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LOWER PALEOZOIC FRANKLIN MOUNTAIN AND MOUNT KINDLE FORMATIONS, DISTRICT OF MACKENZIE: THEIR TYPE SECTIONS AND REGIONAL DEVELOPMENT

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ABSTRACT

At its type section on Mount Kindle near Wrigley in the southern Franklin Mountains, the Franklin Mountain Formation is more than 917 feet (280 m) thick. It includes varicoloured, thin- to thick-bedded dolomite and argillaceous dolomite, and represents shallow-marine and peritidal environments. The formation is widely distributed in the eastern Mackenzie Mountains and in the Franklin Mountains; in these areas, it appears to be less than 2,500 feet (760 m) thick. In the Interior Plains, where the formation also is widespread, surface thicknesses appear to be less than 2,500 feet (760 m); but more than 3,400 feet (1,035 m) of strata can be assigned to the Franklin Mountain in the subsurface of the Colville Hills area. Three informal units can be recognized widely within the Franklin Mountain Formation. From base to top these are: the cyclic unit (0-450 ft.; 0-137 m), the rhythmic unit (?100-1,600 ft.; ?30-490 m), and the cherty unit (0-?2,400 ft.; 0-?730 m). Over the entire area of outcrop, distribution and thickness of these units may be affected by erosion associated with unconformities beneath the Mount Kindle Formation, beneath Devonian sediments, beneath Cretaceous sediments, and by the present Pleistocene-Holocene surface of erosion. The rhythmic unit (at least 872 ft.; 266 m, thick) and the cherty unit (45 ft.; 14 m, thick) can be recognized clearly at the type section, despite poor exposures. A fourth unit, the porous dolomite unit (381 ft.; 116 m, thick), locally is developed above the cherty unit in the subsurface northwest of the Colville Hills.

Recessive fossiliferous rocks, originally assigned to the uppermost part of the type Franklin Mountain Formation (Williams, 1923), belong to the Mount Kindle Formation (thus emended), and are separated from the underlying Franklin Mountain strata by an erosion surface of regional extent. Removal of these rocks to emend the type Franklin Mountain Formation means that no fossils other than stromatolites are known from its type section. Regionally, Late Cambrian and Early Ordovician faunas are known from the Franklin Mountain Formation. The location of the Cambro-Ordovician boundary is not known; it may lie within the rhythmic unit, or between the rhythmic unit and the overlying cherty unit.

The Mount Kindle Formation is about 895 feet (237 m) thick at its type section at Mount Kindle, and consists of grey, thinly to thickly bedded dolomite; some of which is biostromal and all is of shallow-water, shelf aspect. Distribution and thickness of the Mount Kindle on a regional scale also has been affected strongly by erosion associated with sub-Devonian and sub-Cretaceous unconformities and with the present Pleistocene-Holocene erosion surface. Locally, the Mount Kindle Formation attains thicknesses up to 1,500 feet (455 m) in outcrop. Regionally, the formation consists of a monotonous succession of uniform, medium to dark brownish grey, finely to medium crystalline dolomite containing abundant chert and, in its lowest few hundred feet, halysitid, favositid and solitary corals, brachiopods and orthoconic cephalopods. Facies changes appear to be minimal in the area discussed. The formation, generally, is thinnest or absent in the Interior Plains and northern Franklin

RÉSUMÉ

Dans sa coupe type, au mont Kindle près de Wrigley, dans la partie sud des monts Franklin, la formation du mont Franklin a plus de 917 pieds (280 m) d'épaisseur. Elle se compose de couches tantôt minces tantôt épaisses de dolomie aux couleurs variables et de dolomie argileuse, et répresentent des environnements marins peu profonds, et péritidaux. La formation est largement répartie dans la partie est des monts Mackenzie et dans les monts Franklin; dans ces régions, elle semble mesurer moins de 2,500 pieds (760 m) d'épaisseur. Dans les plaines intérieures, où la formation est également répandue, les épaisseurs de la surface semblent inférieures à 2,500 pieds (760 m); mais des couches formant une épaisseur de plus de 3,400 pieds (1035 m) peuvent être attribuées à la formation du mont Franklin sous la surface de la région des collines Colville. Dans la région, on peut distinguer trois unités de la formation du mont Franklin. De la base au sommet, ce sont: l'unité cyclique (0-450 pieds; 0-137 m), l'unité de cyclothèmes (?100-1,600 pieds; ?30-490 m), et l'unité de chert (0-?2,400 pieds; 0-?730 m). Sur toute la surface de l'affleurement, la répartition et l'épaisseur de ces unités peuvent dépendre de l'érosion et des discordances qui peuvent exister sous la formation du mont Kindle, sous les sédiments dévoniens, sous les sédiments crétacés, de même que de la surface d'érosion pleistocène-holocène actuelle. L'unité de cyclothèmes (au moins 872 pieds, 266 m, d'épaisseur) et l'unité de chert (45 pieds, 14 m, d'épaisseur) peuvent être clairement identifiées dans la coupe type, malgré le fait que les affleurements soient peu visibles.

Les roches fossilifères de récession, qui au début étaient attribuées à la partie qui se trouve tout à fait au sommet de la formation type du mont Franklin (Williams, 1929), appartiennent à la formation du mont Kindle (correction) et sont séparées des couches de la formation du mont Franklin par une surface d'érosion qui s'étend dans la région. Le fait de retrancher ces roches de la formation type du mont Franklin signifie que dans la coupe type de cette formation il n'y a pas d'autres fossiles connus que les stromatolithes. Par endroit, on trouve dans la formation du mont Franklin des faunes de la fin du Cambrien et du début de l'Ordovicien. On ne sait pas où se trouve la limite entre le Cambrien et l'Ordovicien; elle peut se trouver a l'intérieur de l'unité de cyclothèmes, ou entre l'unité de cyclothèmes et l'unité de chert qui la recouvre.

La formation du mont Kindle mesure environ 895 pieds (237 m) d'épaisseur dans sa coupe type au mont Kindle; elle est constituée de dolomie grise en lits tantôt minces tantôt épais; une partie de cette dolomie est un biostrome et elle semble présenter l'aspect d'une plate-forme formée en eau peu profonde. La répartition et l'épaisseur de la formation du mont Kindle semble également dépendre fortement de l'érosion et des discordances qui peuvent se trouver au dessous le Dévonien et le Crétacé qui sont sous-jacents de même que de l'érosion de surface pleistocène-holocène actuelle. Par endroit, la formation du mont Kindle atteint des épaisseurs qui mesurent jusqu'à 1,500 pieds (455 m) dans les affleurements. Par region, la formation est constituée d'une succession régulière de couleur gris

Mountains, somewhat thicker in the frontal Mackenzie Mountains, and thickest in the central Mackenzie Mountains where, apparently, it is equivalent to most of the Whittaker Formation. At the type section, the lower 500 feet (152 m) of the Mount Kindle Formation contain Late Ordovician (Richmond) and Early Silurian (Llandovery) fossils; the upper 400 feet (122 m) are not dated. No overlying strata outcrop at the type section on Mount Kindle, but a supplementary section at the north end of Smith Ridge, four miles (6.5 km) south of Mount Kindle, shows the top of the formation to be separated from the overlying Devonian Bear Rock Formation by about 450 feet (137 m) of poorly exposed beds. These rocks cannot be assigned with confidence to any formation, but may belong to the Delorme Formation (Late Silurian and Early Devonian).

brunâtre qui va d'une teinte moyenne uniforme au foncé, de dolomie dont la cristallisation est de fine à moyenne et qui contient beaucoup de chert et dans les quelques cents pieds de la base d'halysitids, de favositids et de coraux solitaires, de brachiopodes et de céphalopodes orthocératides. Il semble y avoir peu de changement de faciès dans la région dont nous venons de parler. La formation, en général, est très mince ou inexistante dans les plaines intérieures et dans la partie nord des monts Franklin, quelque peu plus épaisse près des monts Mackenzie et atteint sa plus grande épaisseur au centre des monts Mackenzie, où apparement, elle équivaut à la plus grade partie de la formation Whittaker. A la coupe type, les 500 pieds (152 m) de la base de la formation du mont Kindle contiennent des fossiles de la fin de l'Ordovicien (Richmond) et du début du Silurien (Llandovery); les 400 pieds (122 m) vers le haut ne sont pas datés. Il n'y a pas d'affleurement de couches supérieures à la coupe type du mont Kindle, mais une coupe supplementaire située a l'extrémité nord de l'arête Smith, à quatre milles (6.5 km) au sud de mont Kindle, permet de voir que le sommet de la formation est séparé de la formation Bear Rock du Dévonien par environ 450 pieds (137 m) de lits peu exposés. Ces roches ne peuvent être attribuées avec certitude à aucune formation, mais elles font peut-être partie de la formation Delorme (fin du Silurien et début du Dévonien).

LOWER PALEOZOIC FRANKLIN MOUNTAIN AND MOUNT KINDLE FORMATIONS, DISTRICT OF MACKENZIE: THEIR TYPE SECTIONS AND REGIONAL DEVELOPMENT

INTRODUCTION

The Franklin Mountains are a narrow chain of anticlines, commonly reverse-faulted, lying mainly east of the Mackenzie River, and extending from north of Norman Wells to the area west of Fort Simpson (Fig. 1). Within the Franklin Mountains, lower Paleozoic rocks form the cores of most of the anticlines, but a thick sequence of Proterozoic strata outcrops near Wrigley (Douglas and Norris, 1963; Aitken *et al.*, 1974). Cambrian to Silurian rocks are widespread in the Franklin Mountains, eastern Mackenzie Mountains, and northern Interior Plains (Douglas *et al.*, 1970; Cook and Aitken, 1973; Meijer-Drees, in press; and others), and in the subsurface of the lower Mackenzie River area (Tassonyi, 1969). A variety of terminologies (particularly "Ronning Group") has been applied to lower Paleozoic carbonate rocks in the lower Mackenzie River area, but the relationship of these units to the Mount Kindle and Franklin Mountain Formations (Williams, 1922, 1923) of the southern Franklin Mountains has remained obscure.

Stratigraphic studies of lower Paleozoic rocks of the southern Mackenzie and Franklin Mountains were carried out in 1957 as part of Operation Mackenzie, a helicopter-supported regional study by the Geological Survey of Canada (Douglas, 1959). Franklin Mountain, Mount Kindle, and laterally equivalent rocks were examined by W.B. Brady, A.W. Norris, and B.R. Pelletier (Douglas and Norris, 1961, 1963).

Cambrian to Silurian rocks of the northwestern Mackenzie Mountains and the Wernecke, Ogilvie, and Richardson Mountains were studied by Norford (1964) as part of Operation Porcupine, a Geological Survey of Canada regional geological reconnaissance study mainly of the northern Yukon, conducted in 1962 and co-ordinated by D.K. Norris (Norris *et al.*, 1963). Recently, Macqueen (1974) briefly studied lower Paleozoic rocks of the Wernecke, Richardson, and northwestern Mackenzie Mountains. In 1968 and 1969, Macqueen examined lower Paleozoic rocks of the northeastern Mackenzies, the northern Franklins, and the Interior Plains of the lower Mackenzie River, as part of Operation Norman, a Geological Survey of Canada regional geological study co-ordinated by J.D. Aitken and D.G. Cook (Aitken *et al.*, 1969; Aitken, Cook and Balkwill, 1970; Aitken, Macqueen and Usher, 1974; Cook and Aitken, 1971a, b; Macqueen, 1969, 1970). Norford studied selected lower Paleozoic localities in the eastern Mackenzies during Operation Nahanni in 1965 (Gabrielse *et al.*, 1973), as well as the type sections of the Franklin Mountain and Mount Kindle Formations near Wrigley (Norford, 1966). Aitken and Macqueen re-examined the type sections in 1972.

These and other studies have shown that the Franklin Mountain and Mount Kindle Formations can be mapped over a wide area of the Mackenzie and Franklin Mountains and the Interior Plains of the lower Mackenzie River area. Although widespread and thick carbonate successions in the northern Yukon are, at least in part, of the same age as the Franklin Mountain and Mount Kindle Formations, the successions differ so greatly in character that these names cannot be applied to surface exposures in the northern Yukon except in the Mackenzie Mountains.

ACKNOWLEDGMENTS

X-ray diffraction analyses and carbon analyses of a suite of samples from the type sections of the Mount Kindle and Franklin Mountain Formations were completed by A.E. Foscolos, R.R. Barefoot, and A.G. Heinrich, all of the Geological Survey of Canada, Calgary. B.R. Pelletier, of the Geological Survey of Canada at Dartmouth, aided in the planning of Norford's 1965 field work; and H. Gabrielse, of the Geological Survey of Canada, Vancouver, criticized an early version of the manuscript. We thank J.D. Aitken, D.G. Cook, N.C. Meijer-Drees, A.E. Norris, D.K. Norris, and A.E.H. Pedder, all of the Geological Survey of Canada, Calgary, for critical reading of the manuscript. Thanks are due, also, to the following who identified and commented on some of the collected fossils: T.T. Uyeno and W.H. Fritz of the Geological Survey of Canada, R.J. Ross of the United States Geological Survey, C.R. Barnes of the University of Waterloo, and E.L. Yochelson, U.S. National Museum, Washington. A.R. Palmer, State University of New York at Stony Brook, advised on the provenance of Upper Cambrian echinoderm fragments. Aquitaine Company of Canada, Limited, kindly permitted release of confidential data from the Brackett Lake C-21 well.

PREVIOUS STUDIES OF THE MOUNT KINDLE AREA

Paleozoic exposures located along the Mackenzie River valley were first examined systematically in the early part of this century and Silurian rocks were reported from Mount Charles and near Cap Mountain

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Authors' address: Institute of Sedimentary and Petroleum Geology
3303 - 33rd Street N.W.
Calgary, Alberta
T2L 2A7

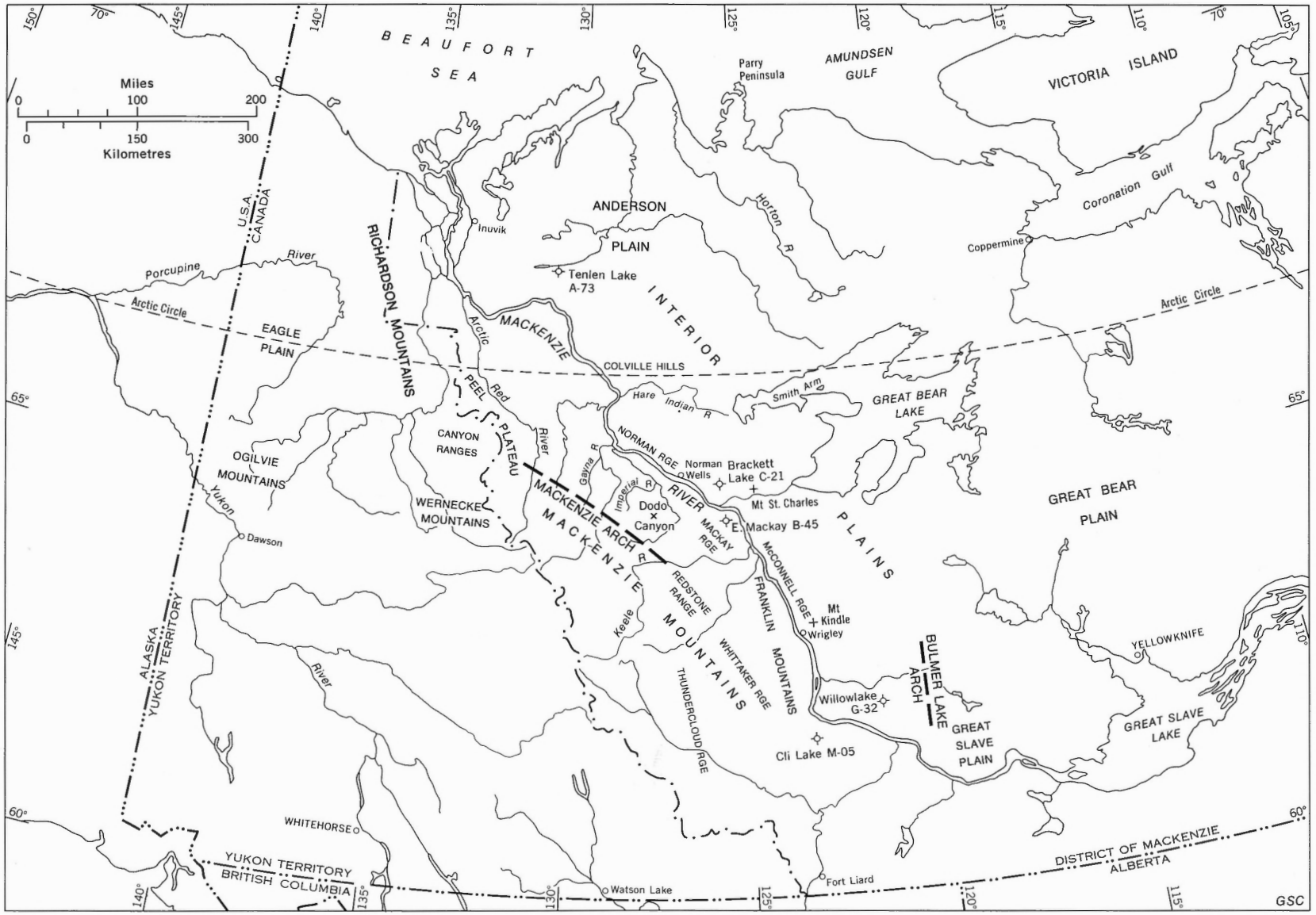


Figure 1. Map showing geological features, localities and wells referred to in the text

by Kindle (1920) and Kindle and Bosworth (1921). Williams (1922, 1923) proposed the names Mount Kindle and Franklin Mountain Formations for two distinct lower Paleozoic stratigraphic intervals studied by him northeast of Wrigley. Brachiopods (*Rhipidomella*) and corals were found at one locality (Williams, 1923, p. 73B, 78B; 1963, p. 231, 233, 235) in strata that he assigned to the Franklin Mountain Formation; the overlying Mount Kindle Formation yielded abundant corals and brachiopods in its lower part and, higher in the formation, *Zaphrentis stokesi* Milne Edwards and Haime, and *Conchidium* sp., the latter in a loose boulder. Both formations were believed by Williams to be Silurian (Fig. 3). Tassonyi (1969, p. 19-31) has summarized relevant data from Williams's early work.

Williams's stratigraphic sequence was accepted widely (Swartz *et al.*, 1942; Hume and Link, 1945; Hume, 1954), although the names Mount Kindle and Franklin Mountain were not used in the Canol Project reports summarizing geological studies in the lower Mackenzie River area to the north of Wrigley (*see* especially Hume, 1954). Supposedly correlative Silurian strata in this area were assigned to the "Ronning Group", a name originally used informally as "Ronning Formation" by Link (unpublished report, dated 1921).

In 1959, Bell suggested that the Mount Kindle Formation was Late Ordovician in age and the Franklin Mountain Formation was Late, Middle, or Early Ordovician (Fig. 3). Bell's conclusions were derived from his interpretations of Borden's (1956) unpublished dissertation that had demonstrated the presence of Late Ordovician coral faunas in the Mackenzie and Franklin Mountains. Late Ordovician fossils later were reported from the Mount Kindle Formation of the type area by Douglas and Norris (1961, p. 13).

Douglas and Norris (1963, p. 11, 12), considered the Franklin Mountain Formation to be Ordovician. The basal beds of the Mount Kindle Formation were dated as Late Ordovician at the type section and an Early Silurian fauna was reported from near the top of the formation at Smith Ridge, four miles (6.4 km) southeast of the type section. These age assignments were based on field observations made by B.R. Pelletier and W.B. Brady in 1957 as part of the Geological Survey's Operation Mackenzie, and on faunal identifications by B.S. Norford and G.W. Sinclair. Three Late Ordovician corals, *Manipora* sp., *Palaeophyllum* sp., and *Sarcinula* sp., collected by Pelletier from the type section of the Mount Kindle Formation had been illustrated earlier (Norford, 1962, Pl. 6, figs. 5-9).

In 1963, Williams published a reassessment of his stratigraphic section, based on his original observations and re-study of the fossils collected by him in 1921 and 1922. He affirmed his earlier opinion that the Mount Kindle Formation was entirely Silurian (Niagara; Wenlock) and that the upper beds of the Franklin Mountain were also Silurian (Medina-Cataract; Llandovery).

Studies in the Mackenzie and Franklin Mountains by geologists of Shell Canada Limited supported Late Ordovician and Early Silurian ages for the Mount Kindle Formation, but indicated Late Cambrian and Early Ordovician ages for the Franklin Mountain Formation (Ziegler, 1967, p. 42-49; 1969, p. 53-57; Bassett and Stout, 1968, p. 722).

In Great Slave Plain, a part of the Interior Plains to the east of the Franklin Mountains, A.W. Norris (1965) divided lower Paleozoic strata into two units, the La Martre Falls Formation, and the Chedabucto Lake Formation. Later work conducted by Balkwill (1971) as part of Operation Norman, and by G.K. Williams (1974) showed that most of the La Martre Falls Formation corresponds to the Mount Cap and Saline River Formations of M.Y. Williams (1922, 1923), and that some of the upper part of the La Martre Falls Formation may be assigned to the Franklin Mountain Formation. The interval, about 32 feet (10 m) thick, of shale and mudstone at the top of the type section of the La Martre Falls Formation, from which Norris (1965, p. 19, 20, 109) collected Middle or Late Ordovician fossils, is unknown elsewhere in the formation and now is judged by Norris (*in* G.K. Williams, 1974, p. 287) as basal Mount Kindle Formation. Norris's description (his units 16 to 21) corresponds to the basal member. The overlying Chedabucto Lake Formation of Norris (1965) is lithologically similar to and can be traced into the lower part of the Mount Kindle Formation (Balkwill, 1971, p. 19; G.K. Williams, 1974, p. 287; Meijer-Drees, in press).

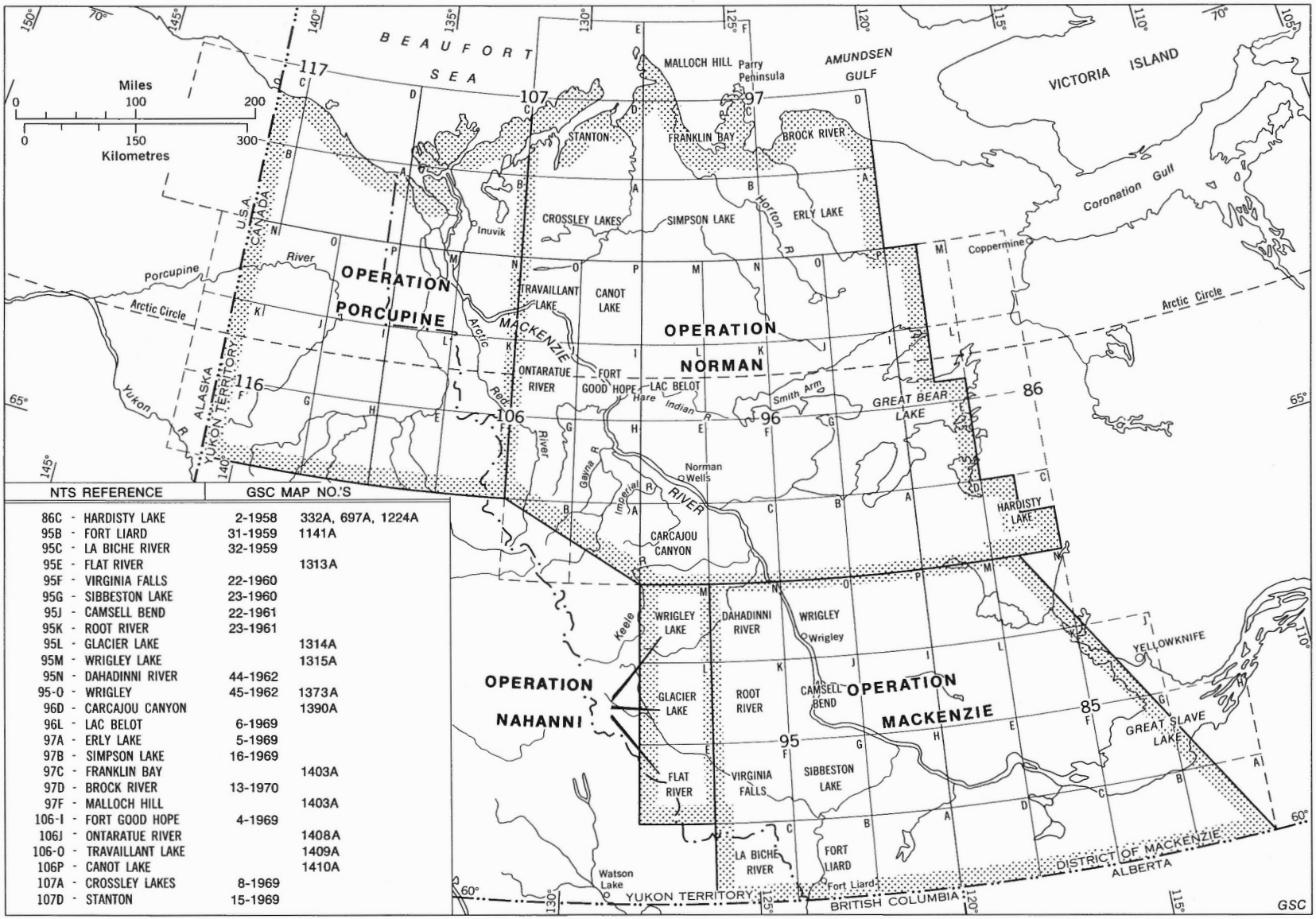
Field work carried out as part of Operation Norman (1968-1970) in the lower Mackenzie River area demonstrated the Mount Kindle and Franklin Mountain Formations to be widespread, mappable units within the lower Paleozoic succession and separated by a regional unconformity of considerable magnitude. The Franklin Mountain Formation was shown to be Late Cambrian and Early Ordovician in age, and the overlying Mount Kindle Formation to be Late Ordovician and Early Silurian in age (Macqueen, 1970). Developments of the Franklin Mountain and Mount Kindle were recognized clearly within the type section of the original "Ronning Formation" at Dodo Canyon in the Mackenzie Mountains (Carcajou Canyon map-area, 96D).

Tassonyi (1969) studied subsurface geology of the lower Mackenzie River area, including lower Paleozoic data available to March, 1961. His study demonstrated that strata now assigned to the informal units recognized in the Franklin Mountain Formation by Macqueen (1970) and others are distributed widely in the subsurface of the lower Mackenzie River area. Recent regional compilations including lower Paleozoic units were made by Lenz (1972) for the northern Yukon and western Northwest Territories, and by Gilbert (1974) and Kunst (1974) mainly for the subsurface of the northern Interior Plains and Peel Plateau respectively. Meijer-Drees (1974 and in press) has studied lower Paleozoic strata of the subsurface of the Mackenzie Trough and Interior Platform in the vicinity of the southern Franklin Mountains.

FRANKLIN MOUNTAIN FORMATION

REGIONAL CHARACTER

Field studies, conducted as part of Operation Norman, demonstrated that in the northern Interior Plains the Franklin Mountain Formation outcrops over



NTS REFERENCE	GSC MAP NO.'S	
86C - HARDISTY LAKE	2-1958	332A, 697A, 1224A
95B - FORT LIARD	31-1959	1141A
95C - LA BICHE RIVER	32-1959	
95E - FLAT RIVER		1313A
95F - VIRGINIA FALLS	22-1960	
95G - SIBBESTON LAKE	23-1960	
95J - CAMSELL BEND	22-1961	
95K - ROOT RIVER	23-1961	
95L - GLACIER LAKE		1314A
95M - WRIGLEY LAKE		1315A
95N - DAHADINNI RIVER	44-1962	
95-O - WRIGLEY	45-1962	1373A
96D - CARCAJOU CANYON		1390A
96L - LAC BELOT	6-1969	
97A - ERLY LAKE	5-1969	
97B - SIMPSON LAKE	16-1969	
97C - FRANKLIN BAY		1403A
97D - BROCK RIVER	13-1970	
97F - MALLOCH HILL		1403A
106-I - FORT GOOD HOPE	4-1969	
106J - ONTARATUE RIVER		1408A
106-O - TRAVAILLANT LAKE		1409A
106P - CANOT LAKE		1410A
107A - CROSSLEY LAKES	8-1969	
107D - STANTON	15-1969	

Figure 2. Index map indicating NTS sheets and published GSC maps at 1:250,000 scale, for Operations Mackenzie, Nahanni, Norman and Porcupine

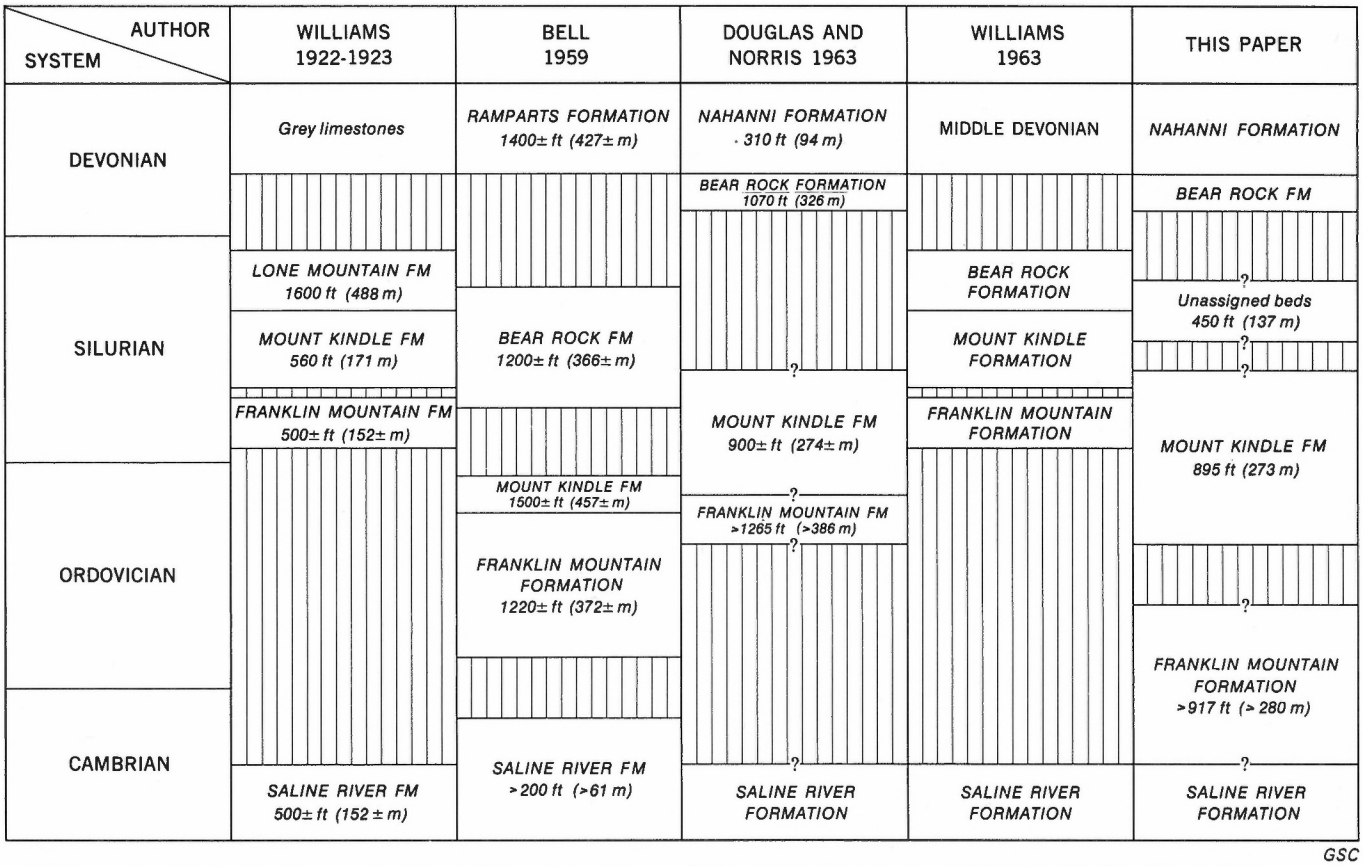


Figure 3. History of correlation of type sections of Franklin Mountain and Mount Kindle Formations.

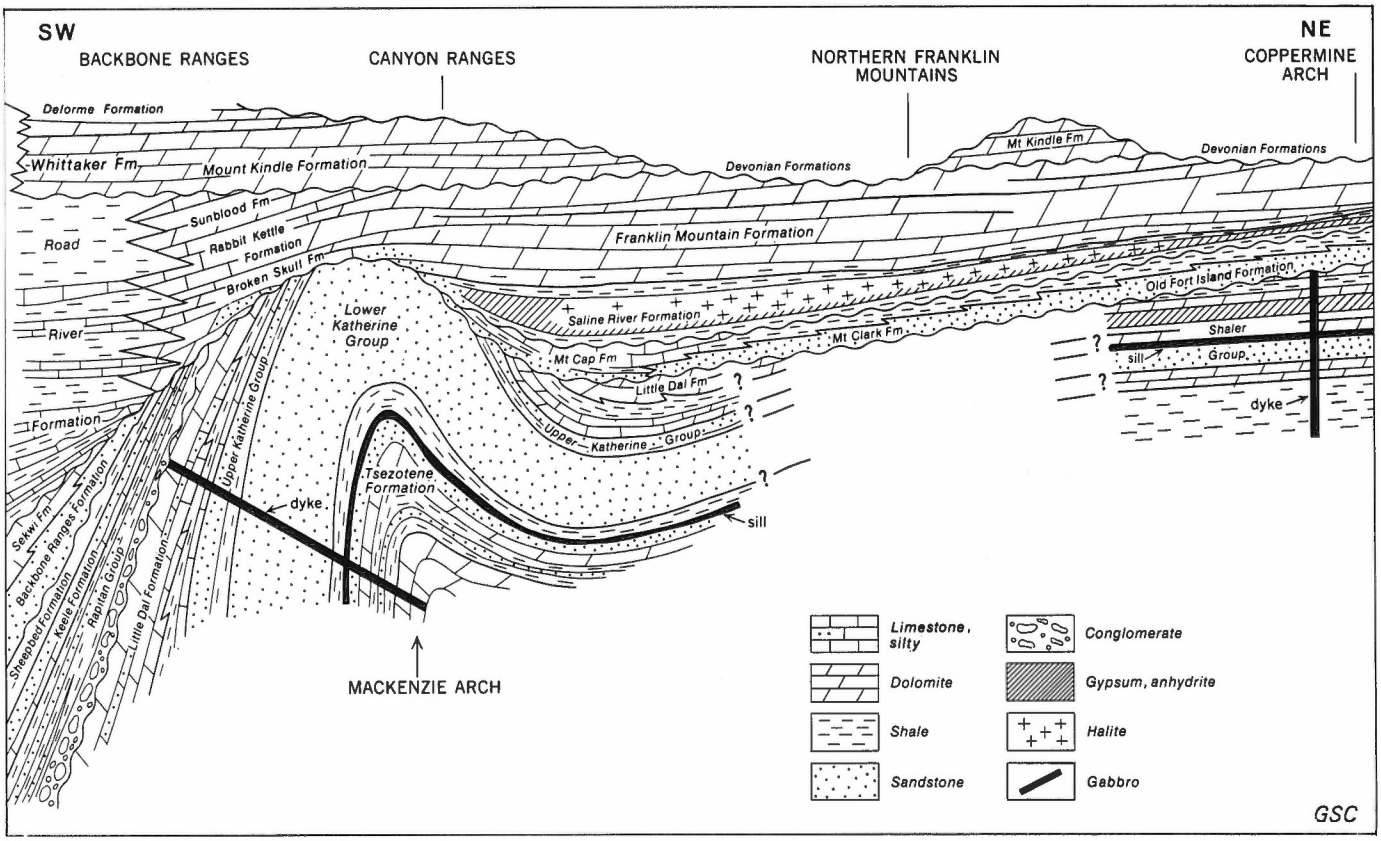


Figure 4. Diagrammatic restored stratigraphic cross-section, interior Mackenzie Mountains (Backbone Ranges) to Coppermine Arch. (Adapted from Aitken *et al.*, 1974).

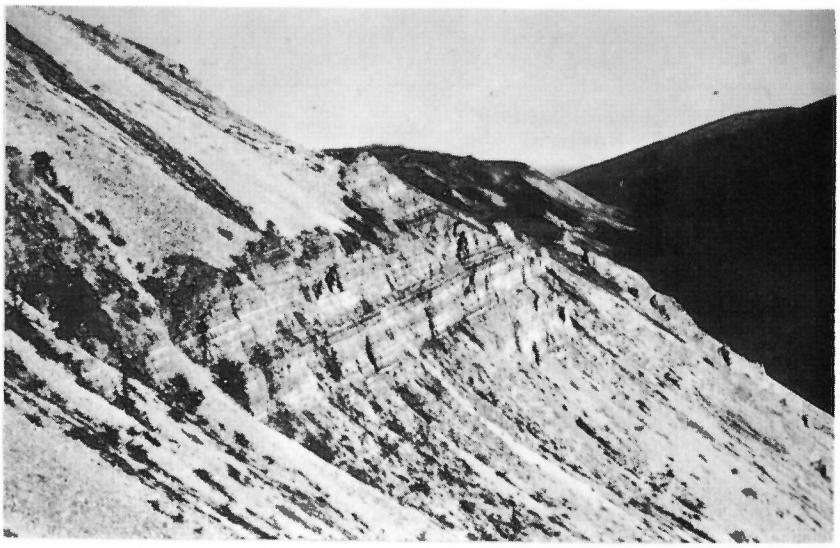


Plate 1.

Northeast face of Mount Kindle; outcrops of the rhythmic unit of the Franklin Mountain Fm. GSC 199075

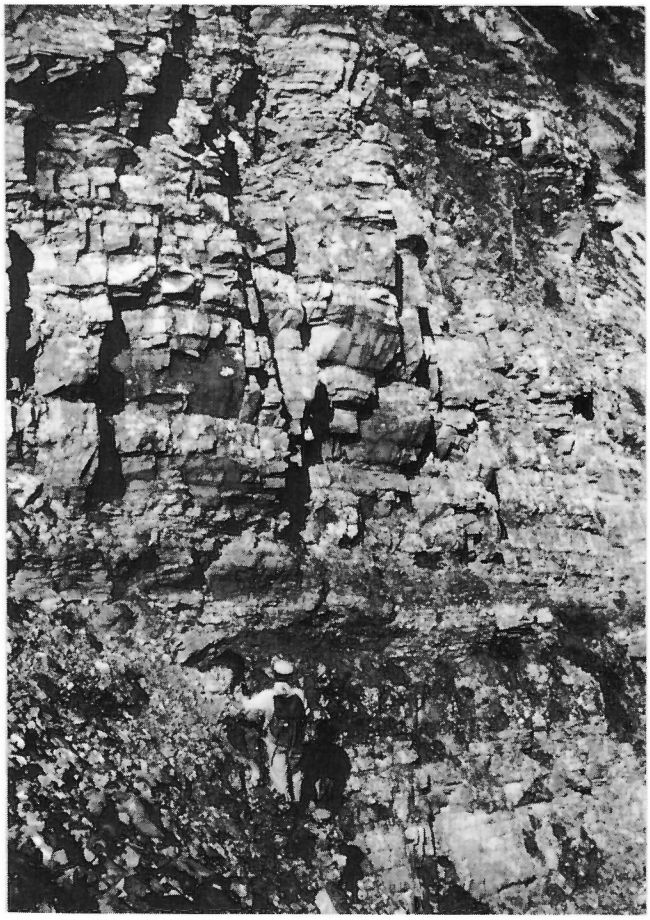


Plate 2A. Northeast face of Mount Kindle; repetitions within the rhythmic unit of the Franklin Mountain Fm. Macrodolomites are dark grey; microdolomites are pale grey. Figure (J.D. Aitken) gives scale. GSC 199078

Plate 2B. Complete rhythm within rhythmic unit of Franklin Mountain Fm. Hammer head indicates base of macrodolomite; overlying recessive microdolomite is pale grey. GSC 199077

a large part of the Parry Peninsula (Yorath, Balkwill and Klassen, 1969), and that farther south the formation outcrops over a broad arcuate band between the upper Horton River area (Cook and Aitken, 1969) and the Smith Arm-Hare Indian River area (Cook and Aitken, 1971b). In the northeastern Cordilleran Orogen, the formation is widespread in the Franklin Mountains and in the frontal Mackenzie Mountains at least as far to the northwest as Arctic Red River. Earlier and largely unpublished studies by geologists of Shell Canada Limited also had suggested that the Franklin Mountain (and Mount Kindle) could be recognized over a large area (Ziegler, 1967, 1969; Bassett and Stout, 1968). Thicknesses are variable over the entire area and are governed mainly by erosion related to unconformities beneath the overlying Mount Kindle Formation, Bear Rock or Gossage Formations, Cretaceous units, or the present Pleistocene and Holocene erosion surface.

Three mappable rock units are recognized readily in the Franklin Mountain Formation in outcrop, and commonly can be distinguished in the subsurface. In ascending order, these are the informal "cyclic", "rhythmic" and "cherty" units (Macqueen, 1970). A fourth unit assigned to the Franklin Mountain Formation, the "basal Franklin Mountain red beds" unit, outcrops only along the Mackenzie Arch in the eastern Mackenzie Mountains. It may be homotaxial with either the cyclic unit or the underlying Saline River Formation and is discussed fully in Aitken, Macqueen and Usher (1974). A "porous dolomite" unit (318 ft., 116 m, thick) recently has been recognized above the cherty unit in the Tenlen A-73 well (Fig. 1) by MacKenzie (1974b).

Data on the nature, distribution and thickness of the Franklin Mountain Formation in the lower Mackenzie River area have been provided by Tassonyi (1969), Gilbert (1974), Kunst (1974), Macqueen and MacKenzie (1973), MacKenzie (1974b), and Meijer-Drees (in press); and in the Great Slave Lake region by G.K. Williams (1974).

Cyclic unit

This is a distinctive succession consisting of several types of dolomite stratigraphically arranged in a repetitive order indicative of cyclic sedimentation and weathering to a pale yellowish orange colour. The unit ranges in thickness from about 150 to 450 feet (45 to 137 m). At the base, it is interbedded with red and green shale and mudstone characteristic of the upper part of the underlying Saline River Formation. The contact, which is gradational and conformable, is chosen arbitrarily at the top of the stratigraphically highest bed of red or green shale or mudstone which is 5 feet (1.5 m) or more in thickness (Aitken *et al.*, 1974). The lithic cycles are developed best in the Norman Range (*see* Macqueen, 1969, p. 240). Although the cycles are less distinct elsewhere, outcrops of the unit can be recognized easily over its entire area of development. No exposure of the cyclic unit occurs in the type section at Mount Kindle and the characteristic yellowish orange weathering smear which normally identifies this unit in areas of poor outcrop was not observed on a helicopter traverse along the Franklin Mountains near Mount Kindle. The unit is known to occur, however, in the subsurface nearby (Meijer-Drees, in press), and it seems probable that the cyclic unit is hidden by talus at the type section. Regionally, it is not present along or to the west of the Mackenzie Arch (Aitken *et al.*, 1974, p. 14).

Rhythmic unit

Overlying the cyclic unit conformably is the prominent and widespread rhythmic unit, which consists of strikingly rhythmic alternations of two types of dolomite. The thickness of the rhythmic unit in outcrop in the Mackenzie and Franklin Mountains of the Operation Norman area ranges from about 500 to 1,600 feet (≈150-490 m) except where it has been bevelled by pre-Devonian erosion (e.g. south end of MacKay Range). Surface and subsurface thicknesses in the Interior Platform and Mackenzie Trough are similar. The rhythms, so prominent in outcrop localities in the Franklin Mountains and frontal Mackenzie Mountains, are more difficult to recognize in the Interior Plains and generally are not apparent even in continuous core from the subsurface of this region (e.g. Macqueen and MacKenzie, 1973). Surface weathering apparently accentuates differences between the two types of dolomite. In southern Great Bear Plain, an area of sparse outcrop, the rhythmic unit apparently is absent over a large area, and the Mount Kindle Formation directly overlies the cyclic unit (Balkwill, 1971, p. 17).

The rhythmic unit is characterized by alternations of:

(a) finely to medium crystalline, brownish grey to light brown, commonly oolitic, locally quartzose dolomite (termed macrodolomite, following Illing *et al.*, 1967) or, rarely, oolitic or bioclastic grainstones and packstones[1], which are either overlain sharply by or grade upward into:

(b) very finely crystalline, greyish orange to brownish grey, silty dolomite (termed microdolomite, following Illing *et al.*, 1967) commonly with flat-pebble conglomerate at the top. This unit is distinctive in the field, because it normally exhibits a striped weathering character (e.g. Macqueen, 1970, Fig. 2, p. 228) that is evident particularly in the frontal Mackenzies, the Norman Range, at Mount St. Charles on the flanks of the McConnell Range, and in the type section at Mount Kindle (Pl. 1; Pl. 2A, B).

Observations at a number of localities in the Operation Norman area indicate that the average complete rhythm is about 9 feet (3 m) thick, although the known range is from 2 to 26 feet (0.5 to 8 m). From studies of this unit in the frontal Mackenzies, the macrodolomites (lower parts of the rhythms) average about 3 to 3.5 feet (1 m) thick and contain about 5 per cent insoluble residue that consists mainly of quartz as sand and minor silt. The microdolomites (upper parts of the rhythms) average about 5 to 5.5 feet (1.5-1.7 m) thick and have about 10 per cent insoluble residue that consists mainly of quartz in the silt and clay size ranges. The characteristics and distribution of the macrodolomites,

[1] Carbonate rock terms after Dunham (1962).

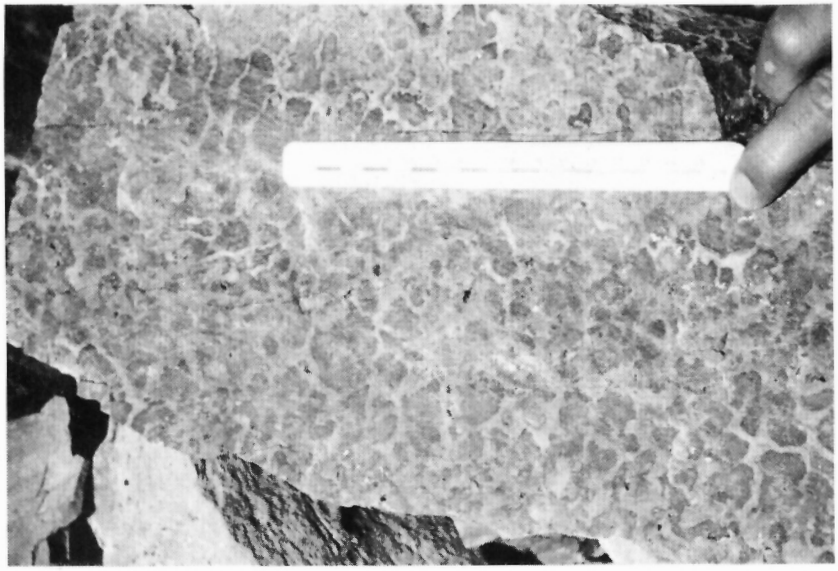


Plate 3.

Northeast face of Mount Kindle; linked and unlinked columnar algal stromatolites (LLH, SH) in the rhythmic unit of the Franklin Mountain Fm. GSC 199076

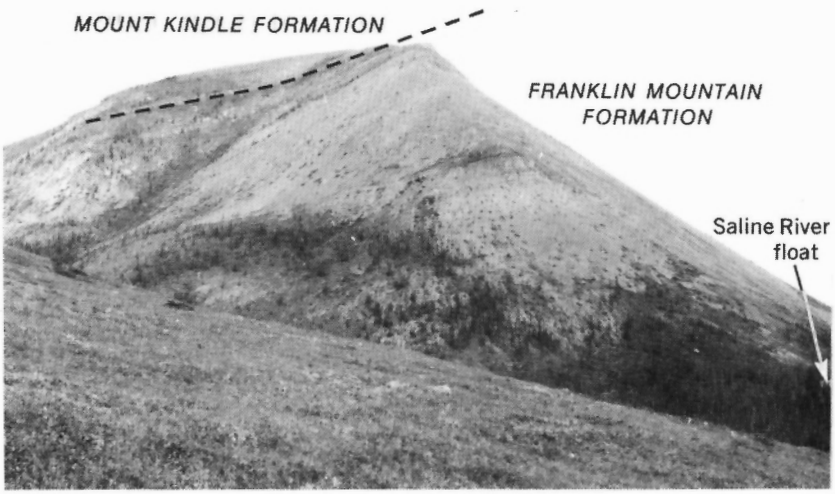


Plate 4A.

Mount Kindle from the southeast. Upper part of the mountain is formed by southwesterly dipping Mount Kindle Fm. and lower part of Franklin Mountain Fm. Float of Saline River Fm. is present, lower right. GSC 118912

Plate 4B.

Southeast part of crest of Mount Kindle. Figure (B.D. Corneil) stands on basal member of the Mount Kindle Fm.; the outcrop shown in Plates 5A, B is about 20 feet (6 m) to right of figure. GSC 118908

or equivalent oolitic or bioclastic grainstones and packstones, indicate that they represent sediments that accumulated in a shallow subtidal or intertidal regime, whereas the overlying microdolomites suggest an origin by penecontemporaneous dolomitization within the highest intertidal or supratidal regime, as is well known from several areas of Holocene carbonate sedimentation (Bathurst, 1971; and others).

A variety of well-developed stromatolites characterizes both the cyclic and, to a lesser extent, the rhythmic units in the northern Franklin and easternmost Mackenzie Mountains. Using the terminology developed by Logan, Rezak, and Ginsburg (1964), the commonest types appear to be spaced, laterally linked hemispheroids (LLH-S), and close laterally linked hemispheroids (LLH-C). Compound varieties also are present, including initial space-linked hemispheroids which commonly pass upward into discrete, vertically stacked hemispheroids (Pl. 3). These and other stromatolites appear to be best developed in a zone or belt which includes the frontal Mackenzie and the northern Franklin Mountains, and possibly trends in a northerly direction slightly oblique to the strike. The locus of such a belt is merely speculation at this time; however, to the east of the Franklin Mountains, the only features observed of possible algal origin consist of cryptalgal laminations (Aitken, 1967). The distinctive and reasonably abundant growth forms of the northern Franklin and easternmost Mackenzie Mountains apparently are missing.

An apparently minor unconformity possibly occurs between the rhythmic unit and the overlying cherty unit. The average thickness of individual rhythms is relatively constant over the area, but the rhythmic unit varies in thickness. Thus thicker sections of the rhythmic unit may have many more rhythms than thinner sections, indicating that thinner sections may have been bevelled by a pre-cherty unit unconformity. Faunal control at present is too sparse either to support or refute this suggestion and detailed tracing of beds has not been performed to determine whether or not individual rhythms are truncated at the contact.

In the Mackenzie Mountains between Keele and Gayna Rivers (Fig. 1), the rhythmic unit interval and, probably, the overlying cherty unit interval pass laterally to the west and southwest into a non-rhythmic unit composed dominantly of finely to medium crystalline dolomite not unlike that of the Mount Kindle Formation, except for its lighter brown colour. This change is thought to mark the passage of peritidal sediments to subtidal, open-marine sediments characteristic of a shallow-water carbonate platform. The zone of facies change, although not well known, also appears to trend in a northerly direction, slightly oblique to the present structural strike. In addition, it cuts across the Mackenzie Arch, such that at Arctic Red River (Fig. 1) along the Mackenzie Mountain front only the basal beds of the rhythmic unit are, in fact, rhythmic. The non-rhythmic sediments appear to be thoroughly dolomitized except close to the area of facies change to Road River shale; there, beds of argillaceous, micritic limestone appear (Aitken *et al.*, 1974).

Cherty unit

A distinctive, finely to coarsely crystalline, thick-bedded dolomite unit overlies the rhythmic unit in many parts of the Interior Plains and Franklin and eastern Mackenzie Mountains. The distinctive characteristics of this unit are the presence of white chert and drusy quartz, silicified oolites, and large silicified stromatolites (Pl. 5A, B) of the laterally linked or space-linked hemispheroid type (Logan *et al.*, 1964). The silicification is pervasive, and occurs in great abundance within this unit in the Horton River area and on Parry Peninsula of the northern Interior Plains, as well as in the subsurface of the Interior Plains (Tassonyi, 1969; Macqueen and MacKenzie, 1973). Because of the several overlying erosion surfaces that may have affected the unit, thicknesses are extremely variable, ranging from zero to about ?800 feet (0-?245 m) in surface exposures. In the Colville Hills area of the Interior Plains, however, the thickness of the cherty unit is more than 2,400 feet (>730 m) in the almost completely cored Mobil Colville E-15 well (Macqueen and MacKenzie, 1973), despite the fact that less than 1,000 feet (<305 m) of strata assignable to this unit were suspected from outcrop studies in the surrounding region. Silicification is common throughout the entire 2,400 foot (730 m) interval; silicified oolites occur at a number of levels (Macqueen and MacKenzie, 1973). In the Tenlen A-73 well, northwest of the Colville E-15 well, MacKenzie (1974b) has described a porous dolomite unit (381 ft., 116 m, thick) of the Franklin Mountain Formation that overlies a thinner (1,120 ft., 341 m) development of the cherty unit.

In the Franklin and Mackenzie Mountains, the amount of silica is significantly less, although silicified stromatolites and oolites are recognizable along the Mackenzie Mountain front as far west as Arctic Red River, where 800 feet (244 m) of strata are assigned to the unit.

Within the interior ranges of the Mackenzie Mountains, two lithologic changes have the effect of unifying the character of the Franklin Mountain Formation such that the rhythmic and cherty unit divisions are no longer recognizable. The changes are the loss of silica from within the cherty unit interval, coupled with the disappearance westward and southwestward of the striking dolomite rhythms of the rhythmic unit interval, as noted above.

TYPE SECTION

Field character

Scattered, laterally discontinuous exposures characterize the type section of the Franklin Mountain Formation on the northeast spur of Mount Kindle (Pl. 1; Pl. 2A, B; Pl. 4A). The measured section is necessarily composite (Appendix I). Nevertheless, both the cherty and rhythmic units are clearly evident within the section. Douglas and Norris (1963, p. 11) indicated a thickness of 1,265 feet (386 m) for the type Franklin Mountain but, in the present study, only 917 feet (280 m) of Franklin Mountain strata were measured at the type section, excluding

Plate 5A.

Disconformable contact between dolomites of basal member of the Mount Kindle Fm., and silicified stromatolitic dolomites of the cherty unit of the Franklin Mountain Fm. GSC 118910

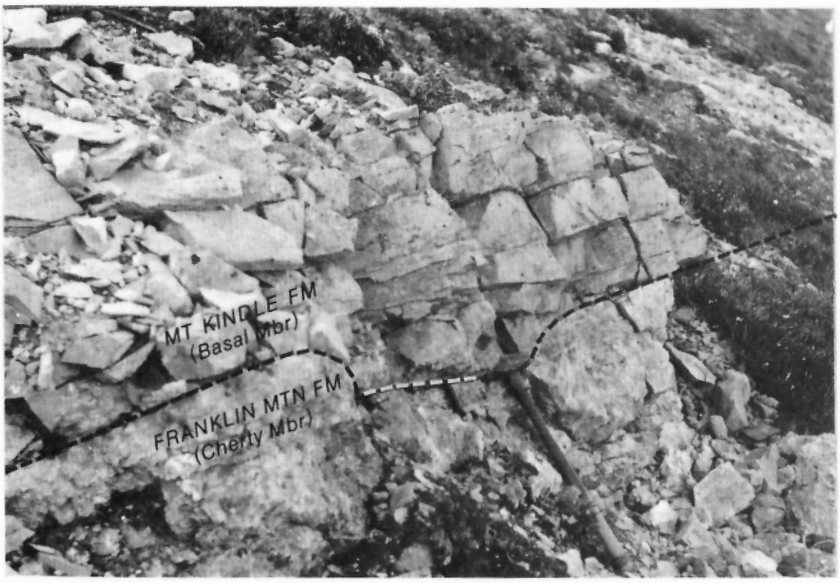


Plate 5B.

Same as Plate 5A. GSC 118911

a covered interval of over 100 feet (>31 m) between the base of the first reasonable exposure of the Franklin Mountain and the underlying gypsiferous rubble of the Saline River Formation. The bulk of this covered interval could represent the Franklin Mountain Formation, and probably includes a development of the cyclic unit.

The contact between the cherty unit of the Franklin Mountain Formation and the overlying Mount Kindle Formation is sharp and disconformable; approximately 6 inches (15 cm) of local relief are evident between silicified stromatolites, which occur at the top of the Franklin Mountain, and overlying microcrystalline to very finely crystalline, greenish grey, silty and recessive dolomite of the basal part of the Mount Kindle Formation (Pl. 5A, B). In addition, small angular fragments of milky white chert are present in at least the basal two feet (0.6 m) of the Mount Kindle Formation. These fragments undoubtedly are derived from the underlying Franklin Mountain cherty unit.

Rhythmic unit

At least 872 feet (266 m) of strata are assigned to the rhythmic unit at the type section. Exposures of the unit, although discontinuous, exhibit the striped weathering aspect (Pl. 1; Pl. 2A, B) characteristic of the unit to the north. On close inspection, the banding is seen to result from the interbedding of microcrystalline to generally very finely crystalline, yellowish brown weathering, silty dolomite (microdolomite), and finely to medium crystalline, greyish brown or greyish red dolomite (macrodolomite), commonly quartzose and rarely with dolomitized or silicified oolites. The quality of exposures is inadequate for precise delineation of individual, laterally persistent rhythms throughout the unit, but observations made on individual outcrops indicate that the rhythms resemble closely those developed to the north in the Norman Range of the Franklin Mountains and in the frontal Mackenzie Mountains, as discussed above and by Macqueen (1970). In thickness, the rhythms of the type section appear to average about 8 feet (2.5 m) with the

basal macrodolomite occupying about 3 feet (1 m) and the overlying microdolomite about 5 feet (1.5 m). Like the rhythms of the Operation Norman area, there is considerable variation in thickness. Oolites are present within some macrodolomite, in association with clastic quartz; some oolites have quartz cores.

Semiquantative X-ray diffraction analyses (Appendix 5) indicate that clastic feldspar also is a minor constituent in samples in which quartz is abundant. Quartz and ?potash feldspar are predominantly of fine sand size (range: silt to medium sand) in the macrodolomite. The few Franklin Mountain microdolomite samples analyzed contain about 4 to 40 per cent quartz and feldspar by semiquantitative analysis, but these constituents are predominantly in the silt-size grade in these rocks. Clay minerals are minor in both rock types, ranging from a trace to a few per cent. Both types of dolomite within the Franklin Mountain at the type section are virtually non-calcareous, as confirmed by the absence of calcite peaks in the X-ray diffraction analyses.

The six carbon analyses completed on samples from the rhythmic unit of the type Franklin Mountain are uniformly low, ranging from 0.39 to 0.51 per cent organic carbon. This is in contrast to values of organic carbon reported by MacKenzie (1974b) from analyses made on core samples from the formation in the CDR Tenlen A-73 well (*see* Fig. 1 for location), where fifty determinations from the rhythmic unit indicate an average organic carbon content of about 1.5 per cent. Franklin Mountain samples from this well are light to dark brown or grey in colour, in contrast to the uniform light to medium yellowish brown, greyish brown, or greyish red colours characteristic of surface exposures of the rhythmic unit. Whether or not surface weathering has removed organic material from the rhythmic unit is unknown.

Red iron-staining is found at a number of levels in the lower part of the rhythmic unit. The staining, which is partly hematite and, probably, hydrous iron oxides ("limonite"), is confined to zones approximately 2 to 5 feet (0.5-1.5 m) in stratigraphic thickness. Analyzed samples show a range in hematite from a trace to 4 per cent (Appendix 5), the maximum value being from a brick-red sample. The staining is present in both macrodolomite and microdolomite, but seems most common in macrodolomite. This compares with staining within the rhythmic unit along the Mackenzie Mountain front in the vicinity of Keele River, where ochrous to red staining is widely developed in the oolitic macrodolomite parts of the rhythms and enhances the colour contrast between the two types of dolomite that constitute the rhythms. At the type section, the staining is clearly secondary and probably is related to oxidation of iron in porous and permeable zones through which formation waters or groundwaters have passed. The red microdolomite tends to part along laminations, thus resembling poorly fissile shale. Some of these red zones may represent rocks which were described by Williams (1922, 1923, 1963) as "red shales". Although the non-carbonate content of the hematitic red-weathering dolomite ranges from 27 to 40 per cent (quartz, feldspar, clay minerals; *see* Appendix 5), silt- and clay-size clastic material is very minor.

The lowest exposed beds of the Franklin Mountain Formation clearly are part of the rhythmic unit. Gypsiferous shale and mudstone of the Saline River Formation occur as rubble associated with sink holes at the base of the section, more than 100 feet (30 m) below the lowest rhythmic beds exposed. The Franklin Mountain-Saline River contact is gradational and conformable to the north (Aitken *et al.*, 1974), but the nature of the contact is unknown at the type section, as is the presence or absence of the cyclic unit.

Despite many similarities, there are minor differences between the rhythms developed at the type section and those of the Franklins and frontal Mackenzies to the north. At the type section, fine- to medium-grained clastic quartz and minor feldspar in macrodolomite appear to be more abundant than at localities in the northern Franklins. The source normally suggested for clastic quartz and feldspar is the crystalline Precambrian Shield to the east. The high degree of rounding exhibited by the quartz suggests, however, that it is polycyclic, and that it could have been derived from a westerly or northwesterly source; ?Helikian Katherine Group quartzite or Lower Cambrian quartzite of the Backbone Ranges Formation exposed along Mackenzie Arch (Aitken *et al.*, 1974). Both units are bevelled along the Mackenzie Arch, which is located to the northwest, along the frontal Mackenzies between Keele River and Arctic Red River in the Operation Norman area; it probably continues in the frontal Mackenzies into the area west of Mount Kindle. In the Operation Norman area, the Franklin Mountain Formation is known to be the oldest unit to cross the Mackenzie Arch; in fact, the arch can be defined by the area in which the Franklin Mountain lies directly on the Katherine Group. In that area, the lower part of Franklin Mountain Formation contains abundant clastic quartz probably derived from the Katherine Group. Alternatively, a local easterly source could have been provided by the Bulmer Lake Arch (Meijer-Drees, 1974), located in the subsurface of the Bulmer Lake-Keller Lake-Willow Lake area (NTS 85L, 95I, 95P) to the east of the Franklins. There, the rhythmic unit is in contact with ?Helikian sediments, dominantly composed of shale but with minor amounts of fine- and medium-grained quartz arenite (Meijer-Drees, in press; *see* also Douglas and Norris, 1963; Aitken *et al.*, 1974).

Stromatolites apparently are less common in the rhythmic unit of the type section than in rhythmic unit rocks of the northern Franklins and easternmost Mackenzies. If stromatolites are developed best within a northward-trending belt or zone including the northern Franklins and easternmost Mackenzies as suggested above, it is likely that the type section is located to the east of this belt. Too little information is available at present on this point to justify further speculation.

Cherty unit

Only 45 feet (14 m) of strata are assigned to the cherty unit at the type section (Appendix 1). The unit is made up of microcrystalline to finely crystalline, olive-grey silty dolomite, with silicified stromatolites in beds 2 to 3 feet (1 m) thick

occurring at two levels, including the bed immediately below the Mount Kindle-Franklin Mountain contact (Pl. 5A, B). The unit is thick bedded and moderately well exposed, and lacks the characteristic banding so typical of the underlying rhythmic unit. Cherty unit dolomite at the type section apparently also contains appreciably more quartz silt and fine-grained sand than normally is found in exposures of this unit to the north in the Operation Norman area. The source in this case may have been the upper part of the rhythmic unit: as noted above, on a regional scale the cherty unit probably lies disconformably on the underlying rhythmic unit. Nowhere is the cherty unit known to rest directly on ?Helikian or Lower Cambrian quartzites over positive features such as the Mackenzie Arch or Bulmer Lake Arch. Alternatively, crystalline rocks of the Precambrian Shield may have been the source.

A careful search over the rubbly exposures of the type section failed to locate any silicifed oolites, although these characterize this unit over a large part of the Interior Plains of the lower Mackenzie River area including the subsurface as described above. The contact between the cherty and underlying rhythmic units is a bedding plane; evidence of unconformity or erosion is lacking.

AGE AND CORRELATION

Other than stromatolites, no fossils were found in the Franklin Mountain Formation at the type section. The basal beds of the overlying Mount Kindle Formation are recessive and slightly argillaceous, and contain corals and brachiopods. These rocks were included in the Franklin Mountain Formation and were dated as Silurian by Williams (1923, p. 78B; 1963, p. 233-235), but are considered Late Ordovician in the present paper.

To the north, a number of diagnostic fossil collections have been made from the Franklin Mountain Formation (Appendix 4). At several localities along the Mackenzie Mountain front in the vicinity of Arctic Red River and in the Canyon Ranges, the brachiopod *Billingsella* and a distinctive echinoderm ossicle of probable Franconian age have been found in an interval assigned to or equivalent to part of the rhythmic unit, about 200 to 700 feet (60-215 m) above the base of the Franklin Mountain Formation. Early Ordovician graptolites are present about 450 feet (137 m) higher in the Canyon Ranges. To the southeast, in the frontal Mackenzies along lower Keele River, strata at the base of the rhythmic unit yielded four trilobite genera that indicate the *Cedaria-Crepicephalus* Zone (Upper Cambrian, Dresbachian). The position of the Cambrian-Ordovician boundary is not known; it may lie within the rhythmic unit, or between the rhythmic and the overlying cherty units.

Three significant collections of Early Ordovician gastropods have been made from the cherty unit: on the Horton River, at the Mackenzie Mountain front on Imperial River, and on the north flank of the Franklin Mountains near Norman Wells. The Early Ordovician brachiopod *Nanorthis* cf. *N. multicostata* Ulrich and Cooper has been identified from the cherty unit near Arctic Red River, and Early Ordovician conodonts have been identified from the cherty unit of the Brackett Lake C-21 well.

The cyclic unit has not yielded any diagnostic faunal collections, and no fossils are known that are indisputably from the underlying Saline River Formation. To the north, Aitken *et al.* (1974) have shown that the Saline River Formation is completely gradational to the overlying Franklin Mountain Formation and sharply overlies the well-dated Lower and Middle Cambrian Mount Cap Formation, indicating that the Saline River either is entirely Upper Cambrian, or is uppermost Middle and Upper Cambrian. Thus, the overlying cyclic unit of the Franklin Mountain can be considered Upper Cambrian.

MOUNT KINDLE FORMATION

REGIONAL DISTRIBUTION AND LITHOLOGY

The Mount Kindle Formation is widespread in the northern Franklin and eastern Mackenzie Mountains, except where removed by pre-Devonian and later erosion. In the Interior Plains, the Mount Kindle outcrops near Great Slave Lake (G.K. Williams, 1974) and in the Hare Indian River-Smith Arm area (Cook and Aitken, 1971b); elsewhere it may occur as small isolated erosional remnants (e.g. Simpson Lake and Brock River map-areas, 97B, 97D; *see* Balkwill and Yorath, 1970a, b). Distribution of the formation in the Interior Plains is affected to a considerable extent by erosion associated with the sub-Bear Rock or sub-Gossage unconformity and with the sub-Cretaceous unconformity.

In the Operation Norman area (Fig. 2), the formation consists of a monotonous succession of medium to dark brownish grey, finely to medium crystalling dolomite containing abundant chert and, in the lower part, silicified halysitid, favositid and solitary corals and orthoconic cephalopods. Facies changes appear to be minimal within the Operation Norman area. Throughout the area of outcrop of the Mount Kindle, the thickness is variable and appears to be related largely to the various erosion surfaces overlying the formation. The Mount Kindle Formation, generally, is thinnest (or absent) in the northern Franklin Mountains and along the Mackenzie Mountain front, and thickest in the southern and southwestern part of the Operation Norman area, in the Mackenzie Mountains.

TYPE SECTION

The Mount Kindle Formation can be divided into three informal members at the type section. The basal member, 68 feet (21 m) thick, consists of recessive beds below a middle, resistant member, 212 feet (65 m) thick, that forms the upper cliffs and summit of Mount Kindle. The upper member, about 615 feet (187 m) thick, is less thickly bedded and lacks the abundance of biostromal material that is present in the resistant member.

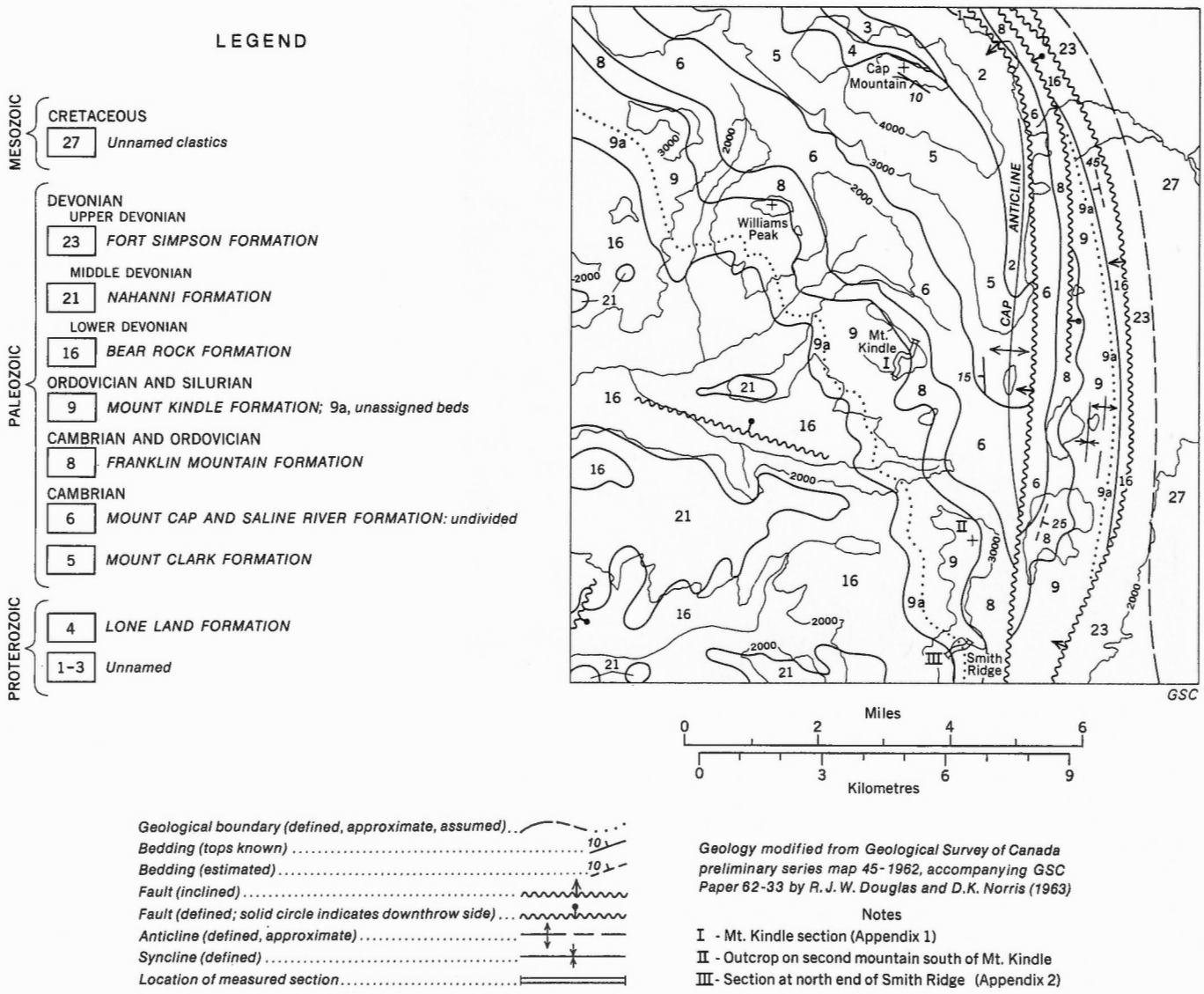


Figure 5. Geological sketch map in the vicinity of Mount Kindle, McConnell Range, Franklin Mountains

Ten X-ray diffraction and nine carbon analyses carried out on selected samples from the type Mount Kindle indicate that the unit is largely dolomite, and is low in organic carbon (Appendix 5). The nine carbon analyses range from 0.32 to 0.77 per cent organic carbon. For comparison, 16 samples from the Mount Kindle in the subsurface of CDR Tenlen A-73 well from the Interior Plains showed wide-ranging values from 0.19 to 1.81 per cent organic carbon, with averages approaching 1 per cent [MacKenzie, 1974; Mount Kindle interval is 787 feet (240 m) in thickness, depths 3,830 to 4,617 feet (1167-1,407 m) MacKenzie, pers. com., 1974]. The subsurface samples show no obvious correlation between colour and organic carbon content.

Three adjacent localities in the vicinity of the type section are critical to the interpretation of the limits of the Mount Kindle Formation. These are Mount Kindle itself (I of Fig. 5 and of Williams, 1963; Pl. 4A, B) that contains the type sections of both the Mount Kindle Formation and the underlying Franklin Mountain Formation; the second mountain south of Mount Kindle (II of Fig. 5 and of Williams, 1963; Pl. 6; Pl. 7A); and the north end of Smith Ridge (III of Fig. 5; Pl. 7A, B; Pl. 8; Douglas and Norris, 1963, p. 12).

Mount Kindle gives reasonable exposures of the Mount Kindle Formation at the summit (Pl. 4A) and in the cliffs at the northeast face of the mountain, but only discontinuous outcrops on the back slope. The stratigraphically highest outcrops are on the southwest ridge of the mountain that ends in a stripped dip-slope. The Devonian Bear Rock Formation outcrops west of Mount Kindle but the formation is not present on the mountain itself and no upper limit to the Mount Kindle Formation can be determined. Most of the stratigraphically and topographically lower outcrops on the face of the mountain are of colourful dolomite of the poorly exposed Franklin Mountain Formation (Pl. 1; Pl. 2A, B). Rocks unequi-

Plate 6.

Second mountain south of Mount Kindle; east side of south ridge. Figure (B.S. Norford) indicates contact between resistent member and the basal member of the Mount Kindle Fm. This outcrop may be the locality from which Williams collected brachiopods reported as from the Franklin Mountain Fm. GSC 118916

vocally representative of the two formations are separated by a recessive interval of argillaceous dolomite that is 68 feet (21 m) thick (Units 11-13 of measured section in Appendix 1; Pl. 4B; Pl. 5A, B) but was not described by Williams (1922, 1923, 1963). The top of this recessive interval is not abrupt at Mount Kindle and is marked primarily by the change in weathering profile and by the lack of argillaceous rocks in the beds immediately above. In the original (1922) description of the Mount Kindle Formation and in subsequent studies by Williams (1923, 1963), the top of this recessive interval, which essentially is the base of the resistant grey dolomite, apparently was identified as the base of the Mount Kindle Formation. Williams's selection of the base of the Mount Kindle Formation placed the recessive beds in the uppermost Franklin Mountain Formation. The base of the recessive interval is marked by a shallow erosion surface (Pl. 5A, B) beneath dolomite beds that contain fragments of chert nodules and an appreciable content of quartz silt. This surface is a significant disconformity that separates the basal, argillaceous dolomite of the Mount Kindle from an underlying, stromatolitic chert bed that is part of the Franklin Mountain cherty unit. The accompanying change in weathering colour from predominantly yellowish brown below the contact to shades of grey above can be mapped readily from a distance. Therefore, the recessive interval is placed within the Mount Kindle Formation; such placement is consistent with regional observations made by Macqueen (1969, 1970), Cook and Aitken (1971a, b), and others working farther to the north.

Basal beds

The recessive interval is regarded as a basal member of the Mount Kindle Formation. Discontinuous outcrops within this interval consist of argillaceous grey-weathering dolomite which weathers flaggy, nodular, and rubbly. The single X-ray diffraction analysis of a sample from this interval (Appendix 5) confirms the presence of quartz, feldspar, and minor amounts of clay minerals, totalling 18 per cent by semiquantitative analysis. Weathering colours are light grey, light olive-grey, and yellowish grey. Corals, brachiopods, gastropods, and echinoderm debris are present but not abundant.

At the second mountain south of Mount Kindle (Fig. 5), about 40 feet (12 m) of strata outcrop approximately 200 feet (61 m) below the ridge crest on the southeast side of the mountain and correspond to the uppermost recessive beds (basal member) and the overlying cliff (lower part of the middle member) of the Mount Kindle Formation at Mount Kindle. The top of the recessive member (Pl. 6) can be recognized readily; the base is covered. Corals are common in the lowermost beds of the resistant member, and corals and brachiopods are present but rare in dolomite of the underlying recessive member (Appendix 3). This outcrop is almost certainly the locality from which Williams (1923, 1963) collected the only fossils that he found in his Franklin Mountain Formation, picking the top of the recessive member as the top of the formation. All the beds at this outcrop can be assigned to the Mount Kindle Formation, and thus Williams's Franklin Mountain fossils are included in the fauna of the basal recessive member of the Mount Kindle Formation.

In the subsurface, the basal member, consisting of argillaceous and silty dolomite and dolomitic shale (Meijer-Drees, 1974 and in press), can be traced over a considerable area; to the south, in the Cli Lake M-05 well, quartz sand is common in this interval.

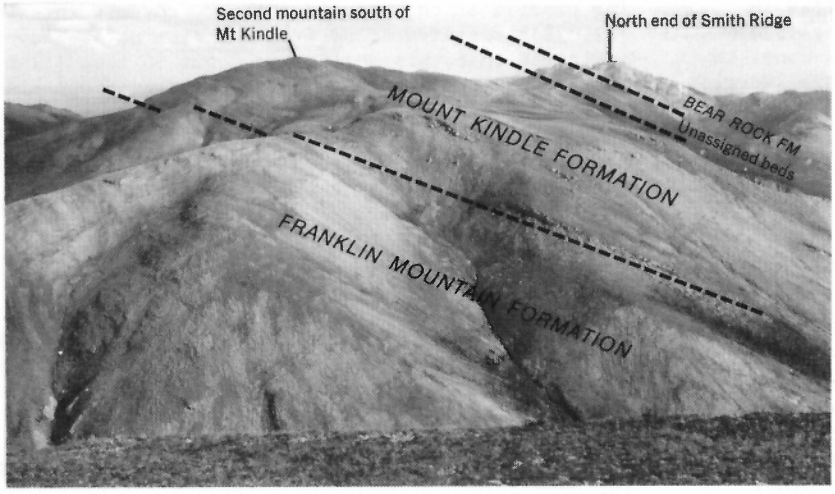


Plate 7A.

View south from Mount Kindle showing succession from Franklin Mountain Fm. to Bear Rock Fm. Region in top right is shown also by Plate 7B. GSC 118906

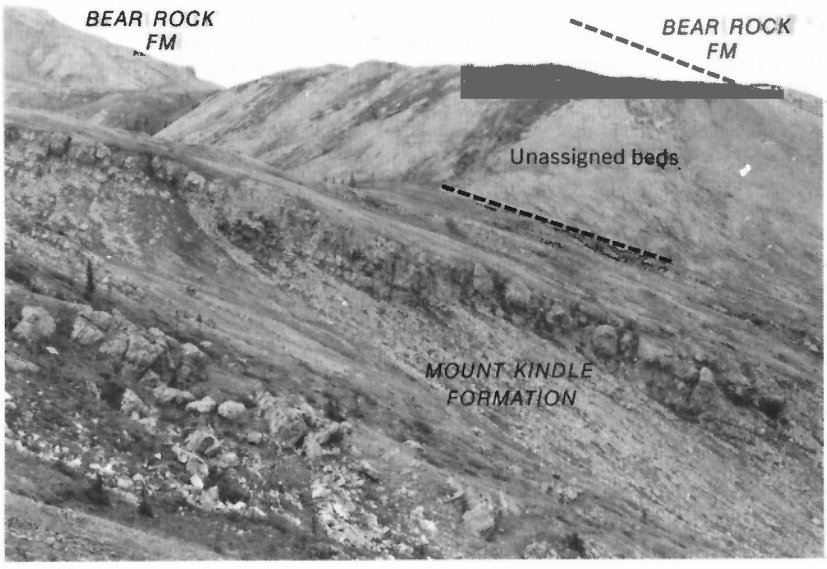


Plate 7B.

View of upper part of section at north end of Smith Ridge. GSC 118914

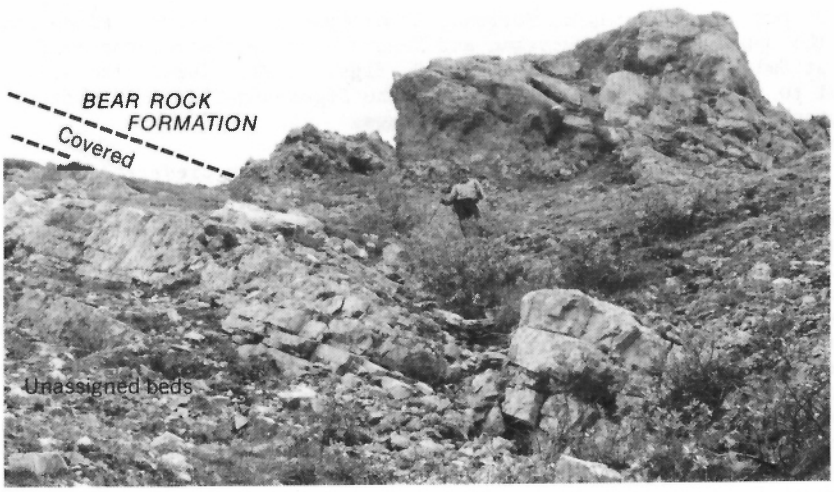


Plate 8.

Section at north end of Smith Ridge. Figure (B.D. Corneil) stands at a covered interval between the Bear Rock Fm. and the unit of unassigned beds that overlies the Mount Kindle Fm. GSC 118915

The basal member also can be recognized in outcrop at Great Slave Lake (G.K. Williams, 1974) where it is about 32 feet (10 m) thick and consists of argillaceous dolomite, mudstone and shale (Norris, 1965, p. 108, 109).

Middle part

The middle, resistant member of the Mount Kindle is 212 feet (65 m) thick at the type section, and consists of thin- to thick-bedded, brownish grey weathering dolomite, generally finely to medium crystalline, and in part sucrosic and showing fair to good intercrystalline and vuggy porosity. Colonial and solitary corals are common in the lower part; many appear to be in growth position. Textures in the dolomite indicate that at least part of the interval was originally a lime-grainstone or lime-packstone made up largely of echinoderm or other skeletal debris in a variably micritic matrix. Small dark grey chert nodules are present at a few levels. Four samples analyzed from the middle member indicate that the unit is almost wholly carbonate, that values of organic carbon are low, and that there is no obvious correlation between rock colour (medium or dark grey) and organic carbon content (Appendix 5).

Upper part

A minimum thickness of 579 feet (176 m) of recessive and yellowish brown weathering, microcrystalline to medium crystalline dolomite make up the upper informal member in the type area. The upper member is less thickly bedded and lacks the abundance of biostromal material that is present in the middle, resistant member. In many of the coarser dolomite units, granular textures indicate derivation from original lime-grainstone or lime-packstone. Local small vugs lined with drusy calcite may represent leached fossils. Colonial and solitary corals, stromatoporoids and pentamerid brachiopods are found in the lower part of this unit, but most fossils are poorly preserved. Carbon and X-ray analyses of selected samples from this interval (Appendix 5) indicate that the rocks are very pure dolomites, lacking in calcite, with only one sample (described as argillaceous in the field) approaching 20 per cent in quartz and clay mineral content. The uppermost beds of the member are best examined at Smith Ridge, which is the third locality critical to the determination of the character and stratigraphic limits of the Mount Kindle Formation in the type area.

Strata exposed on the north end of Smith Ridge (Pl. 7A, B; Pl. 8) apparently were not studied by Williams (1922, 1923). The quality of outcrop there is poor, but the locality does allow measurement of the stratigraphic interval between the base of the Bear Rock Formation and a distinctive level within the upper member of the Mount Kindle Formation. This level is the top of a group of dolomite beds that contains abundant, poorly preserved pentamerid brachiopods, and which can be recognized on the back slope of Mount Kindle within the type section of the formation. At Smith Ridge, a top to the Mount Kindle Formation can be selected at a break in weathering profile at the base of a thick, covered interval (Pl. 7B); measurement up from the distinctive level indicates that this horizon is about 36 feet (11 m) higher than the uppermost bed exposed at Mount Kindle. This figure is within the limits of accuracy of measurement of the two sections and the top bed at Smith Ridge could be the same bed as the uppermost bed exposed on the dip-slope on the southeast ridge of Mount Kindle.

Strata of questionable assignment

An interval of about 450 feet (135 m) separates the Mount Kindle Formation from the Bear Rock Formation at the north end of Smith Ridge. Within this interval, only 139 feet (42 m) of strata outcrop (Unit 5 of measured section, Appendix 2; Pl. 7B). These rocks seem to be lithologically distinct from the underlying rocks of the Mount Kindle Formation and could be equivalent to the recessive upper part of the Whittaker Formation in the Mackenzie Mountains to the southwest (Douglas and Norris, 1961, p. 7, 10) or to the Delorme Formation (Upper Silurian and Lower Devonian) that overlies the Whittaker and Mount Kindle Formations in much of the Mackenzie Mountains. In parts of the Mackenzie Mountains, an unconformity can be mapped beneath the Delorme Formation (Bassett and Stout, 1968), which rests locally on Precambrian rocks (Aitken and Cook, in press, p. 13).

AGE AND CORRELATION

In the type area, the basal member, 68 feet (21 m) thick, of the Mount Kindle Formation contains species of *Bighornia, Lobocorallium, Palaeophyllum, Calapoecia, Catenipora, Favosites,* as well as *Austinella?, Diceromyonia, Hesperorthis, Plaesiomys, Rhynchotrema, Thaerodonta,* and other brachiopods (Appendices 1 and 3; Pl. 9, figs. 10-17). These species are part of the *Bighornia-Thaerodonta* fauna of Late Ordovician age (Norford, 1969).

The resistant middle member, 212 feet (65 m) thick, is abundantly fossiliferous and includes species of *Bighornia, Deiracorallium, Lobocorallium, Favistina, Palaeophyllum, Calapoecia, Catenipora, Coccoseris, Palaeofavosites, Parafavosites?, Sarcinula, Tollina; Diceromyonia, Oepikina?, Plaesiomys, Rhynchotrema* and *Thaerodonta*; and stromatoporoids (Appendix 1, Pl. 9, figs. 7, 9). These also are representatives of the *Bighornia-Thaerodonta* fauna of Late Ordovician age.

Fossils are rare and poorly preserved in the upper member which is 579 feet (176 m) thick (Appendices 1 and 2). *Favosites, Eophacops?, Alispira, Idiospira?,* and a probable pentamerid brachiopod are found in the basal beds; these are Silurian and probably Early or Middle Llandovery in age but associated conodonts are dated by Uyeno as late Late Llandovery (Late Telychian) to early Wenlock. Slightly higher, *Virgiana* (Pl. 9, figs. 1-6, 8) indicates a Middle Llandovery age at 96 to 98 feet (29-30 m) above the base of the member. One hundred feet (30 m) higher, *Cystihalysites, Favosites* and *Pentamerus?* are present and probably are Late Llandovery in age.

The uppermost 400 feet (122 m) of the formation virtually are barren but could be younger than Llandovery. In the type section, the Mount Kindle Formation thus ranges in age from Late Ordovician to Early Silurian (Llandovery) and possibly higher.

Regionally, the Late Ordovician fauna is well developed throughout the area of development of the Mount Kindle Formation and a few collections can be dated as Llandovery (Macqueen, 1970; Norford, 1964, 1972, 1973, in press). No collections from the Mount Kindle have been dated as younger than Llandovery, but fossils are sparse and poorly preserved in the upper part of the formation.

In the Dahadinni River and Wrigley map-areas (NTS 95N, 95-O), the name Mount Kindle was applied by Douglas and Norris (1963) only to rocks within the Franklin Mountains. To the west, in the Mackenzie Mountains, strata in part equivalent to the Mount Kindle but considerably thicker (over 3,000 feet, 915 m) were referred to the Whittaker Formation, the type section of which is in the Root River map-area south-southwest of Wrigley (Douglas and Norris, 1961). In the Redstone Range in the Dahadinni River map-area (95N), the Whittaker was divided into three parts (Douglas and Norris, 1963, p. 12). The lithology of the middle part of the Whittaker, more than 2,060 feet (630 m) thick, along with the presence of Late Ordovician and Early Silurian fossils in this unit, indicates that strata correlative with the Mount Kindle make up at least the middle part of the Whittaker. The Whittaker Formation is distributed widely in the Flat River, Glacier Lake, and Wrigley Lake map-areas (NTS 95E, 95L, 95M) of the Mackenzie Mountains (Gabrielse *et al.*, 1973) where a regional unconformity can be mapped beneath the formation. Except for local, probably Middle Ordovician beds, the Whittaker is Upper Ordovician and Silurian and, like the Mount Kindle, is composed dominantly of resistant dolomite. At the north end of the Thundercloud Range in the Wrigley Lake map-area (95M), the Whittaker is similar to the Mount Kindle Formation of the type section near Wrigley. The Whittaker is 1,369 feet (417 m) thick at the Thundercloud Range locality, and rests directly on the Little Dal Formation of Proterozoic age (Gabrielse *et al.*, 1963, Part II, p. 202-209, Sec. 37). The basal 30 feet (9 m) consist of an interval of recessive, thinly bedded limestone, which is overlain by thickly bedded, resistant dolomite and limestone. Late Ordovician (*Bighornia-Thaerodonta* fauna) fossils are common in the basal 287 feet (87 m); the lowest Silurian fossils found were about 264 feet (80 m) higher. Stromatoporoids are the only common fossils in the upper 598 feet (182 m) of the Whittaker and these are poorly preserved. Faunas younger than Llandovery have not been reported from the Whittaker Formation of the Mackenzie Mountains[1]. The Whittaker is overlain by the less resistant Delorme Formation of Silurian and Devonian ages (Douglas and Norris, 1961; Gabrielse *et al.*, 1973.

ECONOMIC GEOLOGY

OIL AND GAS

The stratigraphic interval comprising the Franklin Mountain and Mount Kindle Formations and their basinal equivalent to the west, the Road River Formation, includes both potential source rocks and potential reservoir rocks. The Road River Formation, whose age ranges from Middle Cambrian (Aitken *et al.*, 1974) to at least Early Devonian (Norford, 1964), is a thick succession of dark grey to black, pyritic, argillaceous limestone and calcareous to non-calcareous shale. The Ordovician to Devonian portion is, in part, of "starved basin" aspect and the laterally equivalent Franklin Mountain and Mount Kindle platform carbonates could be reservoirs for hydrocarbons generated by burial of Road River Formation shale. Unfortunately, the subsequent history of these platform carbonates has been punctuated by several periods of severe erosion as noted previously.

Dolomite of the Mount Kindle Formation would appear to have the greatest reservoir potential. Significant intercrystalline and vuggy porosity is evident in surface Mount Kindle exposures, including those of the type section. Pre-Devonian structural activity is known in the lower Mackenzie region, and probably consisted of faulting with attendant local tilting, possibly producing structural traps within the Mount Kindle. Such traps would require a suitable seal, such as anhydrite beds of the Devonian Bear Rock Formation, argillaceous rocks of the Delorme Formation, or Cretaceous shale. Possible stratigraphic traps would be of two types: those related to the updip wedge-out of the Mount Kindle beneath an unconformity overlain by impermeable rocks able to create a seal, and depositional or compactional draping over Precambrian basement highs such as the Bulmer Arch described by Meijer-Drees (1974) for the Bulmer Lake area (NTS 95I).

[1] Recently Lenx (1974, Can. J. Earth Sci., v. 11, p. 1123-1135) has suggested late Wenlock or early Ludlow age for brachiopods from high in the Whittaker Formation but the correlations are not conclusive.

PLATE 9

UPPER ORDOVICIAN AND LOWER SILURIAN FOSSILS
FROM THE MOUNT KINDLE FORMATION

Figures 1-6, 8. *Virgiana* sp. from the upper member (GSC loc. 69803), 376-378 feet above the base of the Mount Kindle Formation in its type section. 1-3, side, front and rear view of a pedicle valve (GSC 40945); 4, 5, front and side views of another pedicle valve (GSC 40946); 6, 8, brachial views of two brachial valves (GSC 40947 and 40948); all x2.

Figure 7. *Coccoseris astomata* Flower from the resistant member (GSC loc. 69793), 158-165 feet above the base of the Mount Kindle Formation in its type section; longitudinal section of a corallum (GSC 40949); x2.

Figures 9, 10. *Bighornia* sp. 9, transverse section (reflected light) of a corallum (GSC 40950) from the resistant member (GSC loc. 69794), 174-175 feet above the base of the Mount Kindle Formation in its type section; x2. 10, transverse section (reflected light) of a corallum (GSC 40951) from the basal member (GSC loc. 69806), 4-7 feet below its top, second mountain south of Mount Kindle; x2.

Figures 11-14. *Thaerodonta* cf. *T. recedens* (Sardeson). 11, internal view of brachial valve (GSC 40952) from the basal member (GSC loc. 69806, locality data as for Fig. 10); x2. 12-14, pedicle, brachial and rear views of an individual (GSC 40953) from the same locality; x2, x2, x4.

Figures 15, 16. *Hesperorthis* sp. Internal and external views of a fragmentary large brachial valve (GSC 40954) from the basal member (GSC loc. 69806, locality data as for Fig. 10); x2.

Figure 17. *Lobocorallium* cf. *L. trilobatum major* Nelson. Transverse section (transmitted light) of a corallum (GSC 40955) from the basal member (GSC loc. 69806, locality data as for Fig. 10); x2. Corallites of a corallum of *Palaeophyllum* adhere to the specimen.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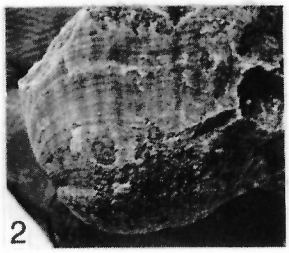
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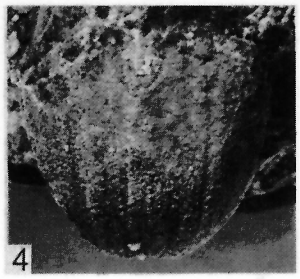
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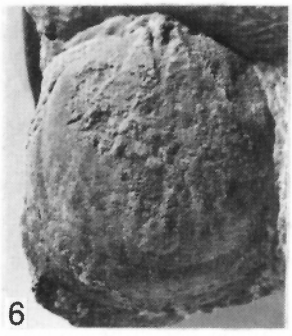
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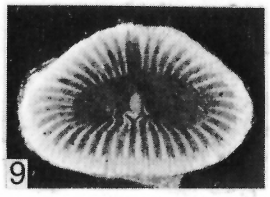
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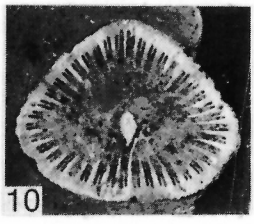
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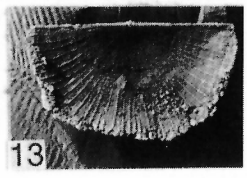
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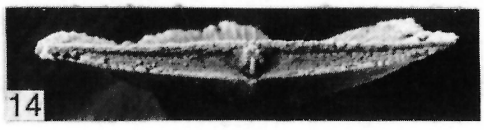
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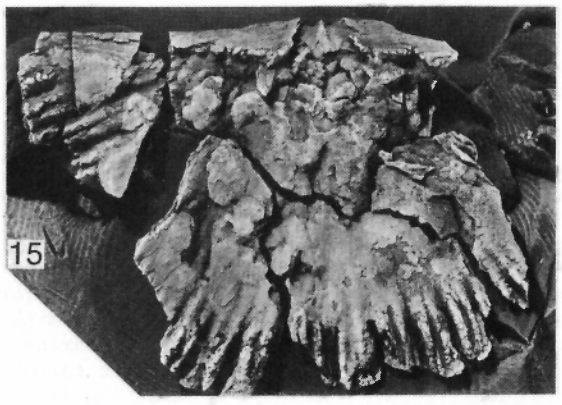
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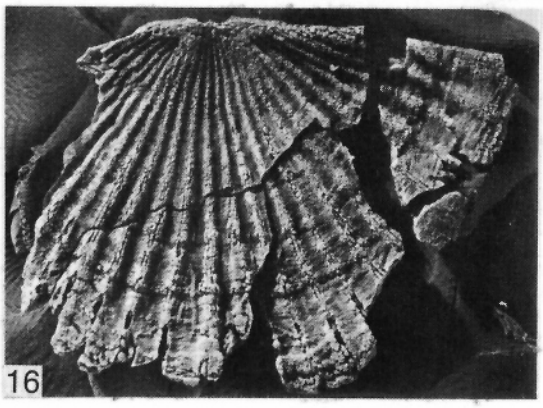
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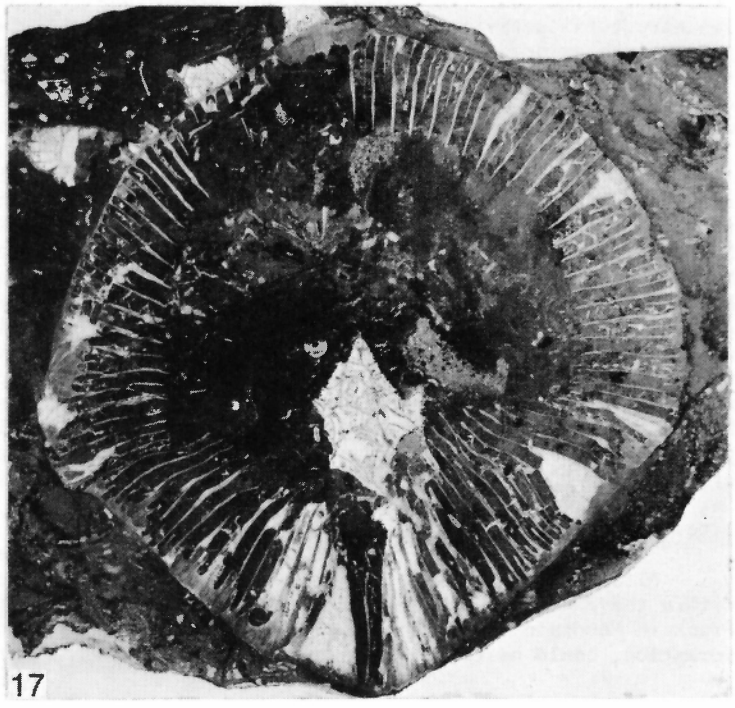
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Analysis of shale from core of the basal member of the Mount Kindle Formation in the Husky *et al.* Willowlake G-32 well [depth 2,530-2,538 ft. (771-774 m); Fig. 1 gives location] shows 0.87 per cent organic carbon and 3.22 per cent mineral carbon, total benzene methanol extract of 0.0091 gm from the 144 gm sample, and a ratio of this extract to organic carbon of 0.00726 (L.R. Snowdon, pers. com.). Snowdon considers that the volume of organic carbon is about normal for shale and that the degree of thermal alteration of the organic matter is low, indicating that these rocks in the Interior Plains were not buried deeply under younger sediments.

The underlying Franklin Mountain Formation is of lesser interest, in that porosity is not well developed within most of the formation and the opportunities for escape of hydrocarbons during pre-Mount Kindle and later periods of erosion have been many. Carbonates of the cherty unit of the Franklin Mountain are of most interest, because they contain many vugs and, in most outcrops, are well dissected by fractures. The Tenlen A-73 well has a local development of porous dolomite above the cherty unit. The only known important oil showing in lower Paleozoic rocks of the lower Mackenzie River area occurs in the Candel *et al.* East Mackay B-45 well (Fig. 1), within a 50-foot (15 m) interval of the Franklin Mountain Formation cherty unit. The interval is at drilled depth 3,992-4,042 feet (1198-1213 m) and the cherty unit extends from 3,992 to 5,146 feet (1198-1544 m); (W.S. MacKenzie, pers. com.). The heavy gravity (20.4° API gravity at 60°F) oil is suggested to be of Cretaceous age, possibly having been derived from the overlying Cretaceous (Albian) shales of the area. The well is sited only about 8 miles (13 km) northeast of the MacKay Range, and encountered 1,154-foot (352 m) thick Franklin Mountain cherty unit, overlain directly by Cretaceous clastics. Within the MacKay Range, however, the highest Franklin Mountain beds exposed belong to the rhythmic unit, and these are truncated progressively from north to south along the range beneath the overlying Devonian Bear Rock Formation. The nature of such pre-Devonian structural activity and the changes in stratigraphy such as occur between the MacKay Range and the East Mackay B-45 well are matters of urgent concern for exploration of the petroleum prospects of the lower Paleozoic rocks of the area.

J.D. Aitken (pers. com.) has pointed out that sediments of the Franklin Mountain Formation and the laterally equivalent Road River shale may not have been buried sufficiently deep prior to the pre-Mount Kindle hiatus for contained hydrocarbons to have been completely matured. Thus, although hydrocarbons initially trapped within the formation may well have escaped during pre-Mount Kindle erosion, there remains potential for a second generation and migration of hydrocarbons during or following burial by Mount Kindle and younger sediments. However, the problem remains as to whether or not lower Paleozoic hydrocarbons could be retained in the formation during the changes resulting from pre-Bear Rock and later episodes of uplift and erosion.

Alternatively, porous and permeable zones within the cherty and porous dolomite units of the Franklin Mountain Formation, or the Mount Kindle Formation, could be traps for hydrocarbons generated from considerably younger sediments, as seems to be the case at the East Mackay B-45 well.

METALLIC MINERALS

Recently, in Canada, interest in Mississippi Valley-type zinc-lead deposits in platform carbonates has increased markedly, to a large extent as a result of studies published by Beales and his co-workers on the Pine Point orebody within Middle Devonian carbonates (Beales and Jackson, 1966; Jackson and Beales, 1967; Beales and Onasick, 1970). Pine Point and other similar orebodies are thought to have originated through normal diagenetic processes operative within sedimentary strata; these include compaction-driven fluid migration, and porosity enhancement by dolomitization or evaporite solution perhaps related to unconformities (paleokarst).

Therefore, based on the above criteria, the Franklin Mountain and Mount Kindle platform carbonate interval with its laterally equivalent Road River basinal shales could be an ideal host for such mineralization. At present, small zinc-lead showings are known within the Godlin Lakes area of the central Mackenzie Mountains (Sekwi Mountain map-area, 105P; Blusson, 1973), west of the region described by the present paper. In the Godlin Lakes area, the mineralization is of two types: a) stratiform, associated with three stratigraphic levels of breccia or pseudo-breccia, one of which is located within the Whittaker Formation (the others are within Devonian strata); and b) as cross-cutting veins or ?fracture fillings which are clearly "late" in origin (S.L. Blusson, pers. com., 1974). The showings to date, all of which appear to be small in size, are located well into the platform rocks, several miles or more "platformward" from the area of carbonate-shale facies change, or carbonate shelf margin (Blusson, pers. com., 1974). If migrating basinal fluids are involved in the stratiform mineralization noted above, the Mount Kindle Formation, as a generally porous and permeable unit, would appear to be most favourable for zinc-lead mineralization within the eastern Mackenzie and Franklin Mountains. Franklin Mountain rocks would be of more interest to the west ("basinward") of the area discussed in this paper, where peritidal rocks characteristic of the eastern Mackenzies, Franklins, and Interior Platform give way within the central Mackenzies to dolomite which appears to have been originally open-marine skeletal limestone, not unlike Mount Kindle carbonates (Macqueen, 1970). Zones of brecciation or pseudo-brecciation in any of these strata should be examined carefully. Brecciation or pseudo-brecciation is rare, however, in rocks which we have examined. Rare, also, is the white Presqu'ile-type dolomite which commonly, although not invariably, is associated with zinc-lead mineralization in Middle Devonian rocks at Pine Point (Beales and Jackson, 1966) and in northeastern British Columbia (Macqueen and Taylor, 1974).

A showing of zinc-lead mineralization (Canada, Department of Indian Affairs and Northern Development, 1973) in the Middle Devonian Headless Formation at the north end of the Camsell Range about 20 miles (32 km) southwest of Mount Kindle demonstrates, however, that proximity to a shale basin

is not a *sine qua non* for metal accumulations in platform carbonates. The facies change from platform carbonates of the Headless Formation to stratigraphically equivalent basinal shale is located at least 50 miles (80 km) to the southwest of the showing.

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APPENDIX 1

MOUNT KINDLE SECTION

Type sections of the Mount Kindle and Franklin Mountain Formations
(Williams, 1922, 1923)

Mount Kindle (Lat. 63°21'N, Long. 123°12'W; Pl. 4A) lies on the west limb of the Cap Anticline (Douglas and D.K. Norris, 1963, p. 25) and is underlain by the Mount Kindle and Franklin Mountain Formations that dip southwest between 13 and 26 degrees. The section begins within the Franklin Mountain Formation in a gully on the northeast face of the mountain (Fig. 5), and continues up to the crest at 1,182 feet (360 m) above the base of the section. The crest is formed by the resistant , middle member of the Mount Kindle Formation. A southwest-flowing creek on the backslope of the mountain exposes higher beds of the Mount Kindle Formation, and the section continues (1,158-1,776 ft., 353-541 m) along this creek, ending at the highest outcrop provided by the southwest ridge of the mountain south of this creek. Measurement was made by staff, June 30 to July 3, 1965 (without any snow cover), by B.S. Norford and B.D. Corneil; R.W. Macqueen and J.D. Aitken examined the section on July 18, 1972. Douglas and D.K. Norris (1963, p. 11) reported an estimated thickness of 900 feet (275 m) for the Mount Kindle Formation, and a measured, incomplete thickness of 1,265 feet (386 m) for the Franklin Mountain Formation.

The colour designations used are those of the rock-colour chart prepared by the Geological Society of America (Goddard, 1963).

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	MOUNT KINDLE FORMATION (minimum thickness 859 ft., 262 m)		
	Upper member (minimum thickness 579 ft., 176 m)		
33	Dolomite, very finely to medium crystalline; yellowish grey, weathering light grey; thin bedded, bedding well developed. Interbedded with dolomite, finely to medium crystalline, dark yellowish brown, weathers yellowish brown and pale yellowish brown; some beds mottled; rare intercrystalline porosity; thin bedded; some beds rubbly. Scattered very light grey irregular chert nodules in some beds. Unfossiliferous. Covered intervals at 1,772-1,774 ft., 1,755-1,766 ft., and 1,751-1,752 ft.	34	1,776
32	Covered interval	18	1,742
31	Dolomite, finely to medium crystalline; dark yellowish brown, weathering pale yellowish brown and light brownish grey; some beds mottled; some beds show up to 2% fine vuggy porosity; thin to thick bedded	39	1,724
30	Dolomite, microcrystalline to very finely crystalline; light grey, weathers yellowish grey and light grey; recessive and platy weathering; contains 1-3% of silt to very fine grained sand-size quartz grains; thin to thick bedded with thicker beds more resistant	7	1,685
29	Covered interval	48	1,678
28	Dolomite, very finely crystalline; olive-grey, weathers light grey; weathered surfaces show 3-6% vuggy porosity with vugs pinpoint to pea-size; thin to thick bedded	22	1,630
27	Covered interval	81	1,608

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
26	Dolomite, very finely crystalline; grey, weathers light grey and yellowish grey; resistant; thin to thick bedded. At 1,526 ft., about 2% fine vuggy porosity, with pinhead-size vugs	58	1,527
25	Mainly covered interval. Poorly exposed outcrop at 1,414-1,422 ft., consisting of dolomite, finely crystalline; light grey weathering; rare irregular chert nodules; thin bedded	55	1,469
24	Dolomite, finely to medium crystalline; dark brownish grey, weathers brownish grey and dark brownish grey; some beds mottled; thin to thick bedded. Slight intercrystalline porosity developed locally; some beds show small vugs lined with drusy calcite, possibly representing leached fossils. Covered intervals at 1,393-1,396 ft., 1,390-1,391 ft. Pentamerid brachiopods abundant in some beds; rare corals. GSC loc. 69804; interval 1,398-1,414 ft.: stromatoporoid *Cystihalysites* sp. *Favosites* sp. *Pentamerus?* sp. age: Silurian, probably Late Llandovery	32	1,414
23	Dolomite, finely crystalline; dark brownish grey, weathers dull dark brownish grey, resistant; weathered surfaces show up to 10% coarse vuggy porosity; thick bedded. Contains colonial corals, stromatoporoids, pentamerid brachiopods	15	1,382
22	Dolomite, finely to medium crystalline; dark grey, weathers light grey and yellowish grey; some beds weather slightly rubbly and recessive; rare beds with small dark grey chert nodules, weathering creamy grey and light grey; thin bedded; very sparse, thin to very thin bedded, platy weathering dolomites. At 1,358 ft., large rounded chert masses (possibly algal stromatolites). Thin, calcareous shale interbed occurs at 1,355 ft. At 1,331-1,333 ft., dark olive brownish grey weathering bed, with large flattened concretionary masses. Some beds show granular texture derived from preservation in dolomite of original calcarenite texture (lime-grainstone or lime-packstone). Covered intervals at 1,340-1,342 ft. and 1,298-1,301 ft. Rare solitary and colonial corals, brachiopods, stromatoporoids, in lower part of unit. GSC loc. 69803; interval 1,293-1,295 ft.: *"Plectospathodus"* cf. *"P." flexuosus* Branson and Mehl indeterminate solitary coral indeterminate brachiopod *Virgiana* sp. (*see* Pl. 9, figs. 1-6, 8) age: Early Silurian, Middle Llandovery GSC loc. 69802; interval 1,247-1,249 ft.: echinoderm debris stromatoporoid solitary coral		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Palaeofavosites sp. indeterminate brachiopod age: probably Silurian	131	1,367
21	Dolomite, microcrystalline to generally finely crystalline; grey and dark grey, weathers brownish grey and pale yellowish brown, less resistant than unit 20; bedding very thin to thin, well developed. Fragments of chert in dolomite at 1,223-1,225 ft.; layer of biogenic debris at 1,224 ft. Some beds with colonial and solitary corals, brachiopods, straight cephalopods.		
	GSC loc. 69801; 1,227 ft.: *Icriodella* sp. *"Neoprioniodus" costatus costatus* Walliser *"Ozarkodina" typica* Branson and Mehl *Panderodus* spp. bryozoan indeterminate solitary coral stropheodontid(?) and undetermined brachiopods *Alispira* sp. *Idiospira?* sp. *Eophacops?* sp. age: Early Silurian, probably Early or Middle Llandovery on brachiopods and trilobites (B.S.N.); late Late Llandovery to early Wenlock on conodonts (T.T.U.)		
	GSC loc. 69800; interval 1,217-1,218 ft.: *Panderodus unicostatus* (Branson and Mehl) indeterminate solitary coral *Favosites* sp. pentamerid(?) brachiopod age: probably Silurian	39	1,236
	Contact with unit 20 apparently conformable		
	Resistant member (212 ft., 65 m)		
20	Dolomite, finely to medium crystalline; dark grey, pale yellowish brown and dark brownish grey, weathers grey, brownish grey, light grey, or very pale yellowish brown; thin bedded, some beds mottled; some beds nodular; dolomite stringers; some beds with 3-8% vuggy porosity; some beds with irregular chert nodules, weathering creamy grey. Granular texture preserved locally, as in unit 22. Colonial and solitary corals, stromatoporoids.		
	GSC loc. 69799; interval 1,192-1,194 ft.: streptelasmid coral *Bighornia* sp. *Catenipora* sp. *Palaeofavosites* sp. *Tollina?* sp. age: Late Ordovician		
	GSC loc. 69798; interval 1,160-1,166 ft.: bryozoans echinoderm debris		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	streptelasmid coral *Palaeophyllum* 2 spp. *Catenipora* sp. *Coccoseris astomata* Flower *Palaeofavosites* 2 spp. *Tollina* sp. fragmentary encrinurid and illaenid trilobites age: Late Ordovician	31	1,197
19	Dolomite, very finely crystalline; slightly silty, dark brownish grey, weathers light grey and light brownish grey; thin bedded; contains sparse, fine dolomite vugs. Lime-wackestone at 1,158 ft. contains coarse- to very coarse grained skeletal fragments derived from ?brachiopods, echinoderms and calcareous algae. Grains are preserved as more coarsely crystalline dolomite in a finely crystalline matrix	9	1,166
18	Covered interval	10	1,157
17	Dolomite, finely to medium crystalline, dark brownish grey, weathers brownish grey and yellowish brown with grey mottling; resistant; dolomite stringers and vugs common; coarse vuggy porosity up to 8% of some beds; also sucrosic in part with moderate intercrystalline porosity; thin to thick bedded. Colonial corals abundant, 5-15% of many beds, some in growth positions; rare solitary corals. GSC loc. 69795; interval 1,133-1,147 ft.: undetermined streptelasmid coral *Bighornia* sp. *Favistina* sp. *Palaeophyllum* 2 spp. *Catenipora?* sp. *Sarcinula* 2 spp. *Tollina* sp. age: Late Ordovician	14	1,147
16	Mainly covered interval. Outcrop at 1,120-1,126 ft., dolomite; microcrystalline to finely crystalline; dark brownish grey, weathers brownish grey and light brownish grey with light grey mottling	24	1,133
15	Dolomite, very finely crystalline to predominantly finely crystalline; dark brownish grey and dark grey, weathers brownish grey, light grey, light brownish grey and grey; many beds mottled; some beds weather rubbly; dolomite vugs and stringers common, amounting to 20% of some rubbly beds; thin to thick bedded. Chert nodules in lower part of unit. Finely crystalline porosity. Some beds show relict granular texture as in unit 22. Colonial and solitary corals common, many in growth positions, rare stromatoporoids. GSC loc. 69794; interval 1,091-1,092 ft.: *Bighornia* sp. (*see* Pl. 9, fig. 9) *Calapoecia* sp. age: Late Ordovician		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	GSC loc. 69793; interval 1,075-1,082 ft.: echinoderm debris undetermined streptelasmid coral *Deiracorallium* sp. *Palaeophyllum* 2 spp. *P.* cf. *P. halysitoides* (Wilson) *Catenipora* cf. *C. rubra* Sinclair and Bolton *Coccoseris astomata* Flower (*see* Pl. 9, fig. 7) *Palaeofavosites* sp. *Palaeofavosites?* sp. *Parafavosites?* sp. *Sarcinula* 2 spp. *Tollina* sp. indeterminate brachiopod age: Late Ordovician		
	GSC loc. 69792; interval 1,028-1,034 ft.: *Lobocorallium?* sp. *Favistina* sp. *Palaeophyllum* cf. *P. halysitoides* (Wilson) *Catenipora* cf. *C. rubra* Sinclair and Bolton *Tollina* sp. favositid(?) coral age: Late Ordovician		
	GSC loc. 69791; interval 1,000-1,020 ft.: stromatoporoid *Bighornia* sp. *Palaeophyllym* cf. *P. halysitoides* (Wilson) *Calapoecia* sp. *Catenipora* sp. *Sarcinula* 2 spp. *Palaeofavosites* sp. *Tollina* sp. *Diceromyonia?* sp. indeterminate brachiopod and trilobite fragments age: Late Ordovician	110	1,109
14	Dolomite, very finely crystalline to finely crystalline; dark grey, weathers light grey and pale yellowish brown; resistant, bedding 6 to 8 ft. thick; greyish black chert nodules common, weathering dark brown; thick bedded. Appears to have contained unsorted echinoderm grains (now coarse crystals of dolomite) in a lime-mud matrix (now very finely to finely crystalline dolomite); originally a packstone or lime-wackestone. Brachiopods and solitary corals.		
	GSC loc. 69790; interval 985-999 ft.: *Drepanoistodus homocurvatus* (Lindström) *Panderodus gracilis* (Branson and Mehl) *Phragmodus undatus* (Branson and Mehl) *Plectodina furcata* (Hinde) echinoderm debris bryozoan *Bighornia* sp. *Lobocorallium* sp.		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	favositid(?) coral *Diceromyonia* sp. *Oepikina?* sp. *Plaesiomys* sp. *Rhynchotrema* cf. *R. kananaskia* Wilson *Thaerodonta* sp. undetermined brachiopod age: late Middle or Late Ordovician on conodonts (C.R.B.); Late Ordovician on macrofossils (B.S.N.)		
	GSC loc. 69797; interval 985-987 ft.: *Oistodus* sp. age: Ordovician	14	999
	Basal member (68 ft., 21 m)		
13	Dolomite, poorly exposed; microcrystalline to very finely crystalline; dark grey, weathers yellowish grey, light olive-grey, and light grey, platy, rubbly, and nodular; mostly argillaceous; very thin to thin bedded. Interbeds of very argillaceous dolomite; dark grey, weathers olive-grey. At 978 ft., layers of large irregular, greyish black chert nodules. Unit very recessive, covered intervals at 974-977 ft., 945-971 ft. Brachiopods and solitary corals.		
	GSC loc. 69784; interval 977-985 ft.: echinoderm debris bryozoan *Lobocorallium* sp. favositid coral *Plaesiomys?* sp. *Rhynchotrema* sp. *Thaerodonta* cf. *T. recedens* (Sardeson) age: Late Ordovician		
	GSC loc. 69788; interval 932-943 ft.: echinoderm debris bryozoan small gastropod debris *Bighornia* sp. *Lobocorallium* sp. indeterminate streptelasmid coral *Catenipora* sp. *Diceromyonia* sp. *Plaesiomys* sp. *Rhynchotrema* cf. *R. kananaskia* Wilson indeterminate strophomenid and other brachiopods age: Late Ordovician	54	985
12	Covered interval	12	931
11	Dolomite, microcrystalline to very finely crystalline; light greenish grey, weathers light olive-grey; contains about 20% quartz silt; very thin to thin bedded; angular fragments of chert present. Shale, silty, olive-grey; as wispy interbeds above 918 ft. Contact with Franklin Mountain Formation irregular with up to 6 inches relief (*see* Pl. 5A, B)	2	919

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	FRANKLIN MOUNTAIN FORMATION (minimum thickness 917 ft.; 280 m)		
	Cherty unit (45 ft., 14 m)		
10	Dolomite, sandy; microcrystalline to finely crystalline; light olive-grey, weathers light grey, light olive-grey, and yellowish grey, somewhat recessive; many beds with 10-30% quartz silt; thin bedded. Uppermost beds (915-917 ft.) are silicified stromatolitic dolomite (*see* Pl. 2A, B), almost white, weathering almost white and pale pinkish grey, thin bedded. At 903 ft., layer of fine pebble-conglomerate within a dolomite bed; matrix largely quartz sand. Covered interval at 913-915 ft.	34	917
9	Dolomite, sandy; finely crystalline; light brownish olive-grey, weathers very pale yellowish brown and light olive-grey, resistant; thick bedded; some beds vuggy when weathered. Contact conformable with underlying rhythmic unit	11	883
	Rhythmic unit (mimimum thickness 872 ft., 266 m)		
8	Dolomite, microcrystalline to very finely crystalline (microdolomite); light brownish grey, and olive-grey, weathers light brownish grey, very pale yellowish brown, and light olive-grey; many beds (especially finer crystalline beds) contain minor quartz silt; thin to thick bedded; some beds poorly laminated. Interbedded with dolomite, finely to medium crystalline (macrodolomite); brownish grey, weathers light grey; rare beds with drusy cavity porosity; some beds show pelletoid or intraclastic texture poorly preserved in dolomite, with original "grains" delineated by inclusions in dolomite crystals, yielding a clouded texture, and original matrix preserved as clear dolomite; single dolomite crystals commonly replace both grains and matrix; some beds rich in fine quartz sand. At 857 and 841 ft., stromatolitic beds, laterally linked hemispheroids. At 858 ft., dolomite breccia. At 820-821 ft., very thinly bedded dolomite, weathers greyish orange and platy	73	872
7	Covered interval. Part of interval outcrops on adjacent ridge and resembles unit 8	90	799
6	Dolomite, microcrystalline to very finely crystalline (microdolomite); brownish grey, olive-grey and dark grey, weathering light grey, yellowish grey, light olive-grey, and pale yellowish brown, some bedding planes stained dark red; many beds contain minor to 25% quartz silt or sand; thin bedded. Interbedded with macrodolomite, finely to medium crystalline, locally rich in quartz, as in unit 8. At 626 ft., 6-inch layer or lenticle of dolomitic quartz sandstone within a macrodolomite bed	117	709
5	Covered interval, uppermost one foot has outcrop of very thinly bedded, greyish orange weathering dolomite	74	592

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
4	Dolomite, microcrystalline to very finely crystalline (microdolomite); brownish grey, weathering yellowish brown, greyish yellow, and brownish grey, with some bedding planes stained dark red; many beds contain quartz silt and very fine sand (up to 25%), commonly concentrated in thin laminae less than 2 mm thick; interbedded with dolomite, finely crystalline (macrodolomite)1 weathering brownish grey or dark greyish orange; thin to thick bedded; quartz sand rarely present. Interbedding of the two rock types lends a characteristic banded appearance to the outcrop (Pls. 4A, B, 7A). Rubbly exposure; interval is partly covered. Some macrodolomite beds show relict granular texture. "Grains" are very well rounded and well sorted (medium sand size), and by size, shape, packing, and comparison with definite oolitic dolomites present in the northern Franklin Mountains at this stratigraphic level, were originally ooids; rare patches of silicified oolite. Grains are preserved only as clouded inclusions (organic matter?) within large single dolomite crystals which replace both grains and matrix; matrix portions of dolomite crystals are mainly free of inclusions (*see* also description of unit 1). Red iron staining noted above is present in both microdolomites and macrodolomites, unlike areas to the north, where red staining in rhythmic unit appears to be confined to macrodolomites. Columnar stromatolites present in some beds, but less common than in rhythmic unit of the Norman Range, Franklin Mountains. At 472-477 ft., 433-435 ft., and 401-416 ft., argillaceous microdolomite zones predominate, weathering greyish orange and yellowish grey, and platy. Lenticular chert nodules occur at 412 ft.; at 443 ft., small quartz masses are common in some beds	126	518
3	Covered interval	63	392
2	Dolomite, microcrystalline to finely crystalline; brownish grey, dark grey, and red, weathering greyish yellow, greyish orange, greyish red, and yellowish brown; quartz silt laminae common in many beds, partly as cross-laminations and on minor erosion surfaces within microdolomites. Some beds (lenses?) of flat-pebble conglomerate of dolomite; rare beds of dolomitic quartz sandstone, in part conglomeratic, medium to coarse or very coarse grained with very well rounded quartz cemented by dolomite. Generally thin bedded; rubbly exposure, interval is partly covered. Minor argillaceous microdolomites, light olive-grey, weathering greyish orange and platy; locally with abundant quartz silt; very thin to thin bedded. Oolitic dolomites not evident; unit also lacks distinctive colour banding of units 4 and 1. Coarse vuggy porosity at 319 and 200 ft. At 255-261 ft., interval weathers red, forming a distinct band. Unit 2 is more recessive than unit 1	164	329
1	Dolomite, microcrystalline to finely crystalline; grey and brownish grey, weathering yellowish grey, light grey, and light olive-grey; some beds laminated, rarely cross-laminated; minor quartz silt and very fine sand; thin bedded. Distinctive banding is imparted by interbedding of thinner beds of yellowish grey and brownish grey weathering, in part laminated and quartz silt-bearing, microdolomite, and thicker beds of olive-grey and red-		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	weathering oolitic macrodolomite, which also contains scattered fine quartz sand and non-silicified columnar stromatolites of several types. Oolitic dolomites contain clearly recognizable medium-grained ooids which are distinguished solely by their content of dark grey, submicroscopic inclusions (organic matter?), as in unit 4. The ooids also contain appreciable amounts of iron, probably as hematite and/or limonite, occurring both as inclusions within, and as coatings between, dolomite crystals. Those portions of dolomite crystals which replace the original pore-space or matrix between oiids are virtually free of both submicroscopic inclusions and hematite and/or limonite. Ooids tend to form solution pits on weathered surfaces. Lenses or layers of flat-pebble dolomite conglomerate, probably of penecontemporaneous origin, are common. Some microdolomites are argillaceous, very thin bedded, light olive-grey, and weather greyish orange, yellowish brown, and platy. Minor faults at 34 and 25 ft. End of outcrop. Underlying cyclic unit covered, if present. Highest Saline River Formation float of red shales and mudstones is more than 100 ft. lower in gully	165	165

APPENDIX 2

SECTION AT NORTH END OF SMITH RIDGE

The north end (Lat. 63°17'N, Long. 123°11'-12'W; Pl. 7A, B) of Smith Ridge lies on the west limb of the Cap Anticline about five miles (8 km) south of Mount Kindle. The ridge is formed primarily by the Bear Rock and Mount Kindle Formations. Dips are southwest at 19 to 28 degrees. The section supplements the Mount Kindle section, revealing the sequence of rocks above those exposed at Mount Kindle, up to the base of the Bear Rock Formation that forms the top of the measured section (Pl. 8). Measurement of the section commenced with two units (1 and 2) that are thought to be equivalent to Units 23 and 24 of the Mount Kindle section and thus allows correlation between the two sections. Additional strata of the Mount Kindle Formation (about 36 ft., 11 m) are exposed at Smith Ridge.

The section is not well exposed and was measured by tape and compass along the ridge crest as a rapid reconnaissance on July 4, 1965.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Unassigned beds (450 ft., 137 m)		
6	Covered interval	25	892
5	Dolomite, microcrystalline to finely crystalline; light brownish olive-grey and light grey, weathers light grey, yellowish grey, light brownish grey, and pale greyish orange, some beds weather platy, some beds finely laminated, some beds show contorted laminae which include quartz silt and very fine grained sand. Very thin to thin bedded. Rare, more recessive,		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	yellowish brown weathering dolomites. Unit recessive and poorly exposed; covered intervals at 830-840 ft., 776-796 ft., 754-771 ft., 733-753 ft., unfossiliferous	139	867
4	Covered interval	286	728
	MOUNT KINDLE FORMATION		
	Upper member (442 ft., 135 m, measured)		
3	Dolomite, intermittently exposed, similar to upper member of Mount Kindle Formation at Mount Kindle. Cursorily examined except for top beds which are dolomite, finely crystalline; grey, weathers pale yellowish brown and brownish grey; thin bedded, bedding well developed	412	442
2	Dolomite, finely crystalline; dark brownish grey, weathers brownish grey and dark brownish grey, some beds mottled; very thin to thin bedded. Colonial corals. GSC loc. 69805; interval 29-30 ft.: stromatoporoid solitary coral (fragments) *Cystihalysites?* sp. (probably conspecific with *Cystihalysites* sp. of GSC loc. 69804 of Mount Kindle section) *Favosites* sp. brachiopod (fragments) age: Silurian	18	30
1	Dolomite, finely crystalline; dark brownish grey, weathers dull brownish grey, resistant; thin to thick bedded; some weathered surfaces show vuggy porosity. Pentamerid brachiopods abundant but poorly preserved	12	12

APPENDIX 3

FAUNA FROM OUTCROP ON SECOND MOUNTAIN SOUTH OF MOUNT KINDLE

Mount Kindle Fm., 4-7 ft. below top of basal member; GSC loc. 69806

Lat. 63°18'N, Long. 123°11'W (Pls. 6; 7A; 9, figs. 10-17)
- echinoderm debris
- cephalopod
- bryozoan
- undetermined solitary coral
- *Bighornia* sp.
- *Lobocorallium* cf. *L. trilobatum major* Nelson
- *Palaeophyllum* sp.
- *Calapoecia* sp.
- *Catenipora* cf. *C. rubra* Sinclair and Bolton
- *Favosites* sp.
- undetermined brachiopods
- *Austinella?* sp.
- *Diceromyonia?* sp.
- *Hesperorthis* sp.
- *Rhynchotrema* sp.
- *R.* cf. *R. kananaskia* Wilson
- *Thaerodonta* cf. *T. recedens* (Sardeson)
- age: Late Ordovician

APPENDIX 4

FAUNAL LISTS, FRANKLIN MOUNTAIN FORMATION

Collections made by J.D. Aitken, D.G. Cook, R.W. Macqueen, B.S. Norford and R.M. Procter; identifications and correlations by W.H. Fritz, B.S. Norford, R.J. Ross, Jr., T.T. Uyeno and E.L. Yochelson.

Horton River, Lat. 68°36'N, Long. 124°01'W

Cherty unit; GSC loc. C-5460	echinoderm fragments straight cephalopod undetermined gastropods *"Helicotoma"* sp. age: Early Ordovician, probably younger than Early Canadian (B.S.N.)

Lat. 65°28'N, Long. 126°43'W

Cherty unit; GSC loc. C-2051	*"Helicotoma"* sp. undetermined gastropods age: Early Ordovician (probably younger than early Early) (E.L.Y.)

Aquitaine Brackett Lake C-21 well, Lat. 65°10'N, Long. 125°05'W

Franklin Mountain Fm., undifferentiated; core at depth 3,878-3,891 ft.; GSC locs. C-23686, C-23687	*Acontiodus staufferi* Furnish *Drepanodus* cf. *Acodus oneotensis* Furnish of Ethington and Clark (1971, Pl. 1, fig. 3) *Scandodus?* sp. age: Early Ordovician (late Tremadoc to early Arenig), Faunas C to E of Ethington and Clark (1971), probably older part of this interval (T.T.U.)

Imperial River section, Lat. 65°07'N, Long. 128°02'W

Cherty unit, 18-19 ft. below base of Mount Kindle Formation; GSC loc. C-3829	cephalopod fragments *Gasconadia* cf. *G. putilla* (Sardeson) age: early Early Ordovician, Gasconade (E.L.Y.)

Arctic Red River west section, Lat. 65°22'N, Long. 131°25'W

Cherty unit, about 402 ft. above base of unit; about 2,016 ft. above base of formation; GSC loc. C-3836	echinoderm fragments *Nanorthis* cf. *N. multicostata* Ulrich and Cooper age: Early Ordovician, Middle Canadian (Zone D to Zone G2) (R.J.R.)
Rhythmic unit, 1,050-1,127 ft. above base of unit and of formation; GSC loc. C-3834	*Matthevia?* sp. age: possibly Late Cambrian, possibly Franconian (E.L.Y.)
Rhythmic unit, about 688-703 ft. above base of unit and of formation; GSC loc. C-3833	echinoderm columnals (including distinctive Form A) *Billingsella* sp. age: Late Cambrian, probably Franconian (B.S.N.)
Rhythmic unit, about 673-678 ft. above base of unit and of formation; GSC loc. C-3832	echinoderm columnals (including distinctive Form A) *Billingsella* sp. age: Late Cambrian, probably Franconian (B.S.N.)

Lat. 65°19'N, Long. 131°07'W

Rhythmic unit; GSC loc. C-2020	undetermined brachiopod *Billingsella* sp. age: Late Cambrian (B.S.N.)

Lat. 65°19'N, Long. 131°02'W

Rhythmic unit; GSC loc. C-4148	echinoderm columnals (including distinctive Form A) *Billingsella* sp. age: Late Cambrian, probably Franconian (B.S.N.)

Lat. 65°06'N, Long. 131°05'W

Rhythmic unit; GSC loc. C-6246	echinoderm columnals (including distinctive Form A) *Billingsella* sp. age: Late Cambrian, probably Franconian (B.S.N.)

Canyon Ranges, Lat. 65°28'N, Long. 132°37'W

Franklin Mountain Fm., undifferentiated; GSC loc. 54064	echinoderm fragments (including distinctive Form A) undetermined brachiopods *Billingsella* sp. age: Late Cambrian, probably Franconian (B.S.N.)

Canyon Ranges section, Lat. 65°28'N, Long. 132°57'W
(Norford, 1964, p. 19-25, 123-124)

Franklin Mountain Fm., undifferentiated, about 852 ft. above base of formation; GSC loc. 53156	echinoderm fragments asaphid trilobite age: probably Early Ordovician (B.S.N.)
Franklin Mountain Fm., undifferentiated, about 730 ft. above base of formation; GSC loc. 53155	*Dichograptus?* sp. graptolite fragments (including ?biserial form) arthropod? fragment age: Early Ordovician (B.S.N.)
Franklin Mountain Fm., undifferentiated, about 392-393 ft. above base of formation; GSC loc. 53154	echinoderm columnals (including distinctive Form A) undetermined brachiopod *Billingsella* sp. age: Late Cambrian, probably Franconian (B.S.N.)

Keele River, Lat. 64°12'N, Long. 126°28'W

Rhythmic unit, near base; GSC loc. C-3806	*Blountia* sp. *Coosina?* sp. *Kingstonia* sp. *Lonchocephalus* sp. or *Welleraspis* sp. age: early Late Cambrian, Dresbachian, *Cedaria-Crepicephalus* Zone (W.H.F.)

APPENDIX 5

Mineralogy and carbon content of selected samples from the type sections of the Franklin Mountain and Mount Kindle Formations, Mount Kindle, District of Mackenzie. Mineralogical analyses determined by Philips X-ray diffractometer using CuKα radiation in conjunction with Lif curved crystal monochromator. Scanning rate 1°/minute; chart speed 1cm/minute; settings 40 kilovolts, 20 milliamperes. Mineral abbreviations: D, dolomite; Q, quartz; F, feldspar; H, hematite; Cy, clays (includes illite, kaolinite, and/or chlorite groups). All values are semiquantitative percentages based on peak-height ratios. Carbon analyses: total carbon determined by Leco induction furnace, mineral carbon removed by boiling of carbonates in 10% HCL solution; organic carbon determined by difference. All organic carbon values are weight per cent. Mineralogical and carbon analyses by A.E. Foscolos, R.R. Barefoot, and A.G. Heinrich, Institute of Sedimentary and Petroleum Geology, Calgary. Macrodolomite and microdolomite used as in Illing, Wood and Fuller (1967); also see text under Franklin Mountain Formation, regional distribution and lithology.

Ft.[1]	Lithology	Minerals (semiquantitative %)					Carbon[2] (weight %)		
		D	Q	F	H	Cy[3]	Total	Min	Organic
	MOUNT KINDLE FORMATION								
	Upper, poorly fossiliferous, member (minimum thickness 579 ft.; 1197 ft.-1776 ft.)								
1708	Macrodolomite, f-mx, med grey, sucrosic, ?fossil fgts.	99	1				12.50	11.73	0.77
1408	Macrodolomite, fx, med grey, sucrosic, fossil fgts.	100					12.64	12.00	0.64
1372	Macrodolomite, fx, dark grey	98	2				12.80	12.35	0.45
1364	Macrodolomite, vfx, argillaceous, reddish brown	82	17			1	*	*	*
1258	Microdolomite, xfx, yellowish brown	97	3				12.40	11.95	0.45
	Middle, fossiliferous, resistant member (212 ft.; 985 ft.-1197 ft.)								
1180	Macrodolomite, fx, dark grey, fossil fgts.	98	2				12.78	12.46	0.32
1164	Macrodolomite, fx, med grey	100					12.78	12.27	0.51
1125	Macrodolomite, fx, dark grey, fossil fgts.	100					12.78	12.27	0.51
1030	Macrodolomite, f-mx, med grey, fossil fgts.	100					12.48	11.90	0.58
	Basal, recessive member (68 ft.; 917 ft.-985 ft.)								
940	Macrodolomite, vfx, brownish grey, argillaceous	82	13	2		3	10.70	10.06	0.64
	FRANKLIN MOUNTAIN FORMATION								
	Rhythmic member (minimum thickness 872 ft.; 0 ft.-872 ft.)								
700	Macrodolomite, fx, med grey	84	11	5		Tr	11.22	10.77	0.45
600	Microdolomite, xfx, yellowish brown	96	3	1			12.52	12.01	0.51
450	Macrodolomite, fx, med grey, with quartz sand	78	16	2		4	*	*	*
319	Macrodolomite, fx, med grey, mottled	88	7	5			10.64	10.19	0.45
300	Macrodolomite, fx, med grey, mottled	91	5	4			11.67	11.22	0.45
256	Macrodolomite, fx, red zone	68	17	8	4	3	*	*	*
250	Microdolomite, vfx, yellowish brown, platy	85	10	5			*	*	*
200	Microdolomite, xfx, yellowish brown	73	15	8	Tr	4	*	*	*
193	Microdolomite, vfx, red zone	60	27	13	Tr	Tr	8.00	7.71	0.39
72	Macrodolomite, fx, yellowish to reddish brown, oolitic	98	2				12.75	12.24	0.51

[1] footages in terms of measured section in Appendix 1.

[2] * indicates sample not analyzed for carbon.

[3] illite, chlorite, kaolinite groups not differentiated owing to very small amounts of clays present.

GSC