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M.P. CECILE

PALEONTOLOGIC APPENDIX
W.H. FRITZ, B.S. NORFORD AND R.S. TIPNIS

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## Preface

The discovery of carbonate-hosted base metal deposits near major carbonate-shale facies boundaries in the western Canadian Cordillera has created interest in these transition zones and their possible control of mineralization. The more recent discovery of shale-hosted base metal deposits has also created interest in the shale basins beyond the carbonate shelf margin. The transition zones and adjacent basins are not only important economically but record the diverse tectonic-depositional history of the Cordilleran cratonic margin.

This report is the result of a Geological Survey of Canada project initiated in 1977 and provides data on the stratigraphy, depositional setting, economic potential and tectonic history of the lower Paleozoic carbonate to shale transition rocks in northeastern Yukon and western District of Mackenzie. In addition, an important lower Paleozoic paleogeographic feature of the cratonic margin, the Misty Creek Embayment, is described. A short section containing recommendations for mineral and hydrocarbon exploration, is included.

OTTAWA, July 1982

R.A. Price
Director General

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# THE LOWER PALEOZOIC MISTY CREEK EMBAYMENT, SELWYN BASIN, YUKON AND NORTHWEST TERRITORIES


## *Abstract*

The Misty Creek Embayment, a 100 x 150 km, northwest-trending, rectangular, early Paleozoic basin, is surrounded on three sides by the Upper Cambrian-Lower Ordovician Franklin Mountain Formation, and the Upper Ordovician-Lower Silurian Mount Kindle Formation, both platform dolostones. These dolostone units define two distinctly different positions of the embayment, the Mount Kindle indicating embayment boundaries about 30 km west of those defined by the Franklin Mountain Formation. These dolostones are thick bedded, recrystallized, and locally preserve shallow water features, such as oolites, birdseye texture, mudcracks, and bioturbation.

To the south the embayment opens into the Selwyn Basin across the Niddery basin high. Basin strata within the embayment, originally mapped as Road River Formation, are divided into six formations and two unnamed units of late Early Cambrian to Early Devonian age - the Hess River Formation (new), Rabbitkettle Formation, Duo Lake Formation (new), Marmot Formation (new) and Cloudy Formation (new), Natla? Formation and unnamed Middle Ordovician and middle Paleozoic limestone units. Basin strata are turbiditic, rhythmic successions of alternating thin-bedded silty limestone and calcareous shale, thin-bedded silty limestone, black graptolitic shale, and chert.

Lower Paleozoic alkalic volcanic rocks are interstratified with some of these basin units. At one location a thick volcanic complex is interpreted as a shoaling volcanic centre consisting of alkaline basaltic hyaloclastites, epiclastites, and massive flows, overlain by fossiliferous limestones and volcanogenic conglomerates.

Platform to basin transition zones are 20-40 km wide linear belts where thin-bedded silty dolostones are interstratified with basin and platform facies rocks. Transition facies rocks equivalent in age to all basin units are known and those correlative with the Franklin Mountain and Mount Kindle Formations are extensively preserved. The identification of Middle Cambrian and Middle Ordovician transition rocks indicates the existence, before erosion, of platform facies of these ages. Abundant intraslope breccias occur within and close to Franklin Mountain transition facies. These breccias consist of clasts of transition or basin facies rocks in a carbonate matrix, either brecciated *in situ*, or moved as debris flows variable distances down the slope.

The embayment is interpreted as a submerged, fault-bounded basin on the basis of geometry, linear facies belts, and alkalic volcanism.

Several bedded barite occurrences are noted in Hess River, Duo Lake and Cloudy Formations; and phosphorite was found at two locations in the Hess River Formation. Shale units show base metal anomalies and are recommended exploration targets. The embayment is comparable in many aspects to the correlative Richardson Trough. Facies relationships and basin geometry of the embayment therefore may be useful for subsurface exploration adjacent to the trough.



## *Résumé*

Le rentrant de Misty Creek est un bassin formé au début du Paléozoique inférieur, rectangulaire, d'orientation nord-ouest, mesurant 100 x 150 km, et bordé sur trois de ses côtés par la formation de Franklin Mountain d'âge Cambrien-Ordovicien inférieur et par la formation de Mount Kindle d'âge Ordovicien supérieur-Silurien inférieur, toutes deux constituées par des dolomies de plate-forme. Ces dolomies définissent deux positions bien distinctes du rentrant; la formation de Mount Kindle indique les limites du rentrant à environ 30 km à l'ouest des limites définies par la formation de Franklin Mountain.

Ces dolomies forment des bancs épais, recristallisés et conservant localement des caractéristiques de sédiments d'eau peu profonde, telles que des oolites, une texture oeillée, des fissures de retrait et une bioturbation. Vers le sud, le rentrant s'ouvre sur le bassin de Selwyn à travers l'élévation du bassin de Niddery. Les strates du bassin, à l'intérieur du rentrant, initialement portées sur la carte sous le nom de formation de Road River, sont divisés en six

formations et deux unités non désignées allant de la fin du Cambrien inférieur au Dévonien inférieur: la formation de Hess River (nouvelle), la formation de Rabbitkettle, la formation de Duo Lake (nouvelle), la formation de Marmot (nouvelle) et la formation de Cloudy (nouvelle), la formation de Natla? et les unités calcaires non désignées de l'Ordovicien moyen et du Paléozoique moyen. Les couches du bassin forment des successions rythmiques à turbidites de calcaires silteux finement lités, alternant avec des schistes argileux calcaires, des calcaires silteux finement lités, des schistes argileux noirs graptolitiques et des cherts.

Les roches volcaniques alcalines du Paléozoique inférieur sont interstratifiées avec certaines des unités du bassin. À un endroit, un complexe volcanique épais que l'on interprète comme un centre volcanique devenant peu profond, contient des hyaloclastites basaltiques alcalines, des épiclastites et des coulées massives, recouvertes par des calcaires fossilifères et des conglomérats d'origine volcanique.

Les zones de transition de la plate-forme au bassin forment des zones linéaires de 20 à 40 km de large ou les dolomies silteuses à lits fins sont interstratifiées avec des roches présentant des faciès de bassin et de plate-forme. On connaît des roches présentant un faciès de transition, contemporaines de toutes les unités du bassin, et celles équivalentes aux formations de Franklin Mountain et de Mount Kindle sont en grande partie conservées. L'identification des roches de transition du Cambrien moyen indique qu'ont existé avant leur érosion, des faciès de plate-forme contemporains. On trouve dans les faciès de transition de Franklin Mountain et près de ceux-ci beaucoup de brèches de pente. Ces brèches sont formées de débris de roches provenant des faciès de transition ou de bassin, dans une matrice calcaire; elles se sont formées sur place ou dans des coulées de débris plus ou moins longues le long de la pente.

On interprète le rentrant comme un bassin submergé, limité par des failles, d'après la géométrie, les zones de faciès linéaires et le volcanisme alcalin.

On rencontre plusieurs manifestations stratifiées de baryte dans les formations de Hess River, Duo Lake et Cloudy; on a aussi trouvé de la phosphorite à deux endroits dans la formation de Hess River. Les unités de schistes argileux montrent des anomalies en métaux de base et on recommande ces unités comme objectifs pour l'exploration. Le rentrant ressemble, sous plusieurs aspects, au bassin de Richardson, qui est contemporain. Les relations de faciès et la géométrie du bassin du rentrant peuvent, par conséquent, être utiles pour l'exploration souterraine adjacente au bassin.

# THE LOWER PALEOZOIC MISTY CREEK EMBAYMENT, SELWYN BASIN, YUKON AND NORTHWEST TERRITORIES

## INTRODUCTION

During early Paleozoic time in the northern Canadian Cordillera a broad, shallow water carbonate platform was established across large parts of the Yukon and adjacent Northwest Territories. The platform carbonates changed rapidly to the south and southwest into relatively deeper water shale, limestone and chert (Gabrielse, 1967; Ziegler, 1969; Douglas et al., 1970). The Misty Creek Embayment is a large irregularity in the platform margin defined by platform to basin transition facies belts and shale filled troughs. The nature and origin of this irregularity has important implications for interpretation of the Paleozoic history of the Canadian Cordillera, resource exploration and metallogeny.

This report is the result of a Geological Survey of Canada project initiated in 1977 to study Lower Paleozoic platform to basin transition facies, and expanded to include studies in adjacent basin areas (see Cecile, 1978; Cecile and Norford, 1979).

### Location

The Misty Creek Embayment is located in the northern Mackenzie and Selwyn Mountains, straddling the border between the central Yukon and Northwest Territories (Figs. 1, 2). The nearest communities are Ross River and Mayo in the Yukon, and Norman Wells in the Northwest Territories, all are about 200 km from the embayment centre. The Canol Road gives ground vehicle access to about 50 km south of the embayment centre and at present it is maintained between Ross River and the Northwest Territories border by the Yukon Government.

### Previous work

Early geological studies in areas fringing the Misty Creek Embayment were published by Camsell (1906) who explored the Peel River and its tributaries, Keele (1906) who studied the upper Stewart River region and McConnell (1906) who wrote a perceptive geological account of his exploration of the MacMillan River.

Keele (1910) crossed the southern part of the Misty Creek Embayment during a reconnaissance transect through the Mackenzie Mountains and noted the abrupt east-west transition of Paleozoic strata: "A radically different geological province begins at Mount Sekwi, and limestone, dolomite, sandstones, and conglomerates, etc. of various bright colours, replace the sombre rocks to the westward". Industry and Geological Survey personnel studied a similar route during construction of the Canol pipe line (Hume and Link, 1945; Kindle, 1946). Wheeler (1954) published a geological sketch map and report on the southwestern part of the embayment.

More recently, the Geological Survey of Canada carried out 1:250,000 scale geological mapping of the region [see Aitken and Cook (1974a, b, 1975), Blusson (1971, 1974), Gabrielse, Blusson, and Roddick (1973), and Norris (1975) (refer to Fig. 1 for more information)]. Ziegler (1969) published a 1:1,000,000 scale geological map of the region compiled by Shell Canada Limited geologists.

Reports on the lower Paleozoic stratigraphy of the study area have been published by: Blusson (1971), who introduced extensive stratigraphic divisions and identified the carbonate to shale transition through the Sekwi Mountain map-area; Aitken, Macqueen and Usher (1973), who provided detailed stratigraphic descriptions from the northern Mackenzie Mountains, through transition facies and into the Misty Creek Embayment; and Fritz (1976, 1978, 1979) and Krause and Oldershaw (1979), who described stratigraphic and sedimentological relationships within Lower Cambrian rocks.

Brock (1976) was the first to note a basinal feature in the position of the Misty Creek Embayment. Although it is not described in his text, an unnumbered figure of Brock's on page 10 shows a narrow lower and middle Paleozoic 'shale trough' close to the axial position of the embayment described in this report.

### Acknowledgments

I would like to thank J.D. Aitken who organized logistic support and introduced me to Mackenzie Mountain geology in 1977. D.G. Cook, S.P. Gordey, and D.W. Morrow all contributed to the development of my ideas in the field. D.G. Cook, S.P. Gordey and R.I. Thompson suggested many useful revisions to the manuscript. W.H. Fritz, B.S. Norford and R.S. Tipnis made paleontological identifications which are fundamental to this study. In the field I was ably assisted by C. Black, K. Kingsmith, R. Sandau, and K. Sharman in 1977, R. Gibsun in 1979, and B. Fischer in 1980.

For their discussions and co-operation I thank S.L. Blusson, K.M. Dawson, H. Gabrielse, W.D. Goodfellow, I.R. Jonasson, A.C. Lenz, R. Ludvigsen, B.S. Norford, D.C. Pugh and D.J. Tempelman-Kluit.

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## THE MISTY CREEK EMBAYMENT

The Misty Creek[1] Embayment (Cecile, 1978) is a northwest-trending depositional feature defined by the change from Upper Cambrian-Lower Ordovician, and from Upper Ordovician-Lower Silurian platform carbonate, into correlative transition and deeper water limestone, shale and chert; and by Middle Cambrian and Middle Ordovician basin shale and transition units (Figs. 1, 2). The embayment is best defined by the transition from platform to basin facies because these strata are extensively preserved within and around the embayment. The geometry and configurations of the embayment are well illustrated by isopach maps, paleocurrent patterns (Fig. 7) and cross-sections (Figs. 36, 38, 39). The isopach maps (Fig. 3) illustrate a rapid increase in thickness of all preserved Middle Cambrian to Early Silurian rocks from 300 to 500 m in platform facies to about 1000 m in transition facies, and in excess of 3000 m in at least one basin centre section (9).

[1]Misty Creek is a geographic feature in the southwestern Bonnet Plume Lake map-area (Fig. 1).

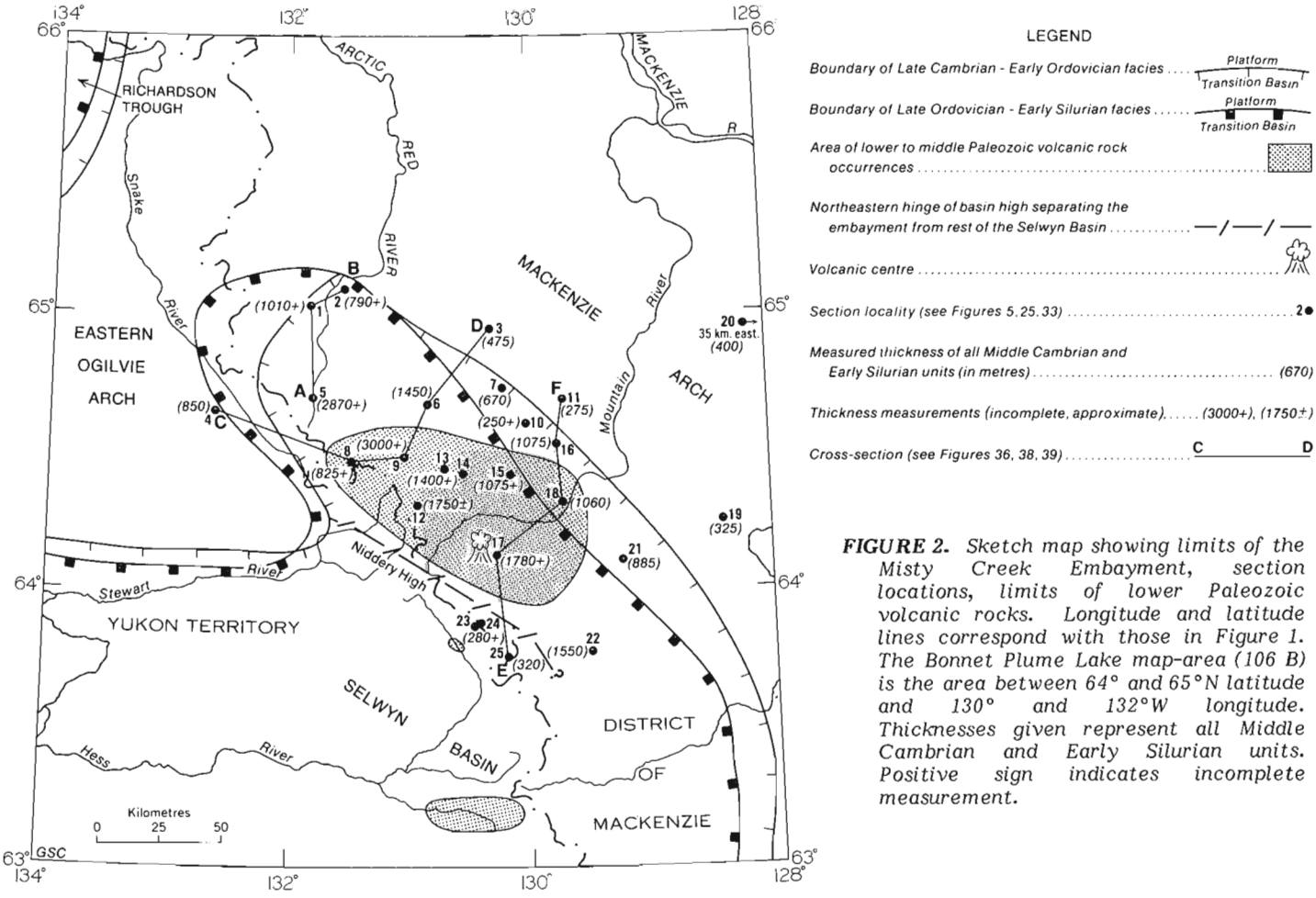



***FIGURE 2.*** *Sketch map showing limits of the Misty Creek Embayment, section locations, limits of lower Paleozoic volcanic rocks. Longitude and latitude lines correspond with those in Figure 1. The Bonnet Plume Lake map-area (106 B) is the area between 64° and 65°N latitude and 130° and 132°W longitude. Thicknesses given represent all Middle Cambrian and Early Silurian units. Positive sign indicates incomplete measurement.*

The Late Cambrian - Early Ordovician position of the embayment is established as follows. The northeast boundary is placed between a belt of mappable transition facies and equivalent platform dolostone of the Franklin Mountain or Broken Skull Formations located only a few kilometres southwest of the flank of the pre-Late Cambrian Mackenzie Arch (see Figs. 1, 42). The northwestern boundary is placed between platform Franklin Mountain Formation mapped across the Snake River (106 F) map-area and time equivalent basin strata to the southeast. The southwestern boundary is placed between a 60 km long belt of lower Paleozoic carbonate (including 530 m of Franklin Mountain Formation at Mount Macdonald) and outcrops of basin strata to the northeast, Nadaleen River map-area (106 C). In the southeastern Nadaleen River map-area the embayment boundary continues southeastward along a basin high (the Niddery High), while the platform to basin transition turns west and forms the northern boundary of the Selwyn Basin. The Niddery High separates the embayment from the Selwyn Basin and is identified by a rapid thinning of the Hess River, Rabbitkettle and Duo Lake Formations (see Section 25 in Appendix I and Fig. 3).

In the Late Ordovician to Early Silurian, the embayment shifted moderately northwesterly and southwesterly (Fig. 2). As with the older rocks the boundary is defined by the juxtaposition of mappable basin or transition facies with time equivalent platform carbonates of the Mount Kindle Formation (Fig. 1).

## Structural setting

Geological studies in the area of the Misty Creek Embayment indicate minimal northeasterly directed shortening, and minor or no northwesterly strike-slip fault dislocations. Palinspastic reconstruction would effect very little change in our concept of the embayment geometry and, therefore, has not been attempted.

In the embayment area Late Mesozoic - Tertiary compression produced typical Mackenzie Mountain structures dominated by open folds and zones of complex folding and thrusting (Douglas et al., 1970, p. 367). The most prominent compressional feature, with the largest probable dislocation, is the Plateau Fault (Gabrielse, Blusson and Roddick, 1973). This fault has been traced as either a single structure or zone of faults for several hundred kilometres. Aitken and Cook (1974a) mapped the northwesterly continuation of the Plateau Fault along the entire northeastern edge of the Misty Creek Embayment. However, Aitken, Cook and Yorath (in press) make the following observations ". . .at the stratigraphic level of the Franklin Mountain Formation contrasting facies are not clearly juxtaposed across the fault. Instead, the transitional facies between Franklin Mountain and Road River Formations crosses Plateau Fault obliquely in the southwestern part of the Upper Ramparts River map-area". This map-area includes the north-northeastern part of the Misty Creek Embayment.

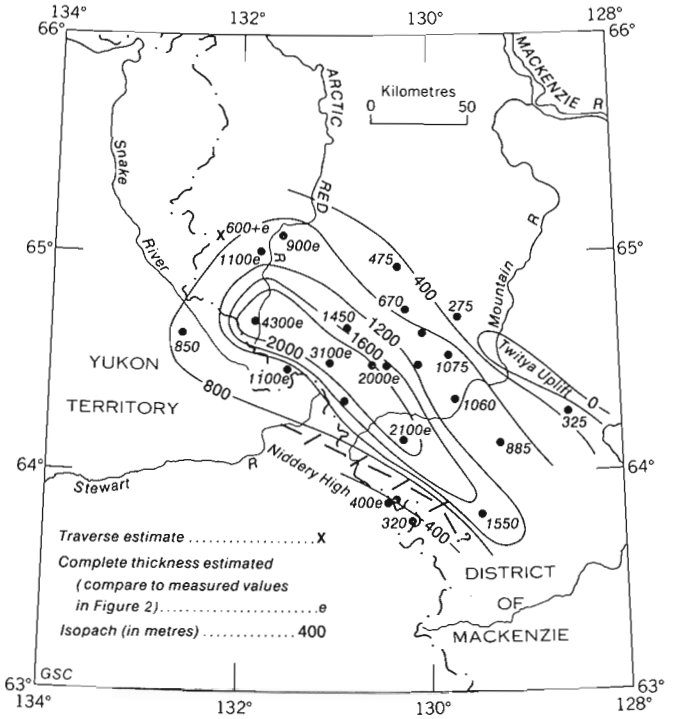



***FIGURE 3.*** *Total thickness map shows the distribution of all platform, transition and basin facies strata of Middle Cambrian to Early Silurian age. For the total thickness map parts of Sections 1, 2, 5, 8, 9, 13, 14, 17 and 25 are estimated. At these sections, if a formation is incompletely measured, a total thickness is assigned on the basis that all units tend to thicken or thin proportionately. The size of the estimates are minimal and can be compared to actual measured values shown in Figure 2. The X represents a visual thickness estimate. The zero contour around the Twitya Uplift is due to post-Early Silurian erosion [see Cook and Aitken (1978)].*

Norris (1974b, 1977) traces an array of ". . .nearly vertical north-trending, right-lateral, strike-slip faults extending from the Arctic Archipelago through the basin [the Cretaceous-Tertiary Bonnet Plume basin] to the Mackenzie and Selwyn Fold Belts". This fault array is linked to the Misty Creek Embayment through a system of arcuate strands and ". . .individual strands change into major high angle reverse faults" (Norris, 1977, p. 12). Lower Paleozoic facies belts trending obliquely across the northwestern embayment show no lateral offsets. Facies belts on the northwest are not completely preserved and one lineament along the Snake River Valley trends, through an erosional gap, into Norris's (1977) Knorr fault. To the southeast this lineament runs directly into the nose of an intact syncline outlined by Paleozoic rocks and, therefore, cannot be a major post-Early Paleozoic strike-slip fault. In addition, major strike-slip movements dislocating lower Paleozoic strata are further negated by structural features of the Selwyn Anticlinorium (Fig. 1). This anticlinorium includes southwest swinging to east-west, fold trends that transect the entire southeastern embayment, without any significant discontinuity of rock units or facies, on northwest trending faults. Norris (1977, and pers. comm., 1979) stresses that most fault movement on the Richardson Array occurred during the Proterozoic and agrees that there is no evidence for large post-Early Paleozoic strike-slip movements.

## STRATIGRAPHY

### Introduction

In the area of the Misty Creek Embayment lower Paleozoic strata are laterally divided into platform, transition and basin facies (Figs. 1, 4). Platform facies rocks are interpreted as shallow water carbonates, although most of these rocks are now thickly bedded, fine- to medium-crystalline, massive, dolostone. The chance preservation of ooid grainstone, mudcracks, birdseye texture, bioturbation, and in the Mount Kindle Formation, coral dominated biostromes, are all evidence of shallow water deposition. Basin facies rocks include graptolitic black shale, chert, monotonous successions of thin bedded limestone and limestone-shale rhythmites. Limestone beds are often graded, may show a partial Bouma sequence (ripple cross-laminated bases to micritic tops), are slump folded, or form thick massive slump breccias. On the basis of these features the limestones are interpreted as deep water strata deposited below the level of strong wave influence. The euxinic nature, preservation of graptolites and radiolarians, and monotonous nature of the shales and cherts indicate relatively deep anoxic conditions of deposition.

Platform facies units, which surround the embayment on the west, north and east, are the Franklin Mountain and overlying Mount Kindle Formations. In the southeastern embayment platform facies in ascending order are the Broken Skull Formation, correlative of the Franklin Mountain Formation, and the Whittaker Formation which is correlative with the Mount Kindle Formation (see Blusson, 1971; Gabrielse et al., 1973).

Along the edges of the embayment platform facies units are separated from equivalent basin facies by a 20-40 km wide belt of intertongued basin and platform strata, and successions of thinly bedded silty dolostone, or massive limestone. These silty dolostones are a lithology which in the embayment area occurs only in transition zones and these dolostone successions are designated as Franklin Mountain or Mount Kindle transition facies. In the southeastern embayment area the Rockslide Formation and Sunblood Formation are here considered to be middle Cambrian and Middle Ordovician transition units (see Blusson, 1971; Gabrielse et al., 1973).

Basin facies rocks are divided into six formations, four of which are new (Figs. 4, 5, 6). At the base is the predominantly Middle Cambrian Hess River Formation (new). The Hess River is overlain in ascending order by the Rabbitkettle Formation (extended from the southern Mackenzie Mountains), the Duo Lake Formation (new), the Cloudy Formation (new) and the Natla? Formation in the southern embayment. A sixth, geographically restricted unit, is a succession of basaltic volcanic rocks, the Marmot Formation (new). The Marmot Formation is intertongued with a number of stratigraphic units, but predominantly occurs with the Duo Lake Formation (Fig. 4). In the southern embayment an unnamed succession of middle Paleozoic thick-bedded limestones unconformably overlies the Duo Lake Formation. In the western embayment area a small unit of Middle Ordovician limestone overlies the Duo Lake Formation, in a transition facies (Fig. 4).

The Franklin Mountain Formation is generally correlative with the Franklin Mountain transition facies and the Rabbitkettle Formation in the basin. The Mount Kindle Formation is generally correlative with the Mount Kindle transition facies and the Cloudy Formation in the basin. Hess River and Duo Lake Formations are correlative with some transition units and erosional gaps between platform carbonates located around the northwestern embayment area. However, in the southeastern embayment the Hess River Formation is equivalent to the Rockslide Formation, and the Duo Lake Formation to the Sunblood Formation (see Blusson, 1971; Gabrielse et al., 1973).

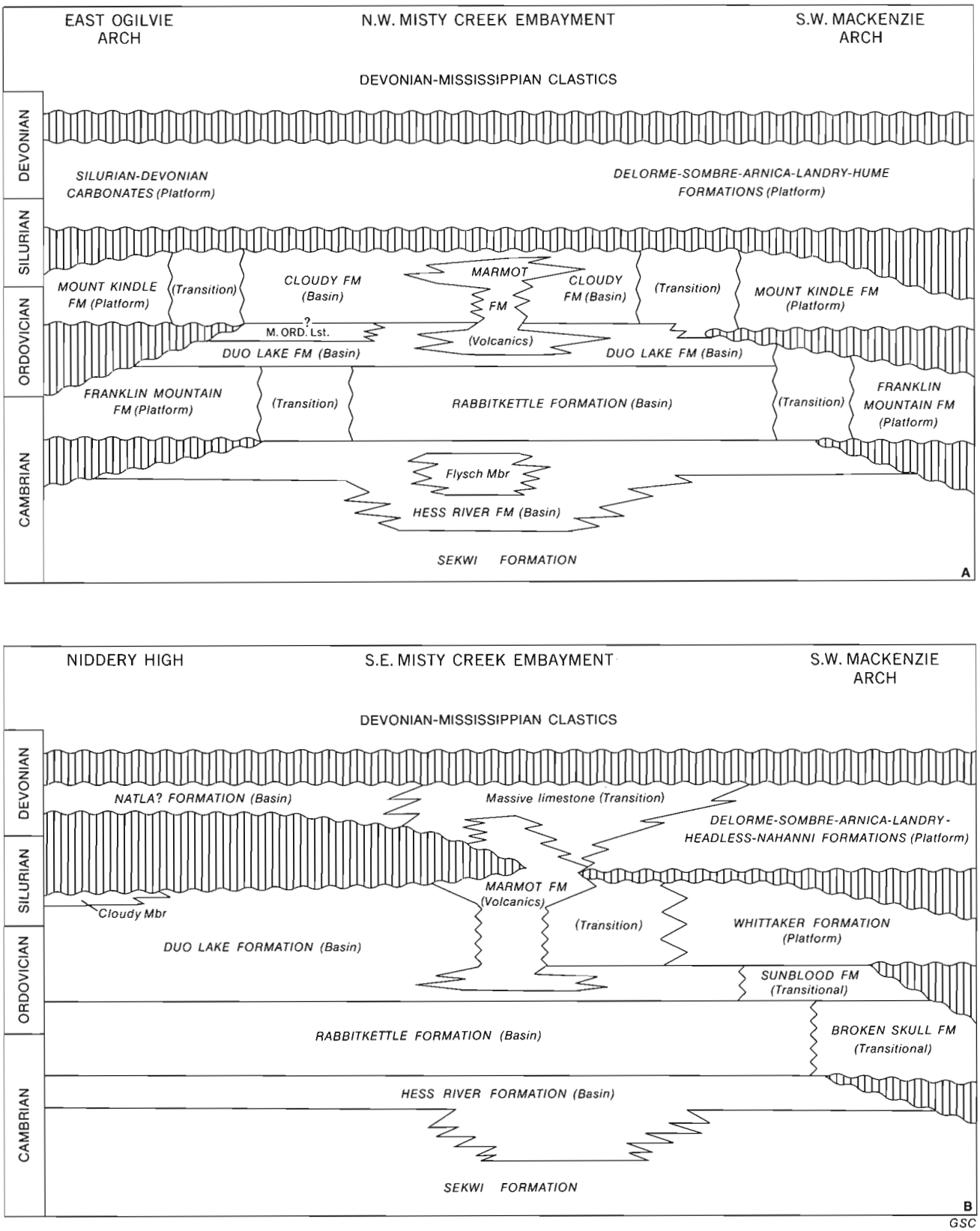



***FIGURE 4.*** *Schematic cross-sections showing the relationships between stratigraphic units across the Misty Creek Embayment.*

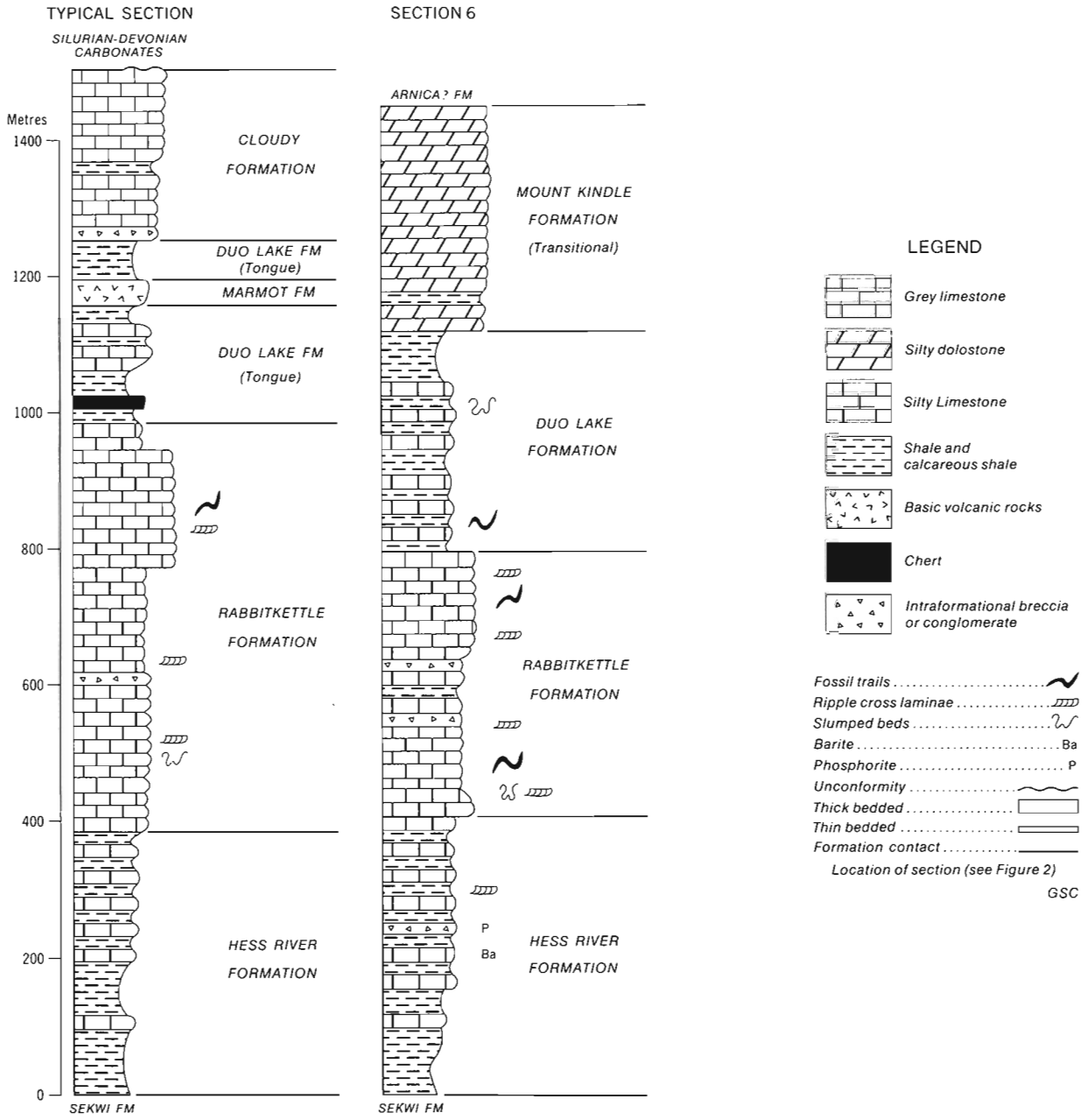



***FIGURE 5.*** *Illustration of a typical basin facies section, central and northern embayment, and Section 6. Section 6 is the type section for the Hess River and Duo Lake Formations, and a reference location for the Rabbitkettle Formation. The upper part of Section 6 was measured to 1200 m and completed with data from D.W. Morrow in an adjacent section 2 km to the southeast.*

## Platform facies

### *Franklin Mountain Formation*

The Franklin Mountain Formation was first described by M.Y. Williams (1922, 1923) with the type section located on Mount Kindle about 300 km east of the Misty Creek Embayment. The type section was redescribed by Norford and Macqueen (1975), who divided the formation into basal cyclic, middle rhythmic and upper cherty dolostone units. Aitken, Macqueen and Usher (1973), Aitken and Cook (1974a), and Norris (1975) introduced use of the term Franklin Mountain Formation to areas bordering the embayment.

The Franklin Mountain Formation is found on the east, north and west sides of the embayment where it unconformably overlies Lower Cambrian to Proterozoic strata on the axis and flanks of the Mackenzie and east Ogilvie Archs, and on a platform area that connected the two archs northwest of the embayment (Fig. 1). Sub-Franklin Mountain Formation erosion increases from the northeast flank of the north Misty Creek Embayment, where Franklin Mountain dolostone overlies Lower Cambrian strata, to the axis of the Mackenzie Arch where dolostone overlies middle Proterozoic strata (Aitken et al., 1973).

Around the embayment the Franklin Mountain Formation varies from 0 to 530 m thick (Fig. 7). Thicknesses are reduced by sub-Mount Kindle erosion, and locally by post-Early Silurian erosion in the area of the Twitya Uplift, where, over a small area, the Franklin Mountain Formation was completely eroded before deposition of Siluro-Devonian

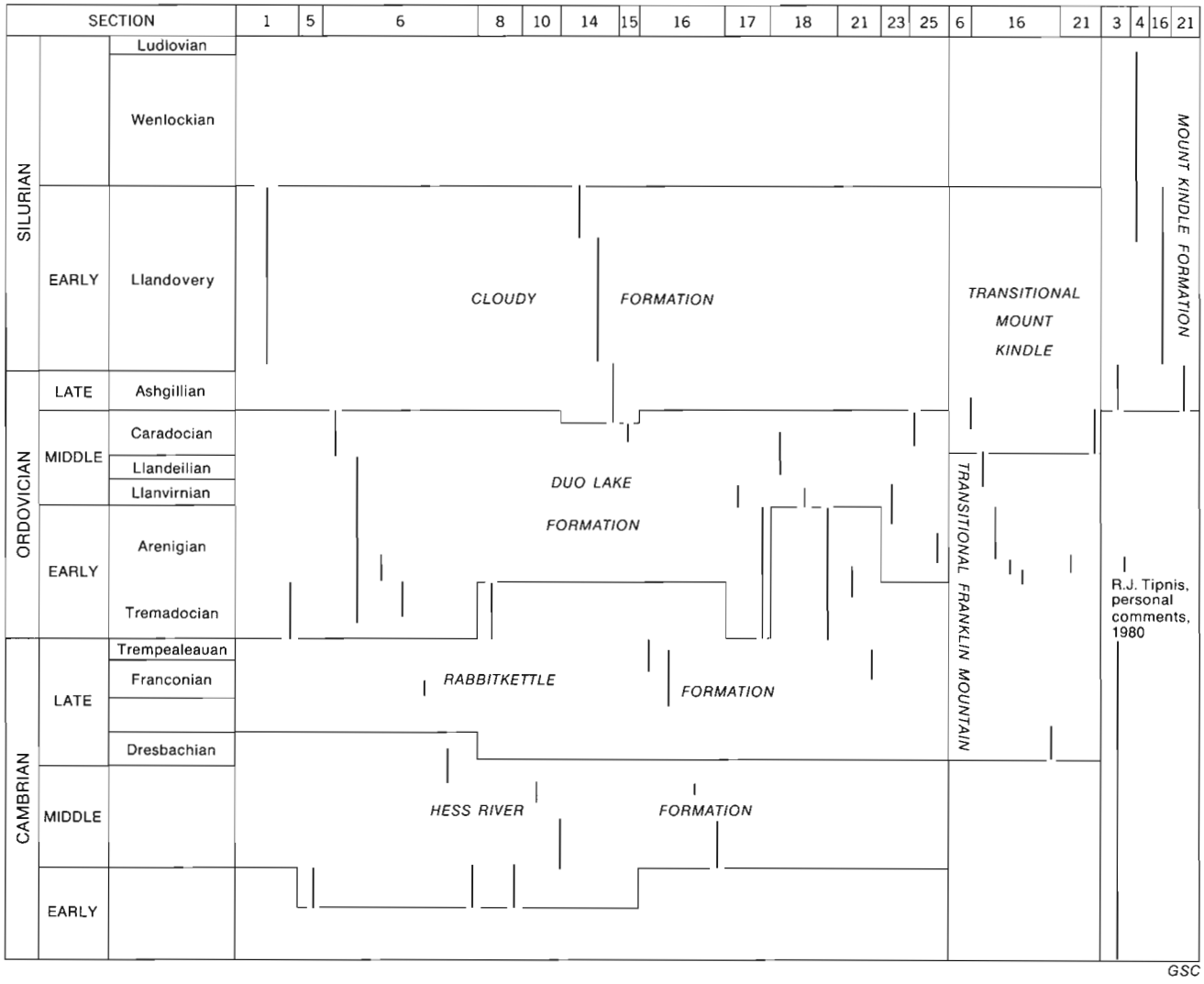



***FIGURE 6.*** *Chart illustrating paleontological control on age of measured units of the Misty Creek Embayment. Data from Fritz, Norford and Tipnis, Appendix II. Numbers refer to sections and bars represent range of one fossil collection.*

carbonates (Cook and Aitken, 1978). The thickest Franklin Mountain Formation was measured at Section 4 (Appendix I) within a belt of undifferentiated Ordovician to Devonian carbonates mapped by Blusson (1974; see Fig. 1).

Around the embayment, the Franklin Mountain Formation consists of a monotonous succession of light grey weathering, vuggy, thick-bedded, fine to coarse crystalline dolostone. On the northeast flank of the Mackenzie Arch (Section 20) it can be divided into cyclic, rhythmic and cherty dolostone units comparable to those recognized at the type section. Along a 70-80 km wide belt centered along the axis of the Mackenzie Arch, there is a discontinuous basal member up to 325 m thick consisting of white, pink and mauve, well sorted, clean, fine to medium grained quartz sandstone with silica and carbonate cement, red and green shale and siltstone, arenaceous yellow dolostone, and dolostone (Section 19). This basal unit has abundant ripple marks, desiccation cracks, mud chips, bioturbation, fossil trails, and rare 10-20 cm thick planar crossbeds; Aitken et al. (1973) have also reported rare salt casts. This basal unit weathers to a distinctive red colour and is described by Aitken et al. (1973) and Aitken and Cook (1974a) as the "basal Franklin Mountain red-beds".

*Age and correlation*

Fauna in the Franklin Mountain Formation around the embayment are rare, and are mainly scattered occurrences of small digitate stromatolite mounds (Fig. 8). R.S. Tipnis (pers. comm., 1980) has identified Cambrian conodonts near the base, and Early Ordovician conodonts near the top, of the Franklin Mountain Formation at Section 3. Silty dolostones of the Franklin Mountain transition facies fringing the embayment contain brachiopods, echinoderm debris, and trilobites and range in age from Late Cambrian, Dresbachian to as young as Middle Ordovician, Llanvirnian or Llandeilian (Fig. 6, and Fritz, Norford and Tipnis, Appendix II). From study over large parts of the District of Mackenzie Norford and Macqueen (1975) have identified stromatolites and scattered occurrences of brachiopods, gastropods, straight cephalopods, echinoderm debris and rare graptolite, and they date the formation as Late Cambrian, Dresbachian to Early Ordovician or younger. Aitken et al. (1973) assign the Franklin Mountain red beds along the Mackenzie Arch to a probable Late Cambrian age.

North and east of the Misty Creek Embayment and the Mackenzie Arch the Franklin Mountain Formation is present

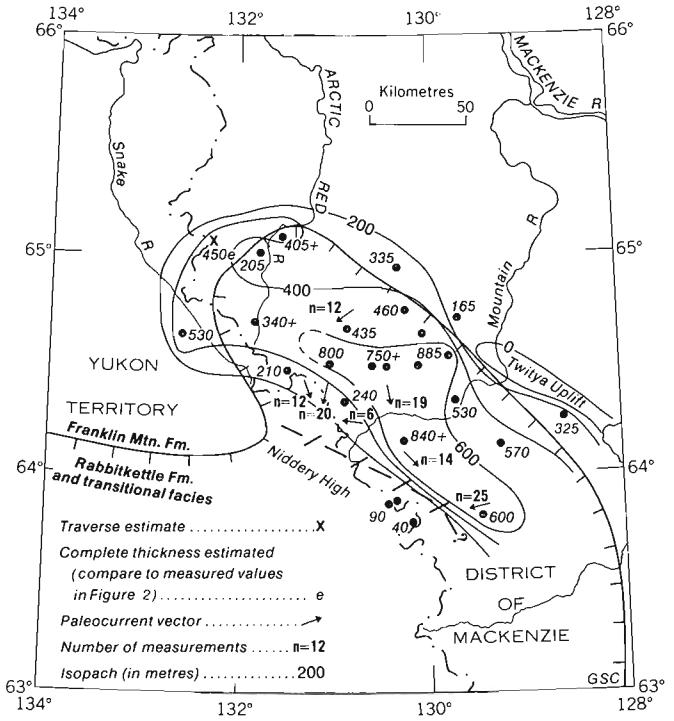



***FIGURE 7.*** *Combined isopach and paleocurrent map for Rabbitkettle and Franklin Mountain Formations. The X represents a visual estimate.*

***FIGURE 8.*** *Stromatolite bioherm consisting of a radiating mass of small discontinuous columns, rhythmic member, Franklin Mountain Formation, Section 20 at Dodo Canyon (map-area 96 D; GSC 199535).*

at surface and within the subsurface over a large part of the Franklin Mountains and the frontal Mackenzie Mountains, and the Northern Interior Plains, including the Eagle Plain (Pugh, in prep.). Norford and Macqueen (1975) estimate 310 m (1017 ft) total thickness at the type section; in the subsurface of the Northern Interior Plains, Gilbert (1973) reports a range of 172 m (565 ft) to 671 m (220 ft). In this region, the Franklin Mountain Formation conformably overlies the Upper Cambrian Saline River and is unconformably overlain by the Late Ordovician to Early Silurian Mount Kindle Formation, a regionally persistent relationship with generally minimal erosion (Norford and Macqueen, 1975; Aitken and Cook, 1974b).

In the southern Mackenzie Mountains, south of 64° Latitude, the Franklin Mountain Formation is correlative with the Broken Skull Formation of Gabrielse et al. (1973) which is described in the type area as about 2700 ft (890 m) of dominantly thick-bedded dolostone and limestone of Late Cambrian to Early Ordovician age.

### *Mount Kindle Formation*

The Mount Kindle Formation was first described by M.Y. Williams (1922, 1923), with the type section located on Mount Kindle about 300 km east of the embayment. Norford and Macqueen (1975) redescribed the type section and divided the Mount Kindle into three informal dolostone units: a basal recessive member, a resistant biostromal member, and an upper sparsely fossiliferous member. The use of the term Mount Kindle Formation was introduced to platform facies around the Misty Creek Embayment by Aitken and Cook (1974a, 1974b, 1975); Blusson (1974); Norris (1975).

The Mount Kindle Formation bounds the embayment on the east, north and west, including the Nadaleen River map-area where it was mapped separately or included in Ordovician to Devonian carbonates by Blusson (1974; Fig. 1). The position of the Mount Kindle Formation around the embayment shows a significant westerly shift in facies (see Fig. 2). It is comprised of up to 570 m (Fig. 9) of thick bedded massive dark grey dolostone and minor limestone that are often vuggy, medium to coarse crystalline, locally silicified, and can contain minor chert nodules and beds. The three-fold division of Norford and Macqueen (1975) was not recognized in Mount Kindle strata surrounding the embayment.

In the embayment area and regionally, the Mount Kindle strata unconformably overlie the Franklin Mountain Formation (Fig. 10) and are unconformably overlain by the Siluro-Devonian carbonates. In transition belts, Mount Kindle transition facies dolostone overlies the Duo Lake Formation, and a tongue of the Mount Kindle overlies part of the lower Cloudy Formation (Sections 6 and 15, Appendix I). The Mount Kindle Formation was completely removed by post Early Silurian erosion along the Twitya Uplift (Cook and Aitken, 1978; Fig. 9).

The Mount Kindle Formation locally contains an unconformity within basal strata (e.g. Section 21, Appendix I).

#### *Age and correlation*

Corals, brachiopods, cephalopods, bryozoans, and stromatoporoids, locally forming biostromes, occur throughout Section 3 and at the top of Section 18, but are

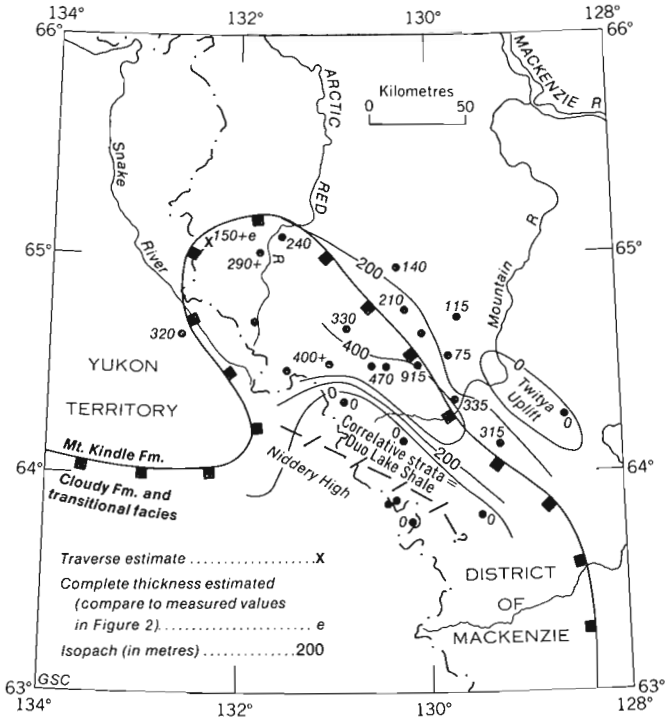



***FIGURE 9.*** *Combined isopach map for the Cloudy and Mount Kindle Formations. The X represents a visual estimate.*

sparse or missing in other sections. These fauna range in age from Late Ordovician to Early Silurian or younger (Fritz, Norford and Tipnis, Appendix II, Fig. 6). Norford and Macqueen (1975) find that regionally all macrofauna in the Mount Kindle Formation range in age from Late Ordovician to Early Silurian.

North and east of the embayment and the Mackenzie Arch, outcrops of the Mount Kindle Formation are widespread in the northern Franklin Mountains, frontal Mackenzie Mountains, near Great Slave Lake, in the Hare Indian River - Smith arm area, and as erosional remnants in the Simpson Lake and Brock River map-areas (see Norford and Macqueen, 1975, p. 12). The formation also occurs extensively in the subsurface of the Northern Interior Plains (Mackenzie, 1974; Meijer Drees, 1975; Williams, 1974; Gilbert, 1973).

The thickness and distribution of the Mount Kindle Formation, in these areas was substantially altered by sub-Devonian and sub-Cretaceous erosion (Norford and Macqueen, 1975). These authors estimate the total thickness of the type Mount Kindle as 273 m; give the maximum outcrop thickness as 455 m, and state that it is thinnest in the Northern Interior Plain.

In the southern Mackenzie Mountains, the Mount Kindle is correlative with the Whittaker Formation, which Gabrielse et al. (1973, p. 59) describe as "...well-bedded, commonly chert, dark grey weathering dolomite and light grey weathering dolomite and limestone". In the Ogilvie Mountains west of the embayment, the Mount Kindle Formation is correlative with most of Unit 8, a dolostone-limestone unit mapped by Green (1972) along the Ogilvie Arch to the Alaska border.

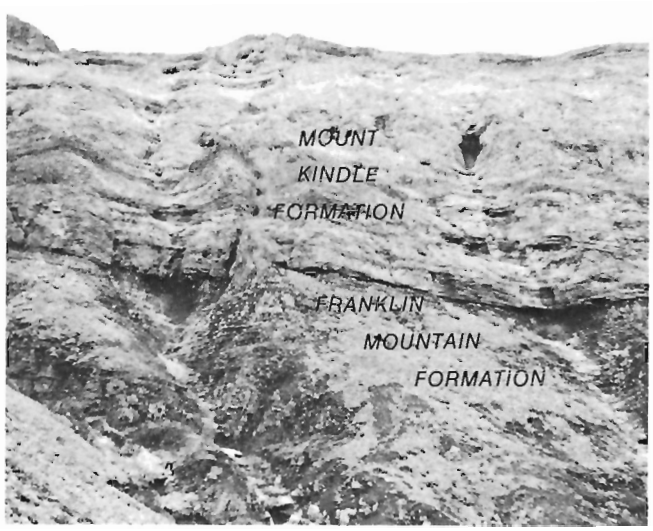



***FIGURE 10.*** *Mount Kindle Formation resting paraconformably on a unit of massive Franklin Mountain dolostone, in a transitional succession, Section 2. Contact is the marked break in the lower-middle of the photograph (GSC 199537).*

## Basin facies

### *Hess River Formation (new)*[1]

The type section (Section 6) is at 62°42', 130°47', 2 km southwest of Goober Lake[2] in the Bonnet Plume Lake map-area (Figs. 11, 12).

At its type section, the Hess River Formation consists of 60 m of moderately well exposed black shale overlain by 360 m of interstratified calcareous shale and argillaceous limestone containing minor barite and phosphorite (Fig. 5).

The Hess River Formation is recognized everywhere in the embayment, and on the Niddery High (Fig. 13, Sections 24 and 25). Within the embayment, thicknesses vary from 100 m near the margin to between 1270+ and 2530 m in central basin locations (Fig. 13). The 2530 m thickness includes 1580 m of quartz sandstone-shale flysch (Hess River flysch).

Throughout the embayment the Hess River Formation is a recessive black to buff weathering unit. The two-fold division into a lower shale and upper limestone-shale unit is recognized in many but not all sections (see Appendix I). Shales are black, fissile and shale successions consist of interstratified calcareous and siliceous shale units. Limestone-shale units consist of monotonous successions of thin silty limestone beds and thin calcareous shale intervals in ratios of 30/70 to 50/50 limestone over shale. At Section 1 thin dolostone beds alternate with shale in what is probably a transitional-to-platform facies.

In most areas within the embayment, the Hess River Formation is conformable with over- and underlying strata. The lower boundary is defined by an abrupt, easily recognized upward change from orange-yellow weathering limestone, dolostone, or sandstone of the Sekwi Formation into dark, recessive shale, or interstratified shale and silty limestone or dolostone. The upper boundary is gradational and placed at the base of the first very thick succession (>10 m) of thin

[1] The Hess River is a geographic name for a major river in the southern embayment area (Fig. 1).

[2] Goober Lake is an informal name for a small lake at 64°44', 130°45'. The name is used by sheep hunters in the area and is recognized by mining personnel who have worked in the area.

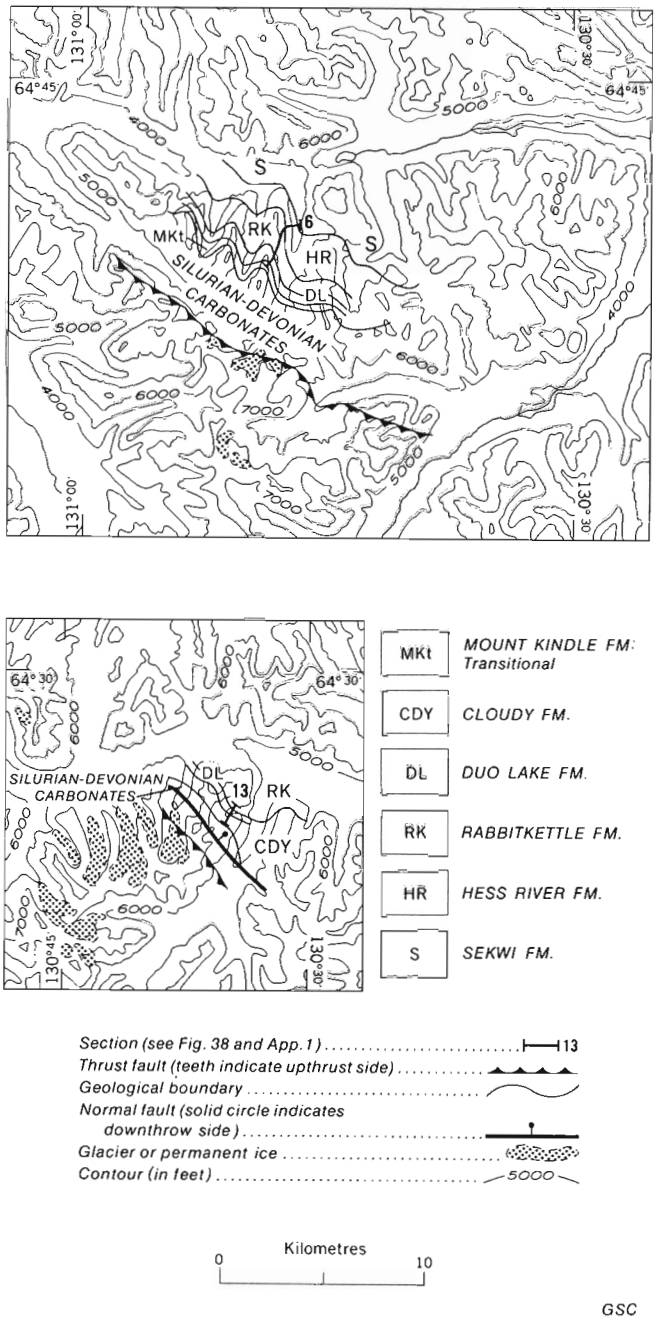



***FIGURE 11.*** *Enlarged topographic maps locating the type sections for the Hess River, Duo Lake (Section 6) and Cloudy (Section 13) Formations. Section 6 is also a reference location for the Rabbitkettle Formation.*

bedded limestone or silty limestone above which shale is a subordinate lithology within the Rabbitkettle Formation. Towards the edges of the embayment, it is probable that some Hess River Formation has been removed during sub-Franklin Mountain erosion, and here the upper contact would be a disconformity between tongues of Franklin Mountain Formation or transitional Franklin Mountain dolostone (Fig. 4). On the Mackenzie and eastern Ogilvie arches the Hess River Formation is not present below Franklin Mountain Formation, and is equivalent to a period of non-deposition or to strata removed by pre-Late Cambrian erosion in platform areas around the embayment (Fig. 4).

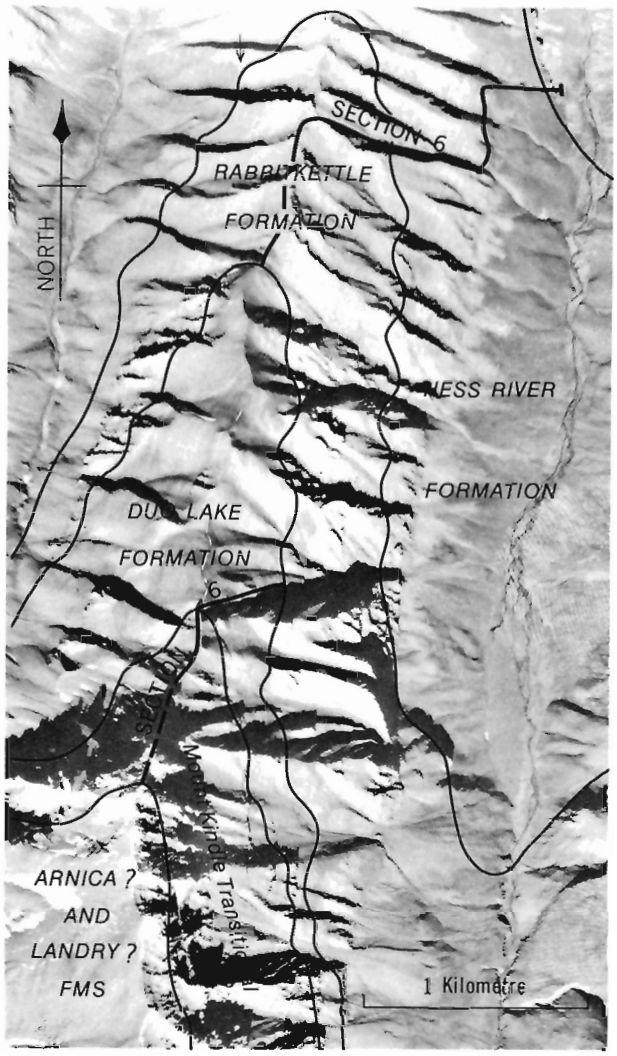



***FIGURE 12.*** *Aerial photograph showing the location of, and geology around the type Section 6 of the Hess River and Duo Lake Formations and reference Section 6 for the Rabbitkettle Formation. Trans. OSK = transitional Mount Kindle. Photography is a part of the N.A.P.L. air photo #A12248-259.*

In the Selwyn Basin 30-40 km southwest of Section 25, the Hess River Formation conformably overlies a Lower Cambrian argillite similar to the 'Buff Shale' unit of Gordey (1980) which is interpreted as a basin equivalent to the Sekwi Formation.

*Age and correlation*

Fauna in the Hess River Formation are sporadically preserved and consist of complete or segmented trilobites and trilobite debris, inarticulate phosphatic brachiopods, sponge spicules, and **Hyolithes.** Fossils collected at Sections 1, 5, 6, 8, 10, 16 (Fritz et al., Appendix II, see also Aitken et al., 1973) range in age from latest Early Cambrian to latest Middle Cambrian. Paleontological data (Fig. 6; Fritz et al., Appendix II) indicate the lower boundary is oldest (latest Early Cambrian) along the axis of the embayment and youngest near the margins (early Middle Cambrian), supporting Fritz's (1976) earlier suggestion that the top of the underlying Sekwi Formation in this area is diachronous.

Northeast of the Mackenzie Arch the Mount Cap Formation, a latest Early Cambrian - Middle Cambrian succession of "glauconitic sandstones, dark grey to black shales, pyritic; thin-bedded micritic limestone" (Aitken et al., 1973, p. 6), is time equivalent to the Hess River Formation. The Hess River Formation probably extends south across the Sekwi Mountain map-area, Unit 15 of Blusson (1971), but continuing south into the west-central Nahanni (105 I) map-area it is missing beneath a sub-Rabbitkettle unconformity (Gordey, 1978, 1979). South of 63°30', in the southern Mackenzie Mountains, the Hess River is equivalent to the Rockslide Formation of Gabrielse et al. (1973).

### *Hess River flysch*

At Section 5, near the northwest margin of the embayment, the Hess River Formation consists of two thick shale-argillaceous limestone units separated by a prominent unit comprising 1580 m of quartz sandstone - shale flysch (Fig. 14).

Sandstones of the Hess River flysch are either pure quartz, or are quartz dominated (80-95%) with the remaining framework grains being dolostone, limestone, siltstone or shale. Sedimentary clasts are abundant in coarser fractions, often as pebbles. Some dolomite clasts contain trilobite fragments and therefore are derived from older Cambrian strata. The flysch consists of a monotonous succession of mainly thin- to medium-thick massive sandstone beds alternating with thin- to medium-thick intervals of shale and/or siltstone. Individual beds are laterally continuous for over 100 m. Sedimentary structures are rare and generally consist of small ripple-cross laminae in sandstones or siltstones and small festoon crossbeds and one example of planar crossbedding. Small black shale intraclasts are frequently found in the sandstones. On fresh surfaces the sandstones are grey and the shales black. Sandstones generally contain very little matrix. Paleocurrents, determined by small-scale cross-laminations, were to the southeast (Section 5, Fig. 13).

Sandstone in the same stratigraphic position as the flysch is reported by Fritz (1976) from the locations 10 to 20 km southwest and northwest of this section. However, the flysch has a restricted lateral distribution because it is completely missing at Sections 8, 9, and 12 measured 30 to 40 km south and southeast of Section 5.

Bed continuity, colour and rhythmic character of the flysch suggest a relatively deep water site of deposition (below zone of wave influence). However, the low matrix content of the sandstones and lack of recognizable Bouma sequences suggests a non-turbiditic origin. A more plausible origin is that the sandstones represent a submarine fan periodically fed sediment by rivers flowing into the northwestern embayment. Sands would move onto the fan during periods of high sediment supply or storms by a grain-flow mechanism, shales would precipitate later from suspension. This model is supported by the lateral discontinuity of the flysch, its location at the northwest end of the embayment, adjacent to land areas (sub-Franklin Mountain erosion), and southeast directed paleocurrents, indicating a northwest source.

### *Rabbitkettle Formation*

Rabbitkettle Formation was introduced by Gabrielse et al. (1973) to describe a Late Cambrian to Early Ordovician succession of thin bedded silty limestone. The type area for this unit is the headwaters of the Rabbitkettle River, southern Selwyn Mountains. A good reference section for the Rabbitkettle, in the Misty Creek Embayment, is at Section 6, 2 km south of Goober Lake (64°27' and 130°52', Figs. 11, 12), where it consists of 437 m of resistant, yellow weathering, thin bedded silty limestone, limestone, minor carbonate breccia, shale and dolostone (Figs. 5, 15, 16).

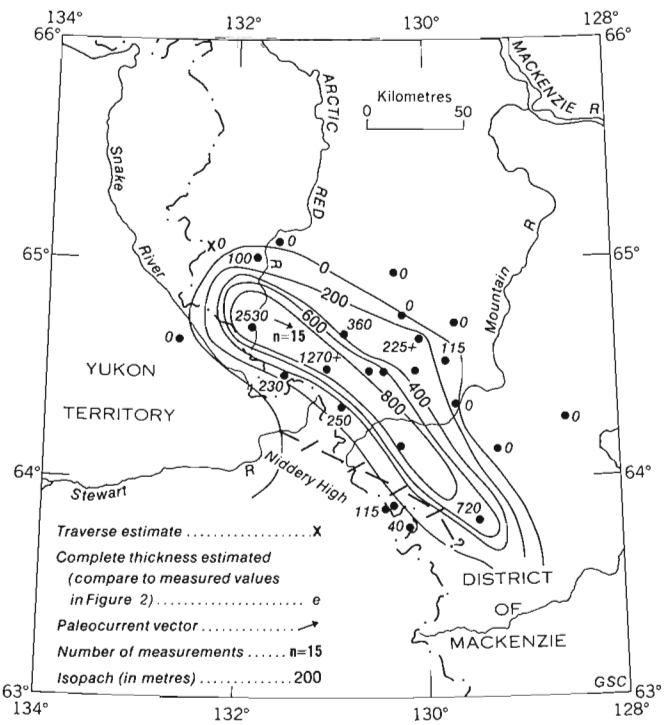



***FIGURE 13.*** *Isopach map of the Hess River Formation. The X is a visual determination.*

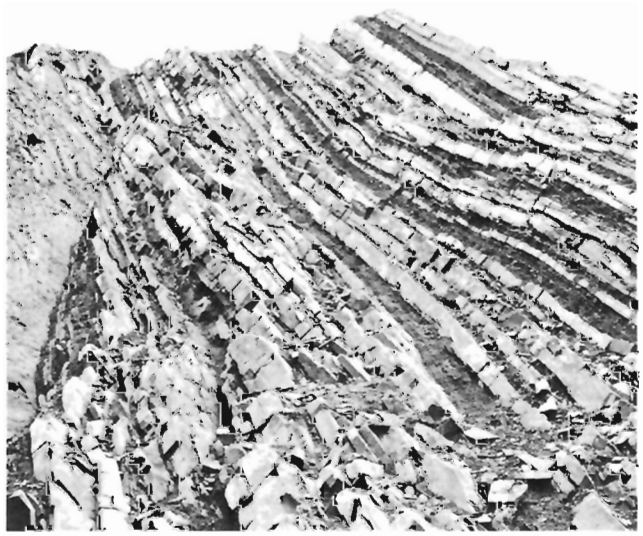


***FIGURE 14.*** *Hess River Flysch. Resistant light grey quartzite beds are 10 to 40 cm thick and alternate with recessive beds of rusty black shale and grey siltstone. Total thickness of the succession in photograph is 8 to 10 m (GSC 199526).*

The Rabbitkettle Formation is present throughout most of the embayment, ranging in thickness from 65 to more than 750 m (Fig. 7). The formation is thickest in the southeast near Section 16 and thinnest on the Niddery High between the Selwyn Basin and the embayment.

The Rabbitkettle Formation, in the embayment is comprised of a resistent, thick, monotonous succession of thin bedded yellow and grey weathering silty limestone. Fossil tracks, ripple cross-laminae, nodules and graded bedding are common sedimentary structures (Fig. 17). The fossil tracks are curved, superimposed, narrow (0.25-0.5 cm wide) tracks preserved on bedding plane surfaces and resemble foraging tracks described by Seilacher (1967). The basal contact with the Hess River Formation is gradational and the upper contact is also gradational and defined at the top of the last thick (>10 m) succession of thin bedded limestones above which calcareous shales of the younger Duo Lake Formation are the major lithology.

Rabbitkettle Formation exposures in the embayment are often on steep erosionally active slopes. Overlying and underlying units all have platy limestones that as loose talus blocks tend to lie parallel to scree slopes and give a false impression of limestone abundance. This combination obscures the distinction between Rabbitkettle and associated units, when viewed at a distance, thus successful mapping will require good ground traverse control.

In the northwestern embayment, the upper Rabbitkettle Formation boundary is diachronous. Here the upper Rabbitkettle limestones are replaced by time equivalent shales of the lower Duo Lake Formation (Fig. 6).

At Sections 23 to 25, on the Niddery High, Rabbitkettle strata are atypically thick bedded and less lenticular or nodular. These strata form a prominent yellow weathering unit with very abundant fossil trails and pyrite nodules. Rabbitkettle strata on the Niddery High are interstratified with up to 30 per cent calcareous shale in thin intervals whereas, in the embayment succession, they consist almost entirely of limestone.

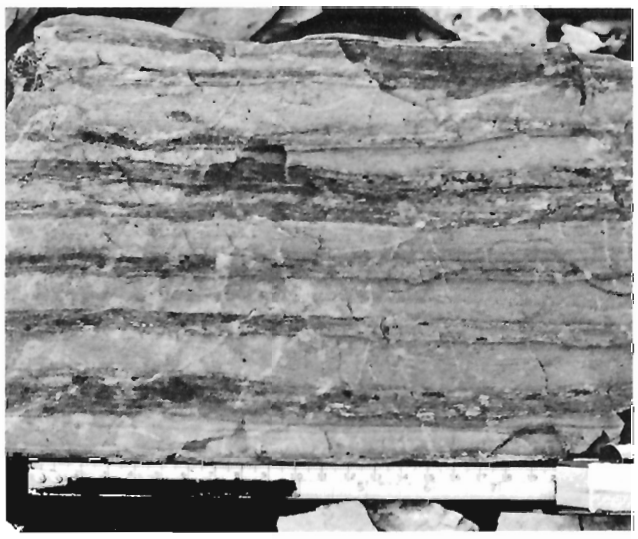


***FIGURE 15.*** *Thin bedded limestone, Rabbitkettle Formation. Darker beds are yellow weathering and silty. Thicker recessive beds are grey weathering and sparry. Upper part scale in centimetres (GSC 199521).*

***FIGURE 16.*** *Thin bedded limestone and very thin beds of calcareous shale, Rabbitkettle Formation. Note graded beds (GSC 199523).*

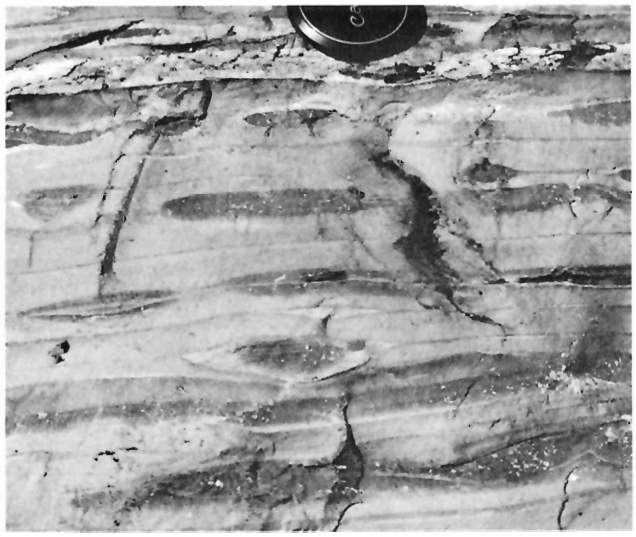


***FIGURE 17.*** *Lensoid and nodular Rabbitkettle limestone. Lenses and nodules are grey weathering calcisiltite surrounded by yellow weathering calcilutite. Nodules form by recrystallization around nuclei of ripple cross-laminated lenses (GSC 199519).*

Abundant slope breccias, conglomerates and slump folds at Section 6 indicate an increased depositional slope during deposition of the Rabbitkettle Formation just basinwards of the Franklin Mountain transition zone. Slope features are found in all basin and transition strata, but represent about 5 per cent of the rocks at Section 6, and are also notably abundant in Section 1 of the Franklin Mountain transition zone.

Slope breccia, composed of angular clasts, and conglomerate, composed of rounded clasts, both consist of calcilutite clasts within a silty spar 'cement'. Clasts and cement resemble the lithologies of interstratified *in situ*

sedimentary rocks. The breccia and conglomerate likely formed syndepositionally from variably lithified sediment which slumped and moved various distances down a submarine slope. The spar 'cement' may have been a lime mud which formed a matrix and flow medium for already cemented calcilutite. The 'cement' subsequently recrystallized during diagenesis. All stages of disaggregation from simple slump folds (Fig. 18), to slump disaggregation from slippage at the base of thick sequences of rock (Fig. 19) to mechanically mixed and transported breccias and conglomerates (Figs. 20, 21) have been observed. These breccias are very similar to slope debris flows described by Cook and Taylor (1977), in Late Cambrian-Early Ordovician strata in Nevada.

*Age and correlation*

Fauna in the Rabbitkettle Formation are sporadically preserved, and most abundant in tongues of Rabbitkettle Formation interstratified with transition facies. Typical fauna are trilobites as bioclastic debris or as complete and segmented specimens, small inarticulate phosphatic brachiopods, graptolites and some crinoid ossicles. In the embayment the formation ranges from the Late Cambrian to Early Ordovician (Fig. 6, Fritz et al., Appendix II) and is correlative with the Franklin Mountain Formation.

Outcrops of Rabbitkettle Formation examined in the Nahanni map-area 40 km northwest of the type area, are comparable in lithology, colour, bedding style and texture to those in the embayment. The type Rabbitkettle however is significantly more silty than that recognized in the embayment or mapped in the Nahanni map-area (W.H. Fritz, pers. comm., 1980). North of the embayment the Rabbitkettle Formation is correlative with, and lithologically similar to, the basal member of the type Road River Formation described by Norford (1964, p. 110) as "limestone, some argillaceous, dark grey, weathers dark grey and yellowish grey, minor dark grey shale; rare cherty beds;. . .". The Road River type section is located in the Richardson Trough, a correlative north-trending sedimentary basin 100 km northwest of the Misty Creek Embayment.

***Duo Lake*[1] *Formation (new)***

The type section (Section 6) is at 64°42' and 130°47', 2 km southwest of Goober Lake, in the Bonnet Plume Lake map-area (Figs. 11, 12). There the formation, including upper and lower contacts, is well exposed along the sides and crest of a major south trending ridge. At its type section the Duo Lake[1] Formation is divisible into two units; a basal 240 m of interstratified thin beds of silty limestone and graptolitic shale, and an upper 76 m of graptolitic siliceous shale and minor chert (Fig. 5).

The Duo Lake Formation is up to 415 m thick (Fig. 22), and is thickest along the embayment axis. The formation is found over most of the embayment area but is generally missing in Franklin Mountain transition zone and platform facies (Fig. 4).

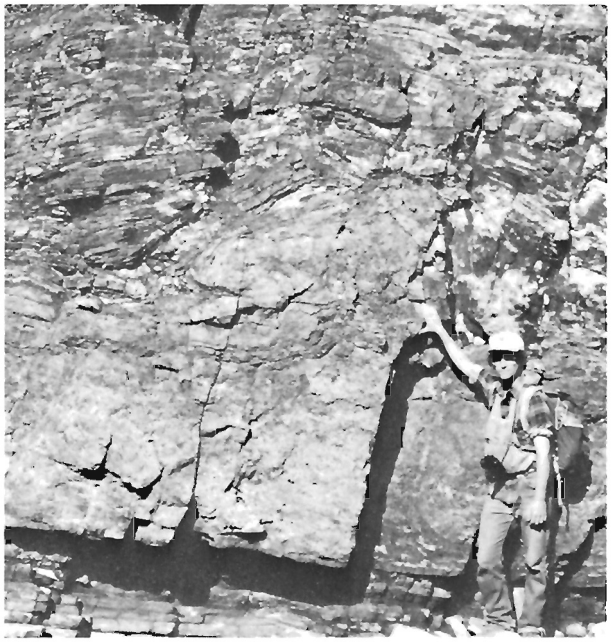
The Duo Lake Formation is a recessive succession of black shale, siliceous shale and rhythmic alternations of shale and yellow weathering silty limestone (Fig. 23), with minor units of chert, silty limestone, and volcanogenic sandstone and conglomerate. The formation cannot be divided into members (compare successions in Appendix I) and is best described as a recessive graptolitic shale dominated (Fig. 24), dark weathering unit.

***FIGURE 18.*** *Slump-folded Rabbitkettle limestone, Section 6 (GSC 199522).*

The formation is commonly divided into tongues by thick successions of Marmot Formation tuffs, flows and associated sediments (see Appendix I). At Sections 9, 13, and 14 minor (5-100 m thick) sandstone and/or conglomerate units in the Duo Lake have a significant volcanic clast component. The sandstones are dominated by quartz with varying amounts of carbonate, volcanic and chert clasts. Volcanic rocks in the embayment are typically altered to carbonate spar, chlorite, limonite and patches of chalcedony or quartz and remnant patches of opaque volcanic rock with microlites of feldspar. Considering the extensive interstratification of Marmot Formation volcanic rocks it is probable that Duo Lake sandstones are derived from erosion of volcanic rocks located in the embayment, rather than the result of correlative sub-Mount Kindle epeirogenesis and erosion of older rocks on the surrounding platform. The sandstone and conglomerate occur as massive, fine to coarse grained, thin to thick beds interstratified with typical Duo Lake Formation lithologies, and are interpreted by this association as submarine deposits.

At the type section and throughout the embayment the basal contact of the Duo Lake Formation is conformable and gradational with the underlying Rabbitkettle Formation. The contact is placed above the last thick (>10 m) succession of platy limestone above which shale comprises more than 40 per cent of the overlying succession. The top of the Duo Lake Formation at the type section is a sharp contact with transitional Mount Kindle Formation dolostone; here the basal Mount Kindle transition is a thick unit of dolostone breccia that contains no clasts from the underlying siliceous shales and is interpreted as a debris flow. Basinward of the Mount Kindle transition zone the upper contact is distinct and conformable and is placed at the base of the first thick (>50 m) succession of thin bedded, sooty grey limestone of the Cloudy Formation, overlying shale, chert or yellow weathering silty limestone - shale rhythms of the Duo Lake Formation. In the southeastern embayment, at Section 22, the Duo Lake Formation is unconformably overlain by about 40 m of vuggy, massive, pale yellow dolostone, which could be either thin Mount Kindle or Delorme Formations. This type of dolostone occurs in both formations.

[1] Duo Lake is a geographic locality on the southwest side of the Misty Creek Embayment (Fig. 1).



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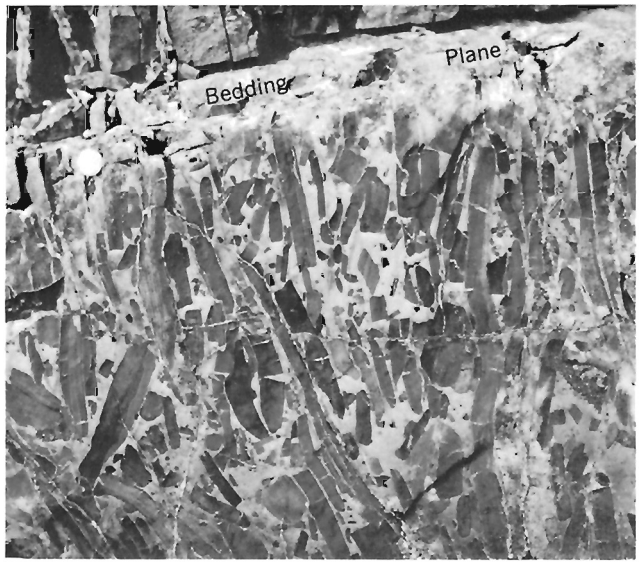


C

*FIGURE 19a. In situ breccia, Rabbitkettle Formation (mass behind Kevin Sharman, upper contact at his head). Note how the overlying intact thin bedded limestone has dragged underlying strata into an upward intruding fold. Strata in this fold are brecciated. These breccias have not been reworked in an aqueous environment and are therefore described as in situ (GSC 199533).*

*FIGURE 19b. Close-up view of the in situ breccia shown in Figure 19a. Mass consists of yellow limestone clasts in a dark grey matrix, disarticulated during slump movement, but without significant mechanical mixing, Rabbitkettle Formation (GSC 199534).*

*FIGURE 19c. Imbricated in situ breccia. Bedded contact runs along the base of the photograph. Delicate clasts of black limestone in a yellow limestone matrix have rotated to a position perpendicular to bedding during slumping of overlying limestone, Rabbitkettle Formation (GSC 199529).*

*Cloudy member*

In the southwestern embayment the upper Duo Lake Formation is diachronous (see below), almost entirely shale and the shale is time equivalent to the Cloudy Formation limestone in the northern embayment (Figs. 4b, 9). Locally, however, a few metres of sooty grey weathering platy limestone, homotaxial with and lithologically similar to the Cloudy Formation are preserved as a unit at the top of the Duo Lake Formation. Because these rocks cannot be mapped but represent a thin, restricted continuation of Cloudy lithologies they are here identified as the Cloudy member of the Duo Lake (see also p. 18). The Duo Lake including the Cloudy member in the southwestern embayment is unconformably overlain by the late Early Devonian Natla? Formation. Fourteen kilometres north-northwest of Section 25 (Fig. 2) a metre-thick limestone-clast conglomerate at the base of the Natla? Formation directly overlies Duo Lake shale containing **Monograptus spiralis** and **Rastrites** sp. Ten kilometres southeast of Section 25 the Natla? Formation overlies at least a 10 m thick Cloudy member with **Monograptids** and **Rastrites** sp.

*Age and correlation*

Graptolites are the most common fauna in the Duo Lake Formation (Fig. 24). However, rare corals, trilobite fragments, crinoid fragments, gastropods, and inarticulate brachiopods have been observed.

The basal contact of the Duo Lake Formation is apparently diachronous (Fig. 6) and ranges in age from earliest Early Ordovician in the northwest part of the embayment to latest Early Ordovician in the southern part of the embayment. The youngest fauna collected in the northern embayment, at Stage level, are latest Middle Ordovician (Caradocian) (Fritz et al., Appendix II). However,

***FIGURE 20.*** *Slope breccia typical of Rabbitkettle Formation consisting of dark limestone clasts in a lighter coloured matrix. Fragments and matrix are similar to overlying and underlying limestones (GSC 199538).*

***FIGURE 21.*** *Slope conglomerate consisting of different sized clasts of subrounded dark grey to black limestone, and light grey to yellow limestone floating in a limestone matrix, Rabbitkettle Formation. Clasts still are typical of enclosing strata although degree of rounding and mixing indicates significant displacement (GSC 199536).*

the upper contact is also diachronous younging to the southwest (Fig. 4). On the Niddery High **Monograptus spiralis** and **Rastrites** sp. have been collected from upper Duo Lake shale making the upper contact as young as late Early Silurian. The best graptolite collections, in the Duo Lake Formation, are at the type section ranging in age from Early Ordovician-Tremadocian to Middle Ordovician-Caradocian.

Duo Lake strata are partly correlative with upper Franklin Mountain and transitional Franklin Mountain

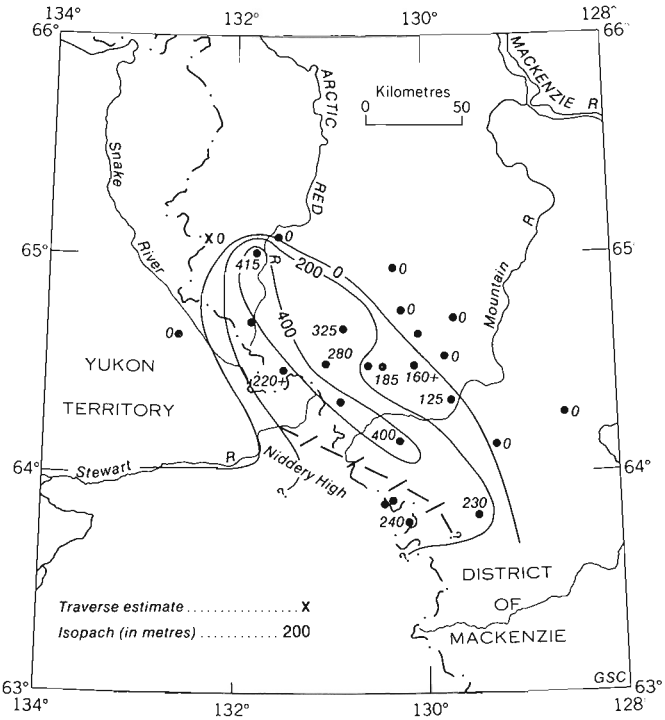


***FIGURE 22.*** *Isopach map of the Duo Lake Formation. The X represents a visual determination.*

***FIGURE 23.*** *Calcareous shale and platy, yellow weathering silty limestone typical of calcareous Duo Lake strata (GSC 199518).*

dolostone. Transitional Franklin Mountain units may be as young as Middle Ordovician (Sections 16, 18, Appendix I). However an equivalent Middle Ordovician platform facies unit is unknown around most of the embayment because of non-deposition or erosion before deposition of the Mount Kindle Formation (Fig. 4). South of 64° Latitude, in the Sekwi Mountain map-area, southeastern embayment, Blusson (1971) has identified a Middle Ordovician platform carbonate, the Sunblood Formation, which is correlative in age with a large part of the Duo Lake Formation.

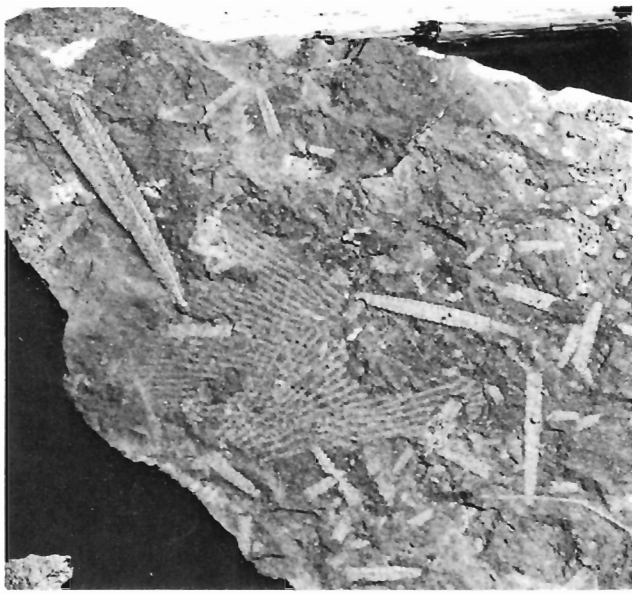

***FIGURE 24.*** *Graptolitic shale of the Duo Lake Formation, bedding plane view. Fragments center to right are mainly Diplograptids, multibranched forms are Dictyonema, at the top left is a Pseudotrigonograptus (A.C. Lenz, pers. comm., 1980) overlying a uniserial branch of an unidentified graptolite (GSC 199528).*

***Marmot Formation (new) and volcanism***

The type section of the Marmot Formation[1] is the upper part of Section 17 located at 64°10' Latitude and 130°20' Longitude (Fig. 25). In most parts of the Misty Creek Embayment, the Marmot Formation occurs as a single thin unit from one to several tens of metres thick, except in basin axis Sections 9 and 17 where it is 250-500 m thick, respectively (Fig. 26). The Marmot Formation represents aerially restricted volcanism deposited contemporaneously with the Duo Lake and Cloudy Formations (Section 13) and unnamed Middle Paleozoic limestones (Section 17).

The thickest Marmot successions are found as tongues dividing the Duo Lake Formation (Sections 8, 9, 12, 17, 18, Appendix I). At Section 9, a thin tuff unit was identified in the upper Hess River Formation, but is too thin to be represented as a separate formation. Blusson (1974) mapped the Marmot Formation, as a Middle Ordovician volcanic unit over large parts of the embayment and parts of the Selwyn Basin (Fig. 1).

Volcanic and volcaniclastic rocks comprising the Marmot Formation, in order of abundance are: lapilli tuff to fine grained breccia (Fig. 27); sandstone, siltstone and argillite (Fig. 28); massive amygdaloidal flow rock; conglomerate (Fig. 29); sills; and minor coarse breccia (Fig. 30) and pillow breccia (Fig. 31). Tuff fragments, flows and sills typically consist of plagioclase microlites and biotite-phlogopite phenocrysts in an opaque ground mass and locally show variolitic textures. Most are altered to carbonate spar, chlorite, chalcedony or quartz, kaolinite, leucoxene, limonite and hematite. Carbonate spar occurs in the matrix, and in large (1 mm-0.5 cm) rectangular patches where it has replaced mafic mineral phenocrysts. The upper and lower contacts of the Marmot Formation are placed above or below the last thick (>10 m) succession of strata with more than 40 per cent volcanic tuffs, flows, or clearly recognizable volcaniclastic sediments.

Preliminary chemical analyses (Table 1) of a dyke, and a sill indicate the rocks are alkalic basalts, anomalously rich in barium. The low sodium and very high barium values indicate substantial metasomatic alteration (Goodfellow, Jonasson and Cecile, 1980a).

In the southeastern part of the Misty Creek Embayment, the anomalously thick (500 m) Marmot Formation at Section 17 coincides spatially with several sills and dykes cutting both the Rabbitkettle and Duo Lake Formations, a discontinuous 60 m unit of monolithic unsorted angular volcanic breccia (Fig. 30), and abundant volcanic conglomerate (Fig. 29) - these lithologies are peculiar to this location and indicate proximity to a volcanic centre. The thick succession of the volcanic centre can be traced around the nose of an open anticline for a strike length of more than 20 km (see Fig. 1).

The Marmot Formation at the volcanic centre can be divided into lower submarine and upper shoaling portions. The lower half of the Marmot Formation at Section 17 (type section, Fig. 25) conformably overlies Middle Ordovician black graptolitic shales of the Duo Lake Formation suggesting, by association, that initial volcanic strata were deposited in a deep basin environment. These lower rocks consist of: unstratified or crudely stratified, thick beds and units of lapilli tuff which contain sedimentary clasts, resembling Duo Lake lithologies, and an abundant carbonate matrix or cement; thin- to medium-bedded volcaniclastic sandstone, siltstone and argillite with ripple cross-laminae, graded beds and abundant scouring; massive to blocky parted amygdaloidal basalt flows, containing rare large xenoliths of carbonate or volcanic rock in very thick successions; and rare pillowed flows or pillow breccia interstratified with the massive flow units.

The lapilli tuffs by their occurrence with graptolitic shale and pillowed flows, are interpreted as hyaloclastites, and can be compared to the "initial hyaloclastite breccias" described by Cucuzza-Silvestri (1963, p. 318) which consist of unsorted, angular pieces of aphanitic lava, often with a glassy crust and cement of calcareous or argillaceous ooze (Fig. 27).

The upper half of the Marmot Formation at the volcanic centre features fossiliferous limestone and abundant volcanogenic conglomerate and conglomeratic sandstone. The limestone indicates shoaling of the complex and the conglomerate indicates extensive subaerial erosion, although the conglomerate may have been deposited in a shallow marine environment. The conglomerate is generally massive with pebbles supported by a dirty sandy matrix. Pebbles are typically 50-70 per cent volcanic rocks and the remainder limestone. Clasts in one conglomerate are dominated by a distinctive volcanic rock, not observed within volcanic units elsewhere in the Marmot Formation. This volcanic rock is composed of 5-10 per cent 0.5-2 cm rectangular white plagioclase and equant, black (originally pyroxene?) phenocrysts in a fine-grained green groundmass. The black phenocrysts have been completely altered to chlorite and carbonate.

Volcanic rocks elsewhere in the Misty Creek Embayment are interpreted as lateral tongues or local lensoid accumulations associated with eruptions at the volcanic centre near Section 17.

*Age and correlation*

Rocks at the volcanic centre directly overlie graptolitic shale with an early Middle Ordovician fauna (Section 17, Fritz et al., Appendix II) and in the upper part, are

[1] The Formation is named after Marmot Pass located about 50 km southwest of the type section (Fig. 1).

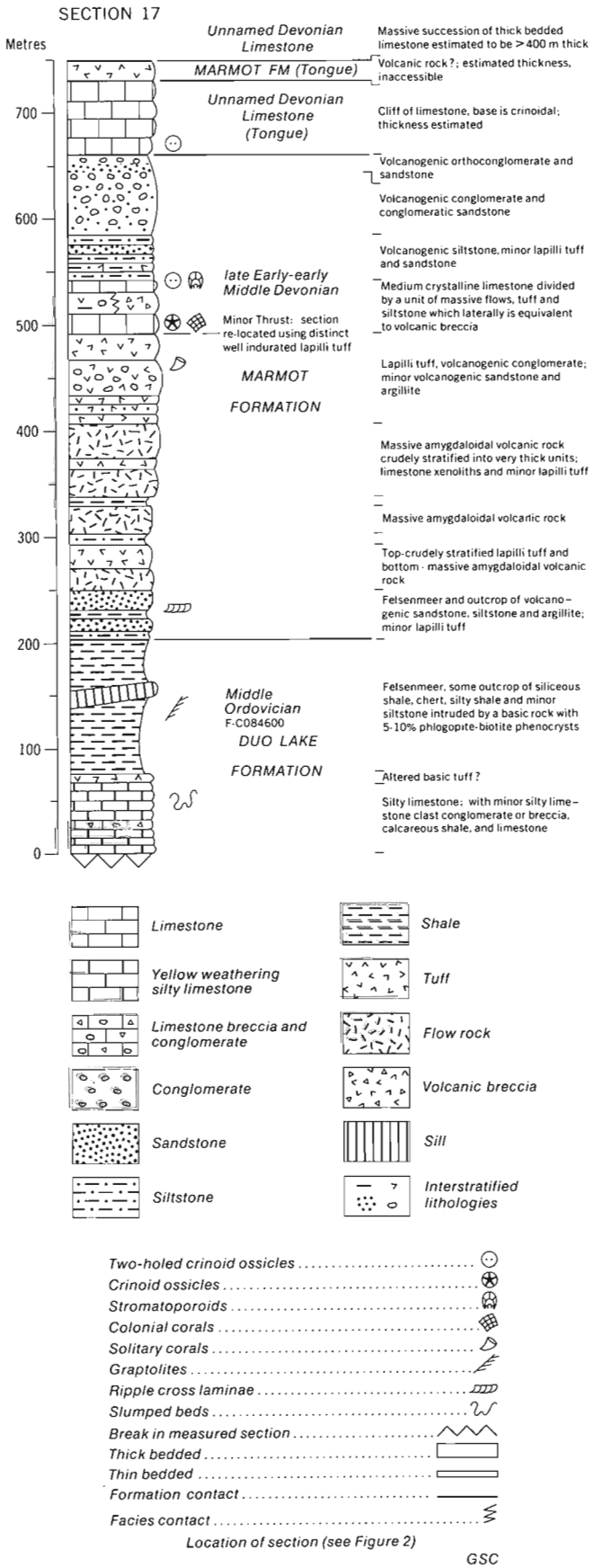


***FIGURE 25.*** *Section 17 (volcanic portion), type section of the Marmot Formation. Note dominance of lapilli tuff and massive flows in the lower half and conglomerate and limestone, upper half.*

**TABLE 1**

COMPARISON BETWEEN MAFIC IGNEOUS ROCKS FROM THE MISTY CREEK EMBAYMENT AND AVERAGE BASALTS DESCRIBED ELSEWHERE
(From Table 1 of Goodfellow, Jonasson and Cecile, 1980a)

| | Misty Creek Embayment Bonnet Plume, Yukon | | Ocean Ridge Basalts (Engel et al., 1965) | | Basalts (Turkian and Wedepohl, 1961) |
|---|---|---|---|---|---|
| | CJA77-40-7 (sill) | CJA77-40-4 (dyke) | Tholeiitic | Alkalic | undifferentiated |
| Per cent | | | | | |
| $SiO_2$ | 41.8 | 50.0 | 49.34 | 47.41 | 49.2 |
| $Al_2O_3$ | 11.6 | 15.0 | 17.04 | 18.02 | 14.7 |
| $TiO_2$ | 3.59 | 2.00 | 1.49 | 2.87 | 2.3 |
| FeO | 0.0 | 8.4 | 6.82 | 5.80 | - |
| $Fe_2O_3$ | 10.3 | 1.0 | 1.99 | 4.17 | - |
| $FeO_T$ | 9.3 | 9.3 | 8.62 | 9.55 | 11.1 |
| CaO | 7.5 | 1.0 | 11.72 | 8.65 | 10.6 |
| MgO | 7.5 | 8.0 | 7.19 | 4.79 | 7.6 |
| $K_2O$ | 3.01 | 3.00 | 0.16 | 1.66 | 1.0 |
| $Na_2O$ | 0.0 | 0.0 | 2.73 | 3.99 | 2.4 |
| $P_2O_5$ | 0.76 | 0.60 | 0.16 | 0.92 | 0.25 |
| MnO | 0.03 | 0.10 | 0.17 | 0.16 | 0.19 |
| $CO_2$ | 5.0 | 0.6 | - | - | - |
| $H_2O$ | 5.2 | 5.9 | 1.27 | 1.40 | - |
| C | 0.4 | 0.2 | - | - | - |
| S | 1.19 | 0.10 | - | - | 0.03 |
| ppm | | | | | |
| F | 1100 | 1920 | - | - | 400 |
| Cl | 160 | 130 | - | - | 60 |
| Zn | 142 | 103 | - | - | 105 |
| Cu | 98 | 45 | 77 | 36 | 87 |
| Pb | 32 | 1 | - | - | 6 |
| Ni | 43 | 161 | 97 | 51 | 130 |
| Co | 105 | 43 | 32 | 25 | 48 |
| Ag | 0.2 | 0.2 | - | - | 0.11 |
| Mo | 4 | 2 | - | - | 1.5 |
| As | 14.7 | 1.1 | - | - | 2 |
| Hg* | 20 | 10 | - | - | 900 |
| Sb | 0.9 | 0.1 | - | - | 0.2 |
| Cd | 2.8 | 2.8 | - | - | 0.22 |
| Li | 171 | 164 | - | - | 17 |
| Rb | 97 | 56 | <10 | 33 | 30 |
| Cs | 3.3 | 3.9 | - | - | 1.1 |
| Sr | 804 | 398 | 130 | 815 | 465 |
| Ba | 17400 | >4000 | 14 | 498 | 330 |
| U | 1.2 | 0.6 | - | - | 1.0 |
| Ce | 574 | 581 | - | - | 48 |
| Cr | 65 | 363 | 297 | 67 | 170 |
| V | 500 | 365 | 292 | 252 | 250 |
| Y | 70 | 45 | 43 | 54 | 21 |
| La | 167 | 167 | - | - | 15 |
| Zr | 351 | 277 | 95 | 333 | 140 |
| Be | 4.8 | 4.0 | - | - | 1.0 |
| Th | 2 | 2 | - | - | 4 |

*Hg in ppb.
Refer to Goodfellow, Jonasson and Cecile (1980a) for method of analysis

interstratified with, and overlain by, upper Lower to early Middle Devonian limestones. Lapilli tuff at Section 18, is of Middle Ordovician age, bracketted by rocks dated as Llanvirnian and Llandeilian to early Caradocian (Appendix II).

The Marmot Formation is partially correlative with the Mountain diatreme which cuts transitional Franklin Mountain facies 50 km to the east of the Marmot volcanic centre. The diatreme, dated as early Middle Ordovician or younger, has been described as 600 m in diameter, containing angular to subrounded carbonatized and chloritized breccia fragments, many of which have phlogopite and rarely pyroxene cores (McArthur, Tipnis and Goodwin, 1980).

Basic volcanic tuff, flows and volcaniclastic rocks occur as minor lithologies and local units in many lower and middle Paleozoic strata of Yukon and northeastern British Columbia. Thicknesses generally range from a few metres to several tens of metres and units are laterally discontinuous. Basic volcanic rocks have been reported in Middle Ordovician and Lower Cambrian strata of the southern Mackenzie Mountain (Gabrielse et al., 1973); within the late Cambrian-Early Ordovician Rabbitkettle Formation,

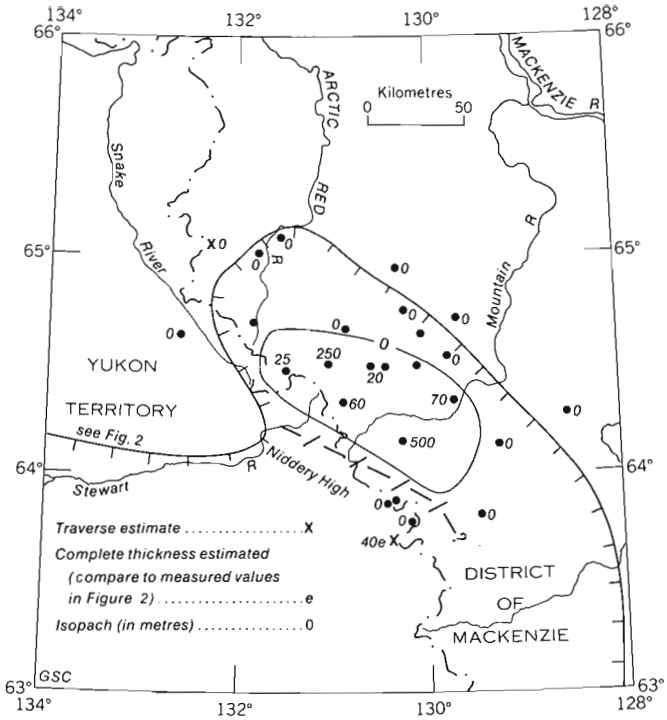


***FIGURE 26.*** *Thicknesses of the Marmot Formation. The X's represent visual determinations.*

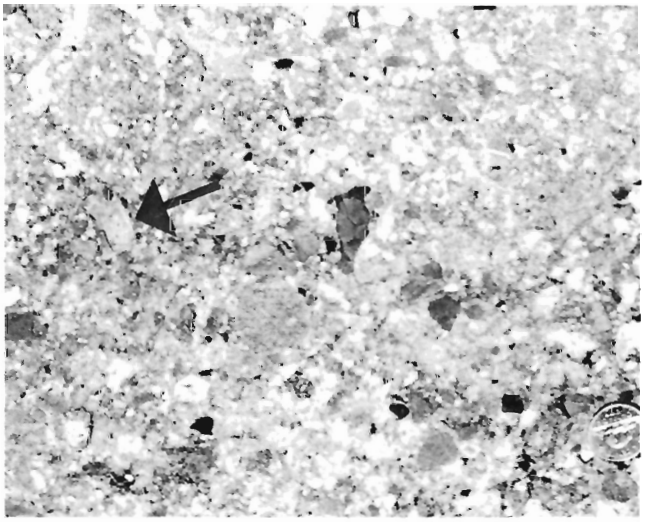

***FIGURE 27.*** *Unsorted, massive lapilli-tuff and fine limestone cemented volcanic breccia. Black clasts are shale, white clasts are mostly volcanic fragments and a small number are limestone. Note alteration rim on clast indicated (GSC 199520).*

Nahanni map-area (S.P. Gordey, pers. comm., 1979); in Lower Cambrian rocks in southeastern Yukon, Coal River area (Gabrielse and Blusson, 1969); in Middle Ordovician platform and basin strata of northeastern British Columbia (Thompson, 1976; Cecile and Norford, 1979); in Cambrian limestones in the area of Romanzof Uplift, northern Yukon (Norris, 1974a); and associated with lower Paleozoic basin strata of the northwestern Selwyn Basin (Green, 1972); with Ordovician

***FIGURE 28.*** *Massive, laminated and ripple cross-laminated (upper beds) volcanogenic sandstone, siltstone and mudstone, Marmot Formation (GSC 199532).*

***FIGURE 29.*** *Volcanogenic conglomerate, Marmot Formation. Eighty per cent of the clasts are massive basalt, the remainder are dominantly limestone (GSC 199531).*

and Silurian carbonates on the Ogilvie Arch (Green, 1972); associated with Lower Paleozoic basin strata throughout the Anvil Range near Ross River (D. Jennings, pers. comm., 1980); and southwest of the Tintina fault in the Pelly Mountains (Tempelman-Kluit, 1977a, b; Gordey, 1977).

### *Cloudy Formation (new)*[1]

The type section for the Cloudy Formation[1] is located at 64°27' and 130°35' (Section 13, Figs. 11, 32) north of the divide between the Arctic Red River and tributaries to the Mountain River in the Bonnet Plume Lake map-area.

[1] This unit is named after Cloudy Creek located 35 km south of the type section (Fig. 1).

***FIGURE 30.*** *Volcanic breccia, Marmot Formation. Clasts are massive amygdaloidal basalt and are cemented by limestone. White and light grey clasts on right are limestones. Marmot Formation Section 17. Amygdales in the basalt are filled with carbonate (GSC 199527).*

***FIGURE 31.*** *Oblique cross-sectional view of pillowed amygdaloidal basalts. White selvages are dominantly porcellanous chert and carbonate. Marmot Formation Section 17 (GSC 199530).*

The Cloudy Formation is a 0 to 470 m thick (Fig. 9) succession of thin- bedded sooty-grey weathering limestones and minor beds and successions of shale, chert, and yellow weathering limestone (Fig. 33). The limestones are black on fresh surface, fine to medium crystalline often with abundant silt to sand size bioclastic debris. Chert is always a minor lithology but shale can comprise as much as 30 per cent of the succession. The Cloudy Formation conformably overlies the Duo Lake Formation and is unconformably overlain by the Delorme Formation at Section 13. Ten kilometres south of Section 13 the Cloudy Formation is overlain by a succession of alternating thick units of light yellow grey and dark grey weathering dolostone, probably the Sombre Formation of Gabrielse et al. (1973). The basal 135 m of the type section consists of thin bedded, sooty-grey weathering limestone, containing thin beds of chert and large chert nodules. Above this are 280 m of thin bedded sooty limestone, crinoidal limestone and minor shale; and at the top of the formation are 25 m of Marmot Formation volcanic tuff overlain by 30 m of Cloudy Formation limestone (Fig. 33). The Cloudy includes a 100 m thick olistostrome unit at Section 9 (Fig. 34).

The basal contact of the Cloudy Formation is easily recognized and placed between uppermost yellow weathering limestone, limestone shale strata, or black shale or chert of the Duo Lake Formation and a thick succession of sooty-grey weathering limestone of the Cloudy Formation. The upper contact is placed at the unconformity between the Cloudy Formation and overlying Siluro-Devonian dolostone. In the southwestern embayment (Figs. 4, 9) the Cloudy Formation is replaced by Duo Lake shale of the same age. A thin, unmappable unit of Cloudy lithologies is locally preserved and included in the Duo Lake Formation as the Cloudy member. In this area the Duo Lake Formation and Cloudy member are unconformably overlain by the Natla? Formation.

*Age and correlation*

The Cloudy Formation ranges in age from Late Ordovician to Early Silurian (Fig. 6). At the type locality and in nearby outcrops the graptolite **Monograptus spiralis** (of late Llandovery age) was collected from beds within the middle part of the formation (Section 13 - C-069417, Section 14 - C-069242, Appendix II). At Section 14, 4 km southeast of the type section, the Cloudy Formation contains scattered colonial corals and, near the top, beds with abundant articulate brachiopods (C-69245, Fritz et al., Appendix II).

The Cloudy Formation is correlative with the Mount Kindle Formation north of, and the Whittaker Formation south of, 64° Latitude in the Mackenzie Mountains.

***Natla? Formation***

In the south central embayment the top of Section 12 consists of 50 m of limestone pebble conglomerate overlain by 90 m of sooty grey limestone, biosparite and minor chert and shale. At this location monoclinally dipping Natla? limestone overlies disharmonically folded, poorly exposed Duo Lake Formation rocks. At the junction of the Misty Creek Embayment and the Selwyn Basin, a thick succession of thin bedded, grey weathering crinoidal limestone interstratified with as much as 40 per cent very thick calcareous shale sequences, and containing light grey weathering very thick units of limestone breccia and conglomerate unconformably overlie the Duo Lake Formation. This limestone is similar in lithology, colour and probably age to the Natla Formation of Gabrielse et al. (1973) and is tentatively assigned to that formation.

Throughout the southwestern embayment the Natla? Formation is overlain by unnamed black to silver-white weathering Middle and/or Late Devonian siliceous shale, siltstone or chert.

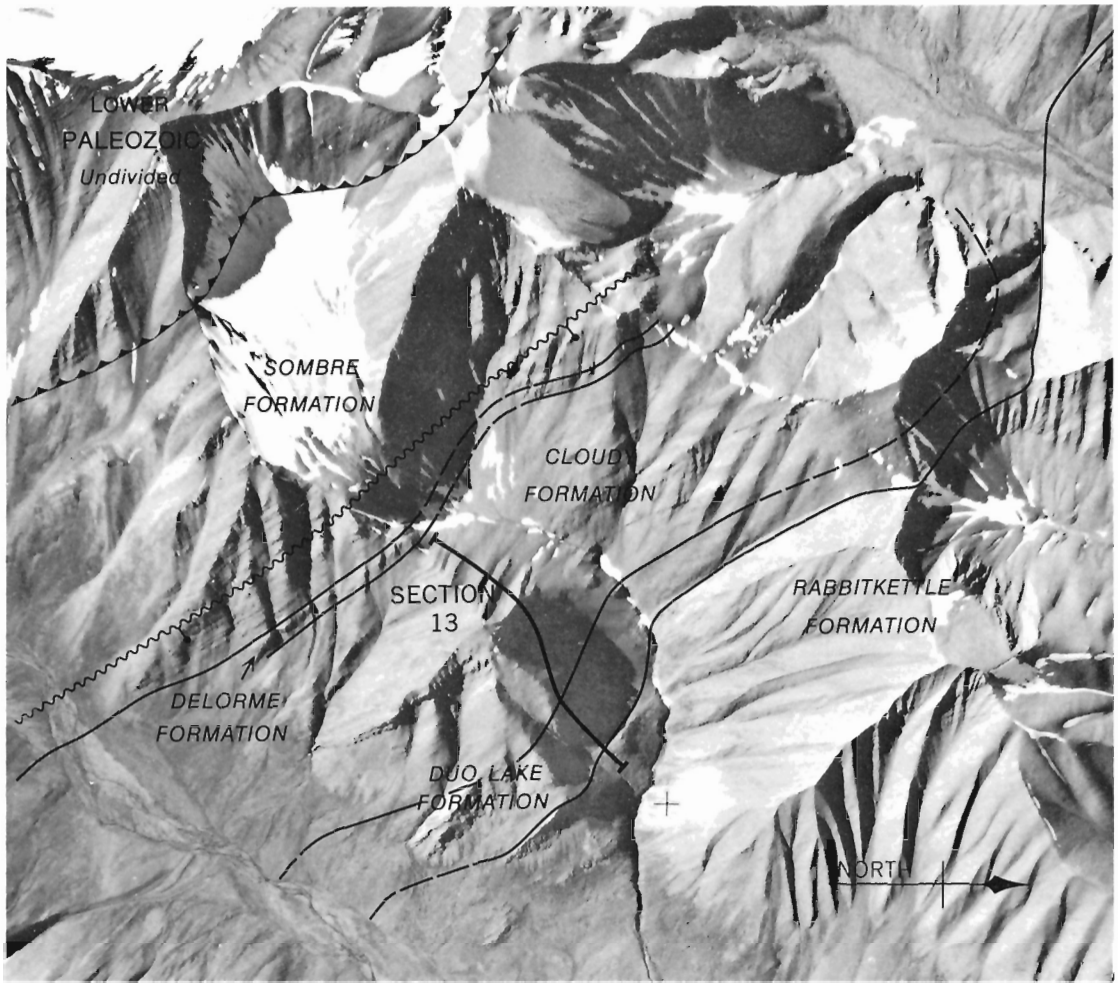


***FIGURE 32.*** *Aerial photograph showing the location of, and geology around the type Section 13 of the Cloudy Formation. Photograph is a part of the N.A.P.L. air photo # A12251-178.*

*Age and correlation*

The Natla? limestone contains abundant bioclastic debris with echinoderm, bryozoan, and coral detritus and abundant two-holed crinoid ossicles (Appendix II, Section 12). Further southwest graptolites are locally abundant in more shaly rocks associated with the bioclastic debris (Locations 116, 117 in Fritz et al., Appendix II). Both the graptolites and two-holed ossicles[1] indicate a mainly late Early Devonian age for this unit, with the upper part possibly as young as early Middle Devonian. Gabrielse et al. (1973) date the upper 10-30 m of the Natla as early Middle Devonian.

Natla? limestone is at least partially correlative with Siluro-Devonian carbonates that blanket the southern embayment (Fig. 1) which could include all or parts of the Sombre, Arnica and Landry Formations.

In the southeastern embayment the Natla? limestone unit is correlative with a succession of unnamed massive and thick-bedded crinoidal limestones that are transitional facies of the Siluro-Devonian platform facies carbonates (as at top of Section 17, Appendix I).

***Road River Formation - problems with nomenclature***

The Road River Formation was first described by Jackson and Lenz (1962) as 910+ m (2985 ft) of graptolitic shale, argillaceous limestone and minor chert, dolostone, siltstone and sandstone, from a section on a tributary to the Road River, Richardson Mountains, Yukon. Norford (1964), followed the suggestion of Jackson and Lenz (1962) and divided the Formation into two distinct members within the type area: a lower member of limestones and argillaceous limestone, and an upper recessive member comprised of shale, argillaceous limestone, shaly argillite and chert. The lower member is Late Cambrian and Early Ordovician in age (Norford, 1964) and the upper member has faunal zones ranging through the Ordovician, Silurian, and Early Devonian (Jackson and Lenz, 1962; Lenz, 1966, 1972).

[1]A.W. Norris, pers. comm., 1980 gives the range of two-holed crinoids as spanning the Zlichovian and Dalejan and into the earliest Couvinian (late Early Devonian to early Middle Devonian).

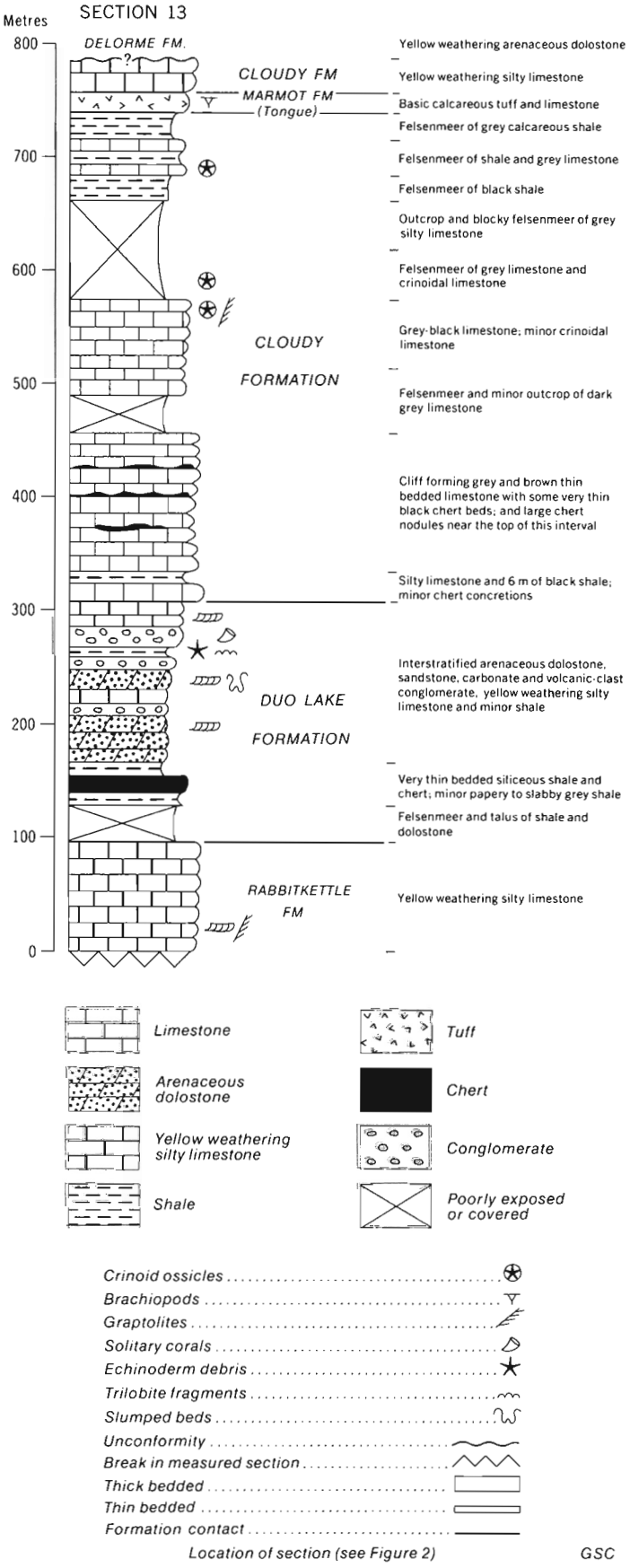


***FIGURE 33.*** *Type section (Section 13) of Cloudy Formation. Location shown in Figures 11, 32.*

***FIGURE 34.*** *Slump folded limestone olistolith in an olistostrome of platy grey limestone and black chert, basal Cloudy Formation, Section 9. Exposure is 2 m high (GSC 199524).*

Road River outcrops are reported from the arctic coast of the Yukon, southward through the White, Richardson and Ogilvie Mountains into east central Alaska (Churkin and Brabb, 1965; Brabb, 1967) and south through the Selwyn Basin, into the northern Peace River area of British Columbia.

South of the Misty Creek Embayment across the southeastern Yukon and into northeastern British Columbia current usage following Gabrielse et al. (1973) has restricted the Road River Formation to basin facies strata that overlie Rabbitkettle Formation (Fig. 35), or its partial equivalent - the Kechika Group and a variety of platform carbonate formations; and which are overlain by either Silurian-Devonian platform carbonates or Middle Devonian to Mississippian clastic rocks (see for instance Gabrielse et al., 1973; Gordey, 1979; Cecile and Norford, 1979). This usage differs from that in the type area even though Rabbitkettle strata are lithologically similar to, and correlative with, the basal member of the Road River Formation (see section on the Rabbitkettle Formation).

Basin rocks (here assigned to Hess River Formation to Cloudy Formation inclusively) in the Misty Creek Embayment were mapped by Blusson (1974) and described by Aitken et al. (1973) as Road River Formation. The Rabbitkettle to Cloudy Formations described here (Fig. 35) can be shown to be correlative with, and lithologically similar to the type Road River Formation. It is natural then to consider up-grading Road River Formation to a group that might include all basin strata in the Misty Creek Embayment, including the Hess River Formation, because of its lithological affinity to the rest of the succession. However, several factors suggest delaying use of the term Road River in the Misty Creek Embayment. The first is that the different usage of Road

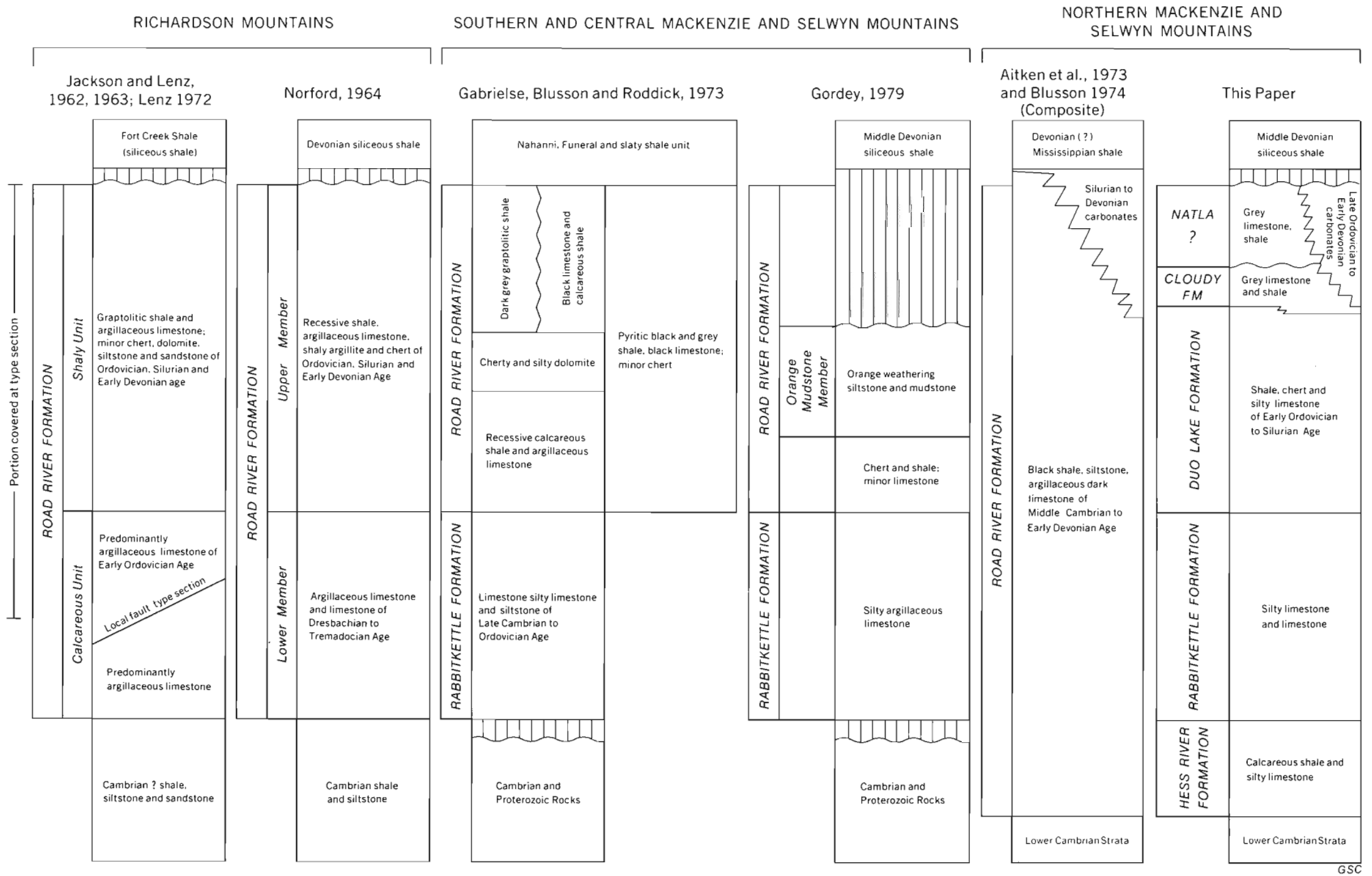


***FIGURE 35.*** *Correlation chart illustrating various usages of Lower Paleozoic basin facies nomenclature north and south of the study area.*

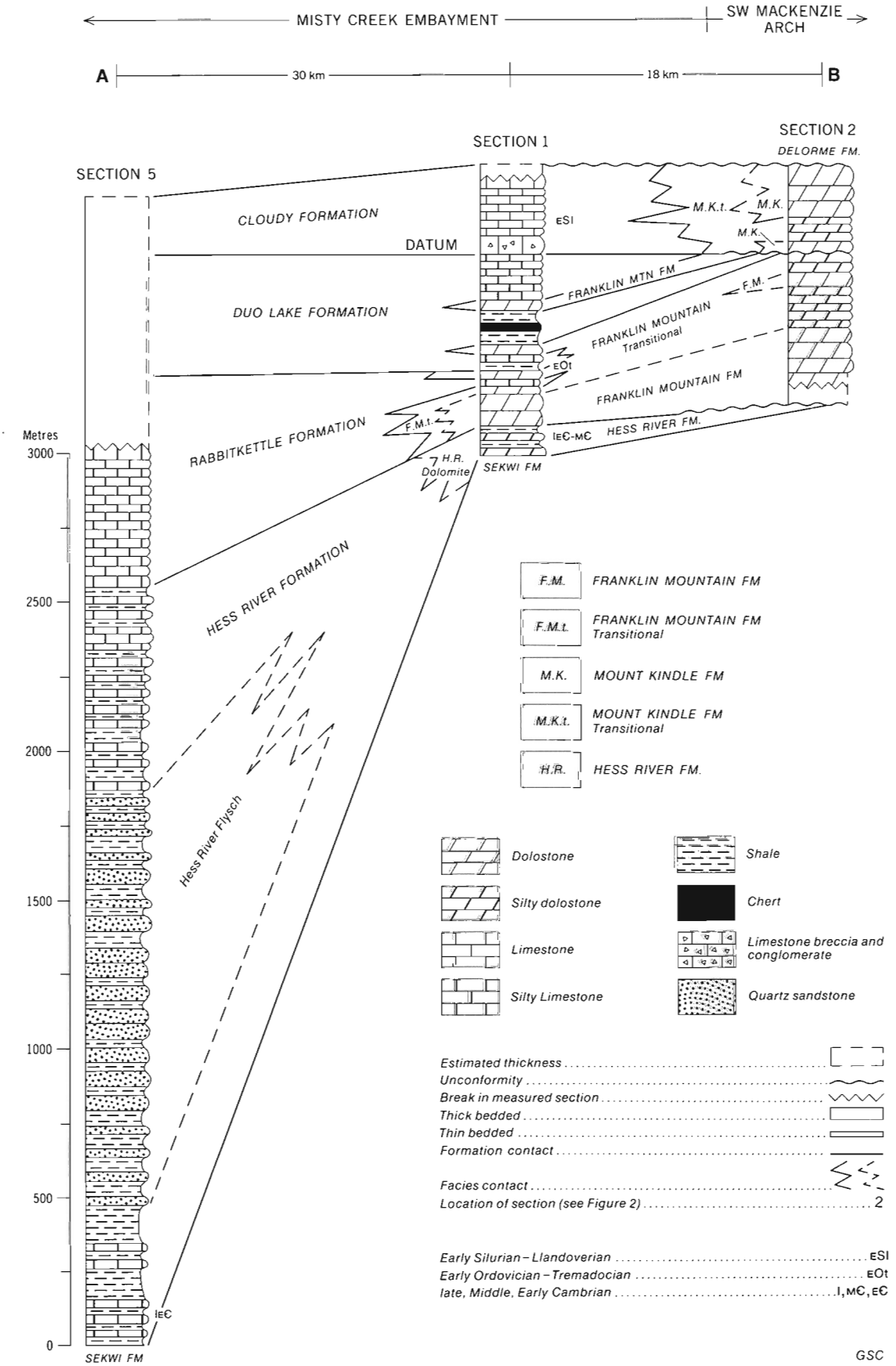


***FIGURE 36.*** *Stratigraphic cross-section A-B, northern embayment, located on Figure 2. Section 1 has transitional Hess River and Franklin Mountain strata. Section 5 includes a thick sequence of Hess River flysch. Note sections are generalized - refer to Appendix I for detail.*

River Formation by Gabrielse et al. (1973) which has been adopted by others (e.g. Morganti, 1977; Gordey, 1979; Cecile and Norford, 1979) creates a problem in how to extend the use of Road River from the type area. The second is that the Road River Formation was first described seventeen years ago at a type section with a faulted base. It seems more appropriate that any further consideration of the term 'Road River' should begin with a re-study of the type section in the type area. If this procedure is followed the result may be a regionally useful and consistently used term applied to lower Paleozoic basin strata of the Yukon and northern British Columbia, and may avoid potential nomenclatural conflicts.

## Transition facies

One of the more important features of the Misty Creek Embayment is the complex zone where platform carbonate rocks change laterally into time-equivalent basin strata. Often in the area of such transitions thick successions of platform carbonate - potential reservoir rocks - are juxtaposed and interstratified with basin shale and limestone - potential source rocks; consequently, this zone is a natural target for mineral exploration.

Transition zone is a relative term which can depend on the size of the area involved. If we are discussing the Selwyn Basin, then the entire Rabbitkettle Formation, a basin succession which extends halfway across the northern and across the entire southern basin area into the eastern Selwyn Basin, could be described as the transition belt of silty limestones separating Franklin Mountain dolostones from shale and chert facies of the outer Selwyn Basin. In the area of the Misty Creek Embayment, a narrow definition is more appropriate. Transition belts described here refer to the zone in which there is interstratification of platform and basin rocks, and units unique to this overlap, such as the thin bedded silty dolostones of the Franklin Mountain transition.

In the Misty Creek Embayment, transition rocks equivalent to the Franklin Mountain and Mount Kindle Formations are well preserved. Transition facies of Middle Cambrian and Middle Ordovician are less extensively preserved due to extensive removal through erosion.

Transition facies stratigraphic nomenclature is used as follows: although interstratified with one another, basin unit and platform units retain their original names, and where they are divided by another unit they are referred to as tongues (see Appendix I). Strata peculiar to the transition zone carry the equivalent platform unit name, i.e. Franklin Mountain transition dolostone (Figs. 36-39).

### *Middle Cambrian transition*

Middle Cambrian transition facies around most of the Misty Creek Embayment were extensively eroded before deposition of the Franklin Mountain Formation.

Abundant thin-bedded silty dolostone in the Hess River Formation at Section 1 in the northwestern embayment shows at least partial preservation of a Middle Cambrian transition zone. Southeast of the embayment the Rockslide Formation (Gabrielse et al., 1973), a widespread unit of thin bedded Middle Cambrian limestone, represents the transition from Hess River Formation shale and limestone to thick-bedded Middle Cambrian platform dolostone of the Avalanche Formation which outcrops in the southern Mackenzie Mountains (Gabrielse et al., 1973).

### *Franklin Mountain transition*

Transition facies of the Franklin Mountain Formation is recognized along the northeastern and northwestern parts of the embayment (Sections 1, 2, 7, 16 18, 21; Figs. 36-39). Platform and basin facies rocks along the southwest part of the embayment are generally exposed only in widely separated outcrops.

Franklin Mountain transition facies can be divided into two belts, the first adjacent to the platform and the second adjacent to basin facies rocks. Sections 2 and 7 are from the first belt (Fig. 36). At these sections the basal 150-200 m are typical platform dolostone, and the upper 250-300 m consists of thin bedded silty dolostone (Fig. 37) with several very thick intervals (2-30 m) of massive dolostone. The second belt is recognized at Sections 1, 16, 18, and 21 (Figs. 38, 39). These sections are a complex interstratification of Rabbitkettle Formation (basin limestone), Franklin Mountain transition dolostone, massive thick bedded Franklin Mountain dolostone, and, in the northwestern embayment, dolomitic shale, shale and chert of the Duo Lake Formation.

Sections of transition facies are half to twice the thickness of equivalent platform dolostone successions but contain less than half the thickness of this dolostone. The transition zone is 20-40 km wide.

Unconformities are common above and below Franklin Mountain transition rocks. Platform dolostones of the younger Mount Kindle Formation rest unconformably on all Franklin Mountain transition sections along the northeastern flank of the embayment. However, at the northwest end of the embayment this relationship changes. There, the Cloudy Formation basin equivalent to the Mount Kindle overlies transitional Franklin Mountain facies. The Franklin Mountain transition rocks generally overlie the Sekwi Formation paraconformably except basinward of Sections 1

***FIGURE 37.*** *Thin bedded silty dolostones unique to transitional facies. Photo of transitional Franklin Mountain Formation, Section 2. Black beds are chert (GSC 199517).*

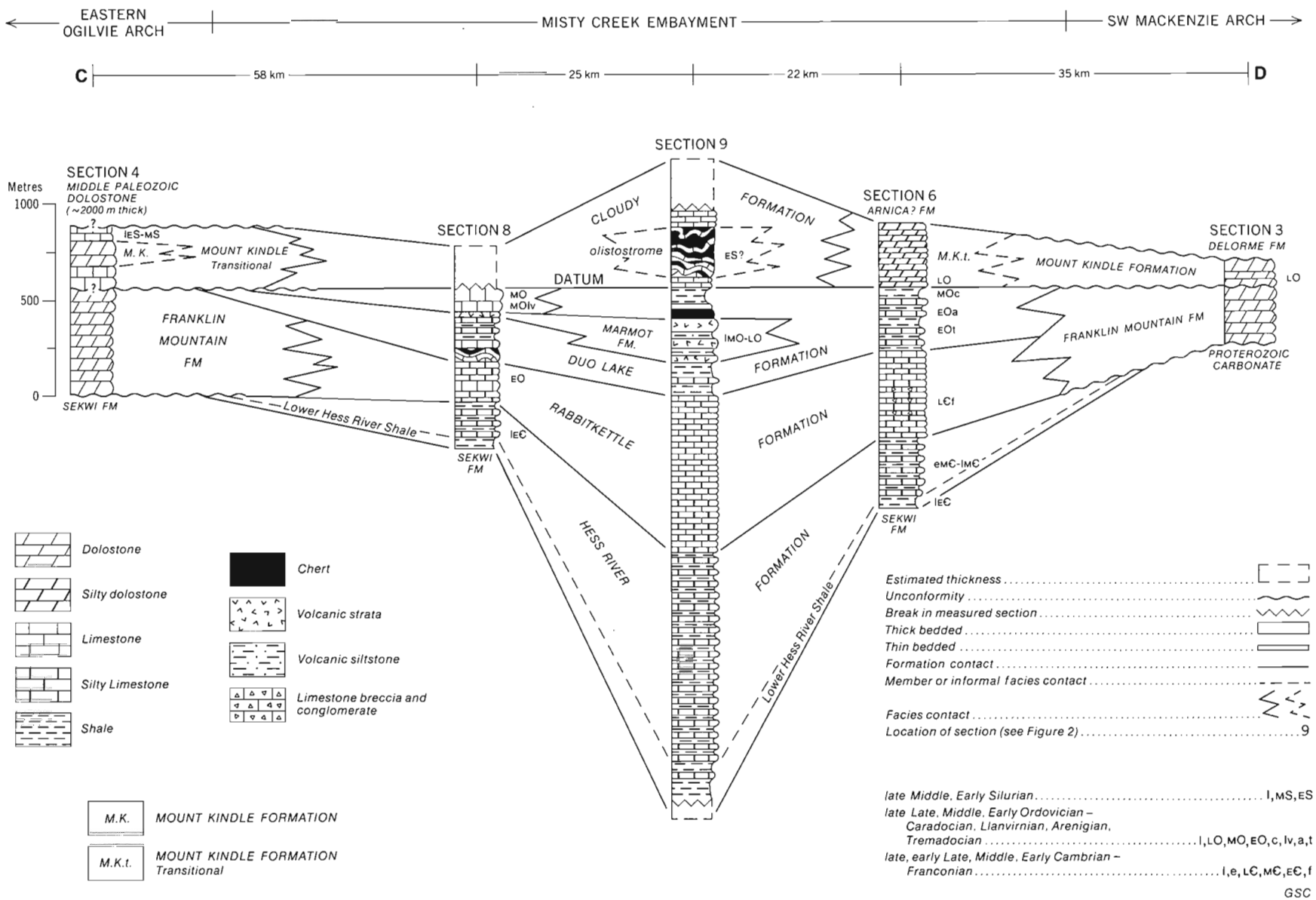


***FIGURE 38.*** *Stratigraphic cross-section C-D, central embayment, located on Figure 2. Section 6 contains transitional Mount Kindle dolostones and is the type locality for the Hess River and Duo Lake Formations. Section 9 is the thickest measured (axial) section. Section 8 includes a unit of massive Middle Ordovician limestones. Note sections are generalized - refer to Appendix I for detail.*

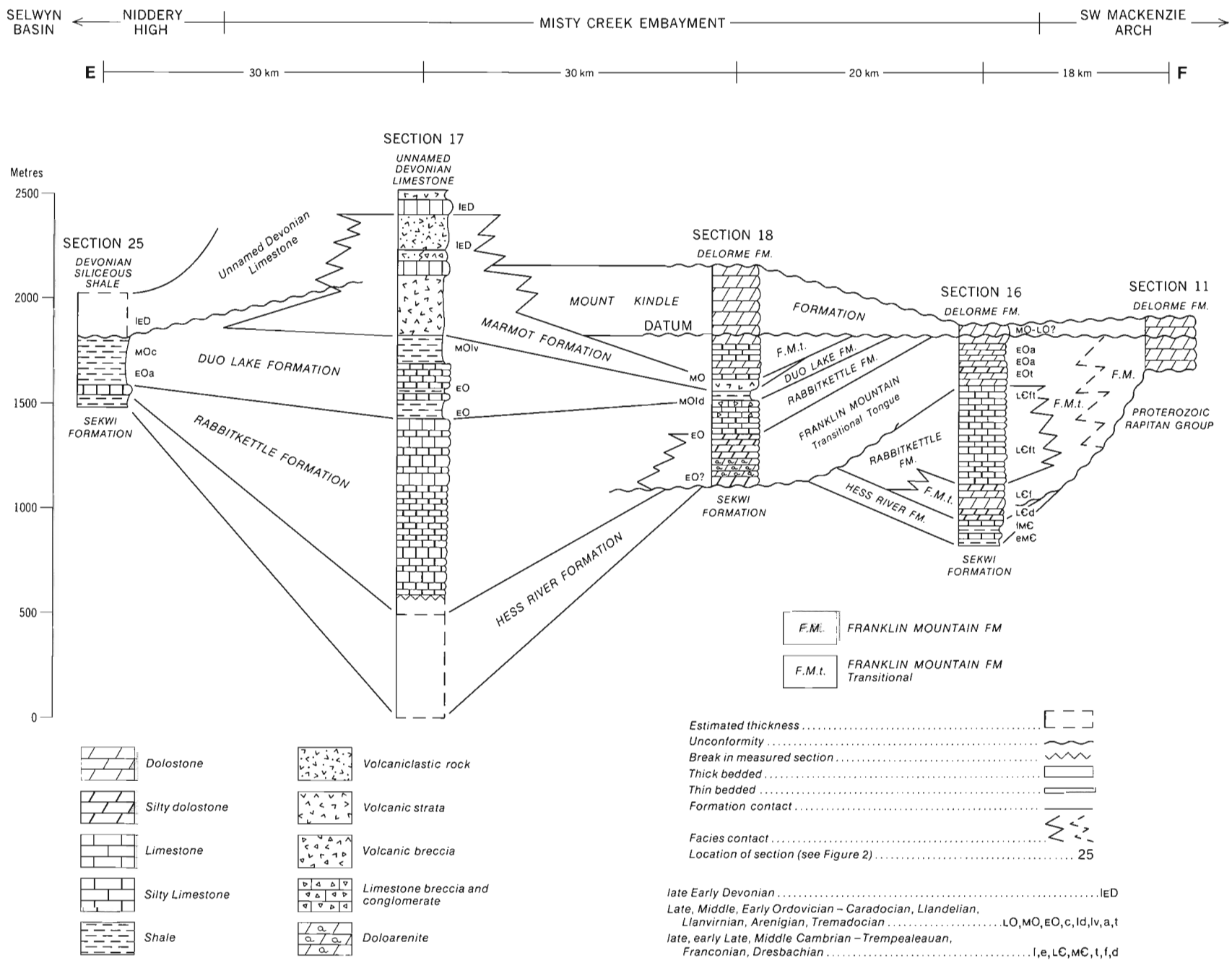


***FIGURE 39.*** *Stratigraphic cross-section E-F, southeast embayment, located on Figure 2. Sections 16 and 18 include transitional Franklin Mountain facies. Note all Middle and Late Cambrian strata are missing at Section 18 (see text on fault control of the embayment). Note sections are generalized - refer to Appendix I for detail.*

and 16 where they are conformable with thin successions of Middle Cambrian Hess River Formation. One basinward section (Section 18), however, is anomalous in that transitional Franklin Mountain facies of probable Early Ordovician age paraconformably overlie the Sekwi Formation (Fig. 39).

*Age and correlation*

Transitional Franklin Mountain dolostones range in age from Late Cambrian, Dresbachian to as young as Middle Ordovician, Caradocian (Sections 16, 18, Fritz, Norford and Tipnis, Appendix II).

Lower transitional Franklin Mountain dolostone is correlative with the preserved platform facies Franklin Mountain Formation, and the Rabbitkettle Formation in the embayment. The upper part, however, is partly correlative with the younger Duo Lake Formation in the embayment and Sunblood Formation south of 64° Latitude (Fig. 4).

***Middle Ordovician transition***

Middle Ordovician platform and transition facies are missing because of erosion or non-deposition around most of the embayment. In the northern embayment Franklin Mountain transition dolostone ranges in age through the Middle Ordovician (Llandeilian to Caradocian, Section 18) and Mount Kindle transition dolostones at Location 137 (Appendix II) are known to be as old as Caradocian (Fig. 6).

On the southwest side of the embayment an unnamed unit of Middle Ordovician limestone is interpreted as a tongue of transition facies (Section 8). This unit consists of 110+ m of massive grey weathering medium-crystalline limestone which conformably overlies the Duo Lake Formation (Figs. 1, 4a). This unit is dated as Llanvirnian to Llandeilian or younger (Fritz et al., Appendix II).

In the southeastern embayment area, Blusson (1971) has mapped the Middle Ordovician Sunblood Formation throughout the eastern Sekwi Mountain map-area. The Sunblood in this area is described as 500 m of thin bedded limestone and dolomitic limestone, with distinct units of dolostone in the upper and lower parts. This combination of lithologies is identical with Franklin Mountain or Mount Kindle transition zones. Consequently, it is probable that the Sunblood Formation in the Sekwi Mountain map-area is a Middle Ordovician transition facies. East of the Sekwi Mountain map-area Middle Ordovician rocks have been eroded prior to deposition of the Mount Kindle Formation (Gabrielse et al., 1973).

This evidence from within and adjacent to the embayment suggests the existence of a major Middle Ordovician transition belt and therefore implies a Middle Ordovician platform facies, of probably limited lateral extent, surrounded the embayment before sub-Mount Kindle erosion (Fig. 44).

***Mount Kindle transition***

Mount Kindle transition rocks were identified at Sections 2, 4, 6 and 15, and can be divided into three types (Figs. 36, 38). One type, represented in Section 4 involves a change from massive Mount Kindle dolostone to a transition unit of massive limestone in the lower and upper parts of the section (Fig. 38). Another type involves the appearance of a thin-bedded Mount Kindle transition dolostone unit dividing massive dolostone in part of Section 2 and completely replacing the Mount Kindle Formation in Section 6 (Figs. 36 and 38). A third type, Section 15, has a basal succession of thin-bedded Cloudy Formation limestone overlain by massive Mount Kindle dolostone.

Peculiar to Mount Kindle transition rocks in the northeastern embayment are isolated, large, lensing dolostone mounds. Two of these mounds are located in a succession of thin bedded, brown weathering transitional Mount Kindle dolostone 20 km north of Section 6 (Fig. 40). These mounds are several tens of metres thick and up to 300 m long and consist of white to grey, medium crystalline massive dolostone and dolostone breccia. The breccia consist of grey angular fragments suspended in a medium crystalline dolostone cement. Scattered silicified bryozoans, gastropods, solitary and colonial corals were found in the breccias.

Because most of the original carbonate fabric has been destroyed by recrystallization at least four models for mound development are viable - debris flows, mud mounds, algal growths, or chemical deposits (lithoherms). Lithoherms with epifauna are described off the Bahamian Platform by Gebelein (1974) and are interpreted as accumulations of carbonate precipitating from upwelling waters because of $CO_2$ loss.

Lensoid mounds similar to those at Location 137 were observed but not visited in cliff exposures of Mount Kindle and transitional Mount Kindle strata along the first northern branch of the Mountain River in the central 106 B map-area.

Mount Kindle transition facies are equivalent to the basin facies Cloudy Formation, and to the Mount Kindle and Whittaker Formations in platform facies.

The oldest Mount Kindle transition facies are those containing the mounds at Location 137 which have late Middle Ordovician (Caradocian) fauna. The basal Mount Kindle transition facies at Section 6 are Late Ordovician in age and at Section 4 transition limestone is overlain by dolostone with late Early Silurian to Middle Silurian fauna (Fritz et al., Appendix II).

***FIGURE 40.*** *Dolostone mound, centre, in thin bedded dark brownish grey dolostone of transitional Mount Kindle Formation Mound is about 3 m at thickest point. (Photo by J.D. Aitken, GSC 199525).*

## SEDIMENTATION, COMPOSITION AND PROVENANCE

Compositions of sedimentary rocks were determined through analysis of sixty thin sections; x-ray diffraction[1] of both whole rocks and light mineral residues, after solution of carbonates in acetic acid. Samples analyzed were from all stratigraphic units, and most measured sections. Samples were chosen to range over all stratigraphic levels (e.g. six thin sections from base to the top of one formation).

Limestone, silty limestone and dolostone, irrespective of formation are similar in terrigenous component types. Terrigenous components are predominantly quartz (90-99%), minor feldspar (trace to 5%), usually plagioclase, muscovite-illite (trace to 5%), chlorite (trace to 5%) and rarely biotite. Basin rocks are rich in pyrite (1-4%), carbon (1-2%) and hematite or limonite (up to 2%).

Vast areas of the Selwyn Basin and surrounding platform facies north to the Arctic coast and east beyond Great Bear Lake (Fig. 1b) are underlain by thick successions of Proterozoic sedimentary rocks. Numerous early Paleozoic erosional events affected vast areas of the platform (e.g. sub-Franklin Mountain and sub-Mount Kindle, Norford and Macqueen, 1975). The sub-Franklin Mountain event produced extensive erosion of Proterozoic and Lower Cambrian strata on the Mackenzie and probably the Ogilvie Archs. Thus the most likely source of abundant quartz in the terrigenous component is the multiple-reworking of these older sedimentary strata.

Some of the feldspars, chlorite, and micas may have been derived from older sedimentary terrain. However the association of basin strata with volcanic rocks containing plagioclase, chlorite, and biotite-phlogopite, indicates a volcanic component. Goodfellow, Jonasson and Cecile (1980a, b) note that chemical analysis of Hess River and Duo Lake shales (at Section 6, Fig. 41) show high $TiO_2$, $Na_2O$ and MgO values and indicate a volcanic component in the chemistry of these rocks.

The Hess River flysch is derived from older sedimentary rocks. Large clasts in this unit are quartz, siltstone, shale, limestone, and dolostone. The source area for these rocks is not known, however paleocurrents and abundance of terrigenous material in Middle Cambrian strata mapped northwest of the embayment in the Richardson Mountains (see legend of Norris, 1975) suggest a source area from that general direction.

In nearly all the platform dolostone, and the majority of basin rocks, the carbonate component has recrystallized, destroying or obscuring primary textures. However, in basin strata, remnant textures and sedimentary structures suggest that most of this crystalline carbonate was deposited in alternating beds of silt and mud-size[2] sediments. Carbonates containing terrigenous silt may be ripple laminated, laminated, or lie above scoured surfaces, and have rarely preserved silt-size carbonate grains. These types of mechanically produced sedimentary structures indicate that much of the carbonate was originally of silt or fine sand size. Basin carbonate rocks tend to be dominated by calcite, and dolomite is present in minor units, beds or as part of the total carbonate component in a rock.

Sedimentary structures and presence of silt size-carbonate grains indicate widespread mechanical transport of the carbonates. Materials for these rocks probably were derived through current erosion of both shallow water platform carbonates and adjacent transition or basin facies. Slope breccias at Section 6 are an example of a basin facies-derived clastic carbonate component.

Basin facies strata at Section 6 were continuously sampled over 50-100 cm intervals, grouped into single samples covering stratigraphic intervals of up to 100 m, and chemically analyzed (Fig. 41). The results and methods of these analyses are discussed at length in Goodfellow, Jonasson and Cecile (1980a, b). Some of their conclusions are: 1) major element abundances reflect stratigraphic division, but show high silica content to the basal Hess River Formation which was not noted in the field; 2) a volcanic component was detected in the Hess River and Duo Lake Formations (see previous discussion); 3) carbonaceous shales and cherts in the Hess River and Duo Lake Formations have anomalous contents of Zn, Cu, Ni, Ag, Mo, As, Hg, Sb and V; 4) a phosphate anomaly was identified in the Hess River Formation and high Ba values were found in a number of samples.

## IMPLICATIONS FOR REGIONAL EARLY PALEOZOIC PALEOGEOGRAPHY

Paleogeographic reconstructions of Lower Paleozoic rocks in the northern Canadian Cordillera have been given by Norford, 1964; Gabrielse, 1967; Ziegler, 1969; Douglas et al., 1970; and Lenz, 1972. Figures 42 to 44 are paleogeographic maps based on these reconstructions with modifications to include the Misty Creek Embayment, to incorporate Middle Cambrian and Middle Ordovician carbonate facies - predicted by studies in the embayment, and to incorporate data from more recent Geological Survey of Canada maps such as those referenced in Figure 1.

Persistent, early Paleozoic tectonic features, identified by many workers in the northern Cordillera, are shown in Figure 42. The Richardson Trough is a "more or less linear north-northwest-southeast-trending trough" of "at least Late Cambrian to Early Devonian" age coincident with the present Richardson Mountains (Lenz, 1972, p. 329). The Mackenzie Arch is a positive feature on which Franklin Mountain, in the north, and correlative Broken Skull Formation, in the south rest unconformably on middle to late Proterozoic and Lower Cambrian strata (Aitken et al., 1973; maps of Gabrielse et al., 1973). The Ogilvie Arch is an east-west trending positive feature over which Ordovician-Silurian carbonates rest unconformably on Proterozoic and Lower Cambrian rocks (Gabrielse, 1967; maps of Green, 1972). Most fossils collected from the carbonate unit on the Ogilvie Arch range from Late Ordovician to Early Silurian, with some occurrences of older Ordovician fauna (Unit 8 of Green, 1972). Most of the erosion on the Ogilvie Arch is post-Lower Cambrian and pre-Late Silurian. The Blackstone Trough, as defined by Lenz (1972), is an east-west trending depression which developed in late Early to early Middle Ordovician and continued through to the Late Silurian or Early Devonian. The trough was filled with shale, calcareous shale, basin limestone and rare chert and siliceous shale. The Kechika Trough is a basin area beween the Cassiar and Macdonald Platforms (Douglas et al., 1970). The Selwyn Basin is a large area of lower and middle Paleozoic basin facies that overlie thick successions of Proterozoic sedimentary rocks (Gabrielse, 1967; Blusson, 1976). Basin facies include limestone, shale, siltstone and major chert facies. The Cassiar Platform is a belt of strata in which basin facies are interstratified with a lower Paleozoic and a major middle Paleozoic succession of shallow water carbonates, deposited west of the Kechika Trough in a narrow, north trending belt (Gabrielse, 1967; Tempelman-Kluit, 1977). Tempelman-Kluit (1977) shows in his illustration (Fig. 45.2) that the middle Paleozoic carbonates developed on top of thick lower Paleozoic volcanic rocks. Cecile (1979) speculated that the carbonates may have developed on a basement ridge similar to that which underlies Mesozoic carbonate buildups along

[1] X-ray diffraction and mineral identification by G.P. Michael, Geological Survey of Canada, Calgary.

[2] Size ranges used here are identical with those of terrigenous clastic rocks.

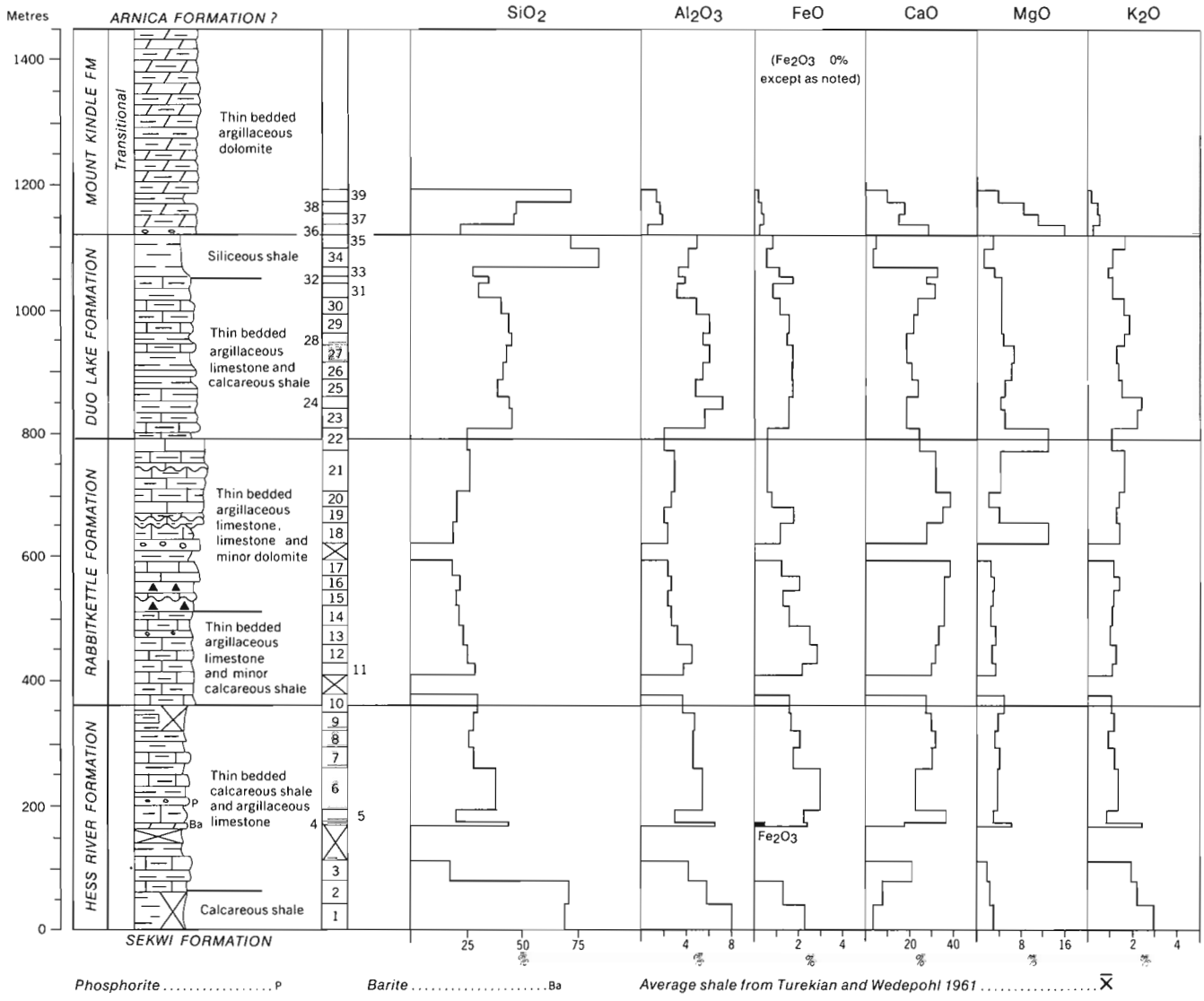


***FIGURE 41.*** *Variations in major and minor elements, Section 6. See Appendix I for legend. Procedures and analytical methods are described in Goodfellow, Jonasson and Cecile, 1980a, p. 155.*

the edge of the present day eastern North American shelf (see Emery et al., 1970). The Mackenzie Platform (Lenz, 1972) and Macdonald Platform (Gabrielse, 1967) are areas dominated by extensive lower Paleozoic shallow water strata. The Tintina Fault is a young strike-slip structure that has dextral offsets of 450 km (Tempelman-Kluit, 1979). Basin facies rocks similar to those in the Selwyn Basin are widespread southwest of this fault. Small or short lived features such as the Twitya Uplift (Cook and Aitken, 1978) are not included here.

The paleogeographic reconstructions of Lenz (1972) are the most detailed and cover only the Yukon and adjacent Northwest Territories. Two features interpreted by Lenz the "Bonnet Plume High" and a shale connection between the Richardson Trough and the northwestern Misty Creek Embayment, are modified by recent evidence.

The "Bonnet Plume High" is described by Lenz (1972, p. 327-328) as a positive structural feature ". . . coincident with the Knorr Range and its southern extension into the Wernecke Mountains" and ". . . was emergent from at least Early Ordovician to Early Siegenian and again from late Emsian to Givetian". Lenz's identification of this feature is controlled by a single section (his Section 20) located in the Knorr Ranges, at the northern tip of this positive feature. Norris (1977, p. 9 and 11) reports "the discovery by W.H. Fritz (pers. comm., 1973) of graptolites in shale and chert on the east flank of the Knorr Range of Middle Ordovician to Early Silurian age (B.S. Norford, pers. comm., 1973)" and ". . . which suggest that this feature was inundated for a longer part of the early Paleozoic than was originally surmised . .". The southern half of the "Bonnet Plume High" includes a large 60 km long belt of lower and middle Paleozoic platform carbonates, that outcrops along the axis of Lenz's high. Section 4, measured in this belt, consists of both the Late Cambrian to Early Ordovician Franklin Mountain Formation and the Late Ordovician to Early Silurian Mount Kindle Formation, and is overlain by more than 2000 m of Siluro-Devonian carbonates. These data suggest that the "Bonnet Plume High" is restricted to the area of Lenz's Section 20 and as interpreted by Norris (1977, p. 11) is more likely "just one of several intermittently positive, fault-bounded masses within the Richardson

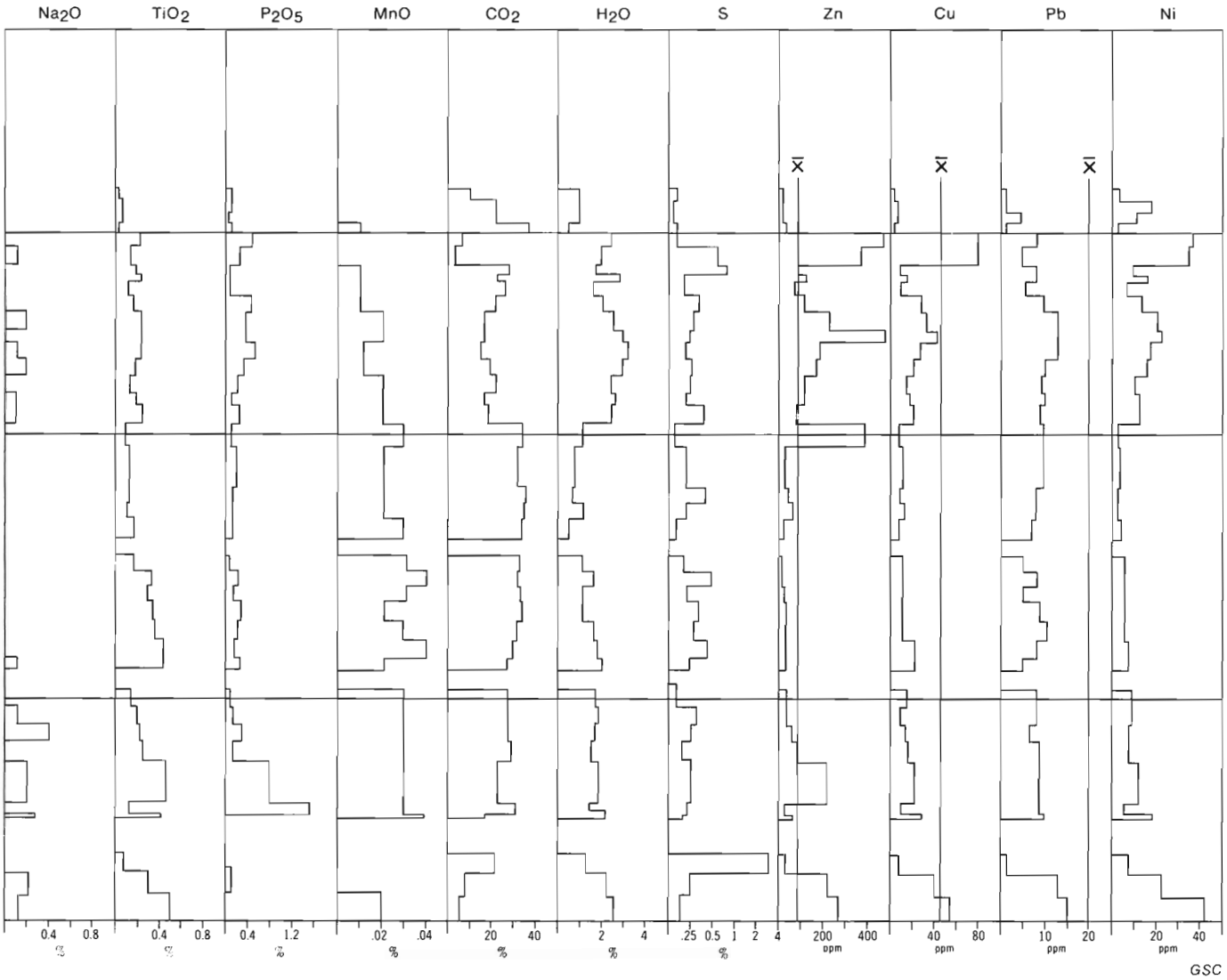


***FIGURE 41.*** *(cont.)*

Anticlinorium". The Richardson Trough is a sedimentary basin of similar age, geometry, (Fig. 42) and stratigraphy to the Misty Creek Embayment. Lenz (1972) and Ziegler (1969) in various Ordovician reconstructions show a 'shale' connection between the Richardson Trough and the northwestern Misty Creek Embayment. Norris (1977, p. 11) postulates that if a "variably shallow and deep seaway", in the position of the [Mesozoic-Tertiary] Bonnet Plume Basin connected the Richardson Trough with the Selwyn Basin, the connection would be similar to that shown by Lenz and Ziegler. However, the presently mapped distribution of lower Paleozoic platform carbonates around the northwestern embayment and west along the Ogilvie Arch suggests that the existence of any connection is unlikely (Fig. 1). Both Franklin Mountain and Mount Kindle Formation dolostone can be traced around the northwest embayment with the exception of a gap 10 to 20 km wide near the valley of the Snake River where no Lower Paleozoic rocks are preserved. Any deep connecting seaway had to be less than 10 km wide and so it is unlikely that there was one. Certainly, however, the Richardson Trough, Misty Creek Embayment and Selwyn Basin were connected by a shallow sea across a broad carbonate platform.

## EXTENSION ORIGIN FOR THE MISTY CREEK EMBAYMENT

The facies distribution, geometry, and volcanism indicate an extensional fault origin for the Misty Creek Embayment. The narrow facies transition zones are interpreted as controlled by conjugate northwest and northeast trending faults because of their linearly persistent nature (Fig. 1). However, with one possible exception, growth faults, or stratigraphic anomalies, suggesting faults, were not observed. The exception is in the outer Franklin Mountain transition zone at Section 18 where Early Ordovician Franklin Mountain transition dolostone rests directly on Lower Cambrian Sekwi Formation whereas just 30 km northwest in the same transition belt, there is a continuous section of Middle Cambrian Hess River strata (Section 16) overlying the Sekwi Formation (Fig. 39). This implies that an isolated fault?? block of unknown scale stood high during Middle and probably Late Cambrian. The Early Ordovician age at the base of Section 18 is established from two float collections reported by Fritz (1976). There float samples are from Franklin Mountain transition strata which could be as old as Late Cambrian (Fig. 6). Considering the monotony and similarity within basin facies units, the

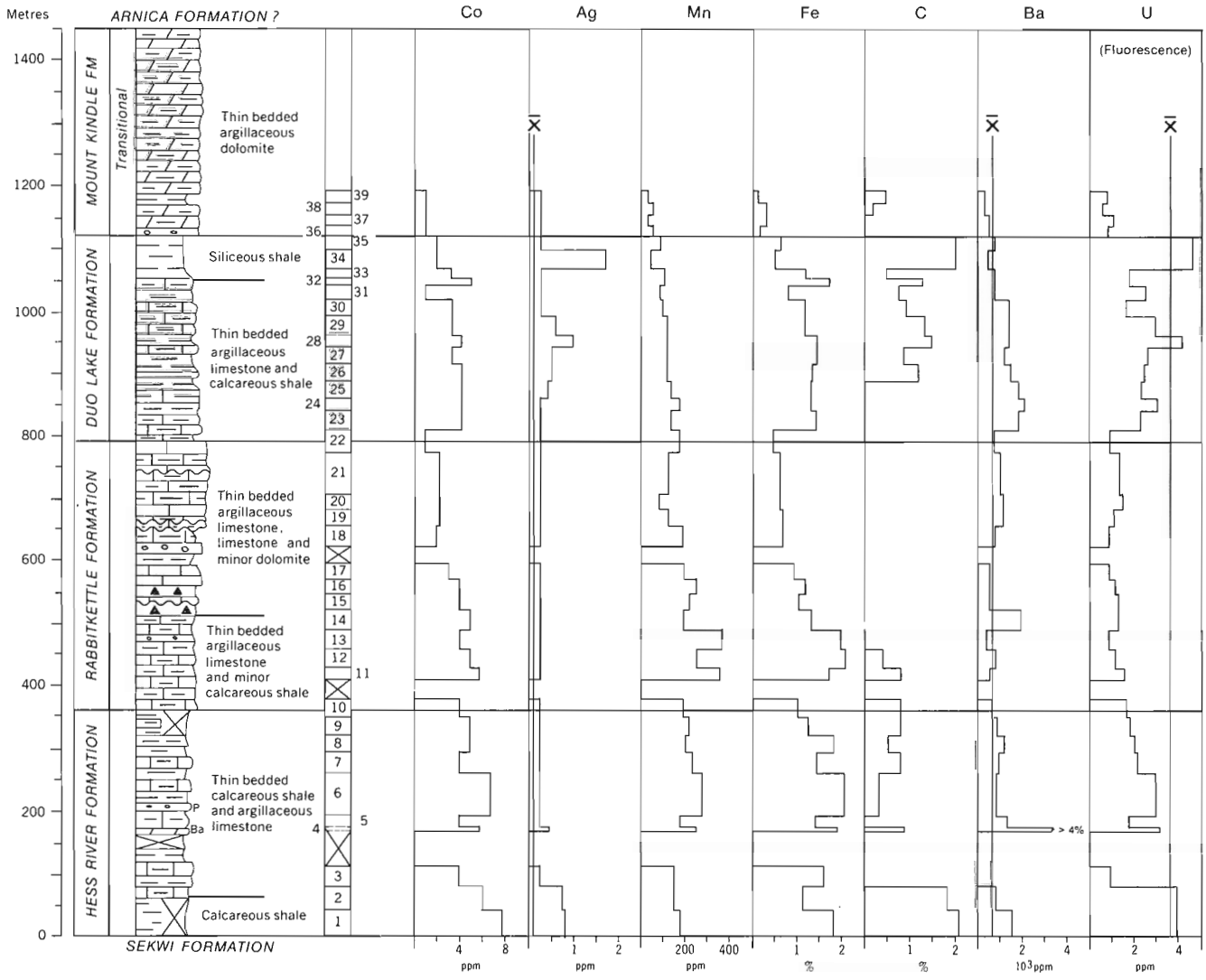


*FIGURE 41. (cont.)*

complexity of the transition zone, where growth faults are most likely located, and parallelism of post-Jurassic faults to the orientation of potential growth faults, non-recognition, at the scale of this study, is not surprising. Extensional faults of Cambrian age, with displacement in excess of 500 m, have been recognized in northeastern British Columbia (Taylor et al., 1979).

The geometry and scale of the embayment compare with segments of the east African rift system. The Kenya rift, is described by Baker, Crossley and Goles (1977), as a 68 km-wide graben with a length of about 120 km flanked by fault escarpments as high as 1500 m on the west and 200-500 m on the east, the rift floor slopes from north to south (900 m change in elevation along the rift). The Misty Creek Embayment is 70-80 km wide, 150 km long and has a 300-500 m thickness of Lower Paleozoic rocks on the flanks, including thin basin strata at the junction with the Selwyn Basin, compared with up to 3000 m in the embayment axis. Embayment centre paleocurrents are parallel to and directed southeast along the basin axis.

The presence of lower Paleozoic basalt, which preliminary analyses suggest are alkalic, also suggests an extensional origin. Alkalic basalts are typically associated with continental areas and mid-oceanic islands, highly alkalic basalts with high $K_2O/Na_2O$ ratios are associated with tectonically stable areas or areas affected by large scale rifting (Verhoogen et al., 1970). The Marmot basalts have low silica values and low iron to magnesium ratios. In the field, the basalts commonly have phenocrysts of biotite-phlogopite, and show a limited range in composition. The presence of biotite-phlogopite phenocrysts suggests further analysis will show the basalts to be strongly alkalic. The mica phenocrysts are usually fresh, euhedral to subhedral, and located in fine grained matrices of flows, sills or dykes. The phenocrysts vary in size (microcrystalline to 2 cm) between volcanic units but are only slightly variable in size within volcanic units. The micas occur in volcanic rocks of all ages and must be crystallizing from an original 'basalt' magma. Similar micas are abundant in igneous material of the Mountain diatreme.

On a regional scale (Fig. 42) the Misty Creek Embayment, the Niddery High, the Richardson Trough, and the Mackenzie and Ogilvie Archs can all be regarded as related basins and uplifts. In fact the size and geographic distribution of these features and of the embayment

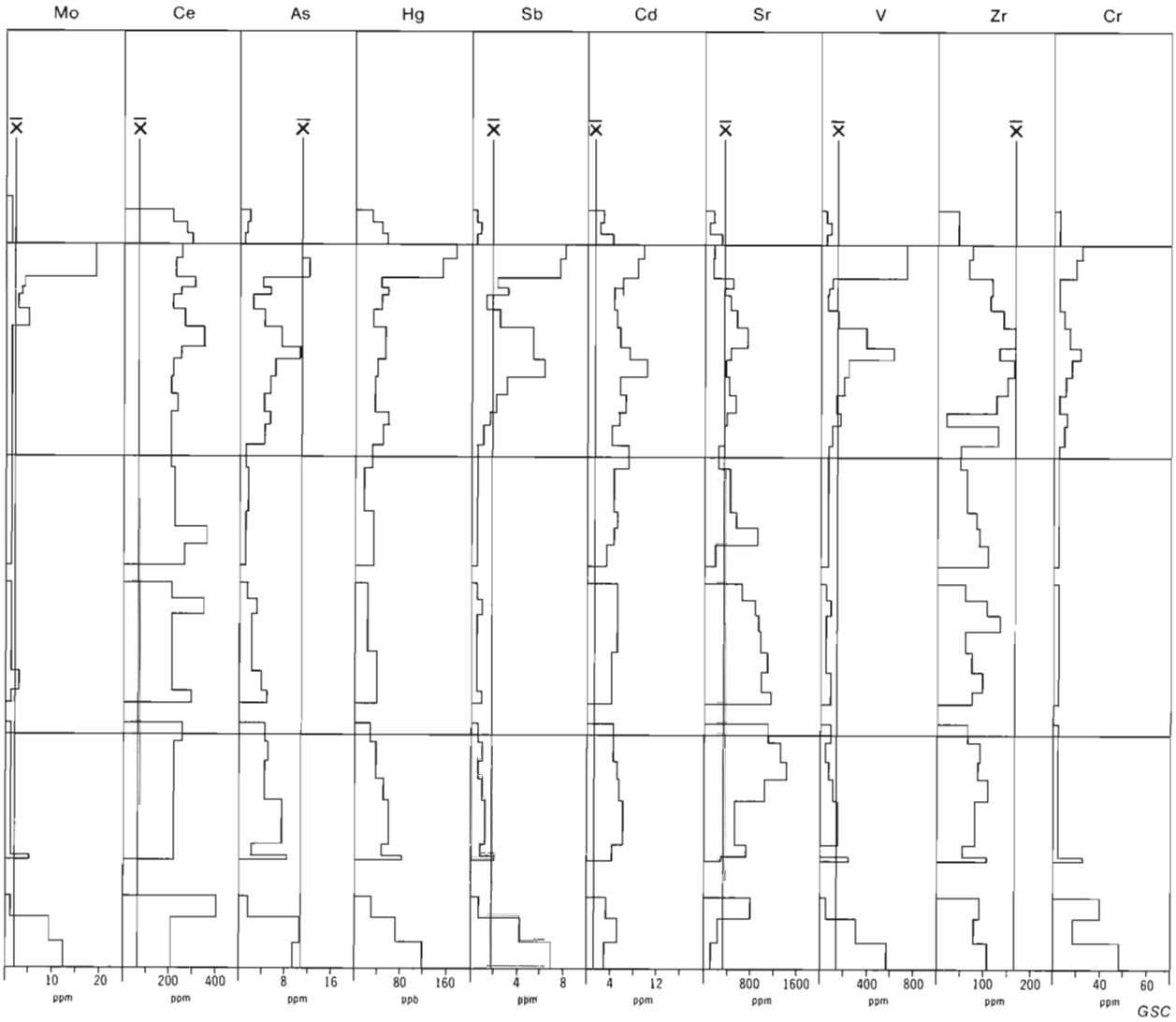


***FIGURE 41.*** *(cont.)*

compares with the broad, variously oriented, complex pattern of grabens, horsts and plateaux associated with the East African Rift Zone (cf. Brock, 1965, Fig. 12). The known ages of these tectonic features suggests that they all could have formed in post-Lower Cambrian and pre-Late Cambrian time. The Ogilvie, Mackenzie Arch and platform areas north and east of the embayment were also positive areas sometime during the Middle Ordovician.

## RECOMMENDATIONS FOR MINERAL AND HYDROCARBON EXPLORATION

The Selwyn Basin and adjacent carbonate platform comprise a significant base metal province. Mineral occurrences are well described by: Blusson (1978, 1976); Brock (1976); Carne (1979); Cecile and Morrow (1978); K.M. Dawson (1979, 1978, 1977, 1975); Dawson and Dick (1978); K.R. Dawson (1975); Gibbins et al. (1977); Harris (1977); Hewton (1977); Macqueen (1976); Macqueen and Thompson (1978); McLaren and Godwin (1979); Morganti (1977); Morin et al. (1977); Reeve (1977); Sangster and Lancaster (1976); and Tempelman-Kluit (1978).

Along the north and east margin of the Selwyn Basin these main occurrences are: Zn, Pb, Ag, Ba vein and stratiform hosted deposits; Ba, Zn, Pb, Ag shale-hosted deposits; and metasomatic tungsten associated with the intrusion of Cretaceous plutons into Paleozoic and Proterozoic strata.

In the Misty Creek Embayment area most mineral occurrences are base metal deposits in Proterozoic (Little Dal Formation), Lower Cambrian (Sekwi Formation), and Ordovician to Devonian (Mount Kindle, Delorme, Arnica, Landry Formations), all being secondary mineralization in platform carbonates. Just south of the embayment, in the Macmillan Pass area, are major Ba, Zn, Pb, Ag deposits hosted in Devonian shales, and two major tungsten skarn deposits (see Carne, 1979 and Dawson, 1978).

Mineral deposits in lower and middle Paleozoic carbonates around the embayment consist of stratabound and cross-cutting veins of coarse crystalline sphalerite, galena, barite and some fluorite.

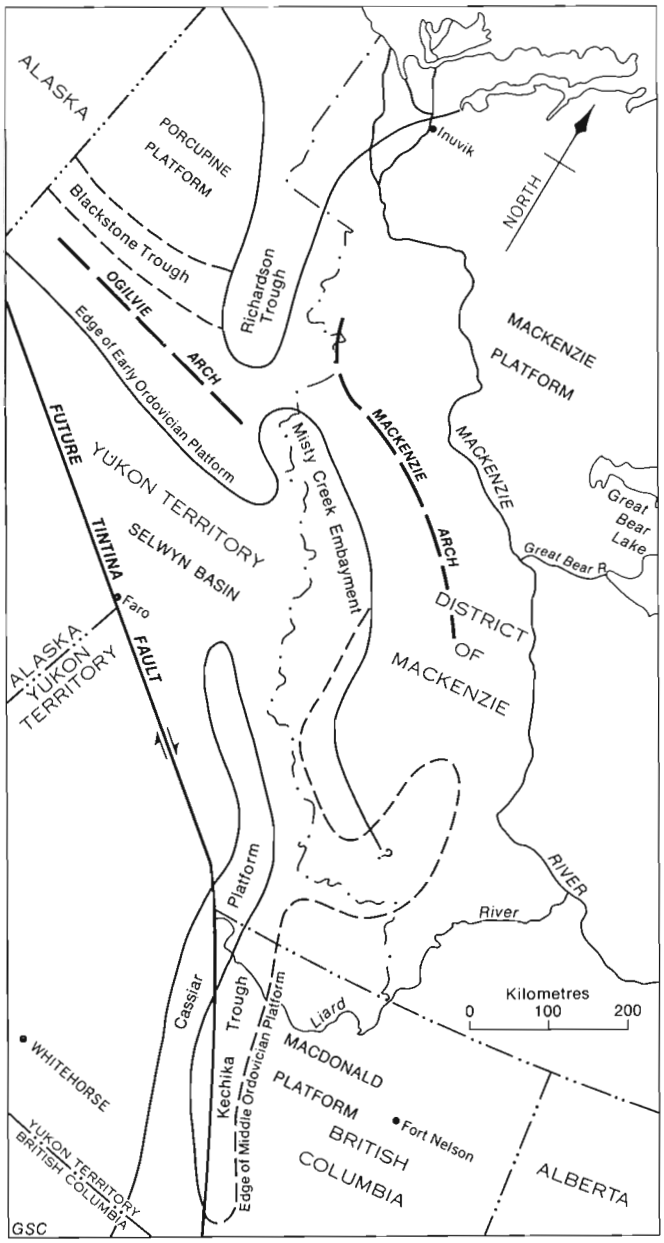


***FIGURE 42.*** *Persistent tectonic elements controlling lower Paleozoic facies distribution in the northern Cordillera allowing for 450 km strike-slip motion on the Tintina Fault. Data from Gabrielse (1967), Douglas et al. (1970), Lenz (1972), Aitken et al. (1973), Tempelman-Kluit (1979), Pugh (in prep.) and this paper. Other than the Tintina Fault no palinspastic reconstructions have been made.*

Major mineral occurrences in basin facies of the Misty Creek Embayment have not been reported. During this study small amounts of sphalerite were found in veins over a 10 m interval near the base of Section 18. Stratiform barite was identified in the Hess River, Duo and Cloudy Formations. Barite in the Hess River Formation was identified at Section 6 and consists of coarse crystalline beds and scattered crystals in silty limestone. The mineralized interval is 2 m thick and was traced over 1 km. Barite in the Duo Lake Formation consisted of a few coarse crystalline nodules in chert at Section 12. Barite in the Cloudy Formation was identified in the southeast 106 F map-area, traced for over 1 km and consists of large crystals scattered in a yellow limestone that directly overlies the Franklin Mountain Formation.

Small amounts of phosphorite were found in the middle Hess River Formation at Sections 6 and 25. Associated with the few centimetres of visible phosphorite at Section 6 are 97 m of phosphatic shale averaging 0.97 per cent $P_2O_5$.

The potential for major mineral occurrences in embayment basin facies is good. The embayment was a restricted basin of probable fault origin. Extensional growth faults and associated volcanism provided excellent physical conditions for circulation of metal leaching brines through older sediments or for introducing metals into the basin. The more argillaceous units are the best exploration targets. Carbonate-rich rocks derived their sediment from fringing platforms and these could easily dilute ore precipitates, whereas, argillaceous rocks, fed by sources cratonward of the fringing carbonates, the erosion of elevated carbonates facies, or distant volcanic islands, likely represent slow rates of deposition. Siliceous shales and cherts in the Hess River and Duo Lake Formations, which at Section 6 show anomalous metal values, are excellent exploration targets (Fig. 41). Shale similar in age to the Cloudy Formation and upper Duo Lake Formation on the Niddery High host large tonnages of stratiform lead-zinc deposits at Howards Pass southeast of the embayment (J.M. Morganti, pers. comm., 1979). Ore deposits in the Anvil Range near Ross River occur around the boundary of a western equivalent to the Rabbitkettle Formation and underlying phyllitic strata (D. Jennings, pers. comm., 1980).

Volcanic strata, especially in the embayment axis and at the Marmot complex, are also recommended exploration targets. Lower Paleozoic volcanic rocks 150 km southeast of the embayment are associated with massive base metal sulphide deposits (Dawson, 1979).

The similar age, geometry and stratigraphy of the Misty Creek Embayment and Richardson Trough suggest that the embayment may be an analogue for the Richardson Trough; from which subsurface facies relationships in the trough could be predicted. Transition zones along the Richardson Trough are deeply buried by younger strata in the Peel and Eagle Plains areas. Potential reservoirs in the embayment transition zone are vuggy and coarse crystalline dolostones interstratified with basin facies and Mount Kindle mounds and biostromes. Bitumens were commonly found in vugs of the Franklin Mountain and Mount Kindle Formations (Sections 11, 15, 16, Appendix I). Basin facies in the embayment are excellent source rocks with 1-2 per cent carbon in the Hess River and Duo Lake Formations (Fig. 41).

Only a few drill holes have penetrated into Lower Paleozoic rocks in the area of the Richardson Trough transition. Perhaps future economic conditions may create renewed interest in this belt.

## CONCLUSIONS

The Misty Creek Embayment was a long-lived lower Paleozoic basin surrounded by platform carbonate everywhere but in the southern embayment. In the south the embayment is separated from the Selwyn Basin by the Niddery High. The embayment was activated during late Early Cambrian to Middle Cambrian time by extensional faulting that resulted in a rectangular depression, with narrow linear transition belts. Further extension in Middle Ordovician time resulted in a major pulse of alkalic volcanism.

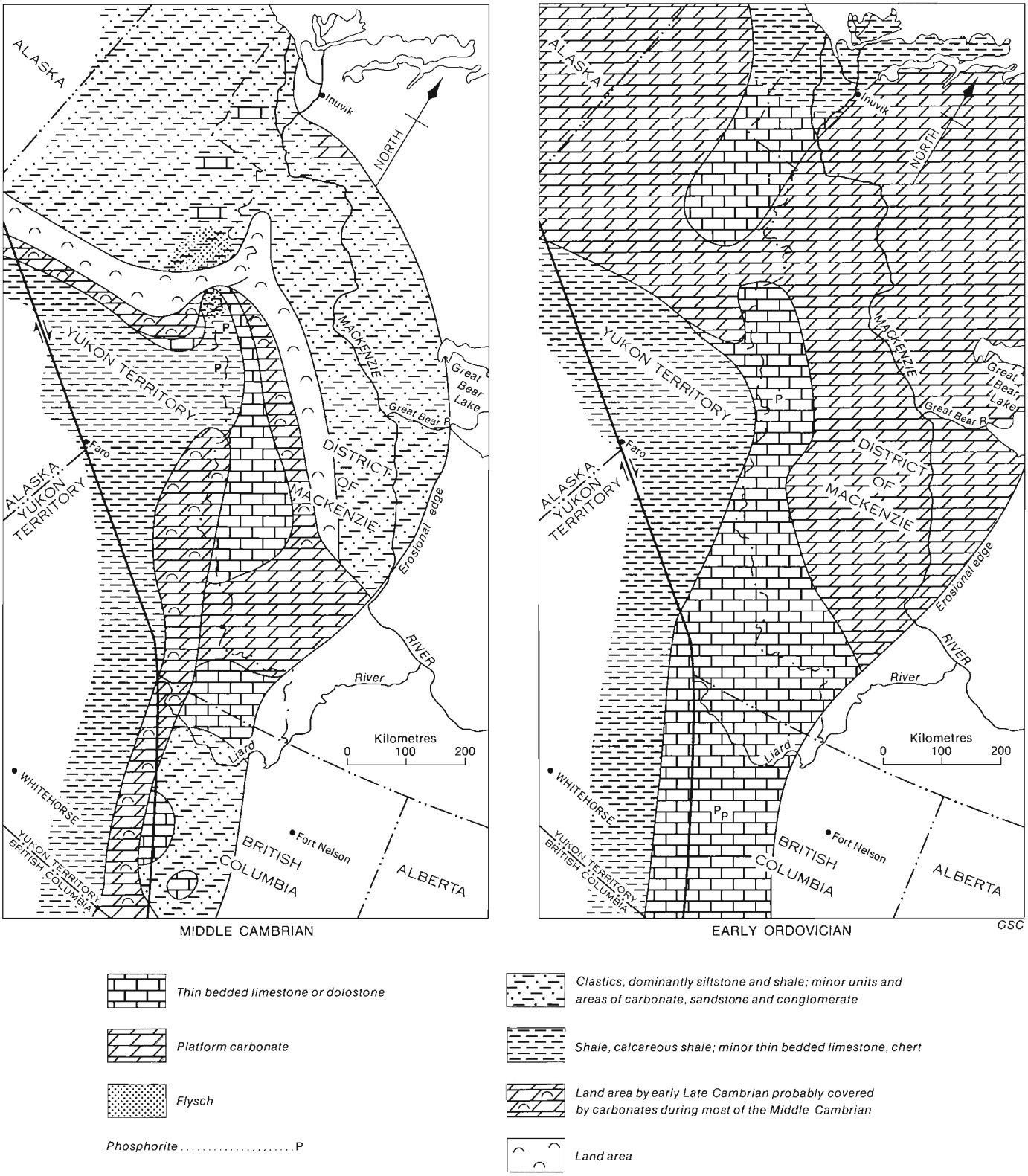


***FIGURE 43.*** *Middle Cambrian and Early Ordovician paleogeography. Reconstructions based on this paper, other reconstructions referred to in text, and Geological Survey of Canada reports and maps.*

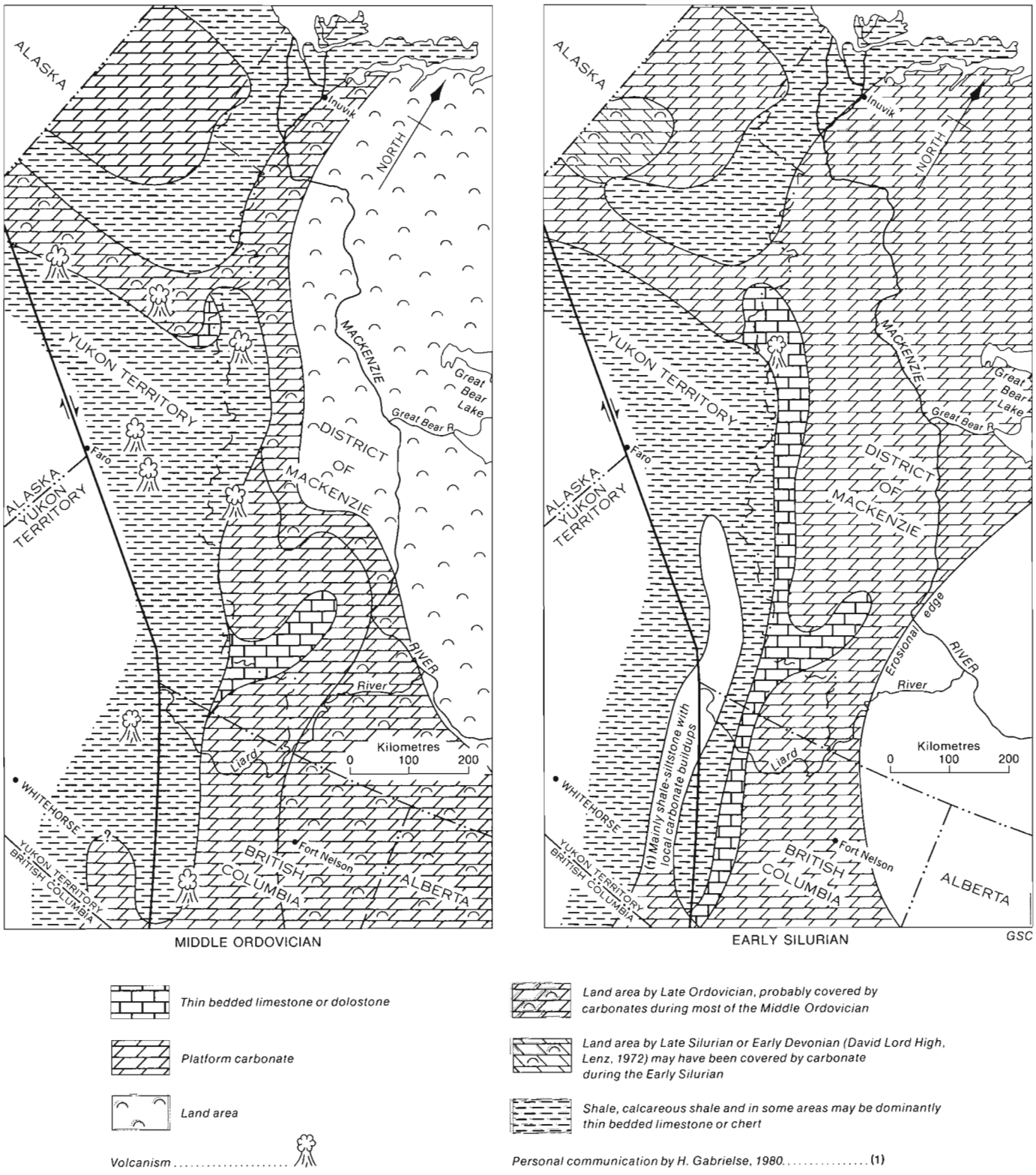


***FIGURE 44.*** *Middle Ordovician and Early Silurian paleogeography. Reconstructions based on this paper, other reconstructions referred to in text, and Geological Survey of Canada reports and maps.*

Strata within and around the embayment can be divided into platform, transition and basin facies. Platform strata are massive thick bedded dolostone of the Franklin Mountain and Mount Kindle Formations, interpreted as shallow water facies on the basis of remnant sedimentary textures and fauna. These platform units are Late Cambrian to Early Ordovician and Late Ordovician to Early Silurian in age. Late Ordovician to Early Silurian rocks show a moderate westward shift in the position of the embayment. Transition facies consist of intertongued platform, basin strata, and units of thin bedded silty dolostone. Linear transition belts 20-40 km wide separate platform and basin facies. Transition strata are Middle Cambrian to Early Silurian in age and indicate that some form of platform facies existed during Middle Cambrian and Middle Ordovician but have been eroded during sub-Late Cambrian and sub-Late Ordovician erosional events.

Basin strata in the embayment are deep water limestone, shale, chert and volcanic rocks which are divided into eight units, the Hess River (new), Rabbitkettle, Duo Lake (new), the Marmot (new), Cloudy (new) and Natla? Formations and two unnamed limestone units. Basin strata range in age from late Early Cambrian to late Early Devonian. In platform areas these units are equivalent to the Franklin Mountain, Mount Kindle and a variety of Silurian to Devonian carbonates as well as Middle Cambrian and Middle Ordovician erosional gaps.

Included with the Middle Cambrian Hess River Formation is a thick succession of quartz sandstone - shale flysch, the Hess River flysch, which is found only at the northwest end of the embayment and is interpreted as submarine fan deposits supplied by source areas to the northwest of the embayment.

Volcanic rocks (Marmot Formation) are Middle Ordovician to Early Devonian alkalic basalts found over most of the central embayment. Volcanic strata are generally thin accumulations of tuffs, flows and volcaniclastic sediments. Flows, sills and dykes contain mica phenocrysts which have crystallized from the 'basalt' magma and give evidence of the alkalic composition of these rocks. Anomalous thicknesses at one location coincide with the occurrence of several dykes, sills, coarse volcanic breccia, and volcanic conglomerates. These strata are interpreted as a shoaling centre of volcanism located in the central embayment area.

Basin strata are rich in quartz silt derived from erosion of older seidmentary strata. Small amounts of plagioclase, chlorite and mica, and high $TiO_2$, $Na_2O$, MgO values indicate a significant volcanic component in shale units.

In modified regional paleogeographic reconstructions around the embayment, the Bonnet Plume High of Lenz (1972) is restricted to a single location and connections between the Misty Creek Embayment and Richardson Trough are shown to be improbable.

Recommended mineral exploration targets are argillaceous basin strata of the Hess River and Duo Lake Formations which have anomalously high base metal and barium values, and volcanic strata which are mineralized southeast of the embayment.

The well exposed facies of the Misty Creek Embayment may be analogues for subsurface, potentially hydrocarbon-bearing, equivalent lower Paleozoic strata of the Richardson Trough. In the Misty Creek Embayment, source shales with up to 2 per cent carbon are in facies juxtaposition with potential carbonate reservoir rocks.

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## APPENDIX I

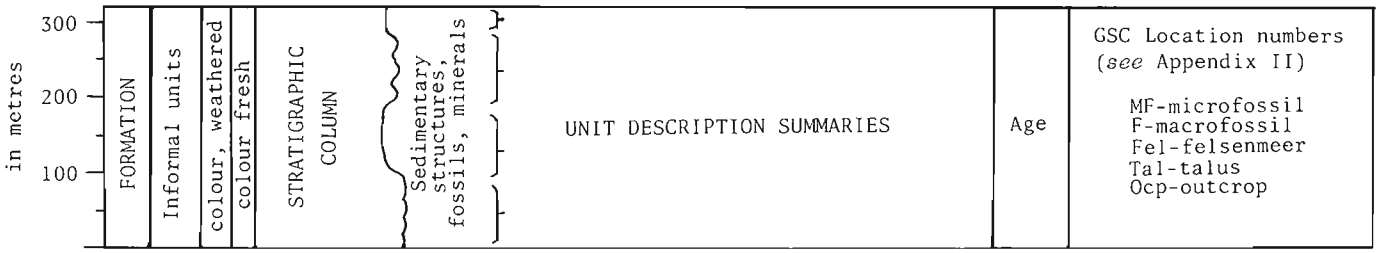
MEASURED SECTIONS

This appendix consists of twenty-five measured stratigraphic sections displayed in columnar form. All symbols, patterns and abbreviations are explained in Figure 45. Additional paleontologic data is given in Appendix II.

All sections were measured at surface using a Jacob staff. Sections 1 to 22 were measured in late June, July and early August, 1977. Sections 23 to 25 were measured in July, 1979.

## Legend to Appendix I

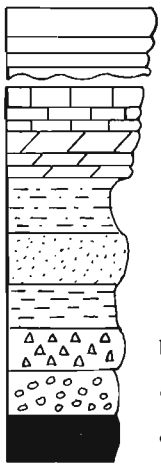
KEY TO COLUMNAR SECTIONS



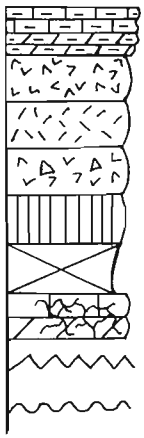

COLOUR SYMBOLS

BLACK
GREY
DARK GREY
YELLOW
ORANGE
GREEN
BROWN
RED

STRATIGRAPHIC COLUMN



thick to very thick bedded
very thin to medium bedded
wavy bedded
limestone
dolostone
siltstone
sandstone
shale
breccia
conglomerate
chert



silty or argillaceous limestone, dolostone
volcanic tuff
volcanic flow
volcanic breccia
volcanic sill
covered
carbonate with extensive veins
break in section
unconformity

AGE

E, M, L - Early, Middle, Late

e, l - early, late

Camb., Ord., Sil., Dev., Perm. - Cambrian, Ordovician, Silurian, Devonian, Permian

Dresb. - Dresbachian
Fran. - Franconian
Tremp. - Trempealeauan
Llanv. - Llanvirnian
Lland. - Llandeilian
Cara. - Caradocian
Ash. - Ashgillian
Lland. - Llandoverian

SYMBOLS

limestone nodules
breccia
slumped strata
nodules
chert nodules or discontinuous beds
cross-bedded
cross-laminated
vuggy
ooids
intraclasts
mud intraclasts
birdseye textured
stylolites
sparry
mudcracked

crinoid ossicles
stromatolites
stromatactis or stromatoporoids
colonial corals
solitary corals
hyolithes
cephalopods
gastropods
trilobites
sponge spicules
brachiopods
bryozoans
graptolites
bioturbation
fossil trails

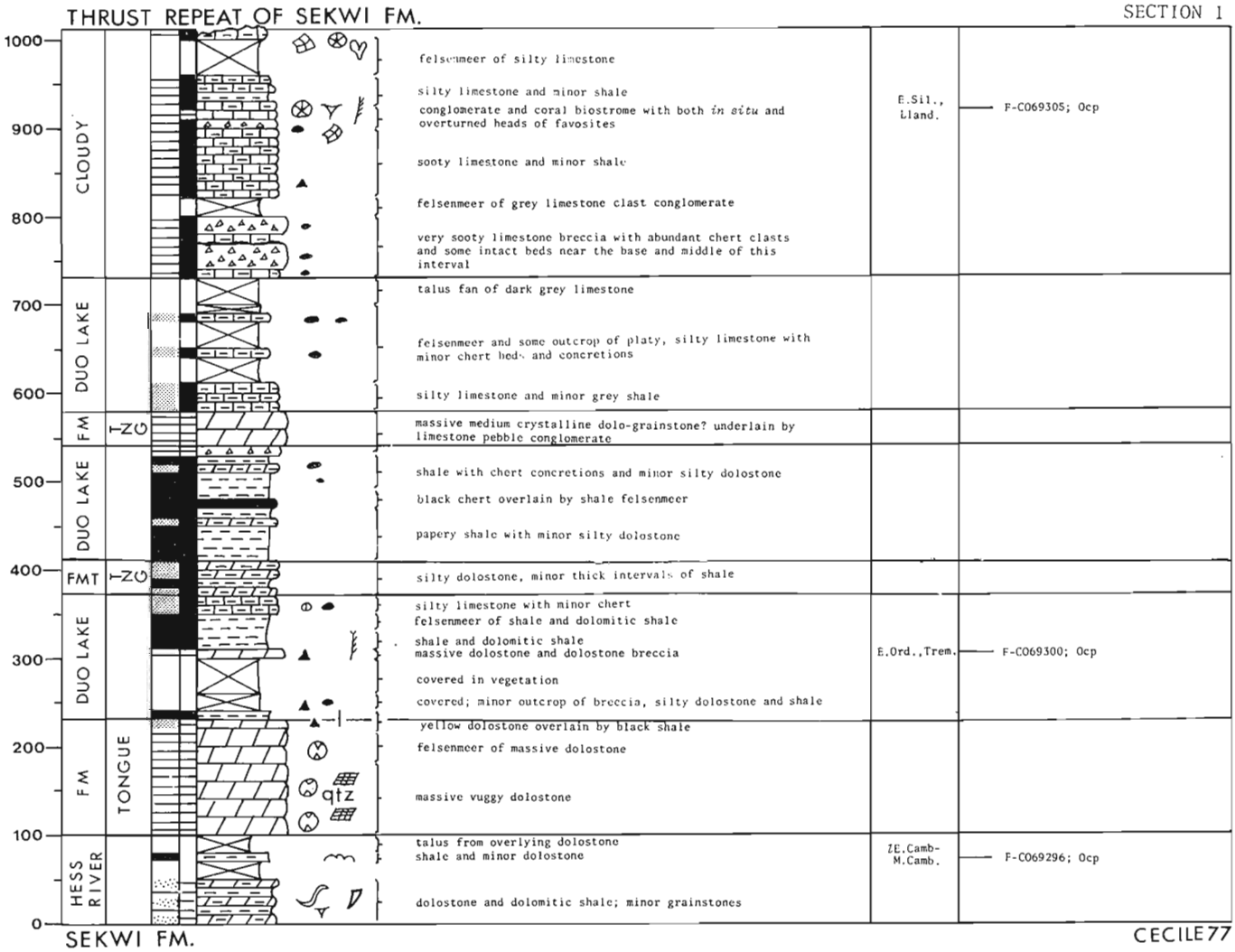
py - pyrite
ga - galena
zn - sphalerite
cu - malachite
p - phosphorite
ba - barite
hmt - hematite
lmt - Limonite
bt - bitumen
si - silicification
qtz - secondary quartz
l - laminated
il - irregular laminae
cx - coarse grained

STRATIGRAPHIC ABBREVIATIONS

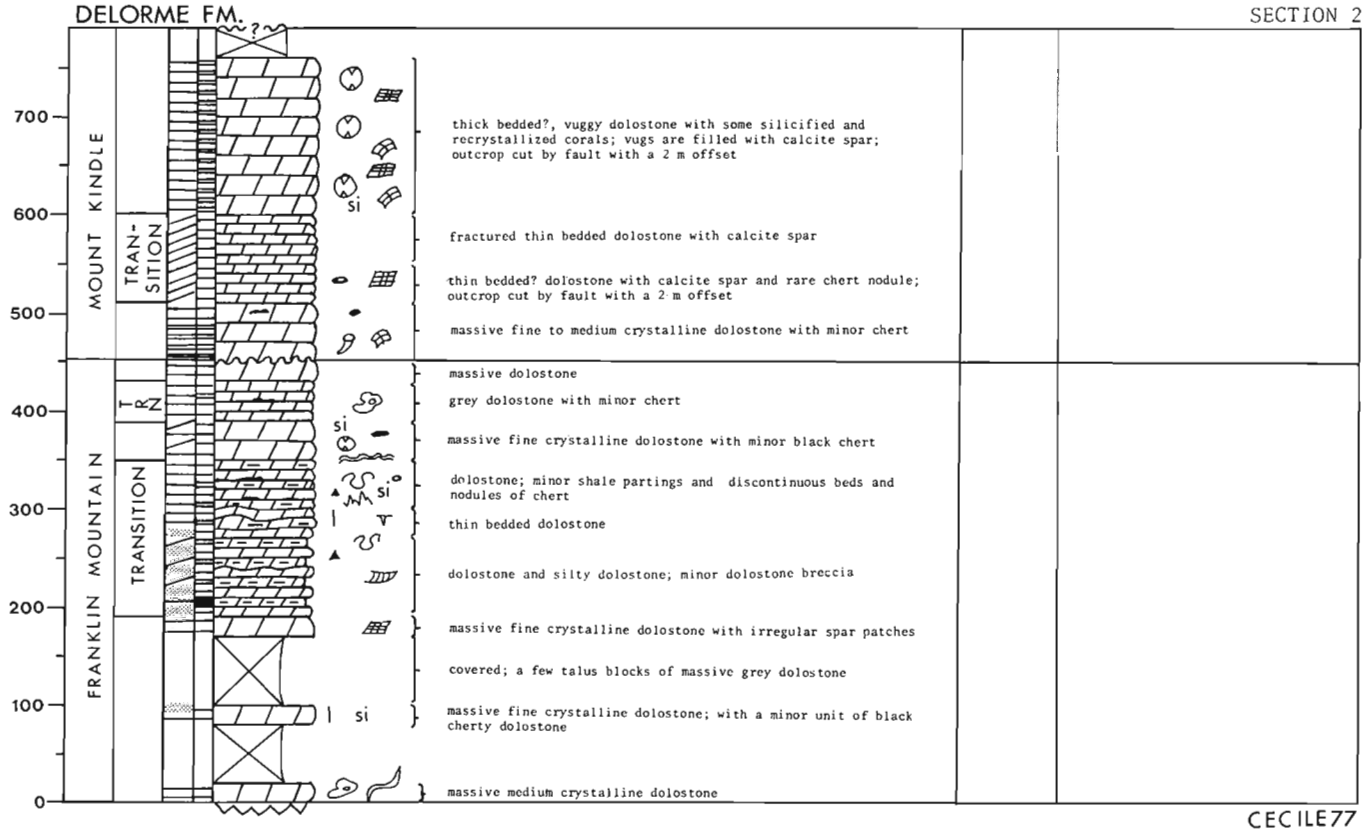
UMD - Unnamed
DLM - Delorme
FM - Franklin Mountain
FMT - Transitional Franklin Mountain
CDY - Cloudy
DL - Duo Lake
MRT - Marmot
RK - Rabbitkettle
HR - Hess River
TNG - Tongue
TRN - Transition facies

MPC

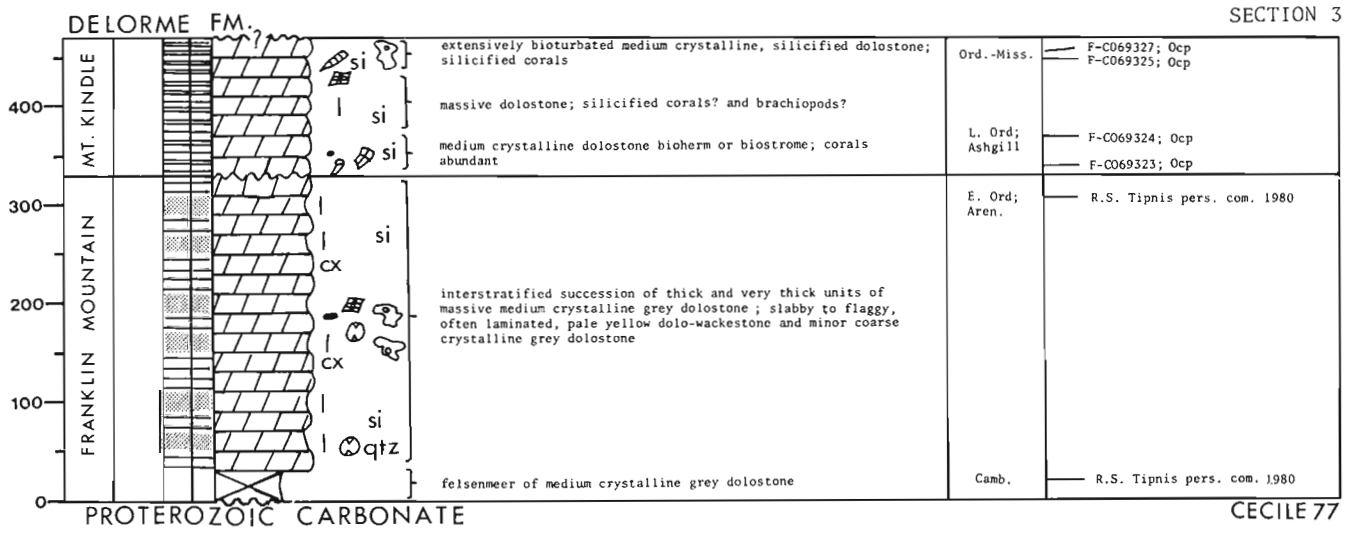
SECTION 1- Located in the southwest Upper Ramparts River map-area (106G); base at 65°02' Latitude, 131°46' Longitude, and top at 65°01' Latitude, 131°48' Longitude. Section was measured on a small mountain between two north-flowing tributaries of the Arctic Red River.



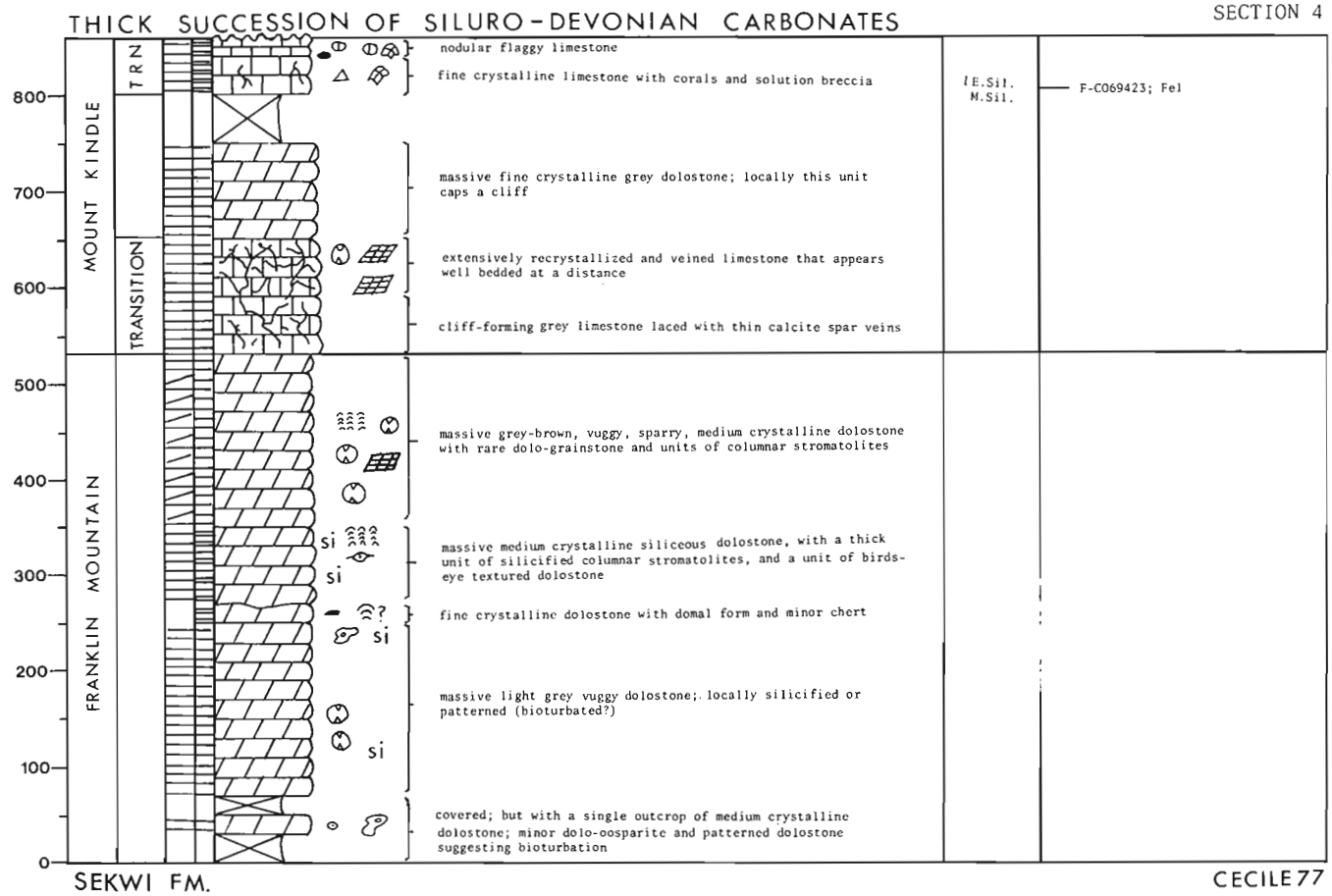
SECTION 2- Located in the southwest Upper Ramparts River map-area (106G); base at 65°07.5' Latitude, 131°30' Longitude, and top at 65°07.5' Latitude, 131°30' Longitude. Section was measured on the north side of an east-west ridge, south of a major tributary to the Arctic Red River.



SECTION 3- Located in the northeast Bonnet Plume Lake map-area (106B); base at 64°56.5' Latitude and 130°16' Longitude and top at 64°55.5' Latitude, 130°18' Longitude. Section was measured northeast of a 7500' peak, 4 km south of Gayna River.

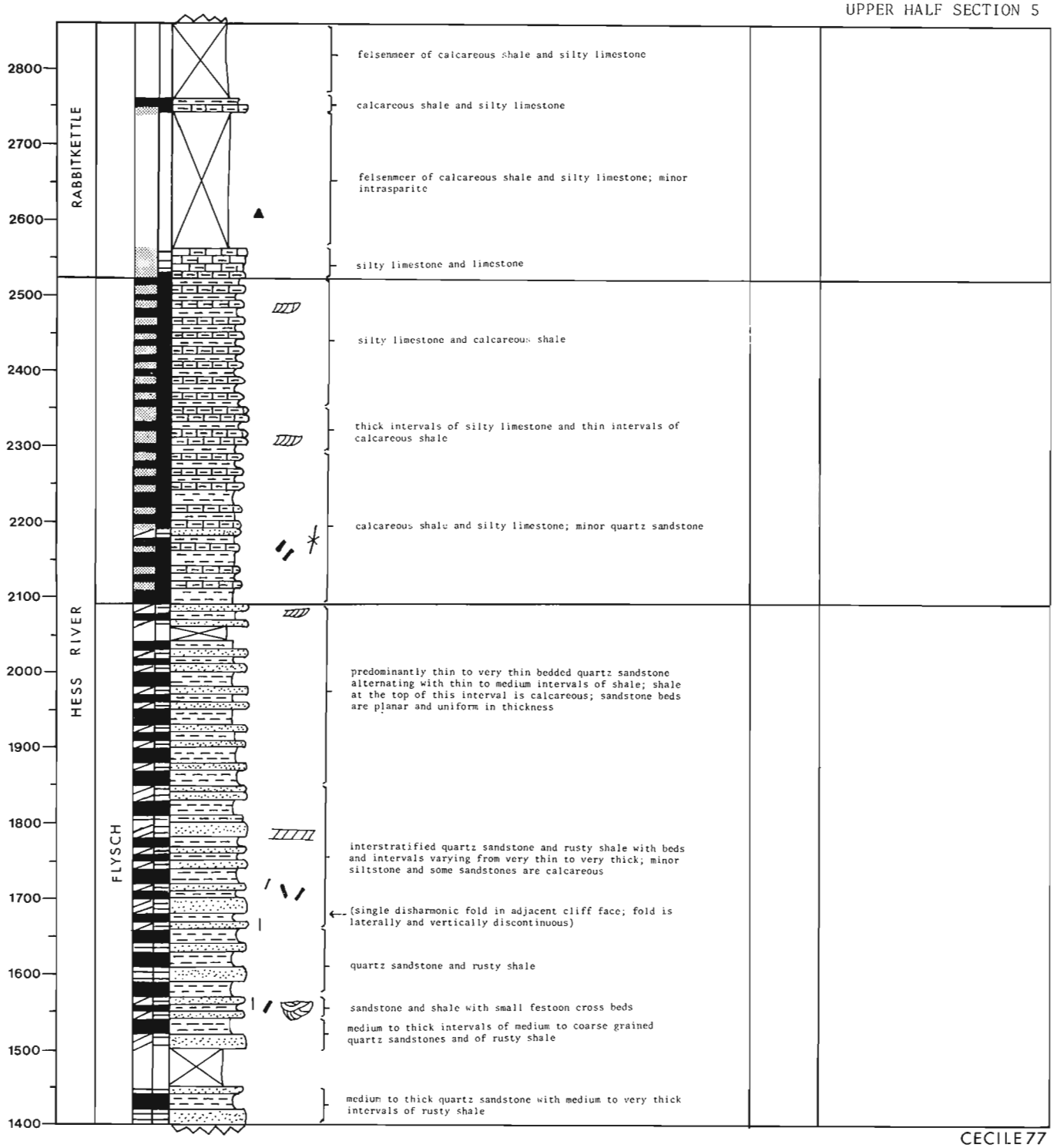



SECTION 4- Located in the northeast Nadaleen River map-area (106C); base at 64°39' Latitude, 132°50' Longitude and top at 64°39' Latitude, 132°46' Longitude. Section was measured along the valley floor of an east-west headwaters tributary to Corn Creek, 8 km south of Mount Macdonald.



SECTION 5- Located in the northwest Bonnet Plume Lake map-area (106B); base at 64°43.5' Latitude, 131°39' Longitude, and top at 64°43' Latitude and 131°43' Longitude.

UPPER HALF SECTION 5

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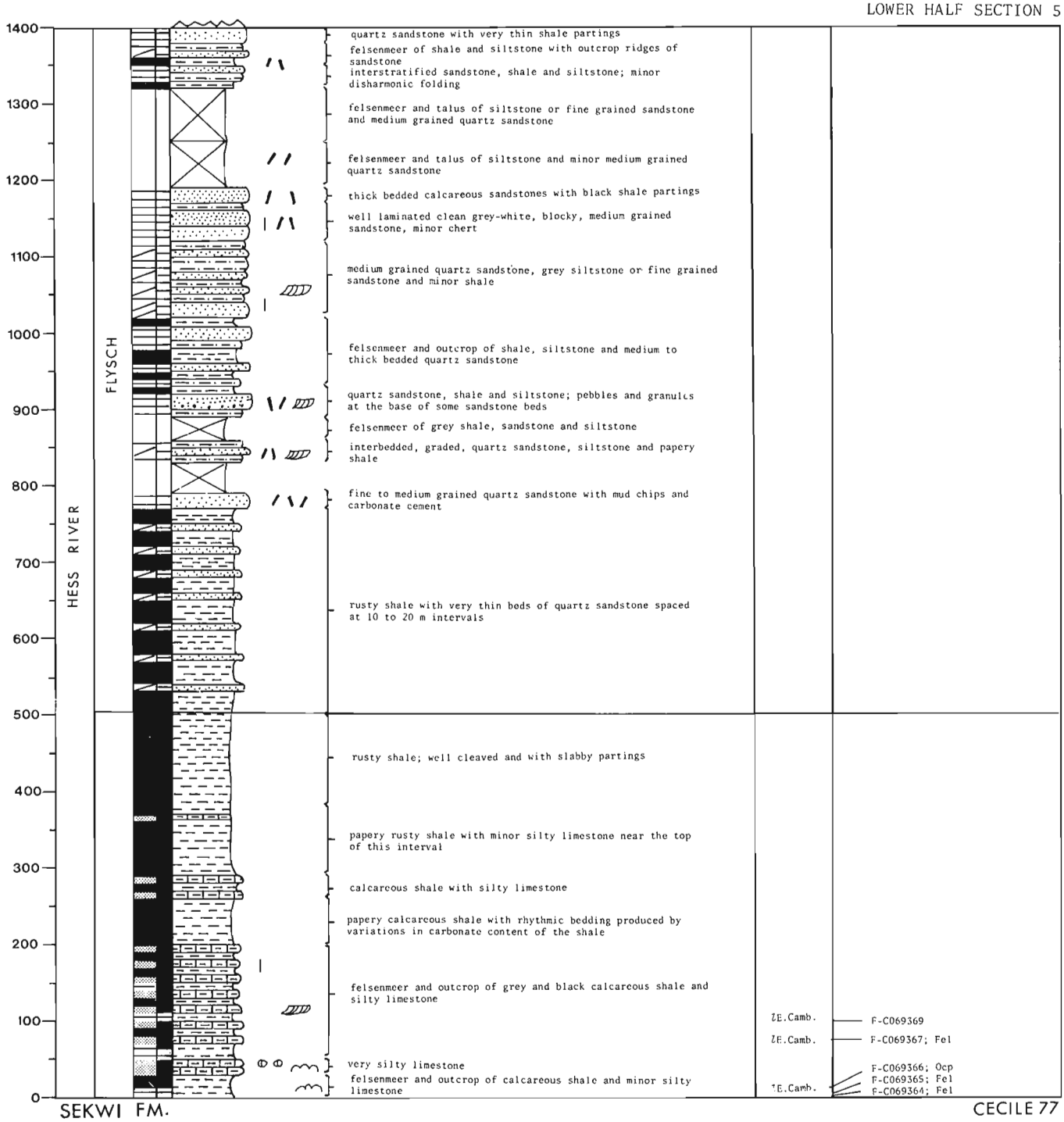
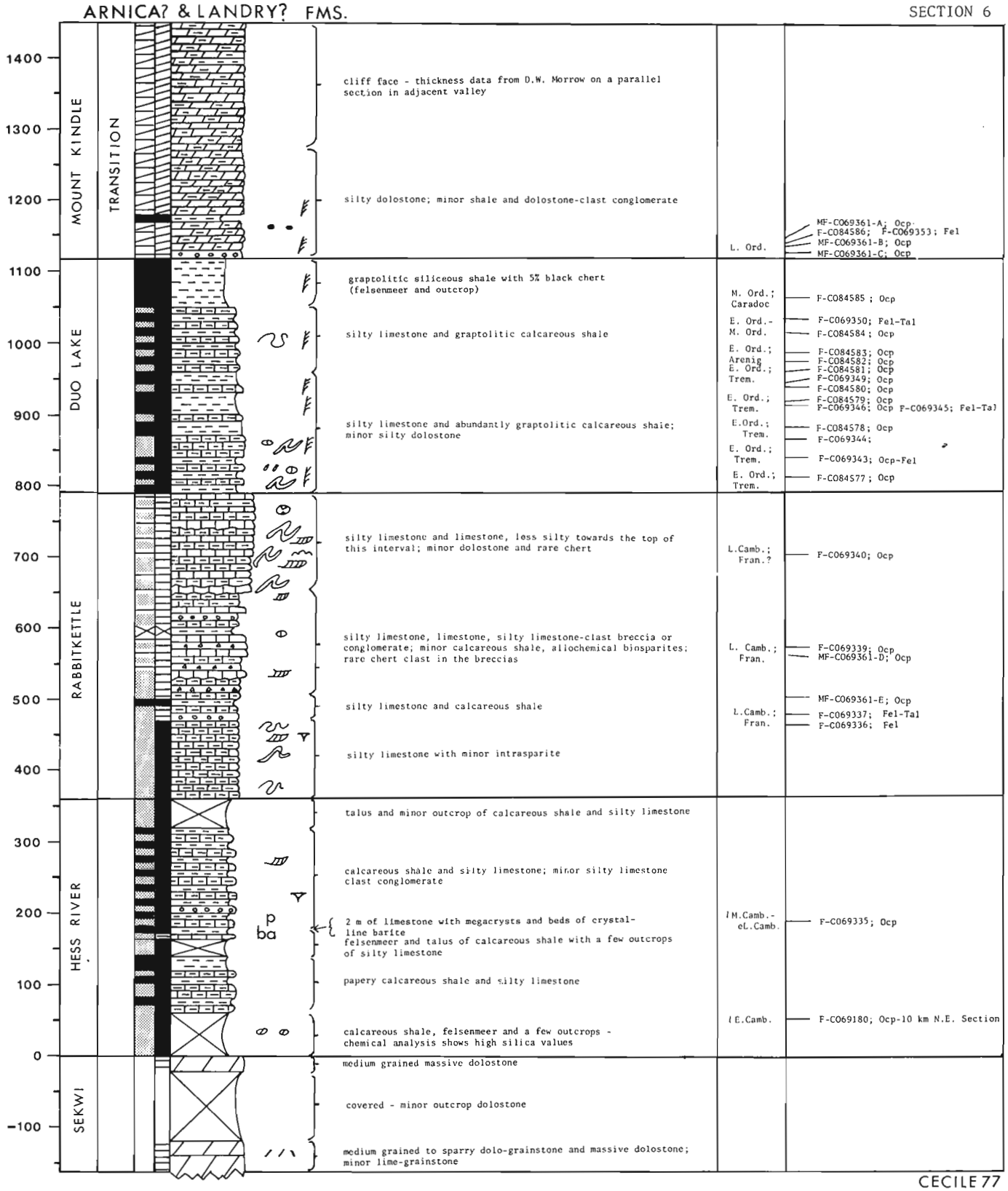
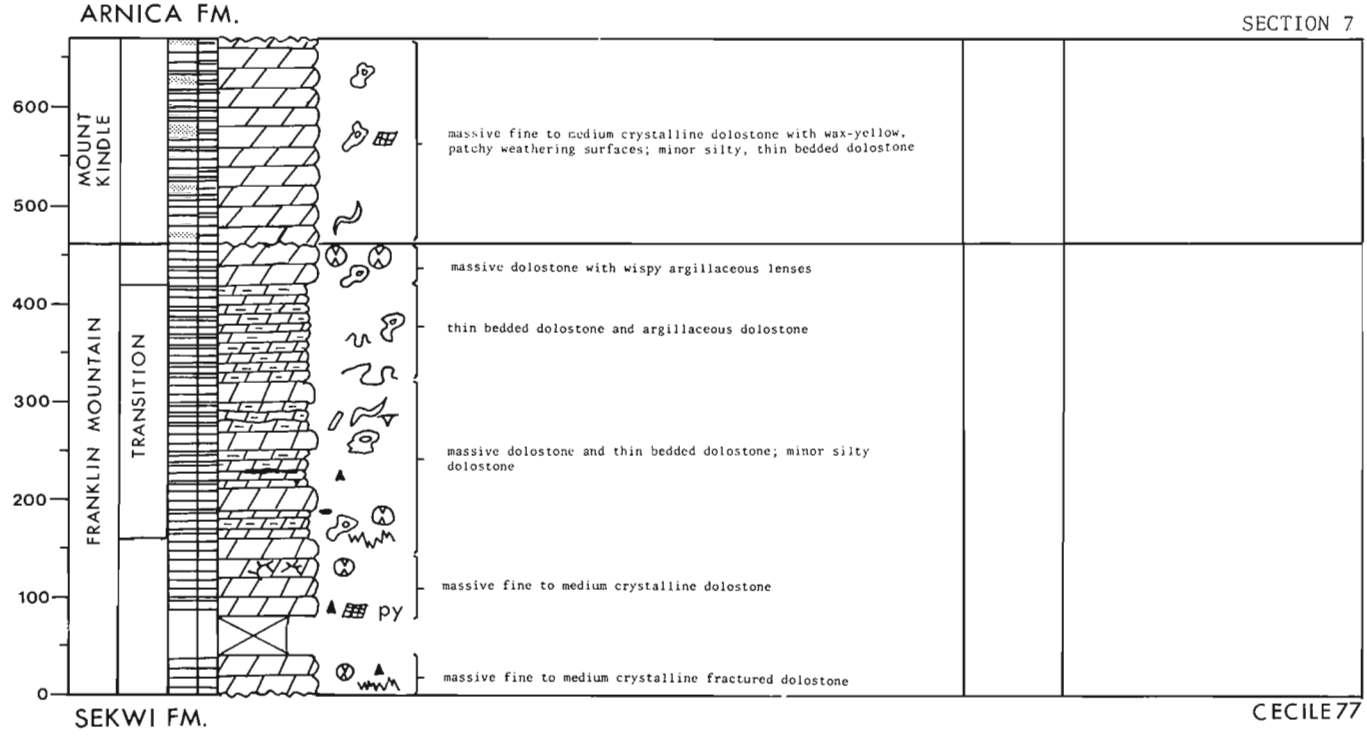
LOWER HALF SECTION 5



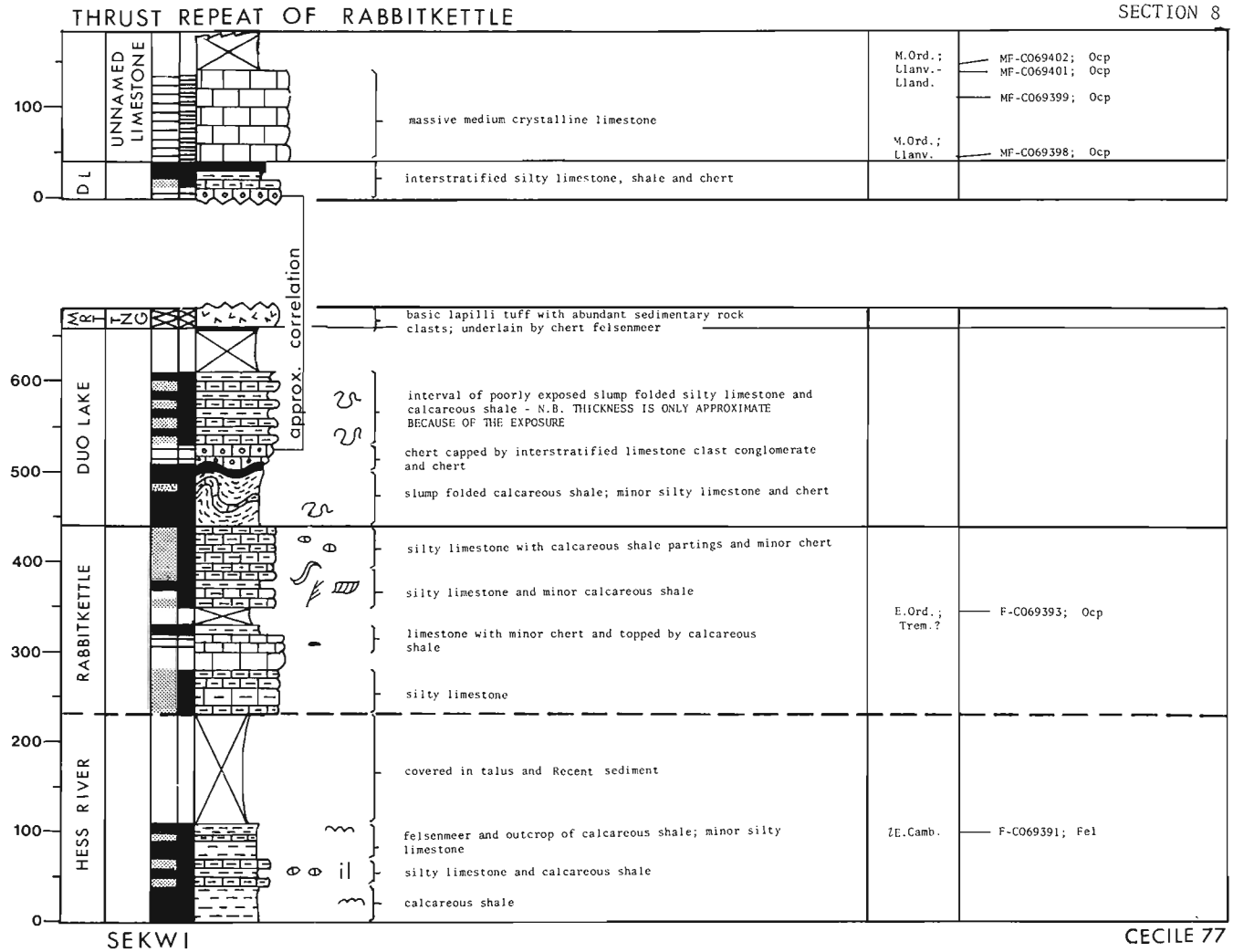
SECTION 6- Located in the northeast Bonnet Plume Lake map-area (106B); base at 64°42' Latitude, 130°48' Longitude, and top at 64°40' Latitude, 130°49' Longitude. Type section for the Hess River and Duo Lake Formations. Reference section for the Rabbitkettle Formation.



SECTION 7- Located in the northeast Bonnet Plume Lake map-area (106B); base at 64°44' Latitude, 130°10' Longitude, and top at 64°43' Latitude, 130°13' Longitude. Base of the section was measured on a northeast trending ridge crest, then across a valley to a point low on the north slope of a second ridge.

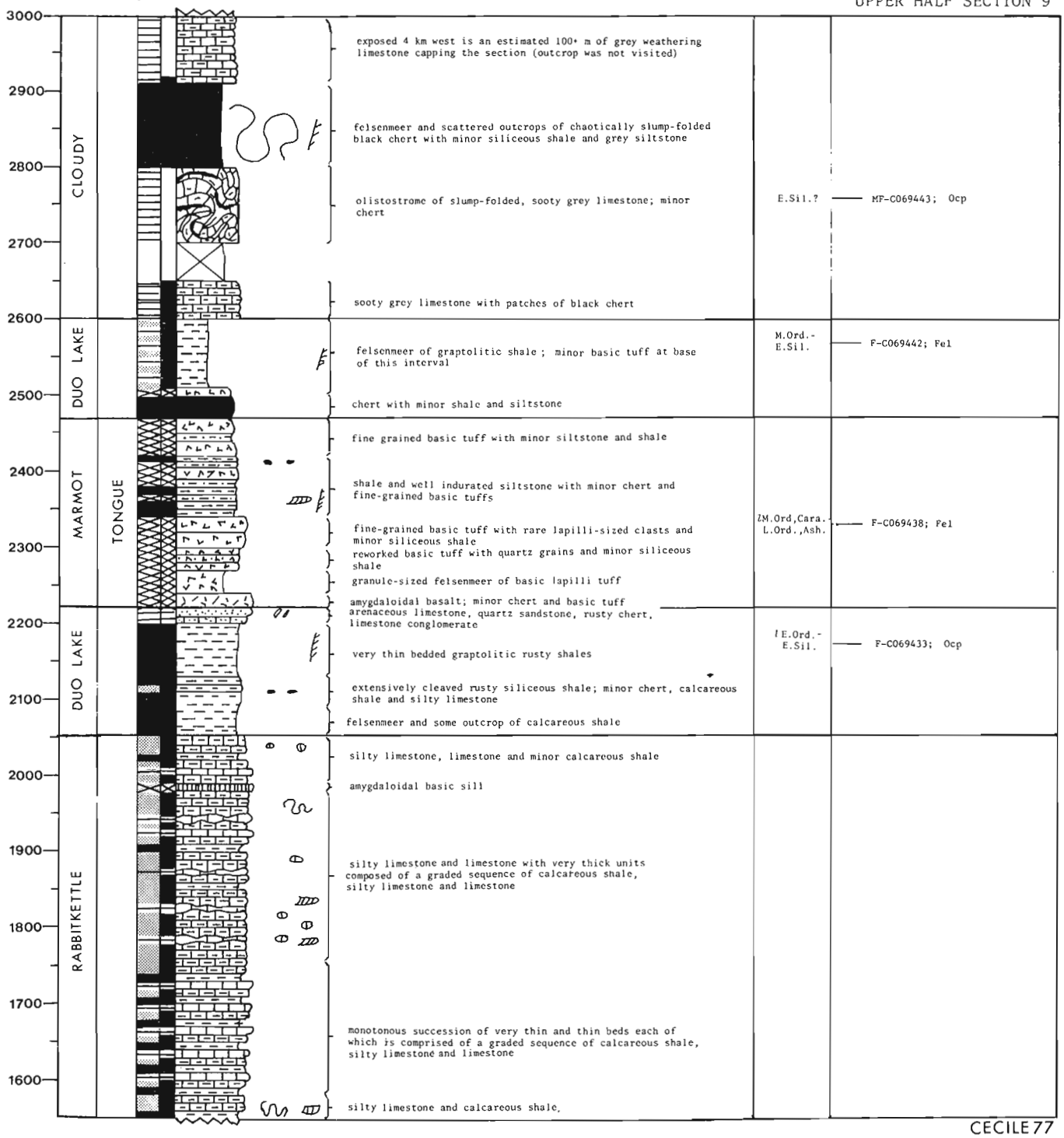


SECTION 8- Located in the southwest Bonnet Plume Lake map-area (106B); base at 64°28' Latitude, 131°30' Longitude and top at 64°28' Latitude, 131°34' Longitude. Section was measured in two parts. The lower part was measured on a north facing slope east of the northern to two small lakes. The upper part was measured in a small valley west of the same lake and northeast of a prominent 7500' peak.

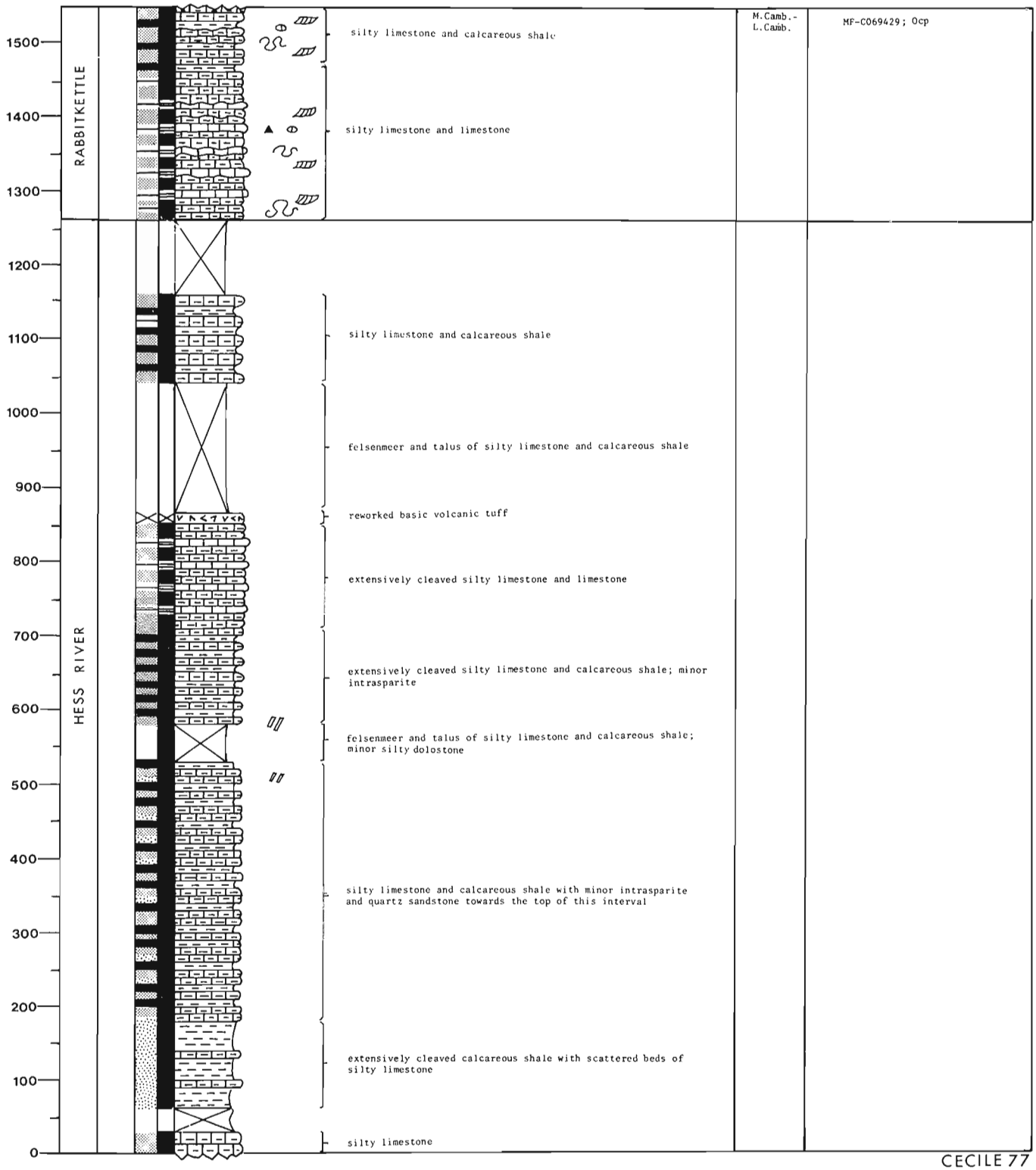


SECTION 9- Located in the center of the Bonnet Plume Lake map-area (106B); base at 64°31' Latitude, 131°02' Longitude and top at 64°28' Latitude, 131°04' Longitude. Section was measured on an east facing slope near the headwaters of a tributary of the Arctic Red River.

UPPER HALF SECTION 9



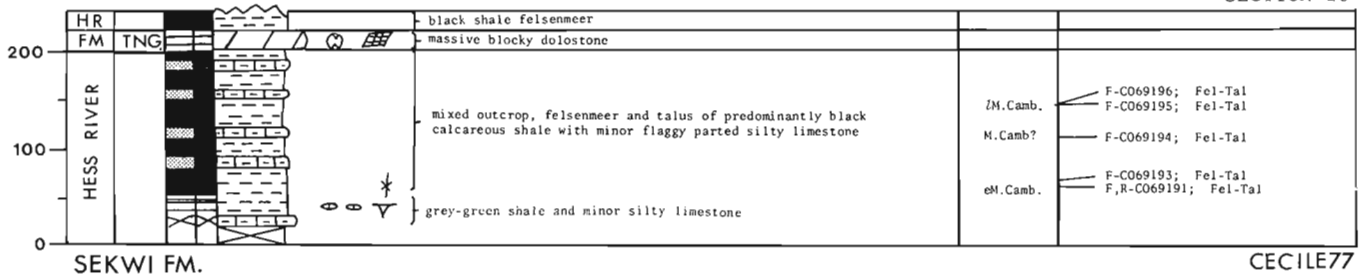

CECILE 77


RABBITKETTLE
HESS RIVER
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
silty limestone and calcareous shale
silty limestone and limestone
silty limestone and calcareous shale
felsenmeer and talus of silty limestone and calcareous shale
reworked basic volcanic tuff
extensively cleaved silty limestone and limestone
extensively cleaved silty limestone and calcareous shale; minor intrasparite
felsenmeer and talus of silty limestone and calcareous shale; minor silty dolostone
silty limestone and calcareous shale with minor intrasparite and quartz sandstone towards the top of this interval
extensively cleaved calcareous shale with scattered beds of silty limestone
silty limestone
M.Camb.-L.Camb.
MF-C069429; Ocp

CECILE 77

SECTION 10- Located in the northeast Bonnet Plume Lake map-area (106B) at 64°36' Latitude and 130°02' Longitude. Section was measured 3 km northeast of a northwest flowing river tributary.

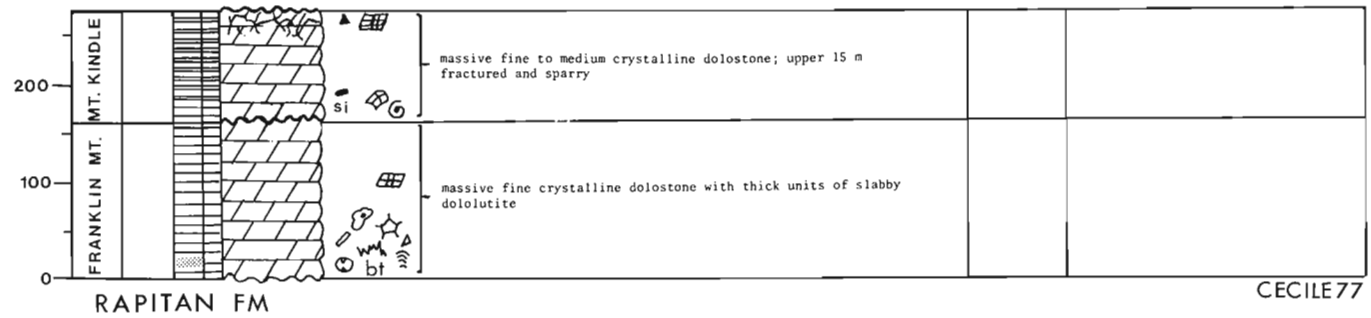
SECTION 10




SECTION 11- Located in the northwest Mount Eduni map-area (106A) at 64°43' Latitude and 129°42' Longitude. Section was measured on the north-east side of a prominent ridge just west of a major north-south tributary to the Mountain River.

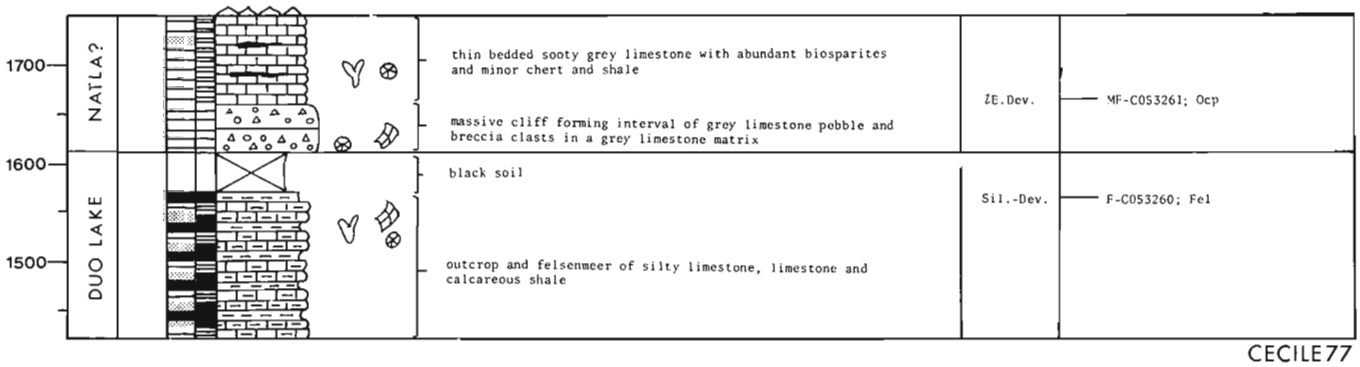
DELORME FM.

SECTION 11

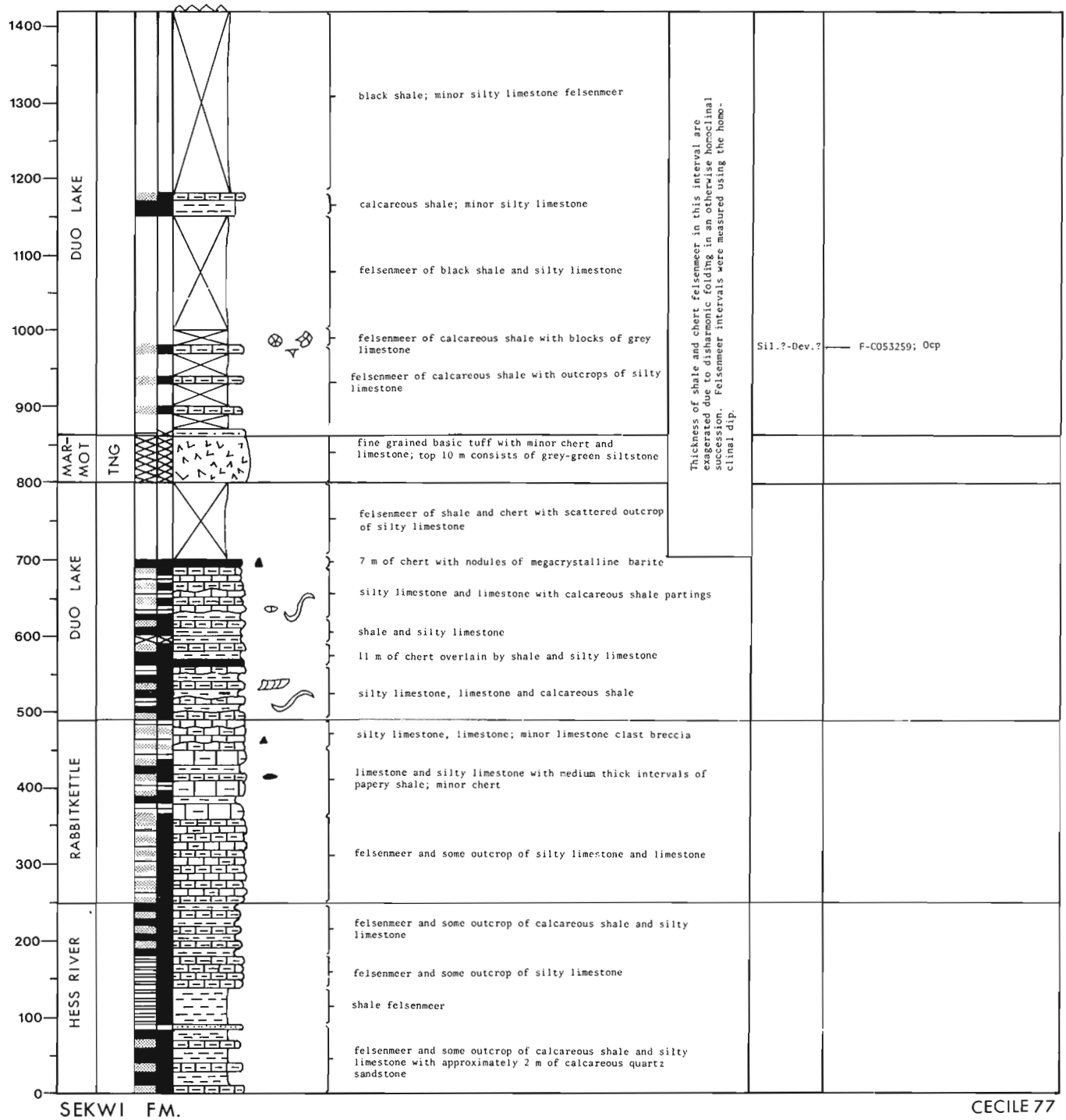



SECTION 12- Located in the southeast Bonnet Plume Lake map-area (106B); base at 64°18' Latitude, 130°58' Longitude and top at 64°18' Latitude, 130°49' Longitude. Section was measured along high ridges between 6500 and 7500' above sea-level.

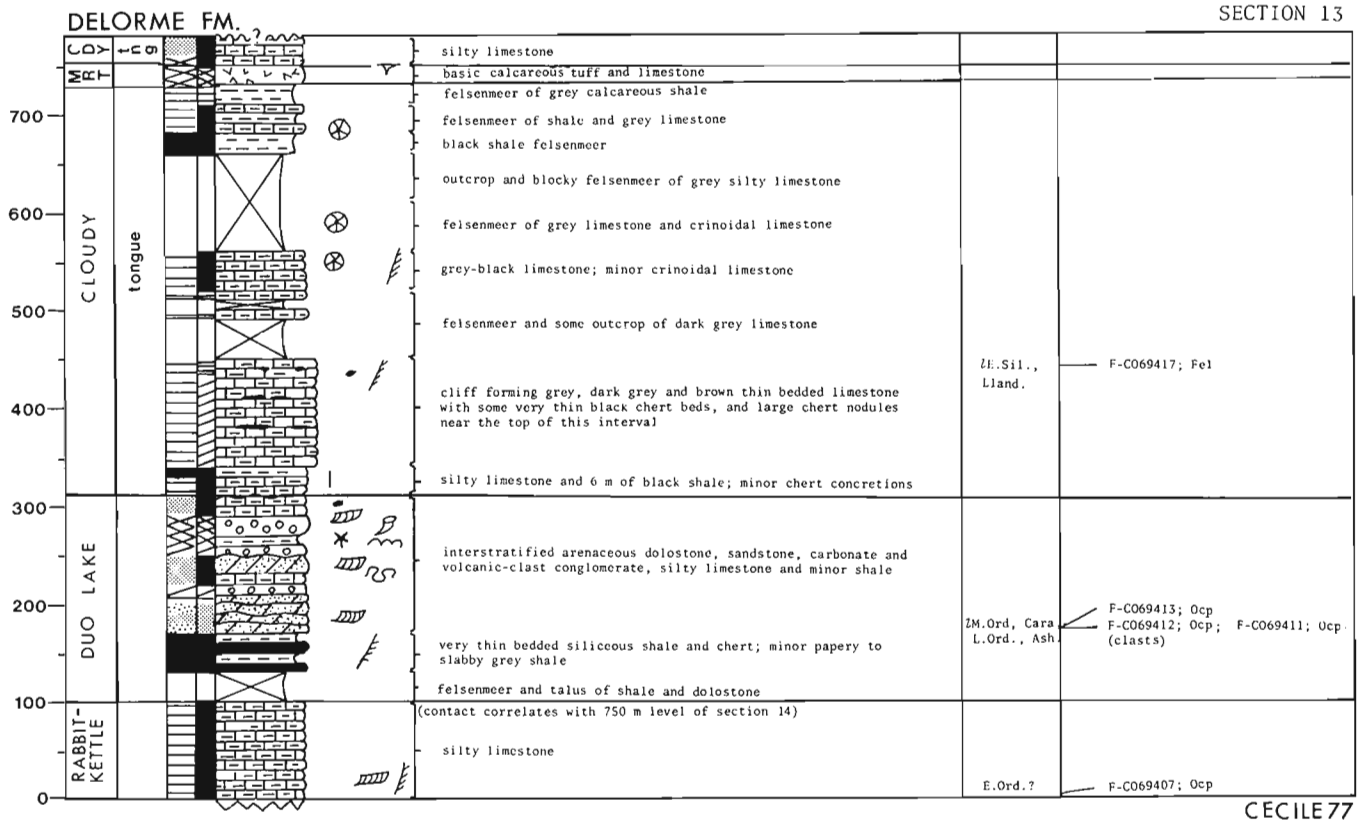
UPPER ONE QUARTER SECTION 12



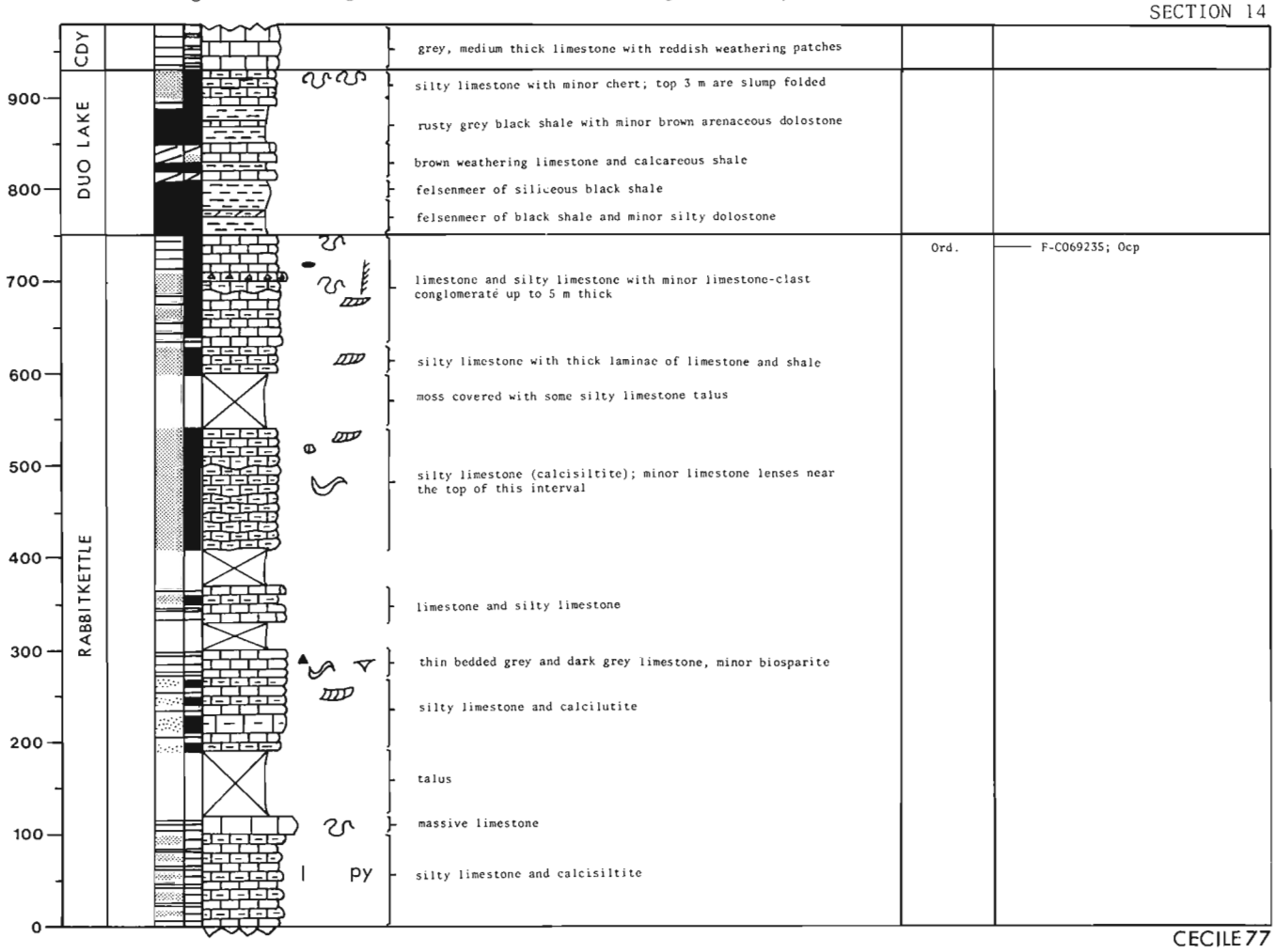
LOWER THREE QUARTERS SECTION 12



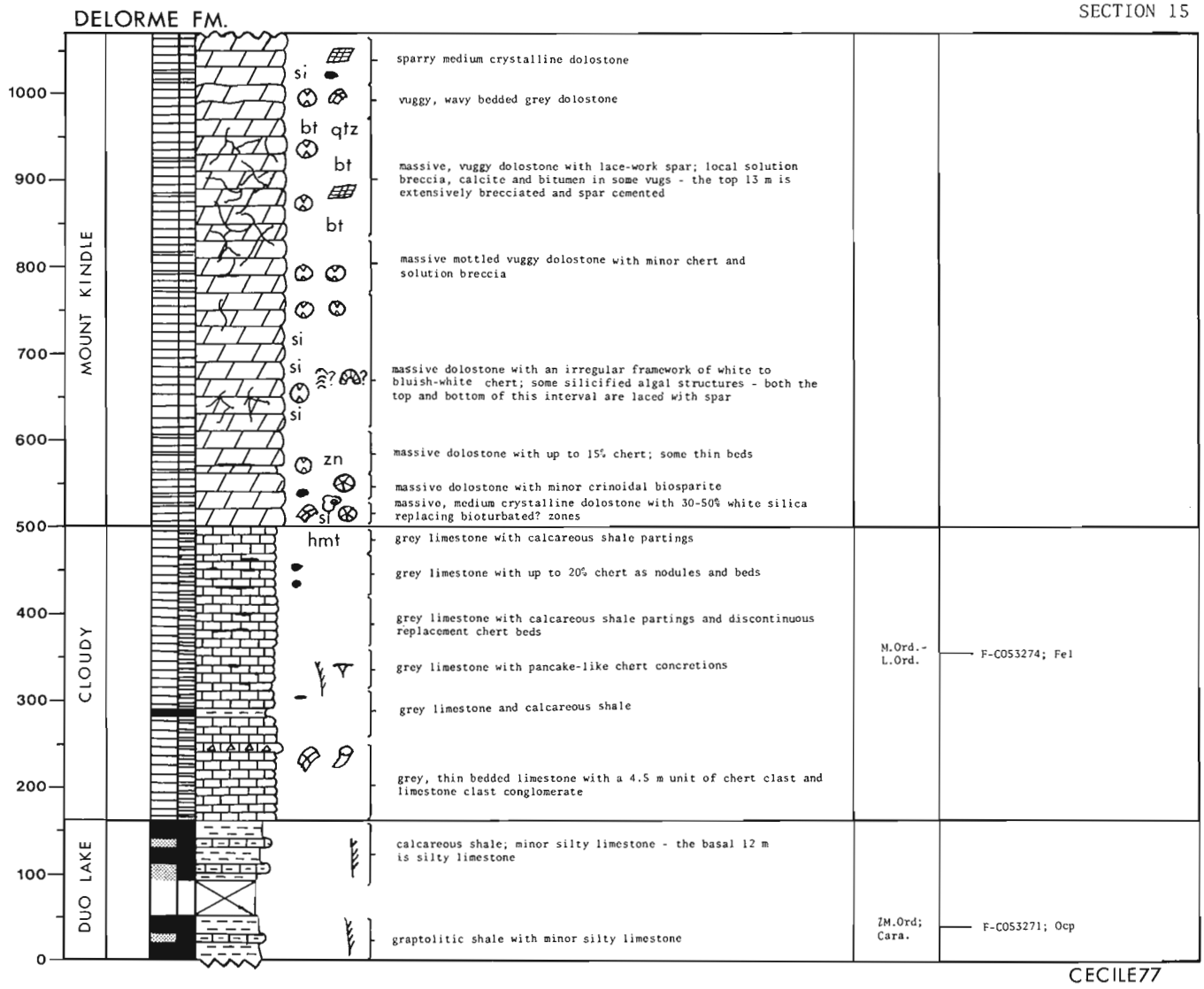
SECTION 13- Located in the southeast Bonnet Plume Lake map-area (106B); base at 64°27' Latitude, 130°35' Longitude and top at 64°26' Latitude, 130°36' Longitude. Section was measured on east side of a north-south ridge. The ridge is east of a set of glaciers.



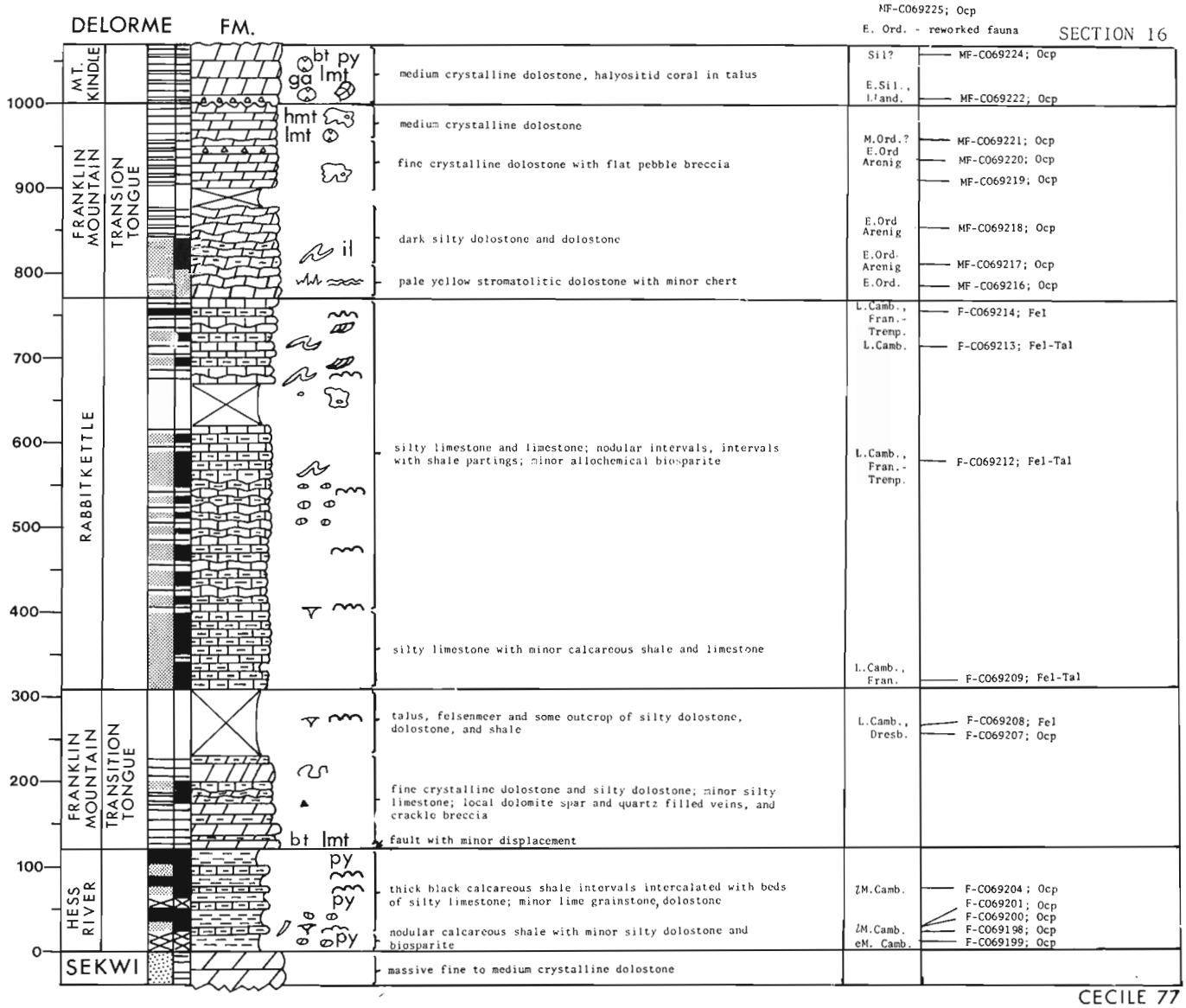
SECTION 14- Located in the southeast Bonnet Plume Lake map-area (106B); base at 64°27' Latitude, 130°30' Longitude, and top at 64°25.5' Latitude, 130°30' Longitude. Section was measured on a north facing incised ridge, south of an east flowing tributary of the Mountain River.



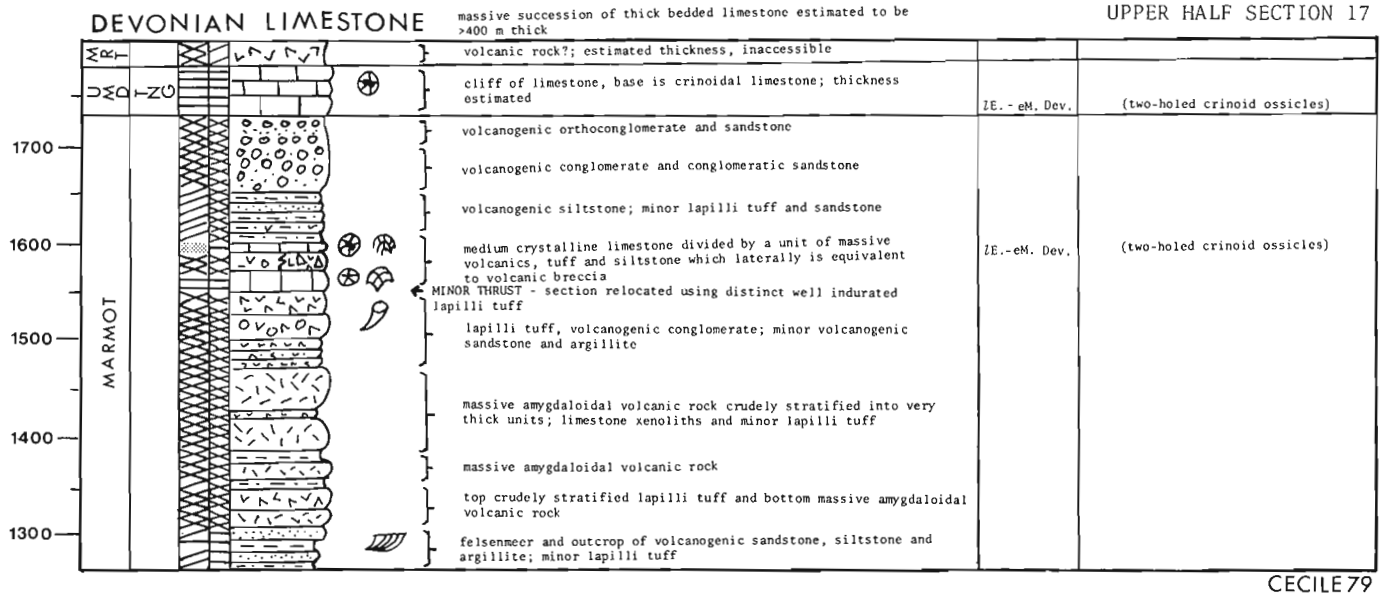
SECTION 15- Located in the southeast Bonnet Plume Lake map-area (106B); base at 64°27' Latitude, 130°06' Longitude, top at 64°25' Latitude, 130°06.5' Longitude. Section was measured initially in a north-trending valley bottom, then south-southwest up a northeast jutting ridge promontory.



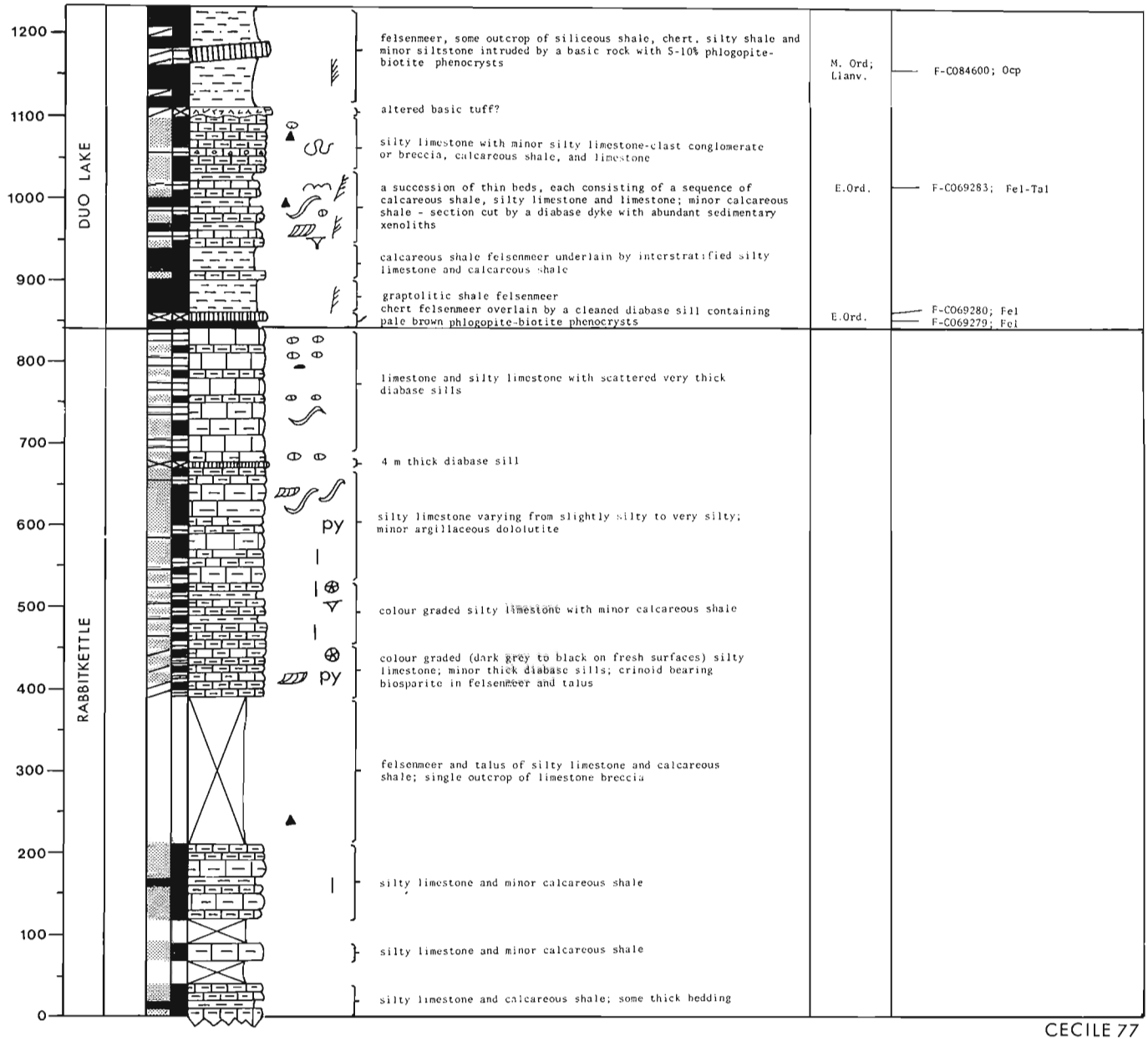
SECTION 16- Located in the northwest Mount Eduni map-area (106A); base at 64°31.5' Latitude, 129°47.5' Longitude, and top at 64°32' Latitude, 129°48.5' Longitude. Section was measured on the east face of a north-trending slope.



SECTION 17- Located in the southwest Bonnet Plume Lake map-area (106B); base at 64°07.5 Latitude, 130°16' Longitude and top at 64°10' Latitude, 130°20' Longitude. Section was measured south of a peak which is at elevation 8750'.

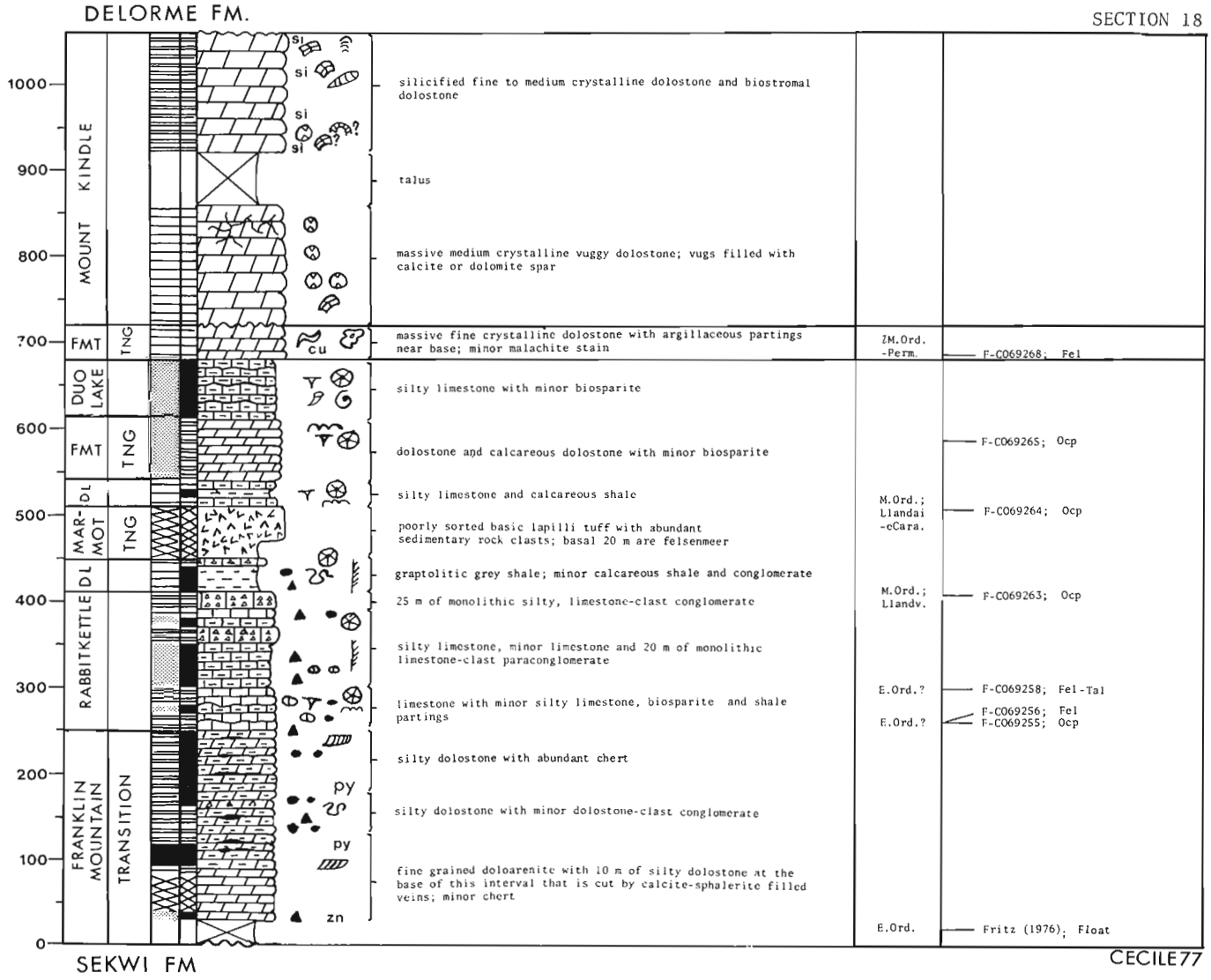


LOWER HALF SECTION 17

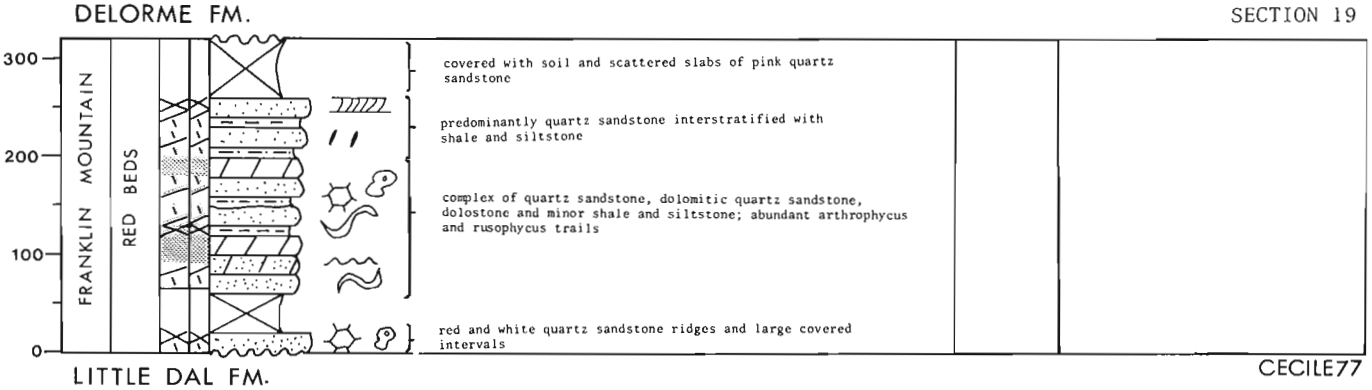



CECILE 77

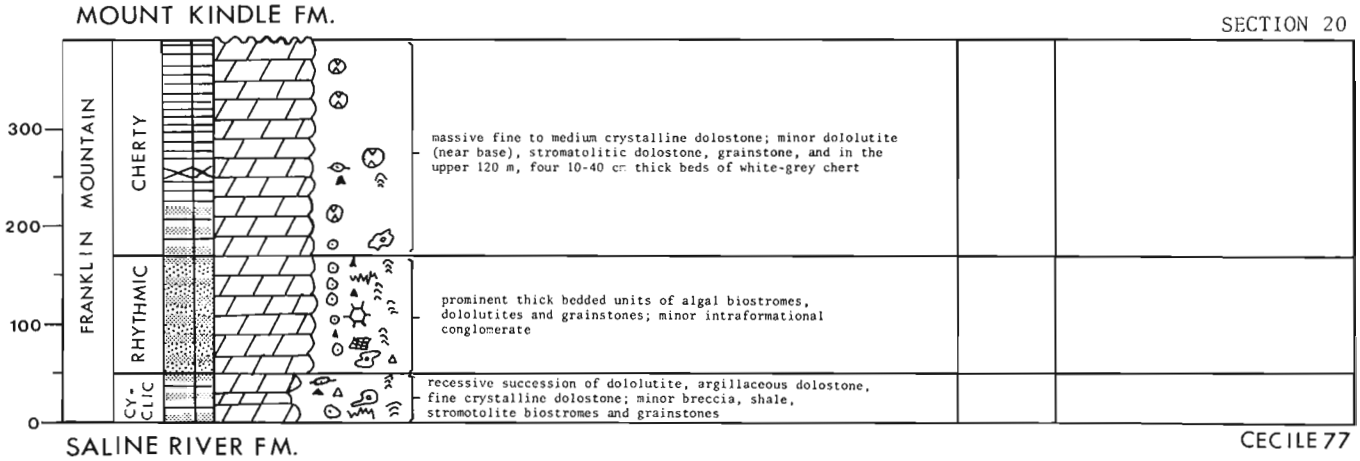
SECTION 18- Located in the southwest Mount Eduni map-area (106A); base at 64°19' Latitude, 129°40' Longitude, top at 64°19' Latitude, and 129°42' Longitude. Section was measured on an east facing ridge slope, immediately west of the Mountain River.



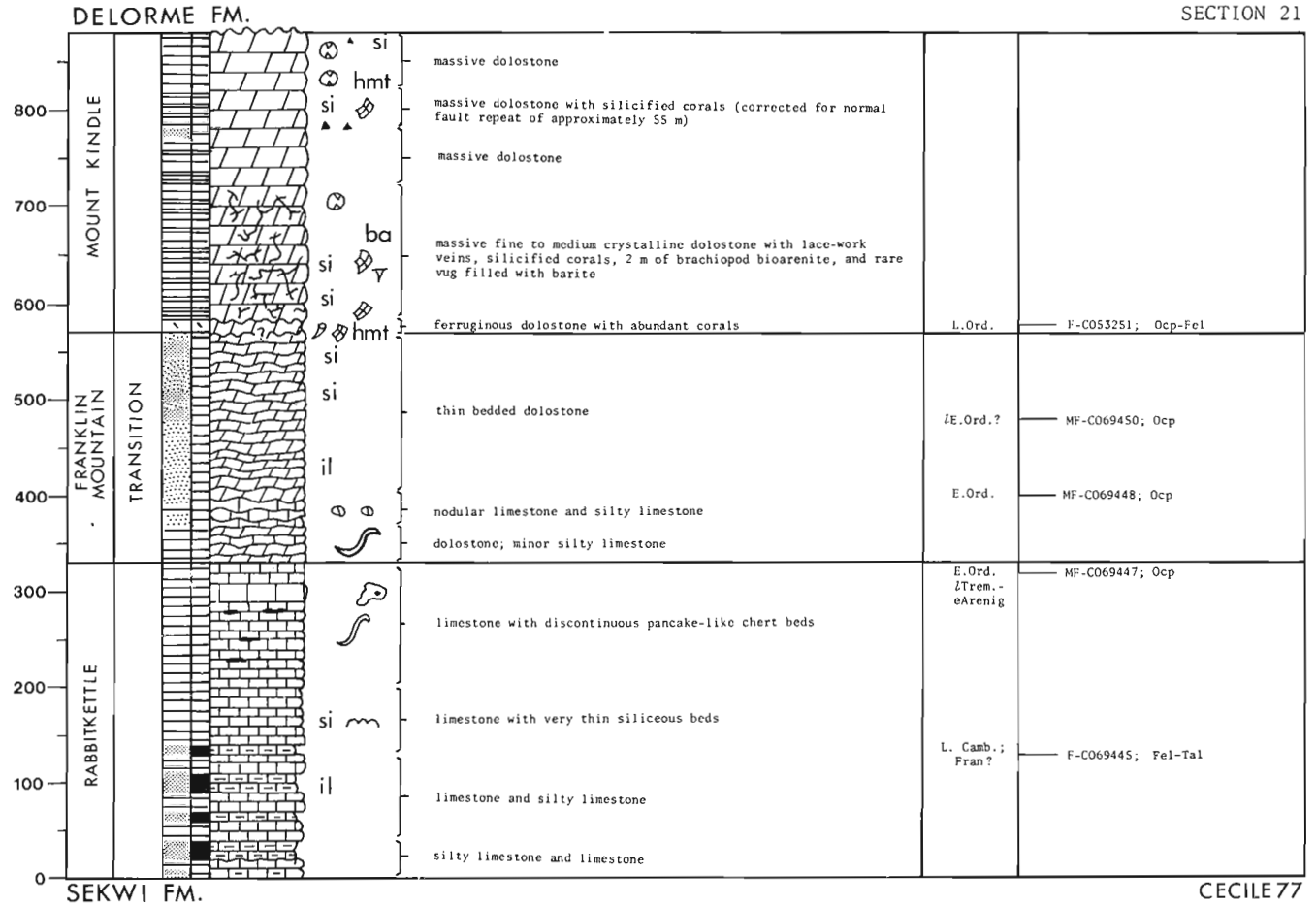

SECTION 19- Located in the southeast Mount Eduni map-area (106A) at 64°22' Latitude and 128°40' Longitude. Section was measured on the southwest facing side of a narrow ridge.



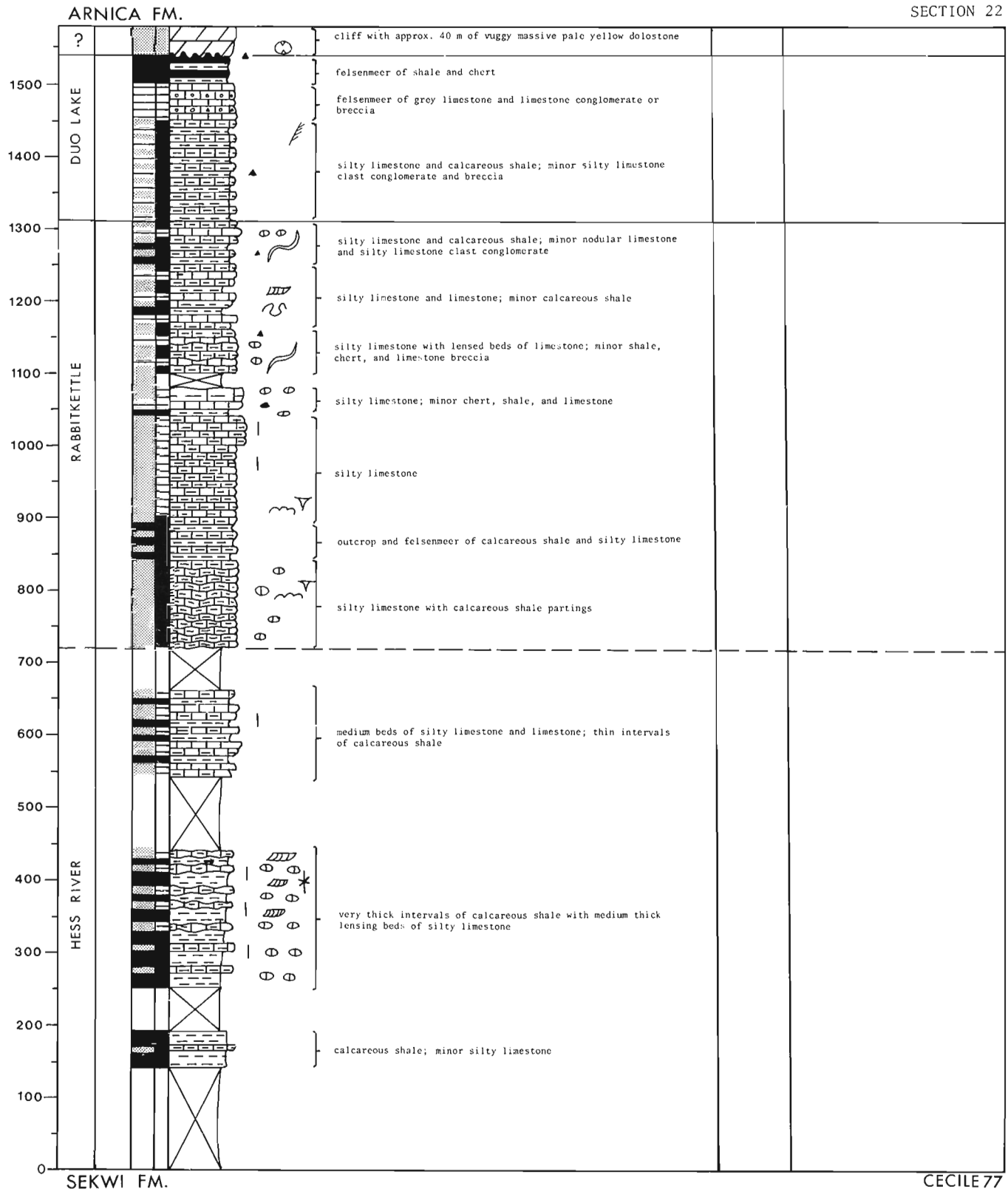
SECTION 20- Located in the northwest Carajou Canyon map-area (96D) at 64°52' Latitude and 127°16' Longitude. Section is measured along Dodo Creek, west of Dodo Mountain.



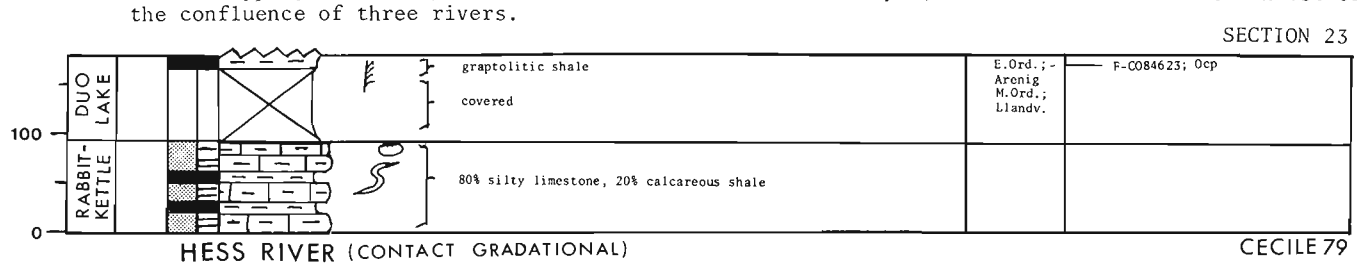

SECTION 21- Located in southwest Mount Eduni map-area (106A); base at 64°07' Latitude, 129°14' Longitude and top at 64°07.5' Latitude, 129°15' Longitude. Section was measured on the southeast end of a south-southwest trending ridge, north of the Twitya River.



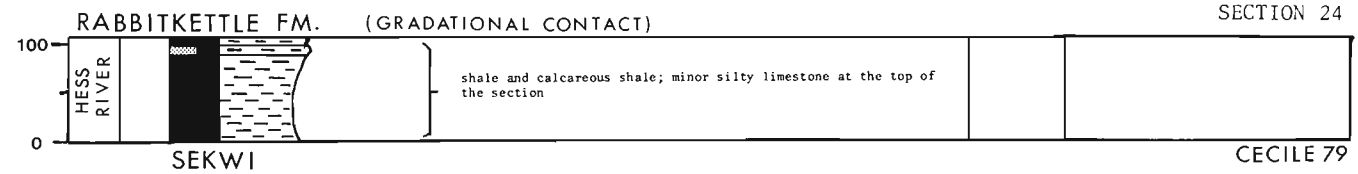
SECTION 22- Located in the northwest Sekwi Mountain map-area (105P); at 63°48.5' Latitude, 129°33' Longitude and top at 63°47.5' Latitude, 129°38' Longitude. Section was measured on an isolated northeast-trending ridge with two small 7000' peaks and a 7500'+ peak. Section was started low on the ridge, measured southwest into a creek south of the ridge, along the creek and then northwest up the ridge below the two smaller peaks.



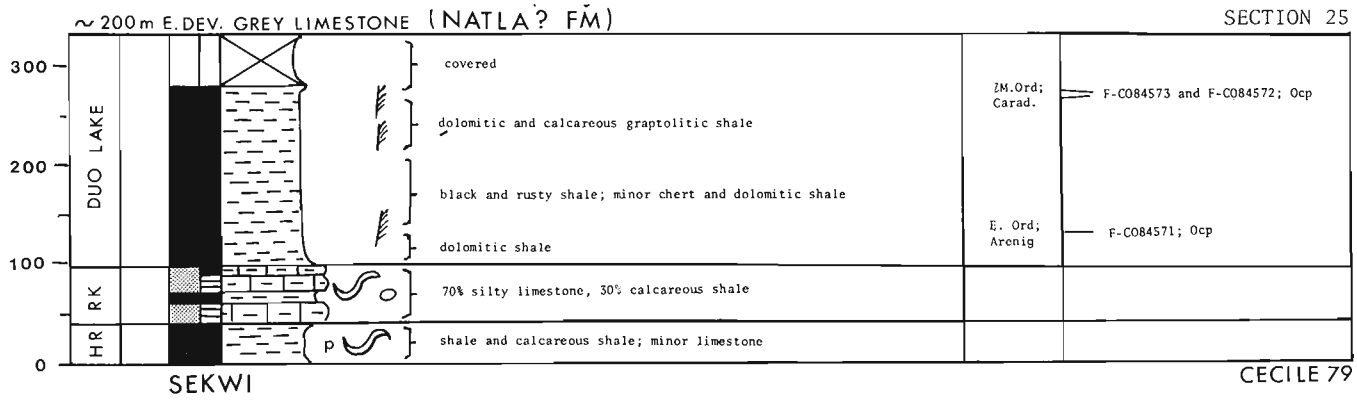
SECTION 23- Located in the northeast Niddery Lake map-area (105-0) at 63°47.5' Latitude and 130°28' Longitude. Strata dipping moderately west, were measured in a river canyon, a few hundred metres southwest of the confluence of three rivers.




SECTION 24- Located in the northeast Niddery Lake map-area (105-0) at 63°48.5' Latitude and 130°28' Longitude. The section was measured in the bottom of a southeast-trending river tributary.




SECTION 25- Located in the northeast Niddery Lake map-area (105-0) at 63°45' Latitude and 130°17' Longitude. Section is located on the west side of a prominent ridge cored by Sekwi Formation. The section was measured in a small creek cut into the ridge.



## APPENDIX II - PALEONTOLOGY

W.H. Fritz, B.S. Norford and R.S. Tipnis

Basin facies strata in the Misty Creek Embayment contain a variety of macrofauna consisting mainly of trilobites and graptolites and locally corals, brachiopods, echinoderm debris, sponge spicules and the arthropod **Caryocaris.** Franklin Mountain Formation rocks surrounding the embayment are mostly unfossiliferous except in transitional facies where trilobites, brachiopods and echinoderm debris have been collected and in rare sections (Sections 4 and 20) where some domed stromatolite colonies are preserved. Rocks of the Mount Kindle Formation frequently contain corals and coral dominated biostromes as well as minor amounts of other shelly fauna.

Conodonts are common in Ordovician to Devonian strata and in some Cambrian units. They are especially abundant in rocks of the Arenigian and Llanvirnian stages, where the conodonts are primarily of the North Atlantic type. Those from older and/or younger Ordovician collections contain either a "mixture" of identifiable midcontinent and North Atlantic elements, or lack the diagnostic fauna belonging to either biogeographic province. The predominance of North Atlantic elements along the margins of North American ancestral cratons has been documented by Tipnis (1978, amongst others) and the southern Mackenzie Mountains, near the embayment, by Tipnis, Chatterton and Ludvigsen (1978).

Macrofaunas were collected from outcrop or felsenmeer in narrow stratigraphic intervals of a few centimetres to one or two metres. Conodont samples of about a kilogram were collected either from a single bed or rock chips over a narrow interval of a few centimetres to a metre. Samples are arranged by section. Lithologic and location data are given with section description in Appendix One. Faunal zones are those given in Fritz (1970; p. 394); Norford, Bolton, Copeland, Cumming and Sinclair (1970, p. 602) and Bergstrom (1977).

W.H. Fritz (W.H.F.) is responsible for identifications of Cambrian macrofauna, B.S. Norford (B.S.N.) for Ordovician and Silurian fauna and R.S. Tipnis (R.S.T.) for conodonts.

SECTION 1 - Base at 65°02'N and 131°46'W, NTS 106G.

| | |
|---|---|
| GSC Loc. C-69305 (BSN)<br>Cloudy Fm., outcrop at<br>194 m above the<br>Duo Lake Fm. | echinoderm debris<br>indeterminate brachopod<br>**Favosites** sp.<br>diplograptid<br>Age: Early Silurian, Llandovery |
| GSC Loc. C-69307 (BSN)<br>Cloudy Fm., outcrop several<br>kilometres east of section-<br>position estimated to be<br>similar to Loc. C-69305. | echinoderm debris<br>bryozoan<br>stromatoporoid<br>**Cystihalysites** sp.<br>**Favosites** sp.<br>indeterminate solitary corals<br>Age: Silurian |
| GSC Loc. C-69304 (BSN)<br>Cloudy Fm., talus from cliff<br>just above this point in<br>section, which is 536 m<br>above Duo Lake Fm.<br>Lithologies similar to rocks<br>at 750-800 m. | bryozoan<br>solitary coral (with dissepiments)<br>Age: Silurian to Permian (pebbles in conglomerate) |
| GSC Loc. C-69300 (BSN)<br>Duo Lake Fm., outcrop at<br>210 m above the Hess<br>River Fm. | **Adelograptus**? sp.<br>**Clonograptus** 2 spp.<br>Age: Early Ordovician, Tremadoc, probably **Adelograptus antiquus** Zone |
| GSC Loc. C-69296 (WHF)<br>Hess Fm., outcrop at<br>75 m above the Sekwi Fm. | **Ogygopis** sp.<br>Age: late Early to Middle Cambrian |

SECTION 3 - Base at 64°56.5'N, 130°16'W, NTS 106B. Base of section is unconformable contact between Franklin Mountain Fm. and Proterozoic dolomite.

| | |
|---|---|
| GSC Loc. C-69327 and<br>C-69325 (BSN)<br>Mount Kindle Fm.,<br>outcrop at 123 and 116 m above<br>the Franklin Mountain Fm. | actinocerid cephalopod<br>Age: Ordovician to Mississippian |

SECTION 3 (cont'd)

GSC Loc. C-69324 (BSN)
Mount Kindle Fm. biostrome or bioherm, outcrop at 35 m above the Franklin Mountain Fm.

echinoderm debris
bryozoan
**Plaesiomys** sp.
**P. rockymontana** (Wilson)
**Thaerodonta**? sp.
undetermined solitary and tabulate corals
**Bighornia** sp.
**Calapoecia** sp.
**Catenipora** sp.
**Favosites**? sp.
**Lobocorallium** sp.
**Palaeofavosites** spp.
**Palaeophyllum** 2 spp.
**Sarcinula** sp.
Age: Late Ordovician, Ashgill, **Bighornia-Thaerodonta** Fauna

GSC Loc. C-69323 (BSN)
Mount Kindle Fm., outcrop at 7 m above the Franklin Mountain Fm.

**Catenipora** sp.
Age: Middle Ordovician to Late Silurian

SECTION 4 - Base at 64°39'N, 132°50'W, NTS 106C.

GSC Loc. C-69423 (BSN)
Mountain Kindle Fm., felsenmeer at 272 m above the Franklin Mountain Fm.

solitary corals 4 spp.
**Cystihalysites**? sp.
**Favosites favosus** (Goldfuss)
**Favosites**? sp.
**Halysites** sp.
Age: Silurian, Late Llandovery or Wenlock

SECTION 5 - Base at 64°43.5'N, 131°39'W, NTS 106B.

GSC Loc. C-69369 (WHF)
Hess River Fm., 92 m above the Sekwi Fm.

**Goldfieldia** sp.
Age: late Early Cambrian

GSC Loc. C-69367 (WHF)
Hess River Fm., felsenmeer at 69 m above the Sekwi Fm.

**Bonnia** sp.
**Olenellus puertoblancoensis** (Lochman)
**Ogygopis** sp.
Age: late Early Cambrian, late **Bonnia-Olenellus** Zone

GSC Loc. C-69366 (WHF)
Hess River Fm., outcrop at 10 m above the Sekwi Fm.

**Olenellus puertoblancoensis** (Lochman)
Age: late Early Cambrian, late **Bonnia-Olenellus** Zone

GSC Loc. C-69365 (WHF)
Hess River Fm., felsenmeer at 5 m above the Sekwi Fm.

**Olenellus puertoblancoensis** (Lochman)
**Olenellus** sp.
Age: late Early Cambrian, late **Bonnia-Olenellus** Zone

GSC Loc. C-69364 (WHF)
Hess River Fm., felsenmeer at 1 m above the Sekwi Fm.

**Olenellus** sp.
Age: late Early Cambrian, **Bonnia-Olenellus** Zone

GSC Loc. C-69363 (WHF)
Sekwi Fm., outcrop at 61 m below Hess River Fm.

**Olenellus paraoculus** Fritz
Age: late Early Cambrian, **Bonnia-Olenellus** Zone

GSC Loc. C-69362 (WHF)
Sekwi Fm., felsenmeer and outcrop at 71 m below the Hess River Fm.

**Olenellus sequomalus**? Fritz
**Olenellus** sp.
**Salterella** sp.
**Wanneria** sp.
Age: late Early Cambrian, **Bonnia-Olenellus** Zone

SECTION 6 - Type section for Hess River and Duo Lake Formations, and reference section for the Rabbitkettle Fm. in the study area. Base at 64°42'N, 130°48'W, NTS 106B.

GSC Loc. C-69361-A (RST)
Transitional Mount Kindle Fm.
outcrop at 36 m above the
Duo Lake Fm.

**Panderodus** sp.
Age: Middle Ordovician to early Silurian
Sample weight: 1220 g
No. of conodonts: 2

GSC Loc. C-84586 (BSN)
Transitional Mount Kindle Fm.
felsenmeer 30 m above the
Duo Lake Fm.

**Amplexograptus**? sp.
Age: Middle or Late Ordovician, probably Llanvirn to Ashgill

GSC Loc. C-69353 (BSN)
Transitional Mount Kindle Fm.,
felsenmeer, very likely close to
original stratigraphic position,
26 m above the Duo Lake Fm.

**Climacograptus** sp.
Age: Middle Ordovician (Llanvirn) to Early Silurian (late Llandovery)

GSC Loc. C-69361-B (RST)
Transitional Mount Kindle Fm.,
outcrop 16 m above the
Duo Lake Fm.

**Panderodus unicostatus** (Branson and Mehl) s.f.
**Walliserodus curuatus** (Branson and Branson)
**Drepanoistodus suberectus** (Branson and Mehl)
**Oistodus venustus** (Stauffer) s.f.
**Pseudooneotodus** ?sp.
cf. **Plectodina furcata** (Hinde) s.l.
**Belodina**? sp.
Age: latest Ordovician - Early Silurian
Sample weight: 1583 g
Conodonts: abundant

GSC Loc. C-69361-C (RST)
Transitional Mount Kindle Fm.,
outcrop 8 m above the
Duo Lake Fm.

**Panderodus gracilis** (Branson and Mehl)
**Panderodus panderi** (Stauffer)
**Plectodina furcata** (Hinde) s.l.
**Drepanoistodus suberectus** (Branson and Mehl)
**Oistodus venustus** (Stauffer) s.f.
cf. **Belodina compressa** (Branson and Mehl)
**Pristognathus** sp.
Age: Late Ordovician, probably Faunas 11 and 12 of Sweet et al. (1971)
Sample weight: 1579 g
Conodonts: abundant

GSC Loc. C-84585 (BSN)
Duo Lake Fm., outcrop
272 to 275 m above the
Rabbitkettle Fm.

**Climacograptus** sp.
**Dicranograptus** sp.
**Glossograptus** cf. G. **hincksi** (Hopkinson)
retiolitid graptolite
Age: Middle Ordovician, Caradoc, probably **Climacograptus bicornis** Zone

GSC Loc. C-69350 (BSN)
Duo Lake Fm., felsenmeer
and possibly talus, 239 m
above the Rabbitkettle Fm.

**Didymograptus extensus** (Hall)
Age: Early to Middle Ordovician, **Tetragraptus fruticosus** Zone to **Glyptograptus** cf. G. **teretiusculus** Zone

GSC Loc. C-84584 (BSN)
Duo Lake Fm., outcrop
220 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
**Didymograptus extensus** (Hall)
graptolite fragments
Age: Early or Middle Ordovician, **Tetragraptus fruticosus** Zone to **Glyptograptus** cf. **G. teretiusculus** Zone

GSC Loc. C-84583 (BSN)
Duo Lake Fm., outcrop
190 m above the
Rabbitkettle Fm.

**Tetragraptus approximatus** Nicholson
**T.** aff. **T. quadribrachiatus** (Hall)
graptolite fragments
Age: Early Ordovician, Arenig, **Tetragraptus approximatus** Zone or **Tetragraptus fruticosus** Zone

SECTION 6 (cont'd)

GSC Loc. C-84582 (BSN)
Duo Lake Fm., outcrop
180 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
**Clonograptus** sp.
**Tetragraptus approximatus** Nicholson
**T.** aff. **T. phyllograptoides** (Linnarsson)
graptolite fragments
Age: Early Ordovician, Arenig, **Tetragraptus approximatus** Zone or **Tetragraptus fruticosus** Zone

GSC Loc. C-84581 (BSN)
Duo Lake Fm., outcrop
168 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
**Clonograptus** sp.
**Didymograptus**? cf. **D.**? **stelcki** Jackson
**Kiaerograptus**? cf. **Didymograptus pritchardi** Hall
Age: Early Ordovician, Tremadoc, **Adelograptus antiquus** Zone

GSC Loc. C-69349 (BSN)
Duo Lake Fm., outcrop at
155 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
graptolite fragments
**Dictyonema** sp.
Age: Ordovician

GSC Loc. C-84580 (BSN)
Duo Lake Fm., outcrop
150 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
**Adelograptus** sp.
**Clonograptus** sp.
**Kiaerograptus**? cf. **Didymograptus pritchardi** Hall
**Tetragraptus** sp.
Age: Early Ordovician, Tremadoc, **Adelograptus antiquus** Zone

GSC Loc. C-84579 (BSN)
Duo Lake Fm., outcrop
135 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
**Adelograptus** sp.
**Clonograptus** sp.
**Kiaerograptus**? cf. **Didymograptus pritchardi** Hall
**Tetragraptus** sp.
Age: Early Ordovician, Tremadoc, **Adelograptus antiquus** Zone

GSC Loc. C-69346 (BSN)
Duo Lake Fm., outcrop
at 129 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
**Adelograptus** sp.
**Clonograptus** sp.
**Temnograptus** or **Tetragraptus** sp.
Age: Early Ordovician, Tremadoc, **Adelograptus antiquus** Zone

GSC Loc. C-69345 (BSN)
Same as C-69346 but from
felsenmeer.

**Caryocaris** sp.
**Adelograptus**? sp.
**Clonograptus** cf. **C.** sp. A of Jackson 1974
**Clonograptus**? sp.
Age: Early Ordovician, Tremadoc, **Adelograptus antiquus** Zone

GSC Loc. C-84578 (BSN)
Duo Lake Fm., outcrop
96 m above the
Rabbitkettle Fm.

**Adelograptus** spp.
**Clonograptus** spp.
**Clonograptus**? sp.
**Tetragraptus**? sp.
Age: Early Ordovician, Tremadoc, **Adelograptus antiquus** Zone

GSC Loc. C-69344 (BSN)
Duo Lake Fm., felsenmeer
and possibly talus at
74 m above the
Rabbitkettle Fm.

inarticulate brachiopod
**Caryocaris** sp.
**Adelograptus** sp.
**Clonograptus**? sp.
**Kiaerograptus**? sp.
Age: Early Ordovician, Tremadoc, **Adelograptus antiquus** Zone

GSC Loc. C-69343 (BSN)
Duo Lake Fm., outcrop,
felsenmeer and possibly
talus at 50 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
**Adelograptus**? sp.
**Clonograptus** sp.
Age: Early Ordovician, probably Tremadoc, probably **Adelograptus antiquus** Zone

GSC Loc. C-84577 (BSN)
Duo Lake Fm., outcrop
26 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
**Clonograptus** sp.
Age: Early Ordovician, Tremadoc, or **Adelograptus antiquus** Zone

SECTION 6 (cont'd)

GSC Loc. C-69340 (WHF)
Rabbitkettle Fm., outcrop at 349 m above the Hess River Fm.

**Pareuloma**?sp.
cf. **Yüpingia** sp.
Age: The above fossils are questionably assigned to the Late Cambrian, Franconian Stage

GSC Loc. C-69339 (WHF)
Rabbitkettle Fm., outcrop at 220 m above the Hess River Fm.

cf. **Dunderbergia** or **Iddingsia** sp.
cf. **Pareuloma** sp.
**Pseudagnostus** sp.
Age: Late Cambrian, Franconian, **Dunderbergia** or **Elvinia** Zone

GSC Loc. C-69361-D (RST)
Rabbitkettle Fm., outcrop at 209 m above the Hess River Fm.

**"Prooneotodus" tenuis** (Müller)
**Proconodontus muelleri muelleri** Miller
Age: **Proconodontus** was reported from Franconian rocks by Fåhreaus and Nowlan (1978) **P. muelleri** is the zonal taxon for lower but not the lowermost of the four Late Cambrian **Proconodontus** zones of Miller (1975). The age therefore should approximate the lower part of Trempealeauan, or possibly upper part of Franconian
Sample weight: 1185 g

GSC Loc. C-69361-E (RST)
Rabbitkettle Fm., outcrop at 144 m above the Hess River Fm.

**"Prooneotodus" tenuis** (Müller)
**Pelagiella** spp.
Age: Probably Late Cambrian, Franconian (*see* discussion for C-69361-D)
Sample weight: 1189 g

GSC Loc. C-69337 (WHF)
Rabbitkettle Fm., felsenmeer possibly talus at 117 m above the Hess River Fm.

**Irvingella** sp.
Age: Late Cambrian, Franconian, **Elvinia** Zone

GSC Loc. C-69336 (WHF)
Rabbitkettle Fm., felsenmeer at 98 m above the Hess River Fm.

**Lingulella** sp.
sponge spicules
Age: Nondiagnostic

GSC Loc. C-69335 (WHF)
Hess River Fm., outcrop at 195 m above the Sekwi Fm.

**Dicellomus**? sp.
**Cedaria**? sp.
Age: latest Middle Cambrian or Dresbachian, **Cedaria** Zone.

GSC Loc. C-69180 (WHF)
Hess River Fm., outcrop at about 50 m above the Sekwi Fm. Sample from location 10 km northeast, along strike, from Section 44.

**Bonnia columbensis** Reeser
**Piaziella** sp.
**Olenellus puertoblancoensis** (Lochman)
**Oryctocephalus**? sp.
Age: late Early Cambrian, late **Bonnia-Olenellus** Zone

SECTION 8 - Base at 64°28'N, 131°30'W, NTS 106B.

GSC Loc. C-69406 (RST)
Rabbitkettle Fm., outcrop 29 m above thrust at top of the section.

**Drepanodus arcuatus** (Pander)
**Drepanoistodus forceps** (Lindström)
**Oepikodus evae** (Lindström)
**Paracordylodus gracilis** (Lindström)
**Oistodus multicorrugatus** sensu Serpagli, 1974
**Walliserodus australis** Serpagli
Age: Early Ordovician, late Early- early Middle Arenigian, **Oepikodus evae** Zone
Sample weight: 1290 g
No. of conodonts: >20

GSC Loc. C-69405 (RST)
Rabbitkettle Fm., outcrop 6 m above thrust at the top of the section.

cf. **Triangulodus brevibasis** (Sergeeva)
cf. **Peridon flabellum** (Lindström)
cf. **Prioniodus elegans** Pander
aff. **Acodus deltatus deltatus** (Lindström)
Age: Early Ordovician, early Middle Arenigian
Sample weight: 1190 g
No. of conodonts: 15

GSC Loc. C-69404 (BSN)
Rabbitkettle Fm., outcrop 4 m above thrust at the top of the section.

**Clonograptus** sp.
Age: Early Ordovician, Tremadoc or Arenig, **Adelograptus antiquus** Zone to **Isograptus caduceus** Zone

SECTION 8 (cont'd)

GSC Loc. C-69402 (RST)
Unnamed massive limestone, outcrop 108 m above the Duo Lake Fm.

**Belodina moniterensis** Ethington and Schumacher
**Panderodus gracilis** (Branson and Mehl)
cf. **Pygodus anserinus** (Lamont and Lindström)
**Strachanognathus parvus** Rhodes
Age: If the identification of **P. anserinus** is correct, the age would be late Llandeilian. Accompanying taxa could be accommodated quite comfortably within this age range but are also known from slightly older as well as younger strata. A Late Ordovician date can however be ruled out.
Sample weight: 2000 g
No. of conodonts: ≈25

GSC Loc. C-69401 (RST)
Unnamed massive limestone, outcrop at 97 m above the Duo Lake Fm.

**Periodon aculeatus** Hadding
**Plectodina** n. sp.
Age: Middle Ordovician, late Llanvirnian to Llandeilian
Sample weight: 1584 g
No. of conodonts: 8

GSC Loc. C-69399 (RST)
Unnamed massive limestone, outcrop at 70 m above the Duo Lake Fm.

**Panderodus gracilis** (Branson and Mehl)
Age: Middle to Late Ordovician
Sample weight: 1559 g
No. of condonts: 4

GSC Loc. C-69398 (RST)
Unnamed massive limestone, outcrop just above contact with the Duo Lake Fm.

**Protopenderodus robustus** (Hadding) s.f.
**Eoplacognathus foliceous** (Fåhraeus)
**Oistodus venustus** Stauffer
**Panderodus gracilis** (Branson and Mehl)
**Periodon aculeatus** Hadding
**Pygodus serrus** (Hadding)
Age: The **Eoplacognathus foliaceous** subzone of **Pygodus serrus** zone, i.e. Middle Ordovician, upper middle but not uppermost part of the Llanvirnian. In terms of North American stages, late Whiterockian-early Chazyan [i.e. late Fauna 4 or early Fauna 5 of Sweet et al. (1971)]
Sample weight: 1590 g
No. of conodonts: >40

GSC Loc. C-69393 (BSN)
Rabbitkettle Fm., outcrop at 113 m above the Hess River Fm.

inarticulate brachiopod
**Caryocaris**? sp.
**Clonograptus** aff. C. sp. C of Jackson 1976
Age: Early Ordovician, probably Tremadoc, probably **Adelograptus antiquus** Zone

GSC Loc. C-69391 (WHF)
Hess River Fm., felsenmeer at 100 m above the Sekwi Fm.

**Olenellus** sp.
**Onchocephalus**? sp.
Age: late Early Cambrian, **Bonnia-Olenellus** Zone

GSC Loc. C-69388 (WHF)
Sekwi Fm., felsenmeer at 1 m below the Hess River Fm.

**Olenellus**? sp.
**Wanneria**? sp.
**Salterella** sp.
Age: late Early Cambrian, **Bonnia-Ollenellus** Zone

SECTION 9 - Base at 64°31'N, 131°02'W, NTS 106B.

GSC Loc. C-69443 (RST)
Cloudy Fm., outcrop at 160 m above the Duo Lake Fm. Sample from an olistostrome.

**Decoriconus fragilis** (Branson and Mehl)
**Ozarkodina** sp.
cf. **Walliserodus curvatus** (Branson and Branson)
Age: No diagnostic taxon is present. **Decoriconus fragilis** however has not been reported from Ordovician whereas elements of **Ozarkodina** sp. appear to be closer to early Silurian ozarkodinids than to the Ordovician ones. Therefore a Silurian age, probably early Silurian, is indicated.
Sample weight: 1139 g
No. of conodonts: 7

GSC Loc. C-69442 (BSN)
Duo Lake Fm., felsenmeer at 517 m above the Rabbitkettle Fm.

inarticulate brachiopod
diplograptid
**Climacograptus** sp.
Age: Middle Ordovician to Early Silurian

SECTION 9 (cont'd)

GSC Loc. C-69438 (BSN)
Marmot Fm., felsenmeer
at 284 m above the
Rabbitkettle Fm.

**Climacograptus** sp.
**Dicellograptus** sp.
**Orthograptus** sp.
Age: late Middle to Late Ordovician, Caradoc to Ashgill

GSC Loc. C-69433 (BSN)
Duo Lake Fm., outcrop
at 120 m above the
Rabbitkettle Fm.

diplograptid
**Glyptograptus** sp.
Age: late Early Ordovician (late Arenig) to Early Silurian

GSC Loc. C-64329 (RST)
Rabbitkettle Fm., outcrop
at 275 m above the
Hess River Fm.

**"Prooneotodus" tenuis** (Müller)
**Pelagiella** sp.
**Anabarella** spp.
Age: Middle Cambrian to Late Cambrian, Franconian. The two phosphatic microfossils **Pelagiella** and **Anabarella** are restricted to the Middle Cambrian while **"P" tenuis** is a long ranging taxon and extends from Middle Cambrian to Late Cambrian. Absence of **Proconodonts** is taken to imply Middle Cambrian or early Franconian age following Fåhreaus and Nowlan (1978).
Sample weight: 1209 g

SECTION 10 - 64°36'N; 130°02'W, NTS 106B. Section of poorly exposed shales and silty limestones. All samples are from felsenmeer and may include talus.

GSC Loc. C-69196 (WHF)
Hess River Fm., 147 m above
the Sekwi Fm.

**Bathyuriscus adaeus**? Walcott
**Elrathia** sp.
Age: late **Bathyuriscus-Elrathina** Zone

GSC Loc. C-69195 (WHF)
Hess River Fm.,
147 m above
the Sekwi Fm.

**Alokistocare** sp.
**Bathyuriscus adaeus**? Walcott
**Elrathina** sp.
cf. **Elrathia** sp.
**Olenoides** sp.
**Pachyaspis** sp.
**Kootenia** sp.
**Pagetia** sp.
**Peronopsis** sp.
corynexochid trilobite
Age: Middle Cambrian, late **Bathyuriscus-Elrathina** Zone

GSC Loc. C-69194 (WHF)
Hess River Fm., 110 m above
the Sekwi Fm.

**Kootenia**?
Age: Middle? Cambrian

GSC Loc. C-69193 (WHF)
Hess River Fm., 60 m above
the Sekwi Fm.

ptychoparioid trilobite
sponge spicules
Age: Middle? Cambrian

GSC Loc. C-69191 (WHF)
Hess River Fm., 53 m above
the Sekwi Fm.

**Poliella** sp.
Age: early Middle Cambrian, **Plagiura-Poliella** Zone or **Albertella** Zone

SECTION 12 - Base at 64°18'N, 130°58'W, NTS 106B. Most of the Duo Lake Fm. disharmonically folded.

GSC Loc. C-53262
Natla? Fm., outcrop 80 m
above the Duo Lake Fm.

echinoderm and bryozoan debris, including abundant two holed crinoids
Age: late Early to early Middle Devonian, Zlichovian to earliest Couvinian (A.W. Norris and A.E. Pedder pers. comm.)

GSC Loc. C-53261 (RST)
Natla? Fm., outcrop 50 m
above the Duo Lake Fm.

**Pandorinellina exigua exigua** (Philip)
**Polygnathus inversus** Klapper and Johnson
**Belodella** sp.
**Panderodus** sp.
Age: **inversus** Zone of Klapper and Johnson (1978), of early Dalejan age (late Early Devonian) (as identified by T.T. Uyeno)
Sample weight: 886 g
No. of conodonts: 12

GSC Loc. C-53260 (BSN)
Duo Lake Fm., felsenmeer
44 m below the Natla? Fm.

echinoderm, bryozoan, rugose and tabulate coral debris and clasts
Age: Silurian or Devonian

SECTION 12 (cont'd)

GSC Loc. C-53259 (BSN)
Duo Lake Fm., outcrop in the middle of disharmonically folded Duo Lake Fm.

echinoderm and brachiopod debris and clasts
**Coenites**? sp.
**Favosites**? sp.
Age: Silurian to Middle Devonian

SECTION 13 - Type section for the Cloudy Fm. Base at 64°27'N, 130°35'W, NTS 106B. Base in upper Rabbitkettle Fm.

GSC Loc. C-69417 (BSN)
Cloudy Fm., felsenmeer at 138 m above the Duo Lake Fm.

(mixed collection)
Slabs A & B: **Monograptus** sp.
**M.** ex gr. **M. spiralis** (Geinitz)
Age: latest Llandovery, **M. spiralis** Zone
Slab C: **M.** aff. **M. becki** (Barrande)
Age: Late Landovery
Slab D: graptolite fragments **Climacograptus**? sp.
Age: Llanvirn to Llandovery (not latest), probably Ordovician
N.B.: The unit of slope and strike of units at this location suggests that these slabs are stratigraphically with a few metres of each other (*see* also GSC Loc. C-69240 at Sec. 14).

GSC Loc. C-69413 (BSN)
Duo Lake Fm., outcrop at 72 m above the Rabbitkettle Fm.
Sample of *in situ* coral.

**Palaeophyllum** sp.
Age: late Middle Ordovician (Caradoc) to Early Silurian (Llandovery)

GSC Loc. C-69412 and C-69411 (BSN)
Duo Lakes Fm., outcrop at 72 m above the Rabbitkettle Fm.
Samples from clast in conglomerate.

**Hypodicranotus** sp. (hypostome only)
echinoderm debris
bryozoan(?)
streptelasmid coral
Age: late Middle Ordovician (Caradoc) to Late Ordovician (Ashgill)

GSC Loc. C-69407 (BSN)
Rabbitkettle Fm., outcrop at about 100 m below the Duo Lake Fm.

dichograptid or **Clonograptus** sp.
Age: probably Early Ordovician (Tremadoc to Arenig)

SECTION 14 - Base at 64°27'N, 130°30'W, NTS 106B. Base of section with the lower? part of the Rabbitkettle Fm.

GSC Loc. C-69245 (BSN)
Sample from outcrop near the top of folded Cloudy Fm., south of the top of Section 34.

probable atrypoid brachiopod
Age: Silurian or Devonian

GSC Loc. C-69242 (BSN)
Sample from outcrop near the top of folded Cloudy Fm., south of the top of Section 34.

**Monograptus**? sp.
**M.** ex gr. **M. spiralis** (Geinitz)
Age: late Early Silurian, latest Llandovery, **M. spiralis** Zone.

GSC Loc. C-69240 (BSN)
Sample from thin shale outcrop near the top? of folded Cloudy Fm., south of the top of Section 34.

mixed collection BSN
Slab A: **Cyrtograptus** sp.
Age: latest Llandovery (late **M. spiralis** Zone) to Wenlock
Other Slabs: trilobite fragments
**Climacograptus** sp.
**Glyptograptus**? sp.
**Monograptus** sp.
Age: late Early Silurian, Llandovery (not latest)

GSC Loc. C-69239 (BSN)
Sample from the lower? part of folded Cloudy Fm., south of the top of Section 14.

rhynchonellid brachiopod
**Grewingkia** sp.
**Halysites** sp.
**Palaeofavosites** sp.
**Propora** sp.
Age: Early Silurian, early or middle Llandovery

GSC Loc. C-69235 (BSN)
Rabbitkettle Fm., outcrop at 749 m above base of the section.

**Caryocaris** sp.
Age: Ordovician

SECTION 15 - Base at 64°27'N, 130°06'W, 106B. Base of section in upper Duo Lake Fm.

GSC Loc. C-53274 (BSN)
Cloudy Fm., felsenmeer
191 m above the Duo Lake Fm.

echinoderm debris
inarticulate and rhynchonellid brachiopod fragments
**Amplexograptus**? sp.
Age: Middle to Late Ordovician.

GSC Loc. C-53271 (BSN)
Duo Lake Fm., outcrop
122 m below the Cloudy Fm.

**Climacograptus** ex gr. **C. bicornis** (Hall)
**Dicranograptus** cf. **D. nicholsoni** Hopkinson
**Glossograptus hincksii** (Hopkinson)
**Orthograptus** sp.
**Ptilograptus** sp.
Age: late Middle Ordovician, Caradoc, **Climacograptus bicornis** Zone

SECTION 16 - Base at 64°31.5'N, 129°46.5'W, NTS 106A

GSC Loc. C-69225 (RST)
Delorme Fm., outcrop
75 m above the Mount
Kindle Fm.

**Drepanoistodus forceps** (Lindström)
cf. **Oepikodus evae** (Lindström)
**Walliserodus australis** Serpagli
Age: The age of this collection as determined by conodonts, (early-middle Arenigian) because of its stratigraphic position, is anamolous. No evidence of stratigraphic admixture (such as Lower and Upper Ordovician) was found. Conodonts are poorly preserved. Age of underlying strata and absence of structural repetition, suggests this to be reworked fauna.
Sample weight: 1000 g
No. of conodonts: 6

GSC Loc. C-69224 (RST)
Mount Kindle Fm., outcrop
at 59 m above underlying
transitional Franklin
Mountain Fm.

**Oulodus** sp.
**Panderodus** sp.
**Ozarkodina** sp.
Age: Probably Silurian
Sample weight: 1269 g
No. of conodonts: 10

GSC Loc. C-69222 (RST)
Mount Kindle Fm., outcrop
at 8 m above underlying
transitional Franklin
Mountain Fm.

**Decoriconus fragilis** (Branson and Mehl)
**Icriodella**? aff. **I.** n. sp. Pollock, Rexroad and Nicoll
cf. **Ozarkodian typica**
cf. **Oulodus jeannae** Sweet and Schönlaub
**Walliserodus curuatus** (Branson and Branson)
**Panderodus unicostatus** (Branson and Mehl) s.f.
**Pseudooneotodus** sp. s.f.
**Exochognathus** sp.
Age: Early Silurian, Llandovery
Sample weight: 1273 g
Conodonts: abundant

GSC Loc. C-69221 (RST)
Transitional Franklin
Mountain Fm., outcrop
at 843 m above the
Hess River Fm.

**Acontiodus robustus** (Hadding) s.l.
cf. **Belodella erecta** (Rhodes and Dineley)
**Drepanodus arcuatus** Pander
**Pygodus** sp?
**Prioniodus** sp?
**Plectodina** sp.
Age: **Pygodus** identification, if correct, would restrict the age to the middle part of Middle Ordovician, late Llanvirnian to Llandeilian. This is also supported to some extent by other taxa, namely that **A. robustus** and **D. arcuatus** are not known to occur above this age
Sample weight: 1350 g
Conodonts: abundant

GSC Loc. C-69220 (RST)
Transitional Franklin
Mountain Fm., outcrop
at 820 m above the
Hess River Fm.

**Bergstroemognathus ex-tensus** (Graves and Ellison)
**Drepanodus arcuatus** Pander
**Drepanoistodus forceps** (Lindström)
**Oistodus lanceolatus** Pander
**Periodon flabellum** (Lindström)
cf. **Oepikodus evae** (Lindström)
**Oepikodus communis** (Ethington and Clark)
Age: Early Ordovician, early Middle Arenigian, Fauna E - Fauna 1, ? early Fauna 2 of Sweet, Ethington and Barnes (1971)
Sample weight: 1230 g
Conodonts: abundant

SECTION 16 (cont'd)

GSC Loc. C-69219 (RST)
Transitional Franklin Mountain Fm., outcrop at 792 m above the Hess River Fm.

**Acodus deltatus deltatus** Lindström
**Drepanodus arcuatus** Pander
**Drepanoistodus forceps** (Lindström)
**Juanognathus variabilis** Serpagli
**Oepikodus evae** (Lindström)
**Oepikodus communis** (Ethington and Clark)
Age: Early Ordovician, early Arenigian, Fauna E
Sample weight: 1233 g
Conodonts: abundant

GSC Loc. C-69218 (RST)
Transitional Franklin Mountain Fm., outcrop at 742 m above the Hess River Fm.

**Drepanoistodus forceps** (Lindström)
**Drepanoistodus conulatus** (Lindström)
**Scolopodus filosus** Ethington and Clark
Age: Early Ordovician, early Arenigian, Fauna D
Sample weight: 1060 g
No. of conodonts: >20

GSC Loc. C-69217 (RST)
Transitional Franklin Mountain Fm., outcrop at 689 m above the Hess River Fm.

**Drepanoistodus inconstans** (Lindström)
**Drepanoistodus numarcuatus** (Lindström)
**Drepanoistodus conulatus** (Lindström)
**Drepanodus arcuatus** Pander
**Protopanderodus gradatus** Serpagli
**Scolopodus filosus** Ethington and Clark
**Triangulodus subtilis** Van Wamel
Age: Early Ordovician, early Arenigian, Fauna D
Sample weight: 2000 g
Conodonts: abundant

GSC Loc. C-69216 (RST)
Transitional Franklin Mountain Fm., outcrop at 668 m above the Hess River Fm.

cf. **Paltodus variabilis sensu** Klapper et al., 1977
cf. **Scolopodus iowensis** (Furnish) s.f.
cf. **Scolopodus quadraplicatus** (Branson and Mehl)
**Drepanodus** sp.
Age: latest Tremadocian ?basal Arenigian; Fauna C-? Fauna D of Ethington and Clark (1971)
Sample weight: 1117 g
No. of conodonts: >20

GSC Loc. C-69214 (WHF)
Rabbitkettle Fm., felsenmeer sample at 638 m above the Hess River FM.

**Hungaia**? sp.
Age: Late Cambrian, late Franconian or Trempealeauan, **Ptychaspis-Prosaukia** Zone or **Saukia** Zone

GSC Loc. C-69213 (WHF)
Rabbitkettle Fm., felsenmeer, possibly talus, at 595 m above the Hess River Fm.

olenid trilobite
Age: Late Cambrian

GSC Loc. C-69212 (WHF)
Rabbitkettle Fm., felsenmeer, possibly talus, at 457 m above the Hess River Fm.

**Eurekia** sp.
Age: **Ptychaspis-Prosaukia** Zone or **Saukia** Zone

GSC Loc. C-69209 (WHF)
Rabbitkettle Fm., felsenmeer, possibly talus, 203 m above the Hess River Fm.

**Taenicephalus** sp.
**Pseudagnostus** sp.
Age: Late Cambrian, Franconian, **Conaspis** Zone

GSC Loc. C-69208 (WHF)
Transitional Franklin Mountain Fm., felsenmeer at 148 m above the Hess River Fm.

**Dicellomus** sp.
Age: Late Cambrian, Dresbachian, **Cedaria-Crepicephalus** Zone

GSC Loc. C-69207 (WHF)
Transitional Franklin Mountain Fm., outcrop at 141 m above the Hess River Fm.

**Cedaria**? sp.
**Kormagnostus**? sp.
**Modocia**? sp.
Age: Late Cambrian, Dresbachian, **Cedaria-Crepicephalus** Zone

SECTION 16 (cont'd)

GSC Loc. C-69204 (WHF)
Hess River Fm., outcrop at
85 m above the Sekwi Fm.

**Bathyuriscidella** sp.
**Bathyuriscus adaeus** Walcott
**Elrathina spinifera** Rasetti
**Oryctocephalus** sp.
**Pagetia** sp.
**Peronopsis columbiensis** Rasetti
**Zacanthoides** sp.
Age: Middle Cambrian, late **Bathyuriscus-Elrathina** Zone

GSC Loc. C-69201 (WHF)
Hess River Fm., outcrop at
25 m above the Sekwi Fm.

**Oryctocephalus** sp.
ptychoparioid trilobite
**Hyolithes** sp.
Age: Middle Cambrian

GSC Loc. C-69200 (WHF)
Hess River Fm., outcrop at
25 m above the Sekwi Fm.

acrotretid brachiopods
**Chancia**? sp.
**Ogygopsis klotzi**? (Rominger)
**Hyolithes** sp.
Age: Middle Cambrian, **Bathyuriscus-Elrathina** Zone?

GSC Loc. C-69198 (WHF)
Hess River Fm., outcrop
100 m south of Section 31
and estimated at 20 m
above the Sekwi Fm.

**Bathyuriscus** sp.
**Elrathina spinifera** Rasetti
**Pagetia** sp.
**Peronopsis columbiensis** Rasetti
**Zacanthoides** sp.
Age: Middle Cambrian, late **Bathyuriscus-Elrathina** Zone

GSC Loc. C-69199 (WHF)
Hess River Fm., outcrop
at 10 m above the Sekwi Fm.

**Poliella** sp.
ptychoparioid trilobite
Age: early Middle Cambrian, **Plagiura-Poliella** Zone(?)

SECTION 17 - Base at 64°07.5'N and 130°16'W, NTS 106B. The uppermost cliff forming limestones in this section contain abundant two holed crinoids of Zlichovian to earliest Couvinian age (A.W. Norris and A.E. Pedder, pers. com.). Base of section is in middle? Rabbitkettle Fm.

GSC Loc. C-69292 (BSN)
Marmot Fm., outcrop at
370 m above the Duo Lake Fm.
Sample from limestone lens
in shale.

echinoderm debris
**Palaeofavosites**? sp.
solitary coral fragment
leptaenid and atrypoid brachiopods
Age: Late Ordovician to Middle Devonian

GSC Loc. C-84600 (BSN)
Duo Lake Fm., outcrop at
315 m above the
Rabbitkettle Fm.

**Climacograptus**? sp.
**Glyptograptus**? sp.
**Glossograptus** sp.
**Isograptus**? sp.
**Pterograptus**? sp.
Age: Middle Ordovician, Llanvirn, **Paraglossograptus etheridgei** Zone

GSC Loc. C-69283 (BSN)
Duo Lake Fm., felsenmeer,
possibly talus at 173 m
above the Rabbitkettle Fm.

indeterminate trilobite and inarticulate brachiopod
dichograptid or **Clonograptus** sp.
Age: Early Ordovician (Tremadoc or Arenig)

GSC Loc. C-69280 (BSN)
Duo Lake Fm., felsenmeer
at 20 m above the
Rabbitkettle Fm.

**Caryocaris**? sp.
**Clonograptus** sp.
Age: Early Ordovician (Tremadoc or Arenig)

GSC Loc. C-69279 (BSN)
Duo Lake Fm., felsenmeer
at approx. 10 m above the
Rabbitkettle Fm.

**Caryocaris** sp.
Age: Ordovician

SECTION 18 - Base at 64°19'N and 129°40'W, NTS 106A. Fritz (1976, p. 2) from his Section 4, four kilometres north of this section reports that "late Lower Cambrian(?) dolomite of the Sekwi Fm. is unconformably overlain by dark shale and platy limestone of early Ordovician age". This Ordovician age is based on identification of macrofauna in float at 21 m (68') and 22 m (73') above the Sekwi Fm.

GSC Loc. C-69268 (BSN)
Transitional Franklin Mountain Fm., felsenmeer at 681 m above the Sekwi Fm.

undetermined solitary coral
fragments of trilobites and bryozoans
Age: late Middle Ordovician (Caradoc) to Permian

GSC Loc. C-69265 (BSN)
Transitional Franklin Mountain Fm., outcrop at 590 m above the Sekwi Fm.

conulariid
indeterminate trilobite
Age: Paleozoic

GSC Loc. C-69264 (BSN)
Duo Lake Fm., outcrop at 508 m above the Sekwi Fm.

**Amplexograptus**? sp.
bryozoan
**Sowerbyella**? sp.
rafinesquinid, orthid, inarticulate and other brachiopods
**Cnemidopyge** sp.
**Geragnostus** sp.
**Lonchodomas**? sp.
**Platycalymene** sp. (with incipient 4th lateral glabellar furrow)
**Staurocephalus** sp.
asaphid, encrinurid and other trilobites
Age: Middle Ordovician, Llandeilo or early Caradoc

GSC Loc. C-69263 (BSN)
Duo Lake Fm., outcrop at 418 m above the Sekwi Fm.

**Amplexograptus**? sp.
**Climacograptus** sp.
**Cryptograptus** sp.
dichograptid
**Dictyonema** sp.
**Didymograptus extensus** (Hall)
**D.** aff. **D. serratulus** Hall
**D.** cf. **D. spinosus** Ruedemann
**Glossograptus** sp.
**Phyllograptus**? sp.
**Ptilograptus**? sp.
**Tetragraptus** sp.
**Tristichograptus** sp.
Age: early Middle Ordovician, Llanvirn, **Paraglossograptus etheridgei** Zone

GSC Loc. C-69258 (BSN)
Rabbitkettle Fm., felsenmeer, possibly talus, at 304 m above the Sekwi Fm.

echinoderm, bryozoan
brachiopod and trilobite fragments
**Protopliomerops**? sp.
Age: probable Early Ordovician (Tremadoc to Arenig)

GSC Loc. C-69256 (BSN)
Rabbitkettle Fm., felsenmeer, at 268 m above the Sekwi Fm.

orthid brachiopod
not diagnostic

GSC Loc. C-69255 (BSN)
Rabbitkettle Fm., outcrop at 268 m above the Sekwi Fm.

echinoderm and brachiopod fragments
**Protopliomerops**? sp.
Age: probably Early Ordovician (Tremadoc to Arenig)

SECTION 21 - Base at 64°07'N, 129°14'W, NTS 106A.

GSC Loc. C-53251 (BSN)
Mount Kindle Fm., outcrop and felsenmeer between 0 and 10 m above transitional Franklin Mountain Fm.

echinoderm debris
indeterminate brachiopods
actinocerid cephalopod
indeterminate solitary coral
**Catenipora** sp.
**Lobocorallium**? sp.
**Paleofavosites** sp.
**Palaeophyllum**? sp.
Age: Late Ordovician

GSC Loc. C-69450 (RST)
Transitional Franklin Mountain Fm., outcrop at 478 m above the Sekwi Fm.

cf. **Drepanoistodus forceps** (Lindström)
Age: Arenigian?
Sample weight: 869 g
No. of conodonts: 2

SECTION 21 (cont'd)

GSC Loc. C-69448 (RST)
Transitional Franklin Mountain Fm., outcrop at 400 m above the Sekwi Fm.

cf. **Drepanoistodus forceps** (Lindström)
cf. **Triangulodus subtilis** Van Wamel
cf. **Acodus deltatus deltatus** Lindström
Age: Early Ordovician, early Arenigian
Sample weight: 982 g
No. of conodonts: 12

GSC Loc. C-69447 (RST)
Rabbitkettle Fm., outcrop at 327 m above the Sekwi Fm.

cf. **Drepanoistodus forceps** (Lindström)
**Paltodus variabilis** s.l. **sensu** Klapper et al., 1977
cf. **Triangulodus subtilis** Van Wemel
**Histiodella**? sp. s.f.
cf. **Drepanoistodus conulatus** (Lindström)
Age: Early Ordovician, latest Tremadocian or basal Arenigian
Sample weight: 884 g

GSC Loc. C-69445 (WHF)
Rabbitkettle Fm., felsenmeer or talus at 135 m above the Sekwi Fm.

**Tostonia**?
Age: Late Cambrian, Franconian, **Ptychapis-Prosaukia** Zone or **Conaspis** Zone

SECTION 23 - Base at 63°47.5'N, 130°48'W, NTS 105O.

GSC Loc. C-84623 (BSN)
Duo Lake Fm., outcrop 80-86 m above the Rabbitkettle Fm.

**Caryocaris** sp.
**Clonograptus** sp.
**Didymograptus** spp. (pendant and horizontal forms)
**Isograptus** sp.
Age: Early Ordovician, probably **Isograptus caduceus** Zone possibly **Paraglossograptus etheridgei** Zone

SECTION 25 - 63°45'N, 130°17'W, NTS 105O. Section of moderately exposed calcareous shale, shale and silty limestone.

GSC Loc. C-84573 (BSN)
Duo Lake Fm., outcrop 174 m above the Rabbitkettle Fm.

**Climacograptus** ex gr. **C. bicornis** (Hall)
**Dicellograptus** sp.
**Dicranograptus** sp.
**Orthograptus** sp.
Age: Middle Ordovician, Caradoc, **Climacograptus bicornis** Zone to **Orthograptus quadrimucronatus** Zone

GSC Loc. C-84572 (BSN)
Duo Lake Fm., outcrop 168 m above the Rabbitkettle Fm.

**Climacograptus** ex gr. **C. bicornis** (Hall)
**Dicellograptus** sp.
**Dicranograptus** sp.
Age: Middle Ordovician, Caradoc, **Climacograptus bicornis** Zone to **Orthograptus quadrimucronatus** Zone

GSC Loc. C-84571 (BSN)
Duo Lake Fm., outcrop 35 m above the Rabbitkettle Fm.

**Caryocaris** sp.
**Didymograptus** sp.
**D.** cf. **D. gracilis** Törnquist
**D.** cf. **D. protobifidus** Elles
**Phyllograptus** sp.
**Sigmagraptus** sp.
**Tetragraptus** spp.
Age: Early Ordovician, Arenig, **Didymograptus protobifidus** Zone

LOCATION 108 - Single sample from the lower part of the Mount Kindle Formation in the south-central part of the Carcajou Canyon map-area (96D) at 64°02'N and 127°08'W.

GSC Loc. C-69157 (BSN)

echinoderm debris
bryozoan, straight cephalopod
streptelasmid and favositid corals
**Catenipora** sp.
**Palaeophyllum** 2 spp.
**Rhynchotrema** cf. **R. windermeris** Wilson
Age: Late Ordovician, Ashgill.

LOCATIONS 116 and 117 - 63°46'N, 130°28'W and 63°52'N, 130°17'W, NTS 105O. Both samples from isolated outcrops of unnamed Early Devonian basin limestone.

| | |
|---|---|
| GSC Loc. C-84622 (BSN)<br>Outcrop sample Location 116 | **Monograptus** cf. **M yukonensis** Jackson and Lenz<br>Age: Early Devonian, Pragian, **Monograptus yukonensis** Zone |
| GSC Loc. C-84625 (BSN)<br>Outcrop sample Location 117 | **Monograptus** ex gr. **M yukonensis** Jackson and Lenz<br>Age: Early Devonian, Lochkovian or Pragian, **Monograptus uniformis uniformis** Zone to **Monograptus yukonensis** Zone |

LOCATION 137 - Sample from a massive dolostone mound, in transitional Mount Kindle Fm. at 64°56'N, 130°45'W, NTS 106B. Fossils rare in this mound.

| | |
|---|---|
| GSC Loc. C-53281 (BSN) | fragmentary rugose coral<br>Age: late Middle Ordovician to Permian |
| GSC Loc. C-53282 (BSN)<br>Felsenmeer sample | bryozoan<br>gastropod<br>indeterminate streptelasmid coral<br>**Catenipora** sp.<br>**Palaeophyllum** sp.<br>undetermined orthid and strophomenid brachiopods<br>**Diambonia**? sp.<br>**Dicoelosia** sp.<br>**Christiania**? sp.<br>**Ptychoglyptus** sp.<br>Age: late Middle Ordovician, Caradoc |

LOCATION 156 - Sample of Cloudy Fm., at 65°03'N, 132°20'W, 106F.

| | |
|---|---|
| GSC Loc. C-53264 (BSN)<br>Cloudy Fm., estimated at near the middle of this unit (150+ m thick) | echinoderm debris<br>rugose coral fragments<br>**Favosites** sp.<br>Age: latest Ordovician to Middle Devonian |

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