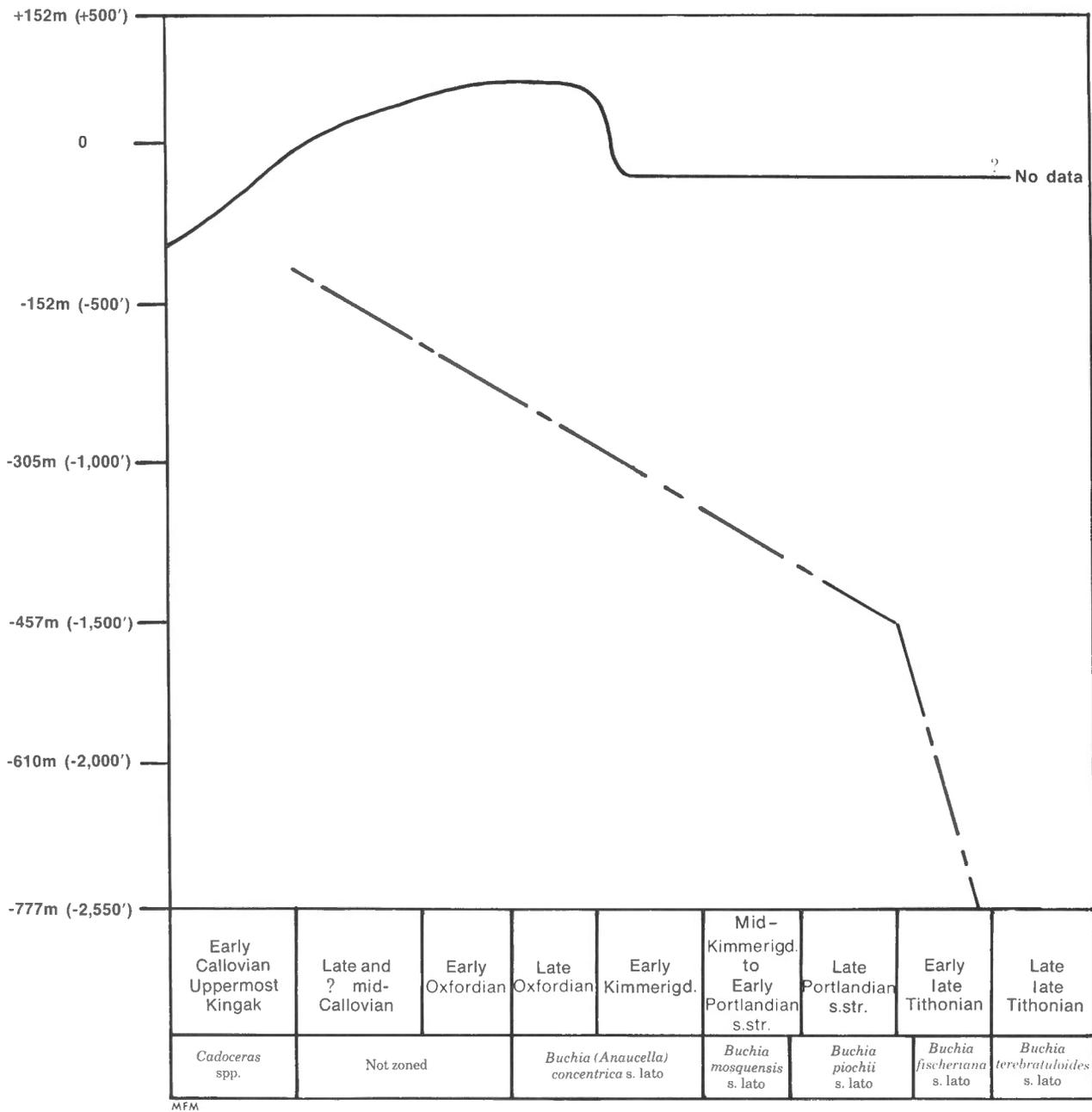


Figure 3. Depositional-tectonical behaviour of the typical facies of Porcupine River Formation. Solid line (—) depicts the tectonically caused changes in the height of land and depth of basin as deduced from the lithofacies and character of macroinvertebrate fauna and flora of the formation. Broken line (---) represents the depth of subsidence of the base of Porcupine River Formation as indicated by its preserved thickness. The steady rate of subsidence, indicated for most of the interval, is an oversimplification but an approximation to it is suggested by comparable thicknesses of most *Buchia* zones below *Buchia fischeriana* s. lato Zone.

(Jeletzky, 1975a, p. 35, 37, 43-48), no appreciable quantities of medium- to coarse-grained arenaceous (not to mention grit and pebble conglomerate) rocks are known to exist in the middle and upper parts of the nonmarine facies. This suggests the deposition of sediments of this facies on the wide, slowly rising, eastern coastal plain of Keele-Old Crow Landmass (see Jeletzky, 1975a, p. 29-31, Fig. 10; this report, Figs. 1 and 2). The almost exclusively fine arenaceous, well-sorted and rounded character of these sediments suggests also an absence of any strongly elevated areas farther westward and northwestward in the

adjacent inner areas of Keele-Old Crow Landmass which was the source area of Porcupine River Formation sediments (see Jeletzky, 1975a, p. 29-30, 41-42, 46, Figs. 10, 18). Were it not for the evidence of greater, nearly contemporary, uplifts within the Barn Mountain and southeastern Keele Range deltaic lobes of the Porcupine River Formation (see Jeletzky, 1975a, p. 29-31, Fig. 10; this report, Fig. 1 and in following sections of this paper), one could conclude that the deposition of the nonmarine facies of the formation was caused solely by a gradual silting up of the western belt of the Richardson Mountain-

Porcupine Plain Trough in late or ?mid-Callovia to late Oxfordian time with the resulting eastward prograding of nonmarine wedges within this belt. The inferred uplift must have been proceeding contemporaneously with a steady subsidence of the eastern Keele Range-Dave Lord Ridge area because, otherwise, an accumulation of 168 to 335 m (550-1100 ft.) of lagoonal, deltaic and lowland deposits of the nonmarine facies would have been impossible (see Fig. 3).

In contrast to the slowly progressing regressive episode that caused the deposition of the nonmarine facies, the marine facies reflects the occurrence of a momentary (geologically speaking) subsidence of the whole eastern Keele Range-Dave Lord Ridge area of the western flank of Richardson Mountain-Porcupine Plain Trough. This subsidence resulted in a transgression of early Kimmeridgian (late *Buchia* (*Anaucella*) *concentrica* time) sea over all that area (Jeletzky, 1963, p. 80, 81, Fig. 6; 1975a, p. 46, Fig. 18). The fine to very fine grained, quartzose to orthoquartzitic sandstones of the marine facies were deposited on the rocks of the nonmarine facies as the result of this subsidence. The exclusively, or at least predominantly, littoral (including upper littoral or intertidal), open-shelf depositional environment of the sandstones of the marine facies is suggested first of all by the character of its abundant fauna consisting largely of thick-shelled, large pelecypods and commonly including such stenohaline types as starfish and belemnites (see Unit 7 of Sec. 1). The prevalence of open-shelf conditions also is suggested by the ubiquitous presence of thin intercalated beds of coquinoid sandstone and by an extreme rarity of sequences characterized by an upward coarsening and an upward increase in content of carbonaceous and coaly particles within the marine facies, such as would suggest the presence of offshore bars. However, the presence of some offshore bar deposits is suggested by the occurrence of interbeds of presumably lagoonal to estuarine carbonaceous to coaly, rootlet-bearing sandstone and siltstone in the marine facies.

The small vertical amplitude of the early Kimmeridgian subsidence of the northeastern Keele Range-Dave Lord Ridge area is evidenced by the exclusively, or at least predominantly, littoral character of the arenaceous deposits of the marine facies. A subsidence of some 61 to 91 m (200-300 ft.) would have been ample to replace the lowland to deltaic sedimentary environment of the nonmarine facies with the littoral sedimentary environment of the marine facies. The macroinvertebrate fauna (i.e. the continuing prevalence of thick-shelled, large pelecypods forming coquinoid layers) and the lithology of the marine facies clearly indicate the absence of any progressive deepening of this late Porcupine sea, following its initial transgression in the early Kimmeridgian, at least to the end of early late Tithonian (i.e. *Buchia fischeriana*) time. However, in addition to the early Kimmeridgian subsidence pulse, the northeastern Keele Range-Dave Lord Ridge area of the western half of Richardson Mountain-Porcupine Plain Trough must have been continuing to subside slowly but steadily throughout the early Kimmeridgian to late Portlandian s. str., and then at a much faster rate in early upper Tithonian to accommodate the 213 to 678 m (700-2225+ ft.) sequences of the littoral sandstones of the marine facies (Fig. 3).

The absence of any correlation between the depth of the Porcupine Basin (see Fig. 1) within the area of typical development of the Porcupine River Formation and the

rate of subsidence of its base (Fig. 3) suggests the existence of a strong surplus of sediment supply throughout the time of deposition of the formation within the Dave Lord Ridge deltaic lobe. The varying rates of subsidence of the area controlled the amount of sediment that could have been deposited at any given time. However, the invariably shallow depth of the sea, which shows no correlation whatsoever with the rate of subsidence, suggests strongly that there always was considerable extra sediment that was sufficient to compensate for the increases in the rate of subsidence and to leave an excess of sediment to be carried into quieter and deeper water by waves and currents.

AGE, CORRELATION, AND FACIES CHANGES

Age limits in area of typical development

The lower or nonmarine facies of the Porcupine River Formation did not yield any diagnostic marine macroinvertebrates in its northeastern Keele Range-Dave Lord Ridge sections. However, the upper beds of its marginal development in the eastern confluent of Waters River (see Jeletzky, 1974, p. 7, and unpublished) contain *Buchia* (*Anaucella*) *concentrica* s. lato fauna at several levels. Only the equivalents of the lower, largely or entirely upper Oxfordian (see Jeletzky, 1967, p. 10, 36), part of the *Buchia* (*Anaucella*) *concentrica* Zone are contained in the Waters River sections of the nonmarine facies as the index species ranges into the lower part of the overlying marine facies in these sections (see Jeletzky, 1974, p. 7, 8). The correlative upper part of the nonmarine facies of northeastern Keele Range-Dave Lord Ridge area also includes only the lower, presumably upper Oxfordian, part of *Buchia* (*Anaucella*) *concentrica* s. lato Zone, since late forms of this *Buchia* species were found higher in the basal part of the overlying marine facies (e.g. Unit 10 of Sec. 4, Appendix and in the type area of Sharp Mountain Formation; see Jeletzky, 1975b, p. 240).

The lower part of the nonmarine facies of eastern Keele Range-Dave Lord Ridge area must be older than the upper Oxfordian part of *Buchia* (*Anaucella*) *concentrica* Zone for the following reasons.

First, the lower part of its partly marine marginal development outcropping in headwaters and eastern confluent of Waters River (see Jeletzky, 1974, p. 7 and Sec. 6, Appendix), locally contains a rich fauna of marine pelecypods devoid of *B. (A.) concentrica* s. lato and any other *Buchia*. This fauna contains instead large, coarsely sculptured *Meleagrinnella* ex gr. *echinata* (Smith) which appear to be restricted to the Middle Jurassic (Bathonian to Callovian) rocks in the Richardson Mountain-Porcupine Plain Trough. Second, the lower part of the nonmarine facies is superimposed directly on the uppermost Kingak beds containing presumably early Callovian *Cadoceras* faunas in the eastern headwaters of Waters River and in the eastern Keele Range-Dave Lord Ridge area (e.g. *Cadoceras voronetsae* Frebold, 1964, p. 9, Tables I, II, collected at GSC loc. 17669; and *Cadoceras* aff. *barnstoni*-*C. crassum* fauna found in Unit 1 of Sec. 4, Appendix). The contact between Kingak and Porcupine River formations is covered in Section 4 (see above) and the *Cadoceras* fauna was found about 11 m (36 ft.) stratigraphically below the visible top of Kingak Formation. The exact contact relationships between the uppermost Kingak shale and the overlying basal beds of the nonmarine facies in the Waters River section containing *Cadoceras voronetsae* Frebold also are obscure because of

poor exposures (Jeletzky, unpubl.). However, the widespread presence of either early Callovian *Cadoceras* fauna or roughly equivalent *Cylindroteuthis* (*Communicobelus*) aff. *subextensa* (Nikitin) fauna (e.g. in Sec. 5, Appendix) closely below the base of the nonmarine facies suggests at least a generally conformable contact of these units and an absence of a prolonged hiatus between them. For reasons explained in the section on depositional environment and tectonic regime of the Porcupine River Formation, the writer believes that the marine beds of the uppermost Kingak Formation grade upward into deltaic to paludal basal beds of the nonmarine facies throughout the eastern Keele Range-Dave Lord Ridge area and in that of eastern confluent of Waters River.

Because of the above considerations, it is concluded that the lower part of the nonmarine facies of the Porcupine River Formation is older than the lower (i.e. upper Oxfordian) part of the *Buchia* (*Anaucella*) *concentrica* Zone and includes at least the lower Oxfordian and upper Callovian (and possibly middle Callovian beds also) beds in nonmarine facies (Figs. 4, 5).

The upper or marine facies of the typical development of Porcupine River Formation can be dated directly (see Jeletzky, 1967, p. 9) using the contained diagnostic fossils. In all sections studied these predominantly marine beds contain the following *Buchia* faunas of the Canadian standard (upward sequence; see Fig. 5):

1. Late, presumably early Kimmeridgian, phase of *Buchia* (*Anaucella*) *concentrica* (Sowerby) fauna;
2. Early and late phases of *Buchia mosquensis* (v. Buch) s. lato fauna of mid-Kimmeridgian to early Portlandian s. str. age;
3. Undivided, *Buchia piochii* (Gabb) s. lato fauna of mid-Portlandian s. str. to earliest late Tithonian age; and
4. Undivided, *Buchia fischeriana* (d'Orbigny) s. lato fauna of early, but not the earliest, late Tithonian (= early late Volgian) age. These generalized mid- to late, but not the latest, Late Jurassic *Buchia* faunas and their more refined faunal phases are widespread in Arctic and Western Canada (see Jeletzky, 1966, p. 43; 1967, p. 10, 33-36; in Jeletzky and Tipper, 1968, p. 8, 11-13). The reader is referred to these publications for more detailed information about these *Buchia* zones.

Buchia (*Anaucella*) *concentrica* fauna was not found in the marine facies of the type section of Porcupine River Formation. However, its presence in the basal part of the marine facies of Section 4 (in Unit 10, Appendix) combined with the presence of the early, mid- to late Kimmeridgian phase of *Buchia mosquensis* fauna in the interval 83 to 137 m (272-450 ft.) below the top of Unit 7 of the type section suggests that the basal 76 m (250 ft.) of that unit are correlative with the upper part of *Buchia* (*Anaucella*) *concentrica* Zone (Figs. 4, 5).

The late (i.e. early Portlandian s. str.) phase of *Buchia mosquensis* fauna (see Jeletzky, 1967, p. 10, 35 for further details about its age and correlation) is widespread in the middle part of the marine facies of the eastern Keele Range-Dave Lord Ridge area where it ranges through an interval, at least 95.5 m (300 ft.) thick (see Units 3 and 7 of Sec. 3; Unit 3 of Sec. 2; and Unit 13 of Sec. 4, in Appendix). Judging by the evidence obtained in the northeastern Richardson Mountains (Jeletzky, 1967, p. 35), the late phase of the *Buchia mosquensis* fauna occurs immediately above the early phase of this fauna

and intergrades with the latter. However, in the area of typical development of the Porcupine River Formation the two phases were found only once in direct superposition in a continuous, well-exposed section (see in Unit 7 of Sec. 1).

As elsewhere in Western and Arctic Canada (see Jeletzky, 1967, p. 10, 35-36; in Jeletzky and Tipper, 1968, p. 8, 13), the *Buchia mosquensis* s. lato Zone is followed by the *Buchia piochii* s. lato Zone (see Units 3 and 4 of Sec. 3, Appendix). However, the records of *Buchia piochii* s. lato in the upper part of the marine facies are too sparse and too uncertain stratigraphically for any further subdivision, such as was carried out elsewhere in the Richardson Mountain-Porcupine Plain Trough (Jeletzky, 1967, p. 34, 35). Furthermore it is impossible to estimate the thickness of the *Buchia piochii* s. lato Zone in eastern Keele Range and Dave Lord Ridge area beyond a tentative suggestion that it could be 46 to 61 m (150-200 ft.) thick in most of the suitable sections studied.

Buchia fischeriana fauna is widespread in the uppermost part of the marine facies (see Units 13 and 15 of Sec. 3 and Unit 14 of Sec. 4, of Appendix; Jeletzky, 1971a, p. 211, Fig. 2; and a number of unpublished sections).

As already mentioned, the *Buchia fischeriana* (s. lato) fauna ranges up to the top of the marine facies in all sufficiently extensive, fossiliferous sections of the typical development of the Porcupine River Formation studied by the writer. In most sections, this fauna is restricted to the uppermost 61 to 91 m (200-300 ft.) exposed, immediately overlies *Buchia piochii* (s. lato) Zone, and contains a mixture of *Buchia piochii* s. lato and *B. fischeriana* (s. lato). This is the case, for example, in Unit 13 of Section 3 and in Unit 14 of Section 4 (see Appendix). These relationships (see Jeletzky, 1967, p. 34 for further details) suggest that the upper part of the *Buchia fischeriana* (s. lato) Zone is eroded in all such sections. This idea is confirmed by the presence of about 396 m (1300 ft.) of rocks of *Buchia fischeriana* s. lato Zone in the topmost preserved part of Section 5 (Appendix). Furthermore, the upper part of this interval (e.g. Unit 10 of Sec. 5) contains an uncontaminated fauna of advanced forms of *B. fischeriana* which indicates that the *Buchia fischeriana* (s. lato) Zone is largely or completely represented in Section 5. It is concluded, accordingly, that the *Buchia fischeriana* (s. lato) Zone was originally at least as thick in all previously mentioned, more centrally situated sections of the typical development of the Porcupine River Formation. However, at least 305 m (1000 ft.) of its beds were lost there through a subsequent erosion.

Age, thickness and facies changes in other outcrop areas

Outside of the area of typical development of the Porcupine River Formation encompassing the deltaic lobe of Dave Lord Ridge (Figs. 1, 2), the thickness and biochronologically measured time span (as indicated by *Buchia* zones included) fluctuate very strongly in a general north-south direction on the western limb of the Richardson Mountain-Porcupine Plain Trough. These north-south lateral facies changes, which are graphically summarized in Figure 4, are as follows. South and southwest of the area of typical development of the Porcupine River Formation its biochronological span and thickness decrease rapidly in the headwaters of Bluefish River-Lord Creek and on lower Johnson Creek, but

increase again in the area situated 16 to 19 km (10-12 miles) farther southwestward on the southeastern slope of the Keele Range (see Jeletzky, 1974, p. 1; 1975a, p. 29, 31, Fig. 10; this paper, Fig. 4). These drastic lateral changes of thickness and biochronological span of the Porcupine River Formation are accompanied by a corresponding increase and decrease of argillaceous interbeds within the formation.

The decrease of the biochronological span and thickness of the Porcupine River Formation toward the southwest is illustrated by the previously published section (Jeletzky, 1974, p. 1; 1975a, p. 9, Fig. 4, Sec. D1) situated in the headwaters of Bluefish River and Lord Creek; this section also illustrates the rapid shaling out of the unit toward the southwest. There, the entirely shallow marine sandstones of the Porcupine River Formation are only about 122 m (400 ft.) thick and include only fossils of the *Buchia mosquensis* s. lato Zone. Furthermore, the attenuated formation includes numerous interbeds of marine siltstone. In this area the time equivalents of nonmarine facies and those of the rest of the *Buchia* zones present in the typical development of Porcupine River Formation in eastern Keele Range-Dave Lord Ridge area obviously are contained in the underlying argillaceous rocks of the Kingak Formation (which, so far, have yielded no fossils), and the overlying equally unfossiliferous argillaceous rocks of the Husky Formation respectively.

The same lateral decrease of thickness and biochronological span of the Porcupine River Formation is believed to occur toward the south because of its marine facies in the Molar-YT P-34 well (see Jeletzky, 1975a, p. 8, Fig. 4, Sec. 2). However, these facies changes cannot be documented as well as those taking place farther west in the surface sections because of poor paleontological control and subsequent pre-Albian erosion of the Porcupine River Formation which may range from considerable to total in the subsurface of northern Eagle Plain.

The trend of southwestward thinning and shaling out of the Porcupine River Formation is reversed in the southeastern Keele Range. This is evidenced by the presence of a section, about 549 m (1800 ft.) thick, of almost exclusively nonmarine Porcupine River Formation on the 1409 m (4620 ft.) high, nameless mountain situated at Latitude 66°51'N and Longitude 139°54'W (see Jeletzky, 1971a, p. 213, Fig. 3; this paper, Fig. 4, Pl. 2, fig. 3). This section situated only 16 to 19.2 km (10-12 miles) south (see Jeletzky, 1975a, p. 30, Fig. 10) of the above-described outcrop area of the formation in the headwaters of Bluefish River and Lord Creek, has yielded *Buchia mosquensis* (v. Buch) s. lato, probably representing the early forms of the species, at a level about 165 m (540 ft.) below the visible top (GSC loc. 86956). Late forms of *Buchia* (*Anaucella*) *concentrica* (Sowerby), possibly representing the topmost part of *Buchia* (*Anaucella*) *concentrica* s. lato Zone, occur in the uppermost beds of the underlying Kingak Formation (see Jeletzky, 1971a, p. 213, Fig. 3; this paper, Fig. 4). Therefore, at least the bulk of the lower 384 m (1260 ft.) of apparently exclusively nonmarine facies of Porcupine River Formation in this section is equivalent to about 122 m (400 ft.) thick, entirely marine facies of the formation outcropping in the headwaters of Bluefish River and Lord Creek. The presumably nonmarine uppermost 165 m (540 ft.) of the southeastern Keele Range section overlying the apparently unique marine interbed admittedly may be

younger and represent *Buchia piochii* s. lato and *Buchia fischeriana* s. lato zones (Jeletzky, 1971a, p. 213). However, the only *Buchia mosquensis* (s. lato) fauna found in this section is better compared to the early (i.e. mid- to late Kimmeridgian) phase of *Buchia mosquensis* s. lato Zone. Therefore, and because of an obviously very rapid accumulation of Porcupine River Formation sandstones in the southeastern Keele Range section, the writer is inclined to place its topmost 165 m (540 ft.) entirely into the upper part of *Buchia mosquensis* (s. lato) Zone. If so, all of the thick, almost exclusively nonmarine southeastern Keele Range facies of Porcupine River Formation would be equivalent approximately to its attenuated, entirely marine facies outcropping in the headwaters of Bluefish River-Lord Creek area.

The thickness of Porcupine River Formation remains comparable to the above discussed southeastern Keele Range section for 56 to 64 km (35-40 miles) south from it. Outcrops of this thick facies form a belt, 5 to 13 km (3-8 miles) wide, extending from the nameless 1409 m (4620 ft.) high mountain massif to the lower course of Bern Creek in northwestern Nahoni Range. So far as could be ascertained from spot landings, the facies of Porcupine River Formation remains similar to that of the southeastern Keele Range section (i.e. that described by Jeletzky, 1971a, p. 213, Fig. 3 and reproduced in this paper in Figs. 1 and 4) all along this belt. However, the ratio of marine rocks appears to increase markedly eastward (i.e. basinward) across the belt. A good example of this facies change was observed in several, so far unpublished, closely spaced sections measured 5 to 6.5 km (3-4 miles) east of the almost exclusively nonmarine section discussed above (see Jeletzky, 1971a, p. 213, Fig. 3; this paper, Fig. 1). In these sections of the Porcupine River Formation, situated at the eastern margin (a pre-Albian erosional edge) of its outcrop belt, only its lower part up to 152 m (500 ft., est.) thick is preserved. The downward sequence of eastward tilted but otherwise undisturbed rocks (see Pl. II, fig. 1) is as follows:

1. A predominantly marine unit, about 76 m (250 ft.) thick consisting of white to buff, quartzose, predominantly noncarbonaceous, fine to very fine sandstone with several thin interbeds of fossiliferous sandstone containing long-ranging marine pelecypods of usual type. The marine unit is underlain, apparently gradationally by;
2. An entirely nonmarine unit, about 21 m (70 ft.) thick, consisting of dull to dark grey, carbonaceous to coaly, very fine grained, silty but nevertheless quartzose sandstone rich in subvertical rootlets of plants and carbonized plant fragments but devoid of marine fossils.

The nonmarine unit of the eastern sections discussed previously is situated very close to the base of the Porcupine River Formation, since undisturbed, dark grey, marine shale of the uppermost Kingak Formation outcrops only 30.5 to 45.5 m (100-150 ft.) stratigraphically below its invariably covered base (see Pl. II, fig. 1). These stratigraphic relationships indicate a complete lateral replacement of the overlying marine unit of the eastern sections by entirely nonmarine, carbonaceous to coaly, plant- and plant-rootlet-bearing sandstone of the basal few hundred feet of the 549 m (1800 ft.) thick section of the Porcupine River Formation measured only 5 to 6.5 km (3-4 miles) farther west. As mentioned, the lower and middle parts of this well-exposed section appear to lack any fossiliferous marine interbeds to the level of 384 m (1260 ft.) above base.

As pointed out by Jeletzky (1971a, p. 213-215, 218, Fig. 3; 1975a, p. 4-6, 29-31, Figs. 2, 3, 10), the thick and at least predominantly nonmarine facies of the Porcupine River Formation, becomes rapidly replaced laterally by a much thinner, entirely marine facies of the formation in the headwaters of Bern Creek and those of Fishing Branch or Porcupine River. Still farther south and southeast, in the headwaters of Fishing Creek and those of Kandik River, the sandstones of the Porcupine River Formation are either reduced to insignificant (30-45 m; 100-150 ft.) pinch out tongues within the open marine, argillaceous rocks of the Husky Formation or are replaced totally by these outer neritic to upper bathyal rocks. A similar eastward attenuation of sandstones of Porcupine River Formation and their lateral replacement by deeper water argillaceous rocks of the Husky Formation takes place within an interval, 8 km (5 miles) wide, in the headwaters of Bern Creek and Fishing Branch of Porcupine River (Jeletzky, 1971a, p. 214-215; 1975a, p. 4-5, Fig. 2, Secs. A2, A3). Though its southern and southwestern flanks are destroyed by post-Late Jurassic erosion, this westward-directed protuberance of deep-water, argillaceous equivalents of the Porcupine River Formation (see Fig. 4) is interpreted herein as a wide westward-convex embayment of the Porcupine Sea flanking the southeastern Keele Range deltaic lobe of the formation from the south and southwest (Fig. 1). This embayment is designated herewith as the Kandik Embayment. For reasons explained below in connection with the discussion of the Keele Embayment of the Porcupine Basin, this Late Jurassic embayment is believed to have been terminated either at or just west of the Yukon-Alaska border (Fig. 1). Further details of these facies changes of the Porcupine River Formation have been discussed comprehensively by Jeletzky (1971a, 1975a) and do not need to be recapitulated here.

As pointed out (Jeletzky, 1975a, p. 29-31, Fig. 10), the outcrop area of the Porcupine River Formation in the southeastern part of the Keele Range and northwestern-most part of the Ogilvie Mountains (Nahoni Range) forms an eastward directed protuberance of its very thick, predominantly nonmarine facies, surrounded by attenuated, largely to entirely marine facies in the north, east, and south. Therefore, and because of the apparently complete absence of marine and nonmarine Upper Jurassic rocks farther west in the western Keele Range and in adjacent parts of the Charley River and Coleen quadrangles of east-central Alaska, this protuberance was interpreted (Jeletzky, 1974, p. 2, 3, Fig. 1; 1975a, p. 29-31, Fig. 10) as an eastward-prograding deltaic lobe deposited by a large eastward or southeastward flowing river(s) draining the Late Jurassic Keele-Old Crow Landmass. The attenuated, entirely marine facies of the Porcupine River Formation outcropping in the headwaters of Bluefish River-Lord Creek and intervening between the deltaic lobe of the southeastern Keele Range and that of the northeastern Keele Range-Dave Lord Ridge area was interpreted as a narrow but deep, westward convex marine embayment of the Porcupine Sea ending within the Keele-Old Crow Landmass (Jeletzky, 1974, p. 3, Fig. 1; 1975a, p. 29-31, Fig. 10). This embayment is designated the Keele Embayment in this paper (Fig. 1), this term replacing the so-called Keele Trough of Norris (1972, p. 91, 93, Fig. 1).

Since its introduction, the interpretation of the Late Jurassic paleogeography of the Keele Range and adjacent areas of northwestern Yukon discussed above was

confirmed by results of an independent study of the Late Jurassic paleobiogeography of Alaska carried out by Imlay and Detterman (1973). This research confirmed the results of earlier American workers (Brabb and Churkin, 1969; Brabb, 1969; Brosgé and Reiser, 1969) regarding a complete absence of Late Jurassic marine fossils in east-central Alaskan areas adjoining the Keele Range. Imlay and Detterman (1973, p. 2, 20, Figs. 5-9) concluded, accordingly, that these areas were above sea level and undergoing erosion throughout Late Jurassic time. Because of the above considerations, the writer continues to reject the hypothesis of a Keele Trough (Norris, 1972, p. 91, 93, Fig. 1) purporting to connect the Jurassic basin of northern Richardson Mountains with that of the east-central Alaskan part of the Kandik Basin. The recent advocacy of this hypothesis by Young (1975, p. 315-316, Fig. 3) is not convincing in the writer's opinion. The great reduction in thickness of Porcupine River Formation sandstone in Ridge YTF-48 well situated just west of Porcupine River Canyon is inconclusive since obviously it is caused by considerable erosion of the formation in pre-Albian time rather than by a lateral change of facies. The inferred deposition of these basal beds of the Porcupine River Formation "in the shoreface environment" (Young, 1975, p. 316) agrees perfectly with the inferred position of Ridge YTF-48 well at the southern margin of Dave Lord Ridge deltaic lobe (see Jeletzky, 1975a, p. 29-31, Fig. 10; this paper, Fig. 1). The lateral southward replacement of the nonmarine facies of the typical development of the Porcupine River Formation by marginal shoreface deposits is to be expected in about that position (see Jeletzky, 1975a, p. 29-31, Fig. 10; this paper, Fig. 4). Section 601YA measured on the eastern slope of Mason Hill (Young, 1975, p. 315, Fig. 3) is incomplete at the base as well as at the top (see the description and analysis of Sec. 3, Appendix, which essentially duplicates the above Sec. 601YA). This section is irrelevant for the writer's (Jeletzky, 1974, 1975a, this paper) interpretation of the nonmarine facies as a deltaic deposit since the bulk of it (see Unit 6 of Sec. 1 or Units 2-9 of Sec. 4) does not outcrop therein. Finally, in the writer's opinion, the interpretation of Late Jurassic paleocurrent directions is meaningless for reasons fully explained elsewhere (Jeletzky, 1975a, p. 1, 2). In addition to general unreliability of trends of paleocurrent directions for the purpose of reconstruction of the paleogeography of a geographically complex, tectonically active paleobasin, none of Young's (1975, Fig. 3) paleocurrent localities is dated in terms of paleontological stages or zones contained within the Porcupine River Formation. Because the typical development of the formation spans most of Late Jurassic time (many millions of years), the chances of these scarce paleocurrent localities representing the same stage of geological history of the paleobasin concerned are effectively nil.

As pointed out (Jeletzky, 1971a, p. 213, Fig. 3; 1975a, Figs. 2, 3; and previously in this paper), the deposition of the deltaic facies of the Porcupine River Formation on both flanks of the southeastern Keele Range lobe only began within the early Kimmeridgian phase of *Buchia* (*Anaucella*) *concentrica* time (see Fig. 4). This suggests strongly that this deltaic lobe is entirely younger than the previously discussed late or ?mid-Callovia to late Oxfordian deltaic lobe of the northeastern Keele Range-Dave Lord Ridge which began to subside and was flooded either shortly before or at the beginning of early Kimmeridgian time (see Fig. 4 and in section on age limits of Porcupine River Formation in the area of its typical development).

Only the marine sandstone member, 53 to 104 m (175-340 ft.) thick, occurring about 396 m (1300 ft.) stratigraphically below the top of the Kingak shale in the southeastern Keele Range section (Jeletzky, 1971a, p. 213, Fig. 3) and shown in Figure 4 of this paper, but also present in other sections in this area, may be correlative with the topmost part of the nonmarine facies of northeastern Keele Range-Dave Lord Ridge outcrop area of Porcupine River Formation. Its lower beds, at least, contain *Buchia (Anaucella) concentrica* forms referable to the upper Oxfordian part of *Buchia (Anaucella) concentrica* s. lato Zone. This facies appears to wedge out completely farther south, in the headwaters of Bern Creek and in those of Fishing Branch of Porcupine River, where no significant amounts of sandstone are known to occur in the upper Oxfordian part of *Buchia (Anaucella) concentrica* Zone. In the southeastern Keele Range, therefore, this presumably lower rather than upper littoral sandstone facies is the only expression of late or ?mid-Callovian to late Oxfordian uplift that produced the northeastern Keele Range-Dave Lord Ridge deltaic lobe farther north (see Fig. 4).

The evidence presented clearly indicates that the area of southeastern Keele Range deltaic lobe began to rise at about the same time (geologically speaking) when that of the Dave Lord Ridge lobe began to subside. This conflicting (apparently hinge-like) tectonic behaviour of adjacent segments of the western flank of Richardson Mountain-Porcupine Plain Trough is one more instance of the Jurassic-Cretaceous tectonic regime described by Jeletzky (1975a, p. 43-46, Figs. 17, 18) in this tectonically active region.

In contrast to the rather complex southwestward facies and thickness changes of the Porcupine River Formation, the corresponding eastward changes of its typical development appear to be rather simple (see Fig. 5). At first, the gradual eastward decrease in the biochronological time span of the Porcupine sandstone is a result of its marked shaling out and not of any appreciable decrease in the thickness. Only after the area of easterly confluents of Waters River is crossed does the thickness of Porcupine sandstone begin to decrease markedly. This is illustrated by the complete thickness of Porcupine River Formation being about 498 m (1635 ft.) in the section measured at approximately Latitude 67°38'30"N to 67°30'45"N and Longitude 137°06'W to 137°07'W on the western slope of the nameless mountain 1344 m (4409 ft.) high (see Jeletzky, 1974, p. 7). However, this section of the Porcupine River Formation includes only beds ranging from the ?mid- or ?upper Callovian to upper Kimmeridgian or lower Portlandian s. str. (i.e. middle or upper part of *Buchia mosquensis* Zone). The sandstone facies of overlying *Buchia piochii* and *Buchia fischeriana* zones is replaced laterally by the argillaceous facies of the Husky Formation. The formation remains comparably thick, though still more attenuated biochronologically and including yet more argillaceous interbeds at least for another few miles eastward (Jeletzky, 1974, p. 8) within the eastern headwaters of Waters River. Still farther east, the Porcupine River Formation appears to thin out rapidly and, at the same time, to become more and more attenuated biochronologically (i.e. reduced to the lower part of *Buchia (Anaucella) concentrica* Zone). It is only 12 m (40 ft.) thick in the apparent eastern pinch-out wedge in McDougall Pass (Jeletzky, 1974, p. 8; 1975a, p. 11, Fig. 6) and has a similar thickness in the three pinch-out wedges observed on the eastern flank of the

White Mountains (Jeletzky, 1972, p. 18, 19; 1975a, p. 14, Fig. 7). No traces of the Porcupine River sandstone have so far been recognized farther east on the eastern slope of Richardson Mountains (Jeletzky, 1975a, p. 11) and it is presumed to be completely replaced laterally by inner neritic siltstones of the lower part of the Husky Formation throughout this area (see Fig. 5).

The eastward facies changes summarized above, of the Porcupine River Formation (formerly Unnamed Upper Jurassic sandstone division) were discussed and illustrated comprehensively by Jeletzky (1971a, p. 205-206, 211, Fig. 2; 1972, p. 18, 19; 1974, p. 6-9; 1975a, p. 9-11, 29-31, 46; Figs. 4, 5, 10, 18) so that it is unnecessary to recapitulate here these still fully valid data.

Only a few poorly exposed and strongly disturbed sections of the Porcupine River Formation are known to exist in the interval between the headwaters of Berry Creek and Waters River on the one hand, and the headwaters of Blow River on the other. However, they suffice to document a gradual northward decrease of biochronological span and thickness of the formation in this area (see Fig. 4). As elsewhere around the area of typical development of the formation represented by Sections 1 to 6 inclusive, the decrease of biochronological span and thickness is accompanied by a marked shaling out of the formation.

The section measured in the headwaters of northern Johnson Creek (see Fig. 4), which is chosen to illustrate the above-mentioned facies changes of Porcupine River Formation, is incomplete and considerably faulted. This entirely shallow marine section, 104 m (350 ft.) thick, can include only the upper (lower Kimmeridgian) part of the *Buchia (Anaucella) concentrica* s. lato Zone and most or all of the *Buchia mosquensis* (s. lato) Zone.

The lower age limit of Porcupine River Formation in this section is determined approximately by the presence of early and possibly some of the late representatives of *Buchia (Anaucella) concentrica* (s. lato) fauna in the underlying uppermost 120 m (400 ft.) of siltstones of the Kingak Formation. Furthermore, these upper Oxfordian siltstones grade upward into the lithologically recognizable (i.e. gritty and fine pebbly siltstone) basal bed of the Porcupine River Formation (see Fig. 4). The presence of an extremely disturbed grey shale unit, apparently a few hundred feet thick, stratigraphically between the principal preserved sandstone unit of Porcupine River Formation and its gritty and pebbly basal bed, suggests that the upper (lower Kimmeridgian) part of *Buchia (Anaucella) concentrica* Zone is represented by this argillaceous (i.e. laterally shaled-out) part of the formation. If so, this sandstone unit begins within the lower (mid- to upper-Kimmeridgian) part of *Buchia mosquensis* (s. lato) Zone.

The upper age limit of the northern Johnson Creek section of Porcupine River Formation is defined by the presence of *Buchia* cf. *blanfordiana* (Stoliczka) which is diagnostic of the lower part of *Buchia piochii* (s. lato) Zone in the basal exposed beds of the overlying Husky Formation (see Jeletzky, 1972, p. 28 and Fig. 4 of this paper). This indicates that the age of the principal preserved sandstone unit of the formation is not younger than the lower part of the *Buchia piochii* (s. lato) Zone, and probably ends within the upper part of *Buchia mosquensis* (s. lato) Zone.

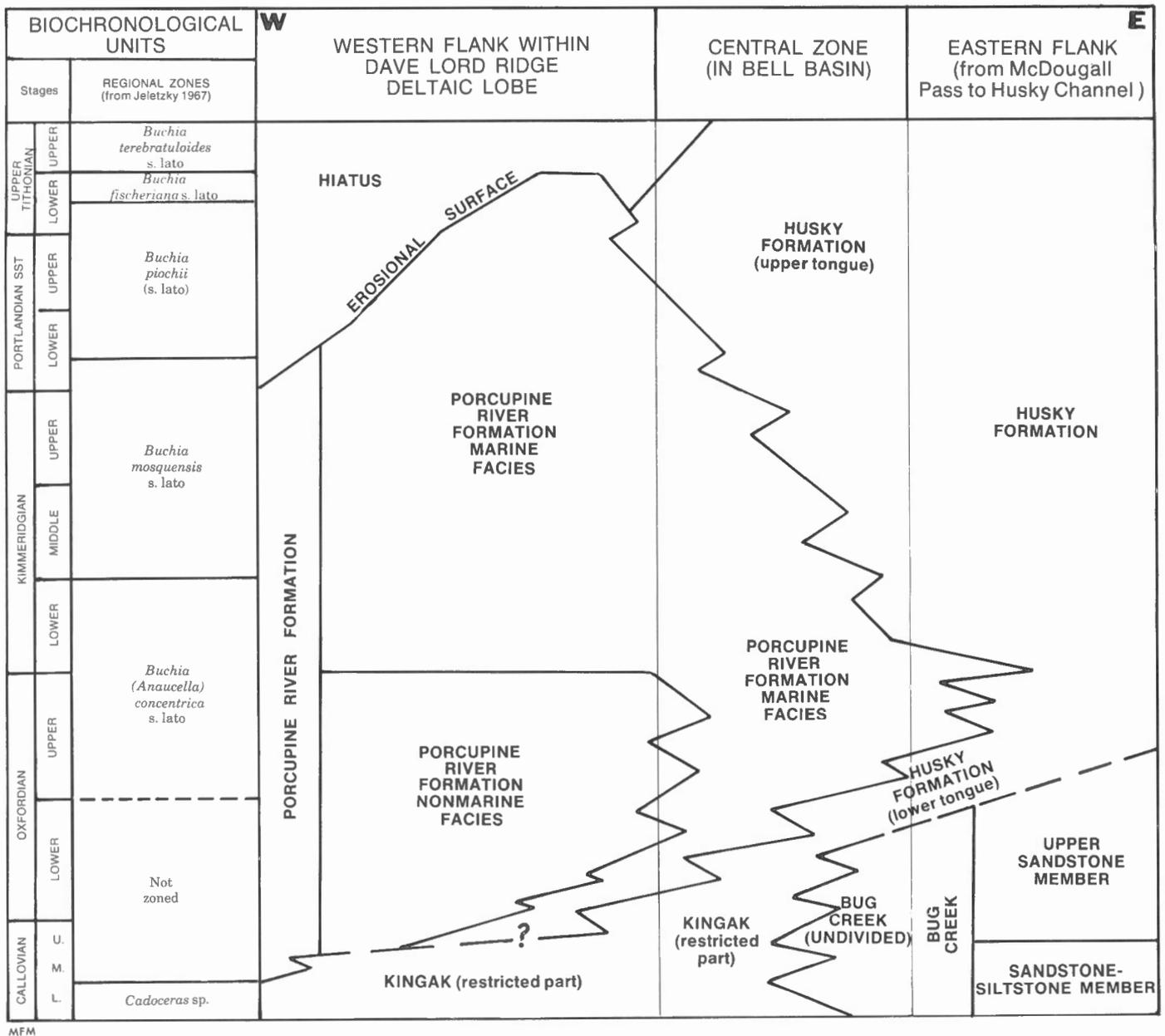


Figure 5. Age limits of Porcupine River Formation in Dave Lord Ridge deltaic lobe and its external correlation across Richardson Mountain-Porcupine Plain Trough.

In the northern Johnson Creek section, the main sandstone unit of the formation consists of very fine grained, silty, strongly bioturbated sandstones rich in small *Dentalium*-like shells and lacking any traces of cross bedding and ripple marks. This indicates the shaling out of the formation in this area. These marine sandstones were deposited apparently offshore in a low-energy, lowermost littoral or upper neritic environment. Furthermore, this sandstone unit is underlain by shale-siltstone strata that appear to represent a southward pinching out tongue of the Husky Formation within the Porcupine River Formation.

Rather thick (up to 442+ m; 1450+ ft.), largely nonmarine sections of the Porcupine River Formation occur 40 to 48 km (25-30 miles) north of northern Johnson Creek in the southwesternmost headwaters of Blow River

and just south and southeast of the southeastern slopes of Barn Mountains (see Jeletzky, 1972, p. 27-28; 1974, p. 20, 21; 1975a, p. 18, 19, Fig. 8, Sec. G1). This indicates that the trend of gradual northward decrease of biochronological age span and thickness of the Porcupine River Formation, accompanied by its gradual shaling out between the headwaters of Berry Creek and Waters River on the one hand and those of northern Johnson Creek on the other (see above), is reversed within the Bonnet Lake-Blow Pass area.

As pointed out by Jeletzky (1972, p. 23; 1975a, p. 18, 19, 29-31, Fig. 10), the outcrops of the Porcupine River Formation surrounding the southern and southeastern slopes of Barn Mountains form an eastward directed protuberance of its markedly thickened, predominantly nonmarine facies. This protuberance is the last of three

such protuberances known to exist on the western flank of Richardson Mountain-Porcupine Plain Trough. Like the other two (i.e. Dave Lord Ridge and southeastern Keele Range protuberances), the Barn Mountain protuberance is interpreted herein as an eastward prograding deltaic lobe deposited by large, eastward or southeastward flowing river(s) draining the Old Crow-British Mountain part of the Late Jurassic Keele-Old Crow Landmass. It is named herein the Barn Mountain deltaic lobe (see Fig. 1).

The attenuated, entirely marine facies of the Porcupine River Formation outcropping in the headwaters of northern Johnson Creek (see Fig. 4) and intervening between the Barn Mountain and Dave Lord Ridge deltaic lobes (see Jeletzky, 1975a, p. 29, 31, Fig. 10) was interpreted as the second, narrow but deep, westward convex embayment of the Porcupine Sea (Jeletzky, 1972, p. 28, Fig. 1; 1974, p. 20, 21, Fig. 1; 1975a, p. 29, 31, Fig. 10) within the investigated part of the Richardson Mountain-Porcupine Plain Trough. In this paper (see Fig. 1) this embayment is treated as the northernmost of three such embayments which presumably ended within the northern part (i.e. beneath Old Crow Plain) of the Keele-Old Crow Landmass east of the Yukon-Alaska border. This northernmost embayment is named herewith the Driftwood Embayment (Fig. 1).

The interpretation, in the Barn Mountain outcrop area, of the thick and predominantly nonmarine facies of the Porcupine River Formation as an eastward prograding deltaic lobe derived from the northern part of the Keele-Old Crow Landmass is accepted as valid in this paper. However, its exact nature is not nearly as well documented as are the deltaic interpretations of the Dave Lord Ridge and southeastern Keele Range protuberances, because only the facies pattern around the southern, southeastern and eastern sides of the Barn Mountain outcrop area was explored systematically. As pointed out by Jeletzky (1975a, p. 19), it is still impossible to deduce, from extremely scarce published data, what happens to the Porcupine River Formation north, northeast, west, northwest and southwest of the Barn Mountains. The writer is inclined to think that it was never deposited in these areas, which represented a source area for the Barn Mountain deltaic lobe; however, much more work needs to be done in the Babbage River Basin, on the Old Crow Plain and elsewhere in the northwesternmost Yukon. It is possible, for example (Jeletzky, 1975a, p. 19), that the source area of the Barn Mountain deltaic lobe was a Late Jurassic island situated within the northwestern part of the Richardson Mountain-Porcupine Plain Trough.

The lithology, thickness, and facies of the outcrops of the Porcupine River Formation occurring in the southwesternmost headwaters of Blow River and just east and southeast of the southeastern slopes of Barn Mountains have been discussed elsewhere (Jeletzky, 1974, p. 20, 21; 1975a, p. 18, 19) and most of these details are not repeated in this paper. The successions are thick, unfossiliferous and carbonaceous to coaly. They are considered to have been deposited in deltaic, lagoonal, and offshore bar environments. It should be stressed, however that, unlike the Dave Lord Ridge and southeastern Keele Range deltaic lobes, the Barn Mountain outcrop area of the predominantly nonmarine facies of the Porcupine River Formation locally includes minor interbeds and pods of grit and fine pebble conglomerate with poorly rounded to angular, evidently locally derived chert and quartz clasts (Jeletzky, 1972, p. 28).

Furthermore, the Porcupine River Formation sandstones of all sections studied in the southwesternmost headwaters of Blow River and just off the southern and southeastern slopes of the Barn Mountains are considerably less quartzose, more poorly sorted as to the grain size, and consist of grains that are much less rounded than their counterparts in Dave Lord Ridge and southeastern Keele Range lobes (see Jeletzky, 1972, p. 27, 28; 1974, p. 20-22; 1975a, p. 18, 19). This suggests that the western and (or) northwestern source area of the Barn Mountain deltaic lobe was situated much closer to the depositional area and was more elevated than those of the other two deltaic lobes of the Porcupine River Formation. This source area is inferred to be situated within the present Barn and (or) Buckland Mountains (Jeletzky, 1972, p. 28; 1974, p. 22; 1975a, p. 19).

The biochronological span of the Porcupine River Formation increases markedly in the southwesternmost headwaters of Blow River and just off the southern and southeastern slopes of the Barn Mountains in comparison with the headwaters of northern Johnson Creek. This is particularly well illustrated by the diachronism of the lower boundary of the formation. In the headwaters of northern Johnson Creek, the deposition of the formation began late in the time of *Buchia* (*Anaucella*) *concentrica* s. lato. This is indicated by the occurrence of early (i.e. late Oxfordian) and possibly late forms of the species in the uppermost 122 m (400 ft.) of the underlying Kingak Formation. However, in sections situated in southwesternmost headwaters of Blow River (see Jeletzky, 1974, p. 21) and just off the southeastern slopes of Barn Mountains (Jeletzky, 1972, p. 27, 28) the lower boundary of the Porcupine River Formation is considerably older. Judging by a complete absence of *Buchia* (*Anaucella*) *concentrica* fauna in the underlying Kingak shale and by the first appearance of primitive early forms of the species in the basal sandstone unit of Porcupine River Formation, this zonal (or the lower/upper Oxfordian) boundary approximately coincides with the Kingak-Porcupine contact (Fig. 4).

In the studied sections of the formation situated in the southwesternmost headwaters of Blow River and just off the southeastern slopes of Barn Mountains its upper contact is invariably faulted. Furthermore, diagnostic marine fossils are all but absent in the predominantly nonmarine upper parts of these sections. This makes it difficult to estimate the northward increase of biochronological time span of the upper part of Porcupine River Formation in the interval between the headwaters of northern Johnson Creek and the southwesternmost headwaters of Blow River. However, the presence of early forms of *Buchia* ex gr. *mosquensis* (v. Buch) in the lower, predominantly marine part of one of the sections situated in southwesternmost headwaters of Blow River (see Jeletzky, 1974, p. 21 and this paper, Fig. 4), and the apparent total absence of any younger Late Jurassic zonal *Buchia* within the area occupied by the markedly thickened, predominantly to entirely nonmarine facies of the Porcupine River Formation, suggest strongly that this facies extends upward either into the late Late Jurassic (e.g. *Buchia fischeriana* s. lato time) or to the very top of the Jurassic. This idea is accepted tentatively as valid in this paper (see Fig. 4). The thickened and predominantly nonmarine facies of the Porcupine River Formation discussed here does not extend any higher since it is known to be overlain by an unfossiliferous upper tongue of the Husky Formation followed by the abundantly fossiliferous, marine facies of the Lower sandstone division (see Jeletzky, 1972, p. 28, 29).

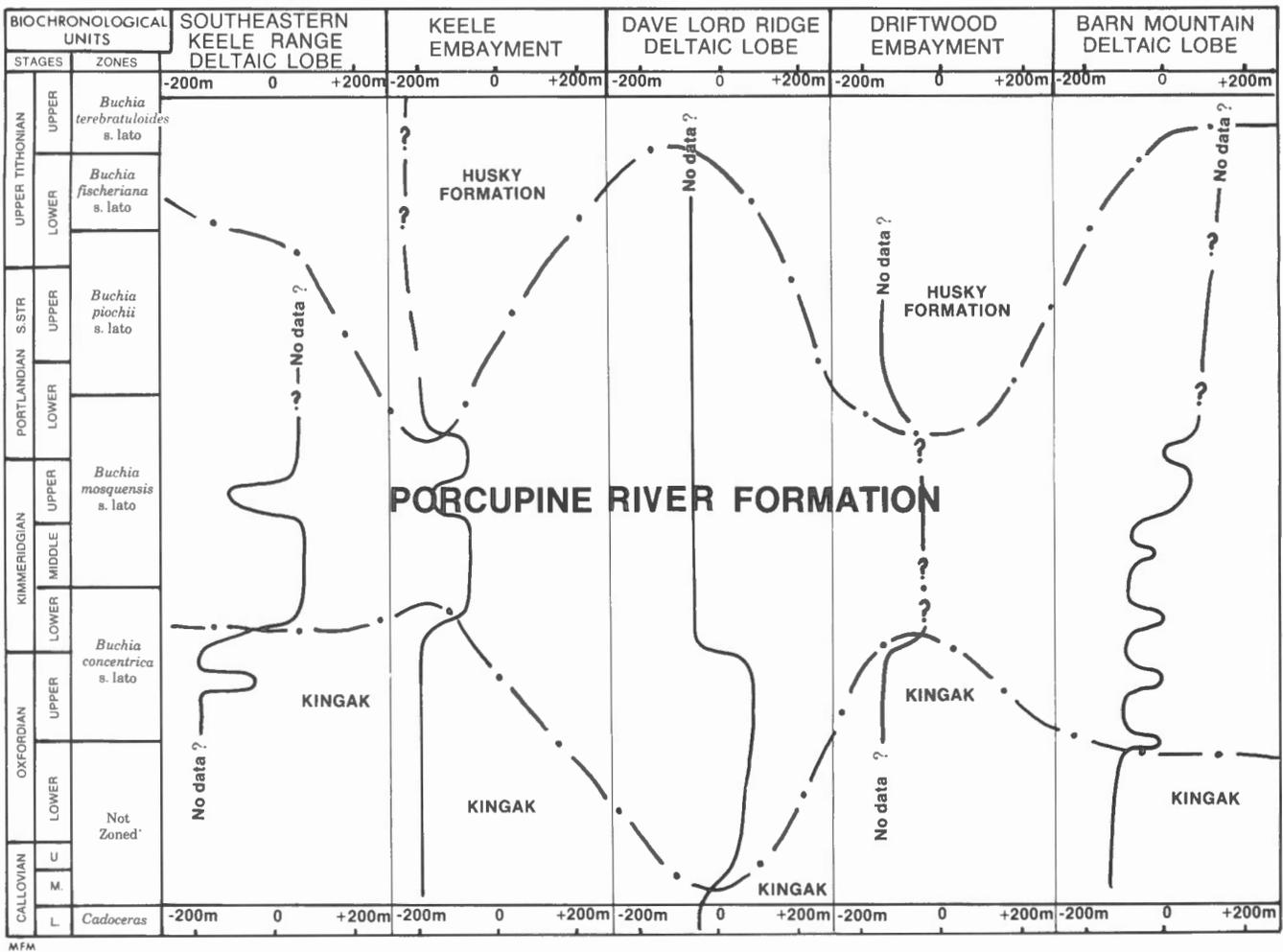


Figure 6. Comparative depositional tectonics of Porcupine River Formation on west flank of Richardson Mountain-Porcupine Plain Trough. The positioning of individual graphs in relation to indicated hypsographic values (i.e. 200 m depth of the sea; 0 or mean sea level; and +200 m elevation of land areas) is always roughly approximate only. The diagram is meant to be semiquantitative and to convey an idea about the order of movements involved.

As noted by Jeletzky (1971a, p. 205; 1974, p. 22; 1975a, p. 18, 19, Fig. 8, Sec. G1, G2, G3), the lower boundary of the Porcupine River Formation is markedly diachronic also in the east-west direction within the Barn Mountain-Blow Pass area. However, the reader is referred to the publications listed for further details of these facies changes.

It is apparent from the previous discussion that the Porcupine River Formation of Barn Mountain deltaic lobe cannot be divided into the same marine and nonmarine units as the formation of Dave Lord Ridge lobe further south. In the Barn Mountain lobe the marine sandstone beds are concentrated in the lower part of the formation whereas its upper part is mostly to almost entirely nonmarine. This is an exact opposite of the situation in the Dave Lord Ridge lobe where the lower part of the Porcupine River Formation is predominantly nonmarine while the upper part is predominantly to entirely shallow marine. In the Barn Mountain lobe one may subdivide conveniently the Porcupine River Formation into a local marine facies below and a local nonmarine facies above. This peculiar sequence of facies, reflecting a very gradual uplift of the Barn Mountain lobe which reached its acme

either toward or at the end (instead of rather early) of the Late Jurassic episode of uplift, stresses further the peculiarity of its tectonical regime (see Figs. 4, 6).

External correlation of typical facies

Since the variations of age limits and thickness of Porcupine River Formation within its known extent have been discussed in preceding sections, the discussion of external correlation of the formation is concerned only with its typical development confined to Dave Lord Ridge deltaic lobe. The external correlations of all other known developments of Porcupine River Formation can be deduced readily from data about its internal correlation provided in the preceding sections and summarized graphically in Figure 4.

As pointed out, the lower part of the nonmarine facies outcropping in the Dave Lord Ridge deltaic lobe and the eastern headwaters of Waters River overlies conformably and possibly gradationally lower Callovian beds containing *Cadoceras* spp., does not contain any representatives of *Buchia* (*Anacella*) *concentrica* fauna and, locally, contains the presumably pre-upper Oxfordian

Meleagrinnella ex gr. *echinata* (Smith). It is concluded accordingly that this part of the nonmarine facies includes beds equivalent to the Upper sandstone member of Bug Creek Formation as developed in Aklavik Range (see Jeletzky, 1967, p. 13-18; this paper, Fig. 5). This is indicated by the presence of lower Callovian *Cadoceras* (*Stenocadoceras*) *canadense* Frebold and *Cadoceras septentrionale* Frebold var. *latidorsata* Frebold (see Frebold, 1964, p. 8, 9, 16, 17, Table II) in the upper part of the underlying Sandstone-siltstone member of Aklavik Range. These ammonites are either of approximately the same age as, or slightly younger than, the *Cadoceras voronetsae* fauna and *Cadoceras crassum* fauna found in the uppermost Kingak beds directly underlying the nonmarine facies of the typical development of Porcupine River Formation (see Unit 1 of Sec. 4 and p. 11).

The Upper sandstone member of the Bug Creek Formation has not yielded any diagnostic fossils either in the type area or elsewhere in northeastern Richardson Mountains (Jeletzky, 1967). However, it is believed to represent all of middle and late Callovian as well as part or all of early Oxfordian time and, thus, to correspond approximately to the pre-upper Oxfordian part of the nonmarine facies of Porcupine River Formation (Fig. 5). This is indicated by an apparently gradational superposition by the Upper sandstone member of the reliably dated lower Callovian beds of the Sandstone-siltstone member in the type area of Bug Creek Formation (Jeletzky, 1967, p. 14) and elsewhere in the northeastern Richardson Mountains (unpublished observations of the writer). Furthermore, the characteristically abrupt and sharp contact of the Upper sandstone member with the overlying Husky Formation (Jeletzky, 1963, p. 80; 1967, p. 17, 29) does not appear to be erosionally disconformable in the sense of involving an uplift of the Upper sandstone member above sea level and its subaerial erosion prior to the transgression of Husky Sea. As pointed out by Jeletzky (1967, p. 29): "No accumulation of coarser detritus particles, let alone a basal conglomerate, was, however, observed at the base of Husky Formation (see Secs. 2 and 22 of the Appendix). This contact may, therefore, reflect an abrupt, regional subsidence of the sea bottom accompanied by organic or inorganic etching of the upper surface of Bug Creek Formation, rather than its upheaval and emergence followed by erosion and subsidence". This conclusion agrees well with the early recognized (Jeletzky, 1963, p. 80) and subsequently confirmed (Jeletzky, 1975a, p. 5, 8, 9, 11, 15, 18, 31, 46, Figs. 10, 18) occurrence of a strong, regional, eastward-spreading transgression of the Husky Sea on the eastern flank of Richardson Mountain-Porcupine Plain Trough. This transgression lasted from the onset of Husky time until, and including, the time of deposition of the early Berriasian Red-weathering shale member. Throughout this time no signs of uplift or westward-prograding deltaic lobes have been observed on the eastern flank of the trough. Because of the above considerations the writer does not accept the existence of any biochronologically measurable hiatus between the Bug Creek and Husky formations on the eastern flank of Richardson Mountain-Porcupine Plain Trough (see Fig. 5).

The previously mentioned existence of *Buchia* (*Anauella*) *concentrica* (s. lato), *Buchia mosquensis* (s. lato), *Buchia piochii* (s. lato), and *Buchia fischeriana* (s. lato) faunas in the typical facies of Porcupine River Formation (see Fig. 5) indicates that its preserved part corresponds to all of the Lower member of Husky Formation as

redefined by Jeletzky (1967, p. 32-33) and the lower part of the overlying Arenaceous member (i.e. its *Buchia fischeriana* s. lato-bearing part; see Jeletzky, 1967, p. 34 for further details) of the same formation. As mentioned previously in this paper, none of the studied sections of typical facies (or for that matter of any other facies) of Porcupine River Formation includes equivalents of younger parts of Husky Formation (Fig. 5). However, the writer believes that these uppermost Jurassic and earliest Cretaceous rocks were deposited originally, either in marine or in nonmarine facies, at least within the Dave Lord Ridge deltaic lobe of Porcupine River Formation (see Jeletzky, 1974, p. 9). Most of the details of gradual lateral replacement of marine to nonmarine arenites of Porcupine River Formation by deeper water marine argillaceous rocks of the Husky Formation have been discussed in previous sections.

The writer doubts the presence of any Upper Jurassic rocks younger than the late Oxfordian (i.e. the lower part of *Buchia concentrica* Zone) on Yukon's Northern Slope north of Bonnet Lake-Blow Pass area and in an extensive area of northwestern Yukon Territory between Barn Mountains and the Alaska border. This suggestion is based on an apparently complete absence of fossils representing the late (i.e. early Kimmeridgian) phase of *Buchia* (*Anauella*) *concentrica* Zone and any part of the overlying *Buchia mosquensis* (s. lato), *Buchia piochii* (s. lato), *Buchia fischeriana* (s. lato), and *Buchia terebratuloidea* (s. lato) zones in the numerous fossil collections brought in by various industrial and governmental geologists who have worked in these areas since the late fifties. The absence of these normally prolific faunas can hardly be ascribed to a collecting failure, all the more so as the early phase of *Buchia* (*Anauella*) *concentrica* fauna and the early Lower Cretaceous *Buchia* faunas (beginning with *Buchia okensis* f. typ.; see unpublished intradepartmental fossils reports of the writer) are all found in these areas.

The scanty stratigraphical and structural data about the Upper Jurassic rocks of Yukon's North Slope and the area of northwesternmost Yukon confined between Barn Mountains and Alaska border do not permit any definitive conclusion about the reason for this apparent absence there of early Kimmeridgian to latest Tithonian faunas. However, it does suggest that these rocks may never have been deposited in the above areas which may have formed part of an extensive Late Jurassic Landmass (northern part of Keele-Old Crow Landmass of Jeletzky, 1971a, p. 205, Fig. 1; 1972, p. 9a-9c, Fig. 1; 1974, p. 3, Fig. 1; 1975a, p. 27, 29, 31, Fig. 10). It is, of course, also possible that the Upper Jurassic rocks discussed here were destroyed during the latest Aptian orogenic event which is known to have affected strongly at least some parts of the areas concerned (see Young, 1973, p. 279; Jeletzky, 1975a, p. 26, 27, 47, Fig. 21). An older Cretaceous (e.g. Valanginian) orogenic event could effect this destruction also.

Argillaceous equivalents of Porcupine River Formation are contained definitely in North Alaskan rocks customarily referred to the upper part of type Kingak Formation by American workers (e.g. Imlay and Detterman, 1973; Detterman et al., 1975 and references contained therein). These rocks contain *Buchia mosquensis* (s. lato) and *Buchia fischeriana* s. lato faunas (Imlay and Detterman, 1973, p. 19, 20, Fig. 15; Detterman et al., 1975, p. 20, 33). However, these *Buchia*-bearing Upper Jurassic rocks appear to occur in more than one

geographically separated argillaceous unit and may represent more than one disconnected onlap of Late Jurassic seas upon the northern flank of ancestral Brooks Range (see Jeletzky, 1963, p. 81, 82, Fig. 5). This is suggested by the stratigraphic relationships of *Buchia*-bearing Kingak rocks in different North Alaskan sections summarized by Imlay and Detterman (1973, p. 12, 13, Fig. 11, columns 15-18) and is obvious in the case of the uppermost Jurassic beds containing *Buchia fischeriana* (d'Orbigny) and *Buchia unshensis* (Pavlow) outcropping along Joe Creek a few miles west of Yukon-Alaska boundary. As pointed out by Detterman *et al.* (1975, p. 20), these uppermost Jurassic: "beds unconformably overlie the Shublik Formation and indicate a Late Jurassic marine incursion". The writer interprets this incursion as a southward onlap of the latest Tithonian Sea from the more permanent Kingak basin that occupied the Yukon-Alaska coastal plain on the northern flank of ancestral Brooks Range which included the Canadian Keele-Old Crow Landmass (see Jeletzky, 1963, p. 81, 82, Fig. 5; 1975a, p. 29, 31, Fig. 10) as its easternmost part. This inferred southward onlap of the latest Tithonian (i.e. latest Jurassic) sea agrees well with the previously noted absence of late Oxfordian to latest Tithonian marine faunas on Yukon's North Slope and in the area of northwesternmost Yukon confined between Barn Mountains and Alaska boundary. Furthermore, it agrees well with the writer's idea (see p. 17) that this northern part of Late Jurassic (i.e. pre-latest Tithonian) Keele-Old Crow Landmass extended eastward all the way to Barn Mountains forming an elevated peninsula immediately to the west and northwest of the previously discussed Barn Mountain deltaic lobe of the Porcupine River Formation. No arenaceous equivalents of the Porcupine River Formation are known to occur anywhere in northeastern Alaska.

Brabb (1969, p. 113) believed that the Glenn shale of the American part of the Kandik Basin in east-central Alaska: "ranges in age from Middle Triassic (Ladinian) to early Cretaceous (probably Valanginian)." However, all stratigraphic information provided by Brabb (1969, p. 110-113) is against such an assumption, the unit being based on a number of briefly studied, poorly exposed, partly tightly folded and strongly faulted sections. The diagnostic Middle to Late Triassic, Early Jurassic, and early Early Cretaceous (Berriasian to Valanginian) fossils have not been found in the same continuous sections. Furthermore, the writer (Jeletzky, 1971a, p. 213, 214, Fig. 3) has found that in the northwesternmost Nahoni Range and headwaters of Kandik River adjacent to the Alaskan part of Kandik Basin Upper Triassic rocks lithologically similar to and representing a direct continuation of Middle to Upper Triassic rocks included in the Glenn Shale by Brabb (1969) are separated from the overlying argillaceous Lower to lower Upper Jurassic rocks by an unconformity and a hiatus of a highly variable magnitude.

The above data, in combination with the total absence of Middle and Upper Jurassic fossils in Charley River, Coleen and Porcupine quadrangles in Central Alaska led the writer (Jeletzky, 1972, p. 9a-9c, Fig. 1; 1974, p. 2, 3, Fig. 1; 1975a, p. 7, 29, 31, Fig. 10) to the conclusion that neither marine nor nonmarine sedimentary rocks correlative with the Porcupine River Formation of northern and west-central Yukon were ever deposited in the American part of Kandik Basin. In the writer's opinion, the Glenn Shale consists of a Middle to Upper Triassic shale-limestone sequence unconformably overlain by a Lower Jurassic shale sequence which is, in turn, unconformably overlain by lower Lower Cretaceous shale sequence. The name Glenn Shale should either be abandoned or restricted to one of the obviously continuous

shale sequences included in it by Brabb (1969). Because of the above considerations, the writer (Jeletzky, 1971a, p. 213, 214, Fig. 3; 1974, p. 1-3, Fig. 1) declined to apply the name Glenn Shale to any of the lithologically similar Mesozoic sequences of adjacent Canadian areas (i.e. northwestern Nahoni Range and headwaters of Kandik River) and used an entirely different stratigraphic nomenclature there.

It must be stressed in this connection that the above conclusions of the writer agree completely with the results of an independent study of Jurassic stratigraphy and paleobiogeography of Alaska carried out by Imlay and Detterman (1973). This research confirmed the results of earlier American workers (Brabb and Churkin, 1969; Brabb, 1969; Brosgé and Reiser, 1969) about a complete absence of Late Jurassic marine fossils in the American part of Kandik Basin and elsewhere in east-central Alaska. Imlay and Detterman (1973, p. 2, 20, Figs. 5-9) concluded accordingly that all these Alaskan areas were flooded only by Early Jurassic seas. Throughout the Late (and also in the Middle) Jurassic, the American part of Kandik Basin and the adjacent parts of Coleen, Sheenjok and Porcupine rivers areas were uplifted above sea level and underwent erosion. The paleogeographical consequences of these stratigraphical conclusions of Jeletzky (1971a, 1972 and 1974) and Imlay and Detterman (1973) have been discussed in the section on age, thickness and facies changes in other outcrop areas of Porcupine River Formation.

SOME GENERAL REMARKS ABOUT DEPOSITIONAL TECTONICS

The deposition of sandstones of the Porcupine River Formation began considerably later in the Barn Mountain lobe than in the Dave Lord Ridge lobe. However, neither does the beginning of this event in the Barn Mountain lobe coincide with the beginning of deposition of the Porcupine River Formation in the southeastern Keele Range lobe. The following comments and Figure 6 elucidate this semi-independent tectonic behaviour of the three deltaic lobes concerned.

As discussed previously, the initial Late Jurassic uplift and eastward progradation of Barn Mountain deltaic lobe began at about the onset of the late Oxfordian (or *Buchia concentrica* time) when the uppermost part of the nonmarine facies of Dave Lord Ridge lobe was still being deposited. In the writer's opinion, the late Oxfordian time was the acme of the uplift of Dave Lord Ridge lobe. In contrast, the area of southeastern Keele Range, which was soon to become the site of the southeastern Keele Range deltaic lobe, was deeply submerged and continued to subside throughout most or all of the late Oxfordian. This subsidence was only briefly interrupted by a very weak and short-lived uplift reflected in deposition of the fairly thick (53-104 m; 175-340 ft.) shallow marine sandstone facies within the thick (1220 m; 4000 ft.) outer neritic sequence of argillaceous rocks of the *Buchia* (*Anauella*) *concentrica*-bearing upper part of Kingak Formation (restr.).

The marine, westward-protruding embayments flanking the centrally situated deltaic lobe of Dave Lord Ridge and separating it from deltaic lobes of southeastern Keele Range and Barn Mountains are characterized by a relatively short lived, entirely lower littoral to inner neritic development of the Porcupine River Formation. These tectonically negative elements of the western flank of Richardson Mountain-Porcupine Plain Trough evidently began to rise later and resumed their subsidence earlier

than either the southeastern Keele Range or the Barn Mountain lobe. So far as is known, neither of these embayments became emergent at any time during the deposition of the predominantly nonmarine facies of Porcupine River Formation in adjacent deltaic lobes. The structural behaviour of the embayments is included in Figure 6 to illustrate their relatively negative character and semi-independent tectonical behaviour.

The Late Jurassic tectonic style discussed above of the western flank of Richardson Mountain-Porcupine Plain Trough stresses once more the determining role of periodic oscillatory (i.e. alternatively positive and negative) movements of major tectonic elements of the region upon its geological history (Jeletzky, 1971b, p. 75, 76; 1975a, p. 42, 43). As elsewhere in Richardson Mountain-Porcupine Plain Trough, the most positive northeast-trending tectonic element – the Aklavik Arch of Jeletzky (1961, p. 538, 539, 576, 577, Fig. 22; this paper, Fig. 1) – controls the northeast-southwest oriented vertical oscillations. This is indicated by the Late Jurassic tectonic pulse starting much earlier in Dave Lord Ridge deltaic lobe situated astride of the Dave Lord Uplift of that arch (see Jeletzky, 1975a, p. 29, 31, Fig. 10) and spreading only gradually into the less positive areas of the trough flanking the Aklavik Arch on both sides (Fig. 6). As one would expect, this retarded impact of the Late Jurassic tectonic pulse was felt first within the relatively more positive tectonic elements, such as southeastern Keele Range and Barn Mountain deltaic lobes. This is reflected by these two lobes beginning to prograde eastward much later (see Fig. 6) than the Dave Lord Ridge lobe. They also emerged above sea level much later than the Dave Lord Ridge lobe. The tectonic pulse began to be felt even later in the relatively negative Keele and Driftwood embayments of Porcupine Basin separating the southeastern Keele Range and Barn Mountain deltaic lobes from Dave Lord Ridge lobe. As indicated in Figure 6, the sea within these embayments began to shoal toward the end of Oxfordian (i.e. *Buchia concentrica* s. lato) time. Furthermore, the magnitude of uplift was considerably less within the embayments than within the adjoining deltaic lobes as the former did not emerge above the sea level even at the uplift's acme. When making this statement, one has to qualify it by taking into consideration a much smaller rate of deposition within the embayments as compared with that within the deltaic lobes. However, the writer does not believe that the difference in rate of sedimentation was capable of either obliterating or reversing the effects of Late Jurassic uplift in this particular instance and regards it as a complicating factor only¹.

The period of gradual waning of the Late Jurassic pulse is characterized by an even more diversified, truly semi-independent tectonic behaviour of the major structural elements of the western flank of Richardson Mountain-Porcupine Plain Trough recognized in this paper.

As shown in Figure 6, the Dave Lord Ridge deltaic lobe became submerged at the end of Oxfordian time because of a relatively minor but widespread pulse of subsidence discussed more extensively in preceding sections of this paper. Thereafter, the lobe, and hence the Dave Lord Uplift of Aklavik Arch underlying it, apparently remained tectonically inactive, except for participating in previously discussed, continuing regional subsidence of the west flank of Richardson Mountain-Porcupine Plain Trough which permitted the accumulation of a thick sequence of arenites of the marine facies of Porcupine River Formation (see Figs. 3, 4). The effects of the subsidence pulse within Dave Lord Ridge lobe only affected belatedly the southern and northern embayments of Porcupine Basin, as these negative tectonic elements only began to subside at about the end of Kimmeridgian time (or late in *Buchia mosquensis* time; see Fig. 6). However, the subsidence pulse apparently was considerably more strongly expressed within the embayments (here again one has to consider a rather slower rate of sedimentation in the embayments as compared with Dave Lord Ridge lobe), as the deposition of upper to lower littoral arenites was replaced by that of outermost neritic to (?) upper bathyal shales and siltstones of upper Husky Formation.

While the tectonic behaviour of southern and northern embayments of Porcupine Basin remained coupled with that of the leading tectonic element of the region (i.e. the part of Aklavik Arch underlying the Dave Lord Ridge lobe), experiencing the retarded influence of its subsidence, the southeastern Keele Range and especially Barn Mountain lobes apparently "failed to respond" to the subsidence of Aklavik Arch for a long time. As indicated in Figure 6, only a feeble, very short-lived episode of subsidence interrupting the continuing uplift of Barn Mountain lobe late in the Kimmeridgian (or in the middle of *Buchia mosquensis* s. lato time) can be interpreted as a belated reaction to the early Kimmeridgian subsidence of Aklavik Arch. The presence of an equally feeble and short-lived late Kimmeridgian episode of subsidence in southeastern Keele Range lobe (see Fig. 6) confirms the validity of this interpretation. However, this episode of subsidence only briefly interrupted the continuing uplift of these two deltaic lobes. In southeastern Keele Range lobe the deposition of deltaic arenites was resumed almost immediately and lasted at least until the end of the early Portlandian s. str. (or *Buchia mosquensis* s. lato time) when the record ends. In the Barn Mountain deltaic lobe the uplift was resumed almost immediately and, so far as is known (see in preceding section), continued at least to the end of early late Tithonian (i.e. end of *Buchia fischeriana* s. lato) time and possibly till the end of the late Tithonian. As the influence of the Valanginian tectonic pulse began to be felt almost immediately thereafter (i.e. in the deposition of upper littoral arenites of restricted Lower sandstone division) it is difficult to interpret the tectonic behaviour described above of Barn Mountain deltaic lobe as a

¹ It must be pointed out in this connection that, like every other worker constructing oscillation graphs of ancient depositional basins, the writer only deals with the movements of the interface between the sediment and the sea water (or the atmosphere when that interface is uplifted above sea level) in relation to the mean sea level. Neither the thickness of sediments accumulated during the corresponding intervals of the geological time nor the resulting subsidence of the basins' "bottoms" (i.e. of the lower surfaces of the rock units concerned) are being taken into the consideration in Fig. 6 as there is no co-ordination between these processes and the relative movements of the interface between the sediment and the sea water (or the atmosphere). This lack of co-ordination was documented earlier in this paper on the example of the Dave Lord Ridge deltaic lobe (see p. 11 and Fig. 3). Because of technical considerations it was not feasible to include the presentation of thickness of sediments accumulated and the rates of resulting subsidences of the basins' "bottoms" in Fig. 6. Therefore, these processes are only discussed in the text of this section.

retarded reaction to the previously mentioned latest Oxfordian subsidence pulse that affected the Dave Lord Ridge lobe (i.e. the underlying part of Aklavik Arch) and adjoining embayments of Porcupine Basin. The writer is inclined to think that the Barn Mountain lobe was simultaneously affected by some other powerful extraneous tectonic event (e.g. a tectonic pulse in Romanzof Uplift) which completely offset the influence of relatively feeble subsidence pulse that affected Aklavik Arch.

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1973: Cretaceous stratigraphy between Babbage and Blow Rivers, Yukon; in *Report of Activities, Part A*, Geol. Surv. Can., Paper 73-1A, p. 277-281.
1975: Stratigraphic and sedimentological studies in northeastern Eagle Plain, Yukon Territory; Geol. Surv. Can., Paper 75-1B, p. 309-319.

Plates I and II

PLATE I

Figure 1.

Middle part of marine facies of typical Porcupine River Formation exposed on southeastern side (at the tip) of a sharp rocky point in the western bank of Porcupine River. This point, which forms the upper portal of Porcupine River Canyon, is situated about 13.5 km (8.25 miles) below the mouth of Bell River. Fossil locality GSC loc. 35649 situated about 89 m (292 feet) below top of unit 7 of the type section of Porcupine River Formation (see p. 6 of the text for further details) is in the topmost bed visible near the left margin of the photograph; it is marked by white arrow with an appropriate fossil locality number. Fossil locality GSC loc. 35648 situated about 94.5 m (310 feet) below the top of the same unit is situated near the right margin of the photograph; it is also marked by white arrow with an appropriate fossil locality number. View due northwest to north-northwest (i.e. obliquely downstream and almost into the strike of exposed rocks) from boat stationed in the midstream. GSC Photo No. 112143J.

Figure 2.

Basal part of marine facies of typical Porcupine River Formation exposed in the western bank of Porcupine River Canyon between the points about 183 m (200 yards) and 1.6 km (1 mile) downstream from the tip of rocky point shown in Figure 1. The northwestern base of this point is situated just outside of the left margin of Figure 2. View due northwest and approximately into the strike of exposed rocks from station on the eastern bank opposite the above-mentioned rocky point.

Lower part of marine facies extending approximately from the level 106.5 m (350 feet) below the top of unit 7 of Section No. 1 (see p. 6 of the text for further details) to that 152 m (500 feet) below its top underlies the river bank and the precipitous rocky slope above it in the middle and left foreground to the tip of the low and wooded rocky point closest to the camera. The mouth of a small nameless creek hidden behind this point is situated about 0.4 km (0.25 mile) downstream from the rocky point shown in Figure 1. The gentle, rubble-covered slope visible in the middle background (i.e. behind the first point and the first creek's valley) is underlain by the basal beds of the marine facies (i.e. of unit 7 of Section No. 1) and the upper part of nonmarine facies (i.e. of unit 6 of Section No. 1).

The second creek falling into the Porcupine River from the west at the right margin of the photograph is the Third creek of Figure 2 and the text (see p. 7 of the text and description of Figure 3 for further details). This creek, the mouth of which is situated about 2 km (1.25 mile) downstream of the rocky point shown in Figure 1, is marked by a white arrow and named in the photograph. The light coloured, almost entirely wooded slope in far background (i.e. beyond the valley of the Third creek) is entirely built of the lower part of unit 6 of the nonmarine facies of the Porcupine River Formation (see p. 7 of text for further details). So far as it was possible to determine, all rocks of Porcupine River Formation shown in the photograph dip to the left at low angles. However, they are definitely disturbed by strike faults. GSC Photo No. 112143N.

Figure 3.

View of the lower end of Porcupine River Canyon with the richly fossiliferous section of shallow water facies of Kingak Formation (see p. 8 of the text for further details) in left middle background (marked K). The mouth of First creek adjoins the bluff of this section from the left while the mouth of the Second creek (see Fig. 2) is situated closer to the left margin of the photograph and is marked accordingly. The base of the type section of Porcupine River Formation (see unit 1 of Section No. 1, p. 7) is situated 0.4 km (0.25 mile) farther upstream (i.e. outside of the photograph). Unit 1 of Section 3 (see p. 27 of the text) underlies the east bank of the river near the right margin of the photograph and is marked accordingly. The round topped hill (marked P) in far background is situated north of the place where the river changes its course abruptly from northeast to southwest (looking downstream) and the Porcupine River Canyon ends. This hill is underlain by Permian rocks. GSC Photo No. 112143D.

PLATE I



FIGURE 1



FIGURE 2

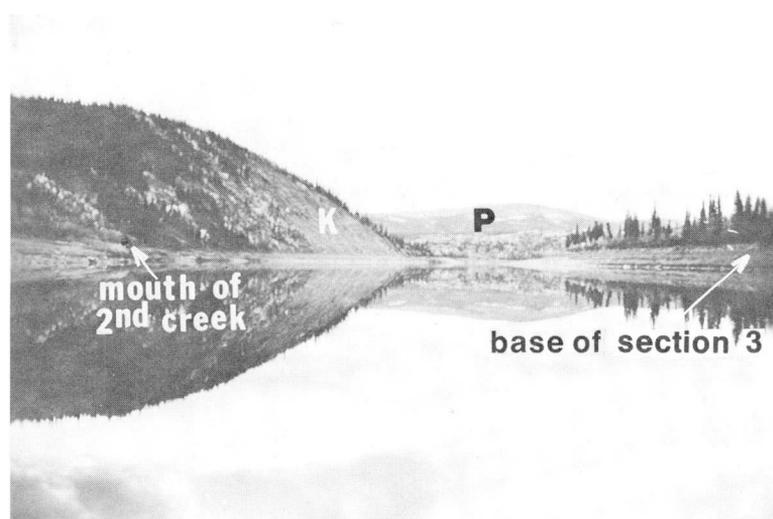


FIGURE 3

PLATE II

Figure 1.

View of the basal beds of Porcupine River Formation unconformably overlapped by the Upper Aptian-Lower Albian flysch division (Alb.). Southeastern Keele Range, unnamed ridge 5 to 6.5 km (3-4 miles) east of the top of unnamed 1409 m (4620-foot) high mountain massif shown in Figure 3. This section is described in p. 13 of the text. View due north-northeast. All rocks strike north, dip east at moderate angles, and are not disturbed otherwise. Pm – Marine sandstone unit 1; Pnm – Nonmarine unit 2; K – *Buchia concentrica* s. lato-bearing upper part of Kingak shale (restr.) underlying the lower, wooded slopes and locally exposed in small ravines (see text p. 13 for further details). GSC Photo No. 164274.

Figure 2.

View of the lower part of Section No. 4. View due northeast into eastern headwaters of Berry Creek. Sandstones of units 6 and 7 (numbered accordingly) of nonmarine facies of Porcupine River Formation comprise the bluff in the foreground; they dip obliquely toward the camera. The approximate position of fault cutting through unit 7 is marked by broken wavy line. Lower, gentle slopes in the middle background are underlain by very poorly exposed offshore facies of Kingak shale (restr.) marked K.sh. The intervening round topped, light coloured ridges expose minor sandstone-sandy siltstone members of Kingak Formation (marked K.ss.) interbedded with recessively weathering shale. Wooded ridges in far background (marked P) are in the Paleozoic (Permo-Carboniferous) core of the major anticline, the eastern flank of which exposes the here discussed Jurassic rocks (see text, p. 30-31 for further details). GSC Photo No. 164298.

Figure 3.

General view of the eastern flank of unnamed 1409 m (4620-foot) high massif crowned by synclinally bent, about 549 m (1800 feet) thick sequence of almost exclusively nonmarine facies of Porcupine River Formation (marked P) typical of Southeastern Keele Range deltaic lobe (see in text p. 13 for further details). The *Buchia concentrica* s. lato-bearing marine siltstones of upper Kingak shale (restr.) (marked K) occupy gentler lower slopes of the massif. The approximate position of Kingak-Porcupine River contact is marked by dotted white line. The approximate position of Marine sandstone member (K.ss.) of Kingak Formation is indicated by white arrows. Approximate stratigraphic position of marine *Buchia mosquensis*-bearing member (marked mm) of Porcupine River Formation in the section measured by Jeletzky (see Fig. 4) is indicated by black arrow. The approximate location of fossil locality GSC loc. 86956 of the outcrop of this marine interbed which actually yielded readily identifiable *Buchia mosquensis* s. lato is indicated by another black arrow and the locality number. View generally due west across the axis of a major north-trending anticline from station on the crest of ridge of Porcupine River Formation shown in Figure 1. All rocks of 1409 m (4620-foot) massif strike approximately north and dip west (i.e. away from the camera) at moderate angles. North-trending synclinal axis of Porcupine River Formation is on the crest of massif and the trace of major thrust discussed and mapped by Norris (Geol. Surv. Can., Map 10-1963) is hidden behind the massif. GSC Photo No. 164270.

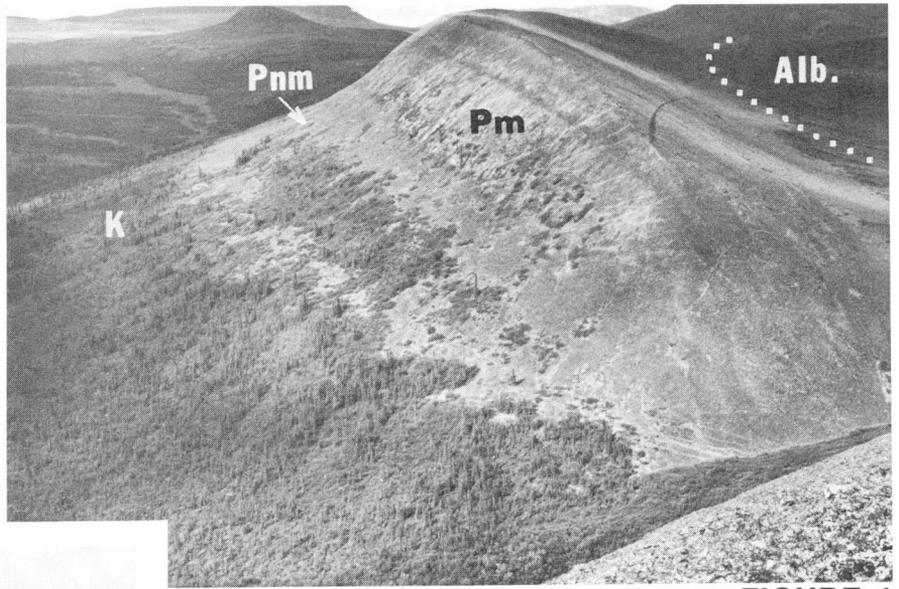


FIGURE 1

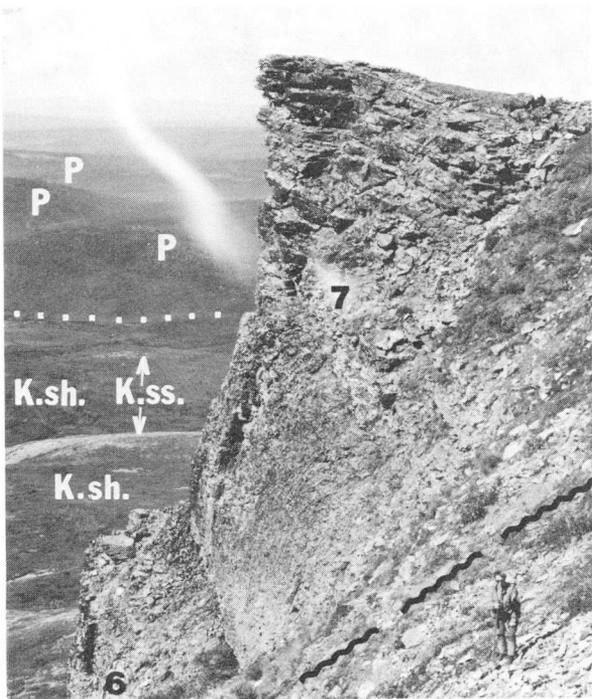


FIGURE 2

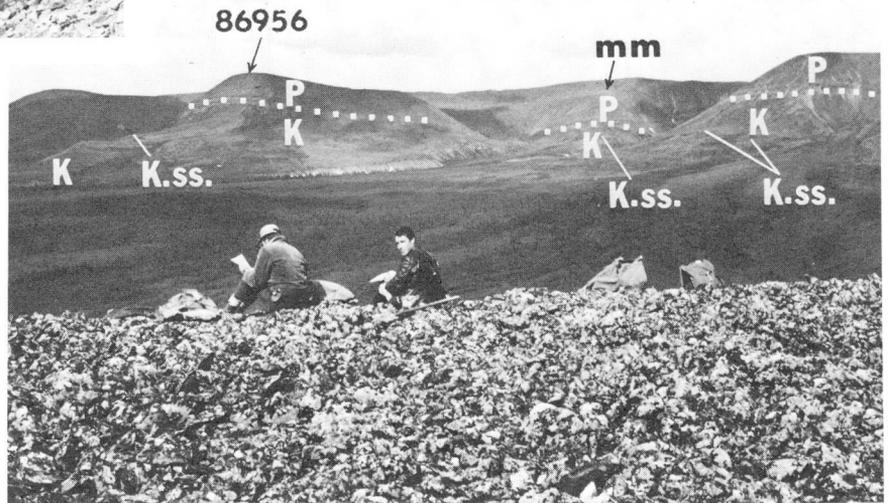


FIGURE 3

APPENDIX

Reference Sections

1. Section 2 (Field No. JA-F71-20)
2. Section 3 (KS-116 P5/5-10, Shell Canada Ltd.)
3. Section 4 (= JA-F71-40; upper part)
 4. Section 5 (= JA-F70-20)
 5. Section 6 (= JA-F73-16)
6. Section 7 (Field No. JA-F75-9)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
<u>Section No. 2</u>			
(Field No. JA-F71-20)			
The following section was measured on the undercut right (eastern) bank of Porcupine River where the southwesternmost Jurassic outcrops occur. These begin at the upstream end of the first major eastward-convex loop of Porcupine River at the point 9 to 10 km (5.5-6 miles) downstream (or about 6.5 km; 4 miles below) of the mouth of Bell River (Fig. 2).			
PORCUPINE RIVER FORMATION <u>Marine facies</u> Buchia piochii Zone (lower part)			
4	Sandstone, greenish grey to olive grey and brownish tinged when fresh, weathers dark brown to rust coloured, quartzose but with an appreciable admixture (15-20%, est.) of limonite, glauconite and dark mineral (?chert) grains; ferruginous, fine to very fine grained, mostly silty; thinly bedded and/or laminated; locally cross-bedded and ripple marked; some thin layers and laminae of hard, orange-weathering clay ironstone; a 15 to 25 cm (6-10 in.) thick clay ironstone band occurs at the level believed to be about 51 m (170 ft.) above the base of the unit; numerous (up to about 6-9 m; 20-30 ft.) thick interbeds of sandstones similar to those of Units 3 and 1 occur at several levels; top not seen; no fossils found in place but angular and apparently locally derived blocks of fossiliferous sandstone lithologically indistinguishable from that of Unit 4 have been found loose on the surface of the unit; these have yielded: Buchia piochii (Gabb) s. lato (early forms), Aucellina? n. sp. aff. A. ?schmidti Sokolov, and Thracia? sp. indet. (GSC loc. 38805); visible up to.....	82.5 (270)	198 (650)
Buchia mosquensis Zone (upper part)			
3	Sandstone, grey to greenish grey, weathers orange to rust coloured, fine grained, clean to silty, more regularly and thinly bedded than that of Unit 1; locally cross-bedded; grades upward into Unit 4 and contains some interbeds of sandstone like that of this unit near the top; contact with Unit 1 covered and adjacent beds of Unit 3 are disturbed by strike faulting and drag folding; fossils collected 3 to 4 m (10-13 ft.) above the visible base of the unit include: rare Buchia mosquensis (Buch) s. lato (late forms?) and numerous Aucellina? n. sp. aff. A. ?schmidti Sokolov; those collected 2 to 3 m (8-10 ft.) higher in the sequence include: numerous late forms of Buchia mosquensis (Buch) s. lato including B. mosquensis var. rugosa (Fischer) and Buchia aff. mosquensis Anderson 1945 and rare Thracia? sp. indet. (GSC locs. 38794, 38791); visible up to.....	39.5 (130)	115.5 (380)
2	Covered interval some 12 to 15 m (40-50 ft.) across the strike appears to harbour a major strike fault which causes the disappearance of all beds of the Porcupine River Formation exposed in its type section...	--	--
KINGAK FORMATION <u>(shallow water facies)</u>			
1	Sandstone, light to whitish grey or greenish grey, dense, very indistinctly bedded to massive-looking, fine grained, quartzose, glauconitic?, contains some interbeds of carbonaceous sandstone and carbonized fossil wood in places; numerous inclusions of rust- to orange-weathering, ferruginous sandstone rich in fossils are scattered irregularly throughout the unit; according to Dr. Hans Frebald (Report No. J-19-1971-HF) the fauna collected from the uppermost exposed part of the unit includes:		

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
	<p>A. <u>GSC loc. 87608</u> situated 2-2.5 m (7-8 ft.) below unit's top. "Fauna consists of mostly broken shells of small ammonoids and pelecypods, belemnoids (holes of), and Dentalium. One partial imprint of a small ammonoid could be a cadoceratid but is indeterminable. Among the pelecypods a small form of Oxytoma is common. Age: ?Callovian".</p> <p>B. <u>GSC loc. 87608</u> (situated about 7 m (20 ft.) below locality A). "2 whorl fragments of a very big ammonite. Possibly a ?Cobbanites. Age: Bathonian – early Callovian".</p> <p>The writer believes the unit to be equivalent to the topmost beds of the richly fossiliferous Middle Jurassic section occurring on the western bank of Porcupine River at the lower end of Porcupine Canyon (see Jeletzky in Frebold, 1961, p. 2, Footnote); top covered and faulted (see under the description of Unit 2); base concealed at the southern end of outcrop and believed to be cut off by a major northeast trending fault; visible up to.....</p>	76 (250)	76 (250)

Section No. 3

(KS-116P5/5-10, Shell Canada Ltd.)

The following section was measured on the rounded, partly overgrown western slopes of a high, flat-topped Mason Hill (about 762 m (2500+ ft.)), overlooking Porcupine River from the east near the lower (i.e. northern) end of the canyon (Fig. 2). This section, which was measured by Mr. Richard Farley of Shell Canada, Ltd. in 1971, exposes the following downward sequence of beds (reorganized by the writer from the plotted lithological log of the section, his fossil identifications, and general comments appended to the lithological log).

PORCUPINE RIVER FORMATION
Marine facies
Buchia fischeriana Zone

17	Sandstone, light orange-brown in fresh and weathered state, fine grained, quartzose with some 2 per cent chert grains and some white mineral (?kaolinized feldspar) grains; some carbonaceous material; moderately spherical subangular to angular; no fossils seen; outcrops poor and mostly talus-covered; top not reached at Mason Hill top; base covered; visible.....	9 (30)	416 (1,365)
16	Covered interval about 76 m (250 ft.) wide.....	--	--
15	Sandstone, light orange-brown when fresh, weathers light brown-grey, much as in Unit 17; contains about 5 per cent of white mineral (?kaolinized feldspar) and some rounded chert grains; outcrops poor and mostly talus covered; Buchia sp. resembling B. fischeriana (d'Orb.) s. lato but not identifiable definitively as to the species (GSC loc. 88434) found in fresh locally derived talus on the lower part of unit; top and base covered; visible.....	15 (50)	407 (1335)
14	Covered interval about 73 m (240 ft.) wide harbouring a fault.....	--	--
13	Sandstone, essentially as in Unit 17; contains about 3 per cent of rounded chert grains, some white mineral (?kaolinized feldspar) grains, and some carbonaceous matter; outcrops poor and mostly talus-covered; mixed fauna of Buchia fischeriana (d'Orb.) s. lato and B. piochii (Gabb) s. lato (GSC loc. 88430) was found at unit's base; top and base covered; visible.....	20 (65)	392 (1285)
12	Covered interval about 19 m (65 ft.) wide.....	--	--

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
11	Sandstone, much as in overlying Units 13, 15, and 17; fine grained; contains 3 to 8 per cent of rounded chert grains, 3 to 8 per cent of white mineral (?kaolinized feldspar) grains, and some carbonaceous matter; in the basal part strongly carbonaceous and includes some coal and plant remains; otherwise no fossils; weathers to medium and large blocks; outcrops poor to very poor and mostly covered by frost-heaved blocks and slabs; top and base covered; visible.....	55 (180)	372 (1220)
10	Covered interval about 59 m (195 ft.) wide.....	--	--
9	Sandstone, as in overlying Units 17, etc.; contains 3 per cent each of rounded chert grains and white mineral (?kaolinized feldspar) and some carbonaceous matter; some coquinoid interbeds rich in long-ranging pelecypods (no <i>Buchia</i> , cephalopods, or asteroids seen); fauna of GSC loc. 88429 collected 59.5 m (195 ft.) above base includes: <i>Modiolus</i> cf. <i>M. strajeskianus</i> (d'Orbigny), <i>Panope?</i> sp. indet., <i>Arctica</i> (s. lato) sp. indet., <i>Astarte</i> sp. indet., <i>Thracia</i> sp. indet. and indeterminate pelecypod; fauna of the locality GSC loc. 88428 collected 53 m (175 ft.) above base includes: <i>Pleuromya</i> cf. <i>postculminata</i> McLearn, <i>Arctica</i> (s. lato) sp. indet. and indeterminate pelecypods; weathers to small slabs and medium blocks; outcrops poor to very poor and mostly talus-covered; top covered, base faulted; visible.....	87 (285)	317 (1040)
<u>Nonmarine facies</u>			
8	Sandstone, much as in overlying units; contains about 3 per cent of rounded chert grains, some white mineral (?kaolinized feldspar) grains, carbonaceous; resistant and weathers to about 10 cm (4 in.) thick slabs; contains some indeterminate ?marine pelecypods; top and base covered; outcrops poor and mostly talus-covered; visible.....	6 (20)	230 (755)
7	Covered interval, about 15 m (50 ft.) wide.....	--	--
6	Sandstone, much as in overlying sandstone units; contains up to 8 per cent of rounded chert grains, up to 3 per cent of white mineral (?kaolinized feldspar) grains and is carbonaceous; in the upper part are some interbeds of fossiliferous sandstone containing indeterminate pelecypods and poorly preserved belemnites; basal 3 m (10 ft.) or so contain numerous worm burrows 0.6 cm (0.25 in.) in diameter; coaly, subvertical rootlets, and some coaly inclusions; weathers to large blocks; outcrops poor; base and top covered; visible.....	27.5 (90)	224 (735)
5	Completely covered interval, about 4 m (15 ft.) wide.....	--	--
4	Sandstone, much as in the overlying units, contains up to 5 per cent of rounded chert grains, up to 3 per cent of white mineral (?kaolinized feldspar) grains, and 3 to 8 per cent of carbonaceous material; no fauna found but plant remains and coaly interbeds occur at several levels suggesting nonmarine origin of the unit (in the writer's opinion); the unit contains subvertical coaly rootlets at several levels and is commonly bioturbated (worm burrows); medium bedded to massive and weathers thin to medium 10 to 20 cm (4-8 in.) and slabby or irregularly to large blocky; outcrops poor and debris-covered for the most part; top covered, base faulted; visible.....	56.5 (185)	196.5 (645)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
Marine facies (repeated by faulting)			
3	Sandstone, much as in overlying units, mostly fine to very fine grained but includes some interbeds of medium-grained sandstone, contains about 5 per cent of rounded chert grains, 2 to 8 per cent of white mineral (?kaolinized feldspar) grains and is carbonaceous; worm-burrowed; contains carbonaceous subvertical rootlets and fossil wood in the uppermost part; farther down is devoid of these structures and fossil wood and contains marine pelecypod fauna including <i>Buchia</i> sp. indet. of Upper Jurassic affinities (GSC loc. 88703) at 10 m (35 ft.) level below top; still farther down, beginning with 55 m (180 ft.) level below top, rootlets, burrows and fossil wood reappear and occur at intervals to the unit's base; plant remains occur at several levels within this interval which, at the same time, includes a number of thin 2.5 to 10 cm (1-4 in.) interbeds rich in marine pelecypods; fauna collected at 76 m (250 ft.) level (GSC loc. 88438) includes: <i>Buchia</i> cf. <i>piochii</i> (Gabb) (s. lato) (a single shell), <i>Buchia</i> sp. indet., ? <i>Arctica</i> (s. lato) sp. indet., ? <i>Meleagrinnella</i> sp. indet.; fauna collected at 61 m (200 ft.) level includes: <i>Buchia</i> cf. <i>mosquensis</i> (von Buch) s. lato, <i>Pleuromya postculminata</i> McLearn, <i>Meleagrinnella</i> sp. indet., <i>Thracia</i> sp. indet., ? <i>Arctica</i> sp. indet. (GSC loc. 88437); fauna collected at 55 m (180 ft.) level (GSC loc. 88436) includes: indeterminate long-ranging pelecypod (?Mesozoic), fossil wood; outcrops poor and mostly debris-covered; rocks are faulted locally; base covered; visible.....	87 (285)	140 (460)
2	Covered interval, about 1.5 m (5 ft.) wide.....	--	--
1	Sandstone, as in overlying beds, contains up to 3 per cent each of rounded chert grains and white mineral grains (?kaolinized feldspar); noncarbonaceous; marine fauna including <i>Pleuromya</i> cf. <i>postculminata</i> McLearn, and indeterminate long-ranging pelecypods (GSC loc. 88435) was found 41 m (135 ft.) above the base of the unit, farther down unfossiliferous, except in the basal part where indeterminate pelecypods reappear; these basal beds also contain fossil wood, coaly subvertical rootlets and are burrowed; weathers to large blocks; outcrops poor and talus covered for the most part; base covered by water of Porcupine River at the lower end of the canyon (see Pl. I, fig. 3); visible.....	53 (175)	53 (175)
<p>Because of the presence of <i>Buchia</i> cf. <i>mosquensis</i> (v. Buch) s. lato in Unit 3 in the interval 61 m (200 ft.) above its base this unit is correlative with the upper and ?middle part of Unit 7 of the type section. This suggests that the underlying Unit 1 of Section 3 corresponds to the lower part of the same unit of the type section. The presence of fossil wood and coaly rootlets in the basal part of Unit 1 suggests its very low position in Unit 7 of the type section. There is no reason to correlate these basal beds of Section 3 with the upper part of the lower, nonmarine facies of the type section (i.e. its Unit 6). However, Units 4, 6 and 8 of Section 3 are similar to this nonmarine facies of the type section in their lithology, absence of <i>Buchia</i>, rarity of marine fauna, and common occurrence of plant remains, subvertical coaly rootlets, fossil wood, and coaly interbeds and inclusions. Considering their separation by faults from underlying and overlying units, these units are interpreted herein as a relatively upthrown fault block of the nonmarine facies. Unit 13 of Section 3 contains a mixed <i>Buchia fischeriana</i> - <i>B. piochii</i> fauna which is younger than either the <i>Buchia mosquensis</i> f. typ. fauna of the topmost exposed beds of the type section or the <i>Buchia piochii</i> (early forms) fauna of the topmost beds (i.e. Unit 4) of Section 2. This indicates that Units 9 to 17 of Section 3 represent a relatively downthrown fault block of the youngest known part of Porcupine River Formation which is entirely younger than the youngest exposed beds of other measured sections within the type area.</p>			

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
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Section No. 4

(JA-F71-40; upper part)

The following section of the Porcupine River Formation, measured on the western slope of a nameless 1067+ m (3500+ ft.) mesa-like mountain in the eastern headwaters of Berry Creek (approx. Lat. 67°36'30"N; Long. 137°25'15"W; see Fig. 2) is designated herewith as the first reference section of the formation because it exposes all units and facies of Sections 1 to 3 of the type area in direct superposition. This section also elucidates the stratigraphic relationships of the nonmarine facies of the Porcupine River Formation with the well-dated offshore facies of the Kingak Formation (restricted).

PORCUPINE RIVER FORMATION

Marine facies

Buchia fischeriana Zone

- | | | | |
|----|---|----------|------------|
| 14 | <p>Sandstone, mottled bright orange- and cream-coloured when fresh, weathers mottled dull and light grey or dirty white, very fine grained, clean (no silt particles seen), almost pure orthoquartzite with only a trace of dull green glauconite grains; moderately hard and dense, not silicified (poor in cement) and with a good to excellent interstitial porosity; well sorted but only moderately well rounded with most grains being subrounded to subangular, thick (0.3-0.9 m; 1-3 ft.) and indistinctly but unevenly bedded; resistant and fractures into huge (several feet to a side) blocks and slabs; contains a considerable number of interbeds of coquinoid sandstone replete with hollow casts of various thick-shelled, long-ranging pelecypods including Arctica (s. lato) sp. indet., Modiolus sp. indet., ?Thracia sp. indet., and ?Tancredia sp. indet. (writer's field identifications; no collection was made); this fauna lacks completely any stenohaline elements such as cephalopods or starfish; no Buchia were seen in the upper 79m (260 ft.) of the unit; the nonfossiliferous and coquinoid varieties are, generally speaking, noncalcareous; includes some interbeds of thinly (1.3-10 cm; 0.5-4 in.) and evenly bedded to laminated, lavender-coloured when fresh, weathering buff to dull orange, partly carbonaceous sandstone, otherwise similar to the above-described principal variety; at the level of 79 to 82 m (260-270 ft.) below top one of these interbeds yielded a rich mixed fauna of Buchia fischeriana (d'Orb.) s. lato and B. piochii (Gabb) s. str. (GSC loc. 87815); except for the thinly bedded to laminated carbonaceous interbeds, the sandstone appears to be noncarbonaceous; no fossil wood or plant remains were seen; no distinct ripple marks or cross-bedding noted; outcrops poor and intermittent throughout; regular strike 030°; regular dip 15°E; top not reached at mountain's summit; grades downward into Unit 13; visible.....</p> | 82 (270) | 469 (1540) |
|----|---|----------|------------|

Buchia piochii and
Buchia mosquensis Zones combined

- | | | | |
|----|---|--|--|
| 13 | <p>Sandstone, predominantly similar to the thinly bedded to laminated carbonaceous variety of Unit 14; more carbonaceous or coaly than the latter; dark grey, carbonaceous to coaly laminae and thin beds alternate with light grey to lavender-grey, noncarbonaceous to slightly carbonaceous laminae and 2.5 to 15 cm (1-6 in.) beds; a considerable ratio (up to 20%, est.) of grains of black, shiny coal occur in the carbonaceous to coaly variety, otherwise the sandstone remains quartzose to orthoquartzite; distinctly cross-bedded and ripple marked at several levels but these structures do not appear to be common overall; interbeds of coquinoid sandstone with</p> | | |
|----|---|--|--|

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
	thick-shelled long-ranging pelecypods appear to be much less common than in Unit 14; thin-shelled, small ?unionid (i.e. ?non-marine) pelecypods (writer's field identification) are common at the 105 m (345 ft.) level below top (GSC loc. 87816); some <i>Buchia</i> cf. <i>mosquensis</i> (v. Buch) s. lato were collected from fresh, locally derived slabs (GSC loc. 87817) at the 84 m (275 ft.) level below top; outcrops mostly poor, intermittent, and the slope is mostly debris-covered; attitude as in Unit 14 and the rocks are not disturbed otherwise; grades downward into Unit 12.....	85.5 (280)	387 (1270)
12	Sandstone, mostly brownish grey to dull grey when fresh, weathers mottled white and light grey with bluish grey specks and spots; some interbeds of sandstone coloured as in Unit 14; lithologically similar to that of Unit 14, except in containing numerous specks and small inclusions 1.3 to 10 cm (0.5-4 in.) of dark grey coaly matter and in being hard and dense with but little visible interstitial porosity; medium bedded (15-30 cm; 6-12 in.), but indistinctly and very unevenly (corrugated); black to dark grey carbonaceous matter is concentrated commonly on these irregular to corrugated bedding planes, locally forming <i>Spirophyton</i> -like whorls; no marine pelecypods, or for that matter any other fossils were seen in this unit; strikes 130° (regular), dips 12°E (regular); lower contact obscured by debris for a few feet; visible.....	17 (57)	301.5 (990)
11	Siltstone, dark brownish grey to dark grey, weathers dull grey to light bluish grey and chunky, mostly sandy to very sandy, micaceous, fairly friable to moderately hard and is recessive; massive looking; medium to thick (0.3 to 0.9 m; 1-3 ft.), beds indistinct and corrugated; commonly grades laterally into and is in places interbedded with superficially similar, extremely fine grained, silty, quartzose sandstone; includes two or three 0.3 to 0.9 m (1-3 ft.) interbeds of clean, quartzose, laminated to thinly bedded sandstone as in Unit 13; some worm burrows and subvertical, 0.6 cm (0.25 in.), rounded tubes filled with carbonaceous matter (?plant rootlets) occur locally; a few poorly preserved pelecypods seen in the topmost 6 m (20 ft.), otherwise no fossils; strike (regular) 030°; dip (regular) 20°E; lower contact appear to be abrupt and uneven.....	50.5 (165)	284.5 (933)
<i>Buchia (Anaucella) concentrica</i> Zone			
10	Sandstone, mostly lithologically similar to that of Unit 14 but predominantly light to whitish grey when fresh and dull yellow to orange-weathering; some interbeds of coquinoid sandstone as in Unit 14; at the level 33.5 m (110 ft.) below top the fauna collected from fresh, locally derived sandstone slabs (GSC loc. 87818) includes <i>Buchia (Anaucella)</i> cf. <i>concentrica</i> (Sowerby) s. lato and <i>Pleuromya</i> cf. <i>vancouverensis</i> (Whiteaves) in addition to thick-shelled, long-ranging pelecypods; no distinct cross-bedding, ripple marks, or worm burrows noted; strike (regular) 040°; dip (regular) 20°E; appears to grade into Unit 9 through a 1.5 m (5 ft.) thick zone of dull grey to bluish grey, carbonaceous to coaly, mostly thinly bedded to laminated but locally medium bedded, silty, very fine grained sandstone rich in carbonaceous, argillaceous partings and laminae on bedding planes.....	44 (145)	234 (768)
Nonmarine facies			
9	Siltstone, generally lithologically similar to that of Unit 11 but thinly bedded to laminated and with 2.5 to 10 cm (1-4 in.) interbeds of dark rusty-weathering, ferruginous siltstone; carbonaceous to coaly throughout and contains numerous wood and plant fragments on some bedding planes; it is recessive and outcrops are poor throughout; lower contact covered by debris; visible.....	4.5 (15)	190 (623)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
8	Completely covered interval corresponding to 9.5 m (31 ft.) of the section assuming attitude as in adjacent beds.....	9.5 (31)	185.5 (608)
7	Sandstone, mostly medium to brownish grey when fresh but with numerous interbeds of mottled light grey and buff or dull orange sandstone, weathers light grey to dirty whitish grey; very fine grained, no silt particles seen (clean), orthoquartzite with but a trace of orange-coloured limonite grains and of ?mafic mineral (?or coal) grains; commonly carbonaceous to coaly and contains dark grey, coaly specks and spots; well sorted as to the grain size but only moderately rounded, most grains being subrounded to subangular; structure varies from that of true, very dense quartzite with shiny break surfaces and devoid of any visible porosity to that of a medium hard, moderately dense, slightly to fairly porous sandstone; these structural extremes alternate variably throughout the unit's thickness and intergrade laterally and vertically; true quartzite and quartzite-like varieties strongly predominate; contains some subvertical rounded tubes (?plant rootlets) filled with carbonaceous to coaly matter and locally rich in worm burrows; no fossils seen; occurs in thin to medium (2.5-15 cm; 1-6 in. and rarely 12 in.) beds; beds uneven to corrugated; includes some intensively cross-bedded and ripple marked interbeds; carbonaceous shale partings commonly occur on bedding planes; strike (regular) 010°; dip (regular) 20°E; resistant and forms sheer bluffs on both sides of the traversed ravine (see Pl. II, fig. 2); at 12 m (40 ft.) level below top the unit is transected by a presumably minor (amplitude unknown) fault striking 090° and dipping 75° to 80°W; this fault causes a zone of strongly disturbed, near vertically dipping rocks about 3.05 m (10 ft.) wide; measuring carried across the fault to the northern side of the ravine; grades downward into Unit 6; assumed thickness.....	23 (75)	176 (577)
6	Sandstone, dark grey to dark brown-grey when fresh, weathers dull to dark bluish grey with rust to bright yellow stains and spots, very fine grained, silty, mainly quartzose but carbonaceous to coaly throughout; rock structure varies as in Unit 7 but hard to medium hard, dense to very dense quartzite-like to true quartzite varieties are much less prominent, most sandstones being moderately dense and exhibiting at least some interstitial porosity; thin to medium bedded; (mostly 2.5-15 cm; 1-6 in.) but extremely irregularly corrugated to knotted; numerous microlaminae and tiny specks of dark brown to black, shiny coal and some poor plant fragments occur at many levels; no other fossils seen; attitude as last; base covered; visible.....	18 (60)	153 (502)
5	Completely covered interval corresponding to 13.7 m (45 ft.) of section assuming the attitude as in adjacent beds.....	13.7 (45)	135 (422)
4	Irregular interbedding of sandstones as in Units 6 and 7; outcrops poor and intermittent and rocks are almost invariably slumped; top and base covered; no reliable attitude; visible.....	8 (27)	121 (397)
3	Siltstone, as in Unit 11 and with considerable 1.5 to 4.5 m (5-15 ft.) thick interbeds of sandstone as in that unit; outcrops extremely poor and patchy; only deeply weathered, slumped rock was seen for the most part; exposed parts of the unit contain vertical to subvertical coaly tubes (plant rootlets) and various worm burrows; a thick bed of coaly sandstone about 3 m (10 ft.), occurs at the visible base; strike (regular) 010°; dip (regular) 30°E; base covered; visible.....	27.5 (90)	113 (370)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
2	Siltstone, dark brownish grey to dark grey when fresh, weathers dull to light bluish grey and chunky, mostly sandy to very sandy, micaceous, carbonaceous to coaly in part and contains some subvertical, rounded 0.3 to 0.6 cm (0.125-0.25 in.) wide tubes filled with coaly matter (?plant rootlets); recessive and outcrops are mostly poor and slumped except at the bottom of the traversed ravine; lower contact covered for a few feet; visible.....	55 (180)	85.5 (280)
KINGAK FORMATION (restricted) Lower Callovian part			
1	Irregular and medium to thick interbedding of: A. Sandstone, brown-grey to buff coloured, fine to very fine grained, sublithic to ?lithic and estimated to be fairly rich in chert (15%), limonite (15-20%) and weathered feldspar grains; fairly well sorted as to the grain size but only poorly to moderately rounded, most grains being subangular to (more rarely) subrounded; medium hard to hard and fairly porous to quartzite-like, mostly very thin to thin (0.3 to 5 cm; 0.125-2 in.) and regularly bedded; pronouncedly cross-bedded and ripple marked; and B. Siltstone, dull brown-grey to dull brown, sandy to very sandy, ferruginous, friable, massive looking, with numerous spherical 15 to 45 cm (6-8 in.) concretions and 7.5 to 25 cm (3-10 in.) bands of medium hard, rust- to orange-weathering, very sandy siltstone ("clay ironstone"); early Callovian <i>Cadoceras</i> aff. <i>barnstoni</i> (Meek) and <i>C. crassum</i> (Madsen) (GSC loc. 87819) were collected in place 11 m (36 ft.) below top; attitude as in overlying beds; forms a 10.5 to 12 m (35-40 ft.) hogsback across the slope at the western base of steep slope of the mountain; base covered; visible.....	30.5 (100)	30.5 (100)

Section No. 5

(= JA-F70-20)

The following section of the Porcupine River Formation measured across the eastern slope of a nameless, 1067+ m (3500+ ft.) high mountain overlooking the upper course of Waters River from the west (approximate co-ordinates of base. Lat. 67°39'10"N; Long. 137°21'30"W; approximate co-ordinates of top. Lat. 67°38'00"N; Long. 137°23'45"W; see Fig. 2) was selected as the second reference section since it includes about 305 m (1000 ft.) of beds which are younger than any beds exposed in Sections No. 3 and No. 4. Therefore, this Waters River section gives some idea of the thickness of the marine facies of the formation missing by erosion in the two other sections.

PORCUPINE RIVER FORMATION

Marine facies

***Buchia fischeriana* s. lato Zone**

11	Sandstone, light brownish grey, often with black specks and dots of ?carbonaceous matter; weathers cream to buff with rusty spots and specks, quartzose, fine grained, mostly massive looking to heavily bedded, medium hard, weathers large to medium (1.2-0.2 m; 4 to 1/2 ft. to a side) blocky; beds on the flat mountain top virtually horizontal; at 42.5 m (140 ft.) level strike 190°; dip 5°W; top not reached in the syncline's axis, at triangular point crowning the mountain; <i>Buchia</i> cf. <i>fischeriana</i> (d'Orb.) s. lato was collected (GSC loc. 86838) from topmost 0.3 m (1 ft.) exposed; visible.....	49 (160)	1051.5 (3447)
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Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
10	Sandstone, lithologically similar to that of Unit 11 (especially in colour and grain size) but predominantly medium (15-30 cm; 6-12 in.) bedded and weathering slabby; above the 52 m (170 ft.) level becomes medium to thinly bedded and weathers flaggy; some <i>Buchia fischeriana</i> (d'Orb.) s. lato (GSC loc. 86836) collected in place at the 62.5 m (205 ft.) level; another fossil collection consisting of large advanced forms of <i>Buchia fischeriana</i> (d'Orb.) was collected (GSC loc. 86837) at 66 m (217 ft.) level from fresh, locally derived slabs; attitude as last.....	97.5 (320)	1002.5 (3287)
9	Sandstone, as in Unit 11; at the 53.5 m (175 ft.) level above base fresh angular debris are replete with <i>Buchia fischeriana</i> (d'Orb.) s. lato collected as GSC loc. 86835; rare, 7.5 to 15 cm (3-6 in.) interbeds of coquinoid sandstone replete with large <i>Arctica</i> -like pelecypods occur at the 92 to 107 m (300-350 ft.) level; 0.6 to 2.5 cm (0.25-1 in.) wide, carbonaceous tubes and worm burrows are numerous in the interval 175 to 182 m (575-597 ft.); between the 155 m (510 ft.) level and unit's top, bedding becomes extremely corrugated with carbonaceous or, more commonly, ferruginous partings at many levels; attitude (fairly reliable) at 155 m (597 ft.) level 020°, 10°W; grades upward into Unit 10.....	241 (790)	905 (2967)
	<i>Buchia piochii</i> s. lato and <i>Buchia mosquensis</i> (upper part) zones combined		
8	Sandstone, buff to rust coloured in fresh and weathered state, fine grained, quartzose, mostly medium to heavily (17.5-78 cm; 5 in.-7 ft.) bedded but with some interbeds of thin-bedded to laminated sandstone, mostly friable and with good interstitial porosity but includes some harder but nevertheless porous sandstone; carbonaceous specks and vertical to subvertical tubes filled up with dark grey carbonaceous sandstone (?plant rootlets) are common in some beds; bedding mainly irregularly corrugated (?interference cross-bedding); some interbeds of intensively and regularly cross-bedded, very thinly bedded to laminated sandstone, cross-bedding exhibits well-developed foreset and topset packages of layers; some flattened ferruginous clay balls occur locally; above the 17.5 to 18.5 m (56-60 ft.) level occur numerous interbeds of sandstone, cream to dirty white in fresh and weathered state, medium hard, thinly to medium bedded, partly carbonaceous and with carbonaceous to coaly partings and specks; some poorly preserved <i>Buchia</i> cf. <i>russiensis</i> (Pavlow) were found in fresh, locally derived sandstone slabs at the 17.5 to 18.5 m (56-60 ft.) level (GSC loc. 86833) and some <i>B. cf. mosquensis</i> var. <i>gracilis</i> (Pavlow) and <i>Modiolus</i> sp. were collected at GSC loc. 86834 from similar slabs at the 67.5 m (221 ft.) level (<i>Modiolus</i> and <i>Buchia</i> were not associated though).....	158.5 (519.5)	664 (2177)
	<i>Buchia mosquensis</i> Zone (?lower part)		
7	Sandstone, dull brown when fresh, weathers mottled buff-, rust- and cream-coloured and thin slabby, more or less quartzose but commonly includes up to 10 per cent of white ?kaolinized feldspar grains and up to 10 per cent of chert grains (both estimated); mostly fine to very fine grained, micromicaceous, fairly friable with good interstitial porosity, thinly to very thinly (1.3-10 cm; 0.5-4 in.) bedded and locally cross-bedded but includes some 0.8 to 2.6 m (2.6-8.6 ft.) interbeds of thick-bedded sandstone; some <i>Buchia</i> cf. <i>mosquensis</i> (v. Buch) s. lato (?possibly early forms) were collected at the 17.5 m (56 ft.) level from fresh, locally derived float (GSC loc. 86832); generally speaking, fossils are rare or absent; outcrops mostly poor and slumped and no reliable attitude was obtained, but the attitude is assumed to be as in Unit 9.....	67.5 (221)	505.5 (1657.5)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
6	Sandstone, as in Unit 8; outcrops mainly poor and intermittent; includes some lenticular (17.5-52 cm; 5-21 in.) banks of coquinoid sandstone replete with <i>Astarte</i> - and <i>Thracia</i> -like pelecypods; lot GSC No. 87062 containing these long-ranging marine pelecypods was collected from fresh, locally derived float at about 4 m (13 ft.) above base; upper contact covered for a few metres; forms the basal slope of the mountain proper; the attitude is assumed to be as in Unit 4 but no reliable attitude was seen anywhere.....	66 (216.5)	438 (1436.5)
	<u>Marine facies</u>		
	Buchia (Anaucella) concentrica s. lato Zone		
5	Interbedded siltstone and shale, black when fresh, weathers dark brown with rust-coloured specks and forms fine rubbly to coarse flaky talus; exposures poor and intermittent except for a 21 m (70 ft.) zone immediately above the contact with the underlying Unit 4; occupies the westernmost part of a broadly V-like wooded valley between more resistant, ridge-forming Units 6 and 4; no fossils seen; upper contact covered for some 30.5 m (100 ft.) across the strike and is inferred to be faulted; the amplitude of this presumably north-south trending fault cannot be determined but is believed to be considerable; visible.....	26 (85)	372 (1220)
4	Sandstone, dull grey with brownish tinge when fresh, weathers same or dark brown with orange specks; thinly (2.5-10 cm; 1-4 in.) to very thinly (0.6-2.5 cm; 0.25-1 in.) and regularly bedded, hard and dense; some interbeds of nonporous, quartzite-like sandstone; quartzose, with dark grey carbonaceous to coaly specks and tubes (burrows?); rare <i>Buchia (Anaucella) cf. concentrica</i> (Sowerby) s. lato occur locally (GSC loc. 86831); both contacts poorly exposed but appear to be gradational; strike 220°, dip 40°W, forms a sharp-topped cross-ridge.....	4.5 (15)	346 (1135)
3	Interbedded shale and siltstone as in Unit 5; outcrops extremely poor and patchy; underlies eastern part of the same broadly V-like wooded valley as the Unit 5; no fossils seen; both contacts covered; corresponds to about 228.5 m (750 ft.) of section assuming attitude as in Unit 4.....	228.5 (750)	341.5 (1120)
2	Sandstone, as in Units 8 and 6 but with numerous lenticular interbeds, 15 to 60 cm (6 in.-2 ft.), of coquinoid sandstone replete with thick shelled <i>Arctica</i> - and <i>Thracia</i> -like marine pelecypods, and containing very rare and poorly preserved <i>Buchia cf. concentrica</i> (Sowerby) s. lato and a single poor imprint of perisphinctid ammonite (no collection made); top covered in the lower part of eastern slope of the above-mentioned wooded valley; lower contact appears to be gradational; visible.....	52 (170)	113 (370)
1	Sandstone as in Unit 7; contains some worm burrows; forms a flat ridge at the ±762 m (±2500 ft.) level, capping gentle, completely covered slope and overlooking the wooded valley of upper Waters River from the west; outcrops begin 244 m (800 ft.) above water's level (est.); pelecypod fauna, including some <i>Buchia concentrica</i> Sowerby (s. lato) (GSC loc. 86830) was collected from the fresh, locally derived float of the basal few feet of the unit; outcrops poor and mostly affected by frostheave and slumping; apparent attitudes vary from 205° \angle 30°W to 135° \angle 40°W but the study of air photographs (see photo A13751-17) indicates that the unit strikes roughly north-south and dips very steeply eastward; the base of the unit was not reached and may be cut off by a major strike fault; grades upward into Unit 2; visible.....	61 (200)	61 (200)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
	<p>Units 6 to 11 inclusive of Section 5 form an uninterrupted section, about 693.5 m (2225 ft.) thick, of the upper part of the marine facies of Porcupine River Formation beginning with some part (?lower) of <i>Buchia mosquensis</i> (s. lato) Zone. Units 1 to 5 of the section comprise an unrelated sequence of beds, about 370.5 m (1215 ft.) thick, of the lower part of the marine facies faulted against the section consisting of Units 6 to 11 inclusive.</p> <p>The section of Units 6 to 11 inclusive is unique in including about 396 m (1300 ft.) of <i>Buchia fischeriana</i> s. lato Zone. Most of this interval, beginning with the upper half of Unit 9, is younger than <i>Buchia fischeriana</i> s. lato bearing-beds crowning Sections 3 and 4.</p> <p>The above description and explanatory notes revise and supercede the preliminary interpretation of Section 5 published by the writer (Jeletzky, 1971a, p. 211, Fig. 2) in which the writer failed to recognize its faulted state.</p>		

Section No. 6

(= JA-F73-16)

The following section was measured on the upper part of the north-western slope of a nameless mountain, about 1067+ m (3500+ ft.) high, situated at the point about 1.8 km (1.125 mile) southeast of the point of confluence of the upper forks of Waters River (see air photograph A13751-17). It was selected as the third reference section of the Porcupine River Formation. The top of this section is situated at about Latitude 67°41'00"N, and Longitude 137°17'00"W, and about 5.6 km (3.5 miles) north of north-northeast of the top of Section 5 (see Fig. 2). The succession was measured downward from the mountain's top.

PORCUPINE RIVER FORMATION

Marine facies

Buchia piochii s. lato Zone (undivided)

- 13 Sandstone, dull to light grey with specks and spots of dark grey, carbonaceous sandstone, weathers buff to light orange, fine to rarely medium grained, generally quartzose but contains an appreciable admixture (some 10-15% overall; est.) of chert and ?kaolinized feldspar grains; mostly noncarbonaceous but with some interbeds of slightly carbonaceous sandstone; moderately hard to friable and exhibits a good to excellent interstitial porosity; locally rich in dark grey worm burrows and trails (hieroglyphic) filled with carbonaceous sandstone; thinly to medium but indistinctly bedded, weathers slabby to platy; contains numerous 1.3 to 10 cm (0.5-4 in.) interbeds of coquinoid sandstone containing usual fauna of long-ranging marine pelecypods, rare belemnites, starfish, etc.; fossils collected from fresh, angular float evidently derived from one of such interbeds at the level about 30.5 m (100 ft.) below visible top (GSC loc. 92199) include single valves of following marine pelecypods: *Buchia piochii* (Gabb) s. lato, *B. aff. mosquensis* (Anderson, 1945), *Pleuromya cf. post-culminata*, indeterminate pelecypods; this fauna also includes *Onychites* sp. ind. (belemnite arm hooks), and brittle starfish (ophiuroid), genus and species indet.; includes some interbeds of dark grey, sandy, friable siltstone 0.3 to 1.5 m (1-5 ft.) thick; general strike 210° to 220° with dips ranging from 10° to 15°SE; the unit underlies the uppermost 137 to 152.5 m (450-500 ft.) of the traversed slope, including the top of the mountain; relatively good (but frostheaved) exposures are limited to the topmost 46 m (150 ft.) of the unit; top not reached at mountain's top; lower contact covered; visible (estimated thickness only).....

167.5 (550)

599 (1965)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
Buchia mosquensis s. lato Zone (undivided)			
12	Sandstone, dull brown-grey to light brown-grey when fresh, weathers mottled dirty white to light grey with orange spots and specks; almost orthoquartzite to more quartzose than sandstone of Unit 13; the combined admixture of chert and ?kaolinized feldspar grains mostly less than 10 per cent (est.); contains some orange-coloured grains of limonite (?weathered glauconite); fine grained to very fine grained, moderately hard to hard but only moderately dense and with a slight to excellent interstitial porosity (locally vuggy); mostly thick to heavily and indistinctly bedded or massive looking and weathers into large to very large (0.6-0.9 m; 2-3 ft. to a side) or moderately sized blocks; contains Buchia and other marine pelecypods at several levels and is believed to be shallow marine throughout; contains some 0.3 to 1.5 m (1-5 ft.) interbeds of siltstone as in Unit 13 and some similarly thick interbeds of dark grey, friable, rubbly to flaky-weathering, sandy to very sandy siltstone; mostly noncarbonaceous in the upper 52 m (170 ft.) but is interbedded with carbonaceous to coaly sandstones as in Unit 11 in the basal 9 m (30 ft.); some 24.5 m (80 ft.) below top Buchia mosquensis (v. Buch) s. lato and other long-ranging pelecypods of usual type were collected from angular, locally derived sandstone blocks (GSC loc. 92198); outcrops are poor and almost covered by scree; general strike 210°; general dip 30° to 35°SE; however, the rock is strongly slickensided locally and appears to be disturbed by faulting; grades downward into Unit 11 at the head of a deep gully incised into the traversed slope.....	61 (200)	431.5 (1415)
Buchia (Anaucella) concentrica Zone (?upper part)			
11	Sandstone, dull to bluish grey and mottled to evenly coloured when fresh; weathers same or dull blue to ash grey with rust coloured spots; fine to very fine grained, generally quartzose (as in Unit 12) but carbonaceous to coaly throughout; hard to friable with hard varieties prevalent in the upper half while the friable varieties are prevalent in the lower half; external appearance varies from massive or extremely thick and indistinctly bedded to very thinly and regularly bedded to laminated, the latter variety exhibits a regular alternation of black to dark grey, coaly laminae and light grey, slightly carbonaceous to noncarbonaceous lamellae; thin but irregular (conchoidal to ropy) bedding with similar alternation of coaly and noncarbonaceous beds is common also in the latter variety; partings of coaly or carbonaceous clay with or without poor plant remains are common on bedding planes; includes some interbeds of coaly siltstone, dark grey to black when fresh, weathering dull blue or ash grey and flaky to rubbly; well-developed cross-bedding and ripple marks rare or absent; basal 15 m (50 ft.) consist almost exclusively of mottled dark and blue-grey, coaly, friable, very fine grained to fine-grained sandstone with mostly thin but indistinct and irregular (conchoidal to ropy) bedding; vertical coaly rootlets present locally in these basal beds; marine, in part at least, as it includes several interbeds of coquinoid sandstone containing marine pelecypods throughout (including the basal coaly beds); a diversified pelecypod fauna including well-preserved Buchia (Anaucella) concentrica (Sowerby) s. lato (?late forms) was collected (GSC loc. 92197) 15 to 17 m (50-55 ft.) below assigned top of the unit from fresh, locally derived debris; similar fauna including Buchia ex gr. concentrica (Sowerby) was seen (no collection made) in basal 15 m (50 ft.) of the unit; regular strike 215°; regular dip 11°SE; outcrops in the uppermost part of traversed gully.....	46 (150) (est.)	370.5 (1215)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
<u>Nonmarine facies</u>			
Upper Oxfordian to ?middle Callovian			
10	Siltstone, black to dark grey when fresh, weathers same with rust-coloured spots and specks and fine rubbly to flaky; mostly sandy to very sandy; appears to be carbonaceous to coaly throughout; mostly indistinctly and conchoidally to ropy bedded but with minor interbeds of thinly and well-bedded to laminated siltstone; some interbeds of friable, silty, sandstone as in basal 15 m (50 ft.) of Unit 11; friable and recessive; no fossils seen; grades downward into Unit 9 through a 3 to 4.5 m (10-15 ft.) thick unit consisting of interbedded sandstone and siltstone.....	36.5 (120)	324.5 (1065)
9	Sandstone, mottled dark and dull brown-grey when fresh, weathers mottled dull and light brown, very fine grained, quartzose but silty and carbonaceous to coaly; contains irregularly twisted, often rootlet-like, 5 to 13 cm (2-5 in.) long, and 0.6 to 1.3 cm (0.25-0.5 in.) thick, inclusions of black, coaly sandstone or siltstone; moderately to fairly hard and dense and moderately porous; mostly medium (15-30 cm; 6-12 in.) and indistinctly bedded but with some interbeds of thinly bedded to laminated sandstone; no fossils seen; grades downward into Unit 8.....	7.5 (25) (est.)	288 (945)
8	Sandstone, similar to that of Unit 9 in colour, weathering, and lithology but thinly and regularly bedded to laminated and mostly intensively cross-bedded; partings and laminae of dark grey coaly sandstone or siltstone with fine plant fragments are common on bedding planes but some disarticulated marine pelecypods occur on the same bedding planes; sandstone becomes mostly noncarbonaceous to slightly carbonaceous below 12 m (40 ft.) level and includes several 10 to 60 cm (4 in.-2 ft.), apparently lenticular interbeds of hard to very hard, ferruginous siltstone weathering bright orange ("clay ironstone") in this lower part of the unit; these siltstone interbeds are rich in variegated marine pelecypods; the same marine pelecypods also occur at intervals in the upper 12 m (40 ft.) of the unit; the pelecypod fauna lacks any <i>Buchia</i> throughout and accordingly is believed to be of a pre-upper Oxfordian age; fauna GSC loc. 92193 collected in place 6 m (20 ft.) below unit's top; fauna GSC loc. 92196 collected 15 to 17 m (50-55 ft.) below unit's top; and GSC loc. 92195 containing large and coarsely sculptured <i>Meleagrinnella</i> ex gr. <i>echinata</i> (Smith) was collected 33.5 m (110 ft.) below unit's top; regular strike 210°; regular dip 16°SE; grades downward into Unit 7.....	46 (150)	280.5 (920)
7	Sandstone, lithologically as in the essentially noncarbonaceous variety prevalent in lower 33.5 m (110 ft.) of Unit 8 and similarly coloured; however, hard and resistant and mostly medium to thick bedded (15-90 cm; 6 in.-3 ft.); occupies a narrow, deeply incised, partly gorge-like, middle part of traversed gully; rich in the same marine pelecypods as in Unit 8 at many levels; pelecypods occur exclusively as disarticulated valves on bedding planes (no collection made); weathers large slabby to blocky; no cross-bedding or ripple marks noted in this shallow marine unit.....	36.5 (120)	234.5 (770)
6	Sandstone; much as the very hard, thick bedded to massive variety of Unit 11 but still harder and predominantly quartzite-like with little or no visible interstitial porosity; coaly to carbonaceous throughout; no fossils seen; occupies a narrow, crevice-like gorge of the traversed gully; strike (regular) 340°; dip (regular) 16°S; grades downward into Unit 5 through a zone, about 3 m (10 ft.) thick, of lithologically transitional sandstone.....	61 (200)	198 (650)

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
5	Sandstone, generally as in basal 15 m (50 ft.) of Unit 11 but contains several 0.3 to 3 m (1-10 ft.) interbeds of siltstone as in Unit 10; no fossils seen; grades downward into Unit 4.....	24.5 (80)	137 (450)
4	Sandstone, as in Unit 6; occupies the second short, gorge-like segment of traversed gully with a 3.5 m (12 ft.) high cascade; no fossils seen; grades downward into Unit 3.....	18 (60)	112.5 (370)
3	Sandstone, generally as in Unit 5 but becomes interbedded with very sandy siltstone as in Unit 10 below the 24.5 m (80 ft.) level and grades into siltstone of Unit 2; locally contains some long-ranging marine pelecypods of a usual type; lot (GSC loc. 92194) of this fauna was collected at 36.5 m (120 ft.) level below top.....	67 (220)	94.5 (310)
2	Siltstone, much as in Unit 7 but apparently less coaly or carbonaceous; exposures very poor and intermittent on lower part of the slope until the level about 91.5 m (300 ft.) (est.) above the first terrace of Waters River where the outcrops end; no fossils seen in this unit which is considered to be equivalent to Unit 3 of Section 4; base not reached; visible.....	27.5 (90) (est.)	27.5 (90)
1	Completely debris-covered and mostly overgrown lower slope of the mountain, about 91.5 m (300 ft.) high.....	--	--

Section 6 was introduced principally to demonstrate that the lithologically recognizable (albeit containing considerably more marine interbeds than its more southerly sections (e.g. Sec. 4, Units 2 to 9 incl.)) nonmarine facies persists northward into the headwaters of Waters River. The presence of this nonmarine facies in Section 6 and farther east in the headwaters of the left confluents of Waters River (see Jeletzky, 1974, p. 8) suggests the presence of this facies in unexposed parts of Section 5 beneath an exceptionally thick sequence of the marine facies. This inference forms the basis for an estimate of the total thickness of the typical development of Porcupine River Formation in the headwaters of Berry Creek and Waters River (see p. 9).

Section No. 7

(Field No. JA-F75-9)

The following section exposing the lower contact of the Porcupine River Formation was measured in the undercut eastern bank of southern Johnson Creek at about Latitude 67°14'45"N and Longitude 138°18'W (see Fig. 2).

PORCUPINE RIVER FORMATION

(Nonmarine facies)

- 2 Sandstone, white when fresh, weathers buff to pale or bright orange (mottled), mostly pure to almost pure orthoquartzite, except for a minor admixture of carbonaceous grains, particles, and specks in some beds, very fine grained, well sorted as to grain size and well rounded, most grains being subrounded; hard and dense but neither quartzite-like nor true quartzite and exhibits at least some interstitial porosity; massive-looking for the most part; resistant, and exhibits no bedding whatsoever for the most part; weathers into large blocks and variously sized chunks following jointing planes, forms a steep bank of the creek;

Unit	Lithology	Thickness metres (feet)	Height above base metres (feet)
	<p>mostly unfossiliferous but a few <i>Arctica</i> (<i>s. lato</i>)-like ?marine pelecypods were found in fresh angular blocks at the bluff's base (GSC loc. 92923); includes several interbeds, 10 to 50 cm (4-20 in.) thick of light, dull or whitish grey (in fresh and weathered state), quartzose but feebly to moderately carbonaceous sandstone rich in fragments of petrified wood, well-preserved petrified twigs and small (1-5 cm; 0.5-2 in.) pods of impure or pure (shiny) black coal; neither of the two above described sandstone varieties exhibit any sedimentary structures whatsoever; strike (regular) 220° to 230°, dips (regular) 20° to 25°E; lower contact abrupt and uneven with the sandstone filling up a few cm deep depressions in the surface of underlying siltstone; however, no accumulation of grit, or pebbles or even of coarser grained arenaceous particles, was noted in the 0.5 m (2 ft.) thick interbed of carbonaceous (?nonmarine) sandstone variety immediately overlying this probably erosionally disconformable (?an erosional channel) contact; top concealed at the southern end of the undercut creek's bank and higher up the slope; visible.....</p>	25 (82)	29 (95)
	KINGAK FORMATION (restr.)		
1	<p>Siltstone (perhaps better mudstone), dull grey to dark grey when fresh, weathers dull to ash grey and fine rubbly to chippy, friable to almost unconsolidated, sandy and micaceous; contains some 10 to 15 cm (4-6 in.) bands and rounded 10 to 15 cm (4-6 in.) concretions of hard, rusty-weathering clay ironstone; the exposed thickness varies from 0 to about 4 m at the northernmost end of the exposure; geologists of Shell Oil Canada Ltd. (GSC loc. 88702) collected uppermost Bathonian to lower Callovian <i>Cylindroteuthis</i> (<i>Communicobelus</i>) aff. <i>subextensa</i> (Nikitin) from this unit but the writer only found in it <i>Pleuromya</i> sp. indet. (GSC loc. 92925); base covered at the northern end of exposure; visible up to.....</p>	4 (13)	4 (13)