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D.W. Morrow

1991

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PREFACE

This bulletin outlines the Silurian-Devonian stratigraphy of the northern part of the Mackenzie Mountains, as part of a broader Geological Survey of Canada project encompassing the lower Paleozoic stratigraphy of the cratonic sedimentary cover of northwest Canada east of Tintina Trench. Major changes in the thicknesses of Silurian-Devonian stratigraphic sequences indicate that a highly mobile tectonic regime influenced the locations of many vein-type, lead-zinc mineral showings in Devonian strata of this region. These deposits may have been remobilized and consequently may be a guide to the locations of other, older deposits.

The stratigraphic data of this study have led to the documentation of several new tectonic features, such as Godlin Salient and Twitya Uplift. Models for the tectonic evolution of this part of western North America must take into consideration the existence of these tectonic elements and of other Silurian-Devonian elements, such as Redstone Arch, one of the subjects of this study. The paradox of the development of intrashelf arches contemporaneous with a time of extensional tectonics, as proposed previously, is emphasized in this study providing new insights that may lead to the development of radically different models for the tectonic development of the early Paleozoic of western North America.

Elkanah A. Babcock
Assistant Deputy Minister
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PRÉFACE

Le présent bulletin passe en revue la stratigraphie du Silurien et du Dévonien de la partie nord des monts Mackenzie dans le cadre d'un grand projet de la Commission géologique du Canada portant sur la stratigraphie du Paléozoïque inférieur de la couverture sédimentaire cratonique du nord-ouest du Canada, à l'est du sillon de Tintina. Les variations importantes au niveau de l'épaisseur des séquences stratigraphiques du Silurien et du Dévonien indiquent qu'un régime tectonique très mobile a eu des effets sur l'emplacement de nombreuses occurences de plomb et zinc de type filonien dans des couches dévoniennes de cette région. Comme ces gisements ont peut-être été remobilisés, ils pourraient servir de guide à la localisation d'autres gisements plus anciens.

Les données stratigraphiques de cette étude ont servi à documenter plusieurs nouveaux éléments tectoniques comme le saillant Godlin et le soulèvement Twitya. Les modèles de l'évolution tectonique de cette partie de l'ouest de l'Amérique du Nord doivent tenir compte de l'existence de ces éléments tectoniques et d'autres éléments d'âge Silurien et Dévonien, notamment de l'arche de Redstone, l'un des sujets de la présente étude. Le paradoxe que crée la formation d'arches au sein d'une plate-forme survenant en même temps que des épisodes tectoniques de grande envergure, tel que proposé antérieurement, est mis en relief dans le cadre de cette étude et pourrait se traduire, grâce aux renséignements recueillis, par la mise au point de modèles radicalement différents pour reproduire l'évolution tectonique de l'ouest de l'Amérique de Nord au début de Paléozoïque.

Elkanah A. Babcock
Sous-ministre adjoint
Commission géologique du Canada

CONTENTS

Illustrations

Figures

Tables

THE SILURIAN-DEVONIAN SEQUENCE IN THE NORTHERN PART OF THE MACKENZIE SHELF, NORTHWEST TERRITORIES

Abstract

The 500 to 3000 m thick Siluro-Devonian carbonate succession exposed in the northern Mackenzie Mountains was deposited on the Mackenzie Shelf, which bordered Selwyn Basin. Tectonic elements, such as Root Basin, the Redstone Arch and Godlin Salient, influenced the thickness and distribution of facies in the lower part of this sequence.

The Late Silurian-Early Devonian sea level lowstand coincided with the development of landlocked evaporite basins on the shelf. Thick sequences of silty evaporites (Camsell Formation) accumulated in the basins, and the surrounding shelf regions were mantled with a thin, silty dolostone sequence (Tsetso Formation). The subsequent Early Devonian sea level rise was accompanied by deposition of a blanket of carbonates (Sombre, Arnica and Landry formations) and evaporites (Bear Rock Formation) across the shelf. The carbonate-evaporite facies boundary of this sedimentary blanket is oriented subparallel to the Mackenzie Shelf edge instead of around local depocentres. The uppermost part of the Siluro-Devonian carbonate succession, the Hume Formation, marks the end of intrashelf tectonic activity and consists of open marine limestone that was deposited with a uniform thickness across the entire northern part of the Mackenzie Shelf.

Résumé

La succession carbonatée siluro-dévonienne de 500 à 3 000 m d'épaisseur qui affleure dans le nord des monts Mackenzie a été mise en place sur la plate-forme du Mackenzie, qui bordait le bassin Selwyn. Les éléments tectoniques comme le bassin de Root, l'arche de Redstone et le saillant de Godlin, ont influencé l'épaisseur et la répartition des faciès dans la partie inférieure de cette séquence.

Au Silurien tardif et au Dévonien précoce, le bas niveau de la mer a coïncidé avec la formation de bassins évaporitiques fermés sur la plate-forme. D'épaisses séquences d'évaporites silteuses (Formation de Camsell) se sont accumulées dans les bassins, et les régions environnantes de la plate-forme ont été recouvertes d'une mince séquence de dolomies silteuses (Formation de Tsetso). La montée ultérieure du niveau de la mer au cours du Dévonien précoce a été accompagnée de l'accumulation d'une couverture de roches carbonatées (formations de Sombre, d'Arnica et de Landry) et d'évaporites (Formation de Bear Rock) sur toute l'étendue de la plate-forme. Dans cette couverture sédimentaire, la limite entre les faciès carbonatés et évaporitiques est orientée subparallèlement au bord de la plate-forme du Mackenzie, et non aux contours de centres de sédimentation maximum régionaux. La partie sommitale de la succession carbonatée siluro-dévonienne, la Formation de Hume, marque la fin de l'activité tectonique se produisant à l'intérieur de la plate-forme, et se compose de calcaire de milieu marin ouvert, dont une couche d'épaisseur uniforme s'est accumulée sur toute la partie septentrionale de la plate-forme du Mackenzie.

Summary

The 500 to 3000 m thick Silurian-Devonian carbonate sequence exposed in the northern Mackenzie Mountains was deposited on the northern part of the early Paleozoic Mackenzie Shelf. The activity of intrashelf tectonic elements, such as Root Basin or the Camsell Sub-basin, the Norman Wells High, Redstone Arch, and the Godlin Salient, in conjunction with changes in sea level, were the major factors that influenced thickness variations and the distribution of lithological facies. The pronounced Late Silurian fall in sea level and the following earliest Devonian rise were accompanied by a high degree of tectonic mobility on the shelf. At this time, the shelf area was occupied by basins with a high degree of continentality. Thick sequences of silty evaporites (Camsell Formation) accumulated in these basins, whereas the surrounding regions were mantled only discontinuously by a thin cover of silty dolostones (Tsetso Formation).

A reduction in intrashelf tectonic mobility, possibly accompanied by a continuous sea level rise, caused the inundation of all exposed land areas on the Mackenzie Shelf and led to deposition of a blanket of carbonate (Sombre, Arnica and Landry formations) and evaporite (Bear Rock Formation) sediments in which terrigenous material was absent. These evaporites were not confined to intrashelf basins, but instead occupied a strip along the entire eastern side of the Mackenzie Shelf. Intrashelf tectonic mobility caused thickness variations in this sediment blanket but was insufficient to markedly influence the disposition of facies. The Camsell Sub-basin and Godlin Salient region remained as areas of relatively rapid subsidence and sediment accumulation.

The uppermost part (Hume Formation) of this Silurian-Devonian sequence is separated from underlying strata by an event horizon that marks a profound change in the pattern of sedimentation. Argillaceous and fossiliferous open marine limestones of the Hume Formation extend with uniform thickness across the entire shelf area. The facies and thickness variations of underlying strata have no counterparts in the Hume Formation. It is hypothesized that deposition of the Hume Formation was preceded by a brief fall in sea level, and that intrashelf tectonic movements ceased during Hume deposition. The spectacular carbonate breccias of the Camsell and Bear Rock formations in surface exposures are the result of the dissolution of evaporites by meteoric groundwater. The aligned fabrics displayed in many breccia exposures are probably the result of gravitational compaction during the process of solution-collapse in inclined strata.

Rocks of the Delorme Formation of previous usage have been assigned to the Tsetso and the Camsell formations; and the Delorme Formation has been raised to group status. The Delorme Group embraces the Tsetso and Camsell formations in the northern Mackenzie Region. Farther south this group includes the Root River, Vera and Cadillac formations.

Sommaire

La séquence carbonatée siluro-dévonienne de 500 à 3 000 m d'épaisseur qui affleure dans le nord des monts Mackenzie a été mise en place sur la partie nord de la plate-forme du Mackenzie (formée au Paléozoïque précoce). L'activité d'éléments tectoniques à l'intérieur de la plate-forme, comme le bassin de Root ou le sous-bassin de Camsell, la hauteur de Norman Wells, l'arche de Redstone et le saillant de Godlin, conjointement avec les variations du niveau de la mer, ont été les principaux facteurs qui ont influencé les variations d'épaisseur des strates et la répartition des faciès lithologiques. L'abaissement prononcé du niveau de la mer au cours du Silurien tardif et la montée ultérieure du niveau de la mer suivant le début du Dévonien, ont été accompagnés d'un fort degré de mobilité tectonique de la plate-forme. À cette époque, la région de la plate-forme était occupée par des bassins qui avaient un caractère continental prononcé. D'épaisses séquences d'évaporites silteuses (Formation de Camsell) se sont accumulées dans ces bassins tandis que les régions environnantes ont été recouvertes seulement de façon discontinue par une mince couverture de dolomies silteuses (Formation de Tsetso).

Une réduction de la mobilité tectonique de l'intérieur de la plate-forme, qui a peut-être été accompagnée d'une montée continue du niveau de la mer, a provoqué l'ennoyage de toutes les régions terrestres exposées de la plate-forme du Mackenzie, et entraîné la mise en place d'une couverture carbonatée (formations de Sombre, d'Arnica et de Landry) et d'évaporites (Formation de Bear Rock), au sein desquelles les matériaux terrigènes étaient absents. Ces évaporites n'ont pas été confinées aux bassins d'intérieur de plate-forme, mais ont occupé une bande de terrain sur tout le côté est de la plate-forme du Mackenzie. La mobilité tectonique de l'intérieur de la plate-forme a provoqué des variations d'épaisseur de la couverture sédimentaire, mais n'a pas été assez forte pour influencer de façon prononcée la disposition des faciès. Le sous-bassin de Camsell et la région du saillant de Godlin sont restées des zones de subsidence et d'accumulation sédimentaire relativement rapides.

La partie sommitale (Formation de Hume) de cette séquence silurienne-dévonienne est séparée des strates sous-jacentes par un horizon uniforme qui indique une variation profonde de mode de sédimentation. Une épaisseur uniforme de calcaires argileux et fossilifères, de milieu marin ouvert, appartenant à la Formation de Hume, s'étendent sur toute l'étendue de la plate-forme. Les variations de faciès et d'épaisseur des strates sous-jacentes n'ont pas d'équivalents dans la Formation de Hume. On suppose que la mise en place de la Formation de Hume a été précédée d'un bref abaissement du niveau de la mer, et que les mouvements tectoniques de l'intérieur de la plate-forme ont cessé au cours de la mise en place de la Formation de Hume. Les brèches carbonatées spectaculaires des formations de Camsell et de Bear Rock, que l'on observe dans des affleurements, résultent de la dissolution des évaporites par les eaux souterraines météoriques. Les fabriques alignées qui caractérise de nombreaux affleurements de brèches sont probablement dues au tassement qui s'est produit en raison de l'effondrement par dissolution de portions des strates inclinées.

Les roches de la Formation de Delorme, selon la nomenclature ancienne, ont été classées dans les formation de Tsetso et de Camsell; et la Formation de Delorme a changé de catégorie pour devenir un groupe. Le Groupe de Delorme englobe les formations de Tsetso et de Camsell dans la région située au nord du Mackenzie. Plus au sud, ce groupe comprend les formations de Root River, de Vera et de Cadillac.

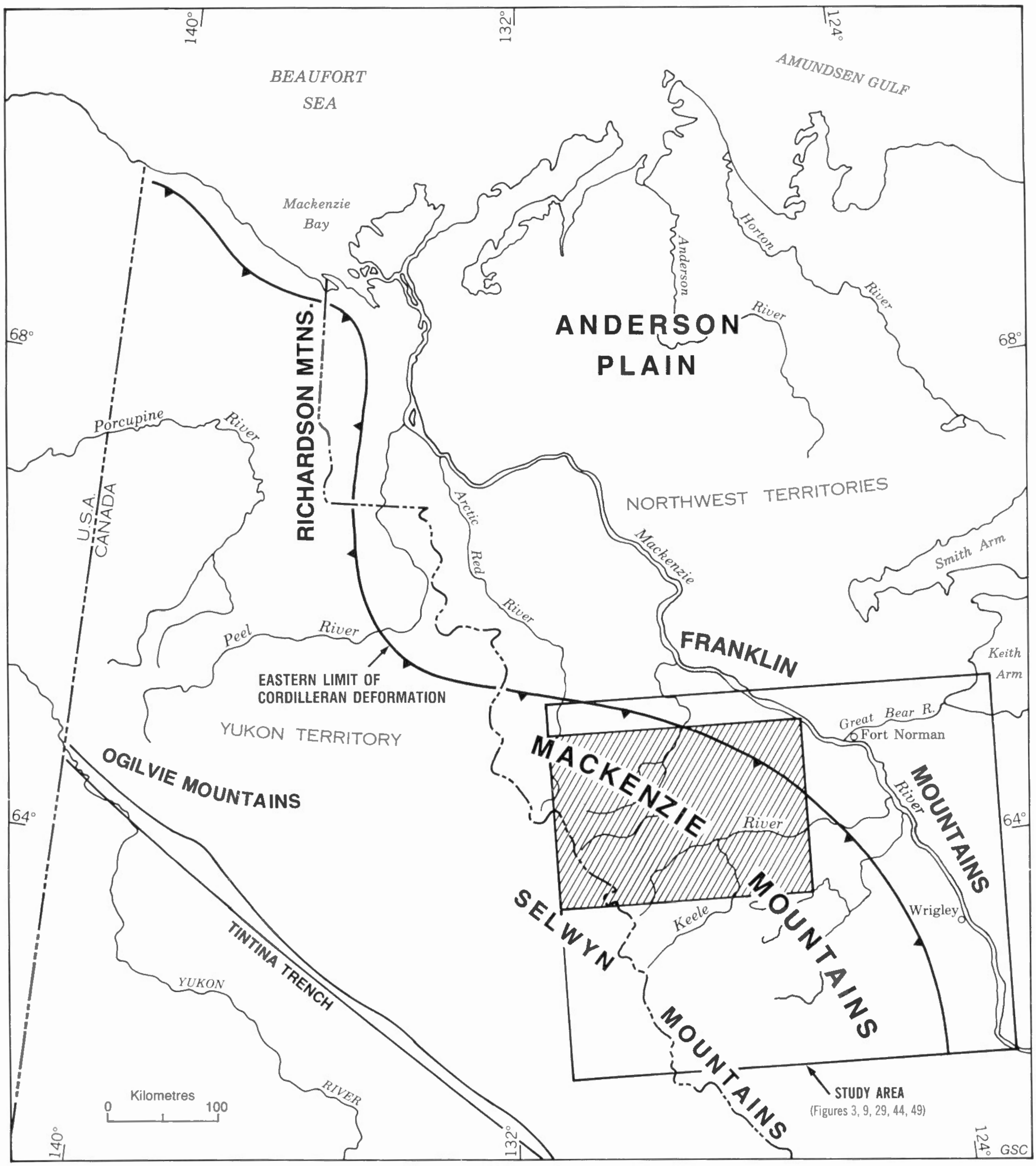

Figure 1. Index map of study region. Area studied most intensively is shown cross-hatched.

INTRODUCTION

The primary intent of this study is to elucidate the Silurian-Devonian geological history of the northern part of the Mackenzie Mountains (Fig. 1). The stratigraphic information provided by this study will provide a basis for more detailed, future stratigraphic, sedimentological or geochemical work concerning individual units within this Silurian-Devonian sequence and also will be an aid to future geological mapping in the Mackenzie Mountains, particularly in the Mount Eduni (106 A) and Bonnet Plume Lake (106 B) map areas. Information was gathered from as many stratigraphic sections as possible with the intent of obtaining a clear representation of the major regional lithological and thickness changes of the units examined.

In the study area, Silurian-Devonian strata lie almost entirely within the Mackenzie Shelf or miogeosyncline (Fig. 2). This shelf is defined here as an area occupied by lower Paleozoic carbonate strata within the Mackenzie and Franklin mountains and the Mackenzie Plain. The Silurian-Devonian deposits of this region may be conveniently assigned to three stratigraphic groupings, or assemblages. In ascending stratigraphic order these are: the Delorme Group (new group) comprising the Tsetso and Camsell formations; the Arnica-Bear Rock assemblage, which is composed of the Arnica, Sombre, Bear Rock and Landry formations; and, lastly, the Hume Formation, which in itself constitutes a distinct phase of sedimentation. In addition to information from the Silurian-Devonian sequence of the Mackenzie Shelf, some information was obtained from the basinal sequence in the Misty Creek Embayment (Cecile, 1982) sequence farther west, a shelfward extension of the Selwyn Basin, which embraces the basinal sediments adjoining the western margin of the Mackenzie Shelf (Gabrielse, 1967).

Location and accessibility

Data from fieldwork were acquired mainly from the Mount Eduni (106 A) and Bonnet Plume (106 B) map areas, with smaller amounts obtained from the Sekwi Mountain (105 P), Sans Sault Rapids (106 H) and Carcajou Canyon (96 D) map areas (Fig. 2). Field investigations took place over a two month period during the summer of 1977, when the author was part of a field party led by J.D. Aitken of the Geological Survey of Canada. This field party was based at a lake informally known as Palmer Lake in the central part of the Mount Eduni map area, at latitude 64°28′N and longitude 129°37′W. Camp provisions were flown in from Norman Wells, about 200 km east of Palmer Lake, by Nahanni Air.

Palmer Lake itself occupies a broad, northwest-southeast oriented valley at an elevation of about 3500 feet (1067 m). The surrounding mountains have peak elevations of about 6000 to 8000 feet (1829-2438 m) and are separated by broad, glacial valleys. A Totem Air Services jet ranger (Bell 206 B) helicopter provided local transportation for fieldwork around Palmer Lake.

Regional geological setting

Most modern continental areas are surrounded by topographic shelves of greater or lesser breadth, commonly between tens and hundreds of kilometres broad. These continental shelves are largely underlain by, or are inferred to be underlain by, continental crust, the upper surface of which is at a much lower elevation than the continental crust of the cratonic interior (Kinsman, 1975). The shelves are also commonly covered by a thick sequence of sediments deposited in water depths ranging from sea level to a maximum of about 200 m. The seaward limit of these shelves is marked by an abrupt change in slope termed the shelf edge break.

Ancient shelf sequences have been identified in various regions bordering the North American Craton. Most pertinent perhaps are the lower Paleozoic shelf sequences of the Cordilleran Structural Province (Wheeler et al., 1972; Aitken, 1978) and the Innuitian Province (Trettin et al., 1972), which together coincide with the entire mountainous region of western North America and the Arctic.

The shelf sequence examined in this study is part of the Cordilleran Miogeocline, a sedimentary prism of shelf deposits that forms a belt along the east side of the Cordilleran Structural Province (see Wheeler et al., 1972). The Silurian-Devonian depositional shelf sequence of the Mackenzie Mountains area is, however, separated from the Cordilleran miogeocline farther south in British Columbia by an extensive embayment, the Meilleur River Embayment (Fig. 2; Morrow and Cook, 1987). The Meilleur River Embayment may be considered to form the southern boundary of the Mackenzie Shelf sequence or Miogeocline. The location of the northern boundary is more difficult to determine, but may be considered to be in the region between 64°N and 65°N latitude at the northern end of the Misty Creek Embayment, the northernmost limit of the Selwyn Basin near the junction of the Ogilvie Arch and Richardson Trough (Cecile, 1982).

The eastern limit of the Mackenzie miogeoclinal assemblage may be placed at a line that forms the boundary of the east side of the Mackenzie Mountains

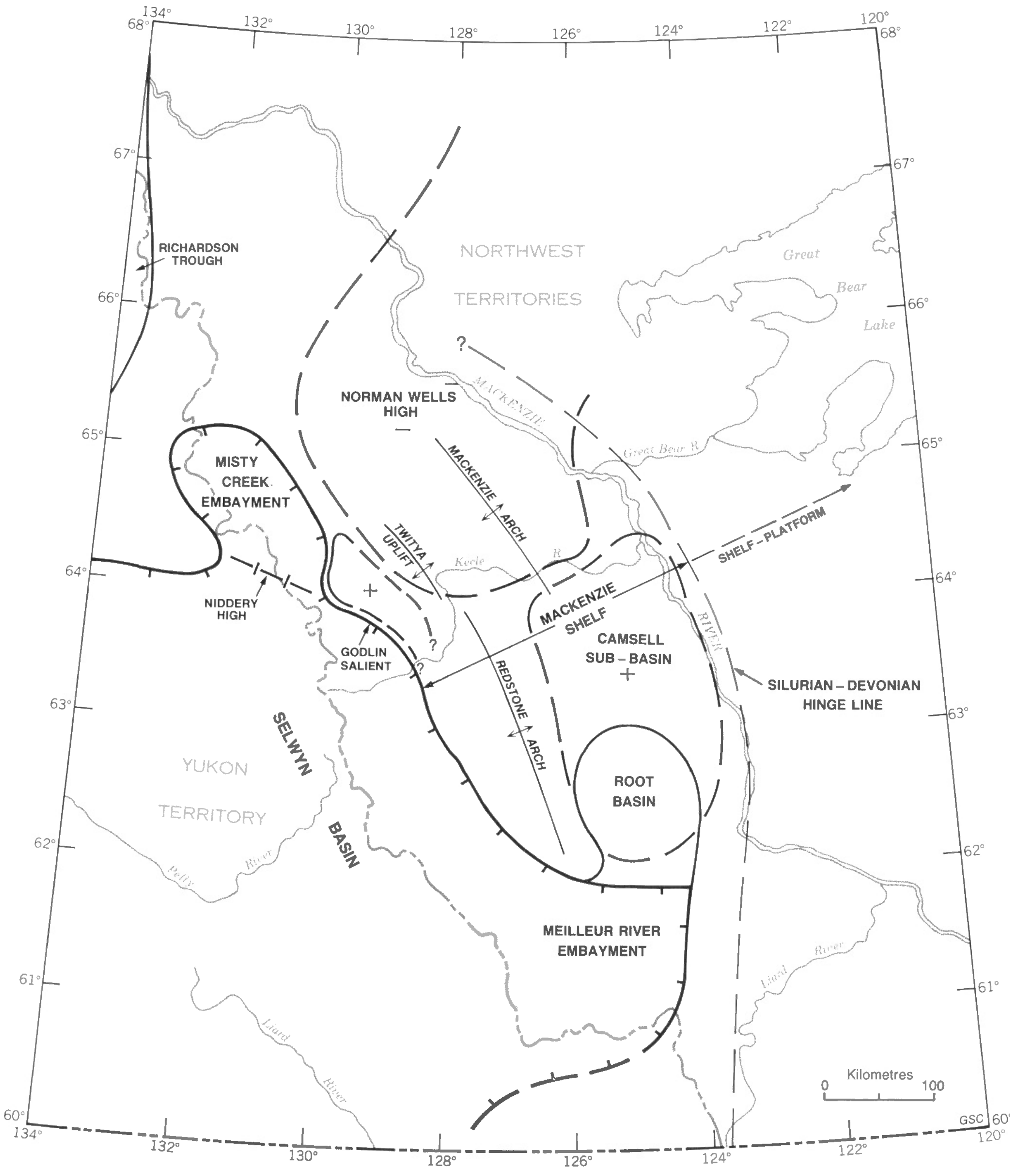

Figure 2. Distribution of regional tectono-sedimentological elements. The Mackenzie Shelf area contains several positive tectonic features such as Redstone Arch, Twitya Uplift and the Norman Wells High. Regions of intrashelf differential subsidence include Root Basin, the Camsell Sub-basin and Godlin Salient. A "plus" sign indicates the centre of a positive tectonic feature and a "negative" sign indicates the centre of a region of differential subsidence.

and accompanying smaller mountain ranges such as the Franklin Mountain Range (Fig. 2). This line separates the rapidly westward-thickening prism of sediments that forms the Mackenzie Miogeocline, from a thinner, Silurian-Devonian sequence of more uniform thickness. The influence of the shelf-platform boundary is clearly illustrated in Figure 4 of Law (1971). Griffin (1967) and Trettin (1972) have identified similar boundaries in the Silurian-Devonian strata of British Columbia and the Arctic Islands that separate uniformly thin, cratonic, shelf platform sequences of shallow water sediments from shallow water shelf sequences that thicken rapidly basinward, and have applied the name 'hinge line' to those tectonic platform-shelf boundaries. Similarly, the name 'hinge line' is applied to the platform-shelf boundary of the Mackenzie Shelf (Fig. 2).

The idea of the Mackenzie Shelf and Miogeocline is emphasized in this study to emend some previous studies in which the Mackenzie Shelf is not mentioned as a paleophysiographic element or tectonic entity. Law (1971) introduced the term Western Mackenzie Basin to describe the Silurian-Devonian tectonic setting of the Mackenzie Shelf region. This obscures the distinction between the shallow water shelf deposits of the Mackenzie Shelf area and the truly basinal rocks of the Selwyn Basin, farther west. A similar objection may be raised against the term Mackenzie Trough as used by Douglas et al. (1970). It is, of course, important to recognize that there are large-scale tectonic features within the shelf and platform areas that have influenced deposition profoundly in the Mackenzie Mountain region, but this fact should not be allowed to overshadow the basic distinction between depositional platform shelf (miogeocline) and basinal sequences, particularly where similar distinctions may be discerned in contiguous areas north and south of the Mackenzie region.

Early Paleozoic deposition on the Mackenzie Shelf has been influenced strongly by several intra-shelf tectonic features (Fig. 2). The Mackenzie Arch (Aitken et al., 1973), the Redstone Arch (Gabrielse, 1967) and Twitya Uplift (Cook and Aitken, 1978), and the Norman Wells High (Williams, 1975) were all positive tectonic features at various times during the early Paleozoic. These arches and uplifts were flanked by intrashelf regions of sediment accumulation such as the Root Basin (Gabrielse, 1967) and its successor basin, the Camsell Sub-basin (Williams, 1975) and the Godlin Salient, defined here for the first time as the thick wedge of Silurian-Devonian shelf sediments flanking the west side of Twitya Uplift. It is apparent that the Mackenzie Shelf region was characterized by a greater degree of differential intrashelf tectonic movement than the adjoining shelf region of British Columbia. This differential mobility is expressed in a correspondingly complex set of stratigraphic relationships, which form the subject of this report and that of Morrow and Cook (1987).

Previous work

Previous geological investigations in the broad region of the northern Mackenzie Mountains and the adjoining interior plains have been summarized by Aitken et al. (1982) and the reader is referred to that publication and those of Hume (1954) and Hume and Link (1945) for detailed accounts of early geological exploration in the northern Mackenzie Mountains. Geological investigations and studies that are most pertinent to this study began in the period following 1960. Studies of individual map areas that are most relevant to this report include those of Aitken et al. (1982) of the San Sault Rapids (106 H) and Upper Ramparts River (106 G) map areas, Aitken and Cook (1974a) of the Carcajou Canyon map area (96 D), Cook and Aitken (1976) of the Blackwater Lake (96 B) and Fort Norman (96 C) map areas, Aitken and Cook (1974b) of the Mount Eduni (106 A) and Bonnet Plume Lake (106 B) map areas, Blusson (1971) of the Sekwi Mountain map area (105 P), and Gabrielse et al. (1973) of the Flat River (95 E), Glacier Lake (95 L) and Wrigley Lake (95 M) map areas.

The stratigraphic studies of Tassonyi (1969), Williams (1977), Meijer Drees (1980; in press), Morrow and Meijer Drees (1981) and Cecile (1982) provide additional stratigraphic details of the Silurian-Devonian sequence of the northern Mackenzie Mountains region. Regional compilations and paleogeographic syntheses that are pertinent to this study include those of Bassett (1961), Basset and Stout (1967), Gabrielse (1967), Ziegler (1969), Law (1971) and Gilbert (1973).

Method of study

Twenty-one stratigraphic sections of Silurian and Devonian strata in the Mount Eduni (106 A), Bonnet Plume Lake (106 B), Sekwi Mountain (105 P), San Sault Rapids (106 H) and Carcajou Canyon (96 D) map areas were measured and described, and provided the basic data for this study (Fig. 3, Table 1 and Appendix 1). The total measured thickness of strata contained in these sections is 19 082 m, or an average thickness of about 900 m per section. Some Ordovician strata were included in some of these sections as well. In addition to these sections, four short stratigraphic sections of the thin, Tsetso and Bear Rock sequences overlying Precambrian strata near Twitya River were also measured. A total of 394 hand samples were collected from these sections, of which 22 are paleontological samples (Appendix 2) and the remainder are lithological samples. The data in these measured sections are supplemented by published information from 11 well sections and from 15 measured sections that have been published in Gabrielse et al. (1973) and in Douglas and Norris (1961).

The majority of hand samples were slabbed and many were polished for detailed examination, and 60 representative thin sections of these hand samples were examined. Identification of carbonate minerals was facilitated by the staining methods of Friedman (1959). X-ray diffraction analysis of 12 samples provided additional verification of minerals present (Table 2).

The amount and density of data are sufficient merely to indicate the major lithological changes between, and, to a lesser extent, within the formations that are examined. The Tsetso Formation and the breccias of the Camsell and Bear Rock formations were sampled more

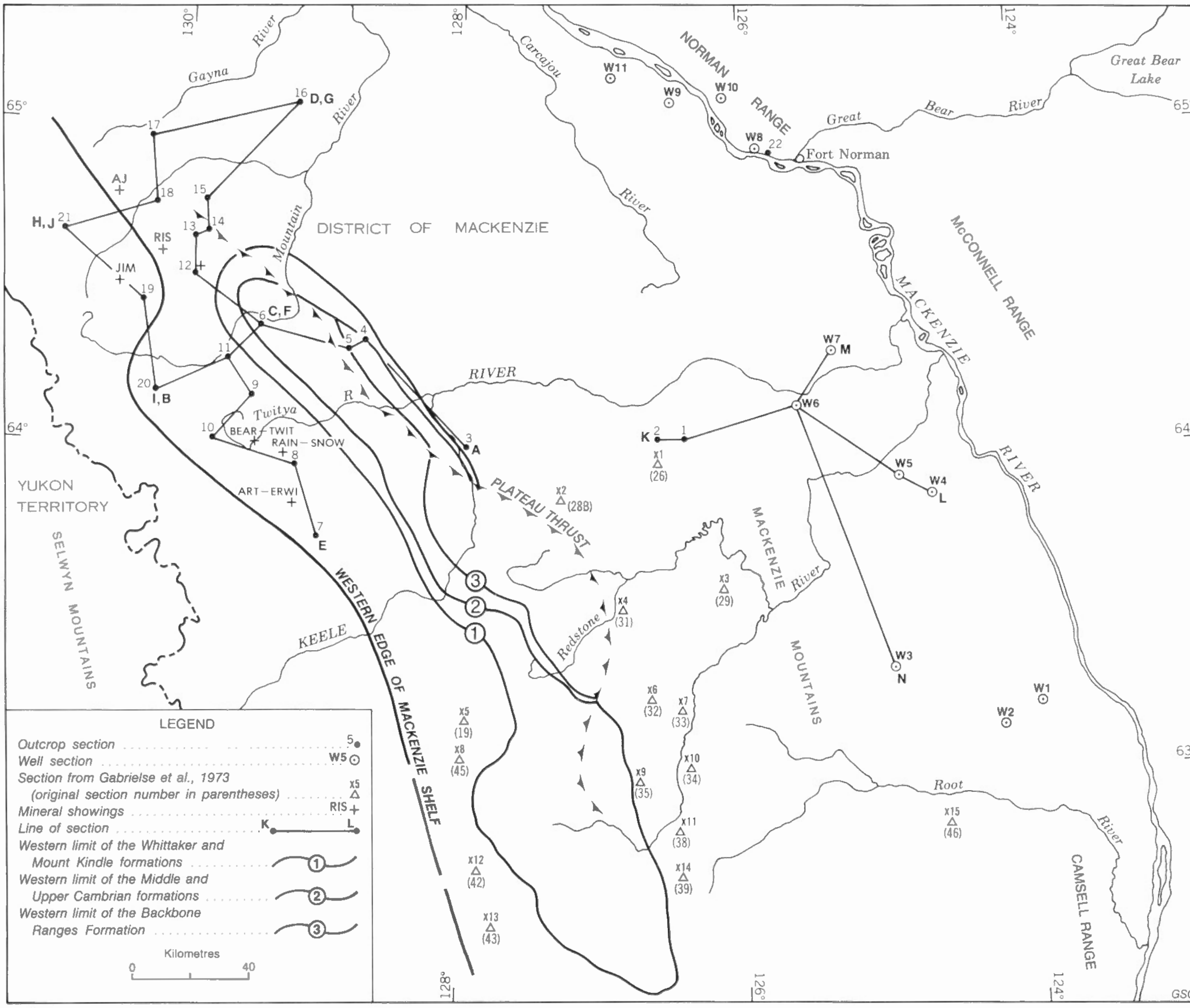

Figure 3. Locations of measured sections and well sections, lines of section from stratigraphic cross-sections, and locations of Silurian-Devonian zinc-lead showings. Also shown is a generalized subcrop map beneath the Delorme Group illustrating the limits of Twitya Uplift (after Cook and Aitken, 1978) with respect to the Plateau Thrust Fault. No attempt has been made to derive a palinspastic reconstruction. See Table 1 for sources of data and well and section names.

extensively than the other units, but any precise facies analysis will require much more meticulous and systematic sampling from more closely spaced sections.

The classification of Dunham (1962) was used for carbonate rock classification. Terrigenous sediments are classified according to Folk (1968). Bed thickness terminology is that of Zenger (1965) and Kahle and Floyd (1971).

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I would like to thank J.D. Aitken and D.G. Cook of the Geological Survey of Canada who organized logistical support in the summer of 1977 and who provided background information concerning the character and distribution in the field of the Silurian-Devonian sequence of the northern Mackenzie Mountains. Discussions with M.P. Cecile, D.G. Cook, and J.D. Aitken contributed to many of the ideas contained in this study. B.D.E. Chatterton of the University of Alberta and B.S. Norford and A.E.H. Pedder of the Geological Survey of Canada identified most of the fossil faunas that were collected. In the field I was ably assisted by C. Black, K. Kingsmith, R. Sandau and K. Sharman. Critical readers D. Pugh and A.W. Norris also provided useful suggestions for the improvement of this paper.

STRATIGRAPHIC NOMENCLATURE

The stratigraphic chart shown in Figure 4 illustrates the formational nomenclatures that have been applied to lower Paleozoic strata in a series of map areas along a corridor across the northern Mackenzie Mountains and across the interior plains east of the Mackenzie Mountains. The ages of units shown in this chart are derived from reports dealing with these map areas or from notes in the legends accompanying geological maps of these areas. The units examined in this study include all the Silurian and Devonian strata contained between the laterally very continuous, dark, chert-bearing dolostones of the Mount Kindle Formation and the Middle and Upper Devonian shales of the Hare Indian, Canol and Besa River formations. This sedimentary package is also bounded by two fossiliferous and well-dated formations. The Mount Kindle Formation, which underlies the sequence, is reliably dated as Late Ordovician to Early Silurian (Llandovery) (Norford and Macqueen, 1975; Ludvigsen, 1975). The age of the uppermost formation of the sequence, the Hume Formation, has been dated as Middle Devonian, almost entirely Eifelian (or Couvinian) in age with a few metres of Givetian beds at the top (Lenz and Pedder, 1972; Bassett and Stout, 1967). Little biostratigraphic information is available concerning the Late Silurian and Early to Middle Devonian sequence between these two well-dated intervals, however, and the relative time relationships of units within this sequence have been inferred largely from lithostratigraphic studies (Aitken and Cook, 1974c). Some new faunal data that aid in interpreting the time relationships are presented in this report (Appendix 2).

A basic regional understanding of the lithostratigraphy of this sequence cannot be derived from the stratigraphic framework provided by previous studies (Fig. 4). Perhaps the major stratigraphic problem is the relationship of rocks mapped as the Delorme Formation or as the Unnamed Silurian-Devonian (SD) map unit (Aitken and Cook, 1974c; Aitken et al., 1982) to rocks of the Camsell and Bear Rock formations. In addition, it is likely that the argillaceous and sandy, yellow and orange dolostones that occupy the stratigraphic interval between the grey limestone breccia of the Bear Rock Formation and the underlying dark dolostones of the Mount Kindle Formation should not be included in the Delorme Formation. Aitken et al. (1982) and Aitken and Cook (1974b) have expressed reservations concerning the inclusion of these rocks in the Delorme Formation because they are unfossiliferous and are far from the type area of the Delorme Formation in the Root River map area (95 K) in the southern Mackenzie Mountains. A more compelling objection to the inclusion of these strata in the Delorme Formation is derived from the redefinition and replacement of the Delorme Formation itself by a number of new units of formational rank: the Root River Formation, the Cadillac Formation and the Vera Formation (Morrow and Cook, 1987) and the Tsetso Formation (Meijer Drees, in press). The Delorme Formation has been rendered an obsolete name by Morrow and Cook (1987) and the reader is referred to that publication for a discussion of the stratigraphic problems that have been created by the use of the term Delorme Formation throughout the Mackenzie Mountains. Their objection to the use of the term Delorme Formation is based primarily on the fact that a wide variety of lithofacies, mappable at a 1:250 000 scale, were included within the Delorme Formation unlike the more lithologically homogeneous formations that overlie and underlie Delorme beds.

The uncertainty in the correlation of these strata with the Camsell and Bear Rock formations has been discussed by Aitken and Cook (1974b) and by Williams (1975). Aitken and Cook (1974c) present alternative models for correlations between these formations but favour the interpretation that the Camsell Formation may be correlated entirely with the lower part of the Bear Rock

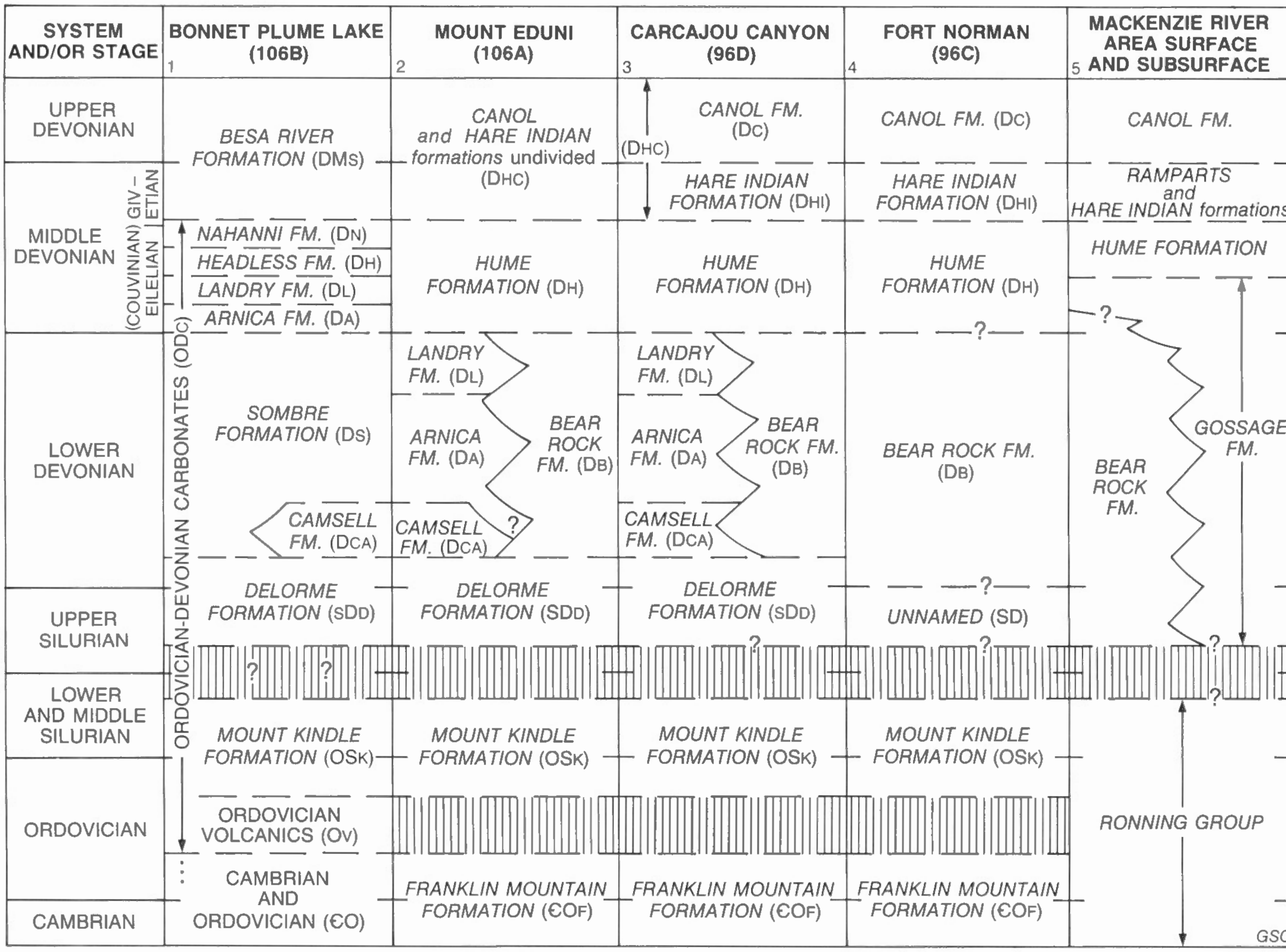


Figure 4. Chart of published stratigraphic nomenclature for the northern Mackenzie Mountain region. (Columns 1 to 5 inclusive are after Blusson, 1975; Aitken and Cook, 1974a; Aitken and Cook, 1974b; Cook and Aitken, 1976; and Tassonyi, 1969, respectively.)

Formation in the Carcajou Canyon map area. In a stratigraphic study of these units in the region of the northern Mackenzie Mountains, based mainly on subsurface data, Williams (1975) favoured the alternative interpretation – that the Camsell Formation is stratigraphically entirely beneath the Bear Rock and Arnica formations and bears no facies relationship to these units. This alternative relationship is favoured also by Blusson (1971) for the Sekwi Mountain map area (105 P) and by Gabrielse et al. (1973) for the Flat River, Glacier Lake and Wrigley Lake map areas (95 E, L, M). A major part of this report is devoted to resolving these differences.

Other problems concerning stratigraphy and correlation, which are illustrated in Figure 4, include the relationship of the Arnica, Landry and Hume formations east of the Bonnet Plume Lake map area, to the Sombre, Arnica, Landry, Headless and Nahanni formations in the Bonnet Plume Lake map area. The subsurface Gossage Formation is not dealt with in this report, but it is clear from Aitken et al. (1982) and from Pugh (1983) that the three members of this formation correspond to the "Delorme" or Unnamed Silurian-Devonian (Tsetso Formation), and Arnica and Landry formations, and that the term, Gossage Formation, may become obsolete. The obsolete term, Ronning Formation, has now been replaced by the terms, Mount Kindle Formation and Franklin Mountain Formation (Norford and Macqueen, 1975). Pugh (1983) raised the Ronning Formation of previous usage (Tassonyi, 1969) to group status.

The evidence provided by this study has led to the adoption of the set of stratigraphic relationships and correlations illustrated in Figure 5. Some important features of this stratigraphic scheme for the northern Mackenzie Mountains, which represent changes from

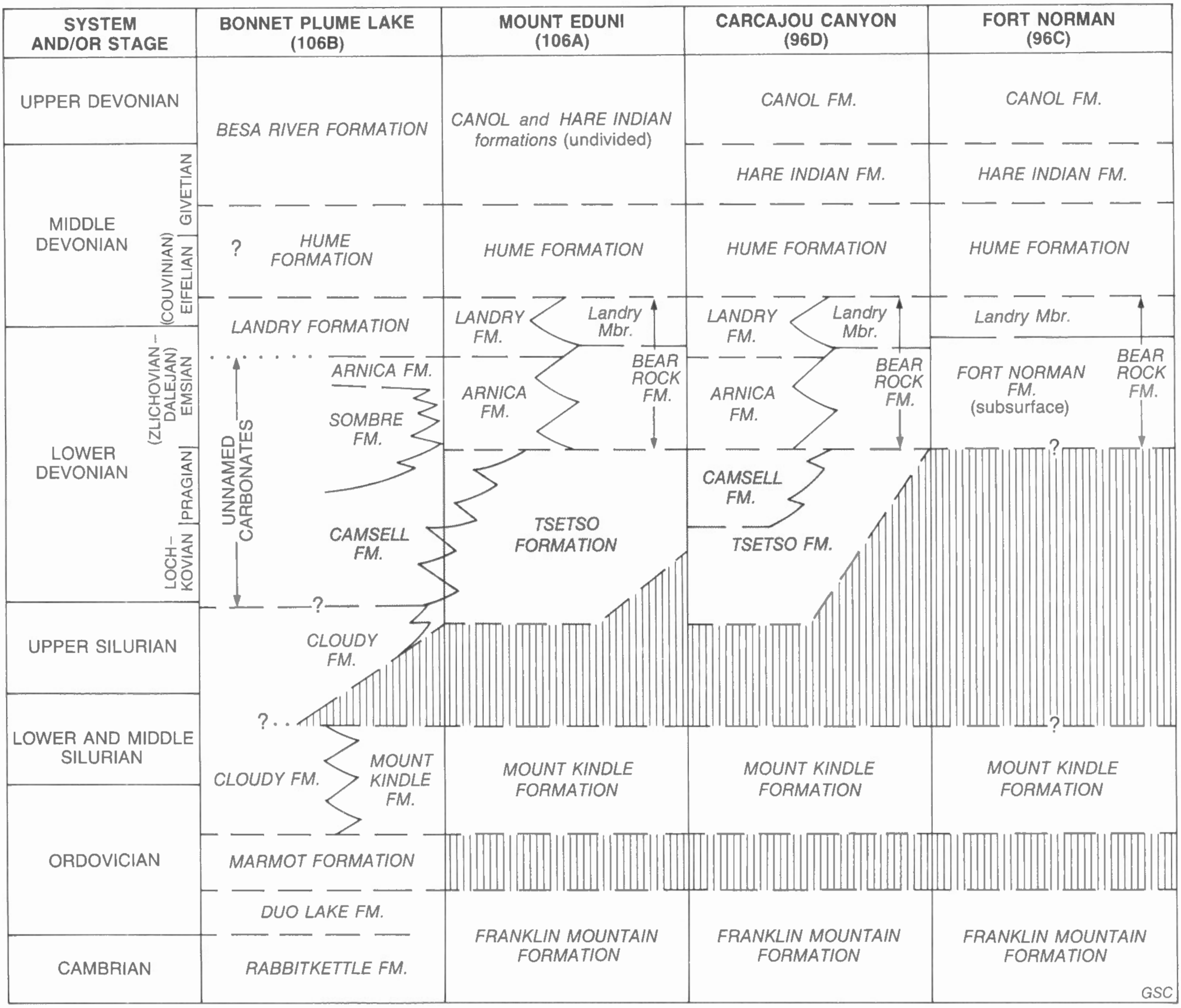


***Figure 5.** Chart of revised stratigraphic nomenclature for the northern Mackenzie Mountain region, as used in this report; shaded area indicates Delorme Group.*

previously published correlations, include the replacement of the Delorme Formation as a formation name by the term Tsetso Formation; the recognition that the Camsell formation underlies entirely the combined Arnica-Bear Rock sequence; and the inclusion of the Tsetso and Camsell formations within a new group, the Delorme Group. Minor changes involve the relationship of the Landry and Hume formations, the relationship of the Sombre Formation to the Arnica Formation and the nature of the profound "sub-Devonian unconformity" above the Mount Kindle Formation across this region. Recent stratigraphic work by Cecile (1982) in the Bonnet Plume Lake map area has been incorporated into this revised stratigraphic chart.

STRATIGRAPHIC ASSEMBLAGES OF THE MACKENZIE SHELF

The subdivision of this Silurian-Devonian formational sequence into groups or assemblages of genetically-related formations highlights the major factors that influenced sedimentation on the Mackenzie Shelf. The transition from one assemblage to another is marked by abrupt changes in patterns of sedimentation. This sequence is readily divisible into three such formational assemblages, designated the Delorme assemblage, the Arnica-Bear Rock assemblage and the Hume Formation. In this context, the Hume Formation is regarded as an assemblage in its own right, composed, in the Mackenzie

Mountains, of two, well defined members (Aitken et al., 1982; Pugh, 1983). It is inferred, with some support from faunal data, that the transitions between these assemblages approximate synchronous surfaces across which patterns of sedimentation were altered abruptly. This is, of course, a generalization, which for certain parts of the shelf, particularly near the shelf edge, is not entirely valid, but nonetheless provides a reasonable basis for the discussion and description of Silurian-Devonian shelf sedimentation across the shelf area as a whole.

The deposition of facies (i.e., formations) within these assemblages and the abrupt transitions between assemblages were caused primarily by the interplay of tectonics and sea level changes and, secondarily, by the influence of climate or climatic changes and also by the purely sedimentological controls that influenced shelf sedimentation.

Delorme assemblage

The Delorme assemblage is identical to the Delorme Group and is composed of the Camsell Formation and the Tsetso Formation.[1] This assemblage is a record of sedimentation that occurred during the Late Silurian to earliest Devonian transgression onto the subaerially exposed surface at the top of the Mount Kindle Formation. The sediments of this assemblage tend to be argillaceous, yellow and orange, peritidal and supratidal dolostones and evaporites that display considerable regional variation in thickness and lithological facies.

Arnica-Bear Rock assemblage

The Arnica-Bear Rock assemblage is composed of the Arnica, Sombre, Bear Rock and Landry formations. It is a record of carbonate platform sedimentation on a subsiding shelf. In contrast to the bright colours of the underlying silty and argillaceous Delorme assemblage, this assemblage is characterized by rocks of a sombre grey colour, containing very little terrigenous material. Thickness and facies variations are far less pronounced in the Arnica-Bear Rock assemblage than in the Delorme assemblage. Dolostones and limestones of the Sombre and Arnica formations dominate this assemblage on the outer part of the shelf, whereas evaporites predominate in the inner shelf region.

[1]This includes the Unnamed Silurian-Devonian (SD) map unit in the Mackenzie Mountains.

Recently, Pugh (1983, p. 27) suggested that much of the strata included here in the informal Arnica-Bear Rock assemblage be included in a Bear Rock Group in the subsurface of the Peel River map area. Norris (1985) has extended this group name into the northwest part of the Mackenzie Mountains. However, the use of the name Bear Rock Group is not adopted in this report for the following reasons:

1. The Arnica Formation and the combined Fort Norman and Bear Rock formations (Meijer Drees, in press) are, for the most part, geographically separate in the northern Mackenzie Mountain region (Fig. 29). This geographic separation of facies is less evident farther north in the Peel River map area, where the Fort Norman, Arnica and Landry formations occur in stratigraphic sequence as mappable formations (Pugh, 1983).

2. The Bear Rock Formation, as defined by Hume and Link (1945) and as subsequently mapped in the northern Mackenzie Mountains, cannot be subdivided into regionally mappable members that could themselves be raised to formational status. In other words, the Bear Rock "Group" in the region of outcrop of the Bear Rock Formation could be represented only by strata of this formation. The erection of a group with the name Bear Rock would entail giving the strata previously mapped as Bear Rock Formation a new formation name if the Bear Rock "Group" were considered to include all strata contained in the Arnica-Bear Rock assemblage. The desire to create a group name is not, in itself, sufficient reason to change an existing, useful formational name.

3. It would also be possible to designate a Bear Rock "Group" to include all strata included in the Arnica-Bear Rock assemblage with the exclusion of the Bear Rock Formation itself. In other words, in the area of occurrence of the Bear Rock Formation, the Bear Rock "Group" would be merely a formation. Unfortunately, the adoption of a Bear Rock "Group" defined in this manner that does not include the Bear Rock Formation itself compromises the utility of the term Bear Rock "Group" as a name to embrace all the strata included in the Arnica-Bear Rock assemblage.

Certainly a formal group name to embrace the strata included in the Arnica-Bear Rock assemblage is desirable. However, designation of a new name for this group is deferred to a subsequent report.

TABLE 1

Formation (and member) thicknesses (in metres)

Section[1]	Location (latitude; longitude)	Sub-Mount Kindle	(Cloudy) Mount Kindle	Delorme Group (undifferentiated) Tsetso	Camsell breccia	Camsell banded	Arnica (Sombre)	Bear Rock	Landry (Landry Mbr. of Bear Rock)	Hume (Headless-Nahanni)	Arnica platform dolomite
1	64°01′ 126°28′		20.0+	427.0	142.0			282.0	(28.0)	176.0	67.0?
2	64°01′ 126°30′	89.0+	407.0	264.0				226.5+			
3	64°02′ 127°55′	254.5+	112.5	12.0				69.0	(39.0)	63.0+	
4	64°21′ 128°38′	177.5+		118.5				141.0	(13.0)	135.0	
5	64°18′ 128°47′	8.0+		114.5				45.0+			
6	64°23′ 129°25′	66.0+		33.0			248.0		60.0+		
7	63°43′30″ 129°02′	20.0+	205.5*	337.5		165.0	(950.0) estimated		83.0	112.5	
8	63°52′ 129°12′		20.0+	259.0	414.0		363.0		505.0	50.0+	168.0?
9	64°12′ 129°27′		75.0+	126.0	571.5	234.0	295.5		261.0	20.0+	48.0?
10	64°00′ 129°43′	446.0+	315.0	113.0			381.5		319.0	90.0+	65.0?
11	64°17′ 129°38′		8.0+	46.5	375.0	159.0	301.5		156.0	138.0+	133.5?
12	64°32′ 129°52′		10.0+	184.5			131.0		115.5+		
13	64°37′ 129°53′		172.5+	36.0			152.0		147.0	147.0	
14	64°43′ 129°52′	283.0+	148.5	65.5			121.5		146.5		

TABLE 1

Formation (and member) thicknesses (in metres) - Continued

Section[1]	Location (latitude; longitude)	Sub-Mount Kindle	(Cloudy) Mount Kindle	Delorme Group (undifferentiated) Tsetso	Camsell breccia	Camsell banded	Arnica (Sombre)	Bear Rock	Landry (Landry Mbr. of Bear Rock)	Hume (Headless-Nahanni)	Arnica platform dolomite
15	64°43′ 129°49′	20.0+	-271.0	9.0			189.0		165.0	159.0+	
16	65°02′ 129°17′		183.0+	28.5				87.0	(120.0)	91.5+	
17	64°57′ 130°17′		20.0+	25.0			94.5		240.5	15.0+	
18	64°43′ 130°10′		30.0+	24.0			102.0		204.0	145.0	
19	64°28′ 130°17′	401.5+	160.0+								
20	64°11′ 130°08′	366.0+	276.0			315.0	(669.0)		60.0	121.5+	
21	64°39′ 130°45′	490.5+	360.0+*						24.5?	200.0	
22	64°52′ 124°37′		142.0+	34.0				81.0+			
W1	64°13′33″ 123°54′32″				546.0+ 4670[2]		352.0 2585	137.0 3740	47.0[3] 2432	251.0 1257	146.0 4190
W2	63°09′17″ 129°11′50″				1463.0 6270		671.0 4070		128.0 3650	231.0 2893	177.0 5690
W3	63°19′41″ 124°56′35″				2062.0+ 5250		1163.0 300	124.0 4112	75.0+ 55		223.0 4520
W4	63°52′59″ 124°39′15″							1445.0 5014	120.0 4620	213.0[3] 3545	84.0+ 9750
W5	63°55′44″ 124°52′39″						122.0 6900	1062.0 7300	201.0 6240	222.0 5517	163.0+ 10 780
W6	64°08′43″ 125°34′55″				1219.0+ 2790		56.0 717	576.0 900	45.0 568	174.0+ 0	80.0 2245

TABLE 1

Formation (and member) thicknesses (in metres) - Continued

Section[1]	Location (latitude; longitude)	Sub-Mount Kindle	(Cloudy) Mount Kindle	Delorme Group (undifferentiated)			Arnica (Sombre)	Bear Rock	Landry (Landry Mbr. of Bear Rock)	Hume (Headless-Nahanni)	Arnica platform dolomite
				Tsetso	Camsell breccia	Camsell banded					
W7	64°19′12″ 125°19′20″				320.0+ 8625		81.0 6943	314.0 7210	89.0 6650	206.0 5974	117.0 8240
W8	64°56′01″ 125°50′54″							189.0 2920	17.0 2863	105.0 2520	
W9	65°07′20″ 126°28′51″		3340					311.0 2320	46.0 2170	115.0 1793	
W10	65°07′51″ 126°05′00″		1865					285.0 930	26.0 845	114.0 470	
W11	65°11′06″ 126°54′23″		4510					286.0 3573	19.0 3510	107.0 3160	
X1	63°57′ 126°36′				235.0		(436.0+)				
X2	63°51′ 127°13′				72.0		(119.0) 108.0		256.0	(119.0+)	
X3	63°37′ 126°10′				1009.0		(723.0)		(178.0)	(262.0+)	
X4	63°31′ 126°48′				229.0		(124.0+)				
X5	63°10′ 127°53′				351.0+						
X6	63°40′ 126°15′				326.0		(229.0) 171.0		177.0		
X7	65°12′ 126°25′						(393.0) 368.0		154.0	(244.0)	
X8	63°03′ 127°57′				76.0+		(480.0) (140.0+)				
X9	62°59′ 126°42′				225.0		(239.0)		203.0	(165.0)	

TABLE 1
Formation (and member) thicknesses (in metres) - Continued

Section[1]	Location (latitude; longitude)	Sub-Mount Kindle	(Cloudy) Mount Kindle	Delorme Group (undifferentiated) Tsetso	Camsell breccia	Camsell banded	Arnica (Sombre)	Bear Rock	Landry (Landry Mbr. of Bear Rock)	Hume (Headless-Nahanni)	Arnica platform dolomite
X10	63°02′ 126°22′					416.0+	(357.0) 342.0		210.0	(323.0)	
X11	62°48′ 126°28′					598.0					
X12	62°42′ 127°50′									(336.0)	
X13	62°33′ 127°25′									(203.0+)	
X14	62°42′30″ 126°29′						(515.0) 470.0		201.0	(380.0)	
X15	62°45′ 125°15′			881.0 (Whittaker)		1524.0	(488.0) 640.0		91.5	(314.0)	

*Mount Kindle equivalent.

[1]Sections 1-21 inclusive area sections measured during the course of this study. Sections W1-W11 inclusive are subsurface sections from wells. Sections X1-X15 are surface sections published by Gabrielse et al. (1973) and Douglas and Norris (1961).

[2]Numbers in italics indicate formation tops in feet below kelly bushings of wells for subsurface sections.

[3]These intervals contain fault repeats (see Meijer Drees, 1980).

[4]The well names are:

W1	Decalta et al. Wrigley I-54	(6460 ft/1969 m T.D.)
W2	Shell West Wrigley G-70	(1463 ft/446 m T.D.)
W3	IOE et al. Dahadinni I-70	(12013 ft/3662 m T.D.)
W4	Candel et al. Dahadinni M-43A	(10024 ft/3055 m T.D.)
W5	Shell Cloverleaf I-46	(11313 ft/3448 m T.D.)
W6	Amoco et al. Red Dog K-29	(7050 ft/2149 m T.D.)
W7	Candel et al. Stewart B-30	(9671 ft/2948 m T.D.)
W8	Imperial Canol Bluefish I-A	(3539 ft/1079 m T.D.)
W9	Imperial Loon Creek No. 2	(5093 ft/1552 m T.D.)
W10	Imperial Vermilion Ridge No. 1	(5972 ft/1820 m T.D.)
W11	Imperial Loon Creek No. 1	(5450 ft/1661 m T.D.)

[5]Sections X1-X14 from Gabrielse et al. (1973). Accompanying numbers in brackets are original section numbers of Gabrielse et al. (1973). X1(26); X2(288); X3(29); X4(31); X5(19); X6(32); X7(33); X8(45); X9(35); X10(34); X11(38); X12(42); X13(43); X14(39); X15, this section is from Douglas and Norris (1961) and contains the type section of the 'Delorme Formation' of Douglas and Norris (1961).

[6]Section 22 is section MTA-80-3 in Morrow and Meijer Drees (1981).

[7]The Arnica platform dolomite is part of either the Bear Rock Formation or the Arnica Formation in surface sections but is a separate unit beneath Bear Rock evaporites in well sections. The entire interval, including Arnica platform dolomite, Bear Rock, and Arnica could be assigned entirely to the Bear Rock or Arnica formations depending on the proportion of evaporites present.

TABLE 2

Mineralogical data

Section	Formation	Cumulative thickness above base in metres	GSC locality number	Sample field number	Illite	Quartz	Calcite	Dolomite
13	Arnica	23.2	C-075532	A8C		2	96	2
13	Arnica	150.5	C-075533	A10a		4	24	72
5	Bear Rock	12.5	C-075573	C14	1	4	88	7
4	Bear Rock	14.0	C-075593	D15b	1	2	26	71
6	Camsell	247.5	C-075623	F6c			89	11
6	Camsell	370.5	C-075624	F8			94	6
6	Camsell	531.5	C-075630	F11c	2	4	77	17
15	Bear Rock	8.5	C-075774	P3b		1	34	65
9	Camsell	359.9	C-075844	V12		1	19	80
8	Camsell	117.0	C-075788	Q5a	2	3	95	
1	Bear Rock	112.0	C-079686	MP4c		1	33	66
14	Arnica (Bear Rock tongue)	109.5	C-079696	MM8		1	37	62

Hume assemblage

The Hume Formation itself is considered here to be an assemblage with a tectono-sedimentological importance equivalent to the other formational assemblages because it represents a profound change in the pattern of shelf sedimentation from the underlying Arnica-Bear Rock assemblage. Unlike the underlying assemblages, the Hume assemblage is a very fossiliferous and argillaceous, open marine limestone deposited entirely in subtidal environments, and it extends across the entire region of the northern Mackenzie Mountains and adjacent parts of the Interior Plains and Franklin Mountains with only minor facies variations and a remarkably uniform thickness. This is in strong contrast to the marked facies and thickness variations characteristic of the underlying assemblages.

PRE-DELORME STRATA

Pre-Delorme formations on the shelf

Strata on the Mackenzie Shelf beneath the sub-Devonian unconformity were not studied systematically but they were examined at many localities (Table 1). The generalized distribution of pre-Delorme units is outlined in Cook and Aitken (1978) and in Figure 3. The Upper Ordovician and Lower Silurian Mount Kindle Formation underlies and is separated from the Delorme Group by the 'sub-Devonian' unconformity at the base of the Delorme Group throughout most of the northern part of the Mackenzie Mountains (Figs. 3, 6).

Formations older than the Mount Kindle directly underlie the Delorme Group in the region affected by Twitya Uplift. In this region, uplift along a northwest-southeast axis occurred after deposition of the Mount Kindle Formation and before deposition of the overlying strata of the Delorme Group. This uplift caused both the Upper Cambrian and Lower Ordovician Franklin Mountain Formation and the older, Proterozoic to Lower Cambrian sequence beneath the regional sub-Franklin Mountain unconformity to be exposed following deposition of the Mount Kindle Formation (Figs. 3, 6). This period of erosion associated with the sub-Devonian unconformity in the region of Twitya Uplift has exhumed the sub-Franklin Mountain sequence in a paleo-inlier surrounded by the Mount Kindle and Franklin Mountain formations (Cook and Aitken, 1978). The sub-Franklin Mountain sequence dips uniformly southwestward beneath the sub-Devonian unconformity in the region affected by Twitya Uplift (Fig. 6) reflecting the fact that this sequence forms part of the southwest flank of the much larger and older Mackenzie Arch (Aitken et al., 1973).

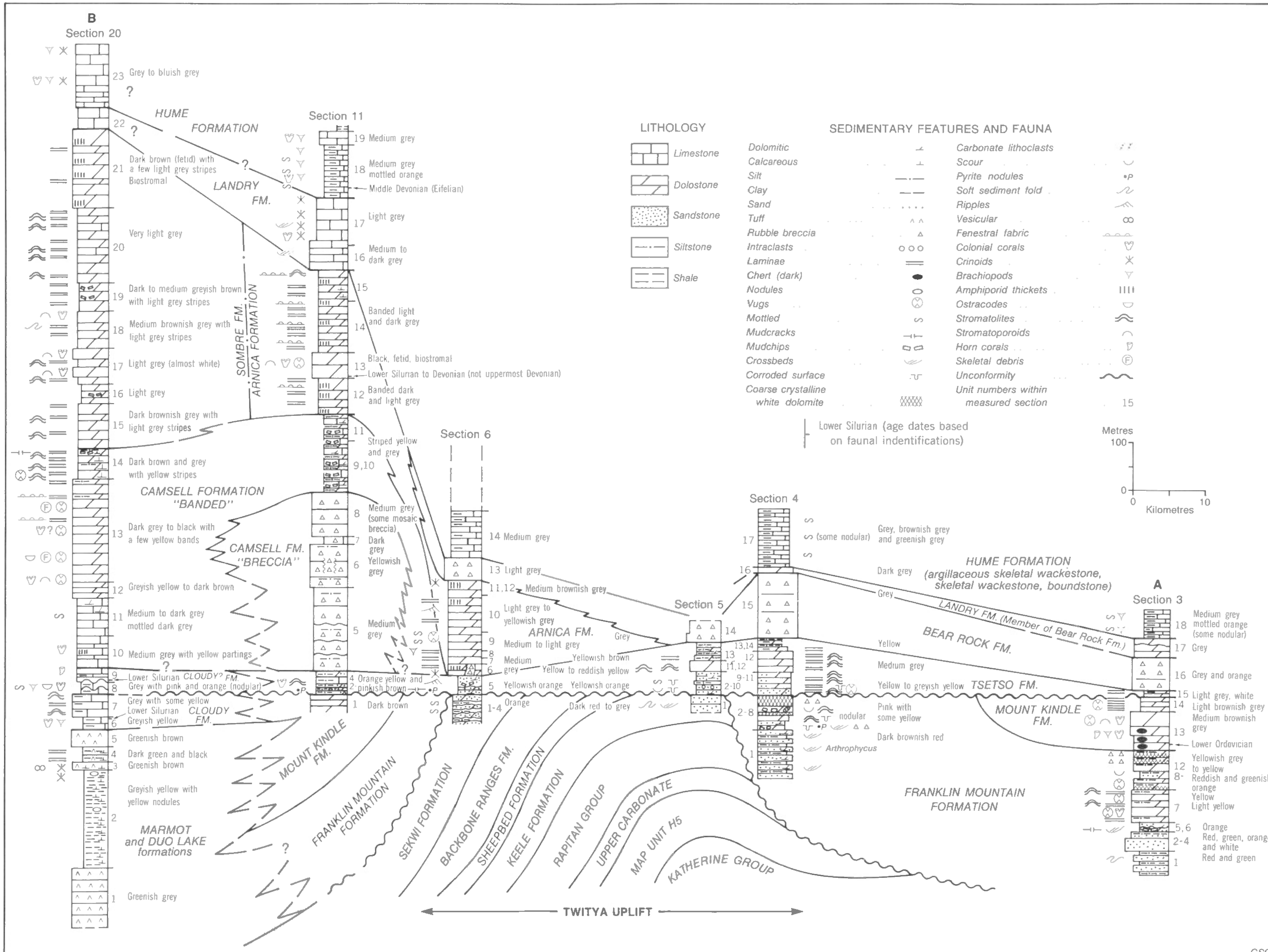


Figure 6. Stratigraphic cross-section of Twitya Uplift along the line of section A-B in Figure 3.

Lithological and other data concerning the sub-Delorme sequence have been published previously (Aitken et al., 1973). For the purpose of this study it is worthwhile only to note that a considerable part of this sequence is either dominantly sandstone (e.g., Katherine Group, Backbone Ranges Formation and lower part of Franklin Mountain Formation) or contains an admixture of sand (e.g., Map unit H5 of Aitken and Cook (1974a), Rapitan Group and Sekwi Formation); and that iron-bearing orange and red beds occur in many parts of this sequence (Aitken et al., 1973; Fig. 6). The siltstone, sandstone and iron oxides that were eroded from the sub-Delorme sequence during the period of subaerial exposure associated with Twitya Uplift may have been reworked into the silty and sandy beds of the Tsetso and Camsell formations. Many of the quartzarenite sandstone beds in the sub-Delorme sequence (Fig. 6) resemble the orange quartzarenite sandstones in the overlying Delorme Group.

Pre-Delorme formations in the Misty Creek Embayment and Selwyn Basin

The lower Paleozoic pre-Delorme sequence in the basinal sequence of the Misty Creek Embayment has been described recently by Cecile (1982) and the stratigraphic nomenclature applied by Cecile to this sequence is utilized in this study (Fig. 5). The shelf-to-basin correlations suggested by Cecile for the pre-Delorme sequence are consistent with those inferred from the data of this study (Figs. 7, 8).

The Upper Cambrian and Lower Ordovician Franklin Mountain Formation may be correlated with the silty lime mudstone and shales of the Rabbitkettle and Duo Lake formations (Cecile, 1982) in the basinal sequence. Similarly, the overlying Mount Kindle Formation may be correlated with the argillaceous dolostone of the Mount Kindle transition strata and the Cloudy Formation (Cecile, 1982; Figs. 6, 8). The lithological and faunal attributes of the Rabbitkettle, Duo Lake and Cloudy formations and the Mount Kindle transition strata have been described in detail by Cecile (1982). The reader is referred to the measured section descriptions in Appendix 1 for details concerning the lithology and fauna in the basinal units of the Misty Creek Embayment in the three sections studied (Secs. 19-21) that include these units. The thin bedded, chert-bearing, dark dolostone of the Mount Kindle transition strata are similar to those of the Whittaker Formation in the region of Root Basin in the southern Mackenzie Mountains (Morrow, 1982a), and it may be appropriate to include the Mount Kindle transition strata in the Whittaker Formation. The Whittaker Formation is mapped extensively in most areas south of the Bonnet Plume Lake map area (106 B) on the west side of Redstone Arch; for example, in the Sekwi Mountain map area (105 P) (Blusson, 1971). The Mount Kindle transition strata in the Bonnet Plume Lake map area may be regarded as simply a northward extension of the slope and basinal chert-bearing dolostones of the Whittaker Formation in the Sekwi Mountain map area (Blusson, 1971).

Volcanic tuffs and sandstones and flow rocks of the Marmot Formation (Cecile, 1982) are exposed in Section 20 (Fig. 6). This section is located 7 km east-northeast of Section 17 of Cecile. Cecile reported the occurrence of two-holed crinoids in the limestone beds within the upper part of the Marmot Formation in Section 17, and assigned an Early Devonian age as an upper age limit to the Marmot Formation on the basis of this occurrence. However, the faunal identifications from that part of the carbonate sequence directly overlying the Marmot Formation in Section 20 of this study indicate that this formation is no younger than Late Silurian at Section 20 (Fig. 6, Table I). This may be interpreted as indicating that the Devonian part of the Marmot Formation has a much smaller geographic distribution than the older, Silurian and Ordovician parts of this formation.

THE DELORME ASSEMBLAGE

Delorme Group

The use of the term "Delorme Formation" in quotation marks is intended to mean the Delorme Formation of previous usage (Douglas and Norris, 1961). This formation in the southern Mackenzie Mountains has been superseded by a threefold subdivision comprising the Root River, Vera and Cadillac formations (Morrow and Cook, 1987; map areas 95 F, 95 G). Morrow and Cook also suggested raising the "Delorme Formation" to group status but did not propose this formally because they examined the Delorme and equivalent strata only over a part of its extent in the Mackenzie Mountains.

The data of this study, in conjunction with the data supplied by Morrow and Cook (1987) and by Meijer Drees (in press) provide a firm basis for a change in the stratigraphic rank of the "Delorme Formation" to group status (Fig. 5). It is desirable to retain the name Delorme for the strata of this group because they previously have been mapped extensively as the "Delorme Formation" throughout the Mackenzie Mountains (Fig. 4).

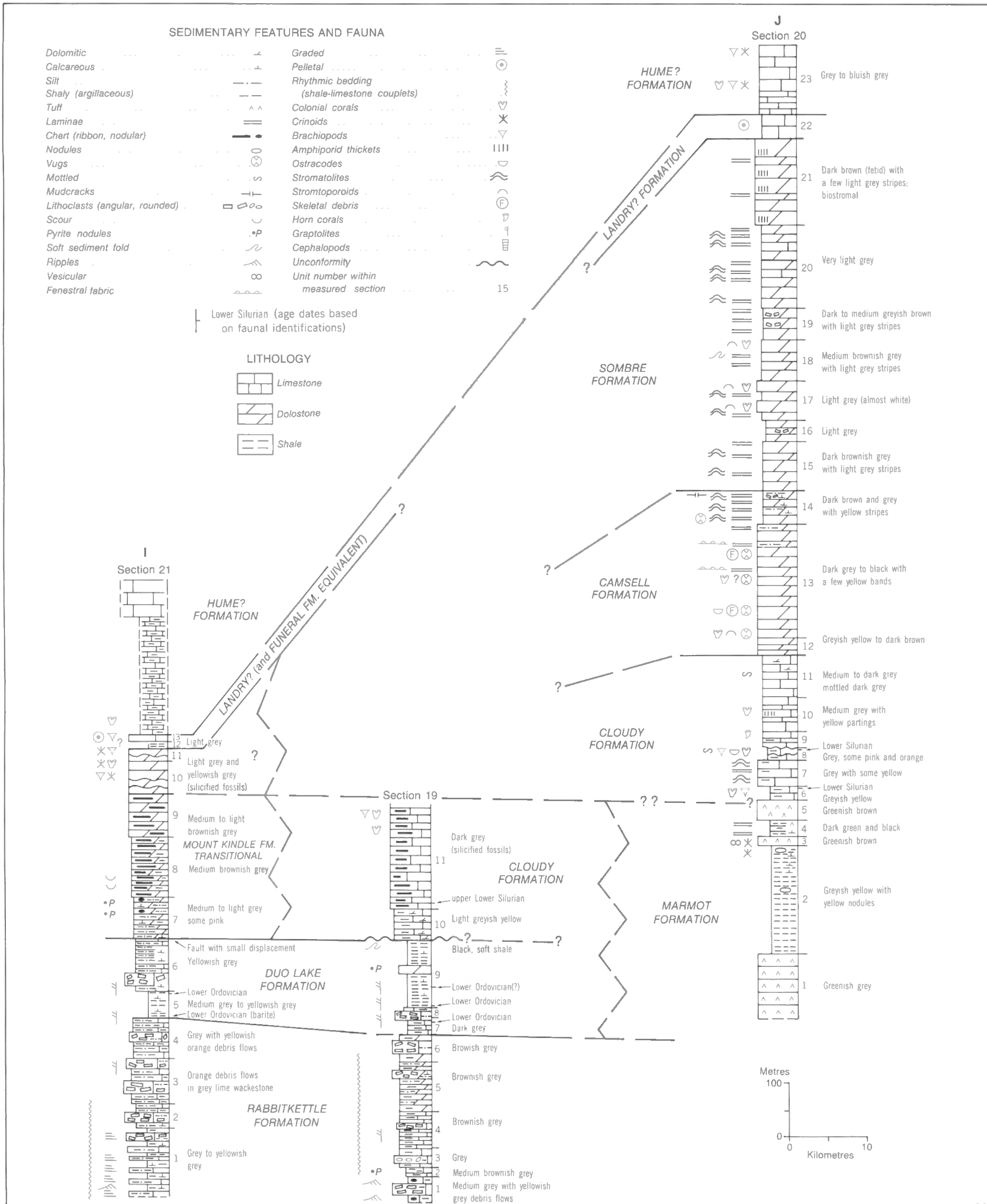


Figure 7. *Stratigraphic cross-section along the line of section I-J in Figure 3. Shelf-to-basin transition in the region of Godlin Salient.*

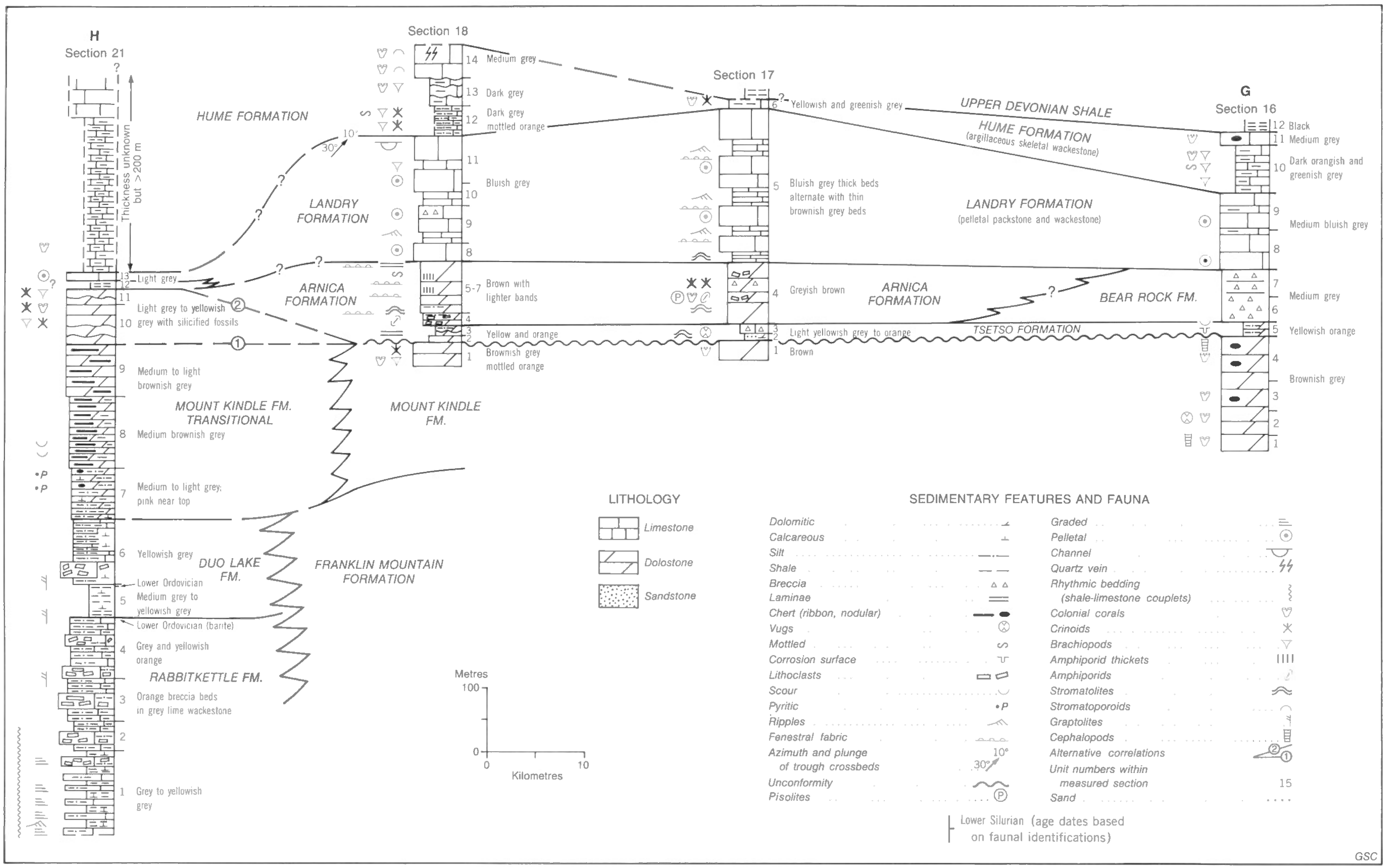


Figure 8. *Stratigraphic cross-section along the line of section G-H in Figure 3. Shelf-to-basin transition in the region of Misty Creek Embayment.*

In addition to strata previously mapped as "Delorme Formation", two other units are included in the Delorme Group: the Unnamed Silurian-Devonian (SD) map unit beneath the Bear Rock Formation of the Interior Plains and Franklin Mountains regions (Aitken and Cook, 1974a; identified in this report as part of the Tsetso Formation), and the Camsell Formation in the Mackenzie Mountains (Fig. 4). These units have been included in the Delorme Group for the following reasons:

1. Strata identical to the Unnamed Silurian-Devonian map unit (i.e., Tsetso Formation) have been mapped already as part of the "Delorme Formation" described by Aitken and Cook (1974b) in the Carcajou Canyon map area (96 D), in the Dahadinni River map area (95 N) (Douglas, 1974), and also in the Mount Eduni map area (106 A) (Aitken and Cook, 1974a).

2. Strata between the Whittaker and Sombre formations in the Glacier Lake and Wrigley Lake (map areas 95 L, M) have been mapped as part of a map unit that is assigned to the Delorme Formation but includes strata of both the Delorme and Camsell formations (Gabrielse et al., 1973). This is true also for the Delorme Formation mapped by Blusson (1971) in the Sekwi map area (105 P). No consistent distinction or criteria for distinguishing between the "Delorme" and Camsell formations are evident in these studies.

3. Strata that have been mapped previously as part of the "Delorme Formation" appear to be correlative with the combined Unnamed Silurian-Devonian map unit and the Camsell Formation in areas such as the Mount Eduni and Bonnet Plume Lake map areas (106 A, B) as shown in Figures 4 and 5.

4. Strata in both the Camsell Formation and the Tsetso Formation contain a significant admixture of terrigenous silt, sand and argillaceous material, and are stained yellow and orange by iron oxides. These components may have had a common origin or source, and their occurrence in both the Tsetso Formation and the overlying and laterally equivalent Camsell Formation is a further argument in support of the inclusion of these units in the same group

Tsetso Formation (Unnamed Silurian-Devonian)

Except for the region of the Norman Wells High in the northeast, where rocks of the Delorme Group are absent (Fig. 9), the Tsetso Formation extends across the entire study area. In map areas across the northern Mackenzie Mountains and in the adjoining Interior Plains, the strata that are included here in the Tsetso Formation have been mapped previously as either "Delorme" Formation or as an unnamed Silurian-Devonian map unit (Figs. 4, 5). The Tsetso ranges in thickness from a feather edge in the region of the Norman Wells High to a maximum thickness of 337.5 m in Section 8. Most sections of this unit, however, are less than 150 m thick (Table 1). It is composed predominantly of light-yellow weathering, argillaceous and silty, thin to medium planar bedded dolostone. In many thin stratigraphic sections of the Tsetso this may be the only rock type present (Figs. 8, 10).

Thicker sections commonly contain a variety of rock types, including: light yellow-grey, thick bedded and vuggy dolostones; greenish grey, medium to thick planar beds of lime mudstone and intraclastic (i.e., lithoclastic) lime wackestone; orange-yellow, platy, laminated to very thin bedded silty dolostone or dolomitic siltstone; and orange weathering, dolomitic, fine to medium sandstone (Figs. 6, 10). In some parts of the Mount Eduni map area a tripartite division is evident, similar to that described by Aitken and Cook (1974a) in which thin to thick bedded, light yellow and grey dolostones are sandwiched between more recessive, orange, silty and sandy beds at the base and at the top of the Tsetso Formation (Figs. 6, 11).

Sandstone forms a significant part of the Tsetso Formation in the region of Twitya Uplift (Fig. 11) in Sections 4, 5, 6 and 9 (Figs. 6, 12) as solitary beds (Fig. 13A) or in small groups of beds. Most of the sand may be classified, according to the classification of Folk (1968), as a fine sandstone: dolomitic and hematitic mature quartzarenite (Fig. 13B) that also contains some grains of microcline, orthoclase and chert. Detrital dolomite sand occurs in some beds (Fig. 13C). Many of these sandstones are polymodal, with a well sorted, fine sand mode at about 0.1 to 0.2 mm and a coarser, moderately to well sorted mode at 1.0 mm (Fig. 13B). Common and undulose quartz (Folk, 1968) forms most of the quartz grain fraction but a few polycrystalline grains are present also. Thin laminae of dolomicrite (aphanocrystalline dolomite) and reworked platy clasts and chips of dolomicrite occur within many sandstone beds (Fig. 14). Much of the sandstone in the Tsetso Formation resembles sandstone that occurs in formations beneath the sub-Devonian or sub-Delorme unconformity (Fig. 6). In particular, the petrographic characteristics of sandstones in the Franklin Mountain Formation are very similar to those in the Tsetso Formation (Fig. 13D). Indeed, parts of the Franklin Mountain Formation are indistinguishable in the field from sequences in the Tsetso.

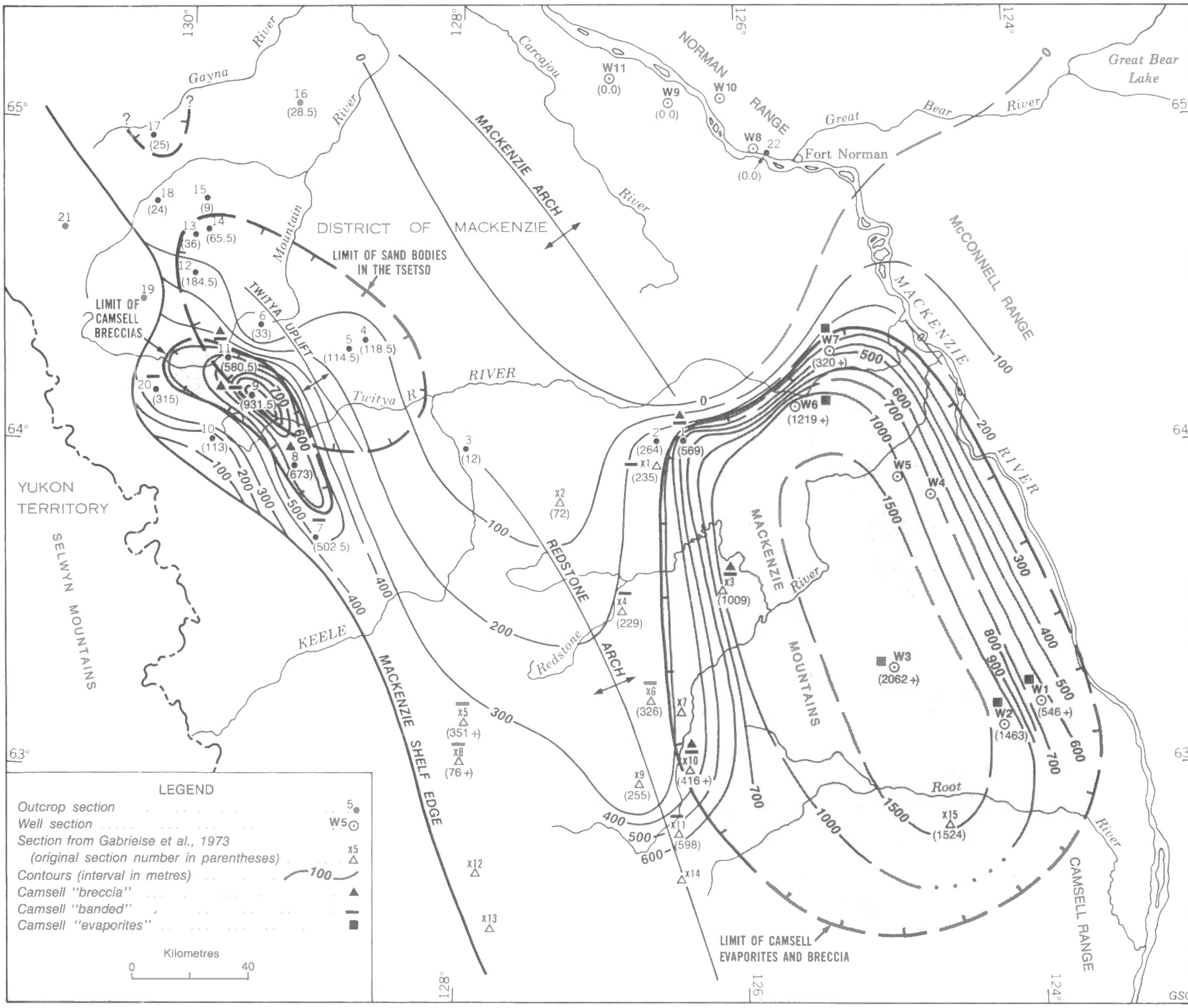


Figure 9. Distribution and thickness of the Delorme Group and the distribution of major laterally equivalent facies within this group, the Tsetso Formation and the Camsell Formation. Evaporites of the Camsell Formation are confined to the regions of the Camsell Sub-basin and the Godlin Salient (Fig. 2). See Table 1 for identification of wells and sections.

The thin bedded, yellow weathering dolomicrites contain a variety of small-scale, bed surface and intrabed sedimentary features. These include finely laminated and stromatolitic beds (Figs. 6, 15). Laminated intervals contain solitary, scattered, platy clasts and aggregates of clasts of reworked dolomicrite. A few bed surfaces display small-scale ripples (Fig. 16A). Mudcracks are common in some of the more argillaceous and platy intervals (Fig. 16B). The upper surfaces of some dolomicrite beds are pock-marked with small solution pits (Figs. 6, 11) and, in Section 5, some larger scale solution features are developed. These large solution features occur as subvertical pipes of red coloured, more oxidized dolomicrite (Fig. 16C). The reddish material appears merely to line the pipe, and the central part of the pipe may have been hollow. In some pipes, the reddish material is a dolomite-cemented crackle breccia (Fig. 16D). Both the small-scale solution pitting and the solution pipes probably developed after lithification and during a period of subaerial exposure, and the bed surfaces containing or overlying these features are interpreted as minor unconformities (Fig. 11).

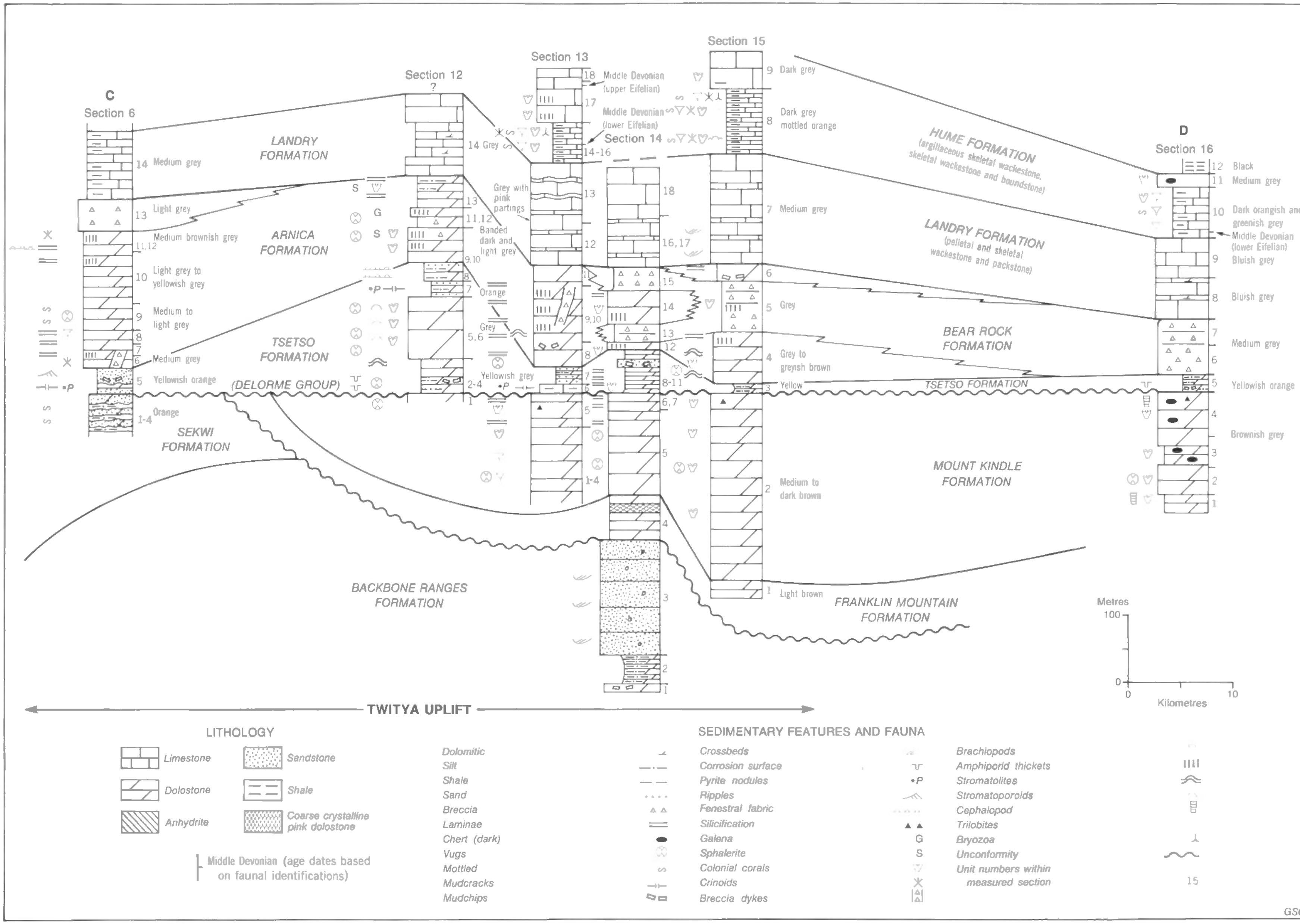


Figure 10. Stratigraphic cross-section along the line of section C-D in Figure 3 through the northern part of Twitya Uplift.

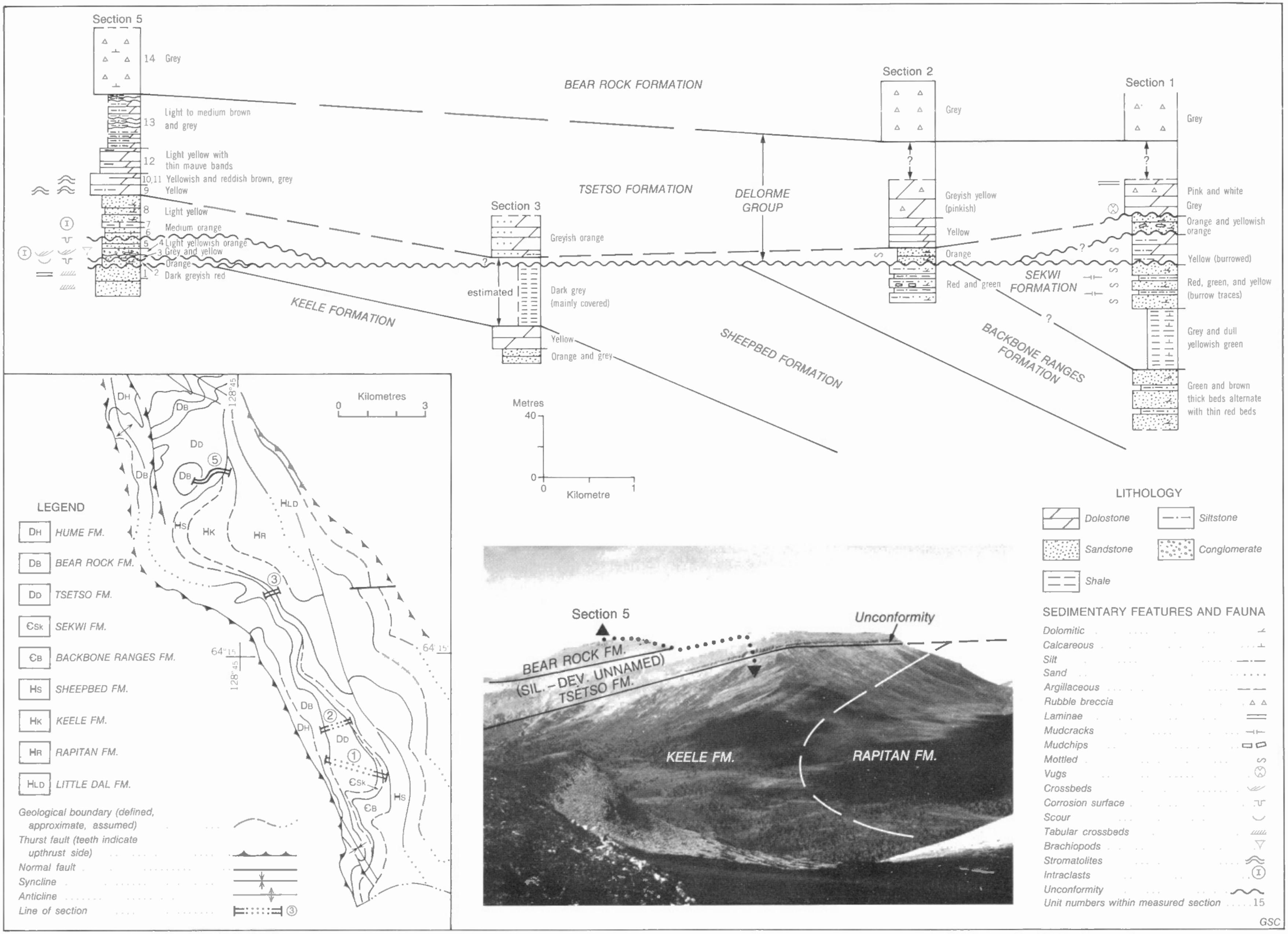


Figure 11. *A detailed stratigraphic cross-section along a southeast-northwest line of section through the centre of Twitya Uplift. Strata of the Tsetso Formation contain several unconformities in addition to the unconformity at the base of the sequence. Inset geological map shows location of measured sections. Photograph of Section 5 shows a south facing exposure of the Tsetso. Note the dip divergence of bedding beneath the 'sub-Devonian' unconformity (GSC photo no. 1184-B).*

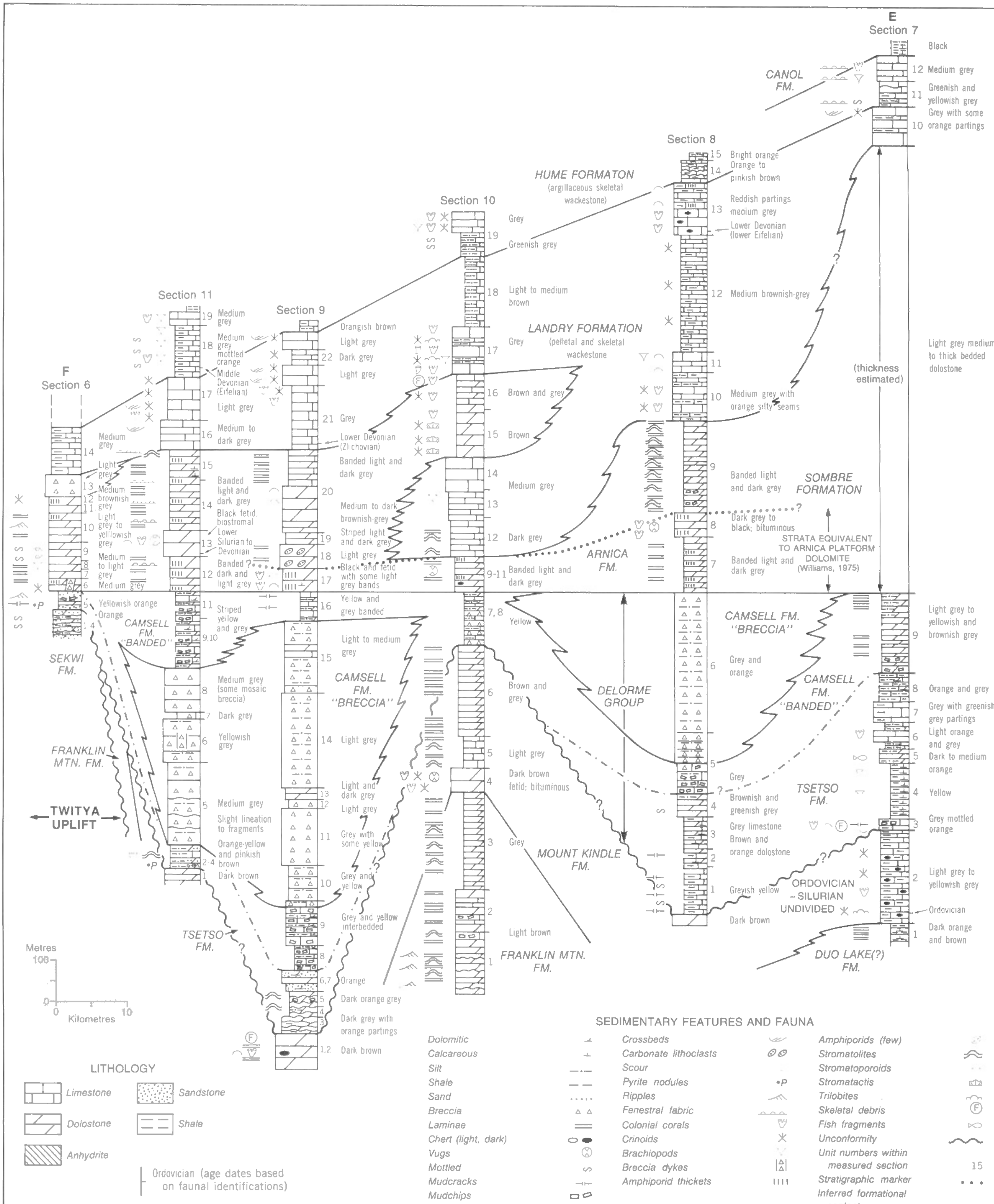


Figure 12. Stratigraphic cross-section along the line of section E-F in Figure 3 through the region of Godlin Salient.

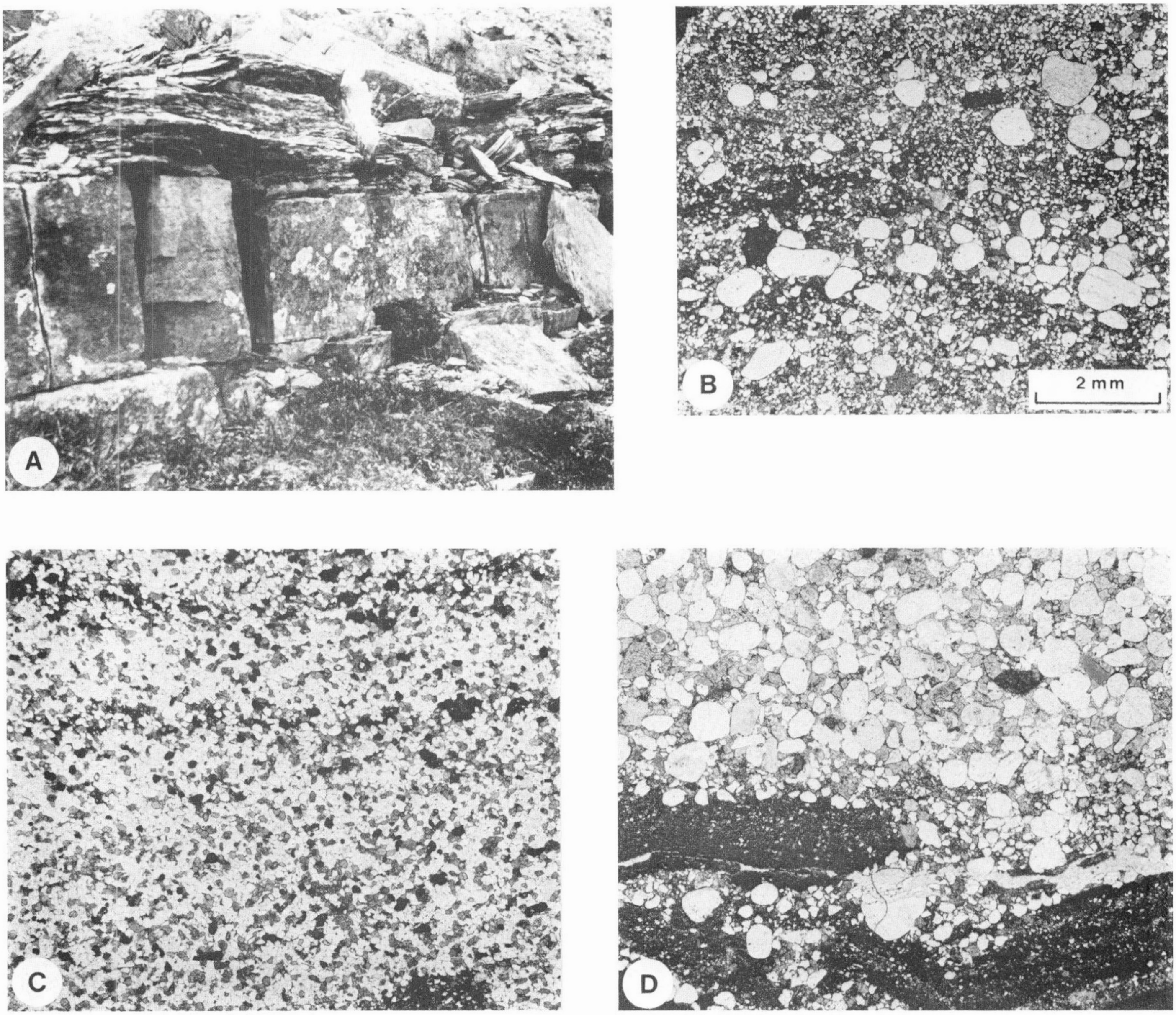


Figure 13. *Photographs of an outcrop of the Tsetso Formation and of thin sections of the Tsetso and Franklin Mountain formations.*

A. *A 0.5 m thick planar, orange sandstone bed overlain by very thin, lenticularly bedded, yellow silty dolostone, 125 m above the base of the Tsetso Formation in Section 9 (GSC photo no. 2011-7).*

B. *Photomicrograph of fine to medium sandstone: bimodal, supermature, dolomite-cemented quartzarenite, 27 m above the base of the Tsetso Formation in Section 6 (GSC loc. C-075507) (GSC photo no. 2015-12).*

C. *Photomicrograph of fine sandstone: dolomitic and hematitic, mature, dolarenitic quartzarenite, 165 m above the base of the Tsetso Formation in Section 12. Detrital dolomite grains are abundant (GSC loc. C-075880) (GSC photo no. 2015-14).*

D. *Photomicrograph of coarse sandstone: dolomitic and hematitic, mature chert and feldspar-bearing quartzarenite, 10 m below the top of the Franklin Mountain Formation at Station 2 (Fig. 11). Bimodal Franklin Mountain sand is similar to sands in the overlying Tsetso Formation (GSC photo no. 2015-10).*

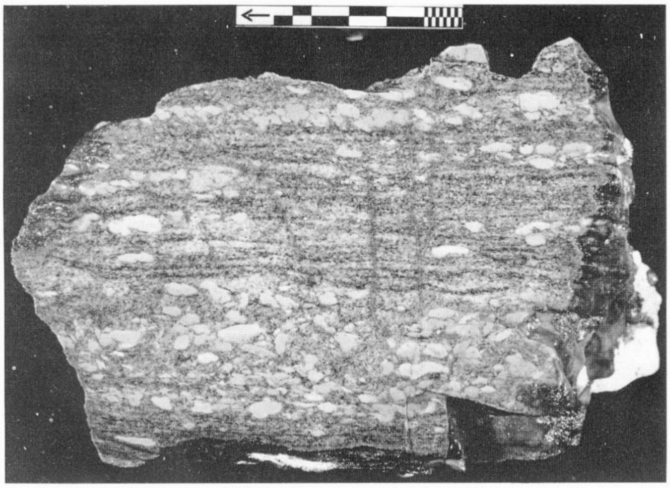


Figure 14. Polished hand specimen of medium grained, dolomitic and hematitic sandstone from the Tsetso Formation that contains abundant granule- and pebble-sized chips of laminated dolomite. These may have been mudchips reworked from supratidal flats during storm-related activity. Sample from the Tsetso Formation at Section 14, 65.5 m above the base of the unit (GSC photo no. 2014-16).

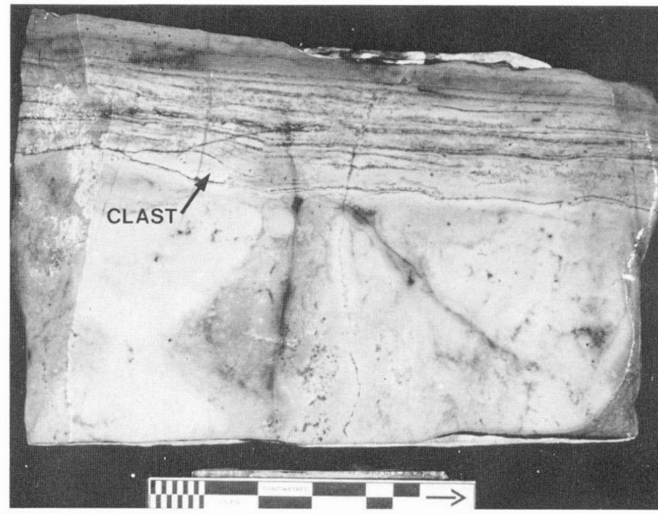


Figure 15. Polished hand specimen of yellow, laminated, aphanocrystalline dolostone or dolomicrite from the Tsetso Formation. Dolomite intraclasts lie on the contact between the laminated and nonlaminated dolostone indicating that this contact was an exposure surface. The laminated dolostone is interpreted as the result of supratidal deposition, whereas the nonlaminated part may be intertidal in origin. Sample from 9 m above the base of the Tsetso Formation in Section 16 (GSC photo no. 2014-10).

The thick bedded, vuggy dolostones that, in some areas, form a resistant, middle band within the Tsetso Formation are composed of fine to medium crystalline, partly sucrosic dolomite (Fig. 17A). In some places, colonial corals, small hemispheroidal stromatoporoids and amphiporids can be discerned (Fig. 17B). Most vugs appear to be the result of the leaching of biogenic material. In Section 12, galena and sphalerite line some of these vugs (Cecile and Morrow, 1978; Fig. 10). Commonly, however, these vugs are lined with white, very coarse crystalline dolomite. This vug-filling dolomite has been stained pink in some places.

Limestone beds are not common, but they do occur as thin intervals in Sections 5 and 13 within the sandy sequence in the region of Twitya Uplift (Figs. 10, 11). Intraclastic packstone and wackestone form most of these limestones, and pale green to bright green argillaceous material forms bed partings. Thinner beds are more argillaceous, and a few contain poorly developed mudcracks and display fenestral fabric. Pockets of green clay containing lime mudchips also occur within some beds. Pyrite tends to be concentrated along bed partings but some occurs within beds (Fig. 18). Unit 4 in Section 5 (Figs. 11, 19A) is an unusual, 4 m thick interval of crossbedded, medium sandstone and conglomeratic sandy limestone. Subrounded, tabular to equant clasts of pelletal grainstone are abundant, and, in places, the rock may be classified as a sandy rudstone in which the limeclasts form a grain-supporting fabric (Fig. 19B). The sand component in these impure quartzarenite beds is medium to coarse grained with an average grain size of 0.4 mm, and contains a significant admixture of orthoclase and microcline.

The Tsetso overlies the Mount Kindle Formation and older formations with a sharp, unconformable contact, particularly in the region of Twitya Uplift (Fig. 6). In areas beyond Twitya Uplift, this contact is disconformable rather than an angular unconformity, but the uppermost bedding surface of the Mount Kindle Formation beneath the Tsetso commonly displays solution pits infilled by Tsetso sediment. The contact of the Tsetso with formations that overlie the Tsetso is sharp but conformable.

Faunas in the Tsetso Formation are sparse. Poorly preserved corals and stromatoporoids occur in the middle resistant band, which is developed where the Tsetso is relatively thick in the region of Twitya Uplift (Fig. 6). Brachiopods and fish fragments occur in some sections

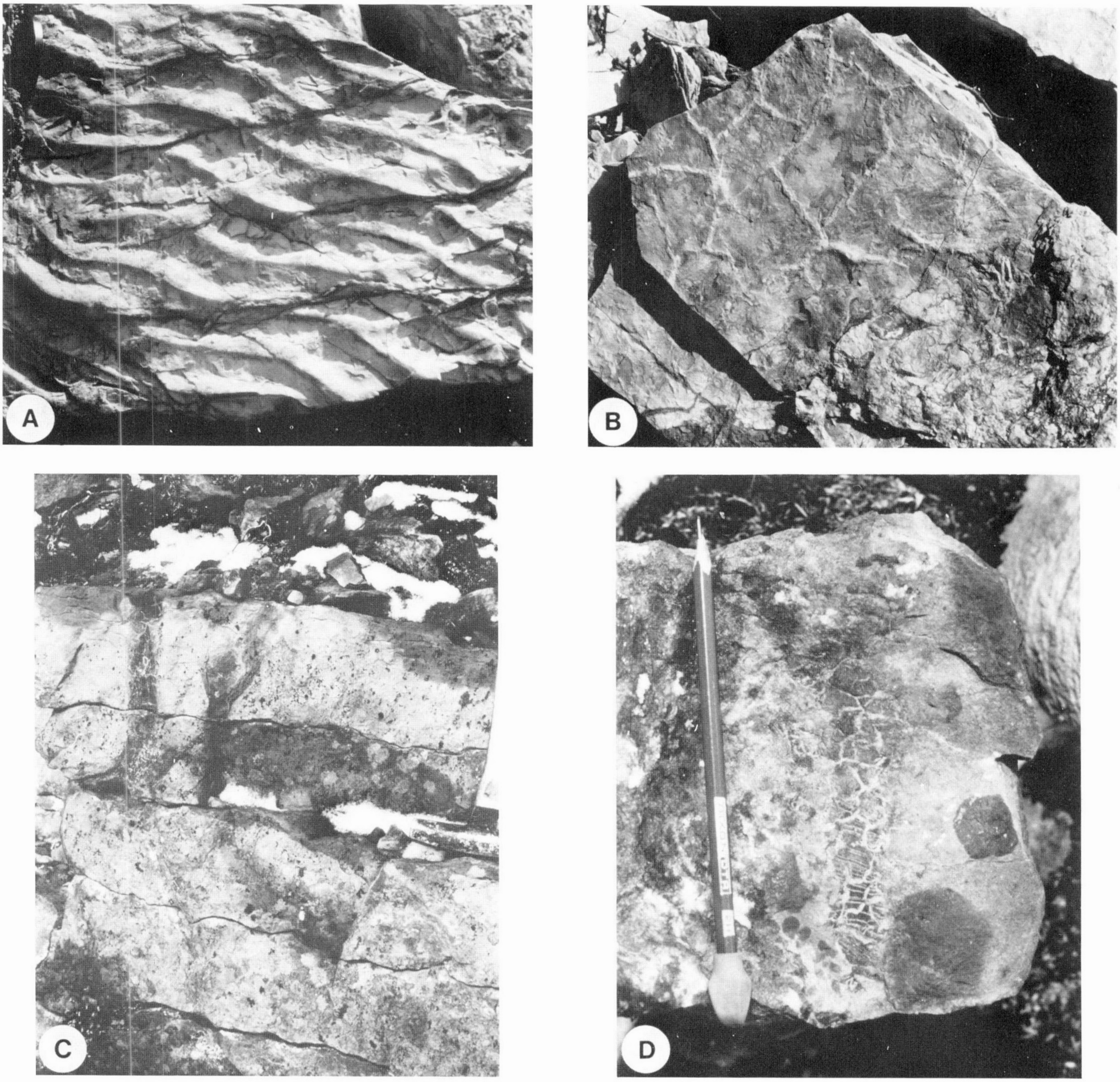


Figure 16. *Sedimentary and diagenetic features of the Tsetso Formation.*

A. A bedding plane view of interference ripple marks on a bedding surface of greenish yellow dolostone. This may be the result of the modification of parallel ripples by currents during falling tide. The occurrence is 17 m above the base of of the Tsetso Formation in Section 6 (GSC photo no. 2011-15).

B. Mudcracks on bedding plane surface about 40 m above the base of the Tsetso Formation in Section 1 (GSC photo no. 2011-8).

C. Red-stained pipes or conduits extending perpendicularly down from an irregular bedding surface overlain by orange sandstone grading into several beds of yellow dolostone. These red pipes may be vadose solution channels that developed beneath a subaerially exposed surface. They are found 3 m above the base of the Tsetso Formation at Section 5 (GSC photo no. 2011-5).

D. A close-up view of one of the inferred karst solution pipes at the same locality as in 16C. Note that the red-stained lining hosts an extensive network of shrinkage cracks (GSC photo no. 2011-13).

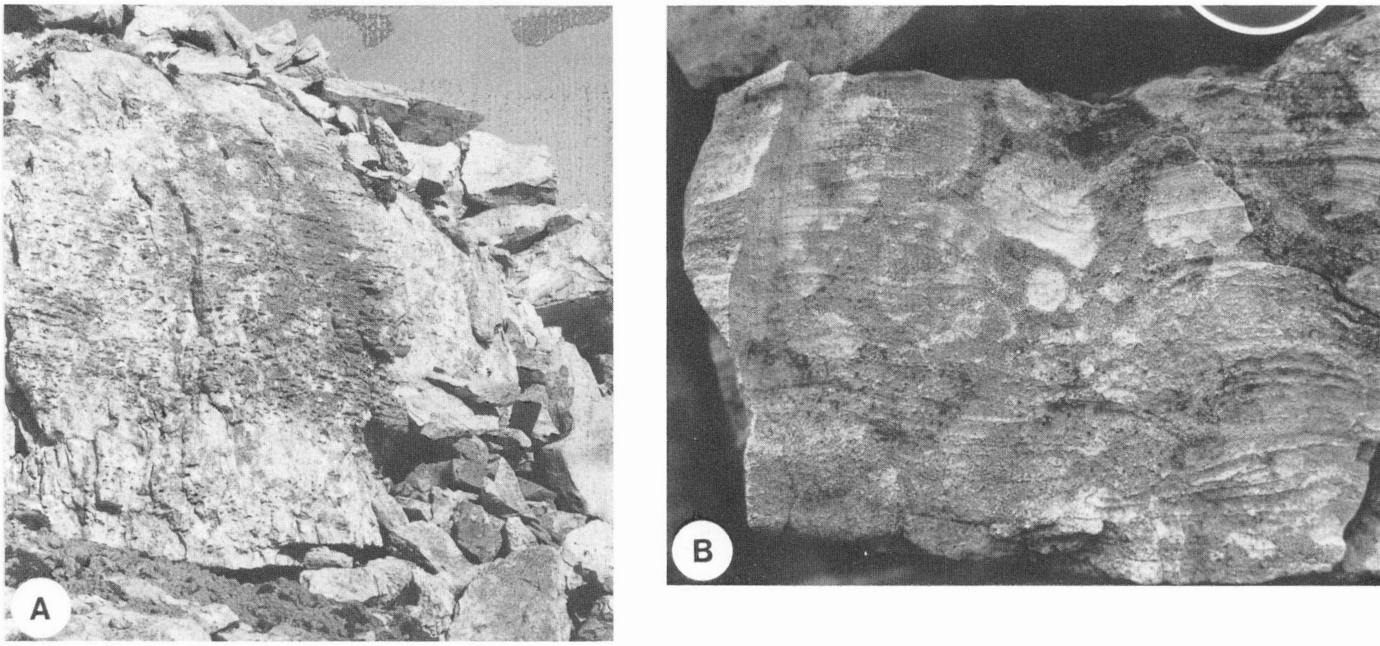


Figure 17. Outcrops of the middle, resistant member of the Tsetso Formation in the region across Twitya Uplift in the Mount Eduni (106 A) map area.

A. Thick bedded, light grey, vuggy dolostone typical of the resistant middle member, 110 m above the base of the Tsetso Formation in Section 12 (GSC photo no. 975-13).

B. Laterally-linked, hemispheroidal stromatolites in a thick, yellowish grey dolostone bed, 48 m above the base of the Tsetso Formation of Section 5. See also Figure 11 (GSC photo no. 2011-4).

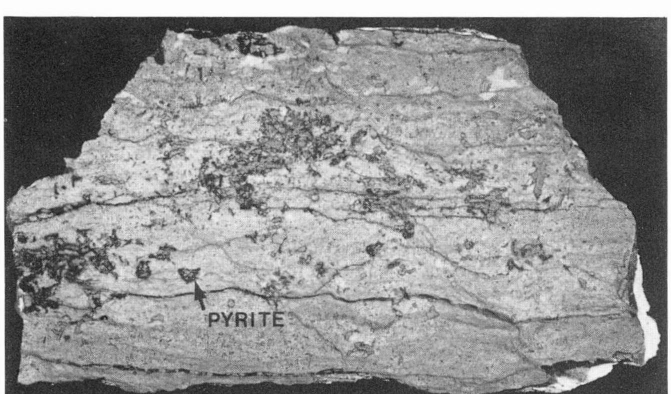


Figure 18. Polished hand specimen of pyrite-bearing, argillaceous, intraclastic and pelletal lime wackestone and packstone from the Tsetso Formation in the region of Twitya Uplift. Light green, argillaceous material outlines the irregular, nodular bedding and forms wavy, discontinuous partings. Green argillaceous material also infills mudcracks developed in the bed from which this sample was removed. Sample from 13.5 m above the base of the Tsetso Formation in Section 13 (GSC photo no. 2014-3).

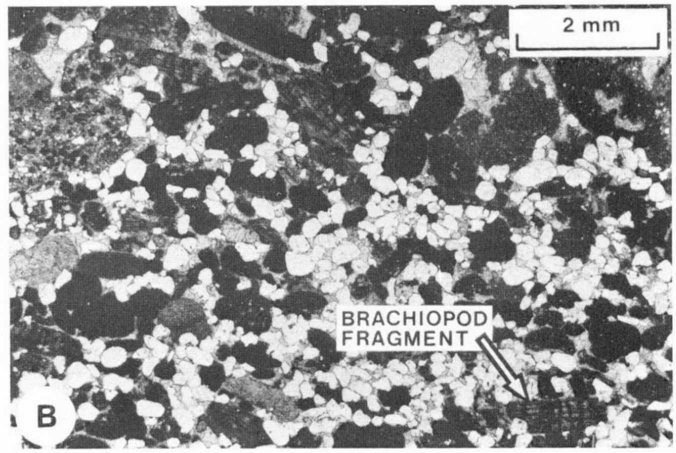



Figure 19. *Sandy, limestone-granule conglomerates in the Tsetso Formation in the region of Twitya Uplift.*

A. An outcrop of sandy lime rudstone 9.5 m above the base of the Tsetso Formation in Section 5. The lime rudstone fragments are granule-sized. Wavy, thick bedding and trough crossbedding are common (GSC photo no. 2011-12).

B. A photomicrograph of sandy lime rudstone, 8.5 m above the base of the Tsetso Formation in Section 5. Tabular rudite fragments are silty pelletal packstone and wackestone with some abraded brachiopod fragments. Mature quartz sand is abundant with a few grains of orthoclase and microcline (GSC loc. C-075560) (GSC photo no. 2015-11).

west of Twitya Uplift (Fig. 12). The only age-diagnostic faunas were two collections of conodonts from Section 8 that included the species *Ozarkodina remscheidensis* Ziegler (subspecies indeterminate) indicating a Late Silurian to earliest Devonian age (i.e., Ludlovian to Pridolian; Appendix 2).

Camsell Formation

The Camsell Formation (Douglas and Norris, 1961), less widely distributed than the Tsetso Formation, is absent from most of the northern part of the study area and from the region along the axis of the Redstone Arch and Twitya Uplift (Figs. 9, 21). Developments of the Camsell Formation 1000 to 1500 m thick occur in the region of Root Basin, or the Camsell Sub-basin of Williams (1977), and in the region of the Godlin Salient west of Twitya Uplift (Figs. 2, 9).

This formation may be subdivided readily into a silty carbonate facies and an evaporite facies. The silty carbonate facies is largely co-extensive with the Camsell Formation as a whole but the evaporite facies is confined to the areas of Godlin Salient and the Camsell Sub-basin (Fig. 9). In this study, the evaporite facies includes both the anhydrite-bearing, subsurface Camsell sequences and the intensely brecciated Camsell strata in outcrop sections. The close proximity of the anhydrite-bearing subsurface sections to brecciated outcrop sections is compelling evidence in favour of the interpretation that the Camsell breccias originated from the dissolution of anhydrite in anhydrite-bearing strata exposed to surface weathering. Therefore, the Camsell breccias are included in the evaporite facies on the assumption that the breccias represent the former presence of evaporites (Fig. 20).

The silty carbonate facies in the northern Mackenzie Mountains is similar to the Corridor Member of the Camsell Formation described by Morrow and Cook (1987) in the southern Mackenzie Mountains, and to the Camsell Formation of the western Mackenzie Mountains (Gabrielse et al., 1973). This facies is prominently colour banded and well bedded (Fig. 22). Typically, dark grey lime mudstone or dark greyish brown dolostone grade upward into light grey laminated dolostones and very thin bedded, platy, silty and argillaceous dolostone in intervals several metres thick (Fig. 12). These intervals are commonly, but not always, developed as hemicycles in which the darker, subtidally-deposited beds rest with

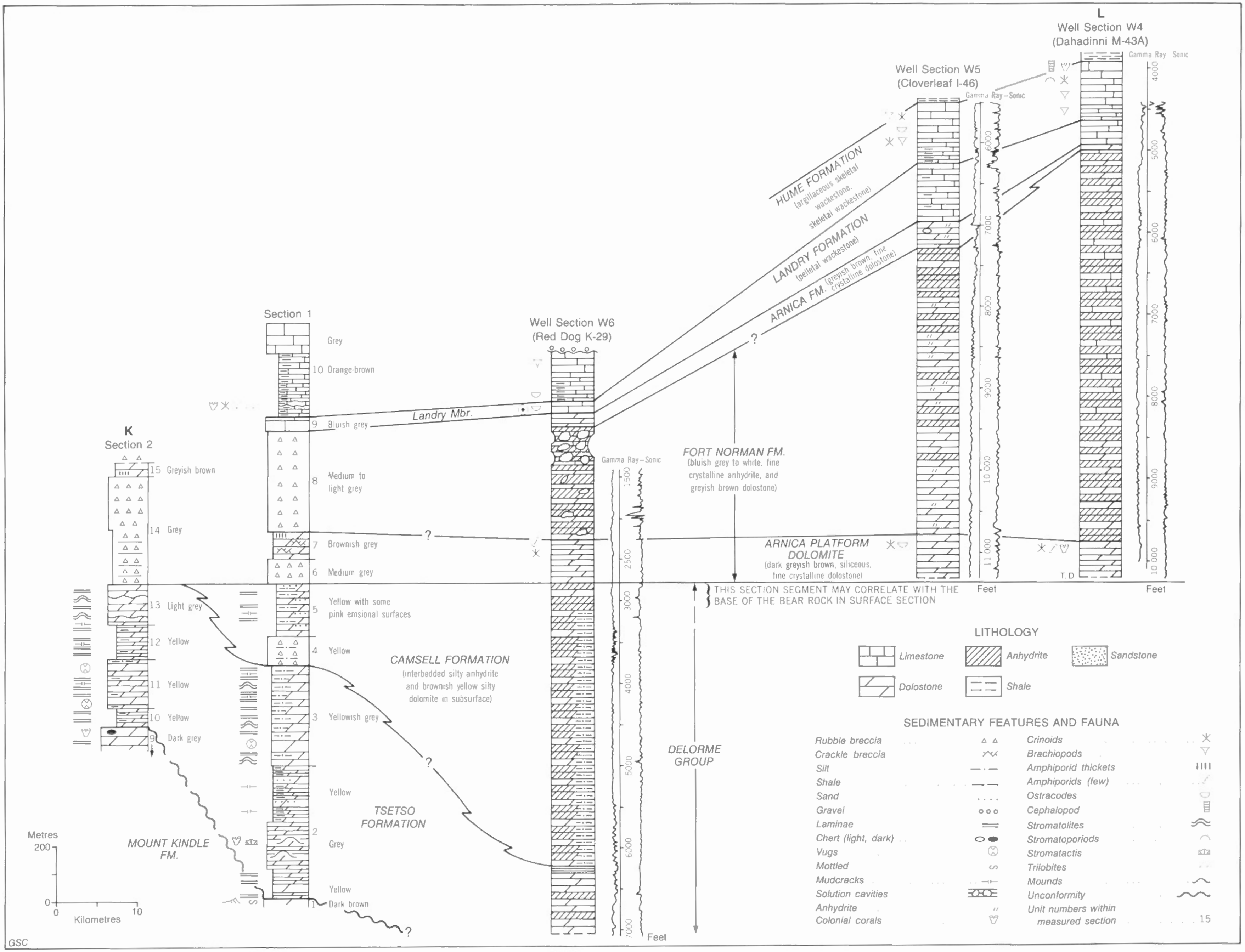


Figure 20. *Stratigraphic cross-section along the line of section K-L on Figure 3. Surface to subsurface correlations along the west flank of Camsell Sub-basin.*

abrupt contacts upon the underlying beds and pass gradationally upward to lighter coloured, intertidally deposited beds. They are interpreted as regressive depositional sequences that were deposited after slight relative rises in sea level, as described by Morrow and Cook (1987) for Camsell hemicycles in the southern Mackenzie Mountains. However, it should be noted that correlations of these hemicycles between sections have not been established.

The dark dolostones and limestones in these hemicycles are relatively featureless. Some dark dolostones contain small vugs strung out parallel to bedding and contain lighter grey laminae or thin bands of finely comminuted skeletal material and carbonate mud chips (Fig. 23). These features are more common in sections such as Section 20, that are close to the boundary between the Mackenzie Shelf and the Selwyn Basin or Misty Creek Embayment. The thin, light coloured bands have erosional bases and are weakly graded, implying that they were deposited as sediment gravity flows. The material for these thin mass flow deposits was possibly derived from marine shoals that developed close to the shelf edge. Also, it should be noted that the dark, subtidal intervals in the Camsell hemicycles tend to be thicker and darker in sections closer to the shelf edge. In the Camsell Sub-basin farther east, these dark intervals are merely medium grey.

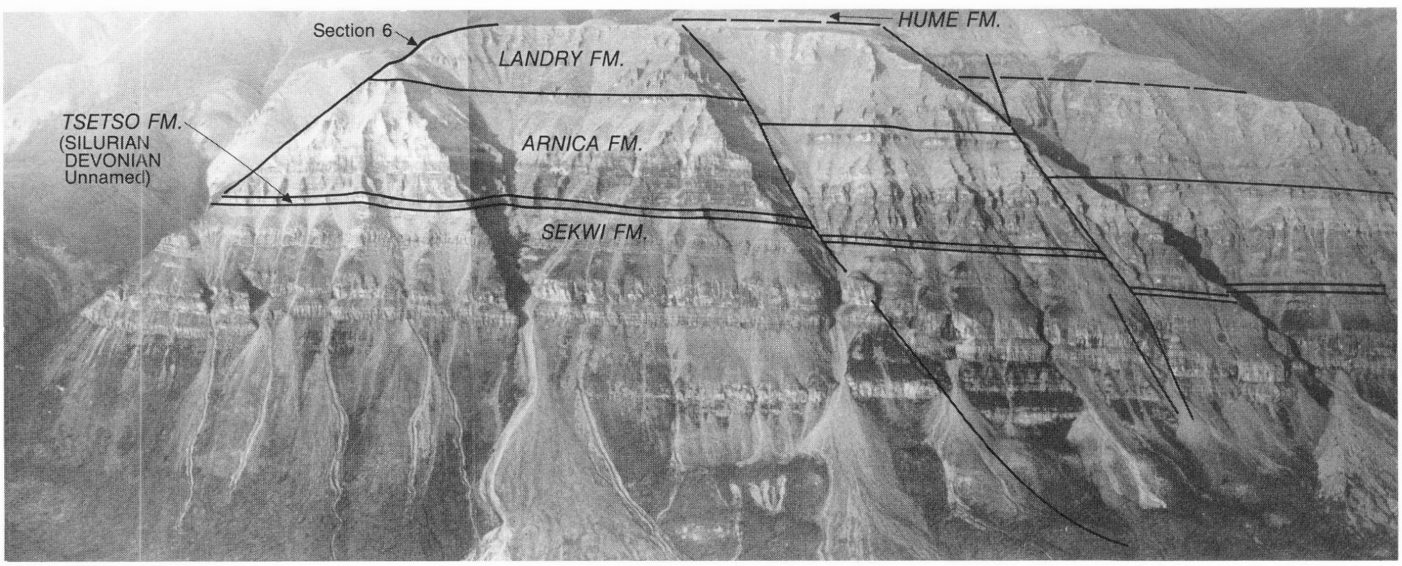


Figure 21. Panoramic view of Section 6 (Mountain River Section) along an east-facing cliff, typical of the thin, Silurian-Devonian sequence that overlies the sub-Devonian unconformity across Twitya Uplift. Note the slight divergence in dips between bedding above and below the unconformity (GSC photo nos. 975-24, 25).

Figure 22. Panoramic view of the south side of the ridge line immediately north of Section 20 (South Bonnet Section), characteristic of the thick Silurian-Devonian sequence in the Godlin Salient region (GSC photo nos. 2011-21, 22).

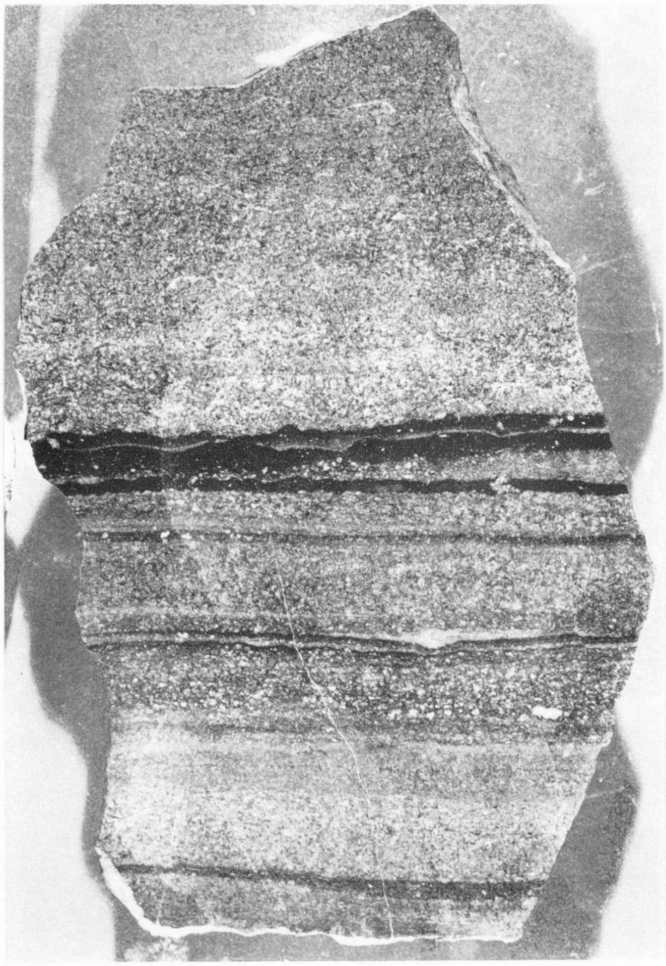


Figure 23. *Polished hand specimen of laminated, pelletal wackestone and packstone from the Camsell Formation. Light grey, pelletal packstone is interlaminated with darker, organic-rich pelletal wackestone. Some light grey laminae have erosional basal contacts and contain algal conceptacles and ostracodes. Sample taken 145.5 m above the base of the Camsell Formation in Section 20; sample is 0.84 times the natural scale (GSC loc. C-075683) (GSC photo no. 2014-13).*

The thin bedded, light grey, laminated dolostones and platy, yellow, argillaceous dolostones in the upper parts of these hemicycles display a variety of sedimentary features indicative of intertidal deposition. These include mudcracks, mudflakes, fenestral fabric, laterally-linked hemispheroidal stromatolites and polygonal stromatolites (Figs. 6, 12).

Unlike the silty carbonate facies, the other characteristic facies of the Camsell Formation (the evaporite facies) is developed in two distinct areas (Fig. 9). Surface exposures of this facies are entirely brecciated, but subsurface well sections in the Camsell Sub-basin are composed of interbedded anhydrite and silty dolostone (Figs. 20, 24). Unfortunately, none of these well sections has cored intervals within the Camsell Formation. Surface exposures of Camsell breccia are extensive in both the Camsell Sub-basin and in the area of Godlin Salient in the northern Mackenzie Mountains. No correction has been made for the decrease in thickness of the Camsell Formation due to the solution-removal of evaporites.

Camsell breccias have a surface expression that is virtually indistinguishable from the breccias of the Bear Rock Formation (Fig. 25) and, like the Bear Rock breccias, are dominantly limestone (Table 2). They are characterized by recessive, yellow weathering slopes of weathered talus or felsenmeer interrupted by irregular, rough weathering, more resistant breccia bands that are extremely hard and difficult to sample. Also, like the Bear Rock, the Camsell breccias at some localities have weathered to form hoodoos; however, this is not common. More resistant breccia bands within breccia sequences are composed primarily of calcite-cemented, mosaic packbreccia with smaller amounts of particulate and cemented rubble packbreccia and crackle breccia (Morrow, 1982b, and Fig. 26A, B). The more recessive, slope-forming breccia intervals tend to be composed solely of particulate rubble floatbreccia (Fig. 27A, B). Fragments in the recessive weathering rubble floatbreccia tend to be very angular and, in many places, display a crude alignment parallel to bedding (Fig. 27A). The matrix is very poorly sorted carbonate silt and sand. Fragments in the resistant packbreccias are also angular but less so than fragments in the floatbreccias. Part of the inter-fragment space in the packbreccia is unfilled by cement or particulate matrix and thus remains as open space (Fig. 26B).

An Early Devonian age (probably Lochkovian to Pragian) for the Camsell Formation may be inferred from its stratigraphic position between the Tsetso Formation and the overlying Arnica and Bear Rock formations (Fig. 5). No faunas were found in the Camsell Formation to substantiate this inference, and indeed, no age determinations have been reported previously from the Camsell Formation (Chatterton, 1978). The upper contact of the Camsell with the Arnica and Sombre formations is sharp and conformable (Fig. 6). The lower contact with the Tsetso Formation is less well defined but also appears to be conformable (Fig. 6).

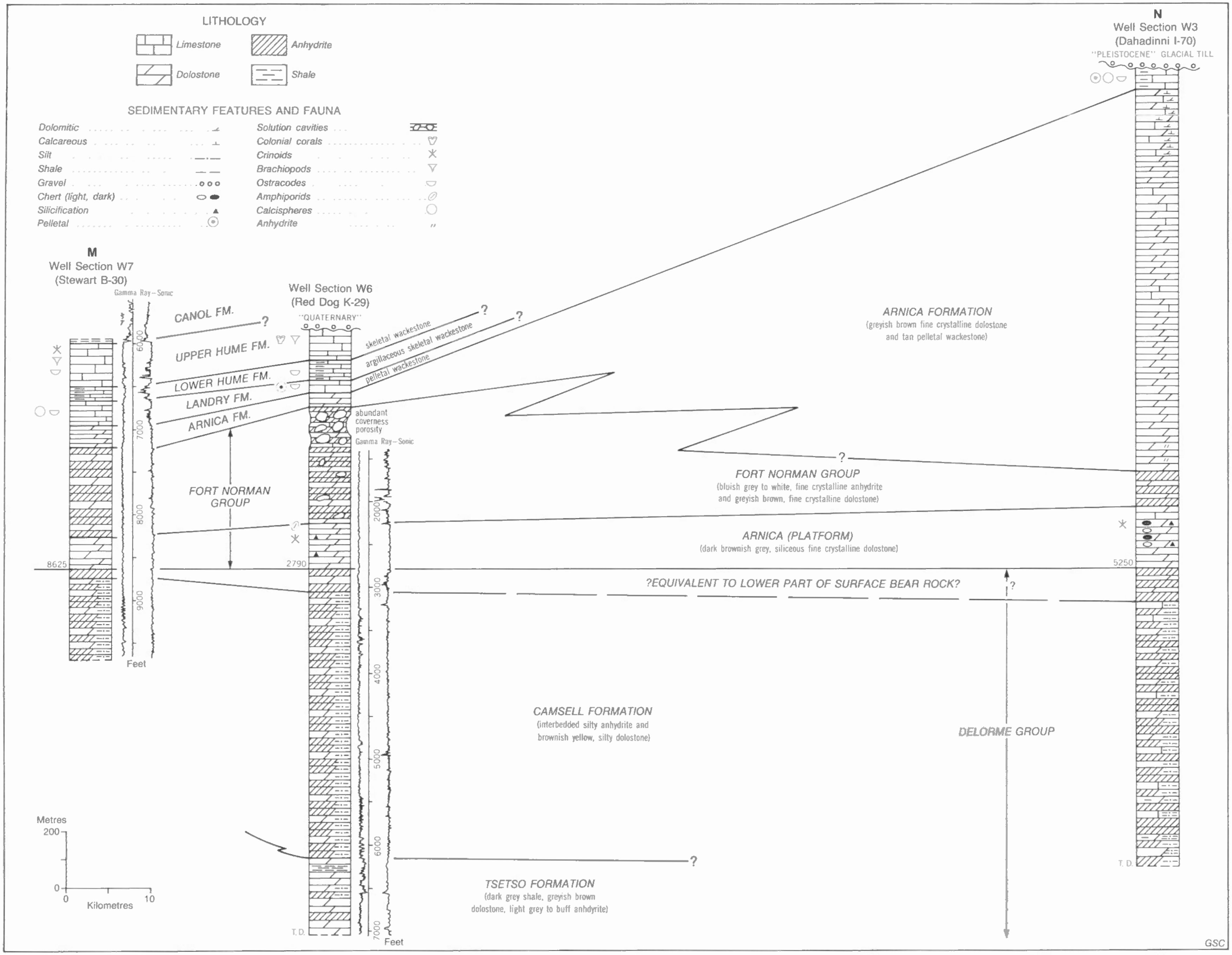


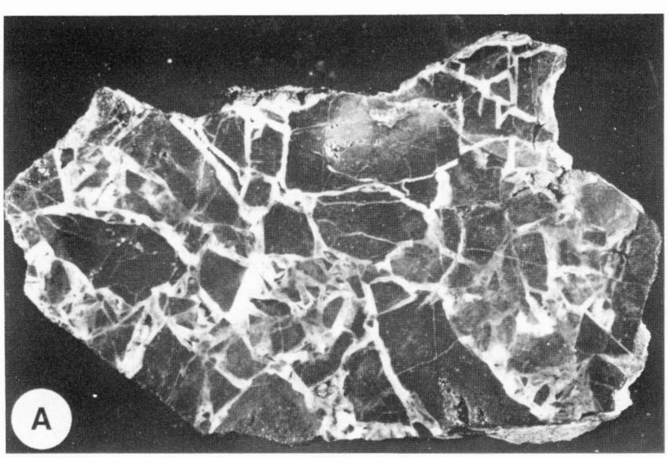
Figure 24. *Stratigraphic cross-section through the Camsell Sub-basin along the line of section M-N in Figure 3.*

Figure 25. A view north from Section 11. A more resistant, cliff forming, limestone breccia band occupies the middle of the light grey-yellow weathering Camsell Formation. Cemented rubble packbreccia is common in these resistant bands, whereas the more recessive parts of the Camsell are formed of particulate rubble floatbreccia (GSC photo no. 2011-18).

Origin of the Camsell breccia

The most reasonable hypothesis to explain the restriction of brecciation to surface exposures of the Camsell Formation is, as was previously mentioned, the removal of evaporites by solution in areas where it is exposed subaerially. The volume change associated with the conversion of anhydrite to gypsum may also have aided this brecciation. If it is assumed that this hypothesis is correct, then it should be possible to derive an explanation for the fabrics and textures observed in Camsell breccias consistent with this hypothesis.

The attributes of the resistant intervals of cemented packbreccia appear to be consistent with a solution-collapse origin. The collapse of thin to thick beds of carbonate into open spaces created by the solution removal of anhydrite interbeds is a reasonable explanation for the origin of partly cemented mosaic packbreccias such as that shown in Figure 26. The fragments, though angular, tend to display slightly rounded edges (Fig. 26A, B). Such rounding in mosaic breccias cannot be the result of sedimentary transport; instead this must be caused by in situ solution rounding. The cements that partly occlude the interfragment space are equant to weakly bladed and isopachous, and coarsen toward the centres of pores. This style of cementation corresponds to that taking place in the active zone of a freshwater, phreatic diagenetic environment (Longman, 1980).



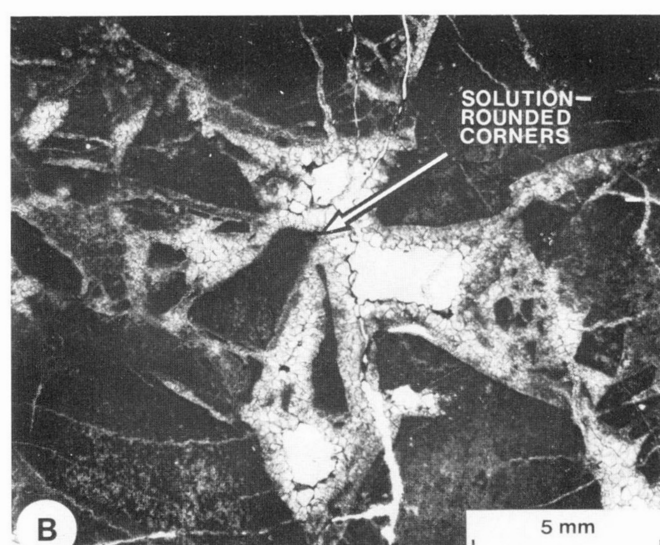
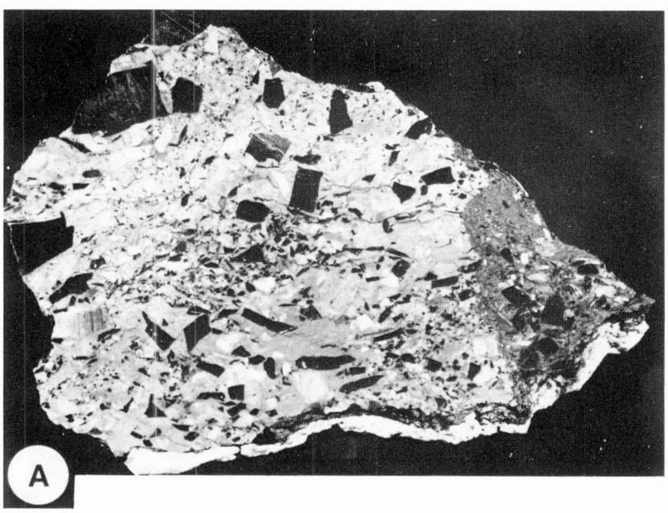


Figure 26. Cemented packbreccia of the Camsell Formation.

A. Polished hand specimen of calcite-cemented rubble and mosaic packbreccia. Sample taken 370.5 m above the base of the Camsell Formation in Section 11 (GSC loc. C-075624) (GSC photo no. 2014.1).

B. Photomicrograph of sample in Figure 26A. Note the slight rounding of corners of breccia fragments (GSC photo no. 2015-8).

The attributes of the recessive intervals of rubble floatbreccia are less obviously consistent with a solution collapse origin. The angular, nonrounded fragments suspended in a particulate carbonate matrix and the orientation of many fragments parallel to bedding (Fig. 27) form a fabric that is reminiscent of a sedimentary mass flow breccia deposit. The fact that the Camsell breccias are restricted to areas of surface outcrop, however, effectively precludes the possibility that this texture has a sedimentary origin. An explanation that is consistent with a solution-collapse origin is that solution-collapse of a very thinly interbedded anhydrite and dolostone sequence occurred in beds that were steeply dipping. The collapse of beds vertically downward because of the solution removal of interbedded evaporites would cause brecciation of the type normally associated with solution-collapse. The chaotic "rubble" texture of these breccias may, in part, be due to solution-collapse in a sequence with a high original content of bedded anhydrites. This would cause fragments to be displaced a greater distance during collapse than would occur if the sequence contained less anhydrite. The abundant fine matrix material could be the concentration of an insoluble residue of carbonates originally present as thin stringers, blebs or as isolated crystals in the anhydrites. The preferred orientation of fragments parallel to bedding may be explained as the consequence of solution collapse that occurred within inclined bed sequences. The vertical component of compaction in inclined beds undergoing solution-collapse would tend to be resolved into two components; one parallel to bedding, and the other perpendicular to bedding, particularly at the boundary between beds that underwent different degrees of solution-collapse. For example, where a highly compactable bed overlies a noncompactable bed during solution-collapse, there would be a strong component of shear developed near the base of the more compactable bed (Fig. 28). The underlying, noncompactable bed would act as an inclined surface, resisting the tendency of the overlying bed to compact vertically, and redirecting the stresses in the overlying, compacting bed into components parallel and perpendicular to bedding. The component parallel to bedding must act as a shear component because the frictional resistance to sliding is at a



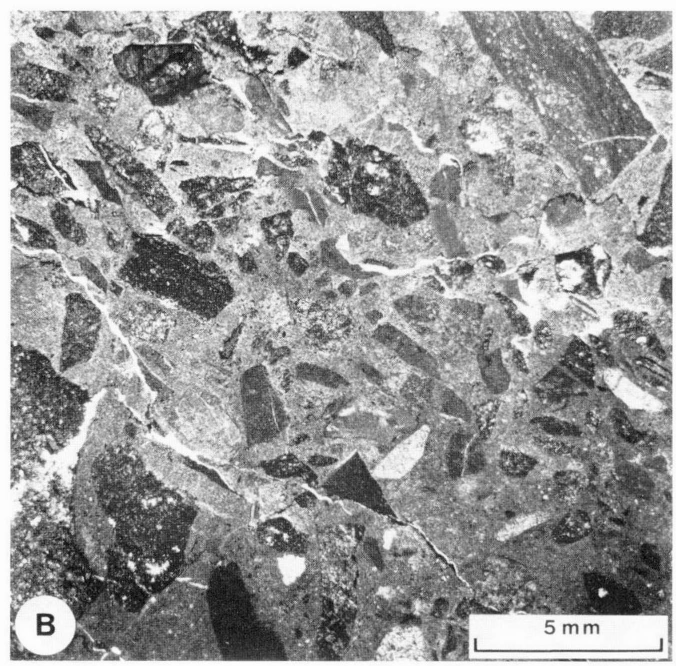


Figure 27. *Particulate floatbreccia of the Camsell Formation.*

A. *Polished hand specimen of particulate rubble floatbreccia. Weakly aligned clasts of lime mudstone and dolomicrite in an argillaceous calcilutite matrix. Clasts tend to be more tabular than the clasts in the cemented packbreccias. Sample taken 531.5 m above the base of the Camsell Formation in Section 11 (GSC loc. C-075630) (GSC photo. no. 2014-9).*

B. *Photomicrograph of the same in Figure 27A. Preferential orientation of fragments is evident. The corners of these fragments are typically sharp as opposed to the more rounded fragments in the cemented packbreccias (GSC photo no. 2015-7).*

maximum at the basal contact of the compactable bed, and declines upward in a manner analogous to that described for sediment gravity flows (e.g., Lowe, 1982). It seems reasonable to suggest that this differential shear stress would be transmitted mainly through the fine grained matrix and that the larger fragments would tend to be rotated parallel to bedding. Preferential compaction of the matrix perpendicular to bedding could also be expected to cause the larger fragments to be oriented parallel to bedding.

In summary, it is apparent that the textures of the Camsell breccias are consistent with a solution-collapse origin despite the fact that some Camsell breccias superficially appear to be examples of sedimentary breccias, like those found in sediment gravity flows. This is true also for the breccias in the overlying Bear Rock Formation, and the reader is advised to peruse the discussion concerning Bear Rock breccias for further documentation of this type of solution-collapse breccia.

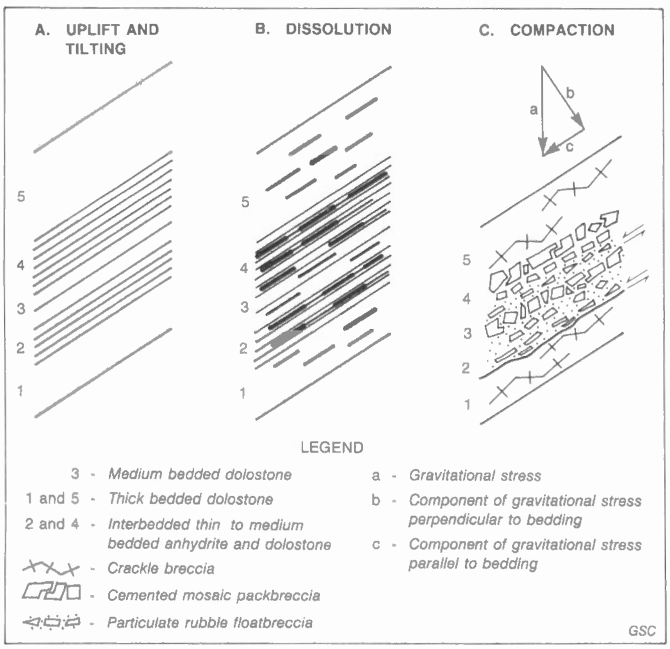


Figure 28. *Origin of Camsell and Bear Rock breccias.*

A. *Interbedded dolostone and anhydrite of the Camsell and Bear Rock formations were tilted, uplifted and exposed by the Cretaceous and Tertiary deformation that formed the Mackenzie Mountains.*

B. *Anhydrite was preferentially dissolved by meteroic groundwater and void spaces oriented parallel to bedding were created; voids shown as solid black.*

C. *Gravitational compaction brecciated the thin dolostone beds between anhydrite beds, and their fragments tended to be oriented parallel to bedding by a component of shear developed against less compactable, thicker dolostone beds.*

Stratigraphic relationships and tectonic development of the Delorme Group

The stratigraphic relationships between formations within the Delorme Group and between the Delorme Group and other stratigraphic assemblages are shown in a series of stratigraphic cross-sections (Figs. 6, 10, 12, 20, 24). Two different datums have been used in the construction of these cross-sections; the sub-Delorme unconformity, and the base of the combined Arnica and Bear Rock formations.

The 'sub-Devonian' unconformity or sub-Delorme unconformity has been chosen as a datum for cross-sections in areas where the Camsell Formation is absent, such as across the Twitya Uplift (Figs. 6, 10). This datum emphasizes the pre-Devonian or pre-unconformity distribution of units and provides, in conjunction with map data and the study of Cook and Aitken (1978), an accurate representation of the disposition of formations beneath the unconformity at the time when this unconformity surface was subaerially exposed. It is also assumed that the basal beds of the Tsetso Formation overlying the unconformity are approximately synchronous. In areas where the Camsell Formation is present, such as in the region of Godlin Salient and the Camsell Sub-basin, the base of the Arnica and Bear Rock formations is the preferred datum. This datum emphasizes the development of the discrete basins in which sediments of the Camsell Formation accumulated (Fig. 12). It is assumed that the base of the Arnica-Bear Rock sequence is also an approximately synchronous surface.

The Delorme Group is thin or absent over large areas of the northern Mackenzie Mountains (Fig. 9). It is absent entirely from the region of the Norman Wells High (i.e., the Carcajou Salient of Aitken et al., 1982). The type section of the Bear Rock Formation (Hume and Link, 1945; Morrow and Meijer Drees, 1981) in which the Bear Rock Formation rests unconformably on older strata with no intervening silty dolostone beds that could be assigned to the Tsetso Formation, is typical of this region. Delorme Group strata increase in thickness westward and southward from the Norman Wells High and reach their maximum thickness in the Camsell Sub-basin. A separate basin containing a thick Delorme Group sequence occurs in Godlin Salient. These basins are separated by a region approximately coincident with the Redstone Arch of Gabrielse (1967) in which, (although data are sparse) the Delorme Group is thin (Fig. 9).

The Camsell Formation is restricted to these basins, and the Camsell evaporite facies preferentially occupies the basin centres (Fig. 9). Strata of the Tsetso Formation underlie the Camsell in both of these basins and it is proposed here, in agreement with Meijer Drees (in press), that the Camsell Formation is correlative either in large part or completely with the upper part of the Tsetso outside the areas of Camsell development (Fig. 12). In the absence of suitable faunal data this interpretation is founded on the assumption that the base of the Arnica-Bear Rock sequence is isochronous. This assumption rests in turn on a sedimentological premise – that the deposition of the terrigenous material that characterizes the Delorme Group ended nearly simultaneously across the shelf, when deposition of the Arnica and Bear Rock formations began.

The pre-Ordovician Mackenzie Arch does not appear to have influenced sedimentation of the Delorme Group. However, there is some data to support the hypothesis that Twitya Uplift influenced Delorme Group sedimentation. The thickness of the Delorme Group does not appear to have been influenced markedly by Twitya Uplift, but there is an indication that, locally at least, thicker sections of the Tsetso Formation may have been deposited in this region. These thicker sections are indicated by the perturbations of Delorme Group isopach lines in the vicinity of Twitya Uplift, primarily in the Mount Eduni map area (106 A) (Fig. 9). The sections commonly display the tripartite subdivision described by Aitken and Cook (1974a) for these strata in the Mount Eduni map area, in which a middle, resistant dolostone is sandwiched between silty and sandy, orange weathering beds. In general, the occurrence of sand within Tsetso strata appears to be confined almost entirely to the region around Twitya Uplift (Fig. 9). Some of these sands, as noted previously, are subtidal foreshore deposits, in contrast to the intertidal-supratidal aspect of most Tsetso strata. Also, some subtidally deposited limestones occur within the Tsetso in the Twitya Uplift region.

Taken together, these observations suggest that the region around Twitya Uplift underwent increased subsidence immediately following development of the sub-Delorme unconformity. The assumption that this unconformity was essentially planar is supported by mapping data, which indicate that the angle between the unconformity and the contacts between successively older formations truncated by the unconformity remains relatively constant (Fig. 11).

An alternative explanation for post-unconformity subsidence in the region of Twitya Uplift is that it is contemporaneous with the subsidence in Godlin Salient associated with deposition of the Camsell Formation. Although this explanation cannot be discounted, the distribution of sandstone in the Tsetso is perhaps an indication that the subsidence over Twitya Uplift largely predated the development of the Camsell Basin in the region of Godlin Salient and possibly in the Camsell Sub-basin farther east. If this is true, the Camsell sequence in the Godlin Salient correlates with or is time equivalent to only the uppermost part of the Tsetso in the region of Twitya Uplift. More stratigraphic and faunal data are required to document this hypothesis.

THE ARNICA-BEAR ROCK ASSEMBLAGE

The Arnica-Bear Rock assemblage is an informal grouping of formations across the Mackenzie Shelf that includes the Bear Rock, Arnica, Landry and Sombre formations. This package of carbonate and evaporitic rocks occupies the stratigraphic interval between the Delorme Group and the Hume Formation (Fig. 5). Terrigenous material is characteristically absent from this assemblage.

In contrast to strata of the underlying Delorme Group, strata of this assemblage are present across the entire study region (Fig. 29). The average thickness of the Arnica-Bear Rock assemblage is approximately 500 m, or about the same as that of the underlying Delorme Group or Delorme assemblage, although thickness variations within the Arnica-Bear Rock assemblage are much less than those within the Delorme Group or assemblage. In addition to a less complex pattern of thickness variations, the Arnica-Bear Rock assemblage is characterized also by a less complex distribution of lithological facies (Fig. 29).

Arnica and Sombre formations

The Arnica Formation is one of the most geographically widespread formations in the Mackenzie Mountains. It extends northward from its type section in the Virginia Falls map area (95 F) near the southern limit of the Mackenzie Mountains (Douglas and Norris, 1961) with remarkably little lithological variation. In the northern Mackenzie Mountains, this formation is largely confined to an area between the western limit of the Bear Rock Formation and the eastern limit of the Sombre Formation. A maximum thickness of 390.5 m was measured at Section 10 close to the main Sombre-Arnica facies contact (Fig. 29). The Arnica Formation is thickest where it passes laterally westward into the Sombre

Formation, and the combined Arnica-Sombre formations are confined to the western part of the shelf in the northern Mackenzie Mountains region because of the presence of the laterally equivalent Bear Rock Formation farther east (Fig. 29). Tongues of Arnica-type strata extend considerable distances both east and west of this region, however. An eastward extension of the basal part of the Arnica sequence beneath the Bear Rock Formation in the Camsell Sub-basin has been termed the 'Arnica Platform Dolomite' by Williams (1975; Fig. 24). This Arnica tongue is about 100 to 200 m thick (Table 1). On air photos, the Arnica Formation can commonly be seen as a medium and dark grey, faintly colour banded and moderately resistant but poorly exposed unit that is sandwiched between either the underlying, light coloured, recessive, Tsetso Formation or the Camsell Formation, and the overlying, light grey, more resistant Landry Formation (Fig. 30). Rocks of the Arnica Formation that are near the Arnica-Bear Rock facies contact tend to be lighter grey and show less colour banding.

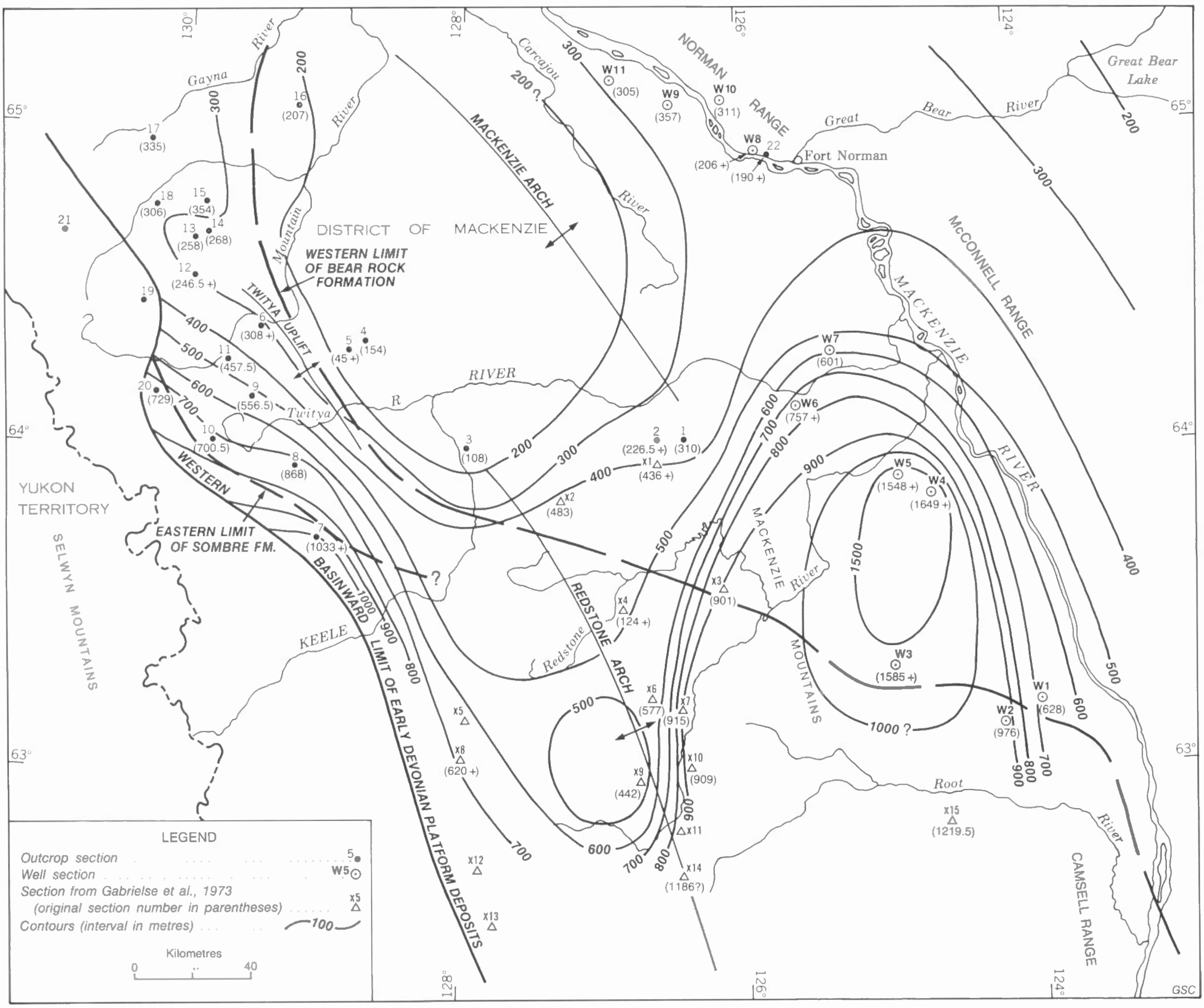


Figure 29. Thickness of the Arnica-Bear Rock assemblage and the distribution of the major laterally equivalent facies of this assemblage, the Sombre, Arnica and Bear Rock formations. See Table 1 for identification of wells and sections.

The dominant rock type of the Arnica Formation is dark brownish grey, bitumen-bearing, fine to medium crystalline dolostone. Commonly, dark brownish grey, medium to thick, planar bedded, slightly vuggy and fossiliferous dolostone beds grade upward to light grey, thin beds of laminated dolostone in cycles that are less than one metre to several metres thick. Arnica intervals of this type are prominently colour banded in outcrop (Fig. 12). The darker beds commonly contain abundant amphiporids (Fig. 12) and some thamnoporid-like corals,

Figure 30. A vertical aerial view (RCAF airphoto A12244-371) of Section 12 showing the light and dark banded character of the Arnica Formation. Also shown is the thick Tsetso sequence that is characteristic of the region around Twitya Uplift.

indicating a subtidal depositional environment, whereas the light grey laminated dolostones display stromatolitic laminae (Fig. 31A) and fenestral fabrics (Fig. 31A, B) indicative of intertidal deposition. The lighter colours associated with intertidal beds may be related to bleaching of their content of organic material during periods of exposure on tidal flats.

In the region of Godlin Salient, the Arnica has some distinctive lithological features that set it apart from the Arnica Formation north and east of Godlin Salient. In the Godlin Salient region, the Arnica is more prominently colour banded on a large scale, with alternating dark and light grey bands that are many tens of metres thick (Fig. 12). The dark bands are formed of medium to thick beds of dark grey, vuggy, fine to medium crystalline dolostone. Some thicker, possibly biostromal beds contain abundant, large, bulbous or hemispheroidal stromatoporoids (Fig. 31C) in addition to ubiquitous amphiporids (Fig. 31D). The light grey bands are formed of thin to medium bedded, light grey, fine crystalline dolostone. Thinner beds tend to be laminated and are inferred to be intertidal deposits. Pisolitic and stromatolitic beds are common (Fig. 12). Some dolomitized pelletal and intraclast grainstone occurs in association with stromatolites in some beds (Fig. 32A). Larger intraclasts in these grainstones appear to be fragments reworked from stromatolites (Fig. 32B). Some of these detrital carbonate beds display crossbedding and may represent beach ridge deposits.

Both the light and dark, thick, colour banded intervals in this variant of the Arnica Formation are in part themselves faintly colour banded on a scale of metres. Like the more typical Arnica north and east of Godlin Salient, this finer scaled colour banding is due to the alternation of beds deposited under slightly different environments of deposition. Beds that display features indicative of intertidal deposition tend to be lighter in colour than associated beds that are inferred to be subtidal deposits. This is probably a result of the preferential bleaching of organic material on tidal flats. Thus, the segregation of the light and dark beds that form the large-scale colour banding in the Arnica Formation near Godlin Salient may be explained as being a consequence of dominantly subtidal deposition for the dark bands and dominantly intertidal/supratidal deposition for the light coloured bands.

The presence of abundant limestone interbeds in the Arnica Formation of the northern Mackenzie Mountains represents a major departure from the lithology of the Arnica Formation at its type area in the southern Mackenzie Mountains. Many sections contain intervals of interbedded dolostone and limestone (e.g., Unit 11 of Section 13, Appendix 1). Some thicker Arnica sections, particularly in the Godlin Salient area, contain intervals of limestone many metres thick that contain no dolostone interbeds (e.g., Section 10 in Appendix 1 and Figure 12). Limestone interbeds are most common near the upper contact of the Arnica with the Landry Formation, as noted by Aitken et al. (1982). Most of these limestones are thin to medium, planar, and smooth bedded, tan, pelletal lime wackestones or brown lime mudstones that are indistinguishable from beds in the Landry Formation. Stromatolite bindstone that occurs in some Arnica limestones (e.g., Unit 8 of Section 13, Appendix 1) appears to be the undolomitized precursor of the dolomitized stromatolite bindstones that are more common in the Arnica (e.g., Unit 4 of Section 15, Appendix 1). Some stromatolite bindstone exhibits a distinctive diagenetic texture, in which very coarse crystalline, bladed, white calcite has infilled subparallel spaces in the rock that largely conform to the original laminated fabric of the stromatolite bindstone (Fig. 33). In some places, this rock is a calcite-cemented, mosaic floatbreccia, as indicated by the prevalence of matching contacts between fragments (Fig. 33). The simplest explanation for this fabric is that it is the result of the growth of displacive, synsedimentary calcite cement that separated and broke individual stromatolite laminae during the growth of cement layers perpendicular to the stromatolite laminae. The occurrence of coarsely crystalline, synsedimentary, submarine $CaCO_3$ cements are well documented in modern environments (e.g., Bricker, 1971).

The Sombre Formation forms the west side of the Mackenzie Shelf sequence from its type area in the southern Mackenzie Mountains (Douglas and Norris, 1961) to the northern Mackenzie Mountains. In the northern Mackenzie Mountains, the Sombre Formation is confined to the western side of Godlin Salient and does not appear to extend any farther north (Fig. 29). The thickness of the Sombre Formation in the Godlin Salient ranges from about 700 to 1000 m. Strata of the Sombre Formation are laterally contiguous with strata of the Arnica Formation farther east.

The Sombre Formation in the northern Mackenzie Mountains was examined only at Section 20 (Fig. 6). At this section, the Sombre Formation consists of thin to thick bedded, grey dolostone similar to the previously described dolostones of the Arnica Formation. The same alternations of thick bedded, dark brownish grey, stromatoporoid and amphiporid-bearing dolostones, and light grey, stromatolite-bearing, lamianted dolostones are present in both of these formations (Figs. 6, 22). The only apparent lithological distinction between these formations as they are mapped in the northern Mackenzie Mountains is that the Sombre Formation contains a greater proportion of light grey weathering strata than the Arnica Formation. The tripartite subdivision of the Sombre Formation – a thin, dark interval sandwiched between two thicker, light grey intervals that is characteristic of the Sombre in the southern Mackenzie Mountains (Douglas and Norris, 1961) – was not observed in the northern Mackenzie Mountains.

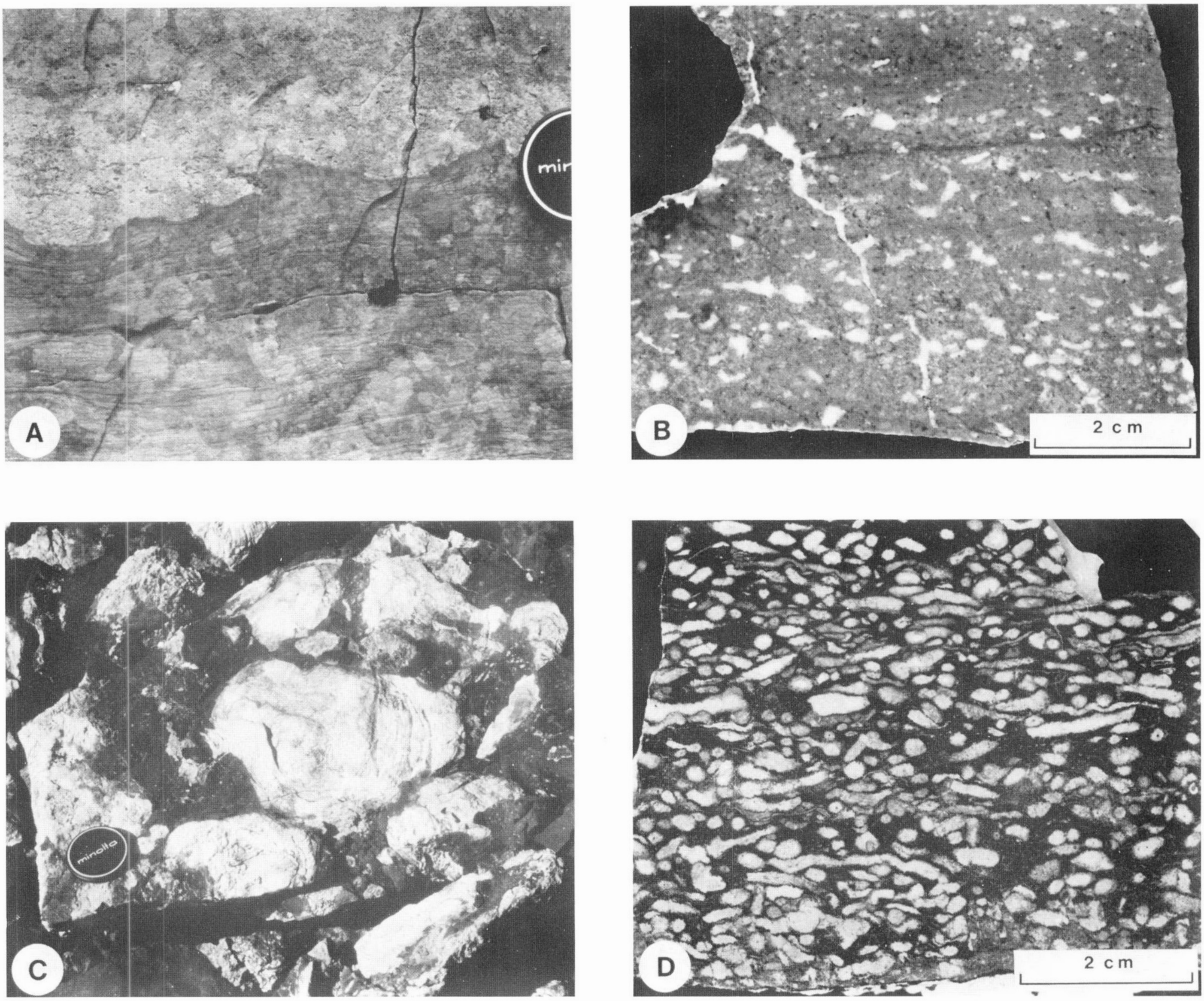


Figure 31. *Characteristic rock types and sedimentary features of the Arnica Formation.*

A. Fenestral fabric above intertidal, stromatolitic, laminated dolostone, 259.5 m above the base of the Arnica in Section 11 (GSC photo no. 2011-19).

B. Fenestral fabric in a polished hand sample of tan pelletal dolostone taken 59.5 m above the base of the Arnica in Section 6 (GSC loc. C-075511) (GSC photo no. 2014-7).

C. Large, bulbous and hemispheroidal stromatoporoids in a matrix of nearly black, organic rich, fetid dolostone; 120.5 m above the base of the Arnica in Section 9 (GSC photo no. 2011-1).

D. Dolomitized amphiporid packstone and wackestone in a polished hand sample taken 18.5 m above the base of the Arnica in Section 13 (GSC loc. C-075530) (GSC photo no. 2014-8).

Unfortunately, faunas collected from the Arnica and Sombre formations during this study could not be used to derive precise ages (Appendix 2). An Early Devonian age is certain, based on the stratigraphic position of the Arnica-Sombre between the Late Silurian to earliest Devonian strata of the Delorme Group, and the Early to early Middle Devonian strata of the Landry Formation (Zlichovian to Couvinian). This is approximately consistent with age determinations for the Arnica and Sombre formations in the southern Mackenzie Mountains based on conodont evidence (Chatterton, 1978; Morrow and Cook, 1987). It seems probable that the Arnica and Sombre formations in the northern Mackenzie Mountains include strata of the Pragian and Zlichovian stages, and, possibly, even of the Dalejan Stage. Dalejan aged strata are present in the Arnica Formation of the southern Mackenzie Mountains (Morrow and Cook, 1987). If strata of the Dalejan Stage are absent from the Arnica Formation of the northern Mackenzie Mountains, then this might indicate that the upper contact of the Arnica Formation becomes younger southward along the Mackenzie Mountains. However, this hypothesis is based on only one Zlichovian age date from the base of the Landry Formation at Section 9 (Appendix 2). An alternative hypothesis is that the Arnica-Landry contact may become slightly older westward across the northern Mackenzie region (see also Pugh, 1983). Both of these hypotheses are dependent on the assignment of a Zlichovian age to the fauna collected from the base of the Landry Formation at Section 9 (Appendix 2).

The Arnica Formation overlies the Camsell and Tsetso formations with a sharp, conformable contact. The upper contact of the Arnica with the Landry Formation is gradational and rock types characteristic of the Arnica and Landry are commonly interbedded over a distance of many metres (Fig. 8). The Sombre Formation conformably overlies the Camsell Formation and is conformably overlain by the Landry Formation.

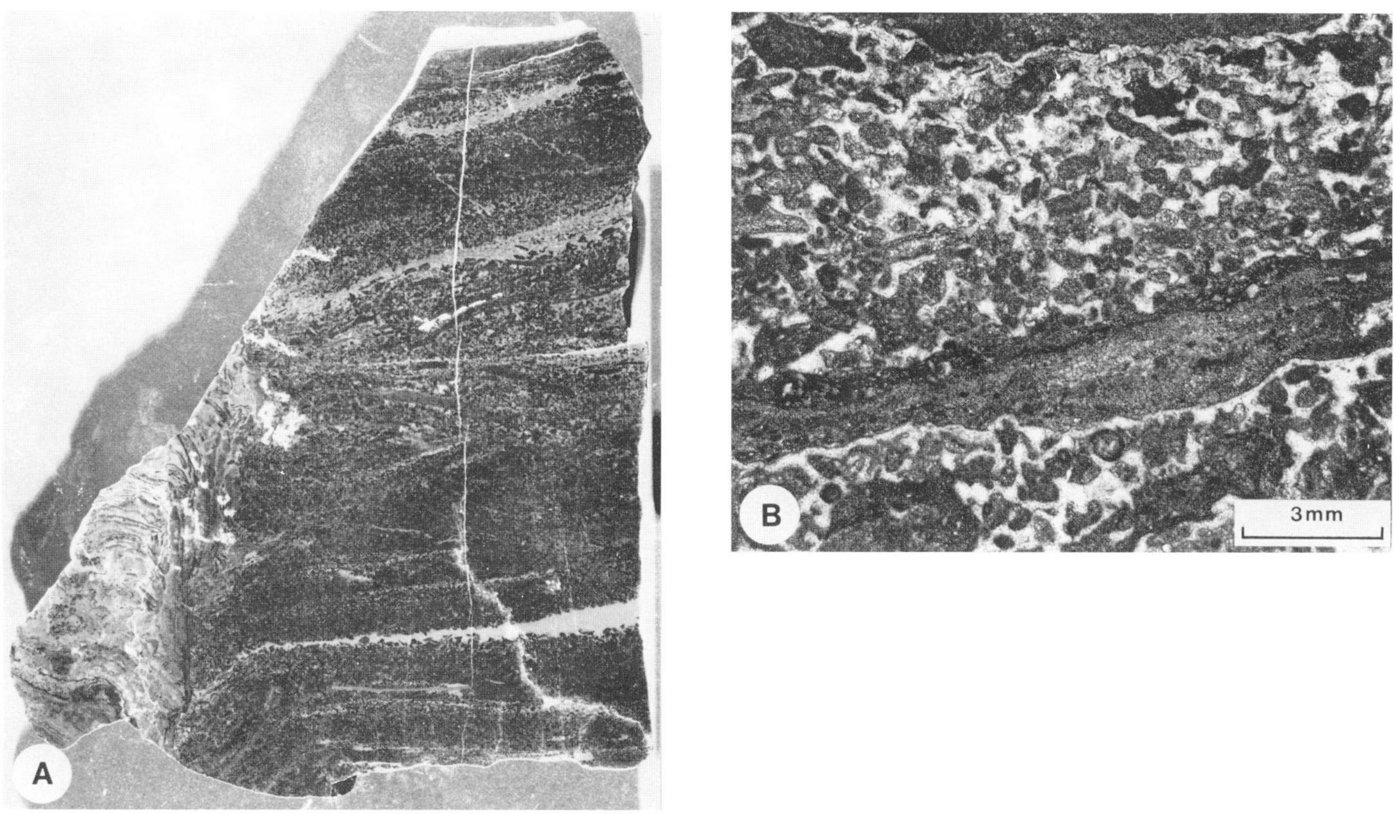


Figure 32. Beachrock dolostone of the Arnica Formation.

A. Dolomitized pelletal and intraclast packstone. Many clasts are tabular, reworked pelletal crusts. Some vague crossbedding is developed. Polished hand sample taken 55.5 m above the base of the Arnica Formation (GSC photo no. 2014-18).

B. Photomicrograph of sample shown in Figure 32A. The smaller grains appear to be compound grains. Most grains are surrounded by a thin rim of clear, isopachous cement that is similar to some modern beachrock cement (see Bricker, 1971) (GSC photo no. 2015-1).

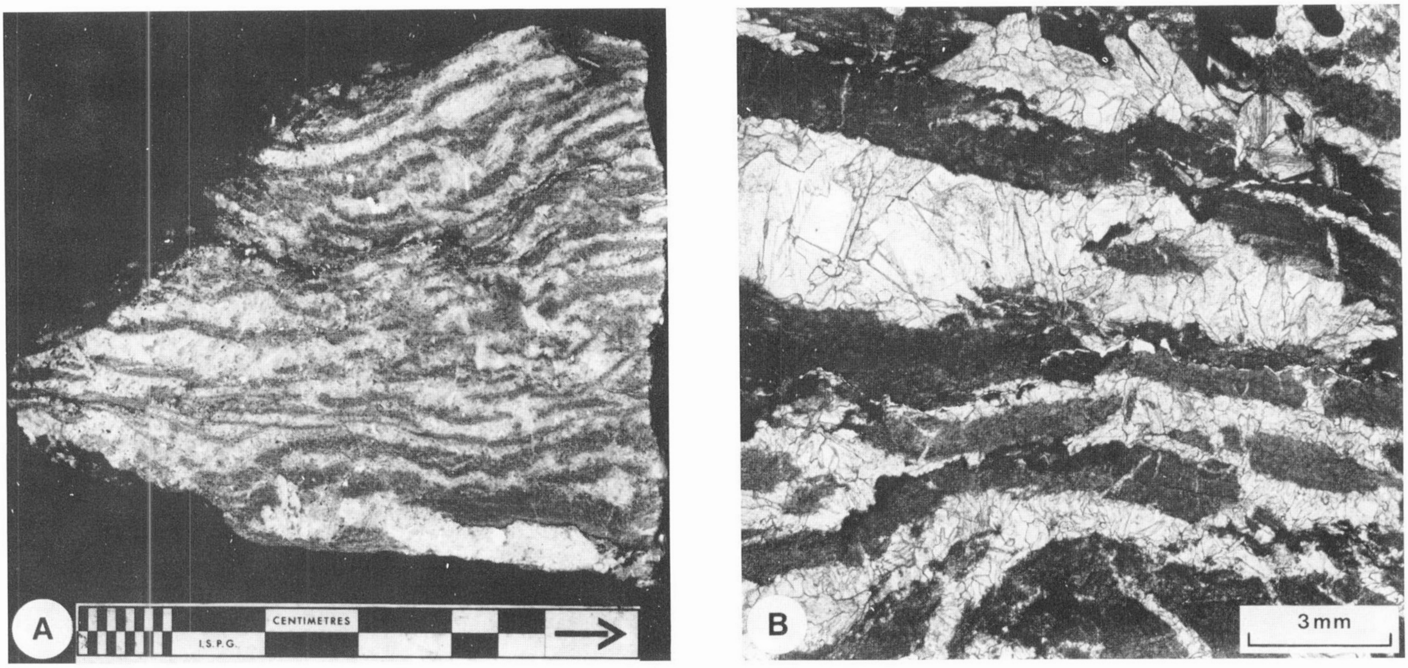


Figure 33. *Coarse palisade cements in stromatolite bindstone of the Arnica Formation.*

A. The separation of stromatolite laminae by these cements is apparent in this polished hand sample taken 27.5 m above the base of the Arnica in Section 12 (GSC photo no. 2014-2(A)).

B. This photomicrograph is a closer view of the cements in the laminae shown in Figure 33A. Crudely bladed crystals of calcite cement have replaced part of the stromatolite laminite (GSC photo no. 2015-3(B)).

Bear Rock Formation

The Bear Rock Formation is not as well defined as most of the other formations described in this report, and this has led to inconsistencies in the manner in which it has been reported in many geological studies. The Bear Rock Formation, as originally defined by Hume and Link (1945), included "the brecciated and non-bedded dolomites and limestones lying below Middle Devonian strata and above a sharp disconformity with well-bedded Silurian limestones below it." Tassonyi (1969) extended the definition of the Bear Rock Formation to include the evaporite and dolostone succession in the subsurface that is the lateral facies equivalent of the Bear Rock Formation breccias exposed on the surface. Recently the name Fort Norman Formation has been proposed to embrace these subsurface strata formerly included in the Bear Rock Formation (Meijer Drees, in press).

An ambiguity concerning the upper contact was introduced by Bassett's (1961) definition of the Bear Rock Formation. This revised definition included in the Bear Rock Formation all the strata between the bedded limestones of the Hume (above) and Ronning formations at Bear Rock near Fort Norman. Although this is a more precise stratigraphic demarcation of Bear Rock strata, it does include an interval of thin to medium planar bedded, pelletal lime mudstone more than 50 m thick at the type section on Bear Rock, which overlies the breccias of the Bear Rock Formation and underlies the Hume Formation (Morrow and Meijer Drees, 1981). This definition of the Bear Rock has been adopted by many workers, particularly by those involved in geological studies of surface exposures (Aitken and Cook, 1974a, b; Aitken et al., 1982). This definition is perhaps the most practical for surface mapping on a 1:250 000 scale, as the thin limestone band above the Bear Rock breccias is not present at all localities (Fig. 6) or is itself partly brecciated. It should be noted, however, that this upper limestone band can be recognized throughout most of the regional extent of the Bear Rock Formation (Figs. 6, 8) as mapped by Aitken and Cook (1974a, b). Aitken and Cook (1974a, b) and Aitken et al. (1982) have implicitly recognized the presence of these limestone beds by their correlation of the upper part of the Bear Rock Formation with the Landry Formation (Fig. 4). These limestone beds are more consistently recognizable in unbrecciated subsurface well sections (Fig. 20), and Tassonyi (1969) mapped them in the subsurface as a tongue of the Gossage Formation rather than as part of the Bear Rock Formation. In summary, it may be asserted that these limestone beds represent a laterally continuous, albeit thin, interval of homogeneous lithology above the Bear Rock evaporites and breccias throughout the entire region of the northern Mackenzie Mountains.

Aitken and Cook (1974b) have previously recognized that the Camsell, Arnica, and Landry sequences mapped by them in the Mackenzie Mountains correlate with the lower, middle and upper units, respectively, of the Gossage Formation as described by Tassonyi (1969). The name Landry Member is applied, therefore, to the bedded limestones in the upper part of the Bear Rock Formation in the northern Mackenzie Mountains (Morrow and Meijer Drees, 1981). The name Landry is used in preference to Gossage because the Gossage Formation has not been mapped in the Mackenzie Mountains (see also Aitken et al., 1982). Also the formational names Camsell, Arnica, and Landry have historical precedence for this part of the Devonian stratigraphic sequence.

Recognition of a formal Landry Member as part of the Bear Rock Formation has several advantages. Firstly, it indicates that the Landry Formation continues recognizably in the Bear Rock Formation, and, secondly, that these Landry-like beds in the Bear Rock are not really mappable at the existing 1:250 000 scale of mapping. The attributes of this member are discussed in the section dealing with the Landry Formation. The main body of the Bear Rock Formation extends across most of the northern Mackenzie Mountains region and also is extensive north and east of this region (Fig. 10 *in* Aitken et al., 1982). Its western limit in part coincides with the western edge of the Norman Wells High, but it also cuts across the Camsell Sub-basin and crosses the Mackenzie River at Camsell Bend east of the Camsell Range (Fig. 29). It should be noted that this configuration for the limit of the Bear Rock Formation is slightly different than that presented by Aitken et al. (1982, Fig. 10).

Breccias of the Bear Rock Formation are extensively exposed in the northern Mackenzie Mountains and range in thickness from a minimum of 69 m in Section 3 to a maximum of 382 m in Section 1. Like the Camsell breccias, no thickness correction has been applied to sections of Bear Rock breccia in surface exposures. The subsurface Bear Rock evaporites in the region of the Camsell Sub-basin appear to be much thicker (Table 1) but the Bear Rock sequence in some of these wells, such as the Dahadinni M-43A well (W4, Fig. 3) is moderately to steeply dipping and may contain fault repeats (Meijer Drees, 1980). In the absence of other data, the maximum thickness of the Bear Rock evaporite succession may be best represented by its thickness of 1062 m in the undeformed, flat-lying sequence in the Cloverleaf I-46 well (W5, Fig. 20).

The Bear Rock Formation in the subsurface of the northern Mackenzie Mountains has not been examined closely in this study. Detailed lithological information is available only from the single, completely cored well in this region, the Dahadinni M-43A well. The Bear Rock Formation in this well is composed largely of interbedded dolostone and anhydrite in repetitive sequences less than one metre to several metres thick (Meijer Drees, 1980; Fig. 20). Meijer Drees (1980) inferred that these sequences reflect episodes of regressive sedimentation under peritidal to supratidal conditions, in an environment similar to that present across the sabkhas and adjacent offshore areas of the modern-day Persian Gulf. Recently, Meijer Drees (in press) has assigned the subsurface part of the Bear Rock Formation to a new formation, the Fort Norman Formation (Fig. 5).

The threefold, informal subdivision of the subsurface Bear Rock (i.e., Fort Norman) recognized by Meijer Drees (1980) is adopted in this report also (Fig. 20). The basal subdivision is predominantly dark greyish brown dolostone with very little anhydrite, and contains some fossiliferous beds. Fauna present in these fossiliferous beds include crinoids, gastropods, brachiopods and amphiporids. This subdivision is the 'Arnica platform dolomite' of Williams (1975) and is regarded as a tongue of Arnica strata in the Bear Rock Formation (Williams, 1975; Meijer Drees, 1980; Figs. 20, 24). The middle, thick, evaporite-bearing subdivision constitutes the bulk of the Bear Rock Formation, and is composed of the rock types that are most characteristic of this formation. The thin, uppermost subdivision of the subsurface Bear Rock is predominantly dolostone with some interbeds of dolomitic limestone. This upper subdivision is also a tongue of the Arnica Formation in the Bear Rock Formation that becomes thicker southward at the expense of the middle subdivision (Fig. 29).

The lowermost subdivision, the 'Arnica platform dolomite' is particularly useful for the discrimination of Bear Rock strata from strata of the underlying Camsell Formation (Williams, 1975). This is because in most wells, the Arnica platform dolomite can be readily identified from mechanical logs as well as from core and sample examination. The combined gamma ray/sonic log is the most useful mechanical log in this respect. Typically, the Arnica platform dolomite, like the overlying Bear Rock strata, is characterized by a uniform and relatively nonradioactive gamma ray response that is in sharp contrast to that of the underlying argillaceous and silty evaporites of the Camsell. The sonic log response is more definitive, because the dense, hard dolostones of this subdivision characteristically have a more uniform and higher velocity response than the 'spiky' sonic log response of the underlying and overlying strata (Figs. 20, 24).

Williams (1975) suggested that the Arnica platform dolomite may extend as a reliable marker bed beyond the region of the Camsell Sub-basin, and correlated this subdivision using the subsurface data and some published surface sections in the southern Mackenzie Mountains. A tentative correlation has been made here between the Arnica platform dolomite in the subsurface and the basal part of the Bear Rock Formation exposed in Sections 1 and 2 on the northwest rim of the Camsell Sub-basin. The lower part of the Bear Rock sequence in these sections contains discernible bedding and Arnica-like rock types (Fig. 20). It should also be noted that the basal part of the Bear Rock/Arnica in some sections west of the main Arnica-Bear Rock facies transition contains dark, siliceous strata that also may correlate lithostratigraphically with the Arnica platform dolomite (Fig. 12).

Breccias in the Bear Rock Formation are similar to breccias in the underlying Camsell Formation and in many places are indistinguishable from them except by their position in the stratigraphic sequence. Like the Camsell breccias, the Bear Rock breccias are dominantly limestone, but contain variable amounts of dolomite (Table 2). They form massive, rough weathering cliffs that alternate with more recessive, talus covered slopes (Fig. 34), and in some places Bear Rock breccias, much like the Camsell breccias, have weathered to for hoodoos. There is a tendency, however, for much of the Bear Rock breccia to weather a light to medium grey colour rather than the pronounced yellow that is characteristic of the Camsell breccias. This may indicate that the Bear Rock breccias contain less terrigenous material than the Camsell breccias.

Bear Rock breccias exhibit the same variety of textural features as do the Camsell breccias. The more resistant, rough weathering bands tend to be composed of calcite cemented mosaic and rubble packbreccia whereas the more recessive slope-forming parts are formed predominantly of particulate rubble floatbreccia (Figs. 34, 35).

Fragments in the cemented packbreccias are not oriented and are very poorly sorted, equant, and angular, with some fragments almost one metre across. Like their counterparts in the Camsell Formation, they display rounded corners (Fig. 36). The corners of these fragments may have undergone preferential dissolution during the period when these strata underwent solution collapse.

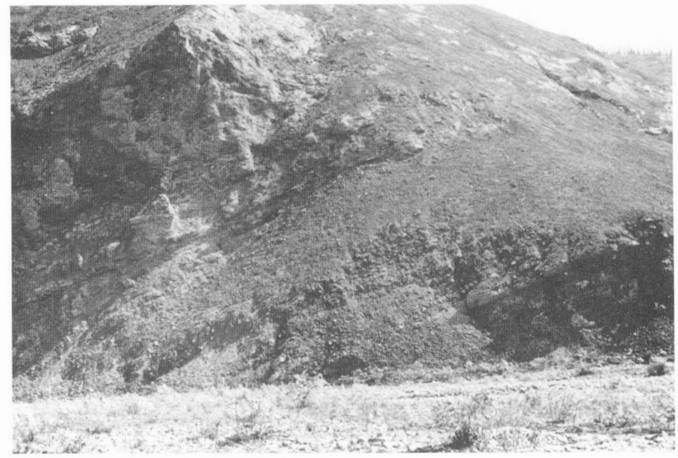


Figure 34. *A west-facing exposure of the lower part of the Bear Rock Formation in Section 1. Bedded Arnica-like dolostone in the lower right of the photograph passes upsection into an interval of oriented, particulate, rubble floatbreccia limestone that, in turn, is overlain by a prominent cliff-former containing a large proportion of cemented packbreccia limestone (GSC photo no. 1184-1).*

In contrast, fragments in the particulate floatbreccias are platy or shard-like and display some degree of orientation parallel to bedding (Fig. 37). The better sorting of fragments in the floatbreccias is a reflection of the fact that very few fragments exceed a few centimetres in size. Preferential solution-rounding of the corners of fragments is not evident in these breccias.

In many places, there appears to be an alternation of these breccia types on a scale of metres to tens of metres. Typically, thin zones of oriented, particulate, rubble floatbreccia grade upward to much thicker zones of cemented packbreccia (Figs. 34, 37). In many places, surface weathering has obscured this relationship, but these sequences are unequivocally displayed by the intervals of Bear Rock breccia that occur within the Arnica Formation in the transitional zone between the Bear Rock and Arnica formations. In some Bear Rock intervals within the Arnica, the contacts between underlying particulate floatbreccia and overlying cemented packbreccia are discernible (Fig. 37). The fine grained, silt-size and sand-size particulate carbonate matrix along the upper surfaces of particulate floatbreccias within these intervals display characteristics typical of a sediment/water interface, such as the draping of these surfaces away from breccia clasts and the occurrence of a palisade of coarse crystalline, bladed calcite along these upper surfaces (Fig. 38).

Figure 35. A closer view of part of the particulate rubble floatbreccia described in Figure 34. The lens cap marks the demarcation between the limestone floatbreccias and the underlying bedded dolostone crackle breccias of the Arnica tongue (GSC photo no. 1184-3).

The Bear Rock Formation breccia overlies the Tsetso and Camsell formations with a sharp, conformable(?) contact that is poorly exposed. The conformable contact with the overlying Hume Formation is also abrupt. In the region of the Norman Wells High, the Bear Rock rests unconformably on the Mount Kindle Formation and other, older formations.

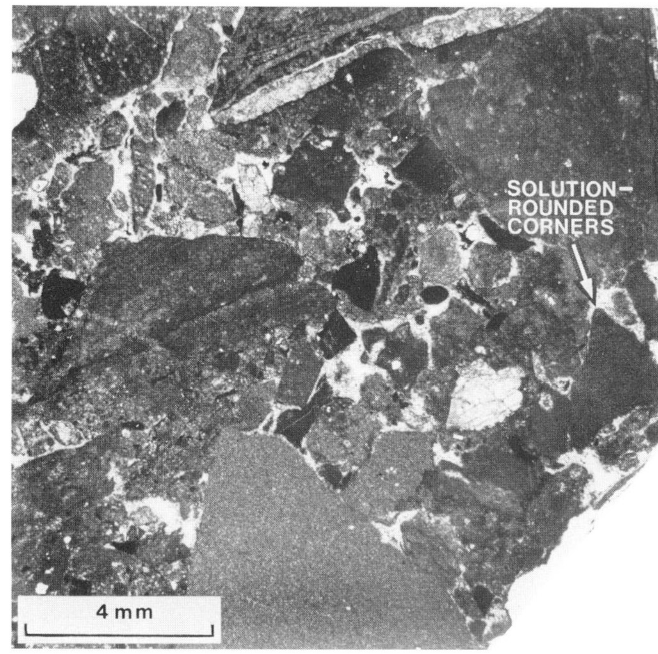


Figure 36. A photomicrograph of breccia in the Bear Rock Formation. This breccia is predominantly a calcite-cemented, rubble packbreccia exhibiting a considerable admixture of particulate material between fragments. Note the rounded corners of many fragments. Sample taken 14 m above the base of the Bear Rock in Section 4 (GSC photo no. 2015-5).

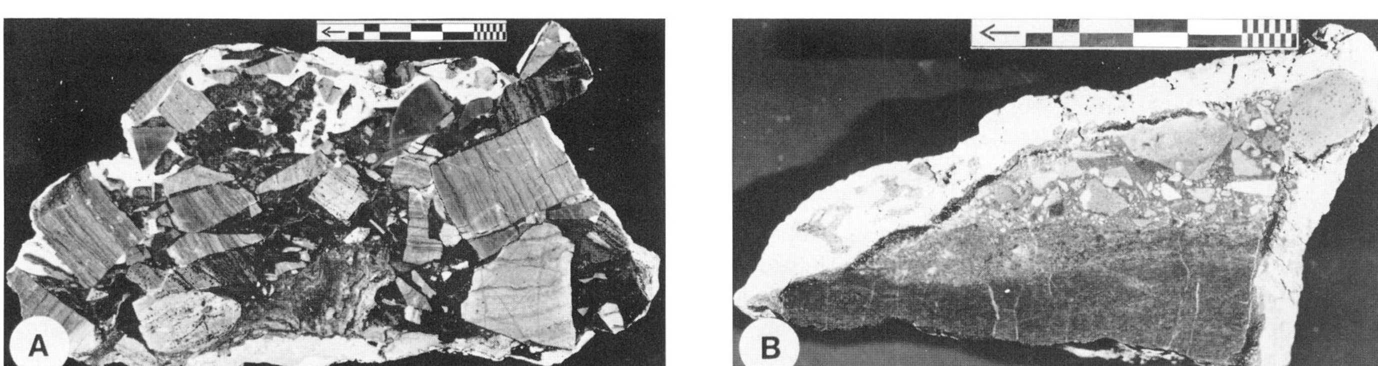


Figure 37. Two hand specimens of Bear Rock-like, calcareous dolostone breccia within the Arnica Formation (79.0 and 79.5 m above the base of the Arnica Formation in Section 15 (GSC loc. C-075774). Particulate rubble floatbreccia overlies the lower contact of this breccia bed with Arnica dolostone. Note the preferred orientation of breccia fragments near the contact, and the contact of the particulate rubble floatbreccia with the calcite-cemented rubble packbreccia in the hand sample from the upper part of this breccia bed (GSC photo nos. 2014-5, 2014-17).

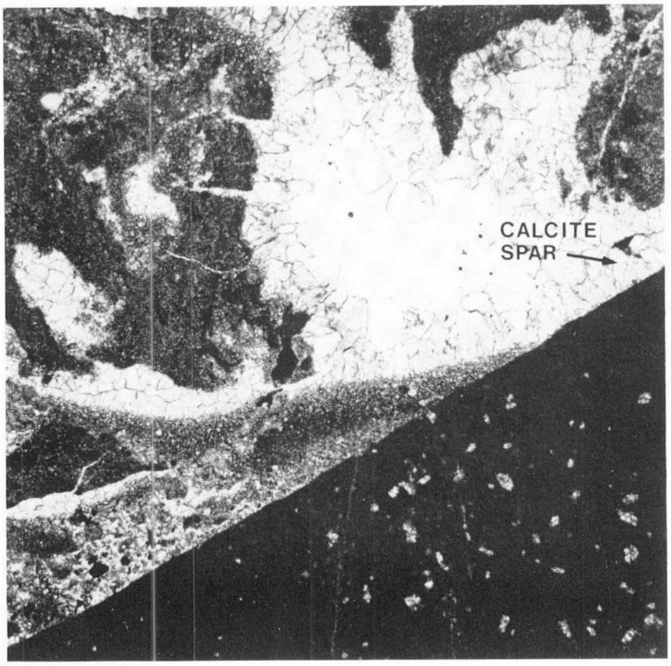


Figure 38. Photomicrograph of the contact between particulate material and interfragment cement in the uppermost hand specimen shown in Figure 37 (GSC photo no. 2015-6).

Origin of the Bear Rock breccias

The close similarity of the Bear Rock and the Camsell breccias implies that they have a common origin. As with the Camsell breccias, the restriction of Bear Rock breccias to surface exposures indicates that the brecciation of the Bear Rock is due to the near-surface removal of evaporites by dissolution.

Like the Camsell breccias, the variety of breccia types in the Bear Rock Formation may be explained as a consequence of solution collapse that occurred in dipping strata (Fig. 28). Intervals of thinly bedded and interbedded anhydrite and dolostone would undergo a large amount of solution related gravitational compaction relative to overlying and underlying intervals in which anhydrite was absent. A component of shear stress parallel to bedding might have developed along the bases of anhydrite-bearing intervals at their contacts with non-anhydritic dolostones because of their differing degrees of compactability as discussed previously with regard to the Camsell breccias (Fig. 28).

These differences in behaviour during solution-compaction are reflected in the sequences of breccia types that are displayed by the Bear Rock Formation. The oriented, particulate, rubble floatbreccias are derived from thinly bedded anhydrite and dolostone intervals that underwent considerable solution-compaction and concomitant shear stress parallel to bedding. The mosaic and rubble packbreccias are the result of solution-compaction of non-anhydritic dolostone sequences.

Unlike the Camsell and Bear Rock formations in the subsurface, both the Camsell and Bear Rock breccias are predominantly limestone rather than dolostone. The most reasonable explanation for this is that calcitization of the Bear Rock and Camsell dolostones took place during the time of solution collapse. The dissolution of large amounts of anhydrite by meteoric groundwater would greatly increase the concentration and activity of the calcium ion in the groundwater. This increase in calcium ion activity would, in turn, greatly increase the potential for the calcitization of dolostone according to the relationship (after Morrow, 1982c):

$$(1\text{-}x)\ Ca^{2+} + Ca\ Mg\ (CO_3)_2 \rightleftharpoons (2\text{-}x)\ CaCO_3 + Mg^{2+} + xCO^{2-}_3 \quad (1)$$

Evidence that the carbonate component of these breccias underwent solution and reprecipitation also lies in the fact that few, if any, primary depositional textures can be discerned within breccia fragments.

Solution collapse of the Bear Rock sequence may be occurring at present in the Red Dog K-29 well (Fig. 24). The upper part of the Bear Rock sequence in this well is a zone of lost circulation and inferred cavernous porosity at a subsurface depth of less than 1500 feet (~460 m). This phenomenon is not present in the other, much deeper subsurface Bear Rock well sections.

Landry Formation and the Landry Member of the Bear Rock Formation

The Landry Formation (Douglas and Norris, 1961), which caps the Arnica-Bear Rock assemblage, extends across the entire Mackenzie Shelf region in the northern Mackenzie Mountains, from the Mackenzie River westward to the shelf edge. However, the bedded limestones that overlie exposures of Bear Rock breccia have been assigned to the Landry Member of the Bear Rock Formation rather than to the Landry Formation itself (Fig. 5), as discussed previously. Both the Landry Formation and the Landry Member of the Bear Rock Formation are described here.

Landry strata, like Bear Rock strata, are relatively thin in the region of the Norman Wells High but become much thicker westward toward the shelf edge, and somewhat thicker southward toward the southern

Mackenzie Mountains. Across Norman Wells High, the Landry sequence has a uniform thickness of about 20 m, but strata assigned to the Landry Formation reach a maximum observed thickness of 505 m (Sec. 8) near the shelf edge. Most of this westward thickness increase is at the expense of the underlying Arnica Formation, and major tongues of Landry-like strata occur within the Arnica Formation near the shelf edge (Fig. 12).

It should be noted, however, that there is considerable variation in thickness of the Landry Formation near the shelf edge in the Godlin Salient region, as may be seen by a comparison of Sections 7, 8, 9, 10 and 20 (Figs. 6, 12). One explanation for this variation is that only Sections 7 and 20 represent true shelf-edge sections. In these sections, a thin Landry sequence overlies a thick Sombre sequence, whereas in Sections 8, 9 and 10 a thick Landry sequence overlies a thin Arnica sequence. This observation is consistent with the interpretation that part of the Landry sequence in Sections 8, 9 and 10 is equivalent to and intertongues with the upper part of the Sombre Formation in Sections 7 and 20. The fact that the base of the Landry Formation at Section 9 is close to the boundary between the Zlichovian and Dalejan stages (Appendix 2) may corroborate this hypothesis, because most of the Landry Formation in the Mackenzie Mountains is of late Emsian to early Eifelian age or slightly younger than Landry strata in Section 9.

North of Godlin Salient, where the shelf edge carbonates border Misty Creek Embayment, the Landry Formation is more uniformly thick and the combined Arnica-Landry sequence extends up to the shelf edge because of the absence of the Sombre Formation.

The lower contact of the Landry Formation with the Sombre and Arnica formations is gradational because of interbedding and is chosen at the base of the lowest thick interval of bluish grey weathering limestone as described also by Aitken et al. (1982). The upper contact of the Landry Formation and the Landry Member of the Bear Rock Formation with the overlying Hume Formation is abrupt and conformable.

The lithology, sedimentary structures and weathering characteristics of Landry strata are very uniform across the Norman Wells High and across the shelf edge adjacent to the east side of Misty Creek Embayment. In this region, Landry strata are composed of very resistant, blue-grey weathering limestones that display a pronounced 'ribbed' appearance in outcrops because of a regular alternation of thick resistant and thin recessive intervals (Fig. 39). The resistant intervals are composed of single or at most a few thick planar beds of tan, pelletal lime wackestone or lime mudstone with smooth bed partings. The intervening thin recessive intervals are formed of very thin bedded, dark grey weathering, brown lime mudstone and pelletal mudstone with planar to wavy bedding (Fig. 39). In some places, distinct couplets are evident where the very thin bedded, recessive intervals pass gradationally upward to thick bedded, resistant intervals. These recessive intervals rest with sharp contact on underlying intervals of thick, resistant beds (Fig. 39). However, in most places, these couplets, although discernible, are not well developed.

Figure 39. *Outcrop of the Landry Formation displaying the prominently ribbed appearance characteristic of this formation. Recessive, thin beds grade upward into resistant, thick beds in distinct deposition couplets. Located 138 m above the base of the Landry Formation in Section 18 (GSC photo no. 2011-21).*

The resistant, thick beds contain virtually no sedimentary structures, and very little evidence of macrofauna is visible in hand specimens. Algal fragments, some of which contain conceptacles, are abundant in the upper parts of some resistant intervals, and, in a few places, algal material is abundant enough to form beds of algal pelletal lime packstone (Fig. 40). Ostracodes are also abundant locally. Charophytes are scattered sparsely in some beds (Fig. 41). Fenestral fabric (Fig. 8) occurs in the upper parts of some resistant intervals. The only large-scale sedimentary structures in the Landry Formation are large, sigmoidally shaped channel fillings (Fig. 42) that occur as resistant intervals within Sections 15 and 18 (Fig. 8). These channel fill deposits appear to have occupied channels that were about one metre deep and several metres across.

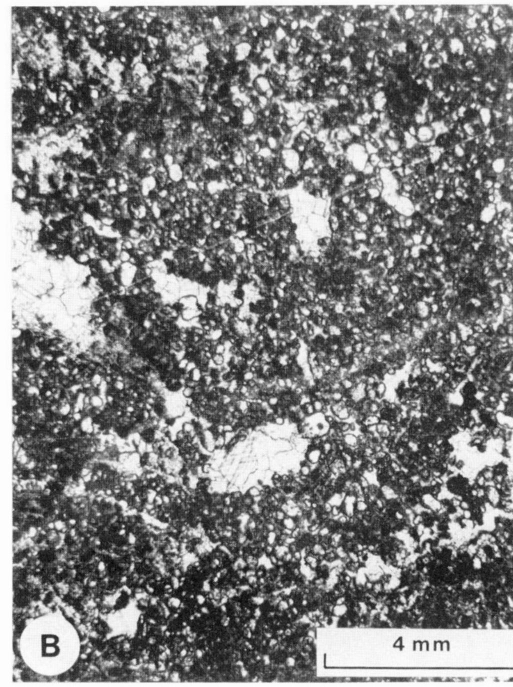


Figure 40. Polished hand sample and photomicrograph of algal pelletal wackestone and packstone in the Landry Formation.

A. The hand sample is from the lower part of a Landry recessive-resistant bed couplet 44.5 m above the base of the Landry in Section 6 (GSC loc. C-075519) (GSC photo no. 2014-14).

B. The photomicrograph is of a sample taken from the top of a recessive-resistant bed couplet 12.0 m above base of the Landry Formation in Section 1 (GSC loc. C-075720). Note the abundant algal conceptacles and fenestral fabric shown in the photomicrograph (GSC photo no. 2015-13).

The recessive intervals are dark brown because of a high, noncalcareous organic content of dark brown sapropelic material. The only fauna observed in the recessive intervals are occasional ostracodes. These intervals display wavy to irregular bedding and in places some beds contain ripple-drift cross-stratification. Pockets of intraclasts occur within some beds.

The simplest interpretation of the origin of the recessive-resistant couplets of this part of the Landry Formation and the Landry Member in the Bear Rock Formation is that they represent individual, regressive episodes of deposition. The recessive, thin bedded, organic-rich lower parts of these couplets represent a protected subtidal environment. The thin bedding may be the result of slow discontinuous sedimentation, which, in turn, would have permitted the accumulation of a relatively large proportion of organic material. The thick bedded, resistant parts of these cycles reflect more continuous and rapid sedimentation, perhaps indicating deposition in an upward shallowing sequence. Less organic material is present because of the rapid accumulation of the sediments that formed these thick beds. Also, the organic material in the thick beds may have been more affected by oxidation during deposition. The presence of fenestral fabric in the upper parts of some resistant intervals indicates that these intervals are capped by intertidally deposited sediments. If these recessive-resistant deposits do represent upward shoaling cycles, then their sharp bases may represent abrupt relative rises of sea level that initiated each episode of regressive sedimentation.

The Landry Formation in the region of Godlin Salient (e.g., Secs. 7-11, 20) departs somewhat from the characteristics of the more typical Landry strata across the Norman Wells High and bordering the Misty Creek Embayment. As previously described, the Landry is thicker and more variable in thickness in the region of Godlin Salient. Large parts of the Landry Formation in this region are fossiliferous, with many abundantly crinoidal beds (Figs. 12, 43). Corals, amphiporids and hemispheroidal stromatoporoids are also common in some units (e.g., Unit 13 of Section 9, Appendix 1). These very organic-rich, fossiliferous lime wackestone beds are typically nearly black and have many, reddish-orange or ochre coloured, argillaceous seams that form bed partings. In most of this fossiliferous Landry strata, abundant faunas occur in thick bedded intervals that alternate with intervals of thin to medium bedded pelletal wackestone with little visible macrofauna. The characteristics of this variant of the Landry Formation indicate deposition in a more open marine environment than that which could be inferred for the more typical, unfossiliferous Landry.

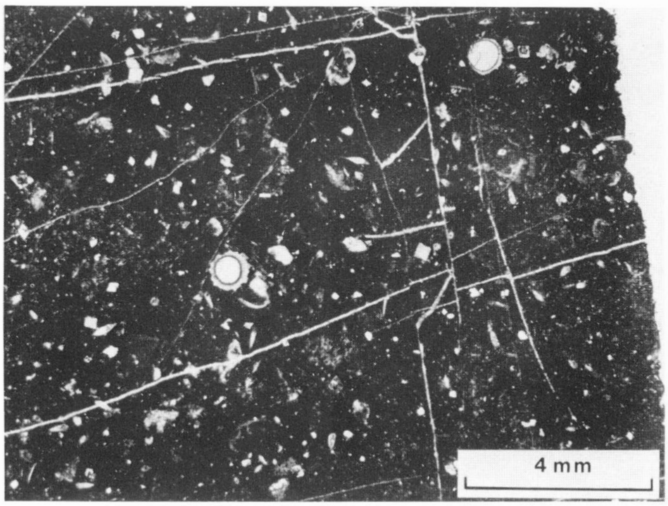


Figure 41. Charophyte oogonia in slightly dolomitic lime mudstone of the Landry Formation. Photomicrograph of sample taken 0.5 m above the base of the Landry Formation in Section 17 (GSC loc. C-075718) (GSC photo no. 2015-15).

Direct age dates for Landry strata in the northern Mackenzie Mountains were obtained from two collections, both in the Godlin Salient area (Secs. 8, 9). One conodont collected near the top of the Landry Formation at Section 8 (GSC loc. C-75798, Fig. 12) was dated as late Emsian to early Couvinian, with an early Couvinian age most likely (Appendix 2). A collection of macrofauna near the base of the formation at Section 9 (GSC loc. C-75848, Fig. 12) was dated as probably late Zlichovian but possibly Dalejan. These age dates are largely consistent with age determinations for Landry strata in other areas (Chatterton, 1978; Morrow and Cook, 1987), except that the age of the base of the Landry in Section 9, and probably in other Landry sections in the Godlin Salient area, may be slightly older than the base of the Landry in other areas.

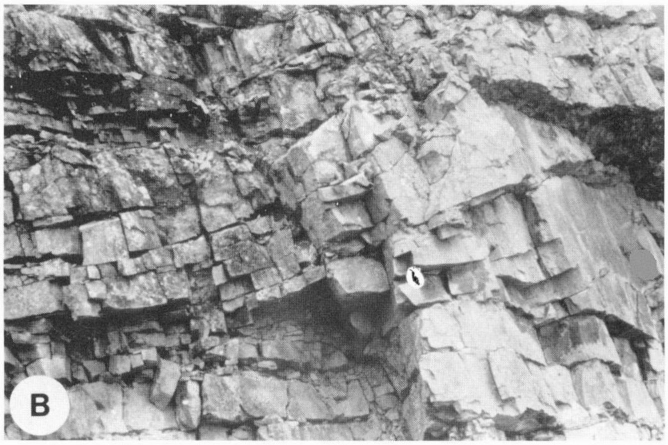


Figure 42. Sigmoidal cross-stratification (A) and trough crossbedding (B) in limestone of the Landry, 154 m above the base of the Landry Formation in Section 18 (GSC photo nos. 2011-22 (A), 2011-17 (B)).

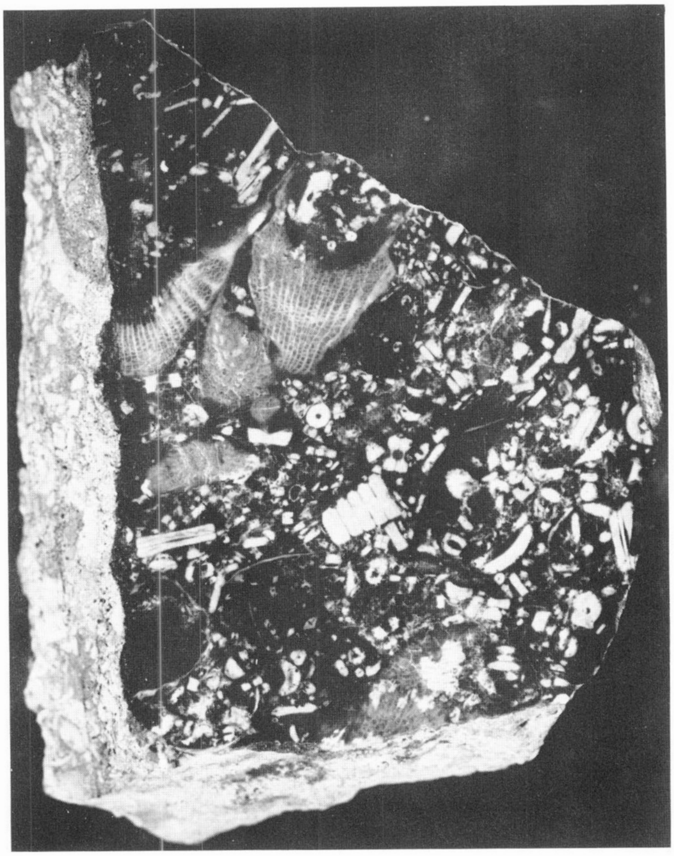


Figure 43. Polished hand specimen of crinoidal wackestone and packstone from the Landry Formation. Some solitary rugose corals. Sample taken 95 m above the base of the Landry Formation in Section 9 (GSC loc. C-075849) (GSC photo no. 2014-4).

Stratigraphic relationships and tectonic development of the Arnica-Bear Rock assemblage

Stratigraphic relationships between formations within the Arnica-Bear Rock assemblage and between this assemblage and other rock units are shown in the series of cross-sections mentioned previously. Across the Norman Wells High, the Arnica-Bear Rock assemblage maintains a uniform thickness of about 150 to 300 m (Figs. 6, 29). In the Godlin Salient region and the Mackenzie Shelf edge in general, and south of the confluence of the Keele and Mackenzie rivers, it is much thicker. In the Godlin Salient region, the assemblage forms a westward-thickening wedge up to 1000 m thick (Fig. 29). Southeast of Keele River, there is a pronounced thickening of the assemblage coinciding with the Camsell Sub-basin and extending southward across Root River into the southern Mackenzie Mountains. In this region, the Arnica-Bear Rock assemblage is up to 1500 m thick.

These two areas of thick Arnica-Bear Rock assemblage are separated by a south-southeast trending region in which the Arnica-Bear Rock assemblage is thin. The long axis of this region coincides with the Redstone Arch (Fig. 29). Redstone Arch apparently was an area of a more modest rate of subsidence during deposition of the Arnica-Bear Rock assemblage than were the flanking regions of Godlin Salient and the Camsell Sub-basin. There is no evidence to suggest that either Twitya Uplift or the more ancient Mackenzie Arch have influenced deposition of this assemblage, although the Norman Wells High appears to have been an area of reduced subsidence. More data are needed from the region of the Norman Wells High to substantiate this inference, and it is of course not known to what extent solution of evaporites has reduced the thickness of the Bear Rock in this region.

However, the distribution of the major lithological facies within the Arnica-Bear Rock assemblage, as outlined by the generalized facies contact between the Arnica and Bear Rock formations (Fig. 29), does not coincide with or follow the pattern of thickness variations displayed by this assemblage. Instead, this facies boundary intersects the axis of Redstone Arch and cuts across the region of the Camsell Sub-basin (Fig. 29). This is in strong contrast to the distribution of facies within the underlying Delorme Group, in which the evaporites of the Camsell Formation are confined to the Godlin Salient and the Camsell Sub-basin (Fig. 9). In the Delorme Group, the distribution of depositional environments appears to have been linked to differential subsidence, with the evaporite facies of the Camsell Formation confined to the more rapidly subsiding areas of Godlin Salient and the Camsell Sub-basin. Differential subsidence appears to have had little effect on the accumulation of evaporites in the Arnica-Bear Rock assemblage, however.

Another factor, perhaps of greater importance for the deposition of evaporites in the Delorme Group, is that during deposition of this group, the Norman Wells High region was an exposed land area and part of the area along Redstone Arch and west of the Norman Wells High was exposed intermittently also. In other words, the Godlin Salient region and the Camsell Sub-basin were areas of marine deposition with a high degree of continentality during deposition of the Delorme Group. Basins with a high degree of continentality favour the precipitation of evaporites because of the lower relative humidity associated with landlocked basins (Kinsman, 1975). This may have been the prime factor favouring the deposition of evaporites in the Delorme Group. The opposite was true during deposition of the Arnica-Bear Rock assemblage, when marine deposition spread across the entire Mackenzie Shelf. This marine inundation undoubtedly raised the relative humidity in the air mass over the Mackenzie Shelf and caused the sites of Bear Rock evaporite deposition to move inland toward regions of lower relative humidity nearer the cratonic hinterland.

Evidently, the subsea shelf topography and an environmental gradient were maintained uniformly across the Mackenzie Shelf during deposition of the Arnica-Bear Rock assemblage in spite of differential subsidence across the shelf. It is well known that the rate of deposition of Holocene peritidal carbonates (e.g., 1.0 m/1000 yrs, Wilson, 1975) is sufficient to keep pace with all but the more extreme varieties of tectonically induced subsidence.

The stratigraphic relationships between the Sombre, Arnica, Bear Rock and Landry formations have been outlined briefly as part of the discussion concerning these formations. Landry strata conformably overlie the Bear Rock, Arnica and Sombre formations across the Mackenzie Shelf. North of Godlin Salient, the Arnica-Landry sequence extends up to the shelf edge with the thickness of the Landry Formation becoming greater toward the shelf edge at the expense of the Arnica Formation. In the Godlin Salient area, however, the Landry Formation becomes abruptly thinner where it overlies the Sombre Formation along a narrow belt at the shelf edge (Fig. 12). Faunal data as well as thickness data indicate that the upper part of the Sombre Formation may correlate with part of the thick Landry Formation east of the Sombre-Arnica transition in the Godlin Salient.

THE HUME ASSEMBLAGE

The Hume assemblage, composed solely of the Hume Formation (Bassett, 1961) is exposed in most areas in conjunction with the underlying Middle and Lower Devonian formations. Unfortunately, complete surface sections of the Hume Formation are rare because the overlying Middle and Upper Devonian shales are easily eroded and subject to structural deformation. The only complete sections of the Hume Formation that were measured in this study are parts of Sections 7, 11, 16 and 18. In all other sections that contain strata of the Hume Formation, the upper part of the formation is missing.

The Hume Formation is present throughout the northern Mackenzie Mountains and the adjoining Interior Plains, and has an average thickness of about 150 m (Fig. 44). The thickness of the Hume Formation and its lateral equivalent, the combined Nahanni-Headless formations (Tassonyi, 1969) increases uniformly southward from about 90 m at 65° latitude to more than 350 m at 63° latitude. South of 63° latitude, this interval decreases in thickness to an approximate maximum thickness of 250 m in the southern Mackenzie Mountains (Morrow and Cook, 1987). A regional southward increase in the thickness of the Hume Formation has been documented also by Gilbert (1973) for the region between the Arctic Coast and 64° latitude. There may be a slight thickness increase from the Fort Norman area, where it is about 110 m thick, westward to the Mount Eduni map area, where it is about 150 m thick. This conforms with, but is of smaller magnitude than, the basinward Hume thickness increase across the shelf suggested by Aitken et al. (1982) and less than its pronounced southward increase in thickness.

The characteristic rock type of the Hume Formation is a dark grey, argillaceous and fossiliferous limestone with minor shale interbeds. In outcrop, the Hume Formation can be divided readily into two parts or members of about equal thickness: a lower, recessive, dark greyish brown to orange weathering, thin to medium bedded, argillaceous limestone with shale interbeds and irregular to nodular bedding; and an upper, resistant, medium grey weathering, thick bedded limestone that is a prominent cliff-former. This twofold character combined with the recessive nature of the overlying Hare Indian Formation imparts a distinctive topographic expression to the Hume Formation, which can easily be recognized on air photos (Aitken et al., 1982). These informal members correspond to the Headless and Nahanni formations mapped in the southern Mackenzie Mountains (Aitken et al., 1972). In the northern Mackenzie Mountains, the lower member is markedly thicker than the upper member (Fig. 10).

The lower member is typically a thin bedded, skeletal wackestone with irregular but planar bedding and some nodular bedding. Yellowish orange and greenish grey argillaceous material forms the bed partings and some argillaceous material occurs in patches within beds. Thin intervals of platy, very thin bedded and laminated, orange weathering, reddish grey siltstone and shale occur within this member in some places (e.g., Unit 15 of Section 13, Appendix 1). The diverse fauna in this member includes brachiopods, crinoids, solitary rugose corals, ostracodes and bryozoans (in approximate order of abundance). Minor skeletal components include ostracodes, trilobites, and goniatites. Some thin, skeletal packstone coquina beds are scattered throughout this member. The upper surfaces of these coquina beds are well-cemented pavements of skeletal packstone and are stained bright yellowish orange. These bedding surfaces may be examples of sediment condensation horizons (Seilacher, 1982), perhaps firm grounds or even hardgrounds (see Aigner, 1981). The lower member passes gradationally upward to the resistant upper member through a gradual

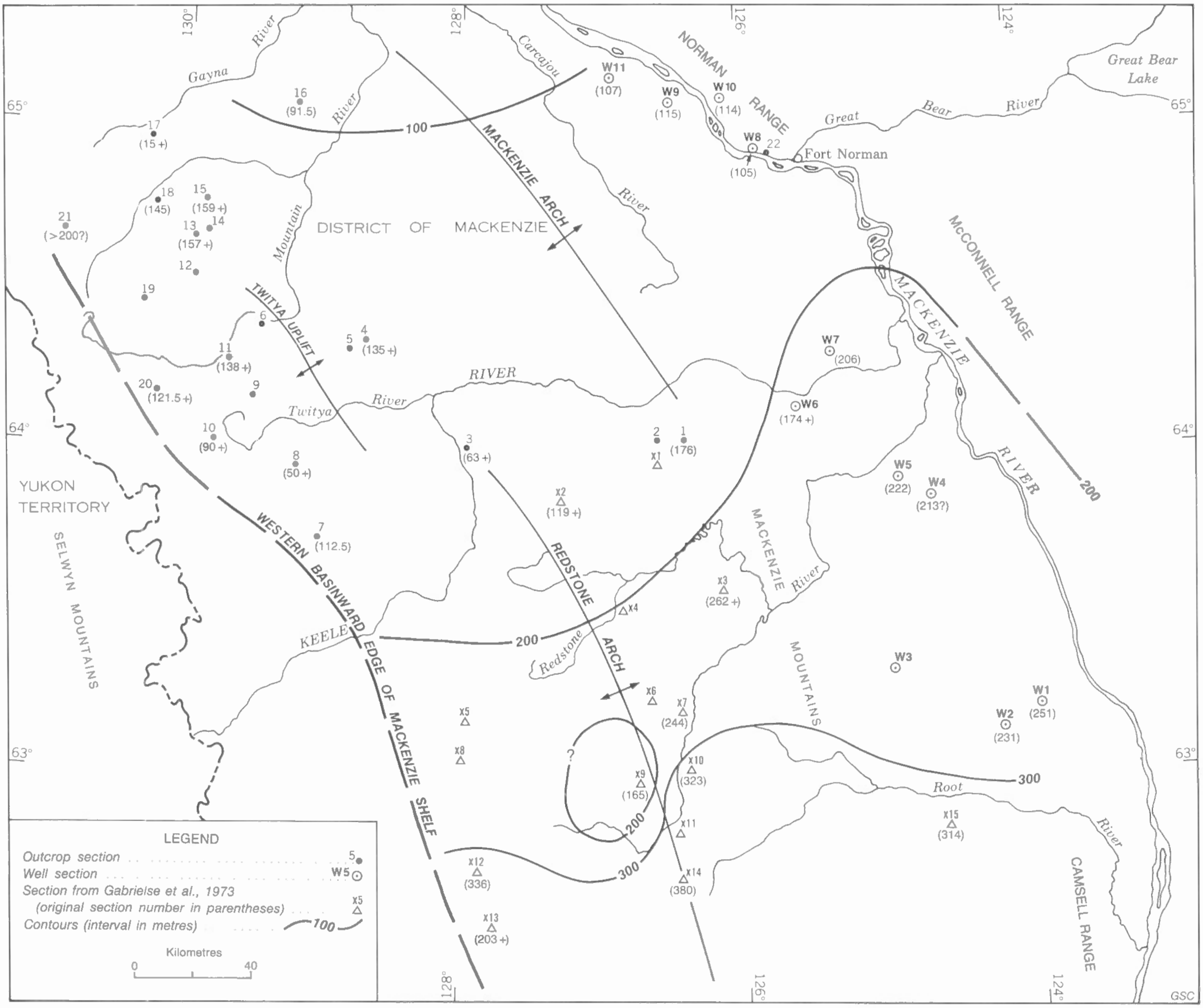


Figure 44. Distribution and thickness of the Hume Formation across the Mackenzie Shelf. See Table 1 for identification of wells and sections.

increase in bed thickness and a reduction in the argillaceous content. Overturned colonial rugose corals occur in some of these transition beds (Fig. 45).

The upper member is commonly a medium to dark grey, very thick bedded skeletal wackestone and fossiliferous lime mudstone and floatstone containing scattered corals and stromatoporoids. In some places, the upper member is a coral and stromatoporoid boundstone that commonly contains favositid and hexagonarid-like colonial corals. The skeletal wackestones and fossiliferous mudstones contain a fauna of finely comminuted crinoid, brachiopod, and ostracode fragments. The upper contact of the Hume with the overlying shale of the Hare Indian Formation appears to be sharp, but is not well exposed, and the possibility that Hume beds are interbedded with basal Hare Indian shale is not excluded.

The Hume Formation in the subsurface has been described by Tassonyi (1969) and Meijer Drees (1980). Tassonyi (1969) subdivided the subsurface Hume Formation into three informal members rather than the two members recognized as a result of surface mapping, and designated the Imperial Loon Creek No. 2 well as the reference well for the Hume Formation in the subsurface. Tassonyi (1969) recognized that the more argillaceous lower and middle subsurface Hume members correlate with the Headless Formation and that the upper Hume member correlates approximately with the Nahanni Formation farther south. The lower two subsurface Hume members, therefore, together correlate with the lower member of the Hume Formation in surface exposures, and the upper subsurface Hume member coincides with the upper Hume member in surface exposures (Aitken et al., 1982). The simple, twofold subdivision of the Hume Formation into a lower, argillaceous, thin bedded member and an upper, thick bedded member with little argillaceous material, is a more fundamental and easily recognizable subdivision than the subsurface threefold Hume subdivision. Tassonyi (1969) Meijer Drees (1980) and Pugh (1983) give details of correlations within Hume strata of the subsurface.

The prolific and diverse macro- and microfaunas of the Hume Formation have been studied and dated extensively (Bassett, 1961; Warren and Stelck, 1962; McLaren, 1962; Pedder, 1964; Braun, 1966; Norris, 1968; Lenz and Pedder, 1972; Chatterton, 1978; and others). The published faunal evidence, as summarized by Chatterton (1978), indicates that the lower part of the Hume Formation is of early to middle Eifelian (or Couvinian) age, whereas the upper part of the Hume is late Eifelian, with the possibility that the topmost Hume beds are early Givetian in age.

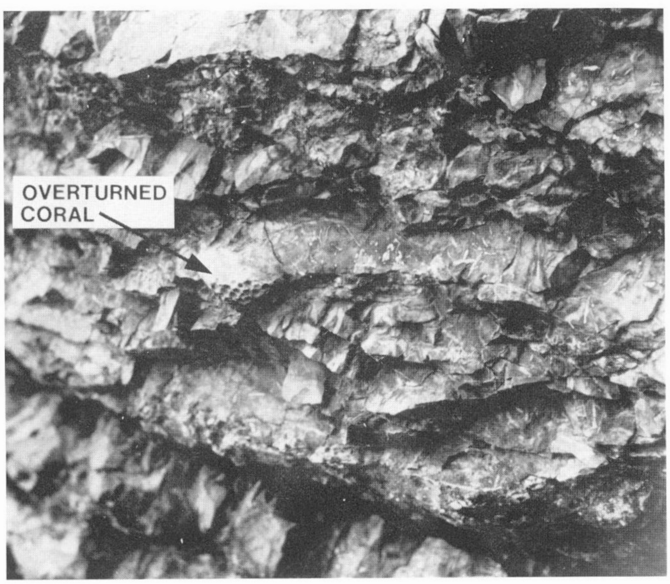


Figure 45. An overturned, hexagonarid-like coral in the lower part of the Hume Formation, located 91 m above the base of the formation in Section 18 (GSC photo no. 2011-9).

The six age diagnostic faunas in collections from the Hume Formation examined in this study denote ages that are consistent with previously published data. Five of these collections were obtained from the lowermost 30 m of the Hume (Appendix 2). All of these indicated an early Eifelian age (*adoceta* Zone). The remaining age determination, of a collection taken from the upper member of the Hume (C-75540, Appendix 2) is late Eifelian (*dysmorphostrata* Zone). The firmly dated strata of the Hume Formation provide, as mentioned previously, a secure upper boundary to the age of the entire Silurian-Devonian sequence between the top of the Mount Kindle Formation and the top of the Hume Formation.

Hume strata overlie Landry strata abruptly but conformably, and no transition or gradation between Landry and Hume strata is apparent in surface exposures (Figs. 8, 10). This is true also of the Landry-Hume transition in the subsurface near the Mackenzie River (Tassonyi, 1969; Meijer Drees, 1980).

POST-EARLY SILURIAN FORMATIONS IN MISTY CREEK EMBAYMENT

Very few data concerning the post-Early Silurian or post-Mount Kindle sequence within Misty Creek Embayment were obtained from this study. Strata of possible post-Mount Kindle age were examined only in Section 21. Speculative correlation between this section and the adjacent post-Mount Kindle Mackenzie Shelf sequence are shown in Figures 7 and 8.

The topmost measured unit of Section 21 is a tan, pelletal wackestone, similar to the pelletal wackestones of the Landry Formation farther east (Fig. 10). This unit caps a prominent bench in the topography (Fig. 46). Above this unit is a pronounced cliff of argillaceous limestone with a recessive and resistant subdivision similar to that of the Hume Formation farther east (Fig. 46). The upper, more resistant part of this cliff appears on air photos to be overlain by dark, soft weathering shale (Fig. 46) like the Hume Formation. If this cliff-forming sequence is, in fact, part of the Hume Formation, then the post-Mount Kindle sequence beneath the Hume becomes considerably thinner where it passes from the Mackenzie Shelf into the Misty Creek Embayment (Figs. 7, 8). Units 7, 8, 9 and 10 of Section 21 have been previously assigned to the Mount Kindle transitional sequence of Cecile (1982, Sec. 6). However, the absence of chert in Unit 10 may indicate that this unit correlates with post-Mount Kindle strata, such as the Arnica and Sombre formations (Figs. 7, 8).

Much more data concerning the Silurian-Devonian sequence in the Misty Creek Embayment need to be gathered to substantiate the correlations indicated in Figures 7 and 8. It is certain, however, that the post-Mount Kindle sequence is dramatically thinner in Misty Creek Embayment than across the Mackenzie Shelf.

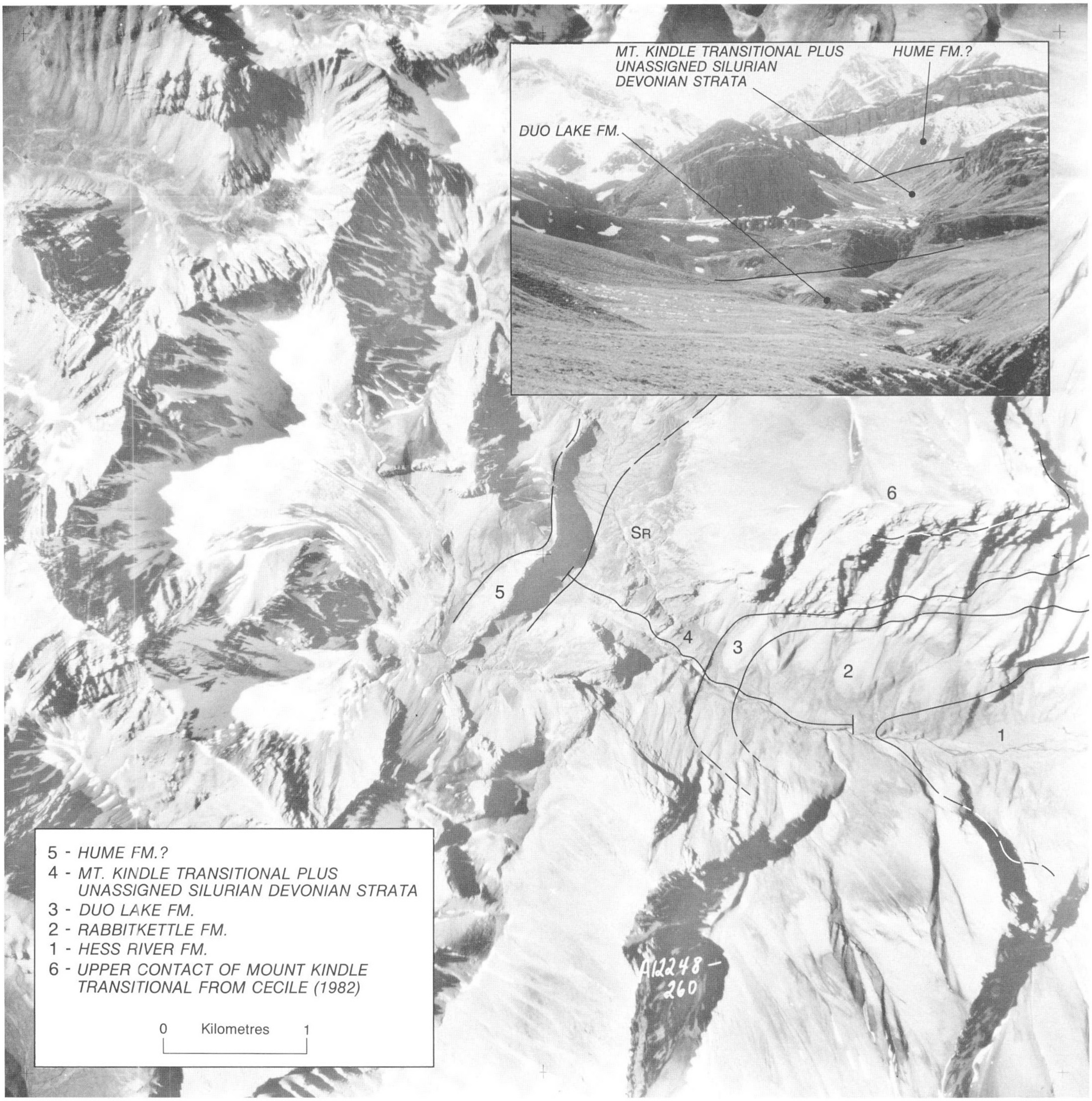


Figure 46. *A vertical aerial view (RCAF airphoto A12248-260) of Section 21, showing the relationship between this section and Section 6 of Cecile (1982). The base of the Devonian in Section 21 is uncertain (see Figures 7, 8) but it is probable that the prominent limestone rib at the top of the section is equivalent to the Hume Formation. The accompanying inset photograph is a view looking to the south at the upper part of Section 21. The photograph shows the recessive character of the lower part of the prominent limestone rib at the top of the section, characteristic of the Hume Formation (GSC photo no. 2011-27).*

DEPOSITIONAL HISTORY, PALEOGEOGRAPHY, AND TECTONICS

The depositional history of the Silurian-Devonian sequence of the northern part of the Mackenzie Shelf reflects the influence of the same variables that governed deposition in the southern Mackenzie Mountains during this time (Morrow and Cook, 1987). Foremost among these variables were eustatic variations of sea level, the paleolatitudinal position of the Mackenzie Shelf, and tectonic movements that affected this shelf. These are fundamental variables that, in general, govern other factors such as climate, water depth and the supply of terrigenous sediments, all of which influence shelf sedimentation more directly.

Most Silurian and Devonian paleogeographic reconstructions of the world's continents place ancient North America in the equatorial region between the paleoequator and 30° north latitude (Smith et al., 1981; Ziegler et al., 1979). The fact that the Silurian-Devonian sequence in the Mackenzie Mountains is dominated by carbonates and evaporites is, at least in part, a reflection of the low latitudinal position of ancient North America. Modern shallow water carbonate deposition is confined to the equatorial region between 30° north and south latitudes (Wilson, 1975, Fig. I-1). Virtually no shallow water carbonates occur north and south of this region.

Also, the latitudinal position of the Mackenzie Shelf changed slightly from 10° north latitude in Middle Silurian to 25° north latitude in late Early Devonian time (Smith et al., 1981). This period of northward migration of the Mackenzie Shelf may be reflected in some degree by an upward transition from the restricted marine dolostones and evaporites of the Delorme assemblage to the open marine limestones of the Hume assemblage in a manner similar to that suggested by Morrow and Cook (1987).

It is more difficult to separate the effects of sea level variations from those of tectonism. However, the hypothesis that major, long term eustatic changes in sea level occurred is supported by the worldwide correlation of certain unconformities (Sloss, 1963). Vail et al. (1977) have recently proposed a detailed scheme of eustatic sea level changes for the Phanerozoic Eon based in part on earlier work (Fig. 47). The major Silurian and Devonian eustatic sea level changes proposed by Vail et al. (1977) in the early Paleozoic sequence of the southern Mackenzie Mountains have already received documentation (Morrow and Cook, 1987). The unconformity separating strata of the Mount Kindle Formation and older formations from the younger strata of the Delorme Group and the Arnica-Bear Rock assemblage in the northern Mackenzie Mountains is consistent with the occurrence of a profound Late Silurian to Early Devonian decline in sea level (Fig. 47). The Lower Devonian Delorme Group contains a large admixture of terrigenous material that may have been reworked from the "sub-Devonian unconformity" at the base of the Delorme Group. The upward transition from the Delorme Group to the 'clean' carbonates and evaporites of the Arnica-Bear Rock assemblage, which are free of terrigenous material, is consistent with the long term Early Devonian rise of sea level that followed the lowering in the earliest Devonian. This sea level rise inundated areas of exposure on the Mackenzie Shelf, such as the Norman Wells High. The supply of terrigenous material was reduced progressively as the edge of the exposed hinterland of the craton moved farther inland, away from the Mackenzie Shelf (Fig. 47).

Unlike the clean carbonates of the Arnica-Bear Rock assemblage, the limestones of the overlying Hume assemblage have a considerable terrigenous component. Noble and Ferguson (1979) suggested that the sediments of the combined Nahanni and Headless formations, the southern equivalent of the Hume Formation, were deposited on a westward prograding wedge of shallow water sediments that advanced seaward across an open marine shelf.

In the subsurface east of the Mackenzie Shelf, the Hume Formation and its correlatives, the Lonely Bay Formation and the upper part of the Chinchaga Formation, may rest unconformably on underlying strata (Law, 1971; Belyea, 1970). If this is true, then a period of exposure and erosion preceded deposition of Hume strata. Lenz (1982) and Morrow and Cook (1987) have suggested that this period of exposure was due to a eustatic drop in sea level in Eifelian (i.e., Couvinian) time. This Eifelian sea level drop is inferred to have been less pronounced than the sea level drop at the end of Silurian time (Lenz, 1982). The terrigenous material in the Hume Formation may have been derived in part from the erosional surface exposed in Eifelian time prior to Hume deposition.

Differential intrashelf tectonic movements have exerted a considerable influence on variations in thickness and the distribution of facies within the Delorme assemblage, and to a lesser extent within the Arnica-Bear Rock assemblage. During the time of deposition of the Delorme Group, the Mackenzie Shelf region was composed of a number of subregions, each with a different subsidence history. The Norman Wells High and the Redstone Arch were areas that underwent little or no subsidence, whereas the flanking regions of the Camsell Sub-basin and Godlin Salient were areas of pronounced subsidence. This pattern of differential intrashelf subsidence continued in a more subdued manner during deposition of the Arnica-Bear Rock assemblage. Although the Twitya Uplift did not obviously influence deposition of either the Delorme Group or the Arnica-Bear Rock assemblage, there is a possibility, as previously mentioned, that some subsidence may have occurred across the region of Twitya Uplift following the period of erosion associated with the development of the sub-Devonian unconformity. If Twitya Uplift were a result of subcrustal thermal expansion related to extensional tectonics and the upwelling of mantle material, then it is possible to estimate the amount of subsidence that must have occurred during the period of thermal cooling and contraction that followed thermal expansion and erosional truncation. If it is assumed that at 100 km depth the earth's crust and outer mantle are at isostatic equilibrium, then the removal by erosion of about 1000 m (i.e., the Mount Kindle and Franklin Mountain formations) of strata from an assumed 30 km thick sialic crust across Twitya Uplift implies a potential maximum subsidence of about 220 m when thermal cooling took place (Kinsman, 1975, see pages 91-94, and Figure 48). This is in accord with the 100 to 200 m thickness of many sections of the Tsetso Formation across Twitya Uplift and the less than 100 m thickness of this formation in Sections 9, 10 and 11 (Fig. 9), which are located basinward of Twitya Uplift.

This scenario relies on the assumption that the subsidence across Twitya Uplift largely predates the development of the basin filled with Camsell Formation sediments in Godlin Salient. This, in turn, depends on the premise that the Tsetso is mostly older than the Camsell. No faunal data are available to confirm this premise, but the fact that sand-bearing beds are confined to the Tsetso strata and that these beds are restricted to the region of Twitya Uplift may provide some confirmation of this premise. An alternate hypothesis is that much of the Tsetso Formation was deposited contemporaneously with the Camsell Formation and that both accumulated in the Godlin Salient area during the same phase of subsidence. This phase of subsidence and local basin formation may have been caused by propagation southeastward onto the shelf of the rift system that has been proposed to explain the origin of the Misty Creek Embayment (Cecile, 1982). The fact that the basin filled with Camsell sediments in the Godlin Salient is subparallel and in such close proximity to Twitya Uplift renders it difficult to analyse their individual effects on Delorme Group deposition.

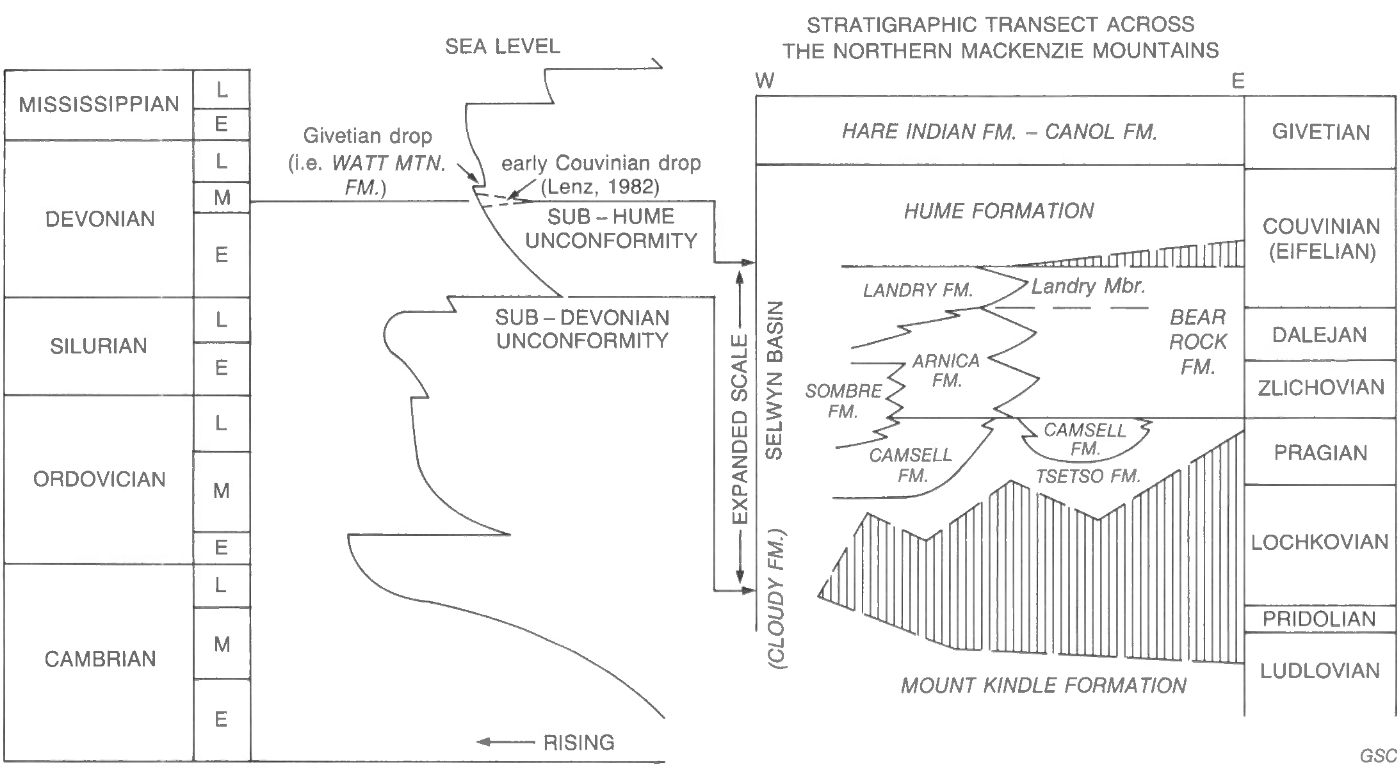


Figure 47. A chart of Paleozoic sea level changes (after Vail et al., 1977; and Lenz, 1982) compared with the Silurian-Devonian stratigraphy of the northern Mackenzie Mountains (Mackenzie Shelf). The unconformity at the base of the Tsetso Formation coincides with a Late Silurian to Early Devonian drop in sea level. Similarly, the unconformity or disconformity at the base of part of the Hume Formation and its equivalents may reflect a late Early Devonian drop in sea level.

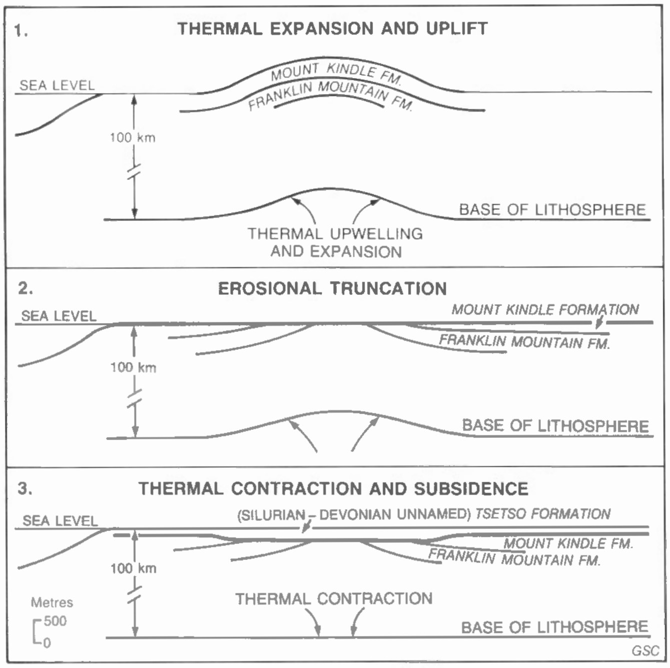


Figure 48. *A possible origin and post-uplift development of Twitya Uplift.*

1. *A thermal bulge at the base of the lithosphere caused thermal expansion and uplift.*
2. *The uplifted strata were truncated close to sea level by erosion.*
3. *Thermal contraction on cooling of the thermal bulge under Twitya Uplift caused subsidence and the accumulation of an anomalously thick and sandy Tsetso sequence over the former uplift.*

If in fact no subsidence related to thermal contraction occurred over Twitya Uplift or over the older, much larger Mackenzie Arch, then both of these regional arches may have been simple flexures of the earth's crust. Such flexures could only reasonably be expected in a compressional regime unlike the extensional tectonic regime proposed by Cecile (1982) for this area. Crustal flexures of the magnitude of Twitya Uplift and Mackenzie Arch have been documented along the present day western edge of North America and are attributed to crustal compression adjacent to a subduction zone (Yorath and Hyndman, 1983). The interpretation of Twitya Uplift as an ephemeral thermal bulge rather than a crustal flexure seems feasible based on the data of this study and is more in accord with an interpretation of predominantly extensional rift development in the early Paleozoic (Cecile, 1983). However, it must be noted that the much larger Mackenzie Arch cannot be interpreted as readily as a thermal bulge. This is apparent if one considers that a nearly 7 km thick sequence of strata has been removed by erosion along the crestal portion of Mackenzie Arch (Aitken et al., 1973), implying that between 1 and 2 km of thermal subsidence should have occurred after erosional truncation of the uplifted strata. Yet the Franklin Mountain Formation, which unconformably overlies the erosionally truncated older formations that comprise this arch, extends uniformly across the entire Mackenzie Shelf without major thickness or facies changes (Aitken et al., 1973). At present the Mackenzie Arch is more readily interpretable as a crustal flexure related to compression rather than as a thermal bulge.

The intrashelf tectonic elements that dominated sedimentation during deposition of the Delorme assemblage and the Arnica-Bear Rock assemblage do not appear to have influenced deposition of the Hume assemblage. Instead, the uniform southward increase in thickness of the Hume and its equivalents (Fig. 44) implies that the entire Mackenzie Shelf underwent uniform, southward differential subsidence during Hume deposition in Eifelian time. The reader is cautioned, however, that this trend is based on comparatively few complete sections and therefore is not as firmly based as the thickness variations documented for strata underlying the Hume Formation. Thickness variations of the upper and lower parts of the Hume do not appear to exhibit a consistent pattern.

In summary, the depositional patterns and thickness variations exhibited by Silurian and Devonian shelf sediments of the northern Mackenzie Mountains reflect the interplay between factors dependent on paleolatitude, tectonics and changes in sea level. The evolution of a complex paleogeography during deposition of the Delorme Group to a simple paleogeography during Hume deposition primarily reflects the progressive change from complex, intrashelf, differential tectonism to uniform, shelfwide subsidence.

The maximum thickness of the entire sequence, from the top of the Mount Kindle Formation to the top of the Hume Formation, is about 3000 m in the Camsell Sub-basin (Fig. 49). If an accumulation time of 50 x 10^6 years is assumed (i.e., Ludlovian to Givetian stages) then the mean accumulation rate of this sequence is 60 m per 10^6 years. This high accumulation rate is characteristic only of the central region of the Camsell Sub-basin. Most of the shelf is characterized by subsidence rates of 20 m per 10^6 years or less, a rate typical for subsidence of the distal parts of modern continental shelves (Fischer, 1975). The high subsidence rate associated with the Camsell Sub-basin is more typical of modern day shelf edge basins, such as the Los Angeles Basin (Fischer, 1975).

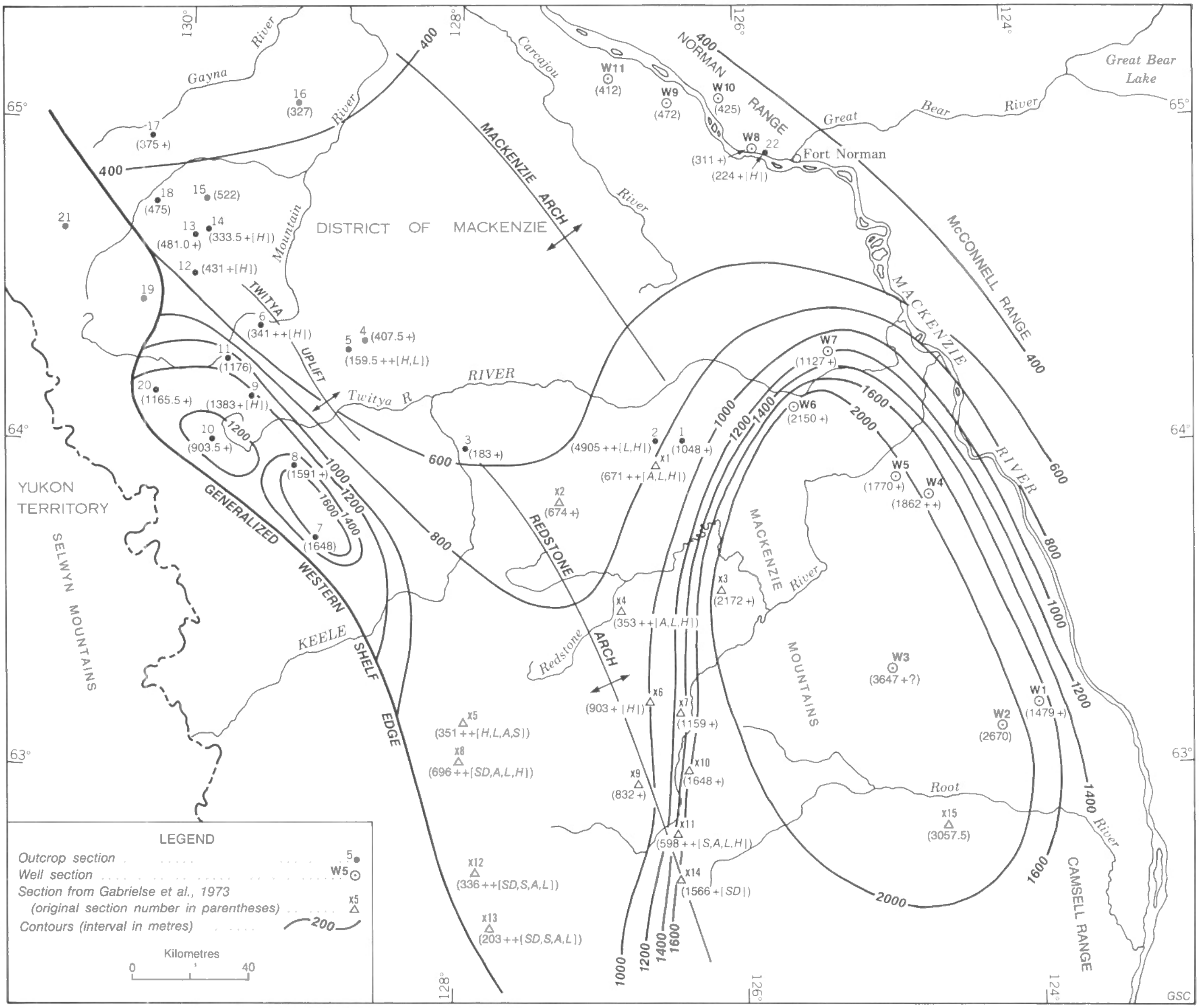


Figure 49. Isopach map showing the distribution and total thickness of strata contained between the top of the Mount Kindle Formation and the top of the Hume Formation. A, Arnica; L, Landry; H, Hume; S, Sombre; SD, Silurian-Devonian Unnamed (Tsetso).

ECONOMIC CONSIDERATIONS

Although suitable source rocks and reservoir rocks are present, the oil and gas potential of this region appears to be minimal for several reasons. Firstly, almost all major structures of the northern Mackenzie Mountains are breached, with the exception of the Paleozoic strata covered by the Plateau Thrust Plate (Cecile et al., 1982). Determinations by Cecile et al. (1982) on the level of organic alteration in samples from this region were ambiguous but indicated that alteration is mature to overmature with respect to oil generation. This indication of overmaturity is confirmed by a Colour Alteration Index (CAI) of 4 to 5 in conodonts collected from the Ordovician-Silurian undivided or Cloudy Formation(?) of Section 7 (GSC loc. C-075748), the Cloudy Formation of Section 20 (GSC loc. C-075704), and the Tsetso Formation of Section 8 (GSC locs. C-075783, C-075784). Also, conodonts with CAI indices of 4 1/2 to 6 have been collected from the Hume and Funeral formations (i.e., Landry Formation of this study) of the Dahadinni M-43A well (well no. W4 - Fig. 24; Meijer Drees, 1980). It can be inferred tentatively that a CAI index of 4 to 6 characterizes most, if not all, of the early Paleozoic strata of the northern Mackenzie Mountains. A CAI of 4 to 6 indicates a temperature far beyond 200°C (Epstein et al., 1977), denoting an overmature level of thermal alteration with respect to oil generation (Tissot et al., 1974). Organic material in sediments containing conodonts with a CAI index of 4 to 5 should be thermally altered to dry gas (i.e., methane).

Potential source rocks for thermally-generated methane include the Devonian-Mississippian shales overlying the Hume Formation, and the Road River shale mass in Selwyn Basin and the Misty Creek Embayment. Potential reservoir rocks include the biostromal upper part of the Hume Formation, and the sucrosic, biostromal and biothermal dolostones within the Sombre and Arnica formations and within the Mount Kindle Formation at or near the basinal edge of the Mackenzie Shelf, particularly in the region covered by the Plateau Thrust Plate (Fig. 3; Cecile et al., 1982).

The mineral potential of Silurian-Devonian strata of the northern Mackenzie Mountains is still in its early stages of assessment. Almost all known showings are of the carbonate-hosted zinc-lead type and include such occurrences as the BEAR-TWIT property of Cominco, the RAIN-SNOW property of Welcome North, and several other properties in which galena and sphalerite occur as space-filling cements in brecciated and veined dolostones (Dawson, 1975; Fig. 3). One such showing was examined at Section 12, where yellow sphalerite and galena occur within the Mount Kindle and Arnica formations and the Unnamed Silurian-Devonian (i.e., Tsetso Formation) as described by Cecile and Morrow (1978 and Fig. 30).

Dawson (1975) has suggested that many of these zinc-lead deposits have been remobilized and upgraded locally by tectonic activity. The proximity of these Siluro-Devonian showings to the Mackenzie Shelf edge (Fig. 3) may indicate that their metal content was derived directly or indirectly from the basinal strata of Selwyn Basin and Misty Creek Embayment.

RECOMMENDATIONS FOR FURTHER RESEARCH

The nature of the shelf-to-basin transition of Silurian-Devonian strata in the northern Mackenzie Mountains requires more study, particularly in the Bonnet Plume Lake map area (106 B), to substantiate or modify the tentative shelf-to-basin correlations suggested in this report. This is important to metallogenic studies as well as for the establishment of a stratigraphic framework for a Silurian-Devonian shelf-to-basin transition. The region of the Norman Wells High (Fig. 2) is also an area where stratigraphic information concerning Silurian-Devonian strata is lacking. Further work in this area should involve finding out more about the nature of the contact of the Bear Rock Formation with the underlying Tsetso Formation, particularly at those places where strata of the Tsetso wedge out beneath the Bear Rock over the Norman Wells High.

An effort should be made to acquire more complete sections of the Hume Formation to substantiate the thickness trends inferred in this report and to document changes in the character of the upper and lower contacts of the Hume. The nature of the upper contact is particularly important, as it is a major event horizon separating the underlying shelf carbonate sequence from the thick overlying sequence of basinal shales. As pointed out by Aitken et al. (1982) the contact between the Hume and the overlying Canol Formation has been regarded as an unconformable surface of subaerial erosion by some workers (Bassett and Stout, 1967) but as conformable by other workers (Williams, 1983). Those who regard this contact as conformable interpret the top of the Hume beneath the Canol Formation to be a condensation surface related to a sudden Givetian/Frasnian rise in sea level (Williams, 1983).

CONCLUSIONS

The three major subdivisions of the Silurian-Devonian sequence between the Mount Kindle Formation and the top of the Hume Formation – the Delorme assemblage, the Arnica-Bear Rock assemblage, and the Hume assemblage – are a record of the influence of latitudinal position, a tectonic regime that changed unidirectionally, and of an oscillatory sea level superimposed on a continuously subsiding shelf. The upward transition from the restricted evaporitic deposits of the Delorme Group to the open marine limestones of the Hume Formation probably reflects, in part, the northern migration of the Mackenzie Shelf from a position near the equator to a position near or at 30°N latitude. This stratigraphic transition reflects, to an even greater degree, changes in the tectonic regime of the Mackenzie Shelf. During deposition of the Delorme Group, the Mackenzie Shelf was strongly affected by differential intrashelf tectonic movements. These movements caused the formation of intrashelf basins, such as the Camsell Sub-basin and the basin occupying Godlin Salient, which were separated by land areas such as the Norman Wells High. This large portion of land occupying the shelf region also favoured the accumulation of evaporites during deposition of the Delorme Group. Intrashelf tectonic movements were less evident during deposition of the Arnica-Bear Rock assemblage and they no longer determined the distribution of facies. Finally, no differential intrashelf movements occurred during deposition of the Hume Formation. The absence of intrashelf movements during Hume deposition allowed Hume sediments to accumulate on an open marine shelf. The overall average rate of subsidence for the Mackenzie Shelf during accumulation of this Silurian-Devonian sequence is about 20 m per million years – typical for passive continental shelf margins – although locally, as in the Camsell Sub-basin, the rate of accumulation or subsidence is considerably greater.

The extensive "sub-Devonian" unconformity beneath the Delorme is consistent with a Late Silurian to earliest Devonian drop in sea level. The marine inundation of land areas that accompanied the transition from sedimentation of the Delorme Group to deposition of the Arnica-Bear Rock assemblage is consistent with a uniform Early Devonian sea level rise that diminished the supply of terrigenous material. This sea level rise may have been interrupted by a brief fall of sea level in early Eifelian time. The Hume Formation was deposited during renewed sea level rise, and contains terrigenous material that may have been, in part, reworked from the sub-Hume exposure surface east of the Mackenzie Mountains.

The degree of subsidence that occurred across Twitya Uplift after its erosional truncation in Late Silurian time is consistent with the interpretation that Twitya Uplift is the result of sub-crustal thermal expansion related to thermal upwelling of the asthenosphere beneath. Such an explanation does not appear to be valid for the older and much larger Mackenzie Arch, however. If both Twitya Uplift and Mackenzie Arch are compressional flexures of the earth's crust rather than thermal uplifts, then scenarios invoking an early Paleozoic extensional plate tectonic regime for the Mackenzie Shelf and adjacent regions (e.g., Cecile, 1982) will have to be modified.

One new paleotectonic and paleogeographic feature, named Godlin Salient, was identified. The Godlin Salient is a particularly thick development of Silurian and Devonian strata that projects into the junction of the Misty Creek Embayment with the Selwyn Basin. This salient may reflect the extension into the shelf of the proposed rift zone that may have formed the Misty Creek Embayment (Cecile, 1982).

The Silurian-Devonian of the Mackenzie Shelf region has the potential for only dry gas reserves because of its thermal history. Mineral potential is restricted to carbonate-hosted zinc-lead occurrences. Proximity to argillaceous basinal strata on a regional scale appears to be a factor that may control the distribution of known zinc-lead occurrences.

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APPENDIX 1

MEASURED SECTIONS

Section 1 - Toochinka Creek East

This section includes strata of the Mount Kindle, Tsetso, Bear Rock, Landry and Hume formations in the southeast part of the Carcajou map area (NTS 96 D). This is an eastward-dipping reconnaissance section that extends eastward 4 km down a stream valley at latitude 64°01′N and longitude 126°28′W. The section is best seen on RCAF air photograph A12055-280. Unit thicknesses were estimated from the air photo.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
10	**Argillaceous limestone**: grey, weathers yellowish and orange-grey; very thin to thin, irregular bedding in lower part with orange argillaceous partings; moderately recessive; an argillaceous, dark grey, skeletal lime wackestone with abundant crinoids, brachiopods, trilobites, and corals crowding the bedding surfaces; upper part thin to thick bedded lime mudstone; resistant, cliff forming; contains colonial corals; upper part of the Hume was observed only from a distance	176.0	1075.0
	Total thickness of the Hume Formation is 176 m.		
	Bear Rock Formation Landry Member		
9	**Limestone:** dark to medium brown-grey pelletal wackestone; very smooth, medium to thick, planar and continuously bedded with thinner bedded intervals separating thicker bedded intervals; some fenestral fabric at the top of some thick beds; resistant, medium to light blue-grey cliffs; the lower part of this unit is weakly brecciated and gradational with the underlying Bear Rock Formation breccias	28.0	899.0
	Total measured thickness of the Landry Member is 28 m.		
	Bear Rock Formation		
8	**Limestone breccia:** medium to light grey; massive, poorly sorted, particulate rubble packbreccia; very resistant; cliffs tend not to be continuous but instead are castellated in appearance; carbonate breccia fragments tend to be angular and equant and are up to 1.0 m across; some poorly exposed particle size grade alternations within this unit	185.0	871.0
7	**Calcareous dolostone:** dark grey to brown-grey weathering; medium planar bedded; slightly recessive; some amphiporid-bearing beds; many beds have been weakly brecciated in situ to form incipient crackle breccias, some of these beds are partly dedolomitized; dedolomitization has imposed a light grey mottled appearance on these beds	50.0	686.0
6	**Limestone breccia**: very similar to the breccia unit of Unit 8 but no fragments in the breccia of this unit are more than 0.5 m across	47.0	636.0
	Total measured thickness of the Bear Rock Formation is 310 m.		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Camsell Formation		
5	**Silty dolostone:** grey-yellow weathering; thin to medium planar bedded with some laminated intervals; moderately resistant with ragged cliffs; medium bedded grey intervals tend to grade upward to more recessive, yellow, thin bedded and laminated beds; pink stained erosional surfaces tend to separate the "rhythms" of the medium to laminated beds; some thinner beds are slightly sandy, more markedly rhythmic and more yellow weathering toward the top of the unit	100.0	589.0
4	**Limestone breccia:** yellow weathering; mostly massive, but still a few places where original bedding may be discerned; moderately resistant; silty, particulate, rubble packbreccia, very similar to overlying Bear Rock breccia but more yellow weathering and silty	42.0	489.0
	Total measured thickness of the Camsell Formation is 142 m.		
	Tsetso Formation		
3	**Silty dolostone:** yellowish grey weathering; medium to thick planar bedded, silty dolostone laminite; very resistant and cliff forming; stromatolitic intervals are common; some vuggy, thick, grey beds; vugs occluded with white dolomite and quartz	185.0	447.0
2	**Silty dolostone:** grey-yellow weathering; resistant; unit is divisible into three parts: a thin, lower part of yellow weathering, platy to flaggy, thin bedded, dark brown-grey to light grey dololaminite, with a few thick interbeds of vuggy dolostone; a middle part of grey-yellow dololaminite, containing stromatactoid and coralline bioherms that are several metres in width and about 1.0 m high; the uppermost part constituting nearly half of the unit, a bright yellow weathering interval of very argillaceous, green-yellow, platy dololaminite (almost a dolomitic shale!) with scattered thick beds of sandy, mudcracked laminated dolostone	242.0	262.0
	Total measured thickness of the Tsetso Formation is 427 m.		
	Mount Kindle Formation		
1	**Dolostone:** dark grey, dark brown-grey weathering; thin and irregularly bedded; resistant; bituminous, fetid and vaguely mottled by bioturbation; some small-scale ripples	20.0	20.0
	Incomplete thickness of the Mount Kindle Formation is 20 m.		
	Total thickness of the Toochinka Creek East Section (Section 1) is 1075 m.		

Section 2 - Toochinka Creek West

This section includes the Franklin Mountain, Mount Kindle and Tsetso formations, and parts of the Sekwi and Bear Rock formations, and dips gently westward in the southeast corner of the Carcajou Canyon map area (NTS 96 D). It extends westward along a west-flowing creek that flows into Toochinka Creek at latitude 64°01′N and longitude 126°38′W, and is best seen on RCAF air photograph A12055-397.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Bear Rock Formation		
15	**Dolostone:** grey-brown weathering; slightly uneven planar bedding, maximum medium bedded, minimum thin bedded, mode medium bedded; gradational lower contact; an amphiporid-bearing, slightly fetid dolomite with some grey mottlings or patches of dedolomite, slightly recessive; 80% exposed	27.0	986.5
14	**Limestone breccia:** grey weathering; lower part of unit very thick bedded but upper part is massive breccia; a chaotic, poorly sorted packbreccia of fine crystalline, recrystallized limestone clasts in a calcilutite matrix; very resistant cliff former; 70% exposed	199.5	959.5
	Total measured thickness of the Bear Rock Formation is 226.5 m.		
	Tsetso Formation		
13	**Dolostone:** light grey weathering; continuous planar to wavy bedding, maximum thick bedded, minimum thin bedded, mode medium bedded; fine to medium crystalline (recrystallized); a stromatolite laminite with laterally linked hemispheroidal stromatolites (20 cm in amplitude and wavelength); resistant; unit caps hill	76.5	760.0
12	**Dolostone:** yellow weathering; smooth bedded, maximum thin bedded, minimum laminated, mode thin bedded; recessive unit exposed on west side of valley; intervals <1 m thick of fissile, platy and lenticularly bedded, yellow laminite occurring sporadically throughout	63.0	683.5
11	**Dolostone:** yellow weathering; continuous planar bedding (more evenly bedded than underlying unit), maximum medium bedded, minimum very thin bedded, mode thin bedded; thinner beds are faintly laminated, thicker beds contain small, biogenic vugs; one orange weathering, silty, thick dolostone bed caps this resistant unit and forms a dip slope down to valley floor	91.5	620.5
10	**Dolostone:** yellow weathering; continuous smooth planar bedding in light grey argillaceous dolostone laminite with a few thicker vuggy beds; maximum medium bedded, minimum very thin bedded, mode thin bedded; vugs partly infilled with quartz; recessive, but 100% exposed	33.0	529.0
	Total measured thickness of the Tsetso Formation is 264 m.		
	Mount Kindle Formation		
9	**Dolostone:** dark grey weathering; planar continuous to slightly irregular bedding; maximum thick bedded, minimum thin bedded, mode medium bedded; scattered 1 m thick fossiliferous horizons (scattered corals) partly silicified with chert nodules; abundant laminated stromatolitic beds; one 5 m thick light grey-yellow bed of dolomite laminite; moderately resistant; 90% exposed	138.0	496.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
8	**Dolostone:** lower two thirds light grey to cream weathering, light brown dolostone (biostromal); massive; sucrosic; coralline; upper third medium grey, thick bedded, vaguely mottled dolostone; dark grey chert nodules tend to occur in horizons throughout; unit is capped by 3 m of recessive, yellow fenestral and stromatolitic laminite; resistant, and 100% exposed	99.0	358.0
7	**Dolostone:** dark brown, mainly dark to medium brown weathering; fetid very thick biostromal beds with irregular discontinuous partings that grade upward to light grey and yellow recessive and thin bedded dolostone laminite; partly biostromal with some stromatactis and stromatoporoid-bearing horizons; silicified fauna with dark grey chert nodules; a slightly mineralized stromatactis bed at 252 m; prominent 5 m thick recessive units at 188.5 m and 233.5 m; overall, a resistant, well exposed unit	105.0	259.0
6	**Dolostone:** uninterrupted dark to medium brown-grey fetid dolostone with abundant black chert nodules; very thick bedded with discontinuous irregular partings; very resistant unit; many corals in situ with abundant *Halysites*, occasional orthoceroid cephalopods	57.0	154.0
5	**Silty dolostone:** light yellow-grey, yellow weathering; thin to very thin planar bedding with argillaceous partings; basal recessive unit of the Kindle	8.0	97.0
	Measured thickness of the Kindle Formation is 407 m.		
	Franklin Mountain Formation		
4	**Dolostone:** dark to medium grey weathering, thick, slightly vuggy beds alternate with thin bedded intervals 0.5 to 1.5 m thick of yellow-grey to yellow weathering silty dolostone laminite; brown silty dolostone occurs as ill-defined pods 0.5 m across in the laminites and as beds over the laminites; abundant laterally linked hemispheroidal stromatolites; a completely exposed, moderately resistant unit	17.0	89.0
3	**Dolostone:** dark grey, medium to dark grey weathering; thick bedded, with a few bioturbated slightly silty thinner beds; strongly resistant some thin intraclastic rudstone bands; at 65.0 m a thick bed with large vugs filled with orange carbonate cement as in underlying units; completely exposed	19.0	72.0
2	**Dolostone:** medium to dark grey, medium grey to yellow-grey weathering; smooth, thin bedded, faintly laminated intervals are interbedded with bioturbated, medium bedded intervals that have slightly irregular bedding surfaces; pinkish toward top of unit with some pinpoint porosity; irregular vugs up to 10 cm long and vertical tension gashes filled with orange ferroan dolostone(?) and quartz; scattered pods of pinkish dolostone breccia in sandy dolostone; a few dewatering 'dish' structures in silty dolostone laminite; moderately resistant; completely exposed	13.0	53.0
	Measured thickness of the Franklin Mountain Formation is 49 m.		
	Sekwi Formation		
1	**Sandstone:** light grey, orange weathering; dolomitic; thin bedded, with a few burrow mottled silty dolostone beds with red staining; vugs lined with orange carbonate cement scattered parallel to bedding; only 15% exposed; moderately resistant	40.0	40.0
	Incomplete thickness of the Sekwi Formation is 40 m.		
	Total thickness of the Toochinka Creek West Section (Section 2) is 986.5 m.		

Section 3 - Keele River

This section includes the Mount Kindle, Tsetso, Bear Rock and Landry formations, and parts of the Franklin Mountain and Hume formations. It dips westward in the southwest corner of the Carcajou Canyon map area (NTS 96 D) and extends westward across a north-trending ridge down the dip slope near Keele River at latitude 64°02′N and longitude 127°55′W. It is best seen on RCAF air photograph A12229-416.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
18	**Limestone:** mottled orange and yellow, medium grey weathering; planar, but irregular and nodular bedded, maximum medium bedded, minimum very thin bedded, mode thin bedded; basal contact sharp; recessive; 70% exposed; argillaceous skeletal wackestone with abundant brachiopods	63.0	550.0
	Incomplete thickness of the Hume Formation is 63 m.		
	Bear Rock Formation Landry Member		
17	**Dolostone:** dark grey weathering; smooth planar to broadly wavy bedding, maximum medium bedded, minimum very thin bedded, mode medium bedded; moderately resistant; basal contact gradational; a dolomitized argillaceous calcilutite, 90% exposed	39.0	487.0
	Total measured thickness of the Landry Member is 39 m.		
16	**Limestone breccia:** medium grey and orange weathering; massive bedded, becoming medium bedded toward the top of the unit; basal contact abrupt; angular breccia clasts in lower part tend to be oriented parallel to bedding in a bituminous calcilutite matrix but most of unit is largely chaotic packbreccia with clasts up to several metres across; resistant; cavernous; 100% exposed	69.0	448.0
	Total measured thickness of the Bear Rock Formation is 108 m.		
	Tsetso Formation		
15	**Dolostone:** light grey weathering interbedded with yellow-grey weathering; in 1 to 2 m thick intervals, smooth planar bedding, maximum medium bedded, minimum thin bedded, mode thin bedded; recessive; 50% exposed	12.0	379.0
	Total measured thickness of the Tsetso Formation is 12 m.		
	Mount Kindle Formation		
14	**Dolostone:** light grey and light brown weathering; planar smooth bedding except for some thicker beds, maximum thick bedded, minimum thin bedded, mode medium bedded; thinner beds dolostone laminite, one interval of biostromal vuggy thick beds (small vugs <2 cm); lower part of this unit is transitional upward from the underlying thick biostromal unit to the overlying Tsetso; moderately recessive; 50% exposed	31.5	367.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
13	**Dolostone:** brown-grey to dark grey weathering; lower part (up to about 290 m) is a thick bedded, chert-bearing, fossiliferous, slightly silty and sandy, brownish grey dolostone with black, irregular, chert nodules, scattered colonial corals (*Halysites* and *Syringopora*), solitary corals and brachiopods; above 270 m this unit is massive, biostromal, with abundant, large, colonial coral heads with no bedding (forms the top of the cliff) One faunal collection was taken 15.5 m above the base of the unit at GSC loc. C-75672 and includes: brachiopod and trilobite fragments *Bighornia* sp. *Catenipora* sp. favositid coral *Palaeophyllum* sp. *Sarcinula* indicating a Late Ordovician age (*Bighornia-Thaerodonta* Fauna); identified by B.S. Norford	81.0	335.5
	Total measured thickness of the Mount Kindle Formation is 112.5 m.		
	Franklin Mountain Formation		
12	**Dolostone:** light yellow-grey weathering; planar bedded, maximum thick bedded, minimum thin bedded, mode medium bedded; a yellow, silty dolostone laminite with 1 to 2 m thick intervals of pinkish light grey solution collapse breccias at 228 and 245 m; mosaic stratiform breccias with recrystallized pinkish grey fragments cemented by white, coarse crystalline dolostone; abrupt lower contact; resistant cliff former	27.0	254.5
11	**Dolostone:** three cycles of medium to thick bedded, yellow-grey, vuggy dolostone grading upward to thin to medium, smooth bedded, silty dolostone laminite; moderately resistant; lower contact gradational	18.0	227.5
10	**Dolostone**: lower part is yellow-grey, upper part varicoloured; silty; thin to medium bedded, medium beds are slightly vuggy with a few thick beds; moderately resistant; one zone at 204 to 209 m with bright red, sandy, stratigraphic pods of dolomite in an interval of yellow-green silty dolostone, pods are 2 to 5 m across	14.0	209.5
9	**Dolostone:** bright orange weathering; silty and slightly sandy; planar continuous bedding, maximum thick bedded, minimum medium bedded, mode medium bedded; moderately resistant; some thicker beds contain vugs cemented by orange- and red-stained dolostone	12.5	195.5
8	**Dolostone:** yellow weathering; silty; planar bedded, maximum thick bedded, minimum thin bedded, mode medium bedded; many rhythmic alternations of vuggy, thick, slightly uneven beds with thinner featureless beds; basal 10 m of this unit are stratiform mosaic breccia with fragments cemented by coarse crystalline white dolostone; fragments weather faintly pink, lower contact gradational; prominent, resistant cliff former	24.0	183.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
7	**Dolostone:** light yellow weathering; slightly silty; planar continuous bedding, maximum thick bedded, minimum thin bedded, mode medium bedded; rhythmic alternation of vuggy biostromal thicker beds with thinner stromatolitic laminites, moderately resistant	56.0	159.0
6	**Sandstone** and **dolostone:** 70% medium sandstone; orange weathering; medium to thick bedded; a dolostone and hematite cemented quartzarenite; scattered dolostone mud chips in sandstone and some sand filled mudcracks, 30% silty yellow dolostone that predominates toward the top of the unit; slightly recessive	10.0	103.0
5	**Sandstone** and **dolostone:** 90% medium sandstone; orange weathering; medium to thick bedded, irregular load casting and slumped bedding; a dolostone and hematite-cemented quartzarenite; pods of dolostone chip breccia are scattered throughout; some trough(?) crossbeds in uppermost part of silica-cemented capping unit; 10% silty dolostone; yellow weathering; thick bedded with some thin beds; occurs as scattered thin intervals; moderately resistant to recessive	9.0	93.0
4	**Sandstone:** orange weathering dolostone; hematite-cemented **quartzarenite:** fine sandstone with some red and green streaks; planar bedded, maximum medium bedded, minimum thin bedded, mode thin bedded; pale blocky dolomitic sand marks the top of the unit; unit transitional between the lower sandy part of the Franklin Mountain and the upper dolomitic part; moderately recessive; 90% exposed	2.0	84.0
3	**Sandstone:** silty; fine grained; red and green; recessive; interbedded in 0.5 m thick intervals with **quartzarentie**: white to pink; resistant; maximum thick bedded, minimum thin bedded; detrital mud chips on upper bed surface at contact with the overlying unit; quartzarenite beds basal contact gradational; moderately resistant; 90% exposed	13.0	82.0
2	**Quartzarenite:** very light grey; smooth planar bedding, but becoming wavy bedded near upper contact, maximum very thick bedded, minimum medium bedded, mode thick bedded; one or two red stained beds near basal contact; a resistant, prominent cliff former	25.5	69.0
1	**Sandstone** and **siltstone:** medium quartzarenite; greyish green; resistant; calcite-cemented; interbedded with red, argillaceous siltstone intervals; irregularly interbedded and interlaminated, wavy discontinuous bedding, some slumped beds, maximum thin bedded, minimum very thin bedded, mode thin bedded; recessive; 90% exposed	43.5	43.5

Incomplete thickness of the Franklin Mountain Formation is 254.5 m.

Total thickness of the Keele River Section (Section 3) is 550 m.

Section 4 - Twitya River 2

This section includes parts of the Franklin Mountain, Delorme, Bear Rock and Landry formations, and part of the Hume Formation in the Mount Eduni map area (NTS 106 A). The section dips southwest and extends westward across a northwest-trending ridge 25 km north of Twitya River at latitude 64°21′N; longitude 128°38′W, and is best seen on RCAF air photograph A:12188-124.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
17	**Limestone:** medium grey weathering; planar, slightly uneven bedding, maximum very thick bedded, minimum medium bedded, mode thick bedded; argillaceous and bituminous skeletal wackestone containing corals; basal contact covered, 5% exposed; recessive; very poor exposure	135.0	585.0
	Total measured thickness of the Hume Formation is 135 m (probably complete).		
	Conformably overlain by rusty weathering, black, siliceous shale of the Canol Formation.		
	Bear Rock Formation Landry Member		
16	**Dolostone:** medium grey weathering; medium planar bedding; a dark grey dolomitized calcilutite(?), slightly argillaceous; basal contact covered; moderately recessive; 30% exposed	13.0	450.0
	Total measured thickness of the Landry Member is 13 m.		
15	**Limestone** and **dolostone breccia:** medium grey weathering; very thick to massive bedding; oligomictic rubble breccia of poorly sorted and packed, angular, fine crystalline dolostone clasts (clasts up to 0.5 m across observed), clasts cemented with a drusy calcite crust; some detrital calcite silt and bituminous shale chips (less than 2.0 cm long), near the base of the unit, fragments are oriented parallel to bedding, floating in a carbonate silt matrix; basal contact abrupt; resistant; 90% exposed	141.0	437.0
	Total measured thickness of the Bear Rock is 154 m.		
	Tsetso Formation		
14	**Mudstone:** yellow weathering; maximum thin bedded, minimum laminated, mode very thin bedded; dolomitic, some of this unit is probably an argillaceous dolostone; basal contact covered, very recessive; 15% exposed	15.0	296.0
13	**Dolostone:** light yellow and light greyish yellow; thin planar bedding; slightly argillaceous; basal contact gradational; recessive; 5% exposed	8.5	275.0
12	**Dolostone:** medium grey weathering; planar laminated bedding, maximum thick bedded, minimum thin bedded, mode medium bedded; some stromatolitic intervals; basal contact gradational; slightly resistant; 90% exposed	43.5	266.5
11	**Dolostone:** yellow and orange weathering; maximum medium bedded, minimum thin bedded mode thin bedded; silty and argillaceous; some stromatolite laminite; one or two orange dolomite cemented sandstone beds; basal contact gradational; resistant; 100% exposed	24.0	223.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
10	**Sandy dolostone:** yellow to orange weathering; maximum medium bedded, minimum thin bedded, mode thin bedded; sandy parts tend to be orange and laminated; about 50% quartz silt and sand (average grain size 0.01 mm) with a few chert and microcline grains; basal contact gradational; resistant; 100% exposed	12.5	199.0
9	**Dolostone:** medium grey weathering, with a slightly pink tint; maximum medium bedded, minimum thin bedded, mode thin bedded; many small (<2 cm) vugs strung out parallel to bedding; laminae appear stromatolitic; basal contact gradational; moderately resistant; 80% exposed	9.0	186.5
	Total measured thickness of the Tsetso Formation is 118.5 m.		
	Franklin Mountain Formation		
8	**Dolostone breccia:** red to pinkish grey weathering; massive bedded; a crackle and mosaic breccia with pink, angular fragments broken parallel and perpendicular to bedding as a stratiform breccia body; some pinkish grey beds are unbrecciated; interfragment pores are filled with white, coarse crystalline dolostone and drusy quartz; moderately resistant, with a castellated appearance; 60% exposed	30.0	177.5
7	**Dolostone:** yellow weathering, with reddish breccia pods several metres across at the top of the unit; these breccia pods occupy shallow scours on the top surface of the unit, and are filled with red, subangular dolostone fragments up to 5 cm across; some patches of green stain in breccia pods; most of unit is medium to thin bedded, stromatolitic laminite and smooth bedded, finely clastic beach ridge sedimentary rocks; moderately resistant; 80% exposed	7.5	147.5
6	**Dolostone:** same as at Unit 8 but only 80% exposed	4.5	140.0
5	**Dolostone:** yellow weathering; planar to wavy bedded; maximum medium bedded, minimum very thin bedded, mode thin bedded; medium bedded dolomite grades upward to rubbly, nodular beds in 1 to 2 m thick cycles; some stromatolitic laminae and leached amphiporids in medium beds; nodular, thin beds stained red, some appear to be caliche; a little green staining in some nodular beds; some scouring at the base of medium beds overlying nodular beds; basal contact gradational; resistant	20.0	135.5
4	**Dolostone** and **dolomitic sandstone**		
	Dolostone (80%): yellow weathering; planar to wavy bedded, maximum medium bedded, minimum thin bedded, mode medium bedded; some fine sand scattered throughout; one breccia pod of sandy dolostone in reddish silt; some beds slightly pyritic; resistant, with slightly recessive, interbedded sand		
	Dolomitic sandstone (20%): reddish brown and orange weathering; maximum thin bedded, minimum laminated, mode very thin bedded, minimum laminated, mode very thin bedded; planar to wavy, flaggy bedded; fine grained; some crossbedding		
	Basal contact gradational; 100% exposed	4.0	115.5
3	**Sandstone:** orange weathering; dolomitic; medium grained; basal contact gradational, planar to wavy bedded, maximum medium bedded, minimum thin bedded, mode thin bedded, thicker beds are crossbedded, some irregular bedding; basal contact gradational; slightly recessive; 90% exposed	1.5	111.5

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
2	**Dolostone:** greenish yellow weathering with pink mottles; wavy bedded, maximum medium bedded, minimum very thin bedded, mode thin bedded; some coarse and fine sand lenses; some pyrite along corrosion surfaces; conglomerate with angular clasts marks the base of unit; basal contact abrupt; recessive; 20% exposed	8.0	110.0
1	**Sandstone** and **siltstone**		
	Sandstone (90%): medium brownish red weathering; hematitic and dolomitic; fine grained; planar to slightly wavy bedded; maximum bedded, minimum very thin bedded, mode thin bedded; some *arthrophycus* burrows; some crossbeds		
	Siltstone (10%): dark red weathering; laminated and fissile; occurs as thin interval <0.5 m thick in the lower part of the unit	102.0	102.0

Incomplete thickness of the Franklin Mountain Formation is 177.5 m.

Total thickness of the Twitya River 2 Section (Section 4) is 585 m.

Section 5 - Twitya River 1

This section includes part of the Keele Formation and the Delorme Group, which unconformably overlies the Keele Formation in the Mount Eduni map area (NTS 106 A). It also includes part of the Bear Rock Formation. The section dips southwest and extends up a south-facing cliff 12 km north of Twitya River at latitude 64°18′N; longitude 128°47′W. It is best seen on RCAF air photograph A:12188-204.

14	**Breccia:** medium grey weathering; massive bedded; packed angular to subangular, poorly sorted fragments (up to 10 cm long) of fine crystalline limestone that appear to be recrystallized pelletal wackestone; drusy calcite (average crystal size ~0.5 mm) cements fragments and partially infills cavities; some interfragment carbonate silt and fine fragments with a few brown pyritic shale chips; unit is a resistant cliff former; basal contact covered; 90% exposed	45.0	167.5
	The incomplete thickness of the Bear Rock Formation is 45 m.		
	Tsetso Formation		
13	**Siltstone:** medium brown to brownish grey weathering; maximum medium bedded, minimum very thin bedded, mode thin bedded, planar lenticular bedding; very dolomitic (may be a silty dolostone); argillaceous, some fine sand grains; basal contact gradational; recessive; 10% exposed	36.0	122.5
12	**Dolostone:** varicoloured, light yellow, grey and mauve weathering; planar bedded, maximum medium bedded, minimum very thin bedded, mode thin bedded; argillaceous and slightly silty; basal contact abrupt; moderately recessive; 70% exposed; units 12 and 13 form a saddle	16.5	86.5
11	**Dolostone:** light to medium grey weathering; smooth to planar bedded, maximum medium bedded, minimum thin bedded, mode medium bedded; very fine crystalline and featureless; basal contact gradational; moderately resistant; this unit forms the top of the resistant lower part of the Tsetso	4.5	70.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
10	**Dolostone:** medium brown to reddish brown weathering; planar bedded, maximum thick bedded, minimum medium bedded, mode medium bedded; slightly argillaceous; abundant stromatolites (laterally linked hemispheroidal); resistant; 100% exposed	3.0	65.5
9	**Dolostone:** light yellow to greyish yellow weathering; planar bedded, maximum very thick bedded, minimum thick bedded, mode very thick bedded; slightly argillaceous; basal contact gradational; resistant; essentially bedded stromatolites (laterally linked hemispheroidal), amplitude of stromatolites up to 0.5 m	7.0	62.5
8	**Fine sandstone:** light yellowish grey to greyish yellow weathering; even, planar bedded, maximum thick bedded, minimum thin bedded, mode medium bedded; very calcareous and dolomitic quartzarenite gradational upward from limestone; a little medium sand; some yellow dolomite beds; thin dolomitic beds grade up to thicker, sandy beds in cycles; resistant; 100% exposed	20.5	55.5
7	**Limestone:** bluish grey weathering; medium, planar, dicontinuous bedding; brown intraclastic wackestone with some green clay pockets containing lime mudchips; basal contact abrupt; resistant; 100% exposed	1.5	35.0
6	**Fine sandstone:** orange weathering; planar laminated bedding, maximum medium bedded, minimum thin bedded, mode medium bedded; thinner beds weather darker orange; dolomitic quartzarenite, some medium sand; basal contact abrupt, slightly recessive; 70% exposed	7.0	33.5
5	**Fine sandstone:** light yellowish orange weathering; planar bedded, maximum medium bedded, minimum thin bedded, mode minimum bedded; darker thin beds grade upward to thicker beds; dolomitic quartzarenite; unit has an erosional, karsted upper surface with solution pipes extending upward to 20 cm below the upper surface; green argillaceous material fills these pipes; basal contact abrupt; slightly recessive; 80% exposed	6.5	26.5
4	**Medium sandstone** and **sandy limestone conglomerate:** light yellow and grey weathering; wavy to planar bedded, maximum very thick bedded, minimum thick bedded, mode very thick bedded; 60% dolomitic quartzarenite (average grain size 0.4 mm); common quartz, undulatory quartz and some polycrystalline grains with sutured contacts, quartz overgrowth and hematite cement, nearly 5% orthoclase and microcline grains; 40% sandy intraclast packstone conglomerate with elongate pelletal intraclasts and occasional brachiopods; yellow, sandy, crossbedded beds grade upward to grey, crossbedded, sandy limestone conglomerate; some nodular green clay zones occur at the tops of grey beds; basal contact abrupt; resistant; 100% exposed	4.0	20.0
3	**Coarse sandstone:** yellowish orange weathering; wavy to lenticular bedding, maximum medium bedded, minimum thin bedded, mode medium bedded; basal contact abrupt and scoured, dolomitic quartzarenite, coarser sand in basal scours, slightly recessive; 80% exposed	3.5	16.0
2	**Medium sandstone:** orange weathering; planar bedded, maximum thick bedded, minimum medium bedded, mode medium bedded; dolomitic and hematitic quartzarenite with a great variety of quartz grain types including common,		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	undulatory and polycrystalline quartz; some chert and microcline grains; some silty and sandy dolostone (grains about 0.25 mm); reworked overgrowths on quartz grains with chattermarks; karsted exposure surface at 11.0 m, with solution breccia pipes extending downward from the erosional surface; resistant; 100% exposed	4.5	12.5
	Total measured thickness of the Tsetso Formation is 114.5 m. It overlies the Keele Formation with a pronounced angular unconformity.		
	Keele Formation		
1	**Medium sandstone:** medium reddish brown weathering; planar bedded, maximum thick bedded, minimum medium bedded, mode thick bedded; hematite and silica cemented quartzarenite; laminated with some tabular crossbed sets; moderately resistant; 90% exposed	8.0	8.0
	Total thickness of the Keele Formation is 8 m.		
	Base of measured section is within the Keele Formation.		
	Total thickness of the Twitya River 1 Section (Section 5) is 167.5 m.		

Section 6 - Mountain River 1

This section includes the Tsetso to Landry sequence resting unconformably on the Sekwi Formation in the Mount Eduni map area (NTS 106 A). The section dips westward and extends along a ridge on the north side of Mountain River at latitude 64°23′N and longitude 129°25′W and is best seen on RCAF air photograph A12230-021.

	Landry Formation		
14	**Limestone:** dark grey, medium grey weathering; packed pelletal wackestone or packstone; some fenestral fabric; slightly argillaceous; planar smooth bedded, maximum thick bedded, minimum thin bedded, mode medium bedded; moderately resistant; abundant green algal fragments (about 0.5 mm long), a few amphiporids; 100% exposed	60.0	407.0
	Incomplete thickness of the Landry Formation is 60 m.		
	Arnica Formation		
13	**Breccia:** medium grey, light grey weathering; massive bedding; poorly sorted limestone fragments (up to 0.3 m across) in a lime-silt matrix with some white dolomite interfragment cement; may be a tongue of the Bear Rock Formation; 100% exposed	43.5	347.0
12	**Dolostone:** medium brown weathering; thick bedded; a few light grey laminated intervals; moderately resistant; abundant amphiporids; 100% exposed	4.5	303.5
11	**Dolostone:** dark brown, medium brownish grey weathering; thick bedded, slightly uneven planar bedding; moderately resistant; a few scattered crinoids	23.5	299.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
10	**Dolostone:** light grey to yellowish grey weathering; medium bedded with some thin and thick beds; planar to slightly irregular limonitic argillaceous partings, some laminated in upper third of unit; dark brownish grey, thick amphiporid-bearing beds grade upward to light grey laminite in cycles 0.5 to 2.0 m thick; slightly recessive; 70% exposed	76.0	275.5
9	**Dolostone:** light grey, medium to light grey weathering; probably medium bedded overall; poorly exposed unit that extends up a scree slope to the foot of a cliff; 40% exposed	41.0	199.5
8	**Dolostone:** medium to light grey weathering; intervals of thick bedded medium grey dolostone alternate with thinner intervals of light grey dolomite laminite containing fenestral fabric; moderately resistant; prominent brachiopod-bearing bed at 141 m; 100% exposed	19.0	158.5
7	**Dolostone:** medium grey, medium grey weathering; thick bedded dolostone with leached amphiporids alternates with thin bedded dolomicrite in about 12 hemicycles or rhythms; moderately resistant; 90% exposed	18.0	139.5
6	**Dolostone:** light grey, medium grey weathering; medium to thick bedded; some beds with abundant leached amphiporids or "spaghetti stone"; one subvertical clastic carbonate dyke near the base of the unit; moderately resistant; 90% exposed	22.5	121.5
	Total thickness of the Arnica Formation is 248 m.		
	Tsetso Formation		
5	**Silty dolostone** and **sandstone**		
	Silty dolostone (70%): orange and grey, brick orange to greenish grey weathering; thin to medium, planar, smooth to irregular bedding; interference pattern oscillation ripple marks at 83 m; sand occurs as thin laminae; abundant mudcracks throughout; moderately recessive bench in slope; 70% exposed		
	Sandstone (30%): yellowish orange weathering; dolomitic; fine grained sandstone to sandy dolomite; mainly thick bedded, but some medium and thin silty and sandy dolostone beds; dolomicrite mudchips occur as streaks in the sandy beds; abundant streaks of limonite, limonitized pyrite, and pyrite in sandstone beds; quartzarenite sand with a few orthoclase and microcline grains; one pyroxene grain observed; weakly bimodal with most grains about 0.1 mm, but some scattered coarsed grains about 0.5 mm		
	Slightly to moderately resistant; 90% exposed	33.0	99.0
	Total thickness of the Tsetso Formation is 33 m.		
	Sekwi Formation		
4	**Dolostone:** medium to dark reddish orange and brown weathering; medium to thin bedded; slightly silty; current crosslaminated beds alternate with burrowed beds, very low angle crosslaminae; moderately resistant; 100% exposed	15.0	66.0
3	**Dolostone:** medium orange-grey, yellow-orange to pink weathering; relatively recessive intervals of laminated, argillaceous dolostone alternate with intervals of medium bedded sandy dolostone; silt laminae outline ripples; 100% exposed	12.0	51.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
2	**Sandstone:** medium grey, orange weathering; fine grained; wavy and rippled beds with argillaceous partings; some oscillation ripples; possibly an erosional lower contact; some scattered pyrite and bluish stain (copper mineralization?); a poorly exposed (40%) unit on a scree slope	33.0	39.0
1	**Dolostone:** light grey, light yellowish grey weathering; mode medium bedded but some thick and thin beds, mainly planar but some wavy to lenticular bedding; scattered blobs of limonite (after pyrite?) strung out parallel to bedding; unit forms the upper part of a large cliff; 100% exposed	6.0	6.0

Incomplete thickness of Sekwi Formation is 66.0 m.

Total thickness of the Mountain River 1 Section (Section 6) is 407 m.

Section 7 - Godlin Lakes

This section includes strata of the Road River (Duo Lake Formation equivalent), Mount Kindle, Camsell, Sombre, Landry, Hume and Canol formations and the Unnamed Silurian-Devonian in the north-central part of the Sekwi Mountain map area (NTS 105 P) 10 km southwest of Godlin Lakes. This is a vertically dipping section that extends 5 km northeastward down a ridge spur and along a valley floor, from its base at latitude 63°53′30″N and longitude 129°02′W; it is best seen on RCAF air photograph A:12062-335.

Canol Formation

14	**Shale:** black, black and rusty weathering; slightly calcareous and silty; fissile laminated to very thin bedded; recessive; 50% exposed	54.5	1928.0

Incomplete thickness of the Canol Formation is 54.5 m.

Hume Formation

13	**Limestone:** medium grey; thick to very thick, planar but irregular bedding; fetid, dark brown, bioturbated lime mudstone in units 2 to 4 m thick, separated by thinner intervals of light grey, dolomitic, tan, pelletal wackestone and lime mudstone containing some laminar fenestral fabric; beds immediately underneath the Canol shale are partly silicified; a few large vug-fillings of megacrystalline white calcite in vugs up to 1.0 m across; this unit is the resistant, cliff forming, upper part of the Hume Formation	93.0	1873.5
12	**Limestone:** greenish grey weathering; thin to medium, bioturbated, wavy bedding; orange or green mottled, grey lime-mudstone beds with fenestral fabric alternate with greyish yellow beds of platy, argillaceous lime mudstone; unit is the recessive lower part of the Hume; 90% exposed; unfossiliferous	19.5	1780.5

Total measured thickness of the Hume Formation is 112.5 m.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Landry Formation		
11	**Limestone:** medium grey weathering; thin bedded units of lime mudstone alternate with thick bedded intervals, imparting the characteristic ribbed weathering appearance; recessive, thin bedded intervals have argillaceous bituminous partings; some orange staining and orange bed partings; one thick bed of crossbedded recrystallized crinoidal packstone or encrinite caps unit; resistant; 70% exposed	83.0	1761.0
	Total measured thickness of the Landry Formation is 83 m.		
	Sombre Formation		
10	**Dolostone:** light grey weathering; medium to thick planar bedding; some brown beds toward top of unit; resistant; unit forms an entire small mountain, thickness of unit was merely estimated from air photograph measurements	950.0	1678.0
	Total estimated thickness of the Sombre Formation is 950 m.		
	Camsell Formation (formational assignment is tentative)		
9	**Dolostone:** light grey to yellowish grey weathering; slightly argillaceous; thin to medium, planar bedded dololaminite; brown dolomitic laminated lime mudstone dominates toward top of unit with a few orange silty dolostone beds; several thick breccia beds occur near the base of unit, with light grey fragments of dolostone in a darker dolostone matrix; moderately recessive; 80% exposed, unit extends down to valley floor	165.0	728.0
	Total measured thickness of the Camsell Formation is 165 m.		
	Tsetso Formation		
8	**Dolomitic limestone:** grey and orange weathering; medium planar bedding, with some thin and thick bedded intervals; argillaceous and silty dolomitic lime mudstone, recessive; only 10% exposed	70.0	563.0
7	**Limestone:** grey; thin to medium, planar to slightly irregular bedding; resistant; prominent cliff former; fossiliferous **lime mudstone**; light brown; as discontinuous seams and partings of argillaceous material; finely comminuted skeletal fragments tend to be concentrated along parting surfaces; 100% exposed	37.5	493.0
6	**Limestone:** intervals of medium to thick bedded coralline wackestone (some favositid-like corals) interbedded in 1 to 2 m thick units with thin bedded, faintly laminated, light orange white dolomitic lime mudstone; a resistant unit that weathers to ragged grey spurs; 100% exposed	60.0	455.5
5	**Dolostone:** dark to medium brown-orange, orange weathering; silty; thin, planar bedded with a few thin and thick beds; moderately resistant; some fish fragments on bedding surfaces; 100% exposed	27.5	395.5
4	**Calcareous mudstone:** yellow weathering unit that extends down the steep part of the ridge; very thinly laminated, platy and fissile; some small brachiopods on bed surfaces; very recessive; 40% exposed	120.0	368.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
3	**Limestone:** grey, orange mottled, grey weathering; medium bedded lime mudstone; orange argillaceous mudstone fills mudcracks; most beds contain a network of orange cracks; some crackle breccia; some stromatoporoids and corals; finely comminuted skeletal material concentrated in shallow scour-fillings within bed partings; moderately resistant; 80% exposed	22.5	248.0
	Total measured thickness of the Tsetso Formation is 337.5 m.		
	Ordovician-Silurian Undivided (or Cloudy Formation) (Whittaker Formation equivalents)		
2	**Limestone:** medium grey to yellowish grey weathering; medium planar bedding with some thin beds; argillaceous lime mudstone containing abundant black chert nodules strung out parallel to bedding; trilobites occur in the lower part of the unit and favositid-like corals in the middle part; some beds of crinoidal wackestone or packstone; slightly but not markedly resistant; 60% exposed		
	Two faunal collections have been identified from this unit: a. GSC loc. C-75746 at 40 m above the base of the unit contained: isotelid trilobite cephalopod? indicating an Ordovician age; identified by B.S. Norford. b. GSC loc. C-75748 at 90 m above the base of the unit contained the conodont fauna: *Aulacognathus bullatus* (Nicoll and Rexroad) *Aulacognathus ceratoides* (Nicoll and Rexroad) *Pseudooneotodus* sp. "*Neoprioniodis planus*" Walliser "*Roundya trichonodelloides*" Walliser "*Ligonodina egregia*" Walliser indicating a Silurian age near the Llandovery-Wenlock boundary – *amorphognathoides* Zone (identified by B.D.E. Chatterton of the University of Alberta)	205.5	225.5
	Total measured thickness of the Ordovician-Silurian Undivided (Cloudy Formation?) is 205.5 m.		
	Road River Formation (or Duo Lake Formation?)		
1	**Siltstone** and **shale:** dark orange and brown weathering; very thin and planar, smooth, platy bedding; calcareous, orange-brown, very thin bedded siltstone intervals alternate with shaly beds; dark grey to black shale underneath this unit; some green malachite staining; recessive; 90% exposed	20.0	20.0
	Incomplete thickness of the Road River Formation is 20 m.		
	Total measured thickness of the Godlin Lakes Section (Section 7) is 1928.0 m.		

Section 8 - South Twitya 1

This section includes part of the Mount Kindle, Tsetso, Camsell, Arnica, Landry and Hume formations. The section extends southwest along a ridge on the south side of Twitya River in the Sekwi map area (NTS 105 P). It is at latitude 63°52′N and longitude 129°12′W and may be seen on RCAF air photograph A12246-161.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
15	**Siltstone:** orange, bright orange weathering; calcareous; very thin bedded with some thin (wackestone) beds and some laminated beds; crinoids and some brachiopods in some silty wackestone beds sparsely scattered throughout unit; very recessive; 30% exposed	12.5	1591.0
14	**Limestone:** orange to pinkish brown weathering; platy, pinkish brown, silty calcilutites interbedded with platy to flaggy, argillaceous, orange weathering, brachiopod- and crinoid-bearing wackestones; very thin planar, somewhat nodular bedding, with some laminated and some thin beds; slightly resistant with prominent limestone spurs; 70% exposed	37.5	1578.5
	Incomplete thickness of the Hume Formation is 50 m.		
	Landry Formation		
13	**Limestone:** medium brownish grey, medium grey weathering wackestone; medium bedded with some thin and thick bedded intervals, planar to irregular bedding with reddish orange (ochre) parting seams; unit tends to be thicker bedded near the base, with scattered silicified corals and chert nodules; middle to upper part is unfossiliferous and medium to thin bedded; toward the top are several black, fossiliferous beds with abundant amphiporids and hemispheroidal stromatoporoids; lower contact abrupt; resistant cliff former with prominent crags; 100% exposed		
	One faunal collection taken at 12 m above the base of the unit at GSC loc. C-75798. It includes: indet. laminar tabulate coral fragments *Microplasma* sp. nov. or *M. caespitosum* (Schlüter) subsp. nov. *Lekanophyllum* (*Scissoplasma*) sp. nov. *Conocardium* sp. indet. gastropods sp. indet. biaxial crinoid ossicles *Icriodus culicellus* (Bultynck) (small form)		
	The macrofauna indicates a Middle Devonian age, probably early Eifelian; identified by A.E.H. Pedder. The microfauna indicates a late Emsian-early Couvinian age, but the small form of the *Icriodus* element is more characteristic of the early Couvinian (Co1a and Co1c); identified by T.T. Uyeno	112.0	1541.0
12	**Limestone:** brownish grey, medium brownish grey weathering wackestone, planar to slightly wavy, medium to thin bedding; a long steep rise along ridge line; abundant crinoids in some beds, with two-holed crinoids (*Gasterocoma bicaula*?); resistant; 100% exposed	246.0	1429.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
11	**Limestone:** brownish grey, light to medium grey weathering wackestone; in this unit, 5 to 10 m thick intervals of dark grey, thick to very thick bedded biostromal wackestone containing large stromatoporoids and brachiopods are interbedded with intervals of medium to thick, planar bedded, pelletal wackestone; resistant cliff former; 100% exposed	43.5	1183.0
10	**Limestone:** brown, light to medium grey weathering calcilutite; medium planar bedding with orange silty partings; a few thicker beds with abundant crinoids and scattered corals; some thinner orange-grey silty beds; an abrupt lower contact; resistant cliff former; 100% exposed	103.5	1139.5
	Total thickness of the Landry Formation is 505 m.		
	Arnica Formation		
9	**Dolostone:** light grey and dark brownish grey, banded light and dark grey weathering; intervals of faintly bioturbated, dark grey, medium to thick bedded dolostone grade upward to and are interbedded with light grey and yellowish grey dolostone laminite; about 25 light grey intervals occur in this unit; dark grey bands have erosional lower contacts with light grey bands; unit forms a relatively soft weathering ridge line; stromatolites and fenestral fabric occur in some light grey bands; 100% exposed	195.0	1036.0
8	**Dolostone:** dark grey, dark grey to black weathering; very thick to massive bedding; a very fetid petroliferous dolostone; very resistant; abundant amphiporids and corals; 100% exposed	48.0	841.0
7	**Dolostone:** banded dark and light grey; similar to Unit 9; an abrupt lower contact; slightly recessive; abundant amphiporids in some beds; 100% exposed One faunal collection from 80.0 m above the base of the unit at GSC loc. C-75791 included: *Amphipora* sp. indet. indicating a Late Silurian to Devonian, but not latest Devonian (Famennian) age; identified by A.E.H. Pedder	120.0	793.0
	Total thickness of the Arnica Formation is 363 m.		
	Camsell Formation		
6	**Breccia:** grey weathering; very thick but indistinct bedding; rubble floor breccia of angular, poorly sorted lime mudstone fragments, with observed fragments up to 1.0 m across; small chips floating in silty, greyish yellow lime mudstone of interfragment matrix; chips appear to have been oriented by flowage, some fragments appear plastically deformed; resistant; poorly exposed (10%)	289.5	673.0
5	**Breccia:** light grey weathering; very thick to massive, indistinct bedding; similar to Unit 6 but perhaps less argillaceous and more resistant	124.5	383.5
	Total thickness of the Camsell Formation is 414 m.		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Tsetso Formation		
4	**Dolostone:** yellow, yellowish orange weathering; silty; thin to very thin planar bedding; thicker beds are brownish to greenish mottled medium grey dolomite and have slightly irregular bed partings; a few thin, orange weathering, silty beds; unit forms upper part of grassy slope; slightly more resistant than underlying unit but still poorly exposed (30%)	54.0	259.0
3	**Limestone** and **dolostone** **Limestone** (70%): medium grey, medium grey weathering lime mudstone; medium planar bedding with some thin and thick beds; some beds argillaceous and weather greenish grey **Dolostone** (30%): greyish brown, brown weathering; calcareous; medium planar bedding with some thin beds; dolostone more common toward the top of the unit Unit forms a flat, broad bench leading up to a slightly more resistant overlying unit Two faunal collections were taken, one from 7.5 m above the base of the unit at GSC loc. C-75783, which included: *Ozarkodina remscheidensis* Ziegler (subsp. indet.) sagittodontan elements of *Icriodus* or *Pelekysgnathus* or *Caudicriodus* indicating a Late Silurian to earliest Devonian age (*eosteinhornensis* to *eurekanensis* Zones) and; the second from 42.5 m above the base of the unit at GSC loc. C-75784, which included: *Ozarkodina remscheidensis* Ziegler indicating the same age; both collections identified by B.D.E. Chatterton (University of Alberta)	67.5	205.0
2	**Limestone** and **dolostone** **Limestone** (90%): greyish yellow, yellow weathering lime mudstone; interlaminated yellow, argillaceous lime mudstone and grey weathering lime mudstone (like tiger stripes); thin planar bedding with some medium and very thin beds **Dolostone** (10%): yellowish orange weathering dolomicrite; medium planar bedded, with some thick and thin beds Poorly exposed, near the brow of a cliff	37.5	137.5
1	**Limestone:** greyish yellow, yellow weathering lime mudstone; thin, planar, flaggy bedding with a few medium and very thin beds; some yellow and grey "tiger striping" as in overlying unit, and some grey weathering, slightly mottled, nodular, dolomitic limestone mudstone; some mudcracks; abrupt lower contact, with medium bedded, dark brown dolostone of the Mount Kindle Formation; a scree slope above the Mount Kindle with poor exposures (about 5%)	100.0	100.0

Total thickness of the Tsetso Formation is 259 m.

Total thickness of the South Twitya 1 Section (Section 8) is 1591 m.

Section 9 - Sayunei 3 Section

This section includes part of the Mount Kindle Formation, the Delorme Group (including the Tsetso and Camsell formations) the Arnica Formation and the Landry Formation in the Mount Eduni map area (NTS 106 A). It is southwest-dipping and extends southwestward along a ridge equidistant between Twitya and Mountain rivers at latitude 64°12′N and longitude 129°27′W. It may be seen on RCAF air photograph A12188-429.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Landry Formation		
22	**Limestone:** light and dark grey, light and dark grey weathering crinoidal wackestone and packstone; medium to thin planar bedding, with some thick to very thick beds; a dark grey, relatively recessive crinoidal wackestone interval separates two light grey crinoidal packstone cliffs; 100% exposed; this unit is overlain by orange-brown beds of the Hume Formation	108.0	1563.0
21	**Limestone:** brownish grey to brown, grey weathering, pelletal(?) wackestone; medium planar beds with a few thick beds; a few thicker beds are crinoidal and contain scattered colonial rugose corals; recessive; 80% exposed One faunal collection taken from 15 m above the base of the unit at GSC loc. C-75848, includes: *Favosites* sp. indet. *Spongonaria* sp. cf. *S. parca* Crickmay biaxial crinoid ossicles indicating an Early Devonian probably late Zlichovian; possible Dalejan age; identified by A.E.H. Pedder	153.0	1455.0
	Total thickness of the Landry Formation is 261 m.		
	Arnica Formation		
20	**Dolostone:** medium to dark brownish grey weathering brownish grey dolostone, medium planar bedding with some thin and thick beds, thick beds occur in the lower part of the unit and some contain large hemispheroidal stromatoporoids, whereas the upper part is banded dark and light grey with hemicycles of dark grey dolostone grading upward to light grey dolostone laminite; a couple of dolomitic wackestone beds also occur; moderately resistant; 90% exposed	180.0	1302.0
19	**Dolostone:** light and dark grey, light and dark grey weathering; banded; thick planar bedding with some medium and very thick beds; intervals of thick bedded, dark grey dolostone grade upward to light grey dolomite laminite; slightly recessive but 100% exposed	22.5	1122.0
18	**Dolostone:** light to medium grey, light grey weathering; a few thin and thick beds; mainly medium bedded light grey dolomite with some beds of dolomitized beachrock(?); an intraclast packstone and grainstone; spar cemented, pelletal, bahamite type intraclasts; forms a moderately resistant, light grey knob between dark grey units; 100% exposed	45.0	1099.5

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
17	**Dolostone:** lower part of unit is banded dark and light grey, with abundant amphiporids in the dark beds; medium to very thick planar bedding; dark beds grade upward to light beds of dolostone laminite, a few beds of light grey lime wackestone; upper part of unit is composed of thick to very thick biostromal beds containing abundant amphiporids, stromatoporoids and thamnoporoid corals in black, fetid dolostone; resistant, 100% exposed	48.0	1054.5
	Total thickness of the Arnica Formation is 295.5 m.		
	Camsell Formation		
16	**Limestone** (50%) and **dolostone** (50%): banded yellow and grey weathering; cycles of grey, medium bedded lime mudstone grade upward to very thin bedded argillaceous and silty mudcracked yellow dolomicrite; yellow intervals are less than 1 m thick but the grey limestone intervals may be many metres thick; moderately recessive; 80% exposed	64.5	1006.5
15	**Breccia:** yellowish grey weathering chaotic rubble packbreccia of poorly sorted recrystallized wackestone fragments in a yellow argillaceous lime silt matrix; very poor contrast between matrix and fragments in this and underlying units; poorly developed, discontinuous thick to massive bedding; several intervals of platy, very thin bedded, yellow, recrystallized lime mudstone; moderately resistant; 100% exposed	154.5	942.0
14	**Breccia:** light grey weathering, chaotic rubble packbreccia; poorly sorted, angular blocky fragments; massive discontinuous bedding; resistant; 100% exposed	204.0	787.5
13	**Dolostone:** light and dark grey, banded light and dark brownish grey weathering; intervals of medium bedded, dark grey dolostone grade upward to thin bedded, light grey dolostone; erosional contacts of dark grey on light grey; recessive; 50% exposed	22.5	583.5
12	**Breccia:** medium grey, light grey weathering, chaotic rubble breccia; poorly developed, very thick bedding; very poorly sorted angular to subrounded fragments of dolomicrite and pelletal wackestone with a crude orientation of fragments parallel to bedding; observed fragments less than 10 cm across, but weathering may obscure larger fragments; fragments tend to be more equant than in underlying and overlying units; many fragments are themselves made of breccia; matrix is mainly fine crystalline hypidiotopic dolomite, but irregular patches of dedolomite are common, and some clasts are partly dedolomitized; some mosaic breccia with white calcite cement; recessive but 100% exposed	18.0	561.0
11	**Breccia:** yellowish grey, grey weathering rubble breccia of lime mudstone fragments floating in a silty and argillaceous, greyish yellow mottled, lime mudstone matrix; some fragments may be dedolomitized (up to 10 cm in diameter observed – perhaps some larger fragments but none observed); fragments tend to have rounded and deformed outlines and are also silty; fragments tend to be rimmed with argillaceous material; massive, poorly developed bedding with slight orientation of fragments parallel to bedding; resistant cliff former	115.5	543.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
10	**Breccia:** yellowish grey, yellowish grey weathering rubble breccia with angular, poorly sorted lime mudstone fragments similar to breccias in overlying units; a few banded yellow and grey bedded intervals of dolostone and limestone as in Unit 8; a largely recessive unit below the main Camsell breccia cliff; only 5% exposed	79.5	427.5
9	**Limestone:** banded yellow and grey lime mudstone as in Unit 8; occasional thick beds of breccia as in overlying breccia units; recessive; 5% exposed	94.5	348.0
8	**Limestone:** banded yellow and grey weathering; intervals of medium bedded to thin bedded grey lime mudstone grade upward to yellow, silty, thin bedded platy lime mudstone; some angular, yellow, silty breccia clasts in grey lime mudstone; yellow bands commonly less than 1 m thick alternate with thicker, grey lime mudstone intervals; recessive; 20% exposed	52.5	253.5
	Total thickness of the Camsell Formation is 805.5 m.		
	Tsetso Formation		
7	**Sandstone:** greyish orange, orange weathering; dolomite cemented; medium grained; thin to medium beds of orange dolomitic quartzarenite sandstone and sandy dolomite alternate with thin, platy, relatively recessive intervals of silty, yellow dolostone; uppermost resistant cliff of Tsetso	25.0	201.0
6	**Sandstone:** greyish orange and grey; orange weathering; dolomite cemented; medium and coarse quartzarenite sandstone; yellowish grey beds of sandy dolostone grade upward to orange dolomitic sandstone; much of unit is grey sandy dolostone; medium planar bedding with some thin and thick beds; resistant	18.5	176.0
5	**Dolostone:** dark grey to dark yellowish grey weathering; silty; medium to thin planar to wavy bedding, many beds of large LLH-C (laterally linked hemispheroidal-closely spaced) stromatolites and dolostone laminites; a few interbeds of orange, dolomitic sandstone one of which marks the base of the unit; a few coarse, detrital, intraclastic channel deposits in the stromatolite beds; resistant	27.0	157.5
4	**Dolostone:** dark to medium grey, dark yellowish grey weathering dolomicrite; medium to thin, planar to wavy bedding; some laminated wavy beds may be stromatolitic; argillaceous partings; resistant	21.0	130.5
3	**Dolostone:** dark yellowish grey weathering dolomicrite; medium, smooth planar bedding with a few thin and thick beds; a few platy intervals; yellow and orange argillaceous partings; abrupt lower contact; moderately resistant	34.5	109.5
	Total thickness of the Tsetso Formation is 126 m.		
	Mount Kindle Formation		
2	**Dolostone:** grey, medium grey weathering; fine crystalline; medium to thick planar and slightly irregular bedding; thicker beds are fossiliferous with scattered corals; a little yellow mottling; resistant; unit forms a bench at the top	25.5	75.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
1	**Dolostone:** grey, medium to dark grey weathering; dark, thick to very thick biostromal beds grade upward to light grey algal(?) dolomicrite laminite with a thin, current laminated zone at the base of each hemicycle; four of these hemicycles occur in this unit; some white calcite cement in vugs; resistant; silicified *Favosites* and *Halysites* and stromatoporoids are common	49.5	49.5

Incomplete thickness of the Mount Kindle Formation is 75 m.

Total thickness of the Sayunei 3 Section (Section 9) is 1563 m.

Section 10 - Sayunei 2 Section

This section includes part of the Franklin Mountain Formation, the Mount Kindle, Tsetso, Arnica and Landry formations, and part of the Hume Formation. It extends and dips northeast along a northeast trending ridge immediately north of Twitya River on the north side of the boundary between the Mount Eduni (NTS 106 A) and Sekwi Mountain (NTS 105 P) map areas. The base of the section is at latitude 64°00′N and longitude 129°43′W. The section may be seen on RCAF air photograph A12225-375.

Hume Formation

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
19	**Limestone:** medium to dark grey, medium to dark grey weathering skeletal wackestone; recessive, thin, irregular but planar bedded argillaceous crinoidal wackestone beds with scattered brachiopods grade upward to resistant intervals of medium and thick bedded coralline wackestone in three distinct hemicycles; first cycle thickest and ends at 76 m; recessive to resistant; 90% exposed	90.0	1664.5

Incomplete thickness of the Hume Formation is 90 m.

Landry Formation

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
18	**Limestone:** medium bluish grey weathering, brown pelletal(?) wackestone; very thin planar bedding with some very thinly laminated fissile intervals and a few thin beds; recessive scree slope; about 70% exposed	146.0	1574.5
17	**Limestone:** brownish grey, medium grey weathering skeletal wackestone and packstone; an interval of thin silty and argillaceous crinoid-bearing wackestone beds with trilobites and brachiopods is overlain by thick reefal beds with *Favosites* and horn corals in a crinoidal wackestone matrix; resistant; unit forms the upper Landry cliff	99.0	1428.5
16	**Limestone:** brown, grey weathering lime mudstone and pelletal(?) wackestone; medium planar bedding with some thin and thick beds; many brown dolostone or dolomitic limestone beds near the base of the unit; some coral-bearing beds; a recessive unit leading up to the upper Landry cliff; 70% exposed	74.0	1329.5

Total thickness of the Landry Formation is 319 m.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Arnica Formation		
15	**Dolostone:** medium brown, brown weathering; thick to very thick bedding; fetid; recessive and very rubbly; crinoids and abundant stromatactis in some thick biostromal beds; 80% exposed	105.0	1255.5
14	**Limestone:** light brownish-grey, light grey weathering lime mudstone and/or pelletal wackestone; medium planar bedding with a few thick beds; resistant, prominent cliff former	69.0	1150.5
13	**Limestone:** medium brown, light grey weathering, pelletal wackestone and/or lime mudstone; medium planar to wavy bedding with a few thin beds; slightly thicker bedded and more resistant than the underlying unit; occasional zones with brachiopods (e.g., at 1075 m)	60.0	1081.5
12	**Limestone:** tan, light grey weathering lime mudstone and/or pelletal wackestone; thin, smooth, planar bedding with some very thin and medium beds; lower part laminated and stromatolitic; resistant cliff former; 100% exposed, units 12, 13 and 14 are essentially a tongue of Landry in Arnica	82.5	1021.5
11	**Dolostone:** brownish grey, medium brownish grey weathering; thick planar bedding with some medium and very thick beds; mostly a medium bedded laminite; some thicker beds contain amphiporids; slightly recessive but 100% exposed	27.0	939.0
10	**Dolostone:** medium brownish grey, medium brownish grey weathering; medium to thin and very thin beds with some thick beds; thinner beds are laminated; thicker beds are darker brown and vuggy	20.0	912.0
9	**Dolostone:** light grey and brownish grey, banded light grey to white and dark brownish grey weathering; dark beds grade upward into, or are interbedded with, light grey laminites in poorly developed hemicycles; medium to thick bedded dark beds contain amphiporids and occasional black chert nodules; light grey beds are composed of pelletal laminae about a centimetre thick; lighter laminae of pelsparite and darker laminae of pelletal wackestone comprise these laminites; moderately resistant; 100% exposed, with an abrupt lower contact	18.0	892.0
	Total thickness of the Arnica Formation is 381.5 m.		
	Tsetso Formation		
8	**Dolostone:** yellow, light greyish yellow weathering dolomicrite; silty; thin, planar, smooth bedding with some very thin to laminated silty beds; silty seams common; several medium grey, medium lime wackestone beds; slightly recessive; 80% exposed	24.0	874.0
7	**Limestone:** yellowish grey, yellow weathering dolomitic lime mudstone laminite, possibly pelletal; thin, planar bedding with a few, very thin, yellow and medium grey beds; some yellow mudchip breccias in light grey lime mudstone; some laminated and dolomitic; slightly silty; recessive; 80% exposed	89.0	850.0
	Total thickness of the Tsetso Formation is 113 m		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Mount Kindle Formation		
6	**Dolostone:** brown, medium brown weathering dolostone laminite; medium to very thin planar bedding; some thin beds are stained with ochre; resistant; 100% exposed	195.0	761.0
5	**Limestone:** medium to light grey, light grey weathering dolomitic lime (pelletal?) mudstone; faintly colour laminated thin planar to wavy bedding with some very thin and medium beds; some beds slightly stromatolitic; recessive but 100% exposed; unit may be an intertongue of basinward limestone transitional to Road River shale	69.0	566.0
4	**Dolostone:** dark brown, dark brown weathering; fetid; massive to thick bedded with a little solution collapse breccia cemented by white dolostone; very resistant cliff former; crinoidal with abundant silicified corals; 100% exposed	51.0	497.0
	Total thickness of the Mount Kindle Formation is 315 m.		
	Franklin Mountain Formation		
3	**Dolostone:** brownish grey, grey weathering; calcareous; medium planar bedding with some thin and very thin beds and some thick beds; a laminite that has undergone some soft sediment deformation; slightly stromatolitic; slightly recessive but 100% exposed	211.0	446.0
2	**Limestone** and **dolomicrite**		
	Limestone (50%): light to medium brownish grey, light grey weathering, laminated lime mudstone; medium to thin planar bedding with scattered thick beds; some thicker beds are brecciated		
	Dolomicrite (50%): brownish grey, light brownish grey weathering; laminated; featureless, medium planar to irregular bedding, with some thick and thin beds		
	Slightly recessive; 80% exposed	90.0	235.0
1	**Dolostone** and **limestone**		
	Dolostone (85%): brown, brown weathering; thin to medium bedded intervals of dolostone laminite alternate with thick beds; some large stromatolites up to 0.5 m high		
	Limestone (15%): grey, light to medium grey weathering lime (pelletal?) mudstone; thin bedded		
	Platy, wavy, stromatolitic intervals occur between thick beds; resistant	145.0	145.0
	Incomplete thickness of the Franklin Mountain Formation is 446 m.		
	Total thickness of the Sayunei 2 Section (Section 10) is 1664.5 m.		

Section 11 - Sayunei 1 Section

This section includes strata of the Mount Kindle, Tsetso, Camsell, Arnica, Landry and Hume formations in the southwest part of the Mount Eduni map area (NTS 106 A). It extends southwest across a ridge on the south side of Mountain River from its base at latitude 64°17′N and longitude 129°38′W. The section is best seen on RCAF air photograph A12225-364.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
19	**Limestone:** dark grey; prominent cliff former or very thick bedded coralline wackestone	30.0	1184.0
18	**Limestone:** orange, grey mottled, orange weathering; medium to thick bedded; skeletal wackestone containing brachiopods and corals forms most of unit, but a few thin intervals of ochre coloured, platy, silty lime mudstone are scattered throughout; moderately recessive One faunal collection was taken from 22.0 m above the base of the unit at GSC loc. C-75642 and included: *Favosites* sp. indet. *Digonophyllum* sp. *Schizophoria* sp. indet. *Eoschuchertella adoceta* (Crickmay) *Variatrypa aperanta* (Crickmay?) ambocoeliid brachiopod indicating an early Eifelian age, *adoceta* Zone; identified by A.E.H. Pedder	108.0	1154.0
	Total measured thickness of the Hume Formation is 138 m.		
	Landry Formation		
17	**Limestone:** bluish grey to light grey weathering; thick planar to irregular bedding, mostly lime mudstone and coralline wackestone; moderately resistant, although somewhat less resistant than underlying units; intervals of crossbedded, crinoidal packstone and wackestone (encrinite) containing abundant two-holed crinoids at 23.0 m and 83.0 m above the base of the unit	99.0	1046.0
16	**Limestone:** medium grey; medium planar and smooth bedded intervals separated by very thin bedded to laminated, ochre stained, platy intervals; lime mudstone (pelletal?); some poorly developed low-angle crossbedding in thicker beds; the basal resistant cliff former of the Landry Formation	57.0	947.0
	Total measured thickness of the Landry Formation is 156 m.		
	Arnica Formation		
15	**Dolostone** and **limestone:** thick beds of dark brown amphiporid-bearing dolostone grade upward into light grey dololaminites containing fenestral fabric and stromatolitic laminae in hemicycles several metres thick; mainly dolostone but there are a few, particularly resistant, grey limestone cliffs 3 to 10 m thick formed of lime mudstone; moderately resistant but less resistant than the overlying Landry Formation	63.0	890.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
14	**Dolostone:** medium to thick planar beds of dark brownish grey, commonly amphiporid-bearing dolostone alternate with medium beds of light grey dololaminite containing fenestral fabric; a relatively recessive, colour banded unit that separates two more resistant units	105.0	827.0
13	**Dolostone:** nearly black weathering; very thick and indistinctly bedded; biostromal; abundant, large vugs infilled with white megacrystalline calcite; some patches of calcite cemented rubble packbreccia and floatbreccia where vugs are more abundant; amphiporids common; unit capped by a few medium thick, dark brownish grey, amphiporid-bearing beds; a very resistant cliff-forming interval; abundant, large inplace corals and stromatoporoids (some corals up to 0.5 m across) One faunal collection was taken from the base of the unit at GSC loc. C-75634 and included: stromatoporoids, bulbous coenostia *Amphipora* sp. indet. *Alveolites* sp. indet. *Thamnopora* sp. indet. *Syringopora* sp. indet. indicating a Late Silurian to Devonian (excluding Famennian) age; identified by A.E.H. Pedder	54.0	722.0
12	**Dolostone:** medium brownish grey, somewhat colour banded unit; dark brownish grey, medium to thick beds containing amphiporids alternate with thin bedded, light grey dololaminite intervals containing some fenestral fabric; recessive; only 20% exposed	79.5	668.0
	Total measured thickness of the Arnica Formation is 301.5 m.		
	Camsell Formation		
11	**Silty limestone:** greyish yellow weathering; thinly laminated and platy, dolomitic and silty lime siltstone and lime mudstone beds overlie medium bedded intervals of medium grey lime mudstone in hemicycles 1 to 3 m thick; laminated intervals predominate, one bed of particulate rubble floatbreccia at the top of the unit, slightly resistant, 90% exposed; unit extends across a flat part of the ridge crest	55.5	588.5
10	**Silty limestone:** same as overlying unit but only 70% exposed; unit extends upslope to the flat crest of a spur	19.5	533.0
9	**Silty limestone:** yellowish grey weathering; thick intervals of medium, smooth planar bedded, medium grey lime mudstone are separated by thinner intervals, about 0.5 m thick, of silty and calcareous, platy, yellow, very thin bedded dolostone and dololaminite; 70% of unit is lime mudstone; in some lime mudstone beds, there are many mudclasts and larger angular fragments of yellow silty dolostone that almost constitute a particulate rubble floatbreccia; recessive; unit extends up a steep rise; only 5% exposed	84.0	513.5
8	**Limestone breccia:** medium grey weathering; a particulate, mosaic packbreccia that is very thick bedded to nonbedded, with some preservation of original bedding; resistant; cliff forming; 70% exposed; unit extends over a rise in the ridge line	91.5	429.5
7	**Limestone:** dark grey weathering; a medium wavy bedded lime mudstone with minor particulate rubble floatbreccia; some thin and thick beds; unit is only 50% exposed	18.0	338.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
6	**Limestone breccia:** greyish yellow weathering; very thickly but indistinctly bedded; silty, particulate, rubble packbreccia with very poorly sorted subangular fragments, a few up to 0.5 m across; some breccia dikes cut across bedding; a prominent, cliff former	91.5	320.0
5	**Limestone:** medium grey; thick bedded grey lime mudstone with abundant intervals of limestone particulate floatbreccia; unit extends up a steep rise to the foot of the cliff that forms the overlying unit; very recessive; only 5% exposed	174.0	228.5
	Total measured thickness of the Camsell Formation is 534 m.		
	Tsetso Formation		
4	**Limestone** and **dolostone:**		
	Limestone (80%): light yellowish orange weathering; thin to medium, planar to wavy bedded lime mudstone with some vuggy beds (leached corals); a few yellow weathering beds composed of large, laterally linked, hemispheroidal stromatolites (amplitude up to 0.5 m)		
	Dolostone (20%): pinkish brown to orange and yellow weathering; silty and sandy; platy and fissile dololaminite; yellow and orange dolostone tends to be lenticularly bedded		
	Resistant; 90% exposed	41.5	54.5
3	**Sandy dolostone:** medium yellowish and greenish grey weathering; medium, slightly irregular bedding with abundant quartz sand and granule stringers; abundant reworked darker grey calcareous mudchips(?); a few thin intervals of argillaceous, recessive, platy, yellowish and greenish grey dololaminite; resistant	4.0	13.0
2	**Dolostone:** pinkish and greenish brown; brownish grey weathering; very thin bedded, planar to weakly lenticularly bedded; abundant pyrite concretions; abrupt lower contact with the Mount Kindle Formation; resistant	1.0	9.0
	Total thickness of the Tsetso Formation is 46.5 m.		
	Mount Kindle Formation		
1	**Dolostone:** dark brown; fine to medium crystalline; thick planar bedded; contrasts with the very fine to fine crystalline dolostones of the overlying Tsetso; resistant; cliff former	8.0	8.0
	Incomplete thickness of the Mount Kindle Formation is 8 m.		
	Total measured thickness of the Sayunei 1 Section (Section 11) is 1184 m.		

Section 12 - North Eduni 4 Section

This section includes strata of the Mount Kindle, Tsetso, Arnica and Landry formations on the west side of the Mount Eduni map area (NTS 106 A). This is a northwest dipping section, which extends about 2 km northwest along the nose of a ridge near Palmer Lake. The base of the section is at latitude 64°32′N and longitude 129°52′W, and the section may be seen on RCAF air photograph A12244-371.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Landry Formation		
14	**Limestone:** light bluish grey weathering; medium, smooth, and planar bedded, pelletal lime mudstone; some thin and thick beds; resistant; the interval between 22.5 m and 54.0 m is more recessive, dark grey and thinner bedded, and contains some brown, dolomitic beds	115.5	441.0
	Incomplete thickness of the Landry Formation is 115.5 m.		
	Arnica Formation		
13	**Dolostone:** grey, light grey weathering, a few dark grey beds near the top; medium bedded; several yellow weathering silty beds near the top of the unit; several subvertical white quartz and calcite veins trending at 123°; a resistant unit but less so than the overlying Landry Formation; fossiliferous, scattered corals; some brown sphalerite in corals	48.5	325.5
12	**Dolostone:** dark brownish grey; medium to thick bedded biostromal dolostone with abundant vugs; a little coarse crystalline galena in some vugs; a little particulate rubble floatbreccia consisting of angular dolostone fragments at the top of the unit; resistant	10.5	277.0
11	**Dolostone:** medium brownish grey to light grey, colour banded; medium bedded; less resistant than the overlying units; some darker dolostone beds contain amphiporids	19.5	266.5
10	**Dolostone:** medium to dark brownish grey, medium grey weathering; thick bedded; some medium grey dolostone beds of particulate rubble floatbreccia; some silicification of breccia beds; moderately resistant	22.5	247.0
9	**Dolostone:** dark brownish grey; mainly medium to thick bedded, slightly vuggy dolostone, with some medium to light grey, thin to medium beds of dolostone; some sphalerite in veins and vugs; slightly more resistant than the overlying unit and with a pronounced colour banding; amphiporid and coral bearing; abrupt contact with the underlying Tsetso Formation	30.0	224.5
	Total measured thickness of the Arnica Formation is 131 m.		
	Tsetso Formation		
8	**Dolostone:** grey, greenish yellow weathering; thin to medium bedded, many beds contain fenestral fabric; several thin beds of orange, fine sandstone quartzarenite; some scattered small vugs in dolostone beds are infilled with pink coloured dolomite, quartz and pyrite; resistant; a cliff former that stands out well above the underlying unit	17.0	194.5

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
7	**Dolostone** and **sandstone:** yellowish grey, orange-yellow weathering; mainly silty, thin bedded dolostone containing vugs with reddish dolomite and quartz cement; some platy, mudcracked beds; 15% of unit is orange, dolomite cemented, fine quartzarenite; recessive	25.5	177.5
6	**Dolostone:** medium to light grey, light grey weathering; thick, planar, and smooth bedded, with faintly yellow partings; some vug horizons and scattered corals or amphiporids in thicker beds but not as vuggy as in underlying unit; fenestral fabric occurs in the upper parts of many of these beds and in some thin beds; a large white calcite vein at 47.0 m above the base of the unit with some massive sphalerite and galena mineralization; a resistant unit that, together with the underlying unit, forms a prominent cliff	54.0	152.0
5	**Dolostone:** light grey, light grey weathering; biostromal, thick to very thick bedded coralline and stromatoporoidal dolostone; vugs are common and some vugs contain galena and sphalerite mineralization; vuggy beds tend to be recrystallized to medium and even coarse crystalline dolomite; a few thin to medium stromatolitic beds; very resistant	33.0	98.0
4	**Dolostone:** light grey, very light grey weathering; thin to medium, smooth to wavy planar bedded stromatolitic dololaminite; some yellow stained intervals; vugs occur in the lowermost 1.0 m of the unit; recessive; 50% exposed	19.0	65.0
3	**Dolostone:** light grey, light grey weathering; medium to thick planar bedded; several hemicycles in which smooth, medium bedded dolostone grades upward to a rough weathering, vuggy and sucrosic dolostone overlain by an irregular, green stained erosional (karst?) surface; some green mottling of upper parts of hemicycles; vug infillings of white dolomite and clear quartz; moderately resistant	21.0	46.0
2	**Dolostone:** light yellowish grey weathering; hemicycles several metres thick, consisting of thick beds of light grey, vuggy dolostone grading up to thin, irregular beds and yellow, platy, silty dolostone; some vugs in thick beds are very large and are up to 0.5 m long; vugs filled with orange dolomite cement and quartz crystals; some dolomite-cemented mosaic and rubble packbreccia is developed in some of the more vuggy beds; abrupt contact with the underlying Mount Kindle Formation; slightly resistant	15.0	25.0
	Total measured thickness of the Tsetso Formation is 184.5 m.		
	Mount Kindle Formation		
1	**Dolostone:** brownish grey, dark brownish grey weathering; medium planar to irregularly bedded; vuggy; white dolomite, pyrite and bitumen line the vugs; small vugs strung out parallel to bedding, imparting a laminated appearance to the unit; more resistant than the overlying unit	10.0	10.0
	Incomplete thickness of the Mount Kindle Formation is 10 m.		
	Total measured thickness of the North Eduni 4 Section (Section 12) is 441 m.		

Section 13 - North Eduni 1

This section includes strata of the Mount Kindle, Tsetso, Arnica, Landry and Hume formations. It extends 1 km northwest up the nose of a ridge in the west-central part of the Mount Eduni map area (NTS 106 A), and the base of the section is at latitude 64°37′N and longitude 129°53′W. The section may be seen on RCAF air photograph A12232-395.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
18	**Limestone:** medium grey weathering; similar to underlying unit but somewhat thinner bedded; resistant; the top of the section ends at a fault contact	30.0	653.5
17	**Limestone:** medium grey weathering; a very thick bedded skeletal wackestone (biostromal?) with scattered corals, brachiopods and amphiporids; this and the overlying unit constitute the resistant upper part of the Hume Formation; 90% exposed One faunal collection was taken from 55.5 m above the base of the unit at GSC loc. C-75540; and includes: *Amphipora ramosa* Phillips *Dendrostella trigemme* (Quenstedt) indicating a late Eifelian (*dysmorphostrata* Zone); identified by A.E.H. Pedder	60.0	623.5
16	**Limestone:** medium grey mottled orange, brownish grey weathering (at a distance); a thin planar to irregularly bedded lime mudstone and skeletal wackestone; orange-yellow argillaceous bed partings; abundant brachiopods and crinoids in some beds; somewhat recessive; only 50% exposed	22.5	563.5
15	**Limestone** and **siltstone:** dark grey with orange mottling, greyish brown weathering (at a distance); mainly very thin planar but irregularly bedded skeletal wackestone and packstone; argillaceous orange mottlings; yellow-orange parting seams; some platy, very thin bedded to laminated, calcareous, orange weathering, reddish grey siltstone; corals, bryozoan and brachiopod coquinas; recessive; 70% exposed Two faunal collections were made 5 m above the base of the unit at GSC loc. C-75538 and C-75539, and include: "*Microcyclus*" *multiradiatus* (Meek) *Digonophyllum rectum* (Meek) *Eoschuchertella adoceta* (Crickmay) ambocoellid brachiopod cystimorph coral fish plate and cricoconarids indicating an early Eifelian age (*adoceta* Zone); identified by A.E.H. Pedder	12.0	541.0
14	**Limestone:** greenish yellow weathering; a thin to very thin bedded skeletal wackestone, (brachiopods and corals); wavy, irregular bedding with greenish yellow, argillaceous partings; a recessive slope leading down to saddle; only 10% exposed	22.5	529.0
	Total measured thickness of the Hume Formation is 147 m.		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Landry Formation		
13	**Limestone:** brown; bluish grey weathering; medium, smooth planar bedded pelletal wackestone and packstone; thin bedded intervals separate thicker bedded intervals; thin bedded intervals have a pink tint and some are lenticularly or wavy bedded and faintly laminated (algal?); resistant; unit forms the upper part of the Landry cliff	85.5	506.5
12	**Limestone:** same as overlying unit except that there are no wavy bedded intervals; thinner bedded intervals are relatively recessive; lower contact is obscured	61.5	421.0
	Total measured thickness of the Landry Formation is 147 m.		
	Arnica Formation		
11	**Dolostone:** brown weathering; rock types are the same as in the underlying unit, with some scattered bluish grey weathering limestone beds of brown, pelletal wackestone; unit extends up the ridge line to the foot of the Landry cliff; 40% exposed	30.0	359.5
10	**Dolostone:** brown, brownish grey weathering; thick bedded with some medium bedded, light grey, laminated dolomite interbeds; large exposures of white, dolomite-cemented angular rubble and mosaic packbreccia (some cemented floatbreccia also) of probable solution-collapse origin; some subvertical pipes or dikes of breccia; moderately resistant, 90% exposed	49.0	329.5
9	**Dolostone:** brownish grey weathering; thick beds of brownish grey dolostone separated by light grey, thinner bedded dolostone; some penecontemporaneous rubble floatbreccias; moderately resistant; 80% exposed; amphiporids occur in some thicker beds	34.5	280.5
8	**Limestone:** bluish grey weathering; medium planar bedded, stromatolitic lime mudstone; large, laterally-linked, hemispheroidal stromatolites form many entire beds; palisade style, white calcite cement has infilled many prism-like cracks or spaces between stromatolitic laminae that have separated; a little calcite cemented mosaic and rubble packbreccia; about 40% of unit is medium to thick bedded brown amphiporid dolostone and thin to medium bedded, light grey dolostone; gradational contact with underlying unit; resistant, bounded by less resistant units	37.5	246.0
	Total measured thickness of the Arnica Formation is 151 m.		
	Tsetso Formation		
7	**Sandy dolostone:** sandy, silty and argillaceous; fine crystalline; yellowish orange weathering; thin to medium bedded; sand present as small, discontinuous stringers in the dolostone; pyrite nodules are common in the more brightly orange coloured lower part; resistant; 80% exposed	19.5	208.5
6	**Limestone:** light brown, light greenish grey weathering; medium bedded pelletal wackestone; apple-green argillaceous material along bed partings, typically infilling a vague mudcrack pattern on the irregular microtopography of bed surfaces; oxidized pyrite nodules common along bed contacts at base of unit; at 13.5 m above the base, and at the top of the unit, some scattered, thin, more argillaceous beds occur; resistant	16.5	189.0
	Total measured thickness of the Tsetso Formation is 36 m.		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Mount Kindle Formation		
5	**Dolostone:** medium crystalline (sucrosic); light to medium grey; light to medium grey weathering; thick bedded; scattered corals in intervals interbedded with thin, light to medium grey, algal laminated beds resistant	51.0	172.5
4	**Dolostone:** tan to medium grey, light grey weathering; medium to thick bedded; a recessive scree slope; only 10% exposed	37.5	121.5
3	**Dolostone:** fine crystalline (not vuggy); weathers medium grey; very thick bedded; a rubbly caliche zone caps the unit with white, sucrosic, calcareous, recrystallized dolostone; a resistant cliff former	10.0	84.0
2	**Dolostone:** light grey and tan, light grey weathering; thick bedded; a little white dolomite cemented mosaic and rubble packbreccia; recessive scree slopes; abundant large brachiopod moulds in some beds (up to 5 cm across—possibly pentamerids) only 20% exposed	51.5	74.0
1	**Dolostone:** brown to tan, medium grey to brownish grey weathering; medium bedded; a few calcite filled vugs; forms a resistant, light grey cliff	22.5	22.5
	Incomplete thickness of the Mount Kindle Formation is 172.5 m.		
	Total thickness of the North Eduni 1 Section (Section 13) is 653.5 m.		

Section 14 - North Eduni 3

This section includes strata of the Backbone Ranges, Franklin Mountain, Mount Kindle, Tsetso, Arnica and Landry formations. It extends southwest over the nose of a broad ridge in the northwest part of the Mount Eduni map area (NTS 106 A). The base of the section is at latitude 64°43′N and longitude 129°52′W, and the section is best seen on RCAF air photograph A12246-246.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Landry Formation		
18	**Limestone:** dark grey to brown, medium grey weathering; lime mudstone (pelletal?); thick to very thick bedded; upper contact of the unit is at a fault; a resistant cliff former	70.0	765.0
17	**Limestone:** brown, medium grey weathering; medium to thick, smooth bedded lime mudstone and pelletal wackestone; some small intervals of thin bedded lime mudstone are relatively recessive, imparting a 'ribbed' appearance to the unit; a resistant cliff former	55.5	695.0
16	**Limestone:** medium grey weathering; intervals of thick, smooth planar bedded, tan pelletal wackestone are separated by much thinner intervals of thin bedded, dark brown, lime mudstone that are more recessive; a few brown weathering somewhat dolomitic beds; the thin bedded intervals dominate in the lower part of the unit; a resistant cliff former, this and the overlying units are more resistant than the underlying Arnica Formation; lower contact gradational	21.0	639.5
	Incomplete measured thickness of the Landry Formation is 146.5 m.		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Arnica Formation		
15	**Limestone** and **dolostone breccia:** grey, grey to yellowish grey weathering; thick bedded, fine crystalline limestone crackle breccia with rubble packbreccia along the base of many beds; the upper parts of many of these beds are yellow stained dolomitic limestone and dolostone laminite; moderately resistant; this unit appears to be a tongue of the Bear Rock Formation within the Arnica Formation	42.0	618.5
14	**Dolostone:** light grey and brown weathering bands; medium beds of dark brown, sucrosic dolostone containing scattered amphiporids, interbedded with light grey and light yellowish grey, thin to medium beds of dololaminite; dark beds commonly display erosional contacts on light coloured beds; a slightly recessive unit along the ridge	48.0	567.5
13	**Limestone breccia:** medium grey weathering, massive nonbedded particulate rubble and mosaic breccia with poorly sorted angular fragments (<0.5 m across) in a grey lime mudstone or siltstone matrix, fragments tend to have a slight brownish tint; top of unit is capped by a thick bed of relatively unbrecciated stromatolite laminite with immediately subjacent crackle breccias	22.5	528.5
12	**Limestone** and **dolostone:** brownish grey weathering unit; intervals of grey, thick bedded, dolomitic limestone and brown dolostone with abundant amphiporids and thamnoporid-like corals, interbedded with medium bedded, laminated, grey lime mudstone; moderately resistant	9.0	506.0
	Total measured thickness of the Arnica Formation is 121.5 m.		
	Tsetso Formation		
11	**Dolostone:** light yellow weathering; fine crystalline; argillaceous; medium to very thin bedded; platy; recessive	4.5	497.0
10	**Dolostone:** yellow, yellow weathering; argillaceous; sandy; thin to medium bedded with brown laminae of silt and sand; a basal interval, 1.0 m thick, of light brown sandy dolostone; some pockets of penecontemporaneous mud chip breccias in the dololaminites; less recessive than adjacent units	11.5	492.5
9	**Dolostone:** light grey weathering; thin bedded, faintly laminated; recessive	27.0	481.0
8	**Dolostone:** yellow weathering; thin to very thin planar bedding; laminated; thicker bedded intervals tend to be more grey in colour; recessive but more resistant than the overlying unit	22.5	454.0
	Total measured thickness of the Tsetso Formation is 65.5 m.		
	Mount Kindle Formation		
7	**Dolostone:** dark brown; rubbly weathering; medium irregular bedding, bed parting surfaces have a slight pink and yellow tint; very fossiliferous with abundant silicifed corals including halysitid-like corals; forms a resistant marker bed at the top of the Mount Kindle Formation	1.5	431.5
6	**Dolostone:** light grey, light grey weathering; a medium and smooth bedded dololaminite; a resistant marker at the top of the Mount Kindle Formation	21.0	430.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
5	**Dolostone:** medium greyish brown weathering; thick beds of brown, vuggy, medium crystalline dolostone are interbedded with light grey dololaminite; brown intervals have a rough weathering surface; light grey intervals have a smooth weathering surface; some brown beds are pink stained and bioturbated; some areas of white, dolomite cemented, rubble packbreccia; lower contact is obscured; resistant and cliff forming	126.0	409.0
	Total measured thickness of the Mount Kindle Formation is 148.5 m.		
	Franklin Mountain Formation(?)		
4	**Dolostone:** medium grey weathering; fine crystalline; medium bedded; faintly laminated; irregular bedding in the lower part of the unit passes upward to smooth planar bedding toward the top of the unit; scattered patches of white, coarse crystalline, 'late stage' dolomite in stratigraphic pods up to several metres across; a few yellow stained beds near the base of the unit; lower contact obscured by felsenmeer	70.5	283.0
	Total measured thickness of the Franklin Mountain Formation is 70.5 m.		
	Backbone Ranges Formation		
3	**Sandstone:** white weathering, some light brown beds but most very light grey to white; thick to very thick bedded quartzarenite sandstone, a fine to medium silica-cemented sandstone with quartz pebbles along the bases of some beds as gravel lag deposits; some festoon crossbedding; a very resistant cliff that forms most of the hillside leading up to the ridge line	172.5	212.5
2	**Silty dolostone** and **shale:** some dark reddish brown dolomitic siltstone; very thin bedded dolostone and siltstone to thinly laminated and fissile silty shale; unit is recessive and forms a low saddle along the ridge line	30.0	40.0
1	**Dolostone:** orange weathering; thin to very thin, smooth bedded, laminated; shaly greyish green bed partings; some penecontemporaneous, platy rip-up clasts scattered throughout these dololaminites; somewhat resistant; base of unit is at the limit of exposure	10.0	10.0
	Incomplete measured thickness of the Backbone Ranges Formation is 212.5 m.		
	Total thickness of the North Eduni 3 Section (Section 14) is 765 m.		

Section 15 - North Eduni 2

This section includes strata of the Franklin Mountain, Mount Kindle, Tsetso, Arnica, Landry, and Hume formations, and extends southwest for 2.5 km up a small stream valley in the northwest part of the Mount Eduni map area (NTS 106 A). The base of the section is at latitude 64°43′N and longitude 129°49′W, and the section may be seen on RCAF air photograph A12697-169.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
9	**Limestone:** dark grey, medium grey weathering; thick to very thick bedded; bituminous lime mudstone and wackestone; this is the upper part of the Hume Formation; some colonial corals; resistant and cliff forming, upper contact with overlying shale of the Hare Indian Formation is not exposed	66.0	813.0
8	**Argillaceous limestone:** dark to medium grey, brownish grey weathering from a distance, orange mottled; wavy to nodular, very thin to medium bedded, thinner bedded and more recessive toward the base; silty, orange and pink bed partings in lower part, orange colouration decreases upward; skeletal wackestone with abundant brachiopods, crinoid fragments, corals, trilobite and bryozoan fragments particularly on bed surfaces; an abrupt lower contact; recessive; 70% exposed	93.0	747.0
	Total measured thickness of the Hume Formation is 159 m.		
	Landry Formation		
7	**Limestone:** medium grey weathering; "ribbed", thin to thick bedded lime mudstone and pelletal wackestone; thick beds are light brown to tan pelletal wackestone and packstone, whereas the thinner, more recessive, thin to very thin bedded intervals are dark brown lime mudstone; some large channels with breadths of up to 10.0 m and amplitudes of 2 to 3 m; resistant; an abrupt lower contact with the underlying Arnica Formation	165.0	654.0
	Total measured thickness of the Landry Formation is 165 m.		
	Arnica Formation		
6	**Dolostone:** brown to greyish brown, brown weathering; some calcareous dolostone; thin to medium planar bedded; faintly laminated; some medium wavy beds of dolostone consist of oriented, particulate rubble packbreccia formed of small, platy dolostone chips (less than 2 cm long) (these beds may be beach ridge deposits); moderately resistant; 80% exposed	33.0	489.0
5	**Dolostone** and **breccia:** greyish brown; indistinctly bedded; thick, brown beds containing amphiporids and thamnoporids are interbedded with thin, greyish brown stromatolitic beds; many beds are brecciated, beginning at 8.5 m above the base of the unit, and the upper part of the unit is almost totally brecciated; typically these breccias have a definite pattern of development: a basal zone of oriented, particulate, rubble float- and packbreccia at the base of a brecciated bed passes upward to disoriented rubble packbreccia, to mosaic packbreccia, and, finally, at the top of the brecciated zone, even to crackle breccia; some breccia zones, however, are very thick and indistinct; somewhat recessive; 60% exposed		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	One faunal collection was taken from 2.5 m above the base of the unit at GSC loc. C-75773, and includes: *Amphipora* sp. indet. indicating a Late Silurian to Devonian age; identified by A.E.H. Pedder	85.5	456.0
4	**Dolostone:** brownish grey, medium grey weathering; medium bedded, stromatolitic dololaminite; laterally linked hemispheroidal stromatolites, a few vuggy beds but the unit is 80% stromatolite laminite; resistant; sharp basal contact	70.5	370.5
	Total measured thickness of the Arnica Formation is 189 m.		
	Tsetso Formation		
3	**Dolostone:** yellow weathering, argillaceous; thin, smooth planar bedded; thinner beds tend to be wavy and more yellow and argillaceous, but thicker beds are more grey and planar bedded; at 0.5 m above base of unit there is a zone of large, calcite-cemented vugs; authigenic pyrite occurs 7.0 m above the base of the unit; recessive; lower contact very planar and sharp	9.0	300.0
	Total measured thickness of the Tsetso Formation is 9 m.		
	Mount Kindle Formation		
2	**Dolostone:** brown, medium brown weathering; medium to thick bedded; some medium beds of laminite; scattered patches of white, dolomite-cemented rubble packbreccia; scattered corals; this unit was only briefly examined but nonetheless measured accurately; very resistant; lower contact with the Franklin Mountain Formation is obscured	271.0	291.0
	Total measured thickness of the Mount Kindle Formation is 271 m.		
	Franklin Mountain Formation		
1	**Dolostone:** tan to brown, light orange-brown weathering; thin to medium planar bedded within very thick bedding (a 'megabedding'); a dololaminite containing current ripple marks and fenestral fabric; the Franklin Mountain Formation continues beneath this unit	20.0	20.0
	Incomplete thickness of the Franklin Mountain Formation is 20 m.		
	Total thickness of the North Eduni 2 Section (Section 15) is 813 m.		

Section 16 - Houdini Creek

This section includes strata of the Mount Kindle, Tsetso, Bear Rock, Landry, Hume, and Hare Indian formations and extends 1.5 km to the northeast, near Houdini Lake in the southern part of the Sans Sault Rapids map area (NTS 106 H). The base of the section is at latitude 65°02′N and longitude 129°17′W, and the section itself may be seen on RCAF air photograph A12758-021.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hare Indian Formation (or Canol Formation)		
12	**Shale:** mainly dark grey, dark grey weathering; laminated to finely laminated fissile shale with a few, thin, brown siltstone beds; recessive	9.0	519.0
	Incomplete thickness of the Hare Indian Formation is 9 m.		
	Hume Formation		
11	**Limestone:** grey, medium grey weathering; thick to very thick beds of lime mudstone; bed partings are irregular; the uppermost bedding surface of the Hume is partly silicified (or 'chertified'); scattered corals; this unit is the uppermost, resistant cliff former of the Hume Formation	18.0	510.0
10	**Limestone:** greyish brown or orange weathering from a distance; thin to medium bedded skeletal wackestone with abundant corals and brachiopods; orange and greyish green argillaceous partings; some large colonial corals such as *Hexagonaria* occur in some beds; basal beds are thinner, more irregularly bedded and more argillaceous One faunal collection was taken from 13.5 m above the base of the unit at GSC loc. C-74743 and included: "*Microcyclus*" *multiradiatus* (Meek) *Eoschuchertella adoceta* (Crickmay) *Spinulicosta stainbrooki* Crickmay atrypid, tentaculitid and trilobite fragments indicating an early Eifelian age (*adoceta* Zone). Identified by A.E.H. Pedder	73.5	492.0
	Total measured thickness of the Hume Formation is 91.5 m.		
	Bear Rock Formation Landry Member		
9	**Limestone:** greyish brown; medium to thick, smooth bedded lime mudstone and pelletal wackestone; unit forms the upper, bluish grey part of the Landry cliff	60.0	418.5
8	**Limestone:** same as overlying unit except for a few recessive beds of brown, dolomitic limestone that are brownish grey; gradational lower contact; resistant; 90% exposed	60.0	358.5
	Total measured thickness of the Landry Member is 120 m.		
	Bear Rock Formation		
7	**Limestone breccia:** mainly grey but some yellow stained areas, light grey and yellow weathering; medium to very thick, laterally discontinuous planar to wavy bedding; poorly sorted, particulate mosiac packbreccia and crackle breccia of lime mudstone; very rubbly weathering, moderately resistant but less so than the overlying Landry Formation	42.0	298.5

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
6	**Limestone breccia:** medium brownish grey; a nonbedded to very poorly but thick bedded sequence of very poorly sorted particulate rubble packbreccia; some zones, less than 1.0 m thick, of oriented rubble float breccia in which angular elongate clasts are oriented parallel to bedding; clasts throughout most of the sequence tend to be equant; basal contact is obscured; moderately resistant cliff former	45.0	256.5
	Total measured thickness of the Bear Rock Formation is 207 m.		
	Tsetso Formation		
5	**Dolostone:** light grey, medium yellowish grey and yellowish brown weathering; thin, smooth bedded, laminated dolostone at base of unit passes upward to medium and even thick bedded, brown, slightly vuggy dolostone with rough weathering surfaces toward the top of the unit; yellow, argillaceous material forms bed partings; some erosional discontinuity surfaces lined with green, argillaceous material and limonite stained; some thin solution pipes(?) infilled with green, argillaceous material extend downward from these discontinuity surfaces; some erosional contacts between beds, discontinuity surfaces observed at 9.0 m and 21.0 m above the base of the unit; some penecontemporaneous mud chip breccia 1.0 m above the base of the unit; lower contact with the Mount Kindle Formation is very sharp and slightly erosional because the uppermost Mount Kindle bed surface is finely pitted; moderately resistant	28.5	211.5
	Total measured thickness of the Tsetso Formation is 28.5 m.		
	Mount Kindle Formation		
4	**Dolostone:** brown, medium greyish brown weathering; thick planar bedded; rough weathering, with scattered black chert nodules and patches of silicification; very resistant; orthoconic cephalopods occur on the uppermost bed surface	69.0	183.0
3	**Dolostone:** similar to underlying unit in that it is mainly a thick bedded, vuggy, brownish grey mottled dolostone with abundant vugs; however, the lower part of this unit is more recessive than the underlying unit and only medium bedded, with some black chert nodules; massive, brown cliff former	46.5	114.0
2	**Dolostone:** brownish grey; thick to very thick, planar but unevenly bedded; vuggy; scattered silicified corals; a massive, brown cliff former	37.5	67.5
1	**Dolostone:** brown to brownish grey, brown weathering; medium planar to slightly wavy, discontinuous bedding; mottled, rough weathering; resistant, but less so than overlying units; vaguely fossiliferous matrix (crinoids?), orthoconic cephalopods scattered throughout	30.0	30.0
	Incomplete thickness of the Mount Kindle Formation is 183 m.		
	Total measured thickness of the Houdini Creek Section (Section 16) is 519 m.		

Section 17 - Gayna River

This section includes strata of the Mount Kindle, Tsetso, Arnica, Landry, and Hume formations, and extends northeast about 0.6 km along the nose of a ridge near Gayna River in the northeast corner of the Bonnet Plume Lake map area (NTS 106 B). The base of the section is at latitude 64°57′N and longitude 130°17′W, and the section may be seen on RCAF air photograph A12258-282.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
6	**Limestone:** dull yellowish and greenish grey weathering; thickly and unevenly bedded; a skeletal wackestone with some scattered large corals including *Hexagonaria*; the upper contact with the brownish grey shales of the Hare Indian Formation is obscured because brown argillaceous material from the overlying shales has mantled the uppermost beds of the Hume Formation; lower contact is sharp but not well exposed; slightly resistant but less resistant than the underlying Landry Formation	15.0	395.0
	Total measured thickness of the Hume Formation is 15 m.		
	Landry Formation		
5	**Limestone:** light bluish grey; thin to thick bedded, light brown lime mudstone and pelletal wackestone; sharply demarcated hemicycles about 2.5 to 4.0 m thick formed of thin planar to slightly wavy bedded, medium brown lime mudstone in recessive intervals 1 to 2 m thick, alternating with resistant intervals of thick, smooth and planar bedded pelletal wackestone that are much thicker than the thin bedded intervals, contain abundant algal material, and display fenestral fabric; some of the thin bedded intervals appear to contain some stromatolitic laminae although most these laminae are rippled traction current deposits; very resistant, cliff forming	240.5	380.0
	Total measured thickness of the Landry Formation is 240.5 m.		
	Arnica Formation		
4	**Dolostone:** medium greyish brown, brownish grey weathering; medium bedded; darker dolostones containing some rip-up clasts are interbedded with lighter coloured, smoother weathering dolostones that tend to be thinner bedded (some contain stromatolitic laminae); a very thick, dark, vuggy, possibly biostromal bed at 40.0 m above the base of the unit; some pisolitic horizons in the light coloured beds; at 51.0 m above the base of the unit a dolomitized crinoid grainstone bed with some two-holed crinoid fragments; 70% exposed; lower contact abrupt; forms a somewhat recessive scree slope leading up to the Landry cliffs	94.5	139.5
	Total measured thickness of Arnica Formation is 94.5 m.		
	Tsetso Formation		
3	**Limestone:** tan, grey weathering; thick bedded; recrystallized lime mudstone; many beds are finely brecciated to form calcite cemented crackle breccia; some beds appear to be algal laminated with some definite but isolated hemispheroidal stromatolites; resistant, cliff forming	12.0	45.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
2	**Sandstone** and **limestone:** orange, orange yellow weathering; intervals of thin bedded, orange, dolomite cemented, quartzarenitic, fine to medium sandstone alternates with thin to thick bedded, medium grey weathering, tan lime mudstone that is thinner bedded and stromatolitic toward the top of the unit; some zones of augen-shaped vugs occluded with calcite spar; a few thin to medium beds of silty, yellow dolostone; basal contact is sharp; recessive; 80% exposed	13.0	33.0
	Total measured thickness of the Tsetso Formation is 25 m.		
	Mount Kindle Formation		
1	**Dolostone:** brown, brown weathering; thick planar to unevenly bedded; bituminous; contains scattered silicified corals such as *Halysites*; the topmost beds of the Mount Kindle Formation form a poorly exposed, talus covered dip slope; resistant; only 40% exposed	20.0	20.0
	Incomplete thickness of the Mount Kindle Formation is 20 m.		
	Total thickness of the Gayna River Section (Section 17) is 395 m.		

Section 18 - Arctic Red 2

This section includes strata of the Mount Kindle, Tsetso, Arnica, Landry, and Hume formations, and is located in the northeastern part of the Bonnet Plume Lake map area (NTS 106 B) about 40 km east of Arctic Red River. The base of the section begins at latitude 64°43′N and longitude 130°10′W. The section itself may be seen on RCAF air photograph A12243-381.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Hume Formation		
14	**Limestone:** medium grey; very thick bedded coralline and stromatoporoidal wackestone or boundstone(?); a large quartz vein accompanied by some brecciation occurs 11.5 m above the base of the unit; this unit is the resistant upper part of the Hume; upper contact with Devonian shale is not well exposed but appears to be abrupt; lower contact is sharp and well exposed; very resistant; cliff forming	52.5	505.0
13	**Limestone:** dark grey weathering; thin to medium, very irregular and wavy bedded; slightly argillaceous bed partings; a slightly argillaceous lime mudstone containing scattered corals (*Hexagonaria*?), several of these corals are upside down; somewhat recessive; 70% exposed	44.5	452.5
12	**Limestone:** orange, grey mottled, dark greyish brown weathering; thin to very thin, planar but irregularly bedded; argillaceous, skeletal wackestone with abundant crinoids and brachiopods; fossils are particularly abundant along bed partings; lower contact obscured; recessive; only 40% exposed One faunal collection taken 18 m above the base of the unit at GSC loc. C-75555, includes: "*Microcyclus*" *multiradiatus* (Meek) *Eoschuchertella adoceta* (Crickmay) gastropod indicating an early Eifelian age (*adoceta* Zone); identified by A.E.H. Pedder	48.0	408.0

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Total measured thickness of the Hume Formation is 145 m.		
	Landry Formation		
11	**Limestone:** brown, grey weathering; medium to thick, smooth planar bedded pelletal(?) lime mudstone; many solitary thick beds or groups of a few beds are separated by thin recessive intervals of very thin bedded to laminated dark brown pelletal(?) lime mudstone containing some current ripple stratification; at 29 to 35 m above the base of the unit there are abundant, large, channel fill deposits, 4 to 5 m broad and more than 1.0 m deep; a resistant, bluish grey cliff former but with a somewhat "ribbed" appearance	72.0	360.0
10	**Limestone:** brown, bluish grey weathering; medium, smooth planar bedded pelletal(?) wackestone, with some thin to very thin bedded intervals; a shell horizon marks the top of the unit; resistant but less so than overlying unit	37.5	288.0
9	**Limestone:** brown, bluish grey weathering; thin, planar, smooth bedded pelletal(?) wackestone with some very thin and medium beds; a little orange-stained, calcite-cemented rubble packbreccia at the top of the unit; resistant but more recessive than the overlying two units and the underlying unit	57.0	250.5
8	**Limestone:** bluish grey weathering; medium planar and smooth planar bedded, more uniformly bedded than the overlying units of the Landry Formation; resistant	37.5	193.5
	Total measured thickness of the Landry Formation is 204 m.		
	Arnica Formation		
7	**Dolostone:** brown, slightly mottled, greyish brown weathering; thick planar bedded; fine to medium crystalline; same as in underlying units of the Arnica Formation but with very few light grey beds of laminated dolostone; moderately resistant but less resistant than the overlying Landry Formation	28.5	156.0
6	**Dolostone:** colour banded, dark brownish grey and light grey; this unit comprises 6 hemicycles, in which medium to thick beds of brown dolostone grade upward to thin beds of light grey (almost white) dolostone that contain laminoid fenestral fabric (e.g. 12 m above the base of the unit); abundant moulds of *Amphipora* in thick, dark brown beds; moderately resistant	22.5	127.5
5	**Dolostone:** same as overlying unit but fewer light grey beds; some yellow silt in light grey beds; generally thick bedded	33.0	105.0
4	**Dolostone:** colour banded, brownish grey and light grey; medium to thick, dark brownish grey beds grade up to light grey beds (white) with stromatolitic and fenestral fabric; dark beds rest on light coloured beds with sharp erosional contacts, and chips of the light grey beds occur in the basal parts of many dark beds; these colour banded cycles are typically one metre to a few metres thick; many dark beds contain amphiporids; lower contact sharp; slightly recessive; 50% exposed	18.0	72.0
	Total measured thickness of the Arnica Formation is 102 m.		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Tsetso Formation		
3	**Dolostone:** yellowish grey and yellow, weathers yellowish orange; silty, thin to medium planar to wavy bedded; a little green malachite staining; some pyrite, recessive; 50% exposed	15.0	54.0
2	**Dolostone:** greyish yellow, light grey weathering with some yellowish orange staining; fine crystalline; very thin to thin bedded, finely laminated, laminae formed of medium to coarse crystalline dolomite; recessive but more resistant than overlying unit; 80% exposed, sharp lower contact, this unit forms a small basal cliff in the Tsetso Formation	9.0	39.0
	Total measured thickness of the Tsetso Formation is 24 m.		
	Mount Kindle Formation		
1	**Dolostone:** light orange, brown mottled, brown and rough weathering; medium and planar bedded; some large coral and brachiopod moulds partly occluded with white dolomite cement (partly orange stained); abundant crinoids at 29 m; resistant; 80% exposed	30.0	30.0
	Incomplete measured thickness of the Mount Kindle Formation is 30 m.		
	Total measured thickness of the Arctic Red 2 Section (Section 18) is 505 m.		

Section 19 - Arctic Red 4

This section includes strata of the Rabbitkettle, Duo Lake, and Cloudy formations, and is located in the east-central part of the Bonnet Plume Lake map area (NTS 106 B) about 30 km east of the headwaters of the Arctic Red River. The section extends southward down a small valley. The base of the section is at latitude 64°28′N and longitude 130°17′W, and the section may be seen on RCAF air photograph A12258-300.

	Cloudy Formation		
11	**Limestone:** medium brownish grey weathering; medium planar bedded lime mudstone with abundant black chert nodules; a resistant cliff-forming unit; top of unit is the end of the exposure; scattered silicified corals, some of which appear to be favositid-like, and some brachiopods	100.0	661.5
10	**Limestone:** light grey, greyish yellow weathering; argillaceous and dolomitic, featureless lime mudstone; thin to medium planar bedded; a very sharp abrupt lower contact with the underlying shale of the Duo Lake Formation; resistant but more recessive than overlying unit	60.0	561.5
	Incomplete measured thickness of the Cloudy Formation is 160 m.		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Duo Lake Formation		
9	**Shale:** black, black weathering; very thinly planar laminated, fissile; a few resistant and solitary, thin to medium planar beds of grey, pyritic, fine crystalline dolostone beds punctuating the sequence; a slump zone with contorted beds occurs in the top 1.0 to 2.0 m; graptolites were observed at 1.0 m and 39.0 m above the base of the unit; these graptolites included biserial types and the distinctive Early Ordovician graptolite *Tetragraptus*; very recessive	130.5	501.5
8	**Limestone** and **shale:** dark grey weathering; very thin to thin planar bedded; rhythmically bedded limestone shale couplets 5 to 10 cm thick, consisting of lime mudstone beds separated by calcareous grey shale; several large (1 to 2 m thick) breccia beds (particulate rubble floatbreccia and packbreccia) of probable debris flow origin, with plastically deformed fragments apparently reworked from the rhythmically bedded strata; some zones with nodular bedding in which the limestone beds within lime shale couplets are discontinuous; recessive but less so than the overlying unit	22.5	371.0
7	**Shale** and **limestone:** dark grey weathering; very thin to laminated, fissile bedded 1 cm thick shale-limestone and shale-dolostone couplets (almost varve-like bedding); graptolites, including *Tetragraptus*, 22.5 m above the base of unit; very recessive; a gradational lower contact	33.0	348.5
	Total measured thickness of the Duo Lake Formation is 186 m.		
	Rabbitkettle Formation		
6	**Dolostone** and **dolostone breccia:** brownish grey weathering unit; 50% very thin to thin, planar bedded, argillaceous, fine crystalline dolostone; 50% very thick bedded dolostone breccia with several intervals composed solely of very thick beds of particulate rubble floatbreccia and packbreccia of probable debris flow origin, with plastically deformed breccia fragments; breccia fragments appear to have been reworked from thin bedded dolostone similar to that which separates the bedded breccia intervals; one extremely thick (3.5 m thick) breccia bed 23 m above the base of the unit displays ball and pillow structure; the grey carbonate mud matrix of these breccias tends to be calcareous; resistant	49.5	315.5
5	**Dolostone:** grey to brownish grey weathering; argillaceous; very thin to thin, very smooth and evenly bedded dolostone in 1 to 10 cm thick shale and dolostone couplets; a few, scattered, thin beds and lenticular pods of breccia with a fabric similar to that described in unit 4; a resistant, canyon-forming unit	94.5	266.0
4	**Limestone:** medium to dark grey and brown weathering; very rhythmically bedded, very thin, evenly and smooth bedded lime mudstone and shale couplets 5.0 to 10.0 cm thick; in some more resistant intervals, the proportion of shale or argillaceous material in these couplets is less than that in the less resistant units; a few, scattered, thin beds of particulate rubble floatbreccia with pebbly, well rounded, platy carbonate clasts, as in the underlying unit; graptolites in shale 23.0 m above the base of the unit; top of this unit occurs at a fault with about 20.0 m of displacement; resistant and cliff forming	69.5	171.5

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
3	**Limestone** and **shale:** grey weathering; thin to very thin, rhythmically bedded lime mudstone and shale with very smooth planar bedding, in couplets 5 to 20 cm thick; a few scattered debris flows in beds 10 to 30 cm thick of particulate rubble floatbreccia with rounded equant to platy clasts oriented subparallel to bedding in a lime mud matrix; a slightly recessive, slope-forming unit that extends up to the base of the cliff formed by the overlying unit; 90% exposed	36.0	102.0
2	**Limestone** and **shale:** medium brownish grey weathering; thin to very thin, rhythmically bedded lime mudstone and shale couplets; 9 m above the base of the unit; some pyrite nodules in thicker beds are elongate parallel to 60°; some black chert nodules surrounded by pyrite; more recessive than both the overlying and underlying units	18.0	66.0
1	**Limestone** and **shale:** medium yellowish grey and grey weathering; mainly thin to very thin, rhythmically bedded lime mudstone and shale couplets or lime mudstone with yellow argillaceous partings (almost a striped yellow and grey appearance); some widely spaced, thin, shaly, recessive intervals; a few thick beds of particulate rubble floatbreccia with plastically deformed clasts of bedding material in a lime mud matrix; imbrication of clasts trends at about 235°; black chert nodules common; slightly recessive	48.0	48.0

Incomplete measured thickness of the Rabbitkettle Formation is 315.5 m.

Total thickness of the Arctic Red 4 Section (Section 19) is 661.5 m.

Section 20 - South Bonnet Section

This section includes the Marmot, Tsetso, Camsell, Arnica, Landry, and Hume formations. The base of the section is at latitude 64°11′N and longitude 130°08′W, and it extends eastward several kilometres from a large valley floor and along a high, east-trending ridge line in the southeast part of the Bonnet Plume Lake map area (NTS 106 B). This section is best seen on RCAF air photograph A12243-403.

Hume Formation

23	**Limestone:** grey to bluish grey weathering; thick to very thick, planar, continuously bedded; bedding surfaces irregular; lower part of unit is thinner bedded and darker grey (slightly more bituminous); a crinoidal wackestone with brachiopods and scattered colonial corals, including some tentatively identified as *Hexagonaria*; resistant	121.5	1807.5

Total measured thickness of the Hume Formation is 121.5 m.

Landry Formation

22	**Limestone:** light grey to bluish grey weathering; medium to thick planar bedded; moderately resistant, but considerably more recessive than the underlying Arnica Formation; a pelletal wackestone with some crinoid-bearing beds	60.0	1686.0

Total measured thickness of the Landry Formation is 60 m.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Sombre Formation		
21	**Dolostone:** dark brown weathering; thick to very thick planar bedded with some thin bedded intervals; bituminous; vuggy, rubbly weathering; fine to medium crystalline, sucrosic; some beds contain scattered patches of white silicification; thin bedded intervals are laminated and are light brownish grey; many beds contain abundant remains of *Amphipora*; resistant, forming a prominent bluff; 90% exposed	165.0	1626.0
20	**Dolostone:** white weathering; a stromatolitic dolostone laminite; medium planar bedded but some thin and thick beds; abundant, laterally linked, hemispheroidal stromatolites with a "wavelength" of 5 cm; a few stromatolitic limestone beds; resistant	156.0	1461.0
19	**Dolostone:** dark brown weathering resistant flatirons alternate with light grey recessive intervals; dark brown, thick to very thick planar bedded, grey, calcareous dolostone with rough spiny weathering surfaces forms the flatirons; medium bedded, light grey, laminated dolostone forms the recessive intervals; in some places chips of light grey dolostone occur in the basal part of dark brown dolostone beds that overlie light grey intervals; a slightly recessive unit that extends down a dip slope to a level part of the ridge; 95% exposed	61.5	1305.0
18	**Dolostone:** medium to dark brownish grey, medium brownish grey weathering with light grey stripes; thick bedded; laminae abundant in the upper parts of many beds; uppermost cliff may be biostromal as it contains many large vugs partly occluded with white dolomite; soft sediment deformation in some laminated intervals; resistant, with a cliff at the top of the unit	76.5	1243.5
17	**Dolostone:** dark brownish grey weathering; thick to very thick bedded; (?)biostromal dolostone; vague remnants of stromatoporoids; thinner, more recessive beds are laminated and stromatolitic; some penecontemporaneous slumped laminae 32.5 m above the base of the unit; resistant and cliff forming, particularly near the top of the unit	75.0	1167.0
16	**Dolostone:** light grey, light to medium grey weathering; thick to medium, and smooth bedded; some dolomite cemented, particulate, rubble packbreccia at 14.5 m above the base of the unit	42.0	1092.0
15	**Dolostone:** throughout the unit, dark brownish grey weathering resistant ribs alternate with more recessive, light grey weathering intervals in couplets that are a few metres thick; these couplets are formed by dark brownish grey, thick and irregular, slightly stromatoporoidal beds that grade upward to the thin, and smooth bedded, light grey dolostones that contain good examples of laterally linked, closely spaced, hemispheroidal stromatolites; a few dark grey calcareous beds	93.0	1050.0

Total measured thickness of the Sombre Formation is 669 m.

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	Camsell Formation(?)		
14	**Silty dolostone** and **limestone:** medium brown to brownish yellow weathering; intervals of dark greyish brown, thin to medium bedded, fine crystalline dolostone or lime mudstone grade upward to light grey, thin bedded, stromatolitic dolostone; many of these intervals are capped by thinner, recessive intervals of yellow, very thin bedded,platy, silty and argillaceous dolostone, which contain mudflakes, mudcracks, and polygonal stromatolites; vugs 1 to 2 cm across occur in the dark grey intervals; a slightly resistant unit that leads eastward down to a saddle from a high point on the ridge; 95% exposed	63.0	957.0
13	**Dolostone:** mainly dark grey to nearly black; fetid; medium and smooth bedded; thicker beds tend to be brownish and contain many small vugs strung out parallel to bedding (biostromal); some poorly developed 3 to 10 m thick cycles of brownish grey, thick beds grading upward to thin bedded, light grey algal(?) laminated beds containing fenestral fabric and some ostracodes; some thin (1 to 3 m) thick intervals of yellow, silty dolostone separate these cycles in the upper part of the unit; dark beds contain abundant interlaminae of recrystallized grainstone or wackestone containing well sorted, comminuted, recrystallized skeletal fragments that range in size from 1 to 3 m (probably traction carpet deposits); a resistant unit that extends across a high point along the ridge	199.5	894.0
12	**Dolostone:** alternating dark and light grey intervals, light greyish yellow weathering; thin to medium bedded with a prominent, thick bedded dark brownish grey to black biostromal(?) band at the top of the unit; a little dolomite-cemented rubble packbreccia in the vuggy biostromal band; moderately resistant	52.5	694.5
	Total measured thickness of the Camsell Formation is 315 m.		
	Cloudy Formation(?)		
11	**Limestone:** dark grey, dark to medium grey weathering; medium planar to wavy bedded lime mudstone; some finely comminuted skeletal debris; unit becomes slightly dolomitic toward the top; many intervals display wavy to irregular partings that form platy 'parting' zones between thicker beds; resistant but more recessive than the overlying units; 80% exposed	81.0	642.0
10	**Limestone:** similar to overlying unit; medium grey weathering; thin to thick and smooth bedded lime mudstone and wackestone; thin bedded intervals with yellow staining and partings alternate with thick bedded intervals; resistant; a few, scattered thamnoporid-like corals	66.0	561.0
9	**Limestone:** grey; thin to thick smooth planar bedding with yellow, argillaceous partings; some thin bedded intervals with red or pink partings; lime mudstone with some horn corals at the top of the unit; a moderately resistant cliff former	30.0	495.0
8	**Limestone:** medium grey; thin, irregular to nodular bedding with abundant yellow argillaceous parting seams and pink and ochre coloured staining on irregular bed surfaces, some thick and medium beds, thin bedded intervals separate thicker bedded intervals; fossiliferous lime mudstone; abundant corals, ostracodes and brachiopods occur 9 m above the base and at the top of the unit; a recessive unit beneath the overlying cliff-forming unit		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	One faunal collection of corals was made from the fossiliferous horizon at the top of the unit at GSC loc. C-75707, and included: *Weissermelia* sp. nov. indicating a Late Silurian age; identified by A.E.H. Pedder	24.0	465.0
7	**Limestone:** medium grey; unit is formed of 10 intervals, each 1 to 5 m thick, in which smooth, medium bedded, grey lime mudstone beds grade upward to greyish yellow weathering, argillaceous, platy lime mudstone; some stromatolite laminite in platy, very thin bedded intervals; some of thicker beds are bioturbated and contain skeletal fragments; a prominent cliff former	49.5	441.0
6	**Limestone:** greyish yellow weathering; medium to thin planar bedded, fossiliferous lime mudstone with scattered corals and brachiopods; some thin platy intervals; a recessive unit beneath a prominent cliff		
	One conodont faunal collection was taken from 24.0 m above the base of the unit at GSC loc. C-75704 and included: *Ozarkodina confluens* gamma morphotype Klapper and Murphy indicating a Late Silurian age (*ploeckensis* to *index* Zones); identified by B.D.E. Chatterton	25.5	391.5
	Total measured thickness of the Cloudy Formation is 276 m.		
	Marmot Formation (or Duo Lake?)		
5	**Volcanic tuff:** brown weathering; thick to very thick bedded (or nonbedded, massive) greenish grey, altered crystal or lithic volcanic sandstone or tuff; a prominent, resistant cliff former	36.0	366.0
4	**Volcanic tuff** and **silty mudstone:** greenish grey weathering; brown to black, well laminated, thin bedded intervals of silty mudstone alternate with slightly thicker bedded and more resistant (medium bedded) intervals of faintly laminated, greyish green, volcanic siltstone; a recessive and friable interval separating two cliffs	34.5	330.0
3	**Volcanic tuff** and **basalt(?):** greyish green, brown weathering; medium bedded; lapilli tuff or volcanic sandstone (or granule conglomerate) at base, with some detrital quartz grains and limonite staining; one thick bed of coralline lime wackestone occurs about one-fourth of the unit thickness above the base of the unit; medium to thick, planar to wavy bedded, vesicular basalt and volcanic tuff occupies the upper part of the unit; rests with a sharp, slightly irregular contact on the underlying unit; forms a very prominent cliff	15.0	295.5
2	**Calcareous shale:** light grey, yellowish grey weathering; calcareous shale that weathers to platy discoidal fragments; abundant, bright yellow, discontinuous 'ironstone' bands or elongate nodules parallel to bedding in a zone 10 m thick, the base of which is 195 m above the base of the unit; a few thick lime mudstone beds in lower and middle parts of unit; some indistinct corals 190 m above the base of the unit, a recessive, brownish grey unit that forms the lower part of the east side of a large, south trending valley; 80% exposed; this unit could be considered to be part of the Duo Lake Formation	205.5	280.5

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
1	**Volcanic tuff** or **sandstone:** light greenish grey; grey volcanic sandstone(?) with some granule and coarse-sand sized, detrital quartz grains and pyrite; resistant; 30% exposed	75.0	75.0

Incomplete thickness of the Marmot Formation is 366 m.

Total thickness of the South Bonnet Section (Section 20) is 1807.5 m.

Section 21 - Arctic Red 1

This section includes strata of the Rabbitkettle and Duo Lake formations and, possibly, the Landry Formation (or the Cloudy Formation), and the Mount Kindle "Transitional". The section is located in the northeastern part of the central region of the Bonnet Plume Lake map area (NTS 106 B) where it extends southward along a valley floor occupied by a small tributary of Arctic Red River. The base of the section is at latitude 64°39′N and longitude 130°45′W, and the section itself may be seen on RCAF air photograph A12248-259.

	Landry Formation(?)		
12	**Limestone:** tan, light grey weathering; a few very thick beds that cap the underlying recessive unit; pelletal wackestone with some wisps of yellow, argillaceous material; this unit underlies a slope and cliff that has the appearance of the Hume Formation, and itself forms a recessive lower part leading up to a resistant capping cliff; limestone talus (skeletal wackestone?) forms the slope and some *Coenites*-like corals were noted; resistant	2.0	875.0
11	**Limestone** and **shale:** medium grey weathering; most of the unit consists of solifluction material in which some limestone fragments were noted; high argillaceous content probably indicates presence of shale; perhaps this unit could be assigned to the Funeral Formation; very recessive unit with no outcrop; extends across a shallow slope and bench	22.5	873.0
	Total measured thickness of the Landry (Funeral) Formation is 24.5 m.		
	Mount Kindle "Transitional"		
10	**Dolostone:** medium brownish grey to light yellowish grey weathering; medium to thin planar to slightly wavy bedding; some small scours developed between beds, with crinoid and brachiopod fragments in some scours; some dark grey silicified spherical nodules that possibly may be silicified sponges; this unit is a resistant cliff former, lighter coloured than and forming a single cliff distinct from the underlying units	87.0	850.5
9	**Dolostone** and **chert:** medium grey to brownish grey weathering; medium to thin, planar to wavy bedded, broadly anastomosing bedding; medium brownish grey dolostone intimately interlaminated with discontinuous dark grey chert laminae; some intervals are nearly 'ribbon' chert; resistant	79.5	763.5

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
8	**Dolostone:** medium yellowish grey weathering; thin to medium planar bedded with argillaceous partings between beds; some small scours at the bases of some beds; slightly silty and some streaks of dark grey silicification parallel to bedding; resistant; 80% exposed	117.0	684.0
7	**Dolostone:** yellowish grey weathering; uniformly thin bedded in lower part becoming very thin bedded toward the top of the unit; abundant dark grey chert nodules elongated parallel to bedding; some pyrite; argillaceous bed partings become silty toward top of unit; some brownish pink and red coloured bedding surfaces toward the top of the unit; dolostone in lower part of the unit is somewhat calcareous; a small fault of unknown displacement may occur at the base of this unit; resistant and cliff forming, slightly more resistant than overlying unit	76.5	567.0
	Total measured thickness of the Mount Kindle "Transitional" unit is 360 m.		
	Duo Lake Formation		
6	**Shaly limestone:** dark grey; platy laminated to very thin planar bedded; argillaceous lime mudstone that becomes slightly thicker bedded toward the top of the unit; six thick debris flow beds occur in the lower part of the unit, these beds are formed of particulate rubble packbreccias and floatbreccias in which tubular, plastically deformed, yellow clasts float in a grey lime mudstone matrix; recessive	100.0	490.5
5	**Calcareous shale:** dark grey, dark grey weathering; thinly laminated, platy and fissile; a few more resistant intervals of shaly lime mudstone; some pyrite and barite concretions A graptolite fauna was collected from 45 m above the base of the unit at GSC loc. C-75606 and includes: *Caryocaris* sp. *Clonograptus* sp. *Kiaerograptus*? cf. *K. pritchardi* (Hall) *Tetragraptus* cf. *T. decipiens* (Hall) indicating an Early Ordovician age or late Tremadoc (*Adelograptus* Zone); identified by B.S. Norford	52.5	390.5
	Total measured thickness of the Duo Lake Formation is 152.5 m.		
	Rabbitkettle Formation		
4	**Argillaceous** and **silty limestone:** yellow-orange to yellow-grey weathering; very thin planar bedded; argillaceous lime mudstone with silty partings punctuated by many thin to medium lime mudstone beds (debris mudflow beds?); the thicker lime mudstone beds contain floatbreccia like that in the underlying unit; graptolites were observed 60 m above the base of the unit; unit forms broad, rocky canyon in the valley floor; moderately resistant Graptolites collected from 160.5 m above the base of the unit at GSC loc. C-75605 include: *Adelograptus*? sp. *Clonograptus* sp. inarticulate brachiopod		

Unit	Description	Unit thickness (m)	Cumulative thickness above base (m)
	indicating an Early Ordovician age or late Tremadoc (*Adelograptus* Zone); identified by B.S. Norford	161.0	338.0
3	**Limestone:** dark grey weathering; 65% of unit is very thin, rhythmically bedded lime mudstone and shale in couplets, with some authigenic pyrite; 35% of unit is composed of thick to very thick breccia beds of probable debris flow origin, formed of particulate rubble packbreccia composed of tabular to equant lime mudstone clasts in a slightly silty and orange tinted lime mudstone (or siltstone) matrix; some breccias extensively pyritized; recessive	48.0	177.0
2	**Limestone** and **shale:** yellowish orange to greyish yellow weathering; calcareous, fissile, platy shale with intervals of thin bedded, argillaceous and silty lime mudstone; 30% of unit is formed of medium to very thick beds of breccia, as in the overlying unit; one breccia bed is more than 5 m thick; platy clasts tend to be flat-lying near the bases of the beds; mostly conglomeratic packbreccia; moderately recessive	52.5	129.0
1	**Limestone:** yellowish orange weathering; thin to very thin bedded, silty and argillaceous lime mudstone; a few thick wackestone beds that may be mass flow deposits, rhythmically bedded with silty partings; some ripple drift crossbedding; this unit is the first canyon-forming unit on the valley floor and is probably near the base of the Rabbitkettle Formation; slightly resistant	76.5	76.5

Incomplete measured thickness of the Rabbitkettle Formation is 338 m.

Total measured thickness of the Arctic Red 1 Section (Section 21) is 875 m.

APPENDIX 2

Faunal data

Formation and height above base (below top) (m)	Section no. and cumulative thickness above base of section (m)	Fauna and age	GSC locality no. (and source)
Rabbitkettle - (0.5)	21-337.5	Inarticulate brachiopod *Adelograptus*? sp. *Clonograptus* sp. *Clonograptus*? sp. Early Ordovician, late Tremadoc (*Adelograptus* Zone)	C-75605 B.S. Norford
Duo Lake - 45.0	21-383.0	*Caryocaris* sp. *Clonograptus* sp. *Kiaerograptus*? cf. *K. pritchardi* (Hall) *Tetragraptus* cf. *T. decipiens* Hall undetermined graptolite fragment Early Ordovician, late Tremadoc (*Adelograptus* Zone)	C-75606 B.S. Norford
Cloudy(?) - 99.0	20-468.0	*Weissermelia* sp. nov. Late Silurian	C-75707 A.E.H. Pedder
Cloudy(?) - 24.0	20-418.5	*Ozarkodina confluens* gamma morphotype Klapper and Murphy Late Silurian – *ploeckensis* to *index* Zones	C-75704 B.D.E. Chatterton
Ordovician-Silurian Undivided (Cloudy?) - 40.0	7-60.0	isotelid trilobite cephalopod? Ordovician age	C-75746 B.S. Norford
Cloudy(?) - 90.0	7-110.0	*Aulacognathus bullatus* (Nicoll and Rexroad) *Aulacognathus ceratoides* (Nicoll and Rexroad) *Pseudooneotodus* sp. "*Neoprioniodus planus*" Walliser "*Roundya trichonodelloides*" Walliser "*Ligonodina egregia*" Walliser Silurian age near the Llandovery/Wenlock boundary (*amorphognathoides* Zone)	C-75748 B.D.E. Chatterton
Mount Kindle - 15.5	3-270.0	brachiopod and trilobite fragments *Bighornia* sp. *Catenipora* sp. favositid coral *Palaeophyllum* sp. *Sarcinula* Late Ordovician (*Bighornia-Thaerodonta* fauna)	C-75672 B.S. Norford
Mount Kindle "Transitional" - 227.5	21-768.0	subspherical silicified objects of possible, but improbable, sponge origin	C-75612 A.E.H. Pedder

Formation and height above base (below top) (m)	Section no. and cumulative thickness above base of section (m)	Fauna and age	GSC locality no. (and source)
Tsetso - (114.0)	8-145.0	*Ozarkodina remscheidensis* Ziegler (subsp. indet.) sagittodontan elements of *Icriodus* or *Pelekysgnathus* or *Caudicriodus* Late Silurian to earliest Devonian (*eosteinhornensis* to *eurekaensis* Zones)	C-75783 B.D.E. Chatterton
Tsetso - (79.0)	8-180.0	*Ozarkodina remscheidensis* Ziegler (subsp. indet.) Late Silurian to earliest Devonian (*eosteinhornensis* to *eurekaensis* Zones)	C-75784 B.D.E. Chatterton
Arnica - 73.0	15-373.0	*Amphipora* sp. indet. Late Silurian to Devonian, but not latest Devonian (i.e., not Famennian)	C-75773 A.E.H. Pedder
Arnica - 80.0	8-873.0	*Amphipora* sp. indet. Late Silurian to Devonian, but not latest Devonian (i.e., not Famennian)	C-75791 A.E.H. Pedder
Arnica - 79.5	11-668.0	stromatoporoids, bulbous coenostia *Amphipora* sp. indet. *Alveolites* sp. indet. *Thamnopora* sp. indet. *Syringopora* sp. indet. Late Silurian to Devonian, but not lastest Devonian (i.e., not Famennian)	C-75634 A.E.H. Pedder
Landry - 15.0	9-1573.0	*Favosites* sp. indet. *Spongonaria* sp. cf. *S. parca* Crickmay biaxial crinoid ossicles Early Devonian, probably late Zlichovian; possible Dalejan	C-75848 A.E.H. Pedder
Landry - 405.0	8-1553.0	indet. laminar tabulate coral fragments *Microplasma* sp. nov. or *M. caespitosum* (Schlüter) subsp. nov. *Lekanophyllum (Scissoplasma)* sp. nov. *Conocardium* sp. indet. gastropods sp. indet. biaxial crinoid ossicles Middle Devonian, early Eifelian	C-75798 A.E.H. Pedder
Landry - 405.0	8-1553.0	*Icriodus culicellus* (Bultynck) (small form) Devonian, late Emsian – early Couvinian, but the small form is more characteristic of early Couvinian	C-75798 T.T. Uyeno
Hume - 27.5	13-534.0	"*Microcyclus*" *multiradiatus* (Meek) cystimorph coral, indet. cricoconarid, not studied	C-75539 A.E.H. Pedder

Formation and height above base (below top) (m)	Section no. and cumulative thickness above base of section (m)	Fauna and age	GSC locality no. (and source)
		fish plate (possible pineal plate of psammosteid) Devonian, early Eifelian (*adoceta* Zone)	
Hume - 27.5	13-534.0	"*Microcyclus*" *multiradiatus* (Meek) *Digonophyllum rectum* (Meek) *Eoschuchertella adoceta* (Crickmay) ambocoeliid brachiopod, indet. cricoconarid not studied bivalve fragments Devonian, early Eifelian (*adoceta* Zone)	C-75538 A.E.H. Pedder
Hume - 112.5	13-619.0	*Amphipora ramosa* Phillips *Dendrostella trigemme* (Quenstedt) Devonian, late Eifelian (*dysmorphostrata* Zone)	C-75540 A.E.H. Pedder
Hume - 22.0	11-1176.0	*Favosites* sp. indet. *Digonophyllum* sp. *Schizophoria* sp. indet., fragmentary *Eoschuchertella adoceta* (Crickmay) *Variatrypa aperanta* (Crickmay)?, fragment ambocoeliid brachiopod, indet. Devonian, early Eifelian (*adoceta* Zone)	C-75642 A.E.H. Pedder
Hume - 18.0	18-426.0	"*Microcyclus*" *multiradiatus* (Meek) *Eoschuchertella adoceta* (Crickmay) gastropod and other fragments Devonian, early Eifelian (*adoceta* Zone)	C-75555 A.E.H. Pedder
Hume - 13.5	16-432.0	"*Microcyclus*" *multiradiatus* (Meek) *Eoschuchertella adoceta* (Crickmay) *Spinulicosta stainbrooki* Crickmay atrypid, tentaculitid and trilobite fragments Devonian, early Eifelian (*adoceta* Zone)	C-75743 A.E.H. Pedder